



Menomonee River Fish Passage

Identifying Stream Passage Impediments and
Opportunities to Address Aquatic Habitat
Fragmentation in the Menomonee River Watershed

Milwaukee Riverkeeper



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Executive Summary

Land use changes and increased imperviousness in the Menomonee River watershed have caused increased flow volumes (causing habitat degradation, erosion, removal of woody debris, etc); decreased base flows; increased sediment transport (which can smother eggs, fill in pools and habitat, reduce macroinvertebrate diversity); change of substrate (most notably sediment filling in pools and gravel needed by fish and macroinvertebrates); and loss of woody debris (most of this debris is washed down, reducing cover, altering local pool formation, and causing obstructions downstream). In addition, development in the watershed has created many impassable culverts, has filled in or altered habitat, and created other artificial barriers like dams and drop structures that impair both passage for fish, as well as habitat for all aquatic life. Barriers fragment important habitats for rearing and spawning, and impede fish and other life from reaching existing higher quality habitats in the upstream portions of the watershed. The first step to addressing fish passage issues and fragmentation of aquatic stream habitat is identifying impediments to fish movement. This inventory of stream passage impediments and opportunities for addressing aquatic habitat fragmentation included both a desktop analysis and field surveys of potential barriers and associated habitats expected to provide spawning habitat to northern pike (*Esox lucius*), which was selected as our focal species.

The mainstem of the Menomonee River and 10 main tributaries were surveyed. It's important to note that we did not survey concrete channelized creeks such as Honey Creek and Underwood Creek for potential fish passage issues due to the complexity and expense of removing concrete channel and associated barriers. Likewise, the majority of our survey work was focused downstream of the Lepper Dam in Menomonee Falls (we did survey Willow Creek upstream of the Dam as well as several unnamed creeks). Over 382 potential barriers were identified and assessed, with 126 barriers found to be significant. In addition, 75 areas of potential spawning habitat were identified (the identified areas were not exhaustive, and will require further investigation over several seasons to determine suitability as northern pike habitat). Suspected barriers fell into several categories including: minor debris jams (expected to be passable); major debris jams (expected to be potential barriers to fish passage); human caused barriers such as perched culverts, weirs, fords, or degraded pipe crossings; and natural barriers such as the namesake waterfalls in Menomonee Falls, areas of sediment deposition, etc. It is important to note that often natural barriers are exacerbated or caused by human activities upstream (e.g. more volatile flows from human activities, increased sedimentation from bank failure/destruction of riparian corridors, etc.). We conclude that there is excellent opportunity to address many natural and human caused barriers to fish passage to better address aquatic habitat fragmentation and connect native fishes like northern pike with suitable areas of upstream habitat for spawning.

Introduction

The Menomonee River Watershed covers 136 square miles, originating in wetlands in southeastern Washington County and southwestern Ozaukee County, and then flowing 28 miles through northeastern Waukesha County and through western and central Milwaukee County, where it joins the Milwaukee River just prior to its confluence with Lake Michigan.

The lower 12 miles of the Menomonee River downstream from the Little Menomonee River confluence and an additional mile of the Little Menomonee upstream to the former Moss American/Kerr McGee Superfund Site are part of the Milwaukee River Estuary Area of Concern (AOC). The AOC contains 11 of 14 beneficial use impairments including degradation of fish and wildlife populations, degradation of benthos, degradation of aesthetics, and loss of fish and wildlife habitat.

It is thought that the Menomonee River portion of the Milwaukee River Estuary once included over 40,000 acres of wetland prior to European settlement. Filling, dredging, channel relocation and engineering have destroyed most of these wetlands and the ecological functions they once provided. Spawning habitat for fish requiring wetlands like northern pike and marsh spawning walleye are absent from the lower reaches of the Menomonee River and Milwaukee Estuary; however, habitat suitable for sustaining potadromous fish populations is present throughout the upper Menomonee River and some of its major tributaries (estimated at 3,700 acres of riparian wetlands).

Fisheries and Water Quality

The Menomonee River fishery is characterized as a poor fishery due to a high proportion of low dissolved oxygen fishes, and Index of Biotic Integrity rankings show that there has not been a significant change in the overall quality of the fishery compared to historic conditions. According to the Southeastern Wisconsin Regional Planning Commission's (SEWRPC) recent Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds (2008), there has been a small increase overall of six species of fish from 1900 to 2004 in the Menomonee River based on review of historic data. The most notable gains of species included brook trout, brown trout, smallmouth bass, black crappie, walleye, and greater redhorse (a threatened species in Wisconsin). This increase in species in recent years is due largely to removal of the Falk Dam in 2001, as the dam provided an impediment to fish migration from Lake Michigan prior to that time and colonization by lake fishes.

Despite an increase in overall species abundance, there has been a decrease in the percent of *native* fishes in the watershed, with most notable losses including the blacknose shiner, spottail shiner, the least darter, and redbreast dace among others. When looking at *only the number of*

native and game fish species present, there are important differences throughout the watershed: the river upstream of Menomonee Falls has been stable as compared from 1902-1999 to 2000-2009 with around 22-23 fish species; the river between the Menomonee Falls "Lepper Dam" barrier and the concrete-lined section of the Menomonee (near Miller Park) has experienced a decline in fish species from 33 to 28; and number of native and game fish species in the downstream end increased from 11 to 38 (SEWRPC, 2010). Most notable also are the increased number of pollution intolerant species that have been captured in the downstream end, which is ostensibly due to a better connection to Lake Michigan as water quality tends to get poorer moving downstream along the river (SEWRPC, 2010).

In general, water temperatures in the Menomonee increase from upstream to downstream, and likewise, dissolved oxygen levels decrease from upstream to downstream. This is likely due the vast majority of 153 point source discharges and 236 "major" stormwater outfalls (about 60% of total outfalls) located in the southern half of the watershed (SEWRPC, 2010). There are also thermal impacts from the We Energies Valley Power Plant and other non-contact cooling water discharges in the lower Menomonee, making the lower portions of the river less hospitable for fish. This is another reason why it is important to pass fish to more upstream areas of the watershed, where water quality improves significantly.

The overall stagnation of the fishery is largely attributed to habitat loss and degradation resulting from human activities, including conversion of natural shorelines to steel and concrete seawalls in the majority of the Estuary. Urban land use has increased dramatically in the Menomonee River Watershed, from 21% in 1950 to over 63% in 2000 (SEWRPC 2007), and these land use changes and increased imperviousness in the watershed has caused habitat degradation and stagnated fish diversity. Specifically, these changes have caused increased flow volumes (causing habitat degradation, erosion, removal of woody debris, etc); decreased base flows; increased sediment transport (which can smother eggs, fill in pools and habitat, and reduce macroinvertebrate diversity); change of substrate (most notably sediment filling in pools and gravel needed by fish and macroinvertebrates); and loss of woody debris (most of this debris is washed down, reducing cover, altering local pool formation, and causing obstructions downstream). In addition, development has created many impassable culverts, has filled in/altered habitat, and created other artificial barriers like small dams and drop structures. Barriers fragment important habitats and impede fish and other aquatic life from accessing existing higher quality habitats, mostly in the upstream portions of the watershed. In addition, stream impediments also affect recreation, decreasing fishing opportunities and creating hazards for paddlers.

In general, the poorest biological communities in the Menomonee River Watershed are still located in more urbanized watersheds, such as Underwood and Honey Creeks (which we did

not assess due to concrete channelization), with higher quality biological communities in the less developed, upstream portions of the watershed (SEWRPC, 2010). In general, the biological community is limited by periodic but intense stormwater loads (associated with increased flashiness from urban development), as well as to decreased base flows in area streams and increased water temperatures due to urbanization, as well as physical habitat loss as detailed above. Despite these challenges, habitat conditions are generally ranked good to excellent within the Menomonee River Watershed, and invertebrate communities throughout the watershed consistently rank as good in Hilsenhoff Biotic Index studies (SEWRPC, 2010). The "good" rankings for habitat and macroinvertebrates that provide "food" for fish are both positive signs that the stream is improving, and this may be a hopeful sign that the fishery needs more time to recover, and that fish need better access to spawning habitats that have been taken from them due to fragmentation and isolation of aquatic habitats due to urbanization.

Target Species

Wisconsin Department of Natural Resources (WDNR) has recommended that northern pike be used as a target species when determining whether or not stream barriers are obstructing passage, due to the pike's need to move to its spawning grounds during adverse flow conditions and its limited swimming and jumping ability (Wawrzyn, 2013). Northern pike are known as "burst" swimmers, and they are not likely adapted to passing obstacles or swimming long periods in fast moving waters (Ozaukee County et. al, 2007).

Historically, northern pike migrated up many low-gradient streams in southeast Wisconsin to spawn, and it is likely that identifying barriers and designing solutions to northern pike passage is likely to increase the probability that other fish species, most of which have superior swimming and leaping abilities, would be able to pass those same barriers. In addition, northern pike has been used by both Ozaukee County and MMSD as target species for their fish passage efforts. WDNR fisheries biologists have identified wetland habitats within the Menomonee River that northern pike could exploit for spawning, including those along Underwood Creek, the Little Menomonee River and Lily Creek which support about half of the riparian wetland parcels in the Menomonee River watershed (Wawrzyn, 2013). We did not include Underwood Creek in our assessment area nor Honey Creek, due to extensive sections of concrete channel that separate downstream portions of the Menomonee River with upstream habitats in those creek systems.

Allowing fish passage and creating habitat niches for "emerging" species that have been re-populating the estuary in the lower stretches of river should also be given attention in the design of the fish barrier mitigation. Some of the fishes that should be looked at for passage are the redhorse species (greater redhorse is state threatened), catfish, and small non-game

species (Interfluve, 2013). Darter species could serve as a good representative of the non-game species because of their intermediate pollution tolerance, their need to reach spawning habitat during low flow conditions and because there is good documentation of their swimming abilities (Interfluve, 2013).

Project Justification

The Milwaukee Metropolitan Sewerage District (MMSD), Southeastern Wisconsin Watershed Trust, Inc. (Sweet Water) , SEWRPC and WDNR have all identified eliminating fish passage barriers in the Menomonee River Watershed as a high priority in their stream planning and management efforts. Thus, this project to identify fish passage barriers and opportunities to reduce habitat fragmentation fills an important need.

MMSD recognized the benefits of removing fish barriers and providing better connection between the river and its floodplain and aquatic habitats in their Sediment Transport Study of the Menomonee River Watershed (MMSD, 2001). This report stated that MMSD could implement three main activities to better support a native fishery, including:

- "Removal of barriers (velocity or physical) within the watercourse which impede fish passage...
- In-stream activities to mitigate the impacts of development include the rehabilitation of floodplain connections and channel diversity. Several reaches within the Menomonee River system have been straightened and/or separated from their floodplain. Rehabilitation of the connection with the floodplain (especially for more frequent events) will provide needed spawning sites for northern pike and provide other benefits to the system. Additional in-stream activities may include the creation of pools or other measure to reduce the impact of increased temperature associated with development at lower flows.
- Off-stream activities to mitigate the impact of development."

In addition, SEWRPC has suggested a three-tiered approach for restoring aquatic habitat connectivity in the Menomonee River Watershed, which focuses on the reconnection of waterways that have been historically isolated from the Lake Michigan stream system through construction of dams, roadways, and flow control structures, or modified through construction of single-purpose systems, such as stormwater conveyances (SEWPPC, 2010). The three main components of the SEWRPC strategy are:

- "Tier 1 – Restoring connectivity and habitat quality between the mainstem waterways and the Lake Michigan endpoint,

- Tier 2 – Restoring connectivity and habitat quality between the tributary streams and the mainstems of the Menomonee and Kinnickinnic Rivers, and
- Tier 3–Expanding connection of highest-quality fish, invertebrate, and habitat sites within each of the watersheds."

Furthermore, Sweet Water echoes these recommendations in their 2010 Watershed Restoration Plan for the Menomonee River Watershed, as well as the Implementation Plan and Priority Project List (Sweet Water, 2010).

WDNR's Milwaukee River Estuary AOC Remedial Action Plan (RAP) recognizes that degradation of fish and wildlife *habitat* and degradation of fish and wildlife *populations* are closely linked, and that since the more urban portions of the AOC have been so heavily modified and engineered that there are very few opportunities to improve habitat in these areas. The Remedial Action Plan has also recognized that the most effective approach for addressing these beneficial use impairments is to improve access to existing high quality habitat areas for fish spawning and rearing in upstream areas of our watersheds (WDNR, 2012). The RAP recognized that decreasing impediments to fish migration has the best chance to increase both diversity and abundance of native fish species resident to Lake Michigan and the Estuary, and will move us closer to delisting these beneficial use impairments. Thus, this project to identify fish passage impediments and opportunities to address aquatic habitat fragmentation is an important first step to addressing beneficial use impairments in the Menomonee River portion of the Milwaukee AOC.

Project Goals

This goal of this fish passage project was to: 1) identify, inventory, and document existing barriers in the Menomonee River Watershed; 2) analyze physical features of barriers and impacts on fish movement (e.g., partial or complete barrier) and channel stability; 3) prioritize barrier removals; 4) educate and involve the public in this process; and 5) work with local municipalities and counties to address these impediments in the future (e.g., fundraising for restoration activities and infrastructure retrofits, organizing volunteer work days to remove debris jams, etc). This project was funded by both Wisconsin Coastal Management Program as well as by a WDNR River Planning Grant in 2011.

Our objective was to identify, evaluate, and inventory potential impediments along the Menomonee River mainstem and 10 other main tributaries (Figure 1) as well as several unnamed tributaries, including:

- Dretzka Park Creek
- Butler Creek

- Lilly Creek
- Little Menomonee River
- Little Menomonee Creek
- Noyes Park Creek
- Willow Creek
- Goldendale Creek
- Grantosa Creek
- Nor-X-Way Channel
- 3 Unnamed creeks

These streams were chosen because we felt they had the best potential for spawning habitat for northern pike, and were not known to have significant natural or human barriers to fish migration. Honey Creek and Underwood Creek were not surveyed due to the expense and complexity of removing concrete channel and associated barriers. MMSD is already leading efforts to remove concrete channel along portions of Underwood Creek. In addition, most of our inventory efforts were focused downstream of the Lepper Dam in Menomonee Falls, which is a significant barrier to upstream migration of northern pike and other Lake Michigan fishes. We did conduct some investigations of unnamed creeks upstream of the Dam as well as Willow Creek, largely responsive to SEWRPC's "Tier 3 goal" of expanding connections of highest-quality fish, invertebrate, and habitat sites within each of the watersheds.

Investigative Methods

This inventory included both desktop analysis and background research as well "on the ground" inventory and inspection of project streams. Our goal was to identify potential barrier sites and then to inventory those suspected sites, as well as identify other sites where barriers could exist using field verification. These barriers could be physical or temporal as northern pike adults require access to spawning wetlands during high spring flow conditions and larval egress during low-flow conditions.

Desktop Analysis and Background Research

Milwaukee Riverkeeper identified and assessed over 382 different potential stream impediments along the natural mainstem reaches of the Menomonee and Little Menomonee Rivers, as well as major tributaries that are not concrete channelized or enclosed, and that provide access to higher quality natural areas that could be used for fish spawning or rearing. Potential obstructions for investigation were identified by both SEWRPC as well as by WDNR fisheries staff. WDNR staff created a database using GIS layers of road and railroad crossings and dams in the Menomonee River watershed. The crossings were created by intersecting TIGER (2000 version) roads and WI 1:24K railroads with WI 1:24K streams. Dams and drop

structures from WDNR's database were also uploaded and merged with potential barriers identified by Tom Slawski of SEWRPC. A GIS shapefile was created, and then this shapefile was converted into a Microsoft Access geodatabase that had assessment fields as recommended in WDNR's Stream Crossing Inventory Protocol (Diebel, 2011). WDNR staff then exported this geodatabase file using ArcPad Data Manager to a file onto two Trimble Yuma field computers, which were loaned to us from the U. S. Fish and Wildlife Service (USFWS) through WDNR Science Services.

Over 595 potential barriers were initially flagged for further investigation and pre-loaded into these field computers for assessment. These barriers were largely "guesses" based on suspected road crossings with the state stream layer as delineated using high resolution aerial photos, the WDNR dams and drop structure layer, etc. Aerials were not investigated at a fine level to find debris jams, areas of channel constriction, impassable culverts, areas of pervious channel fill, channel areas of dense vegetation, etc. for survey efforts largely due to the stochastic nature of our urban streams due to volatile flow conditions, high stormwater loads, etc. Many of these pre-identified or flagged barriers were not barriers to fish migration, but rather problems with the historic stream layer not accurately representing current conditions within our streams. For the purposes of presenting the results of this study, Riverkeeper is largely using our own stream layer developed from current aerial photography and existing river conditions.

Aerial maps were also looked at to identify areas of wetland habitat as well as areas of streambed and bank vegetation, where northern pike could spawn. Densely vegetated streambanks, floodplain wetlands, shallow and littoral areas of ponds with good stream connection are all appropriate spawning habitat (Ozaukee County et. al, 2007).

Inventory and Inspection

Our target streams were walked by Riverkeeper staff and volunteers from October 2011 to late November 2012. In particular, 9 of our volunteers (of 14 trained on October 31, 2011) put in an estimated 261 hours of in-kind labor to our survey efforts. Staff and volunteers were trained using WDNR's Stream Crossing Inventory Instructions and associated Fact Sheet (Diebel 2011), which were developed with input from the U.S. Forest Service and U.S. Fish and Wildlife Service among others. Volunteers were also taught how to use the Trimble Field Computers and to enter data into the database for each parameter identified in the protocol (e.g. crossing info, structure shape, condition, pool presence, tailwater elevations, culvert measurements, etc.). For each potential barrier, data sheets were filled out to the best ability of the surveyor and pictures were taken (where possible). For passable barriers such as free spanning bridges and minor debris jams not impeding flow, largely only pictures were taken and notes. Suspected fish passage impediments (e.g. pipe crossings, fords, culverts, major debris jams)--both pre-loaded

assessment points as well as field identified impediments -- were geolocated, measured, and documented with pictures. To measure suspected impediments, standard survey equipment was used including: survey level, leveling rod, tripod for level, and tape measure. Stream miles inventoried and barriers assessed are shown on Figure 1.

All flagged potential fish passage impediment sites were visited and inventoried with the exception of a few sites where:

- Sites could not be safely accessed (e.g. extended culverts under highway 45 along Dretzka Park Creek and Nor-X-Way Channel);
- Land owner permission was not obtainable;
- Access via the river channel was exceedingly difficult due to high water levels and/or dense vegetation growth (e.g. swamp and wetland habitat); or
- Measurements were not able to be taken due to lack of water, especially during the summer 2012 drought; or
- Measurements were not able to be taken due to enormity of structures (e.g. several very high railroad culverts) exceeding our ability to survey with available survey equipment.

Approximately 5% of potential fish passage obstacles were not surveyed due to these reasons.

We also identified and geolocated areas of potential habitat suitability for northern pike spawning, and took pictures of these sites, but no other surveys were completed. While conducting detailed habitat suitability evaluations of these sites was beyond the scope of this project, we did make an effort to identify potential habitat variables that were likely to influence suitability for northern pike spawning, such as:

- Channel or flowage connectivity to mainstem of creek or river segment during high flows, including perched floodplain areas where oxbow streams and ponds are likely connected to the river segments during high flow periods;
- Density of herbaceous vegetation in the streambed or on the streambanks/floodplain; and
- Areas of regular floodplain flooding (as noted by watermarks, trees, drainage patterns, beaver activity, etc.) (Ozaukee County et. al, 2007; Wawrzyn, 2013).

Results

Suspected barriers to fish passage, specifically of northern pike, were noted in each of the inventoried stream segments (Figure 1). Of 382 potential barriers to fish passage, we identified 126 suspected "actual" barriers to fish passage (Table 1). In addition, we found 75 potential

Figure 1: Potential Barriers and Habitat Connections Surveyed

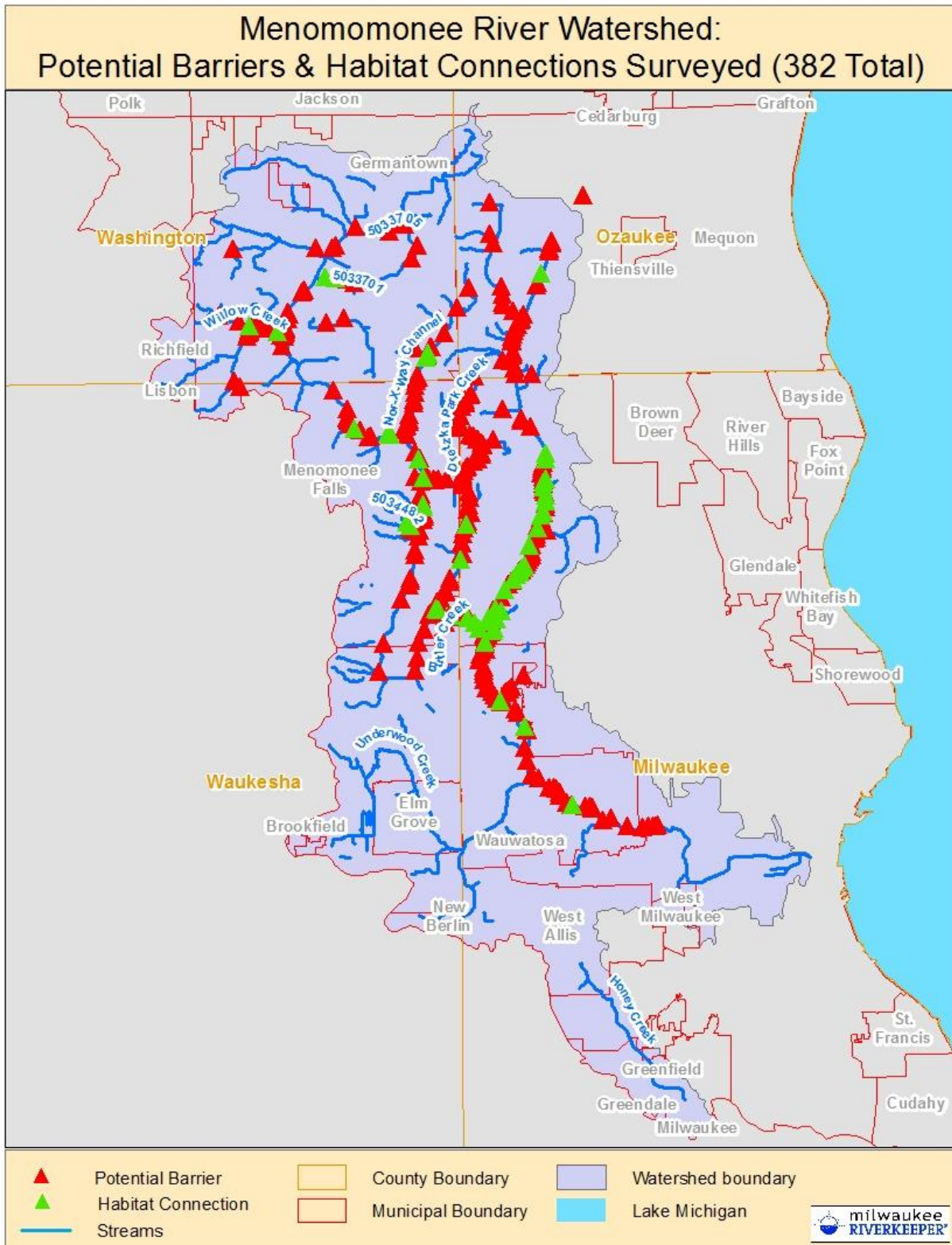


Table 1 Flow and Results of Barrier Inventory and Potential Northern Pike Habitat Areas

Stream Name	Field Inspection Date	Stream Discharge				Barriers		Potential Habitat Observed
		Flow Regime	Field Inspection Flow Condition			Potential	Actual	
			Headwater	Midstream	Outlet			
Butler Creek	7/12 - 9/12	Perennial	None	Low	Low	12	9	2
Dretzka Park Creek	9/14/12 - 11/8/12	Perennial	Low	Base	Base	31	3	3
Goldendale Creek	6/7/12	Perennial	Low	Base	Base	2	0	0
Grantosa Creek	7/6/12 - 8/1/12	Intermittent	Base	Base	Base	8	5	0
Lily Creek	7/9/12 - 9/7/12	Intermittent	Base	Base	Base	21	11	4
Little Menomonee Creek	5/31/12 - 10/5/12	Perennial	None	Low	Base	7	5	0
Little Menomonee River	3/1/12 - 10/26/12	Perennial	Base	Base	Base	117	46	27
Menomonee River	12/1/11 - 11/8/12	Perennial	Base	Base	Base	125	26	15
Nor-X-Way Channel	5/31/12 - 10/26/12	Intermittent	Base	Base	Base	24	12	7
Noyes Park Creek	3/21/12	Intermittent	Base	Base	Low	1	0	0
Willow Creek	6/8/12 - 7/19/12	Intermittent	Base	Base	Base	20	9	3
Unnamed (WBIC 5033701)	7/19/12	Intermittent	Base	Base	Base	4	0	4
Unnamed (WBIC 5033705)	5/31/12	Intermittent	Base	Base	Base	3	0	3
Unnamed (WBIC 5034482)	7/9/12	Intermittent	Base	Base	Base	7	0	7
Totals						382	126	75

habitat areas for northern pike spawning, although a detailed survey of their size, quality, and suitability for northern pike and other native fishes was beyond the scope of this inventory. Table 1 also includes general information on flow regime--either perennial or intermittent--stream as identified by the WDNR on their Surface Water Viewer (available at: <http://dnrm.wi.gov/imf/imf.jsp?site=SurfaceWaterViewer>). Information on stream discharge as observed during field inspections is also included for the headwater, midstream, and outlet of each stream. Flow levels are important in assessing both fish passage barriers as well as potential habitat areas. It is important to note that we were not able to assess these impediments during all flow conditions and seasons.

A map summarizing actual barriers found in the field for each stream segment assessed can be found in Appendix A. Barrier maps are alphabetized per stream and shown in order of downstream to upstream impediments. The barrier maps also include a wetland layer to show potential connections to suitable spawning habitat. Appendix B shows observed habitat areas, which showed potential during field visits as potential spawning areas for northern pike, overlaid with the WDNR Wetland Layer. Many of these habitat areas have become disconnected from the stream due to flashy flows and down-cutting of many stream channels, but could be restored to provide a better connection and provide spawning opportunities for northern pike and other native fisheries.

Data forms for each suspected barrier were downloaded from the Trimble field computers into our Microsoft Access database, including pictures and measurements (if taken), as well as identified areas of potential habitat such as wetlands, ponds, and flowages associated with stream segments surveyed. These Stream Crossing Inventory data sheets were converted into a Microsoft Access forms, and are found in Appendix C alphabetized from Butler Creek to Willow Creek and from downstream to upstream for each stream.

It's important to note that the "Stream Crossing Inventory" protocol that was used for our field surveys (and uploaded into the Trimble units) was largely developed for culverts, and so many of the other suspected impediments (e.g. woody debris barriers, pipe crossings, etc.) and potential habitat areas do not include measurements. There are Site ID or Site Identification Numbers for each potential barrier that are used on both the data sheets provided in Appendix C as well as the maps provided in Appendices A-B. These ID numbers were largely generated to be consistent with how WDNR is identifying fish passage barriers statewide. In addition, "actual" identified barriers have an additional number or "Alternate ID," which was developed for prioritization purposes where each barrier is named for the stream its located on as well as the order of the impediment from downstream to upstream (explained further in prioritization section below). Figure 2 contains an example Stream Crossing Inventory data sheet, and Figure 3 contains an example barrier map for the affected steam segment (found in Appendix A).

Figure 2: Stream Crossing Inventory Example Data Sheet (Butler Creek at Campbell Drive)

Menomonee Fish Passage Barrier Survey

Site ID Stream Road Date

Alt ID Type Pass Pass Method

Habitat Scour Pool Upstream Pond: Photo Other

Shape Drop

Condition Material

Drop Slope Plugged

Length Width Height

Notes
3 large metal corrugated culverts (perched), 3 small concrete stormwater outfalls. Rock blockage upstream of inlet.

No Image Available

Photo Outlet




Photo Inlet




Photo - Downstream




Photo - Upstream




Figure 3: Example Barrier Map (Butler Creek at Campbell Drive)



Prioritization

Fish Passability Scores

Barriers for removal are being prioritized using WDNR's Stream Crossing Inventory protocol, which was developed with input from the U.S. Forest Service, U.S. Fish and Wildlife Service, and other State fishery managers. Each barrier is analyzed and given a passability score based on whether the barrier is determined to be an impediment to passage for northern pike--the assumption being that pike are slow swimming and can't manage elevation changes greater than 0.3 feet. While passability scores were developed for pike, fisheries staff believe the rankings apply to most of our other native, non-salmonid species. It's important to note that the passability scores were largely developed for rural stream crossings, which are mostly culverts; however, if enough data existed as to elevation drops between barrier and tailwater then passability scores were assigned. Scores were also assigned where possible for "major" debris jams in certain cases where it was determined that flow was being impeded. Passability scores are included in barrier report forms (data sheets) found in Appendix C. Rules for determining passability scores are detailed in Table 2 below, where a completely passable structure such as an open span bridge or minor debris jam receives a score of 1, and a large dam or drop structure receives a score of 0, with some intermediate scores assigned based on features of the suspected barrier.

Table 2: Passability Score Criteria

Characteristic of Potential Barrier	Passability Score
Passable barrier: No other criteria met	1
Outlet drop:	
Drop greater than 0.3 feet	0
Drop less than 0.3 feet	0.5
Cascade or freefall, no drop recorded	0.5
Velocity: Culvert slope greater than 1%	0.5
Depth: Square structure with no substrate and water depth less than 0.3 feet	0.5
Structure Type:	
Dam	0
Open bottom culvert or bridge	1
Pike upstream: if pike observed upstream, but passability score is 0	0.5
Other obstructions, unless notes indicate that there is a complete barrier	0.5
Constriction ratio (structure width/bankfull width) less than 0.5	0.5
Length of structure over 100 feet	0.5

These passability scores can provide a very coarse level of prioritization when scanning through a database of 382 potential and 126 actual fish passage barriers to determine the ones that are highest priority to address to enhance passability of northern pike and other non-salmonids. Namely, we would start with the completely impassable structure that received "0" scores and then move on to the "0.5" scores, which could provide passability concerns during different flow conditions. In the case of this project, several additional levels of prioritization have been developed.

Ozaukee County Fish Passage Program Prioritization

We are also applying a prioritization protocol developed by Ozaukee County's Fish Passage Program, with input from WDNR staff, to prioritize impediments for removal based on type, stream miles reconnected, ownership (and difficulty of removal), and estimated expense. Ozaukee County's prioritization is designed to prioritize removal of the most downstream barriers that open up more miles of tributary or stream length upstream, to penalize expensive barrier removal (e.g. public and private "public works" impediments), and to heavily penalize natural barriers such as the Lepper Dam (or "falls" in Menomonee Falls) that pose as a major

permanent impediment. See Appendix D for more explanation on how the prioritization scheme was developed (Descriptions and Equation Explanation) and to view the prioritization spreadsheets of actual barriers identified.

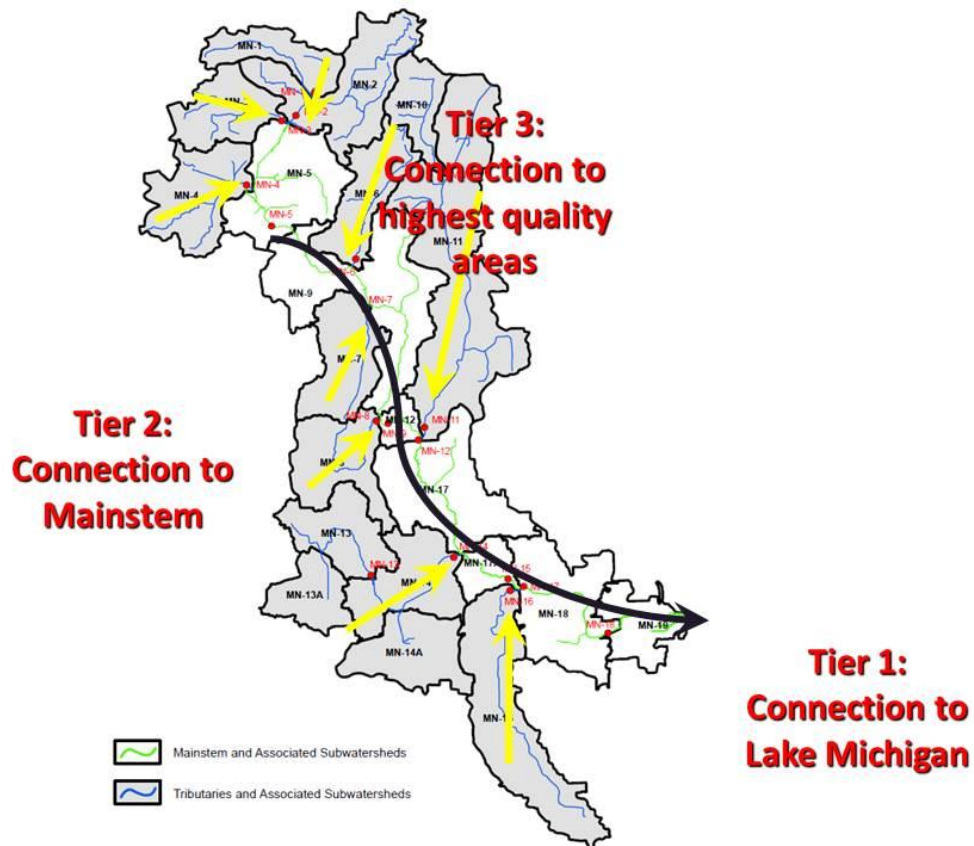
There is one main spreadsheet that lists all actual barriers identified from downstream to upstream in the Menomonee River Watershed, and broken out for each tributary. It's important to note that the Ozaukee County prioritization is based on "reaches" or fragments, and not on barrier numbers. In addition, we did not include 9 barriers identified on Willow Creek in the Ozaukee County prioritization (thus the total barrier number is 117 and not 126), because the confluence of that stream is upstream of the Lepper Dam in Menomonee Falls, and all barriers would be ranked extremely low priority. Willow Creek was not originally included in the scope of this grant, but was surveyed to assess potential for improving internal watershed connections because of its high quality habitat. The main spreadsheet also includes descriptive information, miles isolated by the barrier, barrier type, etc. Impediment significance scores are assigned based on the type of barrier and then the spreadsheet calculates a final tributary fragmentation score using an equation developed by Ozaukee County. The higher or larger numbers are higher priority (numbers are in exponential scale). There are then several linked spreadsheets, which break down the ranges of tributary impediment fragmentation scores into several buckets based on value into a fixed table (impediments broken out into exponential categories) and a dynamic scale (designed to update and adapt as barriers are removed to alter priorities over time). Impediments are ranked from high priority for removal to low priority for removal. These spreadsheets are formatted so that when a barrier is removed in the future, that all spreadsheets automatically update fields such as the miles of a tributary fragmented by the impediment, and priority ranking is adjusted accordingly. This prioritization provides another level of focus for impediment removal efforts to give emphasis to the most environmentally beneficial and cost-effective projects. The ultimate goal is to connect downstream anadromous fish to upstream portions of the watershed with existing upstream spawning habitat in the most cost-effective way possible.

SEWRPC Prioritization

As previously mentioned, SEWRPC recommended in its "Stream Habitat Conditions and Biological Assessment of the Kinnickinnic and Menomonee River Watersheds: 2000-2009 (SEWRPC 2010) that fish passage impediment removals should be prioritized from downstream to upstream along the Menomonee River mainstem in order to provide better connection between Lake Michigan fishes and upstream Menomonee habitats, with a secondary priority being to better connect the mainstem of the Menomonee with tributaries, and a tertiary priority to expand connection of highest-quality fish, invertebrate, and habitat sites within each of the watersheds. See Figure 4 for an illustration of this priority scheme. This overall

prioritization is consistent with the Ozaukee County prioritization scheme, with the exception being that it prioritizes work on the mainstem of the Menomonee River first before moving to tributaries. The SEWRPC recommendation was included in the Menomonee River Watershed Restoration Plan and Implementation Plan developed by Sweet Water (Sweet Water, 2010).

Figure 4: SEWRPC Recommended Fish Passage Priority Scheme for the Menomonee River



As a result of the consensus that we follow the SEWRPC prioritization scheme, the Menomonee River Watershed Restoration Plan recommended addressing the 5 most downstream impediments in the mainstem of the Menomonee River first. These 5 impediments between Swan Boulevard and Harmonie Avenue consist of 3 low flow barriers (MMSD owned pipe crossings that have degraded over the years and now are barriers during low flow periods), a former road or ford to the Wauwatosa Public Works yard, and a grade control structure that was used as a park walkway or pedestrian "ford".

Given that these five barriers were a priority, we contracted with Interfluve to create a conceptual design of what could be done in-stream to deal with these impediments. The

assumption at the time was that pipe removal or replacement would be very expensive, and that there were in-situ options for dealing with the barriers. Interfluve's report, "Low Flow Barriers Concept Plan: Swan Boulevard to Harmonie Drive," is included in Appendix E. Since the beginning of our project several years ago, we have been working with MMSD to find funding to address these barriers. We are happy to report that MMSD has received funding from both NOAA and the Sustain Our Great Lakes program to remediate these barriers. They have also committed MMSD funds for implementation efforts, and received a small grant from Fund for Lake Michigan to do additional design work. We anticipate that most of the barriers will be removed. One of the pipes needs to be either removed and replaced or addressed with a fish ramp structure, as described in the Interfluve report.

Conclusions and Recommendations

Our inventory determined that there were a significant number of impediments to fish passage in the Menomonee River Watershed (around 126), which affect the ability of northern pike and other native fishes to migrate from Lake Michigan to areas of existing, upstream habitat suitable for spawning. Despite absence of large dams, there are significant issues with both minor and major debris jams that cause aquatic habitat fragmentation, as well as human created impediments such as poorly designed or functioning culverts, old pipe crossings that have degraded causing drops in water elevation (of particular note 3 pipe crossings between Swan Blvd and Harmonie Avenue in Wauwatosa, as well as an old road and grade control structure), old fords (both urban and agricultural), and several small agricultural dams. There are also other areas of dense growth of vegetation in channels as well as areas of large rock/pervious fill deposition that pose as suspected impediments (e.g. some significant rock fill issues in Butler Creek). There is also a 3,500 foot section near the confluence of the Nor-X-Way Channel with the Menomonee River that was concrete channelized to deal with excess flows from a large commercial/industrial business park. This channel has degraded, and essentially created a small dam or weir, which blocks upstream portions of the creek, and which contain potential habitat areas suitable for northern pike. In addition, there are many vibrant wetland and floodplain areas associated with Menomonee River streams, which could provide potential spawning habitat for northern pike. Many of these areas have become disconnected from the stream due to flashy flows and down-cutting of many stream channels, but could be restored to provide a better connection and provide spring spawning opportunities.

Going Forward

Riverkeeper plans to provide a leadership role in advancing the removal of fish passage impediments and reconnection of aquatic habitat/floodplains to streams within the Menomonee River Watershed going forward. We plan to start with impediments on the mainstem of the Menomonee River moving from downstream to upstream. We will also start

working on removing high priority barriers as identified in the Ozaukee County Prioritization Matrix as opportunity allows. For example, one of the highest priority obstructions identified is a large debris jam at the confluence of Dretzka Creek and the Menomonee River, and this barrier could likely be tackled as part of similar ongoing work in the adjacent mainstem area. All of the major 126 barriers identified have low passability scores, which would be expected. It is unlikely that going forward we would prioritize passable structures, such as minor debris dams, although we will have to keep an eye on some of these obstructions to ensure they do not degrade over time.

In particular, we can help lead removal of woody debris barriers, which comprise the vast majority of fish passage impediments in the watershed, and which we can remove with our volunteers in some cases. It is clear from survey efforts that many debris barriers are years if not decades in the making. Removing these impediments could substantially improve fish mobility within the watershed. We envision using groups such as the Wisconsin Youth Conservation Corps and Milwaukee Community Service Corps in these projects. We will also seek out possibility to partner with groups such as Trout Unlimited and Student Conservation Association, where our goals coincide.

Riverkeeper also plans to provide a leadership role in ensuring that priority "infrastructure" or "public works" impediments (e.g. perched culverts, pipe crossings, and drop structures) are addressed by helping municipalities and counties to apply for grants (e.g. for design and barrier removal), as well as to advocate for barriers to be removed or retrofitted through use of existing capital improvement funds where possible. A good example of this is our work partnering with MMSD to remove 5 low flow barriers in historic Wauwatosa (3 pipe crossings, a former road crossing, and grade control structure/sidewalk).

Riverkeeper is also working with Menomonee Falls to fundraise for feasibility/conceptual design support to investigate options for removal of 3,500 linear feet of concrete channel near the confluence of the Nor-X-Way Channel and the Menomonee River (unfortunately a recent grant to the Fund for Lake Michigan to support this did not advance). We feel that upstream portions of the Nor-X-Way have good potential fish habitat, and the degradation of this concrete channel (which was put in place to deal with high stormwater flows from an adjacent industrial park) has effectively created a small dam blocking passage of fish to upstream portions of the creek. We will continue to work with Menomonee Falls to advance this project over the long-term (as concrete removal projects often take a long time to remove). These are just two examples of ways we are already reaching out to governments about our work and trying to advance solutions. We did receive a small grant from Freshwater Future to support us in writing a grant to the Great Lakes Restoration Initiative for the second phase of this fish passage work, which is to educate impediment owners, remove priority woody debris barriers,

and to start to work on design/feasibility of addressing some of the infrastructure issues or public works impediments that we have in the Menomonee River Watershed. We were invited to submit an application for Phase II of our fish passage work to the Fund for Lake Michigan (focusing on woody debris removal and design/engineering of priority infrastructure impediments), and also received a WDNR River Planning Grant to support our work to advance removal of impediments in the watershed going forward.

Given the current political and financial climate in Southeastern Wisconsin, most governments are going to need substantial support from the non-profit sector to advance these types of "non-essential" environmental improvement projects. Non-profits like Riverkeeper, while not an owner of any impediments, can help facilitate design and implementation in some cases in a way that bypasses complex municipal and county bid processes. It is clear though that our success going forward into Phase II of this project will largely depend on good relationships between Riverkeeper and our partners at all levels of government--municipal, county, MMSD, State--as well as other community groups and private landowners. We also plan to work closely with Ozaukee County to learn from their experience addressing and removing obstructions in Ozaukee County. We would also contract with engineers who can help us prioritize projects based on feasibility and cost as well as help with design and engineering work.

The overall objectives of Phase II of this work are to:

1. Educate municipalities, counties, and private landowners regarding priority fish passage impediments that need to be addressed;
2. Advocate for existing capital improvement funds to be allocated to address infrastructure issues/upgrades, and assist in writing grants for design/engineering as well as implementation projects to address these fish passage impediments;
3. Seek additional funding for removal of woody debris jams using existing volunteers as well as conservation work crews. Seek collaboration with groups such as the Southeastern Chapter of Trout Unlimited with similar interests;
4. Educate and involve the public in this process; and
5. Document watershed improvements.

We conclude that there is excellent opportunity to address many natural and human caused barriers to fish passage to better address aquatic habitat fragmentation and connect native fishes like northern pike with suitable areas of upstream habitat for spawning. Thanks to funding from Wisconsin Coastal Management Program and WDNR for the survey portion of this work, we feel well suited to move forward into implementation efforts with a goal of removing or retrofitting impediments to fish passage in a cost-effective way that improves habitat and viability of native fish populations within the Menomonee River Watershed.

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