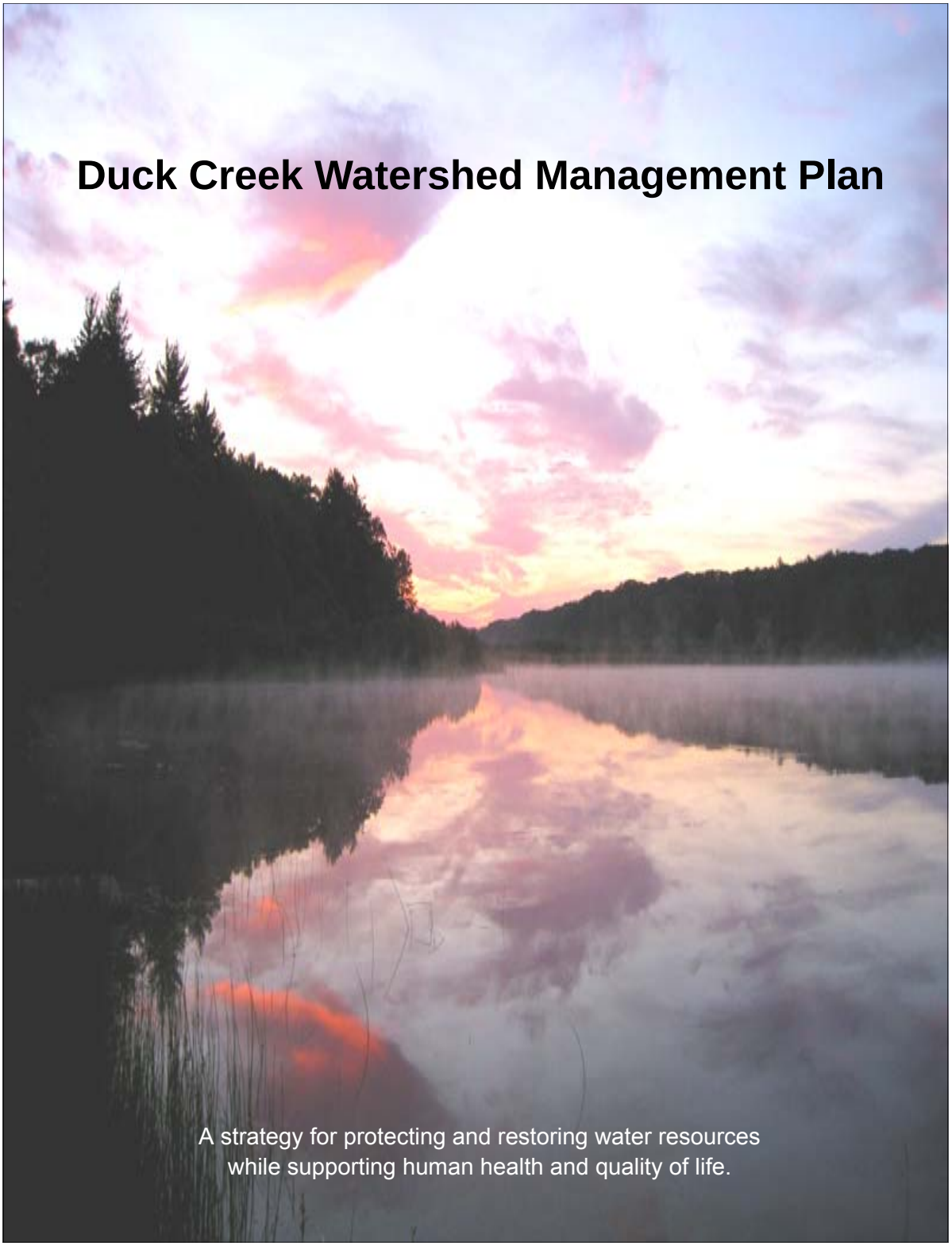
Duck Creek Watershed Management Plan



A strategy for protecting and restoring water resources
while supporting human health and quality of life.

Muskegon Conservation District & Annis Water Resources Institute of GVSU—September 2012

Duck Creek Watershed Management Plan

AWRI Code # MR– 2012-2
MDEQ Tracking Code # 2009-0020
September 2012

Revised
February 2013

Submitted by:
Muskegon Conservation District, and
Annis Water Resources Institute - Grand Valley State University

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Executive Summary

Why is the Duck Creek Watershed important?

The Duck Creek Watershed is 13,952 acres (21.8 sq. mi.) in size, and is located entirely within Muskegon County, Michigan. The watershed is situated between two larger watersheds to the south and north, the Muskegon River and White River watersheds, respectively. Major tributaries within the Duck Creek Watershed include Scholes Creek and Duck Creek which eventually converge and empty into Duck Lake. Duck Lake is a *drowned river mouth* lake with an area of 271 acres. The Duck Creek Watershed finally drains into Lake Michigan via a narrow channel at the mouth of Duck Lake.

The Duck Creek Watershed has a diverse and rich history. Ottawa Indians were known to inhabit the Duck Lake shoreline in the late 1700's followed by European settlers interested first in fur trading and later helping to develop the area as a lumber industry. By the early 1900's most of the timber having any value had been harvested, and ancestors of early residents began to consider tourism and agriculture as a new economic base. Tourism eventually won out as Duck Lake became a haven for recreation attracting many visitors from the Chicago area and elsewhere in the Midwest. The state of Michigan eventually acquired the property on the north side of Duck Lake as a state park, securing a long-term commitment for tourism and recreation use.

Today, the natural beauty and rural setting still characteristic of many places in the watershed coexist with what is advertised as Michigan's largest "Amusement Park and Water Park," Michigan's Adventure located in the upper most reaches of the watershed. While our nation's economy, and the economy of west Michigan specifically has resulted in fewer homes being built, the Duck Creek Watershed remains an attractive location for first and second home construction. It is reasonable to expect that this area will once again experience considerable pressure from all kinds of urban growth.

It was the suspected impacts from the Michigan's Adventure Amusement Park, together with the realization that the Duck Creek Watershed remains a valued and vulnerable resource that is already threatened by existing development that gave local stakeholders and the Michigan Department of Environmental Quality (MDEQ) increased concern for the watershed's future. If we intend to maintain the Duck Creek Watershed as a sustainable area for residential development with a tourism and recreational focus, we need to be proactive and very deliberate about dealing with current water quality problems and protecting against future water quality concerns.

What is the purpose of a Duck Creek Watershed Management Plan?

A watershed management plan like the one prepared for the Duck Lake Watershed typically has several purposes. Because this plan is being paid for in part by the U.S. Environmental Protection Agency (USEPA) through the MDEQ there are certain expectations and guidelines to follow with a focus on the control of *nonpoint source pollution*. We must establish what designated uses are being impaired or threatened. These designated uses include agriculture, navigation, fisheries (both warm and coldwater), aquatic life, recreation, and public water supply. We must determine where known pollution currently exists, where pollution is suspected, and where we think such pollution is a threat both now and in the future. Knowing or suspecting where pollution exists we need to document the source, the cause, and eventually identify control measures intended to eliminate or at least reduce the pollutant threat. Finally, USEPA/ MDEQ guidelines require that we estimate the cost of pollution controls and the benefit such controls are likely to achieve as measurable outcomes. We must even identify who is going to implement and manage such controls, both now and in the future.

The steps required for the development of a watershed management plan are well conceived, thoroughly discussed, and meticulously outlined for anyone to review. But at the heart of all of these detailed instructions is an underlying purpose. The underlying purpose for doing a Watershed Management Plan for the Duck Creek Watershed is to identify in a comprehensive fashion using scientifically based principles how we sustain this watershed, ensure its environmental integrity, guarantee its place as a resource for our residents and its visitors, and continue to support a thriving and critical tourism/recreation industry and ultimately our overall quality of life in west Michigan.

Who was involved in creating the Duck Creek Watershed Management Plan?

It takes a group of dedicated individuals to ensure the success of a watershed management plan. For the Duck Creek Watershed this group is the Duck Creek Watershed Assembly (DCWA). The DCWA was an important partner when it came to shaping the watershed management plan. Furthermore, the DCWA is dedicated to carrying out the goals and objectives outlined in the plan. Without the enthusiasm of the DCWA, the Duck Creek Watershed management plan would not have been possible.

Other key partners in the formation of the Duck Creek Watershed management plan were the Grand Valley State University's Annis Water Resources Institute (AWRI), Muskegon Conservation District (MCD), the Michigan Department of Environmental Quality (MDEQ), and Cardno JFNew.

Others involved in creating the Duck Creek Watershed Management Plan are the many people living in the Duck Creek watershed. Some of these residents have been there for years, even decades. These watershed citizens have a tremendous understanding about the problems impacting the area and what is important to the community. By ensuring that the public is involved and able to contribute to the development of the watershed management plan, we are more likely to create a plan that not only benefits water quality, and the ecological integrity of the entire watershed, but also supports community goals and objectives.

To ensure the participation of watershed residents the DCWA held regularly scheduled bi-monthly meetings. As the plan began to come together, the DCWA began to meet more frequently. These meetings gave stakeholders an opportunity to provide input to the watershed management plan. Participants on the DCWA included riparian owners, an environmental chemist, business owners, and natural resources managers. The DCWA meetings are open to the public and often attended by the Duck Creek Watershed Project Manager. On these occasions the Project Manager was able to provide planning updates and receive suggested inputs for plan development. Two meetings of the DCWA were specifically organized to solicit this kind of interaction from the public at large. As the project progressed, a DCWA Wiki Page was created to receive comments and input on the management plan from all members. The Wiki Page was also promoted via the MCD's webpage where community members could join the DCWA's discussion boards.

As part of the watershed planning project grant, the DCWA, MCD, and AWRI participated in a Social Indicators Planning and Evaluation System (SIPES) project. A social survey questionnaire was prepared and distributed to a random sample of 686 households in the Duck Creek watershed. The results from this survey were used to measure the familiarity of residents with watershed issues and their willingness to implement water quality protection practices.

What is the overall water quality in the Duck Creek Watershed?

As with every watershed, many of the water quality issues facing the Duck Creek Watershed today are an expression of events that occurred in the past. These past events include how the watershed was formed, how the natural setting was changed by native Indians and European settlers, and how *land use* has changed over time. This watershed management plan considers each of these events and others as we begin to understand how the Duck Creek Watershed has its own story to tell.

The analysis of water quality begins with physical inventories conducted by the DCWA and its numerous volunteers, the MCD/AWRI and their consultants, the MDEQ, and the

Michigan Department of Natural Resources (MDNR). Each of these inventories was conducted with specific data gathering objectives in mind. MDEQ trained volunteers looked at macroinvertebrates as an indication of water quality. These same volunteers and others used in place data loggers to collect long term temperature data. These experienced researchers also collected nutrient data at many of the same sample stations. The MDNR has over the years conducted several fishery studies. MCD/AWRI have walked a large portion of most tributaries with the intention of identifying areas of streambank erosion, failing septic systems, poorly designed and/or aging roads and culverts, and agricultural sources of pollution like cattle crossings and manure spreading operations.

Other sources of water quality information include computer models simulating *land use* change and the movement of pollutants throughout the landscape. These models help to identify critical areas in need of restoration and preservation. Using computer models we are even able to predict the cost/benefit of competing management options or generate scenarios that help us to understand what the future might hold.

What have we learned? We have learned that all things considered the Duck Creek Watershed is in pretty good shape! There are areas where we need to show some improvement, and there are considerable threats that we need to take care of sooner rather than later. We have taken the information gathered and have used the data to first identify areas of concern and then prioritize what is most important and what needs to be fixed first.

What does the Duck Creek Watershed Management Plan suggest to protect and restore the Duck Creek Watershed?

Designated uses for the Duck Creek Watershed are for the most part supported, except for concerns regarding the consumption of fish taken from Duck Lake. Duck Lake is connected directly to Lake Michigan and is thus limited by the same restrictions that apply to fish taken from this larger waterbody. Also, there are several designated uses that are threatened. This includes the watershed's coldwater fishery, partial body contact recreation, and total body contact recreation. The coldwater fishery is threatened by rising water temperatures. Partial body contact recreation is threatened by sediment, stormwater *runoff*, nutrients, *E. coli*, and invasive (exotic) species. Those pollutants identified as the highest priority are sediment and temperature. Nutrients are considered a medium priority while *E. coli* and invasive (exotic) species are low priority pollutants. Suspected sources for sediment pollution are stream banks, road stream crossings, stormwater *runoff*, and cattle crossings and all are considered high priority sources. A known source for increased temperature is stormwater *runoff* which is given a high priority. A suspected source of

nutrient pollution and *E. coli* is stormwater *runoff* which is again assigned a high priority source. Finally, invasive (exotic) species are known to originate from human transport and is assigned high priority source.

The identification of these pollutants, their sources, and their causes have led to several specific **restoration goals**.

Goal 1: Protect/Improve water quality by reducing sediment contributions and stabilizing known streambank erosion sites, isolating cattle crossing, repairing damaged/poorly functioning culverts, renewing/rehabilitating former wetlands, and educating property owners regarding use of stormwater management practices. The target will be to reduce the sediment load in the watershed by 167,455 lbs/year. This target was derived by calculating total sediment load reductions from BMP implementation, as reported in Appendix R.

Goal 2: Protect/Improve warm and coldwater fisheries by eliminating sources of warmwater discharges and otherwise stabilizing water temperatures. The target of water temperature will be to keep temperature within the range for warmwater and coldwater fisheries. A monthly maximum limit for coldwater fisheries is 68º F during the months of June, July, and August, and 63º F in September. A monthly maximum limit for warmwater fisheries is 80º F in June, 83º F in July, 81º F in August, and 74º F in September. Heat load is to be measured at the edge of the mixing zone (MDEQ 2006).

Goal 3: Protect/Improve water quality by reducing nutrient contributions from residential, commercial, and agricultural sources including fertilizer users, pet owners, and livestock operators. The target will be to reduce nitrogen by 1,953 lbs/year and phosphorus by 597 lbs/year. This target was derived by calculating total nitrogen and phosphorus load reductions from BMP implementation, as reported in Appendix R. Part 4 Water Quality Standards for plant nutrients state, “nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the surface waters of the state” (MDEQ 2006).

Goal 4: Protect/Improve the recreational uses of the watershed by reducing *E. coli* and other bacteria contributions from residential, commercial, and agricultural stormwater *runoff*. The target will be to stay below the water quality standards to protect partial and total body contact designated uses. Part 4 Water Quality Standards for microorganisms state, “ all surface waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1,000 *E. coli* per 100 milliliters. Compliance shall be based on the geometric mean of 3 or more samples, taken during the same sampling event, at representative locations within a defined sampling area” (MDEQ 2006).

Goal 5: Protect/Improve the recreational uses of the watershed by preventing the spread of

invasive species. The target to reduce the impacts of invasive species is a 50 percent reduction in existing (2011) cover.

The plan also identifies **goals for preservation**.

Goal 1: Ensure high quality drinking water for residents of the Duck Creek Watershed.

Goal 2: Protect high quality and essential habitat for known endangered/threatened species.

Goal 3: Protect high priority Open Space having shared, public, and private ownership.

Goal 4: Protect and preserve current access sites along Duck Creek and Duck Lake.

Goal 5: Give additional focus to navigation needs and the elimination/maintenance of Invasive Species including in particular Eurasian Watermilfoil, Coontail, and Phragmites.

The plan goes on to describe both general and specific areas throughout the Duck Creek Watershed for the implementation of these goals. It also makes recommendations for appropriate management measures.

What are the next steps?

Now that the plan is complete, it is the responsibility of the DCWA and the many supporting stakeholders to implement the plan. This will require continued partnerships and collaboration with local government, regulatory agencies, businesses, and non-profit organizations. Implementation requires a long-term investment including fund raising, grant development, recruiting and training of volunteers, education, and evaluation. The plan will be updated, new targets and schedules developed, new practices investigated, and new leadership nurtured.

Plan implementation is a dynamic process requiring a great deal of commitment. However, the rewards are obvious. A healthy, thriving watershed is a valued asset to any community. Such a watershed contributes to a community's sustainability and impacts the economy, as well as supports the overall quality of life for all its residents.

So, where do we start? The plan contains a detailed assessment of what restoration efforts are required. It offers suggestions on what best management practices might be employed and how we can measure their effectiveness. The plan even suggests which problems should be dealt with first and when. Refer to the various appendices for the details needed.

Chapter 1
Introduction

Chapter Objectives

Define the term “watershed”
Know the location of the Duck Creek Watershed
Understand the purpose of a watershed management plan
Learn how the public was informed and involved in this process

Duck Lake Channel flowing into Lake Michigan. Photo taken by Nichol De Mol 8/2010.

1.1 Chapter 1 Summary

Highlighted below are some of the major points that you will learn in Chapter 1.

- A watershed is the area of land where all of the water that is beneath it or runs off of it goes into the same place, like a river, lake, or reservoir.
- Everyone lives in a watershed. You and everything in your watershed, including birds, animals, fish, etc. are part of this unique community.
- Having an understanding of the common parts of each watershed can provide the groundwork for understanding the complex dynamics of a watershed as a whole.
- The Duck Creek Watershed lies entirely within Muskegon County, Michigan. Together with Scholes Creek, the Duck Creek Watershed drains 13,952 acres (21.8 sq. mi.) of land in Dalton and Fruitland Townships.
- Duck Creek empties into Duck Lake, a *drowned river mouth* lake with an area of 271 acres. Duck Lake, in turn, drains into Lake Michigan via a narrow channel on the west end of the lake.
- The health of our waters is a principal measure of how we live on the land.
- Traditional *land use* planning does not adhere to natural boundaries, but to those boundaries drawn by humans.
- A watershed management plan can investigate all uses and pollutants in a designated watershed, and analyze their impacts on the water.
- Since watershed management plans encompass the whole *ecosystem*, they have the potential to provide an extensive understanding of a watershed's function and condition.
- It takes a group of dedicated individuals to ensure the success of a watershed management plan. For the Duck Creek Watershed this group is the Duck Creek Watershed Assembly (DCWA). Other groups include: the Muskegon Conservation District (MCD), the Michigan Department of Environmental Quality (MDEQ), and Cardno JFNew, a group focused on ecological and *ecosystem* restoration.

- As critical as it is to involve the watershed organizations in the planning process, it is just as vital to include the public from the beginning of plan creation to its completion.
- Citizens are invited to participate by attending watershed association meetings or other planning meetings. They can provide inputs and stay up-to-date on the project by visiting the project website, reading articles about the project in the local paper, and subscribing to various newsletters.

1.2 What is a Watershed?

A watershed is the land that water flows across or under on its way to a river, lake, wetland, or body of water (Figure 1). Watershed boundaries can be identified by tracing along the highest elevations between two areas, often a ridge and sometimes referred to as a divide. Therefore, watersheds do not follow political boundaries and can include many counties and even span across several states or different countries.

Every watershed is different in terms of its shape, size, and landscape features. But one thing remains the same: everyone lives in a watershed. You are part of a watershed community and everything you do, good or bad, in your watershed affects the soil, water, air, plants, and animals.

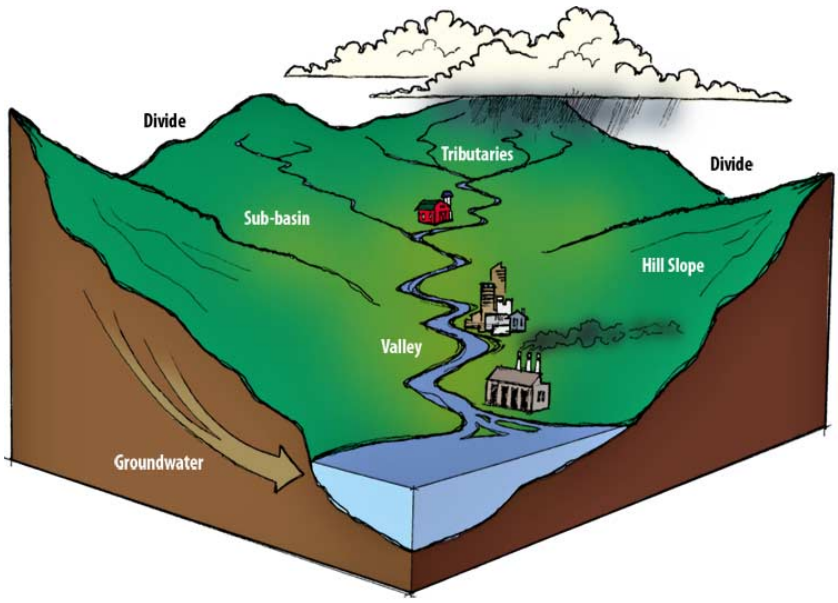


Figure 1.
A diagram of a watershed. Diagram provided by Ducks Unlimited.

1.3 The Duck Creek Watershed

The Duck Creek Watershed is 13,952 acres (21.8 sq. mi.) in size, and is located entirely within Muskegon County, Michigan. The watershed is situated between two larger watersheds to the south and north, the Muskegon River and White River watersheds, respectively (Figure 2). The headwaters of Duck Creek are part of a wetlands complex in western Dalton Township. A major tributary that flows into Duck Creek is Scholes Creek. The headwaters of Scholes Creek are part of a different wetlands complex located in northeast Fruitland Township (Figure 3). Scholes Creek converges with Duck Creek, and then travels 1.8 miles until it empties into Duck Lake. Duck Lake is a *drowned river mouth* lake with an area of 271 acres. The Duck Creek Watershed finally drains into Lake Michigan via a narrow channel at the mouth of Duck Lake (Figure 4).

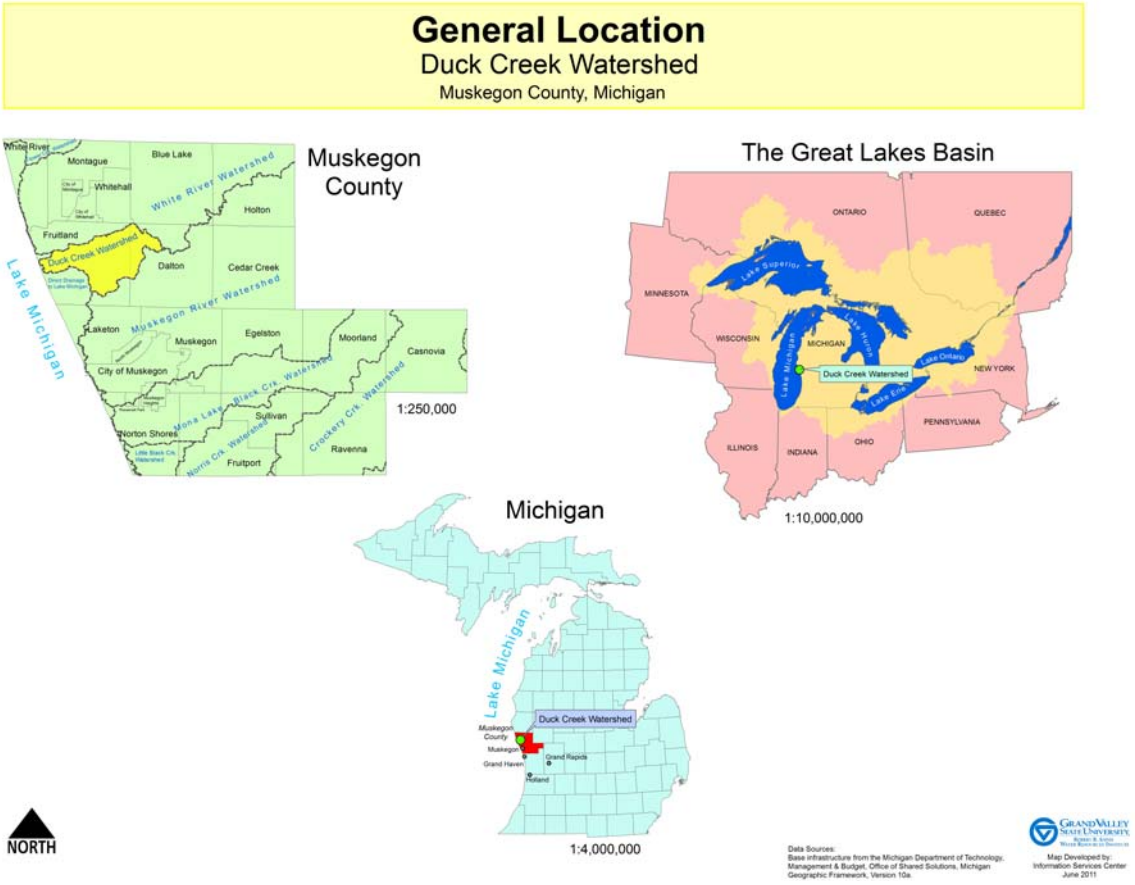


Figure 2. Duck Creek Watershed Reference Map. Produced by GVSU-AWRI.

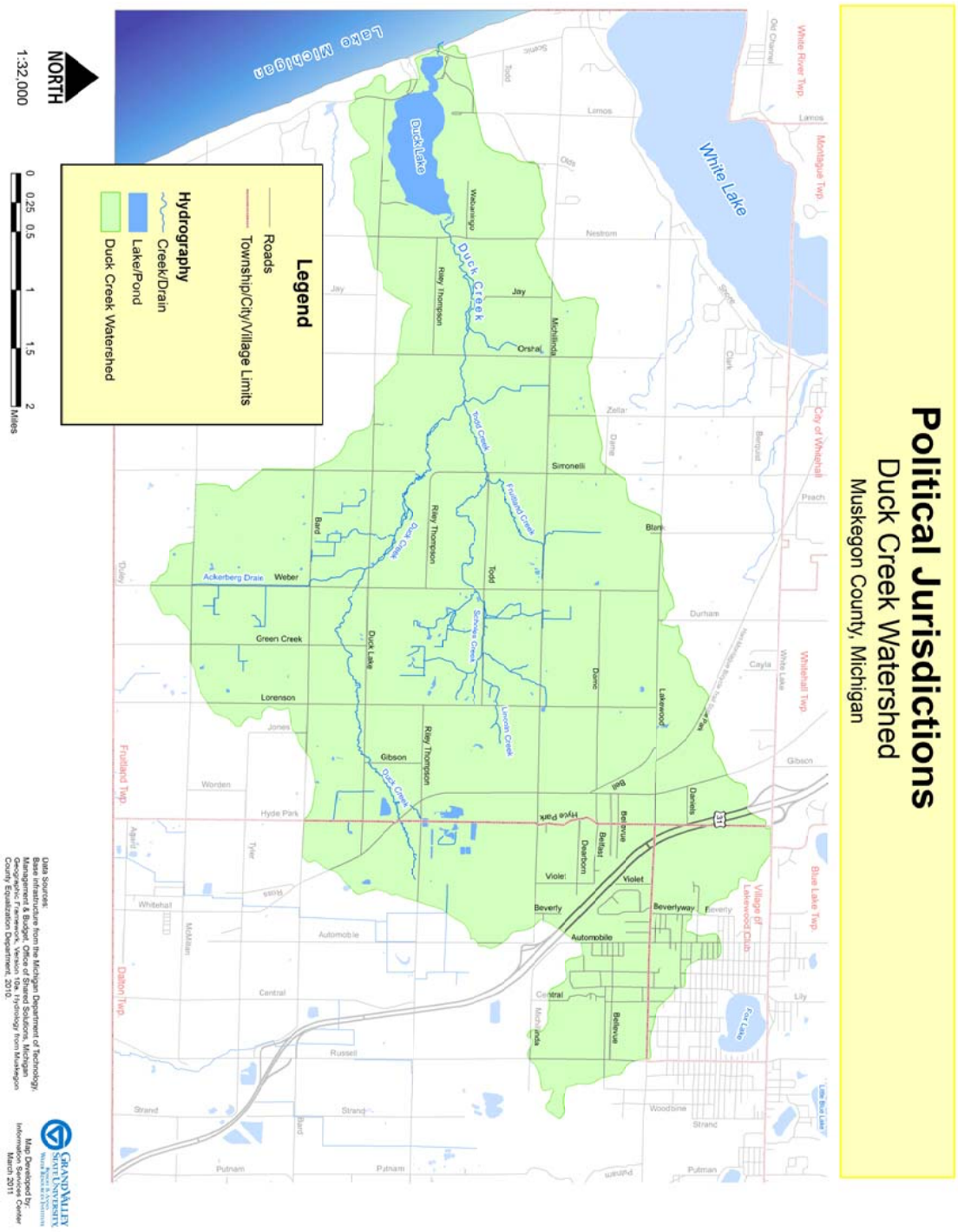


Figure 3. Political Boundaries in the Duck Creek Watershed

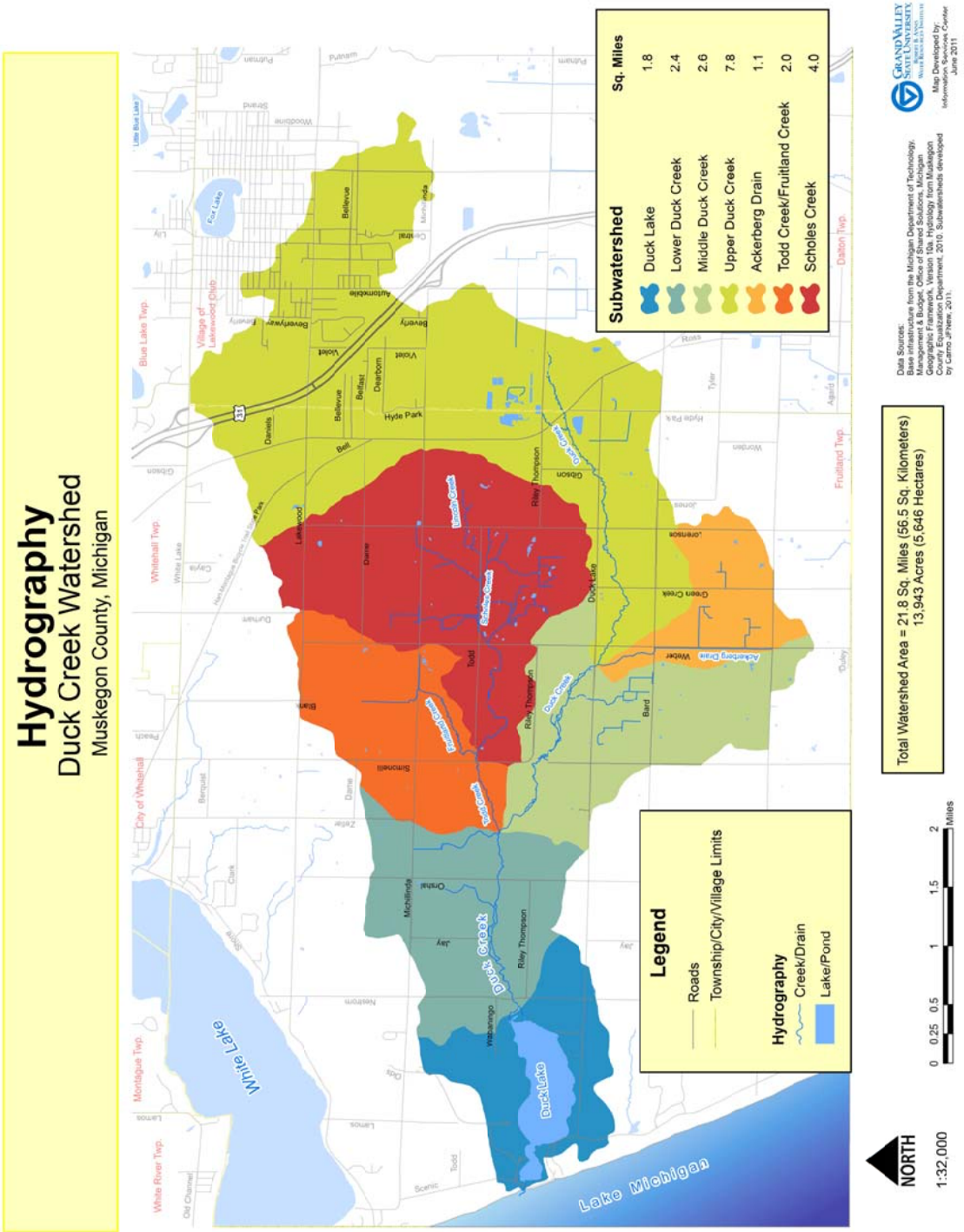


Figure 4. Hydrography in the Duck Creek Watershed

1.4 The Purpose of a Watershed Management Plan

A famous hydrologist named Luna Leopold once stated that the health of our waters is the principal measure of how we live on the land. Leopold was a trailblazer when it came to examining the interconnection between the *anthropogenic* activities on the land, and the quality of the waters which run through it. *Land use* planning has focused traditionally on jurisdictional boundaries such as counties, township, and cities - all boundaries that were developed by humans. Since watersheds do not always match up to political boundaries, the protection of water resources by traditional planning techniques often fall short with less than satisfactory results.

To make planning decisions that will not endanger human and environmental health, we must take a holistic approach to *land use* planning based on *ecosystems*. Watersheds are natural boundaries in which the relationships between humans and the environment can be examined and addressed. Often times, this is done by using a watershed management plan. A watershed management plan can investigate all uses and pollutants in a designated watershed, and the impacts they have on the water. Since these types of plans encompass a whole *ecosystem*, they have the potential to provide an extensive understanding of a watershed's function and condition.

1.5 Plan Developers

It takes many dedicated individuals to ensure the success of a watershed management plan. For the Duck Creek Watershed there is a group of such individuals, the Duck Creek Watershed Assembly (DCWA) (Figure 5). The DCWA was an important partner when it came to shaping the watershed management plan. Furthermore, the DCWA is dedicated to carrying out the goals and objectives outlined in the plan. Without the enthusiasm of the DCWA, the Duck Creek Watershed management plan would not have been possible.

Other key partners in the formation of the Duck Creek Watershed management plan were the Grand Valley State University's Annis Water Resources Institute (AWRI), Muskegon Conservation District (MCD), the Michigan Department of Environmental Quality (MDEQ), and Cardno JFNew.

Figure 5. Duck Creek Watershed Assembly Volunteers Preparing for Sample Collection

Current members of the DCWA include: Bob Brown, Steve Coverly, Chris Deur, Jan Deur, Tom Hamilton, Glenn Hayden, Lee Holly, Kevin Klco, Lynn Knopff, Norman Knopff, David Pequet, Val Rissi, Dave Roberts, Tom Tisue, Bill Traynor, and Rob Zellmer,

1.6 Public Involvement

As critical as it is to involve the watershed organization in the planning process, it is just as vital to include the larger public from the beginning of plan creation to its completion. Many people living in the Duck Creek watershed have been there for years, even decades. These watershed citizens have a tremendous understanding about the problems impacting the area and what is important to the community. By ensuring that the public is involved and able to contribute to the development of the watershed management plan, we are more likely to create a plan that not only benefits water quality, and the ecological integrity of the entire watershed, but also supports community goals and objectives.

Working Sessions

At the beginning of the watershed management planning process the DCWA held regularly scheduled bi-monthly meetings. As the plan began to come together, the DCWA began to meet more frequently as a need developed. These meetings gave stakeholders an opportunity to provide input to the watershed management plan. Participants on the DCWA included riparian owners, an environmental chemist, business owners, and natural resources mangers.

Public Information Meetings

The DCWA meetings are open to the public and often attended by the Duck Creek Watershed Project Manager. On these occasions the Project Manager was able to provide planning updates and receive suggested inputs for plan development. Two meetings of the DCWA were specifically organized to solicit this kind of interaction from the public at large.

Project Articles

Over the course of the project, there were several articles that appeared in both the Muskegon Chronicle and the White Lake Beacon, local newspapers which cover the Duck Creek watershed area. The initial press release that acknowledged receipt of the grant award from the United States Environmental Protection Agency (USEPA)/MDEQ by the Muskegon Conservation District appeared in the Muskegon Chronicle on October 4, 2009 and the White Lake Beacon on October 9, 2009. Another press release was again issued to both newspapers announcing the completion of a draft plan and an invitation for input.

Project Website

As the project progressed, a DCWA Wiki Page was created to receive comments and input on the management plan from all members. The Wiki Page was also promoted via the MCD's webpage where community members could join the DCWA's discussion boards.

Project Survey

As part of the watershed planning project grant, the DCWA, MCD, and AWRI participated in a Social Indicators Planning and Evaluation System (SIPES) project. A social survey questionnaire was prepared and distributed to a random sample of 686 households in the Duck Creek watershed. The results from this survey were used to measure the familiarity of residents with watershed issues and their willingness to implement water quality protection practices. Survey results have been summarized and included in Appendix A as part of the Information and Education Strategy for the Duck Creek Watershed.

1.7 Resources

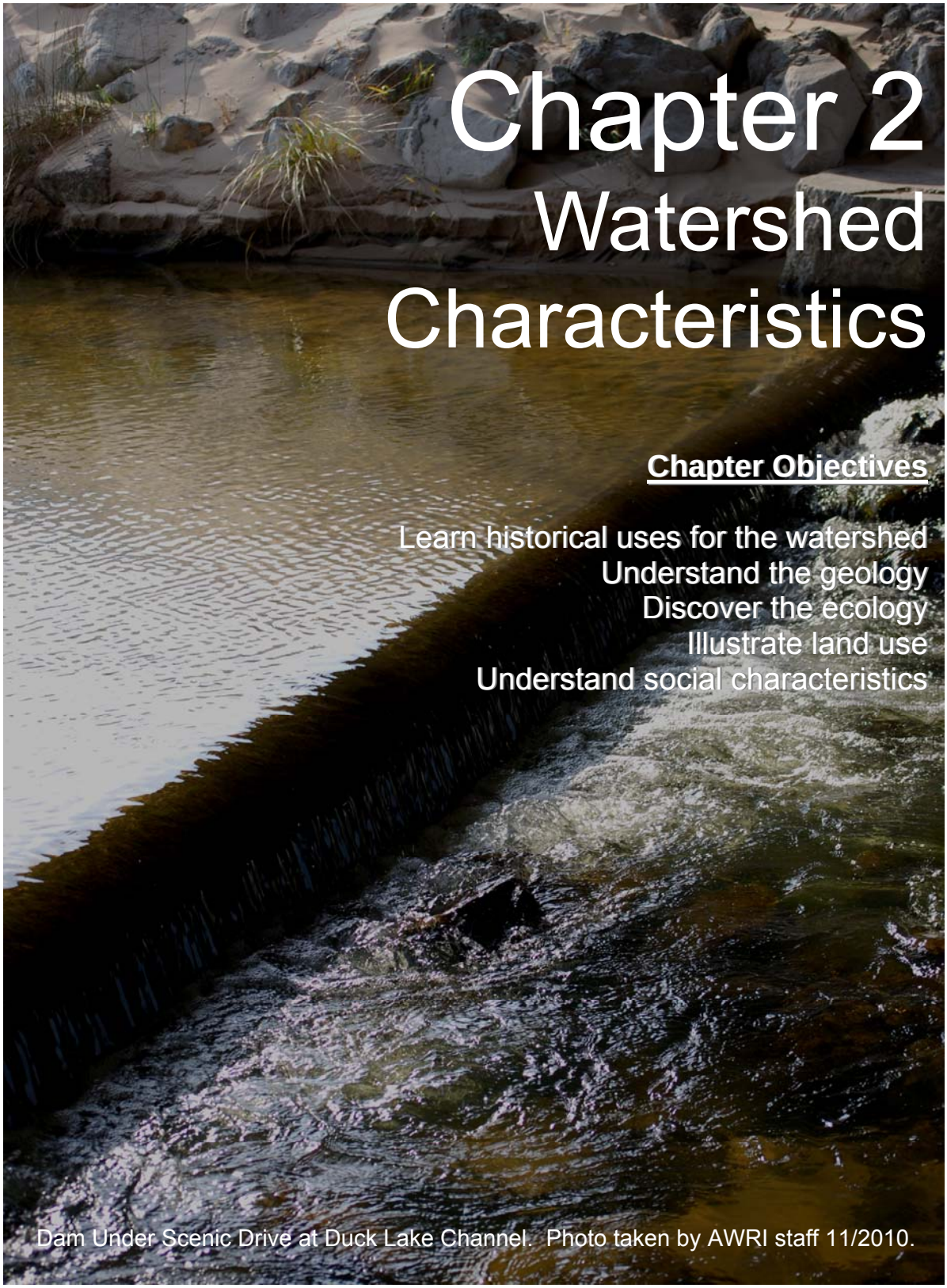
Below is a list of websites where you can go and learn more about the Duck Creek Watershed, as well as watersheds in general. You can also find websites of partners who assisted in the development of the watershed management plan.

Muskegon Conservation District
http://www.muskegoncd.org/

Grand Valley State University's Annis Water Resources Institute
http://www.gvsu.edu/wri/

Michigan Department of Environmental Quality
http://www.michigan.gov/deq/

United States Environmental Protection Agency
http://www.epa.gov/
http://www.epa.gov/owow/surf/



Chapter 2
Watershed Characteristics

Chapter Objectives

Learn historical uses for the watershed
Understand the geology
Discover the ecology
Illustrate land use
Understand social characteristics

Dam Under Scenic Drive at Duck Lake Channel. Photo taken by AWRI staff 11/2010.

2.1 Chapter 2 Summary

Below are some of the key highlights associated with Chapter 2 of the Duck Creek Watershed Management Plan.

- The early history of the Duck Creek Watershed was centered on the trading of the area's natural resources, primarily the animal pelts, and the lumber from its forest.
- When the lumbering industry phased out, tourism in the area began to thrive.
- *Geology* is the study of the Earth. More specifically, *geology* examines the materials in which the Earth consists, how those materials are structured, and the processes acting upon the materials and structures.
- The *geology* of the Duck Creek watershed is important because it allows us to understand why there are different landscapes within the watershed.
- *Ecology* is the study of organisms and their relations to each other and their environment. The Duck Creek Watershed has an array of unique plants, animals, and habitats, including threatened species such as the eastern box turtle, tall green milkweed, cerulean warbler, and nodding pogonia which have been observed some time in the past.
- *Land use* refers to how land is used by humans. *Land use* in the watershed can directly influence the water quality of a stream as well as its underlying structural composition. *Land cover* indicates the vegetation, structures, or other features that cover the land.
- *Ecology* and *land use* must be understood in order to address many concerns within a watershed, especially when understanding the different role each level of government plays in decision-making.
- The social characteristics of interest within the watershed include the perceptions, awareness, attitudes, and behavior of the local residents in the Duck Creek watershed with regard to water quality and the protection of aquatic habitats. These characteristics, in addition to the population, political structure, and overall character of the watershed, are influential in creating effective watershed decisions, goals, and policies.

2.2 Duck Creek Watershed's Early History

History of the Duck Creek Area: The Fur and Lumber Trade

The early history of the Duck Creek Watershed was centered on the trading of the area's natural resources, primarily the animal pelts, and the lumber from its forest. Before the settlement of the Europeans, the Duck Creek Watershed was home to a small tribe of Ottawa Indians. The Ottawas were known as "a quiet, peaceable race, and well liked." (*History of Muskegon County, Michigan*, 1882). The tribe lived around Duck Lake, which they called "*Jibshi Sagagan*" (Cabala 2008). During this time, the watershed's land cover was dominated by two types of forest. Vast white pine and white oak forest were present in the western portion of the watershed, and also in a narrow band along the northern rim of the watershed. The middle section of the Duck Creek Watershed contained forest consisting of beech, sugar maple, and hemlock trees. There were also large conifer swamps in the south and northwest part of the watershed (Figure 6). It was these natural resources that attracted the first Europeans to the Duck Creek area.

The first known European to come to the Duck Creek area was a fur trader named Joseph LaFramboise in the late 1700s. LaFramboise, originally from Nova Scotia, was a fur trader with the John Jacob Astor's trading company. LaFramboise's trading post was on the south side of the Duck Lake channel overlooking Lake Michigan. His trading post was one of many that lined the Lake Michigan shoreline from the Kalamazoo River to Grand Traverse Bay (Cabala 2008). In the 1840s, the start of the lumber industry marked the beginning of a community around Duck Lake. Charles Mears, originally from Massachusetts, came to Michigan in 1836 to run a general store with his brother (Cabala 2008). Mears soon branched out into lumbering and built the first of two sawmills at the mouth of Duck Creek in 1848. The land was purchased from the government at $1.25 an acre (*History of Muskegon County, Michigan,* 1882). Mears and his men were thought to be among the first settlers in Fruitland Township. During the next 25 years Mears would purchase about 40,000 acres of land, construct and operate 15 mills, and build five harbors to transport lumber (Cabala 2008).

At Duck Lake, Mears constructed a water mill and, later, he would build a steam-powered mill. Both would be destroyed in a fire in 1859, reportedly started by his disgruntled unpaid laborers (Cabala 2008). It was around these saw mills that the small village of Cork Point was established and led to the construction of a dam, which was needed to raise the water levels for the mills (Meikle 1976). In the mid to late 1800s, Cork Point had its own post office, blacksmith, store, warehouse, and housing for the mill's workers (Cabala 2008). This village was described by Charles Mears' daughter, Carrie, as "a center of activity for the whole surrounding territory" (Cabala 2008). Eventually, the virgin forests of the Duck Creek watershed were completely gone, and the lumbering era with it. The end of this era coincided with a rise in tourism, agriculture, and other industries. Mears' property at the south-

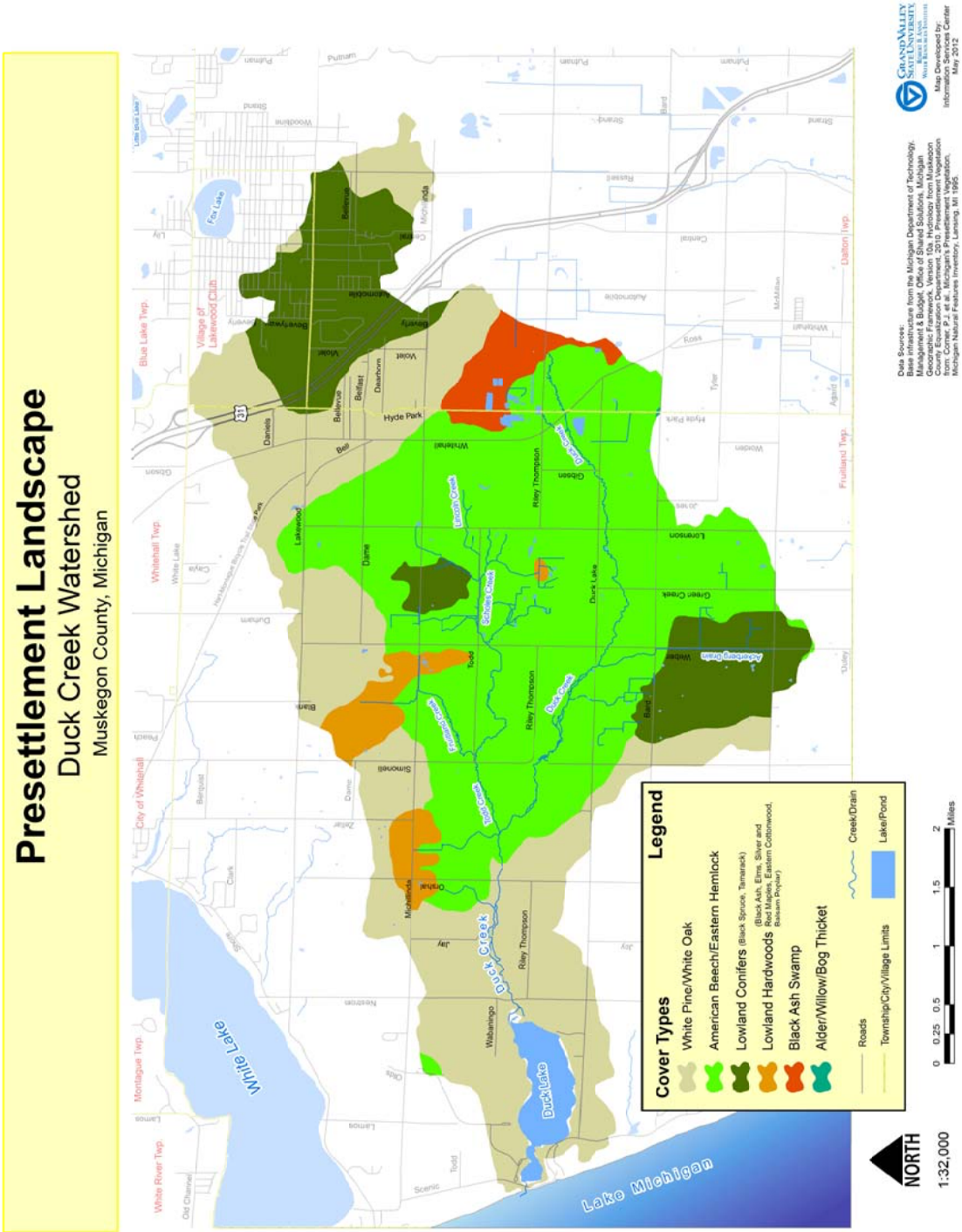


Figure 6. Presettlement Land Cover in the Duck Creek Watershed

ern shore of Duck Lake also transformed, from sawmills to swimming and recreation. The property remained with Mears' daughter Carrie until 1920 when the land was purchased by a Chicago area Boy Scout troop. The Chicago troop, along with a Grand Rapids Boy Scout troop, maintained Camp Wabanigo and Camp Shawondosee for the next 50 years (Cabala 2008). Then, in 1975, the state of Michigan acquired the property and established Duck Lake State Park.

The use of the area over the decades reflected the natural resources available. When the lumbering industry phased out, tourism in the area boasted "boating, bathing, fishing," as described in an advertisement for Duck Lake Resort in 1910 (Meikle 1976). Many farm houses were converted to hotels during this time, including the origins of Duck Lake Inn. People came from all over Michigan, Illinois, and Indiana to vacation around Duck Lake. The Duck Lake area was so popular to visitors that a proposal brought to the Michigan Legislator by property owners in 1901 asked that Duck Lake's name be changed to 'Michillinda' Lake; a combination of MICHigan, ILLinois, and INDiana (La Fayette 1985). Residents in favor of the name change thought it would further promote the area's resort business and distinguish the lake from the several other 'Duck Lakes' in the county and in the state of Michigan. Michillinda was a resort settlement established on White Lake around 1896, where vacationers came from Michigan, Illinois, and Indiana to spend their summer. The matter was eventually dropped due to strong opposition that organized their dissent through petitions and letters. Duck Lake retained its name and history.

History of the Political Units

Fruitland Township:

Fruitland Township, an off-shoot from Dalton, was organized in 1869 when it detached from Dalton Township (*History of Muskegon County, Michigan*, 1882). The township was the largest in the county, encompassing 40 square miles (Meikle 1976). According to the *Bicentennial History of Fruitland Township,* the name Fruitland, or "Land of the Fruit," was chosen because the soil was thought to be suitable for growing fruits of all kinds (Meikle 1976). The land between Duck Lake and Lake Michigan was described as having fine farms of grapes and peaches (*History of Muskegon County, Michigan*, 1882). The soil along the lake seemed well adapted for apples, plums, pears, etc.; and fertility of the land is reflected upon as "The whole township is indeed fine land and will shortly be a garden" (*History of Muskegon County, Michigan*, 1882).

Dalton Township:

Dalton Township, as stated in the *History of Muskegon County, Michigan* of 1882, was organized in 1859. Dalton Township was the sixth township to be developed in Muskegon County. The township was named after Peter Dalton. Dalton arrived to White Lake in 1844 where he started a lumber business and constructed a sawmill on Silver

Creek and, in 1857, a steam mill. (Meikle 1976). Dalton's sawmill established the first settlement. The township land is described as having light and sandy soil in the north and west. The rest was somewhat sandy, but better for agriculture: including wheat and grass (*History of Muskegon County, Michigan*, 1882).

Village of Lakewood Club:

The resort town of Lakewood Club began in 1912 (Van Vorst 1982). The town was promoted as a "summer rendezvous spot for hundreds of Chicago residents." As part of this promotion Chicago residents were offered an unusual opportunity. Between 1912 and 1917 a newspaper based in Chicago offered property lots, to later be incorporated as the Village of Lakewood Club, with the purchase of a one-year subscription to the newspaper. There were 43,250 lots in all; many of the properties were in the middle of the woods, inaccessible by owners and unable to be developed due to the size and location. This "land scam" was responsible for the creation of the village, though it left many properties vacant for years until lots were returned to the state or adjacent lots were bought for development. It wasn't until the early 1930s that the resort population in the summer swelled when more than 400 cottages were built. However, following the Depression, "resort activities became nonexistent;" and the once busy vacation spot converted to mostly permanent housing during the Muskegon area housing shortage of the 1940s. The village entered a "reconditioning" era during the 1980s when stores reopened and Fox Lake's water level and fish stock improved (Van Vorst 1982).

2.3 Geology

Geology is the study of the Earth. More specifically, *geology* examines the materials in which the Earth consists, how those materials are structured, and the processes acting upon the materials and structures. The *geology* of the Duck Creek watershed is important because it allows us to understand why there are different landscapes within the watershed. Duck Creek's geologic history can be divided into three parts, bedrock formation, glacial activity, and top soil depositions. The following is a brief summary of the geologic events that shaped the Duck Creek watershed.

The Formation of Duck Creek's Bedrock

The bedrock of the Duck Creek watershed was formed much like that of the larger Great Lakes basin. During the Precambrian era approximately three billion years ago, volcanic activity resulted in the creation of the Canadian Shield. Over the next several million years the Duck Creek watershed was flooded over and over again by marine seas, which resulted in the deposition of salts, sand, silt, and clay. These sediments consolidated into shale, limestone, sandstone, halite, and gypsum that currently make up the bedrock beneath the Great Lakes basin (Fuller et. al. 1995). The effects of multiple volcanic and flooding events

that were prevalent throughout Michigan's geologic history appear as a deep sedimentary basin centered beneath Michigan (Figure 7). More detailed information on the watershed's *geology* can be found in Appendix B.

Glacial History

The last major geologic event that shaped the Duck Creek watershed happened during the Pleistocene Epoch when a series of glaciers repeatedly covered the area. These large glaciers (up to 6,500 feet thick) scoured the Earth to its bedrock. These glaciers, which last appeared 10,000 years ago, assisted in giving the Duck Creek watershed its most well-known feature, Duck Lake. Duck Lake was formed because glacial activity in the Upper Great Lakes basin caused the water levels in Lake Michigan to be extremely low. This severe drop in the Lake Michigan water levels caused the gradient of Duck Creek to equally increase and cut deeper into the landscape. When the glaciers melted the water levels in Lake Michigan began to rise, the river channel was flooded. The result of this was a large lake that extends far inland. At the same time, the shifting sand dunes enclosed portions of this lake, and forced it to drain into Lake Michigan via a narrow channel, creating a natural dam. As water levels stabilized, sediment that normally would be deposited in Lake Michigan began to fill in this large river valley. The combination of these two events is visible today as a *drowned river mouth* lake. Characteristics of these types of lakes include an extensive wetland complex where the river and lake meet, and a small channel that connects the "drowned" river with Lake Michigan (Figure 8). Other examples of *drowned river mouth* lakes in Muskegon County include Muskegon Lake to the south and White Lake to the north. Duck Lake is not the only feature that glaciers left on the watershed. Duck Creek Watershed is dominated by a lake plain in the west and central areas of the watershed. In the far northeastern part of the watershed is a small outwash plain. Dividing these two areas is an end moraine.

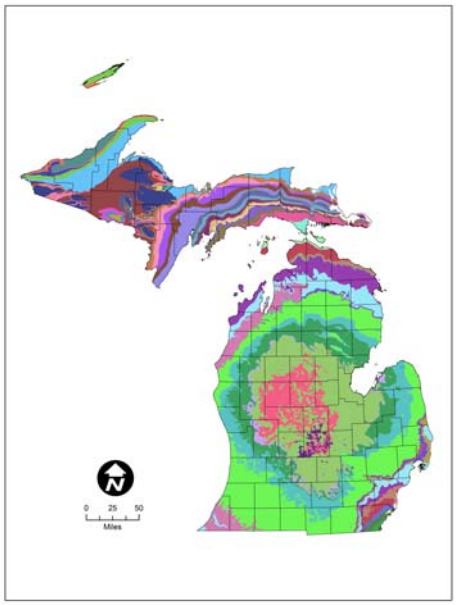


Figure 7. Bedrock Geology of Michigan, Map provided by Michigan Department of Natural Resources. Map Legend and other details provided in Appendix B.

Soils

Soils comprise the top most layer of the Earth, and are a critical component to any *ecosystem*. Soil is made up of extremely tiny, broken up rocks as well as water, air, and *organic* materials. Soils are influenced and shaped by five separate, but interconnected factors:

Figure 8. Duck Lake, a “drowned” river typical of west Michigan’s glacial past

parent material, regional climate, topography, organisms, and time. Each of these factors is dramatically important to the way soil is developed (Ritter 2006).

The majority (78%) of the soils that comprise the Duck Creek watershed have a sandy texture (Figure 9). Sandy soils are well drained due to the coarseness. This soil texture has a high permeability and a very low water holding capacity. Because these soils have a thin *organic* material layer they are not suitable for agriculture and are a poor medium for plant growth. These soils generally require some type of vegetative cover be present on top of these soils to prevent *runoff* and wind erosion (Rediske et. al. 2003). Other major soil textures present in the watershed include sandy-loams (7%) and loamy-sand (6%). Both of these soil types occur around the end moraine in the central part of the Duck Creek watershed. These soil types are suitable for agriculture, are well drained, and possess strong water holding characteristics. More information about the other soil textures that are present in the Duck Creek watershed can be found in Appendix B.

Topography

The configuration of the Earth’s surface, including its elevation, slope, and orientation is known as topography. The shape of the land in a watershed is an important feature when it comes to how and where water flows. The highest areas in the watershed are located in the eastern part of the watershed at the headwaters, while the lowest point is at Duck Lake. An illustration of the elevation of the Duck Creek Watershed can be found in Figure 10. Elevation and slope should be considered before and during planning for any type of development. Consideration of the topography of the land can minimize the effects of flooding, erosion, and the impacts of proposed development on soils, vegetation, and, subsequently, surrounding waterbodies.

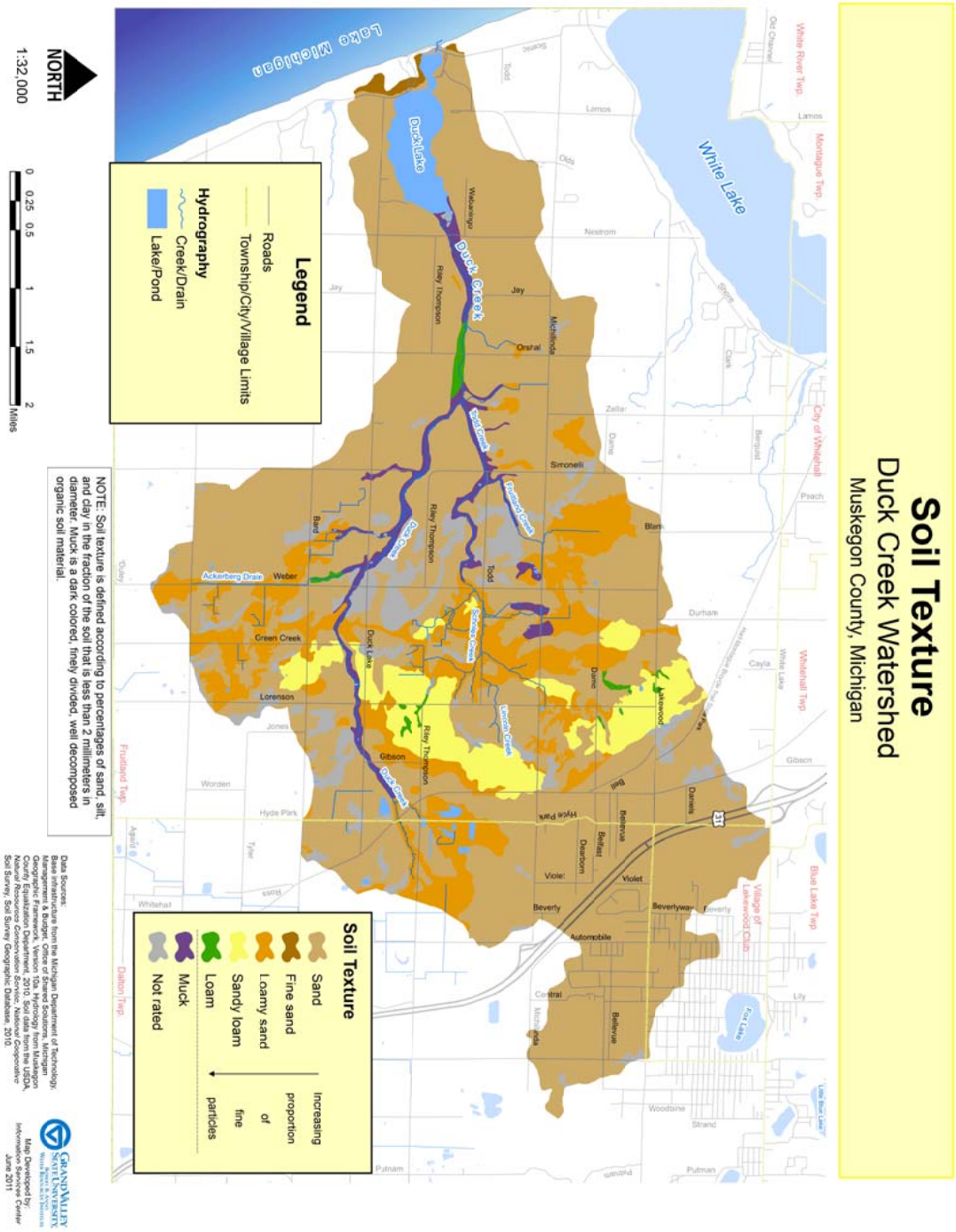


Figure 9. Soil Texture in the Duck Creek Watershed

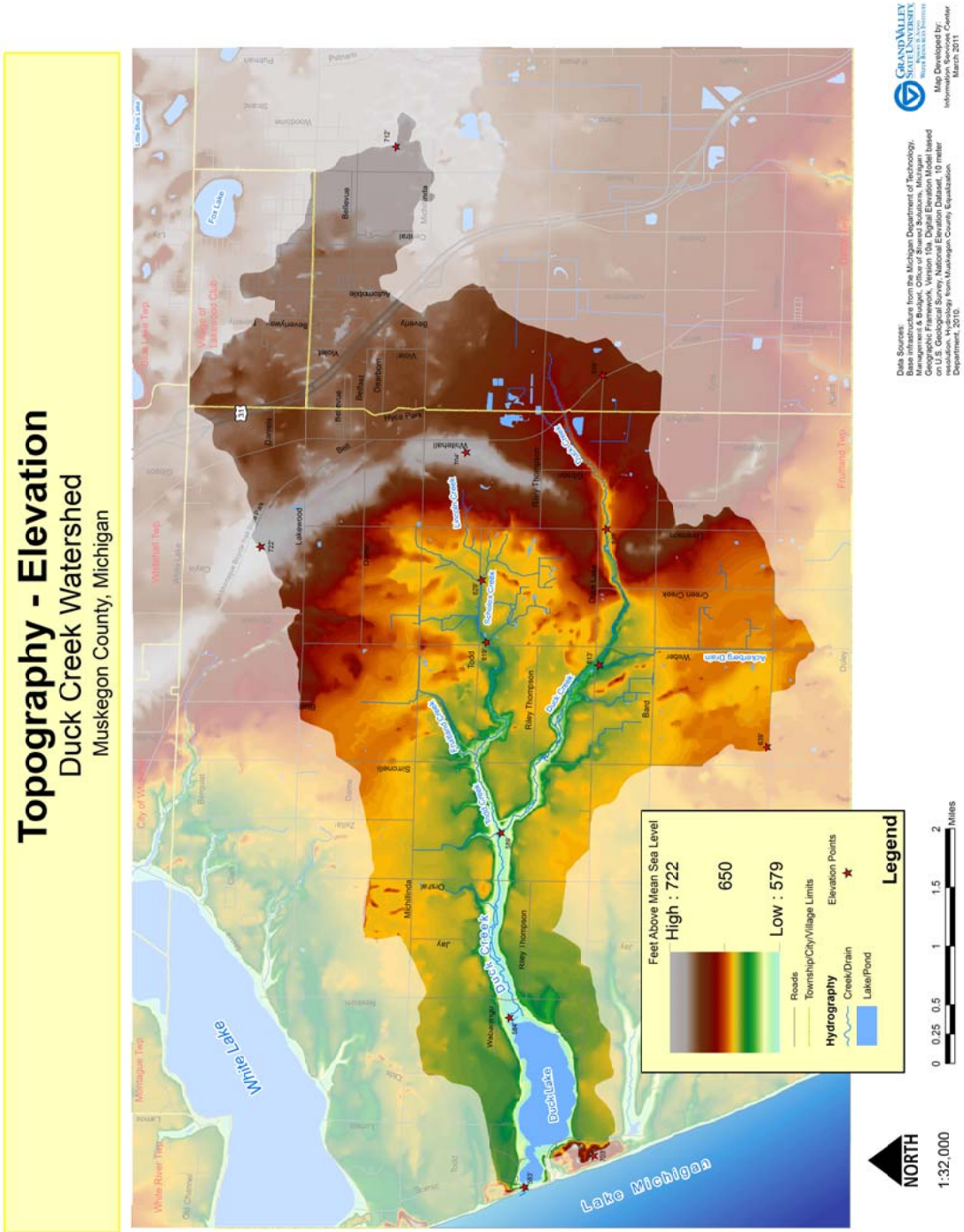


Figure 10. Topography of the Duck Creek Watershed

2.4 Ecology

Ecology is the study of organisms and their relations to each other and their environment. The Duck Creek Watershed has an array of unique plants, animals, and habitats. The waterbodies also have been observed and analyzed in terms of fish populations; however, more information should be collected. By examining the unique ecological characteristics and quality of the habitats and organisms in the watershed, we can better protect and preserve them.

Fisheries

Duck Lake is designated by the Michigan Department of Natural Resources (MDNR) as a Type F Trout Lake. As such, the lake is open to fishing the entire year. However, possession of Lake Trout is limited to January 1 through October 31 of each year. Possession limits and minimum size limits for Brook Trout, Brown Trout, Rainbow Trout, Splake, Lake Trout, Coho Salmon, Pink Salmon, and Atlantic Salmon are reported in the Michigan Fishing Guide published by the MDNR each year and also available on the web at www.michigan.gov/dnr (MDNR 2011). The MDNR's guide to the Duck Lake State Park indicates that bass, crappie, and panfish are plentiful, with Bluegill fishing excellent in early summer (MDNR 2012a).

Duck Creek, historically, had been thought of as a trout stream. Prior to being designated as an official trout stream by the state, it was recognized as an important Northern Pike spawning area and known for having roughly 15,000 trout planted over time, as reported by the Fruitland Township Supervisor in 1971 (Personal communication by Hain, April 27, 1971). During this time, a news article in Fruitland Township advised that Duck Creek was open to sucker spearing, which evoked opposition amongst the township. In December of 1971, the MDNR declared Duck Creek as a designated trout stream, thus revoking permission to spear in Duck Creek, as well as all other designated trout streams in Muskegon County (Personal communication by Trimberger, MDNR, December 1, 1971). Duck Creek was designated as a trout stream because of its high water quality and the presence of trout in it. Although, it was believed that the natural reproduction of trout in this stream would be limited due to its natural characteristics (Personal communication by Trimberger, MDNR).

In the late 1960s, rainbow trout had been planted for three years to establish an inshore fishery in Lake Michigan (Personal communication by Trimberger, MDNR, May 19, 1971). As expected, a survey in 1970 indicated that the rainbow trout planted in the creek had moved out of Duck Lake and into Lake Michigan. There has been no recent stocking in the watershed. The most recent surveys conducted by the MDNR Fisheries Division show a variety of different species; however there is limited data and very few trout species caught in the surveys over the years (Personal communication by O'Neal, MDNR, May 19, 2011). For a list of all the species identified in Duck Creek and pertinent Michigan Fish Advisory

Information, see Appendix C. The most recent fish survey conducted in 1995 revealed that upstream from the permitted discharge at the Michigan's Adventure Amusement Park there were very few fish overall; sculpin and northern redbelly dace were present, as well as mudminnows being most abundant. The only species present at the ditch site of Michigan's Adventure were mudminnow and stickleback. Downstream from the park, species found were the mudminnow, creek chub, sculpin, green sunfish, largemouth bass, white sucker, and blacknose dace. It was also reported that although no Brook Trout were sited, a portion of the creek near Gibson Road looked capable of supporting Brook Trout. The greatest conclusion to be drawn from the limited data collected in the watershed is that more efforts must be taken to preserve and promote diverse and sustainable fish populations in Duck Creek (Personal communication by O'Neal, MDNR, May 19, 2011).

Unique Plants & Animals

There are seven different rare species identified in the Duck Creek Watershed by the Michigan Natural Features Inventory. By learning about each of the species, their general location in the watershed, and the threats presented to the populations in the Duck Creek system, we can better create and implement Best Management Practices. Information on each of the seven species can be found in Appendix D, including recommended management and conservation efforts and the general location of each species.

Tall Green Milkweed (Asclepias hirtella):

Tall green milkweed is a vascular plant deemed threatened by the State. Throughout Michigan there have been 20 sites documented for this species; however since 1980, only twelve of these sites have been confirmed (Penskar et al. 2001). The last observed date of the species existing in the Duck Creek Watershed was in 1901, according the Michigan Natural Features Inventory (MNFI), but they have been observed twice in Muskegon County as of 2005. Most colonies of tall green milkweed are limited with only one or a few plants. The plant is tall and fleshy, reaching anywhere between 16-40 inches with long narrow leaves covered in small, stiff hairs. The flowers produced are clusters of greenish-white to slightly purple-tinged stalks protruding from the center. There can be 2-10 flower clusters per plant. The plant is in flower from mid-July to mid-August in Michigan. There are many species of bees and wasps that pollinate this milkweed, exemplifying the importance of this rare plant. Conservation of remaining tall green milkweed in the Duck Creek Watershed calls for preservation of its habitat, such as in areas with sandy loam soils (MNFI 2007) (see 2.3 Geology: Soils). Management practices for preservation include manual brush removal in these habitats to maintain open conditions suitable for the plant. Further, a threatened species such as the tall green milkweed has lost much of its habitat via development. Prior to development, efforts must be made to ensure suitable habitats for threatened species are not destroyed or degraded.

Cerulean Warbler (Dendroica Cerulea):

Cerulean warblers are small, short-tailed birds with two wide white wing bars and white-tail spots (MNFI 2007). These birds are characterized as threatened by the State. The cerulean warbler was last documented in the Duck Creek Watershed in 1999, according to the MNFI. The male warbler is a bright blue above the wing and a white below with a black necklace across the breast. Cerulean warblers prefer canopied habitats with large tracts of mature deciduous forest, such as the *mesic* northern forest found in the Duck Creek Watershed (see 2.4 Ecology: Unique Habitats). In their habitat, cerulean warblers can be difficult to identify because they like to sing, nest, and roost high in canopies. These birds arrive to Michigan typically in late April or early May, and they migrate from July through September, reaching the South American wintering grounds around August (Hyde et al. 2000). These threatened birds are a unique attribute to the Duck Creek Watershed. These birds must be protected, as they are threatened by the loss of mature deciduous forest, environmental degradation from stream pollution and timber removal (MNFI 2007). The bird conservation organization, Partners in Flight, rank the cerulean warbler as a species of high priority for conservation attention (Hyde et al. 2000). Cerulean warbler management practices include promoting low-intensity land uses such as single-tree selective timber removal and natural wetland-protection enforcement.

Eastern Massasauga (Sistrurus catenatus catenatus):

The eastern massasauga is the only venomous snake found in the State; although the venom is highly toxic, the snake's short fangs can inject only a small volume thus fatalities are very uncommon (Lee & Legge 2000). The snake can be identified by its dark brown rectangular blotches down its back with alternating dark and light bands along the tail. The underside of the snake is typically black with gray, white or yellowing mottling. This species is a rattlesnake and has a segmented rattle at the end of its tail. Massasaugas are active between April and late October, and then hibernate in the wetlands in crayfish or small mammal burrows. They prefer wetland habitats such as moist grasslands, *mesic* northern forest, floodplain forests, shrub swamps, and any site near a water table with intermixed, sunny areas (MNFI 2007). The greatest threats to this species in the Duck Creek Watershed are habitat loss and degradation due to human activities. These threats include residential development, roads, and pollution, as well as vehicle-caused mortality. The eastern massasauga is protected in Michigan under the Director's Order No. DFI-166.98, Regulations on the Take of Reptiles and Amphibians, which is overseen by the Fisheries Bureau of the Michigan Department of Natural Resources. The snake is designated as threatened by the State and is under considered for federal status. Conservation of suitable wetlands is critical for the protection of the eastern massasauga. Further, public awareness of the species, its habitat, and what should be done if one is found, will support management practices for conservation.

Eastern Box Turtle (Terrapene carolina carolina):

This small land turtle is a species of special concern to the State. The turtle has brown or black markings with a yellow or orange pattern that is highly variable between each scale (Hyde 1999). Around the shell is a raised ridge that ranges from five to six inches. The species can be seen between April and October, especially during egg laying in early June through mid July. The eastern box turtle's typical habitat is in forested areas with sandy soils near a water source, such as a *mesic* northern forest. They may also be found in adjacent thickets, old fields, pastures, or vegetated dunes. An open, sunny area with sandy soil is also critical to the species for reproduction. It is unlawful in Michigan to remove an eastern box turtle because of the Director's Order No. DFI-166.98, Regulations on the Take of Reptiles and Amphibians. There is much concern for the species due to the loss of habitat, high rates of nest predation, and the number of adults killed on roads in Michigan. In addition, the outlook of the box turtle is dim due to the time it takes for turtles to reach sexual maturity. Protection of large tracts of habitat is needed to support this species in the future. Also management efforts should prevent improper off road vehicle use and control invasive weeds in this area. In development plans, including for new roads, separating the turtle's habitat from nesting areas should be avoided. Raising public awareness of the species and encouraging the public to leave wild turtles in their natural habitats will also support any management efforts.

Unique Habitats

***Mesic* Northern Forest:**

A section of the Duck Creek Watershed has been identified as a *mesic* northern forest, one of Michigan's natural communities. A natural community is a classification given by the Michigan Department of Natural Resources to describe a group of interacting plants, animals, and other organisms under similar environmental conditions and landscape. The classification is meant to serve as a means to understand, describe, and document the diversity of natural communities and Michigan, and support the protection and management of these native *ecosystems*. A *mesic* northern forest is considered vulnerable in Michigan due to a restricted range and the relatively few occurrences found. Recent and widespread decline in the *mesic* northern forest give reason to be concern.

A *mesic* northern forest is characterized by primarily northern hardwoods, such as sugar maple and American beech (Kost et al. 2007). Also, conifers such as hemlock and white pine are typically canopy sources. This forest is primarily found on coarse-textured ground and end *moraines,* and on well-drained sandy lake plain and north-facing sand dunes. Soils are typically loamy sand to sandy loam. To offset or reduce the decline in Michigan's *mesic* northern forests, the area within the Duck Creek Water-

shed must be properly managed with conservation efforts. Efforts such as protecting hemlock, white pine, and cedar regeneration, and allowing the natural processes to operate unhindered, will promote a sustainable forest. More specific management practices include erecting deer enclosures to protect regeneration, underplant saplings of hemlock and white pine where they are absent, and control the invasive species in the area.

Critical Ecological Area Analysis:

Another data set that relates to the above discussion and having relevance to the Duck Creek Watershed is the assessment of biological diversity undertaken by the Michigan Department of Natural Resources as part of The Michigan GAP Analysis Project (Donovan et. al. 2004). This assessment process began in 1994 as a joint effort with Minnesota, Wisconsin, Illinois, and Michigan, coordinated by the U.S. Geological Survey. During the project, researchers modeled the predicted range and habitats for 22 amphibians, 30 reptiles, 61 mammals, and 214 birds (http://www.gap.uidaho.edu/bulletins/13/Michigan.pdf). The project and its outcomes are described in detail in the report titled, **The Michigan GAP Analysis Project—Final Report** (Donovan et. al. 2004).

AWRI researchers have taken the data provided by the Michigan GAP Analysis Project and focused attention specifically on the potential location of vertebrate species in the Duck Creek Watershed. AWRI produced a series of maps referred to as "Potential Biological Hot Spots", showing where amphibians, reptiles, mammals, and bird habitats are most likely to be found. This map series is included in Appendix E along with a detailed explanation of how the Michigan GAP Analysis data set was used for this application. Found on the following page is Figure 11, which includes a composite showing the potential hot spots for all vertebrate animals considered. This map is useful as we look at the Duck Creek Watershed with the idea of preserving natural habitats which have the potential to improve or at least protect water quality.

Wetlands:

Wetland types found in the Duck Creek Watershed are mapped in Figure 12. Wetlands are defined in Michigan's wetland statute, Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as "land characterized by the presence of water at a frequency and duration sufficient to support, and that under normal circumstances does support, wetland vegetation or aquatic life, and is commonly referred to as a bog, swamp, or marsh." Wetlands are a valuable natural resource; however, many have been altered by human activities such as farming, ranching, and the building of roads, dams, and towns (USEPA 2003a). People have often regarded wetlands as wastelands. This negative view has resulted in half of America's original wetlands being destroyed. Most were destroyed because they have been drained and

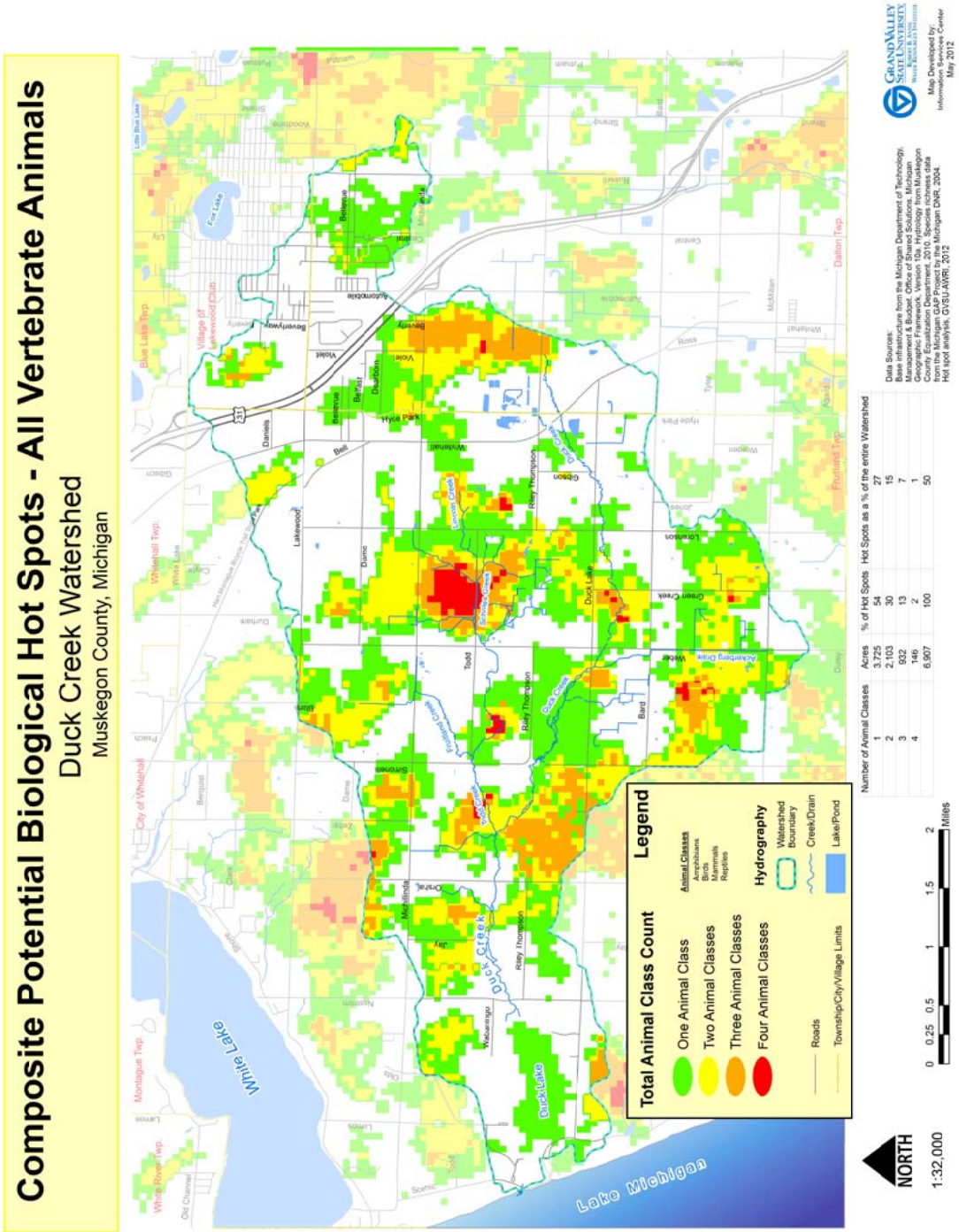


Figure 11 Composite Potential Biological Hot Spots—All Vertebrate Animals

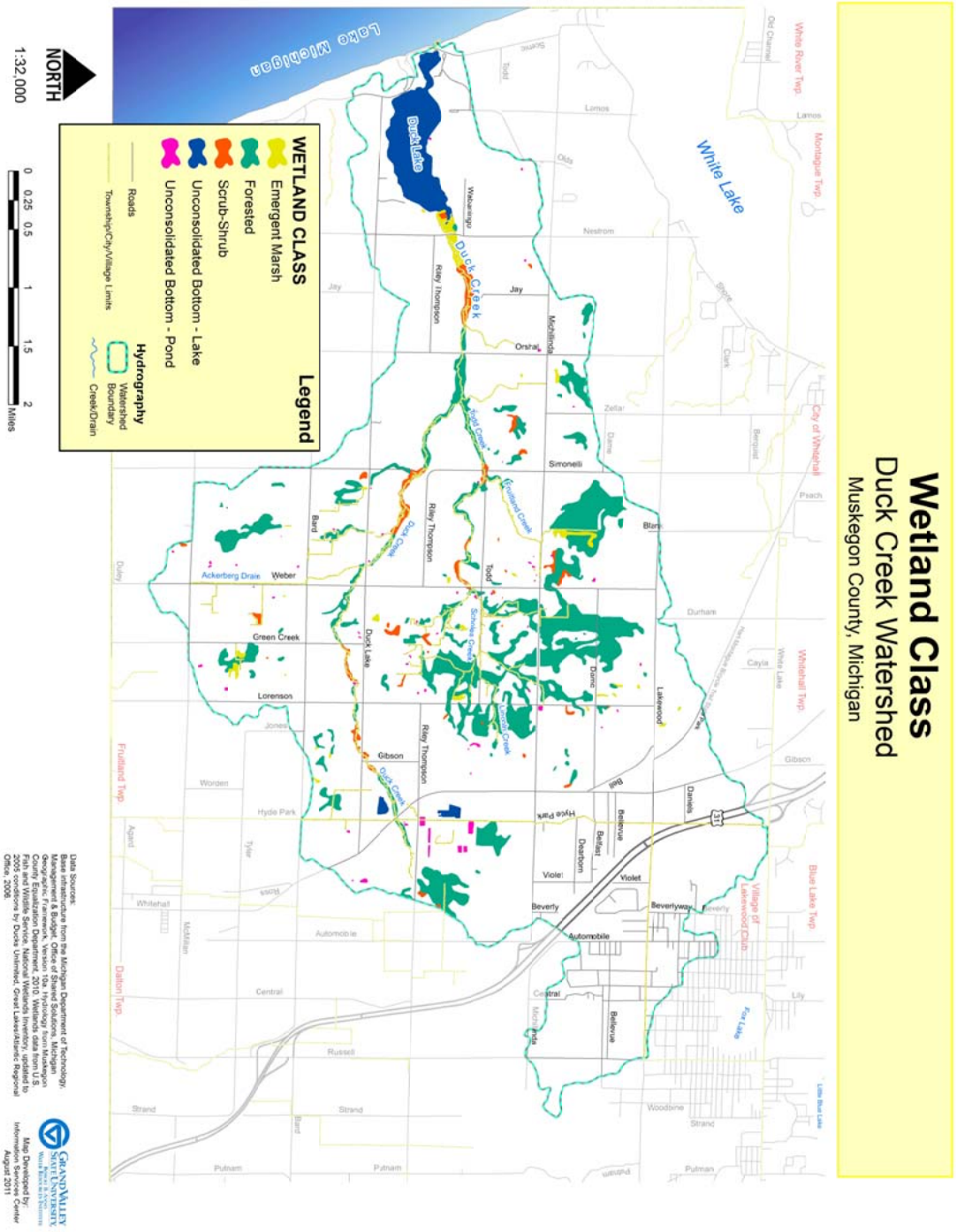


Figure 12. Wetlands in the Duck Creek Watershed

converted to farmland, developed for residential and industrial purposes, or used as a disposal of household and industrial waste (USEPA 2003a).

The natural features of wetlands have been found to help regulate water levels within watersheds, improve water quality, decrease damages from flood and stormwater, protect fish and wildlife habitat, and support hunting, fishing, and other recreational activities (USEPA 2003a). Specifically, wetlands have important filtering capabilities for surface and agricultural *runoff* before the *runoff* reaches open water. From the *runoff*, wetlands hold excess nutrients and other pollutants, including sediment that could clog the waterways. For these reasons, wetland restoration should be an interest in the Duck Creek Watershed. Only 52% of the original wetland acreage remains in the Duck Creek Watershed. As of 2005, 1,170 acres of wetlands have been lost since the area was first settled by the Europeans. Appendix F includes the Landscape Level Wetland Functional Assessment prepared by MDEQ in 2011, along with some highlighted information derived from the MDEQ report (MDEQ 2011).

Protection of wetlands also poses economic benefits for the local economy and communities (USEPA 2012a). The economic value of wetlands is estimated to be close to $300/acre for sport fishing, almost $150/acre for recreational purposes, and approximately $30/acre for hunting (Hickman 1990). A more recent economic analysis has reported the total impacts of 'wetland services' in Michigan provide $10,000 per acre per year (NWF 2011).

2.5 Land Use and Land Cover

Land use refers to how land is used by humans. *Land use* in the watershed can directly influence the water quality of a stream as well as its composition. Land cover is often confused with *land use*, but they are not the same. Land cover includes vegetation, bare soils, bedrock outcroppings, and other features which lay on top the earth's surface. Both of these concepts must be understood in order to properly address many water quality issues within a watershed. This is especially true when it comes to the role different levels of government will play in the protection and management of the watershed. For instance, *land use* decisions are made primarily by local governments, but when it comes to land cover and protecting the natural resources such as wildlife and habitat, traditionally these issues have been the responsibility of the state and federal governments (Ardizone and Wyckoff 2003). It is important for residents and constituents to be aware and knowledgeable of these shared powers and roles. How we use our land and protect our resources takes collaboration, awareness, and involvement from officials at all levels and land owners.

Land use and cover within the watershed has changed considerably from 1978 to 2009 (refer to Figure 13). These changes reflect primarily the priorities and needs of area

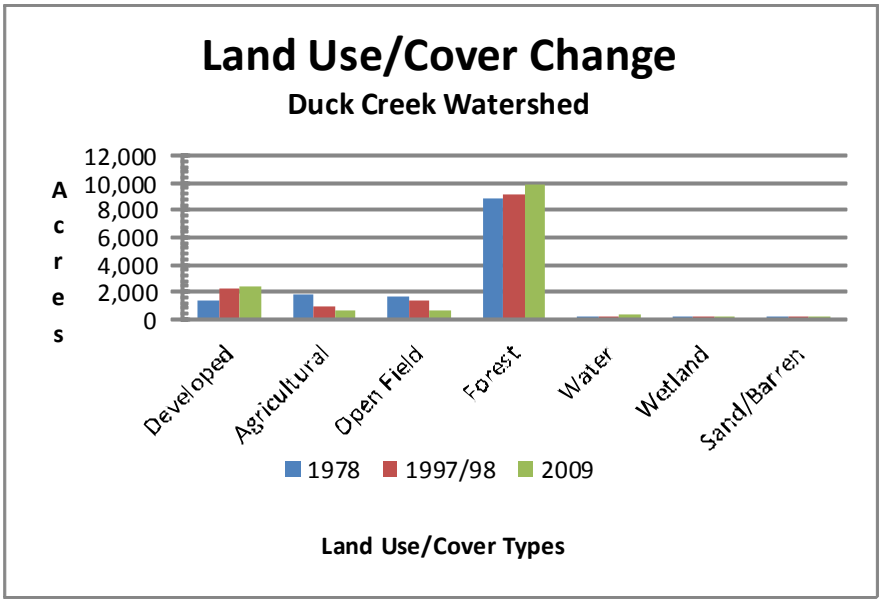


Figure 13. Land Use and Cover Change 1978-2009 - Duck Creek Watershed

residents. Developed land has increased within the watershed by 87% from 1978 to 2009. Many other use and cover types in the watershed have decreased, including agriculture, open field, wetland, and sand/barren land by 67%, 57%, 59%, and 95%, respectively. As of 2009, the majority of the watershed is classified as forested (71%) and the next greatest classification is referred to "developed land" (17%). A complete comparison can be found in Appendix G.

Below, Figure 14 describes *land use* and cover for the Duck Creek Watershed as it existed in 2009. Figure 15 shows how population was distributed through the Duck Creek Watershed in 2010. Using the two figures together gives us a strong indication where population density is the greatest, and hints to where we might find disturbance in the landscape due to human influence.

2.6 Social Characteristics of the Watershed

Duck Creek Watershed is contained entirely within Muskegon County. In 2000, the county's population was 170,200 (United States Census Bureau 2012a). The 2010 census revealed that the population increased by 1,988 people. Figure 15 shows the population density of the watershed. With so much of the county's land area covered by water (approximately 4% of 527 square miles), fishing, boating, and other water-related outdoor activities are important to the county's residents, tourists, and economy. There are three major watersheds that make up Muskegon County: the Muskegon River, Grand River, and

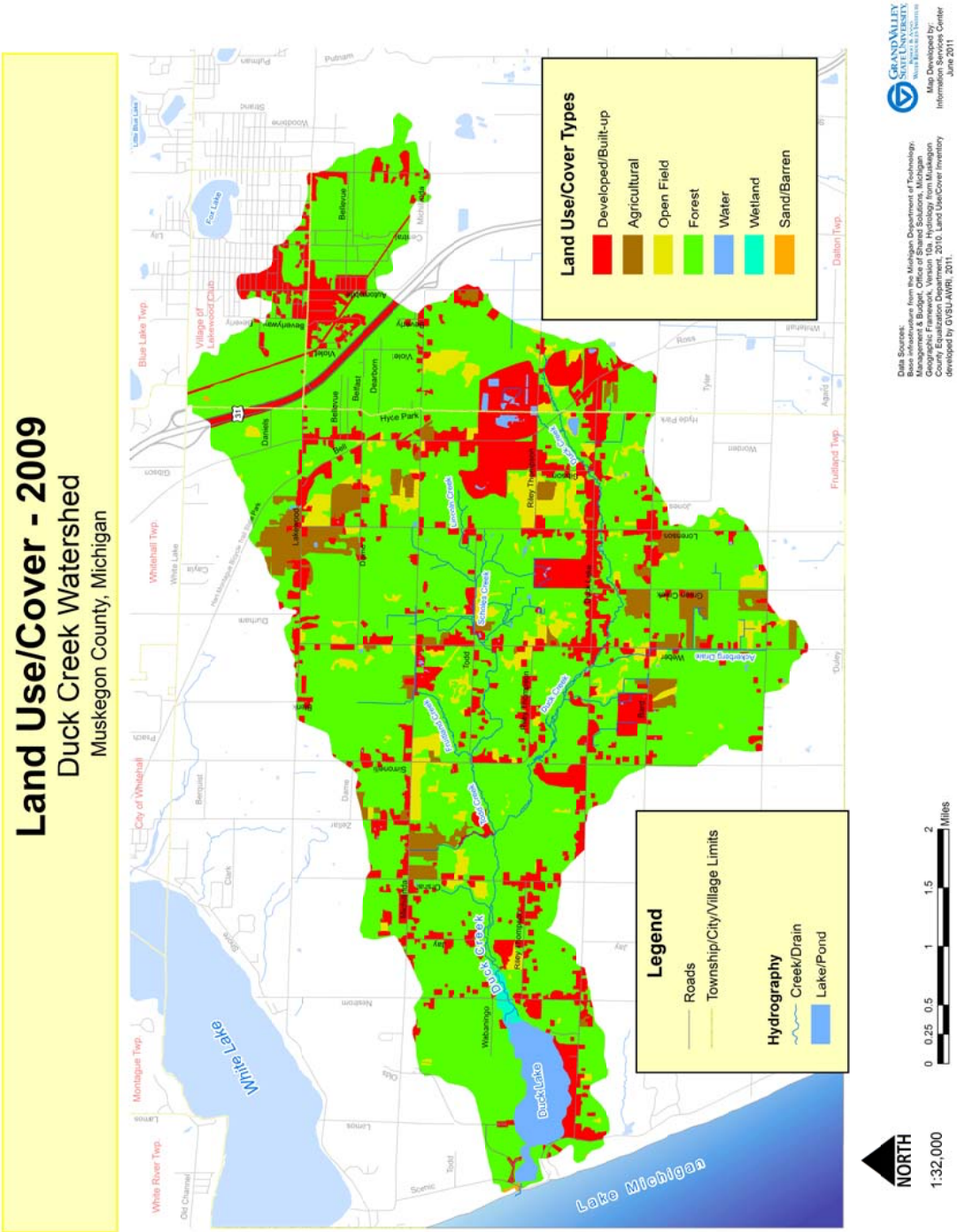


Figure 14. 2009 Land Use and Cover - Duck Creek Watershed

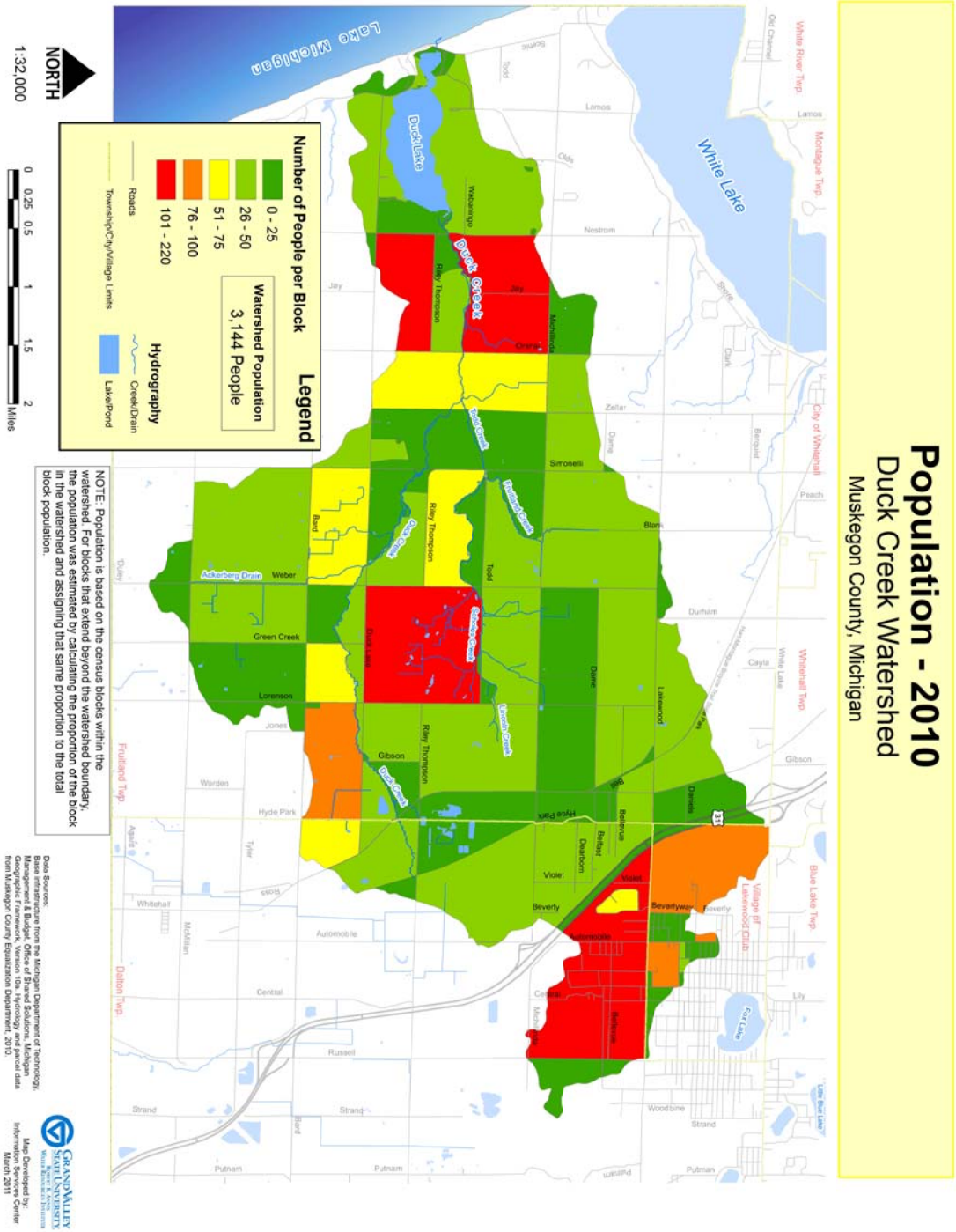


Figure 15. Population Density 2010 Census - Duck Creek Watershed

White River. Muskegon County is also plentiful in farmland; there are approximately 525 farms, or 25% of the total land, in the county (MDARD 2009). Most of the farms are devoted to corn, soy, and wheat production.

The Duck Creek Watershed exists within three political units: Fruitland Township, Dalton Township, and the Village of Lakewood Club. The majority, around 85%, of the watershed resides within Fruitland Township. In 2010, the population of Fruitland Township was 5,543, which is approximately 3% of the county (United States Census Bureau 2012b). The Duck Lake State Park covers 728 acres in the township (MDNR 2012b). The State Park, in addition to other parks, lakes, and recreation areas, offers fishing, hiking, swimming, cross country skiing, and other outdoor activities. Michigan's Adventure is a 250 acre amusement park located within Fruitland and Dalton townships, at the corner of Whitehall Road and West Riley Thomas Road. The park was originally founded in 1959, and as of 2010 is the largest amusement park in the state with more rides than any other park. The park is located to the north of the headwaters of Duck Creek.

2.7 Resources

Listed below are resources where you can learn more about the *geology*, *ecology*, *land use* and social characteristics of the Duck Creek Watershed.

US Census Bureau
http://www.census.gov/

Michigan Natural Features Inventory—Rare Species and Unique Habitats
http://web4.msue.msu.edu/mnfi/

Michigan Natural Features Inventory—Rare Species Explorer
http://web4.msue.msu.edu/mnfi/explorer/index.cfm

Soil Survey of Muskegon County. 1968. United States Department of Agriculture, Natural Resources Conservation Service and Forest Service.

2010 Michigan Fish Advisory: A Family Guide to Eating Michigan Fish. Michigan Depart of Community Health Division of Environmental Health. http://www.michigan.gov/documents/FishAdvisory03_67354_7.pdf

Identifying and Protecting Healthy Watersheds: Concepts, Assessments, and Management Approaches. February 2012. Office Wetlands, Oceans, and Watersheds; U.S. Environmental Protection Agency.

Nature Serve – A Network Connecting Science with Conservation. www.Natureserve.org

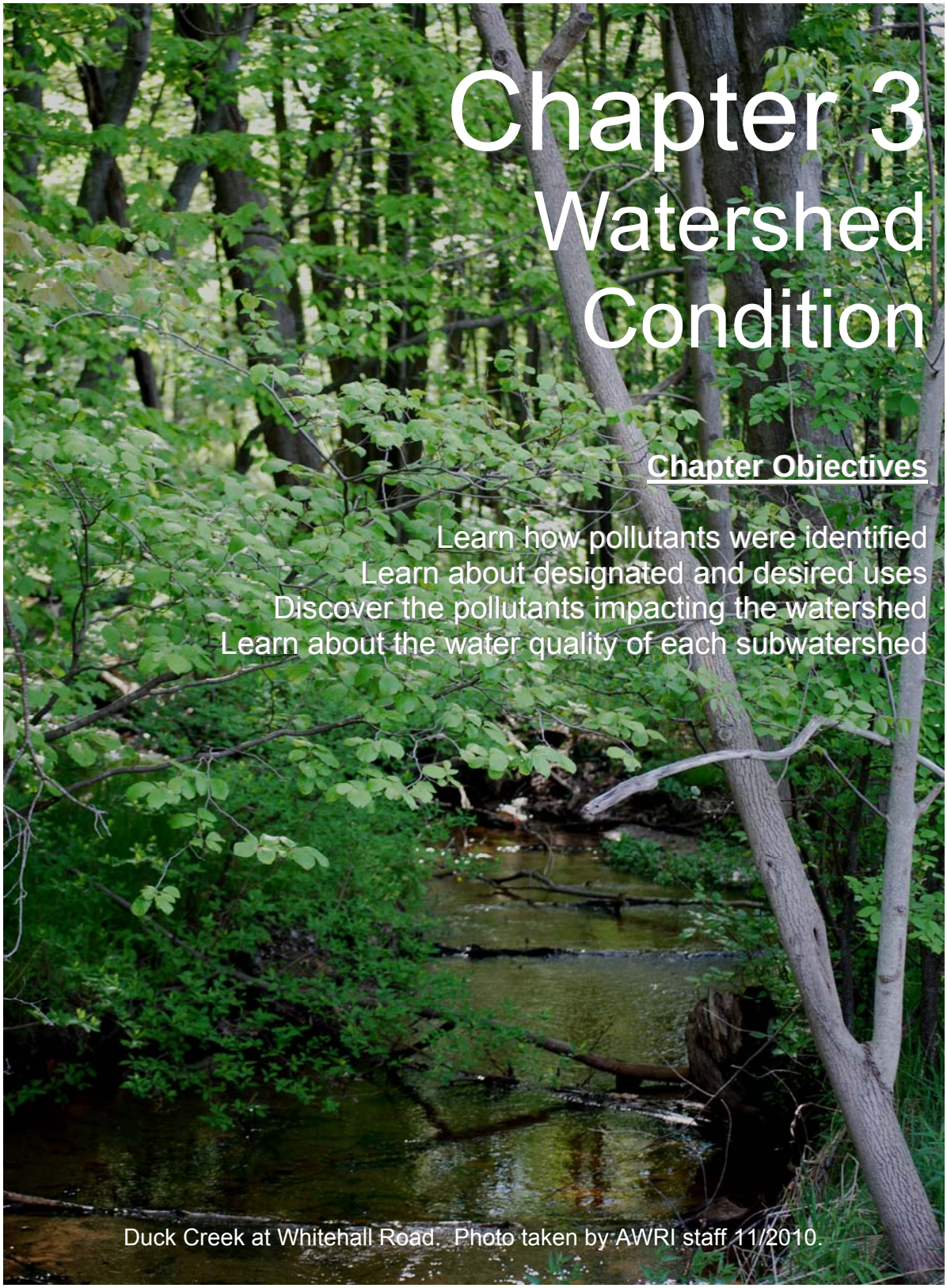
United States Environmental Protection Agency – America's Wetlands: Our Vital Link Between Land & Water. http://water.epa.gov/type/wetlands/toc.cfm

Tip of the Mitt Watershed Council – Michigan Wetlands – Yours to Protect: A Citizen's Guide to Wetland Protection (Third Edition) by Wilfred Cwikiel.

Healthy Lakes, Healthy Lives. www.healthylakes.org

Filling the Gaps: Environmental Protection Options for Local Governments. 2003. Ardizone, K. and Wyckoff, M. Michigan Department of Environmental Quality, Coastal Management Program with financial assistance from the National Oceanic and Atmospheric Administration, authorized by the Coastal Zone Management Act of 1972.

Donovan, M.L., G.M. Nesslage, J.J. Skillen, and B.A. Maurer. 2004. The Michigan Gap Analysis Project Final Report. Wildlife Division, Michigan Department of Natural Resources, Lansing. http://www.fw.msu.edu/~maurerb/gap/downloads/Mi_final_report_updated.pdf



Chapter 3
Watershed Condition

Chapter Objectives

Learn how pollutants were identified
Learn about designated and desired uses
Discover the pollutants impacting the watershed
Learn about the water quality of each subwatershed

Duck Creek at Whitehall Road. Photo taken by AWRI staff 11/2010.

3.1 Chapter 3 Summary

Below are some of the key highlights to be found in Chapter 3 of the Duck Creek watershed management plan.

- Existing and potential water quality issues in the watershed were identified using current as well as historical water quality surveys.

- *Land use* and *land use* change were analyzed using computer models to get a sense of what pollutants might be expected, where these pollutants are likely to become problematic, and when these pollutants might be an issue in the future if not an existing concern.

- Designated uses are recognized uses of water established by the state of Michigan and the USEPA. Designated uses found to be threatened include "Other Indigenous Aquatic Life and Wildlife," "Coldwater Fishery," and "Partial / Total Body Contact Recreation."

- Desired uses are those defined by the people living within the watershed often referred to as "stakeholders" because they have a personal stake in the decisions made about the watershed. Desired uses for the Duck Creek Watershed, were defined by the DCWA and include, "Groundwater / Drinkable Water," "Unique Habitat," "Open Space," "Public Access / Recreation," and "Navigation."

- Water quality concerns include increase in water temperature, increase in sedimentation, increase in nutrients and nuisance algal blooms, increase in nuisance exotic species, degradation of fish and wildlife habitat, and stormwater *runoff*.

3.2 Methods Used and the Identification of Pollutants in the Watershed

Water Quality Analysis and Physical Inventories

The Duck Creek Watershed is a relatively small, yet healthy and unpolluted watershed when compared to many other watersheds in Muskegon County, especially those that are more urban in character and once subject to historic abuse. However, the increase in development throughout the area, the loss of trees and forest stands in general, new houses being built, and new roads being paved can have detrimental and long-term implications for watershed health. The Duck Creek and the Duck Lake waters have received a good deal of attention over the years from some very dedicated and capable volunteers. Many of these volunteers are part of the current Duck Creek Watershed Assembly (DCWA). One of the tasks undertaken by the DCWA is to monitor Duck Creek and Duck Lake water quality, and they have been doing so for more than a decade. While it may be appropriate for us to be cautious about water quality data collected by volunteers, the use of proper equipment and techniques by people appropriately trained can result in a data base which is very useful and certainly worth consideration. If nothing else, data collected by volunteers can help to establish problem areas and overall trends.

One of the easiest and most reliable tests that volunteers can perform is the measure of water temperature. As it turns out, water temperature is a critical water quality parameter in that fish and other aquatic life are sensitive to temperature and exhibit specific tolerances to hot and cold water. For example, Brook Trout, which is indigenous to west Michigan and often used as an indicator for high quality streams, prefer a range of 0-24 degrees C (32-75.2 degrees F). Brook Trout also exhibit optimal growth at temperatures of 11-16 degrees C (51.8-60.8 degrees F). Aside from the direct effects that water temperature has on aquatic organisms, it also impacts food abundance, pollutant toxicity, and changes in oxygen concentrations (Heft 2006). Water Quality Standards (WQS) established for the state of Michigan identify a monthly maximum limit for coldwater fisheries at 68º F during the months of June, July, and August, and 63º F in September. A monthly maximum limit for warmwater fisheries is 80º F in June, 83º F in July, 81º F in August, and 74º F in September. Heat load is to be measured at the edge of the mixing zone (MDEQ 2006).

Using a HOBO Data Logger™, members of the DCWA collected temperature data on an hourly basis for six locations beginning in the summer of 2001 through 2005. An average mean temperature for each day was calculated and summarized by year in Appendix H. Locations included the following Road-Stream Crossings: Duck Creek at Whitehall Road – South (Sample Station #1), Duck Creek at Whitehall Road - North (Sample Station #2), Todd Creek at Simonelli Road (Sample Station #4), Duck Creek at Gibson Road (Sample Station #6), Duck Creek at Green Creek Road (Sample Station #7), and Duck Creek at

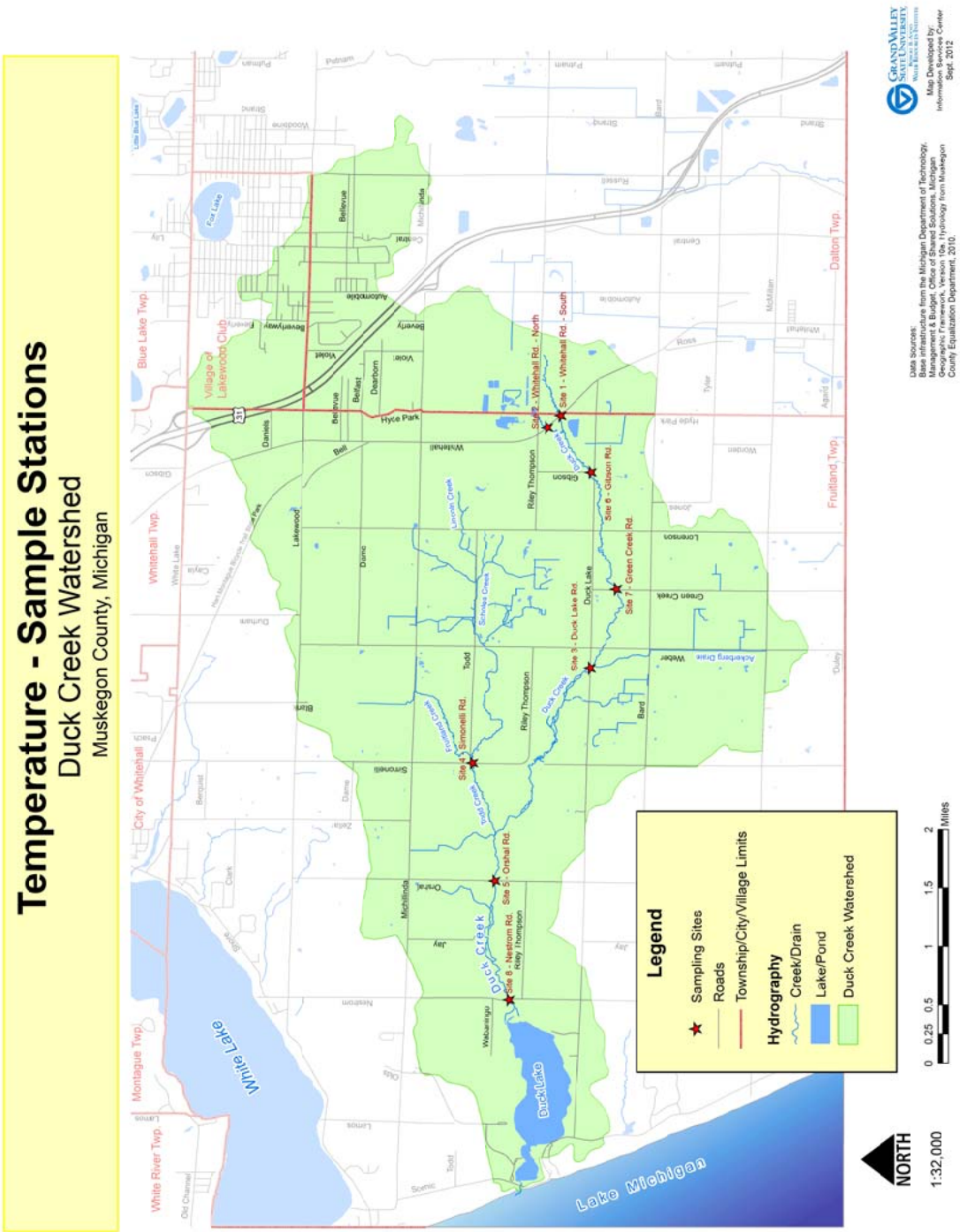


Figure 16. Sample Station Locations—Temperature

Nestrom Road (Sample Station #8) (Figure 16). Water temperatures consistently exceeded the state's WQS at the Duck Creek/Whitehall Road—North sample station in each of the five years sampled. The Duck Creek/Whitehall Road—North temperature collection site lays adjacent to the Michigan's Adventure Amusement Park and the potential impact of this park is under further investigation. Looking at the data provided by the DCWA team it would appear that whatever the reason for this temperature rise at the Duck Creek/ Whitehall Road – North station, this situation has gotten progressively worse in the period of data collection, years 2001 through 2005. The only other sample station where high temperature is a potential concern is the Duck Creek/ Nestrom Road sample station. This station has also experienced slightly elevated temperatures greater than 68º F during the summer months between the years 2001 and 2005.

Except for the two problem areas mentioned above, reported temperatures fall well within the optimal limits desired for Brook Trout. This, of course, is very good news for the Duck Creek Watershed and those concerned about its overall health. However, there is concern that as the watershed continues to attract residential and other types of urban growth that we can expect an increase in overall water temperatures. Remember also that the data collected by DCWA ended in 2005 due to equipment failure and funding limitations. The evidence provided by DCWA was sufficient to persuade the MDEQ to conduct their own investigation which has resulted in an ongoing monitoring effort by both MDEQ and the Muskegon Conservation District (MCD).

The collaborative effort by the MDEQ and MCD to measure water temperatures in the Duck Creek Watershed began with the MDEQ data collection starting June 1, 2011 and ending September 30, 2011. The MDEQ collected its water temperature data at three of five sample stations. The MDEQ sample stations included: Whitehall Road, South (Sample Station #1), Duck Lake Road (Sample Station #3), and Simonelli Road (Sample Station #4) (Figure 16). The MCD also sampled three stations. These included the resampling of Whitehall Road, South (Sample Station #1), plus two new stations: Whitehall Road, North (Sample Station #2), and Orshal Road (Sample Station #5) (Figure 16). Both MDEQ and MCD used data loggers that recorded temperatures hourly.

Results from the MDEQ/MCD 2011 and 2012 temperature analysis are included in Appendix H along with the Quality Assurance Project Plan developed by MCD and approved by MDEQ describing the procedures used for this analysis. Table 1 summarizes the temperature observations reported by both organizations. MCD temperature data began in June 2012 and ended in September 2012.

Again, the monthly maximum limit for coldwater fisheries is 68º F during the months of June, July, and August, and 63º F in September. A monthly maximum limit for warmwater fisheries is 80º F in June, 83º F in July, 81º F in August, and 74º F in September. Heat load is to be measured at the edge of the mixing zone (MDEQ 2006).

Table 1 - MDEQ and MCD Temperature Data – 2011-2012

Station Number and Date	Monthly Mean*	Monthly Maximum**	Daily Mean Maximum***
Station #1— Whitehall Road (South)			
June -11	55.8	64.4	62.8
July – 11	57.3	63.8	61.8
August – 11	57.0	61.8	59.4
September – 11	54.5	60.9	58.5
June - 12****	56.9	60.1	57.7
July - 12	58.3	64.0	60.7
August -12	56.8	62.3	59.0
September - 12	54.6	60.9	58.1
Station #2— Whitehall Road (North)			
June - 12****	72.2	76.0	73.3
July - 12	75.3	83.0	80.1
August -12	70.7	78.8	76.1
September - 12	64.7	76.1	73.4
Station #3— Duck Lake Road			
June -11	58.9	67.0	63.2
July – 11	62.7	70.8	67.3
August – 11	61.5	68.2	65.4
September – 11	56.6	65.5	63.3
Station #4— Simonelli Road			
June -11	56.5	64.4	62.3
July – 11	60.0	68.2	65.4
August – 11	59.1	66.1	63.1
September – 11	54.8	64.4	61.5
Station #5— Orshal Road			
June -12****	64.1	69.9	65.2
July - 12	67.2	76.5	71.9
August -12	62.7	72.7	68.8
September - 12	57.4	68.5	65.9

All temperatures reported in degrees Fahrenheit.

* Arithmetic mean of all hourly temperature values in a given month.

** The maximum value recorded in any given month looking at all hourly values for that month.

*** The maximum of all daily means calculated for each day in any given month.

**** June 2012 data limited to June 26, 2012 through June 30, 2012 only.

The temperature data collected previously for years 2001-2005 by the DCWA compares generally well with the data provided more recently for years 2011-2012 by the MDEQ and MCD. Note that only three stations were monitored by both the DCWA and the MDEQ/ MCD: Whitehall Road, South (Sample Station #1), Whitehall Road, North (Sample Station #2), and Simonelli Road (Sample Station #4). Of the three stations, Whitehall Road, North (Sample Station #2) still gives reason to be concern with a monthly maximum temperature for June 2012 - 76.0º F, July 2012 - 83.0º F, August 2012 - 78.8º F, and September 2012 - 64.4º F. The Simonelli Road station (Sample Station #4) shows some variability from year to year, but the highest monthly maximum temperature thus far reported is 68.2º, offered by MDEQ for August 2011. Duck Creek Road (Sample Station #3) and the Orshal Road Sample Station (Sample Station #5) were not previously monitored by the DCWA so it is impossible to establish any trends with the more recent data provided by MDEQ/MCD. However, the temperature reported for both stations is slightly elevated compared to the Whitehall Road, South Station (Sample Station #1) monitored in 2012. The results reported for the Nestrom Road sample station by DCWA in the years 2001 and 2005, together with results from the Simonelli Road sample station in 2011, Orshal Road sample station in 2012, and Duck Lake Road sample station in 2012 indicate the need for further analysis of Todd Creek and the lower portion of Duck Creek in general.

The DCWA also conducted a series of nutrient tests at another seven sample stations during the year between October 2009 and September 2010. These stations included Duck Creek at Whitehall Road, North (Sample Station #1), Duck Creek at Lorenson Road (Sample Station # 2), Duck Creek at Weber Road (Sample Station # 3), Duck Creek at Duck Lake Road (Sample Station #4), Todd Creek at Simonelli Road (Sample Station #5), Duck Creek at Orshal Road (Sample Station #6), and Duck Creek at Duck Lake Channel (Sample Station # 7) (Figure 17). The DCWA used a properly calibrated and maintained HACH DR/2000 Spectrophotometer to measure the concentration of phosphorus and nitrate-nitrogen. Each of the above mentioned sample stations was visited once per month for a total of 12 months beginning in October 2009. The results from this analysis are again reported as part of Appendix H.

Like temperature, the availability and concentration of nutrients such as phosphorus and nitrogen are also interesting indicators of overall watershed health. Just as these nutrients stimulate plant growth in a farmer's crop and encourage healthy and lush green residential lawns, they also encourage the growth of plants and algae in lakes and streams. The addition of phosphorus and nitrogen to waterways occurs as a natural circumstance and contributes to what scientists call *ecosystem* productivity. These substances are critical to metabolic processes necessary to all life on earth. However, when nutrients are added to an aquatic system in amounts beyond what these systems would expect to receive under natural conditions, the result is often the overabundance of algae and other plants at nuisance levels. Not only is this algae and other plant life sometimes considered unsightly,

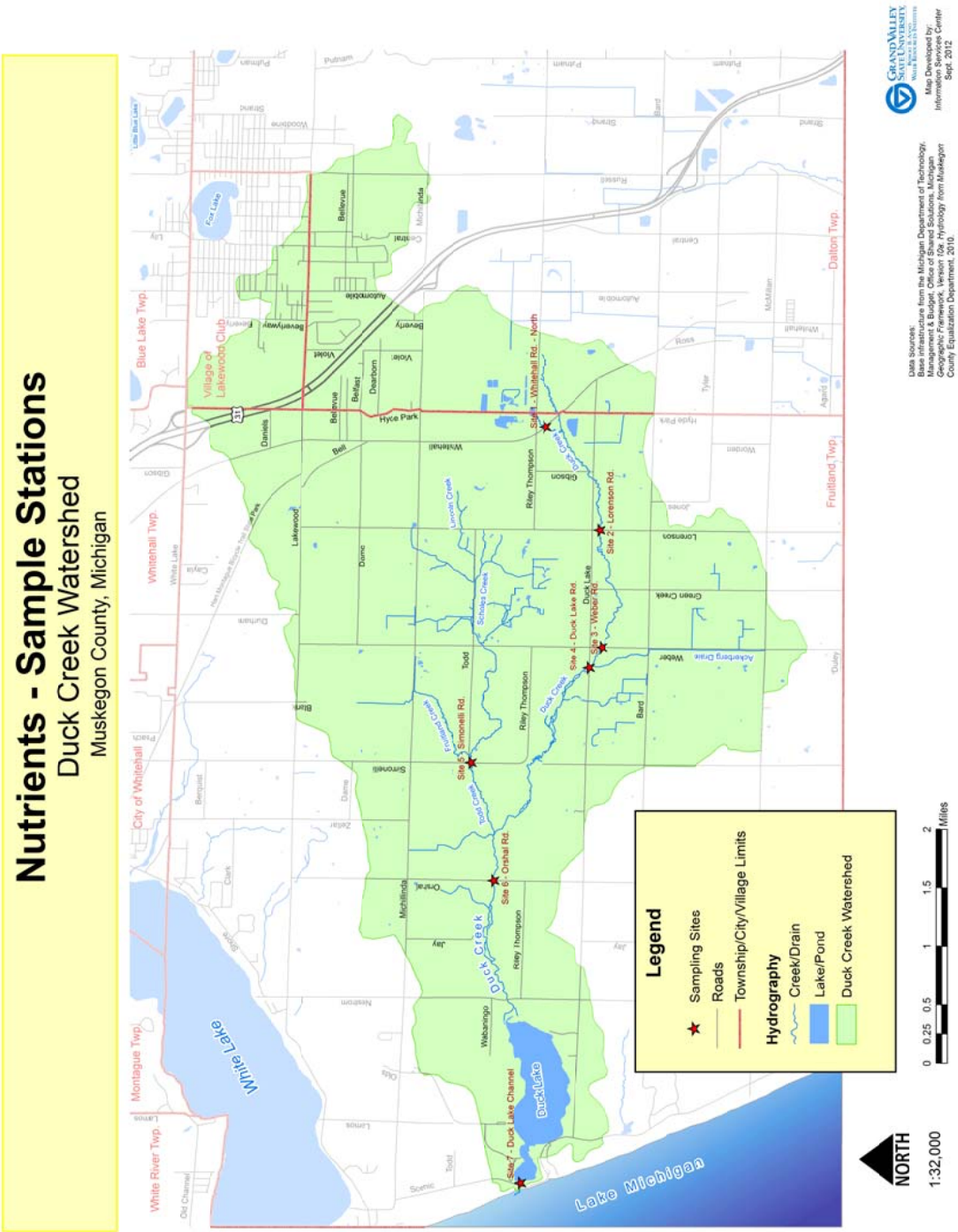


Figure 17. Sample Station Locations—Nutrients

but it also contributes to a cycle of growth and decay which can leave the water low in oxygen and ultimately impacts the survivability of fish and other aquatic life.

The assessment of nutrient data and the impact nutrients have on water quality can be confusing in that what is “normal” will vary from place to place and region to region based on many factors including soils, climate, the plants and animals typical of each region, and if we are talking about a lake/reservoir or a river/stream. For this reason, the USEPA has published separate nutrient criteria for both lakes/reservoirs and rivers/streams specific to various ecoregions in North America. The southern half of Michigan’s Lower Peninsula is located in Ecoregion VII – Mostly Glaciated Dairy Region. This region is divided further into even smaller sub-regions. The sub-region where the Duck Creek Watershed is located is called Sub-Region 56 – Southern Michigan/Northern Indiana Drift Plans (USEPA 2000). The USEPA sampled from several streams in each sub-region in order to estimate reference conditions for that individual sub-region. Total Nitrogen for Sub-Region 56 varied from a minimum of .90 mg/l to a maximum of 2.55 mg/l. The variation between minimum and maximum Total Phosphorus is even more dramatic with the reported minimum at 3.75 µg/l and maximum 295 µq/l.

Many researchers have looked at the impacts of both phosphorus and nitrogen on aquatic habitats. If the goal is to prevent nuisance plants in rivers and streams, the USEPA has recommended a concentration limit of 0.1 mg/l for total phosphorus (USEPA 1986). This threshold limit for total phosphorus was never exceeded during the year-long investigation conducted by the DCWA in 2009-2010. In fact, the highest incidence of total phosphorus observed by the DCWA team was only .03 mg/l. However, other researchers have since indicated that small streams might react when phosphate (PO4-3) reaches levels of .01 mg/l or less. These researchers indicated that in general, concentrations of phosphate over 0.05 will likely have an impact (Behar 1997). This threshold poses a much more stringent limit and was exceeded at Orshal Road and Duck Creek (0.06 mg/l PO4-3) on October 28, 2009, and again at four locations May 8, 2010 at Whitehall/Duck Creek (0.07 mg/l), Lorenson/Duck Creek (0.06 mg/l), Orshal/Duck Creek (0.10 mg/l), and Weber/Duck Creek (0.9 mg/l).

The USEPA has offered similar suggestions regarding safe limits for nitrate nitrogen, indicating that nitrate nitrogen at or below 90 mg/l would have no adverse effects on warmwater fish (USEPA 1986). While it is generally believed that coldwater species like salmonid fishes, including the Brook Trout, have less tolerance for such pollutants, all samples tested by DCWA were well below this threshold. The highest value of nitrate nitrogen recorded at any time at any station was only 0.3 mg/l.

In addition to the temperature and nutrient studies mentioned above, the DCWA partnered with the Muskegon Conservation District (MCD) and the Michigan Clean Water Corps (MiCorps) to create the “Duck Creek Volunteer Stream Monitoring Program.” Duck Creek is currently monitored twice a year at six road-stream crossing sites (Figure 18). Small

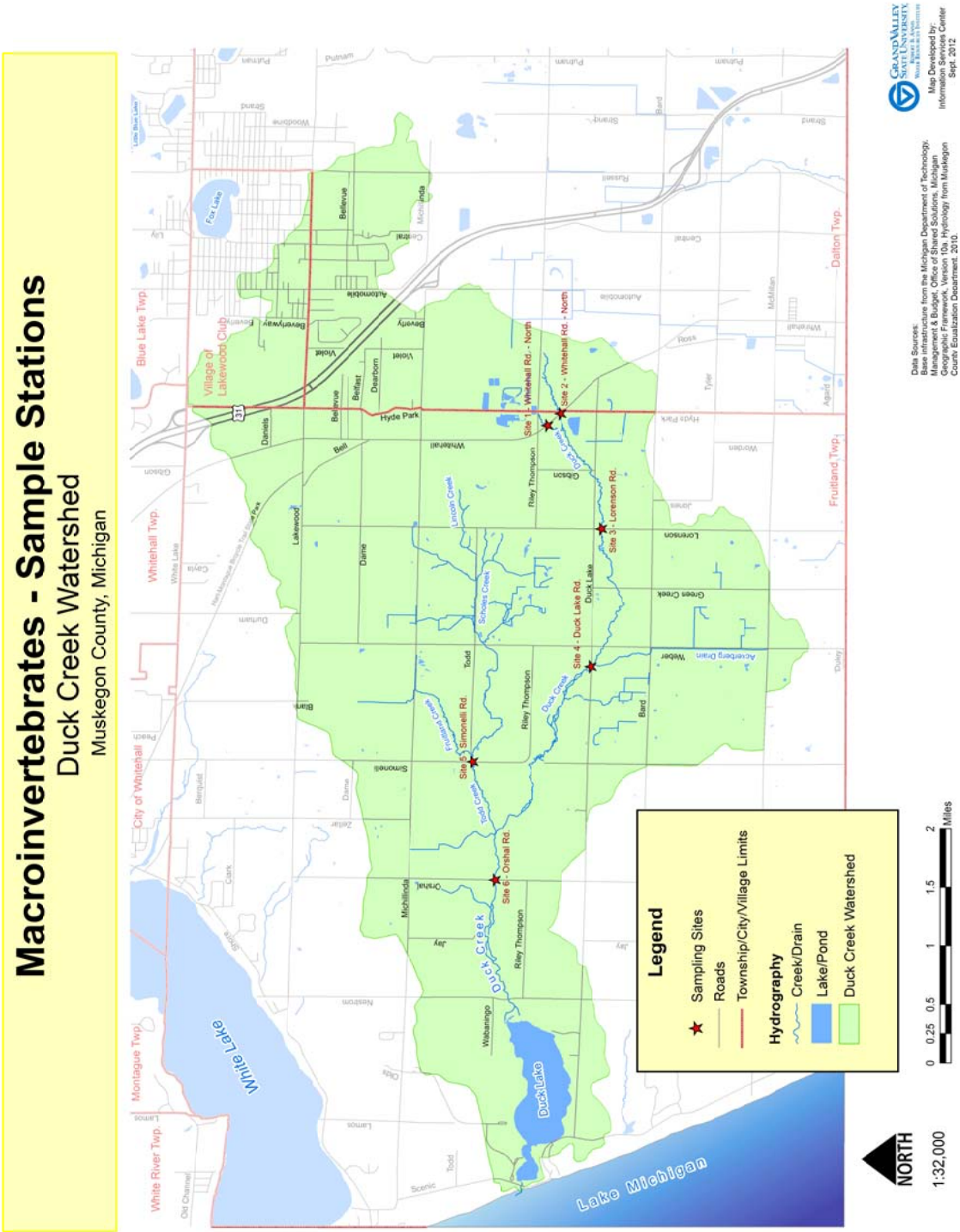


Figure 18. Sample Station Locations—Benthic Macroinvertebrates

insects, snails, and other organisms, referred to as *benthic macroinvertebrates*, are collected and identified at each of these six sites. Identification of these organisms as "pollution-sensitive" or "pollution-tolerant" organisms gives us a clue regarding overall water quality.

In addition to macroinvertebrate data, habitat assessments are conducted through observations of the physical state of the monitoring sites and surrounding area. Summaries of the collections can be found on the MiCorps website (http://www.micorps.net/data/view/search/) and are summarized in Appendix I.

The MiCorps website reports the results for macroinvertebrate inventories conducted on five occasions for the following six road stream crossings. MiCorps macroinvertebrate assessments for each survey location are ranked into three categories: Good, Fair, and Poor (Table 2).

Table 2 – MiCorps Macroinvertebrate Inventories

Date and Time Sampled	1-Whitehall-N	2-Whitehall-S	3- Lorenson	4-Duck Lake Rd	6-Simonelli-S	7-Orshal
2011-11-05	Fair	Fair	-	Fair	Fair	Good
2011-05-21	Poor	Poor	Fair	Fair	Poor	Fair
2010-12-04	Fair	Fair	Fair	Fair	Fair	Fair
2010-05-08	Good	Good	Good	Good	Fair	Good
2009-09-12	Good	Fair	Fair	Good	Good	Good

It is impossible to draw any profound conclusions from the macroinvertebrate data reported except to point out the three sites identified as having "Poor" conditions all occurred during the same sample event on May 21, 2011. This somewhat suspicious anomaly compared to other time periods might be explained by climatic circumstances or other watershed wide disturbance that occurred early that spring. Overall, the macroinvertebrate assessments would indicate a healthy and thriving condition.

As a further attempt to characterize and otherwise understand water quality concerns for the Duck Creek Watershed, the MCD and AWRI project partners conducted a physical inventory of the watershed during the summer of 2011. This inventory included walking all of the *perennial streams and tributaries* within the watershed and documenting any significant findings using field forms recommended by the state, such as the Site Severity Index and modified Bank Erosion Hazard Index (BEHI). The BEHI forms were in fact eventually used in calculating pollutant loadings and in the identification of appropriate control measures. A summary with photographs from the inventory can be found in Appendix J.

During the physical inventory participants looked in particular for areas having steep slopes or lacked appropriate vegetative cover and thus were susceptible to excessive erosion.

Inventory crews also assessed the impacts of roads, bridges, and other man-made structures with the idea that these structures might also contribute to changes in local hydrology, erosion, and sedimentation problems. This physical inventory led to the identification of one road-stream crossings having issues requiring maintenance or modification. Most of the road-stream crossings were either found in “Good” or “Fair” condition. Table 3 summarizes the condition of the 27 road-stream crossings examined. This information is also summarized in Figure 19.

Table 3– Road/Stream Crossing Conditions

General Condition	Number of Road-Stream Crossings
New	4
Good	13
Fair	9
Poor	1
TOTAL	**27**

Also discovered as part of the physical inventory are 26 separate “Inventory Points”, many of which are potential problem areas where actionable improvements are suggested. Several of these inventoried points deal with streambank erosion or invasive species controls. Table 4 helps to summarize these areas of interest, which are also included in Figure 20.

Table 4 – Physical Inventory Areas of Interest

Inventoried Issue	Number of Sites
Streambank Erosion	14
Cattle Crossing	1
Invasive Species	7
Culvert Improvement	2
Groundwater Seepage	1
Septic Seepage (Suspected)	1
TOTAL	**26**

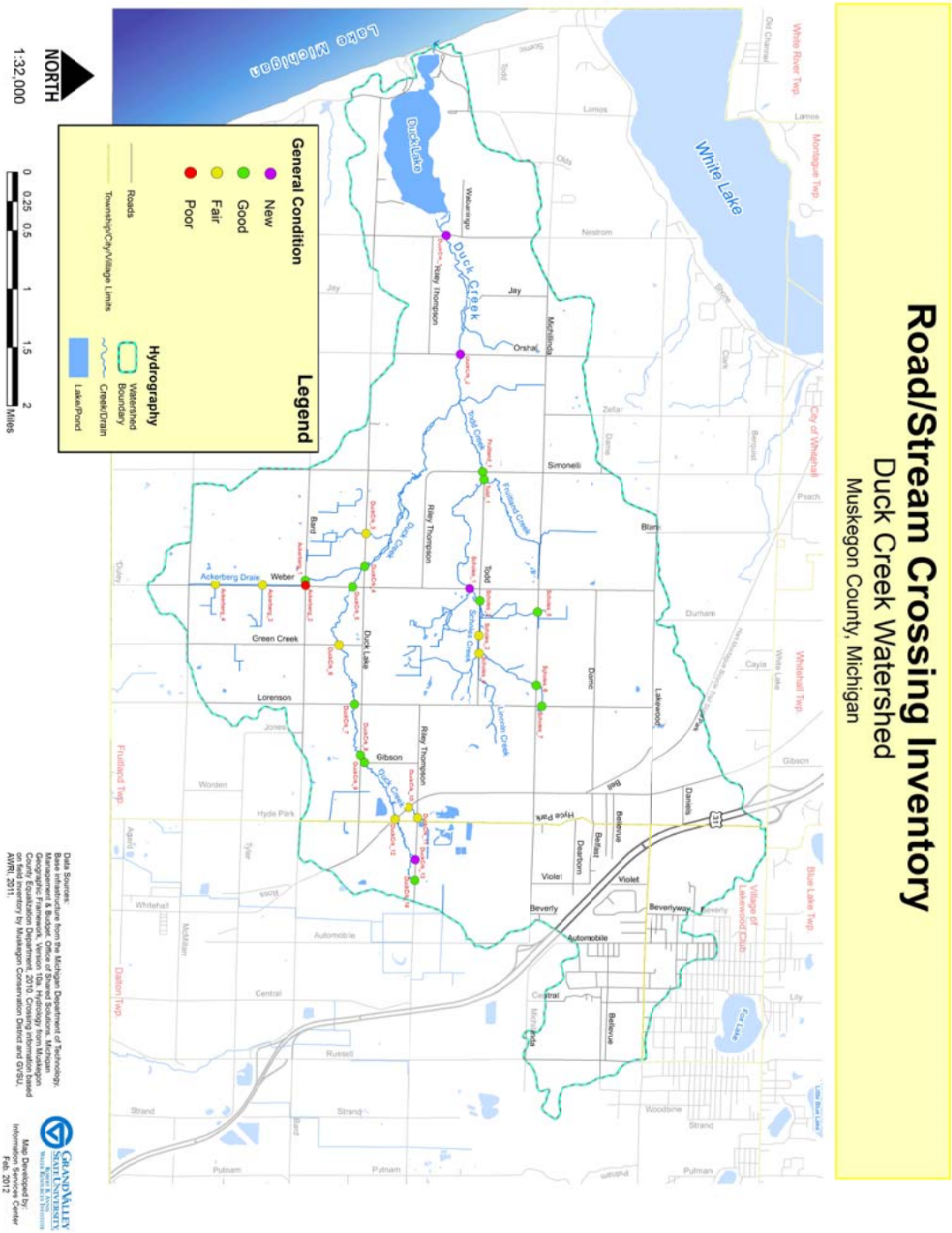


Figure 19. Road –Stream Crossing Inventory

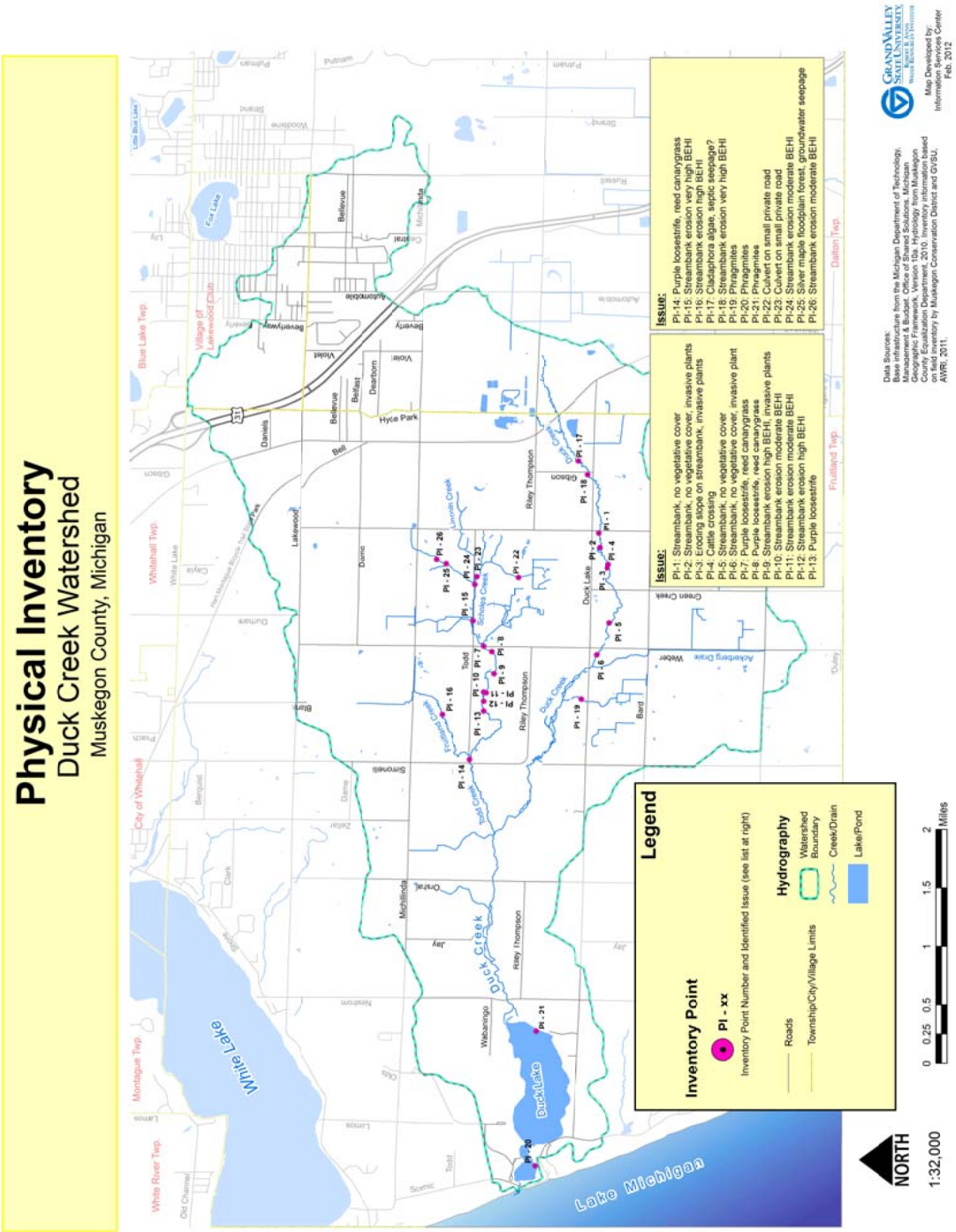


Figure 20. Physical Inventory Areas of Interest

Hydrol-ogy

Another piece of information scientists and others use to determine the quality of a watershed or whether it is under stress is hydrology. The term "hydrology" is defined as the scientific study of the properties, distribution, use, and circulation of the water on Earth and in the atmosphere in all of its forms (Microsoft 2003). The volume of water, timing with respect to rainfall, and duration of high and low flows are important aspects of stream hydrology. Refer below to Catchment Map using information provided by the consulting firm Cardno JFNew (Figure 21). More about the hydrology of the Duck Creek Watershed is reported in Appendix K.

Land Use and Land Cover

Land use and cover in the watershed relates directly to hydrology and is another key factor that can greatly influence the character of a stream as well as its water quality. The increase of *impervious* surfaces such as roads, sidewalks, and roof tops has the ability to modify local hydrology resulting in greater stream flows and accelerated streambank erosion, sedimentation, and loss of aquatic habitat. Excessive sediments, fertilizers, and pesticides from farmlands and residential areas are pollutants that can travel over ground through surface water *runoff* and into a stream after a rain storm (Gordon et al. 2004). The fact is the extent of *impervious* surfaces and the type of *land use* in a watershed can serve as excellent indicators of both existing and future water quality problems. While it is always best to rely on actual water quality measurements taken by reputable sources over several years, such a data base is obviously difficult and expensive to compile. Fortunately, there are a number of computer models that help us to understand the likely impacts of existing and future *land use* scenarios.

Duck Lake Data Sources

Duck Lake has long been an interest of the DCWA. While information specific to the physical and chemical condition of Duck Lake is limited and sporadic, MiCorps volunteers have been collecting secchi disk readings since 1981. More recently, volunteers have recorded phosphorus, chlorophyll, and dissolved oxygen information for 2011 and 2012. The information contained by the MiCorps data base for Duck Lake is summarized in Appendix L. This same information can also be found on the MiCorps website (http://www.micorps.net/data/view/search/).

Of particular interest to the DCWA and others living in the Duck Creek Watershed is the *trophic state* of Duck Lake. Trophic state is a general concept with no agreed definition, but in general it refers to the biological production that occurs in lake. Indicators like water clarity, phosphorus concentrations, and chlorophyll concentrations are often used to help characterize the trophic status of any lake. The trophic status of Duck lake is considered as part of Appendix L.

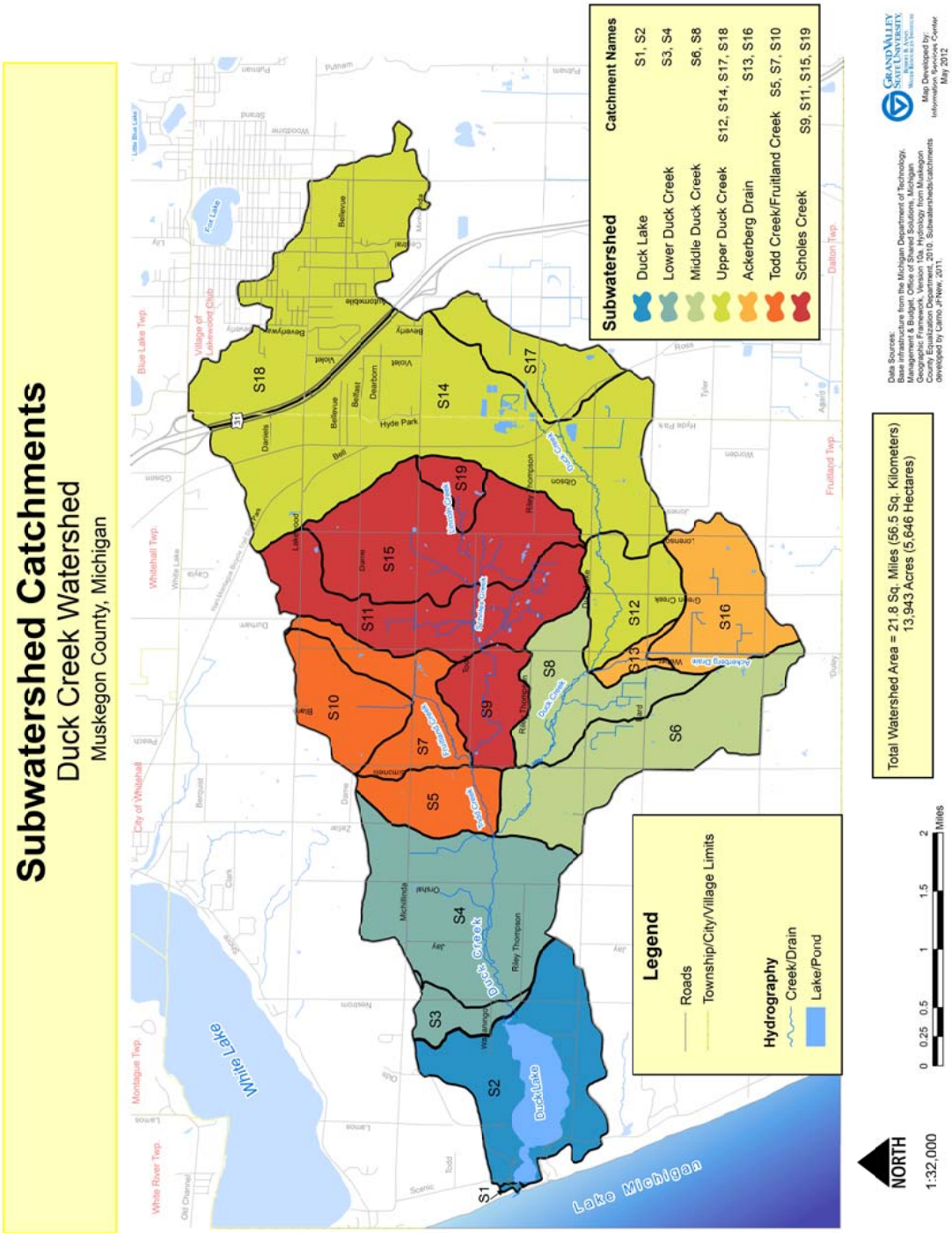


Figure 21. Detailed Delineation of Catchments – Duck Creek Watershed

The DCWA has conducted at least one near shore plant survey with the intention of characterizing the aquatic plant community in Duck Lake. The results from this survey are reported in a document titled: Rooted Aquatic Plants in Duck Lake—Summer 2011 (Tisue 2012). This report has also been included in its entirety as part of Appendix L.. The conclusion offered by the author of this report indicated that the evidence collected did not support the need for additional controls or alterations in management practices. These practices have included in the past the introduction of herbicides targeting plant growth in recreational use zones (2011), and the use of Eurasian milfoil weevils as a deterrent for Eurasian milfoils infestation (2006-07) (Tisue 2012).

3.3 Land Use Models and Subwatershed Analysis

While the previous section refers to several water quality monitoring events documenting existing data for the watershed, this data base is less than ideal suggesting the need for further investigation. The MCD, MDEQ, and DCWA are all involved in the collection of environmental samples and the assessment of Duck Creek Watershed overall health. Unfortunately, it is going to take some time before this much needed additional information will be available. Meanwhile, AWRI has turned to the use of several computer models to help in understanding water quality issues that supplement our existing water quality data base. These models also help us to predict what a likely future is for the Duck Creek Watershed.

The first model considered here is PLOAD. PLOAD is a stormwater pollution loading model developed by the USEPA and available as a sub-routine of its Better Assessment Science Integrating point and Nonpoint Sources (BASINS) model (http://water.epa.gov/scitech/datait/models/basins/). It is a Geographic Information System (GIS) based model specifically designed for watershed analysis. PLOAD uses a map interface to help visualize the distribution of stormwater related pollutants through the landscape.

PLOAD relies heavily on *land use* information in order to calculate stormwater related pollution loadings for a given geographic area. PLOAD uses empirical studies conducted by USEPA and others to associate pollutant loads likely to be created by different land uses during rainfall of specific intensity and duration. PLOAD uses established land use/pollutant coefficients to estimate the release of twenty different pollutants from many different *land use* types. PLOAD doesn't care if the *land use* under investigate is current, from the past, or a reasonable expectation of the future. Therefore, it is possible for us to estimate pollutant loads using current *land use* and compare that with future *land use* scenarios giving us some idea what implications future *land use* might have on the character and health of our watersheds.

AWRI uses another Geographic Information System call IDRISI, Selva Edition, to help in the formulation of future *land use* scenarios. The second important model is the Land

Change Modeler (LCM) by Clark University, Worcester MA (Eastman 2012). The LCM program uses *land use* change that has occurred in the past as an indication of what is likely for the future. Researchers use existing roads, lakes and streams, and the location of urban land uses as drivers in predicting where future urban growth is likely to occur. In the process we also learn where we can expect to see the loss or expansion of other *land use* types such as forest, agriculture, and open land. As each of these future land uses have a propensity to pollute, we can use PLOAD to estimate how our selected future compares to pollution estimates of an existing *land use* matrix. The PLOAD model gives us specific estimates for pollution loads from each subwatershed as either total pounds of pollutant per year or pounds per acre within each subwatershed. However, such loads are only estimates. This fact is complicated even further by the uncertainty regarding future *land use*. Therefore, while it is possible to estimate specific pollutant loads from each subwatershed, it is probably more appropriate to use PLOAD and LCM to give us a relative comparison between competing *land use* scenarios and thus integrate our results as part of a comprehensive planning process.

A detailed explanation of how AWRI used LCM and PLOAD in the development of pollutant priorities for the Duck Creek Watershed can be found in Appendices O and P. A general summary highlighting the outcome of these models is reported below.

PLOAD/LCM Assessment

The first step to the estimate of stormwater pollution loadings using PLOAD is to delineate subwatershed boundaries. Subwatersheds were already presented in Chapter 1 as part of Figure 4. Hydrology in the Duck Creek Watershed.

For purposes of PLOAD analysis, AWRI used the nineteen catchments identified by the consulting firm Cardno JFNew and referred to in Figure 21. AWRI also expanded the previous *land use* and cover map for 2009 to include 16 *land use* categories instead of just the seven original categories (Figure 22). This more detailed *land use* also includes a more detailed wetland assessment provided by the MDEQ (Figure 23). (Note: Figure 23 includes not only the location of existing wetlands, but also makes recommendations for the rehabilitation of former wetland areas. The modeling procedures outlined here make it possible to consider the rehabilitation of former wetlands and compare the pollutant loadings with estimates of the existing condition.)

While PLOAD has the capability of modeling many typical *nonpoint source* water pollutants, AWRI chose to examine just three, Total Nitrogen, Total Phosphorus, and Total suspended Solids. It was determined that these three pollutants were sufficient to show current and future pollution threats in the Duck Creek Watershed. Using the two maps mentioned above the results are summarized in Table 5 and Figures 24, 25, and 26.

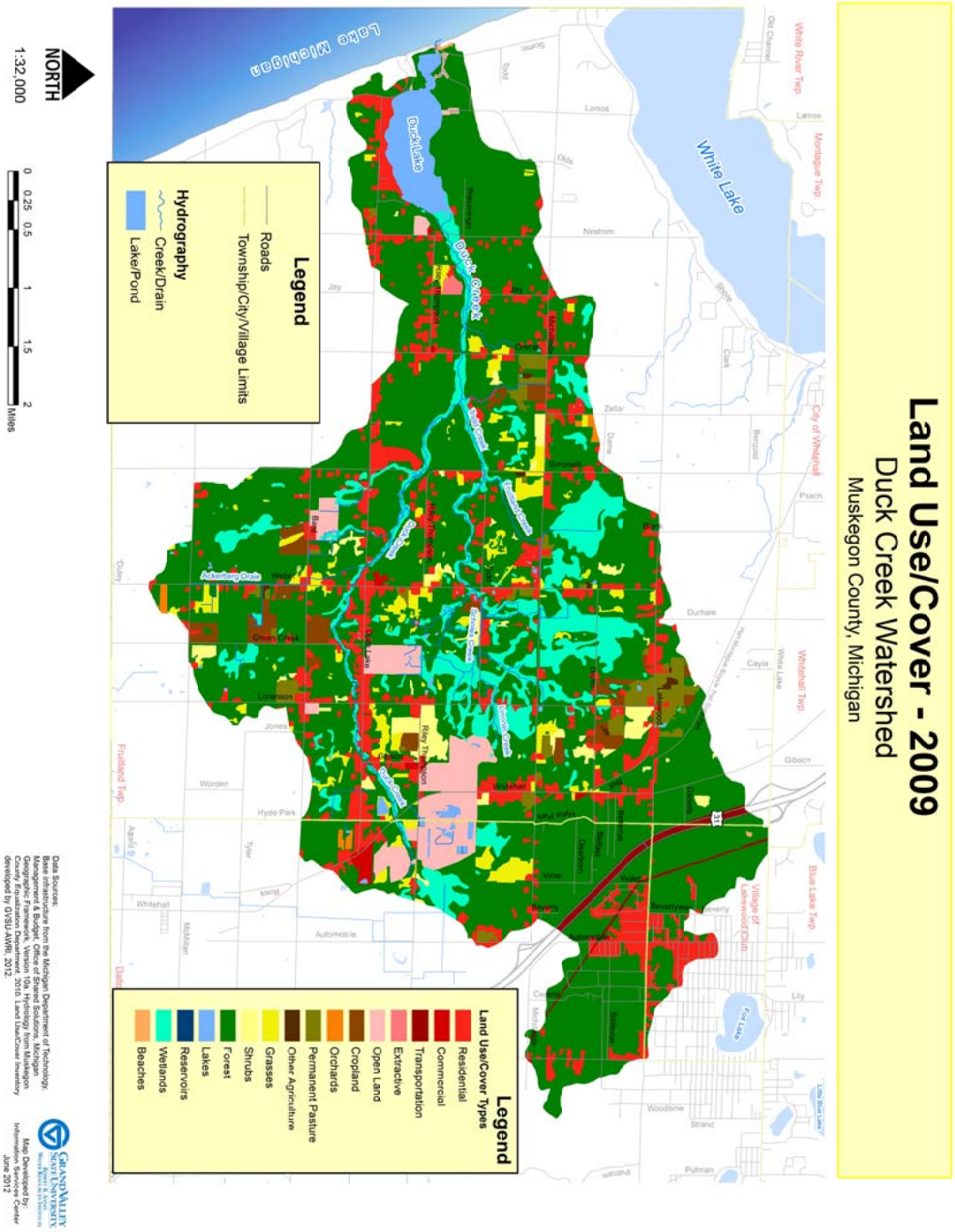


Figure 22. 2009 Land Use and Cover (Sixteen Categories)

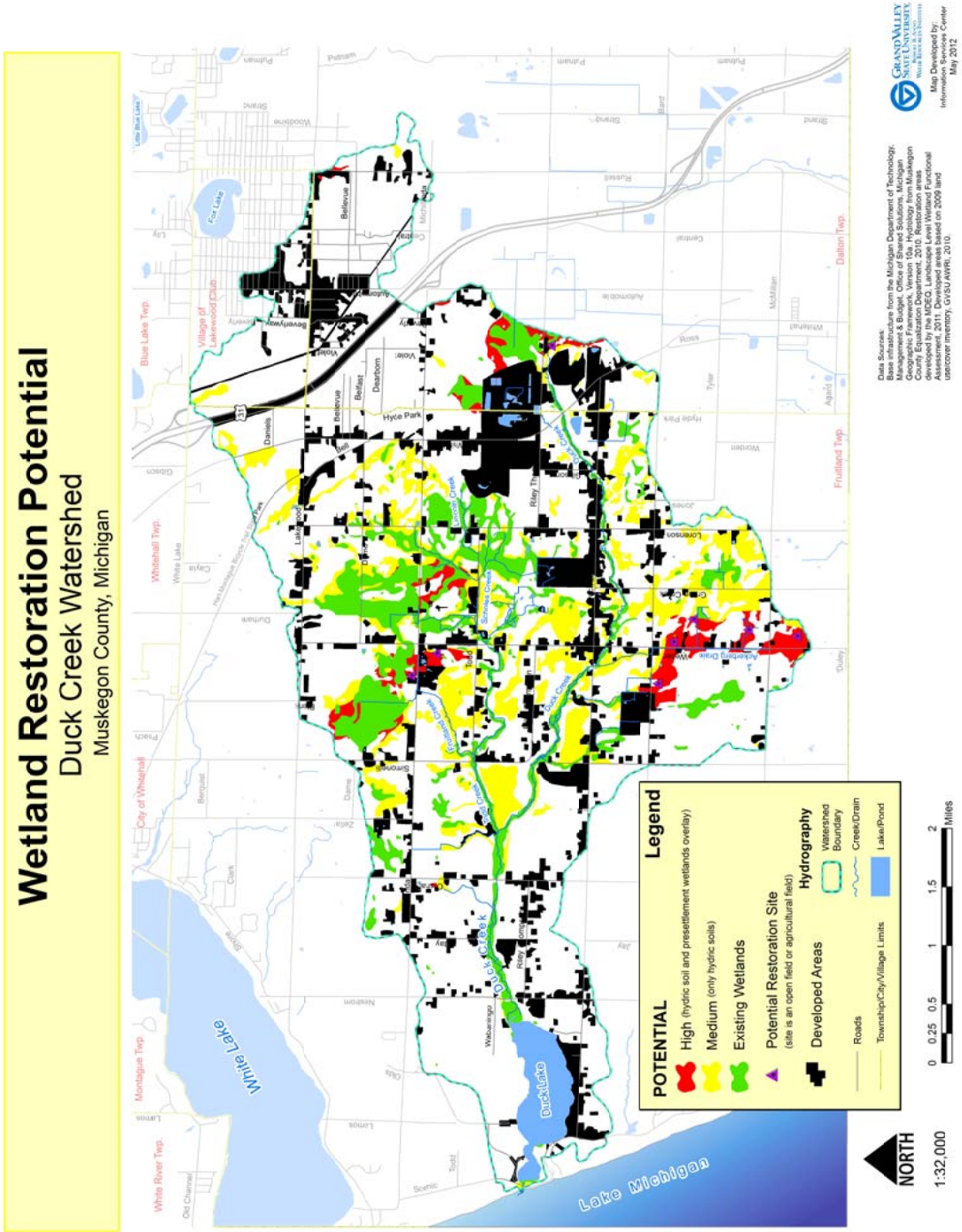


Figure 23. MDEQ Wetland Restoration Potential

Table 5. PLOAD Results for the Duck Creek Watershed in 2009.

		2009 Land Use					
Subwatershed	**Area** (acres)	**TN_load** (lbs)	**TN_acre** (lbs/acre)	**TP_load** (lbs)	**TP_acre** (lbs/acre)	**TSS_load** (lbs)	**TSS_acre** (lbs/acre)
S1-River @ end of Duck Lake	4	1.5	0.373	0.2	0.060	23.8	5.957
S2-Duck Lake	1172	2393.6	2.042	379.8	0.324	20040.4	17.095
S3-Duck Creek 1	177	160.3	0.906	30.2	0.171	2107.5	11.914
S4-Duck Creek 2	1407	1841.3	1.309	370.8	0.263	22642.3	16.091
S5-Todd Creek 1	379	358.0	0.945	68.7	0.181	4782.2	12.625
S6-Duck Creek 3	1053	1122.5	1.066	220.2	0.209	14439.0	13.707
S7-Todd Creek 2	471	607.3	1.290	122.3	0.260	7650.2	16.252
S8-Duck Creek 4	622	893.1	1.437	178.5	0.287	11621.3	18.695
S9-Scholes Creek 1	372	451.5	1.214	89.8	0.241	5753.8	15.476
S10-Todd Creek 3	459	409.7	0.893	78.0	0.170	5248.2	11.441
S11-Scholes Creek 2	902	1020.0	1.130	198.7	0.220	12738.2	14.115
S12-Duck Creek 5	449	825.7	1.840	170.9	0.381	9764.1	21.759
S13-Drainage Ditch 1	82	96.8	1.181	19.4	0.236	1273.4	15.538
S14-Duck Creek 6	2599	4023.0	1.548	779.1	0.300	53661.4	20.643
S15-Scholes Creek 3	1167	1100.4	0.943	207.2	0.178	14139.3	12.113
S16-Drainage Ditch 2	642	627.8	0.978	116.5	0.182	8130.8	12.672
S17-Duck Creek 7	459	787.7	1.717	149.3	0.325	11633.2	25.360
S18-Duck Creek 8	1515	3017.4	1.992	598.5	0.395	42146.8	27.818
S19-Scholes Creek 4	141	81.1	0.576	13.7	0.097	1222.0	8.672

Review of Table 5 will quickly reveal an important consideration. Pollutants loadings are described as a product of the entire subwatershed and on a per acre basis. Both delineations can be useful in understanding the source of existing and projected *nonpoint source pollution*, but the per acre measure allows a more comparable assessment between subwatersheds. Giving focus to the per acre pollutant estimate, those subwatersheds which are consistently in the top five as a source of pollution include S18-Duck Creek 8, S17-Duck Creek 7, and S14-Duck Creek 6. These subwatersheds are all in the upper portion of the Duck Creek Watershed. This is particularly troublesome in that the upper most portion of any watershed is arguably the most sensitive and perhaps even the most critical. If this part of the stream system is not doing the job of efficiently processing *organic* matter, this material is sent downstream to be dealt with by the middle and lower stream system and might, in fact, overwhelm these ecologic stream components.

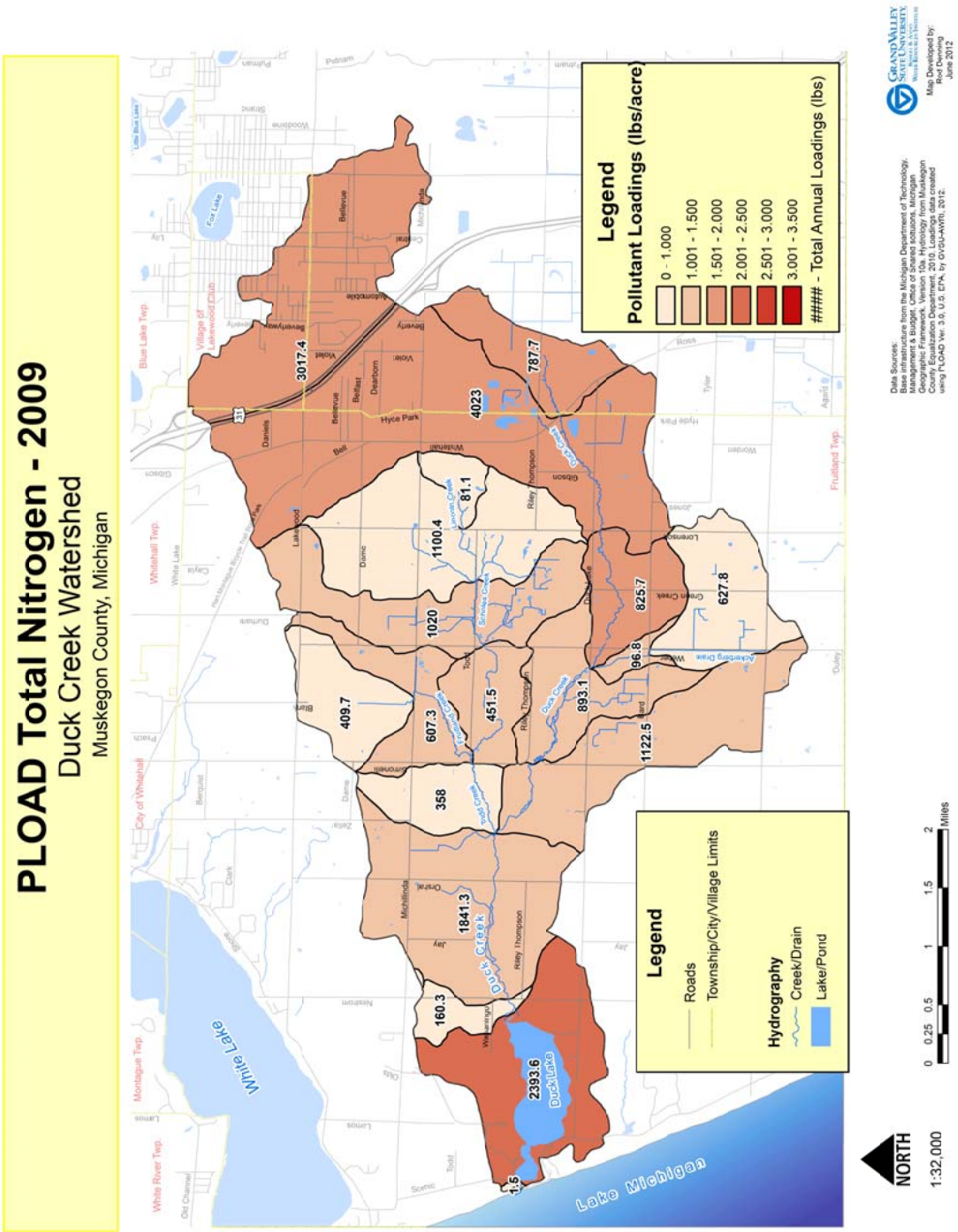


Figure 24. PLOAD Results—2009 Total Nitrogen

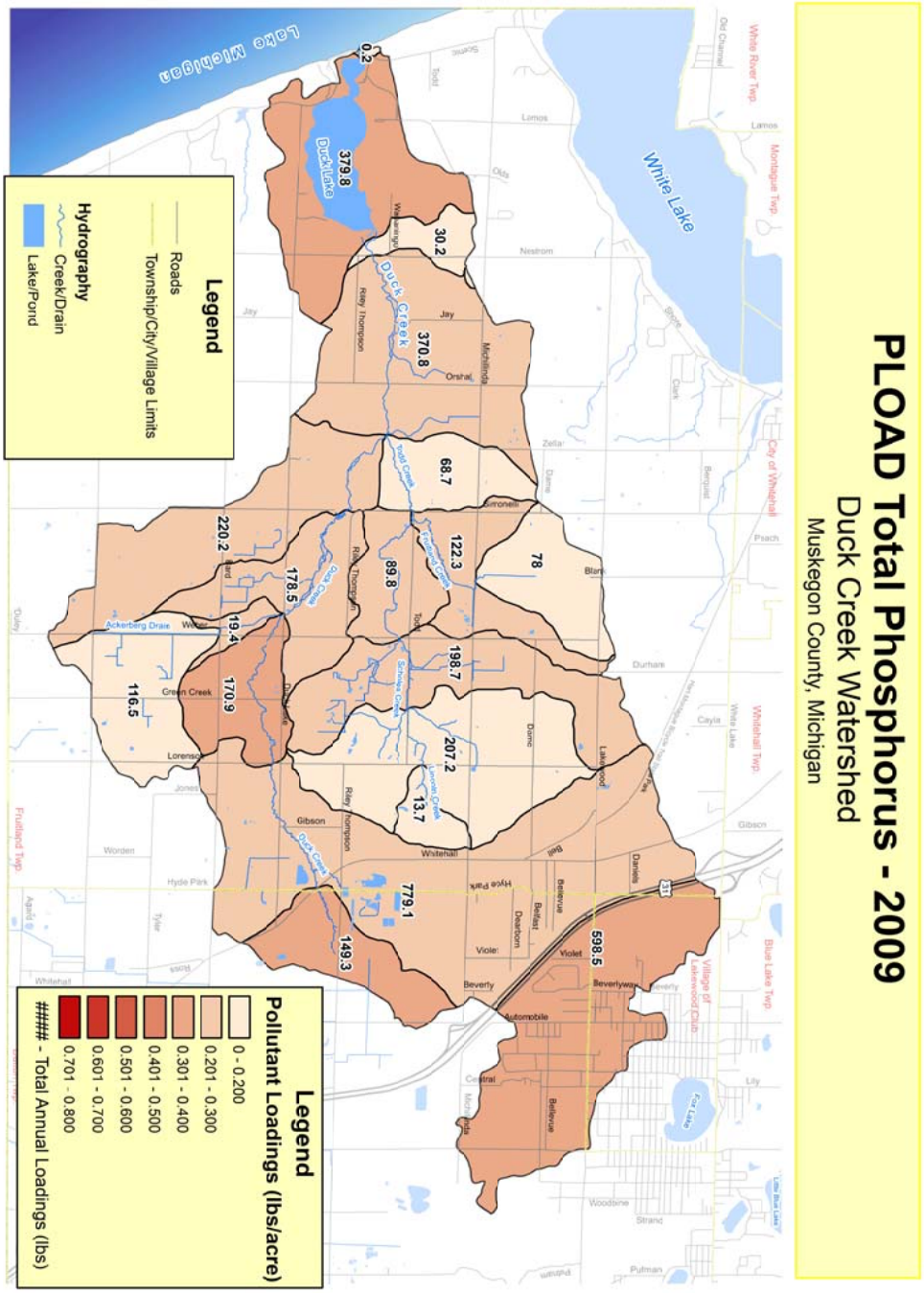


Figure 25. PLOAD Results—2009 Total Phosphorus

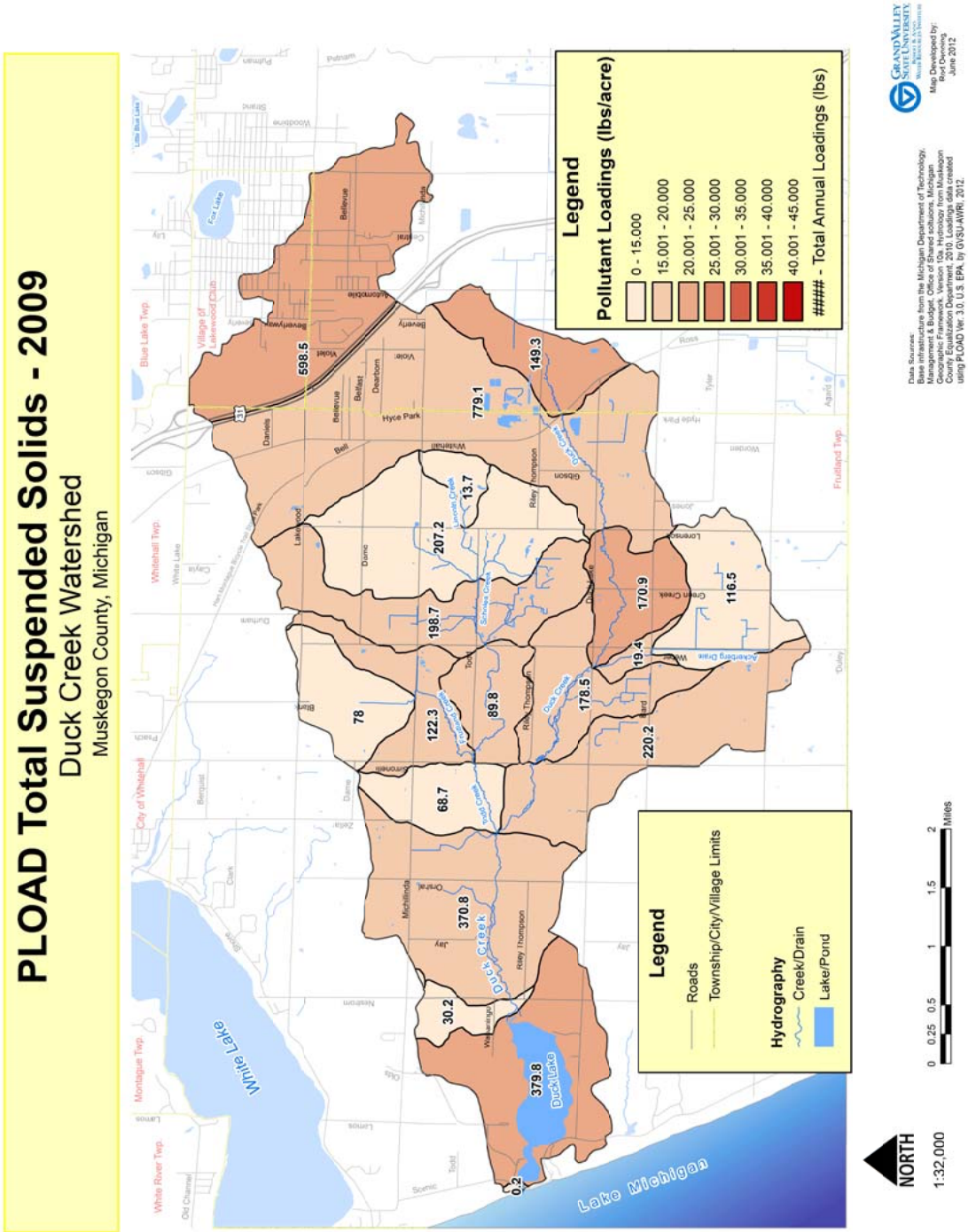


Figure 26. PLOAD Results—2009 Total Suspended Solids

With 2009 *land use* and cover as a starting point, AWRI used LCM to predict a reasonable *land use* and cover map for the year 2040. This map was generated using the change that occurred between the years 1998 and 2009. While it is impossible to predict with certainty what *land use* in the Duck Creek Watershed will look like in the year 2040, the LCM gives a credible picture of our future. This future assumes that people will make similar decisions regarding *land use* choices as they did between the years 1998 and 2009. This future scenario also assumes a similar rate of urban growth that occurred in the eleven years between 1998 and 2009. The recent recession of 2008 and the overall downturn of residential development throughout the country and including Muskegon County make this rate of growth both unlikely and inflated. However, it is possible to see that increase growth regardless of rate will have a consequence on pollutant loads. The result of combining LCM and PLOAD also allows us to see where such growth and thus increased pollutant loads might occur relative to the individual subwatersheds identified. This in turn gives us some idea of where we might focus our attention with regard to future pollutant loads and the implementation of pollution prevention strategies. Using these simulations we have an opportunity to be proactive, to prevent future water pollution, rather than try to deal with it after the fact.

The LCM predicted *land use* and cover for the year 2040 is reported in Figure 27. Table 6 describes PLOAD results for Total Nitrogen, Total Phosphorus, and Total Suspended Solids, again as indicators of how pollutant loadings are related directly to *land use*. Figures 28, 29, and 30 summarize pollutant loadings by subwatershed. Looking quickly at pollutant loadings per acre we see something a little different when compared to 2009. Our 2040 pollutant loading estimates would indicate a shift in our troubled subwatersheds from the upper part of the watershed to the middle of the watershed. Those subwatersheds of particular concern in 2040 are S13-Drainage Ditch 1, S12-Duck Creek 5, and S8-duck Creek 4. This result seems reasonable given the visibly significant urban growth predicted by LCM for the mid-portion of the Duck Creek Watershed.

Refer once again to Figure 23 and the recommendations made by MDEQ regarding the rehabilitation of former wetlands. Ordinarily, one would expect a decrease in pollutant loadings when adding wetland acres to the landscape. Our PLOAD and LCM assessment gives us a chance to test this assumption, at least with regard to the selected *nonpoint source pollutants* being modeled. If we assume the development of both high and medium potential wetlands as identified by the MDEQ, the result is somewhat surprising. Refer to Figure 31 for the expected 2040 *land use* and cover assuming the development of high and medium potential wetlands. The PLOAD result using this 2040 scenario is summarized in Table 7, and in Figures 32, 33, and 34.

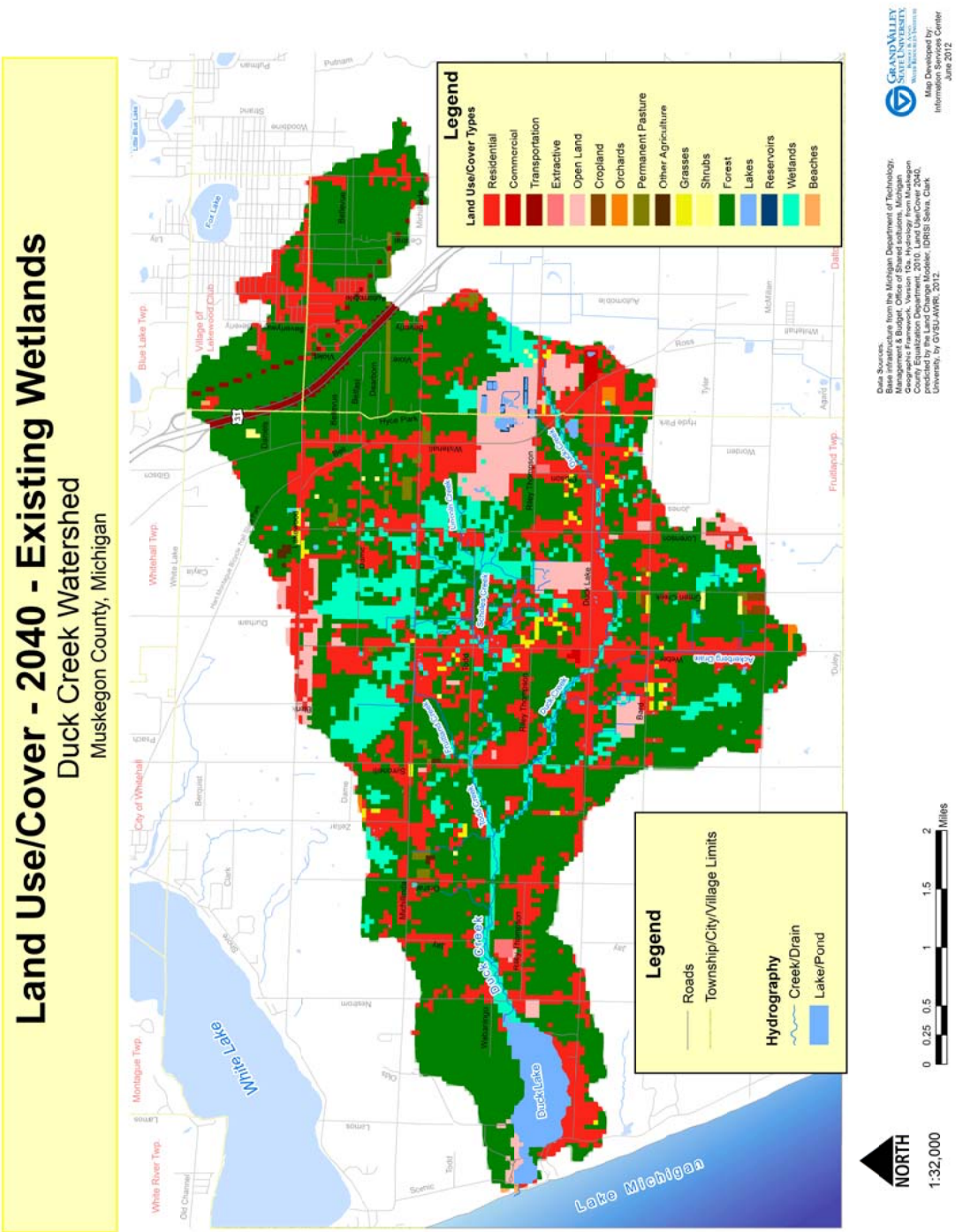


Figure 27. 2040 Predicted Land Use and Cover

Table 6. PLOAD Results for the Duck Creek Watershed in 2040.

		2040 Land Use - Existing Wetlands					
Subwatershed	**Area** (acres)	**TN_load** (lbs)	**TN_acre** (lbs/acre)	**TP_load** (lbs)	**TP_acre** (lbs/acre)	**TSS_load** (lbs)	**TSS_acre** (lbs/acre)
S1-River @ end of Duck Lake	4	5.8	1.453	1.2	0.307	69.4	17.355
S2-Duck Lake	1172	2668.3	2.276	442.9	0.378	22923.1	19.554
S3-Duck Creek 1	177	173.3	0.980	33.2	0.187	2244.2	12.687
S4-Duck Creek 2	1407	2161.5	1.536	446.7	0.317	26139.5	18.576
S5-Todd Creek 1	379	556.1	1.468	114.4	0.302	6779.2	17.898
S6-Duck Creek 3	1053	1312.8	1.246	264.5	0.251	16468.8	15.634
S7-Todd Creek 2	471	1022.8	2.173	217.9	0.463	11963.6	25.415
S8-Duck Creek 4	622	1378.4	2.217	291.3	0.469	16726.8	26.908
S9-Scholes Creek 1	372	801.6	2.156	170.4	0.458	9355.1	25.163
S10-Todd Creek 3	459	608.0	1.325	123.8	0.270	7412.9	16.160
S11-Scholes Creek 2	902	1691.9	1.875	356.8	0.395	19985.5	22.145
S12-Duck Creek 5	449	1096.1	2.443	235.4	0.525	12724.5	28.356
S13-Drainage Ditch 1	82	230.7	2.815	50.1	0.611	2652.0	32.361
S14-Duck Creek 6	2599	5045.9	1.941	1016.7	0.391	64191.9	24.694
S15-Scholes Creek 3	1167	1689.4	1.447	345.5	0.296	20160.9	17.271
S16-Drainage Ditch 2	642	988.4	1.540	202.7	0.316	12073.0	18.817
S17-Duck Creek 7	459	1051.1	2.291	209.7	0.457	14381.4	31.351
S18-Duck Creek 8	1515	3081.8	2.034	612.7	0.404	42806.9	28.253
S19-Scholes Creek 4	141	292.7	2.077	62.3	0.442	3454.7	24.516

LCM assumes that the same number of acres will be converted to urban use regardless of our attempt to rehabilitate former wetlands. That means that residential growth, for instance, is expected to take place at the same rate as it did in the years between 1998 and 2009, yet be dispersed differently than our 2040 prediction in Figure 27. Because a significant amount of high and medium potential wetlands are located in the middle of the watershed, new residential development is expected by LCM to occur in the upper part of the watershed. This has the effect of actually causing more pollutant loadings from the upper part of the watershed. This is an interesting and perhaps unexpected outcome of creating more wetlands in the mid-portion of the watershed, even though the overall outcome of more wetlands results in less *nonpoint source pollution* compared to those scenarios where fewer wetlands are in existence.

The use of PLOAD and LCM can be provocative, especially when we start talking about the future. There are so many variables at play with regarding to future *land use* it would be irresponsible to give too much weight to this assessment. Still, such models are the best source of information we have about how future development might impact this and other watersheds.

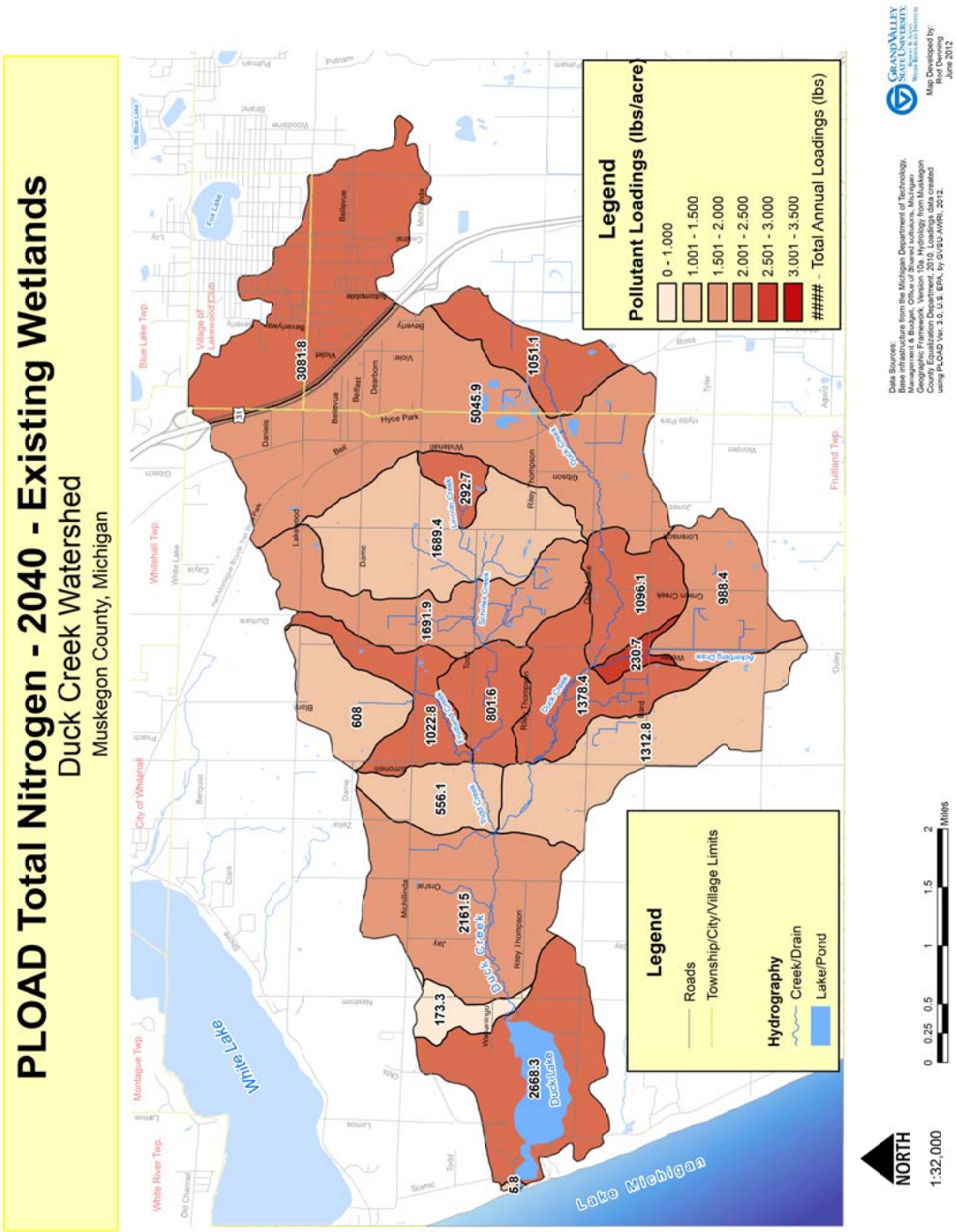


Figure 28. PLOAD Results—**204**0 Total Nitrogen (Existing Wetlands)

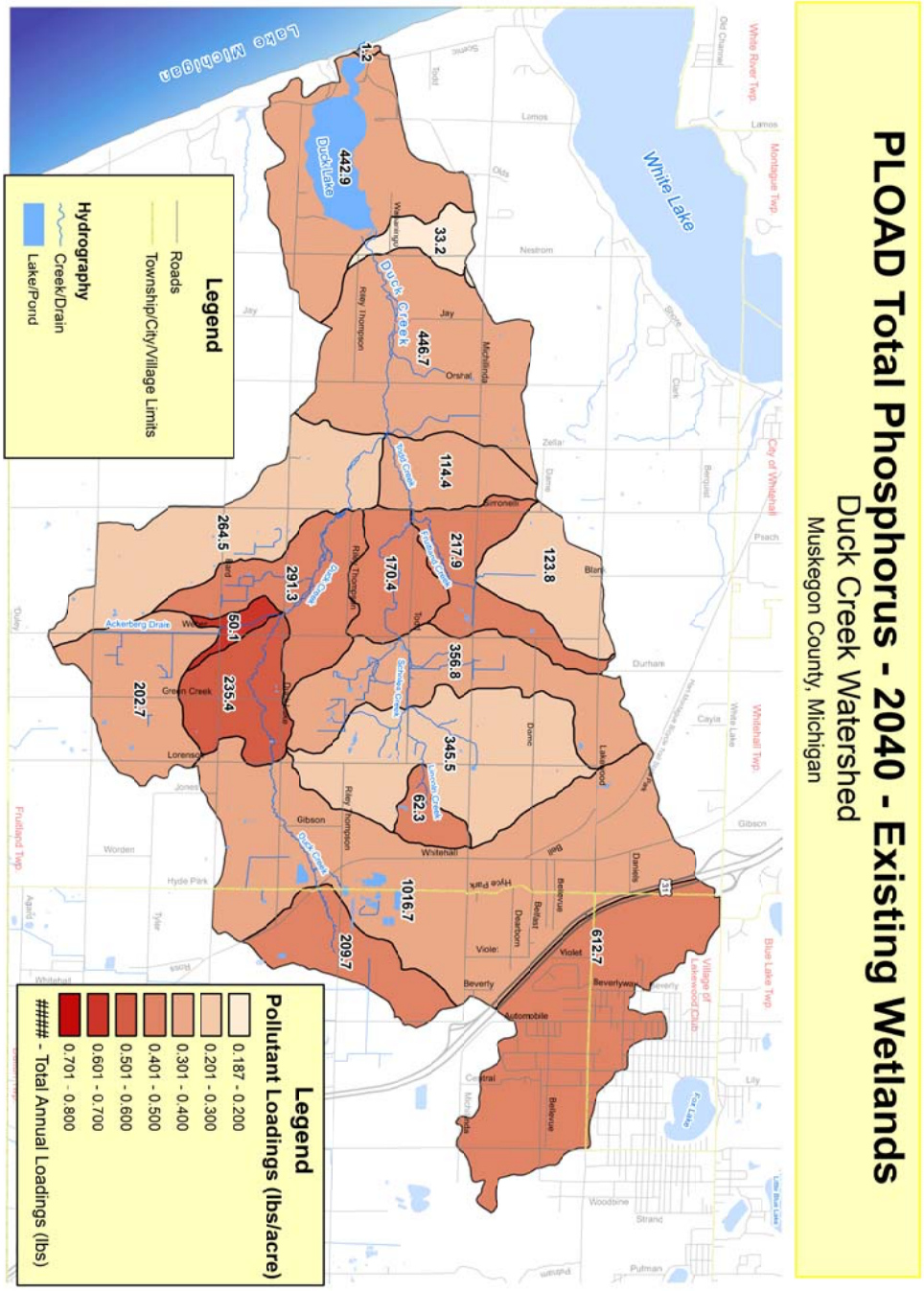


Figure 29. PLOAD Results—2040 Total Phosphorus (Existing Wetlands)

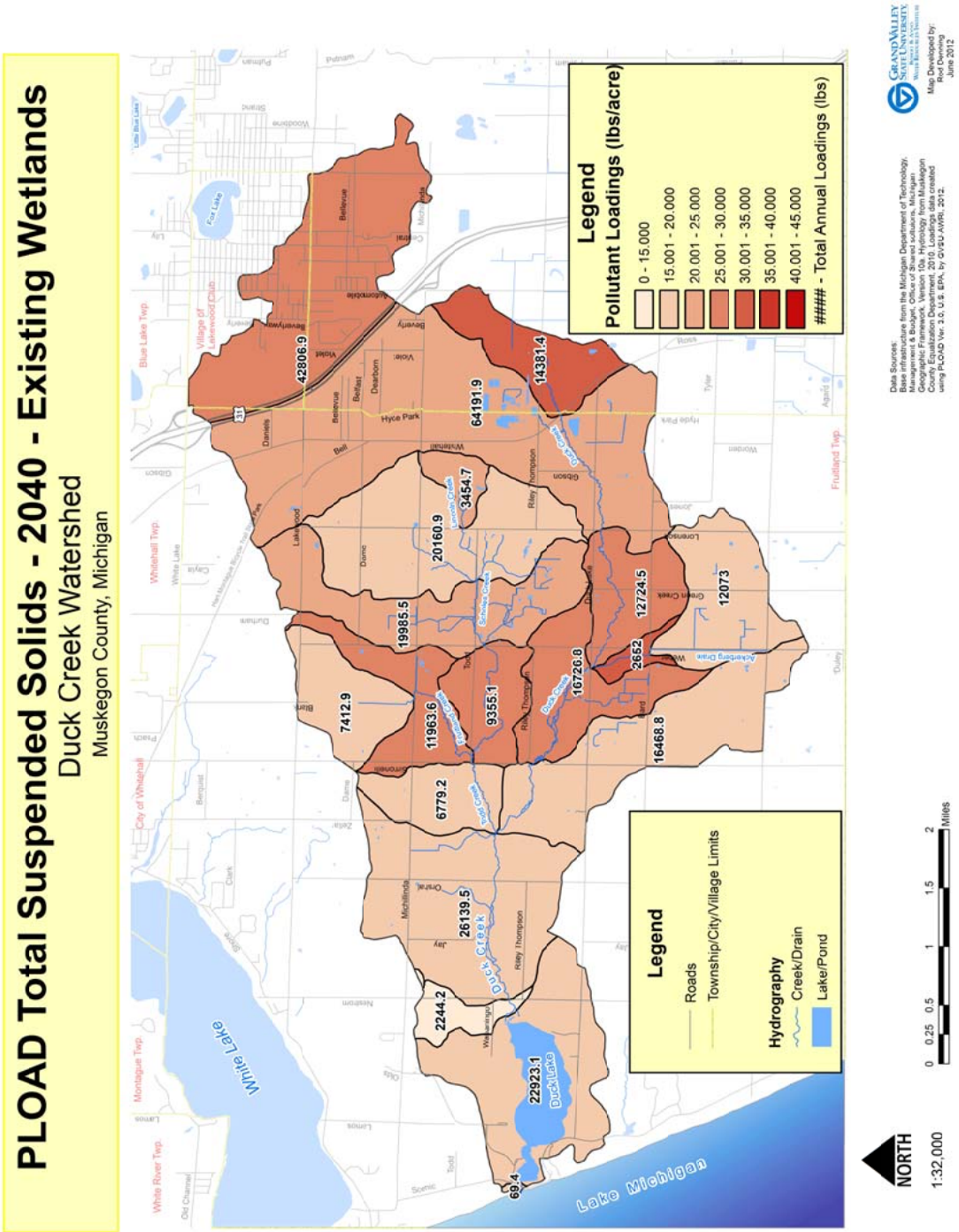


Figure 30. PLOAD Results—2040 Total Suspended Solids (Existing Wetlands)

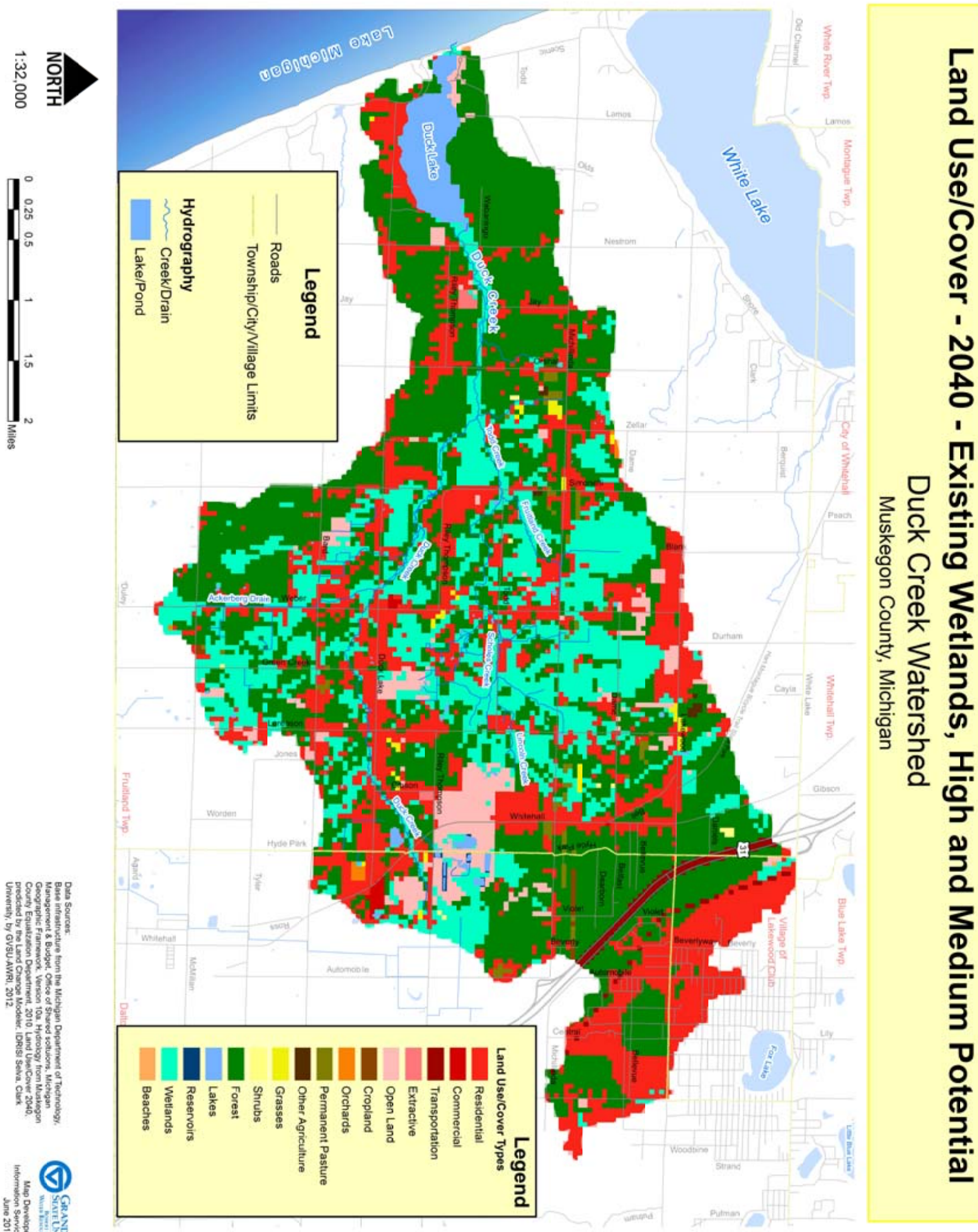


Figure 31. 2040 Predicted Land Use and Cover (with High and Medium Potential Wetlands)

Table 7. PLOAD Results for the Duck Creek Watershed in 2040 with High and Medium Potential Wetlands.

		2040 Land Use - New Existing Wetlands, High & Medium Potential					
Subwatershed	**Area** (acres)	**TN_load** (lbs)	**TN_acre** (lbs/acre)	**TP_load** (lbs)	**TP_acre** (lbs/acre)	**TSS_load** (lbs)	**TSS_acre** (lbs/acre)
S1-River @ end of Duck Lake	4	2.1	0.522	0.3	0.078	24.9	6.222
S2-Duck Lake	1172	2495.5	2.129	403.3	0.344	21096.9	17.996
S3-Duck Creek 1	177	160.2	0.906	30.2	0.170	2103.8	11.893
S4-Duck Creek 2	1407	1963.0	1.395	401.2	0.285	23985.9	17.046
S5-Todd Creek 1	379	495.7	1.309	101.0	0.267	5865.8	15.486
S6-Duck Creek 3	1053	1240.4	1.178	248.3	0.236	15499.4	14.714
S7-Todd Creek 2	471	917.9	1.950	193.7	0.411	10531.4	22.373
S8-Duck Creek 4	622	1142.8	1.838	237.6	0.382	13645.3	21.951
S9-Scholes Creek 1	372	642.4	1.728	134.3	0.361	7411.2	19.934
S10-Todd Creek 3	459	771.8	1.683	161.4	0.352	8915.3	19.435
S11-Scholes Creek 2	902	1500.9	1.663	313.5	0.347	17457.6	19.344
S12-Duck Creek 5	449	909.1	2.026	192.8	0.430	10524.0	23.453
S13-Drainage Ditch 1	82	185.4	2.262	39.7	0.485	2118.6	25.852
S14-Duck Creek 6	2599	4570.2	1.758	912.3	0.351	58789.5	22.616
S15-Scholes Creek 3	1167	1393.3	1.194	278.8	0.239	16578.2	14.202
S16-Drainage Ditch 2	642	698.8	1.089	138.2	0.215	8337.4	12.994
S17-Duck Creek 7	459	933.9	2.036	184.7	0.403	12683.4	27.649
S18-Duck Creek 8	1515	5202.9	3.434	1099.7	0.726	65176.7	43.018
S19-Scholes Creek 4	141	265.7	1.885	56.1	0.398	3136.3	22.257

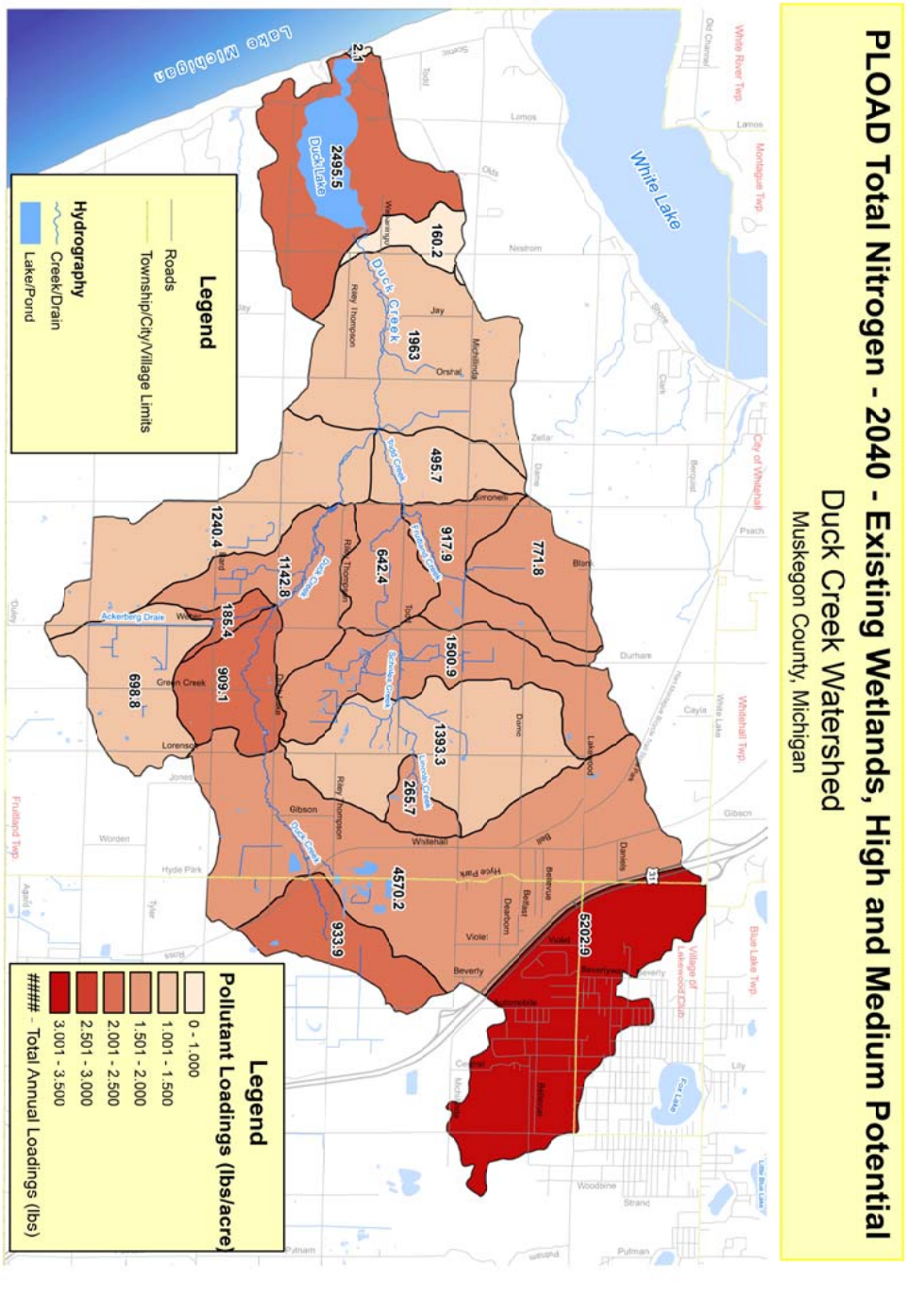


Figure 32. PLOAD Results—2040 Total Nitrogen (with High and Medium Potential Wetlands)

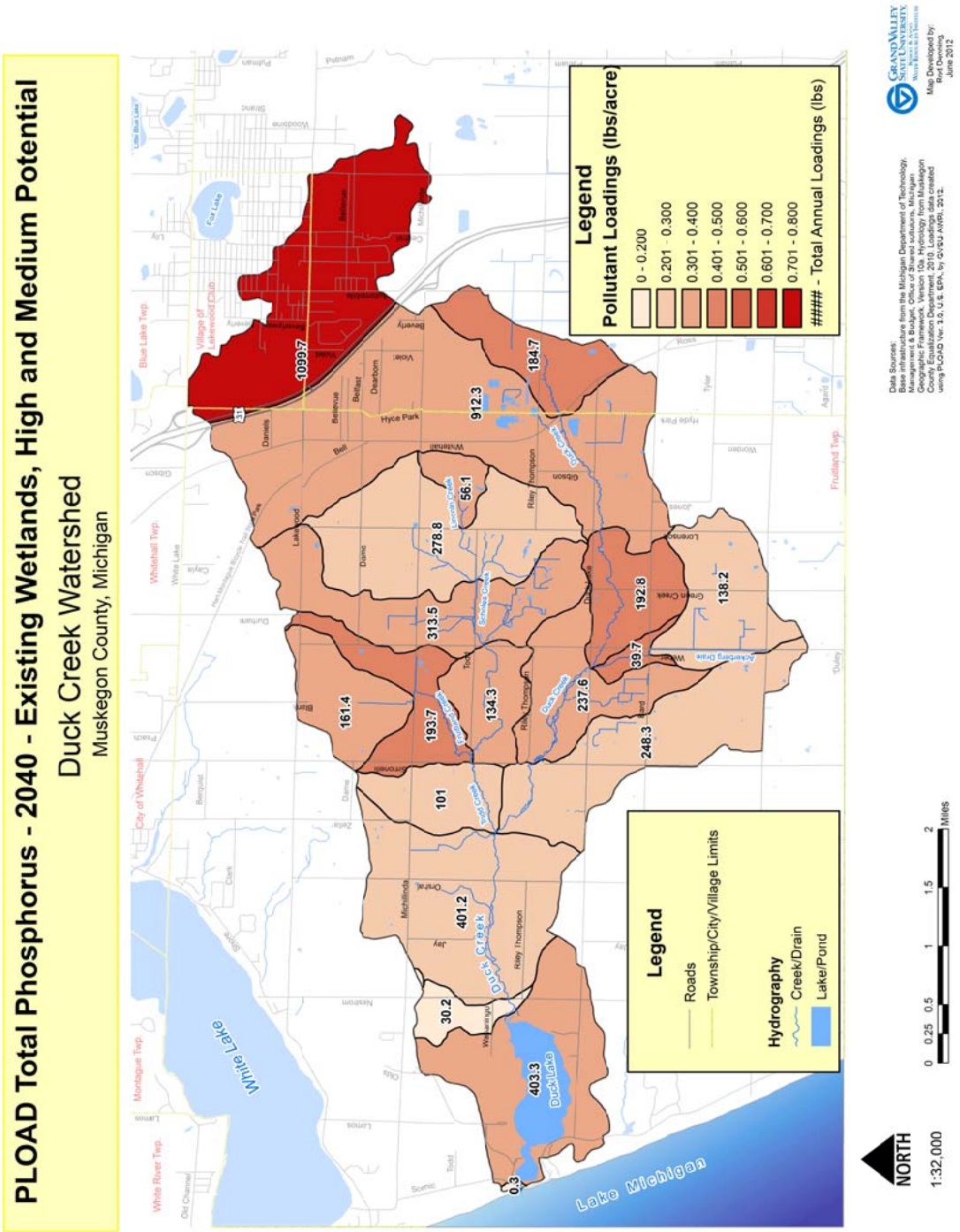


Figure 33. PLOAD Results—2040 Total Phosphorus (with High and Medium Potential Wetlands)

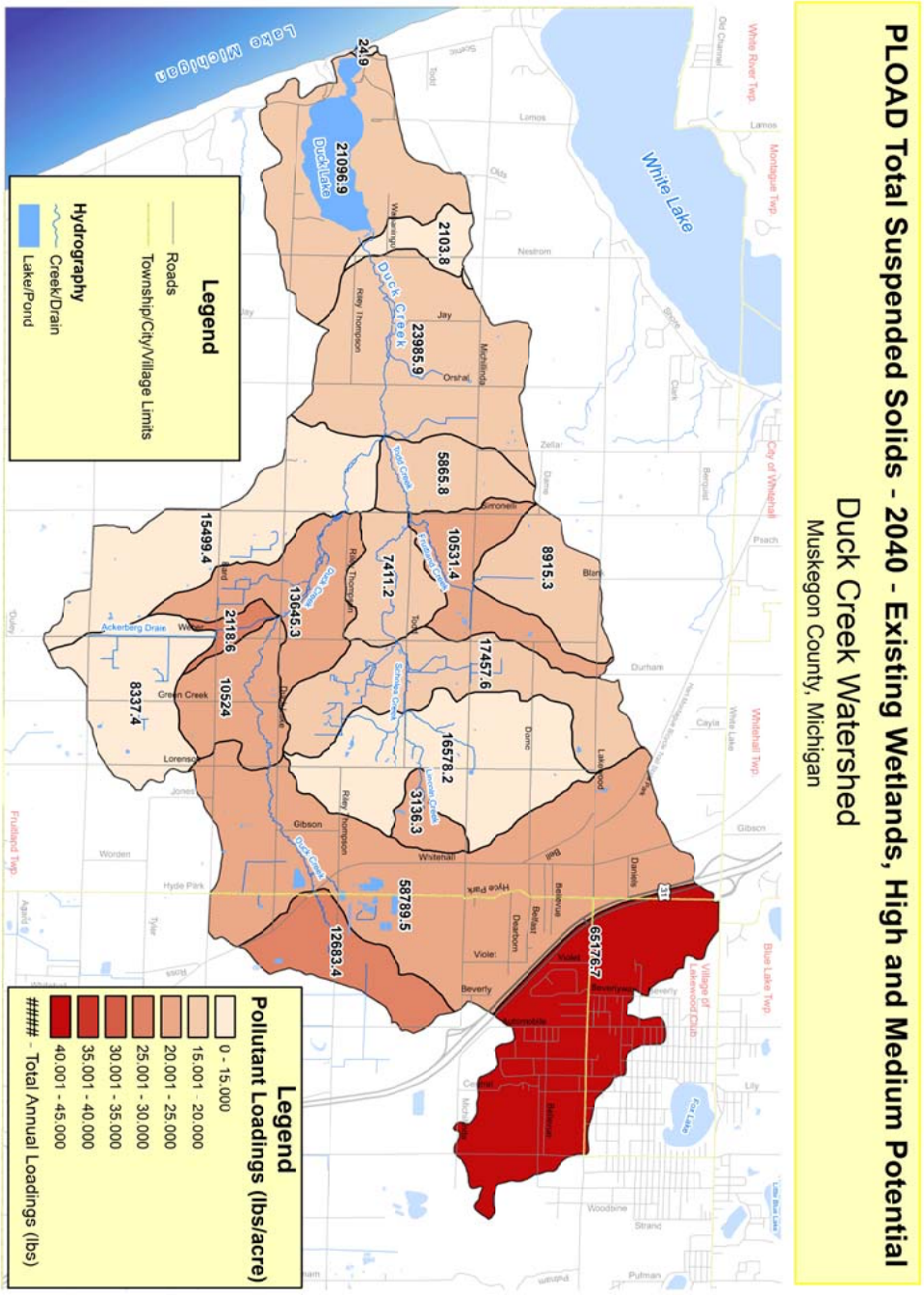


Figure 34. PLOAD Results—2040 Total Suspended Solids (with High and Medium Potential Wetlands)

3.4 Designated Uses

The information obtained through water quality monitoring, macroinvertebrate inventories, and the physical inventory of Duck Creek and its tributaries was added to PLOAD/LCM and Critical Preservation Area Analysis and used to assess the water quality of the Duck Creek Watershed. All of this information was used to determine if the watershed is currently meeting water quality standards and likely to do so in the future. The next question is how does all of this information relate to the watershed's designated uses.

The most important standard for water quality is whether or not the waterbody fulfills its designated uses. The state of Michigan, using federal water quality guidlines, has established designated uses for all waters of the state (Brown et al. 2000). These designated uses are recognized uses of surface water, which include: agriculture, navigation, industrial water supply, warmwater fishery, coldwater fishery, other indigenous aquatic life and wildlife, fish consumption, partial body contact recreation, total body contact recreation, and public water supply.

Each of these designated uses must meet the water quality standards set forth by the state. The standards are created to ensure water quality requirements that protect the public's health and wellbeing, enhance and maintain water quality, and protect the state's natural resources. An initial water quality summary for Duck Creek Watershed's designated uses can be found in Appendix M. This information was used to determine impaired or threatened areas of the Duck Creek Watershed.

Definitions of Designated Uses

Below is a description of each of the established designated uses and the status for that use in the Duck Creek Watershed. A status refers to whether the designated use is impaired (not supported) or supported by the watershed. A designated use can be categorized as supported but also be characterized as threatened if the use currently meets water quality standards but may not in the future (MDEQ 2006).

Agriculture: Surface water must be an available and secure supply of water for agriculture (MDEQ 2006). Agricultural uses of surface water include livestock watering, irrigation, and crop spraying.

This designated use is supported by the entire Duck Creek Watershed.

Navigation: Navigation via surface water is a designated use that enables commerce and recreation, and protects wildlife. Ensuring the state's waterways have proper navigable conditions involves maintaining waterways that are passable and large enough for canoes or kayaks.

Duck Creek and its tributaries are shallow and narrow and are not normally considered for canoe or kayak use. However, Duck Lake remains viable for navigation. Therefore, this designated use is only supported in the Duck Lake Subwatershed.

Industrial Water Supply: Surface waters are expected to provide supply for commercial or industrial applications or for noncontact food processing (MDEQ 2006).

While there are no surface water intakes for industrial or commercial use in the watershed, this designated used is currently supported by the entire Duck Creek Watershed.

Warmwater Fishery : This designated use provides healthy fish populations and supports an abundant fishing industry. The warmwater fishery use means the ability of a waterbody to sustain a balanced, integrated, and adaptive population of fish in warmwater conditions, which include bass, pike, walleye, and panfish. A monthly maximum limit for warmwater fisheries is 80º F in June, 83º F in July, 81º F in August , and 74º F in September. Heat load to be measured at the edge of the mixing zone (MDEQ 2006).

While Duck Lake and Duck Creek are both designated as trout fisheries, there is perhaps greater evidence to indicate their ability to support a warmwater fishery. Warmwater fish species including bass, crappie, and panfish are plentiful in Duck Lake, with green sunfish, largemouth bass, white sucker, and blacknose dace found in sections of Duck Creek downstream of Michigan's Adventure Amusement Park. This designated use is supported within the entire Duck Creek Watershed.

Coldwater Fishery : The coldwater fishery use means the ability of a waterbody to sustain a balanced, integrated, and adaptive population of fish in coldwater conditions, which include trout, salmon, and whitefish. A monthly maximum limit for coldwater fisheries is 68º F during the months of June, July, and August, and 63º F in September. Heat load to be measured at the edge of the mixing zone (MDEQ 2006).

Duck Lake is designated by the MDNR as a Type F Trout Lake. Duck Creek is likewise designated as a trout stream. While there is no current evidence of indigenous trout populations thriving in either the lake or the stream, the potential has not been ruled out. This designated use is supported within the entire Duck Creek Watershed, but threatened throughout.

Other Indigenous Aquatic Life and Wildlife : Aquatic plants and animals are critical to a healthy *ecosystem* and, thus, should have a protected habitat. This designated use protects both aquatic life and wildlife that rely on adequate water quality conditions and are impacted from lifetime exposure to the waterbody (MDEQ 2006). Surface water provides the necessary resources to life for mammal and bird wildlife populations that require drinking water and aquatic food.

Aquatic plants and animals are abundant within the Duck Creek Watershed, but are threatened by encroaching urban development and the spread of invasive species. This desig-

nated use is supported within the entire Duck Creek Watershed, but threatened throughout.

Fish Consumption: Fish consumption is a use that is very important to commerce, tourism, and the human health of a region. This designated use refers to the ability of the state's surface water to provide fishery for human consumption that is consistent with the level of protection provided by state rules (MDEQ 2006).

This use is not supported (impaired) within the Duck Lake Subwatershed in that there exists an open channel between Duck Lake and Lake Michigan. Consumption warnings appropriate for Lake Michigan need also to be observed for fish caught in Duck Lake but living part of their life cycle in Lake Michigan. Fish consumption is supported throughout the remaining portion of the Duck Creek Watershed.

Partial Body Contact Recreation: Partial body contact recreation is a designated use related to fishing, wading, hunting, and dry boating (MDEQ 2006). These activities involve direct contact of some part of the body with water, but, in normal conditions, do not involve fully submerging the head. Part 4 Water Quality Standards for plant nutrients state, "nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the surface waters of the state" (MDEQ 2006). Part 4 Water Quality Standards for microorganisms state, " all surface waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1,000 *E. coli* per 100 milliliters. Compliance shall be based on the geometric mean of 3 or more samples, taken during the same sampling event, at representative locations within a defined sampling area" (MDEQ 2006).

This designated use is supported in the entire Duck Creek Watershed, but threatened throughout.

Total Body Contact Recreation: Recreational activities that normally involve direct contact with water to the point of complete submergence would be protected with this designated use (MDEQ 2012). Particularly, if the head is immersed with a significant risk of ingesting water, such as swimming. Water Quality Standards for Partial Body Contact Recreation also apply.

This designated use is supported in the entire Duck Creek Watershed, but threatened throughout.

Public Water Supply: This designated use indicates that the municipal water supplies from surface water must be safe and adequate (MDEQ 2006).

There are no surface water intakes for public water supply in the watershed. Groundwater is the primary source of drinking water for residents living in the Duck Creek Watershed. This designated use is supported by the entire Duck Creek Watershed.

The federal Water Pollution Control Act requires that each state provide the USEPA with an assessment of water quality annually. The most recent report prepared by the Michigan Department of Environmental Quality is titled, "Water Quality and Pollution Control in Michigan 2012 Sections 303(d), 305(b), and 314 Integrated Report." This report mentions the need to develop a Watershed Management Plan for the Duck Creek Watershed. It also references concerns by the Muskegon Conservation District and others regarding the planned expansion of the Michigan Adventure Amusement Park. However, the Integrated Report does not list any specific waters in violation of Water Quality Standards (MDEQ 2012).

3.5 Desired Uses

Desired uses were determined by the partners and stakeholders involved in the development of the Duck Creek Watershed Management Plan. A desired use refers to what we want to use our watershed for, and how we want all of the watershed's natural features to look (Brown et al. 2000). These uses are based on factors the watershed community finds important and may include current or potential natural resource concerns (Brown et al. 2000). Table 8 lists the desired uses identified by the Duck Creek Watershed Assembly.

Table 8. Desired Uses in the Duck Creek Watershed

Desired Uses	Goals
Groundwater / Drinkable Water	Ensure groundwater and surface water quality throughout watershed.
Unique Habitat	Identify critical habitat for endangered / threatened species and ways to protect their habitat.
Open Space	Establish permanent easements and nature preserves within the watershed.
	Implement cluster development ordinances.
	Increase buffer zone along streams and implement waterfront overlay.
Public Access / Recreation	Protect and preserve current access sites along Duck Creek and Duck Lake.
Navigation	Reduce Invasive Species throughout the watershed. Concentrate on Eurasian Watermilfoil / Coontail in Duck Lake.
	Reduce sediment and nutrient inputs throughout the watershed, and consider specific navigation improvements at the Duck Creek/Duck Lake Channel.

3.6 Pollutants Causing Impairments and Threats

Pollutants

Activities within the watershed can result in pollutants that threaten the overall water quality. When water bodies are threatened, they may meet current water quality standards but are not guaranteed to do so in the future. A designated use becomes threatened due to one or more pollutants in the water (Brown et al. 2000). In order to address the causes of what is threatening the watershed's designated uses, the pollutants must be determined.

Pollutants were ranked by the Duck Creek project partners with input from the DCWA and other stakeholders based on current and potential impact in the watershed.

High Priority Pollutants: Sediment, Temperature

The high priority pollutants for the Duck Creek Watershed are sediment and temperature. The Duck Creek Watershed partners felt that these pollutants are serious water quality threats in the watershed but many of the sources and causes of these pollutants can be controlled by addressing future hydrologic inputs.

Natural sedimentation is present in all stream environments due to erosion by wind and water. However, excessive sedimentation caused by human alterations can severely degrade a stream system. Sedimentation has been identified as a major cause of degradation to aquatic life in many Michigan streams and rivers (MDEQ 2012). Excess sediment buries gravel and cobble substrate that serve as critical habitat for many fishes and *invertebrates*. Sand deposition can fill, plug, and bury most of the rough substrate and result in a less diverse stream *benthos*, thereby leading to decreases in habitat diversity (Hay-Chmielewski et al. 1995). Sediment is threatening the Cold Water Fishery and Other Indigenous Aquatic Life and Wildlife designated uses.

The next high priority pollutant is temperature. Temperature is important because it governs the kinds of aquatic life that can live in a stream. All aquatic organisms have a preferred temperature range. If temperatures get too far above or below this preferred range, the number of individuals of the species decreases until finally there are none (Michaud 1991). Temperature also is important because it influences water chemistry. As water temperature increases, its ability to hold dissolved oxygen decreases, thereby reducing the amount of oxygen in the water available to fish and other aquatic life. When thermal stress occurs, fish cannot efficiently meet energetic demands (Diana 1995). The Duck Creek Watershed partners felt this was a high priority because substantial portions of the system are being threatened by high water temperatures. Temperature is threatening the Cold Water Fishery designated use.

Medium Priority Pollutants: Nutrients

Nutrients are essential to the growth of all living things. In terms of water quality, nutrients can be considered as pollutants when their concentrations are sufficient to allow excessive growth of aquatic plants and algae. Blooms of algae resulting from nutrient enrichment eventually die and decompose, removing oxygen from the water and potentially leading to levels of dissolved oxygen that are insufficient to sustain normal life forms (Allan 1995).

The main nutrients of concern are phosphorus and nitrogen. Nutrients are threatening the Cold Water Fishery and Other Indigenous Aquatic Life and Wildlife Recreation designated uses.

Low Priority Pollutants: Invasive (Exotic) Species, *E. coli*

Another pollutant of concern in the watershed is invasive (exotic) species. Since the early 1800's, at least 180 new aquatic organisms have become established in the Great Lakes. There has been an increasing rate of invasion in the Great Lakes over the past two centuries. Since 1970, on average, there has been one invader recorded every eight months (Ricciardi 2001). Although exotic species are already a part of our habitat, those species that are highly invasive are degrading local habitats (WLPAC 2002). Some exotic species in the Duck Creek Watershed include zebra mussels (*Dreissena polymorpha*), round goby (*Neogobius melanostomus*), Eurasian milfoil (*Myriophyllum spicatum*), purple loosestrife (*Lythrum salicaria*), coontail (*Ceratophyllum demersum*), Phragmites (*Phragmites australis)* and sea lamprey (*Petromyzon marinus*). Exotic species are threatening the Other Indigenous Aquatic Life and Wildlife designated uses.

Another low priority pollutant for the Duck Creek Watershed is *E. coli.* The Duck Creek Watershed partners felt that while there is very little evidence to indicate that *E. coli* in fact impairs the Duck Creek Watershed, it is a common pollutant found throughout west Michigan and its presence here is suspected, at least in isolated areas.

Escherichia coli (abbreviated as *E. coli*) makeup a large and diverse group of bacteria. Most *E. coli* by itself is not dangerous to humans, but when found it indicates the presence of matter that has gone through some animal or human's digestive track. Such fecal material can in some instances spread diseases. Some ways waste can enter water is from improperly functioning septic systems, improperly treated sewage, and livestock in streams (USEPA 1997). Further monitoring will need to be conducted to determine *E. coli* levels in the Duck Creek Watershed. *E. coli* is threatening the Partial and Total Body Contact designated uses.

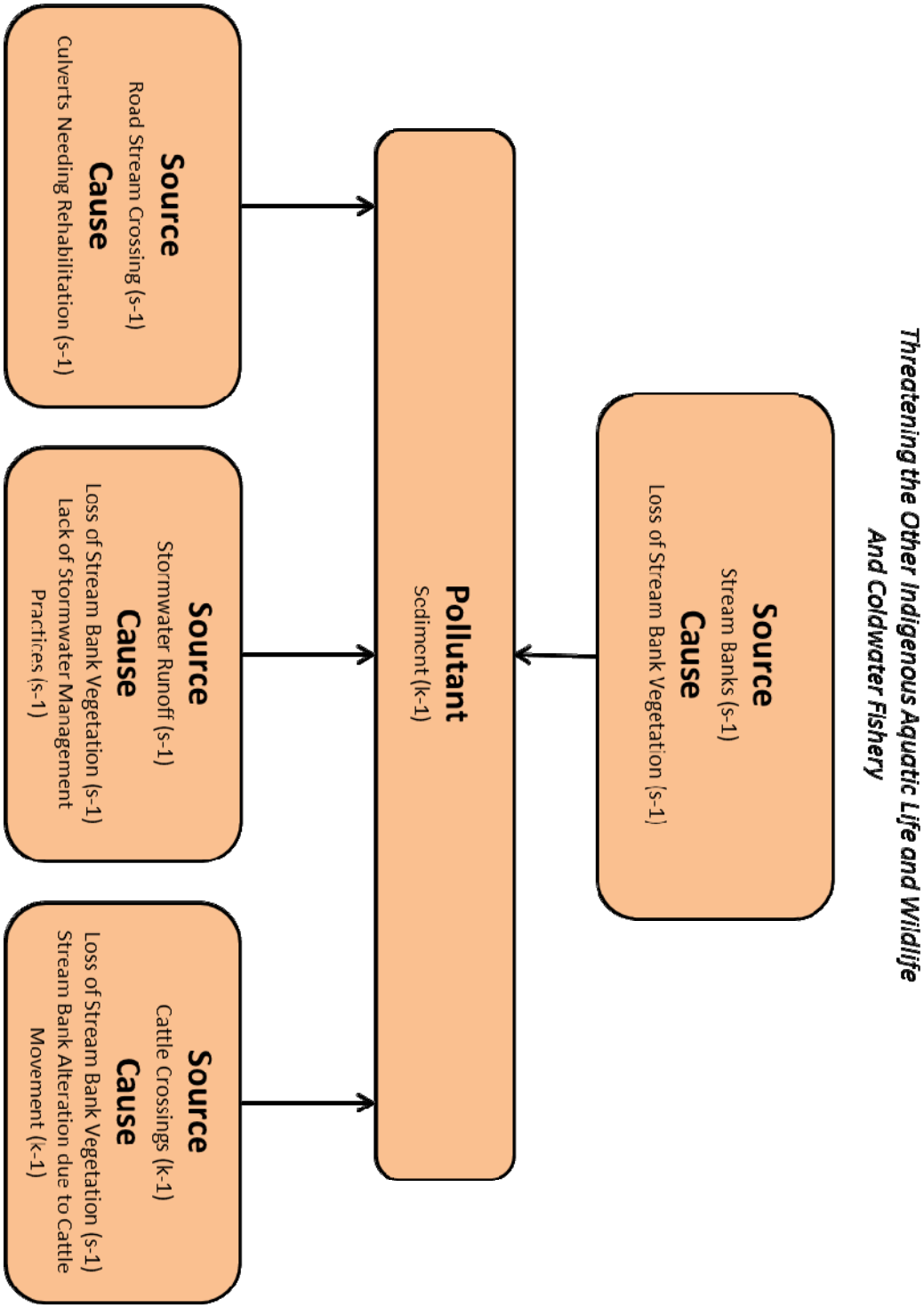
3.7 Sources and Causes of Pollutants Resulting in Impaired or Threatened Designated Uses

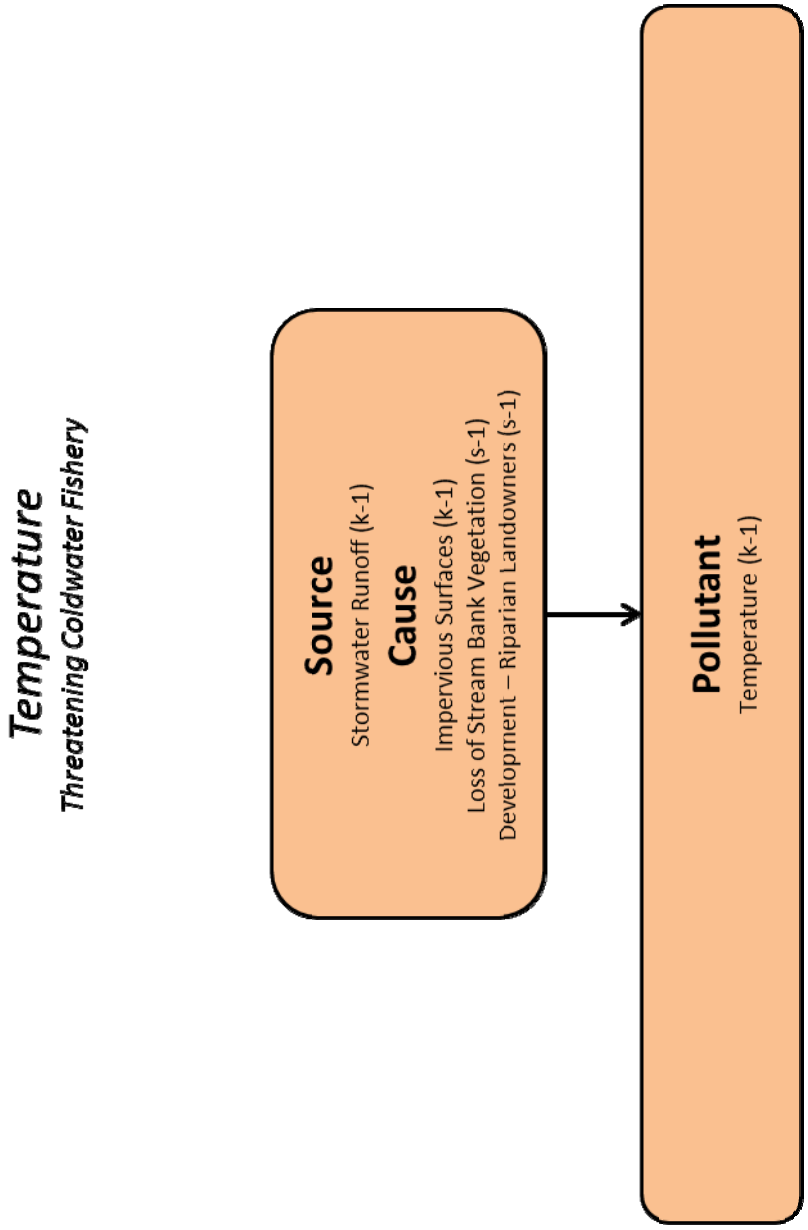
In order to reduce pollutants impairing and threatening the designated uses in the watershed, the origin of the pollutants needs to be determined (i.e. sources and causes). If the origin of a pollutant was verified through monitoring and available information, it is characterized as known (k). Suspected (s) pollutants, sources, and causes haven't been verified but are based on local knowledge and perceptions (i.e. groundwater withdrawals, *E.coli* from agricultural and urban/residential *runoff*, and toxic substances from oil wells). It is recommended that in the future, additional monitoring be conducted to verify these suspected pollutants, sources, and causes.

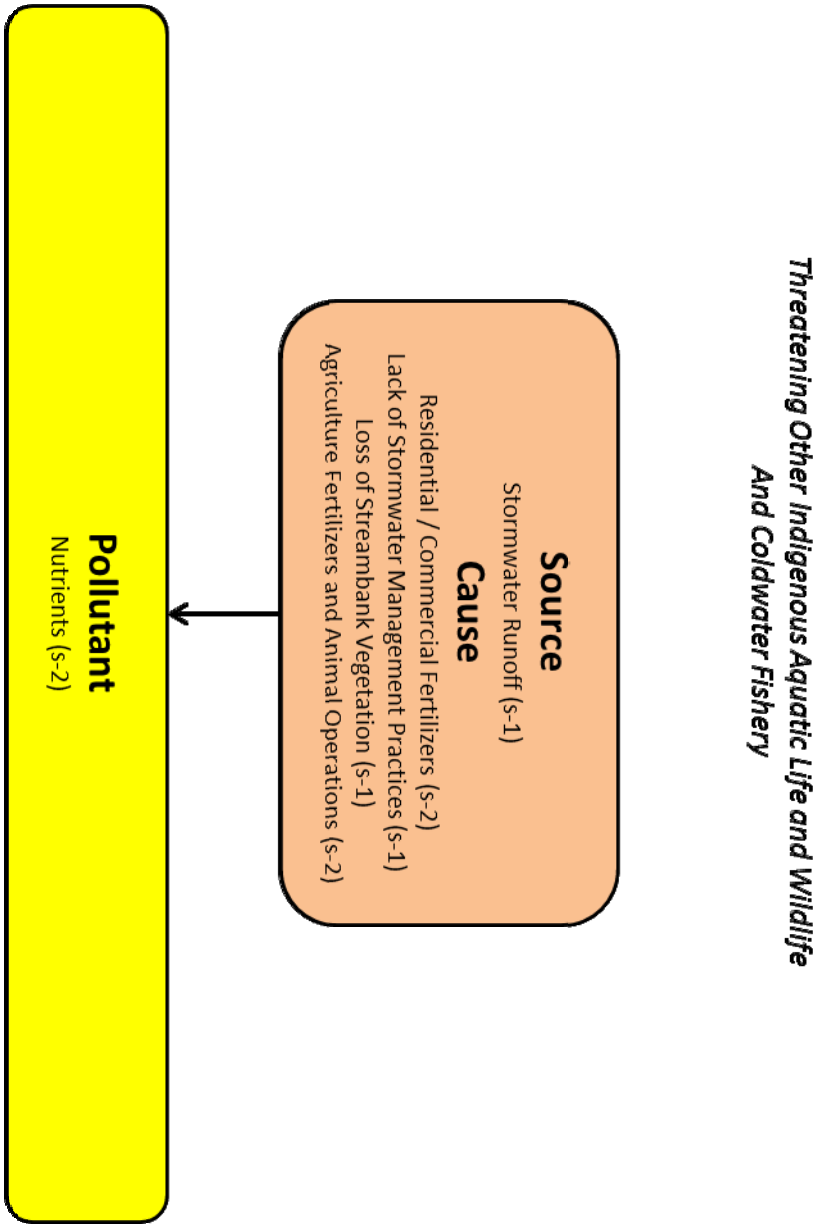
Along with the pollutants, the sources and causes were also ranked. The high priority items (1/orange colored) were determined considering sources and causes that contribute the most to each pollutant. By addressing these sources and causes first, we will be able to achieve the greatest pollutant reduction, leading to the greatest water quality benefit for the money. The next highest sources and causes were categorized as moderate priority (2/yellow colored) and low priority (3/green colored) items.

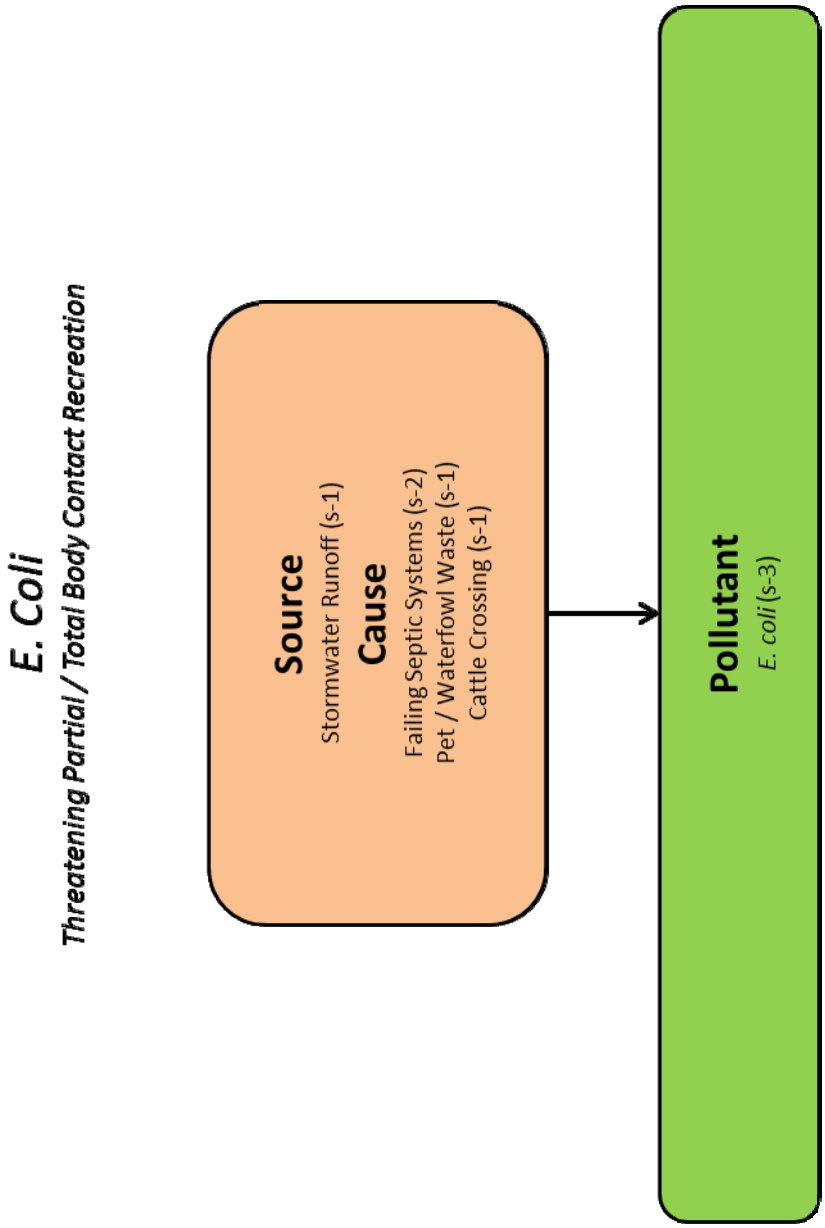
The following charts help to outline each of the pollutants, sources, and causes that impair/threaten designated uses in the Duck Creek Watershed and their ranking. A lettering and numbering system has been used to identify known (k) and suspected (s) items and their ranking (high (orange)—1, moderate (yellow)—2, low (green)—3). For example, sediment is a known pollutant that is a high priority (identified by k-1 and colored orange). Road stream crossings are a suspected source for sediment and also ranked as a high priority (s -1 and colored orange). Maps and tables in Appendix N and O help to visualize where these pollutants are coming from in the watershed and their impact (pollutant loadings).

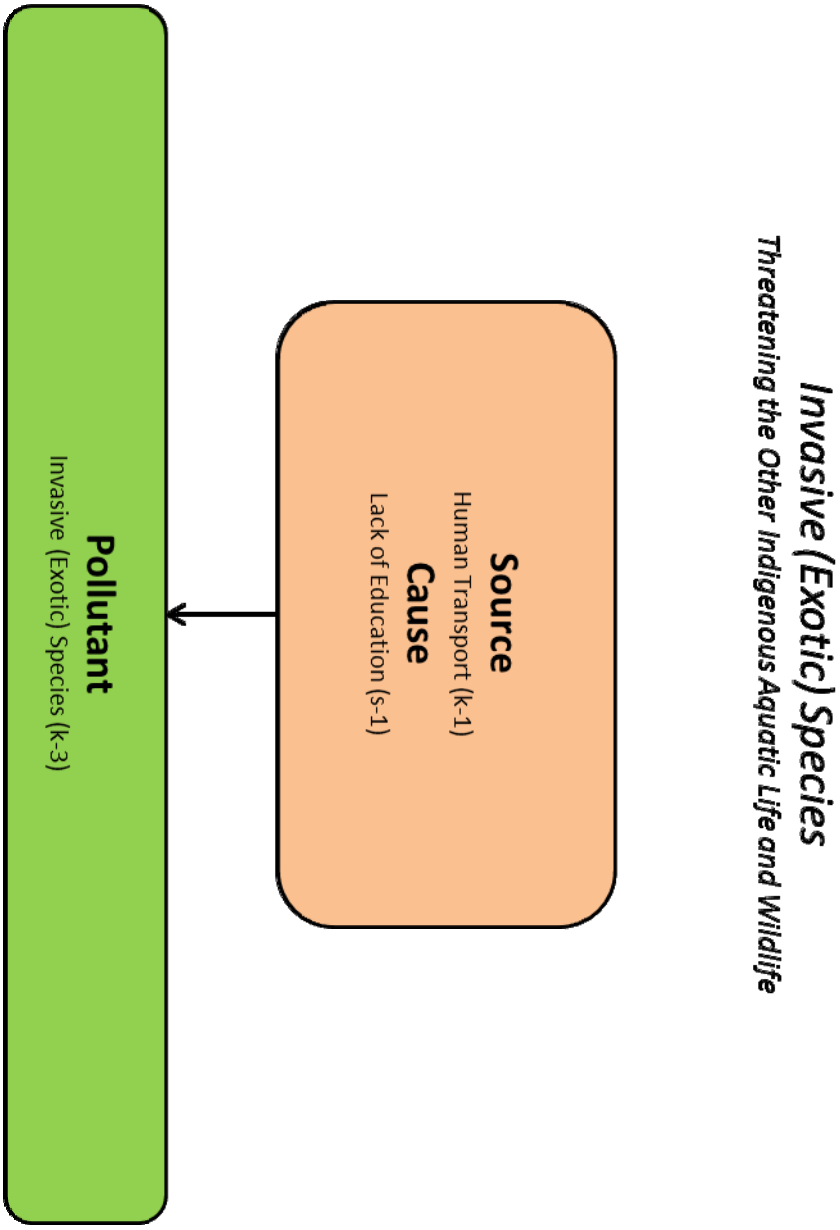
Designated uses and status are summarized by subwatershed in Appendix R. Appendix R also identifies by subwatershed the pollutants, causes, and sources of impaired/threatened designated uses.


Sediment
Threatening the Other Indigenous Aquatic Life and Wildlife
And Coldwater Fishery
Source
Stream Banks (s-1)
Cause
Loss of Stream Bank Vegetation (s-1)
Pollutant
Sediment (k-1)
Source
Road Stream Crossing (s-1)
Cause
Culverts Needing Rehabilitation (s-1)
Source
Stormwater Runoff (s-1)
Cause
Loss of Stream Bank Vegetation (s-1)
Lack of Stormwater Management
Practices (s-1)
Source
Cattle Crossings (k-1)
Cause
Loss of Stream Bank Vegetation (s-1)
Stream Bank Alteration due to Cattle
Movement (k-1)


Temperature
Threatening Coldwater Fishery
Source
Stormwater Runoff (k-1)
Cause
Impervious Surfaces (k-1)
Loss of Stream Bank Vegetation (s-1)
Development – Riparian Landowners (s-1)
Pollutant
Temperature (k-1)


Nutrients
Threatening Other Indigenous Aquatic Life and Wildlife
And Coldwater Fishery
Source
Stormwater Runoff (s-1)
Cause
Residential / Commercial Fertilizers (s-2)
Lack of Stormwater Management Practices (s-1)
Loss of Streambank Vegetation (s-1)
Agriculture Fertilizers and Animal Operations (s-2)
Pollutant
Nutrients (s-2)


E. Coli
Threatening Partial / Total Body Contact Recreation
Source
Stormwater Runoff (s-1)
Cause
Failing Septic Systems (s-2)
Pet / Waterfowl Waste (s-1)
Cattle Crossing (s-1)
Pollutant
E. coli (s-3)


Invasive (Exotic) Species
Threatening the Other Indigenous Aquatic Life and Wildlife
Source
Human Transport (k-1)
Cause
Lack of Education (s-1)
Pollutant
Invasive (Exotic) Species (k-3)

3.8 Resources

The resources listed below pertain to designated and desired uses, pollutants affecting the watershed, the quality of subwatersheds, and additional parameters critical to water quality monitoring.

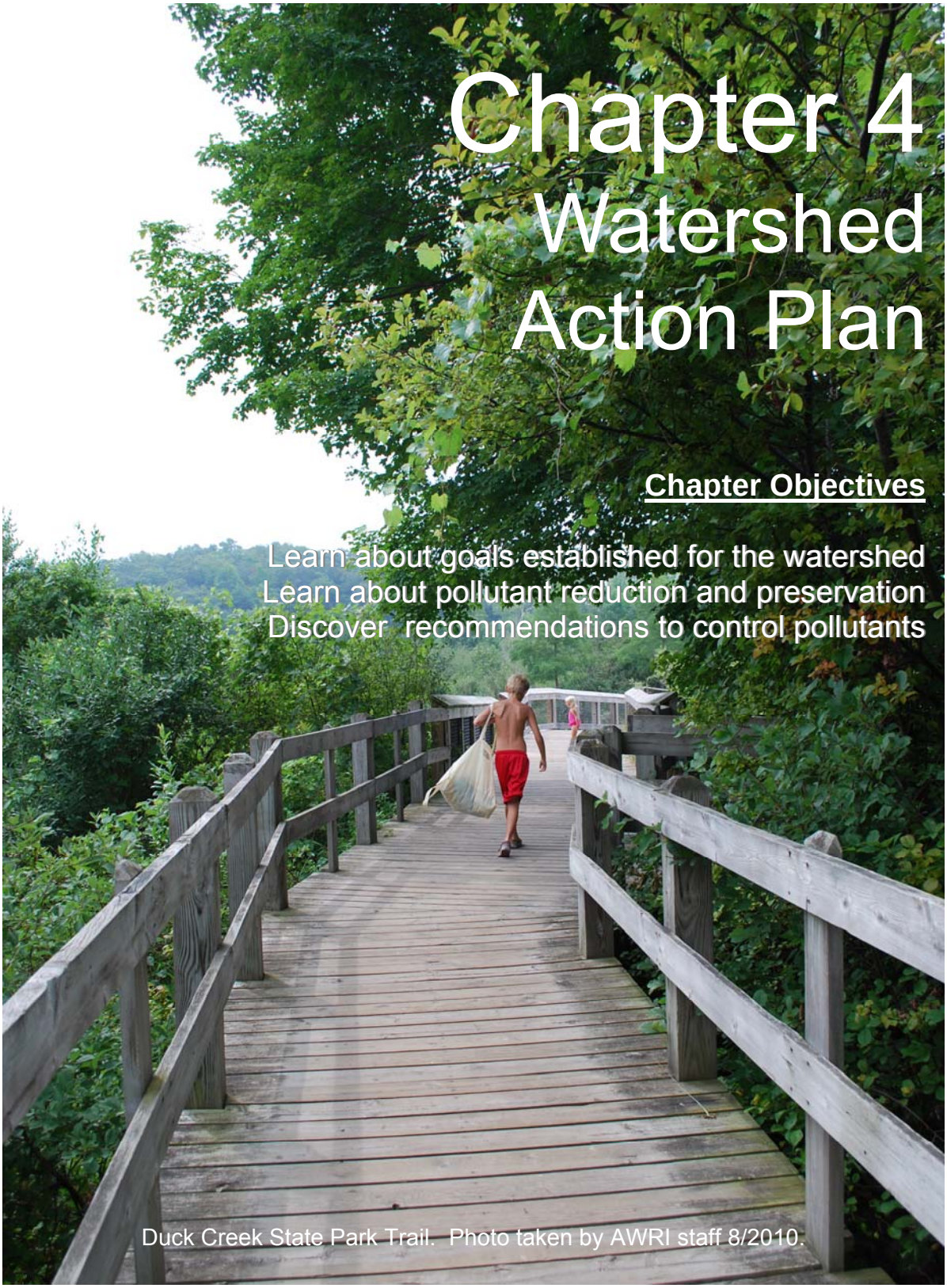
Developing a Watershed Management Plan for Water Quality: An Introductory Guide. Brown, E., Peterson, A., Kline-Robach, R., Smith, K., and Wolfson, L., 2000. Michigan Department of Environmental Quality.

Volunteer Stream Monitoring: A Methods manual. 1997. United States Environmental Protection Agency (USEPA). Report # 841-B-97-003.

Water Quality and Pollution Control in Michigan 2008 Sections 303(d), 305(b), and 314 Integrated Report. April 2008. Michigan Department of Environmental Quality (MDEQ) Water Bureau. Report # MI/DEQ/WB-08/007.

Michigan Clean Water Corps: www.micorps.net

Michigan Water Resources Commission. Water quality study of Duck Lake, Muskegon County, Michigan. January 1, 1973. Print. Report Number: 025180.



Chapter 4
Watershed Action Plan

Chapter Objectives

Learn about goals established for the watershed
Learn about pollutant reduction and preservation
Discover recommendations to control pollutants

Duck Creek State Park Trail. Photo taken by AWRI staff 8/2010.

4.1 Chapter 4 Summary

Below are some of the key highlights to be found in Chapter 4 of the Duck Creek watershed management plan.

- There are two goal types developed for the Duck Creek Watershed. The first deals with **restoring** those areas of the watershed that are known or suspected as a nonpoint pollution source impairing or threatening desired uses. The second goal type deals with the **protection** of desired uses.

- Given that there will always be limitations regarding available funding and resources for restoration and protection, it is necessary to be strategic in selecting a problem solving approach. This Chapter will identify ***critical areas*** found at the subwatershed level in the Duck Creek Watershed.

- Factors used in identifying *critical areas* for restoration include: percent of urban and agricultural *land use* within a 50 foot stream buffer, erosion rates, poorly drained soils, road density, stream length, stream density, total suspended solids ranking, and total suspended solids loadings per acre ranking.

- Those subwatersheds ranked the highest and thus identified as *critical areas* for restoration include: S11-Scholes Creek 2, S14-Duck Creek 6, S12-Duck Creek 5, and S4-Duck Creek 2. These subwatersheds tend to cluster around the center of the watershed and are characterized as having the most stream length and density, poorly drained soils, and high percentage of urban/agricultural land within the identified stream buffer

- Factors used in identifying *critical areas* for preservation include: percentage of existing wetlands, percentage of potential wetlands, percentage of residential *land use*, percentage of biological hotspots, stream length, stream density, total suspended solids ranking, and total suspended solids loadings per acre ranking.

- Those subwatersheds ranked the highest and thus identified as *critical areas* for preservation include: S11-Scholes Creek 2, S16-Drainage Ditch 2, S19-Scholes Creek 4, S5-Todd Creek 1, and S15-Scholes Creek 3. These subwatersheds, like the areas for restoration, also tend to cluster around the center of the watershed. In fact, it is interesting to note that S11-Scholes Creek 2 is

ranked the highest for both restoration and protection. Common characteristics of all high ranked preservation areas include low residential density, high percentage of biological hotspots, and low percentage of total suspended solids per acre.

- Field inventories point to specific areas in need of restoration efforts. This includes 14 streambank erosion sites, one cattle crossing, seven areas with invasive species, one culvert in need of repair, one area of groundwater seepage, and one area with suspected septic system seepage. Management options specific for these areas and others which may present a problem in the future are discussed. Management measures useful to the protection of high priority areas are also included.

- Like every watershed, there are going to be water quality problems which exist not because they are difficult to correct or even particularly expensive, but simply because people are unaware of the influence and effect they have on nearby streams and natural resources. For this reason, every Watershed Management Plan should contain a well thought-out and easily implemented Information and Education Strategy. Such a Strategy will identify the specific water quality problems to be addressed. This Strategy will target specific audiences most responsible for the problems, and develop materials and techniques most likely to influence this audience. Elements of the Information and Education Strategy developed for the Duck Creek Watershed are highlighted in this Chapter.

4.2 Goals for the Watershed

Now that the sources and causes of *nonpoint source pollution* have been identified, the next step is to establish goals so as to guide a clear and well defined course of action. The goals below are divided into two types. The first kind of goal deals with areas where restoration of designated uses is required. The second goal type focuses on areas where protection of desired uses is the most important. Refer again to Sections 3.3 and 3.4 for a list of all designated and desired uses for the Duck Creek Watershed**.**

Goals to Restore and Protect Designated Uses

Goal 1: Protect/Improve water quality by reducing sediment contributions and stabilizing known streambank erosion sites, isolating cattle crossing, repairing damaged/poorly functioning culverts, renewing/rehabilitating former wetlands, incorporating Low Impact Development (LID) techniques, establishing Conservation Easements, and educating property owners regarding use of stormwater management practices. The target will be to reduce

the sediment load in the watershed 167,455 lbs/year. This target was derived by calculating total sediment load reductions from BMP implementation, as reported in Appendix R.

Objective 1.1: Stabilize streambank erosion sites found along Duck Creek (6), Scholes Creek (7), and Todd Creek (1)

Objective 1.2: Isolate cattle crossings on Duck Creek (1)

Objective 1.3: Repair culvert located on Ackerberg Drain (2)

Objective 1.4: Renew and rehabilitate 10 percent of high and medium potential wetland areas (170 acres), based on estimates provided by MDEQ, 2005

Objective 1.5: Incorporate Low Impact Development (LID) techniques and natural resource protection in existing and proposed master plan and zoning ordinances

Objective 1.6: Establish Conservation Easements within high priority critical areas

Objective 1.7: Educate watershed homeowners/renters, farmers, and business owners regarding stormwater management practices

Goal 2: Protect/Improve warm and coldwater fisheries by eliminating sources of warmwater discharges and otherwise stabilizing water temperatures. The target of water temperature will be to keep temperature within the range for warmwater and coldwater fisheries (Appendix P). A monthly maximum limit for coldwater fisheries is 68º F during the months of June, July, and August, and 63º F in September. A monthly maximum limit for warmwater fisheries is 80º F in June, 83º F in July, 81º F in August, and 74º F in September. Heat load is to be measured at the edge of the mixing zone (MDEQ 2006).

Objective 2.1: Abate as necessary the warmwater contributions from all *impervious* services including road crossings, parking lots, and stormwater infrastructure, with specific attention given to operations at the Michigan's Adventure Amusement Park

Objective 2.2: Replace the loss of streambank vegetation at strategic locations including those identified in Objective 1.1

Objective 2.3: Educate watershed homeowners/renters, farmers, and business owners regarding stormwater management practices

Objective 2.4: Incorporate Low Impact Development (LID) techniques and natural resource protection in existing and proposed master plan and zoning ordinances

Objective 2.5: Establish Conservation Easements within high priority critical areas

Goal 3: Protect/Improve water quality by reducing nutrient contributions from residential, commercial, and agricultural sources including fertilizer users, pet owners, and livestock operators. The target will be to reduce nitrogen by 1,953 lbs/year and phosphorus by 597 lbs/year. This target was derived by calculating total nitrogen and phosphorus load reductions from BMP implementation, as reported in Appendix R. Part 4 Water Quality Standards for plant nutrients state, "nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the surface waters of the state" (MDEQ 2006).

Objective 3.1: Replace the loss of streambank vegetation at strategic locations including those identified in Objective 1.1

Objective 3.2: Isolate cattle crossings including the site identified in Objective 1.2

Objective 3.3: Educate watershed homeowners/renters, farmers, and business owners regarding stormwater management practices

Objective 3.4: Renew and rehabilitate 10 percent of high and medium potential wetland areas (170 acres), based on estimates provided by MDEQ, 2005

Objective 3.5: Incorporate Low Impact Development (LID) techniques and natural resource protection in existing and proposed master plan and zoning ordinances

Objective 3.6: Establish Conservation Easements within high priority critical areas

Goal 4: Protect/Improve the recreational uses of the watershed by reducing *E. coli* and other bacteria contributions from residential, commercial, and agricultural stormwater *runoff*. The target will be to stay below the water quality standards to protect partial and total body contact designated uses (Appendix P). Part 4 Water Quality Standards for microorganisms state, " all surface waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1,000 *E. coli* per 100 milliliters. Compliance shall be based on the geometric mean of 3 or more samples, taken during the same sampling event, at representative locations within a defined sampling area" (MDEQ 2006).

Objective 4.1: Abate as necessary the *E. coli* and bacteria contribution coming from homeowners/renters, farmers, and business owners operating onsite septic systems, with special attention to the suspected source found on Duck Creek (Physical Inventory)

Objective 4.2: Minimize impacts resulting from pet and waterfowl wastes through a program of education that targets appropriate audiences

Objective 4.3: Isolate cattle crossings including the site identified in Objective 1.2

Objective 4.4: Educate watershed homeowners/renters, farmers, and business owners regarding stormwater management practices

Objective 4.5: Incorporate Low Impact Development (LID) techniques and natural resource protection in existing and proposed master plan and zoning ordinances

Objective 4.6: Establish Conservation Easements within high priority critical areas

Goal 5: Protect/Improve the recreational uses of the watershed by preventing the spread of invasive species. The target to reduce the impacts of invasive species is a 50 percent reduction in existing (2011) cover.

Objective 5.1: Eliminate where possible the human transport of invasive species through a program of education that targets appropriate audiences

Objective 5.2: Facilitate when reasonable the physical removal of invasive species through property owners and volunteer teams

Goals to Protect Desired Uses

Goal 1: Ensure high quality drinking water for residents of the Duck Creek Watershed.

Objective 1.1: Renew and rehabilitate 10 percent of high and medium potential wetland areas (170 acres), based on estimates provided by MDEQ

Objective 1.2: Outline steps to protect groundwater supplies through a program of education that targets appropriate audiences

Goal 2: Protect high quality and essential habitat for known endangered/threatened species.

Objective 2.1: Develop a cost effective strategy including a mix of private maintenance, conservation easements, and public purchase of the most essential habitats in the Duck Creek Watershed with the intent to compliment the Duck Creek State Park

Objective 2.2: Outline steps to enhance private properties as wildlife habitat through a program of education that targets appropriate audiences

Objective 2.3: Renew and rehabilitate 10 percent of high and medium potential wetland areas (170 acres), based on estimates provided by MDEQ, 2005

Objective 2.4: Establish Conservation Easements within high priority critical areas

Goal 3: Protect high priority Open Space having shared, public, and private ownership.

Objective 3.1: Develop a cost effective strategy including a mix of private maintenance, conservation easements, and public purchase of high priority Open Space in the Duck Creek Watershed

Objective 3.2: Modify existing zoning ordinances and master plans to accommodate cluster development, open space development, viewshed preservation, and stream buffers as desired by residents

Objective 3.3: Outline steps to enhance private properties as wildlife habitat through a program of education that targets appropriate audiences

Objective 3.4: Renew and rehabilitate 10 percent of high and medium potential wetland areas (170 acres), based on estimates provided by MDEQ, 2005

Objective 3.5: Establish Conservation Easements within high priority critical areas

Goal 4: Protect and preserve current access sites along Duck Creek and Duck Lake.

Objective 4.1: Incorporate as part of existing zoning ordinances and master plans current access sites to Duck Creek and Duck Lake, with the potential for additions as appropriate

Objective 4.2: Advertise the availability of access sites for the enjoyment of all potential users

Objective 4.3: Ensure the continued upkeep and maintenance of existing access sites through user fees or other appropriate means as necessary

Objective 4.4: Establish Conservation Easements within high priority critical areas

Goal 5: Give additional focus to navigation needs and the elimination/maintenance of Invasive Species including in particular Eurasian Watermilfoil, Coontail, and Phragmites.

Objective 5.1: Conduct inventories and develop eradication programs that ensure long-term maintenance of nuisance plant and animal species

Objective 5.2: Conduct education programs so as to support ongoing and future Invasive Species treatment strategies

Objective 5.3: Establish a long-term funding mechanism necessary to assist eradication programs and education efforts

Objective 5.4: Establish a long-term funding mechanism necessary to assist eradication programs and education efforts

Objective 5.5: Consider restoration of Duck Creek/Duck Lake Channel so as to support greater recreational opportunities and in particular kayak and canoe usage.

4.3 Areas of Focus for Pollutant Reduction and Preservation

The Duck Creek Watershed offers an unique opportunity for researchers and planners given its relative small size, less than 14,000 acres. It is small enough so that members of the Duck Creek Watershed Assembly and others conducting resource inventories can literally walk most of the streams comprising the Duck Creek system. It is possible, therefore, to be very specific about the location of known problem sites: areas of streambank erosion, cattle crossings, invasive species, culverts in need of attention, and even septic system failures. This ability to see what is happening on the ground is of course invaluable, and offers a definite advantage when it comes time to select best management practices and control measure options intended to solve the identified problem. However, neither trained volunteers nor experienced professionals will catch everything as they conduct in-field surveys. Their view is often obstructed by vegetation, and limited by topography and access to the stream. Unless such inventories are undertaken during rain events, it is often difficult to ascertain just what might be happening with the movement of stormwater and the creation of *nonpoint source pollution*. Also, those conducting such inventories are limited by what they see around them on the day of their investigation. So unless researchers are able to make multiple visits to the same location over time, it is difficult to put into perspective what has happened in the past and what trends are likely for the future. It is for these reasons and others that computer models are often used to help identify and prioritize *Areas of Concern*.

Areas of Concern are divided into two types. The first type are *Critical Areas for Restoration/Pollution Prevention* and includes those locations within the watershed that are expected to contribute the greatest pollutant load either now or in the future. These critical areas are pollution hotspots, areas where we are likely to see the greatest return as we implement pollution controls. The second type are *Priority Preservation Area*s and includes those areas that are typically most fragile, often sensitive to development, and frequently contribute to the overall integrity of the *ecosystem*. Wetlands are a good example of what might be included as a *Priority Preservation Area.*

An analysis was done on a subwatershed scale with the intention of comparing each subwatershed with all the others in a ranking so as to identify which were in need of the greatest attention. This analysis borrows heavily from the data presented in the previous chapters including the *land use* and land cover data base, soils, PLOAD analysis, analysis of wetland function, and biological hotspots.

The Identification of Critical Areas for Water Quality Restoration and/or Pollution Prevention

Factors ultimately used in identifying *critical areas* for restoration include: percent of urban and agricultural *land use* within a 50 foot stream buffer, erosion rates, poorly drained soils, road density, stream length, stream density, total suspended solids ranking, and total suspended solids loadings per acre ranking. More about the ranking process can be found in Appendix Q.

Tables 9 and 10 below summarize the critical area ranking and assigned status by subwatershed. Those subwatersheds ranked the highest and thus identified as *critical areas* for restoration include: S11-Scholes Creek 2, S14-Duck Creek 6, S12-Duck Creek 5, and S4-Duck Creek 2. These subwatersheds tend to cluster around the center of the watershed and are characterized as having the most stream length and density, poorly drained soils, and high percentage of urban/agricultural land within the identified stream buffer. See Figure 35 for a map summarizing critical area ranking by subwatershed.

Table 9. Subwatershed Ranking - Critical Areas for Restoration/Pollution Prevention

Subwatershed Name	Percent Urban-Ag	Erosion Rates	Soil Drainage	Road Density	Stream Length	Stream Density	TSS Annual Load	TSS Load/ Acre	TOTAL
S11-Scholes Creek 2	4	4	4	1	4	4	3	2	26
S14-Duck Creek 6	4	2	3	4	4	1	4	4	26
S12-Duck Creek 5	2	2	4	4	3	3	2	4	24
S4-Duck Creek 2	3	2	2	2	4	3	4	3	23
S8-Duck Creek 4	2	1	3	2	4	4	3	3	22
S16-Drainage Ditch 2	4	1	4	3	3	3	2	2	22
S7-Todd Creek 2	3	1	3	3	2	3	2	3	20
S13-Drainage Ditch 1	3	3	2	3	1	4	1	3	20
S15-Scholes Creek 3	2	4	3	2	3	2	3	1	20
S2-Duck Lake	4	2	1	2	1	1	4	3	18
S17-Duck Creek 7	2	1	2	2	2	2	3	4	18
S9-Scholes Creek 1	1	1	2	3	3	3	2	2	17
S18-Duck Creek 8	1	1	1	4	1	1	4	4	17
S6-Duck Creek 3	3	1	1	1	3	2	3	2	16
S19-Scholes Creek 4	1	4	4	1	1	2	1	1	15
S1-River -end of Duck Lake	1	1	1	4	1	4	1	1	14
S3-Duck Creek 1	1	3	3	1	2	1	1	1	13
S5-Todd Creek 1	1	1	2	1	2	2	1	2	12
S10-Todd Creek 3	1	1	1	3	1	1	2	1	11

Table 10. Subwatershed Status—Critical Areas for Restoration/Pollution Prevention

Subwatershed Name	Total Rank	Priority Status
S11-Scholes Creek 2	26	Severe
S14-Duck Creek 6	26	Severe
S12-Duck Creek 5	24	Severe
S4-Duck Creek 2	23	Severe
S8-Duck Creek 4	22	High
S16-Drainage Ditch 2	22	High
S7-Todd Creek 2	20	High
S13-Drainage Ditch 1	20	High
S15-Scholes Creek 3	20	High
S2-Duck Lake	18	Moderate
S17-Duck Creek 7	18	Moderate
S9-Scholes Creek 1	17	Moderate
S18-Duck Creek 8	17	Moderate
S6-Duck Creek 3	16	Moderate
S19-Scholes Creek 4	15	Slight
S1-River -end of Duck Lake	14	Slight
S3-Duck Creek 1	13	Slight
S5-Todd Creek 1	12	Slight
S10-Todd Creek 3	11	Slight

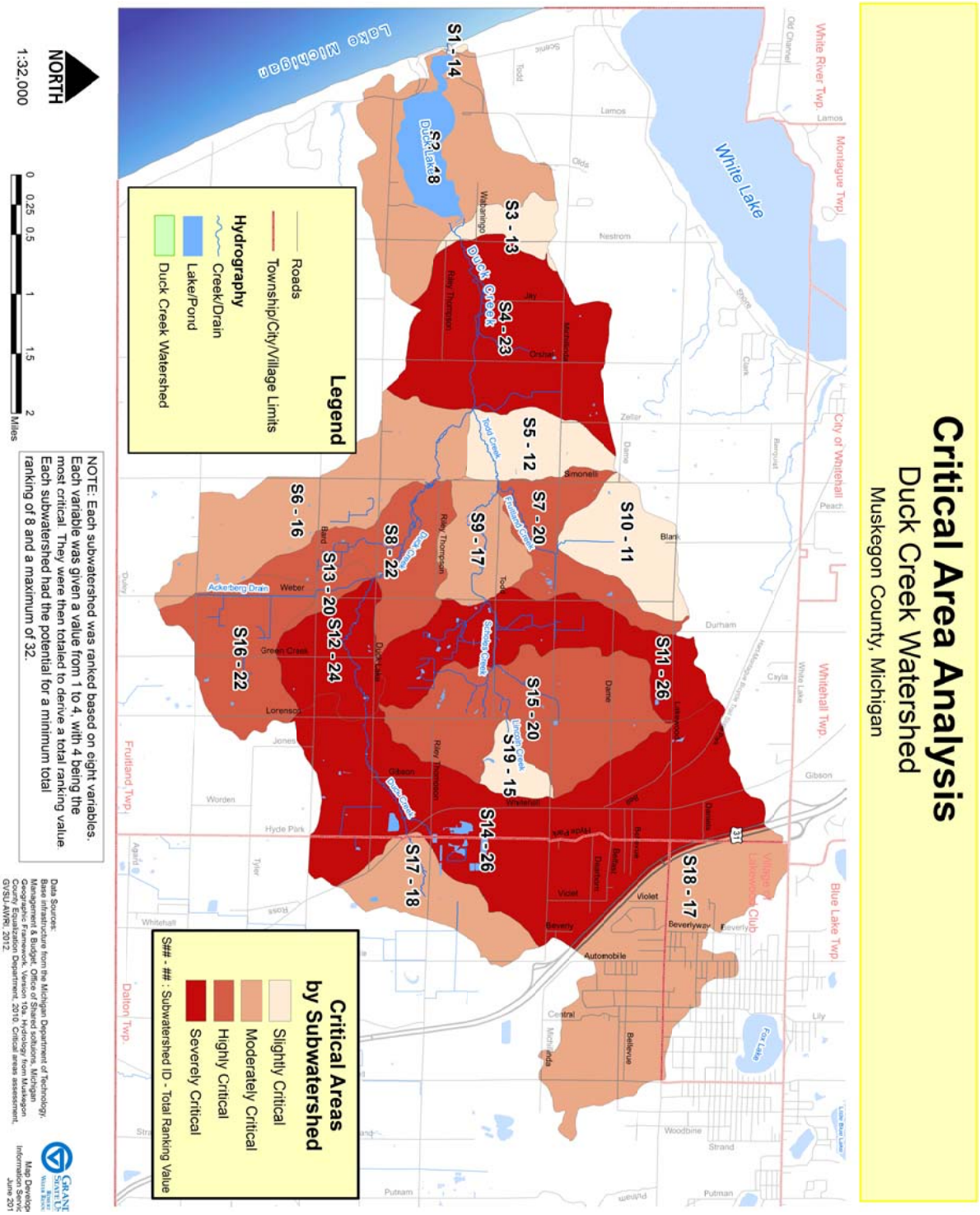


Figure 35. Critical Area Analysis by Subwatershed

The Identification of Priority Preservation Areas

Factors used in identifying *Priority Preservation Areas* include: percentage of existing wetlands, percentage of potential wetlands, percentage of residential *land use*, percentage of biological hotspots, stream length, stream density, total suspended solids ranking, and total suspended solids loadings per acre ranking. Again, more about the ranking process can be found in Appendix Q.

Tables 11 and 12 below summarize the protection area ranking and priority status by subwatershed. Those subwatersheds ranked the highest and thus identified as priority areas for preservation include: S11-Scholes Creek 2, S16-Drainage Ditch 2, S19-Scholes Creek 4, S5-Todd Creek 1, and S15-Scholes Creek 3. These subwatersheds, like the areas for restoration, also tend to cluster around the center of the watershed. In fact, it is interesting to note that S11-Scholes Creek 2 is ranked the highest for both restoration/pollution prevention and protection. Common characteristics of all high ranked preservation areas include low residential density, high percentage of biological hotspots, and low percentage of total suspended solids per acre. See Figure 36 for a map summarizing critical preservation area ranking by subwatershed.

Table 11. Subwatershed Ranking - Priority Preservation Areas

Subwatershed Name	Existing Wetlands	Potential Wetlands	Percentage Residential	Biological Hotspots	Stream Length	Stream Density	TSS Annual Load	TSS Load/ Acre	TOTAL
S11-Scholes Creek 2	4	3	3	3	4	4	2	3	26
S16-Drainage Ditch 2	2	4	4	4	3	3	3	3	26
S19-Scholes Creek 4	4	2	4	4	1	2	4	4	25
S5-Todd Creek 1	3	4	3	3	2	2	4	3	24
S15-Scholes Creek 3	4	2	4	3	3	2	2	4	24
S1-River -end of Duck Lake	1	4	4	1	1	4	4	4	23
S8-Duck Creek 4	2	4	1	3	4	4	2	2	22
S9-Scholes Creek 1	3	3	2	2	3	3	3	3	22
S10-Todd Creek 3	4	2	3	4	1	1	3	4	22
S6-Duck Creek 3	3	1	3	4	3	2	2	3	21
S3-Duck Creek 1	2	1	4	1	2	1	4	4	19
S7-Todd Creek 2	3	3	2	1	2	3	3	2	19
S13-Drainage Ditch 1	1	3	2	2	1	4	4	2	19
S12-Duck Creek 5	2	3	1	2	3	3	3	1	18
S4-Duck Creek 2	2	1	1	3	4	3	1	2	17
S17-Duck Creek 7	3	2	2	2	2	2	2	1	16
S14-Duck Creek 6	1	2	2	1	4	1	1	1	13
S2-Duck Lake	1	1	3	2	1	1	1	2	12
S18-Duck Creek 8	1	1	1	1	1	1	1	1	8

Table 12. Subwatershed Status—Priority Preservation Areas

Subwatershed Name	Total Rank	Priority Status
S11-Scholes Creek 2	26	Very High
S16-Drainage Ditch 2	26	Very High
S19-Scholes Creek 4	25	Very High
S5-Todd Creek 1	24	High
S15-Scholes Creek 3	24	High
S1-River -end of Duck Lake	23	High
S8-Duck Creek 4	22	High
S9-Scholes Creek 1	22	High
S10-Todd Creek 3	22	High
S6-Duck Creek 3	21	Moderate
S3-Duck Creek 1	19	Moderate
S7-Todd Creek 2	19	Moderate
S13-Drainage Ditch 1	19	Moderate
S12-Duck Creek 5	18	Moderate
S4-Duck Creek 2	17	Low
S17-Duck Creek 7	16	Low
S14-Duck Creek 6	13	Low
S2-Duck Lake	12	Low
S18-Duck Creek 8	8	Low

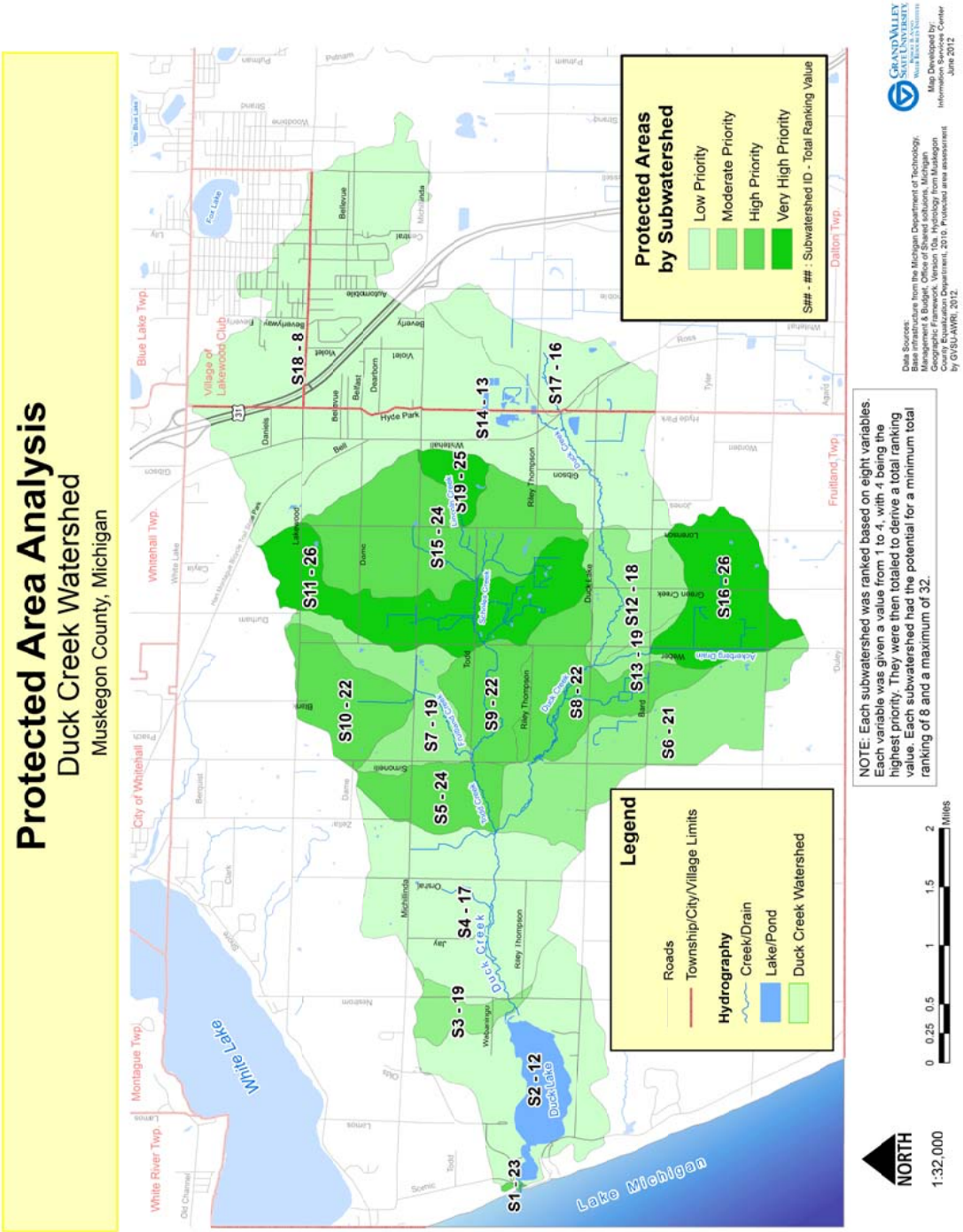


Figure 36. Protected Area Analysis by Subwatershed

4.4 Recommendations to Control Pollutants

Having identified our *critical areas* for restoration and preservation, the next step is to develop a management strategy. This section outlines management measures and practices to be implemented to control *nonpoint source pollutants* in the Duck Creek Watershed. These management measures are grouped together based on their ability to control the pollutants of concern including sediment, temperature, nutrients, *E. coli*, and invasive species. The reduction and/or prevention of these pollutants require that we deal with a multitude of sources including eroding streambanks, stormwater *runoff* from urban and agricultural lands, road/stream crossings, cattle and other livestock crossings, improper use of fertilizers, failing septic systems, and pet and waterfowl wastes. We also need to consider proactive strategies that would enhance the watershed at the same time helping to stabilize its water quality. This includes the preservation of open space and wetlands, the rehabilitation of wetlands, and an education program that makes clear how property owners and other resource users impact the watershed's overall *ecosystem*. **Detailed information on each management practice including location for implementation, pollutant load reductions, costs, and partners needed for implementation is listed in Appendix R.**

Management measures establish performance expectations and specify actions that can be taken to prevent or minimize *nonpoint source pollution*. These specific actions, or management practices, are generally designed to control a particular type of pollutant from specific activities and land uses (USEPA 2005a). These management practices, also known as best management practices, are a method for preventing or reducing the pollution resulting from an activity.

Best management practices can be separated into two categories: structural and non-structural. Structural practices refer to engineered techniques implemented on the ground. Examples include constructed wetlands, streambank stabilization, and *rain gardens*. The second category, non-structural, refers to practices that change a personal behavior such as using phosphorus free fertilizer, maintaining septic systems, and applying conservation easements on your land. For best management practices to be effective, the correct method, installation, and maintenance need to be considered.

Management Measures to Control Nonpoint Source Pollution from Urban/Residential Areas

Problems in urban waterbodies are caused by *runoff* that is inadequately controlled or treated. These problems include changes in flow, increased sedimentation, higher water temperature, lower dissolved oxygen, degradation of aquatic habitat structure, loss of fish and other aquatic organisms, and decreased water quality due to increased levels of nutrients, metals, and bacteria (USEPA 2005a).

To manage *runoff*, the EPA has divided urban/residential activities into categories. To address urban/residential issues in the Duck Creek Watershed the categories include (1) new development, (2) existing development, and (3) pollution prevention. Below are descriptions of these activities and specific management measures to be applied in the Duck Creek Watershed. This information was taken from the National Management Measures Control *Nonpoint Source Pollution* from Urban Areas Manual (USEPA 2005a) and Guidebook for Best Management Practices for Michigan Watershed (MDEQ 1998).

New Development:

Description: Development in and around urban areas is inevitable as the population grows. By recommending standards for new development we can reduce environmental damage caused by development.

Management Measures:

- Implement filtering practices that capture and temporarily store *runoff* and pass it through a filter bed of soil (i.e. bioretention systems—*rain gardens*).
- Work with local units of government to update master plan and zoning ordinances to incorporate Low Impact Development (LID) techniques and natural resources protection. This update can address issues such as:
    - promoting designs that preserve and minimize impacts to predevelopment site hydrology and topography by maintaining natural drainage features and storage areas that help infiltrate flows and filter pollutants,
    - minimizing the amount of *impervious* land coverage,
    - and protecting environmental sensitive areas and open space (wetlands, springs, *groundwater recharge* areas, surface water, forests, highly erodible areas, etc.).

Existing Development:

Description: Maintaining water quality becomes increasingly difficult as urbanization occurs and areas of *impervious* surface increase. Increase peak *runoff* volumes from *impervious* surfaces result in alteration of stream channels, which results in increased bank cutting, streambed scouring, increases in in-stream temperature, and siltation (USEPA 2005a).

Management Measures:

- Implement filtering practices that capture and temporarily store *runoff* and pass it through a filter bed of soil (i.e. bioretention systems—*rain gardens*).
- Establish vegetated areas (*buffer/filter strips*) along waterbodies.

- Restore wetlands that act as filters and remove pollutants from *runoff*.
- Identify undeveloped and privately owned land for acquisition (i.e. conservation easements). The acquisition and preservation of open space in developed areas can protect against the threat of further development, reduce *runoff* volume, and provide stormwater treatment.

Pollution Prevention:

Description: Everyday activities of citizens and businesses have the potential to contribute to *nonpoint source pollutant* loadings. Activities to be addressed under pollution prevention include lawn/turf grass and septic system maintenance.

Management Measures:

- Implement filtering practices that capture and temporarily store *runoff* and pass it through a filter bed of soil (i.e. bioretention systems—*rain gardens*).
- Establish vegetated areas (*buffer/filter strips*) along waterbodies.
- Restore wetlands that act as filters and remove pollutants from *runoff*.
- Ensure appropriate lawn fertilization by having a soil test done through the Home*A*Syst program or MSU extension.
- Work with Muskegon County to implement and police phosphorus fertilizer ordinance.
- Promote the Michigan Turfgrass Environmental Stewardship Program to golf courses in the watershed.
- Work with Muskegon County to develop and adopt Septic System Point of Sale Ordinance.
- Educate the public on septic system function and maintenance.

Management Measures to Control Nonpoint Source Pollution from Agriculture

The primary agricultural *nonpoint source pollutants* of concern in the Duck Creek Watershed include nutrients, sediment, and animal wastes. Agricultural activities also have the potential to directly impact the habitat of aquatic species through physical disturbances caused by livestock and equipment (USEPA 2003b). Below are descriptions of specific management measures to be applied in the Duck Creek Watershed. This information was taken from the National Management Measures Control Nonpoint Pollution from Agriculture

Manual (USEPA 2003b) and Guidebook for Best Management Practices for Michigan Watersheds (MDEQ 1998).

Nutrients:

Description: Nitrogen and phosphorus are the two major nutrients from agricultural land that degrade water quality. Nutrients are applied to agricultural land in several different forms and come from various sources including commercial fertilizer, manure from animal production, and irrigation water. Nitrogen and phosphorus generally are present in aquatic environments at natural levels, however introduced at higher rates they can become a problem. What results is excessive aquatic plant growth which eventually dies and decays leading to depleted oxygen levels that can reduce the quality of fish habitat and other aquatic organisms (USEPA 2003b).

Management Measures:

- Conduct monitoring to verify which portions of the watershed are contributing large nutrient loads to the system.
- Establish vegetated areas (*buffer/filter strips*) along water bodies.
- Establish cover crops and promote residue and tillage management on fields for seasonal protection.
- Promote the Michigan Commission of Agriculture reports, “Generally Accepted Agricultural and Management Practices for Irrigation Water Use, Nutrient Utilization, Manure Management and Utilization, and Site Selection for new and expanding livestock production facilities “.
- Restore wetlands that act as filters and remove pollutants from *runoff*.
- Establish watercourse crossings and fencing to keep livestock out of waterways.

Erosion and Sediment Control:

Description: The types of erosion associated with agriculture that produce sediment are (1) sheet and rill erosion, (2) gully erosion, (3) wind erosion, and (4) streambank erosion. Eroded sediment in aquatic systems can reduce the amount of sunlight available to aquatic plants, cover fish spawning areas, clog and harm gills of fish, and bury aquatic insects (USEPA 2003b).

Management Measures:

- Establish vegetated areas (*buffer/filter strips*) along water bodies.
- Establish cover crops and promote residue and tillage management on fields for seasonal protection and soil improvement.

- Restore and protect wetlands which act as filters and removes pollutants from *run-off*.

Animal Wastes:

Description: An indication of animal wastes in water is the presence of *E. coli*. Most *E. coli* by itself is not dangerous to humans, but fecal materials can in some instances spread diseases. Some ways these bacteria can enter water is from livestock in the stream and *runoff* of manure applied on fields.

Management Measures:

- Conduct research to determine portions of the watershed that are contributing large *E. coli* loads to the system.
- Establish watercourse crossings and fencing to keep livestock out of waterways.
- Promote the Michigan Commission of Agriculture reports, "Generally Accepted Agricultural and Management Practices for Manure Management and Utilization and Site Selection for new and expanding livestock production facilities ".

Management Measures to Control Nonpoint Source Pollution from Road Stream Crossings

Description: Road-stream crossings represent the places where the road system and stream system intersect (Robison et al. 1999). Poorly constructed road-stream crossings can result in an entry point for sediment and pollutants, an alteration of hydrology and water temperature, and can affect aquatic organisms including fish and aquatic *invertebrates*. Roads can create more pollution, in the form of sediment, than agricultural activities, and stream crossings are the most frequent sources of sediment introduction (Taylor et al. 1999).

Below are specific management measures and practices to be applied in the Duck Creek Watershed. This information was taken from the National Management Measures Control *Nonpoint Source Pollution* from Urban Areas (USEPA 2005a) and Guidebook for Best Management Practices for Michigan Watershed (MDEQ 1998).

Management Measures:

- Use live plant materials to provide erosion control and slope/streambank stabilization.
- Implement structural practices to control road *runoff* and install new crossings if necessary.

Management Measures to Control Streambank and Shoreline Erosion

Description: Streambank erosion occurs when the force of flowing water in a river or stream exceeds the ability of soil and vegetation to hold the banks in place. Eroded material is carried downstream and re-deposited in the channel bottom or in point bars located along bends in the waterway. Shoreline erosion occurs in large open waterbodies when waves and currents sort coarser sand and gravels from eroded bank materials and move them along the shore away from the area undergoing erosion. It is important to note that streambank and shoreline erosion are natural processes, however human activities along or adjacent to streambanks and shorelines can increase erosion (USEPA 2007).

Management Measures:

- Installation of stream bank stabilization practices. Several systems of practices can be used but emphasis should be given to “softer”, less rigid structure (vegetative practices).
- Installation of slope/shoreline stabilization structures, which stabilize shorelines and slopes that cannot be stabilized with vegetation.

Management Measures to Protect Resources in the Watershed

Wetlands and Riparian Areas*:*

Wetlands and riparian areas play a significant role in protecting water quality and reducing adverse water quality impacts associated with *nonpoint source pollution*. They also help decrease the need for costly stormwater and flood protection facilities. Thus, wetlands and riparian areas are an important component in a combination of management practices that can be used to reduce *nonpoint source pollution*. In addition, in their natural condition wetland and riparian areas provide habitat for feeding, nesting, cover, and breeding for many species of birds, fishes, amphibians, reptiles, and mammals (USEPA 2005b).

Below are descriptions of specific management measures to be applied in the Duck Creek Watershed to protect these natural resources. This information was taken from the National Management Measures to Protect and Restore Wetlands and Riparian Areas for the Abatement of *Nonpoint Source Pollution* (USEPA 2005b) and Guidebook for Best Management Practices for Michigan Watersheds (MDEQ 1998).

Management Measures:

- Work with local units to update master plan and zoning ordinances to incorporate Low Impact Development (LID) techniques and natural resources protection.
- Promote establishment of conservation easements on wetland and riparian areas.

Habitat and Endangered/Threatened Species:

The primary threat to the world's biodiversity is habitat destruction, sometimes referred to as habitat loss. Habitat loss alters or eliminates the conditions needed for plants and animals to survive. Loss of habitat leads to a decline in the abundance of a species, which reduces the genetic diversity within that species. This makes a species more susceptible to extinction, by making it less resistant to disease or catastrophic events. Habitat loss also reduces the potential for population maintenance or growth, as there is not sufficient area to support more individuals. These conditions make it easier for invasive species to move into these disturbed areas and take over. Below are descriptions of specific management measures and practices to be applied in the Duck Creek Watershed.

Management Measures:

- Develop management strategies (biological, manual—hand pulling and chemical-localized treatment) to control and decrease populations of exotic plants.
- Field inventory endangered and threatened species in the watershed to identify critical habitat for protection.
- Field inventory the watershed to determine areas for fish habitat and implement stream enhancement projects to add fish structures and substrate conducive to reproduction and spawning.
- Protect existing habitat by promoting the establishment of conservation easements.

Groundwater:

Groundwater is the term used to describe the water stored underground in areas of permeable materials, known as aquifers. Groundwater is a major national resource that is used by people for drinking, cooking, and cleaning. This water is also ecologically important for wetlands, lakes, and rivers. Some groundwater resources are not being used sustainably or are at risk of over extraction. Below are descriptions of specific management measures and practices to be applied in the Duck Creek Watershed.

Management Measures:

- Work with Muskegon County to develop and adopt a Septic System Point of Sale Ordinance.
- Work with agricultural producers to follow the Michigan Commission of Agriculture report, “Generally Accepted Agricultural and Management Practices for Irrigation Water Use”.
- Work with homeowners to utilize the Home*A*Syst program to use water resources sustainably.
- Gather information on large water extraction in the watershed (agriculture and commercial), if any exists.
- Work with local units of government to adopt local water diversion ordinances.
- Conduct research to determine portions of the watershed that are contributing large sodium, chloride, and sulfate loads to the system. Once sources are identified, take proper management measures to address them.

Existing Policies:

To build upon existing *land use* management tools, an analysis of local ordinances and programs was done (Appendix S). In addition, a “Site Plan Review Guide” was also prepared suggesting specific regulatory measures appropriate for water quality issues. This Site Plan Review Guide in included as Appendix T. Below are some suggestions offered as part of this analysis:

- Require the use of naturally vegetated buffers along drainage ways/corridors instead of recommending their use.
- Require a variable width, naturally vegetated buffer that encompasses the 100 year floodplain allowing for increased protection within higher risk land units.
- Within the Master Plan call for minimizing impervious surfaces in new construction and redevelopment projects to reduce the amount of runoff and improve infiltration.
- The community needs to adopt a local wetlands ordinance that protects wetlands less than five acres in size.
- The Master Plan should call for the preservation of natural features for the purpose of preserving or improving infiltration of stormwater.

Information and Education Activities:

Many of the water quality problems in the Duck Creek Watershed are the result of actions by individuals not aware of their impact. Consequently, the solutions will rely on individuals knowingly and voluntarily taking actions that will secure the health of the watershed. The promotion of plan implementation and adoption of best management practices along with the informed changes in behavior and effective involvement by a variety of watershed stakeholders will help improve watershed resources.

To change behavior and involve watershed stakeholders, an Information and Education (I/E) Strategy was developed (Appendix A). The I/E strategy, an essential element of watershed planning, helps to draw the attention of watershed residents to Duck Creek and its watershed and links their informed actions to the watershed's health and well-being.

The outreach proposed in the I/E strategy is intended to cultivate greater awareness in watershed stakeholders of the impact of their decisions on water quality in the Duck Creek Watershed, from applying fertilizers and maintaining riparian buffers, to writing master plans and implementing zoning ordinances. Sharing relevant information with stakeholders – those individuals and groups interested in or affected by the health of the watershed – will be essential to safeguarding the Duck Creek Watershed. Stakeholder education will be fundamental to the successful implementation of virtually every part of the watershed management plan.

Some environmental outreach efforts remain ineffective because they try to communicate in a general fashion with everyone in a large geographic area, such as a watershed. What we have learned is that the general public is too vast and diverse, and communicating meaningfully with this "public" challenges most budgets. In reality, there is no such thing as the "general public". Outreach needs to target specific groups within this "public", such as watershed stakeholders, and to think about these stakeholders as different audiences, e.g., landowners, riparian landowners, Duck Creek Watershed landowners, or retired Duck Creek Watershed landowners. These audiences will have very different information and outreach needs. By dividing the audience into more manageable targets, the message, resources, and strategy can be focused on where it will be most effective. At the same time, the role of these audiences in protecting and restoring the watershed can be more clearly articulated.

The priority target audiences for the Duck Creek Watershed include general watershed, riparian landowners, developers / commercial industry, local government officials, recreational users, K-12 educators / students, and agricultural producers. The strategy for communicating with each one of these target audiences is presented in more detail in Appendix A. Listed are a few educational techniques to engage these audiences.

General Watershed:

- When addressing a broad audience, means of delivery should be focused on widely accessible media such as newspapers, e-news articles, newsletters, and websites. Within the Duck Creek Watershed, some specific examples would be the Muskegon Conservation District's e-newsletter, DCWA's newsletter and website, the Muskegon Chronicle, and the White Lake Beacon.

Riparian Landowners:

- Riparian landowners will be reached by interaction through the DCWA. Due to the size of the Duck Creek Watershed, a complete list of riparian landowners has already been developed. Direct mailings can be sent utilizing this list. Information will also be distributed through websites, DCWA meetings, and workshops.

Developers / Commercial Industry:

- Developers influence water quality with sedimentation and nutrient loading in the watershed. Increased stormwater runoff volumes from impervious surfaces from these areas, as well as commercial lots, is a threat to water quality due to the increasing turbidity and sedimentation in Duck Lake/Duck Creek. The delivery tools that are appropriate for reaching this target audience are workshops, brochures, and conservation tours.

Local Government Officials:

- Perhaps the most useful delivery tool to bring about behavioral change for local government officials is through personal conversations or face-to-face interactions. Local officials can also be reached through the following methods: attendance at watershed meetings, workshops, or personalized presentations. Governmental officials need to be convinced that environmental factors are more important than social or economic factors.

Recreational Users:

- With it being hard to pinpoint who a recreational user is, indirect delivery tools must be used. Signs and brochures will be used for this target audience. Signs will be installed at local recreation destinations such as state parks, campgrounds, and boat launches. Brochures will be left at local sport/tackle shops and local convenience stores as well.

K-12 Educators / Students:

- Educators are the most effective and direct means by which to reach students. A considerable amount of time must be spent collaborating with educators to refine curriculums to incorporate key watershed issues. Involvement by teachers can be stimulated through direct mailings to department heads requesting student involve-

ment with watershed projects. Hands on learning campaigns are often a fun and effective way to introduce watershed friendly concepts. Students can also be used to increase the volunteer base and achieve rudimentary data collection. In this day and age students are becoming more technologically savvy. This provides a unique opportunity to educate through student-website interaction.

Agricultural Producers:

- The appropriate delivery tools for agricultural producers, who represent a small portion of the overall watershed, include face-to-face interactions, as well as educational newspaper/magazine articles, and informational fliers/brochures.

One key to improving water quality is an informed and involved citizenry that are motivated to take appropriate steps on their property, in their neighborhoods, in their schools, and in their communities. Recognizing this important relationship between stakeholder practices and the quality of water resources makes watershed literacy a priority. Challenges to reaching watershed stakeholders include:

- Breaking through the clutter to deliver relevant messages that are noticed and welcomed.
- Increasing public awareness as media costs increase and the nature of media change.
- Providing I/E assistance to education projects when resources are limited.
- Developing, within budget, the necessary programs to serve multiple audiences.
- Reaching the most relevant audiences when they are most receptive to learning.
- Changing long-term habitual behavior that negatively impact water resources.
- Meeting public expectations for immediate and obvious results when improvements to water quality and/or natural resources may not be apparent for years.
- Maintaining meaningful relationships with individuals, landowners, and organizations.
- Addressing the impact that changes in technology has on communication methods.

4.5 Resources

Listed below are resources where you can learn more about information on management practices to control *nonpoint source pollutants*.

Management Measures and Practices to Control Nonpoint Source Pollution for Agriculture

Michigan Commission of Agriculture *Generally Accepted Agricultural and Management Practices for Irrigation Water Use*.
http://www.michigan.gov/documents/MDA_Irrigation_GAAMP_129710_7.pdf

Michigan Commission of Agriculture *Generally Accepted Agricultural and Management Practices for Nutrient Utilization*.
http://www.michigan.gov/documents/MDA_Nutrient_GAAMP_129705_7.pdf

Michigan Commission of Agriculture *Generally Accepted Agricultural and Management Practices for Manure Management and Utilization*.
http://www.michigan.gov/documents/MDA_Manure_GAAMP_129695_7.pdf

Michigan Commission of Agriculture *Generally Accepted Agricultural and Management Practices for Site Selection and Odor Control for New and Expanding Livestock Production Facilities*.

http://www.michigan.gov/documents/MDA_SITE_SELECTION_133281_7.pdf

United States Environmental Protection Agency *National Management Measures for the Control of Nonpoint Pollution from Agriculture.*
http://www.epa.gov/nps/agmm/index.html

Management Measures and Practices to Control Nonpoint Source Pollution from Urban/Residential Areas

United States Environmental Protection Agency *National Management Measures for the Control Nonpoint Source Pollution from Urban Areas.*
http://www.epa.gov/nps/urbanmm/index.html

Southeast Michigan Council of Governments *A Design Guide for Implementers and Reviewers Low Impact Development Manual for Michigan.*
http://www.semcog.org/LowImpactDevelopment.aspx

New Development:

Catching the Rain: A Great Lakes Resource Guide for Natural Stormwater Management—developed by American Rivers which talks about low impact development techniques for the Great Lakes region.
http://www.americanrivers.org

EPA has compiled a number of resources on *Low Impact Development (LID).*
http://www.epa.gov/owow/nps/lid

The Center for Watershed Protection published *Better Site Design: A Handbook for Changing Development Rules in Your Community*.
http://www.cwp.org/

Existing Development:

EPA's *River Corridor and Wetland Restoration* web site.
http://www.epa.gov/owow/wetlands/restore

Land Conservancy of West Michigan—*resources for land protection*.
http://www.naturenearby.org

Natural Resources Conservation Service's *National Conservation Buffer Initiative website.*
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/nedc/training/catalog/?&cid=nrcs143_024138

Stream Corridor Restoration: Principles, Processes, and Practices by the Federal Interagency Stream Restoration Working Group.
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/manage/?&cid=stelprdb1043244

Pollution Prevention:

EPA's GreenScapes program provides cost-efficient and environmentally friendly *solutions for large-scale landscaping*.
http://www.epa.gov/greenscapes

EPA published *Healthy Lawn, Healthy Environment* which is a brochure that describes lawn care practices for citizens.
http://www.epa.gov/oppfead1/Publications/lawncare.pdf

Rain Gardens of West Michigan—information on *rain gardens* and how you can create one.
http://www.raingardens.org/

The International Turf Producers Foundation published *Water Right: Conserving our Water, Preserving Our Environment.*
http://www.turfgrasssod.org/waterright.html

USDA's Natural Resources Conservation Service website sponsors a *Backyard Conservation* web site that provides management practices to beautify the landscape while protecting water resources.
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/newsroom/features/?&cid=nrcs143_023574

Wildlife Reserves and Corridors in the Urban Environment: A Guide to Ecological Landscape Planning and Resource Conservation by Lowell Adams and Louise Dove.
http://users.erols.com/urbanwildlife/bookstor.htm

Management Measures and Practices to Control Nonpoint Source Pollution from Road Stream Crossings

Federal Highway Administration *Manual of Practice for an Effective Anti-Icing Program: A Guide for Highway Winter Maintenance Personnel*
http://www.fhwa.dot.gov/reports/mopeap/mop0296a.htm

National Cooperative Highway Research Program *Best Management Practices for Environmental Issues Related to Highway and Street Maintenance.*
http://trb.org/bookstore

Natural Resources Conservation Service *Bioengineering for Upland Slope Protection and Erosion Reduction* ftp://ftp-nhq.sc.egov.usda.gov/NHQ/pub/outgoing/jbernard/CED-Directives/efh/EFH-Ch18.pdf

Information on alternative deicers can be found at:
http://www.michigan.gov/documents/toc-deice_51451_7.pdf

Management Measures and Practices to Protect and Restore Resources in the Watershed

Wetlands and Riparian Areas:

Izaak Walton League of American's Save our Streams Program provide *technical assistance on stream and wetland restoration techniques*.
http://www.iwla.org

Tipp of the Mitt Watershed Council *Living with Michigan's Wetlands: A Landowners Guide*.
http://www.michigan.gov/deq/0,1607,7-135-3313_3687-10502—,00.html

USEPA *A Citizens' Guide to Wetland Restoration: Approaches to Restoring Vegetation Communities and Wildlife Habitat Structure in Freshwater Wetland Systems*. USEPA Office of Wetlands website has complete list of *wetlands fact sheets* and other technical information. http://www.epa.gov/owow/wetlands/facts/contents.html

USEPA *National Management Measures to Protect and Restore Wetlands and Riparian Areas for the Abatement of Nonpoint Source Pollution*.
http://www.epa.gov/nps/wetmeasures/pdf/guidance.pdf

Habitat and Endangered/Threatened Species
Michigan Natural Features Inventory—Rare Species and Unique Habitats
http://mnfi.anr.msu.edu/mnfi/

Groundwater:

Groundwater Mapping Project
http://gwmap.rsgis.msu.edu/

Water Withdrawal Tool
http://www.miwwat.org/

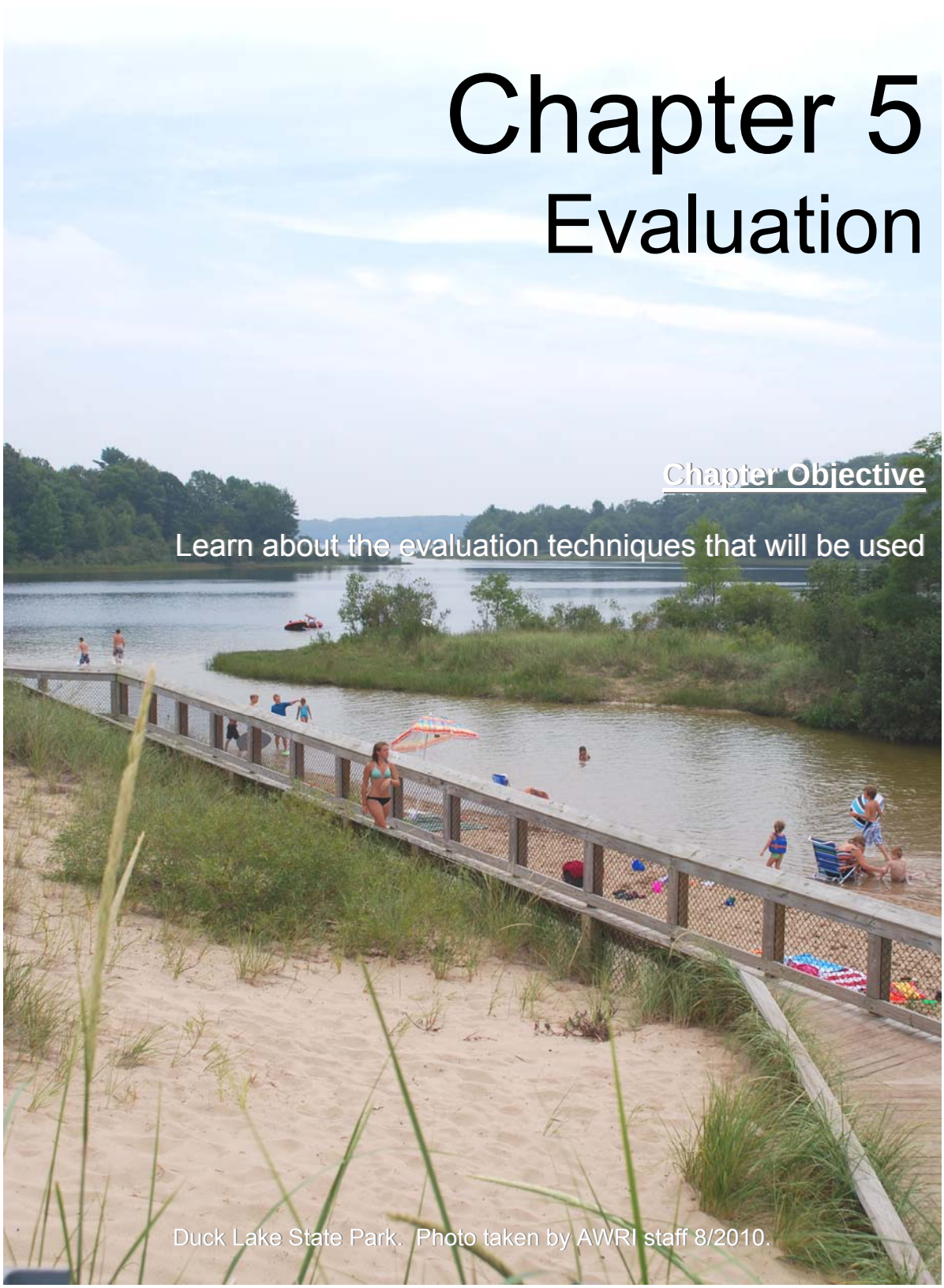
USFS *Groundwater Information* Pages
http://water.usgs.gov/ogw/

New Water Use Regulations
http://www.iwr.msu.edu/WaterUse

Chapter 5
Evaluation

Chapter Objective

Learn about the evaluation techniques that will be used



Duck Lake State Park. Photo taken by AWRI staff 8/2010.

5.1 Chapter 5 Summary

Highlighted below are some of the major points that you will learn in Chapter 5.

- Significant amounts of time and money are dedicated to implementing watershed management plans. Without a well-planned evaluation process, assessing whether or not these implementation efforts are successful is impossible.

- A key consideration when planning the implementation of management measures and information and education activities is how to phase or sequence activities in relation to one another over time. There are three major activity phases under which the recommended activities can be categorized—Phase I: completed in 1 to 3 years, Phase II: completed in 3 to 7 years, and Phase III: completed in 7 to 10 years.

- To ensure project completion, milestones are listed as a guide to determine whether the management practices are being implemented on schedule and in a timely manner. The milestones will provide a dated checklist to refer to as project implementation begins and occurs.

- To evaluate whether pollutant reductions are being achieved over time, a set of criteria (indicators) and targets were determined for each pollutant and the related sources.

- A long-term water quality monitoring program that measures qualitative as well as quantitative parameters is essential to determine where resources should be focused and to move towards watershed goals and objectives. Throughout the three major activity phases, continual evaluation methods will be implemented to measure project successes and failures.

5.2 Management Plan Evaluation

Significant amounts of time and money are dedicated to implementing watershed management plans. Without a well-planned evaluation process, assessing whether or not these implementation efforts are successful is impossible. This chapter includes information on the different types of evaluation techniques that will determine the effectiveness of implementation efforts.

Schedule

A key consideration when planning the implementation of management measures and information and education activities is how to phase or sequence activities in relation to one another over time. Determining which actions will need to take place before other actions will be important in achieving the full potential of each activity. The best order in which to implement management practices can be based on a number of factors such as ecological considerations, length of time for developing the practice, and/or the ranked priority concerns within the watershed.

Listed below are three major activity phases under which the recommended activities can be categorized. A phase (I, II, or III) is indicated for each type of management practice described below. This phasing sequence is a recommendation only and individual circumstances may require alternative staging and phasing periods and timelines.

Phase I:

Phase I will address practices that can be initiated right away, require minimal cost or planning, usually non-structural practices. Examples include information and education programs and some master plan revisions/updates. Actions under this category may be completed in 1 to 3 years; however, certain actions may involve continual implementation.

Phase II:

Phase II will address practices that require significant planning and development, design specifications, require major additional costs (permits), address sources/causes of a problem, can be structural or non-structural practices. Examples include new projects/

programs, ordinances, demonstration sites, studies, and design and construction of best management practices. Actions under this category may be completed in 3 to 7 years; however, certain actions may involve continual implementation.

Phase III:

Phase III will address practices for which success may depend on the success of a previously implemented practice, mostly structural best management practices. An example may include in-stream and streambank restoration projects. Actions under this category may be completed in 7 to 10 years; however, certain actions may require continual implementation.

Milestones

To ensure project completion, milestones are listed as a guide to determine whether the management practices are being implemented on schedule and in a timely manner. The milestones will provide a dated checklist to refer to as project implementation begins and occurs. The implementation schedule and milestones are listed in Appendix A: *Duck Creek Watershed Information and Education Strategy,* and in Appendix U: *Implementation Schedule and Milestones for the Duck Creek Watershed Management Plan.*

To evaluate whether pollutant reductions are being achieved over time, a set of criteria (indicators) and targets were determined for each pollutant (Appendix V). By using these indicators and targets, we can see if substantial progress is being made towards water quality standards. If progress is not being made towards water quality standards, the management approaches will be revised. The Duck Creek Watershed Assembly will evaluate the existing practices and see if the quantities of practices implemented need to be increased or if alternative practices need to be proposed.

Monitoring Success of Implementation Efforts

Establishing monitoring methods allows for a clear picture of whether or not the goals and objectives for water quality improvement are being attained. Results of the evaluation will provide feedback to manage and ensure improved project implementation, which in turn will gain support from watershed stakeholders. Monitoring and measuring progress in the watershed will likely be conducted at the local level by individual agencies, entities and communities, as well as at the watershed and subwatershed levels (i.e., educational institutions, watershed organizations, groups) in order to assess the ecological consequences of

the community and agency actions on the overall health of the Duck Creek Watershed.

Evaluation is difficult due to the social and technical complexity of watershed projects. Evaluations usually take either a qualitative or quantitative approach, with the two approaches often viewed as alternatives (Kerr and Chung 2005). Qualitative approaches deal with how people understand their experiences (i.e. qualities). An example of using a qualitative approach is sending watershed stakeholders a survey which asks them to provide feedback on water quality in their area. By contrast, quantitative approaches deal with numerical outcomes (i.e. quantities). A quantitative approach would be to select a site in the watershed where aquatic insect data are collected and analyzed over a set period of time to determine water quality in that area. Although these methods are presented as if they were in opposition to one another, these approaches can be combined to deal with the complexity inherent in watershed projects. The rising interest in combining methods comes from the recognition that purely qualitative and purely quantitative approaches to evaluation each have limitations, and that the strengths of one often compensate the weaknesses of the other (Kerr and Chung 2005).

A long-term water quality monitoring program that measures qualitative as well as quantitative parameters is essential to determine where resources should be focused and to move towards watershed goals and objectives. Throughout the three major activity phases, continual evaluation methods will be implemented to measure project successes and failures. This will allow for intervention if project goals are not being achieved. Below is a description of quantitative and qualitative methods that will be used to evaluate the effectiveness of implementing the watershed plan and achieving its goals.

Qualitative Evaluation Methods:

Qualitative methods aim to uncover the perspectives of multiple stakeholder groups; learning first-hand about the incentives, motivations, and dynamics behind decisions and actions taken as a result of a project. The objective is not to obtain a numerical estimate, but to develop an in-depth understanding of an issue by probing, clarifying, and listening to stakeholders talk about a topic in their own words (Kerr and Chung 2005). The data gathered are the perceptions of the people living in the watershed and the individual resident is the primary collection instrument. An advantage to qualitative evaluation methods is that it produces in-depth, comprehensive information that focuses on a holistic picture (Key 1997). Qualitative methods can be used to investigate issues and can explore how well project programs are addressing these issues. Details regarding responsible parties, monitoring procedures, sampling sites, and frequency of monitoring for qualitative evaluation techniques will need to be further defined in project work plans as funding resources are secured.

The Information and Education Strategy in Appendix A lists evaluation objectives that should be used to determine the success of implemented information/education efforts. Another resource that should be used in implementing and evaluating these practices is the “Getting in Step – A Guide for Conducting Watershed Outreach Campaigns” prepared by Tetra Tech, Inc. under a contract with the U.S. Environmental Protection Agency. This guide provides the tools needed to develop and implement an effective outreach campaign. It will help understand the audiences in the watershed, create messages that resonate with them, find appropriate ways to communicate the message, and prompt changes in behavior to reduce water pollution.

Some of the qualitative measures to be used in evaluating the implementation of the Duck Creek Watershed Management Plan will likely include:

- Feedback from partners
- Interviews with local officials
- Surveys repeated of local residents
- Workshop evaluations by participants
- Feedback from landowners contacted

Quantitative Evaluation Methods:

Quantitative evaluation begins with the premise that the analyst fully understands the nature and determinants of a program’s success and/or problem issues and can obtain the data needed to measure and relate them statistically (Kerr and Chung 2005). Statistical analysis also requires a sufficient sample size, generated by some form of randomization, rather than a “convenience sample” of a few sites. But measuring improvements in natural resource conditions is difficult. First, the conditions of the project site are not likely to be replicated exactly in other sites. Differences in physical, economic, and social factors may lead to changes in program outcomes. Second, many watersheds projects do not deal with sample sizes that make randomization a feasible strategy for study design. Details regarding responsible parties, monitoring procedures, sampling sites, and frequency of monitoring for quantitative evaluation techniques will need to be further defined in project work plans as funding resources are secured.

The quantitative evaluation methods can be found in Appendix W. It should be noted that the monitoring procedures are based upon existing programs. Most of these programs are volunteer based and have funding constraints. Therefore, the sample frequency and parameters measured are limited. However, the information collected can

still be used to indicate change on a watershed scale.

Some of the quantitative measures to be used in evaluating the implementation of the Duck Creek Watershed Management Plan will likely include:

- Meeting state Water Quality Standards
- Areas protected, restored, etc.
- Number of participant attending meetings
- Number of partners
- Number of landowners contacted
- Feet of buffers installed
- Number of master plans implemented
- Number of ordinances enacted
- Number of workshops, presentations, tours, events, etc. conducted
- Percentage change in responses to subsequent surveys
- Number of brochures distributed

Water Quality Indicators

There is already in place a well-conceived and locally supported system for water quality monitoring, referring once again to Appendix W: Existing Evaluation Techniques to Monitor Success of Structural and Vegetative Practices. Up to this point stream monitoring has been limited to data loggers for temperature analysis, the use of handheld multiparameter meters for the investigation of phosphorus and nitrogen, and macroinvertebrate collection as a technique to measure the overall habitat including the influence of sedimentation as well as nutrient impacts. Duck Lake monitoring has been more sporadic and limited to water transparency (Secchi Disk), and dissolved oxygen, chlorophyll, and phosphorus (handheld multiparameter instruments). The presence of exotic species, the potential for bacteria, and stream bank erosion sites are often tracked as part of routine inventories conducted by the DCWA and others. The identification of potential problems is based on observations alone and frequently documented through photographs.

While there are no immediate plans to expand existing monitoring activities, such is conceivable and might in fact be advantageous as conditions and circumstances change within the watershed. The following guidelines are offered in preparation of this expanded monitoring effort.

Sediment:

Sediment has been identified as the most significant pollutant impacting the Duck Creek Watershed and was assigned a high priority.

"Rule 50 of the Michigan Water Quality Standards (Part 4 of Act 451) states that waters of the state shall not have any of the following unnatural physical properties in quantities which are or may become injurious to any designated use: turbidity, color, oil films, floating solids, foam, settleable solids, suspended solids, and deposits. This kind of rule, which does not establish a numeric level, is known as a "narrative standard." Most people consider water with a TSS concentration less than 20 mg/l to be clear. Water with TSS levels between 40 and 80 mg/l tends to appear cloudy, while water with concentrations over 150 mg/l usually appears dirty. The nature of the particles that comprise the suspended solids may cause these numbers to vary." http://www.michigan.gov/documents/deq/wb-npdes-TotalSuspendedSolids_247238_7.pdf. It is advised that TSS concentrations be measured by a certified laboratory (MDEQ 2006).

Macroinvertebrate analysis has been conducted as part of the MiCorps volunteer program and follows the Surface Water Assessment Section (SWAS) Procedure No. 51.

High Temperature:

To support a coldwater fishery, heat load cannot cause exceedance of monthly limits - maximum 68º F in June, July, and August, and 63º F in September. To support a warmwater fishery, heat load cannot cause exceedance of monthly limits - maximum 80º F in June, 83º F in July, 81º in August, and 74º F in September. Heat load is to be measured at the edge of the mixing zone (MDEQ 2006).

Continuously recording data loggers are currently used to collect temperature data. Monitoring sites are described in Figure 16 on page 50 of this report, and also referenced in Appendix W.

Nutrients:

Rule 60 of the Michigan Water Quality Standards (Part 4 of Act 451) states, "nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the surface waters of the state." http://www.michigan.gov/documents/deq/wb-swas-rules-part4_254149_7.pdf (MDEQ 2006).

Phosphorus and nitrogen were at one point monitored at six locations on Duck Creek and Todd Creek using handheld analyzers. This practice is considered

sufficient given current circumstances but might require the collection of water samples for laboratory analysis as a means to verify automated procedures and better quantify increasing problematic areas. The same is true regarding Duck Lake nutrient analysis.

Bacteria:

Rule 62 of the Michigan Water Quality Standards (Part 4 of Act 451) states, "all surface waters of the state protected for total body contact recreation shall not contain more than 130 Escherichia coli (*E. coli*) per 100 milliliters, as a 30-day geometric mean. Compliance shall be based on the geometric mean of all individual samples taken during five or more sampling events representatively spread over a 30-day period. Each sampling event shall consist of three or more samples taken at representative locations within a defined sampling area. At no time shall the surface waters of the state protected for total body contact recreation contain more than a maximum of 300 *E. coli* per 100 milliliters. Compliance shall be based on the geometric mean of three or more samples taken during the same sampling event at representative locations within a defined sampling area."

"All surface waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1,000 *E. coli* per 100 milliliters. Compliance shall be based on the geometric mean of three or more samples, taken during the same sampling event, at representative locations within a defined sampling area." http://www.michigan.gov/documents/deq/wb-swas-rules-part4_254149_7.pdf (MDEQ 2006).

Suspicion of bacterial contamination is limited to one cattle crossing identified during the inventory process. Another potential source of bacterial contamination is failing septic systems. The need for more specific sampling and analysis will be determined with cooperation from MDEQ and the Muskegon County Health Department. This type of analysis falls outside the capabilities of the DCWA and requires the assistance from a qualified laboratory.

Other Environmental Assessments

In addition to the water quality indicators listed above, there are assessment tools to aid in the evaluation of erosion sites and hydrologic concerns, which contribute in part to sedimentation problems currently identified in the Duck Creek Watershed.

Erosion Assessments:

The Bank Erosion Hazard Index (BEHI) assessment was used during the streambank inventory conducted for the Duck Creek Watershed. The BEHI procedure is intended to help characterize the changes in stream stability and provide a basis for

water quality recommendations. It is also a useful tool when comparing erosion sites and assigning implementation priorities. BEHI will be used to assess future changes in the watershed and to measure the benefits of those BMPs implemented.

A tool that was useful in calculating load reductions was the Michigan Pollutants Controlled Spreadsheet , 2010. http://www.michigan.gov/deq/0,1607,7-135-3313_3682_3714-118554--,00.html. This same tool will continue to be used as part of the ongoing assessment and will help determine BMP effectiveness.

Hydrology:

Hydrologic modifications often lead to streambank erosion. This issue is not considered a principal concern in the Duck Creek Watershed. However, continued urbanization of the watershed in combination with expected changes in climate could in the future prove to have significant consequences for local hydrology. Hydrologic monitoring, including the placement of stream gages intended to measure stream flow, might prove advantageous in the design of future stream restoration and streambank stabilization projects.

Summary of Evaluation Framework

The management practices recommended for implementation are included in Appendix R: *Best Management Practices and Estimated Load Reductions for the Duck Creek Watershed*. The implementation schedule and milestones needed to guide the actions of the DCWA and its partners are defined in Appendix A: *Duck Creek Watershed Information and Education Strategy*, and Appendix U: *Implementation Schedule and Milestones for the Duck Creek Watershed Management Plan*. The schedule for implementation is divided into three phases with Phase I: completed in 1 to 3 years, Phase II: completed in 3 to 7 years, and Phase III: completed in 7 to 10 years. Evaluation will be measured using the same schedule in judging performance.

Indicators developed to determine whether pollutant reductions are achieved over time are included in Appendix V: *Related Goals and Pollutants, Sources, Causes and Set of Indicators to Determine Whether Loading Reductions are Being Achieved*. Appendix W: *Existing Techniques to Monitor Success of Structural and Vegetative Practices* lists monitoring programs currently underway and expected to continue.

Evaluation methods will include both qualitative and quantitative measures. Qualitative measurements will be critically important in the assessment of public opinion and in determining the effectiveness of the Watershed Management Plan in meeting the expectations of watershed residents. Quantitative measures will include many of the same monitoring methods used in the past to determine the long-term impacts associated in particular with

land use change and continued urban growth. Critically important with regard to quantitative measurement is the continued assessment of water quality with regard to sediment, temperature, nutrients, and bacteria. Broader concerns include the assessment of erosion and hydrology.

Responsibility for evaluation will be divided between current project partners (DCWA, MCD, and AWRI) and other project partners yet to be defined. The collection and analysis of needed information is contingent of available funding.

The Duck Creek Watershed Management Plan was prepared as a flexible and dynamic tool for the DCWA and others interested in the improvement and protection of the Duck Creek Watershed, including Duck Lake. The evaluation process is designed to capture new ideas, identify new management strategies, in short discover and document what works and what doesn't. The Duck Creek Watershed Management Plan will adapt to both expected and unexpected changes in the watershed itself as well as the techniques and methods used to evaluate, monitor, and deal effectively with nonpoint source pollution.

5.3 Resources

Evaluating Watershed Management Practices: A Practical Econometric Approach by Kerr, J. and Chung, K. 2005. Chapter 10 in Shiferaw, B., H. A. Freeman, and S. M. Swinton, eds. Natural Resource Management in Agriculture: Methods for Assessing Economic and Environmental Impacts.

Getting in Step – A Guide for Conducting Watershed Outreach Campaigns by Tetra Tech, Inc. http://www.epa.gov/owow/watershed/outreach/documents/getnstep.pdf.

Chapter 6
Final Comments

Chapter Objective

A Continuous Process of Updates and Implementation

Mears Historic Site. Photo taken by AWRI Staff

6.1 Closing Remarks

This management plan would not have been possible without the assistance and dedication of the Duck Creek Watershed Assembly. Their support and passion for this valued resource has inspired both the Muskegon Conservation District and staff from the Annis Water Resources Institute. The Duck Creek Watershed is truly a special place, not just because of its natural beauty and rich history, but because of the people living here and the willingness they have shown to protect and preserve this watershed. This plan lays out for all to see and understand what is important about the Duck Creek Watershed, where it is most vulnerable, and what we need to do next to maintain its integrity. However, completion of this plan is only the beginning. The implementation process requires a long-term investment by the Assembly in partnership with local government, regulatory agencies, businesses, and non-profit organizations. There is much that we can do to protect this treasured resource. And if there is one fact that holds true regardless of what watershed we are talking about, and what problems they might be experiencing, it is always easier, more cost effective to **prevent** water pollution than it is to **clean it up**. The future for the Duck Creek Watershed is encouraging, but never forget this is a story for us to write and it will require the support of many groups and individuals.

6.2 Glossary

Anthropogenic— caused by humans, the result of human activities on nature.

Aquifer— a geologic feature containing permeable rock, sand, and/or gravel in which groundwater flows, serving as a potential source for drinking water wells.

Areas of Concern — Critical Areas for Restoration/Pollution Prevention and Priority Preservation Areas are identified in water quality management plans so as to give focus and help in establishing priorities.

Benthos— organisms that live in or on the bottom of a body of water.

Buffer/Filter Strips— a narrow band of vegetation along a drain, stream, or lake which helps to filter some pollutants and sediment that might be carried by *runoff.*

Critical Areas for Restoration/Pollution Prevention — those geographic areas that are known or expected to create the greatest pollution load in the watershed.

Drowned River Mouth— occurs when the lower end of a river is submerged or flooded by encroaching water from the Great Lakes.

E. coli— the common abbreviation of *Escherichia coli*. One of the members of the coliform groups of bacteria indicating fecal contamination from humans, birds, pets, etc.

Ecosystem— a natural unit consisting of all plants, animals and micro-organisms (biotic factors) in an area functioning together with all of the physical (abiotic) factors of the environment.

Geo-rectify— a process where a photograph is assigned a coordinate base or cartographic projection so that it might be included as a registered image in a Geographic Information System.

Groundwater recharge— the natural process of infiltration and percolation of rainwater from land areas or streams through permeable soils into water-holding geologic formations that provide underground storage (i.e. aquifers).

Holding capacity— the ability of soil to retain or store water.

Hydrologic Soil Group— four soil groups (A, B, C, and D), where soils having similar runoff potential under similar storm and cover conditions are classified. Soils classified as C or D have slow and very slow infiltration rates.

Impervious— a surface through which little or no water will move due to lack of pore space. Impervious areas include paved parking lots and roof tops.

Invertebrate— animal without a backbone.

Lacustrine— deposits formed in part by or associated with lake processes.

Land Use— the pattern of use that characterizes the landscape including residential, agricultural, transportation, recreational, and industrial uses.

Leaf-on— is a reference to an aerial photograph where deciduous trees like oaks and maples have leaves on their branches. In Michigan this generally includes Late Spring through Fall. It is also a period of agricultural productivity or “growing season.”

Mesic— characterized by moderately moist conditions; neither dry nor wet.

Moraines— a mound or ridge of boulders, stones, or other unsorted debris carried and deposited by a glacier.

Nonpoint source pollutants— pollution discharged over a wide land area, not from a specific location. Nonpoint source pollution is contamination that occurs when rainwater, snowmelt, or irrigation washes off plowed fields, city streets, or suburban backyards. As this *runoff* moves across the land surface, it picks up soil particles and pollutants, such as nutrients and pesticides.

Outwash— sand and gravel deposited by streams and meltwater flowing away from a glacier.

Organic— of or relating to or derived from living organisms; “organic soil”.

Perennial Streams and Tributaries— have water that is flowing through them most of the year.

Polygons— are many-sided two dimensional figures about which information is gathered for use in a Geographic Information System.

Preservation Areas — those areas that are most fragile and frequently contribute ecosystem services that benefit water quality.

Rain garden— planted depression that allows rainwater *runoff* from *impervious* areas such as roofs, driveways, walkways, and compacted lawn areas the opportunity to be absorbed. Native plants are recommended for these gardens because they generally do not require fertilizer and are more tolerant of local climate, soil, and water conditions.

Raster— cells of equal dimension reported in an array and used to assign information in a Geographic Information System.

Riparian— is the land area found adjacent to a lake and/or stream.

Runoff— the flow of water, from rain, snow melt, or other sources, over land.

Sheet and Rill Erosion – is erosion of top soils on gentle to steep slopes either as broad overland flow of water (in sheets) or as shallow incisions (rills).

Trophic State - total weight of living biological material (biomass) in a waterbody at a specific location and time.

6.3 References

Allan JD. 1995. Stream Ecology. London: Chapman & Hall.

Anderson JR, Hardy EE, Roach JT, Witmer RE. 1976. A Land Use And Land Cover Classification System For Use With Remote Sensor Data. Washington DC: United States Geological Survey, Government Printing Office. Geological Survey Professional Paper 964.

Ardizone K, Wyckoff, M. 2003. Filling the Gaps: Environmental Protection Options for Local Governments. Lansing, MI: Michigan Department of Environmental Quality, Coastal Management Program.

Behar S. 1997. Testing the Waters: Chemical and Physical Vital Signs of a River. Montpelier, VT: River Watch Network.

Brown E, Peterson A, Kline-Robach R, Smith K, Wolfson L. 2000. Developing Watershed Management Plan for Water Quality: An Introductory Guide. Lansing MI: Michigan Department of Environmental Quality.

Cabala, TA. 2008 June 8. Brief History of Duck Lake. White Lake Beacon.

Carlson RE. 1977. A Trophic State Index for Lakes. Limnology and Oceanography. 22:361-369.

Carson RE, Simpson J. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society.

Diana JS. 1995. Biology and Ecology of Fishes. Carmel, IN: Biological Sciences Press.

Donovan ML, Nesslage GM, Skillen JJ, Maurer BA. 2004. The Michigan Gap Analysis Project Final Report. Lansing, MI: Wildlife Division, Michigan Department of Natural. [cited 2012 August 7]. Available from: http://www.fw.msu.edu/~maurerb/gap/downloads/Mi_final_report_updated.pdf.

Eastman R. 2012. IDRISI Selva, Version 17. Worcester, MA: Clark University.

Fuller K, Shear H, Wittig J, eds. 1995. An Environmental Atlas and Resource Book [3rd edition].. Chicago, IL: United States Environmental Protection Agency. [2012 August 15]. Available from: http://www.epa.gov/glnpo/atlas/index.html. p. Geology.

Gordon ND, McMahon TA, Finlayson BL, Gippel CJ, Nathan RJ. 2004. Stream Hydrology: An Introduction for Ecologists. Chichester: John Wiley & Sons, Ltd.

Hay-Chmielewski E, Seelbach P, Whelan G, Jester D.1995. Huron River Assessment. Ann Arbor, Michigan: Michigan Department of Natural Resources, Fisheries Division. Special Report Number 16.

Heft AA, editor. 2006. Maryland Brook Trout Fisheries Management Plan. Annapolis Maryland: Maryland Department of Natural Resources.

Hickman C. 1990. Forest Wetland Trends in the United States: An Economic Perspective. Forest Ecology and Management 33 (34):227-238.

History of Muskegon County, Michigan. 1882. Chicago, IL: H.R. Page & Co.

Hyde D. 1999. Special Animal Abstract for *Terrapene c. Carolina* (eastern box turtle). Lansing MI: Michigan Natural Features Inventory.

Hyde D, Thomson D, Legge J. 2000. Special Animal Abstract for *Dendronica cerulea* (cerulean warbler). Lansing, MI: Michigan Natural Features Inventory.

Key JP. 1997. Research Design in Occupational Education. [Internet]. Oklahoma: Oklahoma State University; [cited 2012 August 15]. Available from : http://www.okstate.edu/ag/agedcm4h/academic/aged5980a/5980/newpage21.htm.

Kerr J, Chung K. 2005. Evaluating the Impacts of Watershed Projects: A Practical Econometric Approach. Chapter 7 in Shiferaw, B., H. A. Freeman, and S. M. Swinton, eds. Natural Resource Management in Agriculture: Methods for Assessing Economic and Environmental Impacts. Wallingford, UK: CABI Publishing.

Kost MA, Albert DA, Cohen JG, Slaughter BS, Schillo RK, Weber CR, Chapman KA. 2007. Natural Communities of Michigan: Classification and Description. Lansing, MI: Michigan Natural Features Inventory, Report No. 2007-21.

La Fayette T. 1985 Jan 27. Plan to Rename Duck Lake Stirred Controversy in 1901. Muskegon Chronicle.

Lee Y, Legge J. 2000. Special Animal Abstract for *Sistrurus catenatus catenatus* (eastern massasauga). Lansing, MI: Michigan Natural Features Inventory.

Marino WD. 2009. Climate Summary for Southwest Michigan. Grand Rapids, MI: National Weather Service.

Microsoft. 2003. Encarta Reference Library. Redmond, WA: Microsoft Inc.

Meikle B, Committee Chair. 1976. A Bicentennial History of Fruitland Township. Fruitland Township, Muskegon County: Fruitland Township Bicentennial Committee.

Michaud J. 1991. A Citizens' Guide to Understanding and Monitoring Lakes and Streams. Olympia, WA: Washington State Department of Ecology. Publication # 94-149.

Michigan Department of Agriculture & Rural Development (MDARD). 2009. Michigan County and Region Food and Agricultural Systems Profiles. [cited 2012 March 1]. http://www.michigan.gov/documents/mda/County_Food_System_Profiles_292923_7.pdf.

Michigan Department of Community Health (MDCH). 2011. 2011-2012 Michigan Fish Advisory – A Family Guide to Eating Michigan Fish. [cited 2012 September 17]. http://www.michigan.gov/documents/FishAdvisory03_67354_7.pdf

Michigan Department of Environmental Quality (MDEQ). 1998. Guidebook of Best Management Practices for Michigan Watersheds. Lansing, MI: Michigan Department of Environmental Quality Water Resources Division.

Michigan Department of Environmental Quality (MDEQ). 2006. Part 4. Water Quality Standards [cited 2013 February 12]. http://www.michigan.gov/documents/deq/wb-swas-rules-part4_254149_7.pdf.

Michigan Department of Environmental Quality (MDEQ). 2011. Duck Creek Watershed: Landscape Level Wetland Functional Assessment. Lansing, MI: Michigan Department of Environmental Quality Water Resources Division.

Michigan Department of Environmental Quality (MDEQ). 2012. Water Quality and Pollution Control in Michigan 2012 sections 303(d), 305(b), and 314 Integrated Report. Lansing, MI: Michigan Department of Environmental Quality Water Resources Division.

Michigan Department of Environmental Quality (MDEQ). 2013. Surface Water Information Management System [cited 2013 February 6]. http://www.mcgi.state.mi.us/miswims/.

Michigan Department of Natural Resources (MDNR). 1987. 1987 Bedrock Geology of Michigan [cited 2012 August 28]. http://www.dnr.state.mi.us/spatialdatalibrary/pdf_maps/geology/bedrock_geology_map.pdf.

Michigan Department of Natural Resources (MDNR). 2001. 1998 Series USGS Digital Orthophoto. [cited 2012 August 28]. http://www.dnr.state.mi.us/spatialdatalibrary/sdl2/dogs_zip/_metadata/dog_metadata98.htm.

Michigan Department of Natural Resources (MDNR). 2004. Review of Remote Sensing Technologies used in the IFMAP Project-A Final Report. In Integrating Forest Monitoring Assessment and Prescription IFMAP. Ann Arbor, MI: Space Imaging Solutions.

Michigan Department of Natural Resources (MDNR). 2011. Michigan Fishing Guide [cited 2012 March1]. http://www.michigan.gov/documents/dnr/FishingGuide_11-low-res_347106_7.pdf.

Michigan Department of Natural Resources (MDNR). 2012a. Defining Features for Duck Lake State Park. [cited 2012 March 1]. http://www.michigandnr.com/parksandtrails/featurelist.aspx?id=446&type=sprk

Michigan Department of Natural Resources (MDNR). 2012b. Duck Lake State Park. [cited 2012 March 1]. http://www.michigandnr.com/parksandtrails/Details.aspx?id=446&type=SPRK.

Michigan Natural Features Inventory (MNFI). 2007. Web Species Explorer (Web Application) [cited 2011 June 7]. http://mnfi.anr.msu.edu/explorer/search.cfm.

Muskegon Conservation District (MCD). 2012. Duck Creek Watershed Road / Stream Crossing Survey and Physical Inventory. Muskegon, MI: Muskegon Conservation District.

Natural Resources Conservation Service (NRCS), United States Department of Agriculture. 1968. Soil Survey of Muskegon County, Michigan. Washington DC: United State Department of Agriculture, Government Printing Office.

Natural Resources Conservation Service (NRCS), United States Department of Agriculture. 2009. Part 630 Hydrology, National Engineering Handbook – Chapter 7 Hydrologic Soil Groups. Washington DC: United States Department of Agriculture, Government Printing Office.

National Wildlife Federation (NWF). 2011. Weakening the Clean Water Act: What it Means for Michigan. [cited 2012 March 1]. http://healthylakes.org/wp-content/uploads/2011/04/Michigan-Restore-Clean-Water-Act-Protections_Rulemaking.pdf.

Penskar M, Choberka P, Higman, Crispin S. 2001. Special Plant Abstract for *Asclepias hirtella* (tall green milkweed). Lansing, MI: Michigan Natural Features Inventory.

Rediske R, Cooper M, Uzarski D, Denning R, Burton TM. 2003. White River Watershed Preliminary Habitat Assessment. Scientific Technical Reports. Muskegon, Michigan: Annis Water Resources Institute.

Ricciardi A. 2001. Facilitative Interactions Among Aquatic Invaders: is an ―Invasional Meltdown‖ Occurring in the Great Lakes? Canadian Journal of Fisheries and Aquatic Science Vol. 58:2513-2525.

Ritter M. 2006. The Physical Environment An Introduction to Physical Geography. [cited 2012 March 2]. http://www4.uwsp.edu/geo/faculty/ritter/geog101/textbook/title_page.html

Robison G, Mirat A, Allen M. 1999. Oregon Road/Stream Crossing Restoration Guide. Advanced Fish Passage Training Version. Salem, OR: Oregon Department of Fish and Wildlife.

Stormwater Manager's Resource Center (SMRC). 2008. Stormwater Management Fact Sheet: Grassed Filter Strip.

Steinman AD, Sterrett Isely E, Thompson K, VanderMolen J, Koches K. 2009. Rein in the Runoff - Alternative Stormwater Management Practices that Address the Environmental, Social, and Economic Aspects of Water Resources in the Spring Lake Watershed (MI). Muskegon MI: Annis Water Resources Institute.

Syed AU, Jodoin RS. 2006. Estimation of Nonpoint-Source Loads to Total Nitrogen, Total Phosphorus, and Total Suspended Solids in the Black, Belle, and Pine River Basins, Michigan, by Use of the PLOAD Model. Reston, VA: U.S. Geological Survey, Scientific Investigations Report 2006-5071.

Taylor S, Rummer R, Yoo K, Welch R, Thompson J. 1999. What We Know and Don't Know about Water Quality at Stream Crossings. Journal of Forestry 97:12-17.

The Secchi Dip-In. A Trophic State Index. [cited 2013 January 9]. http://www.secchidipin.org/tsi.htm .

Tisue T. 2012. Rooted Aquatic Plants in Duck Lake—Summer 2011. Whitehall, MI: Duck Creek Watershed Assembly and Duck Lake Association.

United States Census Bureau. 2012a. American FactFinder - 2010 Census Counts. [cited 2012 March 1]. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml#none.

United States Census Bureau. 2012b. State & County QuickFacts. Muskegon County, MI. [cited 2012 March 1]. http://quickfacts.census.gov/qfd/states/26/26121.html.

United States Department of Agriculture (USDA). 2012. Farm Service Agency. [cited 2012 August 15]. http://www.fsa.usda.gov/FSA/apfoapp?area=home&subject=prog&topic=nai.

United States Environmental Protection Agency (USEPA). 1986. Quality Criteria for Water 1986. Washington DC: United States Environmental Protection Agency, Government Printing Office.

United States Environmental Protection Agency (USEPA). 1997. Volunteer Stream Monitoring: A Methods Manual. Washington DC: United States Environmental Protection Agency, Government Printing Office. EPA 841-B-97-003.

United States Environmental Protection Agency (USEPA). 2000. Fertilizer Management. State & Local Climate Change Program. Washington DC: United States Environmental Protection Agency, Government Printing Office.

U.S. Environmental Protection Agency 2001. PLOAD version 3.0: An ArcView GIS tool to calculate nonpoint sources of pollution in watershed and stormwater projects. User's Manual. [cited 2012 August 29]. http://water.epa.gov/scitech/datait/models/basins/upload/2002_05_10_BASINS_b3docs_PLOAD_v3.pdf.

United States Environmental Protection Agency (USEPA). 2003a. America's Wetlands: Our Vital Link Between Land and Water. Office of Water & Office of Wetlands, Oceans, and Watersheds [cited 2012 March 1]. http://water.epa.gov/type/wetlands/upload/2003_07_01_wetlands_vital_wetlands.pdf.

United States Environmental Protection Agency (USEPA). 2003b. National Management Measures for the Control of Nonpoint Pollution from Agriculture. Washington DC: United States Environmental Protection Agency, Government Printing Office. EPA 841-B-03-004.

United States Environmental Protection Agency (USEPA). 2005a. National Management Measures for the Control Nonpoint Source Pollution from Urban Areas. Washington DC: United States Environmental Protection Agency, Government Printing Office. EPA 841-B-05-004.

United States Environmental Protection Agency (USEPA). 2005b. National Management Measures to Protect and Restore Wetlands and Riparian Areas for the Abatement of Nonpoint Source Pollution. Washington DC: United States Environmental Protection Agency, Government Printing Office. EPA 841-B-05-003.

United States Environmental Protection Agency (USEPA). 2007. National Management Measures to Control Nonpoint Source Pollution from Hydromodification. Washington DC: United States Environmental Protection Agency, Government Printing Office. EPA 841-B-07-002.

United States Environmental Protection Agency (USEPA). 2012a. Economic Benefits of Wetlands. [cited 2012 March 1]. http://www.epa.gov/owow/wetlands/facts/fact4.html.

United States Environmental Protection Agency (USEPA). 2012b. National Pollutant Discharge Elimination System—Stormwater Wetland. [cited 2012 September 30]. http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=74 .

Van Vorst K. 1982 July 18. Lakewood Club's Grand Land Scam. Muskegon Chronicle.

Walker JD, Geissman JW, compilers. 2009. Geologic Time Scale. Boulder, CO: The Geological Society of America.

Western Michigan University, Department of Geology. 1981. Hydrogeologic Atlas of Michigan. Kalamazoo, MI: Western Michigan University.

White Lake Public Advisory Council. 2002. White Lake Community Action Plan, Remedial Action Plan Update 2002. Muskegon, MI: White Lake Public Advisory Council.

Williams J, Clarke P, Balch P. 2004. Streambank Stabilization: An Economic Analysis from the Landowners' Perspective. Journal of Soil and Water Conservation. Vol. 59 no. 6 pgs. 252-259.