PERE MARQUETTE RIVER WATERSHED MANAGEMENT PLAN

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The Pere Marquette River Watershed Management Plan is the product of a network of partner organizations and agencies working together. On behalf of the Pere Marquette River Restoration Committee, the Conservation Resource Alliance (CRA) thanks everyone involved in completing planning efforts for the benefit of this high quality river and its surrounding watershed.

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The following Pere Marquette River Restoration Committee partners contributed time and effort in completing the management plan:

- Conservation Resource Alliance
- The Watershed Center
- Land Conservancy of West Michigan
- The Nature Conservancy
- Pere Marquette Watershed Council
- Land Information Access Association
- United States Forest Service
- Michigan Department of Natural Resources
- Michigan Department of Environmental Quality
- Natural Resources Conservation Service
- Osceola-Lake, Mason-Lake, Newaygo and Oceana Conservation Districts
- Grand Traverse Band of Ottawa and Chippewa Indians
- US Fish and Wildlife Service
- Little River Band of Ottawa Indians
- Mason, Lake, Newaygo and Oceana Counties
- District Health Department #10, Environmental Health Division

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CHAPTER 1 EXECUTIVE SUMMARY

The Pere Marquette River is a popular, high quality trout stream with stable groundwater flows that meanders through the Huron-Manistee National Forest and rural areas of Northwest Michigan. The Pere Marquette is a state designated Blue Ribbon Trout Stream and Natural River, and a federally designated Wild and Scenic River. Lacking dams on the mainstem, the PM is the only free-flowing river in the Lake Michigan watershed. The Pere Marquette River flows through Lake, Mason, Oceana and Newaygo Counties, and enters Lake Michigan in Ludington. With its abundance of outdoor recreational opportunities, the watershed is a tourist destination for residents in southern Michigan and the Midwest. Steelhead, salmon and trout fishing, fly fishing, canoeing and kayaking, hunting, camping, swimming, and hiking are the main activities that attract vacationers and seasonal residents. In addition, portions of the watershed have soils, infrastructure, and weather conditions that are ideal for agricultural and livestock use. Accompanying these various types of use are the stressors that can compromise the health of the water and woods that attract people in the first place. Consequently, those stakeholders who value the river and its surrounding resources thus find the need to come together and manage the Pere Marquette on a watershed basis.

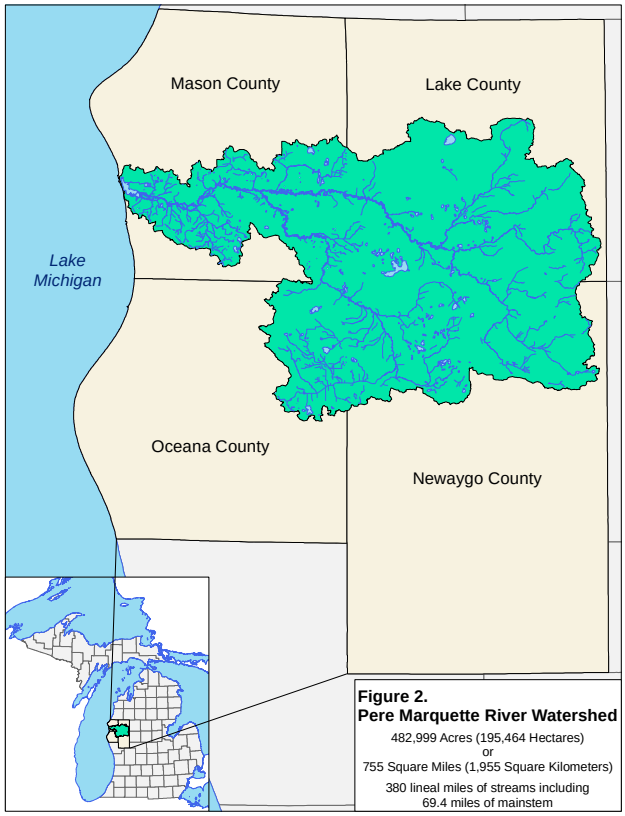


Figure 2.
Pere Marquette River Watershed
482,999 Acres (195,464 Hectares)
or
755 Square Miles (1,955 Square Kilometers)
380 lineal miles of streams including
69.4 miles of mainstem

The Pere Marquette River Restoration Committee (PMRRC) is a partnership of state and federal agencies, local municipalities, and private sector groups that are actively managing the recreational use, development and natural resources of the Pere Marquette River Watershed. In 2001, the Conservation Resource Alliance (CRA) worked with the overall PMRRC to develop a watershed management plan. The purpose of this plan is to formally update, coalesce and complement the variety of ongoing management mechanisms of the Pere Marquette River Watershed. Since 2001, the PMRRC has been active in completing an estimated $15,532,000 in land protection, road crossing, erosion control, stormwater management, and agricultural Best Management Practices (BMPs). Ultimately, the intention of this plan is to maintain that momentum of on-the-ground work and increase it if possible.

One of the challenges with managing the Pere Marquette River Watershed is its significant size and inclusion of large sub-watersheds. The watershed encompasses an area of 755 square miles and contains 380 lineal miles of streams including 69.4 miles of mainstem and over 300 miles of tributaries. The watershed is comprised of five major streams including the

mainstem, the Baldwin River, Middle Branch, Little South Branch, and Big South Branch, and over 75 smaller feeder creeks. Private riparian landowner interests and activities are often tailored to their specific stream and lack identification with the watershed as a whole. Because the river flows through four counties and their corresponding townships, many municipal boundaries are found within the Pere Marquette Watershed, as well.

The Pere Marquette River system is a predominantly groundwater-fed system, a vital characteristic of the river's ability to support high quality cold-water fisheries. The dominantly sandy soils of the Pere Marquette Watershed generally have high rates of permeability, which reduces runoff and enhances water infiltration. The Pere Marquette River Watershed is home to more than 40 species of mammals, 60 species of birds, and 25 species of amphibians and reptiles. The combination of forest, riparian corridors, wetland and fields contributes to the wildlife diversity found in the watershed. The Karner blue butterfly is the only federally endangered species found within the watershed and lays its eggs only on lupine scattered throughout the dry upland oak forests. Land use and cover in the watershed is dominated by a combination of forest types, with wetland areas ranking second. Wetlands account for 15% of the watershed. Larger tracts of wetlands are concentrated in the headwaters of the Baldwin River, Little South Branch, and Beaver and Cedar Creeks of the Big South Branch with smaller pockets throughout the riparian corridor. In the Little South and Big South areas, wetlands are interspersed with agricultural areas where they are used as drainages for fields. A significant portion of the watershed is within the Huron Manistee National Forest and Pere Marquette State Forest, which is helpful in maintaining ideal habitat and water quality. Agricultural use accounts for 11.8% of the watershed with most of it concentrated along the mainstem in Mason County and in the Big South sub-watershed. Development is minimal and is concentrated mostly in the Ludington area. Overall, the watershed is fairly rural.

In 2005, MDEQ completed a biological assessment of the watershed. A total of 27 sites (8 targeted and 19 randomly selected) were surveyed for macroinvertebrate communities, habitat rating and fish communities (for Lichte Creek only). Overall, the macroinvertebrate communities rated from acceptable to excellent with a fair number and relative abundance of sensitive taxa present at many stations. Habitat quality rated from marginal to excellent, as well. In general, instream habitat at many of the Pere Marquette River tributaries was impacted by sand bedload. All sites except three were analyzed for total dissolved solids, nitrite, ortho-phosphate, and conductance. Overall, water chemistry results were within the range of expected concentrations and metals concentrations were below Michigan Water Quality Standards. Some Pere Marquette tributaries contained slightly elevated nutrient concentrations, and these were located in areas with agricultural use. Overall, survey results were consistent with 2000 and 2010 survey results (2010 results were not yet compiled into a report when this plan was written). Based on the combination of rating scores for macroinvertebrates and habitat, the following waterways ranked as follows from overall highest quality to lowest:

1. Little South Branch
2. Baldwin River and Sanborn Creek, and the Middle Branch
3. Main Branch of the Pere Marquette and lower tributaries (Kinney, Weldon, Black, Swan and Lichte Creeks)

4. Big South Branch and tributaries (West Michigan, Tank, Winnepesaug, Cedar, Beaver, Allen and Carr Creeks)

From the 2005 study it can be inferred that the tributaries to monitor and further explore for implementation activities includes Beaver, Allen, Carr, Weldon, Black, and Swan Creeks, and the Middle Branch. Additional observations by CRA staff in the past would add McDuffee Creek (Little South Branch headwaters tributary) and Freeman Creek (Big South Branch tributary) to the list. Beaver Creek is the largest of the listed creeks, and it makes up the headwaters of the Big South Branch with a significant amount of Beaver Creek designated as county drain, and already tiled and drained due to agricultural use. It was noted in the 2005 report that the streams most impacted by channelization and nonpoint source pollution included Beaver, Black and Swan Creeks.

With this management plan, pollutant loading in the watershed was determined using the Long-Term Hydrologic Impact Assessment (L-THIA) model, developed by the Agricultural and Biological Engineering Department at Purdue University in conjunction with the EPA. L-THIA has been developed as a straightforward analysis tool that provides estimates of changes in runoff, recharge and nonpoint source pollution resulting from past or proposed land use changes. The L-THIA model uses the following land uses: Water, Commercial, Agricultural, High Density and Low Density Residential, Grass/Pasture, Forest, Industrial, and Other. The model shows that the phosphorus loss leaving the watershed is 19,228 pounds (lbs) per year, while nitrogen is 79,742 lbs per year (Tables 15 and 16). Suspended solids lost in the watershed are almost 1.7 million lbs. By far most of the nutrient and sediment pollution stem from agricultural lands in the Pere Marquette Watershed. According to values obtained using the L-THIA model, agriculture accounts for just 9% of the land use in the watershed, but contributes 91% of the phosphorus and 75% of the nitrogen loading. Additionally, agricultural lands contribute 86% of the suspended solids loss. Commercial land uses are second behind agriculture for phosphorus losses with 1,171 lbs per year, comprising just 6% of the total.

None of the designated uses for the Pere Marquette River Watershed are impaired on a watershed-wide scale. However, in some cases, activities and resulting pollutants in the watershed may prove to be a threat to water quality and designated uses. Threatened water bodies are defined as those that currently meet water quality standards, but may not in the future. The Pere Marquette River Watershed Management Plan thus focuses on five designated uses to protect in order to maintain the water quality of the Pere Marquette River and its many tributaries. The designated uses include the cold water fishery, other indigenous aquatic life, total body contact, navigation, and public water supply at point of intake. The priority pollutants in order of importance include sediment, nutrients, changes to hydrologic flow, invasive species, toxins, loss of habitat and pathogens.

The Pere Marquette River has been identified by the Nature Conservancy as one of two watersheds in the northern Lower Peninsula that is a priority watershed for conservation action due to its high biological significance, ongoing threats, and opportunities for protective action. The Pere Marquette River Restoration Committee's priority areas intersect with the conservation targets identified in the Pere Marquette River Watershed Plan April 2007 authored by The Nature Conservancy and Land Conservancy of West Michigan.

Priority areas are defined as the portions of the watershed that are most sensitive to environmental impacts and have the greatest likelihood to affect water quality and aquatic habitat. Priority areas account for approximately 18% of the watershed and include the portions of the watershed which would have a direct negative impact to the high water quality if they are degraded in the future. Areas that focus on preservation and protection are considered **priority areas** and include the following:

- Headwater Wetlands Complexes
- Intact wetlands throughout the watershed
- Oak-Pine Barrens Complex (most notably in the greater Whelan Lake area)

In addition, through field knowledge and validation from the MDEQ 2005 Biological Assessment, Pere Marquette River Restoration Committee notes that the Baldwin River, Little South Branch and Middle Branch subwatersheds currently contain most of the highest water quality and instream habitat conditions. Thus, implementation projects that focus on protecting and preserving existing conditions will likely be prioritized in those subwatersheds where intact wetlands are present and adjacent to a waterway.

Critical Areas

Critical areas are those within the Pere Marquette Watershed that are especially sensitive, and potentially need restoration, rehabilitation and management (in the form of vegetative buffers, streambank or channel restoration, reforestation, road/stream crossing replacement, stormwater management, etc.). Restoration of these areas is vital to maintaining the high water quality of the watershed. With agricultural use, outdated road stream crossings, and eroding streambanks being the highest sources of nutrients and sediment in the watershed, these uses were the first threshold of criteria in developing critical areas. Currently critical areas account for 17% of the watershed and include the following:

- **Agricultural use areas** which are focused on the headwaters of the Big South Branch, Little South Branch and Middle Branch, and portions of the mainstem corridor in Mason County.
- **50 severe road stream crossings** located throughout the watershed. One road crossing site includes an adjacent dam; this is located on the Baldwin River in the Village of Baldwin.
- **40 severely eroding streambanks** located on the Big South Branch and mainstem.
- **Baldwin, Custer, Scottville** village centers ranked in that order, starting upstream and working downstream in the watershed. These urban areas drain to the surface waters via storm sewers and the locations furthest upstream impact the most miles of river.

The Pere Marquette River Restoration Committee ranked the subwatersheds in order of importance with the Big South and Mainstem being most critical. Thus, those agricultural areas and sites found within the Big South and Mainstem subwatersheds are top critical areas for restoration and rehabilitation work. CRA's river management approach is typically to start work in the headwaters of a stream and continue downstream; this approach will be applied with work on agricultural lands, streambank and road crossing work.

Sources of pollution that the PMRRC will address in the upcoming years include outdated road/stream crossings, improper agricultural and livestock practices, failing septic systems, failing dams, eroding streambanks, stormwater issues, lack of buffer strips, and the potential negative effects of inadequate local government master plans and zoning ordinances. The watershed plan goals and objectives reflect these concerns:

1. Protect and improve the water quality, and fish and wildlife habitat of the Pere Marquette River and its tributaries, connected lakes and wetlands.
2. Improve and maintain the road and railroad transportation system throughout the Pere Marquette Watershed.
3. Promote sound agricultural and livestock practices throughout the Pere Marquette River Watershed.
4. Promote and maintain the natural ecosystem of the Pere Marquette River Watershed.
5. Promote sound stewardship of the Pere Marquette River land and water resources through education and outreach.
6. Balance recreation management in the Pere Marquette River Watershed by collaborating between the different user groups, land and access ownerships, permit systems, and resulting impacts on the natural resources.
7. Maintain and expand the Pere Marquette River Restoration Committee as the primary vehicle of restoration work in the watershed.

In summarizing the implementation plan tasks, the Pere Marquette River Restoration Committee will be focusing heavily on planning and implementing agricultural and livestock BMPs, road/stream crossing replacements with road commissions, and land protection work in priority and critical areas. More attention will also be given to septic systems, working with townships on planning and zoning ordinances, and stormwater management as well. Key to ensuring progress over the next ten years is successful fundraising efforts and it is estimated that $12,203,500 will be needed. This funding will be made up of a combination of federal, state and private sources and program dollars, similar to the last 10 years. An integral part of the information and education strategy is the hiring of a part or full-time watershed coordinator. Outreach and education efforts in the watershed with school-age children, landowners, recreationists, and local leaders could be expanded upon, and having a staff person dedicated to this work would be ideal.

Evaluation of the management plan will be ongoing and conducted by the overall PMRRC. Additional measures to incorporate and keep track of include the social impacts of the Pere Marquette River Watershed Protection Plan. The PMRRC, CDs, CRA, and other organizations conducting outreach must find out what types of outreach are working in the community and what types are not, along with how people's attitudes and behaviors are impacted. The PMRRC will continue to meet bi-monthly as it has over the last 20 years, and will coordinate fundraising and work efforts amongst members. The involvement of the CRA, USFS, PMWC, MDNR, MDEQ, and County Road Commissions will likely remain steady as an increase in involvement from the NRCS, CDs and local municipalities is anticipated with the presumed shift in agricultural, education, planning and zoning efforts.

CHAPTER 2 INTRODUCTION

The Pere Marquette River is a popular, high quality trout stream with stable groundwater flows that meanders through the Huron-Manistee National Forest and rural areas of Northwest Michigan. The Pere Marquette is a state designated Blue Ribbon Trout Stream and Natural River, and a federally designated Wild and Scenic River. Lacking dams on the mainstem, the PM is the only free-flowing river in the Lake Michigan watershed. With its abundance of outdoor recreational opportunities, the watershed is a tourist destination for residents in southern Michigan and the Midwest. Steelhead, salmon and trout fishing, fly fishing, canoeing and kayaking, hunting, camping, swimming, and hiking are the main activities that attract vacationers and seasonal residents. In addition, portions of the watershed have soils, infrastructure, and weather conditions that are ideal for agricultural and livestock use. Accompanying these various types of use are the stressors that can compromise the health of the water and woods that attract people in the first place. Consequently, stakeholders find the need to come together and manage the Pere Marquette on a watershed basis.

A multitude of state and federal agencies, local municipalities, and private sector groups are actively managing the recreational use, development and natural resources of the Pere Marquette River Watershed. The US Forest Service (USFS) has the *Comprehensive River Management Plan for the Pere Marquette National Scenic River*, the Nature Conservancy and Land Conservancy of West Michigan (LCWM) has the *Pere Marquette Watershed Conservation Area Plan*, the Pere Marquette Watershed Council (PMWC) has the *Pere Marquette River Watershed Assessment*, and the Michigan Department of Natural Resources (MDNR) has the *Pere Marquette River Natural River Plan*. In 2001, the Conservation Resource Alliance (CRA) worked with the overall Pere Marquette River Restoration Committee to develop a watershed management plan. The purpose of this plan is to formally update, coalesce and complement the variety of ongoing management mechanisms of the Pere Marquette River Watershed.

2.1 Progress Made from 2000-2011

The initial Pere Marquette River Watershed Management Plan was completed in 2001 by the CRA in cooperation with the Pere Marquette River Restoration Committee. The management plan was developed over the course of two years and public participation consisted of approximately 10 open Restoration Committee meetings held in the Village of Baldwin. A combination of state and federal agencies, local municipalities, landowners, fishing and hunting clubs, and interest groups assisted in the plan's development. The Restoration Committee meetings were attended by 10 to 20 people and the meeting agendas and minutes were mailed by CRA to a list of approximately 130 participants. During the last 10 years since the original plan's completion the following accomplishments have been made:

TABLE 1: 2000-2011 ACCOMPLISHMENTS IN THE PERE MARQUETTE RIVER WATERSHED		
Project Description	**# of Sites/Landowners**	**Estimated Cost**
Lake County Road Stream Crossing Replacements	13	$1,550,000
Mason County Road Stream Crossing Replacements	7	$2,740,000
Oceana County Road Stream Crossing Replacements	2	$190,000
Newaygo County Road Stream Crossing Replacements	15	$1,200,000
Baldwin River Streambank Stabilization	21	$162,000
Sand Traps	4	$50,000
Woody Debris Installation	27	$90,000
Pere Marquette Streambank Stabilization	8	$60,000
Tank Creek Dam Removal	1	$30,000
Storm Water Management Units in the Village of Baldwin	2	$160,000
Land Protection of 1,710 acres (including 18 conservation easements both donated and purchased)	18	$5,500,000
Agricultural BMPs (as reported by Lake-Osceola and Mason-Lake NRCS field offices)		$3,800,000
Totals:	**118**	**$15,532,000**

Over the last 10 years the Natural Resources Conservation Service (NRCS) with the Lake-Osceola Conservation District (CD) in Baldwin reported the following Best Management Practices (BMPs) accomplishments for a value of $300,000 in program payments to landowners as cost share assistance or conservation stewardship payments:

- 2 Comprehensive Nutrient Management Plans
- 2 Tree/Shrub Establishments
- 1 Native Grass Establishment
- 1 Heavy Use Area Protection
- 1 Manure Handling Facility
- 1 Critical Area Planting
- 1 Fence
- 2 Livestock Access Controls
- 1 Invasive Species Control
- 1 Diversion
- 1 Nutrient Management Site
- 1 Pest Management Site
- 1 Roof Runoff Management Site
- 1 Use Exclusion
- 7 Conservation Security/Stewardship Program Participants
- 1 Wetland Reserve Program Easement

Over the last 10 years the NRCS with the Mason-Lake CD in Ludington reported the following BMPs accomplishments for a value of $3,500,000 in program payments to landowners as cost share assistance or conservation stewardship payments:

- 3 Brush Management - Autumn Olive Removal
- 2 Plate Cooler Water - Re-use
- 7 Comprehensive Nutrient Management Plans
- 1 Irrigation Efficiency/Uniformity Project
- 7 Tree/Shrub Establishments
- 8 Native Grass Establishments
- 4 Heavy Use Area Protections
- 1 Animal Mortality Facility
- 5 Manure Handling Facilities
- 3 Grassed Waterways
- 30 Agrichemical Handling Facilities
- 33 Conservation Security/Stewardship Program Participants
- 4 Wetland Restorations

The LCWM is an active partner in the Pere Marquette River Watershed and is responsible for the protection of 1,710 acres of riparian property located along the mainstem and tributaries over the last 10 years as described in Table 2.

TABLE 2: LAND CONSERVANCY OF WEST MICHIGAN SUMMARY OF RESTORATION WORK IN THE PERE MARQUETTE WATERSHED 2001-2011

Conservation Easement	**County**	**Acres**	**Date Protected**	**Grant Funding (if applicable)**
Touhi Hunt Club	Lake	101	12/27/2001	n/a
Santoro	Lake	10	11/24/2004	n/a
Grass Lake East	Newaygo	80	12/30/2005	n/a
Reed	Mason	199	12/28/2006	n/a
Levings	Lake	14	11/15/2007	n/a
Cashion Lake	Lake	160	12/10/2007	n/a
Rasmussen	Lake	22	12/27/2007	n/a
Steketee	Newaygo	155	12/28/2007	n/a
Bigford	Lake	150	12/31/2007	n/a
Nerheim	Mason	55	12/30/2008	n/a
Smith Family	Lake	35	12/30/2008	n/a
Bloom	Newaygo	155	12/31/2008	n/a
Giammalva-Wallace (Maldonado)	Lake	115	7/30/2009	n/a
Betka	Lake	65	11/25/2009	n/a
Kenway and Deloras Smith	Mason	165	12/29/2009	$263,122
Ohse	Mason	76	12/29/2009	$73,122
Lewis	Lake	17	11/30/2010	n/a
Elliott	Mason	136	12/28/2010	n/a
Total - 18 Conservation Easements		**1,710**	**2001-2010**	**$336,244**

Project partners responsible for all of the above completed tasks include the CRA, Road Commissions in Lake, Mason, Oceana and Newaygo Counties, USFS, MDNR, Michigan Department of Environmental Quality (MDEQ), CDs, NRCS, Village of Baldwin, Michigan Department of Transportation, The Nature Conservancy, PMWC, Trout Unlimited (TU), US Fish and Wildlife Service, LCWM, and numerous private landowners, recreationists and volunteers. All of the above listed projects have been communicated through the greater Pere Marquette River Restoration Committee that meets bi-monthly. CRA, PMWC, LCWM, NRCS, Road Commissions and the USFS continue to take the lead in prioritizing and seeking funding for projects that improve water quality and habitat in the Pere Marquette Watershed, and suit each organization or agency's mission. Additional technical assistance is needed in the watershed on a variety of issues including educational outreach to a variety of user groups (landowners, youth and municipalities), combating invasive plant species on private and state lands, storm water management, septic system management, water quality and habitat monitoring, and agricultural/livestock management. It continues to be the Restoration Committee's challenge to develop additional technical capabilities and continue to make progress in familiar natural resource management areas.

The Pere Marquette River Restoration Committee is the primary managing body of the watershed. The Pere Marquette River Restoration Committee formed in 1987 and coordinated the 10-year $1.4 million streambank stabilization project, funded by the Natural Resources Commission and USFS. The original Committee was comprised of the Huron-Manistee National Forest Service (USFS), Michigan Council of TU, Mason-Lake CD, MDNR Fisheries Division, PMWC, and CRA. Today, the Restoration Committee is informally composed of additional agencies and groups like Road Commissions, Townships, landowner associations and fishing and hunting clubs. Pere Marquette River Restoration Committee meetings are held bi-monthly throughout the year with the exception of the months of January and February. These meetings are open to the public and CRA mails agendas and minutes to a current mailing list of 200. The dedication and consistent interest of the Pere Marquette River Restoration Committee will ensure the implementation of the watershed management plan into the future.

Watershed management entails looking at the wide variety of uses of a river and its surrounding lands, and assessing past, current and future affects on resource ecology.

One of the challenges with managing the Pere Marquette River Watershed is its significant size and inclusion of large sub-watersheds. Private riparian landowner interests and activities are often tailored to their specific stream and lack identification with the watershed as a whole. Because the river flows through four counties and their corresponding townships, many municipal boundaries are found within the Pere Marquette Watershed. With this plan streams and feeder creeks will be assessed, and recommendations will be made referring both to specific waterways and the surrounding uplands. Thus, a watershed management plan becomes the ideal tool for people to utilize and operate by.

CHAPTER 3 DESCRIPTION OF THE PERE MARQUETTE RIVER WATERSHED

3.1 Location and Size

The Pere Marquette River Watershed is located in west-central Michigan's Lower Peninsula along the eastern shoreline of Lake Michigan. It encompasses an area of 755 square miles stretching from the Lake Michigan shoreline in Ludington 42 miles to the eastern Lake County line. From the headwaters of the Middle Branch to Pere Marquette Lake, the Pere Marquette River courses a distance of approximately 96 miles and falls 585 feet in elevation (Northern Ecological Services 1999). From where the Pere Marquette River mainstem begins at the confluence of the Middle Branch just east of Baldwin and flowing down to Pere Marquette Lake, is 69.4 miles in length. In total, the Pere Marquette River system contains 380 lineal miles of streams including minor tributaries or "feeder streams". The highest point of the watershed lies at 1,180 above sea level near Hungerford in northeastern Newaygo County (Norwich Township). The watershed reaches its lowest point as the river enters Lake Michigan through the jetties at Ludington. The Pere Marquette River flows through Lake, Mason, Oceana and Newaygo Counties (Table 3, Figure 2). The five largest municipalities within the watershed are the Villages of Baldwin, Chase, Custer, and the Cities of Scottville and Ludington.

TABLE 3: COUNTIES LOCATED IN THE PERE MARQUETTE RIVER WATERSHED

County	Area (square miles)	Area in Watershed (square miles)	% County in Watershed	% Watershed per County
Lake	573.9	286.4	49.9%	38.0%
Mason	509.7	170.5	33.4%	22.6%
Newaygo	861.1	218.3	25.3%	28.9%
Oceana	545.8	79.5	14.6%	10.5%
Totals:		**754.7**		**100%**

3.2 Subwatersheds

The Pere Marquette River Watershed is comprised of five major streams including the mainstem, the Baldwin River, Middle Branch, Little South Branch, and Big South Branch (Table 4). The confluence of the Middle and Little South Branches is where the mainstem begins and is called the "Forks"; this can be seen at James Road at the Forks Bridge southeast of Baldwin. The Baldwin River joins the mainstem west of M-37 and the Big South Branch joins the mainstem further west in Mason County near the town of Custer. Over an additional 75 small streams are estimated to enter the mainstem and main tributaries, as well.

TABLE 4: SUBWATERSHEDS IN THE PERE MARQUETTE RIVER WATERSHED					
Basin	**Square Miles**	**% of Watershed**	**Stream Miles**	**Tributary Miles**	**% of Total Stream and Tributary Miles**
Baldwin River	118	16%	12	35.5	12%
Middle Branch	55	7%	17	10.2	7%
Little South Branch	115	15%	13	16	8%
Big South Branch	263	35%	41.5	111.9	40%
Mainstem	204	27%	66.4	59.1	33%
Totals:	**755**	**100%**	**149.9**	**232.7**	**100%**

**Big South Branch tributary miles includes Beaver Creek designated drain reaches.*

3.3 Historical Uses in the Pere Marquette River Watershed

The Potawatomi, Chippewa and Ottawa tribes inhabited northwest Lower Michigan for thousands of years. The Native Americans named Lake Michigan after their word for "great water." The Pere Marquette River is named after a Jesuit missionary, Pere Jacques Marquette. It was common practice in the 1600s for Jesuit missionaries to establish contact with Native Americans, convert them to Christianity, and encourage them to contribute a portion of their vast resources to support the cause. Pere Jacques Marquette was one of the most prominent missionaries to travel throughout the Great Lakes region. While accounts of his death vary depending upon the source, it is commonly believed that Pere Marquette became ill during the winter of 1675 while visiting a mission on the south end of Lake Michigan. Sensing that his death was near, he desired to travel to St. Ignace, Michigan, the site of his most beloved mission.

The Bonney Bridge spanned the Baldwin River just south of Baldwin on what is known today as M-37. This image was postmarked in 1908. Fortunately, the standards for farming practices and road/stream crossings on rivers are now higher. Photo courtesy of Paul Bigford.

The canoe flotilla did not make it that far for the terminally-ill Marquette proved too weak to travel. The party was forced to set ashore along the west side of what later came to be known as Pere Marquette Lake. Pere Marquette died on May 18, 1675 at this location. Out of their great respect for this missionary, the native people called the river, "the River of the Black Robe" or "Marquette." "The River of the Black Robe" referred to the long black robe he wore as a Jesuit priest (Cassuto 1994). Europeans later adopted the name "Pere Marquette" for the river.

The Lake County Rail Road was established in 1880 and was 11 miles in length. In 1899 the railroad consolidated with others and became the Pere Marquette Railroad (PMR). As lumbering lessened, freight increased and car ferries were built to handle the cross-lake movement of railroad cars. In 1900, 27,000 railroad cars were transported by a single ship – the Pere Marquette. In 1947 the PMR merged with the Chesapeake and Ohio (C and O). The C and O joined the CSX railroad company in 1987. In 2005, CSX began to lease their track to Marquette Rail LLC. Photo and information courtesy of Paul Bigford.

More recent historical use of the Pere Marquette River Watershed comprised mainly of the logging practices characteristic of Michigan in the 1800s and early 1900s. The first recorded saw mill was built in Ludington in the 1840s, and it is estimated that more than 14 sawmills operated along the shores of Pere Marquette Lake. The logs were cut into boards for shipping to markets across Lake Michigan, mostly Chicago and Milwaukee. A large portion of the lumber was used to reconstruct Chicago following the fires of 1871. White pine and other trees were logged throughout the watershed and the river was used to transport the logs to sawmills, towns, railroads and Lake Michigan. Many areas were completely cutover, and fires that consumed the organic soils and brush, often followed. Loggers used the high, steep, sandy bluffs bordering stream channels as log slides. There is strong evidence that large, persistent logjams were common in these rivers before logging began, but were removed in order to use the rivers for log transportation (Gough 1995). The timber industry's exploitation of the Pere Marquette region was so encompassing and voracious that in the early 1900s experts pronounced the river "dead". In 1938, mass replanting of cutover lands throughout the area by the Civilian Conservation Corps during the Depression led to the creation of the Manistee National Forest, a federal holding covering a considerable portion of the Pere Marquette Watershed (National Research Council 1992).

The first railroads moved into the region in 1874. In 1857, the Pere Marquette Rail Company received land grants of five hundred thousand acres funded by government tax-supported bonds in return for constructing rail lines from Pere Marquette (former name for Ludington) to Port Huron. The government hoped to spur increased settlement and create a stronger economic base by providing a means to export marketable materials from the region by constructing railroads. The rail company then sold their acquired lands to timber speculators at prices ranging from $1.25 to $2.50 per thousand stumpage, and to settlers for agricultural land at $5 to $10 per acre. By selling the land, the rail company also generated business for itself by creating a market for supplies they shipped in, and a source of materials to ship out of the watershed. The rail lines then promoted the logging industry by transporting hardwoods from the countryside to mills, and then the lumber to urban areas. Numerous narrow gauge private lines were constructed to link remote areas to the main line. The rails often provided the only means of transportation for agricultural goods and supplies to communities away from the Lake Michigan coast, since improved public roads were so rare (Northern Ecological Services 1999).

A saw shop or sawmill in Chase Township. Photo courtesy of Orville Mund and Lake County Historical Society.

This Chase area sawmill site was probably typical. A tall chimney pinpoints the mill, with four water barrels on the rooftop for protection. The other buildings are workshops and dwellings for the workers. Slabwood, the pieces removed when a log is squared off to make a square cant, has been cut up into firewood, possibly to fuel a locomotive (Lake County Historical Society). Photo courtesy of Orville Mund and Lake County Historical Society.

By 1892, 162 million board feet (382,000 cubic meters [m^3]) of lumber and 52 million wood shingles had been produced by Ludington sawmills. With all of this commerce occurring, Ludington became a major Great Lakes shipping port. In 1897, the Pere Marquette Railroad constructed a fleet of car ferries to continue the railroad cargo across Lake Michigan to Manitowoc, Wisconsin. The fleet was also expanded to carry cars and passengers across the lake. By the mid-1950s, Ludington had become the largest car ferry port in the world. Unfortunately, due to disuse and declining industry, this fleet eventually dwindled. Currently only one car ferry, the SS Badger, makes regular trips across the lake from Ludington, one of only two lake-crossing car ferries on Lake Michigan (www.answerbag.com).

Standing in the Pere Marquette River near Gleason's Landing, 12-year old Bruce Bigford is tying on a fly getting ready to cast to that elusive trout (Lake County Historical Society). Photo courtesy of Paul Bigford.

The woods and water of the Pere Marquette River attracted tourists with its fishing, swimming and canoeing opportunities as early as the late 1800s. In 1883 and 1884 the Pere Marquette was stocked with rainbow trout, and was the first US stream to receive brown trout stockings. Trout populations flourished in the Pere Marquette waterways as the watershed healed from the logging era, and this attracted outdoor enthusiasts from downstate and nearby states.

There are two sites in the immediate vicinity of the Pere Marquette River that are on the National Register of Historic Places. One is the Marlborough Historic District which is located just south and east of Baldwin. This town was built during the experimental stage of Michigan's cement industry following the discovery of marl deposits in the area. By 1910, the booming

village ran out of marl and ruins are all that remain at this privately owned site. The other site on the National Register is the Nat-a-pe-ka-gon Site in Custer Township. This is a relatively undisturbed multi-component site preserving information on the Middle and Late Woodard Periods in Western Michigan. One occupation contains early French trade materials (Lake County Historical Society 2009).

3.4 National Scenic River

On November 10, 1978 a 66.4 mile segment of the main stream between the junction of the Middle and Little South Branches east of Baldwin (the "Forks") and the Old Highway 31 Bridge was classified as a *National Wild and Scenic River* and management responsibilities were delegated to the US Department of Agriculture Forest Service (Pere Marquette National Scenic River Environmental Assessment March 2008). The National Scenic River criteria include those rivers or sections of rivers that:

- Are free of impoundments
- Shorelines are still largely primitive and undeveloped with no substantial evidence of human activity
- The presence of small communities or dispersed dwellings or farm structures is acceptable
- The presence of grazing, hay production or row crop is acceptable
- Evidence of past or ongoing timber harvest is acceptable provided the forest appears natural from the riverbank (Wild and Scenic Rivers Act 1978)

Currently, the Pere Marquette is managed by the USFS under the *Comprehensive River Management Plan – 2008* (http://www.rivers.gov/publications/plans/pere-marquette-plan.pdf). The Pere Marquette National Scenic River corridor is comprised of 13,100 total acres with 17.5% or 2,292 acres federally owned (Figures 5 and 6).

3.5 State Designated Natural River

In July 1978, the Pere Marquette River mainstem and major tributaries were designated a *Michigan Natural River* by the State of Michigan (State Act 231, PA 1970). The Michigan Natural Resources Commission published the *Pere Marquette River Natural River Plan* in 1978 (MDNR 1978). The conservation of Michigan Natural Rivers and their outstanding natural, cultural, and recreational values are important to the heritage, tourism, outdoor recreation, and long-term economic development of Michigan (PMNCREA 2008). As a result of this designation, zoning regulations that restrict development and vegetation management within 400 feet of each side of the river were implemented to protect environmental and aesthetic values (MDNR July 1978). Approximately 70% of the river corridor is privately owned and landowners can request variances from the local appeals board which then has the authority to grant or deny the variance within the Natural Rivers district. The same 66.4-mile section of mainstem from the Forks to Old US Highway 31 Bridge is designated Natural River along with 140 miles of tributaries (Pere Marquette National Scenic River Environmental Assessment March 2008). The following tributaries are designated under the Natural Rivers Act (Figure 7):

- *Lake County Tributaries:*
  - Baldwin River
  - Blood Creek
  - Bray Creek
  - Cole Creek, North and South Branch
  - Danaher Creek
  - Kinney Creek
  - Leverentz Creek
  - Little South Branch
  - Middle Branch
  - Sandborn Creek
  - Sweetwater Creek
- *Mason County Tributaries:*
  - Big South Branch
  - Carr Creek
  - Swan Creek
  - Weldon Creek
- *Newaygo County Tributaries:*
  - Big South Branch
  - Cedar Creek
  - Little South Branch
  - McDuffee Creek
  - Pease Creek
- *Oceana County Tributaries:*
  - Big South Branch
  - Ruby Creek

3.6 State Designated Blue Ribbon Trout Stream

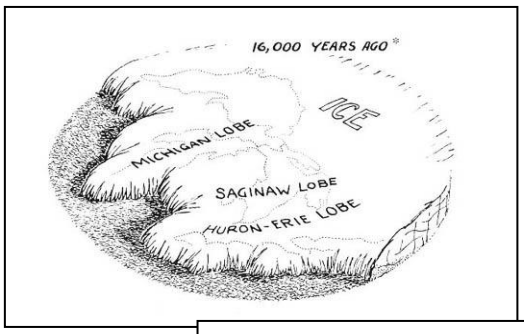
Most of the waterways in the Pere Marquette Watershed are regulated trout streams (Figure 8). In order for a Michigan stream to earn the ranking of a "Blue Ribbon Trout Stream", it must meet certain standards including being able to support excellent stocks of wild resident trout, have the physical characteristics to permit fly casting but be shallow enough to wade, produce diverse insect life and good fly hatches, and have excellent water quality. Three stream reaches totaling 60.5 miles within the Pere Marquette River system are specially regulated to permit flies only in recognition of their designation as "Blue Ribbon Trout Streams". This includes the following reaches:

- The Baldwin River from its confluence with the Pere Marquette mainstem to the upstream limit at 24th Street (12 miles).
- The Middle Branch and Pere Marquette mainstem from Reek Road (Indian Bridge) to the upstream limit at USFS Road 5132 – Broadway Road (39 miles).
- The Little South Branch from its confluence with the Middle Branch at the Forks to the upstream limit at Curtice Bridge (9.5 miles).

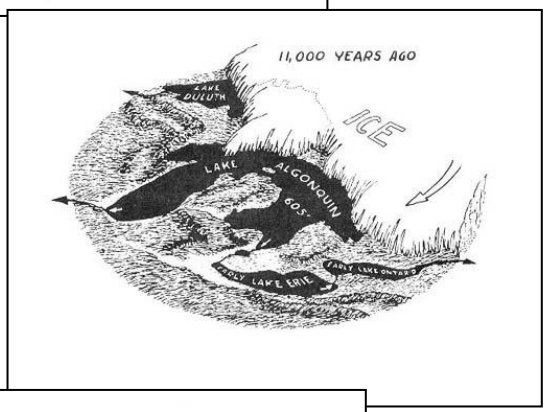
3.7 Geology, Soils and Topography

In the Pere Marquette River Watershed, the oldest bedrock (Coldwater Shale) was deposited during the Silurian Period and is found in western Mason County. The youngest formation (Jurassic Red Bed Sandstone) is found in eastern Lake and Newaygo Counties. Bedrock formations typically range in elevation from sea level to 700 feet above sea level. On average, the elevation of underlying bedrock in the watershed is approximately 425 feet above sea level. The bedrock is covered with 300 to 750 feet of glacial drift (soil materials transported by a glacier) that was deposited at the end of the Pleistocene Epoch (approximately 12,000 years ago). In general, drift thickness is greater where high moraines formed and thinner where low outwash plains formed (approximately 550 feet on average). Drift thickness greatly influences the rate and quantity of ground water loading to the Pere Marquette River and its tributaries. Although no bedrock is exposed at the land surface in the Pere Marquette River Watershed, the character and composition of bedrock influences the chemical composition of groundwater.

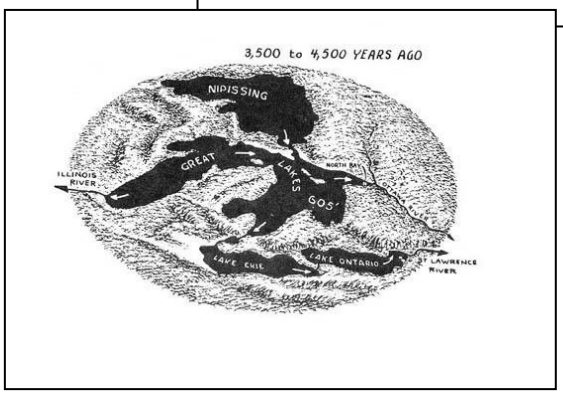
The following text and drawings illustrate the geological history of Michigan and are excerpted from "The Glacial Lakes Around Michigan" by R.W. Kelley and W.R. Farrand (Kelley and Farrand 1967).



The Pere Marquette River was formed by Pleistocene glaciers that moved across Michigan, covering the land one mile thick in places.



When the last of the glaciers retreated, water filled the valley left by the glaciers…



…forming the Great Lakes and the Pere Marquette Watershed.

The bedrock formations of the Pere Marquette River Watershed have been targets for oil and gas exploration and brine disposal, activities that can potentially impact water quality of the Pere Marquette River (Pere Marquette River Watershed Assessment, April 1999). Extensive oil and natural gas fields have been found in the Paleozoic sedimentary rocks beneath the glacial drift in Michigan. However, oil, gas and brine productions are not major industries in the watershed. MDNR has compiled a database that includes information on all prior or presently-permitted oil, gas, brine, and other well types (Figures 9 and 10). Exploitable mineral resources in the Pere Marquette River Watershed mainly consist of construction aggregate (sand, gravel, rock, clay) that can be utilized in road construction and maintenance, and the building industry. At least forty-four gravel, sand and/or rock quarries exist.

The dominant soil textures found within the Pere Marquette River Watershed are sandy (Figure 11). Because sandy soils are so well-drained, the natural soil drainage of most of the watershed ranks moderate to excessive (Figures 12). Sandy soils cannot hold water so natural runoff potential for the majority of the watershed is minimal for most of the Pere Marquette River Watershed as well (Figure 13). The erosion potential for sandy soils is high, thus ensuring plant and tree cover is important for these areas (Figure 14). The watershed does have some hydric soils that are saturated or flooded and are characteristic of wetland areas that provide rich and diverse plant, fish and wildlife habitat (Figure 15). These hydric soils include mucky sand and muck areas correlated with the wetland complexes found in the headwaters of the Baldwin, Little South, Middle Branch and Big South Branches. Loamy textured soils have thicker topsoil layers and are well drained; thus, these soils are where many of the agricultural lands in the watershed are congregated. Steep slopes in the watershed are minimal, also providing ideal landscape for agricultural use (Figures 16 and 17).

3.8 Hydrology and Climate

The climate of the Pere Marquette Watershed is largely influenced by Lake Michigan (Albert 1995). The average annual precipitation is 35.32 inches (calculated from 1971 to 2000), including water equivalent of snow, sleet and hail. The average annual snowfall is 85.04 inches (calculated from 1971 to 2000). The highest and lowest recorded snowfalls on record are 126.1 inches (1981-1982) and 21.4 inches (1948-1949) respectively (Buchanan 1985). The highest recorded rainfall occurred in September 1986, resulting in tremendous flooding throughout the Pere Marquette River system. The measured stream discharge from this rain event was 6,020 cubic feet per second (cfs) at the US Geological Survey (USGS) gauging station at Scottville, approximately eleven times the mean September discharge and eight times the mean annual discharge.

The Pere Marquette River has fairly stable flows, as measured at the gauging station in Scottville. High flows, corresponding to spring runoff, occur from March through May, with the peak in April. Flow steadily decreases to a low in August (average of 499 cfs) and then increases to over 700 cfs by December where it remains relatively steady until the spring. There are no gauging stations in the sub-watersheds and discharge has not been calculated for the main tributaries. However, average annual yield is estimated at 1.0 cfs per square mile (based on the estimated drainage area of 681 square miles upstream of Scottville).

TABLE 5: AVERAGES (MEANS) OF PERE MARQUETTE RIVER DISCHARGE DATA (cfs) TAKEN AT SCOTTVILLE, MI USGS STATION #14122500. STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1939-2009.

	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
Mean	605	707	740	717	734	995	1,041	815	698	540	499	542
Max.	1,507	1,523	1,311	1,129	1,301	1,779	1,732	1,558	1,404	1,232	826	1,880
*Water Year**	*1987*	*1986*	*1992*	*1985*	*1984*	*1976*	*1993*	*2004*	*2004*	*1969*	*1994*	*1986*
Min.	379	439	449	427	440	526	550	425	408	368	354	369
*Water Year**	*1957*	*1945*	*1945*	*1945*	*1958*	*1940*	*1945*	*1958*	*1964*	*1963*	*1941*	*1948*

**Water year is defined as October through September. Note drainage area is 681 square miles. Water Data Report 2009 - 04122500 Pere Marquette River at Scottville, MI. US Department of the Interior, USGS*

Hydraulics and Hydrology

The hydrology of a river system is mainly determined by soils, geology, and land use, and in turn, determines the type of aquatic life that will flourish in a watershed's various types of streams. In streams where groundwater is the principal water source, stable flow patterns occur, characterized by low seasonal and daily fluctuations in discharge. Stable flows promote stable habitat for aquatic life in the form of diverse bottom substrates, secure in-stream cover, and moderate water velocities and temperatures.

Unstable water flow patterns occur in streams with high contributions of surface water runoff and are characterized by high seasonal and daily fluctuations in discharge. During periods of heavy rain or snow melt, flows increase quickly and to high levels, which then lead to increases in water velocities and streambank erosion, the removal of instream cover, and decreased bottom substrate diversity due to scouring. Additionally, during drought conditions, excessively low flows occur that cause extremes in water temperatures and expose and reduce in-stream cover and bottom substrates. Some factors contributing to increases in stream flow are urban and agricultural land development, logging, drains and irrigation, water discharges, hydroelectric dams, and lake-level control structures.

Discharge estimates for the subwatersheds were developed through both an analysis of USGS Gauging Station data, and compared to empirically derived characteristic discharge relationships in alluvial channels at bankfull stage, or at the perennial vegetation trimline in entrenched channels as described by Kellerhalls and Church (1989). In the absence of a comprehensive data set on channel morphology obtained through time consuming survey work, remote sensing was used to estimate bankfull widths for incorporation into the following model to estimate discharge in the listed channels in the watersheds and associated sub-watersheds where:

$$Q = (W/4.5)^{0.5}$$

Note: This relationship is derived in metric units, but converted to standard units for the subsequent analysis.

This relationship was derived for rivers sampled worldwide with channel widths capable of producing discharges between 350 and 350,000 cfs, where many of the observations contributing to this relationship were for gravel bed rivers in Alberta, Canada. Further, it was

found that the correlation between width and depth could also be described predictively for gravel bed channels of rivers much larger than the Pere Marquette; in some cases an order of magnitude higher. Where typically the W/D ratio in gravel dominated streams tended toward 40:1 and in rivers with less mobile bed features such as cobble / boulder dominated streams the ratio was found to be as low as 10:1 (Bray 1973).

Based on known relationships between channel geometry and dimensions, rivers such as the Pere Marquette mainstem, with an inherently large sand component in the bed, the applied model utilized here remains applicable in the absence of field survey data. General observations in the mainstem suggest a tendency towards higher W/D ratios (>40:1); particularly given observed high sinuosity (ranging from 1.3 to 2.1; and averaging 1.6) and relatively low gradients (slopes no greater than approximately 0.9%; and averaging approximately 0.07%). Similarly, these features are pronounced in the Big South Branch of the PM where sinuosity ranges 1.3 to 2.1 averaging approximately 1.6 and slopes no greater than approximately 1.0% with an average of 0.08%; thus contributing substantially to its large number of stream miles relative to valley length, resulting in countless relic oxbows and abandoned channels along its sometimes tortuous meander pattern. In the case of the Big South, a likely major contributor to this characteristic meander scroll patterning and low slopes of this major tributary are the 12 plus miles of channelized and consequently flashy reaches of Beaver Creek (sinuosity slightly greater than 1.1 and average slope of 0.05%), situated southwest of the town of Bitely; thus acting as an extremely efficient sediment delivery system pouring substantial quantities of fine sediments into the Big South directly from the large proportion of agricultural lands this tributary drains.

Given this analysis, it is reasonable that the model utilized to construct the following table describing relative discharge at various locations in the Pere Marquette Watershed may over estimate bankfull discharge, and further illustrates the importance of developing Regional Rating Curves for Michigan (Table 6). This over-estimation is likely due to the inherent nature of rivers (particularly with channelized tributaries)situated in sandy outwash plains and occupying inherited glacially formed valleys; where channel patterns and dimensions can be highly dynamic given the nature of sand bed streams situated in relatively wide valleys, coupled with localized aggradation and incision due to frequent channel adjustments resulting from both natural and anthropogenic occurrences causing periodic instream obstructions (particularly large woody debris - LWD). Such obstructions often result in localized hydraulics that dynamically impact pattern, profile and dimensions of the channel and is often evidenced by chute cutoffs, oxbows, channel avulsion and anastomosis created during channel forming discharges as commonly observed in this watershed. Given this, careful consideration should be given to context of channel adjustments observed and inventoried in order to determine whether they are the result of natural or anthropogenic disturbances (including LWD removal) prior to developing prescriptions to remedy sites undergoing what may be a natural change.

TABLE 6: DISCHARGE ESTIMATES IN THE PERE MARQUETTE RIVER WATERSHED			
Basin	Average Estimated Channel Width (ft)	Estimated Discharge CFS*	Location of Channel Width Estimates
Baldwin River	29	136	Immediately upstream of confluence with Mainstem
Middle Branch	23	86	Immediately upstream of confluence with Little Branch (upstream of James Road/Forks Bridge)
Little South Branch	30	146	Immediately upstream of confluence with Middle Branch (near James Road)
Big South Branch	50	498	Immediately upstream of confluence with Mainstem
Mainstem	48	374	Downstream of confluence of Middle & Little South Branches
	67	727	Downstream of Walhalla approximately 5 miles
	104	1752	Downstream of US 131 approximately 3 miles
**Based on Kellerhalls and Church (1989) empirically derived regression of channel width and discharge described above.*			

3.9 Groundwater

The Pere Marquette River system is a predominantly groundwater-fed system, a vital characteristic of the river's ability to support high quality cold-water fisheries. The dominantly sandy soils of the Pere Marquette Watershed generally have high rates of permeability, which reduces runoff and enhances water infiltration. Consequently, the streams within the watershed have a high proportion of groundwater contribution throughout the year. Water from melting snow and rainfall, for the most part, infiltrates into the ground and replenishes groundwater reserves. The natural filtration process associated with groundwater flow helps to maintain high water quality, cool water temperatures, and stable flows in the Pere Marquette River (Pere Marquette River Watershed Assessment, April 1999). The amount and rate of groundwater discharge to the stream (i.e. groundwater loading) varies through the watershed, and is dependent on local geologic conditions. In general, groundwater loading is greater where streams intersect high glacial moraines (Seelbach 1998, pers comm., Pere Marquette River Watershed Assessment, 1999).

Because the soils of the PM Watershed tend to have high water intake rates, groundwater is vulnerable to contamination. Finer-textured soils tend to offer some groundwater protection by having slower infiltration rates and higher cat ion exchange capacity, which enables the soil to act as a filter. Soil microbes, usually plentiful in finer textured soils with well-developed topsoil layers, are capable of breaking down many potential groundwater contaminants. Upland sandy soils with little topsoil, commonly found in the PM Watershed, provide little in terms of the

natural soil processes that help protect groundwater quality (Pere Marquette River Watershed Assessment, April 1999).

Groundwater usage is predominantly by small private business and residential well owners. Two exceptions include the towns of Baldwin and Scottville, which have larger, municipal supply wells. The wells are virtually all placed in glacial drift, generally less than 150 feet deep. One thousand-eight hundred twenty-four (1,824) domestic water wells exist within the watershed: Lake County, 1,147; Mason County, 124; Oceana County, 213; Newaygo County, 340 (Pere Marquette Watershed Assessment, April 1999) (Figure 18). With groundwater being so plentiful, water withdrawal by commercial interests is a concern in the Pere Marquette River Watershed.

3.10 Wildlife

The Pere Marquette River Watershed is home to more than 40 species of mammals, 60 species of birds, and 25 species of amphibians and reptiles (Pere Marquette River Watershed Assessment). As a result the watershed has a wealth of consumptive (hunting, trapping) and non-consumptive (photography, bird watching) wildlife related activities. The combination of forest, riparian corridors, wetland and fields contributes to the wildlife diversity found in the watershed. Table 7 lists the threatened, endangered and special concern plan and animal species found in the watershed, according to the MDNR Michigan Natural Features Inventory and the USFS. The Karner blue butterfly is the only federally endangered species found within the watershed. The Karner blue butterfly lays its eggs only on lupine and lupine is known to be scattered throughout the dry upland oak forests found in the Pere Marquette River Watershed.

TABLE 7: STATE AND FEDERALLY LISTED THREATENED, ENDANGERED, AND SPECIAL CONCERN PLANT AND ANIMAL SPECIES IN THE PERE MARQUETTE RIVER WATERSHED

Species of Concern

Scientific Name	Common Name	Federal Status	State Status	USFS
Plants				
Berula erecta	Cut-leaved water-parsnip		T	
Eleocharis melanocarpa	Black-fruited spike rush		SC	
Cirsium hillii	Hill's thistle		SC	RFSS
Geum triflorum	Prairie avens		T	
Hemicarpha micrantha	Dwarf bulrush		SC	
Poa paludigena	Bog bluegrass		T	RFSS
Prunus alleghaniensis var. davisii	Alleghany plum		SC	RFSS
Rhunchospora macrostachya	Tall beak-rush		SC	
Rotala ramosior	Tooth cup		SC	
Animals				
Accipiter gentillis	Northern goshawk		SC	RFSS
Buteo lineatus	Red shouldered hawk		T	RFSS
Clemmys guttata	Spotted turtle		SC	
Clemmys insculpta	Wood turtle		SC	
Gavia immer	Common loon		T	RFSS
Haliaeetus leucocephalus	Bald eagle		T	RFSS

Lycaeides melissa samuelis	Karner blue butterfly	E	T	
Martes americana	American marten		SC	
Notropis anogenus	Pugnose shiner		SC	
Sistrurus catenatus catenatus	Eastern massasauga		SC	RFSS
Terrapene carolina carolina	Eastern box turtle		SC	
Pandion haliaetus	Osprey		T	
Acipenser fulvescens	Lake sturgeon		T	
Aquatic Species				
Acipenser fulvescens	Lake sturgeon		T	RFSS
Moxostoma carinatum	Greater redhorse		T	RFSS
Lasmigona compressa	Creek heelsplitter mussel			RFSS

T = threatened, SC = special concern, RFSS = Regional Forester's sensitive species

Please refer to Huron-Manistee National Forests' Plan (2006) for additional guidance, management direction and biological opinion.

3.11 Wetlands and Unique Habitats

Wetlands account for 15% of the watershed. Larger tracts of wetlands are concentrated in the headwaters of the Baldwin River, Little South Branch, and Beaver and Cedar Creeks of the Big South Branch with smaller pockets throughout the riparian corridor of the mainstem (Figure 19). In the Little South and Big South areas, wetlands are interspersed with agricultural areas where they are used as drainages for fields. Significant portions of wetlands in the watershed are under public ownership that further protects them.

Wetland loss in the watershed is estimated at 19%, according to a "Status and Trends" Analysis by MDEQ utilizing 2005 National Wetland Inventory data (Table 34, Figure 36). Data of presettlement conditions (82,253 total acres of wetland) compared to 2005 conditions (66,558 acres) show an estimated 19% loss (15,695 acres) of wetlands in the PM Watershed. Fortunately, significant portions of wetlands remain in the headwaters of tributaries and portions of the mainstem as the river approaches the developed Ludington area. Wetlands provide exceptional wildlife habitat opportunities, help filter sediment and nutrients, support diverse plant and animal life, and provide natural flood storage areas. Wetland cover percentages per subwatershed are shown in Table 8, with the Big South Branch subwatershed supporting the largest percentage of wetland cover.

TABLE 8. PERE MARQUETTE SUBWATERSHED WETLAND CONDITIONS

Subwatershed	Presettlement Wetland Condition - total acres	Presettlement Wetland Condition - percentage	2005 Wetland Condition - total acres	2005 Wetland Condition - percentage
Baldwin River	9,948	13%	9,150	12%
Middle Branch	3,631	10%	3,159	9%
Little South	9,423	13%	8,411	11%
Big South	41,555	25%	30,735	18%
Mainstem	17,696	14%	15,103	12%
Entire Watershed	82,253	17%	66,558	15%

*These statistics exclude open water type wetlands.

Unique habitats in the watershed include oak-pine barrens complexes in the Indian Lake and Whelan Lake management areas owned in part by the USFS (Figure 20). Oak-pine barrens are a savannah community dependent on fire for the oak and pine trees that dominate the landscape. Noteworthy insects found in this habitat type include the Persius duskywing and Karner blue butterflies which are both state threatened; the Karner blue is federally endangered as well.

3.12 Land Use and Cover

Land use and cover in the watershed is dominated by a combination of forest types, with wetland areas ranking second (Figure 21 and Table 9). A significant portion of the watershed is within the Huron Manistee National Forest and Pere Marquette State Forest, which is helpful in maintaining the natural character, and fish and wildlife habitats of the watershed (Figure 6). Agricultural use accounts for 11.8% of the watershed with most of it concentrated along the mainstem in Mason County and in the Big South sub-watershed (Figure 21). Development is minimal and is concentrated mostly in the Ludington area. Overall, the watershed is fairly rural. Wetland comprises 15% of the watershed, with 81% of presettlement wetlands still intact, according to a "Status and Trends" Analysis by MDEQ utilizing 2005 National Wetland Inventory data.

TABLE 9: LAND USE/LAND COVER IN THE PERE MARQUETTE RIVER WATERSHED

Land Use/Cover Type	**Percentage of the Watershed**
Forest (evergreen, deciduous, mixed)	56.4%
Wetland (herbaceous, woody)	15.0%
Shrub/Scrub	3.1%
Grassland	6.4%
Cultivated Crops	9.6%
Pasture/Hay	2.2%
Water	1.3%
Developed (residential, commercial, industrial, etc.)	6.1%
Other (barren, etc.)	0.1%
Total:	**100%**

TABLE 10: LAND USE/LAND COVER IN PERE MARQUETTE SUB-WATERSHEDS

Land Use/Cover Type	**Baldwin River**	**Middle Branch**	**Little South**	**Big South**	**Mainstem**
Forest (evergreen, deciduous, mixed)	67.6%	62.1%	66.7%	53.6%	46.1%
Wetland (herbaceous, woody)	12.5%	9.3%	12.0%	20.3%	12.7%
Shrub/Scrub	4.4%	3.0%	3.6%	2.9%	2.3%
Grassland	6.8%	7.7%	6.6%	5.7%	6.5%
Cultivated Crops	0.9%	8.7%	5.4%	10.8%	15.7%
Pasture/Hay	0.1%	3.4%	2.2%	1.0%	4.6%
Water	1.1%	0.2%	0.2%	1.3%	2.4%
Developed (residential, commercial, industrial, etc.)	6.6%	5.5%	3.3%	4.4%	9.6%
Other (barren, etc.)	0.1%	0.0%	0.0%	0.1%	0.2%
Totals:	**100%**	**100%**	**100%**	**100%**	**100%**

3.13 Population Demographics

In general, areas within the watershed are rural with relatively low population densities, with the largest population concentration being the City of Ludington (Figure 22). The lower population densities are a result of numerous factors including lack of productive farmland, limited transportation corridors, and a high percentage of public land ownership (historically due to reversion from unpaid taxes). Increased utilization of the region's natural resources is anticipated as more citizens reach their retirement age, and tourism grows with the use of public and private recreational land.

Population growth has been most significant in the *watershed counties* overall between 1970-1980 and 1990-2000. Since US Census Data does not follow watershed boundaries, populations from the townships in the four major counties making up the Pere Marquette River Watershed were used to illustrate changes in population. West Michigan Shoreline Regional Development Commission anticipates a 4% growth over 5-year periods between 2010 and 2035 (Table 11).

TABLE 11: POPULATION FIGURES AND PROJECTIONS IN THE PERE MARQUETTE WATERSHED											
	Actual Census Figures				**Census Estimate**	**Forecasted Population**					
	1970	**1980**	**1990**	**2000**	**2008**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Watershed Total:	19,371	24,577	25,117	31,130	31,650	32,124	33,342	34,618	35,946	37,340	38,789
Percent Change:		27%	2%	24%	2%	1%	4%	4%	4%	4%	4%
	Actual Census Figures				**Census Estimate**	**Forecasted Population**					
Lake County	**1970**	**1980**	**1990**	**2000**	**2008**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Township											
Chase	752	858	999	1,194	1,198	1,222	1,283	1,347	1,414	1,485	1,559
Cherry Valley	172	272	248	368	375	382	402	422	443	465	488
Lake	341	516	700	849	822	838	880	924	970	1,019	1,070
Newkirk	426	608	586	719	727	741	778	817	858	901	946
Peacock	144	278	344	445	437	446	468	491	516	542	569
Pinora	249	348	414	643	658	671	705	740	777	816	856
Pleasant Plains	1,211	1,401	1,464	1,535	1,489	1,518	1,594	1,674	1,758	1,846	1,938
Sauble	194	260	297	323	323	329	346	363	381	400	420
Sweetwater	115	206	223	238	246	251	263	277	290	305	320
Webber	614	865	968	1,875	1,616	1,648	1,730	1,817	1,908	2,003	2,103
Yates	425	552	585	714	698	712	747	785	824	865	908
Total	**4,643**	**6,164**	**6,828**	**8,903**	**8,589**	**8,758**	**9,196**	**9,657**	**10,139**	**10,647**	**11,177**
Villages (included in township figures)											
Baldwin	502	674	821	1,107	1,171	1,194	1,254	1,316	1,382	1,451	1,524
	Actual Census Figures				**Census Estimate**	**Forecasted Population**					
Mason County	**1970**	**1980**	**1990**	**2000**	**2008**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Township											
Amber	1,278	1,556	1,684	2,054	2,099	2,115	2,155	2,196	2,237	2,280	2,323
Branch	635	1,021	973	1,181	1,213	1,222	1,245	1,269	1,293	1,317	1,342
Custer	1,204	1,338	1,176	1,307	1,358	1,368	1,394	1,421	1,447	1,475	1,503
Eden	414	511	491	555	601	606	617	629	641	653	665
Logan	154	177	203	329	356	359	365	372	379	387	394
Pere Marquette	1,846	2,068	2,065	2,228	2,355	2,373	2,418	2,463	2,510	2,558	2,606
Riverton	1,151	1,177	1,115	1,335	1,393	1,403	1,430	1,457	1,485	1,513	1,541
Sheridan	433	828	837	969	992	999	1,018	1,038	1,057	1,077	1,098
Sherman	867	996	952	1,090	1,150	1,159	1,181	1,203	1,226	1,249	1,273

TABLE 11: POPULATION FIGURES AND PROJECTIONS IN THE PERE MARQUETTE WATERSHED											
Summit	557	922	815	1,021	1,024	1,032	1,051	1,071	1,091	1,112	1,133
Total	**8,539**	**10,594**	**10,311**	**12,069**	**12,541**	**12,636**	**12,874**	**13,119**	**13,366**	**13,621**	**13,878**
Cities (included in township figures)											
Ludington	9,021	8,937	8,507	8,357	8,324	8,387	8,545	8,707	8,872	9,040	9,211
Scottville	1,202	1,241	1,287	1,266	1,250	1,259	1,283	1,308	1,332	1,358	1,383
Villages (included in township figures)											
Custer	320	341	312	318	315	317	323	330	336	342	349
	Actual Census Figures				**Census Estimate**	**Forecasted Population**					
Newaygo County	**1970**	**1980**	**1990**	**2000**	**2008**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Township											
Barton	482	558	624	820	838	853	892	932	974	1,018	1,064
Beaver	356	443	417	608	613	624	652	682	713	745	779
Home	132	185	202	261	287	292	305	319	334	349	365
Lilley	429	568	565	788	793	807	844	882	922	964	1,007
Merrill	376	508	451	590	596	607	634	663	693	724	757
Monroe	120	263	247	324	347	353	369	386	403	422	441
Norwich	416	450	499	557	609	620	648	677	708	740	774
Troy	80	199	173	243	286	291	304	318	332	348	363
Total	**2,391**	**3,174**	**3,178**	**4,191**	**4,369**	**4,447**	**4,648**	**4,859**	**5,079**	**5,310**	**5,550**
	Actual Census Figures				**Census Estimate**	**Forecasted Population**					
Oceana County	**1970**	**1980**	**1990**	**2000**	**2008**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
Township											
Colfax	222	328	374	574	593	606	639	673	710	748	789
Crystal	453	602	658	832	877	896	944	996	1,050	1,107	1,167
Elbridge	799	899	820	1,233	1,286	1,313	1,385	1,460	1,539	1,623	1,711
Leavitt	773	848	804	845	886	905	954	1,006	1,060	1,118	1,179
Newfield	1,551	1,968	2,144	2,483	2,509	2,563	2,702	2,848	3,003	3,166	3,338
Total	**3,798**	**4,645**	**4,800**	**5,967**	**6,151**	**6,283**	**6,624**	**6,983**	**7,362**	**7,762**	**8,184**
Villages (included in township figures)											
Walkerville	319	296	262	254	253	266	281	296	312	329	347

Sources: Census Bureau, Internal Revenue Service and US Department of Health and Human Services
Forecast by the West Michigan Shoreline Regional Development Commission, 2010 CEDS Annual Report

3.14 Jurisdictions

There are 34 townships and five municipalities that have all or some of their boundaries located within the Pere Marquette River Watershed (Tables 12 and 13, Figure 23). Since the watershed crosses so many political boundaries, it is important for local governments to know and understand watershed boundaries and to plan on a watershed scale with neighboring townships and municipalities.

TABLE 12: TOWNSHIPS, CITIES AND VILLAGES IN THE PERE MARQUETTE WATERSHED

Lake County		**Newaygo County**	
Township (11)	City or Village (1)	Township (8)	City or Village (0)
Chase		Barton	
Cherry Valley		Beaver	
Lake		Home	
Newkirk		Lilley	
Pinora		Merrill	
Peacock		Monroe	
Pleasant Plains	Baldwin (V)	Norwich	
Sauble		Troy	
Sweetwater			
Webber			
Yates			
Mason County		**Oceana County**	
Township (10)	City or Village (3)	Township (5)	City or Village (1)
Amber		Colfax	
Branch		Crystal	
Custer	Scottville (City), Custer (V)	Elbridge	
Eden		Leavitt	Walkerville (V)
Logan		Newfield	
Pere Marquette	Ludington (City)		
Riverton			
Sheridan			
Sherman			
Summit			

TABLE 13: SUB-WATERSHEDS AND AREAS OF TOWNSHIPS AND MUNICIPALITIES IN THE PERE MARQUETTE WATERSHED

Township or Municipality	**Sub-Watershed**	**Total Area (square miles)**	**Total Area in Pere Marquette Watershed (square miles)**	**% of Township or Municipality in Pere Marquette Watershed**
Lake County				
Baldwin (village)	Baldwin	1	1	100%
Chase	Middle Branch	36	28	80%
Cherry Valley	Baldwin	36	35	97%

TABLE 13: SUB-WATERSHEDS AND AREAS OF TOWNSHIPS AND MUNICIPALITIES IN THE PERE MARQUETTE WATERSHED				
Township or Municipality	**Sub-Watershed**	**Total Area (square miles)**	**Total Area in Pere Marquette Watershed (square miles)**	**% of Township or Municipality in Pere Marquette Watershed**
Lake	Mainstem, Big South	36	36	100%
Newkirk	Baldwin	72	13	18%
Pinora	Baldwin, Middle Branch	36	19	52%
Peacock	Baldwin	36	14	39%
Pleasant Plains	Baldwin, Middle Branch, Little South, Mainstem	34	34	100%
Sauble	Baldwin, Mainstem	35	2	6%
Sweetwater	Mainstem	36	35	96%
Webber	Baldwin, Mainstem	35	35	100%
Yates	Baldwin, Middle Branch, Little South	36	36	100%
Mason County				
Custer (village)	Mainstem	1	1	100%
Scottville (city)	Mainstem	1	1	100%
Ludington (city)	Mainstem	4	3	73%
Amber	Mainstem	28	16	57%
Branch	Mainstem, Big South	36	36	100%
Custer	Mainstem, Big South	34	30	88%
Eden	Mainstem, Big South	36	17	46%
Logan	Mainstem, Big South	36	31	85%
Pere Marquette	Mainstem	16	11	68%
Riverton	Mainstem	35	20	56%
Sheridan	Mainstem	36	5	13%
Sherman	Mainstem	35	0.35	1%
Summit	Mainstem	14	0.56	4%
Newaygo County				
Barton	Little South	36	23	65%
Beaver	Big South	36	28	77%
Home	Little South	36	36	100%
Lilley	Mainstem, Big South, Little South	36	35	99%
Merrill	Big South, Little South	36	26	72%
Monroe	Little South	36	17	47%
Norwich	Little South	35	17	49%
Troy	Big South	36	36	100%
Oceana County				
Walkerville(village)	Big South	1	1	100%
Colfax	Big South	36	36	100%
Crystal	Big South	36	6	18%
Elbridge	Big South	36	2	5%
Leavitt	Big South	35	33	95%
Newfield	Big South	36	1	4%

3.15 Economy, Tourism and Recreation

Recreation is a major activity in the watershed. The major recreational land owners are the State of Michigan with the Pere Marquette State Forest and the USFS with the Manistee National Forest. The abundant amount of public lands makes the area very attractive for outdoor oriented activities including fishing, hunting, hiking, nature observation, canoeing, tubing, kayaking, camping, snowmobiling and off-road vehicle use. Between the fall of 1996 and spring of 1997, there were an estimated 940,000 recreational use hours (Nelson et al. 1998). In two separate studies (non-riparian and riparian owner surveys) Nelson et al. (1998) evaluated these activities along the riparian corridor and concluded that both riparian and non-riparian owners use the river predominantly during the summer. Riparian owners spent the majority of their time utilizing the river during the summer (81%), while non-riparian owner use was more evenly distributed over three seasons (with a peak in summer), primarily due to seasonal fishing opportunities (Table 14). Ninety-five percent (95%) of the river users participated in fishing, 53% canoeing or tubing, 42% observed nature, and 16% hunted (Nelson et al. 1998). Use statistics for other portions of the watershed where camping, snowmobiling, cross country skiing, hunting and hiking are more prevalent are unavailable.

Boat and canoe access sites are well distributed on the Pere Marquette mainstem. These include sites at: the Forks, Bowman's Bridge, Rainbow Rapids, Upper Branch Bridge, Walhalla Bridge, Indian Bridge, Scottville, and US 31 Bridge. Access sites are also located on the Baldwin River, Middle Branch, Little South Branch and Big South Branch. Watercraft use on the Pere Marquette River mainstem is managed by a permit system under authority of the National Wild and Scenic River Act. Permits are issued by the USFS for those utilizing federal access sites. A mix of commercial watercraft use, one regulated by the USFS and one regulated by the State of Michigan are in effect. The USFS permits 23 guides with a total of 36 boats to operate from USFS administered access sites. The State of Michigan permits 29 guides, however the number of State permitted commercial guides may change in the future depending on State regulations and administration of their permit process.

TABLE 14: USFS WATERCRAFT PERMIT ALLOCATION - SUMMER SEASON (MEMORIAL DAY THROUGH LABOR DAY)

	Total Daily Canoe Livery and Public Watercraft Permits				
	Forks to Bowman Bridge	Bowman Bridge to Upper Branch	Upper Branch to Walhalla	Total	
Weekdays	82	75	83	240	
Saturday	248	196	198	642	
Sun/Holidays	223	172	149	544	
	Daily Public Watercraft Permits				
	Forks to Bowman Bridge	Bowman Bridge to Upper Branch	Upper Branch to Walhalla	Total/Percent of Total	
Weekdays	12	19	19	50	21%
Saturday	28	56	38	122	19%
Sun/Holidays	25	49	29	103	19%
	Daily Canoe Livery Permits				

TABLE 14: USFS WATERCRAFT PERMIT ALLOCATION - SUMMER SEASON (MEMORIAL DAY THROUGH LABOR DAY)					
	Forks to Bowman Bridge	Bowman Bridge to Upper Branch	Upper Branch to Walhalla	Total/Percent of Total	
Weekdays	70	56	64	190	79%
Saturday	220	140	160	520	81%
Sun/Holidays	198	123	120	441	81%

Commercial canoe liveries are well established on the mainstem and there are over 2,200 private campsites dispersed throughout the watershed. Although not located in the watershed, there are several state parks located in the vicinity of the Pere Marquette River. This includes Ludington, Newaygo and White Cloud state parks. These parks offer almost 600 campsites as well as picnicking, hiking, beach and playground facilities. In addition, there are three state forest campgrounds located near the Pere Marquette River. This includes Bray Creek - 9 campsites; Little Leverentz – 7 campsites; and Big Leverentz - 11 campsites. The USFS campgrounds include Timber Creek, Sulak, Gleason's, Nichols Lake, Bowman's Bridge, Highbanks Lake, and Claybanks and have over 100 camping sites including a combination of family and group sites. The City of Scottville operates a campground on the Pere Marquette River. This facility offers picnicking, playground, boat launch facilities, and over 50 campsites.

Additional recreational opportunities in the watershed are provided, especially in the Ludington area and include golf courses, light houses, farm market, local festivals and fairs, a variety of lodging and restaurant opportunities.

3.16 Fishery

The Pere Marquette River a state designated Blue Ribbon Trout Stream. The river and many of its tributaries provide diverse, high quality fishing opportunities to anglers. The river is home to an exceptional brown trout fishery and anadromous fishery; portions of the watershed support brook trout, as well. The spring and fall spawning runs of steelhead and salmon make this river extremely popular with fishermen. Designated trout streams and lakes are noted in Figure 8.

In 1884, the Pere Marquette River was the first stream in the United States to receive brown trout plants from Germany (MacCrimmon and Marshall 1968). The Pere Marquette River and its main tributaries have been stocked in the past with a combination of brook, brown and rainbow trout. Currently no stocking occurs, and all fish populations are naturally reproducing.

The Pere Marquette fishery is managed primarily by the MDNR Fisheries Division. The MDNR conducts annual fish surveys, and sets and enforces sportfishing regulations (http://www.michigan.gov/documents/streamregs_151765_7.pdf). The USFS and Little River Band of Ottawa Indians also conduct fishery surveys at select sites. The emphasis for current fisheries management of the Pere Marquette River is on habitat protection and restoration. Much of this effort has focused on reducing sources of sediment delivery to lower sand bedload levels. Maintenance of large wood in the river is also being done through the collaborative clearing of navigation hazards by river users and resource agency personnel via annual spring

float trips. Partners are also collaborating on rehabilitation of old log revetment structures installed on the mainstem and primary tributaries in the 1970s, in an effort to provide instream woody debris habitat for both fish and wildlife.

In summarizing the fish collection data for the watershed, 66 different fish species were collected in the Pere Marquette River between 1925 and 1998 (Table 15). Fifty-nine are native to the Great Lakes and considered native to the Pere Marquette in this document, 7 have been introduced (common carp, red ear sunfish, coho salmon, rainbow trout, Chinook salmon, Atlantic salmon, and brown trout) and one that colonized the Great Lakes (sea lamprey). The brook trout, while native to the Great Lakes, is not known to have inhabited the Pere Marquette, but may have (Pere Marquette River Assessment 1999). The lake sturgeon and greater redhorse sucker are noted by the USFS as Regional Forester's Sensitive Species (RFSS) as well.

As noted in the USFS Comprehensive River Management Plan, another important facet of current fisheries management is "people management"; that being providing adequate access while protecting sensitive riparian habitat. Noted USFS goals related to the river's fishery include:

- Balancing aquatic habitat needs with watercraft safety.
- High quality salmonid habitat is maintained and special emphasis is given to the restoration of sensitive aquatic species such as the greater redhorse sucker.
- High levels of fishing for salmon and steelhead are managed to protect sensitive riparian habitat.
- Native and desirable non-native species are self-sustaining.

TABLE 15: LIST OF FISH SPECIES IN THE PERE MARQUETTE WATERSHED

Group of Fishes	Family Name	Common Name	Scientific Name	Origin (status)
Lampreys	Petromyzonitdae	Chestnut lamprey	*Ichthyomyzon castaneus*	N
		Northern brook lamprey	*Ichthyomyzon fossor*	N
		American brook lamprey	*Lampetra appendix*	N
		Sea lamprey	*Petromyzon marinus*	C
Sturgeons	Acipenseridae	Lake sturgeon	*Acipenser fulvescens*	N (T)
Bowfin	Amiidae	Bowfin	*Amia calva*	N
Minnows	Cyprinidae	Common carp	*Cyprinus carpio*	I
		Common shiner	*Luxilus cornutus*	N
		Pearl dace	*Margariscus margarita*	N
		Hornyhead chub	*Nocomis biguttatus*	N
		Golden shiner	*Notemigonus crysoleucas*	N
		Pugnose shiner	*Notropis anogenus*	N
		Blackchin shiner	*Notropis heterodon*	N
		Blacknose shiner	*Notropis heterolepis*	N
		Northern redbelly dace	*Phoxinus eos*	N
		Finescale dace	*Phoxinus neogaeus*	N
		Bluntnose minnow	*Pimephales notatus*	N
		Fathead minnow	*Pimephales promelas*	N
		Blacknose dace	*Rhinichthys atratulus*	N
		Longnose dace	*Rhinichthys cataractae*	N
		Creek chub	*Semotilus atromaculatus*	N
Suckers	Catostomidae	Longnose sucker	*Catostomus catostomus*	N
		White sucker	*Catostomus commersoni*	N

TABLE 15: LIST OF FISH SPECIES IN THE PERE MARQUETTE WATERSHED				
Group of Fishes	**Family Name**	**Common Name**	**Scientific Name**	**Origin (status)**
		Silver redhorse	*Moxostoma anisurum*	N
		Golden redhorse	*Moxostoma erythrurum*	N
		Shorthead redhorse	*Moxostoma macrolepidotum*	N
		Greater redhorse	*Moxostoma valenciennesi*	N
		Unknown redhorse	*Moxostoma sp.*	N
Catfishes	Ictaluridae	Black bullhead	*Ameiurus melas*	N
		Yellow bullhead	*Ameiurus natalis*	N
		Brown bullhead	*Ameiurus nebulosus*	N
Pikes	Esocidae	Grass pickerel	*Esox americanus vermiculatus*	N
		Northern pike	*Esox lucius*	N
Mudminnows	Umbridae	Central mudminnow	*Umbra limi*	N
Trout/Salmon	Salmonidae	Coho salmon	*Oncorhynchus kisutch*	I
		Rainbow trout/steelhead	*Oncorhynchus mykiss*	I
		Chinook salmon	*Oncorthynchus tshawytscha*	I
		Atlantic salmon	*Salmo salar*	I
		Brown trout	*Salmo trutta*	I
		Brook trout	*Salvelinus fontinalis*	N/I
		Arctic grayling	*Thymallus tricolor*	N (X)
Trout-Perches	Percopsidae	Trout-perch	*Percopsis omiscomaycus*	N
Pirate Perches	Aphredoderidae	Pirate perch	*Aphredoderus sayanus*	N
Codfishes	Gadidae	Burbot	*Lota lota*	N
Killifishes	Fundulidae	Banded killifish	*Fundulus diaphanus*	N
Silversides	Atherinidae	Brook silversides	*Labidesthes sicculus*	N
Sticklebacks	Gasterosteidae	Brook stickleback	*Culaea inconstans*	N
Sculpins	Cottidae	Mottled sculpin	*Cottus bairdi*	N
		Slimy sculpin	*Cottus cognatus*	N
Sunfishes	Centrachidae	Rock bass	*Ambloplites rupestris*	N
		Green sunfish	*Lepomis cyanellus*	N
		Pumpkinseed	*Lepomis gibbosus*	N
		Bluegill	*Lepomis macrochirus*	N
		Longear sunfish	*Lepomis megalotis*	N
		Redear sunfish	*Lepomis microlophus*	I
		Smallmouth bass	*Micropterus dolomieu*	N
		Largemouth bass	*Micropterus salmoides*	N
		Black crappie	*Pomoxis nigromaculatus*	N
Perches	Percidae	Greenside darter	*Etheostoma blennioides*	N
		Rainbow darter	*Etheostoma caeruleum*	N
		Iowa darter	*Etheostoma exile*	N
		Fantail darter	*Etheostoma flabellare*	N
		Least darter	*Etheostoma microperca*	N
		Johnny darter	*Etheostoma nigrum*	N
		Yellow perch	*Perca flavescens*	N
		Logperch	*Percina caprodes*	N
		Blackside darter	*Percina maculata*	N

This list was taken from the Pere Marquette River Assessment. This list was compiled using University of Michigan museum records (courtesy of G.R. Smith, University of Michigan), MDNR stream fish collection records, and collections conducted in the Big South Branch, 1998 (courtesy of Dave Cozad, Mainstream Resources). Note that some Lake Michigan species may also inhabit the lower Pere Marquette River and not be represented in this species list (especially potamadromous species). Species origin: N=native, C=colonized, I=introduced. State or federal status (in parentheses): T=threatened, X=extirpated.

3.17 Existing Water Quality Data: Physio-Chemical & Biological Information

Riverine Ecology

The Pere Marquette River Watershed was surveyed by the MDEQ from June through September 2000. Descriptions of watershed characteristics and survey results are detailed in two reports (Walker, 2002a and 2002b). The following results were found from the 2000 surveys:

- Qualitative *fish community* surveys were completed at 10 stations. Six stations attained the coldwater designated use (as determined by the relative abundance of salmonids $\geq$ 1%), salmonids were not found at three stations, and one station was not scored due to low fish density.
- Qualitative *macroinvertebrate* surveys were completed at 37 locations and ratings ranged from acceptable to excellent.

Aquatic insects such as mayflies (left) and caddis flies (right) depend on stable flows, high water quality, and sufficient instream habitat for survival.

- *Habitat* evaluations were completed at 62 locations and ratings ranged from fair to excellent.
- Water samples were collected and analyzed at 25 locations. In general, survey results indicated high quality water in most areas of the watershed with some areas impacted by agricultural land use.

In July and August 2005 the MDEQ Water Bureau conducted and compiled "A Biological Survey of the Pere Marquette Watershed in Mason, Oceana, Lake, and Newaygo Counties, Michigan" (Appendix E). Valuable information was gathered regarding the water chemistry, biological communities, and physical conditions at 27 stations throughout the Pere Marquette Watershed.

2005 Biological Assessment Description and Results

A total of 27 sites (8 targeted and 19 randomly selected) were surveyed for macroinvertebrate communities, habitat rating and fish communities (for Lichte Creek only). Overall, the macroinvertebrate communities rated from acceptable to excellent with a fair number and relative abundance of sensitive taxa present at many stations. Habitat quality rated from marginal to excellent, as well. In general, instream habitat at many of the Pere Marquette River tributaries was impacted by sand bedload. All sites except three were analyzed for total dissolved solids, nitrite, ortho-phosphate, and conductance. Overall, water chemistry results were within the range of expected concentrations and metals concentrations were below Michigan Water Quality Standards. Some Pere Marquette tributaries contained slightly elevated nutrient concentrations, and these were located in areas with agricultural use. Survey results were consistent with 2000 and 2010 survey results (2010 results were not yet compiled into a report when this plan was written).

Based on the combination of rating scores for macroinvertebrates and habitat, the following waterways ranked as follows from overall highest quality to lowest:

1. Little South Branch
2. Baldwin River and Sanborn Creek, and the Middle Branch
3. Main Branch of the Pere Marquette and lower tributaries (Kinney, Weldon, Black, Swan and Lichte Creeks)
4. Big South Branch and tributaries (West Michigan, Tank, Winnepesaug, Cedar, Beaver, Allen and Carr Creeks)

Assessment Highlights

Little South Branch

- Little South Branch and Hayes Road habitat rated excellent with macroinvertebrates rating only acceptable due to low diversity.
- Little South Branch and James Road showed limited Cladophora growth, and habitat and macroinvertebrates rated excellent. MDNR Fisheries Division conducted a Status and Trends random survey near this location in 2004; salmonids represented 78% of the catch by number thus supporting the coldwater fishery designation.
- Little South Branch and South James Road habitat and macroinvertebrates rated excellent.

Baldwin River and Sanborn Creek

- Baldwin River and 24th Street showed heavy sand bedload with woody debris and overhanging brush; habitat rated good and macroinvertebrate community rated acceptable.
- Baldwin River and US-10 dominated by run with large woody debris and gravel substrate sparse. Habitat rated good and macroinvertebrate community rated excellent.
- At all Sanborn Creek sites (State Road, Nelson Road and US-10) the habitat rated good and macroinvertebrate community rated excellent with abundant sensitive taxa present at Nelson Road. Cold groundwater input and juvenile brown trout were observed at State and Nelson Roads.

Middle Branch

- At Middle Branch and 64th Street near Saddler Road, cobble/gravel was present and low water levels were evident at the time of survey. Livestock were heard in adjacent fields and fencing was in place upstream of the crossing, but no signs of animal access were observed in the immediate area. Habitat rated good and macroinvertebrates excellent.
- At Middle Branch and 64th Street near Bonney Road, there were low flows and bank scour indicated flow flashiness, silt deposits over stream substrate were observed. Habitat rated good and macroinvertebrates rated acceptable.
- At Middle Branch and Broadway, sculpin (index species for water quality) were observed, habitat rated good and macroinvertebrates acceptable.
- All Middle Branch sites were assessed for microalgae growth – an indicator of high nutrient inputs. Most locations lacked suitable substrate, and microalgae mean density was low where suitable substrate existed. Nutrient concentrations were highest at the most upstream location.

Big South Branch

- At Cedar Creek and 17 Mile Road, habitat rated excellent though the site was sand dominated and likely affected by connecting lakes.
- At Beaver Creek and Dickinson Avenue and off a Grosbeck Road two-track, flow flashiness and unstable banks, and past channelization were evident. *Beaver Creek's macroinvertebrate community is among the most impacted in the Pere Marquette River Watershed.*
- At Allen Creek and Dickinson Road the bank scour indicated a flashy system and substrate was dominated by sand, with macroinvertebrates rating acceptable.
- Carr Creek and Hawley Road showed heavy sand deposition and evidence of flashy flows; upstream areas were channelized but overall habitat rated good and macroinvertebrates rated excellent.
- Big South Branch habitat rated good at Dickinson Road (sand with woody debris) and excellent at Hawley Road (some cobble/gravel with sand and pools) with macroinvertebrates rating excellent at both locations.

Significant portions of the Big South Branch subwatershed are in federal ownership, fortunately contributing to a heavily forested riparian corridor and intact floodplain in some reaches.

Pere Marquette Mainstem

- Pere Marquette River at the Green Cottage access rated excellent for habitat and macroinvertebrate community.
- Kinney Creek at Wingleton Road showed habitat as good and macroinvertebrates as acceptable. However, this road crossing site was improved in 2010 with installation of a timber bridge that fully spans the stream channel and replaced the undersized culverts that were impounding sand and water. Kinney Creek now has a gravel bottom, narrower stream channel, and higher velocity; perhaps these new site conditions would positively impact the macroinvertebrate community.
- Weldon Creek and downstream of US-10 showed signs of flow flashiness from bank scour. There was abundant large woody debris. *Previous observations by CRA staff showed livestock use (elk farm) in upstream reaches in prior years.*
- Black Creek was surveyed downstream of First Street in the town of Custer, and also observed at upstream crossings. Unrestricted cattle access was observed during the 2000 survey. Heavy sand bedload, flow flashiness, and high erosion potential were observed and likely due to riparian vegetation removal, unrestricted animal access, row crops and pastures at various locations. Overall habitat rated marginal and macroinvertebrates rated acceptable.
- Swan Creek and Hawley Road had mostly sand substrate with silt deposition on substrate, moderate woody debris, and steep banks with exposed areas. Household trash was observed in the stream, and low flows were observed at upstream crossings. *Swan Creek's macroinvertebrate community is among the most impacted in the watershed.* An unnamed tributary to the Pere Marquette at Chauvez Road west of Swan Creek revealed

riparian vegetation removal, unrestricted animal access, raw slumping banks, and high erosion potential. Water samples taken here showed elevated phosphorus concentration.

- Lichte Creek and Morton Road was also surveyed for fish community. Lichte Creek is a designated warmwater stream, however burbot and juvenile coho were collected in 2005 indicating a cool water temperature regime. Fish community is likely limited by lack of suitable habitat, flow (less than one cfs), and small stream size. A heavily vegetated corridor was observed, though dominated by sand.

From the 2005 study it can be inferred that the tributaries to monitor and further explore for implementation activities includes Beaver, Allen, Carr, Weldon, Black, and Swan Creeks, and the Middle Branch. Additional observations by CRA staff in the past would add McDuffee Creek (Little South Branch headwaters tributary) and Freeman Creek (Big South Branch tributary) to the list. Beaver Creek is the largest of the listed creeks, and it makes up the headwaters of the Big South Branch with a significant amount of Beaver Creek designated as county drain, and already tiled and drained due to agricultural use. It was noted in the 2005 report that the streams most impacted by channelization and nonpoint source pollution included Beaver, Black and Swan Creeks.

The bare soil on this Big South Branch streambank downstream of 11 mile Road is likely the result of water level fluctuations in the headwaters due to the extensive system of tributaries, such as Beaver Creek, designated as county drains in surrounding agricultural areas.

MDEQ conducted a biological survey of the Pere Marquette Watershed in 2010. A written report of the data is expected to be ready for distribution in late 2011-2012. A review of field data showed that the watershed was found to be attaining the 'other indigenous aquatic life and wildlife' designated use based on the 2010 macroinvertebrate surveys at random and targeted sites. All selected sites scored acceptable or excellent for the macroinvertebrate community and no algae problems were observed. Habitat assessments of Beaver Creek at 198th Avenue and Comstock Avenue continue to show that the stream appears to be a highly modified waterbody, and in some areas it would benefit from a vegetated buffer zone and tree canopy. In the future, fish community surveys at these crossings on Beaver Creek might be beneficial in better defining habitat and water quality of Beaver Creek.

3.18 Lakes and Lacustrine Ecology

There are a number of inland lakes within the Pere Marquette River Watershed with 11 lakes ranging in size from approximately 40 acres to over 900 acres. Many of these lakes have landowner associations who sometimes communicate with the Pere Marquette River Restoration Committee. Table 16 identifies the lakes of significance within the watershed and lists some of the characteristics.

Lakes are classified according to their trophic state. "Trophic" means nutrition or growth. A eutrophic ("well-nourished") lake has high nutrients and high plant growth. An oligotrophic lake has low nutrient concentrations and low plant growth. Mesotrophic lakes fall somewhere in between eutrophic and oligotrophic lakes. Three main factors regulate the trophic state of a lake:

1. Rate of nutrient supply
    - Bedrock geology of the watershed
    - Soils
    - Vegetation
    - Human land uses and management
2. Climate
    - Amount of sunlight
    - Temperature
    - Hydrology (precipitation + lake basin turnover time)
3. Shape of lake basin
    - Depth (maximum and mean)
    - Volume and surface area
    - Watershed to lake surface area ratio (Aw : Ao)

Most of the lakes in the Pere Marquette Watershed are oligotrophic and mesotrophic, representative of basins with infertile soils that release relatively little nitrogen and phosphorus. Pere Marquette Lake is the only lake that qualifies as being eutrophic, representative of higher nutrient loads, perhaps from agricultural practices or industrial use in that lake's surrounding area.

Pere Marquette Lake is a 554-acre drowned rivermouth lake that connects the Pere Marquette River to Lake Michigan. Pere Marquette Lake empties into Lake Michigan via a dredged channel through the Ludington Harbor. Pere Marquette Lake has a maximum depth of 38 feet, although much of the lake is shallower than that. Currently, the City of Ludington is located on the shores of Pere Marquette Lake and the lake has a long history of heavy industry on its shores. Because of this, areas of the lake have been shown to be contaminated with heavy metals including copper, chromium, zinc, lead, nickel and arsenic (Grant, 1978). Correspondence from MDNR files include discussions regarding brine spills, cyanide discharges, fish kills, and excessive thermal discharges. The lake's shoreline is mostly developed, and has shifted from extensive saw mill operations to heavy industry to residential and recreational use with several new marina/condominium projects completed. Despite all of these issues, Pere Marquette Lake still provides outstanding fishing opportunities. Target species include northern pike, largemouth and smallmouth bass, yellow perch, black crappie and during seasonal migrations, salmon and steelhead. Results of the MDNR fisheries survey in 2005 sampled a total of 201 fish representing 19 species. The most numerous species were rock bass with alewife, bluegill, golden redhorse, northern pike, pumpkinseed sunfish, round goby, smallmouth bass and yellow perch following behind. Species represented by only a few individuals included banded killifish, bowfin, white sucker, freshwater drum, golden shiner, gizzard shad, largemouth bass, silver redhorse, spottail shiner, and mud puppy (Tonello 2005). A fisheries survey in 2009 showed an additional 10 species of fish, including black crappie, black bullhead, bluntnose minnow, brown trout, brown bullhead, common carp, channel catfish, rainbow trout, walleye, and white perch (MDNR, unpublished data). The management direction of MDNR Fisheries

Division for the PM Lake will continue to be conducted on an as needed basis with the current naturally reproducing cool and warmwater fish species found. Northern pike, black crappie, smallmouth and largemouth bass populations should continue to do well without manipulation, as well as the existing seasonal migrations of salmon and steelhead (Tonello 2005).

The Michigan Department of Environmental Quality and US EPA Region 5 National Program Office completed a sediment survey of the Pere Marquette Lake and river mouth in May 2003 as part of the MDEQ Water Division's environmental assessment program (Taft 2003). The goal of the sediment sampling was to determine if there were local sources of Polychlorinated Biphenyls (PCB's) in PM Lake that could be contributing to elevated PCB tissue levels of the fish population in the PM system. PM Lake is on Michigan's list of waterbodies that are not meeting Water Quality Standards for PCBs based upon fish tissue concentrations (Taft 2003). Sediment samples were taken at 14 locations in the lake and river, including one sample at the Ludington Waste Water Treatment Plant outfall. No PCB Aroclors were found above the analytical level of detection, and thus aren't contributing to the PCB levels found in fish tissue. Sediment cores were also sampled for a variety of metals; metals were present but concentrations were below probable effect concentrations. Oily sediments were found in the core adjacent to a dredged channel located near the community boat dock at Copeyon Park, showing compounds associated with petroleum products and these were to be further explored (Taft 2003).

TABLE 16: LAKES IN THE PERE MARQUETTE RIVER WATERSHED

Lake Name	Area (acres)	Lake Trophic Status*	Connected to River	Septic/Sewer	Cisco**	MDEQ I.D. Code	County
Big Star	912	M	No	Septic	no	MI430022	Lake
Idlewild	105	M	No	Septic	no	MI430032	Lake
Paradise	39.3	O	No	Septic	no	MI430049	Lake
Wolf	418	M	No	Septic	no	MI430026	Lake
Pere Marquette	554	E	Yes	Sewer	no	MI530170	Mason
Nichols	160	O	No	Septic	yes	MI620060	Newaygo
Pettibone	44.4	M	No	Septic	no	MI620189	Newaygo
Pickerel	318	M	Yes	Septic	yes	MI620066	Newaygo
Woodland	203	M	Yes	Septic	no	MI620191	Newaygo
Gilbert	172	M	Yes	Septic	no	MI640130	Oceana
Campbell	189	M	Yes	Septic	no	MI640061	Oceana
School Section	182	M	No	Septic	no	MI640065	Oceana

**Tophic Status Key: O=Oligotrophic; M=Mesotrophic; E=Eutrophic*

***Evidence of cisco populations is historical & anecdotal; recent fish surveys have not shown cisco populations.*

CHAPTER 4 DESIGNATED AND DESIRED USES

4.1 Designated Uses in the State of Michigan

Each of Michigan's surface waters is protected by water quality standards for specific designated uses (Table 17). Designated uses as defined by the MDEQ are recognized uses of water established by state and federal water quality laws designed to 1) protect the public's health and welfare, 2) enhance and maintain the quality of water, and 3) protect the State's natural resources.

TABLE 17: DESIGNATED USES FOR SURFACE WATERS IN THE STATE OF MICHIGAN	
All surface waters in the state of Michigan are designed for and shall be protected for all of the following uses:	
Designated Use	General Definition
1. Agricultural	Water supply for livestock watering and cropland irrigation
2. Industrial	Water utilized in industrial processes
3. Public water supply at point of intake	Public drinking water source
4. Navigation	Waters capable of being used for shipping, travel, and other transport by private, military, or commercial vessels
5. Warmwater fishery	Supports reproduction of warmwater fish species
6. Other indigenous aquatic life and wildlife	Supports reproduction of indigenous animals, plants and insects
7. Partial body contact recreation	Water quality standards are maintained for water skiing, canoeing, and wading
8. Total body contact recreation between May 1 - October 31	Water quality standards are maintained for swimming
Citation: R323.1100 of Part 4, Part 31 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended.	

An additional use *not* applied to *all* Michigan waters is "coldwater fishery" and this use is applicable in the Pere Marquette Watershed with many segments of stream being designated by the State as "Blue Ribbon Trout Stream." A watershed's impairment for any of the above designated uses is determined by how well the water quality conforms to the State of Michigan's water quality standards. A general description of the State's water quality standards is found in Table 18.

TABLE 18: STATE OF MICHIGAN WATER QUALITY STANDARDS (as required by sections 3103 and 3106 of 1994 PA 451, MCL 324.3103 & 324.3106)		
Pollutant	State-Required Level	Designated Uses Affected
Dissolved solids	500 mg/L monthly average or 750 mg/L at any time	All
Chlorides	125 mg/L monthly average	Public Water Supply
pH	6.5 to 9/0	
Taste or odor-producing substances	Any concentration	Public Water Supply, Industrial Water Supply, Agricultural Water Supply, Fish Consumption
Toxic substances (selected shown here; see rule for complete listing)	DDT and metabolites: 0.00011 ug/L Mercury, including methylmercury: 0.0013 ug/L PCBs (class): 0.00012 ug/L 2,3,7,8-TCDD: 0.0000000031 ug/L	All but navigation
Radioactive substances	Pursuant to U.S. nuclear regulatory commission and EPA standards	All but navigation
Plant nutrients	Phosphorus: 1mg/L monthly average for permitted point-source discharges	All
Microorganisms	130 Escherichia coli per 100 ml 30-day mean of 5 or more sampling events 300 E. coli per 100 ml 30-day mean 1,000 E. coli per 100 ml 30-day mean Human sewage discharges (treated or untreated) 200 E. coli per 100 ml 30-day mean or 400 E. coli per 100 ml in 7 days or less	All Total body contact recreation Partial body contact recreation
Dissolved oxygen	Minimum 7 mg/L for coldwater designated streams, inland lakes, and Great Lakes/connecting waters; minimum 5 mg/L for all other waters Minimum 5 mg/L daily average	Coldwater fishery Warmwater fishery
Temperature	Natural daily and seasonal temperature fluctuations shall be preserved	Coldwater fishery, other indigenous aquatic life and wildlife, warmwater fishery

If a body of water or stream reach is not meeting the water quality standards set for a specific designated use, then it is said to be in 'nonattainment'. An annually published listing of the bodies of water and stream reaches in the State of Michigan that are in nonattainment can be found in Appendix C of the MDEQ's Integrated Water Quality Report – Water Quality and Pollution Control in Michigan (MDEQ 2008).

The MDEQ uses a rotating watershed cycle for surface water quality monitoring where each of the 58 major watersheds in the state is scheduled for monitoring at least once every five years. The Pere Marquette River Watershed was last monitored in 2010 and compiled results will be distributed in 2011-2012. Results from both the 2010 and the 2005 MDEQ monitoring efforts and integrated reports state that no water body segments in the Pere Marquette Watershed are currently on the state non-attainment list due to nonpoint source causes.

4.2 Impacted Designated Uses in the Pere Marquette River Watershed

None of the designated uses for the Pere Marquette River Watershed are impaired on a watershed-wide scale. However, in some cases, activities and resulting pollutants in the watershed may prove to be a threat to water quality and designated uses. Threatened water bodies are defined as those that currently meet water quality standards, but may not in the future. The Pere Marquette River Watershed Management Plan will focus on five designated uses to protect in order to maintain the water quality of the Pere Marquette River and its many tributaries. The designated uses include the warmwater fishery, coldwater fishery, navigation, other indigenous aquatic life and wildlife, and total body contact (Table 19). The additional coldwater fishery use is defined as a stream's ability to support the natural reproduction of trout (brook, brown or rainbow) and other fish species that thrive in coldwater stream conditions. Threatened designated uses were ascertained through the Pere Marquette River Watershed Assessment 1999, scientific research reports, MDEQ water quality reports, field observations by CRA and Pere Marquette River Restoration Committee members, and personal contact with watershed residents.

TABLE 19: THREATENED DESIGNATED USES IN THE PERE MARQUETTE RIVER WATERSHED	
Warmwater fishery	Threatened
Coldwater fishery	Threatened
Navigation	Threatened
Other Indigenous Aquatic Life and Wildlife	Threatened
Total Body Contact Recreation (May 1 - Oct 31)	Threatened

4.3 Desired Uses

In addition to researching regulated designated uses, the Pere Marquette River Restoration Committee has also identified a number of locally determined desired uses for the watershed. Desired uses can be defined as the ways in which people use the watershed and think should be protected and/or preserved for future generations. They may be very general or very specific, or somewhere in between. Desired uses for the Pere Marquette River Watershed include uses for recreational, aesthetic, and ecosystem preservation purposes (Table 20).

TABLE 20: GENERAL DESIRED USES FOR THE PERE MARQUETTE RIVER WATERSHED	
Desired Use Category	**Goal**
Ecosystem Preservation	• Maintain and preserve ecological corridors throughout the watershed that connect wetlands, riparian corridors and other productive upland areas.
	• Account for state special concern, threatened and endangered and federally listed species (Eastern Massasagua, Karner blue butterfly)
Forest Management	Promote sound forest management practices throughout the watershed on public and private lands.
Aesthetics	• Preserve the distinctive aesthetic character and inherent beauty of the river and its watershed.
Recreation	• Design and promote development that supports privacy, security, visual quality throughout the watershed.
	• Promote the coexistence of recreational activities (fishing, canoeing, boating, hiking, camping, and birding) with a healthy riparian corridor that includes vegetated buffers, stable streambanks and instream woody debris.

CHAPTER 5 WATER QUALITY ISSUES

5.1 Threatened Designated Uses: Pollutants, Sources, and Causes

For each designated use to protect in the Pere Marquette River Watershed there are a number of different pollutants and environmental stressors that adversely affect each of the designated uses, or have the potential to (Table 21). The term environmental stressor is used to describe those factors that may have a negative effect on the ecosystem, but aren't necessarily categorized as contaminants that change water chemistry. Examples of environmental stressors include changes to hydrologic flow, low dissolved oxygen levels, and loss of habitat.

TABLE 21: POLLUTANTS AFFECTING DESIGNATED USES IN THE PERE MARQUETTE RIVER WATERSHED

Pollutant or Environmental Stressor	Designated Uses Affected
Sediment	Coldwater fishery Other indigenous aquatic life and wildlife Navigation
Nutrients	Coldwater fishery Other indigenous aquatic life and wildlife Total body contact
Thermal Pollution	Coldwater fishery Other indigenous aquatic life and wildlife
Toxins (pesticides, herbicides, oils, gas, grease, salt/chlorides)	Coldwater fishery Other indigenous aquatic life and wildlife
Changes to Hydrologic Flow	Coldwater fishery Other indigenous aquatic life and wildlife Navigation
Invasive Species	Coldwater fishery Other indigenous aquatic life and wildlife Navigation Total body contact
Pathogens (*E. Coli* and Fecal Coliform indicators)	Total body contact
Loss of Habitat	Coldwater fishery Other indigenous aquatic life and wildlife

Note: This is a general list that encompasses pollutants for the entire Pere Marquette River Watershed. Not all reaches in the watershed are impacted by all of the pollutants listed above.

Sources and Causes of Pollutants

A Comprehensive Watershed Management Plan Table was developed listing sources and causes of watershed pollutants and environmental stressors (Table 22). This table summarizes key information necessary to begin water quality protection, provides specific targets to act upon for watershed management, and forms the basis for future implementation projects to protect the quality of the watershed. Sources and causes were identified utilizing existing streambank, habitat structure and road/stream crossing inventories, the Pere Marquette River Watershed Assessment, review of existing partners' watershed management plans, meetings with Pere

Marquette River Restoration Committee members, and communications with watershed residents and recreationists.

TABLE 22: POLLUTANTS, SOURCES, AND CAUSES TO WATER QUALITY DEGRADATION IN THE PERE MARQUETTE RIVER WATERSHED			
Environmental Stressor or Pollutant	**Impaired or Threatened Use**	**Sources**	**Causes**
Sediment	*Coldwater Fishery *Warmwater Fishery *Other Indigenous Aquatic Life and Wildlife *Navigation	Road Stream Crossings (k)	Outdated, poor design/construction/maintenance (k)
			Lack of erosion/surface runoff controls (k)
			Steep, unpaved road approaches (k)
			Culverts not aligned to stream channel (k)
			Undersized culverts (k)
			Failing/eroding culverts/bridges (k)
			Steep, exposed road embankments (k)
		Streambank Erosion (k)	Removal of riparian vegetation and woody debris (k)
			Motorized boat traffic/wakes (k)
			Recreational use (k)
			Sandy soils (k)
			High stream flow velocities (k)
		Urban/Agricultural/Rural Storm Water (k)	Poor storm water management practices (k)
		Agricultural practices (k)	Farming to stream's edge (k)
		Livestock (k)	Unlimited access to streams (k)
		Construction (k)	Poor soil erosion practices (s)
			Inability to capture mobilized sediment during road crossing replacement\dam removal efforts (k)
		Dams, Lake-level Control Structures (k)	Physical failures (k)
			Improper dredge spoil disposal (s)
		Wetland Filling (k)	Poor storm water management practices (k)
			Non-compliance with permits (k)
			Development (k)
		Logging (p)	Stream crossings for new access roads (k)
			Clearing land near riparian areas (k)
		Oil and Gas Well Development (k)	Stream crossings for new access roads (k)
			Clearing land for wellhead sites (k)
Nutrients	*Coldwater Fishery *Other Indigenous Aquatic Life and Wildlife *Total Body Contact *Public Water Supply	Septic Systems (s)	Poorly designed, sited, and maintained (s)
			High density/age of systems (s)
		Residential or Commercial Fertilizer (k)	Improper application (amount, timing, frequency, location, method, phosphorus content) (k)
		Urban/Agricultural/Rural Storm Water (k)	Poor storm water management practices (k)
			Development (k)
		Lack of Riparian Buffer (k)	Development (k)
			Clearing by landowner (k)
			Lack of adequate riparian setbacks (p)
		Agricultural Practices (k)	Farming to stream's edge (k)
			Improper manure and/or fertilizer application (amount, timing, frequency, location) (s)
		Livestock (k)	Grazing near stream's edge (k)

			Improper manure storage/handling/application (s)
		Animal Waste (k)	Decaying salmon and waterfowl/wildlife use along riparian areas (k)
		Decrease in Wetlands (k)	Development and filling (k)
		Waste Water Treatment Plant (WWTP) (p)	Discharge of nutrients in waste water (p)
Changes to Hydrologic Flow	*Coldwater Fishery *Other Indigenous Aquatic Life and Wildlife *Navigation	Fluctuating Water Levels (k)	Dams and lake-level control structures (k)
			Urban storm water runoff (k)
			Increase in development and impervious surfaces (k)
			Loss of upland vegetation (k)
			Tributaries designated as county drains (k)
		Reduction of Groundwater Recharge (p)	Increasing development in recharge areas (p)
			Loss of upland vegetation (k)
			Global warming (p)
		Sedimentation (k)	Erosion (k)
		Dams, Lake-level Control Structures (k)	Dam removal (s)
			Changes in operation and maintenance (k)
			Creation/destruction of beaver dams (k)
		Road Stream Crossings (k)	Road crossing flow obstructions/restrictions (k)
			Improper culvert elevations and sizes (k)
		Reduction of Wetlands (k)	Development of wetland areas (k)
Toxins (Pesticides, Herbicides, Oils, Gas, Greases, etc.)	*Coldwater Fishery *Other Indigenous Aquatic Life and Wildlife *Total Body Contact *Public Water Supply	Underground Storage Tanks (k)	Open, leaking underground tanks (k)
		Environmental Contamination Sites (k)	Brine use disposal, improper disposal of contaminants (k)
		Industrial/Municipal Discharges (k)	Discharge limit violations (k)
			Contaminated sediments (k)
		Urban/Agricultural/Rural Storm Water (k)	Poor storm water management practices (k)
		Air Deposition (k)	Vehicle combustion (k)
			Industrial/community/municipal facilities (k)
		Oil, Gas, Hydrocarbon, and Underground Injection Wells (p)	Maintenance, accidents, brine storage, abandoned wells (leaking, uncapped) (p)
		Water Wells (p)	Abandoned wells (leaking, uncapped) (p)
Pathogens (*E. Coli* and Fecal Coliform indicators)	*Total Body Contact	Urban/Agricultural/Rural Storm Water (k)	Poor storm water management practices (k)
		Animal Waste (k)	Decaying salmon and waterfowl/wildlife use along riparian areas(k)
			Livestock use in the riparian corridor. (k)
		Septic Systems (p)	Improperly designed and maintained (p)
		WWTP (p)	Overflowing sewer systems during high flow (p)
Invasive Species (sea lamprey, phragmites)	*Coldwater Fishery *Other Indigenous Aquatic Life and Wildlife	Connected Waterway (k)	Unrestricted movement from Lake Michigan (k)
		Transportation System (k)	Vehicles, equipment inadvertantly spreading seed (p)
Loss of Habitat	*Coldwater Fishery	Development (k)	Poor development and design practices (k)
			Lack of knowledge on impact (k)

	*Other Indigenous Aquatic Life and Wildlife		New construction (p)
			Inadequate laws or regulations (p)
			Habitat fragmentation (k)
			Wetland loss (k)
		Bank Erosion (k)	Removal of or lack of riparian vegetation (k)
			Inappropriate landowner practices in riparian corridor (k)
			High recreation use (k)
Thermal Pollution	*Coldwater Fishery *Other Indigenous Aquatic Life and Wildlife	Urban/Agricultural/Rural Storm Water (k)	Poor/insufficient storm water practices (k)
		Impervious Surfaces (s)	Increase in development and impervious surfaces (k)
		Lack of Riparian Buffer (k)	Removal of or lack of riparian vegetation (k)
		Dams, Lake-level Control Structures (s)	Top draw structures (k)
			Hydrology-low flows on affected streams increase impact(k)
K = known, S = suspected, P = potential			

5.2 Priority Pollutant Ranking

The pollutants listed in Section 5.1 were ranked and prioritized based on how they most affect or have the potential to affect the watershed's designated uses (Table 23). Overall, sediment is the high priority pollutant for the majority of the watershed with nutrients becoming more of an issue in the west and southwest portions of the watershed where active agricultural and livestock management practices are in effect. In addition, nutrients are often attached to soil particles, thus closely linking sediment and nutrient pollution. Changes to hydrologic flow, due to insufficient storm water management, tributaries that are designated as county drains in heavily used agricultural areas, and private dams located on tributaries are also concerns throughout the watershed. Invasive species, especially the sea lamprey, have been a prominent concern in the Pere Marquette Watershed with the US Fish and Wildlife Service utilizing a combination of an electric weir and lampricide treatments in their control program. Unfortunately, the electric weir has not been completely effective and US Fish and Wildlife Service has had to resort to periodic treatments of the chemical, 3-trifluoromethyl, 4-nitrophenol (TFM), throughout the watershed. Phragmites are an invasive plant species that is becoming a growing concern in upland, wetland and riparian areas, especially in the downstream part of the watershed.

TABLE 23: POLLUTANT PRIORITIES FOR THE PERE MARQUETTE RIVER WATERSHED

Pollutant	**Priority Ranking for Pere Marquette Watershed**
Sediment	1
Nutrients	2
Changes to Hydrologic Flow	3
Invasive Species	4
Toxins (pesticides, herbicides, oils, gas, grease, salt/chlorides)	5
Loss of Habitat	6
Pathogens (*E. Coli*, Fecal Coliform indicators)	7
Thermal Pollution	8

Each pollutant has a different effect on the threatened designated uses for the Pere Marquette River Watershed (Table 24). The Pere Marquette River Restoration Committee has prioritized pollutants and environmental stressors in the following way:

TABLE 24: POLLUTANT PRIORITIES FOR THREATENED DESIGNATED USES		
Threatened Designated Use	**Pollutant or Environmental Stressor**	**Priority Ranking**
Coldwater Fishery and Warmwater Fishery	Sediment	1
	Changes to Hydrologic Flow	2
	Invasive Species	3
	Loss of Habitat	4
	Nutrients	5
	Toxins	6
	Thermal Pollution	7
	Pathogens	8
Other Indigenous Aquatic Life and Wildlife	Sediment	1
	Changes to Hydrologic Flow	2
	Nutrients	3
	Loss of Habitat	4
	Invasive Species	5
	Toxins	6
	Thermal Pollution	7
	Pathogens	8
Navigation	Sediment	1
	Changes to Hydrologic Flow	2
Total Body Contact	Pathogens	1
	Toxins	2
	Nutrients	3
Public Water Supply	Nutrients	1
	Pathogens	2
	Toxins	3

The project steering committee noted that it is difficult to rank all of the pollutants and environmental stressors in the watershed because all are important and should be priorities for maintaining and improving watershed health. The pollutant ranking really depends on which area of the watershed is analyzed. Land use and land ownership varies across the 4-county watershed, and impacts the sub-watersheds differently. Often the pollutants and stressors are related and changes in one can cause changes in the other. For instance, a dam failure could increase hydrologic flows in a stream which would increase sedimentation (fill the stream channel and widen it, make it more shallow) and thermal pollution. Excessive sedimentation could contribute to loss of instream habitat, thus weakening an ecosystem and make it more vulnerable to invasive non-native species populating the area.

Addressing the sources of the prioritized pollutants thus becomes an important strategy in keeping pollutants from entering the waterways in the first place (Table 25). With most of the pollutants and stressors being interconnected, dealing with the sources could potentially reduce multiple pollutants and stressors from impacting the overall watershed.

TABLE 25: POLLUTANT SOURCE PRIORITY RANKING		
Environmental Stressor or Pollutant	**Sources**	**Priority Ranking**
Sediment	Road Stream Crossings (k)	1
	Streambank Erosion (k)	2
	Agricultural Practices (k)	3
	Livestock (k)	4
	Construction (k)	5
	Dams, Lake-level Control Structures (k)	6
	Urban/Rural Storm Water (k)	7
	Wetland Filling (k)	8
	Logging (p)	9
	Oil and Gas Development (k)	10
Nutrients	Agricultural Practices (k)	1
	Septic Systems (s)	2
	Urban/Agricultural/Rural Storm Water (k)	3
	Residential or Commercial Fertilizer (k)	4
	Lack of Riparian Buffer (k)	5
	Livestock (k)	6
	Animal Waste (k)	7
	Decrease in Wetlands (k)	8
	WWTP (p)	9
Changes to Hydrologic Flow	Fluctuating Water Levels (k)	1
	Sedimentation (k)	2
	Reduction of Groundwater Recharge (p)	3
	Dams, Lake-level Control Structures (k)	4
	Road Stream Crossings (k)	5
	Reduction of Wetlands (k)	6
Invasive Species	Transportation System (k)	1
	Connected Waterways (k)	2
Toxins (Pesticides, Herbicides, Oils, Gas, Greases)	Underground Storage Tanks (k)	1
	Environmental Contamination Sites (k)	2
	Industrial/Municipal Discharges (k)	3
	Urban/Agricultural/Rural Storm Water (k)	4
	Oil, Gas, Hydrocarbon and Underground Injection Wells (p)	5
	Air Deposition (k)	6
	Water Wells (p)	7
Pathogens (*E. Coli* and Fecal Coliform Indicators)	Urban/Agricultural/Rural Storm Water (k)	1
	Animal Waste (k)	2
	Septic Systems (s)	3
	WWTP (p)	4
Loss of Habitat	Development (k)	1
	Bank Erosion (k)	2
Thermal Pollution	Urban/Agricultural/Rural Storm Water (k)	1
	Impervious Surfaces (s)	2
	Lack of Riparian Buffer (k)	3
	Dams, Lake-level Control Structures (k)	4

5.3 Priority and Critical Areas

Priority Areas

The Pere Marquette River has been identified by the Nature Conservancy as one of two watersheds in the northern Lower Peninsula (the AuSable River is the other river) that is a priority watershed for conservation action because of its high biological significance, ongoing threats, and opportunities for protective action. The Pere Marquette River Restoration Committee's priority areas intersect with the conservation targets identified in the Pere Marquette River Watershed Plan April 2007 authored by The Nature Conservancy and Land Conservancy of West Michigan. The USFS, MDEQ, PMWC and CRA participated in the development and review of the Conservancy's plan. Six terrestrial and freshwater ecological systems are identified as priority areas, encompassing the majority of native natural communities and important species found in the watershed.

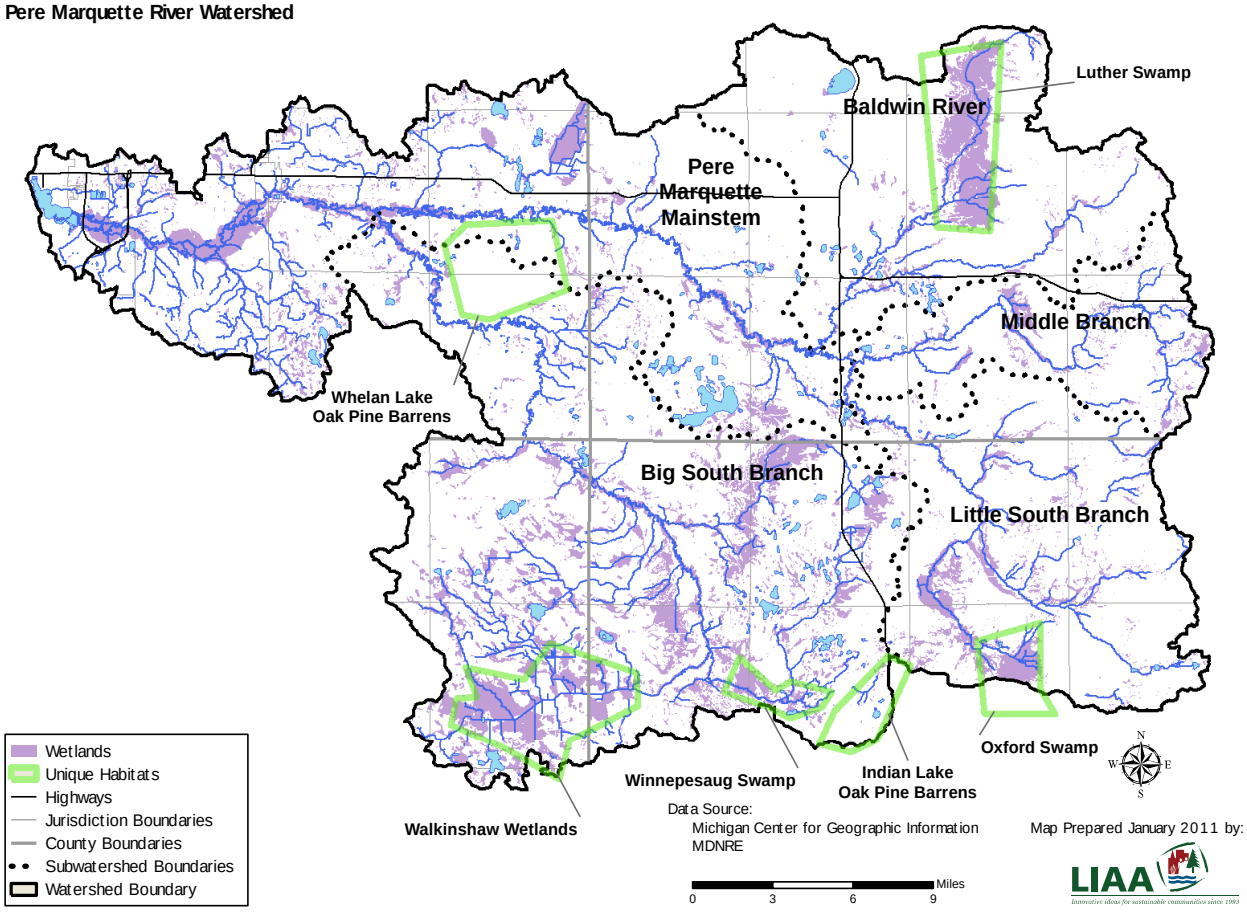
Priority areas are defined as the portions of the watershed that are most sensitive to environmental impacts and have the greatest likelihood to affect water quality and aquatic habitat (Figure 24). Priority areas account for approximately 18% of the watershed and include the portions of the watershed which would have a direct negative impact to the high water quality if they are degraded in the future. Areas that focus on preservation and protection are considered **priority areas** and include the following:

- Headwater Wetlands Complexes
- Intact wetlands throughout the watershed
- Oak-Pine Barrens Complex (most notably in the greater Whelan Lake area)

In addition, through field knowledge and validation from the MDEQ 2005 Biological Assessment, Pere Marquette River Restoration Committee notes that the Baldwin River, Little South Branch and Middle Branch subwatersheds currently contain most of the highest water quality and instream habitat conditions. Thus, implementation projects that focus on protecting and preserving existing conditions will likely be prioritized in those subwatersheds where intact wetlands are present and adjacent to a waterway.

Figure 24. Priority Areas (Unique Habitats & Wetlands)

Pere Marquette River Watershed



Critical Areas

Critical areas are those within the Pere Marquette Watershed that are especially sensitive, and potentially need restoration, rehabilitation and management (in the form of vegetative buffers, streambank or channel restoration, reforestation, road/stream crossing replacement, stormwater management, etc.) (Figure 25). Restoration of these areas is vital to maintaining the high water quality of the watershed. With agricultural use, outdated road stream crossings, and eroding streambanks being the highest sources of nutrients and sediment in the watershed, these uses were the first threshold of criteria in developing critical areas. Currently the critical areas include the following:

- **Agricultural use areas** which are focused on the headwaters of the Big South Branch, Little South Branch and Middle Branch, and portions of the mainstem corridor in Mason County.
- **50 severe road stream crossings** located throughout the watershed. One road crossing site includes an adjacent dam; this is located on the Baldwin River in the Village of Baldwin.
- **40 severely eroding streambanks** located on the Big South Branch and mainstem.

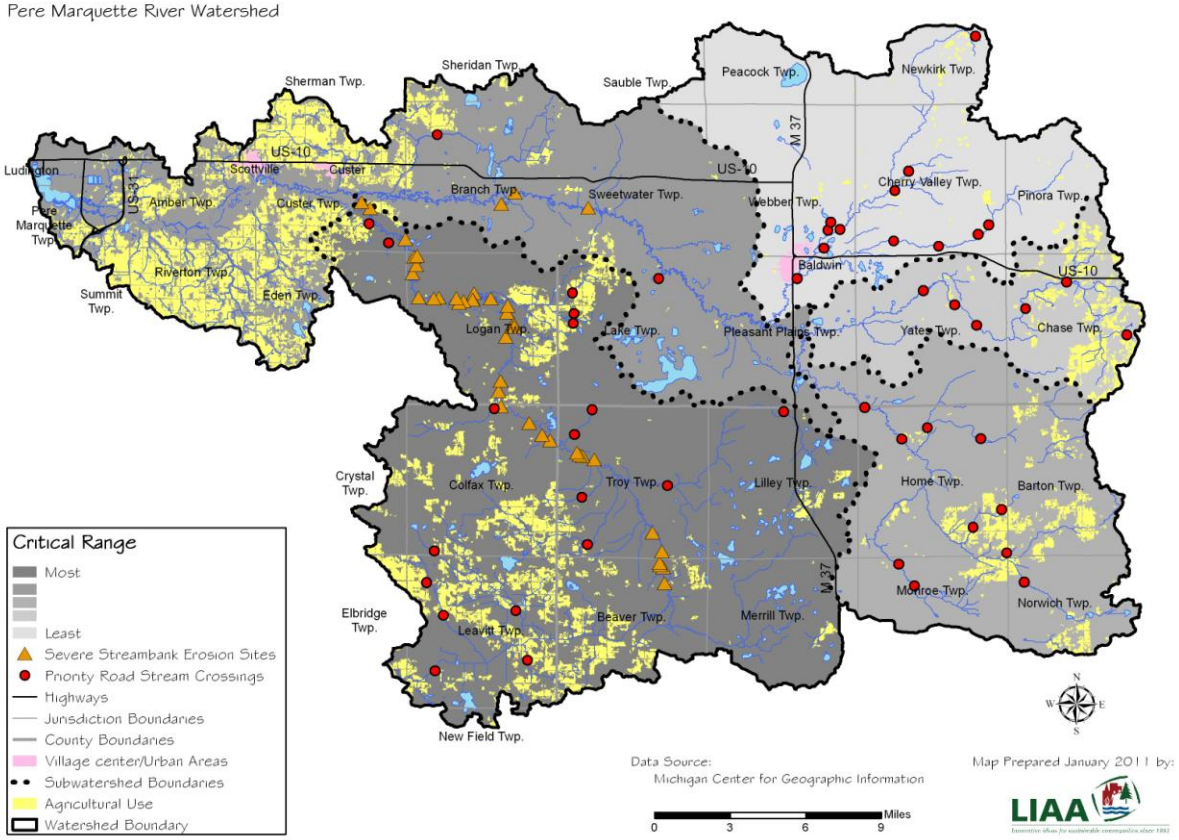
- **Baldwin, Custer, Scottville** village centers ranked in that order, starting upstream and working downstream in the watershed. These urban areas drain to the surface waters via storm sewers and the locations furthest upstream impact the most miles of river.

With the overall watershed being sizeable, the Pere Marquette River Restoration Committee ranked the subwatersheds in order of importance with the Big South and Mainstem being most critical. Ranking criteria included:

- percentage of non-designated trout stream
- percentage of wetland loss
- macroinvertebrate ratings from the 2005 MDEQ Biological survey
- pollutant loadings for eroding streambanks and road/stream crossings
- agricultural use and urban land use impacts calculated from the L-THIA and EPA Region 5 pollutant loading models (Tables 27, 28, 29, 30)

Figure 25. Critical Areas

Pere Marquette River Watershed



Thus, those agricultural areas and sites found within the Big South and Mainstem subwatersheds are top critical areas for restoration and rehabilitation work. CRA's river management approach is typically to start work in the headwaters of a stream and continue downstream; this approach will be applied with work on agricultural lands, streambank and road crossing work. The critical areas for the Pere Marquette River Watershed cover approximately 17% of the watershed and are threatened by the pollutants and causes listed in Table 26.

TABLE 26: CRITICAL AREAS IN THE PERE MARQUETTE RIVER WATERSHED		
Critical Area	**Top Priority Pollutant Contributing**	**Priority Causes**
Streambanks and Road/Stream Crossings	Sediment	Road crossings, bank erosion
	Nutrients	Agricultural practices, fertilizer use, livestock use, septic systems
	Changes to Hydrologic Flow	County drains, drainage ditches, agricultural runoff, dams, road crossings
High Use Agricultural Areas	Sediment	Bank erosion, lack of buffers
	Nutrients	Agricultural practices, fertilizer use, livestock use
	Changes to Hydrologic Flow	Drainage ditches, agricultural runoff, wetland filling
City and Village Centers	Sediment	Development, storm water
	Nutrients	Development, storm water
	Changes to Hydrologic Flow	Storm water

Land Protection

Land protection goals intersect with identified priority areas and also extend beyond those priority areas to encompass the entire watershed because it is all included within the Land Conservancy of West Michigan's (LCWM) service area. Voluntary landowner participation in establishing conservation easements and land acquisition is a major factor in the success of land protection efforts; this also contributes to the reasoning behind LCWM having watershed-wide goals for land protection. Thus, in a separate but related effort, LCWM has identified and ranked high, medium and low priority parcels of land in the Pere Marquette River Watershed that are ideal for protection efforts. LCWM focuses on projects with significant natural resources including river frontage and wetland, larger sized tracts, and those pieces with either adjacent protection or public ownership. LCWM continues to follow the strategy and priorities previously identified in The Nature Conservancy's *Pere Marquette Watershed Conservation Area Plan* from 2007. Maps of priority land protection land are separate from the priority and critical areas identified for the watershed and are provided in Figures 26, 27, 28, 29, 30 and 31.

The primary goal of the LCWM mapping process was the identification of natural lands worthy of protection efforts within the Pere Marquette Watershed in Mason, Lake, Newaygo and Oceana Counties. The ranking of the parcels was based on evaluations of digital orthoquadrangle photos (aerial), topographic, hydrologic and land ownership maps. Special consideration was given to properties providing critical, ecological benefits including water quality protection through having wetland and river/creek frontage, forested or natural land cover, and adjacency to existing protected or public lands. Due to ease of use in the mapping process, and the lack of full ownership parcels throughout the watershed, 40-acre squares (quarter quarter sections) were used as "blocks" identified as high, medium or low priority for future protection. When blocks contained more than one of the following five attributes, its

consideration went up accordingly. For example, a block that contained a Natural River portion of stream with a wetland would garner more consideration than a block with an isolated wetland not attached by surface water to the rest of the watershed. The property attributes utilized in the ranking system are as follows:

1. Forested and Vegetated Riparian Corridor

Vegetated or forested areas surrounding the rivers, creeks, and other waterways promote high water quality and habitat. Special consideration was given to areas that contained the Pere Marquette mainstem or other waterways identified as "Natural Rivers" in the Michigan DNR Natural Rivers Plan (Figure 7). Conversely, less consideration was given to areas where the naturally occurring water course has been altered and "ditched," commonly for agricultural purposes.

2. Connectivity with Surrounding Landscape

Blocks that were adjacent to protected or public lands were evaluated. This included LCWM Conservation Easement lands, Huron-Manistee National Forest land and State of Michigan land, including Pere Marquette State Forest. Special consideration was given if the prospective blocks were surrounded by these lands.

3. Land Ownership Fragmentation

Although consistent parcel data was available through the mapping, either plat books and/or county GIS websites were used to determine parcel data. Through this comparison of sources, the fewer parcels contained within the block, the higher consideration it was given. For example, a 40-acre block with one owner was given higher consideration than a block that contained two or more owners/parcels.

4. Wetlands

Wetlands typically have high water quality and provide wildlife habitat. Blocks that contained wetlands were therefore given strong consideration. Blocks that contained wetlands with surface water connection to the Pere Marquette were given special consideration, and if that connection was to a designated *Natural River* section (Figure 7), it was ranked higher still. Additional consideration was given if the wetlands present represented headwater areas for the *Natural Rivers* waterways.

5. Known Pre-settlement Vegetation Occurrences

In rare instances, an area known to contain European pre-settlement habitats or vegetation occurs throughout the watershed. Special consideration was given to these areas if they were still in a natural land cover state.

5.4 Pollutants of Concern

Water Quality Trend Analysis

Pollutant loading in the watershed was determined using the Long-Term Hydrologic Impact Assessment (L-THIA) model, developed by the Agricultural and Biological Engineering Department at Purdue University in conjunction with the EPA. L-THIA has been developed as a straightforward analysis tool that provides estimates of changes in runoff, recharge and nonpoint

source pollution resulting from past or proposed land use changes. It is an easy, useful way to quickly determine existing pollutant loads in a watershed using an online watershed delineation tool. Once the watershed of interest is delineated, the L-THIA model can be utilized to see what the current runoff and pollutant loads are. The land uses can be manipulated to predict changes in runoff and pollutant loads given specific land use situations. More information can be found at: https://engineering.purdue.edu/~lthia/.

The L-THIA model uses the following land uses: Water, Commercial, Agricultural, High Density and Low Density Residential, Grass/Pasture, Forest, Industrial, and Other. The model shows that the phosphorus loss leaving the watershed is 19,228 pounds (lbs) per year, while nitrogen is 79,742 lbs per year (Tables 27 and 28). Suspended solids lost in the watershed are almost 1.7 million lbs.

By far most of the nutrient and sediment pollution stem from agricultural lands in the Pere Marquette Watershed. According to values obtained using the L-THIA model, agriculture accounts for just 9% of the land use in the watershed, but contributes 91% of the phosphorus and 75% of the nitrogen loading. Additionally, agricultural lands contribute 86% of the suspended solids loss (Tables 27 and 28). Commercial land uses are second behind agriculture for phosphorus losses with 1,171 lbs per year, comprising just 6% of the total.

Interesting to note is that forests comprise the highest land with 74%, and contribute only 1% of the phosphorus and suspended solids loss in Pere Marquette Watershed. However, forests are predicted to contribute the second highest amount of nitrogen losses with 11,131 lbs per year, comprising 14% of the total nitrogen loss (Tables 27 and 28).

TABLE 27: POLLUTANT LOAD OUTPUT FOR PERE MARQUETTE RIVER WATERSHED – CALIBRATED L-THIA MODEL

Land Use	Acres	Ave. Annual Runoff Volume (acre-ft)	Phosphorus loss (lbs)	Nitrogen Loss (lbs)	Suspended Solids Loss (lbs)	Lead (lbs)	Copper (lbs)	Zinc (lbs)	Cadmium (lbs)	Chromium (lbs)	Nickel (lbs)	Oil and Grease (lbs)
Water	17,287	--	--	--	--	--	--	--	--	--	--	--
Commercial	1,471	1,328	1,171	4,907	203,277	46	52	658	3	36	43	32,963
Agricultural	43,368	4,901	17,572	59,483	1,446,530	19	19	215	12	134	-	-
High Density Residential	407	97	151	485	10,944	2	2	21	0	1	2	453
Low Density Residential	2,647	74	115	372	8,396	2	2	15	0	0	2	347
Grass/Pasture	52,527	1,706	46	3,292	4,704	23	46	27	5	34	-	-
Forest	363,419	5,766	157	11,131	15,902	77	157	93	14	118	-	-
Industrial	682.3	21.0	16.1	72.3	3,509.0	0.9	0.9	13.1	1.0	0.4	0.5	172.7
Others	537	--	--	--	--	--	--	--	--	--	--	--
Total	482,345	13,892	19,228	79,742	1,693,262	170	279	1,042	34	323	48	33,936

Average Annual Runoff Depth (in)	0.34										
Average Annual Concentration (ppm)		0.516	2.141	45.462	0.004	0.007	0.027	0.0009	0.008	0.001	0.911
NOTE: Values obtained using online L-THIA model: https://engineering.purdue.edu/~lthia/ *Acre-ft = the volume of water necessary to convey one acre to a depth of one foot (1 acre-foot = 43,560 cubic feet)* *Land Use data = USGS NLCD 2001 LANDSAT satellite data*											

TABLE 28: POLLUTANT LOADING OUTPUT PERCENTAGES FOR PHOSPHORUS, NITROGEN AND SUSPENDED SOLIDS USING L-THIA LAND USES & MODEL

Land Use	Acres	% Total Acres	Phos-phorus loss (lbs)	% Phos-phorus loss	Nitrogen loss (lbs)	% Nitro-gen loss	Suspended Solids loss (lbs)	% Suspended Solids loss
Water	17,287	4%	--		--		--	
Commercial	1,471	0%	1,171	6%	4,907	6%	203,277	12%
Agricultural	43,368	9%	17,572	91%	59,483	75%	1,446,530	86%
High Density Residential	407	0%	151	1%	485	1%	10,944	1%
Low Density Residential	2,647	1%	115	1%	372	0%	8,396	0%
Grass/ Pasture	52,527	11%	46	0%	3,292	4%	4,704	0%
Forest	363,419	75%	157	1%	11,131	14%	15,902	1%
Industrial	682.3	0%	16.1	0%	72.3	0%	3,509.0	0%
Others	537	0%	--		--		--	
Total	482,345	100%	19,212	100%	79,670	100%	1,689,753	100%
Average Annual Concentration (ppm)			0.516		2.141		45.462	

NOTE: Values obtained using online L-THIA model: https://engineering.purdue.edu/~lthia/
Land Use data - USGS NLCD 2001 LANDSAT satellite data

The EPA Region 5 Pollutant loading model was also used in order to go a step further and evaluate subwatersheds. For comparison of the models themselves, the L-THIA land uses were used for the entire watershed in the EPA model (Table 29). Calculations from the EPA model were significantly higher than those from the L-THIA model. For example, with the L-THIA model 1.69 million pounds of suspended solids loss (Table 28) were determined for the watershed whereas the EPA model predicted 17.8 million pounds (Table 29). It is not uncommon to get discrepancies in different models; when this occurs the approach to assessing data should focus on ranges and how each pollutant compares to one another between the models. Comparing the subwatersheds (Table 30), the Big South Branch and Mainstem far outweigh the Baldwin, Little South and Middle Branch in terms of phosphorus, nitrogen and suspended solids inputs. This determination is thus reflected in the identification of the critical areas for the watershed (Figure 25). Between both the L-THIA and EPA models, agricultural use was the greatest source of phosphorus, nitrogen and suspended solids, and this dynamic is also shown in the critical areas map (Figure 25). With agricultural use being dominant in the Big South and mainstem subwatersheds, it is logical for these areas to become more of a priority in the workplan of the Pere Marquette River Restoration Committee and its partners.

TABLE 29: POLLUTANT LOAD OUTPUT FOR PM WATERSHED USING L-THIA GENERATED LAND USES & EPA REGION 5 POLLUTANT LOADING ESTIMATES (lbs/acre/year)

Land Use	Acres	%	Phosphorus Loss (lbs)	%	Nitrogen Loss* (lbs)	%	Suspended Solids Loss* (lbs)	%
Commercial	1,471	0%	1,765	8%	26,478	10%	1,529,840	9%
Agricultural	95,895	20%	17,261	81%	230,148	83%	14,671,935	83%
High Density Residential	407	0%	448	2%	3,500	1%	427,350	2%
Low Density Residential	2,647	1%	1,059	5%	8,206	3%	407,638	2%
Industrial	682.3	0%	887	4%	8,188	3%	736,884	4%
Other (water, forest, other)	381,243	79%	--	0%	--	0%	--	0%
Total	482,345	100%	**21,420**	**100%**	**276,520**	**100%**	**17,773,647**	**100%**

**Notice these loading values are significantly higher than what the L-THIA model calculated.*

TABLE 30: POLLUTANT LOAD OUTPUT PER SUBWATERSHED USING 1992 LAND USES & EPA REGION 5 POLLUTANT LOADING MODEL ESTIMATES (lbs/acre/year)

Subwatershed	Acres	Total Suspended Solids (lbs)	%	Nitrogen (lbs)	%	Phosphorus (lbs)	%
Baldwin	75,674	2,380,580	10%	29,580	9%	9,302	15%
Big South Branch	167,972	7,175,187	31%	99,848	31%	20,223	33%
Little South Branch	73,628	3,608,809	16%	50,176	16%	9,788	16%
Main Branch	130,701	8,097,058	35%	110,268	35%	18,077	29%
Middle Branch	34,947	2,041,488	9%	28,977	9%	4,883	8%
Total	**482,922**	**23,303,122**	**100%**	**318,850**	**100%**	**62,272**	**100%**

The land uses *not* included in these calculations were wetlands, open water & bare rock. 1992 land use data was used because it was categorized as needed for the EPA #5 model to work for subwatersheds.

Sediment

Sediment is fine inorganic soil or sand particles, and sedimentation is the process whereby sediment is deposited in a stream or lake bottom. It occurs naturally in all stream and lake environments due to land erosion by wind and water. However, excessive sedimentation can severely degrade an entire riparian system (Waters 1995) and has been identified as a major cause of degradation to aquatic life in many Michigan streams and rivers (MDEQ 1998). Excessive sediment deposition in many of Michigan's streams also severely impacts the amount of suitable habitat needed to support healthy and diverse communities of fish, wildlife, and aquatic insects and organisms. When abnormally high sediment loadings exceed the stream's transport capacity it can bury gravel, rock and wood substrate thereby leading to decreases in habitat diversity and aquatic plant production. Excessive sediment can alter the stability of channel pattern profile and dimensions. One of the most common changes in channel morphology observed occurs in lower gradient reaches of rivers and streams where ability to transport bedload is reduced causing it to aggrade. This process of vertical bed adjustment typically leads to increased width/depth ratio, mid-channel bar formation and lateral channel adjustments due to increases in near bank shear stresses; thus exacerbating sedimentation issues while the channel tries to re-define its stable pattern, profile and dimension subsequent to disturbance. Such channel adjustments due to anthropogenic causes are of greatest concern as they often lead to undesirable consequences such as temperature increases and overall reduction of substrate and habitat diversity due to unstable channel geometry and dimensions.

Sediment is identified as a major pollutant in the Pere Marquette River Watershed based on inventories, research, and field inspections. Significant known sources of sediment include streambank erosion, road/stream crossings, and surface and storm water runoff. Depending on the severity and number of erosion sites and road stream crossings, a significant amount of sediment, and, subsequently, phosphorus and nitrogen is released into the river and its tributaries.

Significant sources of sediment to the Pere Marquette River and its tributaries include activities that can cause bank erosion and destabilize adjacent upland soils. Historical logging practices initiated the anthropogenic disturbances that lead to excessive sediment bedload. During the second half of the 19th century, settlers cleared northern Michigan forests of the old growth forest that covered much of the land for its lumber. Loggers used the rivers to transport logs downstream to sawmills, railroads, towns, and Lake Michigan. Stream corridors were clear cut, high steep banks were burned of vegetation and used as log rollaways, and stream channels were cleared of all woody debris in order to float logs most efficiently. The arctic grayling that was once dominant in northern Michigan streams became extinct from over fishing and loss of habitat due to logging. Today, road/stream crossings, development, improper agricultural and livestock management practices, dams, heavy recreational use, and unmanaged storm water all contribute excessive sediment to streams in the Pere Marquette Watershed.

This photo was taken of a section of the Baldwin River where the Pere Marquette River Restoration Committee ended up installing a sand trap. Active sand deposition is evident from the wave-like formation of sand in the stream channel.

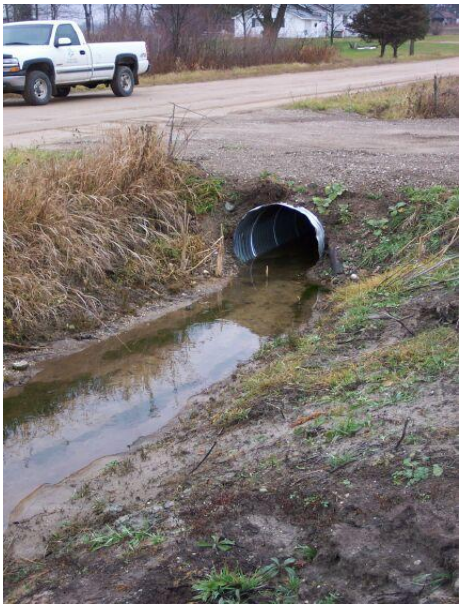
Big South Branch

The major problem in the Big South Branch is sedimentation, as identified in the "Comprehensive Surface Resource Assessment, Big South Branch Pere Marquette River 1998." The system has an abnormally high sediment load evidenced by significant deposition in low gradient reaches and by observable streambed throughout the stream. Sand sediment covers over gravel riffles in the lower gradient areas and creates embedded and aggraded gravels in higher gradient areas. Sediment conditions are improved somewhat in the tributary streams, but are still sufficient to limit macroinvertebrates and fish production. Average summer stream discharge at the Big South's confluence with the Pere Marquette mainstem is approximately 150 cfs (US Fish and Wildlife Service flow data). However, discharge at flood stage is several times this flow. Litter and debris can be found four to five feet high in trees within lower Beaver Creek and the upper Big South Branch. Thus, this system would be characterized as being "flashy." This high variation in flow is caused by local geology, and compounded by agricultural drainage activities in the upper watershed. Beaver Creek helps make up the headwaters of the Big South, and much of Beaver Creek is designated county drain and has been straightened to facilitate land drainage. Channelized sections consist of low gradient glides or runs of very uniform velocities and have flat-bottomed channels that have very low amounts of large woody debris. These channels consist of ripples and dunes of sand, indicating that sediment movement occurs at all flows. The report authors estimated that bedload in the Big South is transported at a rate of approximately one mile in five years; thus, sand stemming from Beaver Creek will take years to move through the system and will be actively replaced by new sediment from flashy flows in the channelized areas that run through agricultural lands. Bank erosion along the Big South aggravates the sediment problem but channelization of the headwaters is the culprit. Fortunately a significant amount of the mainstem is in Federal ownership and a large amount of woody debris has accumulated over the years, helping to provide instream fish and wildlife habitat (Alexander et al. 1998).

It is critical to manage activities within the riparian corridor throughout the Pere Marquette Watershed. A riparian corridor includes the streambanks and land adjacent to a flowing stream. Ideally, the riparian corridor is vegetated or forested so that tree and plant roots stabilize sensitive banks, filter pollutants from nearby runoff problems, and provide flood protection during high water events. A forested corridor also provides habitat for fish, wildlife and insects; from the leaves that fall off a tree into a stream to provide detritus for a stonefly that in turn provides food for fish. Clearing of a riparian corridor for any reason thus reduces the stream's ability to handle floods, provide habitat, filter pollutants, and stabilize the stream channel and banks. The linear corridors provided by stream bank setbacks enhance wildlife movement and migration for sensitive species. Protection of existing natural riparian corridors is critical to the long-term health of streams and downstream receiving waters and is also instrumental in adding aesthetic and economic well-being to the community.

Overtopping of a small earthen dam during spring melt and heavy rains contributed tons of sediment to the East Branch of Tank Creek and eventually the Pere Marquette River.

The Pere Marquette Watershed Road/Stream Crossing Inventory formally identifies 277 road/stream crossing sites with at least 68 ranking severe and 57 ranking moderate in erosion problems that contribute to excessive sedimentation of the river and tributaries, and subsequently phosphorus and nitrogen may be released into river systems (Figure 32, Table 31). A number of crossings in the Pere Marquette Watershed have culverts that are perched and too short, lack diversion outlets and paving for control of surface run-off, lack vegetated and gradually sloped embankments, and need bridges instead of culverts on mid-sized to larger stream channels. These crossings are spread throughout the watershed on the mainstem and tributaries, making the sites one of the most threatening problems to the watershed. Today's outdated and failing road/stream crossings were often designed and built up to 50 or more years ago when water quality and habitat fragmentation weren't recognized as problems. Fortunately, permits and guidelines are in place with current road crossing improvement projects that help prevent repeating past mistakes. Still, road commissions are faced with limited budgets especially in our rural areas where high quality streams and lakes are most prominent. As a result, outreach is still needed in rectifying the problems that road crossings pose in any given watershed.



Designated county drains (Freeman Creek at Maple Island Road, 2004 pictured at the left) and drainage ditches along roads (county road ditch in Mason County, 2003 pictured at the right) are often connected to or part of streams in the Pere Marquette watershed. When not properly designed and vegetated, these drainage areas can contribute significant amounts of sediment to the river and its tributaries.

CRA and the USFS are currently in the process of updating the road/stream crossing inventory for the Pere Marquette River Watershed utilizing an updated inventory form and database developed in 2011 by CRA, USFS, Huron Pines, and the Land Information Access Association and approved by the Lake Michigan Technical Committee lead by the US Fish and Wildlife Service. The new inventory tool calculates fish passability scores and sediment loading for each road crossing, and compiles all site information onto the website, www.michiganstreams.org. Thus, the road stream crossing sites in Figure 32 are not ranked in order of severity due to the ongoing updating effort. The update database for the Pere Marquette is expected be online in late 2012 – early 2013.

TABLE 31: ROAD STREAM CROSSING EROSION ANALYSIS BY SUBWATERSHED					
Subwatershed	**Average Erosion for Severity Type**	**# of Each Type**	**Soil Loss/yr**	**Phosphorus Load/yr**	**Nitrogen Load/yr**
Baldwin River	Severe: 2.6 + tons/yr	15	39+ tons	504+ lbs	1,008+ lbs
	Moderate: 1.1-2.5 tons/yr	8	8.8-20 tons	134-269 lbs	269-538 lbs
	Minor: 0-1 tons/yr	5	0-5 tons	0-85 lbs	0-170 lbs
	Restored or No Action	4	0	0	0
	Unranked: To be inventoried 2011-12	0	To be determined	To be determined	To be determined
	Total	32	64+ tons	858+ lbs	1,716+ lbs
Middle Branch	Severe: 2.6 + tons/yr	5	13+ tons	168+ lbs	336+ lbs
	Moderate: 1.1-2.5 tons/yr	8	8.8-20 tons	134-269 lbs	269-538 lbs
	Minor: 0-1 tons/yr	7	0-7 tons	0-118 lbs	0-236 lbs
	Restored or No Action	11	0	0	0
	Unranked: To be inventoried 2011-12	0	To be determined	To be determined	To be determined
	Total	31	40+ tons	555+ lbs	1,110+ lbs
Little South Branch	Severe: 2.6 + tons/yr	13	33.8+ tons	437+ lbs	874+ lbs
	Moderate: 1.1-2.5 tons/yr	15	16.5-37.5 tons	252-504 lbs	504-1,008 lbs
	Minor: 0-1 tons/yr	4	0-4 tons	0-67 lbs	0-134 lbs
	Restored or No Action	8	0	0	0
	Unranked: To be inventoried 2011-12	0	To be determined	To be determined	To be determined
	Total	40	75.3+ tons	1,008+ lbs	2,016+ lbs
Big South Branch	Severe: 2.6 + tons/yr	34	88.4+ tons	1,142+ lbs	2,284+ lbs
	Moderate: 1.1-2.5 tons/yr	28	30.8-70 tons	470-941 lbs	941-1,882 lbs
	Minor: 0-1 tons/yr	5	0-5 tons	0-84 lbs	0-168 lbs
	Restored or No Action	16	0	0	0
	Unranked: To be inventoried 2011-12	0	To be determined	To be determined	To be determined

	Total	83	163.4+ tons	2,167+ lbs	4,334+ lbs
Mainstem	Severe: 2.6 + tons/yr	1	2.6+ tons	34+ lbs	68+ lbs
	Moderate: 1.1-2.5 tons/yr	1	1.1-2.5 tons	17-34 lbs	34-68 lbs
	Minor: 0-1 tons/yr	1	0-1 tons	0-17 lbs	17-34 lbs
	Restored or No Action	8	0	0	0
	Unranked: To be inventoried 2011-12 *Minor loadings were used for calculations	85	0-85 tons	0-1,445 lbs	1,445-2,890 lbs
	Total	96	91.1+ tons	1,530+ lbs	3,060+ lbs

Overall, streambank erosion is a moderate issue in the Pere Marquette Watershed. Significant streambank stabilization efforts were undertaken when the Pere Marquette River Restoration Committee formed in 1987 and coordinated the 10-year $1.4 million streambank stabilization project, funded by the Natural Resources Commission and USFS. The Committee was originally comprised of the Huron-Manistee National Forest Service (USFS), Michigan Council of TU, Mason-Lake CD, MDNR Fisheries Division, PMWC, and CRA. Today, the Restoration Committee is informally composed of additional agencies and groups like Road Commissions, Townships, landowner associations and clubs. More than 170 moderately and severely eroding banks have been stabilized since the Committee developed involving 30,800 lineal feet of bank and 23,700 cubic yards of rock riprap. Today, streambanks are often stabilized due to landowner concerns of losing land or jeopardizing cabins and homes built close to the water's edge before the Natural Rivers Act was in place. The Pere Marquette River also has some high, steep, sandy banks that become undermined by falling trees and changing river conditions. When CRA is involved in restoring such banks, a combination of log terracing, tree plantings, fieldstone and woody debris installation are used to protect steep, sandy slopes and deflect the current away from sensitive areas and towards the center of the stream channel. The rock and wood techniques promote a more natural looking, stabilized bank condition, and also provide instream habitat for fish and wildlife.

The existing 45 documented severe streambank erosion sites on the mainstem, Little South Branch and Big South Branch contribute between 360 or more tons of sediment, 403 lbs of phosphorus, and 806 lbs of nitrogen to the overall system (Figure 33). These are approximate values and specific erosion and sediment loading calculations were not performed for each site inventoried due to time and budget constraints. Additional streambank erosion information for the sub-watersheds and moderate and minor sites are provided in Tables 31 and 32. The potential exists for more erosion problems on smaller feeder streams that flow through livestock or agricultural use areas; these areas will be analyzed on a case by case basis.

TABLE 32: STREAMBANK EROSION ANALYSIS BY SUBWATERSHED					
Subwatershed	**Average Erosion for Severity Type**	**# of Each Type**	**Soil Loss/yr**	**Phosphorus Load/yr**	**Nitrogen Load/yr**
Baldwin River	Severe: 6+ tons/yr	0	0	0	0
	Moderate: 3.1-5.9 tons/yr	0	0	0	0
	Minor: 0-3 tons/yr	7	0-21 tons	0-31 lbs	0-62 lbs
	Restored or No Action: None	21	0	0	0
	Total	28	21 tons	31 lbs	62 lbs
Middle Branch	Severe: 6+ tons/yr	0	0	0	0
	Moderate: 3.1-5.9 tons/yr	12	37.2-70.8 tons	54-108 lbs	108-216 lbs
	Minor: 0-3 tons/yr	15	0-45 tons	0-67 lbs	0-134 lbs
	Restored or No Action: None	15	0	0	0
	Total	42	115.8 tons	175 lbs	350 lbs
Little South Branch	Severe: 6+ tons/yr	3	18+ tons	27+ lbs	54+ lbs
	Moderate: 3.1-5.9 tons/yr	25	77.5-147.5 tons	112-224 lbs	224-448 lbs
	Minor: 0-3 tons/yr	43	0-129 tons	0-193 lbs	0-385 lbs
	Restored or No Action: None	18	0	0	0
	Total	89	294.5+ tons	444+ lbs	888+ lbs
Big South Branch	Severe: 6+ tons/yr	39	234+ tons	349+ lbs	698+ lbs
	Moderate: 3.1-5.9 tons/yr	31	96.1-182.9 tons	139-278 lbs	278-556 lbs
	Minor: 0-3 tons/yr	29	0-87 tons	0-130 lbs	0-260 lbs
	Restored or No Action: None	2	0	0	0
	Total	101	503.9+ tons	757+ lbs	1,514+ lbs
Mainstem	Severe: 6+ tons/yr	3	18+ tons	27+ lbs	54+ lbs
	Moderate: 3.1-5.9 tons/yr	16	49.6-94.4 tons	72-144 lbs	144-288 lbs
	Minor: 0-3 tons/yr	8	0-24 tons	0-36 lbs	0-72 lbs
	Restored or No Action: None	170	0	0	0
	Total	197	136.4+ tons	207+ lbs	414+ lbs

Calculations used to determine phosphorus and nitrogen load for Tables 26 and 27 were taken from the MDEQ Pollutants Controlled Manual (MDEQ 1999).

Typical Impacts from Sedimentation

Impact #1: Sand and sediment harm aquatic life by covering natural stream and lake substrate, which fish and prey species rely upon for spawning and feeding.

Impact #2: Sediment also increases turbidity, decreasing visibility and clogging fish and insect gills. Turbid stream flow also dislodges fish eggs and insect prey.

Impact #3: When more sand and sediment is deposited than can be moved by stream flow,water levels are raised, causing streambank erosion and potential flooding. Excessive sedimentation may also fill lakes, ponds, and wetlands.

Impact #4: Nutrients, heavy metals, and other pollutants can attach to finer sediment particles and enter the water when suspended.

Impact #5: Excess sedimentation can potentially impair navigation by making the water too shallow for boats and boat access.

Agricultural grazing on or near streambanks may also contribute excessive sediment to streams. Most effects of grazing in riparian areas include increased fine-sediment generation and channel widening caused by bank exposure and animal access, sediment entering from slumping streambanks, increased deposition on the streambed, and much greater streambank damage from storm events (Kauffman et al. 1983, Sheffield et al. 1997).

Nutrients

Nutrients are elements such as nitrogen, phosphorus, carbon, sulfur, calcium, potassium, iron, manganese, boron, and cobalt that are essential to the growth of living things. In particular, nitrogen and phosphorus are critical nutrients for all types of plants, including aquatic species. The nitrogen requirements of these species are typically about 10 times that of phosphorus. Because nitrogen/phosphorus ratios exceed 10:1 in most freshwater systems, nitrogen is usually not the limiting nutrient. In Michigan, rooted aquatic vegetation and algal growth are most commonly limited by the amount of phosphorus in the water column. Ordinarily, as the amount of phosphorus in the water column increases, rooted plant and algal growth increase as well. Generally speaking, total phosphorus concentrations greater than 10 micrograms per liter (µg/L) may contribute to increased aquatic plant growth and are indicative of impaired water quality.

When elevated levels of phosphorus occur in the water column, rooted plant and algae growth can be excessive, resulting in nuisance conditions. Such excessive plant and algae growth eventually dies and the decomposition of plant life removes oxygen from the water and can contribute to dissolved oxygen levels that are unable to support aquatic life (Allan 1995). In terms of water quality, nutrients have a negative impact on the system when their concentrations exceed natural background levels. This condition can effectively reduce the recreational value of

the waters by making the water unpleasant and undesirable for swimming, fishing, or boating due to increased algae and aquatic plant growth.

Nutrients speed up the natural aging process of lakes and ponds. This process is called eutrophication. The signs of an aging water body are deeper bottom sediments and heavy weed growth. This aging process would normally be measured in hundreds of thousands of years if not for the added sediments, fertilizers, and other organic wastes supplied by runoff from a developed watershed.

Sources of nutrients to the Pere Marquette Watershed resulting from human activities include storm water runoff from agricultural, residential and urban areas, commercial fertilizer use (by residents, businesses and agricultural operations), and runoff from animal waste (from both residential and agriculture sources).

Fertilizers are a large source of nutrient input the watershed. Since phosphorus is most often the limiting nutrient in aquatic systems, phosphorus concentrations in fertilizers and consequently in runoff from lawns has an impact in the watershed. While no detailed studies involving nutrient runoff from lawns are available for the Pere Marquette River Watershed, information from lawn studies done in Wisconsin indicate a large amount of phosphorus in the water stemming from fertilizer use. One study conducted in an urban area reported that lawns accounted for 24% of runoff volume, but 56-70% of phosphorus export (Waschbusch et al. 1999).

Another study conducted on a lake with 70% of its shoreline developed with lawns mowed to the water's edge reported that lakeshore lawn drainage area provided just 4% of the water inflow to the lake, but comprised 51% of the total phosphorus input (Garn 2002). The same study measured total phosphorus concentrations in runoff for different fertilizer categories (no fertilizer, no-phosphorus fertilizer, and regular fertilizer) and found that total phosphorus concentrations in runoff from lawn sites with the no-phosphorus fertilizer applications were similar to that of unfertilized sites (Garn 2002). This indicates that no-phosphorus fertilizer use may be an effective, low-cost practice for reducing phosphorus in runoff.

Fertilizers and other pollutants used on agricultural lands in the watershed may also be of concern. Agricultural practices of all types account for 16% or 117 square miles of the total watershed area. Agricultural areas include row crops, pasture, Christmas tree plantations, orchards, vineyards, and ornamental plant crops. Of these, row cropping is the dominant practice with accounting for 12% of the watershed area or 91.6 square miles, and 78% of all agricultural practices. Orchards and

The potential for nutrient pollution coming from fertilized croplands largely depends on the frequency, rate, and time of year fertilizer is applied, runoff rates, and the proximity to a water source. Photo taken of an active farm in Mason County with hayfield. Photo courtesy CRA.

vineyards by nature do not get fertilized often and do not have a high potential for soil erosion, although there is significant potential for 'wind drift' of sprayed on pesticides. Other types of agriculture lands, like row crops and permanent pasture areas, however, many potentially have high soil erosion and nutrient runoff rates. Row crops (i.e., potatoes, hay, asparagus, corn, small grains, etc.) are mainly found in the southeast and southwest portions of the watershed in Oceana and Newaygo Counties, and the northwest portion in Mason County.

Pollutants of Concern – Special Sources

Agricultural Sources

Agriculture is a particular source of pollution to note as it contributes a significant amount of nutrients and sediment to the watershed. As noted in Tables 7 and 8, agricultural land uses comprise just 9% of watershed, but contributes 91% of the phosphorus load, 75% of the nitrogen load, and 86% of the suspended solids loss. The watershed has a large amount of field crops concentrated in the Big South Branch, upper Little South Branch and Middle Branch portions of the watershed.

Sediment Impacts (HIT Model)

The High Impact Targeting (HIT) model was used to determine specific sediment loss from the watershed at a more detailed scale than the L-THIA model (Tables 27 and 28). HIT is an online tool that allows users to prioritize erosion and sedimentation reduction conservation efforts in the Great Lakes Basin. Users can determine total erosion or sediment load, rates of erosion or sediment loading, and the cost benefit of BMPs in their watershed. HIT's modeling design was initially implemented over a multi-year partnership between the Institute of Water Research (IWR) and the US Army Corps of Engineers. IWR refined the model design and developed an initial version of the on-line tool as part of a pilot project, supported with a USDA-NRCS Conservation Innovation Grant and the Michigan Department of Agriculture. More information on the HIT model can be found online: http://35.9.116.206/hit2/home.htm.

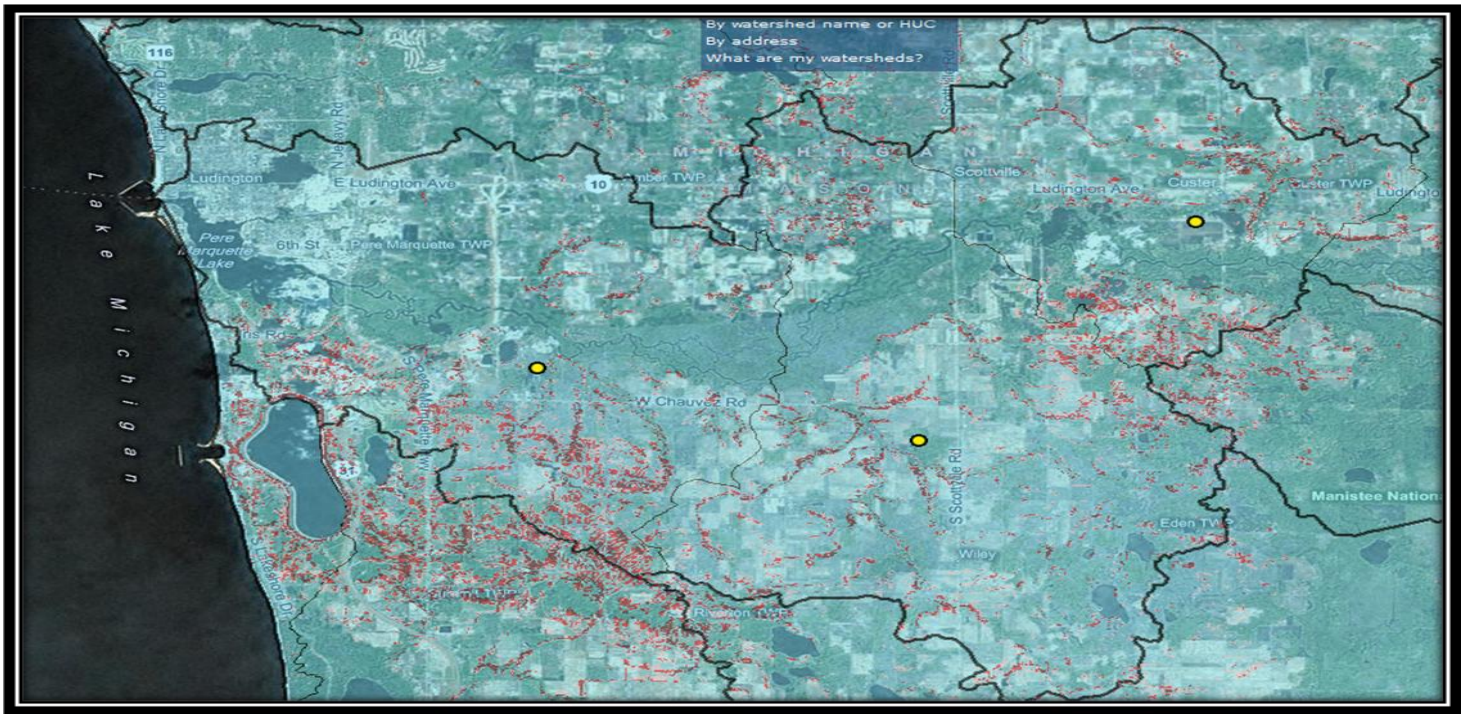
HIT combines an erosion model (RUSLE - Revised Universal Soil Loss Equation1) and a sediment delivery model (SEDMOD - Spatially Explicit Delivery Model2) to calculate annual erosion and sediment loading to streams for areas of the Great Lakes Basin. This combination yields two outputs: field-scale maps identifying areas at risk for erosion and sediment loading, and tonnage estimates for erosion and sediment loading at watershed scales. This on-line tool allows users to interact with these data spatially, and evaluate the potential impacts of BMPs on selected watersheds.

The HIT model reveals that the three main sub-watershed areas of the Pere Marquette River are losing 14,425 tons of sediment each year (Table 33). This is much higher than the generalized L-THIA calculated suspended solids loss from all land uses of 1,693,262 lbs (or 756 tons) each year. The model does take pasture and cropland into account and differentiate between the two by assigning pasture lands with a lower curve number.

TABLE 33: SEDIMENT LOSS IN PERE MARQUETTE RIVER WATERSHED – HIT MODEL VALUES				
Name	**HUC**	**Acres**	**Total(tons/year)**	**Rate(tons/acre/year)**
Big South Branch Pere Marquette River	406010104	168,102	4,483	0.027
Little South Branch Pere Marquette River	406010103	108,660	3,080	0.028
Pere Marquette River	406010105	206,536	6,863	0.033
TABLE TOTALS		**483,297**	**14,425**	**0.03**

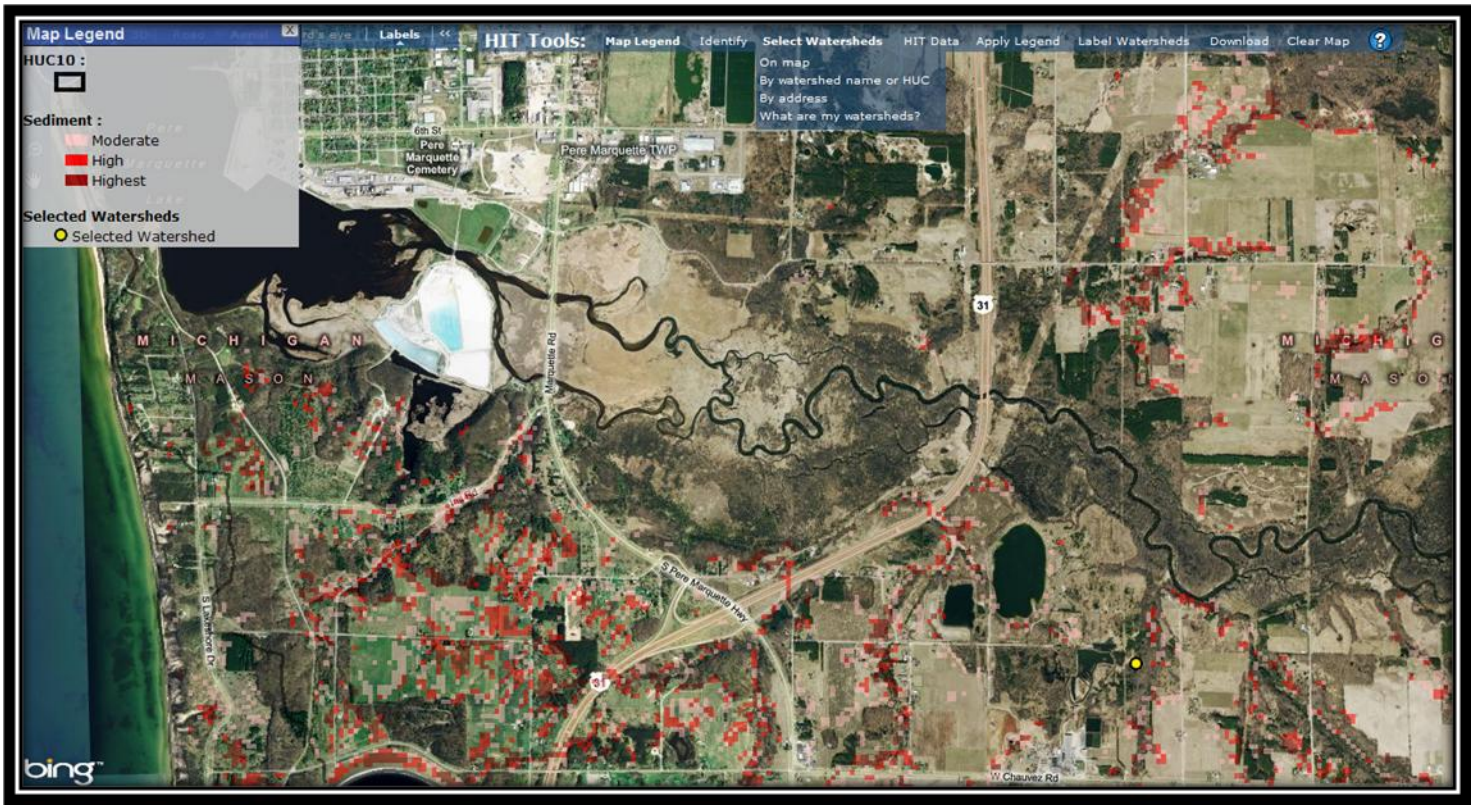
Field-level maps showing areas at high risk for erosion and sediment loading are also available using the HIT model. The following maps (Figures 34 and 35) show areas within fields that are likely eroding and contributing sediment.

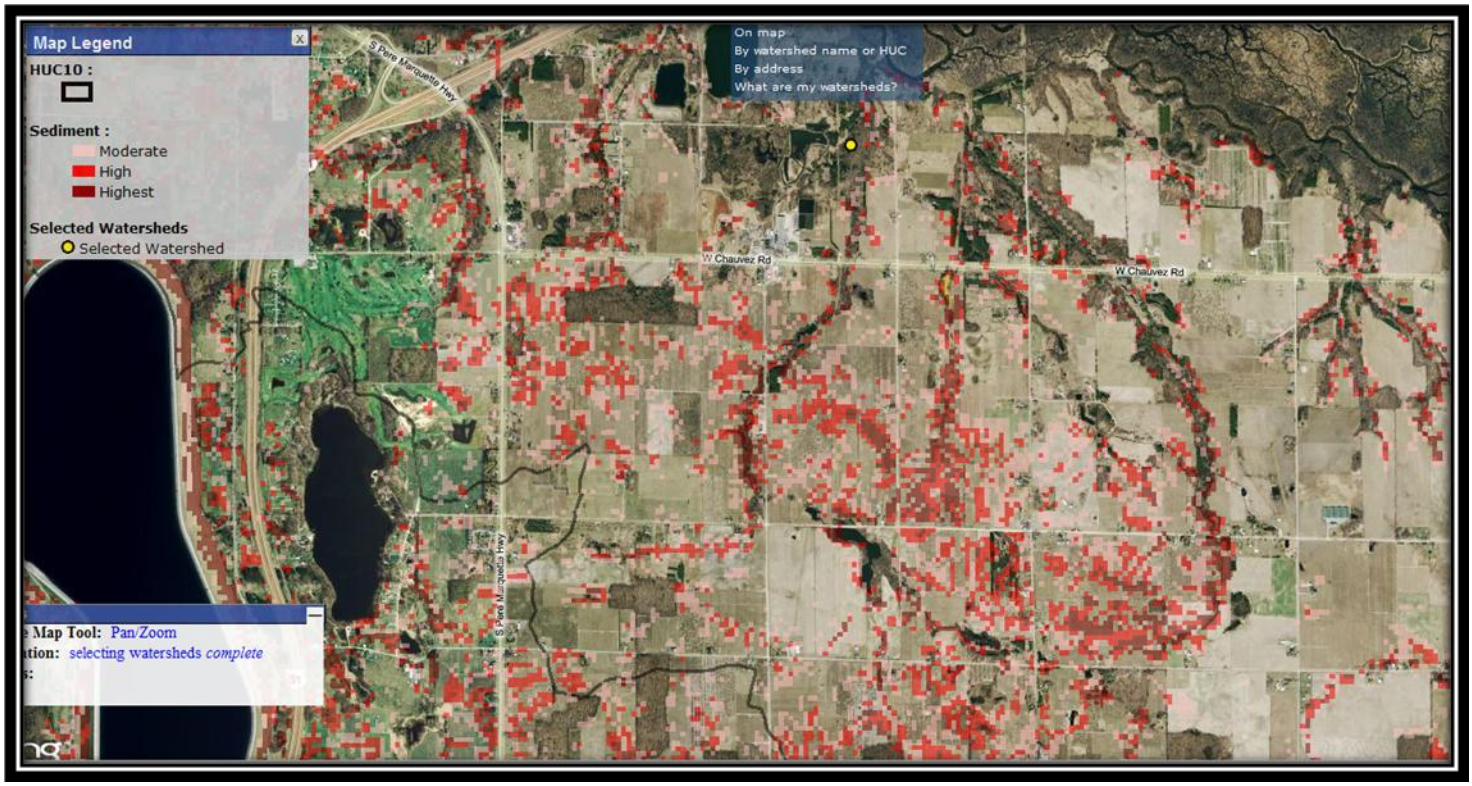
Figure 34: HIT Model Results – Sediment Contributing Areas in Lower Pere Marquette River Watershed



Pink = Moderate, Red = High, Dark Red = Highest

Figure 35. HIT Model Results – Sediment Contributing Areas Lower Pere Marquette River





Another potential source of nutrient enrichment in the Pere Marquette River Watershed is from septic systems. Septic systems are used to treat and discharge wastewater from toilets, wash basins, bathtubs, washing machines, and other water-consumptive items, many of which can be sources of high pollutant loads. They are particularly common in rural or large lot settings, where centralized waste water treatment systems are not economical. The four counties of the Pere Marquette Watershed are located in District Health Department #10 which is comprised of 10 counties in Northwest Michigan. Although the district has a total population of over 255,000 (2000 US Census), most of the public live in small communities, rural settings or on the outskirts of municipalities where on-site septic systems are used and little infrastructure exists for community sewer systems. The District conducts an evaluation of all on-site septic systems that have failed. A system failure is defined whenever waste water discharges to the ground surface or backs up into a dwelling. The District passed a uniform Sanitary Code for on-site septic system in 2008. The District has an estimated 78,000 to 80,000 on-site wastewater septic systems. The District-wide failure rate has ranged from 0.5% (2003, 2010) to 0.7% (2006, 2008), and this rate is low compared to the EPA's national average of 10% in 2000. The individual county failure rates are as follows:

- Lake – 0.4%
- Mason – 1.0%
- Newaygo – 0.7%
- Oceana – 0.6%

The low failure rate is generally reflective of the environmental conditions within the District. The primary soil type throughout the District is a medium to loamy sand with few clay or clay loam areas. This is generally considered ideal conditions for the installation of on-site septic systems. The greatest challenges facing the District would be groundwater protection since the area consists of many wetlands, high water tables, aquifer recharge areas and a large amount of surface water. Lot sizes can also be small due to second homes and vacation homes clustered in high recreation areas (lakes and waterways).

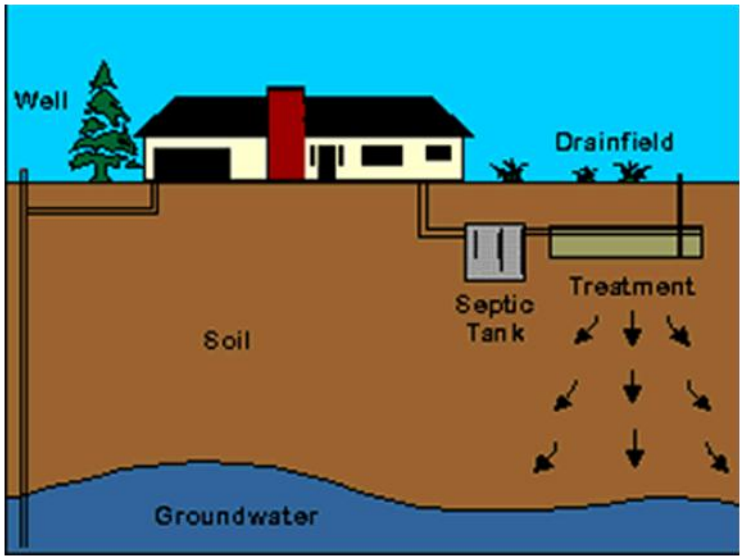
The 2010 On-Site Septic System Failure Report involved evaluating 375 failed septic systems. Since the District issued 1,228 septic permits for the time frame of the report, this meant that 31% of the permits that were issued were for failures. In 2010, the lowest number of reported failed septic systems occurred since 2003. This could be due to the economic decline in the District, in that many homes remain unoccupied and many homeowners with failed systems do not have the financial resources to replace them. The percentage of failures per county for 2010 are as follows and likely reflect the population size and soil conditions:

- Lake – 2%
- Mason – 12%
- Newaygo – 19%
- Oceana – 11%

The evaluation of failed septic systems in the District highlighted the four major reasons for failure as follows:

1. System age – In most of the District, the life-span of an on-site septic system is 25 years or more.

2. Septic system undersized – In 2010, a higher failure rate occurred for systems with tank sizes of less than 1,500 gallons. With the adoption of the new uniform Sanitary Code, minimum septic tank sizes have been increased from 1,000 gallons to 1,200 gallons which may still not be sufficient.
3. Root intrusion – The problem with root intrusion is mostly an issue with dry wells. Dry wells are very prone to tree roots and will often become root-bound after 20 to 30 years even if you maintain the traditional 10 feet from all trees. Dry wells were originally the most common variety of septic system installed 25 and more years ago. Gravel beds are now the most common type since they are relatively easy and inexpensive to install.
4. Hydraulic overload – This can be a symptom of inadequate drainfield size, lack of septic maintenance, intrusion of groundwater or a change in use that negatively impacts the system.



A septic system consists of two basic parts: a septic tank and a soil absorption field or drainfield. Wastes flow from the house into the septic tank where most solids are separated to the bottom and are partially decomposed by bacteria to form sludge. Some solids float and form a scum mat on top of the water. The liquid effluent from the septic tank, carrying disease causing organisms and liquid waste products, is discharged into the soil absorption field. In the absorption field, the water is further purified by filtration and decomposition by microorganisms in the soil. The semi-purified wastewater then percolates to the groundwater system. Image and information courtesy of MSU Institute for Water Research: www.iwr.msu.edu/edmodule/water/septic

The best way to prevent septic system failure is to ensure that a new system is sited and sized properly and to employ appropriate treatment technology and maintenance. Design requirements will vary according to local site factors such as soil percolation rate, grain size, and depth to water table. The most probably causes of septic failures include:

1. Septic tank failure (cracking or collapse)
2. Infrequent tank pumping
3. Sewage pipes filled with solids
4. Damaged or collapsing pipes
5. Hydraulic overload
6. Septic system undersized
7. Insufficient isolation to groundwater table
8. Root intrusion
9. Installation error
10. Unsuitable fill used
11. Dirty stone used
12. Excessive amount of cover on septic system
13. Lack of maintenance
14. System age

Identifying and eliminating these possible failing septic systems will help control contamination of ground and surface water supplies in the watershed from untreated waste water discharges. The effectiveness of septic systems at removing pollutants from waste water varies depending on the type of system used and the conditions at the site. The fact is, even a properly operating septic system can release more than 10 pounds of nitrogen per year to the groundwater for each person using it (Septic System Fact Sheet – www.stormwatercenter.net). The average pollutant removal effectiveness for a conventional septic system is as follows: total suspended solids – 72%, biological oxygen demand – 45%, total nitrogen – 28%, and total phosphorus – 57% (USEPA 1993). This shows that even properly operating conventional septic systems have relatively low nutrient removal capability, and can be a cause of eutrophication in lakes and coastal areas.

Although not identified as a known pollutant in the watershed, failing and improperly maintained septic systems are a concern in the watershed with there being a significant number of homes located directly in the riparian corridor, and most of the watershed being rural with no sewer service. Thus, additional research is required to get a better idea of the specific amount of pollution coming from failing septic systems in the watershed. The District's recommendations stemming from the 2010 Failure Report include continuing to improve the quality of the evaluation reports of failed systems and homeowner education regarding the operation and maintenance needs of on-site septic systems. The District needs to explore ways to educate all landowners with special regards to pumping frequency, landscaping near drainfields, and property use changes. Some townships in Northwest Michigan are known to require prospective home buyers to request updated septic system reports from the health department prior to home purchases. This information provides the landowner with existing conditions and recommendations from the health department regarding the septic system.

Wastewater discharge can also contribute nutrients; currently Michigan Power LP is permitted for four outfalls and Occidental Chemical Corporation is permitted for one outfall on the lower Pere Marquette River in Ludington.

Wastewater treatment in the watershed is present in 4 municipalities. Treatment methods remove nutrients and chemicals from effluent, reducing potential impacts to the Pere Marquette River. Municipality wastewater treatment methods are as follows:

- The village of Baldwin has a ground discharge waste treatment system.
- The Ludington Wastewater Treatment Plant was built in 1974 and 1975, and has 31 acres of aerated lagoons that hold 90 million gallons for biological treatment. Effluent from the lagoons is chlorinated for disinfection and discharged to the Pere Marquette River; fortunately this discharge is in the lowermost portion of the watershed and thus doesn't pose harm to most of the waterways in the watershed.
- The village of Scottville is currently reviewing sewage treatment and disposal alternatives to replace or upgrade the aging Village Waste Water Treatment Plan.
- The Village of Custer recently constructed a $2.6 million wastewater treatment facility with semi-annual discharge to the river, including 21,300 feet of sewer and 3 lagoons. This was a significant upgrade to the town formerly served by only septic tanks.

Typical Impacts from Excessive Nutrients

Impact #1: Increased weed and algae growth impact water recreation and navigation.

Impact #2: Decomposition of algae and weeds removes oxygen from lakes, harming aquatic life and reducing the recreational and commercial fishery.

Impact #3: Exotic plant species like Eurasian Watermilfoil and Purple Loosestrife can better compete with native plants when nutrients are abundant.

Impact #4: Some algae (i.e., blue-green algae) are toxic to animals and humans and may cause taste and odor problems in drinking water.

Impact #5: High nitrogen levels in drinking water are a known human health risk.

Thermal Pollution

Not normally thought of as a pollutant, heated stormwater runoff and elevated stream temperatures are a moderate concern in the Pere Marquette Watershed, especially in developing areas like Ludington. When water temperature increases, its ability to hold dissolved oxygen decreases, thereby reducing the available amount of oxygen in the water to fish and other aquatic life. Temperature also influences the rate of physical and physiological reactions such as enzyme activity, mobility of gases, diffusion, and osmosis in aquatic organisms. For most fish, body temperature will be almost precisely the temperature of the water. So, as water temperature increases, a fish's body temperature increases, which changes their metabolic rate and other physical or chemical processes as well. When thermal stress occurs, fish cannot efficiently meet these energetic demands (Diana 1995). With the Pere Marquette River being known as a Blue Ribbon Trout Stream, it only makes sense to consider the potential ramifications if thermal pollution were to become a more prominent issue.

Thermal pollution also occurs through industrial discharges of warmed process water, solar warming of stagnant pond water and stormwater, and from discharges of warmed water behind dams and other lake-level control structures. The Pere Marquette River lacks dams on its mainstem, however, there are lake-level control structures and dams located throughout the watershed on tributaries. Undersized and perched culverts also act as barriers, causing plunge pools to form and impounding stream water behind the structures making these areas more susceptible to solar warming.

Excessive inputs of sediment into streams and lakes may also contribute to thermal pollution. Excessive sediment takes a long time to flush out of a system, and can fill streams, pools and lakes, making them shallower, wider and susceptible to warming from solar radiation.

Changes in climate due to global activities also may enhance the degree of thermal pollution in a watershed. Average global surface temperatures are projected to increase by 1.5º Celsius to 5.8º Celsius by the year 2100 (Houghton et al. 2001). Increases in surface temperatures may increase stream water temperatures as well, although impacts will vary by

region. Overall, increases in stream water temperature will negatively affect cold-water aquatic species. For example, cold-water fish, such as trout and salmon, are projected to disappear from large portions of their current geographic range in the continental United States due to an increased warming of surface waters (Poff et al. 2002).

Typical Impacts from Thermal Pollution

Impact #1: Surges of heated water during rainstorms can shock and stress aquatic life, which have adapted to cold water environments. Aquatic diversity is ultimately reduced. Constant heating of rivers and lakes ultimately changes the biological character and thus the fishery value.

Impact #2: Thermal pollution decreases the amount of oxygen available to organisms in the water, potentially suffocating them.

Impact #3: Warm water increases the metabolism of toxins in aquatic animals.

Impact #4: Algae and weeds thrive in warmer waters.

Toxins

Toxic substances such as pesticides, herbicides, oils, gas, grease, and metals often enter waterways unnoticed via stormwater runoff. These types of toxins are perhaps the most threatening of all the watershed pollutants because of their potential to affect human and aquatic health. It is highly probably that at any given moment, somewhere in the watershed there is a leaking automobile radiator, a landowner applying herbicides or pesticides to their lawns, or someone spilling gasoline while filling up their car. Every time it rains, these toxic pollutants are washed from the roads, parking lots, driveways, and lawns into the nearest storm drain or road ditch, eventually reaching nearby lakes and streams. Each winter, hundreds of tons of road salt and sand are spread over area roadways; in the spring, it can get washed into the nearest waterway. Additionally, farms, businesses, and homes throughout the watershed are potential sites of groundwater contamination from improperly disposed and stored pesticides, solvents, oils, and chemicals.

The Pere Marquette River Watershed Assessment identifies the open leaking underground storage tanks that were in operation as of 1999 and believed to be leaking in the watershed; most of these are in the Walkerville, Baldwin, Scottville and Ludington areas (Table 39 in The Pere Marquette River Assessment 1999 and Figure 34). The Assessment also identified sites of environmental contamination as of 1999, and these too are primarily located in the Baldwin, Scottville and Ludington areas (Table 40 in The Pere Marquette River Assessment 1999 and Figure 34).

Significant pollution from toxic substances in the Pere Marquette River Watershed likely come from stormwater and urban runoff containing oils, grease, gasoline, and solids. Urban areas with high amounts of impervious surfaces such as those found in Ludington, Baldwin and Scottville all contribute toxic substances to the watershed during storm events when water runs off streets, parking lots, and roofs, and enters storm drains leading to the Pere Marquette River and its tributaries.

There is also widespread atmospheric mercury deposition into Michigan's surface waters. The organic form of mercury, methylmercury, is a highly bioaccumulative toxic pollutant that is hazardous to wildlife and human health. Elemental mercury is converted to the organic form through natural processes, particularly in inland lakes. This has caused elevated mercury concentrations in inland lake sediments (Evans et al. 1991) and fish tissues (Day 1997) throughout the state. As a result, there is a statewide, mercury-based fish consumption advisory that is applied to all of Michigan's inland lakes (MDNR 1997). In May 2003, MDEQ conducted a sediment survey of the Pere Marquette Lake and River Mouth to determine if there were local sources of PCBs that could be contributing to elevated PCB tissue levels of the fish population within the Pere Marquette system. It was found that no PCBs aroclors were detected above the reporting limit for any of the 14 sediment samples collected in Pere Marquette Lake or the river site at the Ludington Waste Water Treatment Plant outfall. Petroleum compounds were found in the shallow sediments near the community boat ramp in Copeyon Park in Ludington at levels requiring further investigation. The report includes additional analysis of metals and solids in surficial and lower sediment layers at the sampling locations (MDEQ Staff Report, Taft 2004).

Typical Impacts from Toxins

Impact #1: Toxic chemicals entering water bodies harm stream life, potentially causing entire reaches of a stream to be killed off if the concentrations of contaminants are high enough.

Impact #2: Persistent toxic pollution in a stream may put human health and recreation at risk.

Impact #3: Contaminated groundwater may pose a problem for homes and businesses throughout the watershed that rely upon groundwater wells for their drinking water. This poses a risk to human health and often requires difficult and costly cleanup measures.

Changes to Hydrologic Flow

Excessive hydrologic flow in a watershed system can cause a variety of problems in the stream and surrounding lowlands and uplands. The term hydrologic flow encompasses all the factors affecting the stream flow and discharge in a watershed. The most notable and significant alteration in stream flow is caused by urban, agricultural and storm water runoff. Stream channel shape, meander pattern, base flow, and storm flow characteristics are largely determined by watershed runoff characteristics. Hydroelectric facilities, dams, lake-level control structures, excessive sedimentation, and channelization by road culverts are additional sources of fluctuations in hydrologic flow. Surges of water from dams and lake-level control structures may cause peak stream flows to increase, leading to unstable bottom substrates, flooding and sedimentation that destroys aquatic habitats and causes property damage (while also changing stream hydrology further).

Loss of wetlands contributes to changes in hydrologic flow. Wetlands absorb runoff from upland areas, and dissipate the energy of high water flows. Wetlands filter out sediment, nutrients and chemicals from runoff before it enters the stream and groundwater. In addition, wetlands are a haven for a variety of wildlife and plant species, enriching the overall habitat diversity of a watershed. Wetland loss in the watershed is estimated at 19%, according to a

"Status and Trends" Analysis by MDEQ utilizing 2005 National Wetland Inventory data (Table 34). Data of presettlement conditions (82,253 total acres of wetland) compared to 2005 conditions (66,558 acres) show an estimated 19% loss (15,695 acres) of wetlands in the PM Watershed. Loss of wetlands in the Pere Marquette Watershed is highest in the Big South subwatershed, where agricultural use is the highest and some tributaries have been straightened and routed into ditches. Through assessing and combining wetland, land cover, soil types and presettlement land cover maps, MDEQ determined areas of potential wetland restoration and illustrated these in Figure xyz. Most of the areas fall into the Big South watershed, Weldon Creek that drains into the mainstem, and McDuffee Creek in the Little South Branch watershed.

TABLE 34: LOSS OF WETLANDS IN THE PERE MARQUETTE RIVER WATERSHED

Subwatershed	Presettlement Wetland Condition - total acres	2005 Wetland Condition - total acres	Total Acreage Loss	Remaining Original Wetland Acreage	Loss of Wetland Resource
Baldwin River	9,948	9,150	798	92%	8%
Middle Branch	3,631	3,159	472	87%	13%
Little South	9,423	8,411	1,012	89%	11%
Big South	41,555	30,735	10,820	74%	26%
Mainstem	17,696	15,103	2,593	85%	15%
Entire Watershed	82,253	66,558	15,695	81%	19%

*These statistics exclude open water type wetlands.

Data obtained from *"Pere Marquette Watershed - Preliminary Status and Trends Presettlement to 2005" MDEQ.*

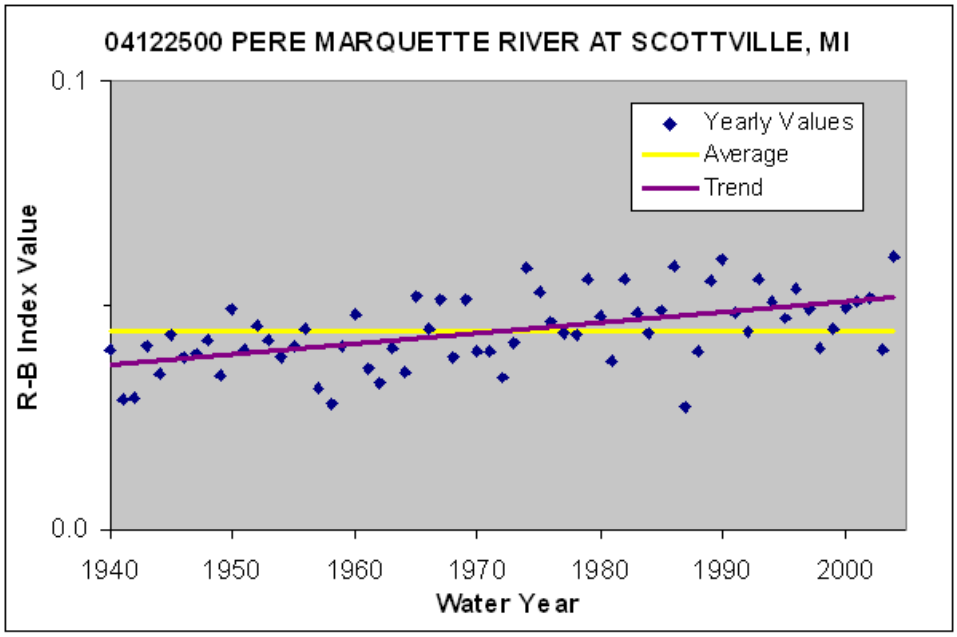
County drains also play a role in altering hydrologic flow in the headwaters of the Big South Branch, headwaters of the Little South Branch, and several smaller tributaries (Weldon Creek included) in the Scottville area. All of these areas have a significant amount of agricultural land that utilize streams as drainage areas. Some of the stream reaches have been straightened and likely have more extreme flow discharge and velocities as a result.

Changes in hydrologic flow may also be affected by the amount of groundwater recharge in the watershed. As more and more development paves over forests and fills wetlands, valuable recharge areas are cut off, and stream base flows may eventually be affected. Freshwater ecosystems, such as the Pere Marquette River Watershed, have specific requirements in terms of the quantity, quality, and seasonality of their water supplies. In order for the system to be sustainable, it must fluctuate within a range of natural variation. If the quantity of the water flow through a system is disrupted, long-term sustainability within the system will be lost.

Another indicator of changes in hydrologic flow are changes in stream flashiness, the stream flow response to storms. Streams that rise and fall quickly are considered flashier than those that maintain a steadier flow. An increase in flashiness, often due to changing land use, is a common cause of stream channel instability where the width, depth, sinuousity, and slope of the stream are subject to change through erosion. In a recent MDEQ study regarding flashiness trends at U.S. Geological Survey gage sites on Michigan streams, stream flow data from 1940 to

2004 at the gage station (#4122500) in Scottville was analyzed and showed that the Pere Marquette River stream flow trend was becoming more flashy (Table 35). This trend is for the gage only (located on the mainstem), thus the trends of flashy flows upstream in the subwatersheds are unknown at this time (Fongers, Manning, Rathbun, 2007).

TABLE 35: MDEQ TREND ANALYSIS OF SCOTTVILLE GAGE STATION



Typical Impacts from Changes to Hydrologic Flow

Impact #1: Deviations in storm flow caused by increased runoff from paved surfaces or channeled flow through culverts often causes erosion of the stream channel, which leads to sedimentation problems.

Impact #2: In some stream reaches, storm surges can spill over banks causing localized flooding, causing hazardous conditions and widespread economic damage.

Impact #3: Severe fluctuations in stream flow may disrupt aquatic habitat and strand aquatic organisms, while also interfering with recreational uses of the river.

Impact #4: Tributaries utilized as county drains can cause the streams and the waterways they are connected to, to become incised which can result in loss of vegetation in the riparian corridor, bank erosion, and increased turbidity.

Pathogens

Pathogens are organisms that cause disease and include a variety of bacteria, viruses, protozoa and small worms. These pathogens can be present in water and may pose a hazard to human health. The US EPA recommends that freshwater recreational water quality be measured by the abundance of *Escherichia coli* (*E. coli*) or by a group of bacteria called Enterococci. Michigan has adopted the EPA's *E. coli* water quality standards. *E. coli* is a common intestinal

organism, so the presence of *E. coli* in water indicates that fecal pollution has occurred. However, the kinds of *E. coli* measured in recreational water do not generally cause disease; rather, they are an indicator for the potential presence of other disease causing pathogens. EPA studies indicate that when the numbers of *E. coli* in fresh water exceed water quality standards, swimmers are at increased risk of developing gastroenteritis (stomach upsets) from pathogens carried in fecal pollutions. The presence of *E. coli* in water does indicate what kinds of pathogens may be present, if any. If more than 130 *E. coli* are present in 100 milliliters (mL) of water in five samples over 30 days, or if more than 300 *E. coli* per 100 mL of water are present in a single sample, the water is considered unsafe for swimming. Fecal pollution entering the Pere Marquette River Watershed may come from urban stormwater runoff, inadequately treated waste water, agricultural runoff, illegal sewage discharge from boats, or from animals on the land or in the water. Different sources of fecal pollution may carry different pathogens. Peak *E. coli* concentrations often occur during high flow periods when floodwater is washing away possible contaminants along the streambank such as waste from ducks and geese.

Currently, none of the county health departments in the watershed test surface waters in the Pere Marquette Watershed for *E. coli*. Each year the amount of swimming beaches in the state closing due to high *E. coli* levels increases.

Based on water chemistry and macroinvertebrate sampling conducted by the Michigan MDEQ, water quality in the Pere Marquette mainstem is meeting the established water quality standards for a coldwater stream. The data indicate that the mainstem system has high quality waters in almost all locations (MDEQ 2002). Water quality parameters meet the criteria for total body contact, recreation, and aquatic life. The river has mildly alkaline hard water. It has adequate mineral and nutrients for aquatic life, yet no indication of enrichment due to organic loading. This is consistent with Northern Ecological Service's (1999) finding that "Water quality parameters reported for the Pere Marquette River system suggest water quality is unimpaired."

Another source of possible *E. coli* contamination is from improperly functioning septic systems within the Pere Marquette River Watershed. Due to the unknown nature of groundwater flow in some watershed areas and the relatively random location of septic systems, it is very difficult to accurately assess their impact to the watershed. Failing septic systems are a suspected source of contamination for parts of the Pere Marquette River Watershed; much of the watershed is rural and residences are mainly supported by septic systems as opposed to municipal wastewater treatment systems.

Typical Impacts from Pathogens

Impact: High levels of potential pathogens in the water pose a threat to human health and can reduce the recreational value of lakes and streams.

Invasive Species

Invasive species (also called exotic or non-native species) have threatened the Great Lakes ever since Europeans settled in the region. Exotic species are organisms that are introduced into areas where they are not native. While many exotic species are introduced accidentally, others are intentionally released, often to enhance recreational opportunities such as

sport fishing. The Pacific salmon, which was purposely stocked in the Great Lakes, is an exotic species, but they are not a "nuisance" species. Species are considered a nuisance when they disrupt native species populations and threaten the ecology of an ecosystem as well as causing damage to local industry and commerce. Without pressure from the competitors, parasites, and pathogens that normally keep their numbers in check, invasive species, may undergo large population increases.

Since the 1800s, more than 140 exotic aquatic organisms of all types, including plants, fish, algae, and mollusks have become established in the Great Lakes. As human activity has increased in the Great Lakes watershed, the rate of introduction of invasive species has increased as well. More than one-third of the current invasive species have been introduced in the past 30 years, a surge coinciding with the opening of the St. Lawrence Seaway. Once introduced, invasive species must be managed and controlled as they are virtually impossible to eradicate (GLIN 2001). While many non-native species have no serious ecological impact, the introduction of a single key species, such as the sea lamprey, can cause a sudden and dramatic shift in the entire ecosystem's structure. New species can significantly change the interactions between existing species, creating ecosystems that are unstable and unpredictable.

The Pere Marquette Watershed is plagued by a multitude of exotic invasive species. Some of the exotic aquatic animal species found in Pere Marquette Lake include the round goby (*Neogobius melanostomus*), zebra mussel (*Dreissena polymorpha*), and quagga mussel (*Dreissena rostriformis bugensis*). All of these species were introduced via the discharge of ballast water from transoceanic ships. The round goby is an aggressive, voracious bottom feeder that out-competes other fish species for food and habitat. Zebra and quagga mussels are extremely efficient water filterers, able to consume large amounts of phytoplankton and other suspended particulates that provide food for zooplankton and other bottom-dwelling organisms, thus altering the aquatic food web. All of these species are exceptionally prolific, with gobies spawning repeatedly in the summer months, zebra mussels colonizing any hard object in the water, and quagga mussels able to thrive directly on a muddy or sandy bottom.

The most recognized exotic invasive species in the Pere Marquette River and many of its tributaries is the sea lamprey (*Petromyzon marinus*). Adult sea lamprey are parasitic on fish in the Great Lakes, attacking with their sucking mouth, and sucking out blood and other body fluids. They swim out of the Great Lakes upstream into tributaries to spawn and then die. Up to 80,000 eggs per female are deposited in nests built in riffles having gravel substrate that is approximately 1.5 to 2.0 inches in diameter, a size that can be manipulated with their mouth. After hatching, larval sea lamprey (ammocoetes) drift downstream to soft-bottom areas of pools and eddies where they live for three to four years as filter feeders. They then transform into a parasitic adult and migrate out to the Great Lakes where they feed on fish for about a year before returning to spawn and die. An adult sea lamprey consumes the equivalent of 40 pounds of fish during its adult life, and the Pere Marquette River has the potential to produce an estimated 500,000 larval sea lamprey annually (Pere Marquette Watershed Assessment 1999). The US Fish and Wildlife Service has attempted to prevent sea lamprey from entering the PM with an electrical weir in Custer. The weir has unfortunately proven to not be as effective as hoped. The US Fish and Wildlife Service has still had to resort to periodic treatments of the lampricide TFM. A single TFM treatment of the watershed has been known to cost upwards of $500,000.

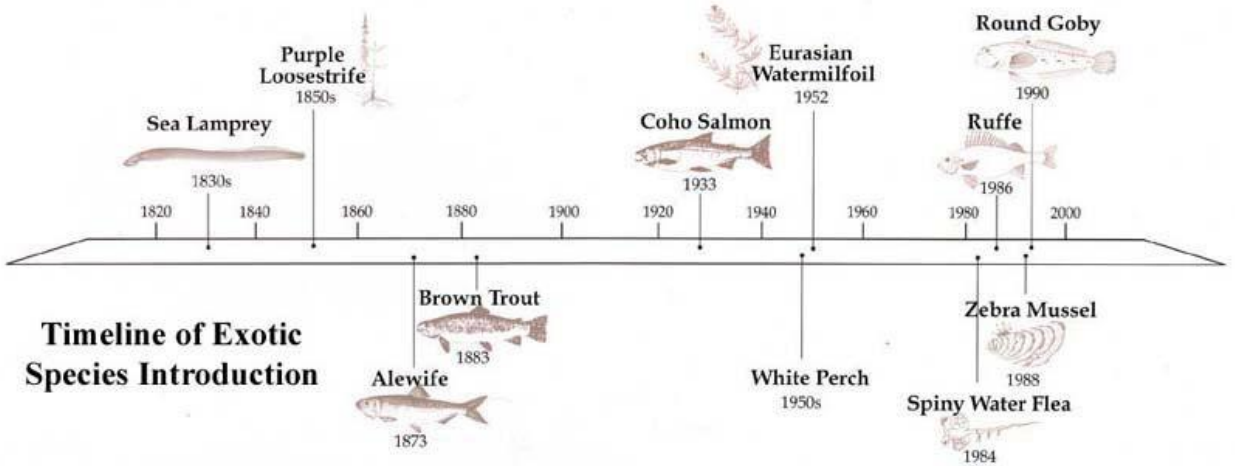
Currently the weir is not in operation and the US Fish and Wildlife Service is assessing its next steps in managing for sea lamprey in the watershed.

Invasive Plant Species

The Pere Marquette Watershed is also home to exotic invasive plants, such as eurasian watermilfoil (*Myriophyllum spicatum*), purple loosestrife (*Lythrum salicaria*), spotted knapweed (*Centaurea maculosa*), and phragmites (*Phragmites australis - invasive*). All of these plants are able to quickly establish themselves and can displace native plants. Environmental and economic problems caused by these plants include impairment of water-based recreation, impairments to navigation and flood control systems, degradation of water quality and fish and wildlife habitat, and accelerated filling of lakes and waterways. Control methods, especially for phragmites, are costly, utilize chemicals and need to be done repeatedly in order to effectively get rid of the problem plants.

The USFS maintains a non-native invasive species list (NNIS) (Table 36) for the Huron-Manistee National Forest, of which the Pere Marquette flows through. As of early 2011, the USFS had recently performed active NNIS treatment of leafy spurge, crown vetch, and Japanese barberry along the Pere Marquette River and observed, but not attempted to treat, spotted knapweed, St. Johnswort, and Phalaris (reed canary grass).

Below is a timeline listing the introduction of some major invasive species into the Great Lakes.



Typical Impacts from Invasive Species

Impact #1: Invasive species often have no natural predators and can out-compete native species for food and habitat.

Impact #2: Introduction of a single key species can cause a sudden and dramatic shift in the entire ecosystem's structure. New species can significantly change the interactions between existing species, creating ecosystems that are unstable and unpredictable.

Impact #3: In some instances invasive species can interfere with recreation in the watershed. For example, rows of zebra mussel shells washed up on shore can cut canoeists' feet, and eurasian watermilfoil can get tangled up in boat propellers.

TABLE 36: HURON-MANISTEE NATIONAL FOREST NON-NATIVE INVASIVE PLANTS LIST 1-1-2010		
Common Name	**Species**	**Forest Rank**
Norway maple	*Acer platanoides*	3
Tree-of-heaven	*Ailanthus altissima*	1
Garlic mustard	*Alliaria petiolata*	2
Wild garlic	*Allium vineale*	5
Greater burdock	*Arctium lappa*	2
Common burdock	*Arctium minus*	4
Yellow rocket (S)	*Barbarea vulgaris*	4
Common barberry	*Berberis vulgaris*	2
Japanese barberry	*Berberis thunbergii*	2
Hoary alyssum (S)	*Berteroa incana*	4
Indian mustard (S)	*Brassica juncea*	5
Black mustard (S)	*Brassica nigra*	5
Smooth brome	*Bromus inermis*	4
Flowering rush	*Butomus umbellatus*	1
Siberian peashrub	*Caragana arborescens*	1
Musk thistle	*Carduus nutans*	1
Asian bittersweet	*Celastrus orbiculatus*	2
Spreading star thistle	*Centaurea diffusa*	5
Spotted knapweed	*Centaurea maculosa/ stoebe*	4
Russian thistle	*Centaurea repens/Acroptilon repens*	5
Canada thistle (S)	*Cirsium arvense*	4
Marsh thistle	*Cirsium palustre*	1
Bull thistle	*Cirsium vulgare*	4
Field bindweed (S)	*Convolvulus arvensis*	5
Purple crown vetch	*Coronilla varia /Securigera varia*	2
Flax dodder (S)	*Cuscuta epilinum*	5
Clover dodder (S)	*Cuscuta epithymum*	5
Black swallow-wort	*Cynanchum louiseae*	1
Pale swallow-wort	*Cynanchum rossicum*	1
Houndstongue	*Cynoglossum officinale*	5
Orchard grass	*Dactylis glomerata*	4
Queen Anne's Lace (S)	*Daucus carota*	4
Chinese yam	*Dioscorea oppositifolia*	5
Common teasel	*Dipsacus fullonum*	1
Cut-leaved teasel	*Dipsacus laciniatus*	1
Autumn olive	*Elaeagnus umbellata*	4
Burningbush	*Euonymus alatus*	2
Cypress spurge	*Euphorbia cyparissias*	5
Leafy spurge	*Euphorbia esula*	3
Smooth buckthorn	*Frangula alnus*	1
Baby's breath	*Gypsophila paniculata*	1
Giant hogweed	*Heracleum mantegazzianum*	1
Dame's rocket	*Hesperis matronalis*	1

TABLE 36: HURON-MANISTEE NATIONAL FOREST NON-NATIVE INVASIVE PLANTS LIST 1-1-2010		
Common Name	**Species**	**Forest Rank**
Japanese hops	*Humulus japonicus*	1
Common St. John's-wort	*Hypericum perforatum*	4
Lathco flatpea	*Lathyrus sylvestris*	5
Lyme grass	*Leymus arenarius*	2
Border privet	*Ligustrum obtusifolium*	2
Amur honeysuckle	*Lonicera maackii*	2
Morrow's honeysuckle	*Lonicera morrowii*	2
Tatarian honeysuckle	*Lonicera tatarica*	2
Whitebell honeysuckle	*Lonicera x bella*	2
Purple loosestrife	*Lythrum salicaria*	3
White sweet clover	*Melilotus alba*	4
Yellow sweet clover	*Melilotus officinalis*	4
Japanese stilt grass	*Microstegium vimineum*	1
Eurasian watermilfoil	*Myriophyllum spicatum*	4
Wild parsnip	*Pastinaca sativa*	1
Reed canary grass	*Phalaris arundinacea*	4
Common reed	*Phragmites australis*	3
Scotch pine	*Pinus sylvestris*	4
Japanese knotweed	*Polygonum cuspidatum*	1
Mile-a-minute weed	*Polygonum perfoliatum*	1
White poplar	*Populus alba*	3
Lombardy poplar	*Populus nigra*	3
Curly pondweed	*Potamogeton crispus*	4
Common buckthorn	*Rhamnus cathartica*	1
Bristly locust	*Robinia hispida*	5
Black locust	*Robinia pseudoacacia*	5
Multiflora rose	*Rosa multiflora*	2
Perennial sow thistle (S)	*Sonchus arvensis (uliginosus)*	5
Lilac	*Syringa vulgaris*	3
Saltcedar	*Tamarix ramosissima*	1
Common tansy	*Tanacetum vulgare*	5
Erect hedgeparsley	*Torilis japonica*	5
Periwinkle	*Vinca minor*	4
1=Not on forests yet; eradicate new occurrences immediately upon discovery *2=Eradicate wherever found* *3=Control source populations, eradicate outliers* *4=Prevent invasion of last areas not invaded, eradicate in high priority areas* *5=Status on forest uncertain, control/eradication site specific* *S = State of Michigan Noxious Weed*		

Lack of Riparian Buffer

Riparian buffers are widely considered one of the best ways to control and reduce the amount of non-point source pollution entering a water body. Also called vegetated stream buffers, filter strips, or greenbelts, these buffers consist of strips of trees, shrubs, and other vegetation lining a stream corridor or lakefront. These linear strips of vegetation serve as a

stream's last line of defense against human activities such as agriculture, grazing, and urban development. Riparian buffers help to reduce the impact of almost all of the pollutants that currently threaten the Pere Marquette Watershed: sediment, nutrients, toxins, thermal pollution, pathogens, changes to hydrology, and loss of habitat. A field assessment of riparian buffer status in the watershed on the mainstem and tributaries is absent at this time. In reviewing aerial maps and land use information, the lack of riparian buffers on a watershed level is minor compared to more developed and urbanized watersheds. Riparian buffers are lacking in some agricultural areas where crops and pastures are adjacent to streams, and in moderately developed areas where houses and lawns are near the water's edge.

Benefits of riparian buffers:

Stabilization of Streambanks – The deep rooted vegetation binds the soil along streambanks, that prevents bank erosion during periods of high runoff.

Improved Water Quality – Trees, shrubs, and grasses along streams remove sediment, nutrients, pesticides, pathogens, and other potential pollutants before they enter surface water. Fertilizers and other pollutants that originate on the land are taken up by tree roots and stored in leaves, limbs and roots of the vegetation instead of reaching the stream. Studies have shown dramatic reductions of 30% to 98% in nutrients (nitrogen and phosphorus), sediment, pesticides, and other pollutants in surface and groundwater after passing through a riparian forest buffer (Chesapeake Bay Program website: www.chesapeakebay.net).

Reduced Flooding and Sedimentation – Trees and shrubs help to retain runoff longer, improve infiltration, and filter out sediment that might otherwise be delivered downstream during floods.

Reduction of Thermal Pollution (Stream Warming) – The canopy provided by the leaves of the vegetation provide shading to the stream, which moderates water temperatures and protects against rapid fluctuations that can harm stream health and reduce fish spawning and survival. Cool stream temperatures maintained by riparian vegetation are essential to the health of aquatic species. Elevated temperatures also accelerate algae growth and reduce the amount of dissolved oxygen the water can hold, further degrading water quality. In a small stream, temperatures may rise 1.5 degrees in just 100 feet of exposure without a leaf canopy. The leaf canopy also improves air quality by filtering dust from wind erosion, construction or farm machinery.

Enhanced Wildlife Habitat – The trees and shrubs contained in a riparian buffer supply a tremendous diversity of habitat and travel corridors for many wildlife species in both the aquatic and upland areas. Travel corridors are particularly important where habitat is limited. In addition, woody debris (fallen trees and limbs) in the stream provides both habitat and cover for fish and other macroinvertebrate species. Leaves that fall into a stream are trapped on woody debris and

rocks where they provide food and habitat for small bottom-dwelling creatures (i.e. crustaceans, amphibians, insects and small fish), which are critical to the aquatic food chain.
Improved Scenery (Desired Uses) – Strips of trees and shrubs along streams add diversity and beauty to the landscape.

Riparian buffers vary in character, effectiveness, and size based on the environmental setting, proposed management, level of protection desired and landowner objectives. To protect water quality, a buffer at least 55 to 100 feet wide should be preserved or created around all bodies of water and wetlands, with strip widths increasing with increasing slope. Research shows that when the buffer is less than 100 feet, stream quality begins to diminish (MDEQ 2001).

Most riparian buffers are composed of three zones, the width of each determined by site conditions and landowner objectives. This three-zone concept provides a conceptual framework in which water quality, habitat, and landowner objectives can be accomplished. The picture and accompanying text on the next page describes the components of each zone.

Streamside areas lacking a riparian buffer have a reduced filtering capacity and do not effectively filter out watershed pollutants. While the lack of a riparian buffer along a stream or lakefront does not add any pollutants to the watershed and is technically not a source of pollution, the lack of a buffer significantly increases the possibility of pollutants reaching a body of water. The actual sources of the pollution are coming from another place and the buffer only reduces their effects on the watershed. Therefore, for the purposes of this protection plan, the lack of a riparian buffer (and streamside canopy) is referred to as sources of pollution and environmental stress in the watershed, with the general understanding that increases in the amounts of riparian buffers will decrease the amount of various pollutants entering the watershed.

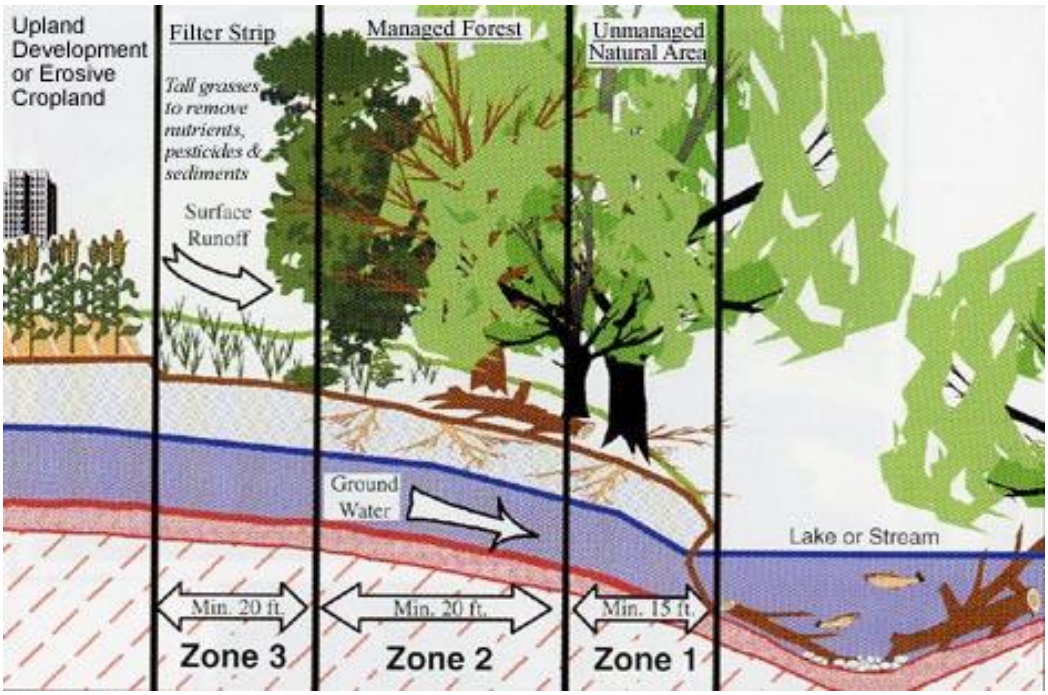


Illustration provided by the Lake and Stream Corridor Owners' Guide for Riparian Buffer Establishment, Southeast Michigan Resource Conservation and Development Council.

Zone Description from the MDEQ's Guidebook of BMPs for Michigan Watersheds and the USDA – NRCS website (www.mi.nrcs.usda.gov):

Zone 1 – The Streamside Zone: This zone is usually made up of mature trees and shrubs that provide shade, leaf litter, and woody debris to the stream, as well as erosion protections. The minimum width of this zone is 15 to 25 feet. Land uses in this zone should be limited to footpaths and well-designed watercourse crossings (for utilities, roads, etc.). The mature forest along the edge of the water maintains habitat, food, and water temperature and helps to stabilize streambanks, reduce flood impact, and remove nutrients.

Zone 2 – The Middle Zone: This zone extends from the outer edge of the streamside zone and protects the stream's ecosystem by providing a larger protective area between the stream and upland development. Ideally, this zone will also be composed of mature trees and shrubs and will be between 20 to 50 feet, with widths increasing to ensure the 100-year floodplain. A primary function of Zone 2 is to filter runoff by removing sediment, nutrients and other pollutants from surface and groundwater.

Zone 3 – The Outer Zone: The outer zone extends from Zone 2 to the nearest permanent structure and is composed of grass and other herbaceous cover. This is the main filtering part of the riparian buffer strip. The vegetation included in this zone is useful in spreading and filtering runoff that may be transporting sediment, nutrients, or pesticides.

5.5 Brownfields and Contamination Sites

If a pending Environmental Protection Brownfield grant proposal is awarded, West Michigan Shoreline Regional Development Commission will be working with community leaders throughout the region, and within the Pere Marquette watershed to identify priority brownfield sites for cleanup and redevelopment. Contamination sites from leaking underground storage tanks in the watershed are identified in Figure 37.

5.6 Dams

There are 32 dams inventoried by the MDEQ in the Pere Marquette River Watershed (Table 37). All of the dams are located on tributaries to the mainstem, with the exception of the Ludington Pump Storage Facility. A number of dams are owned by fishing and hunting clubs, and almost all of them are comprised of earthen berms in private ownership. The challenge with dams is that they completely alter stream morphology. The following are potential negative impacts from dams:

- Standing water in the impoundments behind dams can artificially warm stream water and contribute to thermal pollution.
- Dams are a barrier to the passage of fish and other aquatic life, thus, separating populations of fish, insects and wildlife from upstream and downstream reaches.
- Dams are a barrier to the natural movement of woody debris and substrate, thus causing the excess accumulation of these materials in the impoundment and at the same time depriving downstream reaches of the stream of these naturally occurring materials.

- Earthen berms are prone to seeping, failures, and erosion in response to high water events and time. Dams comprised of earthen berms in poor condition can contribute sediment to the stream during high water events.

Maintenance can be a costly and time consuming requirement for dam owners. The CRA worked with US Fish and Wildlife Service, the landowner and the PMWC in 2009 to remove a small dam on the east branch of Tank Creek because the earthen berm and stand pipe were inadequate. A couple other dams in the watershed have been discussed for possible removal in the coming years. Dam removal can be a challenging process and often involves juggling nearby stream issues, funding sources, and a variety of partner concerns and wishes.

Tank Creek East Branch Dam Removal

Before

After

TABLE 37: DAMS IN THE PERE MARQUETTE WATERSHED (as listed by the MDEQ)										
Dam Name	**Dam ID #**	**Stream**	**County**	**Township**	**Section**	**Owner**	**Type**	**Purpose**	**Head**	**Pond Area**
Little South Branch										
Grass Lake Pond Dam	2493	Pease Creek	Newaygo	Home	12	Grass Lake Hunting Club	Earth	F		40
Pease Creek Dam	406	Pease Creek	Newaygo	Home	12	Grass Lake Hunting Club	Earth	R	13	16
Middle Branch										
Horvath Dam	2093	Tributary to Middle Branch	Lake	Chase	18	Stefan & Maria Horvath	Earth	R	0	4
Lake Connamara Dam	445	Baker Creek	Lake	Yates	32	Alyce Roodvoets	Earth	R	15	19
Baldwin River										
Baldwin Trout Farm Dam	627	Baldwin River	Lake	Pleasant Plains	3	David Stevenson	CN	S	6	1
Zerbis Dam	1419	Tributary to Baldwin River	Lake	Cherry Valley	3	George Zerbis	Earth	R	2	1
Bray Lake Dam	1406	Bray Creek	Lake	Webber	26	Frank Caporale	Earth	R	3	18
Sanborn Creek Dam	1417	Sanborn Creek	Lake	Pinora	20	John Seys	Earth PG	R	5	3
Big Springs Dam	1405	North Branch Cole Creek	Lake	Cherry Valley	15	Dorothy Topping	PG	R	2	1
Venner Dam	2095	North Branch Cole Creek	Lake	Cherry Valley	15	Dorothy Topping	PG	R	2	5
Big South Branch										
Michigan Creek Dam	312	Michigan Creek	Newaygo	Merrill	16	Leonard Kurelo	Earth	R	6	25
Henkin Pond Dam	1759	Tributary to Freeman Creek	Newaygo	Troy	31	Denise Pagura	Earth	R	12	4
Foster Lake Dam	668	Tributary to Big South Branch	Oceana	Elbridge	1	Turkey City Partnership	Earth	R	13	99
Cossette Dam	1407	Carr Creek	Lake	Lake	18	Robert Cossette	Earth	R	7	1
Cossette Dam	1408	Carr Creek	Lake	Lake	17	Paula Barnett		P	8	2
Cossette Dam	1409	Carr Creek	Lake	Lake	17	Paula Barnett	Earth	P	7	3
Mohler Trout Ranch Dam	1415	Carr Creek	Lake	Lake	18	Roger Jones	Earth	R	30	15
Seawright Dam #1	2097	Tributary to Carr Creek	Lake	Lake	7	Robert Ruff			4	1
Seawright Dam #1	2098	Tributary to Carr Creek	Lake	Lake	7	Robert Ruff	Earth	P	4	1
LaPoint Dam	1413	Tributary to Carr Creek	Lake	Lake	7	Ed LaPointe	Earth	I	12	3
LaPoint Farms #2	2100	Tributary to Carr Creek	Lake	Lake	8	LaPointe Farms	Earth	P	4	4
Locke Dam	2099	Tributary to Carr Creek	Lake	Lake	18	Walter Locke	Earth	P	5	1
Rader Dam	2096	Tributary to Carr Creek	Lake	Lake	5	Richard Rader	Earth	R	15	4
Mainstem										
Danaher Lake Dam	573	Danaher Creek	Lake	Pleasant Plains	18	PM Rod & Gun Club	Earth PG	R	20	15
Kinney Creek Dam	1411	Kinney Creek	Lake	Sweetwater	34	Kinney Creek Club	Earth	R	5	2
USFS Dam	2094	Tank Creek	Lake	Sweetwater	20	USDA-FS	Earth	O	6	2
Brookside Cemetery Dam	529	Tributary to Mainstem	Mason	Amber	14	Village of Scottville	Earth	O	5	14
Hall Dam	1539	Tributary to Mainstem	Mason	Branch	22	Rowland Hall et.al.	Earth		4	1
West Riverton Cemetery	1540	Tributary to Mainstem	Mason	Pere Marquette	5	West Riverton Cemetery	Earth		0	2
Romeo & Juliet Lakes Dam	2168	Weldon Creek	Mason	Branch	9	Esther Mier	Earth	R	3	25
Nickelson Pond Dam	2112	Nickelson Pond Outlet	Mason	Amber	7	William Nickelson	Earth PG	R	10	1
Not affecting Pere Marquette flow										
Ludington Pumped Storage Plant	180	None	Mason	Pere Marquette	2	Consumers Energy & Detroit Edison	Earth	H	110	1870

5.7 Local Master Plans and Zoning Ordinances

While not a direct source of pollution, local governments' master plans and zoning ordinances can directly affect water quality. Master plans are long-range documents that help set out a community's vision for guiding growth and development. They can include information about the community's population, demographics, economy, housing, transportation, community facilities, and natural resources. They are based on public input that can be obtained through surveys, public meetings, or other means. Master plans do not regulate land use; zoning ordinances do regulate land use. Zoning ordinances are enacted to avoid land use conflicts and overcrowding, and ensure the public's safety, health, and welfare. They define permitted uses, design standards such as lot size and setbacks, and establish zoning districts among other topics.

There is no requirement that townships or municipalities must adopt a zoning ordinance. However, Michigan state law requires that any zoning ordinance to be based on a plan, so communities that have zoning ordinances must also have a master plan.

Some counties within the watershed have zoning. If a township within those counties chooses to follow county zoning, then the county is responsible for enforcement. If it chooses not to follow county zoning, it can choose to adopt its own zoning ordinance or to remain an unzoned community. In all cases, state land use laws apply in all communities.

The effectiveness of zoning depends on many factors, particularly the strength and clarity of the language, the consistency of enforcement, and public support. In general, zoning helps create predictability for existing and future residents and businesses. It helps a community protect the natural resources and aspects of the community that it decides are important and, in so doing, define its character.

How communities manage their land uses has a direct impact on the community's water resources. Since water quality is directly related to what happens on the land, zoning can be an extremely important watershed management tool. For example, zoning to protect water quality can include limiting the amount of hard surfaces, requiring vegetative buffer zones along bodies of water, protecting wetlands, and requiring the storm water management measures that address water quality.

Regulatory methods are not the only way to protect water resources. Educating landowners about BMPs to protect water quality, installing sample projects on public lands, and creating incentives for good stewardship are all non-regulatory means to support and complement master plans and zoning ordinance provisions. Local governments play an important role in setting the example for residents by installing storm water management approaches that address water quality at government offices or protecting natural vegetation in a riparian buffer on public lands next to rivers, lakes and streams and directing public access to portions of the areas designed for heavier use in this sensitive zone.

This review of master plans and zoning ordinances was completed through a partnership between the CRA and the Watershed Center Grand Traverse Bay. The CRA forwarded to the Watershed Center Grand Traverse Bay the master plans and zoning ordinances it had collected

for review as of January 2011. Not all master plans and zoning ordinances of jurisdictions within the watershed were reviewed because there was no response from some jurisdictions to the document request or the responses were not provided in time to be included in the review.

For the purposes of this review, the watershed includes four counties (Lake, Mason, Newaygo and Oceana), two cities (Ludington and Scottville), three villages (Baldwin, Custer, and Walkerville), and 34 townships, for a total of 43 local governments. Of the local governments that responded to document requests, 13 master plans were provided and 18 zoning ordinances. Nine townships within Mason County have elected to be governed by Mason County's master plan and zoning ordinance, so the review covers 22 jurisdictions in terms of master planning and 24 jurisdictions in terms of zoning. The documents were reviewed on a watershed-wide scale to determine types of protection given to water quality and natural resources (Table 38).

TABLE 38: PERE MARQUETTE WATERSHED MASTER PLANS									
Location	**Maintaining /promoting community character**	**Land use limitations based on environ-mental constraint**	**Protect riparian zone/ Pere Marquette River**	**Protecting wetlands**	**Preserving and protecting streams, surface water, groundwater**	**Soil erosion**	**Storm water measures**	**Protecting dunes/hills /slopes**	**Protecting forests/agri-culture open space**
Lake Township	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Newkirk Township	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Pleasant Plains Twp	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Mason County	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pere Marquette	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City of Ludington	Yes	No	No	No	Yes	No	Yes	No	Yes
Newaygo County	No	Yes	Yes	Yes	Yes	No	No	No	Yes
Barton Township	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Beaver Township	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes
Monroe Township	Yes	No	Yes	No	Yes	No	No	No	No
Oceana County	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Crystal Township	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes
Elbridge Township	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes
Newfield Township	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Greater Ludington Area	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes

Master Plans

Each master plan was reviewed according to nine topics identified by the CRA and the watershed protection plan steering committee. The topics included:

- Maintaining and/or Promoting Community Character
- Limiting Land Use Based on Environmental Constraints
- Protection of the Riparian Zone/ Pere Marquette River
- Protection of Wetlands
- Preservation and Protection of Streams, Surface Waters, Groundwater
- Protection Against Soil Erosion
- Implementation of Stormwater Measures
- Protection of Dunes/Hills/Steep Slopes
- Protection of Forests/Agriculture/Open Space

All of the master plans addressed community character, most often referring to maintaining rural character or protecting natural features as important to community character. All but two master plans addressed growth management or the need to limit land uses because of negative impacts to natural resources, most often referring to limitations related to the use of septic systems because of poorly drained soils. Almost all of the master plans mentioned the need to protect the Pere Marquette River or riparian areas and the need to protect wetlands. All of the master plans addressed the need to preserve and protect streams, surface water, and groundwater, though few included specifics about how to achieve that goal.

Few of the master plans addressed the need to address soil erosion, storm water management, or protecting dunes and steep slopes. It is important to note, though, that the four counties within the watershed implement the State Soil Erosion and Sedimentation Control Act. Likewise, state law addresses management of critical dune areas and any of the dune ecosystems in the region are more directly associated with the Lake Michigan shoreline, which is largely outside of the Pere Marquette River Watershed.

All of the master plans included the need to protect farmland, forests, and/or open space, though few included specifics about to accomplish these protections. One exception is the Mason County Comprehensive Plan Update which outlines multiple strategies for preserving farmland, forest land and open space.

Several of the master plans mentioned the Pere Marquette River Natural River Plan and its management provisions. The language used to address the designation varies within jurisdictions, ranging from simply mentioning it to outlining protection standards. Four of the jurisdictions within the Pere Marquette River Watershed did not specifically mention the river or the natural river plan in their master plans.

The Mason County Comprehensive Plan Update includes several strong goals and objectives to protect natural resources and manage growth, such as creation of a green space system, site plan review procedures and standards for environmental protection, limiting development on land with significant environmental limitations, minimizing incompatibility between residential uses and large farm production facilities, and ensuring careful consideration

of appropriate waste water management. Samples of language from Mason County and other master plans are included in Appendix A.

The natural resources of this area are why many people continue to live in and choose to move to the watershed. The language in the master plans for local governments throughout the Pere Marquette River watershed indicates that most communities value these natural resources and want to protect them.

Zoning Ordinances

Each zoning ordinance was reviewed according to twelve topics chosen by the CRA and the steering committee, including:

- Zoning District for Environmentally Sensitive Areas
- Permit Requirement for Environmentally Sensitive Areas
- Regulation of Riparian Zone/Pere Marquette River
- Special Requirements for Wetlands
- Regulations to Protect Streams, Surface Waters, Groundwater
- Regulations to Prevent Soil Erosion
- Storm Water Management Requirements
- Sewer/Water Regulations
- Open Space Provisions
- Regulation of Impervious Surfaces
- Farmland Preservation Provisions
- Livestock Management Provisions

These are all important tools for protecting water quality in the Pere Marquette River watershed. Some of the local zoning ordinances include a special district for environmentally sensitive areas, such as critical dune districts and greenbelt districts. Some communities require permits for activities in environmentally sensitive areas. About half of the local ordinances include protections of riparian zones generally or the Pere Marquette River specifically. Some of these provisions are simply building setbacks, others protect native vegetation in the riparian zone. Few of the ordinances included protections for wetlands. Most of the local ordinances that addressed wetlands required that they be identified in the site plan review process.

A few ordinances include specific protections for streams, surface water bodies, or groundwater. Most of these provisions involve setbacks for more industrial uses and special requirements to protect groundwater from hazardous substances, such as car fluids at oil change facilities, and soaps and pollutants from car washes. Many ordinances include requirements in their site plan review ordinances regarding controlling soil erosion, and some also address storm water management in site plan review. All of the ordinances require either approved septic systems or connection to a public waste water treatment system for buildings and residences.

Few of the ordinances include open space protection provisions or planned unit development provisions that include protection of open space. The local ordinances that do include protection of open space do not necessarily encourage protection of natural vegetation in open spaces. Some of the ordinances include limits on lot coverage, and a few include parking

lot and private road provisions that may limit the amount of impervious surfaces in the community. The remaining ordinances include parking lot provisions but they do not appear to be designed to reduce or limit the amount of parking lot area.

Most of the ordinances include an agricultural district, but only a few include provisions other than standard language about lot size and permitted uses. Some of the ordinances include provisions addressing potential impacts from livestock management practices on surface water and groundwater by requiring setbacks or special land use review for larger operations.

In general, most communities within the Pere Marquette River Watershed could implement stronger zoning protections for water resources so as to improve the connection between the goals expressed in their master plans and the protections provided in their zoning ordinances. Many of the communities within the watershed have not been extensively developed. These communities have an opportunity to review existing zoning ordinances to decide what kind of development and growth they want in their area and what kind of protection they want for water resources before these assets become degraded.

The areas in need of the greatest attention are wetland protection, vegetated riparian buffers, protection of natural vegetation in open spaces, reduction of impervious cover (in terms of lot coverage, parking lot size and width of private roads), and livestock management practices. For example, federal and state regulations of wetlands address those wetlands that are five acres or greater, but they do not protect smaller wetlands unless they are connected to the Great Lakes. Adopting a wetland setback or buffer requirement would help protect these valuable resources. Likewise, requiring a buffer of natural vegetation along all water bodies, particularly between livestock management areas and surface water bodies, would have important water quality benefits for the Pere Marquette River (Table 39).

TABLE 39: SUMMARY OF ORDINANCE CHARACTERISTICS FOR THE PERE MARQUETTE RIVER WATERSHED												
Location-Zoning Ord.	**Special district environment-ally sensitive areas**	**Permits for environment-ally sensitive areas or uses**	**Riparian zones, Pere Marquette River**	**Special requirements for wetland areas**	**Protect streams, surface water, ground-water**	**Soil erosion**	**Storm water provisions**	**Sewer, water provisions**	**Open space**	**Mgmt. of impervious surfaces**	**Provisions to protect agri-culture**	**Livestock mgmt practices provisions**
Lake Twp	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sauble Twp	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes
Sweetwater Twp	Yes	Yes	Yes	No	No	No	No	No	No	Yes	No	No
Webber Twp	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yates	Yes	No	No	No	No	No	Yes	Yes	No	Yes	No	No
Mason County	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Pere Marquette	Yes	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Yes	Yes
City of Ludington	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No	No
Barton Twp	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Beaver Twp	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Home Twp	Yes	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes
Merrill Twp	Yes	No	Yes	No	No	No	Yes	Yes	No	Yes	No	Yes
Monroe Twp	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	No
Troy Twp	Yes	No	Yes	No	Yes	Yes	No	Yes	No	Yes	No	No
Crystal Twp	No	No	No	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes
Elbridge Twp	No	No	Yes	No	No	No	No	Yes	No	No	No	No
Newfield Twp	No	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No
Pleasant Plains Twp	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Pere Marquette River Natural River Plan

In 1978, the MDNR adopted the Pere Marquette River Natural River Plan and the river was designated a Wild-Scenic River by the Michigan Natural Resources Commission. The plan is designed to protect the river's natural qualities for present and future generations. It addresses land use management decisions within 400 feet on each side of 66.4 miles of the mainstem of the river and 140 miles of designated tributaries in 18 different jurisdictions. The natural river designation requires review of projects under specific ordinance provisions required to protect the river administered by the MDNR through the State Natural River Zoning Administrator. Beaver and Home Townships in Newaygo County administer the natural river plan provisions through their local zoning ordinances.

The area covered by the plan includes all lands within 400 feet of the water on either side of a river or creek. Construction and other development activities within 400 feet of the water require a zoning permit before work begins. If the proposed construction does not meet the zoning standards, a variance must be obtained before a zoning permit can be issued.

In general, the ordinance provisions protect a vegetated riparian buffer along the river's edge of 75 feet on the mainstem and 50 feet on tributaries on private lands, and 150 feet on publicly owned land. The ordinance requires setbacks of buildings and septic systems 150 feet from the ordinary high water mark on the mainstem and 100 feet on tributaries. It restricts future subdivisions of land with river frontage to require 200 feet on the mainstem and 150 feet on the tributaries. It limits the size of docks on the river to no more than 4 feet by 20 feet, with no more than 4 feet extending into the river.

Soil Erosion and Storm Water Ordinances

Local governments can adopt other ordinances in addition to zoning ordinances that impact land use management. These ordinances may stem from specific state laws or from a specific area of concern within the jurisdiction that falls within the government's police powers. Even if a municipality does not have a master plan or zoning, it may still have other ordinances that impact protection of natural resources.

Michigan's Soil Erosion and Sedimentation Control Act requires that counties either adopt their own soil erosion ordinance or follow the state rules as develop by the MDEQ. Villages and townships do not have the option to "opt out" of county soil erosion ordinances as they do for county zoning, though they can become a municipal enforcing agency with its own ordinance and enforcement responsibilities. Because one of the most significant threats to water quality is sedimentation, these ordinances are extremely valuable tools in protecting water quality.

Within the Pere Marquette River Watershed, Mason County and Oceana County have adopted their own soil erosion ordinances that are administered by their drain commissioners. These ordinances work in conjunction with the MDEQ's Part 91 Administrative Rules. The Lake County Building Department and Newaygo County Drain Commissioner administer soil erosion permits according to the MDEQ rules. The road commissions in each county have been approved as soil erosion agencies by the MDEQ, which means that they have had specific procedures for erosion control approved for the various road projects they might pursue.

Most ordinances developed under the state statute address only storm water volume and not storm water quality. In other words, the ordinance requires measures to help control the amount of storm water generated during certain kinds of storm events. The measures are not required to remove any fertilizers or other pollutants before the storm water enters the groundwater, a surface water body or a storm drain system. *E. coli* problems in small urban settings provide an example of how this problem can play out. In some cases, the source of the *E. coli* counts is storm water entering a water body. Storm water entering the water body has been properly managed under the ordinance but it causes water quality problems. Newaygo County does require additional measures to address storm water management, including water quality volume and stream protection.

Storm Water Management

One of the best ways for local governments in the Pere Marquette River Watershed to address water quality protection is to consider how they are managing storm water in their communities. In this context, protecting water quality is directly related to reducing impervious surfaces and protecting natural areas and natural vegetation. In general, the more a local government can do to reduce impervious surfaces and increase the retention or restoration of native vegetation in riparian areas and in open spaces, the better for water quality. Sediments and sand smother the habitat that aquatic organisms need to survive and reproduce. The sediments and sand enter our surface waters through storm water that washes from roads, parking lots, and driveways carrying sediments and sand, as well as nutrients and other forms of pollution along with it.

The large majority of paved areas within a community are roads or parking lots. Most road design is significantly influenced by the county road commissions and local fire departments. Local governments can address the design of private roads. Limiting parking space numbers and space size can also reduce the total amount of paved areas. These savings may seem insignificant on a particular site, but across the community, the reductions in paved area could be substantial. For example, the reduction of parking spaces from 10 feet by 20 feet to 9 feet by 18 feet results in a 20 percent savings in impervious surface. Local governments can also limit paved surfaces by setting a maximum area for a parking lot.

Lot design and general development provisions in zoning ordinances provide great opportunities to encourage alternatives to and reductions of impervious surfaces, such as shared driveways. Ordinances also can be crafted to address the overall development design to benefit water quality, such as providing incentives to protect natural vegetation throughout the development site. Many communities include these goals in planned unit development, open space and cluster ordinance provisions.

Protecting natural features throughout the watershed helps to trap sediments and treat storm water by using nutrients in the storm water to grow. Native vegetation in riparian areas also helps prevent erosion and protect wildlife habitat. In addition, the soils on sites that have not been cleared or graded remain capable of infiltrating larger amounts of storm water.

Storm Water Management on Farms

Agriculture remains an important part of many communities in the Pere Marquette River Watershed. These farms include field crops and livestock operations, as well as many smaller farms where a variety of farming activities occur. Management of storm water on farms involves special consideration, both because of its potential impact on water quality and because of the structure in place to address regulation of agricultural practices.

Michigan's Right to Farm Act, passed in 1981, provides that farms that follow generally accepted agricultural management practices (GAAMPs) cannot be found to be public or private nuisances. It also sets up a system for management of complaints about agricultural practices to be addressed through the Michigan Department of Agriculture (MDA). The department reviews the complaint, including a site visit within seven days of receiving the complaint. Any findings that might involve violations of natural resource protection statutes must be forwarded to the MDEQ. Results of the review are shared with the local government. If the farm operation is not in conformance with adopted GAAMPs, then it must come into conformance or provide a plan as to how it will come into conformance. Finally, local ordinances cannot conflict with an adopted GAAMP.

The MDA has a Manure Management GAAMP, dated February 2011, which addresses issues ranging from runoff management to odor control. The GAAMP states that runoff control is required if runoff leaves the parcel or if it adversely impacts surface water or groundwater. Runoff can be stored on site in properly designed structures or directed to a vegetated area designed for the purpose of absorbing this kind of runoff. Livestock is to be kept out of streams except at designated crossings. No manure is to be applied to fields within 150 feet of surface waters. Vegetative buffers are a desirable conservation practice between manure application areas and surface waters. Runoff from pasture feeding and watering areas should travel through a vegetated filter area. The GAAMP states that farm operations should have manure and nutrient management plans in place.

Local governments within the Pere Marquette River Watershed should work with farmers to identify areas of concern in terms of impacts to surface water and groundwater, and develop strategies to address these concerns that are consistent with the Right to Farm Act and any GAAMPs adopted by the MDA.

Opportunity for Action

Local officials play a crucial role when deciding which land use planning techniques are the most appropriate to modify current zoning in their community. In addition, the MDEQ has published a book titled *Filling the Gaps: Environmental Protection Options for Local Governments* that equips local officials with important information to consider when making local land use plans, adopting new environmentally focused regulations, or reviewing proposed development (Ardizone, Wyckoff, and MCMP 2003). An overview of Federal, State, and local roles in environmental protection is provided, as well as information regarding current environmental laws and regulations including wetlands, soil erosion, inland lakes and streams, natural rivers, floodplains, and more. The book also outlines regulatory options for better natural resources and environmental protection at the local level. A copy of this guidebook is available

via the MDEQ website: www.michigan.gov/deq → Water → Surface Water → Nonpoint Source Pollution (look under Information/Education heading).

Assisting local governments in updating and enacting strong zoning ordinances to protect water quality and secure natural areas is extremely important in the Pere Marquette River Watershed and is a high priority for implementation efforts. While Michigan has laws to protect clean water, much more can be done at the local level because counties, townships, cities and villages know their land resources better and may value them as local assets in a way that the state regulatory structure does not recognize. Master plans and zoning ordinances provide an opportunity for local governments to define their communities, the role that natural resources play in defining the community, and how those natural resources should be protected for the benefit of the community (Table 40).

TABLE 40: LAND USE PLANNING TECHNIQUES

Land Use Planning Technique	Description	Utility as a Watershed Protection Tool
Watershed-Based Zoning	Watershed and subwatershed boundaries are in the foundation for land use planning.	Can be used to protect receiving water quality on the subwatershed scale by relocating development out of particular subwatersheds.
Overlay Zoning	Superimposes additional regulations for specific development criteria within specific mapped districts.	Can require development restrictions or allow alternative site design techniques in specific areas.
Impervious Overlay Zoning	Specific overlay zoning that limits total impervious cover within mapped districts.	Can be used to protect receiving water quality at both the subwatershed and site level.
Floating Zones	Applies a special zoning district without identifying the exact location until land owner specifically requests the zone.	May be used to obtain proffers or other watershed protective measures that accompany specific land uses within the district.
Incentive Zoning	Applies bonuses or incentives to encourage creation of amenities or environmental protection.	Can be used to encourage development within a particular subwatershed or to obtain open space in exchange for a density bonus at the site level.
Performance Zoning	Specifies a performance requirement that accompanies a zoning district.	Can be used to require additional levels of performance within a subwatershed or at the site level.
Urban Growth Boundaries	Establishes a dividing line that defines where a growth limit is to occur and where agricultural or rural land is to be preserved.	Can be used in conjunction with natural watershed or subwatershed boundaries to protect specific water bodies.
Large Lot Zoning	Zones land at very low densities.	May be used to decrease impervious cover at the site or subwatershed level, but may have an adverse impact on regional or watershed imperviousness.
Infill/ Community Redevelopment	Encourage new development and redevelopment within existing developed areas.	May be used in conjunction with watershed based zoning or other zoning tools to restrict development in sensitive areas and foster development in areas with existing infrastructure.
Transfer of Development Rights (TDRs)	Transfers potential development from a designated "sending area" to a designated "receiving area".	May be used in conjunction with watershed based zoning to restrict development in sensitive areas and encourage development in areas capable of accommodating increase densities.

CHAPTER 6 WATERSHED GOALS AND OBJECTIVES

Goals and Objectives

GOAL #1

Protect and improve the water quality, and fish and wildlife habitat of the Pere Marquette River and its tributaries, connected lakes and wetlands.

1. Eliminate excessive sediment delivery in the mainstream and tributaries.
2. Reduce excessive sediment already in the stream and tributaries.
3. Reduce excessive nutrient inputs from residential and agricultural areas.
4. Enhance and maintain in-stream fish cover, woody debris.
5. Promote communication and efforts to stop groundwater contamination in the Pere Marquette Watershed.
6. Remain updated on storm water discharge permits in the Pere Marquette River watershed with the MDEQ.
7. Identify and quantify stormwater effects in municipalities in the Pere Marquette River Watershed.
8. Work with dam owners to remove dams and restore free flowing streams on a voluntary basis.
9. Promote water quality monitoring efforts where deemed necessary in the watershed.

GOAL #2

Improve and maintain the road and railroad transportation system throughout the Pere Marquette Watershed.

1. Redesign and reconstruct crossings that contribute excessive sediment delivery to the mainstem and tributaries.
2. Redesign and reconstruct crossings that pose as fish passage barriers on the river and tributaries.

GOAL #3

Promote sound agricultural and livestock practices throughout the Pere Marquette River Watershed.

1. Promote BMPs for implementation of pesticide and nutrient management for all agricultural producers in addition to livestock waste management for livestock producers.
2. Promote establishment of vegetation buffers along waterways and wetlands, and limit livestock access to these waterways and wetlands.
3. Promote the restoration of previously drained wetlands in farmed areas.
4. Incorporate conservation tillage practices to help in residue management and reduce peak run-off.
5. Promote erosion control practices which impact surface water quality.

GOAL #4

Promote and maintain the natural ecosystem of the Pere Marquette River Watershed.

1. Promote the planting of native plant species in the riparian corridor.
2. Manage against and eradicate nuisance, non-native species in the riparian corridor.
3. Track general population fluctuations, locations, and impacts of species that are non-native and a nuisance.
4. Manage for desirable fish and wildlife species in the watershed.
5. Track general population fluctuations and locations of aquatic species that are desirable in the watershed.
6. Promote mature forest cover and ideal upland habitat types in the riparian zones as appropriate.
7. Support the Natural Rivers zoning of the Pere Marquette River.
8. Promote proper management of wetlands in the watershed.
9. Promote land protection efforts in critical and priority areas in the watershed.

GOAL #5

Promote sound stewardship of the Pere Marquette River land and water resources through education and outreach.

1. To raise community awareness and knowledge about the Pere Marquette River, its tributaries, and the rest of the watershed, including the interconnectedness of the system and the role that an individual's day-to-day activities can play in protecting the resource.
2. Expand the "watershed literacy" of the Pere Marquette River Watershed stakeholders.
3. To develop a set of consistent messages that can be used by partners in a variety of communications.
4. To involve citizens, public agencies, user groups and landowners in the implementation of the watershed management plan.
5. To regularly inform stakeholders about the watershed, implementation activities and successes and opportunities to participate.

GOAL #6

Balance recreation management in the Pere Marquette River Watershed by collaborating between the different user groups, land and access ownerships, permit systems, and resulting impacts on the natural resources.

1. Update various management plans and practices for the Pere Marquette River with attention to recreation management.
2. Reduce erosion and sedimentation at access sites and trails along the Pere Marquette River and its tributaries that are aggravated by heavy use.

GOAL #7

Maintain and expand the Pere Marquette River Restoration Committee as the primary vehicle of restoration work in the watershed.

1. Maintain the operation of the Pere Marquette Watershed Council.
2. Maintain the Restoration Committee and cooperation between project partners.
3. Continue to fundraise for the Pere Marquette River for project and maintenance needs.

CHAPTER 7 IMPLEMENTATION TASKS

7.1 Summary of Implementation Tasks

In an effort to successfully accomplish the goals and objectives listed in Chapter 6, specific recommendations were developed based on the prioritization of watershed pollutants, sources, and causes while also looking at the priority and critical areas in the watershed (Figures 24 and 25). These implementation tasks are listed in Section 7.3 and represent an integrative approach, combining watershed goals and covering more than one pollutant at times, to reduce existing sources of priority pollutants and prevent future contributions. Some of these tasks will be prioritized for implementation priority and/or critical areas in the watershed (Figures 24 and 25) and that is noted alongside the "category" heading of each task. The Pere Marquette River Restoration Committee found it helpful to summarize the implementation tasks by categories. In this way, organizations may work on a specific issue (i.e., land conservation or shoreline restoration) that reduces more than one type of watershed pollutant and meets more than one watershed goal.

The categories and goal(s) they address are as follows:

Category	**Goal(s) Addressed**
1. Shoreline Protection and Restoration	1, 3, 4, 5, 6
2. Road Stream Crossings	1, 2
3. Agriculture	1, 3
4. Habitat, Fish and Wildlife	1, 4, 5
5. Stormwater	1, 5
6. Wastewater	1, 5
7. Human Health	1, 5
8. Wetlands	1, 3, 4, 5
9. Invasive Species	4, 5
10. Land Protection and Management	1, 3, 5, 6, 7
11. Development	1, 5
12. Zoning and Land Use	1, 2, 5
13. Groundwater and Hydrology	1
14. Monitoring and Research	1
15. Desired Uses	1, 6

For each action step, the organization(s) best suited to help implement the task along with estimated costs to implement each item has been identified where possible. A timeframe of 10 years was used to determine the scope of activities and the estimated costs for implementing the tasks. Tasks that should be done in the short term were given a timeframe of one to three years. Tasks that should be undertaken annually were given a timeframe of "ongoing." Funding for most short-term tasks will come from state grant sources (MDEQ: CMI, CWA Sec. 319, MiCorps), federal grant sources (US Fish and Wildlife Service, USFS, EPA, NRCS), private foundations, fundraising dollars from the PMWC, CRA, and LCWM, and volunteer time. Funding for long-term tasks will be discussed as implementation of the plan begins.

In determining tasks for the implementation plan, the Pere Marquette River Restoration Committee assessed those Best Management Practices (BMPs) that are *most* effective in reducing primary pollutants of concern (sediment, phosphorus, nutrients for example). With BMPs being primarily funded through a combination of grants (federal, state and private), NRCS programs and landowner assistance, it is imperative to select those approaches and sites where the cost benefit ratio is highest. Thus project determination becomes an exercise in weighing a variety of factors including the following:

- ✓ Site location (is it in a priority or critical area, or a different part of the watershed)
- ✓ Landowner or site owner interest (cooperation and level of financial commitment)
- ✓ BMP selection
- ✓ BMP effectiveness in reducing which pollutant and the quantity of it
- ✓ How to fund the BMP of choice (this is typically a combination of sources)
- ✓ Project partner participation

7.2 Best Management Practices

BMPs are any structural, vegetative, or managerial practices used to protect and improve surface water and groundwater (MDEQ 2001). It is important to note that 1) no BMP can be used at every site, and 2) no BMP can include so many specifications that all possible uses and all possible conditions are included. Each site must be evaluated, and specific BMPs can be selected which will perform under the site conditions. For BMPs to be effective, the correct method, installation, and maintenance need to be considered for each site. Addressing each of these factors will result in a conservation practice that can successfully prevent or reduce nonpoint source pollution.

Structural BMPs are physical systems that are constructed for pollutant removal and/or reduction. This can include rip-rap along a streambank, rock check dams along a steep roadway or detention/retention basins, oil/grit separators, and porous asphalt for storm water control.

Non-structural BMPs include managerial, educational, and vegetative practices designed to prevent or reduce pollutants from entering a watershed. These BMPs include buffers and filter strips, but also include education and public involvement programs, land use planning, natural resource protection, regulations, operation and maintenance or any other initiative that does not involve designing and building a physical structure. Although most of these non-structural BMPs are difficult to measure quantitatively in terms of overall pollutant reduction and other parameters, research demonstrates that these BMPs have a large impact on changing policy, enforcing protection standards, improving operating procedures and changing public awareness and behaviors to improve water quality and quantity in a watershed over the long term. Moreover, they target source control which has been shown to be more cost effective than end-of-the-pipe solutions (i.e. “an ounce of prevention is worth a pound of cure”). Therefore, these BMPs should not be overlooked, and in some cases, should be the emphasis of a water quality management program.

It is important to note that installing a single BMP has the potential to reduce more than one type of pollutant (and source as well). For example, installing a riparian buffer will reduce a number of different pollutants (sediment, nutrients, toxins, etc.), as well as reduce impacts from

fertilizer use and streambank erosion. Also, installing more than one BMP at a single site will increase the likelihood of pollutant reduction, but the effects will not be cumulative.

Table 41 lists potential systems of commonly used BMPs that deal with various types of pollutant sources, as well as where to find more information about each type of BMP. The table also notes if a potential load reduction estimate is available for a specific BMP. Some of this information was not obtained due to the timeframe and scope of this project, and the fact that some of this type of information is not readily available. In addition, some of the research found was not relevant because it was either conducted in a vastly different region (i.e. southern United States) or done on a much smaller scale.

TABLE 41: BMP EXAMPLES BY SOURCE				
Major Source or Cause	**Affected Pollutant**	**Potential Actions to Address Pollution Source/Cause**	**Potential Load Reduction**	**BMP Manual or Agency Contact**
Bank/Shoreline Erosion	Sediment Habitat Loss	*Streambank stabilization: bank slope reduction, rip-rap, tree revetments, vegetative plantings, bank terracing, etc.	See Table 32; varies according to site severity	-Guidebook of BMPs for Michigan Watersheds -Michigan Agricultural BMP Manual -Michigan Low Impact Development Manual -Green Infrastructure Manual
Lack of Streamside Canopy and Riparian Buffer	Sediment Nutrients Thermal Pollution	*Improving riparian buffers: reshaping banks, planting vegetation, stop mowing, etc.	See Table 42	-Guidebook of BMPs for Michigan Watersheds -Natural Resources Protection Strategy for Michigan Golf Courses -Green Infrastructure Manual -Natural Resources Protection Strategy for Michigan Golf Courses
Storm Water and Impervious Surfaces	Sediment Nutrients Toxins Pathogens Thermal Pollution Changes to Hydro Flow	*Numerous – see Table 42 *Develop storm water management plans	See Table 42	-Storm Water Management Guidebook (The Watershed Center) -Guidebook of BMPs for Michigan Watersheds -Michigan Low Impact Development Manual -Center for Watershed Protection – Storm Water Center Website -Green Infrastructure Manual
Road Crossings - eroding, failing, outdated	Sediment Nutrients Changes to Hydro Flow	*Road Crossing BMPs (vary widely – see Road Stream Crossings in Table 45, Category #2)	Varies (see milestones in Table 45, category 2)	-Guidebook of BMPs for Michigan Watersheds -Michigan Low Impact Development Manual -Green Infrastructure Manual
Residential/Commercial Fertilizer Use	Nutrients	*Education on proper use of fertilizers including: workshops, brochures, flyers, videos, etc.	Not available (see Riparian Buffer)	-Public Information and Education Strategy
Reduction of Wetlands	Sediment Nutrients Changes to Hydro Flow	*Restoration of wetlands – reshaping banks, planting vegetation, altering flow *Track/intervene in wetland permit cases as appropriate	See Table 42	-Guidebook of BMPs for Michigan Watersheds -Center for Watershed Protection
Septic Systems (Leaking)	Nutrients Pathogens	*Conduct education on proper septic system maintenance including: workshops, brochures, flyers, videos, etc. *Inspections *Ensure proper septic system design *Demo projects for alternative waste water treatment systems	Varies/not available	-Public Information and Education Strategy -Health Departments

TABLE 41: BMP EXAMPLES BY SOURCE				
Major Source or Cause	**Affected Pollutant**	**Potential Actions to Address Pollution Source/Cause**	**Potential Load Reduction**	**BMP Manual or Agency Contact**
Development and Construction	Sediment Habitat Loss	*Initiatives to promote open space and land preservation and protection *Encourage 'watershed friendly design' *Implement soil erosion control measures *Utilize proper construction BMPs like barriers, staging and scheduling, access roads, and grading)	Varies/not available	-Guidebook of BMPs for Michigan Watersheds -Public Information and Education Strategy -Michigan Low Impact Development Manual -Green Infrastructure Manual
Erosion stemming from human access problems	Sediment	*Installation of barriers, signs, stairs, boardwalks to accommodate and/or prevent human access	Not available	-Guidebook of BMPs for Michigan Watersheds
Marinas and Gas Stations	Toxins	*Distribution of spill containment kits	Not available	-MDEQ,MDNR
Dams	Thermal Pollution Changes to Hydro Flow Sediment	*Dam removal *Cold water outlet installation *Changes to management	Not available	-MDNR -USGS
Purposeful or Accidental Introduction of Invasive Species	Invasive Species	*Boat washing stations *Workshops, brochures, flyers, videos, etc. *Educational programs	Not available	-Public Information and Education Strategy
Reduction of Groundwater Recharge	Changes to Hydro Flow	*Infiltration basins *Grassed waterways *Plug abandoned wells properly *Groundwater/wellhead protection programs	Not available	-Guidebook of BMPs for Michigan Watersheds -Storm Water Management Guidebook
Green Infrastructure Manual: www.newdesignsforgrowth.com - NDFG Programs *Michigan Low Impact Development Manual - www.semcog.org/lowimpactdevelopmentreference.aspx* *Natural Resources Protection Strategy for Michigan Golf Courses - www.michigan.gov/documents/deq/ess-nps-golf-course-manual_209682_7.pdf*				

Pollutant Reduction Calculations for Streambank and Shoreline Erosion

Erosion from streambanks and shorelines can vary widely. Calculations for estimated sediment loading from existing eroding streambanks in the Pere Marquette Watershed are reflected in Section 5.4, Table 32 (Streambank Erosion Analysis by Subwatershed). The subwatershed with the highest input of sediment from streambank erosion is the Big South Branch with 99 eroding streambank sites ranging in severity from minor to severe, collectively contributing approximately 504 tons of sediment to the stream. In general, one can calculate the sediment and nutrients saved from entering a stream by eliminating the source of erosion using the MDEQ Pollutants Controlled Manual and the Channel Erosion Equation (DEQ 1999):

Sediment Reduced (T/year) = Length (ft) x Height (ft) x LRR (ft/year) x Soil weight (T/ft^3)
LRR = Lateral Recession Rate
Soil weight: Values available in MDEQ Pollutants Controlled Manual, Exhibit 1 (MDEQ 1999)

In turn, phosphorus and nitrogen attached to soil particles will be saved from entering the stream. The following calculations may be used to estimate the amount of phosphorus and nitrogen reduced by repairing an erosion source.

Phosphorus Reduced (lbs/yr) = Sediment reduced (T/yr) x 2000 lbs/T x 0.0005 lbs P/lb of soil x correction factor

Nitrogen Reduced (lbs/yr) = Sediment reduced (T/yr) x 2000 lbs/T x 0.001 lbs N/lb of soil x correction factor
Correction factor: Soil texture correction factors available in MDEQ Pollutants Controlled Manual, Exhibit 2 (MDEQ 1999)

Pollutant Reduction Calculations for Agricultural BMPs

The NRCS of the USDA is the primary federal agency that works with private landowners to help them conserve, maintain and improve their natural resources. NRCS's conservation programs help people reduce soil erosion, enhance water supplies, improve water quality, increase wildlife habitat, and reduce damages caused by floods and other natural disasters. Public benefits include enhanced natural resources that help sustain agricultural productivity and environmental quality while supporting continued economic development, recreation, and scenic beauty.

As noted in Section 5.4, pollution from agricultural land uses, particularly croplands, is of high concern in the watershed. According to the L-THIA modeling summarized in section 5.4, it contributes the majority of both sediment and nutrient pollution to the Pere Marquette River Watershed. There are a wide variety of agricultural BMPs that can be utilized to minimize water quality impacts as part of an overall watershed approach. The Conservation Technology Information Center (housed at Purdue University), in partnership with the USDA Natural Resources Conservation Service, developed an outreach program for the agriculture community called CORE 4 (http://www.ctic.purdue.edu/Core4/). CORE 4 is a common-sense approach to improving farm profitability while addressing environmental concerns. The approach is easily adaptable to virtually any farming situation and can be fine tuned to meet unique needs. The net result is better soil, cleaner water, greater on-farm profits, and a brighter future. The four main agricultural management practices of CORE 4 are:

- Conservation Tillage - leaving crop residue (plant materials from past harvests) on the soil surface reduces runoff and soil erosion, conserves soil moisture, helps keep nutrients and pesticides on the field, and improves soil, water, and air quality.
- Crop Nutrient Management - fully managing and accounting for all nutrient inputs helps ensure nutrients are available to meet crop needs while reducing nutrient movements off fields. It also helps prevent excessive buildup in soils and helps protect air quality.
- Pest Management - varied methods for keeping insects, weeds, disease, and other pests below economically harmful levels while protecting soil, water, and air quality.
- Conservation Buffers - from simple grassed waterways to riparian areas, buffers provide an additional barrier of protection by capturing potential pollutants that might otherwise move into surface waters.

Four additional BMPs that can be considered for increased protection and benefits area:

- Irrigation Water Management - reducing nonpoint source pollution of ground and surface waters caused by irrigation systems.
- Grazing Management - minimizing the water quality impacts of grazing and browsing activities on pasture and range lands.
- Animal Feeding Operations (AFOs) Management - minimizing impacts of animal feeding operations and waste discharges through runoff controls, waste storage, waste utilization, and nutrient management.
- Erosion and Sediment Control - conserving soil and reducing the mass of sediment reaching a water body, protecting both agricultural land and water quality and habitat.

These supplemental agricultural BMPs are aimed at benefitting production while protecting the environment, and are highlighted in the EPA's guidance manual National Management Measures to Control Nonpoint Source Pollution from Agriculture (EPA 2003). This manual is a technical guidance and reference document and contains information on the best available, economically achievable means of reducing pollution of surface and ground water from agriculture. REFERENCE: Environmental Protection Agency. 2003. National Management Measures to Control Nonpoint Source Pollution from Agriculture. EPA 841-B-03-004, July 2003 (http://water.epa.gov/polwaste/nps/agriculture/agmm_index.cfm).

A useful tool to use when calculating the amount of nutrients and sediment saved from entering the stream by installing various agricultural BMP is the MDEQ's Pollutants Controlled Spreadsheet. The spreadsheet allows the user to estimate potential load reductions by utilizing agricultural BMPs like prescribed grazing, residue management (mulch or no till), conservation crop rotation, conservation cover, cover and green manure, critical area planting, stripcropping (contour and field), filter strips, and animal waste systems for feedlots.

The HIT model, described in Section 5.4, was used to estimate the potential load reduction of sediment and the cost benefit of installing two types of agricultural BMPs. The analysis was done for each of the smaller sub-watersheds in the Pere Marquette River Watershed (19 total) looking at the benefits of utilizing the following two BMPs on the worst 5% of the area: Mulch Till and No Till. Results show that using a No Till BMP plan throughout the entire watershed would result in a total of 4,763 tons of sediment prevented from eroding into waterways. Compare this to Mulch Till, which would result in 2,420 tons per year of sediment

reduced. The watersheds with the lowest BMP Cost Benefit ratio are listed at the top of the table and show sub-watersheds and types of BMPs where money will be better spent (lower price per ton of sediment reduced). Looking specifically at this, No Till again would provide a better cost benefit ratio than Mulch Till when comparing between specific sub-watersheds, even though it costs more per acre. The three sub-watersheds closest to the outlet of the Pere Marquette River have the lowest cost benefit ratio to implement the No Till BMP on their worst 5% of areas of eroding sediment (Table 42). These are the Pere Marquette (mainstem at outlet), Swan Creek, and Black Creek sub-watersheds (Table 42). Highly eroding areas in these three sub-watersheds were shown earlier in Section 3.19.

TABLE 42: COST BENEFIT ANALYSIS OF TWO TYPES OF AGRICULTURAL BMPS FOR SUB-WATERSHEDS (HIT MODEL RESULTS)										
			BMP: Mulch Till on Worst 5% of Area				BMP: No Till on Worst 5% of Area			
Name	**Acres**	**Total (tons/ year)**	**Total Reduction (tons/year)**	**Reduction %**	**BMP Cost at $10/acre**	**BMP Cost Benefit ($/ton reduced)**	**Total Reduction (tons/year)**	**Reduction %**	**BMP Cost at $14/acre**	**BMP Cost Benefit ($/ton reduced)**
Pere Marquette River (outlet)	20,168	1,740	289	17%	$10,084	$35	674	39%	$14,118	$21
Swan Creek	21,839	1,973	308	16%	$10,920	$35	718	36%	$15,287	$21
Black Creek	11,939	985	148	15%	$5,970	$40	344	35%	$8,358	$24
Beaver Creek	37,151	1,552	264	17%	$18,575	$70	617	40%	$26,006	$42
McDuffee Creek	25,798	1,129	173	15%	$12,899	$75	403	36%	$18,059	$45
Middle Branch	34,959	1,247	215	17%	$17,480	$81	501	40%	$24,472	$49
Freeman Creek-Big South Branch	22,439	693	122	18%	$11,220	$92	284	41%	$15,708	$55
Big South Branch	32,933	1,084	161	15%	$16,466	$103	375	35%	$23,053	$62
Ruby Creek-Big South Branch	21,886	548	77	14%	$10,943	$142	180	33%	$15,320	$85
Weldon Creek	32,401	652	91	14%	$16,200	$178	213	33%	$22,680	$107
Little South Branch	29,366	569	62	11%	$14,683	$237	145	25%	$20,556	$142
Winnepesaug Creek-Big South Branch	28,369	437	50	11%	$14,184	$285	116	27%	$19,858	$171
Tank Creek	21,240	427	24	6%	$10,620	$439	57	13%	$14,868	$263
Cole Creek-Baldwin River	21,935	286	25	9%	$10,968	$446	57	20%	$15,355	$268
Headwaters Little South Branch	18,536	135	13	10%	$9,268	$718	30	22%	$12,975	$431
Sanborn Creek	18,068	287	12	4%	$9,034	$766	28	10%	$12,647	$460
Cedar Creek	25,325	169	4	2%	$12,662	$3,015	10	6%	$17,727	$1,791
Baldwin River	35,724	254	4	2%	$17,862	$4,060	10	4%	$25,007	$2,452
Danaher Creek	23,221	259	0	0%	$11,611	$58,053	1	0%	$16,255	$32,510
TOTALS	**483,297**	**14,425**	**2,042**		**$241,649**		**4,763**		**$338,308**	

Pollutant Reduction Estimates for Land Conservation Practices

In order to maintain the high quality resources of the Pere Marquette River Watershed, it is essential to address known sources of pollution while at the same time working towards the reduction of future sources of pollution and watershed disturbance. Protecting critical areas in the Pere Marquette River Watershed through conservation easements or the purchase or donation of land are excellent strategies to meet this objective. The LCWM is a local land conservancy using these strategies to protect high quality land in the Pere Marquette River Watershed.

Land conservation BMPs are excellent ways to preserve water quality. When dealing with pollutant reduction from these specific BMPs, the determined quantities are the amount of pollution prevented from entering the watershed by keeping the land in its natural state. The load reduction is essentially the difference between the loading from the current land use and the loading from future land use.

Conservation Easement Establishment Load Pollutant Reduction (lbs/year) = $L_{developed} - L_{existing}$

L = Annual Load (lbs)

To determine the annual load for each type of land use the following equation may be used:

Annual Load (lbs) = 0.226 * R * C * A

0.226 = Conversion Factor; R = Annual runoff (inches); C = Pollutant Concentration (mg/L); A = Area (acres)

Annual runoff (R) is calculated by:

Annual runoff (inches) = $P * P_j * Rv$

P = annual rainfall (in); P_j = fraction of annual rainfall events that produce runoff (usually 0.9)

R_v = runoff coefficienct ($R_v = 0.05 + 0.9 * la$ [where la = impervious surface fraction])

In most cases the actual pollutant concentrations on portions of land are not known, in that case it is possible to use estimated/average pollutant loads for differing land uses from other sources like those listed in Table 43.

TABLE 43: AVERAGE POLLUTANT LOADS BY LAND USE (LBS/ACRE/YEAR)

	Total Suspended Solids	Total Nitrogen	Total Phosphorus
Commercial	1,040	18	1.2
Industrial	1,080	12	1.3
Institutional	790	6.5	0.8
Transportation	1,330	7.7	1.1
Multi-Family	1,050	8.6	1.1
Residential	154	3.1	0.4
Agriculture	153	2.4	0.18
Vacant	40	0.5	0.09
Open Space	20	0.2	0.13

Values obtained from EPA's Region 5 Pollutant Loading Model

Over the past 10 years the LCWM has worked to permanently protect 1,710 acres in the Pere Marquette River Watershed through land conservation practices. Their goal over the next

10 years is to protect an additional 3,300 acres in the watershed. Using average pollutant loads for residential and vacant land uses in Table 43 it is estimated that the LCWM has prevented 114.57 tons of sediment, 4,959 lbs of nitrogen, and 461.7 lbs of phosphorus from entering the watershed each year. If conservation goals are reached, an additional 221.1 tons of sediment, 9,570 lbs of nitrogen and 891 lbs of phosphorus will be stopped from entering the watershed.

Understanding Conservation Easements

A conservation easement is a legal agreement between a landowner and the LCWM that permanently limits a property's uses in order to protect its conservation values. These agreements are not a new concept in property law, as similar agreements have been in force in parts of the United States since the late 1800s. However, conservation easements were a rarity in Michigan before 1990. They are not a rarity any longer, and the LCWM has permanently protected more than 7,000 acres of land since its founding in 1976.

How Conservation Easements Work

When a person owns land, they also "own" many rights associated with it. These property rights include the right to harvest timber, build structures, grow crops, and so on (subject to zoning or other land use restrictions). When the owner grants a conservation easement to a land conservancy, they permanently restrict or eliminate some of those rights and retain others. For example, a landowner may restrict the ability to develop more than one home site in the future, but retain the right to manage the forest for sustainable timber harvest according to an approved forest management plan, and maintain trails and two-track roads. Importantly, all future owners are bound by the conservation easement's terms since they are attached to the deed of the property.

Key Advantages of Conservation Easements

- *Leave the property in private ownership, and owners may continue to live on it, sell it, lease it or pass it on to heirs.*
- *They are flexible and can be written to meet the particular needs of the landowner while protecting the property's conservation values.*
- *They are permanent, remaining in force when the land changes hands.*
- *Can provide significant income, property, and estate tax benefits – often making the difference between a family being able to retain land or being forced to divide and sell because of high property and/or estate taxes.*

Conservation easements can be used to protect a wide variety of land including farms, forests, wildlife habitat, and properties with scenic views. They are drafted in a detailed legal format that spells out the rights and restrictions on the owner's uses of the property as well as the rights and responsibilities of the land conservancy.

The LCWM works with each interested landowner to determine if their land qualifies for permanent protection and helps them determine the most appropriate conservation easement terms to protect the land's conservation values. Thus, each conservation easement is a unique and personalized document. Generally, limitations are made on the number and location of structures and types of land use activities that can take place. A conservation easement can serve as a flexible tool in a family's financial planning as well. Conservation easements may cover all or just a portion of the entire property and they often allow some future construction within an approved area, if that is compatible with the easement's conservation objectives.

Conservation Easement Donations

Conservation easements customarily are donated by landowners who are motivated to protect land for its intrinsic value, and sometimes because they want future generations to enjoy the land and its wildlife as the donor has. Once a landowner has indicated an interest in conveying a conservation easement to the LCWM, a number of steps are required to complete the transaction (i.e. property tour to determine if a conservation easement is appropriate, consultation with legal and tax counsel, negotiation of restrictions to easement, draft documentation and finalize). In addition to recently expanded Federal Income tax incentives for conservation easement donations, the passage of PA 446 late in 2006 gives Michigan property owners the ability to prevent property taxes from skyrocketing when land is passed down in the family by donating a conservation easement over qualifying land before it transfers.

Sales of Conservation Easements:

Watershed protection with permanent conservation easements is a land protection option with great community benefits. While conservation easements are very rarely purchased at full market value due to limited funding, priority protection parcels can qualify for the purchase of a conservation easement when funds are available. In the recent past, the LCWM has had great success utilizing grant funds (awarded by the MDEQ) in combination with private donations to purchase conservation easements for key watershed parcels. Conservation easements are most often are purchased for less than full market value – producing what is known as a bargain sale to a charity. For tax purposes a bargain sale is treated as a "part sale/ part donation." When a conservation easement is sold at less than full market value it can combine the income producing benefit of a sale with the tax-reducing benefit of a donation. The difference between the conservation easement's value as established by an appraisal and its sale price is considered a charitable donation and can be claimed as a Federal income tax deduction as well. The charitable donation component of a bargain sales of a conservation easement is treated exactly the same as an outright gift under federal income tax rules. Additionally, land restricted by a conservation easement, whether the easement was donated or purchased, is not subject to the "pop-up tax" when it is sold or transferred.

More information on establishing conservation easements with the LCWM and the benefits associated with them can be found on their website at: www.naturenearby.org or by calling (616) 451-9476.

Pollutant Reduction Estimates for Storm Water BMPs

The biggest storm water problems in the Pere Marquette River Watershed are runoff from residential lawns, driveways, rooftops, and roads - a large portion of which do not go through a traditional storm water conveyance system with a pipe outlet. The largest urban centers in the watershed are the City of Ludington and the Village of Baldwin, which do have storm drain systems that empty to the Pere Marquette River. Maps of individual storm drains in these municipalities are available on an as requested basis.

The Center for Watershed Protection has compiled a considerable amount of information regarding the effectiveness of selected storm water BMPs. However, in total, very little information is available regarding the effectiveness of storm water BMPs. Table 38 lists the total percent removal of phosphorus, nitrogen, sediment (total suspended solids), and metals and

bacteria for selected storm water BMPs that could be used for storm water pollution particular to this watershed. Listing BMP effectiveness by percentage is a much more useful way of displaying the data rather than using specific values, which can be deceiving depending on the size of BMP implemented or installed. This is because specific values for pollutant removal depend on 1) the size of BMP implemented (feet of riparian buffer installed or acres of storm water detention ponds), and 2) how much pollution was initially coming from the source.

It should be noted that it is assumed that the percent removal values in Table 38 are comparative numbers that state how much pollutant was removed compared to no BMP implementation at the site. For example, it is assumed that Porous Pavement values state the percentage of pollutant removed compared to if regular pavement were there instead; or that Riparian Buffer values state the percentage of pollutant removed compared to if no buffer was there and it was landscaped lawn instead. For more specific information on these stormwater BMPs, please see the Center for Watershed Protection's Storm Water Center website at www.stormwatercenter.net.

Additionally, keep in mind that not every BMP may be the best selection for every site. Some places are better suited for specific kinds of BMPs. There are other factors to consider besides pollutant removal efficiency when deciding which BMP to use at a site. Other factors include the size of site, money available for implementation, and the purpose of the land (i.e., what the site will be used for). Information regarding the pollutant removal efficiency, costs, and designs of structural stormwater BMPs is constantly evolving and improving. As a result, information contained in Table 44 is dynamic and subject to change.

TABLE 44: POLLUTANT EFFECTIVENESS OF SELECTED STORM WATER BMPS FOR POTENTIAL USE IN PERE MARQUETTE RIVER WATERSHED

Management Practice	Total % Phosphorus Removal	Total % Nitrogen Removal	Total % Suspended Solids Removal	% Metal and Bacteria Removal	Other Considerations
Riparian Buffer*	Grass: 39-88 Forest: 23-42	Grass: 17-87 Forest: 85	Grass: 63-89 Forest: n/a	n/a	- Increase in property value - Public education necessary
Porous Pavement	65	82	95	Metals: 98	$2-3/ft^2 (traditional, non-porous asphalt is $0.50-1.00/ft^2)
Infiltration Basin	60-70	55-60	75	Metals: 85-90 Bacteria: 90	$2/ft^3 of storage for a ¼-acre basin - Maintenance is essential for proper function
Infiltration Trench	100	42.3	n/a	n/a	$5/ft^3 (expensive compared to other options)
Bioretention (Rain Gardens, etc.)	29	49	81	Metals: 51-71 Bacteria: 58	$6.80/ft^3 of water treated - Landscaped area anyway - Low maintenance cost

TABLE 44: POLLUTANT EFFECTIVENESS OF SELECTED STORM WATER BMPS FOR POTENTIAL USE IN PERE MARQUETTE RIVER WATERSHED					
					- Note possible export of bacteria
Grassed Filter Strip (150 feet)	40	20	84	n/a	- Cost of seed or sod
Constructed Wetlands** 1) Shallow Marsh 2) Extended Detention Wetland 3) Pond/Wetland	1) 43 +/-40 2) 39 3) 56 +/-35 4) 64	1) 26 +/-49 2) 56 3) 19 +/-29 4) 19	1) 83 +/-51 2) 69 3) 71 +/-35 4) 83	1) Metals: 36-85 Bacteria: 76 2) Metals: (-80)-63 3) Metals: 0-57	- Relatively inexpensive; $57,100 for a 1 acre-foot facility - Data for 1 and 2 based on fewer than five data points
Sediment Basins or Traps at Construction Sites	n/a	n/a	65	n/a	

**Pollutant removal efficiencies increase as buffer width increases. Grasses = native grasses (not lawn or turf grass)*
*** Wetlands are among the most effective storm water practices in terms of pollutant removal, and also offer aesthetic value. While natural wetlands can sometimes be used to treat storm water runoff that has been properly pretreated, storm water wetlands are fundamentally different from natural wetland systems. Storm water wetlands are designed specifically for the purpose of treating storm water runoff, and typically have less biodiversity than natural wetlands both in terms of plant and animal life. There are several design variations of the storm water wetland, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.*
Values obtained from Center for Watershed Protection's Storm Water Center website (www.stormwatercenter.net) and Practice of Watershed Protection Manual (Schueler and Holland 2000).

7.3 List of Implementation Tasks by Category

Categories

1. Shoreline Protection and Restoration
2. Road Stream Crossings
3. Agriculture
4. Habitat, Fish, and Wildlife
5. Storm Water
6. Waste Water and Septic
7. Human Health Issues
8. Wetlands
9. Invasive Species
10. Land Protection and Management
11. Development
12. Zoning and Land Use
13. Groundwater and Hydrology
14. Monitoring and Research
15. Desired Uses

Organization Acronyms
CD – Conservation District
CRA – Conservation Resource Alliance
CGOV – County Governments
EPA – Environmental Protection Agency
LCRC – Lake County Road Commission
LOCD – Lake Osceola Conservation District
LCRPOA – Lake County Riverside Property Owners Association
LCWM – Land Conservancy of West Michigan
LGOV – Local Governments
LIAA – Land Information Access Association
LRBO – Little River Band of Ottawa Indians
MLCD – Mason Lake Conservation District
MCRC – Mason County Road Commission
MDEQ – Michigan Department of Environmental Quality
MDNR – Michigan Department of Natural Resources
MDOT – Michigan Department of Transportation
MSU-E – Michigan State University Extension
NCD – Newaygo Conservation District
NCRC – Newaygo County Road Commission
NRCS – USDA Natural Resources Conservation Service
NWMSBF – Northwest Michigan Sustainable Business Forum
OCD – Oceana Conservation District
OCRC – Oceana County Road Commission
OWTTF – On-site Wastewater Treatment Task Force
PMRRC – Pere Marquette River Restoration Committee
PMWC – Pere Marquette Watershed Council
RR - Railroad Companies
TNC – The Nature Conservancy
TU – Trout Unlimited
USFS – United States Forest Service
USFWS – United States Fish and Wildlife Service
WMSRDC – West Michigan Shoreline Regional Development Council

Others
Lake, Newaygo, Mason and Oceana County Chamber of Commerce Offices
Local Realtors, Businesses
Solid waste management entities
Schools
Area Libraries
Fishing, Guide an d Bait Outfits
Garden Centers and Nurseries
Landscaping Companies
Architects and Engineers

Estimated Costs, Timeframe, and Milestones

For costs associated with salaries, an average watershed technician rate of $45/hour was applied. For tasks to be completed by a specialized consultant, a rate of $65/hour was used. Tasks that will be done on a yearly or site by site basis are noted as such ($/year or $/site). Appendix B lists average rates for costs associated with purchasing materials for and installing standard BMPs. Further details are noted where applicable. In general, funding for short-term tasks (one to five years) will be attained through state and/or Federal grants, other non-profit grant programs, partner organizations' budgets, fundraising efforts, and private foundations. Funding for long-term tasks will be addressed as needed. Project milestones for specific tasks were established where feasible. They are meant to guide implementation priorities and measure progress (Table 45).

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																	
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
Category 1 – Shoreline Protection (Goals addressed: 1, 3, 4, 5, 6 and these tasks span both priority and critical areas)																
1.1	Inventory riparian areas (including identifying landownership) to determine priority areas where riparian vegetated stream buffers should be installed - focus on smaller streams in the watershed (2nd order). (See Section 5.5 of protection plan for a discussion about buffers)	H 5	$20,000 (utilizing interns)	• Complete targeted creeks (Beaver, McDuffee, Weldon, Swan, Black, Freeman)		x	x	x	x	x					CRA, PMWC	1.1, 1.3, 3.2, 4.1
1.2	Work with interested landowners to install riparian buffers in priority areas.	H 10	$5,000/year	• 300 lineal feet/year	x	x	x	x	x	x	x	x	x	x	CRA, NRCS, all CDs, PMWC	1.1, 3.2, 4.1
1.3	Explore potential impacts from motorized watercraft on the mainstem.	M 3	$15,000	• Assessment of impacts		x	x	x							PMWC, PMRRC	6.2
1.4	Establish shoreline riparian buffer demonstration sites to show riparian landowners how to create buffers that are both aesthetic and effective.	M 6	$5,000/site	• Completed demonstration efforts			x	x	x	x	x	x			PMRRC, CDs, PMWC, CRA	5.2
1.5	Conduct streambank and shoreline erosion/sedimentation survey to determine sites where bank stabilization and restoration is needed. Compile list of priority areas.	H 2	$6,000 (utilizing interns)	• Complete by 2012 • Little South and Middle Branch are priorities	x	x	x								CRA, PMWC	1.1, 1.4
1.6	Stabilize moderate and severely eroding streambanks at priority sites and use biotechnical and soft stabilization methods where possible. This will include the mainstem and tributaries.	H ongoing	$20,000/ year	• 2 sites per year	x	x	x	x	x	x	x	x	x	x	PMRRC, PMWC, CRA, LOCD, MLCD, LGOV, Riparian Owners	1.1
1.7	Assess streambank sites already repaired for any maintenance needs and additional erosion problems.	M ongoing	$5,000/year	• 5 sites per year	x	x	x	x	x	x	x	x	x	x	PMRRC	1.1, 1.4

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
1.8	Install barriers, signage, or stairs where needed to manage human access to streambanks at risk of erosion (steep slopes, sandy soils) from recreational foot traffic.	M 6	$3000/year (estimated 10 sites)	• 50% by year 3 • 100% by year 6	x	x	x	x	x	x					USFS, MDNR, PMRRC	6.1, 6.2
1.9	Update local ordinances to ensure BMPs are utilized on private property along the water's edge including shoreline vegetative buffers, minimizing vegetation removal and mowing to the water's edge, and eliminating the dumping of grass clippings and other yard/solid wastes into the water.	L 4	$15,000/ ordinance	• Target 10 townships			x	x	x	x					PMRRC	1.1, 4.1, 5.2
1.10	Continue Home*A*Syst, Lake*A*Syst, and Lawn*A*Syst programs in watershed and encourage residents to utilize them.	M ongoing	$15,000/ year	• Report number residents utilizing program annually	x	x	x	x	x	x	x	x	x	x	MSU-E, CDs, NRCS, Chambers of Commerce Realtors	1.1, 5.1
1.11	Work with CDs to promote and include native trees, shrubs, and plants for riparian buffers in annual seedling sales.	H ongoing	$2,500/year	• Successful annual plant sales • Periodically review list of native shrubs, trees, plants available from each CD	x	x	x	x	x	x	x	x	x	x	CDs, NRCS, PMRRC	1.1, 4.1, 5.2
1.12	Work with area businesses and property owners to encourage proper maintenance and monitoring of underground fuel storage tanks and replace them when there is a risk of leakage from tank age, poor maintenance, or damage.	M 6	$5,500/year	• Replacement of 2 tanks per year			x	x	x	x	x	x			PMRRC, Local Businesses	1.5, 5.1
See also: Zoning and Land Use																

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
Category 2 – Road Stream Crossings (Goals addressed: 1, 2 and these tasks span both priority and critical areas)																
2.1	Redo road stream crossing inventory every 10 years, including railroad crossings. Obtain data regarding completed improvement projects. Determine if excessive erosion, fish passage issues, and potential water quality impairments exist at each site.	H 2	$35,000	• Complete by 2012	x	x									CRA, USFS, LIAA, County Road Commissions, MDEQ, MDNR, PMWC, RR	2.1, 2.2
2.2	Where priority road stream and railroad crossings have been identified, improve, repair, or replace outdated, failing, perched, or eroding road stream crossings by implementing appropriate BMPs from the following: 1. Road Crossings Remove obstructions that restrict flow through the culvert; replace undersized (too small or too short) culverts; remove and replace perched or misaligned culverts to avoid erosion and provide for fish passage; install bottomless culverts and bridges where possible; replace culverts with a length that allows for ≥ 3:1 slope on embankments; re-vegetate all disturbed or bare soils on embankments. 2. Road Approaches Create diversion outlets and spillways to direct road runoff and storm water away streams; pave steep, sandy approaches where feasible; dig or maintain ditches where needed and construct check dams if required. 3. Road Maintenance Encourage Road Commissions to look at the long-term savings of crossing improvements over cumulative maintenance costs.	H ongoing	$2.5 million	• 2 to 5 crossings completed each year between all 4 counties	x	x	x	x	x	x	x	x	x	x	CRA, USFS, all County Road Commissions, PMWC, MDEQ, MDNR, RR	2.1, 2.2
2.3	Map wind turbine farm developments with respect to streams and communicate with those companies on impacts to wildlife movement and stream crossings	H ongoing	$20,000/ year	• Completed maps • Reports of development effects on natural resources		x	x	x	x	x	x	x	x	x	PMRRC	2.3, 1.1

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
2.4	Map oil and natural gas well sites, pipelines, access roads related to fracking that cross streams, and processing facilities and disseminate to city and township planning commissions.	M 9	$20,000/ year	• Completed maps		x	x	x	x	x	x	x	x	x	PMRRC	2.3, 1.1
2.5	Work with appropriate agencies to establish minimum setback of oil and gas wells and wind turbines and their access roads from sensitive areas.	M 9	$10,000/ year	• Completed BMPs		x	x	x	x	x	x	x	x	x	PMRRC	2.3
Category 3 – Agriculture (Goals addressed: 1, 3 and these tasks will be focused in the critical areas, focusing on the Big South subwatershed first)																
3.1	Develop Conservation Plans, Resource Management Plans, or Progressive Plans for all farms in the watershed that do not currently have one. Information should be included on: crop nutrient management, weed and pest management, grassed waterways, sod centers in orchard rows, conservation buffers, proper manure management, conservation tillage, fencing off stream access to livestock, installing watercourse crossings, planting cover crops, and crop rotation. Conservation Plans more than 3 years old should be reviewed and updated to keep them eligible for USDA cost-share programs.	M ongoing	$4,000/year (NRCS staff salary portion)	• Complete plans with 4 farmers in Swan and Black Creeks (2011) • 1 plan per year	x	x	x	x	x	x	x	x	x	x	NRCS, MSU-E, all CDs	3.1, 3.2

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
3.2	Work with agricultural producers with an approved Conservation Plan to implement USDA-NRCS cost-share programs that provide cost incentives and/or rental payments to farmers who implement eligible conservation practices on their land. Examples of these types of programs include: Environmental Quality Incentives Program (EQIP), Conservation Security Program (CSP) and the Conservation Reserve Program (CRP).	M ongoing	$7,000/year	• Implement 1 plan per year	x	x	x	x	x	x	x	x	x	x	NRCS, MSU-E, all CDs	3.1, .3.2, 3.4, 3.5
3.3	Promote the restoration of previously drained wetlands in farmed areas that are no longer being farmed. 1. Inventory potential high quality restoration sites. 2. Identified landowners targeted for assistance. 3. Obtain cost-share through "Partners for Wildlife Program", CRP, WRP or other local cost-share programs to restore a number of wetlands as identified. 4. Technical assistance provided to interested landowners for wetland restorations. 5. Increased participation of producers.	M 9	$50,000/ year	• Identified prime wetland restoration sites • Number of acres with restored hydrology reported annually		x	x	x	x	x	x	x	x	x	NRCS, all CDs, USFWS, CRA, PMRRC, County Drain Commissioners	3.3
3.4	Fence livestock and other animals out of streams and wetlands and establish riparian buffers where needed in agricultural areas. Identify locations where livestock manure is entering watershed (i.e. cattle crossings) and work to remediate any existing problem. Utilize cost share opportunities if available (i.e. CRP). Weldon and Swan Creeks are known to have unfenced livestock with unrestricted access.	M ongoing, as necessary	$2.15/ft-$3.90/ft (depending on soil type, length of fence/buffer and type of crossing)	• Weldon and Swan Creeks have livestock access projects completed	x	x	x	x	x	x	x	x	x	x	NRCS, MSU-E, all CDs	1.1, 3.1, 3.5

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
3.5	Where appropriate, work with farmers to plant cover crops in fall on agricultural lands vulnerable to runoff (i.e., corn, potatoes, etc.).	M ongoing, as necessary	$5,500 (salary costs only)	• 20 acres per year	x	x	x	x	x	x	x	x	x	x	NRCS, CDs	1.1, 3.5
3.6	Focusing on top 5 sub-watersheds identified in HIT model, work with farmers to promote and implement no-till and conservation tillage practices to help in residue management and reduce peak runoff.	M ongoing	$50,000/ year (cost-share and technical assistance)	• 20 acres per year • Demonstrations/ tours with farmers utilizing no-till	x	x	x	x	x	x	x	x	x	x	NRCS, CDs	3.1, 3.2, 3.4, 3.5
3.7	Work with farmers to promote use of grassed waterways, diversions, side inlet, and grade stabilization structures that have a direct impact on reducing surface water sedimentation and nutrient inputs. Consider obtaining cost-share funding to address erosion control and provide technical assistance problems as they occur on cropland, rather than dealing with delays and limitations in the present EQIP cost-share program.	M ongoing	$50,000/ year (cost-share and technical assistance)	• 20 acres per year	x	x	x	x	x	x	x	x	x	x	NRCS, CDs	1.1, 3.1, 3.5
3.8	Minimize water contamination from farm vehicle fuel by installing and maintaining spill containment centers for above ground fueling stations where necessary and possible.	L	$5,500/ station	• 1 station installed per year	x	x	x	x	x	x	x	x	x	x	NRCS, CDs	1.5
3.9	Continue Farm*A*Syst program in watershed and encourage farmers to utilize it.	L	$35,000/ year	• Work with 2 farmers per year	x	x	x	x	x	x	x	x	x	x	MSU-E, NRCS, CDs	3.1
3.10	Conduct inventory to determine where Confined Animal Feeding Operations (CAFOs) are located (type of animal, closest water body, number of animals).	M ongoing	$15,000/ year (technical assistance)	• Develop watershed-wide inventory and update it	x	x	x	x	x	x	x	x	x	x	NRCS, MSU-E, CDEs, PMRRC	1.5

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
3.11	Explore the benefits, need for, and feasibility of developing local ordinances to ensure appropriate management of and to protect against the negative water quality impacts of CAFOs of 1,000 animal units or more and CAFO waste management.	H ongoing	$50,000	• Meetings with townships • Completed ordinances • Monitor off-site CAFO disposal of animal waste	x	x	x	x	x	x	x	x	x	x	MSU-E, NRCS, CDs, PMRRC, WMSRDC	1.5
Category 4 – Habitat, Fish, and Wildlife (Goals addressed: 1, 4, 5 and these tasks will be prioritized in the critical areas, on streams noted per task)																
4.1	Maintain current sand traps and install/operate a new trap as appropriate. Current traps includes Baldwin River sand trap.	M ongoing	$5,000/year	• Completed maintenance	x	x	x	x	x	x	x	x	x	x	CRA	1.2
4.2	Conduct inventories of aquatic habitat and bank conditions (debris, substrate, channel form, riparian corridor, erosion, etc.) throughout the watershed where needed to track trends in habitat condition. Primary targeted streams include those impacted by agriculture: Beaver, Allen, Carr, Weldon, Black, Swan, McDuffee and Freeman Creeks, and Upper Middle Branch. Update every 5 years.	M once every 5 years	$100,000 ($5,000/ stream update)	• Each stream listed is complete	x				x					x	CRA, MDEQ, MDNR, PMWC	1.1, 1.3, 1.4

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
4.3	Collect information that exists, and conduct stream inventories where needed, to evaluate appropriate sites for in-stream habitat improvement projects such as habitat platform structures, island structures, large woody debris, or log jams that will imitate natural processes, such as large wood, in form and function. Criteria to be assessed includes: woody debris, bank stability, riparian vegetation, in-stream cover, flow dynamics, channel morphology, and fish population structure.	M 5	$50,000	• Middle Branch and Little South by 2012 • All primary sub-watersheds inventoried once over 10 years	x				x				x		CRA, PMWC	1.4
4.4	Install stream habitat improvements (i.e., platform structures, large woody debris, submerged fish structures).	M ongoing	$30,000	• Install 30% of improvements by 2011 • 50% by 2015 • 90% by 2020	x	x	x	x	x	x	x	x	x	x	CRA, PMWC, MDNR, Kanouse Outdoor Restoration, USFS	1.4
4.5	Restore as necessary current large woody debris structures between Forks Bridge and Rainbow Rapids. Existing structures that have fallen into disrepair will either be repaired or removed in a manner that maintains the scenic character of the river.	H 3	$100,000	• 40 structures are inventoried and improved	x	x	x								PMWC, PMRRC, TU, MLCD, MDNR, USFS, CRA	1.4
4.6	Implement CRA's Wild-Link program to identify, protect and enhance fish and wildlife habitat on private property within ecological corridors throughout the watershed.	M ongoing	$25,000-$50,000/year	• Establish 2 Wild-Link projects by 2014 • 4 by 2015 • 8 by 2018	x	x	x	x	x	x	x	x	x	x	CRA, MDNR, CDs, LCWM	5.2
4.7	Inventory existing fish cover structures downstream of Rainbow Rapids on the mainstem to assess conditions.	M 1	$5,000	• Inventory document/ database completion			x								CRA, PMWC, USFS, MDNR	1.4

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																	
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
See also: Land Protection and Management																	
Category 5 – Storm Water (Goals addressed: 1, 2, 3, and these tasks will be focused in critical areas as noted per task)																	
5.1	Conduct impervious surface assessments in watershed. Map and count number of culverts/storm drain outlets in Ludington, Scottville, and Baldwin that drain to major rivers, lakes, and streams in the watershed.	M 5	$35,000 consultant – half-time per year	• Completed storm drain inventory			x	x	x	x	x				PMRRC	1.7
5.2	Work cooperatively with Ludington, Scottville, and Baldwin to develop storm water management plans to identify and quantify storm water effects in the watershed. The plans will emphasize Low Impact Development techniques and identify the following: • Existing storm sewer systems • Major sources of storm water • Locations for BMPs (both new and retrofits) to be installed • Identify emergency response plans exist for pollutant spills • Potential ordinances to reduce impacts of storm water.	M 5	$15,000/ plan (3 plans)	• Completed storm water plans					x	x	x	x	x		PMRRC	1.7
5.3	Conduct visual assessment of all county drains in the watershed (located primarily in agricultural areas) to look for any apparent problems affecting the watershed (i.e. erosion, hydrologic issues, lack of buffer, etc.).	M 4	$15,000/ year	• Survey write-ups per county • Look at 1 county per year			x	x	x	x					PMRRC, County Drain Commissioners	1.1

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
5.4	Work with local governments, area businesses, and property owners to install storm water BMPs where appropriate. See Section 7.2 for storm water BMP ideas and their pollutant removal effectiveness. BMPs may include: • Vegetative Filter Strips • Storm Water Filtering Systems • Infiltration Practices: Infiltration Trench/Basin, Porous Pavement • Other Low Impact Design Elements: Rain/Roof Gardens, Native Plantings, Riparian Buffers	M 5	$5,000/year (salary cost) $60,000 ($20,000/ BMP)	• 2012: identify 3 highest problem drains Installation – • 2013: have 1st drain improved • 2015: have 2nd drain improved • 2017: have 3rd drain improved					x	x	x	x	x		PMRRC, Municipalities	1.7, 5.1
5.5	Upgrade or update applicable ordinances for local governments to accommodate and encourage more innovative forms of storm water management.	M 3	$15,000/ ordinance	• Completed ordinances (up to 4 ordinances total)						x	x	x			PMRRC, Municipalities	1.7, 5.1
5.6	Track and monitor NPDES storm water discharge permits on file for watershed. Ensure proper management by permitee.	M ongoing	$5,000/year (staff time)	• Permit compliance	x	x	x	x	x	x	x	x	x	x	PMRRC	1.6
Category 6 – Waste Water and Septic (Goals addressed: 1, 2, 3, and these tasks will be focused in both priority and critical areas)																
6.1	Develop plan for evaluating, prioritizing, and addressing potential pollution from septic systems. Offer advice and assistance to riparian landowners to help identify malfunctioning septic systems.	H 3	$15,000	• Develop plan by 2015			x	x	x						Health Departments, MDEQ, LGOV	1.3, 5.1, 5.3

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
6.2	Monitor reports of cladophora to determine potential sites where there may be improperly working septic systems. Work with landowners to conduct dye testing to determine which septic systems are leaking, if any, in potential sited areas.	H ongoing	$5,000/year	• Cladophora reports at PMRRC meetings	x	x	x	x	x	x	x	x	x	x	MDEQ, Health Departments	1.3, 5.4
6.3	Select and install demonstration projects utilizing alternative on-site waste water treatment systems.	L 2	$100,000	• Successful installation of waste water treatment systems							x	x			Municipalities, PMRRC	1.3, 5.1
6.4	Work with local governments and health departments to establish mandatory septic system inspections (through ordinances or by other means) in priority areas (as requirement of a house sale for example).	M ongoing	$5,000/year	• Create and adopt county of township ordinance by 2015		x	x	x	x	x	x	x	x	x	PMRRC, Health Departments, Municipalities	1.3, 5.4
6.5	Work with health department officials who issue permits for new septic systems to ensure property owners implement proper septic system design for the site conditions and consider their proximity to water bodies prior to installation.	L ongoing	$3,500/year	• Establish an annual meeting with health departments		x	x	x	x	x	x	x	x	x	PMRRC, Health Departments	1.3, 5.4
6.6	Work with MDEQ and health department to address improper land application of septage and from pumped septic tanks or holding tanks.	L ongoing	$3,500/year	• Ongoing communications with MDEQ and health departments	x	x	x	x	x	x	x	x	x	x	PMRRC, MDEQ, Health Departments	1.3, 5.4
6.7	Evaluate the water quality merits of replacing septic systems with a community waste water conveyance and treatment system where there is a high density of old or improperly working septic systems.	L ongoing	$2,500/year	• Communications with municipalities in growing areas		x	x	x	x	x	x	x	x	x	PMRRC, Municipalities, Health Departments	1.3, 1.5

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
Category 7 – Human Health Issues (Goals addressed: 2)																
7.1	Start an *E. coli* monitoring program at up to 3 Pere Marquette River access sites.	L 5 years	$6,000/year	• Funding for program in place by 2015 • Monitor annually						x	x	x	x	x	PMRRC	
7.2	Initiate burn barrel exchange program where people can trade in their burn barrels for a discount on waste hauling and/or garbage bags, or free or discounted compost bins. Work with local authorities to develop ordinances that ban trash burning.	M ongoing	$5,000 per year	• Successful burn barrel exchange program with all 4 counties	x	x	x	x	x	x	x	x	x	x	Health Departments, Trash Haulers, LGOV, CGOV	
See also: Waste Water and Septic, Monitoring and Research																
Category 8 – Wetlands (Goals addressed: 1, 2, 3, and focus these tasks on priority areas, and mapped wetland restoration areas)																
8.1	Work with local governments, landowners, land conservancy, and other organizations to restore wetlands and establish at least one demonstration site. Help enroll eligible landowners in the NRCS Wetland Reserve Program.	M 4	$25,000	• Establish demonstration site by 2014		x	x	x	x						NRCS, CRA, all CDs, LCWM	3.3, 4.9, 5.4, 7.2
8.2	Monitor enforcement of possible wetland filling violations and educate or intervene as appropriate.	L ongoing	$25,000 ($2,500/ year)	• Annually	x	x	x	x	x	x	x	x	x	x	PMRRC	4.8
See also: Land Protection and Management, Development, Zoning and Land Use																
Category 9 – Invasive Species (Goals addressed: 1, 4 and these tasks will span the watershed)																

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
9.1	Monitor spread of aquatic and terrestrial invasive species in the watershed-includes a shoreline survey for terrestrial invasive plants, watershed-wide inventory of NNIS, and an aquatic plant and animal survey (every three years, rotating schedule).	H ongoing	$5,000/year (using interns for surveying)	• 2010, 2013, 2016, 2019: terrestrial exotics • 2011, 2014, 2017: aquatic plant species • 2012, 2015, 2018: aquatic animals • Complete watershed-wide NNIS inventory updated every 5 years	x	x	x	x	x	x	x	x	x	x	CDs, MSU-E, PMRRC, MDNR, USFS	4.2, 4.3
9.2	Develop and implement invasive species control program, targeting specific species. Primary focus on prevention of introduction. Utilization of an integrated management approach of NNIS that uses a combined biological, mechanical and chemical (herbicide) approach.	H 9	$150,000	• Ongoing program targeting phragmites, garlic mustard, other prioritized species • Develop/fund/ operate seasonal crews to assist in eradication (potentially with LCWM and TNC)		x	x	x	x	x	x	x	x	x	CDs, MSU-E, PMRRC, MDNR, USFS, LCWM, TNC, CRA	4.2, 4.3
9.3	Advocate with township zoning and master planning groups to develop ordinances that protect against the spread of invasive species.	M 5	$10,000	• Attendance of township meetings				x	x	x	x	x			PMRRC	4.2, 5.4
9.4	Promote exploration of non-TFM treatment options for sea lamprey control.	M ongoing	$10,000	• Reports from USFWS on experimental treatment options	x	x	x	x	x	x	x	x	x	x	PMWC	4.2
Category 10 – Land Protection and Management (Goals addressed: 1, 2, 3 and these tasks will focus on mapped land protection priority areas)																

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
10.1	Establish permanent conservation easements (CE) with private landowners to protect land identified in Priority and Critical Areas.	H ongoing	$1.5 million	• 10 CEs protecting an average of 50 acres each by 2012 • An additional 5 CE projects by 2015 • Complete by 2020 (2,300 acres total)	x	x	x	x	x	x	x	x	x	x	LCWM	1.1, 4.6, 4.8, 4.9, 5.1, 5.2, 5.4
10.2	Work with local units of government to develop and promote local initiatives that preserve open space and sensitive/important natural areas.	M ongoing	$125,000/ initiative	• Explore purchase or lease of park areas in municipalities (2 inititiatives)	x	x	x	x	x	x	x	x	x	x	PMRRC	1.1, 4.6, 4.8, 4.9, 5.1, 5.2, 5.4
10.3	Assist local land conservancies with protection of lands that maintain or expand wildlife corridors, protect sensitive wildlife and fisheries habitats such as wetlands, riparian corridors, etc., and protect habitat for threatened and endangered species.	M ongoing	$5,500/year	• Technical staff work with LCWM on site visits and assessments, 2 landowners per year	x	x	x	x	x	x	x	x	x	x	PMRRC	1.1, 4.6, 4.8, 4.9, 5.1, 5.2, 5.4
10.4	Work with landowners to assure forest management practices are in compliance with current BMPs, as outlined in “Water Quality Management Practices on Forest Land,” (1994) MDNR.	H ongoing	$15,000	• Introduce forestry BMPs to 5 landowners by 2014 • Work with 10 total by 2019	x	x	x	x	x	x	x	x	x	x	MSU-E, CDs, Regional Foresters, MDNR, CRA, LCWM	1.1, 4.6, 4.9

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
10.5	Develop a funding mechanism or program to assist the local land conservancy in covering technical assistance costs related to promoting and completing land protection work in the watershed. Pursue separate funding needed to purchase land and conservation easements on key priority parcels within the watershed.	M ongoing	$30,000/ year (technical assistance)	• Funding mechanism developed and underway	x	x	x	x	x	x	x	x	x	x	LCWM, CRA, PMWC, TNC, Community Foundations, MDEQ	7.2, 7.3
10.6	Assist state agencies and local units of government in acquiring land for preservation of water quality and sensitive ecological features.	M ongoing	$10,000/ year	• Explore the Baldwin dam restoration site	x	x	x	x	x	x	x	x	x	x	PMRRC, CRA, MDNR, LCWM, USFS, Tribes	4.9
10.7	Identify wildlife corridors in the watershed targeted for habitat management.	M 2	$20,000	• Wildlife corridor maps			x	x							CRA, MDNR, LCWM, TNC	4.4, 4.5
10.8	Cooperate with agencies and municipalities in managing their own lands and tying management activities in with surrounding lands in identified wildlife corridors.	M ongoing	$5,000/ year	• Communicate with USFS and MDNR on land management activities, i.e., burns, plantings, cuttings, etc.	x	x	x	x	x	x	x	x	x	x	PMRRC, CRA, MDNR, LCWM, USFS	1.4, 4.4, 4.5, 5.4
10.9	Offer technical assistance to landowners to help assess and manage their properties for wildlife via CRA's Wild Link and other NRCS programs.	M 5	$50,000	• Number landowners and acreage reported annually being actively managed for wildlife • Pursue grants for the Wild-Link program				x	x	x	x	x			CRA, CDs, LCWM, NRCS	4.4, 4.5
See also: Habitat, Fish, and Wildlife																
Category 11 – Development (Goals addressed: 1, 2, 3 and these tasks will span the watershed)																

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
11.1	Work with homebuilders associations, contractors, realtors, or developers to encourage 'watershed friendly' design, construction and maintenance of new and existing developments in the watershed and work to establish demonstration sites.	L 3	$2,500/year	• 2013: identify one builder to work with on model constructions • 2015: establish showcase site for other builders and prospective new homeowners			x	x	x						PMRRC	1.1, 4.6, 5.1, 5.4
11.2	Work with appropriate local government agencies (i.e., County Drain Commission) to recommend BMPs for developers on construction sites and to ensure compliance with those BMPs (i.e. low impact development or green infrastructure planning).	L ongoing	$2,500/year	• 2014: Establish connection with township planning offices to be alerted of new development plans	x	x	x	x	x	x	x	x	x	x	PMRRC	1.1, 4.6, 5.1, 5.4
11.3	Work with County Drain Commissioners and other appropriate local government entities to implement proper soil erosion control measures at construction sites.	M ongoing	$12,000/ year (Drain Commissioner salary)	• County Drain Commissioner reports at PMRRC meetings	x	x	x	x	x	x	x	x	x	x	County Drain Commissioners, PMRRC	1.1, 5.4
11.4	Monitor soil erosion and sedimentation construction permits to determine the amount and location of new developments throughout the watershed.	L ongoing	$5,000	• Permit reports at PMRRC meetings	x	x	x	x	x	x	x	x	x	x	PMRRC	1.1, 5.4
	Category 12 – Zoning and Land use (Goals Addressed: 3)			•												

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
12.1	Assist townships with zoning and master plans, as needed, to develop ordinances that protect water quality and natural resources and provide financial assistance when possible. Examples of topics to cover in the model ordinances include: mandatory building setbacks from bodies of water, minimizing development clearings by landowners, storm water management, establishing riparian buffers along waterways, and protecting wetlands and unique habitats.	M ongoing	$15,000/year (salary)	• By 2015 pass at least 1 new water quality protection ordinance		x	x	x	x	x	x	x	x	x	PMRRC	1.1, 1.3, 1.4, 4.6, 4.8, 5.4
12.2	Work with townships to develop and adopt possible special overlay districts designed to protect water quality.	L 7	Included in above line item	• 2013: initial feasibility investigations • 2019: if feasible, establish overlay district by 2019		x	x	x	x	x	x	x	x	x	PMRRC	1.1, 1.3, 4.6, 4.8, 5.4
12.3	Work with County Road Commission, MDOT, and energy companies operating/building wells/turbines in the watershed sustainable/green roads planning which would include road salt and sand runoff, storm water issues, and road crossings	M ongoing	$25,000	• Management plans for green roads completed	x	x	x	x	x	x	x	x	x	x	PMRRC, MDOT, Road Commissions, Energy Companies, CRA, PMWC	2.1, 2.2
Category 13 – Groundwater and Hydrology (Goals addressed: 1, 2, 3 and these tasks will span the watershed)																
13.1	Map groundwater flow and major aquifers in watershed. Identify priority groundwater discharge and recharge areas and distribute maps to local governments and other organizations in the watershed.	L 5	$250,000	• Completed maps				x	x	x	x	x			CRA, MDEQ, USFS, Universities	1.5, 5.1, 5.4

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
13.2	Install BMPs (large wood placement) where needed to constrain unnaturally wide channels and concentrate channel flow into deeper, narrower channels.	M 6	$35,000/year	• Installed BMPs where deemed necessary			x	x	x	x	x	x			CRA, PMWC, MDNR, USFS, MDEQ	1.4, 7.2
13.3	Inventory and summarize the status of wellhead protection plans.	L 3	$5,000	• Status reports					x	x	x				PMRRC	1.5
13.4	Inventory and map existing dams and lake-level control structures to identify inoperative, failing, or economically unfeasible dams that should be removed.	M 3	$50,000	• Dam inventory report completed			x	x	x						CRA, PMWC	1.1, 1.8
13.5	Remove inoperative, failing, or economically unfeasible dams as well as priority dams that are blocking fish passage.	H ongoing	$500,000	• Successful dam removals	x	x	x	x	x	x	x	x	x	x	PMRRC, CRA, PMWC	1.1, 1.8
13.6	Inventory abandoned and poorly capped wells and correct properly to prevent contaminants from moving into and among groundwater aquifers via this route. Tasks will be to: 1. Inventory existing abandoned and poorly capped wells through surveys, well logs, and landowner interviews 2. Properly plug the abandoned wells 3. Work with area businesses and property owners to encourage proper maintenance and monitoring of underground fuel storage tanks and improperly stored vehicles (e.g., junkyards).	L 7	$15,000 (consultant to assist in interviews, location, and prioritizing) $10,000/year (thereafter)	• 2013: begin inventory and locating sites • 2014: prioritize biggest offenders, begin working with responsible parties to remediate • 2015: initialize plugging			x	x	x	x	x	x	x	x	MSU-E, MDEQ, PMRRC	1.5, 5.1, 5.2, 5.4
13.7	Monitor and track NPDES permits issued in watershed.	M ongoing	Volunteer or existing staff	• Monitoring reports	x	x	x	x	x	x	x	x	x	x		1.5, 5.1, 5.4
Category 14 – Monitoring and Research (Goals addressed: All and these tasks will span the watershed)																
14.1	Centralize all water quality data for watershed in one common location and format (database). Update water quality monitoring results in database annually.	M ongoing	$5,000 (initial centralization) $1,500/year (thereafter)	• 2010 have data in PMWC office • Maintain annually	x	x	x	x	x	x	x	x	x	x	PMWC, CRA, MDEQ	1.2

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
14.2	Every 5 years summarize and analyze water quality data for long-term trends.	H ongoing	$5,000	• Summarize 2010 and 2015 MDEQ data into reports available to public	x	x	x	x	x	x	x	x	x	x	MDEQ	1.2
14.3	Maintain current MDNR monitoring program of fish surveys and angler creel counts to track changes in watershed.	M ongoing	$150,000	• Evaluate trends every 5 years	x	x	x	x	x	x	x	x	x	x	MDNR, USFS, PMWC, USFWS	4.5
14.4	See Human Health Issues for *E. coli* monitoring task.			•												
14.5	Monitor aquatic insects (macroinvertebrates) in selected streams every 3-5 years, incorporating MDEQ water quality monitoring strategy that utilizes a 5-year cycle. Monitor more frequently than 5 years and in additional areas if volunteers/partners take on that role. If MDEQ monitoring becomes limited due to funding, other partners will assume role as well. Utilizing established MDEQ protocol will provide data consistent to past data collection efforts.	M ongoing	$50,000	• Select streams • Develop program/ schedule • Conduct monitoring		x	x	x	x	x	x	x	x	x	PMRRC, PMWC, CRA, MDEQ, MDNR	1.2
14.6	Document the effectiveness of BMP implementation by taking photographs, completing site data sheets and gathering physical, chemical and/or biological site data.	M ongoing	$100,000	• Input updated data into BMP website	x	x	x	x	x	x	x	x	x	x	CRA, NRCS, PMWC	1.1, 1.4, 2.1, 2.2
Category 15 – Desired Uses (Goals addressed: 1, 2, 3 and these tasks will span the watershed)																
15.1	Monitor the level of use and evaluate the impact at key access points, with assessment of carrying capacities of users on specific stretches of the river.	M ongoing	$5,000/year	• Annual reports of use levels	x	x	x	x	x	x	x	x	x	x	USFS, MDNR, PMWC, CRA	6.1, 6.2, 7.2

TABLE 45: ESTIMATED COSTS, TIMEFRAMES, AND MILESTONES																
Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Milestone**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**	**Objective(s) Addressed**
15.2	Evaluate the condition of fishing access trails. Identify critical sites needing protection and/or rehabilitation.	M ongoing	$5,000/year	• Annual reports of erosion increase or decrease trends at high use areas	x	x	x	x	x	x	x	x	x	x	USFS, MDNR, PMWC, CRA	6.1, 6.2, 7.2
15.3	Evaluate recreational access sites and determine repairs/improvements.	M ongoing	$5,000/year	• Annual assessment of needed repairs	x	x	x	x	x	x	x	x	x	x	USFS, PMWC, CRA, MDNR	6.1, 6.2, 7.2
15.4	Assess power boat impacts on the Pere Marquette (25 horsepower allowed from Indian Bridge downstream).	M ongoing	$1,500/year	• Float trips of motorized boat use stretches	x	x	x	x	x	x	x	x	x	x	PMWC, CRA	6.1, 6.2
15.5	Utilize the Pere Marquette National Scenic River and Pere Marquette State Natural River Management Plans for guidance in identifying and managing desired uses.	M ongoing	In-kind	• Plan reviews and discussions	x	x	x	x	x	x	x	x	x	x	PMWC, USFS, MDNR	5.4, 6.1, 6.2
15.6	Promote cooperative management between USFS and MDNR and other agencies in order to standardize recreational use policies of the Pere Marquette River.	M ongoing	In-kind	• Communication of PMRRC members regarding recreational use at state and federal sites	x	x	x	x	x	x	x	x	x	x	PMWC, USFS, MDNR	6.1, 6.2, 7.1
H = high, M = medium, L = low																

Category Costs

The total cost for implementation efforts for all categories was determined (Table 46). The total costs for implementation of the Pere Marquette River Watershed Plan (excluding outreach activities) is $12,203,500 over the next ten years.

TABLE 46: SUMMARY OF IMPLEMENTATION TASK COSTS BY CATEGORY

Category	Cost
Shoreline Protection and Restoration	$ 622,000
Road Stream Crossings	$2,985,000
Agriculture	$2,470,000
Habitat, Fish, and Wildlife	$ 585,000
Stormwater	$ 450,000
Wastewater and Septics	$ 347,500
Human Health Issues	$ 98,000
Wetlands	$ 125,000
Invasive Species	$ 220,000
Land Protection and Management	$2,340,000
Development	$ 157,500
Zoning and Land Use	$ 175,000
Groundwater and Hydrology	$1,100,000
Monitoring	$ 363,500
Desired Uses	$ 165,000
Grand Total	**$12,203,500**

7.4 Information and Education Strategy

One of the most important tools to use when implementing watershed protection is an effective outreach and education campaign. Watershed residents, local businesses leaders, seasonal residents, and tourists alike are often under-educated when it comes to watershed issues. This Information and Education (IE) Strategy addresses the communication needs associated with implementing the Pere Marquette River Watershed Protection Plan.

A variety of means have already been used by the PMWC and other organizations to inform the public regarding water quality issues for the Pere Marquette Watershed and its many streams. The PMWC has recently updated its website to include more information on the various projects, issues, volunteer efforts, and programs ongoing in the watershed. Their website (www.peremarquette.org) can be easily expanded to include new material deemed important to water quality and habitat improvements.

Watershed residents are often not aware of the impact of their decisions on water quality, from applying fertilizers and maintaining riparian buffers to writing master plans and implementing zoning ordinances. Sharing relevant information will be essential to safeguarding

the Pere Marquette River and its watershed and education will be fundamental to the successful implementation of virtually every part of the Watershed Management Plan.

Local Research Findings

There has not been any local research regarding public knowledge of watersheds and water quality issues in the Pere Marquette River Watershed. However, the White River Watershed Partnership (WRWP) recently completed a Social Profile and Information and Education Strategy for the nearby White River Watershed. Since the White River and Pere Marquette River watersheds share two counties, have some of the same project partners, and are in close proximity of one another, social profile information can be expected to be comparable.

Social Profile for Nearby White River Watershed

The social profile for the White River Watershed presents the human dimensions of the watershed, as opposed to the physical watershed characteristics presented in the watershed plan. It summarizes the influence of social characteristics on the watershed, assesses the attitude of various stakeholders about watershed issues, and was used in the development of their IE strategy (Center for Environmental Study 2009). The WRWP feels that protecting the White River Watershed cannot be based solely on discovering the geophysical and hydrological conditions of the watershed and then installing engineered and structural solutions. As such their social profile complements the more technical data found in the White River Watershed Management Plan by including the human factors that will help them fine-tune the choices that need to be made from a range of possible actions available for protecting the watershed.

The profile is organized around five basic questions, each of which are answered in depth:

1. Who lives in the watershed?
2. How do they make a living?
3. How do they use and impact natural resources in the watershed?
4. What are the issues?
5. How can they be reached?

The most pertinent information that can be gleaned from the profile is that from question #4 - 'What are the issues?' and question #5 - 'How can they be reached?'. A number of stakeholder surveys were conducted in the White River watershed area to assess the understanding and perception of environmental issues and the following is an excerpt of summary results from the Social Profile.

- Water supports many of the recreational activities found in the watershed. Access to clean water remains one of the most basic community health concerns in the watershed as evidenced by the surveys. Most recreational stakeholders – especially those who swim, fish, canoe, and boat as well as those who observe wildlife – expect high quality water. Identifying these stakeholders and making this connection to the watershed will require an active and effective outreach program.

- Although many survey respondents appeared to be familiar with the term watershed, it still may not be connected to water quality or relevant to their everyday lives. Most survey respondents (62%) do not know whether water quality has improved or not. There will be a need to find ways for residents and communities to relate water quality to the watershed without adding to their confusion. The notion of being in a watershed does not take on any meaning within a community until it has been integrated into a system of communication. Consequently, information and education will make the concept of a watershed meaningful.

- The earlier survey of riparian landowners highlight the critical role they will play in water quality improvements in the watershed. In contrast to other watershed residents, riparian owners were able to assess the condition of water quality plus they considered it the most important feature to protect. They viewed the goal for their property as a heritage to pass to their family and to maintain it in a natural condition. They believed the lack of information was the greatest barrier to protecting the river.

- There is a great willingness to act in support of the White River Watershed if residents know specifically what to do, as survey respondents often indicate. However, knowledge alone does not induce action. Individuals and organizations, as research has demonstrated, will take ownership and take action if they are clear about what must be done and if they have personal control over most aspects of the decisions. The effectiveness of actions to protect the watershed, as presented in the watershed survey, demonstrates the need to more thoroughly educate watershed residents about those practices they can implement.

- In the course of a lifetime, an individual may accumulate knowledge about water quality from a combination of schools, the Internet, other media, books, family and friends, outdoor activities, entertainment, and a wide range of other experiences. For a few motivated individuals, these learning experiences may eventually lead to taking true watershed actions.

- As these surveys suggest, watershed residents possess local knowledge that is specific and tuned into local conditions as they perceive them. While watershed planning has identified pollution sources and causes and reduced them further into discrete components for analysis and planning, local knowledge and local willingness to act will remain an integral component in how well the watershed will be managed and how successfully water quality can be improved.

Additionally, a survey completed in Grand Traverse Bay Watershed by The Watershed Center Grand Traverse Bay in 2002 identified a major gap in knowledge amongst watershed residents. 60% of the respondents answered “don’t know” when asked which watershed they lived in (TWC 2005). This basic fact indicates that watershed organizations have a long way to go in informing and engaging the public in watershed issues.

White River watershed surveys also revealed results on how respondents rated the importance of different sources of information on environmental issues (Table 47).

TABLE 47: WHITE RIVER WATERSHED IMPORTANCE OF DIFFERENT SOURCES OF INFORMATION ON ENVIRONMENTAL ISSUES		
	Survey: 2008 White River Watershed	**Survey: 2006 White River Riparian Owners in Newaygo County**
Most important	Environmental groups University scientists State officials	Environmental groups University scientists Local, state, and federal officials
Somewhat important	Family and friends Newspapers TV and radio Local officials Federal officials Internet	Newspapers TV and radio Family and friends
Not important	Fellow workers Business leaders Church leaders	Churches Business leaders

In a Newaygo Community survey, respondents identified the following sources for information:

- Word of mouth (68%)
- City or township mailings (41%)
- Other (37%)
- Public school literature (33%)
- Television (17%)
- City and township officials (17%)
- Websites (13%)
- Radio (12%)

TABLE 48: GRAND TRAVERSE BAY WATERSHED IMPORTANCE OF DIFFERENT SOURCES OF INFORMATION ON ENVIRONMENTAL ISSUES	
Information Source	**Percent**
Newspaper	46.6%
TV News	13.7%
Environmental organization newsletters	7.3%
Friends, neighbors, coworkers	5.2%
Other organizations (churches, clubs, etc.)	2.6%
Magazines	2.3%
Radio	1.6%
Schools	1.3%

Findings from a similar survey in the Grand Traverse Bay watershed point out that most people get their information about the environment and water quality from newspapers and television (Table 48). When this question was cross-tabulated with the respondents' age, more detail was revealed about where specific age demographic groups obtain their information about the environment (TWC 2005)(Table 49). It is worthy to note that since 2002, there has been a boom in the use of the internet as a source of information, especially for the younger generation (specifically on social networking sites).

TABLE 49: SUMMARY OF PREFERRED SOURCES OF INFORMATION BY AGE

Age Range	Preferred Source	Education Level	Preferred Source
18-25	Schools	Graduate Degree	Environmental newsletters or friends, neighbors and relatives
26-35	TV News	Some post grad	Environmental newsletters, newspapers
36-55	Newspapers	College degree	Environmental newsletters, newspapers
56-65	Environmental Newsletters	Some college, high school or some high school	Television news
66+	Newspapers		

Summary of Regional Environmental Education and Outreach Research

Note: The following is an excerpt from the IE Strategy outlined in Chapter 7.3 in the Grand Traverse Bay Watershed Protection Plan (TWC 2005). Even though the Pere Marquette River Watershed differs from the Grand Traverse Bay Watershed, the summary of research findings is relevant and will be helpful when implementing the outreach plan. When it comes to watershed education most of the issues and attitudes are the same across watershed and municipal boundaries.

"Recent regional and national research surveys regarding the environment confirm the basic findings of the Grand Traverse Bay surveys. A recent Roper study (Roper 2001) indicates that while there is increasing public concern about the environment, the majority of the public still does not know the leading causes of such problems as water pollution, air pollution and solid waste. This finding was also confirmed in work done by The Biodiversity Project (2003) as part of their Great Lakes Public Education Initiative. Their research involved both a public opinion poll and a survey of organizations, agencies and institutions engaged in public education efforts on Great Lakes topics. An excerpt follows:

> *...organizations are making a concerted effort to provide reliable information to people who can make a difference when it comes to improving the environmental conditions in the Great Lakes Basin. However, the public opinion poll shows that, for the most part, people are just not grasping the importance of the issues facing the Great Lakes in three important ways: the seriousness of the threats, the need for urgency in taking action to address the threats, and ways that individuals can make a difference. This led us to examine the discrepancy between the level and focus of current communications and public education efforts and the gaps in public awareness. Because of this discrepancy,*

it is concluded that the public knowledge gaps are likely to be attributed to other factors besides the content and volume of materials. Likely factors include the following three points.

- *Limited use of targeting (tailoring messages and delivery strategies to specific audiences).*
- *Heavy reliance on printed materials and the Web – reaching already interested knowledge seekers; limited use of television and other communication tools that reach broader audiences.*
- *Multiple, complex, detailed information as opposed to broad, consistent unifying themes.*

The report goes on to conclude that educators need 'to pay attention to a full spectrum of factors that act as barriers to the success and impact of public outreach.' Factors to be considered include:

- Targeting – Avoid the one-size-fits-all approach.
- Delivery – As resources allow, use the mediums and venues that best reach the target audience. Brochures are easy, the web is cheap, but television is the most used source of information about the environment.
- Content – Facts and figures are important to validate a point, but it is important to address the emotional connection needed to address why people should care, why the issue is relevant, effective solutions and what your audience can do about it.
- Context – Many environmental threats are viewed by the public as long term issues. Issues need to be communicated in a way that makes them more tangible. Beach closings, toxic pollution, sewage spills and water exports tend to feel more immediate than loss of habitat, land use planning and other big picture issues that citizens feel more disconnected from.

The study identified a list of educational needs and actions that should be incorporated consistently in educational efforts:

- Promote understanding of the system.
- Make the connection to individuals.
- Be local and specific.
- Include a reality check on 'real threats.' (For example, industrial pollution was a hot topic ten years ago but, many organizations have shifted their education focus to other current and emerging threats, such as storm water runoff, biodiversity, etc., but the public has not caught up with this shift.)
- Emphasis on 'why is this important to you' messages.
- Make the connection to policy.

Both local and regional research indicates that there are considerable gaps in the public's knowledge and understanding of current environmental issues. But, this knowledge gap is tempered by keen public interest and concern for the environment. Watershed organizations need to do a better job of making issues of concern relevant to their audiences. There is a need for ongoing, consistent and coordinated education efforts targeted at specific groups, addressing specific threats."

The Pere Marquette River Watershed IE strategy addresses these concerns. Both local and regional opinion research findings were carefully considered when developing messages and delivery mechanisms for IE strategy implementation.

Goals and Objectives

The goal of the IE strategy is to "Promote sound stewardship of the Pere Marquette River land and water resources through education and outreach" (goal #5 in Chapter 6). Developing and carrying out a regional vision for stewardship of water resources will require public and community leaders to become more knowledgeable about the issues and solutions, more engaged and active in implementing solutions and committed to both individual and societal behavior changes.

The objectives of this plan focus on building awareness, educating target audiences, and inspiring action. Five major objectives have been identified:

- To raise community awareness and knowledge about the Pere Marquette River, its tributaries, and the rest of the watershed, including the interconnectedness of the system and the role that an individual's day-to-day activities can play in protecting the resource.
- Expand the "watershed literacy" of the Pere Marquette River Watershed stakeholders.
- To develop a set of consistent messages that can be used by partners in a variety of communications.
- To involve citizens, public agencies, user groups and landowners in the implementation of the watershed management plan.
- To regularly inform stakeholders about the watershed, implementation activities and successes and opportunities to participate.

Target Audiences

A number of diverse regional audiences have been identified as key targets for IE strategy implementation. The targets are divided into user groups and decision-making groups.

User Groups

- Households/General Public – The general public throughout the watershed.
- Riparian Landowners – Due to their proximity to water bodies and the critical/priority areas, the education needs of riparian landowners are different.
- Agriculture/Farmers – Agriculture represents a significant economic and land use segment within the Pere Marquette River Watershed. Livestock dominate significant portions of the landscape and row crops, like corn and asparagus, are also well represented.
- Tourists – The Pere Marquette River is known for its scenic beauty and recreational opportunities. This influx of people puts a noticeable strain on area infrastructure and the environment. There is a growing concern that this important economic segment could eventually destroy the very reason why it exists, and that the river's tourism "carrying capacity" may soon be reached.
- Builders/Developers/Real Estate – Members of the development industry segment play a crucial role in growth and providing ongoing education opportunities about their role in protecting water quality and environmental health is critical.
- Education – Area educators and students. Students can be grouped as follows: elementary (K through 6th grade), junior high/high school (7th grade through 12th

grade), and college age. The Pere Marquette River Watershed has several colleges in its vicinity including West Shore Community College, Ferris and Grand Valley State Universities.

- Special Target Audiences – In addition to the above, certain user groups such as recreational boaters, other sports enthusiasts, garden clubs, churches, or smaller audience segments may be targeted for specific issues.
- Local Government Decision Makers
- Elected/Appointed Officials – Township, village, city, and county commissioners; planning commissions; zoning board of appeals; road and drain commissioners; etc.
- Staff – Planners, managers, township supervisors, zoning administrators, etc.

Message Development

General message outlines have been established for each target audience. These messages will be refined as implementation moves forward. They may also be modified or customized depending on the message vehicle (Table 50).

TABLE 50: MESSAGE DEVELOPMENT SUMMARY

Target Audience	Messages
Households/General Public	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Water quality-friendly lawn and garden practices • Housekeeping practices and the disposal of toxic substances • Septic maintenance • Managing storm water on your property
Riparian Landowners	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Riparian land management including the importance of riparian buffers • Water quality-friendly lawn and garden practices • Septic system maintenance • Housekeeping practices and the disposal of toxic substances • Clean boating practices
Agriculture	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Riparian land management including the importance of riparian buffers and BMPs • Water quality-friendly types of agricultural practices • Disposal of toxic substances and pesticides should be done responsibly
Tourists	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Help us protect the beauty that you enjoy when you are a guest • Clean boating practices • Role in controlling the spread of aquatic invasive species

TABLE 50: MESSAGE DEVELOPMENT SUMMARY	
Target Audience	**Messages**
Builders, Developers, Real Estate	• Monetary advantages of and opportunities for Low Impact Development • Identification and protection of key habitats and natural features: aquatic buffers, woodlands, wetlands, steep slopes, etc. • Advantages of and opportunities for open space protection and financial incentives for conservation • Minimize the cutting of trees and vegetation • Impact of earthmoving activities, importance of soil erosion and sedimentation control practices, construction BMPs • Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Educate about and encourage wetland mitigation where landowners will cooperate
Education	• Adoption and promotion of a state-approved watershed curriculum in K-12 schools. • Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • Connection between watershed organizations' programs and school activities • Active participation in watershed protection activities and stewardship
Local Government Decision Makers	• Watershed awareness, the water cycle, key pollutant sources, how individual behaviors impact the watershed • The leadership role that local governments must play in protecting the watershed • The importance of establishing sound, enforceable natural resource protection ordinances • Economic impact and advantages of environmental protection
Table adapted from Grand Traverse Bay Watershed Protection Plan (TWC 2005)	

Action Plan to Implement Strategies

A complete list of tasks by category follows this narrative; the categories are the same as those used to outline the implementation tasks in Section 7.3. Several priority areas for the Pere Marquette River Watershed have been identified and the plan for rolling out the IE Strategy will correspond to these priority areas (Section 5.3, Figures 24 and 25). Additionally, the IE Strategy will support other implementation efforts to control nutrient loading, loss of habitat, input of harmful toxins, and the impacts of invasive species in the watershed, and other pollutants outlined in Section 5.4.

The IE Strategy tasks use a diverse set of methods and delivery mechanisms. Workshops, presentations, demonstration projects, brochures, public and media relations, web sites and other communications tools will be used for the different tasks and target audiences. Broadcast media, most importantly television, is beyond the reach of most area partner

organizations – at least at a level of reach, frequency and timing that can be expected to have any impact on awareness and behavior. This is a barrier to utilizing this effective medium, but effort should be placed on building coalitions that can pool resources to address larger picture issues through broader-based, more long-term communications efforts. Additionally, the use of social networking websites such as Facebook and Twitter have increased exponentially over the past few years. These sites offer advantages to reaching out to a broader segment of individuals that might not be reached via other means.

The PMWC and Pere Marquette River Restoration Committee (PMRRC)

Many of the outreach and action items in the IE Strategy will be carried out by the PMWC. The PMWC is a grassroots conservation organization founded in 1970 dedicated to preserving one of Michigan's priceless natural resources - The Pere Marquette River. This nationally designated Wild and Scenic River and Michigan Named Natural River offers world-class angling for resident brown trout, migratory steelhead and salmon. The PMWC's mission statement is: To preserve, protect and enhance the inherent natural values of the Pere Marquette River Watershed through the gathering and dissemination of information and by working with any organization or agency for the accomplishment of mutual objectives (www.peremarquette.org/).

One of the oldest "grassroots" conservation groups in existence, the PMWC was organized in 1970. It has been active in protecting, enhancing and restoring the entire river system for over four decades. Originally, the PMWC was set up by local residents to end the negative impact of canoeists on the river and stop the building of dams on river tributaries which were raising the water temperatures. The Pere Marquette had never been dammed and the new and proposed impoundments would have ended the river's history as a cold running river. The PMWC's initial actions reduced sand inundation, water pollution, erosion and property destruction.

Incorporated in 1971, the PMWC used local effort and initiative to slowly build a program aimed at maintaining watershed quality and helping landowners solve local problems. Cooperative programs were arranged with Soil CDs in the watershed. In 1993, the PMWC became a 501(c)3 non-profit organization. PMWC frequently partners with the CRA, Michigan Council of TU, Mason–Lake Soil Conservation Service, MDNR and the US Fish and Wildlife Service on restoration activities in the watershed.

Some of the outreach and action items will also be carried out by the greater PMRRC. The PMRRC is a partnership based committee that formed in 1987 and coordinated the 10-year $1.4 million streambank stabilization project, funded by the Natural Resources Commission and USFS. The PMRRC was originally comprised of the Huron- Manistee National Forest Service (USFS), Michigan Council of TU, Mason-Lake CD, MDNR Fisheries Division, PMWC, and CRA. Today, the PMRRC is facilitated by CRA and is informally composed of additional agencies and groups like Road Commissions, townships, landowner associations, and fishing and hunting clubs. PMRRC meetings are open to the public and are scheduled on a bi-monthly basis. Watershed issues are discussed, responsibilities for projects are assigned, and project and funding updates are given by partners.

Goal 6: Promote sound stewardship of the Pere Marquette River land and water resources through education and outreach.

Pollutants Addressed: All

Categories

G. General
1. Shoreline Protection and Restoration
2. Road Stream Crossings
3. Agriculture
4. Habitat, Fish, and Wildlife
5. Storm Water
6. Waste Water and Septic
7. Human Health Issues
8. Wetlands
9. Invasive Species
10. Land Protection and Management
11. Development
12. Zoning and Land Use
13. Groundwater and Hydrology

Note: the Monitoring and Research and Desired Uses categories from the previous section are not included in the IE plan.

Organization Acronyms

CD – Conservation District
CRA – Conservation Resource Alliance
CGOV- County Governments
EPA – Environmental Protection Agency
LCRC – Lake County Road Commission
LOCD – Lake Osceola Conservation District
LCRPOA – Lake County Riverside Property Owners Association
LCWM – Land Conservancy of West Michigan
LGOV – Local Governments
LRBO – Little River Band of Ottawa Indians
MLCD – Mason Lake Conservation District
MCRC – Mason County Road Commission
MDEQ – Michigan Department of Environmental Quality
MDNR – Michigan Department of Natural Resources
MDOT – Michigan Department of Transportation
MSU-E – Michigan State University Extension
NCD – Newaygo Conservation District
NCRC – Newaygo County Road Commission
NRCS – USDA Natural Resources Conservation Service
NWMSBF – Northwest Michigan Sustainable Business Forum
OCD – Oceana Conservation District
OCRC – Oceana County Road Commission
OWTTF – On-site Wastewater Treatment Task Force
PMRRC – Pere Marquette River Restoration Committee

PMWC – Pere Marquette Watershed Council
TNC – The Nature Conservancy
TU – Trout Unlimited
USFS – United States Forest Service
USFWS – United States Fish and Wildlife Service
WMSRDC – West Michigan Shoreline Regional Development Council

Others
Lake, Newaygo, Mason and Oceana County Chamber of Commerce Offices
Local Realtors, Businesses
Solid waste management entities
Schools
Area Libraries
Fishing, Guide and Bait Outfits
Garden Centers and Nurseries
Landscaping Companies
Architects and Engineers

Target Audiences Include:
Builder/Developer/Realtor
Education
Households
Local Governments
Riparian Landowners
Tourists
General

Estimated Costs, Timeframes, and Milestones:

For costs associated with salaries, an average watershed technician rate of $35/hour was applied. For tasks to be completed by a specialized consultant, a rate of $50/hour was used. Tasks that will be done on a yearly or site by site basis are noted as such ($/year or $/site). Appendix B lists average rates for costs associated with educational materials. Further details are noted where applicable. In general, funding for short-term tasks (one to five years) will be attained through state and/or Federal grants, other non-profit grant programs, partner organizations' budgets, fundraising efforts, and private foundations. Funding for long-term tasks will be addressed as needed.

Milestones for the IE Strategy were harder to define because many of the tasks are ongoing. Additionally, the best way to conduct outreach activities is continually evolving and depends on the audience one is trying to reach. This is why many of the IE tasks are general and only outline the audience to reach and the message to convey, but don't include specifically how to convey that message. All of the tasks in the following pages outline the target audience reached for each task, as well as what frequency the task should be performed and the method or medium that should be used to reach the audience (i.e., newsletter, website, workshop, etc.). The most important things listed for each category are the general messages or educational topics that should be focused on.

The most important task to completing effective outreach in the region is to acquire funds to hire a part- to full-time Watershed Outreach Coordinator to complete most of the outlined tasks in the IE Strategy. At present the PMWC does not have the capacity to carry out or organize implementation of the watershed plan, especially the IE Strategy. The PMWC has no formal employees and is a volunteer based organization. Additionally, the CRA is also active in the watershed in on-the-ground restoration projects, but does not specialize in outreach activities nor does it have a dedicated staff person who could work on these types of activities. Without a dedicated staff person to concentrate on the outreach tasks, the entire outreach effort may stall and have no leadership. Most of the educational tasks outlined in the following pages are simple (i.e. write articles for newsletters, update website, consultations with homeowners, distribute handbooks), but do require time and coordination. Once funding is obtained to hire a Watershed Outreach Coordinator a majority of the tasks in the IE Strategy may start. Ideally, the PMWC, CRA and one or more of the CDs in the watershed could partner together to financially support and house a Watershed Outreach Coordinator.

The PMWC will be the lead project partner in many tasks. The General Category G.1 specifies a part-time Watershed Outreach Coordinator be hired. The PMWC and other watershed partner groups will need to obtain a grant to fund this position. All such tasks which will involve this individual are predicated on initial and continuing funding for this position (Table 51).

TABLE 51: INFORMATION AND EDUCATION STRATEGY IMPLEMENTATION TASKS																	
IE Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Target Audiences**	**Frequency/ Milestone**	**Medium or Method**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**
IE Category G - General																	
G.1	Maintain the operation of the PMWC. Continue to conduct regular meetings, *Mainstream* publication, annual banquets, grants, membership, projects and studies, workbees, website, and other PMWC activities.	H ongoing	$5,000/ year	riparian landowners, membership	• Increased membership • Grant awards	newsletter, website, meetings, forums, workbees	x	x	x	x	x	x	x	x	x	x	PMWC
G.2	Maintain the PMRRC and cooperation between project partners. Continue to operate regular meetings, workbees, annual float trips, and grant-funded projects.	H ongoing	$15,000/ year	watershed residents, riparian landowners, partner agencies, municipalities, businesses, and interest groups	• Committee participation • Grant awards • Scheduled events and meetings	meeting minutes and agendas, CRA website, meetings and gatherings	x	x	x	x	x	x	x	x	x	x	CRA, PMWC, USFS, NRCS, CDs, MDNR, MDEQ, TU, LCWM, TNC, Municipalities, Local Businesses
G.3	Continue to fundraise for the Pere Marquette River for project and maintenance needs by raising funds from private groups, individuals, and foundations and continuing to apply for Federal and State funding sources.	H ongoing	$15,000/ year (cash and in-kind)	private, state and federal funding sources	• Successful grant applications	Proposal writing	x	x	x	x	x	x	x	x	x	x	CRA, PMWC, USFS, USFWS, MDNR, LCWM, TNC
G.4	Compile and update business, realtor, landowner databases for mailings and conduct mailings of project updates and activities.	M ongoing	$5,000/ year	realtors, landowners, businesses	• Participation in meetings and events	email, mail	x	x	x	x	x	x	x	x	x	x	CRA, PMWC, CDs

TABLE 51: INFORMATION AND EDUCATION STRATEGY IMPLEMENTATION TASKS																	
IE Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Target Audiences**	**Frequency/ Milestone**	**Medium or Method**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**
G.5	Hire Watershed Coordinator (WC) to complete the bulk of tasks in IE Plan and coordinate organizations' roles in Implementation Tasks. Evaluate need to expand to full time as needed and as resources become available.	H ongoing	$240,000 (4 years at $15,000; 6 years at $30,000)	n/a	• 2012-2015: part time • 2016-2020: full time	n/a	x	x	x	x	x	x	x	x	x	x	PMWC, CRA, CDs
G.6	Provide watershed information and news to local and regional media on a regular basis. Summarize management plan information into a pamphlet that highlights priority goals and tasks, and is easily distributed to the community.	M ongoing	WC, volunteer	general	• Twice a year	articles, releases to local news stations	x	x	x	x	x	x	x	x	x	x	PMWC, WC, CRA
G.7	Develop public attitude survey (as well as follow up surveys) to determine and monitor the public's awareness regarding watershed and water quality issues.	M ongoing	$15,000 each survey - consultant	households	• Every 6 years • 2013: first survey	phone calls or mailed survey				x						x	WC, PMWC
G.8	Install general watershed education and/or watershed boundary signs throughout watershed at parks, boat launches, and parklands.	M 3	$6,000 (6 signs at $1,000 each)	general, tourists	• 2014: complete plan, begin funding search • 2015: install signs	develop, post, updates					x	x	x				PMWC, CDs, WC

TABLE 51: INFORMATION AND EDUCATION STRATEGY IMPLEMENTATION TASKS																	
IE Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Target Audiences**	**Frequency/ Milestone**	**Medium or Method**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**
G.9	Work with elementary, junior high and high schools to develop watershed based curriculum and field trips for kids to get them more involved in the local natural environment (topics include aquatic insect life, anadromous fish life cycle, ideal instream habitat, riparian corridor land management).	L ongoing	$2,500 stipend/ teacher up to $50,000	education	• Completed field trips • Class visits • Curriculum development /use	teacher visits/ meetings/ general commun-ication			x	x	x	x	x	x	x	x	PMWC, CRA, WC, CDs
G.10	Host annual events where people are given opportunity to learn about watershed issues (i.e. PMWC Annual Banquet, workbees, float trips).	M ongoing	$3,000/ year (planning, materials, etc.)	general	• 2 events	workshop-general event		x	x	x	x	x	x	x	x	x	PMWC, CRA, WC, CDs
G.11	Distribute watershed maps for landowners, government and others.	L ongoing	$5,000	riparians, agencies, LGOV	• As requested	ongoing distribution		x	x	x	x	x	x	x	x	x	PMWC, CRA, WC
IE Category 1 – Shoreline Protection and Restoration																	
1.1	Educate the public, new home owners, contractors, builders, landscapers, garden centers, and farmers about: 1. The need for soil testing prior to fertilizer application, and the proper use of residential and commercial fertilizers, pesticides, herbicides. 2. Environmentally-friendly lawn care contractors, availability of non-phosphorus fertilizers, alternative pest management 3. Greenscaping, natural shorelines, and naturalization.	M ongoing	$20,000	riparians, contractors, lawn care providers	• 1 article on each topic per year • WC visits and follow up as requested	incorporate to PMWC website, newsletter articles, handbook, distribution of existing brochures, home visits by WC as requested			x	x	x	x	x	x	x	x	CDs, PMWC, CRA, MDNR, NRCS, USFS, WC

TABLE 51: INFORMATION AND EDUCATION STRATEGY IMPLEMENTATION TASKS																	
IE Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Target Audiences**	**Frequency/ Milestone**	**Medium or Method**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**
1.2	Education and outreach to landowners with CD annual tree sales, on what species to plant and soil/water/temperature suitability, planting techniques, and benefits of buffers.	H ongoing	$50,000	watershed residents including riparian owners	• Articles in newsletter • Annual letter to the editor in local papers	mailings to riparians including utilizing Thunder Bay native species brochure	x	x	x	x	x	x	x	x	x	x	CDs, PMWC, CRA, MDNR, NRCS, USFS, WC
1.3	Increase awareness of boaters and personal watercraft users on the impact of turbulence on natural resources and biological communities.	M ongoing	in-kind and included in other tasks	riparians, tourists	• Articles in newsletter • Annual letter to the editor in local papers	incorporate into website, newsletter articles, handbook			x	x	x	x	x	x	x	x	PMWC, WC
IE Category 2 – Road Stream Crossings																	
2.1	Work with Road Commissions (RC) and Drain Commissioners regarding implementing BMPs at road crossings to reduce harmful sedimentation and storm water runoff.	L ongoing	$18,000 (Drain Commis-sioner: $45/hour x 40 hours/year x 10 years)	county road and drain commissioners	• As needed	meetings with RC managers, engineers, department heads	x	x	x	x	x	x	x	x	x	x	CRA, USFS, MDEQ, County Road Commissions, Drain Commissioners
IE Category 3 – Agriculture																	
3.1	Identify existing farms with conservation practices to serve as a demonstration site. Invite the public for tours and workshops.	M 7	$14,000	agriculture, households	• Annual tours	2013: Identify demo farm(s)				x	x	x	x	x	x	x	MSU-E, CDs, NRCS
See also: Wetlands and Land Protection and Management																	
IE Category 4 – Habitat, Fish, and Wildlife																	

TABLE 51: INFORMATION AND EDUCATION STRATEGY IMPLEMENTATION TASKS																	
IE Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Target Audiences**	**Frequency/ Milestone**	**Medium or Method**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**
4.1	Educate public regarding the harmful effects of herbicides/pesticides on fish and wildlife.	H ongoing	newsletter cost in General Category	general, households	• 1 newsletter article per year	newsletter article		x	x	x	x	x	x	x	x	x	WC, CRA, PMWC, CDs, MSU-E
4.2	Educate public regarding the importance of maintaining diverse wildlife habitats and wildlife corridors on their property.	M ongoing	newsletter cost in General Category	general, households	• 1 newsletter article per year	newsletter article		x	x	x	x	x	x	x	x	x	WC, CRA, PMWC, CDs
IE Category 5 – Storm Water																	
No current tasks. See also: Road Stream Crossings, Agriculture, Development, and Zoning and Land Use																	
IE Category 6 – Waste Water and Septic																	
6.1	Provide public education regarding using proper septic system design for site conditions, new technology, and maintaining existing systems (make page on website, distribute handbook and other existing brochures, newsletter articles, homeowner visits as requested).	H 9	$5,000/ year	general, households	• 1 article per year • Number of WC visits and follow up	newsletter article, website info, distribution of existing brochures, home visits by WC as requested		x	x	x	x	x	x	x	x	x	WC, PMWC, CRA, MDEQ, CDs, District Health Department #10
6.2	Provide public education regarding the importance of pumping existing septic tanks on a regular basis.	H 3	$2,500 (brochure)	riparians, households	• 1 brochure mailing per year • 1 newspaper article/ad per year	brochure, info meeting, include info on website			x	x	x						WC, PMWC, CRA, MDEQ, CDs, District Health Department #10
IE Category 7 – Human Health Issues																	

TABLE 51: INFORMATION AND EDUCATION STRATEGY IMPLEMENTATION TASKS																	
IE Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Target Audiences**	**Frequency/ Milestone**	**Medium or Method**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**
7.1 7.2 7.3 7.4	<u>Public education regarding:</u> Feeding waterfowl and birds Use of pesticides/herbicides Results of *E.coli* monitoring Improper disposal of hazardous wastes including electronics and drugs *(For all: provide info on website, distribute handbook, newsletter articles)*	H ongoing	part of newsletter website costs in General Category	general, riparians, households, LGOV	• 1 newsletter article on each topic per year	newsletter, handbook, website	x	x	x	x	x	x	x	x	x	x	WC, PMWC, CRA, CDs, MDEQ
IE Category 8 - Wetlands																	
8.1	Educate public, local governments, developers, contractors, and farmers regarding the benefits of existing wetlands and restoring them.	M ongoing	$3,000/ year and in-kind	riparians, LGOV, farmers, contractors	• Number people contacted/ interacted with	website, newsletter, brochures, site visits by WC as requested	x	x	x	x	x	x	x	x	x	x	NRCS, MDNR, MDEQ, WC, CRA, CDs
IE Category 9 – Invasive Species																	
9.1	Educate local residents, visitors, garden centers regarding the negative impacts of and appropriate control/eradication measures for both aquatic and terrestrial invasive species (milfoil, zebra mussels, phragmites, etc.).	H ongoing	$3,000/ year	riparians, tourists	• 2013: website update	newsletter, website, handbook	x	x	x	x	x	x	x	x	x	x	WC, PMWC, CRA, MDNR, USFS, CDs
9.2	Create and maintain signs or displays on invasive species prevention at boat launches and access points.	M 2	$6,000 (6 signs at $1,000/ sign)	riparians, general, tourists	• 2014: plan signs • 2015: secure funding • 2016: installation	signs			x	x	x						WC, PMWC, MDNR, USFS
IE Category 10 – Land Protection and Management																	

TABLE 51: INFORMATION AND EDUCATION STRATEGY IMPLEMENTATION TASKS																	
IE Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Target Audiences**	**Frequency/ Milestone**	**Medium or Method**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**
10.1	Educate landowners regarding voluntary conservation easements and other available land protection measures.	H ongoing	$5,000/ year	watershed and riparian landowners	• Number landowners contacted	handbook, newsletter website, site visits by WC as requested	x	x	x	x	x	x	x	x	x	x	LCWM
10.2	Educate landowners regarding ecologically sound riparian shoreline and wetland management practices.	H ongoing	$5,000/ year	watershed and riparian landowners	• Number landowners contacted	handbook, newsletter, website, site visits by WC as requested	x	x	x	x	x	x	x	x	x	x	WC, CDs, CRA, MSU-E, MDNR, MDEQ
IE Category 11 - Development																	
11.1	Educate realtors, developers, contractors, and homeowners regarding storm water and sediment management.	M ongoing	$10,000/ year (Drain Commis-sioner salaray)	developers, contractors	• Number individuals contacted	visit by Drain Commis-sioner at building sites	x	x	x	x	x	x	x	x	x	x	WC, Drain Commissioner
11.2	Educate realtors, developers, contractors, and homeowners on using BMPs to improve and protect water quality when planning construction or development near water bodies.	M 3	$3,000 (printing costs)	developers, contractors, realtors	• Number individuals contacted	workshop, brochure, distribution to local builders			x			x			x		WC, County Soil Erosion Officers
IE Category 12 – Zoning and Land Use																	

TABLE 51: INFORMATION AND EDUCATION STRATEGY IMPLEMENTATION TASKS																	
IE Categories/Tasks		**Priority Duration (yrs)**	**Estimated Cost**	**Target Audiences**	**Frequency/ Milestone**	**Medium or Method**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**Potential Project Partners**
12.1	Educate planning commissioners and township boards regarding the watershed management plan via presentations to township/county board and planning commissions (must be ongoing due to turnover) and distribution of summary pamphlet produced in Task G.6.	H ongoing	$2,500/ year	LGOV	• 4 meetings per year	meetings, present-ations, booklet	x	x	x	x	x	x	x	x	x	x	WC, CRA, PMWC
12.2	Educate planning commissioners and township boards regarding sharing by townships of model ordinances to protect water/natural resources.	M ongoing	$2,500/ year	LGOV	• As needed	meetings	x	x	x	x	x	x	x	x	x	x	PMWC, MDNR, WMSRDC
12.3	Work with realtors to include township and Natural Rivers zoning in property information.	M ongoing	In-kind	realtors, prospective buyers	• number realtors contacted	meetings, handouts	x	x	x	x	x	x	x	x	x	x	PMWC, WC, MDNR, Townships
IE Category 13 – Groundwater and Hydrology																	
13.1	Educate landowners on the negative impacts of small dams and ponds on fish passage, especially on the smaller tributaries that may inhibit ideal coldwater habitat in the watershed.	M ongoing	$2,500/ year plus in-kind	landowners	• number landowners met with	meetings, brochures, Small Dams Guidebook (Huron Pines)	x	x	x	x	x	x	x	x	x	x	CRA, MDNR, MDEQ, PMWC
H = high, M = medium, L = low																	

Table 52 summarizes the total cost for implementation efforts for all categories detailed in the Information and Education Strategy for the Pere Marquette River Watershed Protection Plan is $855,000.

TABLE 52: SUMMARY OF INFORMATION AND EDUCATION TASKS COSTS BY CATEGORY	
Category	**Cost**
General	$356,000
Shoreline Protection and Restoration	$ 70,000
Road Stream Crossings	$ 18,000
Agriculture	$ 14,000
Habitat, Fish, and Wildlife	$ *(costs included in General Category)*
Storm Water	No tasks at this time
Wastewater and Septic	$ 47,500
Human Health Issues	$ *(costs included in General Category)*
Wetlands	$ 30,000
Invasive Species	$ 36,000
Land Protection and Management	$ 100,000
Development	$ 109,000
Zoning and Land Use	$ 50,000
Groundwater	$ 25,000
Grand Total	**$855,500**

7.5 Evaluation Procedures

An evaluation strategy will be utilized to measure progress during the Pere Marquette River Watershed Protection Plan's implementation phase and to determine whether or not water quality is improving. The timeline for the evaluation is approximately every five years, with ongoing evaluation efforts completed as necessary. The first aspect of the evaluation strategy measures how well the PMRRC is doing at actually implementing the watershed management plan and assesses if project milestones are being met. The second aspect is to evaluate how well the PMRRC is doing at improving water quality in the watershed. The following sections address each of these issues.

Evaluation Strategy for Plan Implementation

This aspect of the evaluation strategy was developed to measure progress during the implementation phase of the watershed management plan and to provide feedback during implementation. The evaluation will be ongoing and will be conducted through the existing PMRRC. The PMRRC will meet once a year to specifically assess progress on plan implementation and to learn and share information about existing projects throughout the watershed. In addition, plan tasks, priorities, and milestones will be assessed every five years to ensure that the plan remains current and relevant to the region and that implementation is proceeding as scheduled and is moving in the right direction.

The evaluation will be conducted by analyzing the existing watershed plan goals and objectives, as well as the implementation tasks and 'milestones' in Sections 7.3 and 7.4 to determine progress. Key milestones include completing streambank erosion restoration projects, repairing road stream crossings, implementing agricultural and livestock best management practices, starting stormwater remediation efforts in urban areas, conducting necessary research and water quality monitoring, protecting priority land areas, small dam removals on tributaries, and assisting townships with updating and enacting ordinances to protect water quality. The proposed timeline for each task will also be reviewed to determine if it is on schedule. Other anecdotal evidence (not attached to specific plan milestones) will also be noted that indicates the protection plan is being successfully implemented, such as an increase in the amount of updated or new zoning ordinances that deal with water quality and natural resource protections in watershed townships and municipalities.

Additionally, a number of other evaluation tasks will be completed due to the variety of tasks involved in the watershed plan. They will include but are not limited to the following:

- Utilize PMRRC to evaluate specific projects throughout plan implementation as needed.
- Conduct targeted surveys of project partners by direct mail, phone or by website to assist in information gathering.
- Maintain a current list of future target projects, the status of ongoing projects, and completed projects, along with their accomplishments. Keep track of the number of grants received and the dollars committed in the watershed region to implement aspects of the plan.
- Document the effectiveness of BMP implementation by taking photographs, completing site data sheets and gathering physical, chemical and/or biological site data.

The purpose of the evaluation strategy is to provide a mechanism to the PMRRC to track how well the plan is being implemented and what can be done to improve the implementation process. Additional development of the strategy will occur as the implementation phase unwinds.

Measuring and Evaluating Social Milestones

Section 7.4 outlines an Information and Education Strategy that addresses the communication needs associated with implementing the watershed protection plan. The strategy is important because developing and carrying out a vision for stewardship of the region's water resources will require the public and community leaders to become more knowledgeable about the issues and solutions, more engaged and active in implementing solutions and committed to both individual and societal behavior changes. Residents, local officials, homeowners, and the like must be educated and motivated to adopt behaviors and implement practices that result in water quality improvements.

In this respect, it is important to measure and keep track of the social impacts of the Pere Marquette River Watershed Management Plan. The PMRRC, CDs, CRA, and other organizations conducting outreach must find out what types of outreach are working in the community and what types are not, along with how people's attitudes and behaviors are impacted. Just how much is social behavior changing because of the plan implementation? To

answer this question, social impacts must be included when evaluating the progress of plan implementation.

Key social evaluation techniques that will be used to assess the implementation of the IE Strategy, as well as other watershed BMPs, include:

- Continued cooperation between area organizations submitting proposals to implement aspects of management plan.
- Social surveys (and follow up surveys) for homeowners, local officials, etc. to determine watershed and water quality awareness.
- Determining any increases in 'watershed friendly' design and construction (anecdotal evidence will be used).
- Increased awareness (from both the general public and local government officials) regarding the necessity of water quality protection.
- Increase in the number of townships implementing water quality protection related ordinances.
- Incorporating feedback forms into educational and public events and posting them on the PMWC's website www.peremarquette.org/.
- Maintaining a list of ongoing and completed projects protecting water quality, along with their accomplishments and who is completing/completed the project. This task is also found in next section relating to evaluating the water quality improvements.

Evaluation Strategy for Determining Water Quality Improvement

The EPA dictates that watershed management plans must outline a set of criteria to determine whether proposed load reductions in the watershed are being achieved over time and that substantial progress is being made towards attaining water quality standards. Sediment and nutrients are the top two pollutants in the watershed, and our water quality improvement goals will deal mainly with reducing impacts from them. Since agriculture is the main source of pollution in the watershed for both sediment and phosphorus, one of the main goals of the watershed plan is to reduce sediment and phosphorus inputs to the watershed from agricultural sources by 15%. Improving road stream crossings and stabilizing streambanks will also work to reduce inputs from phosphorus and sediment as well - our watershed plan goal is to reduce phosphorus and sediment from these sources by 15%. The 15% amount is recognized as a goal and starting point for the Pere Marquette River Restoration Committee; thus as individual BMPs are completed, quantities of pollutants controlled will be estimated and tallied with the perspective that more completed agricultural BMPs will complement less streambank stabilization BMPs and so on.

TABLE 53: TARGETED REDUCTION IN POLLUTANTS FOR THE PM WATERSHED						
Pollutant Source	**Current loading of each pollutant of primary concern**			**With 15% reduction in each pollutant *from each source***		
	Sediment (tons)	Phosphorus (lbs)	Nitrogen (lbs)	Sediment (tons)	Phosphorus (lbs)	Nitrogen (lbs)
Streambanks - 243 existing sites ranging minor to severe	1,072	1,614	3,228	161	242	484
Road Crossings - 235 existing site ranging minor to severe	433	6,118	12,236	65	918	1,835
Agricultural use - 96,000 acres (EPA Region 5 model, L-THIA land use results)	7,334	17,261	230,148	1,100	2,589	34,522
Total	**8,839**	**24,993**	**245,612**	**1,326**	**3,749**	**36,842**

Additionally, since the watershed area itself has other threats and problem areas, it is stressed that improvements and protections must be made across the watershed now in order to maintain the current water quality and protect it into the future. Most watershed goals outlined in Chapter 6 and tasks in Sections 7.3 and 7.4 seek to maintain or improve the current state of water quality and habitat, as well as increase awareness of this valuable resource. Additionally, the PMRRC will focus on land protection measures to protect the critical, high quality groundwater recharge areas that are so important to maintaining excellent water quality.

In addition to conducting an evaluation every five years regarding protection plan implementation, the PMRRC will evaluate whether or not water quality in Pere Marquette River Watershed is declining, improving, or staying the same. The following goals and indicators identified in Table 54 will be utilized:

TABLE 54: WATER QUALITY IMPROVEMENT GOALS AND INDICATORS FOR THE PERE MARQUETTE RIVER WATERSHED	
Water Quality Improvement Goal	**Indicators**
Michigan Water Quality Standards are not exceeded in any of the subwatersheds.	Dissolved oxygen, water temperatures, e. coli levels monitored. Water chemistry has been analyzed by MDEQ in 2000 and 2005, and will be analyzed again in 2015. No E. coli levels exceeding Michigan and US EPA water quality standards for both single day measurement (>300 E. coli per 100 mL of water) and 30-day geometric mean measurement (> 130 E. coli per 100 mL of water in 5 samples over 30 days). (See Task #7.1 in Section 7.3)
Improvement in or maintaining of macroinvertebrate populations and diversity in PM tributaries.	Monitoring results and staff reports produced by MDEQ Surface Water Assessment Section staff through their biological surveys of 27 stations in the Pere Marquette Watershed. MDEQ staff assess water chemistry, biological communities (macroinvertebrates and sometimes fish), and physical conditions (instream and riparian corridor habitat). Data has been collected in the years 2000, 2005, 2010 and will be collected in 2015. Primary indicator will be that all stations surveyed in the MDEQ Biological Survey will rate good to excellent for the macroinvertebrate populations.
Improvement in or maintaining of riparian/instream habitat quality throughout the watershed.	All stations surveyed in the MDEQ Biological Survey will rate good to excellent for instream, riparian habitat assessments.
	With completion of the updated Pere Marquette River Road Stream Crossing Inventory, reduction in number of sites with altered stream morphology and fish passage barriers, due to crossing structures.
	Updating of streambank erosion inventory as streambanks are stabilized and restored.
	Increasing level of NRCS WHIP and EQIP program participants for farmers installing buffers on PM streams.
Cladophora reportings and/or occurrences decrease and are non-existent.	Follow up on cladophora reportings by MDEQ, PMWC and other partners find no cladophora and/or there are no cladophora reportings by landowners and recreationists to begin with.
Flashiness trend in streams designated as county drains, streams that have already been tiled, and the Big South Branch.	Flashiness trends are decreasing in response to increased involvement from farmers with NRCS programs to install buffers on tributaries that are designated county drains.
	Re-evaluation of streambank erosion sites on the Big South Branch to see if trends are increasing or decreasing.
	Completion of wetland restoration projects in areas of wetland loss (Figure 36).
Quality of sport fishery is maintained.	Creel survey information from MDNR shows steady trout and salmon recruitment.
	MDNR electroshocking for status and trends surveys show stable fish populations and natural reproduction.
Pere Marquette Lake -eutrophic status does not increase and no PCBs are found in MDEQ survey	MDNR and MDEQ surveys show fish populations and diversity, and water quality and chemistry results are not decreasing.

PMRRC will continue to utilize monitoring results and staff reports produced by MDEQ Surface Water Assessment Section staff through their biological surveys of 27 stations in the Pere Marquette Watershed. As previously mentioned, MDEQ staff assess water chemistry, biological communities (macroinvertebrates and sometimes fish), and physical conditions (instream and riparian corridor habitat) of site locations. Data has been collected in the years 2000, 2005, 2010 and will be collected in 2015. Water chemistry has been analyzed in 2000 and 2005, and will be analyzed again in 2015. MDEQ has followed up on local reports of cladophora during these surveys. PMRRC will stay in close communication with MDEQ regarding these surveys; in the event that MDEQ discontinues these survey PMRRC will pursue other avenues via volunteers, non-profit organizations and consultants to continue the monitoring effort and expand it to other areas of the watershed if needed.

CHAPTER 8 FUTURE EFFORTS

The CRA and other project partners will continue to build partnerships with various groups throughout the watershed for future projects involving the implementation of recommendations made in this management plan. Funding sources for these projects will be pursued aggressively over the next 10 years. Government, foundation, and corporate grants will be researched as possible funding sources. Additionally, potential new mechanisms for funding by local communities will be investigated. It is expected that the implementation phase will last more than 10 years, with some efforts expected to be conducted on a yearly basis indefinitely. Grant funds and other financial sources will be used to implement tasks outlined in Chapter 7, including the continuation of water quality assessment and monitoring, installation and adoption of various BMP (Section 7.3), and educational tasks outlined in the IE Strategy (Section 7.4).

The Pere Marquette River Restoration Committee will continue to meet bi-monthly during the implementation period. As stated in Chapter 7, the Restoration Committee looked at the major sources of pollution in the watershed and decided that focusing on reducing and/or eliminating pollution stemming from road stream crossings, streambank erosion, agricultural practices, lack of riparian buffers, and the reduction of wetlands will address the bulk of sediment and phosphorus entering the Pere Marquette River, its tributaries, and its surrounding watershed. Focus will be given to implementation tasks (both BMPs and educational initiatives) that work to reduce the impacts from these sources in identified critical areas. Primary tasks that should be conducted over the next one to three years are as follows, with the most important tasks listed first:

- Road/stream crossing improvements using BMPs
- Develop Conservation Plans for farms, with focus on the Big South Branch and mainstem tributaries
- Land protection efforts via conservation easements and/or land acquisition
- Establish riparian buffers in critical areas
- Wetland assessment, restoration, and protection
- Streambank stabilization projects
- Initiate outreach and education efforts outlined in the IE strategy
- Assist with developing or revising Master Plans and Zoning Ordinances to include more water quality protection

Environmental awareness, education, and action from the public will grow as the IE Strategy is implemented and resident awareness of the watershed is increased. Implementing the IE Strategy is perhaps the most critical and important long-term task to accomplish. The strategy is designed to be used by a wide variety of organizations involved in managing the Pere Marquette River Watershed. During the implementation phase of the IE Strategy, the critical first steps to take will be to build awareness of basic watershed issues and sources of pollution, as well as how individual behaviors may impact the health of the watershed.

There have been significant accomplishments made in the watershed over the last 10 years as noted in Chapter 2. The current list of projects is constantly changing as various projects finish and new ones are added each year. The involvement of the CRA, USFS, PMWC,

MDNR, MDEQ, and County Road Commissions will likely remain steady as an increase in involvement from the NRCS, CDs and local municipalities is anticipated with the presumed shift in agricultural, education, planning and zoning efforts.

CHAPTER 9 CONCLUSIONS

The Pere Marquette River Watershed Management Plan was originally developed in 2001 to help guide efforts to protect the water quality of the Pere Marquette River and its surrounding watershed. The plan was revised and updated in 2011 to include additional information on pollutant sources and concentrations, load reduction estimates of various BMPs, measurable milestones to guide implementation progress, and a set of criteria to evaluate the effectiveness of implementation efforts. The recommendations outlined in Chapter 7 of the Pere Marquette River Watershed Management Plan will provide guidelines to all types of organizations for taking action during the implementation phase of the project and will be a useful tool in addressing current and future water quality threats to the watershed. The planning phase has allowed some of the key decision-makers, organizations, agencies, and the public to learn about the watershed in which they live.

The Pere Marquette River Watershed is a unique and high quality ecosystem with overall excellent water quality, little development, and a large amount of forested and riparian areas. Much of the watershed is within the Huron-Manistee National Forest and Pere Marquette State Forest. With that said, there are some important issues facing the quality of the natural resources including improper agricultural practices, the threat of invasive species, increased recreational use, and outdated road/stream crossings. Priority should be given to implementation tasks (both BMPs and educational initiatives) that work to reduce the effects from these and other sources. The watershed plan also delineates both priority and critical areas to identify specific places in the Pere Marquette River Watershed that are the most sensitive to environmental impacts and have the greatest likelihood to affect water quality and aquatic habitat (Figures 24 and 25). It is in these areas that the bulk of implementation efforts mentioned above should be focused.

The success of the Pere Marquette River Watershed Management Plan will depend on continued support and participation from key partner groups, along with the availability of monies for implementation of the plan. Partners responsible for the plan implementation are encouraged to review the document periodically, participate in the PMRRC, and take the initiative to promote progress where needed.

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APPENDIX A: MASTER PLAN STATEMENTS RELATED TO TOPICS REVIEWED

Character statements

"The community is characterized by over six miles of Lake Michigan shoreline and dune areas. In addition, its rolling hills and farmlands, attractive neighborhoods, rivers, and inland lakes help to define the Township's character." Pere Marquette Charter Township Comprehensive Plan at 8.

"Pere Marquette Township is fortunate to have large tracts of land offering important shoreline and dunes, wetlands, wildlife habitat, forest lands, and river valleys. These lands are a vital part of the community's identity…" Pere Marquette Township Comprehensive Plan at 75 (description of Conservation District).

"The Rural category is intended to preserve the character of the community. The preservation of agriculture, environmentally sensitive areas, as well as natural corridors shall be encouraged." Newfield Township Master Plan at 41.

"The objective of any regulation dealing with preserving rural character is to preserve as much of a building site as possible in a natural state. Reducing the man-made elements of the landscape is the key to maintaining a feeling of openness and nature." Land Use Plan – Barton Township at 18.

"The most common landscape view in Mason County continues to be a mix of woods, meadows, wetlands, river and lakeshores, and farm fields. …the rural landscape does more than simply provide scenery. The benefits of nature to residents' mental well-being and the attraction for tourists are important. Farming continues as a viable economic sector. Woods and fields help with water infiltration, maintaining biological diversity, and providing habitat for wildlife. Property owners have coordinated the retention of green space connections to create ecological corridors, enhance recreation, and provide a more continuous natural scenic view. Rivers, streams and lakes have buffer plantings that help protect water quality." Mason County Comprehensive Plan Update at 2-2 to 2-3.

"Both cultural and natural resources are preserved through wide community support by citizens who understand the value and principles of preservation." Mason County Comprehensive Plan Update at 2-5.

Land Use Limitations based on Environmental Constraints

"Goal – Guide, and appropriately regulate, the type and amount of growth. Objective – Ensure county and local regulations are properly directed to growth management and intergovernmental coordination. Strategy – Maintain formal site plan review procedures and standards for environmental protection of each of the environmental features listed above, and for groundwater protection in rural areas of the County." Mason County Comprehensive Plan Update at 2-9.

"Over-zoning is insidious in its ability to scatter residential development without regard to scenic and rural character considerations. The reality is that without public water and sewer, that density is dangerous to the health and welfare of the citizens." Oceana County 2020 Master Plan at 72.

"Establish density standards that are consistent with the natural capability of soils to handle on-site septic systems and which promote the preservation of the Township's valuable surface and ground water resources." Pleasant Plains Township Land Use Plan 1985 at 21.

"This plan recognizes the following as environmentally sensitive lands:

Areas with steep slopes
Soils with limitations for building construction
Soils with limitations for septic system suitability
Wetland areas
Water bodies
Protected and active agricultural lands
Sites of environmental contamination
Flood prone areas
Other unique natural resources.

These areas are identified based on soil types or other factors. Caution must be exercised when developing these areas.' Lake Township General Development Plan at 23.

"Limit significant new development in areas with environmental constraints, especially areas with poor soil suitability for septic systems and general building construction without providing available public services." Lake Township General Development Plan at 53.

Protecting Riparian Zone/Pere Marquetter River

The Pere Marquette River… and several branches are designated as both a Natural River by the State of Michigan, and a Scenic River by the Federal government. The Natural River designation requires increased setbacks and lot widths, a natural vegetation strip with limited vegetation clearing, limits on signs, and other provisions for a corridor extending 400 feet landward from each side of the river. The Federal Scenic Rive designation extends approximately ¼ mile inland from the centerline of the river on each side. Scenic rivers are those rivers or river segments that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads. Scenic rivers are managed to help prevent damage due to overuse or misuse of the shoreline." Mason County Comprehensive Plan Update at 3-16.

"Shoreline areas of streams, rivers and lakes would have waterside buffer plantings to filter storm water and provide shade and wildlife habitat." Oceana County 2020 Master Plan at 83.

"Maintain natural buffers between residential uses and the water resources." Lake Township General Development Plan at 52.

Protecting Wetlands

"Of particular concern are wetlands, rivers and streams… Wetlands exist across most of Mason County, which means that development will have to be designed very carefully in order to protect valuable wetland functions. Wetland functions include storm water storage and cleansing, groundwater recharge, spawning area for fish, nesting habitat for birds and other animals, and natural scenery." Mason County Comprehensive Plan Update at 3-7.

"Wetlands are areas which should not be developed in general. They are often transitional areas between upland habitats and aquatic habitats, and are described as the 'kidneys' of our water resources. They play an important role in water quality and need to be protected. Townships should implement a 'Wetland and Watercourse Protection Ordinance.'" Oceana County 2020 Master Plan at 80.

"Wetlands under five acres should likewise be protected and monitored to ensure the environmental integrity of the Township's water resources." Lake Township Geenral Development Plan at 19.

Preserving and Protecting Surface Water and Groundwater

"Goal – Maintain the viability of the primary lake residential communities in the county. Objective – Execute steps necessary to achieve improvement and enhancement of overall water quality for these lakes and connecting waterways." Mason County Comprehensive Plan Update at 2-15.

"In order to protect water quality and sensitive environments in Mason County, careful develop approaches will need to be used along rivers, streams, lakes, floodplains, wetlands and dunes. …most [of the rivers and streams] are of very high quality, supporting desirable species of game fish. Rivers and streams should be protected by setting development back from shorelines, providing vegetative filter strips, directing storm water runoff from impervious surfaces away from surface water and preventing sediment, toxic chemicals and warmed water from entering the water." Mason County Comprehensive Plan Update at 3-7 to 3-8.

"Those environmental elements that should be protected include surface and groundwater, wetlands, shorelines, forests, productive farmland and habitat for threatened and endangered species." Mason County Comprehensive Plan Update at 3-2.

"One of the greatest threats to the quality of surface water is non-point pollution. Rather than occurring from one major source… non-point source pollution comes from rainfall or snow melt moving over and through the ground. As this runoff moves it picks up and carries away natural and man-made pollutants, finally depositing them into lakes, rivers, wetlands, and groundwater. In Michigan, the greatest causes of non-point source contamination are agricultural practices, lawn chemical and soil erosion. One of the most effective means of preventing non-point source contamination is through the protection of the water's edge. The Barton Township Zoning Ordinance has a separate zone district, the Greenbelt District, which encompasses all land of the water's edge. Only residential and farming uses are permitted, along with other institutional and recreational uses by conditional use. Regulations within this district include a requirement for a 50 foot undisturbed strip of vegetated buffer to absorb runoff

nutrients from other areas, reduce erosion into the water, provide shade and cover for fish, and to provide screening. The ordinance also requires a 100 foot setback for main buildings. Clear cutting within the strip is prohibited, the only clearing allowed with in this strip is for dead and diseased trees, and noxious plants. The Barton Township survey results show 91 percent of the residents think protecting ground water sources is very important." Land Use Plan - Barton Township at 17.

"Heavy residential development around natural lakes always raises the need to cautiously monitor water quality for effluent from septic systems and livestock waste, fertilizers, and algae blooms. Accordingly, efforts exist within Newaygo County to upgrade sewage systems in residential areas near natural lakes and other waterfront areas and promote appropriate fertilizing and vegetative buffer areas in agricultural zones that exist near the waterways." Newaygo County Master Plan 2010 at 30.

"Objective 6c: Encourage planning and zoning techniques that protect water quality and minimize risk of overuse of lake, river, stream, and groundwater resources." Newaygo County Master Plan 2010 at 40 (see also other objectives under Goal 6).

Soil Erosion

"Goal 1: The Environment: To ensure that new development takes place in an environmentally consistent and sound manner and that the potential for flood hazard, soil erosion, disturbances to the natural drainage network and surface and groundwater contamination are minimized, thereby protecting natural resources and preserving scenic and environmental quality as well as minimizing the public burden." Pleasant Plains Township Land Use Plan 1985 at 21.

"The number one priority problem area identified in the Resources Plan is the control of streambank erosion along the Pere Marquette River and its tributaries. Streambank erosion releases sediment which can adversely impact on a river's eco-system. This sediment can cover fish spawning sites, fill deep water habitats and reduce fish habitat. Much of the original streambank erosion is due to previous logging practices. However present instability is due to human activity, such as clearing of vegetation and underbrush along rivers and lake edges, adding impervious surfaces (which accelerates water and sediment runoff), and uncontrolled ORV use and foot traffic. Reseeding and revegetation of eroded areas is critical to protecting the waterfronts. Limiting development at or near shorelines and controlling access to shorelines should also be encouraged. Increased enforcement of illegal ORV usage and education, especially for young riders will reduce environmental damage and help raise awareness of the problem. Designation of trails and proper grooming with reseeding, replacement of vegetation or trees to areas overly eroded can protect impacted areas." Lake Township General Development Plan at 20.

Storm Water Measures

"As buildings, parking lots and other impermeable surfaces associated with new development cover more of the Township's land surface, the quantity of storm water runoff is increasing. The vegetated landscape that previously absorbed and slowed much of the water associated with storms is replaced with urban surfaces. Unless specific preventive measures are

taken, this condition encourages flooding, soil erosion, sedimentation and pollution of area water resources. Though these conditions originate from site-specific circumstances, their impact can extend to adjacent properties and more regional areas including other communities within the same watershed. Increased quantities of runoff which occur as a result of property development should be contained on site, if necessary, to avoid placing excess demand on the capacity of the storm water system into which the runoff would otherwise be discharged. Proposed land uses should not be permitted if the level of service currently provided by existing storm water management infrastructure and/or existing drainage patterns will be decreased, unless necessary improvements to such infrastructure or natural drainage courses are first made. All new and existing land uses should comply with all county, state, and federal regulations regarding storm water management and soil erosion, including the regulations of the Newaygo County Drain Commissioner." Beaver Township Land Use Plan at 3-7.

"Manage storm water runoff to minimize impacts on streams and wildlife habitat and work with the County Drain Commissioner to establish consistent guidance for storm water management." Pere Marquette Charter Township Master Plan at 72.

Protecting Dunes/Hills/Steep Slopes

"Development of shoreline properties should not be permitted within the projected [shoreline] recession area. Other measures, such as planting or retaining vegetation on dunes and bluffs, and directing runoff from impervious surfaces away from the top of bluffs should be required." Mason County Comprehensive Plan Update at 3-8.

"In the area of prime beaches and critical dunes (nearly all Lake Michigan frontage for that matter), a High Risk Erosion overlay is of great assistance. Although the townships may want to look at: a) increasing the setback distance for certain areas of the shoreline and b) managing the setback from the bluff rather than from the ordinary high water mark. This overlay district at least sets up the basic mechanism for protection of the principle of tourism related asset for Western Michigan." Oceana County 2020 Master Plan at 79.

"Through zoning and site plan review, encourage developments that take natural features such as soils, topography, steep slopes, hydrology and natural vegetation into account in the process of site design." Newkirk Township Master Plan at 18-19.

Protecting Forest/Agriculture/Open Space

"Goal – Preserve Mason County's natural resources and the beauty of its landscape. Objective – Provide for planning mechanisms and regulatory techniques that will preserve forests, wetlands, sand dunes, and other natural resources as well as farms and other vegetated landscapes. Objective – A greenspace system of interconnected, undeveloped land, buffers, ecological corridors, forests, floodplains, wetlands, and other open spaces in private and public ownership is identified and protected in Mason County." Mason County Comprehensive Plan Update at 2-6 to 2-8.

"Goal – Update agricultural zoning to bring in line with modern farming methods. Objective – Minimize the incompatibility of non-farm rural residential area and large farm production facilities." Mason County Comprehensive Plan Update at 2-11.

"[T]he permitted zoning density on existing agricultural and forest lands should be changed from one dwelling unit per acre, to something substantially less; in the area of on dwelling unit per 40 acres would be best. …the maximum lot size should be 2 acres (unless the District Health Department required more because of soil conditions for the septic system)." Mason County Comprehensive Plan Update at 3-9.

"The county should explore creating its own PDR program and a transfer of development rights (TDR) program as well." Mason County Comprehensive Plan Update at 3-10.

"Protecting the environment is key to the survival of agriculture and tourism and to sustaining a high quality of life." Mason County Comprehensive Plan Update at 3-2.

"Goals and Objectives and Actions

- Townships should develop an Agriculture and Open Space Preservation Plan for the preservation of farmland and open space.
- Agricultural lands must be zoned to protect agriculture and open space by zoning large blocks (at least 40 acres) in Agricultural Protection districts.
- Promote County Implementation of Purchase of Development Rights ordinance and the local governments support of applications of agricultural land owners to apply for PDR or PA 116 to help preserve farmland." Oceana County 2020 Master Plan at 51.

"The Open Space Conservation category includes areas designated for the protection of sensitive and valued natural features such as forests and shorelands. Use of these areas should be reserved for non-motorized outdoor recreation. Development should be limited to park facilities." Newfield Township Master Plan at 40.

"Through careful site analysis and site planning quality development can be realized. The objective of incorporating natural features into site development is to allow new uses of land that do not irreversibly damage natural site features and attributes. The result is cost effective development that allows preservation of natural features and systems, creating long term benefits for the environment and the community." Land Use Plan – Barton Township at 21.

"Encourage land development which actively strives to preserve open spaces as part of a development project by incorporating on-site woodlands, wetlands, lakes, and fields." Beaver Township Land Use Plan at 2-4.

"GOAL: Encourage the continuation of local farming operations and the long-term protection of farmland resources." Beaver Township Land Use Plan at 2-5 (also see six objectives listed to implement this goal).

"Flood prone areas, environmentally sensitive areas, natural beauty areas, and prime agricultural lands in rural areas should not be urbanized. Development in these areas should be limited to avoid negative environmental impacts, and to preserve the agricultural and historical significance of the county." Newaygo County Master Plan 2010 at 2.

APPENDIX B:

ZONING ORDINANCE STATEMENTS RELATED TO TOPICS REVIEWED

Special District for Environmentally Sensitive Areas

"Forestry District: It is the intent of the Forestry District to protect the quantity and quality of the publicly owned woodland resources within Beaver Township, the enjoyment and protection of which is of great public interest and importance to Beaver Township, the State of Michigan, and the United States. …much of the land within this District is characterized by extensive wetland and woodland environments. Together, these public resources are important in providing for wildlife habitats, water and air purification, flood control, timber harvesting, and recreation opportunities, and support the desired rural character of the Township. It is the intent of this district to carefully review and limit the introduction of land uses which will undermine the intent, quantity, quality and value of these resources." Beaver Township Zoning Ordinance, Article 10 Zoning Districts, Regulations and Map, Section 10.06 Purposes of Zoning Districts (A)(1).

"The F, Forestry District is designed primarily to provide opportunities for seasonal type development. Lands in this district are not typically served with infrastructure necessary for more intense or year round development. The F, Forestry District is meant to assure long-term natural resource protection and low-impact recreational opportunities. Development within the Forestry District will require careful review to ensure that the integrity of environmental features and that the natural beauty of these zones are preserved for generations." Mason County Adopted Zoning Ordinance, Article XIV, F, Forestry District, Section 14.01, Statement of Purpose.

"The CON District is intended to protect floodplain areas, open land areas, wildlife areas and areas of scenic landscape and natural features which are generally classified as matters of conservation and in the Conservation District. This Conservation District is also recognized to preserve natural resources and assets and to protect persons and properties from the hazards of floods and soil erosion. It is not intended that any development or structures be established except as authorized by this Ordinance." Pere Marquette Charter Township Compiled Zoning Ordinance, Article III, Section 301, Conservation District, CON.

"The Township has determined that high risk erosion areas present unique environmental, health, safety and welfare concerns due to the potential for erosion by Lake Michigan, due to the general lack of public water and sanitary sewer service for such areas in the foreseeable future, and due to the character of existing development of lands in and near the high risk erosion areas. (The overlay continues to include a definition of boundaries, setbacks, and accessory uses among other topics)." Pere Marquette Charter Township Zoning Ordinance, Section 312.

"A strip fifty (50) feet wide bordering on each bank of the stream or other designated body of water, in this district, shall be maintained in trees or shrubs or in its natural state. Trees or shrubs in a space no more than fifty (50) feet in width may be trimmed or pruned for a view of

the water or for a dock. There shall be no more than one such trimmed or pruned area per principal use." Mason County Adopted Zoning Ordinance, Article XIII, Section 13.05, Native Vegetation Strip.

Permits for Environmentally Sensitive Areas or Uses

"Land Use Regulation for Watercourse Development

A. Permits: No land use shall be permitted unless all required permits or approvals have been obtained from the Department of Natural Resources, Department of Environmental Quality and/or other applicable federal, state, or local governmental agencies or authorities having jurisdiction.
B. Drainage: Footing drains or other subsoil drainage systems shall not empty directly into any lake, stream, river, or other watercourse.
C. Flood Plain and Wetlands: No dwelling or other principal building shall be constructed within a flood plain or wetland. The filling of any flood plain or wetland so as to raise the ground level shall not be permitted." Webber Township Zoning Ordinance, Article 2, General Provisions, Section 2.20, A-C.

"A fifteen (15) foot minimum undisturbed buffer zone between turf areas and natural water bodies, watercourses, or wetlands must be maintained. The buffer zone must contain natural vegetation and shall not chemically treated." Mason County Adopted Zoning Ordinance, Article XVII, Special Land Use Requirements, Section 17.28.2.b., Golf Courses, Buffering Requirements.

Riparian Zones/ Pere Marquette River

"The purpose of this district is to implement the public objectives embodied in the Pere Marquette River Management Plan and to preserve the natural state of the river. These objectives seek to preserve and enhance the values of the Pere Marquette River and its tributaries, as outlined in the respective plans, and especially to preserve tranquility and protect the economic value of this scenic resource and to prevent ecological and aesthetic damage which may result from overcrowding, overuse, or unwise or disorderly development." Sweetwater Township Zoning Ordinance, Article VI, Zoning District Regulations, Section 6.01.

"Greenbelt Preservation: All land within 300 feet of the water's edge of any tributary stream shall be the Greenbelt Zone of Barton Township. In order to preserve water quality in rivers and streams of the Township and to prevent deterioration of these streams and the major Great Lakes tributaries to which these waters drain, it is necessary to regulate the use of adjoining lands. Hereafter, no land within 300 feet of any stream may be used for any purpose other than the following: Single family residences, institutions or essential services, farming, public or private recreational park, playgrounds or clubs. No structure may be erected within 50 feet of the water's edge, or, if the established Flood Plain exceeds 50 feet, then within the Flood Plain area… A strip 25 feet wide, bordering the river banks, shall be planted and maintained in trees and shrubs, or if undisturbed, it shall be left in its natural state; provided, however, that an opening in such planting is permitted on each property to provide convenient access to the river; said access opening shall not exceed five feet. Trees and shrubs may be pruned or trimmed for a distance not to exceed 50 feet to obtain a view of the river or stream. Plans for any construction, grading, or any lot or subdivision preparation which involves removal of ground cover shall conform to the sedimentation control rules of the Newaygo County Soil Conservation District

and no building permit shall be issued until such conformity is assured. No septic tank drain fields may be closer than 100 feet to the water's edge and shall in placement and design conform to all regulations of the Tri-County Health Department." Barton Township Zoning Ordinance and Map, Article IV, General Provisions, Section 4.19.

Special Requirements for Wetland Areas

"Sensitive Lands:

1. Where a portion of a parcel is characterized by sensitive or fragile environmental features, including marshes, hydric soils, or flood plains, new development on the parcel shall only occur on those portions of the parcel void of such features where reasonably feasible.
2. Except where required to do so by state or federal law, the Township shall not approve any land use which requires a county, state, or federal permit until such permit has been obtained and satisfactory evidence has been submitted verifying the acquisition of the necessary permits, or satisfactory evidence has been submitted to the approving body verifying the acquisition of such permit is not necessary.
3. The Township may require mitigation measures to be taken to replace those resources disturbed or destroyed by a land use, or to otherwise lessen the impact of a new land use upon natural resources and sensitive areas. Beaver Township Zoning Ordinance, Article 18 Environmental Protection, Section 18.02(C).

Protect Streams/Surface Water/Groundwater

"Drainage-ways and streams shall be protected by a twenty-five (25 foot) natural vegetation strip measured from the centerline of such drainage-ways or streams." Webber Township Zoning Ordinance, Article 14, Planned Unit Developments, Section 14.04 (P)Project Design Standards, Natural Vegetation Strip.

"A strip fifty (50) feet wide bordering on each bank of the stream or other designated body of water, in this district, shall be maintained in trees or shrubs or in its natural state. Trees or shrubs in a space no more than fifty (50) feet in width may be trimmed or pruned for a view of the water or for a dock. There shall be no more than one such trimmed or pruned area per principal use." Mason County Adopted Zoning Ordinance, Article XIII, Section 13.05, Native Vegetation Strip.

"Planting Strip: A strip 75 feet wide, bordering the river banks, shall be planted and maintained in trees and shrubs, or if undisturbed, it shall be left in its natural state. The following variations may be made:

a) Trees or shrubs, or grass may be pruned or trimmed for a distance not to exceed 50 feet on each property to obtain a view of the river or stream." Zoning Ordinance of the Township of Monroe, County of Newaygo, State of Michigan, Article XIII, G Greenbelt District, Section 13.04 Additional Requirements.

"For projects with more than fifty (50) dwelling units or more than fifty thousand (50,000) square feet of enclosed space.

….

(9) An environmental impact assessment which describes the effect and impact, whether adverse or otherwise, the proposed PUD will or may have upon or with respect to the following matters:

a) The lands involved and the adjacent and nearby lands; streams, rivers, wetlands and the quality and volume of surface water and groundwater; wildlife and trees and other significant vegetation; the effect, if any, on surrounding property values." Webber Township Zoning Ordinance, Article 14, Planned Unit Developments, Section 14.06 (L) Application and Data Requirements.

"Car wash and oil change facilities may be permitted as special land uses provided that:

…

(D)That the use be subject to the following conditions, in addition to those imposed by the Township Zoning Ordinance and by other laws and ordinances.

…

(6)Elements of surface water drainage shall be accomplished so as to have no significant adverse effect upon adjacent or nearby lands or surface waters, by reason of erosion, pollution or otherwise.

a. The site shall be designed to prevent spills and discharges of polluting materials into the air, surface of the ground, groundwater, lakes, streams, rivers, or wetlands.
b. The applicant shall prepare and submit to the Township a Surface Water Drainage Plan, the approval of which shall be required by the Township.
c. State and Federal requirements for storage, spill prevention, record-keeping, emergency response, transport and disposal of hazardous substances and polluting materials shall be met." Webber Township Zoning Ordinance, Article 11, Section 11.04, Special Land Uses.

Soil Erosion

"A strip fifty (50) feet wide bordering on each bank of the stream or other designated body of water, in this district, shall be maintained in trees or shrubs or in its natural state. Trees or shrubs in a space no more than fifty (50) feet in width may be trimmed or pruned for a view of the water or for a dock. There shall be no more than one such trimmed or pruned area per principal use." Mason County Adopted Zoning Ordinance, Article XIII, Section 13.05, Native Vegetation Strip.

"Natural Features: Site plans shall demonstrate that as many natural features as possible have been retained, particularly where such features provide a buffer between adjoining properties or assist in preserving the general appearance of the neighborhood or help control soil erosion or storm water." Mason County Adopted Zoning Ordinance, Article XVIII, Site Plan Review and Approval, Section 18.05.2, Standards for Granting Site Plan Approval.

Storm Water Provisions

"Drainage Courses. Natural or manmade drainage courses which provide for the natural dispersion of snow-melting runoffs, rain runoff, natural drainage or underground waters shall be protected as follows:

(1) No structures, wells, or on-site septic systems may be built within 20 feet of such drainage courses.

(2) Drainage courses may not be filed, and the landowner shall keep same free of any debris, nor shall any organic or inorganic material by allowed to accumulate to obstruct the flow of water.
(3) Any alteration or change in a drainage course shall require a site plan approval by the Zoning Board, who shall find that the alteration shall not:
    a. Impede the flow of water, cause ponding, cause water back-up to public road ditches, or other private property, or cause other diversion of the course of water from the applicant's property to another location.
    b. Cause loss of flooding water back-up space or loss of flood-impeding capacity.
    c. Cause loss of area for effluent cleansing.
    d. Cause erosion." Lake Township Zoning Ordinance, Article 3, General Provisions, Section 3.10 (B) Land Alterations.

Sewer/Water Provisions

"No septic tank drain fields may be closer than 100 feet to the water's edge and shall in placement and design conform to all regulations of the Tri-County Health Department." Barton Township Zoning Ordinance and Map, Article IV, General Provisions, Section 4.19.

"No septic system may be located between the high water mark and the principal structure." Sauble Township Zoning Ordinance, Article 5, Zoning District Regulations, Section 5.6 (G), Building Line for Shoreland and Waterfront Development.

"Unpolluted water. No person shall discharge or cause to be discharged any storm water, surface water, groundwater, roof runoff, subsurface drainage, cooling water or unpolluted industrial process waters to any sanitary sewer. (The ordinance also includes sections defining temperature and substance standards for waste discharged to the sanitary sewer)." Yates Township Code of Ordinances, Chapter 50, Sanitary Sewage Disposal System, Section 50.07(A) Use of the Public Sewers.

Open Space Provisions

"Proper application of this Conditional Use is intended to ensure…the retention of the natural and rural character of the Township through preservation of open spaces, woodlands, streams, ponds, water frontage, hills and similar natural assets and the efficient use of land.

…

Open Space for Residential PUDs and Residential Condominium Developments – A minimum of thirty (30%) percent of the PUD or condominium development shall remain as open space for the common use of all PUD residents or condominium owners. Said open space may remain in a natural vegetative condition or may be developed with recreational facilities consistent with the natural character of the Township." Pere Marquette Charter Township Compiled Zoning Ordinance, Section 601:6 17. Planned Unit Development (PUD)/Condominium Development, subsections 1 and 10.

"This Section is intended to provide a property owner with the option to develop property zoned for residential development in a manner that allows no more than fifty percent (50%) of the property to be developed in the same number of single family dwelling units that could otherwise be developed on the entire property, provided that the remaining property (at least fifty

percent (50%) of the property) is permanently preserved as open space in an undeveloped state, in accordance with the Zoning Act, as amended.

The open space portion must remain perpetually in an undeveloped state by means of a recorded conservation easement, plat dedication, restrictive covenant, or other legal means that runs with the land, subject to the approval of the Township Board. This open space may be used to preserve natural resources, natural features, or scenic or wooded conditions, agricultural use, or a similar use or condition. Land in an undeveloped state does not include a golf course but may include a recreational trail, picnic area, children's play area, greenway, or linear park." Pere Marquette Charter Compiled Zoning Ordinance, Section 601:6 29, Open Space Development Projects, subsections 1 and 6e (Subsection 9 outlines bonus densities for projects preserving more than 55% in open space).

Management of Impervious Surfaces

"The purpose of this Article is to provide standards which will facilitate safe and efficient traffic movement and vehicular access in the Township." The article sets out private road standards for curb cuts, clear vision zones, construction and design standards, and widths of between 15 and 22 feet. This range of widths reduces the amount of impervious surface created by private roads. Beaver Township Zoning Ordinance, Article 19, Access Controls and Private Roads.

"Parking spaces and aisles shall be designed as shown below." The included diagram shows stall width of 9 feet and length of 18 feet, which results in 20% less impervious cover than 10 feet by 20 feet stalls. Pere Marquette Charter Township Compiled Zoning Ordinance, Section 801:1(14) Off-Street Parking Lot Requirements.

"Two or more buildings or uses may collectively provide the required off-street parking in which case the number of parking spaces shall not be less than two thirds of the sum of the requirements for the individual uses computed separately. The Zoning Board shall approve agreements between the parties involved to insure that adequate parking will be available for both uses." Sauble Township Zoning Ordinance, Article 10, Section 10.1(F), General Regulations.

"The Zoning Board may approve a reduction of the required parking if all of the following are shown:

A. The parking requirement is excessive, because of dual functions, joint ownership or use, where the hours of operation do not overlap, or if the use does not attract or provide service for the general public.
B. The maximum number of employees is shown on the site plan.
C. The landscape buffers are maintained.
D. A signed agreement to provide additional parking on site, when and if necessary, is presented." Sauble Township Zoning Ordinance, Article 10, Section 10.6, Parking Exceptions.

Agricultural Provisions

"This District is intended for residential and farm uses, including other uses generally associated with agriculture, and related non-residential uses. The purpose of this District is to

preserve the agricultural and rural residential character of the lands within this District, minimizing public service costs, limiting urban influence, and preserving a maximum of open space. Careful consideration is given to the environmental concerns related to groundwater quality and other related issues pertaining to development in rural areas with limited public services. All uses permitted within this District shall be conducted with due consideration for the potential effects which may result from authorized agricultural uses, in accordance with Public Act 94 of 1995, the Michigan Right to Farm Act." Crystal Township, Oceana County, Michigan, Zoning Ordinance, Chapter 5, Agricultural Rural Residential District – AR, Section 5.01, Description and Purpose.

Livestock Management Practices Provisions

"Intensive Livestock Operations

1. Minimum lot area shall be forty (40) acres.
2. The operation shall be set back a minimum of five hundred (500) feet from property lines, one thousand (1,000) feet from an adjacent Residential District or use, and five hundred (500) feet from a standing body of water or flowing stream.
3. No harm to adjacent property owners shall result from direct runoff from the site upon which the proposed operation is located." Crystal Township, Oceana County, Zoning Ordinance, Chapter 13, Special Land Uses, Section 13.02(Y).

"No animal waste lagoon shall be closer than two thousand (2,000) feet from any lake, stream, river, wetland, or natural drainage way, or ditches and drains under the jurisdiction of the Newaygo County Drain Commissioner." Beaver Township Zoning Ordinance, Article 11, Standards for Specific Special Land Uses, Section 11.09 Concentrated Livestock Operations.

APPENDIX C: Average Rates for Costs of Information and Education Tasks

Information and Education Cost Estimates

Task	Costs	Units	Notes	Source
Promotional				
Flyer	$ 0.28	each	black and white	Grand Valley Community Survey
T-shirts	$ 12.50	each	Three color m,l, and XL	Grand Valley Community Survey
Video Production	$ 6,000.00	each		Grand Valley Community Survey
Telephone book inserts standard	$ 0.07	each	min order of $2500	Verizon Super Pages
Telephone book inserts new resident	$ 0.20	each	min order of $2500	Verizon Super Pages
Bathroom Advertising	$ 75.00	each/month	monthly rate for 11"x 17" plus $95 design and $2 reproduction	Johnny Advertising
Bathroom Advertising	$ 35.00	each/month	monthly rate for 8.5" x 11" plus $95 design and $2 reproduction	
Newspaper Ad	$ 32.00	square inch	Sunday paper full page ad about $4000	Muskegon Chronicle
Newspaper insert	$ 0.05	each	Cost of service only, reproduction is not included (1 sheet max)	Berrien County Drain Commission
Utility bill inserts	$ 0.50	each	Reproduction and distribution	Grand Valley Community Survey
Yellow Pages Ad	$ 5,000.00	each/year	Half Page Add in Yellow Pages	Verizon Super Pages
Watershed Logo Signs	$ 90.00	each	11x17" sign	Grand Valley Community Survey
Operational				
Project Manager/year	$ 29,120.00	$15/hour		Bear Creek Watershed Project
Intern/year	$ 20,800.00	$10/hour		Bear Creek Watershed Project
Vehicle/year	$ 15,000.00	each	does not include maintenance or insurance	Bear Creek Watershed Project
Mileage	$ 3,840.00	$0.32/mile		MDEQ
Fringes (20%)	$ 13,752.00		20 percent of total	MDEQ
Community Development				
Oridinance Development	$ 8,000.00		lawyer fees and meetings	Grand Valley Community Survey

Education					
School Presentation	$	250.00	each	plus 20 hours preparation	Grand Valley Community Survey
4H Program	$	39,000.00	annually	Management, Staff, and programs	Bear Creek Watershed Project
Demonstration Sites					
Agriculture	$	1,350.00	each		Grand Valley Community Survey
demonstration booth	$	200.00	each		Grand Valley Community Survey
Outreach					
Riparian Club	$	8,000.00	annually		Grand Valley Community Survey
field trips	$	16.00	each student		Grand Valley Community Survey
phone hotline	$	1,142.00		first year startup	Bell South
Oil recycling container	$	2.79	each	min order of 300 and $750 delivery	GEOPlastics
Adopt-a-Stream Program	$	3,200.00	annually		Grand Valley Community Survey
Evaluation					
Water Quality Monitoring	$	180,000.00	annually		Bear Creek Watershed Project
Stream Monitoring	$	25,000.00	annually		Bear Creek Watershed Project
Fieldwork					
Canoe trip	$	250.00	each		Grand Valley Community Survey
Watershed tours	$	200.00	each		Grand Valley Community Survey
Public Relations					
Public Meetings	$	250.00	each		Grand Valley Community Survey
Workshop	$	500.00	each	plus 40 hours preparation	Grand Valley Community Survey
Committee Meeting	$	25.00	each		Grand Valley Community Survey
Newsletters					
Mailing	$	0.30	each	bulk non-sorted	USPS
	$	0.12	each	presorted bulk mail rate	USPS
	$	600.00	year	application and accounting fees for bulk mailing	USPS

Color glossy	$	2.30	each		Allegan Conservation District
Inserts	$	0.12	each	black and white	Berrien County Drain Commission
Envelopes	$	0.03	each	business envelopes box of 500	Staples.com
Letter	$	0.27	each	envelop, postage, and form letter	

APPENDIX D: Average Rates for Costs BMP Installation

Best Management Practices Cost Estimates*

Task	Costs	Units	Output	Notes	Source
Agriculture					
Conservation Tillage	$ 10.00	acre			NRCS
Fertility Testing	$ 2.75	acre		Lab testing done to MSU standards	MDA Conservation Service 1992 adjusted for inflation
IPM	$ 5.75	acre			MDA Conservation Service 1992 adjusted for inflation
Windbreaks	$ 2.00	foot		4200 feet needed for a square 40 acre field. Protects ten times as trees are high	NRCS
Cover Crop	$ 14.00	acre		sweet clover if using forage for harvest results in gain of $125/acre	NRCS
Critical Area Planting	$ 1,300.00	acre		Includes: grading, planting, herbicides, mulch, and labor.	NRCS
Livestock Exclusion	$ 3.50	foot			NRCS
Agriculture Crossing	$ 1,200.00	crossing	2/day		NRCS
Watering site	$ 5,100.00	site	.5/day	Well, pump, pipe and water facility	NRCS
Rental Rate	$ 58.00	acre		10 year lease $150/acre with grants	NRCS
Riparian Forested Buffer	$ 900.00	acre		Use of herbicides and establishiment and maintenance	NRCS
Riparian Herbaceous Buffer	$ 225.00	acre		On tilled land includes establishment and maintenance	NRCS

Filter Strip	$ 190.00	acre		establishment, herbicides, fertilizer, and lease	NRCS
Zebra Mussel Control	$ 440.00	acre		Irrigation system to control Zebra Mussels for a 1800 acre establishment	American Water Works Association, 1990 adjusted for inflation
Solar Irrigation Pump	$ 2,500.00	unit	3/day	Pump, controller, pipe, and collector	www.solarelectric.com
Waste Storage Lagoon	$ 45,000.00	unit			NRCS
Stream Erosion					
Live crib wall	$ 25.00	square foot	25 ft/day	see habitat restoration	Rogue River National Wet Weather Demonstration Project
Live staking	$ 2.50	stake		with 3 crew and foreman	Rogue River National Wet Weather Demonstration Project
Vegetated geogrid	$ 20.00	square yard		with 3 crew and foreman	Rogue River National Wet Weather Demonstration Project
Live fascine	$ 9.00	foot		with 3 crew and foreman	Rogue River National Wet Weather Demonstration Project
Brush layer	$ 13.00	foot		with 3 crew and foreman	Rogue River National Wet Weather Demonstration Project
Branch packing	$ 25.00	foot		with 3 crew and foreman	Rogue River National Wet Weather Demonstration Project
Coconut roll	$ 15.00	foot		with 3 crew and foreman	Gull Lake Shoreline Project
Joint Planting	$ 9.00	stake		with 3 crew and foreman	Rogue River National Wet Weather Demonstration Project 4 member crew with foreman
Riprap	$ 60.00	square yard		includes geotextile fabric: 2 member crew and foreman using heavy equipment	Means 1996 and adjusted for inflation: Includes heavy equipment rental
Tree revetments	$ 12.00	foot		with 3 crew and foreman	Means 1996 and adjusted for inflation
Bank Shaping	$ 15.00	cubic yard		With Heavy Equipment	NRCS

Average Bio-Engineering	$ 22.00	foot	Using soft methods only	NRCS
Average Streambank Restoration	$ 32.00	foot	Using hard methods and bioengineering	NRCS
Hydroseeding and Mulch	$ 2,200.00	acre		NRCS
Tile Outlet				
Riprap	$ 75.00	square yard	includes geotextile fabric: 2 member crew and foreman using heavy equipment	Means 1996 and adjusted for inflation
Vegetated geogrid	$ 20.00	square yard	includes geotextile fabric: 2 member crew and foreman	Means 1996 and adjusted for inflation
Pipe	$ 30.00	linear foot	10" pipe steel: 3 member crew, foreman, backhoe	Means 1996 and adjusted for inflation
Inlet/outlet structure	$3,500	each	concrete with riprap splash pool and vegetated geogrid slopes	Means 1996 and adjusted for inflation
Soil Stabilization/Repair	$2.50	square yard	2 member crew and foreman with heavy equipment	Means 1996 and adjusted for inflation
Trash and Debris				
Volunteer Mobilization	$ 60.00	day	Includes flyers, meetings, and memberagement	
Tree removal	$ 325.00	hour	includes crew, equipment, and removal fees	Means 1996 and adjusted for inflation: Includes heavy equipment rental
Waste hauling fees	$ 75.00	load	should include a $2 tip fee for each tire	
Heavy Obstructions	$ 890.00	each	includes, crew, equipment, and removal fees	Means 1996 and adjusted for inflation: Includes heavy equipment rental
Rill and Gully				
Berm and Tube	$ 1,500.00	each	with 3 crew, foreman, heavy equipment and materials	NRCS

Water Bars	$ 300.00	each			NRCS Nebraska Cost Estimator
Grassed Waterway	$ 690.00	acre		Best case Scenario with loose soil, no brush, and already tilled ($2245 ave.)	Means 1996 and Rogue River National Wet Weather Demonstration Project
Grassed Waterway	$ 3,800.00	acre		Worst Case Scenario in hard soil, with brush and dense vegetation ($2245 ave.)	Means 1996 and Rogue River National Wet Weather Demonstration Project
Stone Spillway	$ 9.50	square yard		3 member crew, foreman, heavy equipment and material	Means 1996 and adjusted for inflation
Diversions	$ 3.75	linear foot		grassed terrace to divert flow from tilled earth	NRCS and Means 1996
Habitat restoration					
Wetland Restoration	$ 2,350.00	acre		average of $500/acre and up	NRCS and Zbiciak
Channel block	$ 340.00	log structure	3-4/day	single log	Rogue River National Wet Weather Demonstration Project
Channel block	$ 480.00	log structure	2-3/day	triple height log	Rogue River National Wet Weather Demonstration Project
Channel block	$ 1,600.00	log structure	.5-1/day	crib wall: requires heavy equipment	Rogue River National Wet Weather Demonstration Project
Boulder Cluster	$ 59.20	cluster	25/day	varies depending on distance moved: requires heavy equipment	Rogue River National Wet Weather Demonstration Project
Cover logs	$ 290.00	log structure	5-10/day	3 member crew (requires heavy equipment)	Rogue River National Wet Weather Demonstration Project
Root wads	$ 300.00	wad	6-8/day	4 member crew (requires heavy equipment)	Rogue River National Wet Weather Demonstration Project
Tree Covers	$ 172.00	tree	8-12/day	If dropped in place or already in stream (requires heavy equipment)	Rogue River National Wet Weather Demonstration Project
Tree Covers	$ 215.00	tree	4-8/day	If they must me moved to site (requires heavy equipment)	Rogue River National Wet Weather Demonstration Project
Crib wall	$ 9.50	square foot	120+ feet/day	If done with heavy equipment	Rogue River National Wet Weather Demonstration Project

Crib wall	$ 36.50	square foot	20-30 feet/day	If done by hand	Rogue River National Wet Weather Demonstration Project
Log or Bank Shelter	$ 1,080.00	log structure	2/day	use in small streams with a low gradient (requires heavy equipment)	Rogue River National Wet Weather Demonstration Project
Deflectors	$ 390.00	log structure	2 pairs/day	requires highly experienced foreman to correctly size and place the structure	Rogue River National Wet Weather Demonstration Project
Channel Constrictors	$ 2,520.00	structure	1 pair/day	requires highly experienced foreman to correctly size and place the structure	Rogue River National Wet Weather Demonstration Project
Cross log	$ 680.00	structure	1-2/day	requires highly experienced foreman to correctly size and place the structure	Rogue River National Wet Weather Demonstration Project
Wedge and "K" dams	$ 1,360.00	dam	1/day	requires highly experienced foreman to correctly size and place the structure	Rogue River National Wet Weather Demonstration Project
Soil Stabilization					
Mulch	$ 500.00	acre		Using farm equipment	NRCS
Geotextile Fabric	$ 4.50	square yard		3 member crew, foreman, and material	Means 1996 adjusted for inflation
Seeding	$ 450.00	acre		includes site preparation using heavy equipment and 3 member crew	Means 1996 adjusted for inflation
Sodding	$ 13,068.00	acre		includes site preparation using heavy equipment and 3 member crew	Means 1996 adjusted for inflation
Check Dams	$ 15.00	linear foot		includes site preparation using heavy equipment and 3 member crew	Rogue River National Wet Weather Demonstration Project
Silt fence	$ 1.75	linear foot		Done with 3 member crew	Rogue River National Wet Weather Demonstration Project
Sediment Trap	$ 175.00	each		Done with 3 member crew	Rogue River National Wet Weather Demonstration Project
Road Crossing					
Box Culvert	$ 382.00	linear foot		36" culvert: excavation, crew, foreman, transporation, and installation	NPC Inc.

Bridge	$ 1,125.00	linear foot	72" culvert: excavation, crew, foreman, transporation, and installation	Bark River Culvert and Equipment
Cleaning	$ 8.50	cubic yard	Backhoe excavation of sediment	Rogue River National Wet Weather Demonstration Project
Equipment and Operator Rental				
Loader	$ 150.00	hour	includes operator	Rogue River National Wet Weather Demonstration Project
Excavator (backhoe)	$ 175.00	hour	includes operator	Rogue River National Wet Weather Demonstration Project
Dozer	$ 150.00	hour	includes operator	Rogue River National Wet Weather Demonstration Project
Crew	$ 30.00	hour		Rogue River National Wet Weather Demonstration Project
foreman	$ 50.00	hour		Rogue River National Wet Weather Demonstration Project
Design & legal			typically 25% to 30% of construction costs	Rogue River National Wet Weather Demonstration Project
Mobilization			3 to 5% of construction costs	Rogue River National Wet Weather Demonstration Project
Land Clearing	$ 300.00	acre	clearing and grading smooth	NRCS
Excavation	$ 3.50	cubic yard		Means 1996 and NRCS
Backfill	$ 12.00	cubic yard		Means 1996 and NRCS
Grade and Compact	$ 2.00	square yard		Means 1996 and NRCS

*** Prices are in 2002 dollars**