Red Cedar River

Watershed Management Plan

Submitted by:

Michigan State University
Institute of Water Research

Originally Submitted November 6, 2014
Amended March 24, 2015
Amended June 25, 2015

MDEQ tracking code: #2011-0014

ACKNOWLEDGEMENTS

This document was developed with funding provided by a Clean Water Act, Section 319 grant from the Michigan Department of Environmental Quality (MDEQ), grant number 2011-0014. Financial and in-kind assistance was provided by Michigan State University (MSU).

The Red Cedar River Watershed Management Plan was written by:

Erin Campbell, Tri-County Regional Planning Commission
Ruth Kline-Robach, MSU Institute of Water Research (IWR)
Kalie Nye, MSU Department of Community Sustainability
Aaron Snell, Streamside Ecological Services

The authors wish to acknowledge the following individuals who assisted in the development of the plan:

Jason Piwarski, MSU-IWR and Joe Welsh, MSU-RSGIS, who created the GIS maps
Lois Wolfson, MSU-IWR who assisted with data analysis and summarization
Laura Young, MSU-IWR, who provided valuable design and editorial assistance

In addition, the authors extend appreciation to the following communities, organizations, and agencies that contributed expertise, time and resources in support of the watershed management planning process:

City of East Lansing, City of Lansing, City of Williamston, Clinton Conservation District, Clinton County Drain Commissioner, Delhi Charter Township, Eaton Conservation District, Ingham Conservation District, Ingham County Drain Commissioner, Ingham County Health Department, Lansing Charter Township, Livingston County Drain Commissioner, Livingston County Health Department, Meridian Charter Township, Michigan Department of Environmental Quality, and Williamstown Township.

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

List of Acronyms

ACEP	Agricultural Conservation Easement Program
AUID	Assessment Unit Identitication
BMP	Best management practice
CAFO	Concentrated animal feeding operation
C-CAP	Coastal Change Analysis Program
CD	Conservaiton district
CFU	Colony forming unit
COD	Chemical oxygen demand
DC	Drain commissioner
DO	Dissolved oxygen
E. coli	*Escherichia coli*
ECD	Eaton Conservation District
EQIP	Environmental Quality Incentives Program
FIRM	Flood Insurance Rate Maps
FORC	Friends of the Red Cedar
GIS	Geographic information system
GLRC	Greater Lansing Regional Committee for Stormwater Management
GMM	Green Mid-Michigan
HIT	High Impact Targeting model
HUC	Hydrologic Unit Code
HUD	United States Department of Housing and Urban Development
I/E	Information and education
ICD	Ingham Conservation District
ICHD	Ingham County Health Department
IWR	Institute of Water Research
LCD	Livingston Conservation District
LCDH	Livingston County Health Department
LLFWA	Landscape level functional wetland asssessment
MAEAP	Michigna Agricultural Environmental Assurance Program
MDARD	Michigan Department of Agriculture and Rural Development
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MGROW	Middle Grand River of Watersheds
MGRWP	Middle Grand River Watershed Planning Project
Mid-MEAC	Mid-Michigan Environmental Action Council
MMPGS	Mid-Michigan Program for Greater Sustainability
MNFI	Michigan Natureal Features Inventory
MS4	Municipal separate storm sewer systems
MSU	Michigan State University
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NREPA	Natural Resources Enviornmental Protection Act
NSA	Neighborhood source assessment
PBC	Partial Body Contact
PCA	Potential Conservation Area
PEP	Public Education Plan
QAPP	Quality Assurance Project Plan
RCPP	Regional Conservation Partnership Program
RCRW	Red Cedar River Watershed
SCD	Shiawasee Conservation District
SIDMA	Social Indicators Data Management and Analysis
SMNITP	Southern Michigan Northern Indiana Till Plains
TBC	Total Body Contact

TCRPC	Tri-County Regional Planning Commission
TDS	Total dissolved solids
TMDL	Total maximum daily load
TOC	Total organic carbon
TSS	Total suspended solids
U.S. EPA	United States Environmental Protection Agency
USDA FSA	United States Department of Agriculture Farm Service Agency
USGS	United States Geological Survey
WMP	Watershed management plan
WQS	Water quality standards
WWTP	Wastewater treatment plant

1. INTRODUCTION

The Red Cedar River originates near Cedar Lake, which is located in the southwestern corner of Livingston County, in the south-central portion of the Lower Peninsula. The river flows in a westerly direction for about 51 miles from the area surrounding Cedar Lake, into Ingham County, through Meridian Township, the City of East Lansing and the campus of Michigan State University, and into Lansing, where it joins the Grand River (MDTMB, 2012).

The Red Cedar River Watershed (RCRW) (Hydrologic Unit Code 04050004) (see Figure 1.1), is approximately 294,496 acres (461 sq. miles) and land use in the watershed area is varied. The Red Cedar River has West and Middle Branches, which also originate in southern Livingston County.

Figure 1.1 Red Cedar River Watershed

The RCRW contains a diverse mix of rural lands dominated by agricultural land use and small communities, suburban areas and highly urbanized lands. The watershed is home to thousands of residents who live, learn, work and recreate within its lands and waters. Farms, factories and shopping malls are necessary for our quality of life. Equally important are clean water for fishing, swimming and drinking, and natural landscapes for aesthetic relief. The river and its watershed are also home to a myriad of plants and animals that rely on a clean, protected environment to flourish.

This watershed management plan (WMP) was developed for the protection of lands and waters of the RCRW. It was developed to serve as a guide for protecting and improving the waters that bisect the landscape, flowing adjacent to our homes, under our roads and through our farms.

This WMP is authored by the RCRW management team, comprised of representatives from the Michigan State University (MSU) Institute of Water Research (IWR); Streamside Ecological Services, Inc.; and the Tri-County Regional Planning Commission (TCPRC). The management team coordinated and guided all efforts related to the planning process and overall WMP development, including stakeholder engagement. Several community partners provided in-kind support to the project. A complete list of stakeholders is available in Appendix A.

1.1 Goal of Watershed Planning

The goal of the Red Cedar River Watershed Management Project is to protect, enhance, restore and maintain water quality in order to meet all designated uses and to inspire residents to responsibly manage the land and water in the watershed. Designated uses are recognized uses of water established by state and federal water quality programs.

WMPs are a resource to be used to prevent and improve water quality problems by understanding and addressing nonpoint and point source pollution contributing to a watershed. These plans document impaired areas for improvement or restoration and high-quality areas for long-term protection. A WMP should outline an action-oriented approach for improving and protecting water quality.

This WMP is intended, among other things, to provide a shared strategy for moving community jurisdictions and organizations forward with respect to the watershed’s water quality as affected by nonpoint source pollutants. This plan is intended to supplement, but not replace, the body of work that other organizations in the region have already completed regarding the land, water and policies affecting them.

1.2 Key Elements of Developing a WMP

Watershed planning and implementation is a process that includes building partnerships, characterizing the watershed, setting goals and identifying solutions, designing an implementation program, implementing the watershed plan, and measuring progress and making adjustments (US EPA, 2008a).

The EPA recommends developing a WMP by following their defined planning and implementation process, which includes the following nine elements:

1. **Identification of the causes and sources** or groups of similar sources that will need to be controlled to achieve the load reductions estimated in the watershed-based plan.

2. **Estimate the load reductions** expected for the management measures described in element (3.) below.

3. Describe the **NPS management measures** that will need to be implemented to achieve the load reductions estimated in element (2.) above, and identify the critical areas in which those measures will be needed to implement the plan.

4. Estimate the amounts of **technical and financial assistance needed**, associated costs, and/or the sources and authorities that will be relied upon, to implement the plan.

5. Develop an **information/education component** that will be used to enhance public understanding of the project and encourage early and continued participation in selecting, designing, and implementing the NPS management measures.

6. Develop a **schedule for implementing the NPS management measures** identified in the plan that is reasonably expeditious.

7. Develop a description **of interim, measurable milestones** for determining whether NPS management measures or other control actions are being implemented.

8. Develop a **set of evaluation criteria** that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards (WQS) and, if not, the criteria for determining whether the watershed-based plan needs to be revised.

9. Develop a **monitoring component** to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under element (8.) above.

1.3 Impaired and Threatened Designated Uses

Surface water that is determined by the Michigan Department of Environmental Quality (MDEQ) to be exceeding WQS and therefore not attaining subsequent designated uses is defined as an impaired water body by the State of Michigan and in this report. Part 4 Rules issued in accordance with Part 31 of the Natural Resources and Environmental Protection Act (1994 PA 451, as amended) specify eight designated uses for waters of the state. The designated uses of Partial Body Contact (PBC) and Total Body Contact (TBC) recreation are impaired due to high *Escherichia coli* (*E. coli)* levels throughout much of the watershed. The warmwater fishery designated use is impaired due to low dissolved oxygen (DO) levels and sedimentation in certain portions of the watershed. Based on water quality and land use data in the watershed, sediment and nutrients are additional potential pollutants of concern in the watershed. Potential sources include: agricultural practices, animal waste from cattle/pasture land, fertilizers, pesticides, stream channelization and failing septic systems.

For the purpose of this watershed management planning process, a surface water body that trends towards exceeding WQS as determined through investigations by those other than the MDEQ, is considered threatened.

2. DESCRIPTION OF THE RED CEDAR RIVER WATERSHED

2.1 Land Use

Land use based on the National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP) in the Red Cedar River is approximately 35% agricultural lands including cultivated crops, pasture and hay; 23% shrubland which includes grazing land; 18% developed land; 14% open water and wetlands and; 10% forest (NOAA, 2008) (Table 2.1).

Table 2.1. Land Use in the Red Cedar River Watershed (NOAA, 2008)

Land Use Category	Percent of Watershed
Open Water	1%
Developed Open Space	4%
Developed Low Intensity	7%
Developed Medium Intensity	3%
Developed High Intensity	1%
Barren Land	0%
Forest	10%
Grassland and Shrubland	23%
Agriculture	35%
Wetlands	16%

Historically, the RCRW was predominately forests and wetlands. The upland ecosystem contained mostly Beech/Sugar Maple Forests or Oak/Hickory Forests. Lowlands contained an abundance of conifer swamps, which still can be seen in Lake Lansing Park North (Tetra Tech, 2006).

Permanent human settlement changed the landscape of this watershed. Wetlands were drained to provide land for farming, settlement, and transportation (Tetra Tech, 2006). To this day, the trend continues as agricultural commodity prices are high and wetlands are drained to provide more farmland, urban and suburban development expands, and the demand for increased tile and open ditch drainage continues.

In the western portions of the watershed, compared to pre-settlement conditions, the current landscape contains 90% less forest cover and 60% less wetlands (Figure 2.1). Based on projected land use for various watershed communities on the western part of the watershed, residential, industrial, and commercial land uses will continue to expand. The south-central portion of the watershed is projected to continue to be dominated by agricultural use (Tetra Tech, 2006).

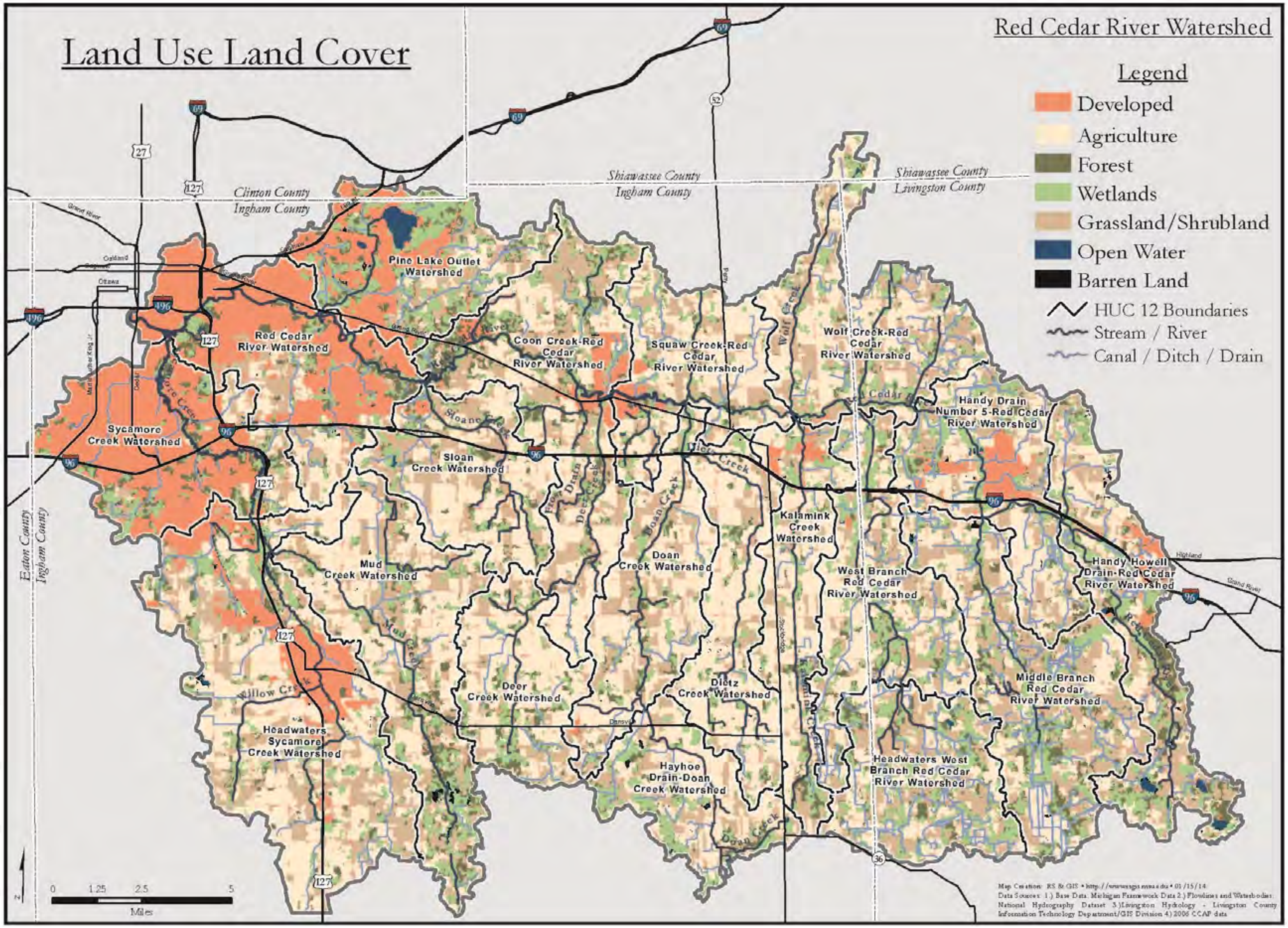


Figure 2.1 Land Use Land Cover

2.2 Geographic Scope

This watershed management plan (WMP) was developed for the RCRW in lower central Michigan. The watershed is identified as Hydrologic Unit Code (HUC) 04050004 by the United States Geological Survey (USGS). The entire watershed, which encompasses approximately 294,496 acres (461 sq. miles), is located in portions of five counties, with the vast majority of its area in Ingham and Livingston Counties. The watershed contains approximately 675 miles of tributaries and 19 subwatersheds (12-digit HUC) (Figure 2.2), ranging from about 16 to 49 square miles in size (MDTMB, 2012). Although field inventory and water quality analyses were conducted in most of the subwatersheds, due to the large size of the watershed, a prioritization strategy was developed to identify the most critical subwatersheds in order to focus initial implementation efforts to protect and improve water quality. This is further discussed in Chapter Seven.

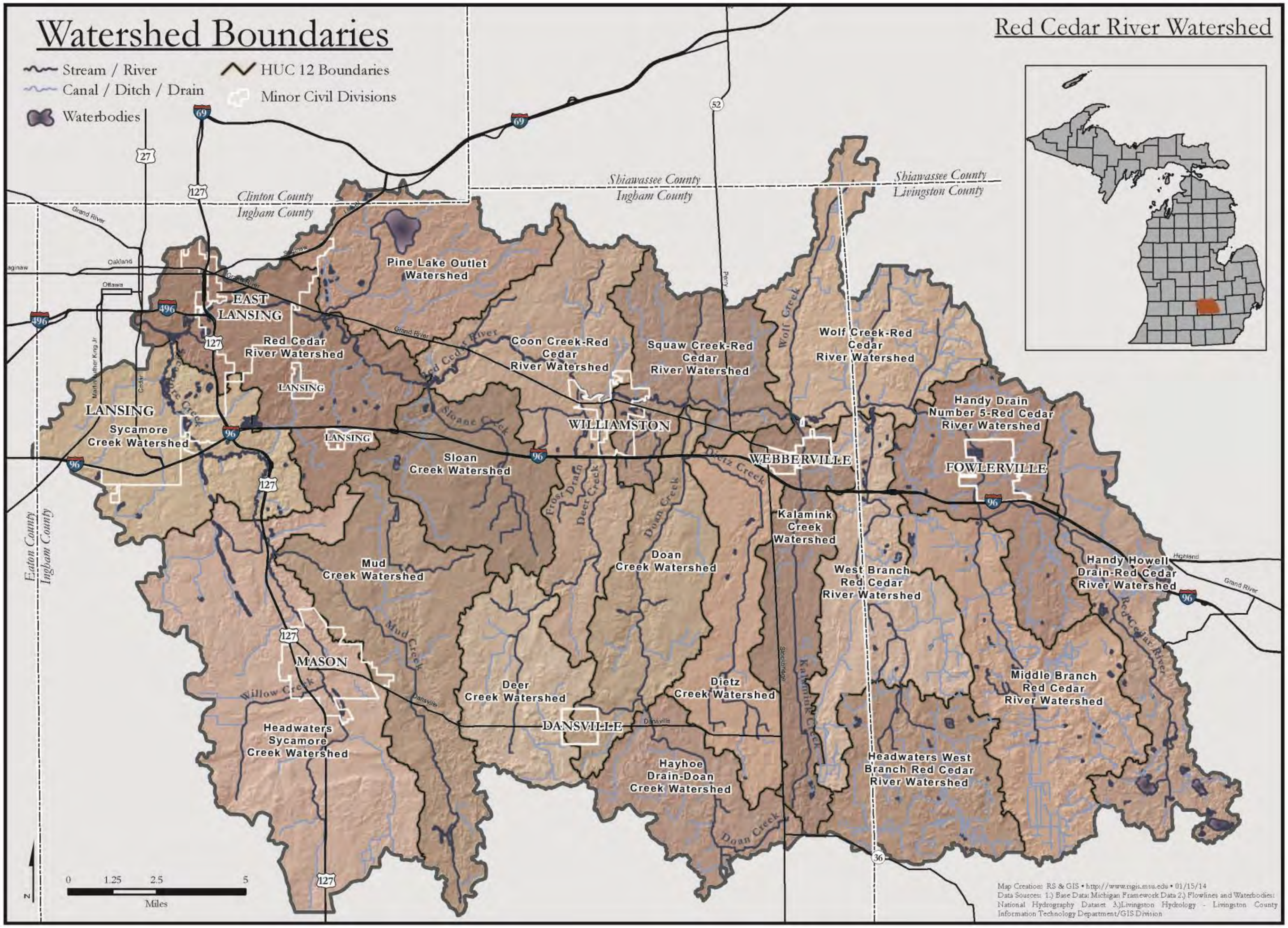


Figure 2.2. Subwatershed Boundaries

2.3 Topography

The topography of the watershed ranges from approximately 800 to 1,000 ft. above sea level (MDTMB, 2012) with rolling plains having slopes ranging from 0 to 30 percent. Hills, with slopes less than six percent, are no higher than 100 feet, and low gradient stream channels are present (MDEQ, 2013a). The topography of the watershed is displayed in Figure 2.3. For the purpose of regional comparison, the average surface elevation of Lake Michigan is 577 ft., Grand Rapids is 640 ft., and Detroit is 646 ft.; the highest elevation in lower Michigan is 1,705 ft. in the vicinity of Cadillac.

From its headwaters at Cedar Lake (elevation 932 ft.) to its confluence with the Grand River (elevation 833 ft), the Red Cedar River drops about 99 feet over 51 miles (MDTMB, 2012). This equates to an average slope of about 0.04%.

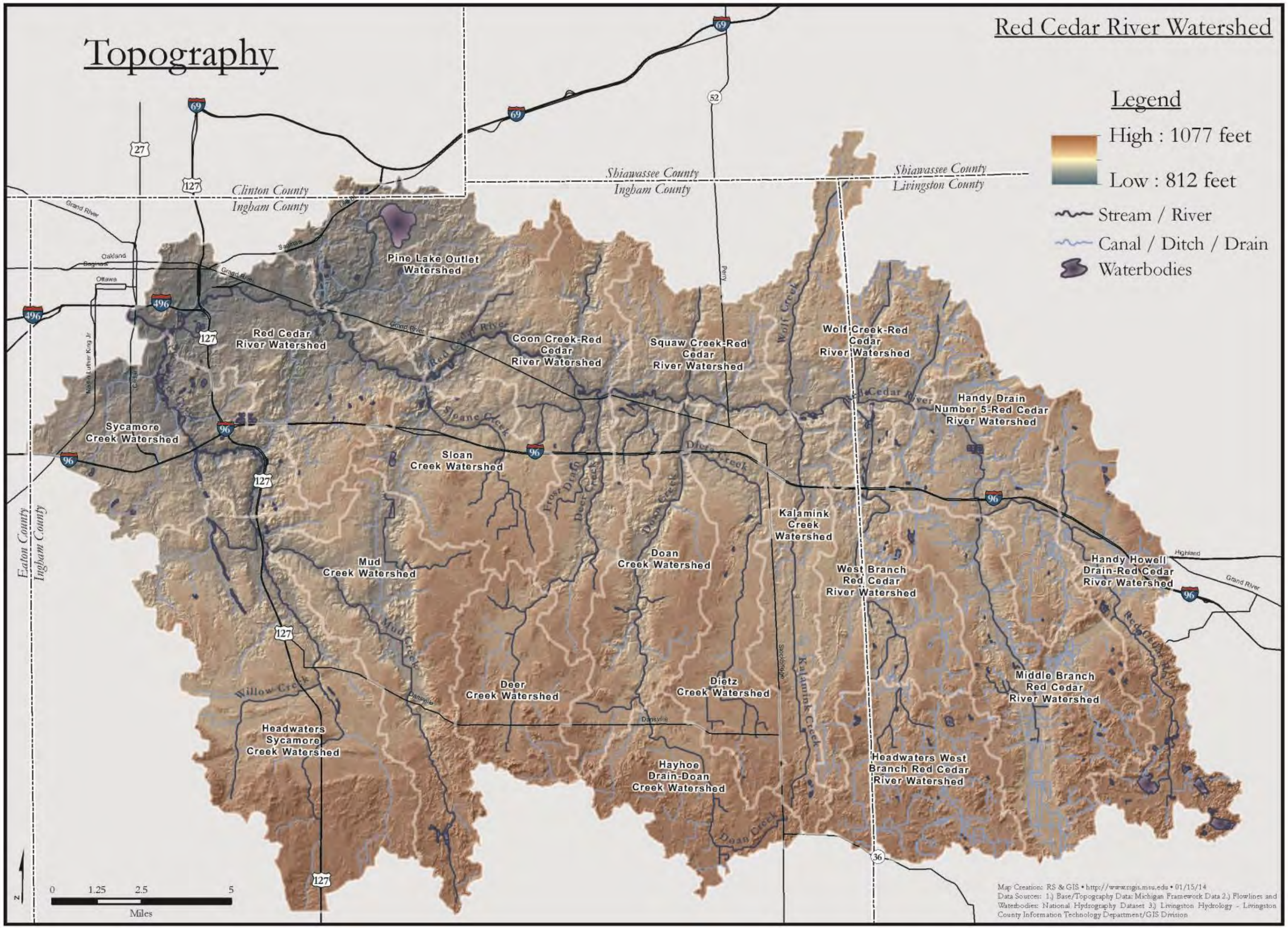


Figure 2.3 Topography

2.4 Geology
Geology in the RCRW is shown in Figure 2.4. The geology was formed by the last of the four continental glaciers, the Wisconsin, which existed approximately 35,000 to 10,000 years ago (Luukkonen, 2009). This glaciation is responsible for most of Michigan's underlying geology, soils, topography, and the Great Lakes. In the RCRW the predominant underlying geology consists of: glacial till, glacial outwash, lacustrine material (deposits from still or ponded glacial meltwater), and alluvial material (recently deposited material from local rivers and streams).

According to Luukkonen (2009), Ingham County sits upon a series of aquifers including shallow glacial aquifers and the Grand River and Saginaw Formations. Closest to the surface are shallow glacial aquifers, comprised of coarse alluvial and outwash materials. Groundwater typically flows from south to north in these uppermost glacial units. Below the glacial deposits are the Grand River and Saginaw Formations. Within the Saginaw Formation are three sandstone aquifers divided by a lower shale unit and interbedded series unit, though these divisions may not be distinct in all areas. A small amount of groundwater flows toward areas of high pumping, but otherwise generally flows from south to north. Recharge within the Saginaw Formation occurs where the uppermost glacial units directly connect to the Saginaw. A small amount of recharge also occurs through confining units. The Saginaw Formation provides the majority of groundwater to communities in the area, though in certain locations the glacial aquifer is the primary groundwater source (Luukkonen, 2009).

According to groundwater statistics compiled by the MDEQ (2013c), Michigan's groundwater is used for drinking water by nearly half of the state's population. In addition, it is used for irrigation and industrial purposes and contributes to the economy and unique quality of life in Michigan.

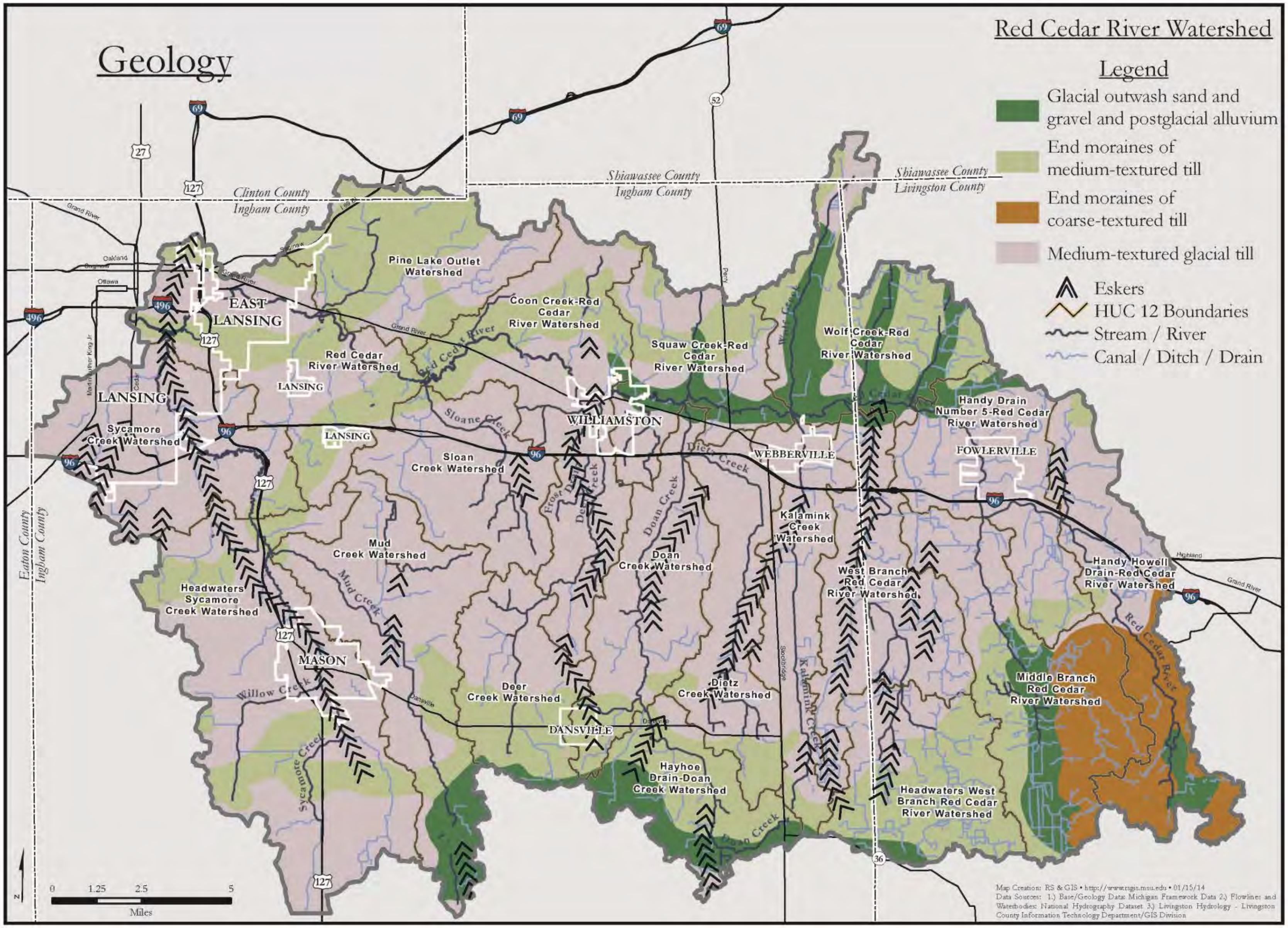


Figure 2.4 Geology

2.5 Soils

Soil types affect the rate and ability of water to infiltrate the soil. Soil properties ultimately affect how pollutants that are land applied or absorbed, such as manure and septage, are transmitted over or through the soil. Soils are classified into hydrologic soil groups (A, B, C and D) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting (USDA NRCS, 2007). The infiltration rate is the rate at which water enters the soil at the soil surface, and is controlled by surface conditions. The hydrologic soil group also indicates the transmission rate, or the rate at which water moves within the soil. This rate is controlled by the soil profile. The following table summarizes the differences in the four hydrologic soil groups.

Table 2.2: Hydrologic Soil Groups

Hydrologic Soil Group	Definition
A	High infiltration (low runoff potential, high rate of water transmission, well drained to excessively drained sands or gravely sands)
B	Medium infiltration (moderate rate of water transmission, moderately well to well drained, moderately fine to medium coarse texture)
C	Low infiltration (slow rate of water transmission, has layer that impedes downward movement of water, moderately fine to fine texture)
D	Very low infiltration (high runoff potential, very slow rate of water transmission, clays with high shrink/swell potential, permanent high water table, clay pan or clay layer at or near surface, shallow over nearly impervious material)

Different soil types also have different erosive properties, with certain soils having greater potential for overland erosion, and other soils have greater potential for transmission. Understanding how soils respond to precipitation is critical in watershed management, especially considering negative impacts connected with erosion and associated sediment. In addition, the functionality of a septic system is dependent on the ability of the soil to allow water to percolate through the soil. It is important to know how development on different soil types will affect runoff and, ultimately, how it will affect water quality of the receiving waters.

Table 2.3 highlights the percentage of hydrologic soil groups throughout the RCRW, and Figure 2.5 shows their spatial distribution. Many of soils in this watershed (29%) have a dual classification. In dual classifications, the first letter refers to the drained condition, and the second letter refers to the undrained condition. The dual classification signifies the presence of a high water table that keeps the soils saturated, and therefore the soils with a dual classification have a very low infiltration rate in their natural saturated state. Second and third to the dual classification, the other predominant soils in the watershed are in groups B (33%) and C (25%), with medium and low infiltration ratings respectively. Soils in group B have a moderately low runoff potential when thoroughly wet, and soils in group C have a moderately high runoff potential when thoroughly wet. Soils with very low or low infiltration rates (soil types C, D, and soils with dual classifications) make up 58% of this watershed in its natural state, and may be more susceptible to overland erosion and may not allow traditional septic systems to function properly when installed. When drained, 29% of the watershed has soils with low or very low infiltration rates. Soils with low infiltration rates and higher erosive properties are more susceptible to contributing sediment, along with any land applied nutrients (e.g., manure and fertilizers) that may be transported to surface water bodies by way of overland erosion. Eroded sediment and the excess nutrients and bacteria it transports can have a negative effect on water quality.

Table 2.3. Red Cedar River Watershed Soils (USDA NRCS, 2013)

Soil Type	Area (Square Miles)	Percent of Watershed
No Data	21.8	5%
A	18.0	4%
A/D	26.5	6%
B	154.2	33%
B/D	73.4	16%
C	116.0	25%
C/D	30.0	7%
D	20.7	4%
Total:	460.6	100%

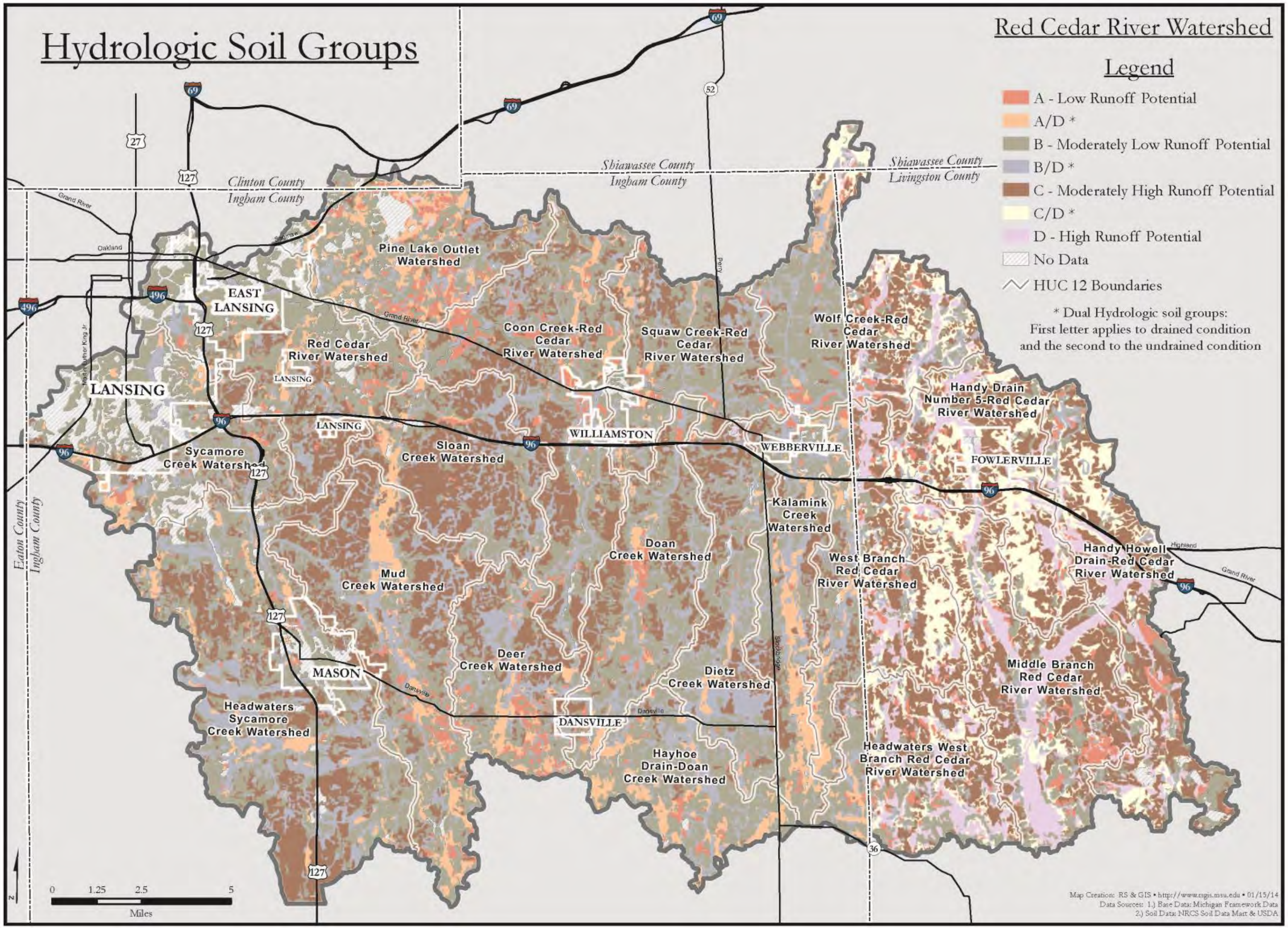


Figure 2.5 Hydrologic Soil Groups

2.6 Climate
The climate of mid-Michigan can be described as having a warm summer and a cool-to-cold winter. According to the NOAA National Climatic Data Center (as cited in Tetra Tech, 2006), the average temperature for the coldest month, January, is 22.7 °F, while August, the warmest month, has an average temperature of 71.2 °F. Like temperature, precipitation is seasonally variable with February, the driest month, receiving an average of 1.57 inches of precipitation and June, the wettest month, receiving an average of 3.73 inches. The average annual precipitation is 32.82 inches. The dominant precipitation in the months of December through February is snowfall, with the largest average snowfall occurring in January (13.4 inches).

2.7 Upstream Watershed
Streams often originate from small, undefined locations such as groundwater seeps or wetland pockets that provide the water that flows and maintains our river systems. In a natural state, these headwater areas can provide groundwater filtering and recharge, recycling of waste products, flood control, spawning and mating grounds for fish and wildlife, and water for human use. However, many of the headwater streams in the RCRW are altered for efficient drainage and/or maintained as designated county drains. As such, they may no longer provide some of their natural functions, but instead provide other important functions necessary for use of the land by humans.

In its natural state, water exists in wetlands or other low areas for periods of time, while water on developed or farmed lands is immediately directed into drainage systems to be moved downstream. Roadside ditches, agricultural field tile lines, and curb and gutter systems, as examples, are all part of an efficient drainage system that has been designed to bypass the natural processes which might cause standing water and flooding.

While often viewed in a negative light, the process of streams and rivers overtopping their banks and flooding adjacent lands is natural and important in a number of ways. Flooding transfers nutrients and soil from the stream to adjacent wetlands and floodplains, renews groundwater supplies, provides critical access to certain fish species for spawning and nursery habitat, and dissipates flow energy that otherwise erodes streambanks and streambeds. A component of the watershed planning process is identifying areas where flooding is acceptable; these areas can be protected or restored to ensure that natural headwaters functions are maintained to the greatest extent.

2.8 Hydrology
Hydrology is a science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere. Hydrology is heavily dependent on topography, geography, soils and climate, as discussed previously in this document. Understanding how this science relates to, and is affected by changes in land use and natural landscapes is the basis for developing successful WMPs.

A number of lakes, streams and wetlands are found throughout the RCRW. There are approximately 40,000 acres of wetlands and 1,850 acres of lakes and ponds (MDTMB, 2012); most of these lakes are smaller than 20 acres in size. The lakes greater than 20 acres in size include Lake Lansing (455 acres) and Dobie Lake (31 acres) in Ingham County and Cedar (118 acres), Pleasant (87 acres), Triangle (53 acres) and Lamoreaux (30 acres) Lakes in Livingston County.

An especially important consideration in the hydrology of the RCRW is the ongoing demand for more efficient drainage from agricultural lands, commercial development and neighborhoods. County Drain Commissioners are burdened with managing this demand for drainage and consistently busy with improving designated county drains to handle larger volumes of water and moving it downstream quicker. Essentially, this transfers problems such as flooding, streambank erosion and decreased water quality to downstream neighbors.

The watershed currently contains active USGS monitoring stations, which are located in the Cities of Williamston and East Lansing and near the City of Mason. These stations measure stream flow on an ongoing basis. The term flashiness reflects the frequency and rapidity of short-term changes in stream flow. A stream described as flashy responds to rainfall by rising and falling quickly. Conversely, a stream that is not flashy would rise and fall less for an equivalent rainfall and would typically derive more of its overall flow from groundwater. Using the Richards-Baker Flashiness Index (R-B Index) to quantify the frequency and rapidity of short-term changes in stream flow, MDEQ (2012a) found the Red Cedar River, at both Williamston and East Lansing, to be one of the more flashy rivers in the lower peninsula of Michigan.

Floodplains

Rivers, streams, lakes, and drains occasionally overflow their banks and into adjacent land areas, called floodplains. In regulatory terms, the word floodplain is often used to describe the land that will be inundated by water resulting from a 100-year flood. Approximately 6% of Michigan's land is flood-prone (MDEQ, 2014). However, smaller areas of the 100-year floodplain can be inundated by water during smaller floods (for example, two or five-year floods). These areas are important for habitat and nutrient connectivity between land and water and are critical for maintaining stream stability.

Riverine flooding often occurs in spring with snow melt and excess rain and in summer with storms. Rivers, streams, and drains will overflow their banks and their floodplains will become partially or fully saturated. Urban flooding is caused when storm sewer systems become overwhelmed by significant amounts of runoff. Flash floods, typically caused by fast-moving runoff, may occur during short but intense heavy rains in localized areas, but will dissipate in a relatively short amount of time. On the other hand, constant, less intense rain can cause “general flooding,” in which large areas are flooded for a relatively longer period of time than a flash flood. This type of flooding can also occur from large snowmelts. During these flooding events, the soil becomes completely saturated and water ponds in depressions or other low-lying areas.

Floodplains often consist of silty soils that are deposited by recurring floods. They are categorized by the frequency of flood events. Risks to structures and people located within the floodplain are calculated. If they are located within a 10 or 100-year floodplain, the risks can impact insurance policies. The Tri-County region has Flood Insurance Rate Maps (FIRM) in place that provide a planning tool for communities and land owners to help assess flood risk. Floodplains in the RCRW are depicted in Figure 2.6.

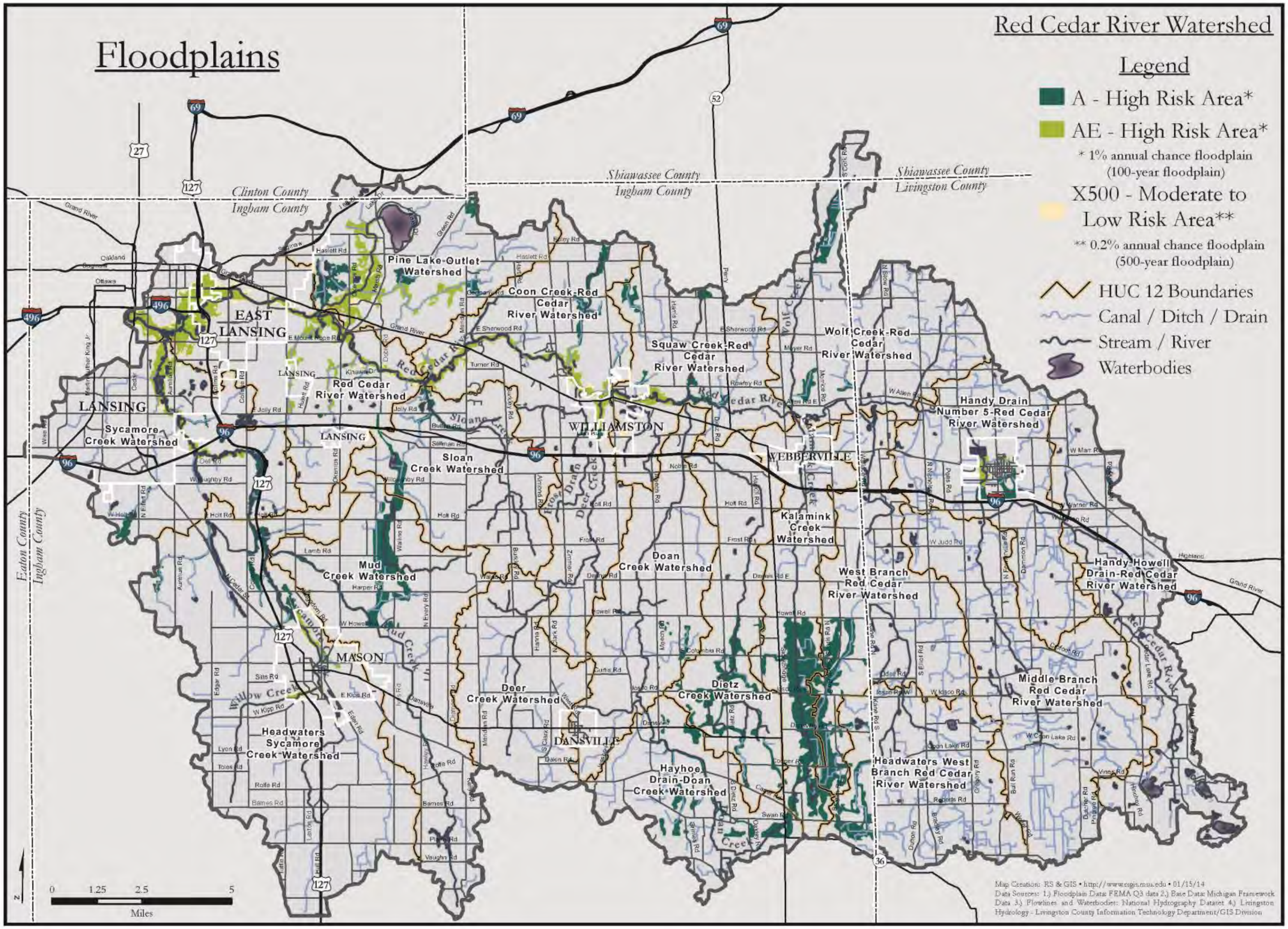


Figure 2.6 Floodplains

Wetlands

Cowadin et. al (1979), as cited by the U.S. EPA (2013b), provided the following general definition of wetlands: “Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface.” To many, wetlands have long been considered “worthless” lands that are an impediment to development and farming or are a breeding ground for mosquitoes and other intolerable pests. While this reasoning still prevails at times, the importance of wetlands in the hydrologic process and as features in a complete ecosystem cannot be understated. Wetlands are especially important for flood control, groundwater recharge and erosion control, and play a critical role in attenuating pollutant loads. They provide critical habitat for wildlife and fish; some species rely entirely on wetlands for reproduction or other phases of their life cycle. Wetlands provide habitat to many threatened and endangered species that are not found elsewhere; about 50 percent of Michigan’s threatened, endangered, rare or special concern plant species depend on wetlands (Cwiekal, 2003). While there are approximately 40,000 acres of wetland existing in the RCRW, about 56% have been lost to farming and development, which is highlighted in Table 3.6 and discussed in Chapter Four. Figure 2.7 shows existing wetland areas in the watershed.

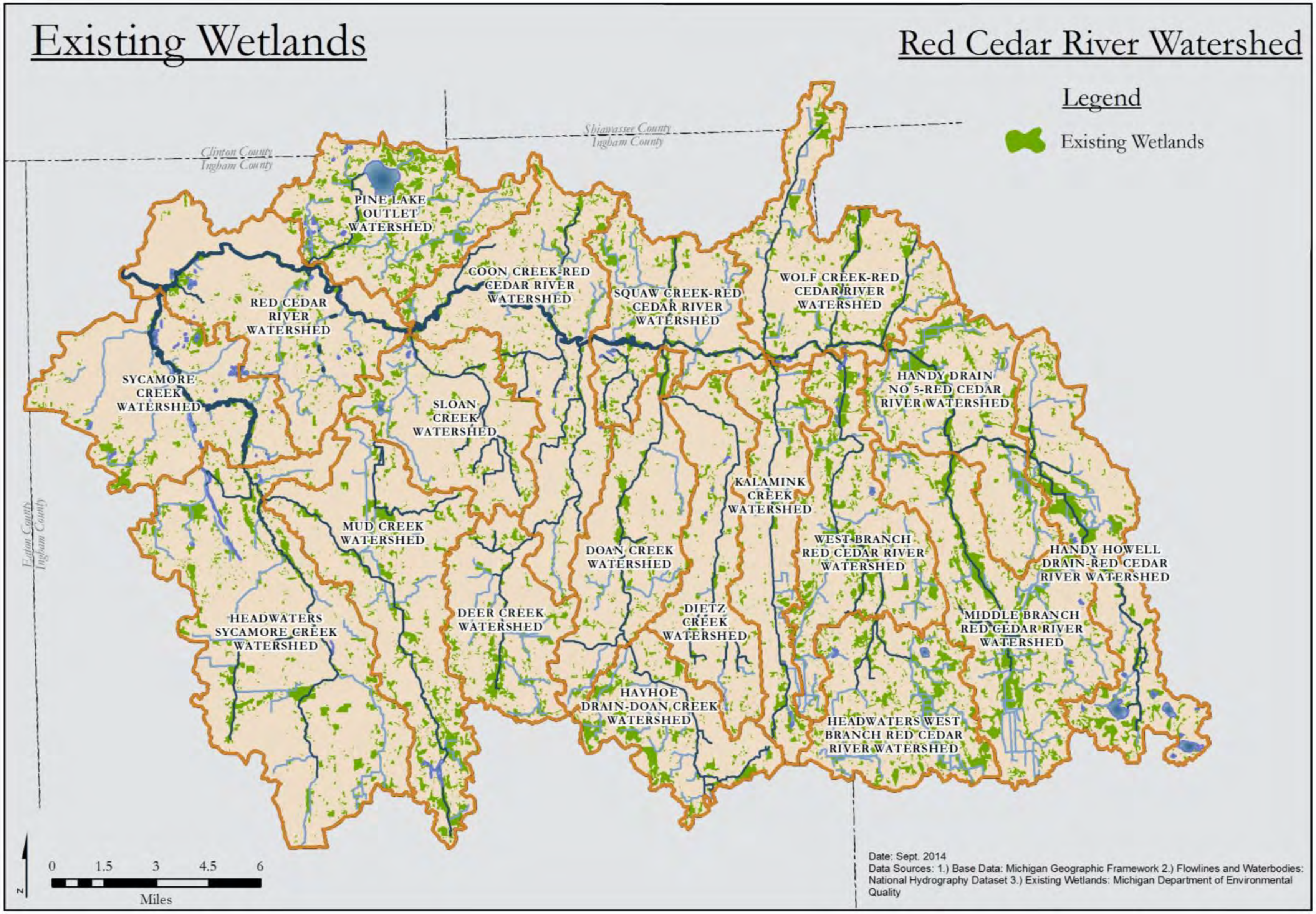


Figure 2.7 Existing Wetlands

Dams

Only one dam is known to exist in the RCRW. This is located on the campus of Michigan State University (MSU). At this location, the Red Cedar River is free-flowing over the crest of the dam; there is no impoundment to alter the water temperature or collect sediment. The dam does, however, serve as a complete barrier to upstream migrating fish. Smaller, unregistered private dams are fairly common in most watersheds; however, none have yet been documented in the RCRW.

2.9 Aquatic Life

The Red Cedar River begins as a first-order, warmwater stream in Livingston County and, as it gains water from several tributaries, eventually becomes a fourth-order warmwater stream as it nears its confluence with the Grand River (MDEQ, 2003). There are eleven main tributaries to the Red Cedar, all of which are considered to be warmwater ecosystems. The entire watershed is in the Southern Michigan Northern Indiana Till Plains (SMNITP) Ecoregion.

Fish communities in the Red Cedar River have not historically been managed through supplemental stocking, although in 2012 a steelhead stocking program was implemented along a short stretch of the Red Cedar River on the MSU campus, on a trial basis. The river boasts a diverse resident warmwater fish community including northern pike, largemouth bass, and smallmouth bass. The river also provides modest fisheries for salmon and steelhead that seasonally migrate upstream from Lake Michigan.

In 2001, the Michigan Natural Features Inventory (MNFI) found high densities of unionid mussels in the Red Cedar River on MSU's campus. A possible reason for this was the site's location downstream of the dam (Hyde et al., 2009).

According to MDEQ (2013a), factors impacting water quality and aquatic life in the RCRW include nonpoint sources of pollution such as nutrients, pathogens and sediment. The MDNR (2011) stated that restoring wetlands and natural hydrology (e.g., through rehabilitating channelized streams) should be the focus of aquatic habitat improvement efforts.

2.10 Protected Species

An understanding of the presence or absence of threatened, endangered and special concern plant and animal species can be used to help guide land conservation and management decisions in the watershed.

Five endangered, 14 threatened and 23 special concern species have been found in the RCRW. Of the rare plants existing in the area, the species are most typically associated with upland mesic forests (mesic southern forest) and riparian zones (floodplain forest) habitats (Hyde et al., 2009). Historically, some species of concern were found in oak barrens, savannas, and prairie grasslands, which are all habitats that are now rare in Ingham County. The species normally found in these habitats may, however, exist on steep hillsides, roadsides, and hedgerows, or in inaccessible areas or places where prairie vegetation is found. The rare terrestrial animal species typically reside in forest, wetland, and grassland ecosystems. The slippershell, a state threatened mussel, and four species of special concern (elktoe, round pigtoe, ellipse, and rainbow) were found at several sites in the Red Cedar River during MNFI surveys in 2001 (Hyde et al., 2009).

Habitat change and destruction is one reason for the threatened existence of our rare species. Regional conservation efforts appear to have the greatest potential on private lands and through existing landowner habitat improvement or protections programs (Hyde et al., 2009).

2.11 Invasive Species

"Invasive species" refers to a species whose introduction does or is likely to cause economic or environmental harm or harm to human health. Like most areas of southern Michigan, the watershed contains many invasive species. Some of the more pervasive include Eurasian water milfoil, purple loosestrife and garlic mustard. Perhaps the most visibly destructive of late is the emerald ash borer, which has destroyed millions of ash trees.

Under a contract with the Michigan Department of Natural Resources (MDNR) Wildlife Division, MNFI evaluated the occurrence of invasive plants throughout the state and created a strategy to manage the harmful effects invasives pose to wildlife (Higman and Campbell, 2009). It was found that southern lower Michigan is especially susceptible to invasive plants given the area's population density. Eurasian bush honeysuckles, common and glossy buckthorn, privet, barberry, multiflora rose, Oriental bittersweet, autumn olive, spotted knapweed and *Phragmites* are prevalent in the region and often introduced through landscaping or conservation activities.

2.12 Recreational Uses and Government Protected Lands

Land is available for a variety of recreational activities on or near surface waters in the RCRW. Recreational activities available include water access for canoeing, fishing, boating, and swimming, and land access available for walking or biking trails adjacent to the river, picnicking or wildlife watching. Government protected land is shown in Figure 2.8.

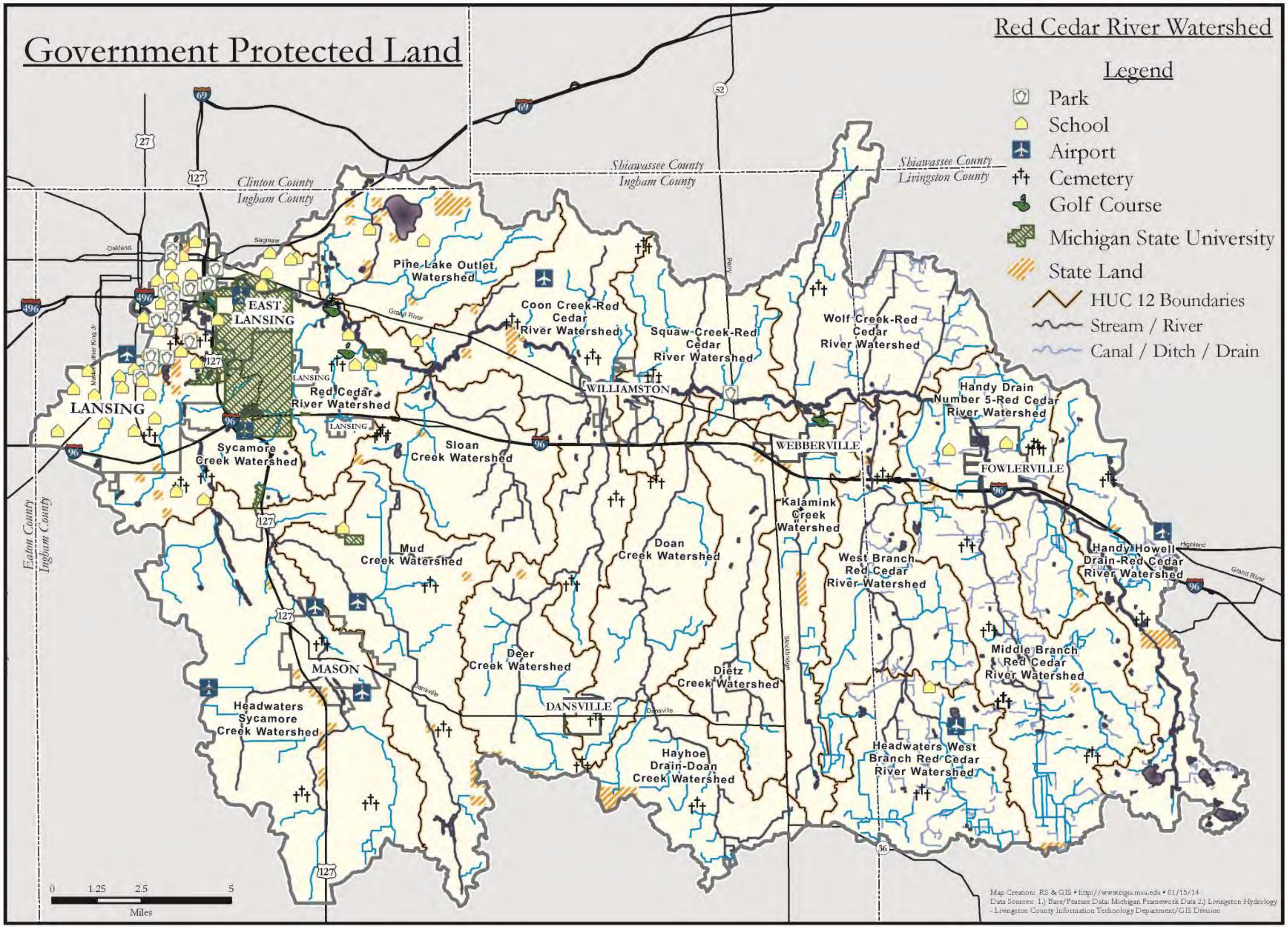


Figure 2.8 Government Protected Land

2.13 Political Jurisdictions

The RCRW is a diverse watershed made up of 37 political jurisdictions. The watershed is primarily located in Ingham and Livingston Counties, with small drainage areas located in Clinton, Eaton and Shiawassee Counties. The watershed has an urbanized area in the northwestern portion of the watershed; here, the confluence of the Red Cedar and Grand Rivers occurs near downtown Lansing. The urbanized areas consist of the Cities of Lansing, East Lansing, and Mason; and Charter Townships of Lansing, Delhi and Meridian. In total, there are five counties, four cities, four charter townships, 21 general law townships and three villages that cover the geographical area of the watershed. Governmental units in the watershed are depicted in Figure 2.9.

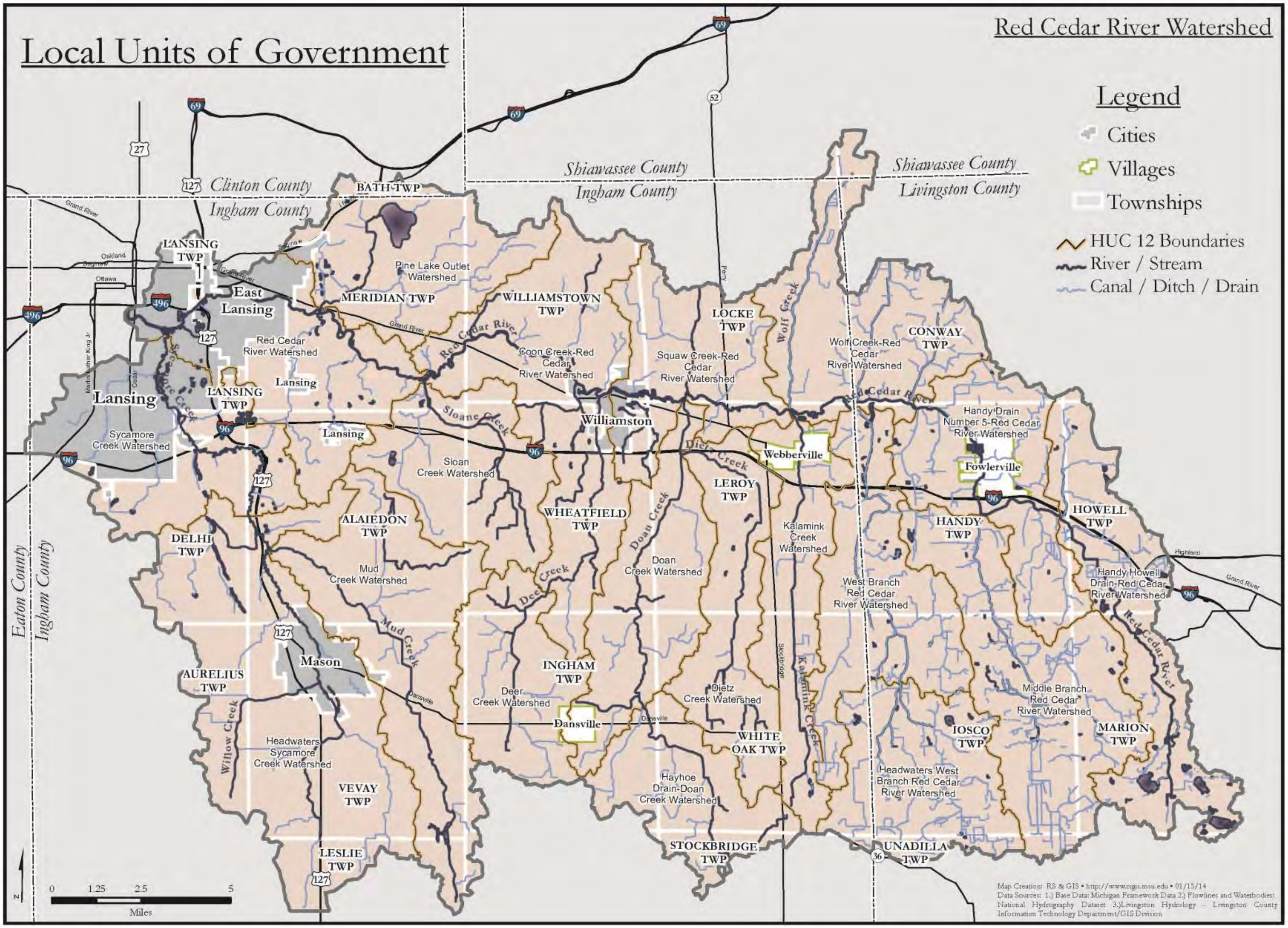


Figure 2.9 Local Units of Government

2.14 Demographics
The most densely populated area in the RCRW is located in the Red Cedar River and Sycamore Creek subwatersheds, which encompass portions of the Cities of Lansing and East Lansing, Meridian Township and Delhi Charter Township. The Cities of Lansing and East Lansing had a combined population of roughly 156,000 in 2010 and have a population density greater than 2,000 people per square mile (MDTMB, 2012). The City of Mason, located in the Headwaters Sycamore Creek subwatershed, and the City of Williamston, located in the Coon and Squaw Creek subwatersheds, had population densities between approximately 1,500 and 1,600 people per square mile. The Village of Fowlerville, located in Handy Drain No. 5 subwatershed, had a population density of 1,241 people per square mile. The 2010 Census indicated that the remaining areas in the RCRW had population densities below 300 people per square mile. Alaiedon, Wheatfield, Locke, Conway and White Oak Townships had population densities less 100 people per square mile (MDTMB, 2012). Population densities by subwatershed are shown in Figure 2.10.

According to Southeast Michigan Council of Governments (SEMCOG) forecasting efforts (2012), significant increases in population by 2040 will occur in portions of the Handy Howell Drain and Middle Branch Red Cedar River subwatersheds (Marion and Howell Townships). The Tri-County Regional Planning Commission (2012), estimates that by 2040, almost half of Ingham County's townships will experience a ten percent increase in population under current growth trends. Under a wise growth scenario, population increases would be concentrated in the cities of Lansing, East Lansing, and Delhi Charter Township, affecting the Red Cedar River and Sycamore Creek subwatersheds.

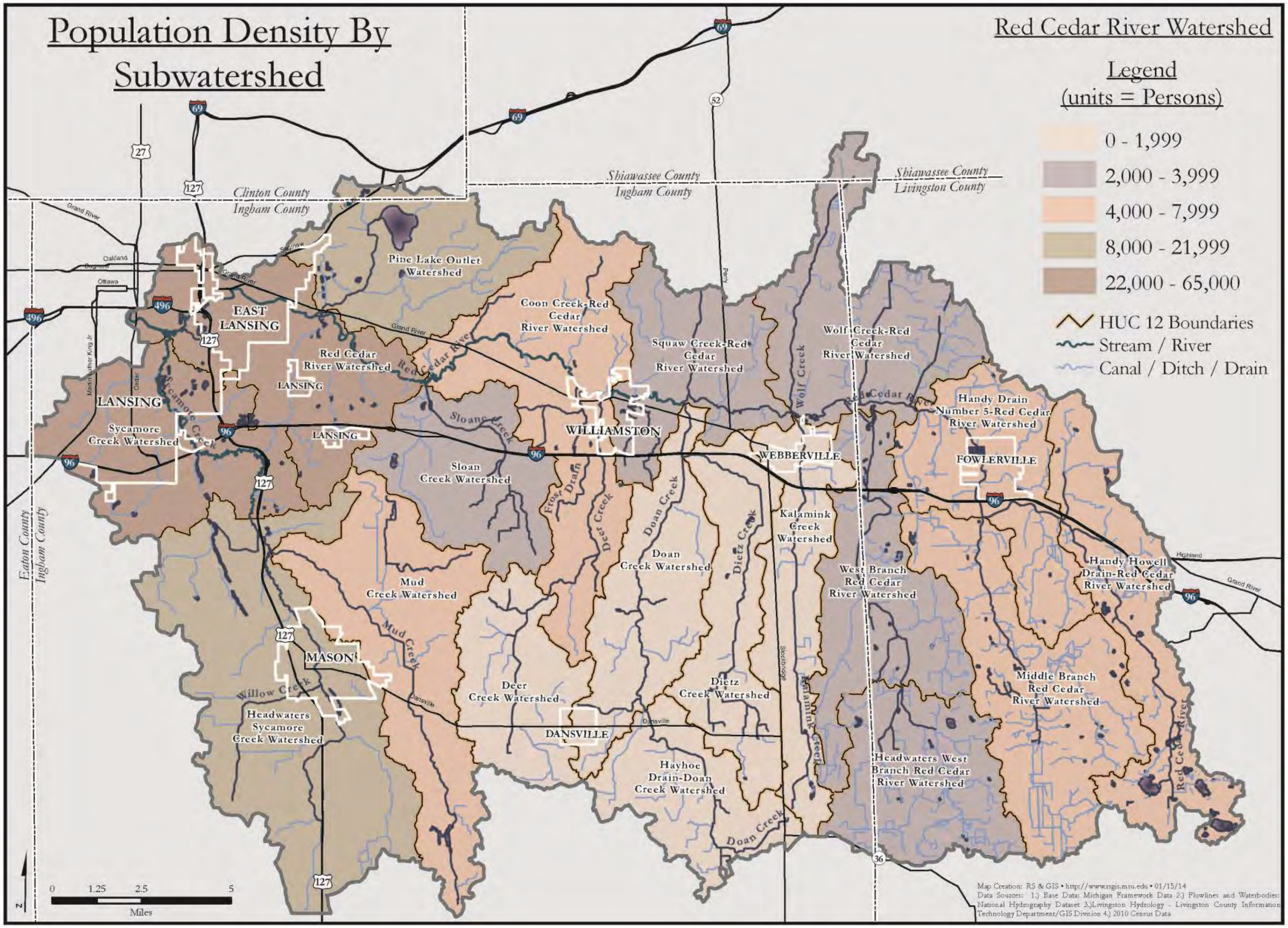


Figure 2.10 Population Density by Subwatershed

3. WATER QUALITY IN THE RED CEDAR RIVER WATERSHED – AN OVERVIEW

A number of organizations and agencies have assessed water quality conditions throughout the Red Cedar River Watershed (RCRW) over the past decade. An overview of the pollutants of concern and sampling results are presented in this chapter. Detailed assessments by subwatershed for each of the pollutant categories are included in Chapter Four.

3.1 Designated Uses

Pollutants are assessed by their potential impact on designated uses. Part 4 Rules issued in accordance with Part 31 of the Michigan Natural Resources and Environmental Protection Act (NREPA) (1994 PA 451, as amended) identify eight designated uses for surface waters of the state:

- Agriculture – Surface water must be of the quality that it can be used for livestock watering, irrigation and other agricultural activities.
- Industrial water supply – Surface waters must meet quality standards for use in commercial or industrial applications.
- Public water supply - after conventional treatment methods, surface waters must provide a source of water that is safe for human consumption, food processing, and cooking.
- Navigation – Surface waters must be of the quality sufficient for passage of boat traffic.
- Warmwater fishery – Water bodies designated as warmwater fisheries should be able to sustain populations of fish species such as panfish.
- Habitat for other indigenous aquatic life and wildlife – Surface waters must support fish, other aquatic life and wildlife that use the water for any stage of their life cycle.
- Partial body contact recreation – Residents of the state should be able to use surface waters for activities that involve direct contact with the water but does not involve the immersion of the head, such as fishing and kayaking.
- Total body contact recreation between May 1 and October 31 – The waters of the state should allow for activities that involve complete submersion of the head such as swimming.

Surface waters of the state can be defined as any of the following:

- The Great Lakes and their connecting waters
- All inland lakes
- Rivers
- Streams
- Impoundments
- Open drains
- Wetlands
- Other surface bodies of water within the confines of the state

As noted in the Water Quality and Pollution Control in Michigan 2012 Sections 303(d), 305(b), and 314 Integrated Report, the Michigan Department of Environmental Quality (MDEQ) assessed designated uses of the RCRW (MDEQ, 2012d). It should be noted that not all subwatersheds were assessed for each criteria.

If monitoring efforts demonstrate that water bodies are not meeting designated uses, the MDEQ may place portions of the water body on the state listing of impaired waterways. Once waterways are listed as impaired, the MDEQ is required to develop a Total Maximum Daily Load (TMDL) for the corresponding waterway(s) and its watersheds. A TMDL is the maximum amount of a particular pollutant a water body can assimilate without violating numerical and/or narrative Water Quality Standards (WQS).

Portions of the RCRW fail to meet minimum WQS in order to meet some designated uses. They are considered *impaired* on the State's 303(d) list of impaired waters requiring TMDL establishment. A final TMDL for *Escherichia coli* (*E. coli)* bacteria was developed in 2012. During the development of the *E. coli* TMDL, a stressor analysis was conducted for the TMDL area to determine priority areas in the watershed.

Several small catchments were identified as top priorities as well as top ranked subgroups. A TMDL for dissolved oxygen (DO) has been drafted. Figures 3.1 and 3.2 show the TMDL reaches for *E. coli* and DO, respectively. A statewide TMDL for mercury and polychlorinated biphenyls (PCBs) is scheduled for 2014.

3.2 Pollutants that May Impair or Threaten Designated Uses
Through literature review, site investigations and stakeholder input, a variety of nonpoint source pollutants have been identified that may threaten or impair water quality within the watershed. These are discussed below.

E. coli
E. coli is identified as a primary pollutant of concern in the watershed. *E. coli* is a type of bacteria associated with warm-blooded animal waste, and is used as an indicator of other disease-causing organisms in the water that are more difficult to measure (US EPA, 2008b). The presence of bacteria in quantities greater than the WQS may impair the designated use of partial and total body contact water recreation.

Michigan's WQS (established by Part 4 Rules issued in accordance with Part 31 of NREPA) set limits on the concentration of microorganisms allowed in surface waters of the state and surface water discharges. Waters of the state must meet a limit of 130 *E. coli* per 100 mL of water as a 30-day geometric mean of five sampling events (3 samples per event) and 300 *E. coli* per 100 mL of water for any single sampling event during the May 1 through October 31 period in order to meet the Total Body Contact (TBC) recreation standard. The limit for the Partial Body Contact (PBC) recreation standard is a geometric mean of 1000 *E. coli* per 100 mL water for any single sampling event at any time of the year.

Each of these TMDL reaches identified by MDEQ is identified by a unique Assessment Unit Identification (AUID) number, listed in Table 3.1. A map of these TMDL reaches is shown in Figure 3.1. Please note that not all subwatersheds were assessed by MDEQ as part of the TMDL development process. One objective of this planning project was to conduct additional monitoring in areas not previously assessed.

Table 3.1 Red Cedar River Watershed *E. coli* TMDL AUIDs

Description	AUID	Size (miles)
Handy Howell Drain-Red Cedar River	040500040401-02	21
Middle Branch Red Cedar River	040500040402-01	11
Handy Drain No 5-Red Cedar River	040500040403-02	15
West Branch Red Cedar River	040500040405-01	21
Kalamink Creek	040500040406-01	21
Wolf Creek-Red Cedar River	040500040407-01	17
Wolf Creek-Red Cedar River	040500040407-02	8
Dietz Creek	040500040409-01	19
Doan Creek and Doan Deer Creek	040500040410-01	23
Red Cedar River and Sullivan Creek	040500040411-01	17
Red Cedar River	040500040411-02	5
Squaw Creek	040500040411-03	8
Sloan Creek	040500040502-02	13
Coon Creek and Red Cedar River	040500040503-03	26
Sycamore Creek	040500040506-01	25
Willow Creek	040500040506-03	11
Cook and Thorburn Drain	040500040506-04	6
Banta Drain and Sycamore Creek	040500040507-01	29
Red Cedar River	040500040508-02	2
Red Cedar River	040500040508-03	18

*Based on data in the 2014 Draft MDEQ Integrated Report

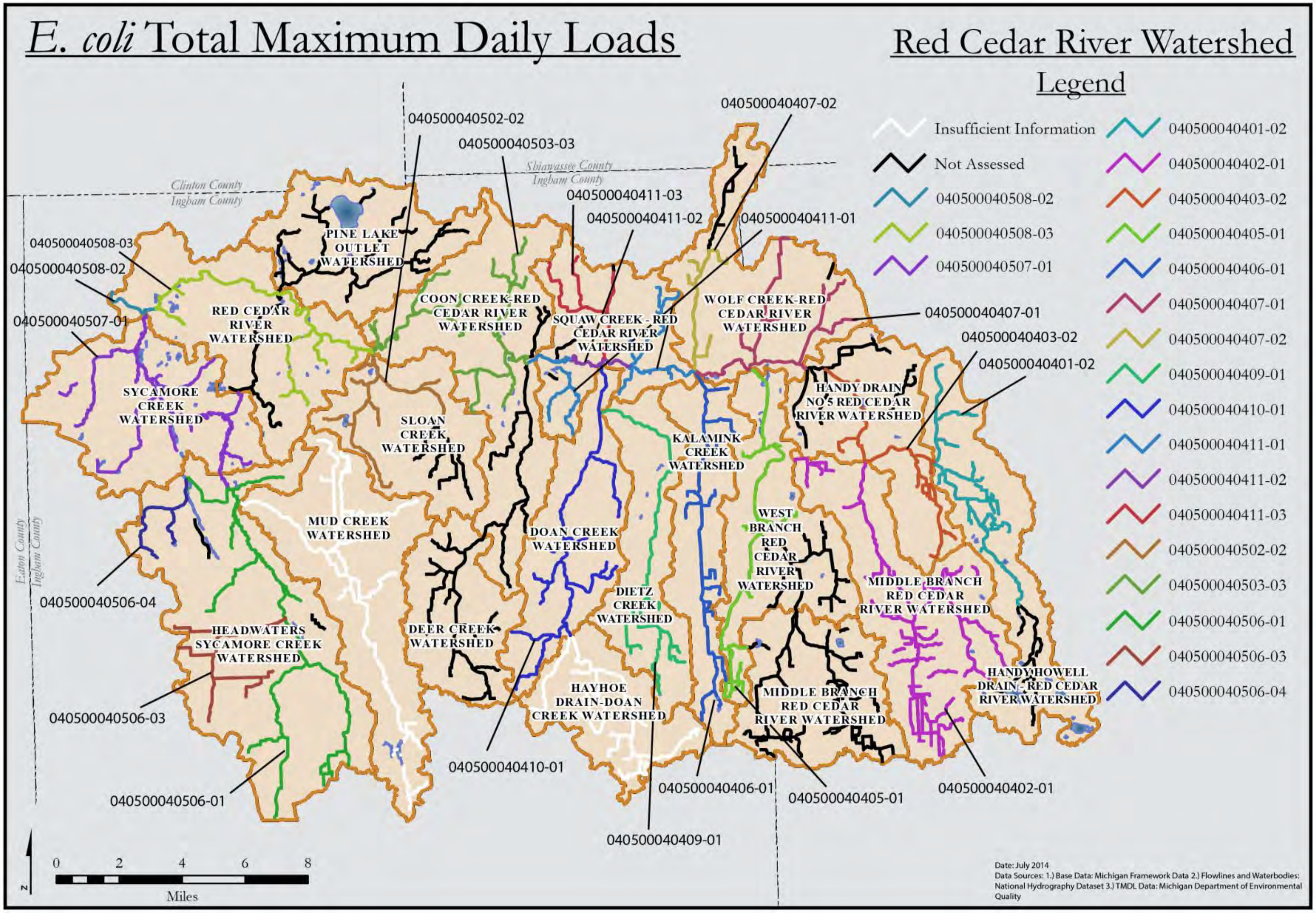


Figure 3.1 Red Cedar River Watershed *E. coli* TMDL

Sediment and Dissolved Oxygen

Excessive sediment in a stream can degrade fish and macroinvertebrate habitat by lowering DO levels as well as burying potential habitat for fish and aquatic macroinvertebrates. In addition, sediment can carry other pollutants to the watershed such as nutrients and *E. coli* bacteria. Although Michigan's WQS do not include numerical limits for total suspended solids, they do require that waters not have any of these physical properties: unnatural turbidity, unnatural color, oil films, floating solids, foam, settleable solids, suspended solids, and deposits (Rule 323.1050). They also state that in no instance shall total dissolved solids in the waters of the state exceed a concentration of 500 milligrams per liter as a monthly average nor more than 750 milligrams per liter at any time, as a result of controllable point sources (Rule 323.1051). Those numbers were used as reference values when assessing the subwatershed data.

Portions of the RCRW are considered impaired due to DO levels and sedimentation/siltation affecting the warmwater fishery and other aquatic life use designation (AUIDs 040500040505-01, 40500040508-02). Michigan WQS specify that a minimum of 5 mg/l of DO be maintained for certain waters of the state. That level was used as a reference value when evaluating the data available for the Red Cedar River. The MDEQ's draft TMDL for DO and sediment is under review. A map of the DO TMDL based on the 2014 draft report is shown in Figure 3.2.

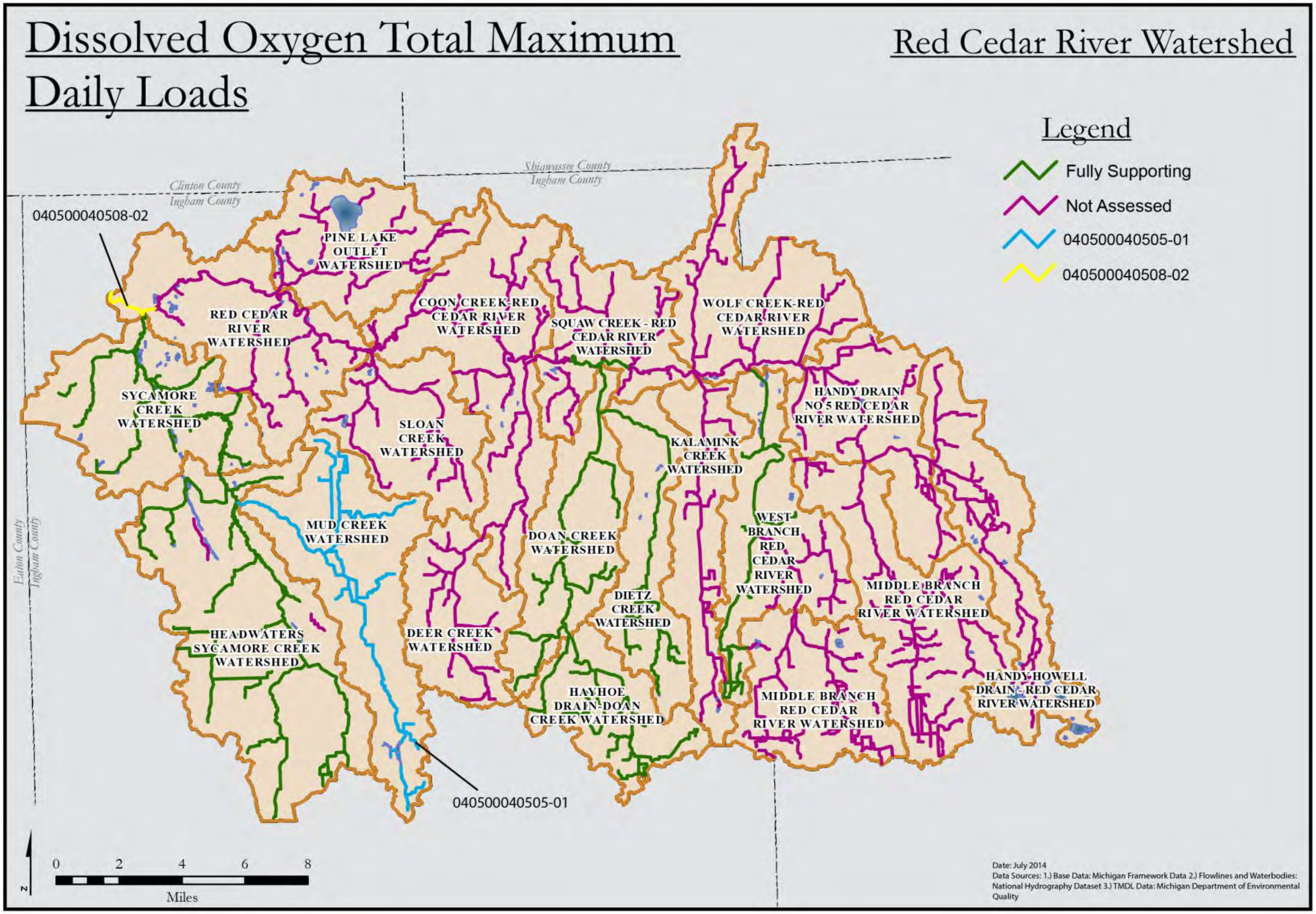


Figure 3.2 Red Cedar River Dissolved Oxygen TMDL

Mercury and PCBs
Most of the RCRW is considered impaired due to mecury and PCBs in the water column and/or fish tissue, which affects fish consumption. The MDEQ is scheduled to develop a statewide TMDL in 2014. Due to this forthcoming TMDL, mercury and PCBs are considered to be causing an impairment to this watershed. However, these pollutants are not addressed in this plan.

Nutrients
Excess nutrients can have a negative impact on water quality. Although nutrient data have not been collected as part of this planning process, nutrient data were collected by stakeholders in previous studies and are summarized in this plan. Nutrient data were collected in 2001 by the Livingston County Health Department (LCHD) and the MDEQ in 2011 for some, but not all, subwatersheds. These data are discussed in Chapter Four.

When available, Michigan Part 4 WQS Rules were used to understand where nutrient concentrations were excessive throughout the watershed. If a WQS does not exist, sampling results were compared to those collected across EPA Ecoregion VII, or the Southern Michigan/Northern Indiana Drift Plains Ecoregion (SMNIDP). The total Kjeldahl nitrogen comparison concentration used was 0.3 mg/L, which is the 25^{th} percentile EPA Ecoregion VII concentration calculated for the decade (US EPA, 2000). The ammonia as nitrogen comparison concentration used was 0.042 mg N/L, which is the SMNIDP Ecoregion mean concentration (Lungdren, 1994 as cited in MDEQ, 2013a). The total phosphorous comparison concentration used was the median value, 0.32mg/L, reported for the state from 250 sites between 2005 and 2009. Total organic carbon (TOC) concentrations were compared against the SMNIDP Ecoregion median concentration of <10 mg/L, calculated from 2000-2008 (Roush, 2013 as cited in MDEQ, 2013a). Nutrient concentrations are reported in the Chapter Four only when exceedances were measured above the WQS or comparison concentrations.

Table 3.2 summarizes the target values used to assess pollutants of concern within the watershed.

Table 3.2. Target Values Used to Assess Pollutants of Concern

Parameter	Target Value	Units	Standard or Comparable	Type	Source
E. coli	130	cfu/100 mL	S	Total Body Contact Recreation in all waters of the state. Calculated as a 30-day geometric mean from 5 or more sampling events.	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards
E. coli	300	cfu/100 mL	S	Total Body Contact in all waters of the state	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards
E. coli	1,000	cfu/100 mL	S	Partial Body Contact in all waters of the state	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards
Dissolved Oxygen	7	mg/L	S	Waters connected to Great Lakes. Coldwater fishery.	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards.
	5	mg/L	S	All other waters. Warmwater fishery 5 mg/l as a daily minimum.	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards.
Ammonia	0.042	mg/L	C	Mean concentration calculated from SMNIDP ecoregion sites	Lundgren, R. 1994. Reference Site Monitoring Report 1992-1993. Michigan Department of Natural Resources, Surface Water Quality Division, Lansing, Michigan. Report No. MI/DNR/SWQ-94-048.
Total Phosphorus	0.032	mg/L	C	Median value calculated using probabilistic data from 250 sites in State from 2005-2009	Roush, D. 2013. Michigan's Water Chemistry Monitoring Program: A Report of Statewide Spatial Patterns 2005-2009 and Fixed Station Status and Trends 1998-2008. MDEQ Staff Report No. MI/DEQ/WRD-13/005
	0.058	mg/L	C	75th percentile calculated using probabilistic data from 250 sites in State from 2005-2009	Roush, D. 2013. Michigan's Water Chemistry Monitoring Program: A Report of Statewide Spatial Patterns 2005-2009 and Fixed Station Status and Trends 1998-2008. MDEQ Staff Report No. MI/DEQ/WRD-13/005
Total Dissolved Solids	500	mg/L monthly avg	S	Point Source	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards.
	750	mg/L at any time	S	Point Source	Michigan Department of Environmental Quality Water Bureau Water Resources Protection. (2006, January 13). Part 4 Water Quality Standards.
Total Suspended Solids	80	mg/L	C	Informal target	
Total Organic Carbon	<10	mg/L	C	SMNIDP ecoregion median from 2000-2008	Roush, D. 2013. Michigan's Water Chemistry Monitoring Program: A Report of Statewide Spatial Patterns 2005-2009 and Fixed Station Status and Trends 1998-2008. MDEQ Staff Report No. MI/DEQ/WRD-13/005
Total Kjeldahl Nitrogen	0.24	mg/L	C	Ambient WQ criteria recommendations; 25th percentile of region stream population	United State Environmental Protection Agency Office of Water Office of Science and Technology Health and Ecological Criteria Division. (2000, December). Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Rivers and Streams in Nutrient Ecoregion VII. EPA 822-B-00-018). Washington D.C.

Reviewing the data available, in this watershed, ammonia as nitrogen, total dissolved solids (TDS), total Kjeldahl nitrogen, total phosphorus, and TOC were nutrients that were found above the reference values. Chemical oxygen demand (COD) was reported as high by MDEQ (2013a). These data are further discussed in Chapter Four.

3.3 Data Collection and Analysis

E. coli Monitoring

E. coli sampling has been conducted in the watershed by a number of partner organizations. The MDEQ collected samples for 16 weeks in 2009 from May to August as part of the *E. coli* TMDL development. The Ingham County Health Department (ICHD) has collected *E. coli* data at sites along the main river channel throughout the recreational season since 2004. The Ingham Conservation District (ICD) conducted both *E. coli* and DO sampling in the watershed in summer 2013. A number of older, previous studies have been conducted in the watershed. For example, the Livingston County and Ingham County Drain Commissioner offices collected *E. coli* samples in 2000 and 2001 at 38 sampling locations. Individual jurisdictions occasionally also collect data in the watershed.

One objective of this watershed planning project was to address gaps in the data by sampling locations that had not previously been assessed. *E. coli* sampling was conducted by Michigan State University (MSU) as part of this watershed planning project for four weeks in 2012 to address some of these data gaps, and one sampling event was conducted in 2013, specifically for the purpose of microbial source tracking. The approved quality assurance project plan (QAPP) for this project is within Appendix B.

A map of sampling locations and site IDs for data collected in 2009-2013 by the various organizations listed above is shown in Figure 3.3.

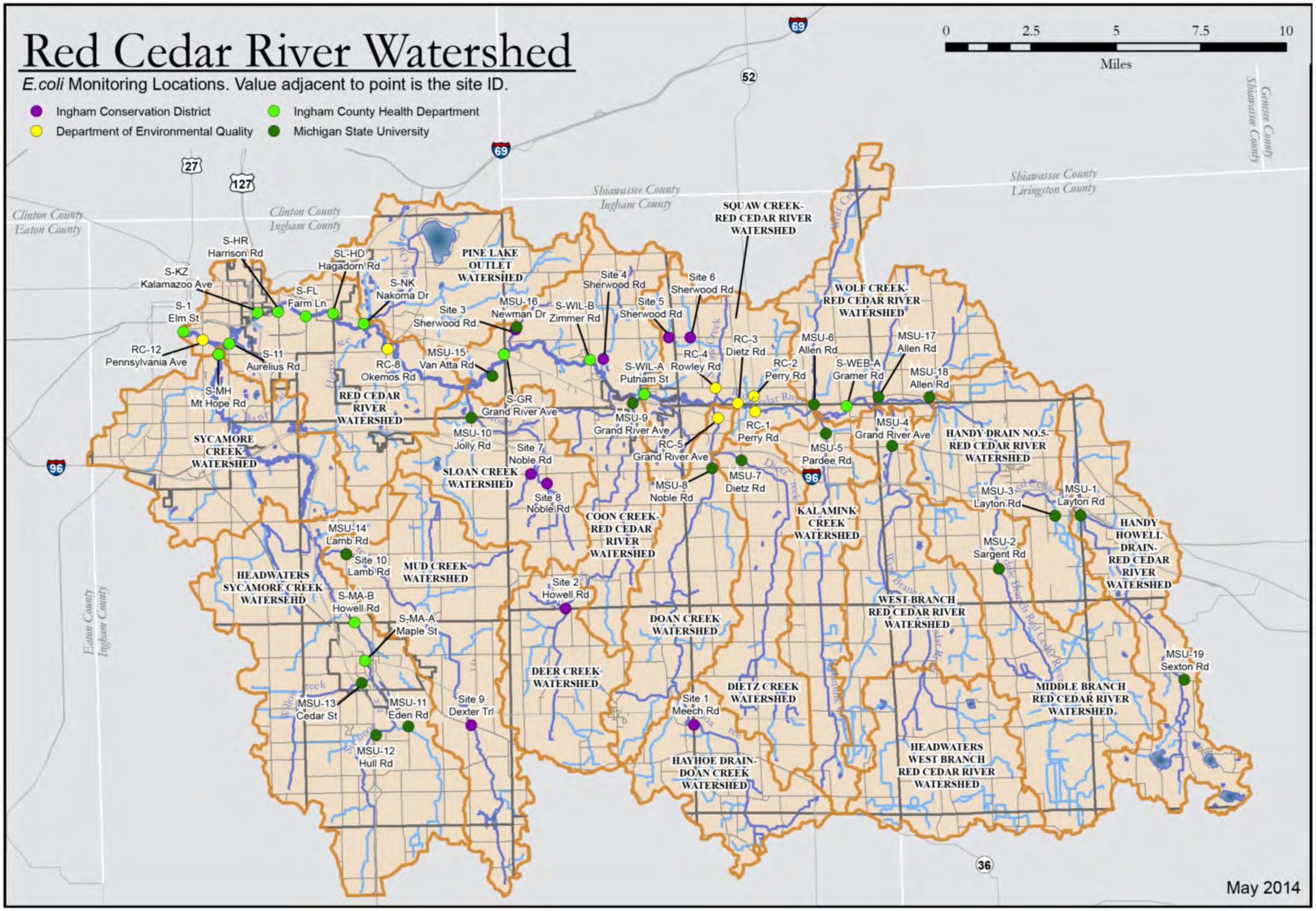


Figure 3.3 *E. coli* Monitoring Locations. *Note: MSU-14 is also Site 10 Mud Creek @ Hagadorn/Lamb Rd for the ICD.*

Results from these sampling activities are briefly summarized below. Full sampling results are included in table format in Appendix C.

E. coli samples are typically collected weekly over multiple weeks in a summer sampling season. *E. coli* is measured by bacterial colony forming units (cfu) present in 100 milliliters of water. Sampling results in the RCRW frequently exceed both the WQS for TBC of 300 cfu/100 mL and for PBC of 1,000 cfu/100 mL. To account for variability within the stream channel, a geometric mean of samples taken from the left, right and center of the river channel is calculated and compared to the WQS for *E. coli*.

Results are often not consistent across the weeks of sampling, as they are affected by various parameters such as temperature, rainfall, and flow. *E. coli* levels vary both spatially and temporally, as bacteria go through growth and die-off phases, and the presence of *E. coli* can be directly related to runoff or may be attributed to dry weather conditions. Caution must be used when comparing *E. coli* results across different sampling events due to this variability.

Precipitation and flow conditions were contrasting in the years that *E. coli* data were collected by MSU (2012 and 2013). In 2012, the MSU Enviro-Weather East Lansing "MSUHort" station reports that 23.71 inches of rain fell in 526 hours, demonstrating that 2012 was much drier than 2013 which had 36.77 inches of rain in 536 hours (MSU, 2014). To further illustrate the flow differences, water depths collected as part of the MSU sampling activities in 2012 and 2013 are shown in Table 3.3 below.

Table 3.3 Stream Depth

Site ID	Avg. depth measured 08-09/2012 (cm)	Depth Measured 7/1/2013 (cm)
MSU-1	21.5	76.2
MSU-6	14.1	99.06
MSU-7	15.8	32
MSU-8	8.9	20
MSU-10	17.4	29
MSU-11	28.6	57
MSU-12	9.3	32
MSU-13	23.3	32

Data analysis is further complicated because each organization used a different strategy for selecting sampling locations. Although caution must be used when assessing the monitoring results due to this variability, the data can be used to better understand impairments and assess changes over time.

E. Coli Sampling – General Observations Across the Watershed

Water samples were taken in 2012 and 2013 by the ICHD and the ICD and measured for *E. coli*. Four weeks of data from 8/29-9/20, 2012, and one week of data from 7/1/13 were also collected MSU. For all sites, samples were taken at three locations across a stream, and *E. coli* results were averaged by taking the geomean for each site. The ICHD sampling took place in 2012 and 2013 for 20 and 22 consecutive weeks from 5/7 - 9/24 and 5/6 - 9/30, respectively, along the main branch of the Red Cedar River. Rainfall data were determined for each corresponding collection date.

The ICD data was collected for 10 consecutive weeks from 6/11 - 8/13 in 2013. Samples were taken at three locations across a stream site from tributaries to the Red Cedar, and were averaged by taking the geomean for each site. *E. coli* counts above 10,000 cfu were recorded at 10,000 as the lab methodology used for this analysis had a maximum sensitivity of 10,000 cfu. Rainfall data were determined for each corresponding collection date.

Ingham County Health Department - Main Branch of Red Cedar River
For 2013, along the main stem of the Red Cedar, which was considered a wet year, sampling was conducted by the ICHD from May 6 - September 30. Except for Site S-MA-B (Howell Rd. in Mason) in the headwaters of the Sycamore Creek for two sampling dates and Site S-MH (Mount Hope Ave in Lansing) for one sampling date, geomeans for *E. coli* were always below the PBC standard when rainfall was less than 0.1” up to 48 hours prior to sampling. For TBC standards, results were much more variable, making it difficult to correlate *E. coli* concentrations with rainfall.

Geomeans for *E. coli* when rainfall was above 0.1” up to 48 hours prior to sampling varied substantially, and there was no apparent correlation between high rainfall and high geomeans across sites or within sites. Thus, at the highest rainfall occurrence at 1.82” on May 28, four of the twelve sites had geomeans above the PBC standard with the rest below the TBC standard. Conversely, at a lesser rainfall of .86” on June 11, all but one site had *E. coli* geomeans above the PBC standard. Refer to Figure 3.4.

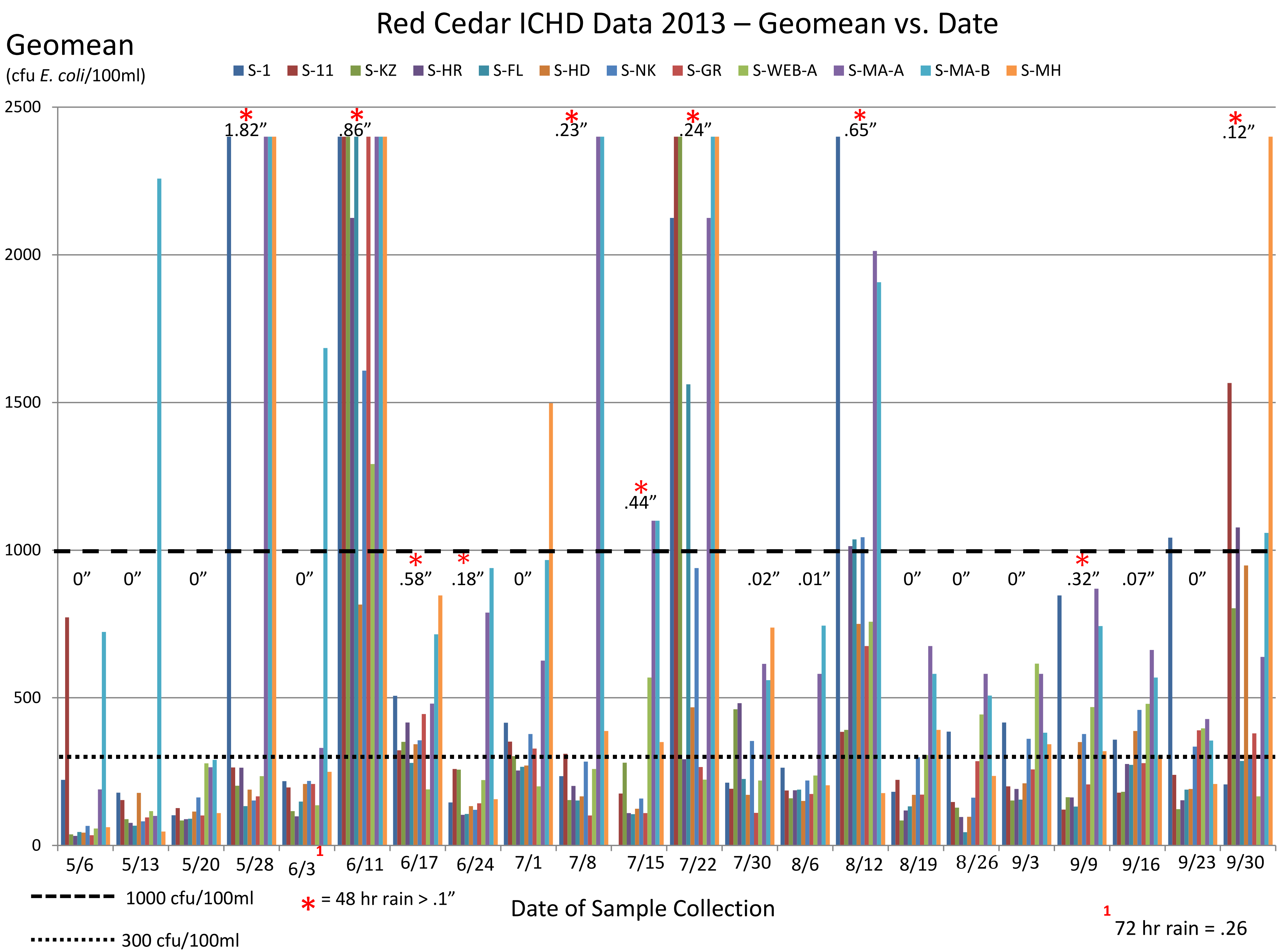


Figure 3.4: ICHD 2013 *E. coli* Geomean vs. Date

Sampling was also conducted in 2012 by the ICHD, which was considered a very dry year, from May 7 - September 24 along the main stem of the Red Cedar. Except for Site S-WIL-A (Putnam St. in Williamston) for two sampling dates, geomeans for *E. coli* were always below the PBC standard when rainfall was less than 0.1” up to 48 hours prior to sampling. For TBC standards, results were much more variable, making it difficult to correlate *E. coli* concentrations with rainfall. Under low rainfall conditions, *E. coli* concentrations on the main branch of the Red Cedar River tend to be low and usually below PBC standards. However, when rain conditions exceed 0.1”, *E. coli* concentrations are much more variable and difficult to predict. See Figure 3.5.

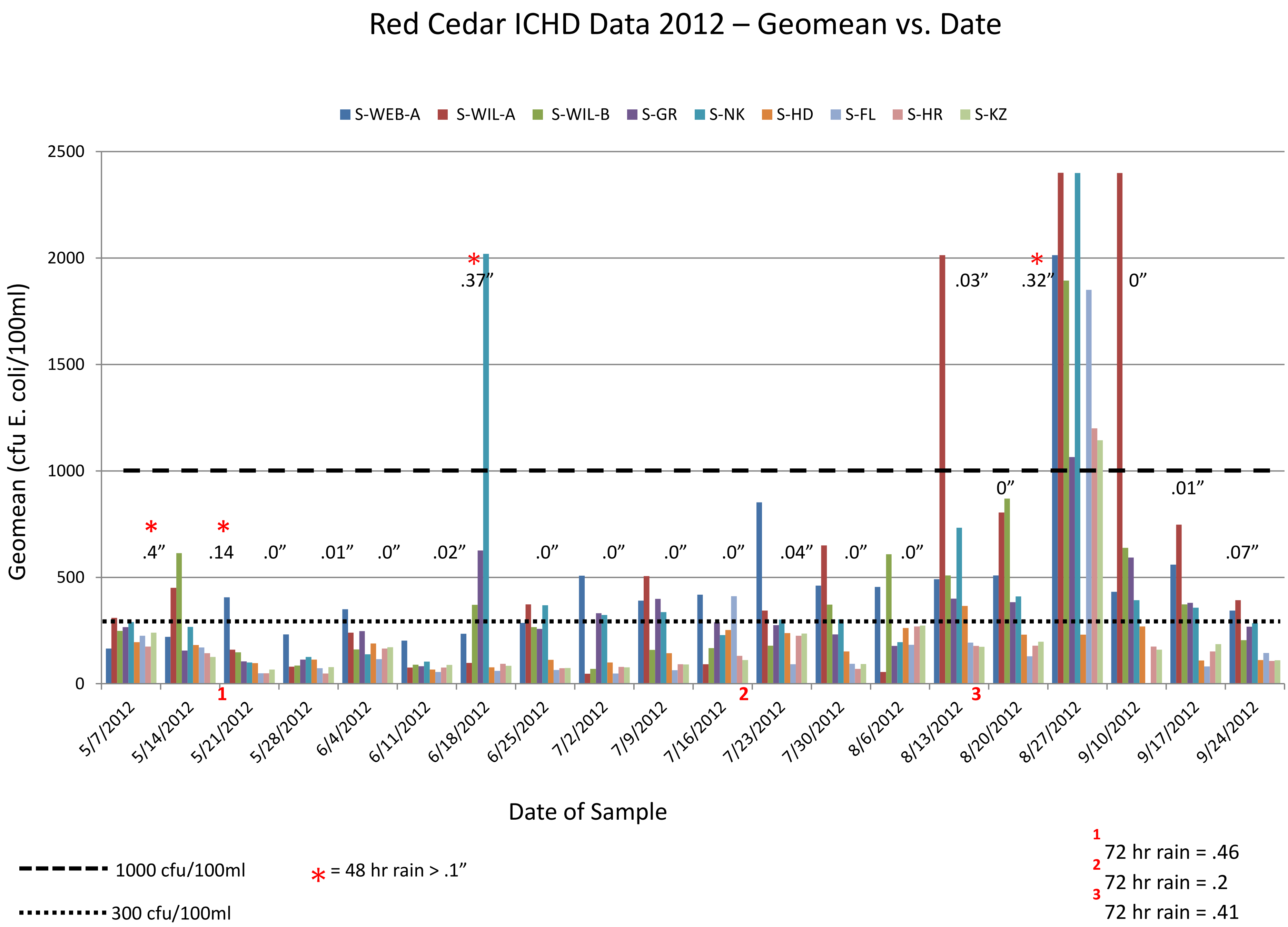


Figure 3.5 ICHD 2012 *E. coli* Geomean vs. Date

MSU Red Cedar Tributaries Sampling
For 2012, data were collected for four weeks from August 29 – September 24. *E. coli* geomeans were often above the PBC level and sometimes above the TBC even under low (<0.1”) to no rainfall. Refer to Figure 3.6. Geomeans for *E. coli* when rainfall was above 0.1” up to 48 hours prior to sampling varied substantially, and there was no apparent correlation between high rainfall and high geomeans across sites.

For the four-week sampling period, the Wolf Creek subwatershed showed *E. coli* concentrations substantially above PBC standards. In all sampling weeks, Wolf Creek had higher *E. coli* counts than any of the other sampling sites. The concentrated animal feeding operation (CAFO) located in this subwatershed may be a contributing factor. The land use in this watershed is discussed in Chapter Four.

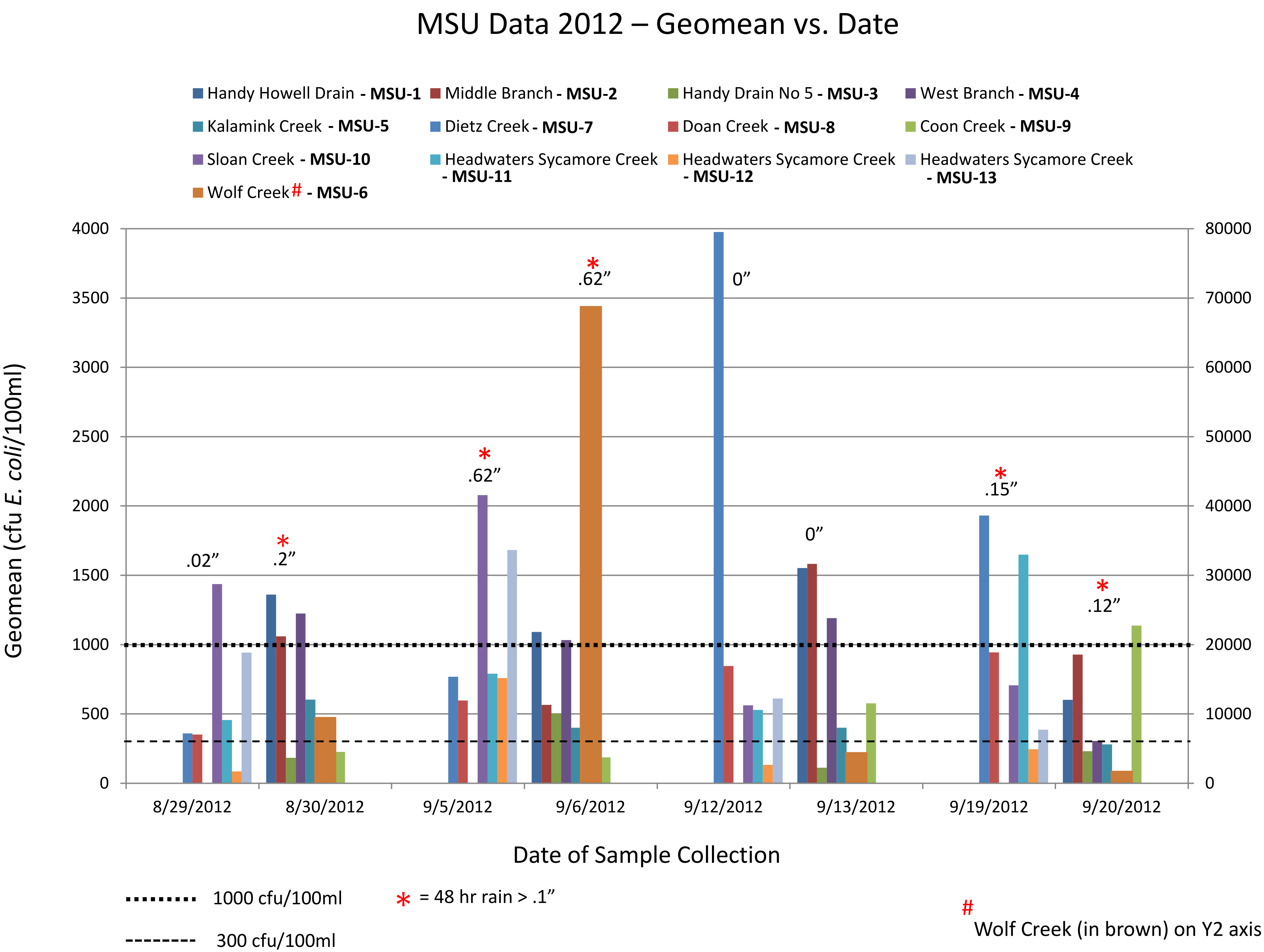


Figure 3.6 MSU 2012 *E. coli* Geomean vs. Date

Ingham Conservation District Tributaries Sampling

For 2013, a wet year, data were collected at 10 sites over 10 weeks from June 11 – August 13. *E. coli* geomeans were often above both the PBC and TBC levels even under low (<0.1") to trace amounts of rainfall. Geomeans for *E. coli* when rainfall was above 0.1" up to 48 hours prior to sampling were above both the PBC and TBC standards the majority of the time at all sites. Figure 3.7 highlights these results.

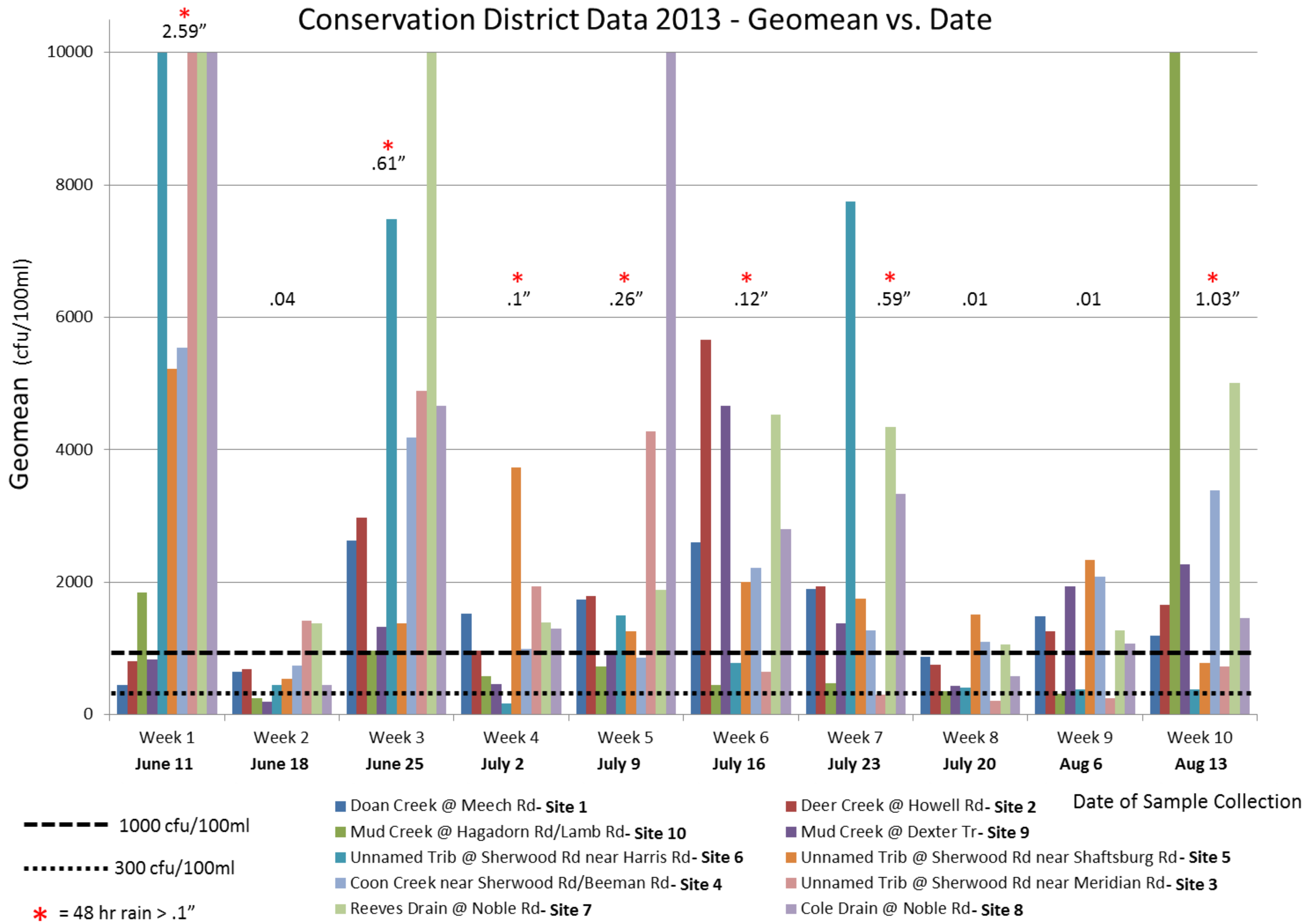


Figure 3.7 Conservation District 2013 *E. coli* Geomean vs. Date

E. coli General Observations Summary
In the RCRW, there is a tendency for *E. coli* concentrations to spike following rain events above 0.1" in both the main branch and in the subwatersheds. This is not always the case, however. In some instances, *E. coli* concentrations remain below the TBC and/or PBC after a rain event above 0.1". Additionally, *E. coli* concentrations are sometimes above both TBC and PBC standards during periods with no rainfall. While this is not predominant, the trend tends to be seen more often in the subwatersheds than in the main branch, possibly due to lower discharge levels associated with smaller watersheds.

<u>*E. coli* Sampling Results 2012-2013 Analyzed by Subwatershed</u>
Results from the 2012 and 2013 sampling seasons were also analyzed to prioritize at the subwatershed level. Table 3.4 represents the average percent of geomeans over the TBC and PBC standards for all samples that were taken from the main branch of the Red Cedar River. The subwatershed associated with the sample is provided. On average, *E. coli* geomeans in the Sycamore subwatershed are higher than those in other subwatersheds. PBC standards were exceeded in 27% of the sampling events for Sycamore Creek subwatershed. Only one site in this subwatershed, site S-MH, exceeded TBC standards in less than 50% of the sampling events. On average, the other sites in Sycamore Creek exceeded TBC standards in 90% of the sampling events. The only other site with average TBC exceeding standards more than 50% of the time occurred in the Wolf Creek subwatershed.

Table 3.4. Averaged data from the Main Branch of the Red Cedar River

Associated Subwatershed	Number of Sampling Event Geomeans	Total Number of Sample Geomeans	Average % TBC in Main Branch	Average % PBC in Main Branch	Average Geomean
Coon	4	82	43	5	258
Sycamore	6	126	77	27	627
Wolf	2	42	55	5	342
Red Cedar	14	292	26	9	225

For samples taken directly from the subwatersheds, the average %TBC standard was exceeded in 100% of the sampling event geomeans for Deer, Dietz, Doan, Middle Branch, Sloan, West Branch and Wolf subwatersheds (Table 3.5). Squaw Creek and Mud Creek had average %TBC exceedences of 95% and 90%, respectively. All subwatersheds except Handy Howell Drain exceeded the TBC standard in 75% of the sampling event geomeans. Wolf had the highest average geomean at 8,539 cfu/100ml followed by Sloan at 2,051 cfu/100ml. It should be noted that Wolf Creek had one geomean of over 68,000 while the other geomeans were 9,560, 4,483, and 1,802 for the four weeks that samples were collected in 2012. In 2013, average geomeans for one date (July 1) at three different sites in the Wolf Creek subwatershed were 441,782, and 1,160 cfu/100ml. However, stagnant water was observed at these locations.

Subwatersheds that exceeded the PBC standard 75% of the sampling event geomeans or more included Wolf Creek (100%) and Sloan Creek (83%), and West Branch (75%).

Table 3.5. Averaged data within subwatersheds of the Red Cedar River

Subwatershed	Number of Sampling Event Geomeans	Total Number of Sample Geomeans	Average % TBC Exceedences	Average % PBC Exceedences	Average Geomean
Coon	3	24	87.5	62.5	1,116
Deer Creek	1	10	100	60	1,474
Dietz Creek	1	10	100	50	1,206
Doan Creek	2	14	100	50	977
Handy Howell Drain	2	8	62.5	37.5	653
Kalamink Creek	1	4	75	0	406
Middle Branch	1	4	100	50	968
Mud Creek	2	20	90	40	873
Sloan	3	24	100	83	2,051
Squaw Creek	2	20	95	65	1,395
Sycamore	3	12	75	17	582
West Branch	1	4	100	75	823
Wolf	1	4	100	100	8,539

Microbial Source Tracking

One sampling event was conducted in the summer of 2013 by MSU at 14 locations. *E. coli* concentrations were measured at the State of Michigan Water Quality Laboratory. In addition, samples were sent to a private laboratory for microbial source tracking to test for the presence of bovine and equine sources of fecal waste. Samples were also collected for canine scent tracking, which was used to indicate potential human sources of fecal waste. Source tracking showed the presence of both equine and bovine DNA in a majority of the subwatersheds analyzed. Furthermore, the canine scent analysis was positive at eight sampling locations. Figure 3.8 depicts the results for the 2013 *E.coli* and microbial source tracking sampling event.

Based on the 2012 and 2013 monitoring data, the subwatersheds most frequently exceeding the WQS for *E. coli* are: Headwaters Sycamore Creek, Doan Creek, Squaw Creek, Sycamore Creek, Handy-Howell, Sloan Creek, Middle Branch, Dietz Creek, and Coon Creek. In addition, the Wolf Creek subwatershed had the highest geomean recorded.

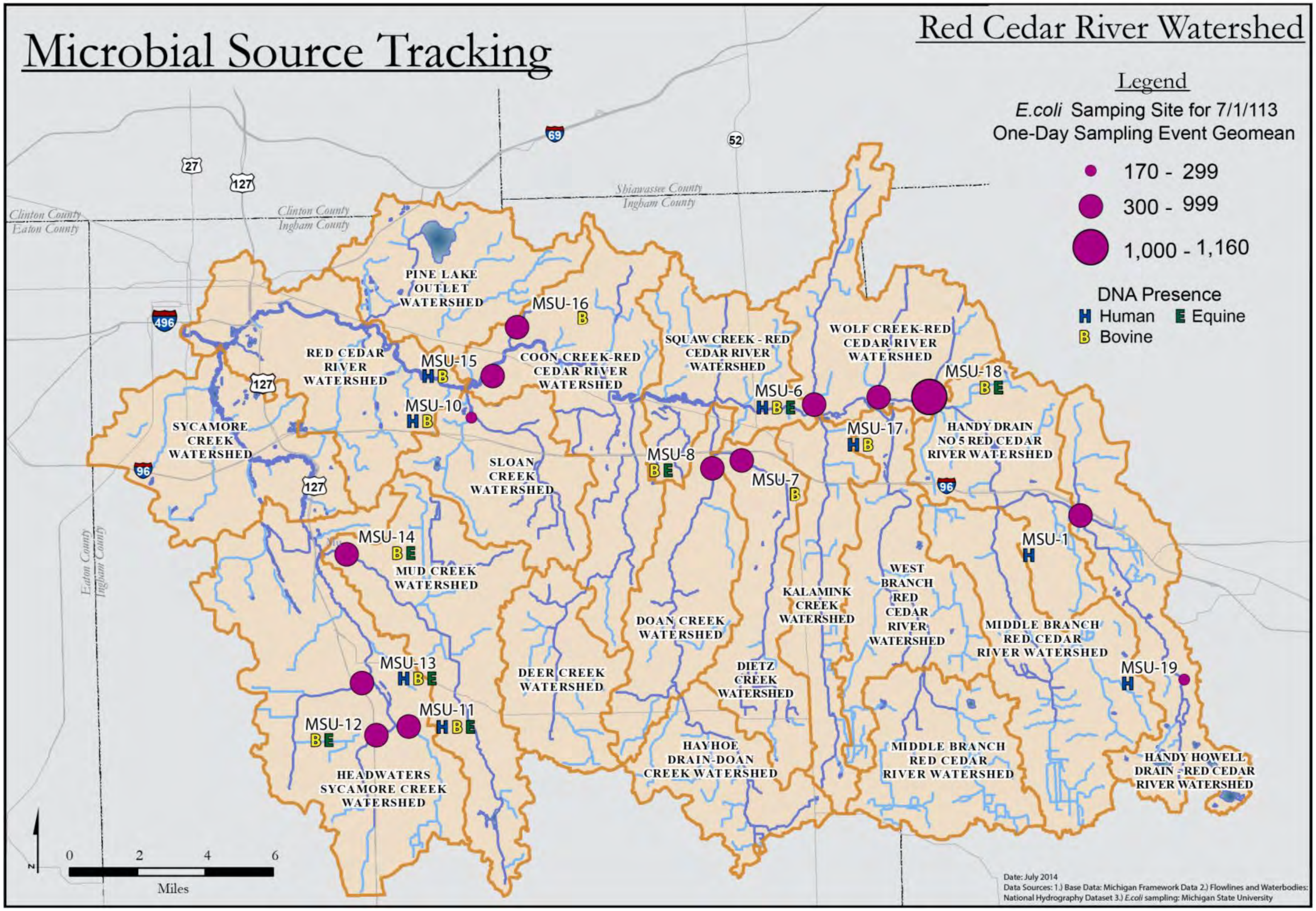


Figure 3.8 Microbial Source Tracking

Sediment Modeling

Modeling was completed for the RCRW using the High-Impact Targeting (HIT) model (MSU IWR, 2009). The HIT model combines two GIS-based models to prioritize areas at risk for sediment loading: the Revised Universal Soil Loss Equation (RUSLE) to estimate soil erosion and the Spatially Explicit Delivery Model (SEDMOD) to estimate the delivery of eroded soil to the stream network. Model inputs include the following: digital elevation model, soil survey (1:100K), rainfall, landuse (with tillage information incorporated if available.

Using the HIT model, sedimentation loading in tons per acre per year by subwatershed was estimated following methods developed by the MSU Institute of Water Research (Ouyang, Bartholic, & Selegean, 2005). A map of the modeling results is shown in Figure 3.9. The HIT model only accounts for sheet erosion and associated sediment loading that originates from agricultural lands (O'Neil, 2010). Therefore, HIT is likely underestimating sediment loading from agricultural fields and is not suitable for urban analysis.

The Ingham and Livingston County Drain Commissioners completed a streambank erosion inventory in 2000; results of those studies were reviewed and conversations with personnel from their offices were used to determine if any of these erosion sites remain. Signs of erosion and sedimentation were also identified through this watershed planning project by conducting a windshield survey (see Appendix D for the methodology). In addition, an erosion assessment was completed on the MSU campus in 2006 (Hamilton Anderson Associates, 2007).

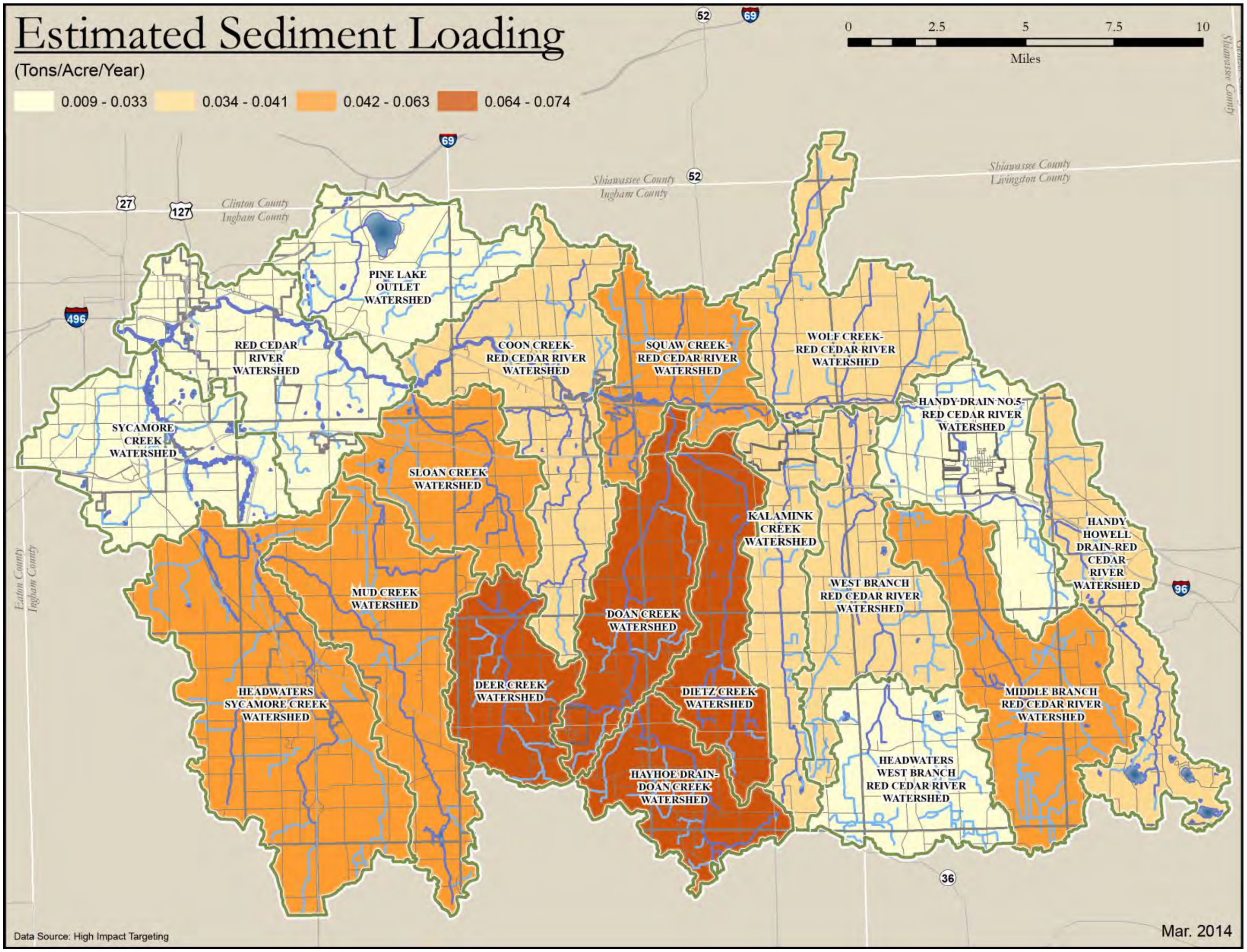


Figure 3.9 HIT modeling results in tons of sediment per acre delivered to surface water per year

Biological Monitoring

Macroinvertebrate diversity and abundance are indicators of stream water quality. A high diversity and abundance of macroinvertebrates present are indicative of higher quality water, but other characteristics also affect water quality ratings, such as the types of macroinvertebrates present and the distribution between sites (MDEQ, 2009 rev.). Macroinvertebrate samples are collected and analyzed for the presence and quantities of various macroinvertebrates. Using a standard procedure and analysis method, a score is calculated based on the quantities of certain macroinvertebrates present in the sample. Results compared over time can signal changes in a stream's health, which may indicate changes in pollutant loadings to the stream.

Biological sampling was not collected specifically as a part of this planning process, but data were retrieved from other stakeholders and included in the plan development. MDEQ collected macroinvertebrate samples following Great Lakes and Environmental Assessment Section Procedure No. 51 (P51) (MDEQ, 2008 rev.). The most recent revision (2008) of P51 includes methods for assessment of macroinvertebrate and fish communities, as well as physical habitat. For macroinvertebrates, the process results in a score based upon on a scale of -9 to 9; -9 to -5 is rated as Poor, -4 to 4 is rated as Acceptable, and anything greater than 4 is rated as Excellent. Generally speaking, flowing waters which harbor a high diversity of macroinvertebrates, specifically different types of mayfly, caddisfly and stonefly, are of higher water quality than those waters that have few taxa. Water bodies with low diversity often have very high numbers of tolerant individuals due to their ability to thrive in degraded water with relatively little competition. The scoring criteria for the fish community are similar, with a total of ten metrics used in the scoring process. For physical habitat, 10 metrics are scored on an individual basis and then compiled, resulting in an overall score of up to 200 points for each site (Pre-2008 P51 habitat metrics were scored on a different scale). Sites scoring less than 56 are considered to be Poor, those scoring between 56 and 104 are Marginal, between 105 and 154 points are Good, and sites scoring over 154 are Excellent. Individual metrics are often used to describe conditions directly affecting the biological community, while overall score describes the general environment at the site.

The Mid-Michigan Environmental Action Council (Mid-MEAC) collected macroinvertebrate samples bi-annually from 2006 to 2012 in six subwatersheds following the MiCorps Volunteer Stream Monitoring Procedures manual (Latimore, 2006). Through simple calculations using the macroinvertebrates found, volunteers calculated a stream score. A score of 49 or higher is an indicator of excellent water quality, 34-48 is good quality, 19-33 is fair quality, and 0-18 is poor quality. More information about this methodology can be found at: http://www.micorps.net./streamresources.html.

The biological assessments of the Red Cedar River indicate that the river, in large part, harbors a diverse community of fish and aquatic insects. Latimore (2005) found diverse fish assemblages near the MSU campus in 2001-2003, with a total of 31 fish species found, representing 11 different families. A large number of macroinvertebrate studies conducted by MSU, MDEQ and Mid-MEAC indicate that, with few exceptions, sampling stations throughout the watershed contain Acceptable communities. Chapter Four of this WMP provides more detail about the aquatic biota within each of the subwatersheds.

Windshield Survey

As part of this planning project, in 2012 and 2013, the watershed was surveyed by driving and collecting data about land use practices and conditions (the methodology is included in Appendix D). In the rural areas, each road was driven, land uses were observed and estimates of the number of large farm animals in each subwatershed were recorded. Smaller livestock such as chickens were not measured as their relative contributions of waste and ultimately *E. coli* to the watershed are considered to be smaller than that of larger livestock. In the urban areas, due to high density and the large number of roads, a general overview was conducted by driving a random pattern of roads and observing the various types of neighborhoods and land use patterns. Each basic "type" of neighborhood, based upon age and size of the homes, size of the parcels, etc. was identified for further inspection using the Unified Subwatershed and Site Reconnaissance guidance, specific to the neighborhood source assessment field sheets and methodology (Center for Watershed Protection, 2005).

The windshield survey found a diversity of land uses in the more rural settings. A large number of farms were located and documented, many of which are small acreages with few animals, where homes and farms are mixed with woodlots, wetlands and other natural areas. In general, the larger farms, which presumably operate as income generators, are noticeably different in that the density of animals is higher and the fields are more intensely managed for crop production. In those locations, there are fewer fence rows, cropland is maintained closer to the edges of roads and streams/drains, and wetlands, forests and other natural areas are fewer in number.

Wetlands

MDEQ analyzed wetland data for the watershed in a landscape level functional wetland assessment (LLFWA) in order to understand wetland trends. Table 3.6 summarizes the percentage of wetland acreage lost in the watershed. Comparing the land from pre-settlement to 2005, on average each subwatershed went from approximately 4,800 acres of wetlands to 2,095 acres of wetlands (MDEQ, 2012b). The Dietz and Sycamore Creek subwatersheds lost the most wetland acreage, with losses around 80% of their original wetlands. Handy-Howell Drain and Handy Drain No. 5 and subwatersheds lost the least amount of wetlands, with 24% and 31% of their original wetlands lost, respectively (MDEQ, 2012b). A copy of the LLFWA is included in Appendix E.

Table 3.6 Red Cedar River Watershed Wetland Resources Status and Trends (MDEQ, 2012b)

Subwatershed	Presettlement Wetland Acreage	2005 Wetland Acreage	Lost Acres	% Wetland Loss
Dietz Creek	4,126	862	3,264	80
Sycamore Creek	6,684	1,429	5,255	79
Red Cedar River	5,185	1,398	3,787	74
Kalamink Creek	4,461	1,234	3,227	73
Headwaters Sycamore Creek	10,306	3,013	7,293	70
Sloan Creek	3,196	1,023	2,173	68
Deer Creek	3,551	1,310	2,241	64
Doan Creek	3,301	1,243	2,058	63
Hayhoe Drain- Doan Creek	3,665	1,509	2,156	59
Coon Creek	4,839	2,077	2,762	58
Mud Creek	6,298	2,875	3,423	55
Wolf Creek	5,025	2,458	2,567	52
Squaw Creek	3,229	1,610	1,619	50
West Branch Red Cedar	4,909	2,790	2,119	44
Pine Lake Outlet	4,828	2,910	1,918	40
Headwaters West Branch	4,596	2,759	1,837	40
Middle Branch Red Cedar	5,912	3,958	1,954	34
Handy Drain No. 5	3,738	2,598	1,140	31
Handy-Howell Drain	3,606	2,743	863	24

Potential Conservation Areas

High quality areas in the watershed contribute to improved ecological watershed health. With watershed efforts meant to prevent ecological degradation, these high quality areas should be conserved. A Potential Conservation Areas (PCA) Assessment was completed by the Michigan Natural Features Inventory (MNFI) in 2008 in Ingham County (Paskus and Enander, 2008). PCAs were defined as “places on the landscape dominated by native vegetation that have various levels of potential for harboring high quality natural areas and unique natural features”. Using land cover data, pre-settlement vegetation maps, and the MNFI database of rare species, this assessment was meant to identify the last remaining areas of native ecosystems, natural plant communities and scenic qualities. Based upon several criteria determined to be important indicators of ecological health, such as total size of a natural area, landscape connectivity, vegetation quality and more, each PCA was ranked on a scale of 1 to 45.

Other Data Analyzed by Subwatershed

In order to assess the subwatersheds for *E. coli* concerns, known, suspected and potential sources of *E. coli* were identified. The number of septic systems was estimated by acquiring an estimated number of drinking water wells. Assuming each household with a drinking water well also uses an onsite septic system, a percentage was calculated for failing septic systems, using a failure percentage of 26%, which is based upon recent studies completed by the Barry-Eaton District Health Department (2011). Dog populations were estimated using each subwatershed’s census population, assuming that 37.2 percent of households have 1.7 dogs each (AVMA, 2007 as cited in MDEQ, 2012c). The percentages of land use types were calculated using the 2006 Coastal Change Analysis Program (C-CAP) dataset to understand which sources were the primary contributors of *E. coli* and other pollutants in each subwatershed (NOAA, 2008). An approximate population of livestock was collected through a windshield survey. Suspected areas of pollutant sources were collected from stakeholders and from a windshield survey. Data collected were used to generalize conditions within the subwatersheds. Data summaries are provided for each subwatershed in Chapter Four.

4. DESCRIPTION OF RED CEDAR RIVER SUBWATERSHEDS

This chapter highlights information specific to each of the nineteen HUC-12 subwatersheds in the Red Cedar River Watershed (RCRW). The information presented here is based upon data collected for this study and from results of previous studies. The emphasis of the data collection for this planning event was to address the *Escherichia coli (E. coli)* Total Maximum Daily Load (TMDL). Due to the size of the watershed, the different jurisdictional boundaries, and the multitude of stakeholders with varying interests, some areas have more data available than others.

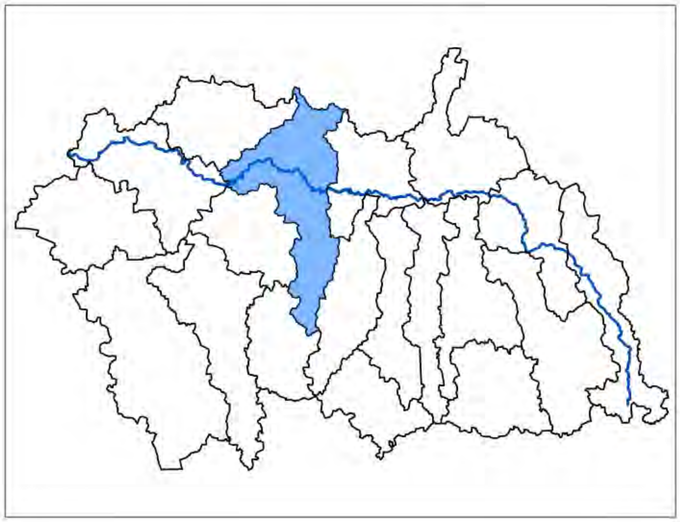
Data described below details characteristics of each subwatershed, which includes census, land use and practices, farm animal, biology, High Impact Targeting (HIT) modeling, water chemistry and *E. coli*, and wetlands data. Furthermore, Table 4.1 provides a summary of pollutant loadings for each subwatershed. Also included are individual maps highlighting the location of each subwatershed and the mainstem of the Red Cedar River. This chapter is meant to provide more detail than the watershed summary information provided in Chapter Three.

Table 4.1 Pollutant Loadings by Subwatershed

	Streambank Erosion (NPS Inventory)			Livestock Access (NPS Inventory)			HIT Modeling (cropland)				
HUC 12 Subwatershed Name	**Sediment Loading*** (tons/yr)	**Phosphorus Loading*** (lbs/yr)	**Nitrogen Loading*** (lbs/yr)	**Sediment Loading*** (tons/yr)	**Phosphorus Loading*** (lbs/yr)	**Nitrogen Loading*** (lbs/yr)	**Sediment Loading** (tons/yr)	**Phosphorus Loading** (lbs/yr) (using 0.85 as correction factor for sand)	**Nitrogen Loading** (lbs/yr) (using 0.85 as correction factor for sand)	**Phosphorus Loading** (lbs/yr) (using 1.15 for correction factor for silt)	**Nitrogen Loading** (lbs/yr) (using correction factor 1.15 for silt)
Coon Creek							826	0.35	0.70	0.41	0.83
Deer Creek							720	0.31	0.61	0.36	0.72
Dietz Creek	403	403	806				796	0.34	0.68	0.40	0.80
Doan Creek				55	55	110	843	0.36	0.72	0.42	0.84
Handy Drain No. 5							456	0.19	0.39	0.23	0.46
Handy Howell Drain							568	0.24	0.48	0.28	0.57
Hayhoe Drain - Doan Creek				20	20	40	744	0.32	0.63	0.37	0.74
Headwaters Sycamore Creek							1,975	0.84	1.68	0.99	1.98
Headwaters West Branch Red Cedar River							382	0.16	0.32	0.19	0.38
Kalamink Creek							430	0.18	0.37	0.22	0.43
Middle Branch Red Cedar River							922	0.39	0.78	0.46	0.92
Mud Creek							1,171	0.50	1.00	0.59	1.17
Pine Lake Outlet							178	0.08	0.15	0.09	0.18
Red Cedar River	405	405	810				287	0.12	0.24	0.14	0.29
Sloan Creek							644	0.27	0.55	0.32	0.64
Squaw Creek							559	0.24	0.48	0.28	0.56
Sycamore Creek							150	0.06	0.13	0.08	0.15
West Branch Red Cedar River							611	0.26	0.52	0.31	0.61
Wolf Creek				5	5	10	539	0.23	0.46	0.27	0.54
TOTAL	**808**	**808**	**1,616**	**80**	**80**	**160**	**12,801**	**5.44**	**10.88**	**6.40**	**12.80**

Source:** ***Pollutants controlled calculation and documentation for Section 319 Watersheds Training Manual (MDEQ, 1999b)

4.1 Coon Creek



The Coon Creek subwatershed (HUC 040500040503) is the second-largest in the greater RCRW, encompassing a land area of 33.1 square miles surrounding the west side of the City of Williamston (MDTMB, 2012). Interestingly, in addition to Coon Creek, the subwatershed contains five other direct tributaries to the Red Cedar River, which enter from both the north and south sides of the Red Cedar River, including the lower portion of Deer Creek on the south side. The main stem of Coon Creek is about 3.5 miles long and flows south to its confluence with the Red Cedar River. There are nearly 54 miles of stream channel in this subwatershed.

<u>TMDL</u>
Coon Creek has an established TMDL for *E. coli* contamination, covering 26 miles of stream channel (AUID 04050040503-03).

<u>Census and Land Use</u>
According to the 2010 Census, about 7,615 people live in this subwatershed, at a density of 230 people per square mile (MDTMB, 2012). Though there are no complete records of septic systems installed, well records were used in estimating the number of septic systems in each subwatershed. It was assumed that houses with wells also have a septic system. An estimated 1,257 homes are served by septic systems (MDTMB, 2012). The 2006 Coastal Change Analysis Program (C-CAP) database of land cover indicates that land use within the watershed is as follows: 35% agriculture, 24% shrubland and grassland that can include grazing, 15% forest, 13% developed, and 12% wetland (NOAA, 2008).

<u>Biology</u>
The Mid-Michigan Environmental Action Council (Mid-MEAC) collected macroinvertebrates from a small tributary that flows into the Red Cedar River just west of Williamston (Mid-MEAC, 2012). Based on the MiCorps protocol (http://www.micorps.net./streamresources.html), riffles, cobbles, pools, woody debris, leaf packs and runs are present at this site, providing good habitat for macroinvertebrates. As discussed in Chapter Three, a score of 49 or higher is an indicator of excellent water quality, 34-48 is good quality, 19-33 is fair quality, and 0-18 is poor quality. Notably, this site received the highest score ever documented by Mid-MEAC, 79 (Excellent), in the spring of 2008. More recently, stream scores have remained around 40 (Good). The lowest score ever recorded at this site was a 24.1 (Fair) in the fall of 2012. No possible explanation is given as to why the site scores continue to decline.

<u>Erosion Assessment</u>
Deer Creek was identified during the windshield survey and in the stakeholder involvement process as potentially having excessive streambank erosion. As such, a detailed walking assessment of the stream (see Appendix D for methodology) was completed between Clark and Holt Roads, a distance of about 3.7 miles. Excessive streambank erosion was identified in the following areas:

- Six distinct locations between Clark and Waldo Roads. Excessive streambank erosion is contributing an annual sediment load of about 36 tons.
- Nearly all outer bends are excessively eroded from Frost Road downstream for about 4,000 feet, with moderate to severe erosion. Excessive streambank erosion is contributing an annual sediment load of about 360 tons.
- Four distinct locations upstream of Frost Road, though most were minor. Excessive streambank erosion is contributing an annual sediment load of about 7 tons.

Farm Animal Survey
A windshield survey (see Appendix D for methodology) conducted as part of this planning project indicates that there are approximately 18 residences or facilities in this subwatershed that house livestock. An estimated 110 cows, 93 horses and six sheep were counted. There are an estimated six large animals per square mile of land, and an average of 12 large animals at each farm. This is one of the lowest densities of large animals in the RCRW. The number of large animals per farm ranged from two to 50, with a cattle herd of approximately 50 animals being the largest operation.

HIT
The HIT model, developed by the Michigan State University (MSU) Institute of Water Research, estimates annual erosion and sediment loading. The model uses inputs from the Revised Universal Soil Loss Equation (RUSLE) and Spatially Explicit Delivery Model (SEDMOD) models to determine how much sediment loading is coming off agricultural lands that are adjacent to streams (O'Neil, 2010). Sediment loading in tons/acre/year was calculated using HIT for each subwatershed. Coon Creek is predicted to have an annual sediment loading of 0.039 tons/acre and is ranked 11th out of the 19 subwatersheds (MSU IWR, 2009). This equates to a total subwatershed load of 826 tons of sediment per year coming from overland sources.

Water Chemistry/*E. coli*
Livingston County Health Department (LCHD) and Ingham and Livingston County Drain Commissioners conducted *E. coli* monitoring at six locations in this subwatershed in 2000 and 2001, half of which were located in tributaries and the other half located on the main stem. The average of the two-year sampling results ranged from below 300 to above 600 cfu/100 mL (LCHD et al., 2001).

Historic concentrations of nutrients were measured from a southern and northern tributary in this subwatershed (LCHD et al., 2001). In the southern tributary, ammonia as nitrogen had a 13-week average concentration of 0.048 mg/L in 2001, which is higher than the median concentration for the Southern Michigan/Northern Indiana Drift Plains (SMNIDP) Ecoregion of 0.042 mg N/L (Lungdren, 1994 as cited in MDEQ, 2013a). The ortho-phosphorus concentration had a 12-week average concentration of 0.189 mg/L (LCHD et al., 2001). In the northern tributary, the 12-week average ammonia as nitrogen concentration was 0.06, which is also higher than the Ecoregion concentration. The 12-week average ortho-phosphorus concentration averaged at 0.1 mg/L (LCHD et al., 2001).

2012 *E. coli* monitoring was completed on one tributary south of the Red Cedar River as part of this planning project by the RCRW management team. These data were summarized in Chapter Three and are available in Appendix C. It should be noted that 2013 was a very rainy summer while 2012 was a very dry summer. The southern tributary had a relatively low four-week geometric mean of 408 cfu/100 mL with two weeks exceeding the Total Body Contact (TBC) standard and one week exceeding the Partial Body Contact (PBC) standard. In this subwatershed, the Red Cedar River has also been monitored along the main stem by the Ingham County Health Department (ICHD) in recent years. A review of ICHD data from 2009-2012 indicate that the summer geomeans of the sample locations were just below and above 300 cfu/100 mL, with about half of the sample results exceeding the TBC standard and few samples exceeding the PBC standard each summer (ICHD, 2012). Sampling conducted in 2009 by the Michigan Department of Environmental Quality (MDEQ) showed that higher *E. coli* concentrations were present following rainfall in only two of four weeks where significant rainfall occurred in this subwatershed. In addition, sampling by MDEQ along the main stem of the Red Cedar River evidenced a declining *E. coli* concentration trend leading into the Coon Creek subwatershed, and found that the lowest *E. coli* concentration was measured in this subwatershed as compared to other sampled locations on the Red Cedar River in other subwatersheds. However, there's an increasing trend flowing downstream of Coon Creek (MDEQ, 2012c).

Microbial source tracking completed by the RCRW management team in this subwatershed for one day during the summer of 2013 and found bovine sources present at one sample site and bovine and human sources present at another sample site. 2013 *E. coli* monitoring was completed on two tributaries on the north side of the Red Cedar River main branch by Ingham Conservation District (ICD). The ten-week geometric means (geomean) at these tributaries were 1,781 and over 1,158 cfu/100 mL, with over half of the weeks exceeding the TBC and PBC standards of 300 and 1,000 cfu/100 mL respectively (ICD, 2013). 2013 *E. coli* monitoring conducted by the ICHD (2013) in one location on the main branch of the Red Cedar River and had a 22-week summer geomean of 216 cfu/100 mL, with six weeks exceeding the TBC standard of 300 cfu/100 mL and one week exceeding the PBC standard. One suspected source is overflow septic systems in two areas of this subwatershed, as reported at stakeholder meetings.

Wetlands

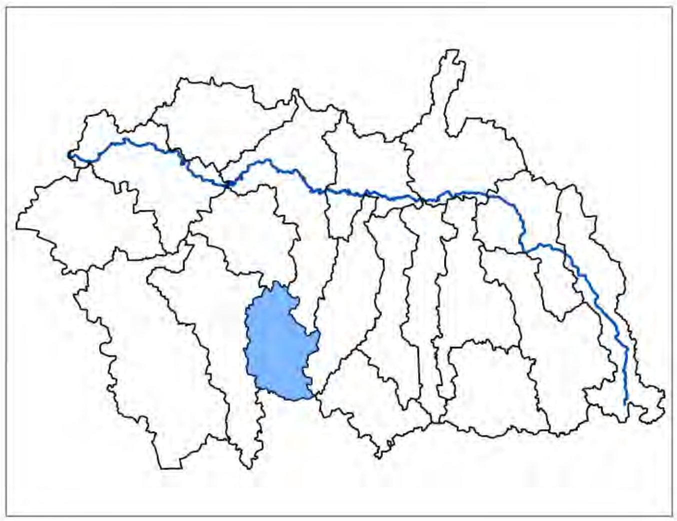
According to MDEQ (2012b), the Coon Creek subwatershed contains about 2,077 acres of wetland, which is roughly 42% of the 4,839 acres estimated to exist during pre-settlement times. The average size of individual wetlands has decreased by almost 60%, from 15 acres to 8.7 acres. This information is summarized for all subwatersheds in Table 3.6 in Chapter Three.

Potential Conservation Areas

Based upon the Potential Conservation Areas Assessment completed by Michigan Natural Features Inventory (MNFI) (Paskus and Enander, 2008), and discussed in Chapter Three of this watershed management plan (WMP), 3,718 acres within the Coon Creek subwatershed are listed as areas for conservation. Of these 3,718 acres, 1,751 acres are listed as High (score of 10-14) or Highest (score of 15-31) Priority.

4.2 Deer Creek

The Deer Creek subwatershed (HUC 040500040501), located northwest of the Village of Dansville, is 16.3 square miles in size and the second-smallest of the subwatersheds in the RCRW. The lower portion of Deer Creek is actually considered to fall within the Coon Creek subwatershed, and all of the Deer Creek subwatershed discharges into the Coon Creek subwatershed. From its headwaters to its confluence with the Red Cedar River, Deer Creek is over 12 miles long (MDTMB, 2012). Headwater tributaries include the Robinson, Brown, and Miller Drains. In total, there are about 20 miles of stream channel in this subwatershed.



Census and Land Use

The 2010 Census indicated that this subwatershed is home to about 1,635 people (MDTMB, 2012), living at a density of 100 people per square mile. An estimated 271 homes are serviced by septic systems in the Deer Creek subwatershed (MDTMB, 2012). Agriculture accounts for 53% of the total land use in the Deer Creek subwatershed. The remaining land use is 18% shrubland and grassland, which includes grazing, 12% forest, 11% wetland, and 5% developed (NOAA, 2008).

Biology

In 2001, Deer Creek was found to be impacted by dredging and snagging (log removal) activities (MDEQ, 2003). Using P51, the habitat was rated as Fair (moderately impaired), and the macroinvertebrate community was found to be Acceptable.

Farm Animal Survey

Windshield survey results indicate that a relatively low density of livestock resides in this subwatershed. An estimated 53 cows, 76 horses and about 20 sheep and alpacas were found at roughly 24 separate farms, with a density of nine animals per square mile and six animals per farm. Farms here, on average, housed the smallest number of animals per farm (one to 20) in the RCRW.

HIT
According to the HIT model, Deer Creek had the second highest estimated annual sediment load/acre out of all nineteen subwatersheds. The model predicts that the subwatershed contributes 0.069 tons of sediment loading/acre/year (MSU IWR, 2009). An estimated 720 tons of sediment enters the waterways each year from overland sources in this subwatershed.

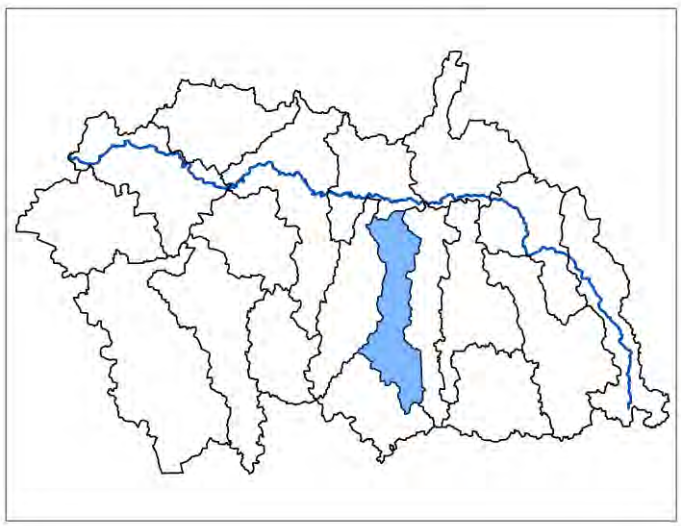
Water Chemistry/*E. coli*
E. coli monitoring was completed by the ICD in 2013. The ten-week geometric mean in this subwatershed was 1,474 cfu/100 mL, with all weeks exceeding the TBC standard and six weeks exceeding the PBC (ICD, 2013).

No nutrient monitoring has been conducted in this subwatershed. However, monitoring on Deer Creek has taken place downstream within the Coon Creek subwatershed, and it can be assumed that this subwatershed is contributing to the elevated levels of ammonia as nitrogen and ortho-phosphorus.

Wetlands
The Deer Creek subwatershed contains about 1,310 acres of wetland compared to 3,551 acres that existed during pre-settlement times (MDEQ, 2012b). In addition to this 64% decline, the average size of individual wetlands has decreased from 18 acres to six acres.

Potential Conservation Areas
About 1,690 acres within the Deer Creek subwatershed are listed as areas for conservation. Of these 1,690 acres, only 155 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.3 Dietz Creek
The Dietz Creek subwatershed (HUC 040500040409) is 18.3 square miles in size and contains about 19 miles of stream channel (MDTMB, 2012). Dietz Creek is about 10 miles long and enters Doan Creek about 1.5 miles southeast of the City of Williamston in eastern Ingham County. The Wilson and Millville Drains are the primary tributaries of Dietz Creek. Dietz Creek discharges into Doan Creek before entering the Red Cedar River.



TMDL
Nineteen miles of Dietz Creek are included in an *E. coli* TMDL (AUID 04050040409-01).

Census and Land Use
About 1,382 people live in the Dietz Creek subwatershed, at a density of 75 people per square mile, according to the 2010 Census (MDTMB, 2012). This is the second-lowest human density in the RCRW. About 138 septic systems are thought to exist in this subwatershed (MDTMB, 2012). Agriculture comprises the majority of land use in the subwatershed at 65%. The remaining land use is as follows: 16% shrubland and grassland, including grazing, 6% forested, 6% wetland, 6% developed (NOAA, 2008).

Biology
MDEQ (2013a) assessed the macroinvertebrate community and habitat at Dietz Road in 2011. The macroinvertebrate community scored in the Acceptable range (-3), while habitat was found to be Marginal (moderately impaired). As discussed in Chapter Three, macroinvertebrate communities are scored on a scale of -9 to 9; -9 to -5 is rated as Poor, -4 to 4 is rated as Acceptable, and anything greater than 4 is rated as Excellent. Nineteen macroinvertebrate taxa were found in Dietz Creek though the sample was dominated by scuds and other tolerant organisms.

Farm Animal Survey

Dietz Creek was found to have a high density of large animals, about 33 per square mile of land. A total of 604 large animals were observed, including 497 cows, 87 horses and 20 sheep. Fifteen farms were counted, with an average of 40 large animals per farm. The largest facility has an estimated 200 cows and appears to be expanding. The smallest farm observed housed three horses.

HIT

Sediment loading in Dietz Creek is estimated at 0.068 tons/acre/year according to the HIT model (MSU IWR, 2009). This is the third highest sediment loading rate for subwatersheds in the RCRW. An estimated 796 tons of sediment per year erodes from agricultural overland sources in this subwatershed. It should be noted that since the HIT model only accounts for sheet erosion coming off agricultural lands, estimated sediment loads will likely be higher in rural subwatersheds (O'Neil, 2010).

Water Chemistry/*E. coli*

Historic sampling in this subwatershed had average *E. coli* concentrations of around 500 cfu/100 mL (LCHD et al, 2001).

E. coli monitoring conducted in 2012 by the RCRW management team resulted in a four-week geomean of 1,206 cfu/100 mL. All four weeks had concentrations exceeding the TBC standard and two weeks exceeded the PBC standard.

Microbial source tracking conducted by the RCRW management team for one day in 2013 determined that bovine and equine sources of waste are present at the downstream portion of the subwatershed.

Wetlands

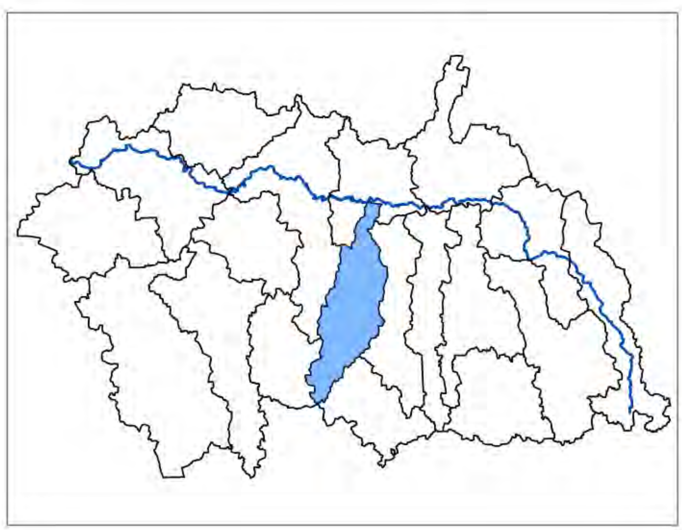
The Dietz Creek subwatershed has lost a greater percentage of wetlands than any other subwatershed in the greater RCRW. Of the estimated 4,126 acres of pre-settlement wetlands, only 862 acres (20%) remain today (MDEQ, 2012b). The average size of individual wetlands has also decreased dramatically, from 22 acres to 3.4 acres.

Potential Conservation Areas

About 1,197 acres within the Dietz Creek subwatershed are listed as areas for conservation. Of these 1,197 acres, only 203 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.4 Doan Creek

The Doan Creek subwatershed (HUC 040500040410) drains 20.9 square miles of land southeast of the City of Williamston and northeast of the Village of Dansville (MDTMB, 2012). The Hayhoe Drain is a primary tributary near the headwaters of the creek, and Dietz Creek is a major tributary that enters Doan about 1.5 miles upstream of its confluence with the Red Cedar River. The Marshall Wilcox, Francis and Mullen Drains are other tributaries. In total, Doan Creek is about 18 miles long, including the portion of stream located in the Hayhoe Drain – Doan Creek subwatershed (MDTMB, 2012). A total of 24 miles of stream channel are contained within the subwatershed boundaries.



TMDL

An *E. coli* TMDL exists for Doan Creek (AUID 04050040410-01). Based on the MDEQ Water Quality and Pollution Control in Michigan Sections 303(d), 305(b), and 314 Integrated Report (2014 draft), 23 miles of Doan Creek are included in the TMDL.

Census and Land Use

The 2010 Census determined that an estimated 1,850 people reside in this subwatershed, at a density of 89 people per square mile (MDTMB, 2012). Septic systems serve 328 homes for wastewater treatment (MDTMB, 2012). Doan Creek is another subwatershed in which is predominantly agricultural. Land use is as follows in the subwatershed: 50% agriculture, 27% shrubland and grassland, including grazing, 9% wetland, 8% forested, and 6% developed (NOAA, 2008).

Biology

MDNR (1992) rated Doan Creek as Fair and found that sediment was negatively affecting habitat and contributing to reduced fish and macroinvertebrate populations. Macroinvertebrate communities in Doan Creek at Holt Road were ranked Poor in 1996, as did the fish community due to less than 50 individuals being captured (MDEQ, 1999a). However, Doan Creek was sampled in four locations in a 2006 survey and macroinvertebrate communities scored Acceptable at all sites (MDEQ, 2009 rev.).

Farm Animal Survey

Windshield survey results indicated about 975 large animals, 854 of which are cows, are in this subwatershed, equating to approximately 47 animals per square mile of land. These animals are housed at 21 facilities, with a density of 46 large animals per farm, ranging from three cows at the smallest to an estimated 600 cows at the largest. The Car Min Vu dairy farm, with an estimated herd size of 100 cows, is currently expanding and in the process of going through the concentrated animal feeding operation (CAFO) permitting process. At another site, ten cows were observed in the stream and bank erosion was substantial, contributing an estimated 55 tons of sediment per year to the stream.

HIT

The HIT model estimates that Doan Creek subwatershed contributes 0.063 tons of sediment/acre/year (MSU IWR, 2009). This is the fourth highest sediment loading rate out of all nineteen subwatersheds, and results in an estimated annual load of 843 tons of sediment from agricultural overland sources.

Water Chemistry/*E. coli*

Two historic nutrient samples were collected in this subwatershed in 2001, which measured contributions of nutrients to tributaries from both Doan and Dietz subwatersheds. A 13-week average of ammonia as nitrogen was measured around 0.05 mg/L, which is greater than the Ecoregion mean concentration of 0.042 mg N/L (Lungdren, 1994 as cited in MDEQ, 2013a). A 12-week average of ortho-phosphorus was around 0.06 mg/L.

Historical monitoring from 2000 and 2001 had average *E. coli* concentrations of around 450 cfu/100 mL (LCHD et al., 2001).

Monitoring conducted by the MDEQ in 2009 had an *E. coli* 16-week geometric mean of roughly 1,000 cfu/100 mL. All weeks exceeded the TBC standard and half of the weeks exceeded the PBC standard. It should be recalled that this monitoring site included the Dietz Creek and Hayhoe Drain-Doan Creek subwatersheds as tributaries (MDEQ, 2012c).

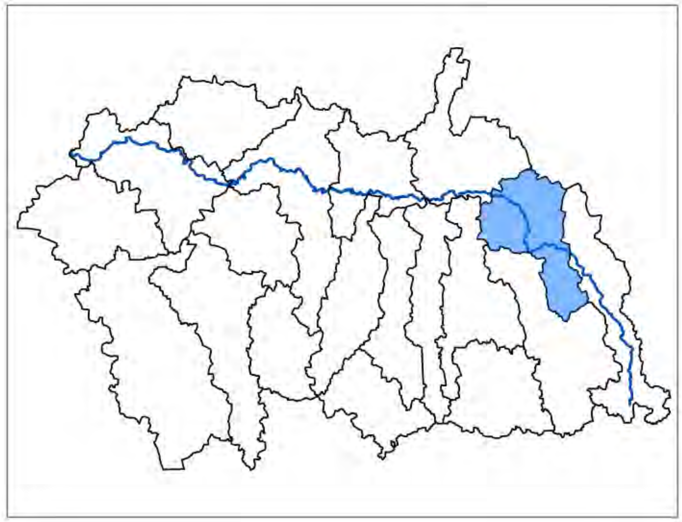
Four weeks of *E. coli* monitoring in 2012 by the RCRW management team resulted in a geometric mean of 640 cfu/100 mL. All four weeks exceeded the TBC standard and zero weeks exceeded the PBC standard.

Microbial source tracking completed for one day in 2013 by the RCRW management team found bovine and equine sources of waste present at the downstream portion of the subwatershed.

Wetlands
Of the 3,301 acres of wetland historically found within this subwatershed, 1,243 acres (37%) still remain, according to MDEQ (2012b). Average size of individual wetlands has also decreased over time, from 17 acres down to 5.6 acres.

Potential Conservation Areas
About 2,016 acres within the Doan Creek subwatershed are listed as areas for conservation. Of this acreage, 1,182 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.5 Handy Drain No. 5



The Handy Drain No. 5 subwatershed (HUC 040500040403) is bisected by I-96, and contains 21.6 square miles of land, including the Village of Fowlerville. There are approximately 31.4 miles of stream channel, including the Red Cedar River and a primary tributary, the Handy Iosco Drain No. 1 (MDTMB, 2012).

TMDL
Based on the MDEQ Water Quality and Pollution Control in Michigan Sections 303(d), 305(b), and 314 Integrated Report (2014 draft), 15 miles of stream channel are impaired for *E. coli* and are included in the TMDL (AUID040500040403-02).

Census and Land Use
An estimated 6,153 people live in this subwatershed, at a density of 285 people per square mile (MDTMB, 2012). It is estimated that there are 428 homes served by septic systems (MDTMB, 2012). Approximately 33% of this subwatershed is comprised of agricultural land. The remaining land is shrubland and grassland including grazing (24%), developed (18%), wetland (16%) and forested (8%) (NOAA, 2008).

Biology
MDEQ conducted studies near the Hoover Ball Bearing plant near Fowlerville, where negative impacts to the river had been documented. MDNR (1992) reported that contaminated sediments were adversely affecting macroinvertebrate communities downstream of the plant. Based on a 2001 survey, MDEQ (2003) found the fish and macroinvertebrate communities to be Acceptable both up and downstream of the facility.

HIT
The HIT model estimates that this subwatershed annually contributes 0.033 tons of sediment per acre (MSU IWR, 2009). The Handy Drain No. 5 subwatershed has a relatively lower rate of sediment loading compared to others and ranks fifteen out of nineteen. About 456 tons of sediment erodes from agricultural overland sources on an annual basis.

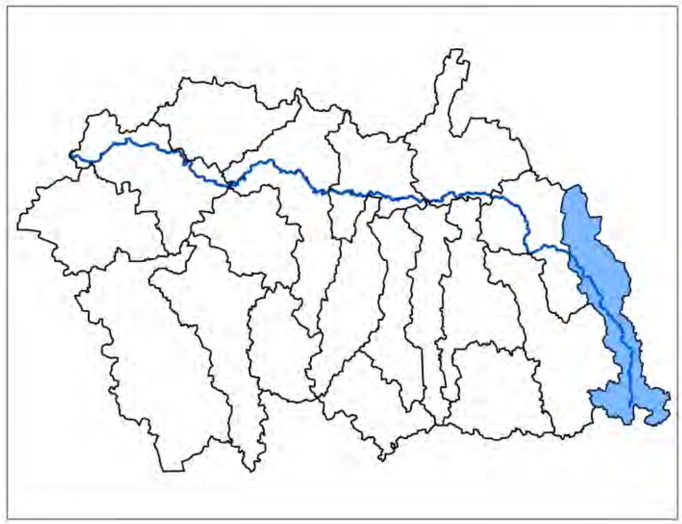
Water Chemistry/*E. coli*
Nutrient concentrations were measured on a tributary and along the Red Cedar River in this subwatershed in 2001 (LCHD et al., 2001). Twelve-week average concentrations for ammonia as nitrogen were approximately 0.1 and 0.2 mg/L, and are much higher than the regional mean of 0.042 mg N/L (Lungdren, 1994 as cited in MDEQ, 2013a). On average, ortho-phosphorous concentrations were 0.04 mg/L (LCHD et al., 2001).

MDEQ (2003) found that water samples had elevated levels of magnesium, nickel, arsenic and zinc downstream of the Hoover facility; however, no exceedances of Water Quality Standards (WQS) were documented.

Historic *E. coli* sampling from 2000 and 2001 had two sites with average summer geometric mean concentration less than the TBC standard, 300 cfu/100 mL, and one site with an average summer geomean just over 500 cfu/100 mL (LCHD et al., 2001).

<u>Wetlands</u>
According to MDEQ (2012b), the Handy Drain No. 5 subwatershed contains 2,598 acres of the 3,738 acres of wetland found during pre-settlement times, a reduction of 31%. This is the second-smallest wetland loss of the Red Cedar River subwatersheds. The average size of individual wetlands, however, has decreased from 16 acres to 6.8 acres.

4.6 Handy Howell Drain
The Handy Howell Drain subwatershed (HUC 040500040401) drains 24 square miles of land in western Livingston County, just west of the City of Howell. This is the eastern-most subwatershed in the RCRW and essentially contains the headwaters of the main branch of the Red Cedar River, at Cedar Lake. The Handy-Howell Drain flows south to its confluence with the Red Cedar River, near I-96. The subwatershed contains almost 47 miles of stream channel (MDTMB, 2012).



<u>TMDL</u>
Based on the MDEQ Water Quality and Pollution Control in Michigan Sections 303(d), 305(b), and 314 Integrated Report (2014 draft), 21 miles of stream channel are impaired for *E. coli* and have been added to the TMDL (AUID040500040401-02).

<u>Census and Land Use</u>
According to the 2010 Census, the Handy Howell subwatershed is home to 5,604 people (MDTMB, 2012), living at a density of 234 per square mile. About 619 septic systems are estimated to be in this subwatershed (MDTMB, 2012). Land use within this subwatershed is mixed. Approximately 27% is shrubland and grassland including grazing, 22% agriculture, 17% forested, 17% wetland, 14% developed, and 2% open water (NOAA, 2008).

<u>Farm Animal Survey</u>
The Handy Howell Drain subwatershed contains one of the lowest densities of large animals in the entire RCRW. Only 123 animals were counted at 13 farms, for an overall density of five animals per square mile and nine animals per farm. There are about 64 cows, 58 horses and one camel living in this area. The largest farm contains around 30 head of cattle.

<u>HIT</u>
This subwatershed is estimated to contribute 0.037 tons of sediment/acre annually (MSU IWR, 2009). It has the 13th lowest sediment loading rate compared to all 19 subwatersheds. An estimated 568 tons of sediment originates from agricultural overland sources in the subwatershed each year.

Water Chemistry/*E. coli*
Historic nutrient concentrations were measured in this subwatershed in 2001. Ammonia as nitrogen had a 12-week average concentration of 0.1 mg/L, which is greater than the Ecoregion mean concentrations of 0.042 mg N/L (Lungdren, 1994 as cited in MDEQ, 2013a).

Historic *E. coli* monitoring in this subwatershed conducted in 2000 and 2001 had a two-year average concentration of less than 300 cfu/100 mL (LCHD et al., 2001).

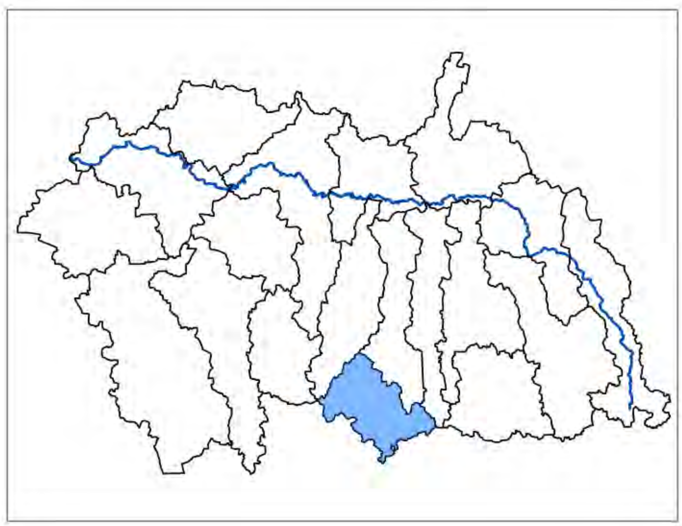
Results from four weeks of sampling in 2012 by the RCRW management team showed a geometric mean of 1,085 cfu/100 mL with all weeks exceeding the TBC standard and three weeks exceeding the PBC standard.

Human sources of waste were present in this subwatershed, according to microbial source tracking conducted for one day in 2013 by the RCRW management team. Bovine sources of *E. coli* were found at the furthest downstream portion of the Handy Howell subwatershed.

Stakeholders reported that in some areas of this subwatershed, older septic systems may possibly be a source of *E. coli* if they are not properly maintained.

Wetlands
This subwatershed has experienced the smallest proportional loss of the historic wetlands in the RCRW. About 76% of the original 3,606 acres still exist today (MDEQ, 2012b). Average size of individual wetlands is about 9.4 acres, compared to 22 acres during pre-settlement times.

4.7 Hayhoe Drain – Doan Creek



This subwatershed (HUC 040500040408) is the smallest in the RCRW, encompassing 15.7 square miles of land southeast of the Village of Dansville. This subwatershed contains over 24 miles of stream channel, including the headwaters of Doan Creek and the Hayhoe and Patrick Drains (MDTMB, 2012).

Census and Land Use
Around 1,144 people live in this subwatershed (MDTMB, 2012), at a density of 73 per square mile, the lowest of all of the Red Cedar River subwatersheds. It is estimated that there are about 207 homes serviced by septic systems (MDTMB, 2012). Land in this subwatershed is predominantly used for agriculture (45%). The remaining land use is as follows: 25% shrubland and grassland, including grazing uses, 15% wetlands, 9% forest, 5% developed (NOAA, 2008).

Biology
In 2011, MDEQ assessed the macroinvertebrate community and physical habitat at Swan Road (MDEQ, 2013a). Macroinvertebrates were found to be Acceptable (-1), while habitat was considered Marginal (72) and received the lowest score of the 24 sites sampled during the 2011 study. The stream was straight with little to no riparian buffers and the bed was heavily impacted by sedimentation.

Farm Animal Survey
Results of the windshield survey indicate that 233 cows, 73 horses and ten goats and llamas live in this subwatershed. These numbers equate to 20 large animals per square mile and 21 per farm. The 15

farms noted in the survey house between one and 200 animals each. One site was identified in which several cows and horses have access to a stream within their pasture.

HIT

According to the HIT model, this subwatershed has the highest sediment loading rate compared to any of other subwatershed in the RCRW. The model estimates that 0.074 tons of sediment loading per acre annually come from this subwatershed, for a total annual load of 744 tons (MSU IWR, 2009).

Water Chemistry/*E. coli*

Historic *E. coli* sampling from 2000 and 2001 had average concentrations just over 400 cfu/100 mL (LCHD et al., 2001).

2013 *E. coli* monitoring was completed by the ICD. The ten-week geometric mean in this subwatershed was 1,315 cfu/100 mL, with all weeks exceeding the TBC standard and seven weeks exceeding the PBC standard (ICD, 2013).

Wetlands

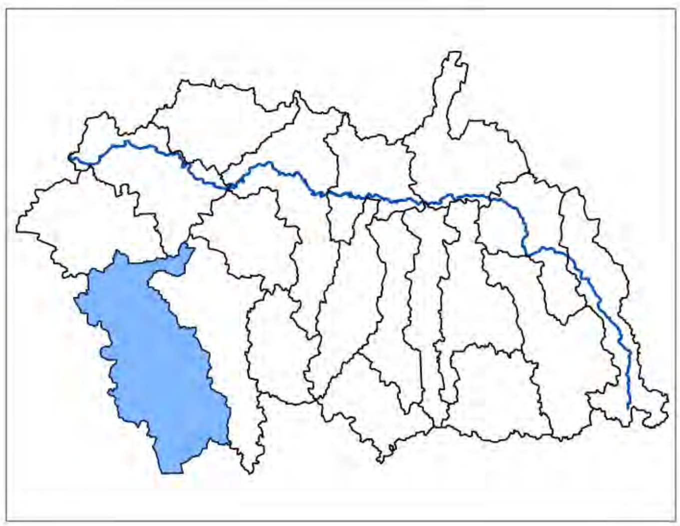
The Hayhoe Drain subwatershed has lost 59% of the historic wetlands, from 3,665 acres during pre-settlement times to 1,509 acres today (MDEQ, 2012b). Average wetland size has also decreased, from 16 acres to 6.2 acres.

Potential Conservation Areas

About 2,240 acres within this subwatershed are listed as areas for conservation. Of this acreage, 1,497 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.8 Headwaters Sycamore Creek

The Headwaters Sycamore Creek subwatershed (HUC 040500040506) is the southwestern-most and largest in the RCRW. The subwatershed contains almost 66 miles of stream channel, is 49 square miles in size, lies entirely within Ingham County and encompasses most of the City of Mason (MDTMB, 2012). Sycamore Creek begins near the southern tip of the subwatershed and flows north through the City of Mason. Tributaries include Willow Creek and the Aurelius-Veva, Talmadge, Hazelton and Cook and Thorburn Drains. Sycamore Creek has historically been impacted by channelization, sediment and stormwater runoff.



TMDL

An *E. coli* TMDL has been established for Sycamore Creek. Based on data in the 2014 draft MDEQ Integrated Report, 42 miles of Sycamore Creek, Willow Creek and the Cook and Thorburn Drain are included in the TMDL (AUIDs 040500040506-01, 040500040506-03, 040500040506-04).

Due to historically low dissolved oxygen (DO) violations, the warmwater fishery designated use for a portion of this subwatershed (AUIDs ranging between 040500040505-507), is listed as impaired on the Section 303(d) list (MDEQ, 2013b).

Census and Land Use

About 16,068 people live in this subwatershed (MDTMB, 2012), at a density of 328 people per square mile. Approximately 1,159 homes rely on septic systems as a means of wastewater treatment (MDTMB, 2012). Land use in the subwatershed is as follows: 38% agriculture, 24% shrubland and grassland, including grazing, 22% developed, 8% wetland, and 6% forest (NOAA, 2008).

Biology

A 2009 WMP for the Cook and Thorburn Drain included macroinvertebrate and physical habitat sampling results; seven out of eight sampling sites were considered to be Acceptable based upon P51 (Spicer Group & Wetland and Coastal Services, 2009). One site was found to have a Poor macroinvertebrate score; however, the site was located on an open channel at the outlet of a storm sewer from a residential neighborhood which likely contributed to the poor score. Two sites were listed as having degraded habitat due to sedimentation and channel straightening.

In 1996, MDEQ conducted a survey of the macroinvertebrate communities within Willow Creek, and the sites scored Poor (MDEQ, 1999a). The sites were also found to have a Poor macroinvertebrate score in 2006, while the warmwater fish community was found to be Acceptable. MDEQ (2009 rev.) also found the fish community on Sycamore Creek, downstream of the Mason Waste Water Treatment Plant (WWTP), to be Acceptable and the fish community of Talmadge Creek to be Poor.

In 1999, a 319 watershed implementation project was conducted for the Sycamore Creek watershed. Specifically, the effort focused implementing best management practices (BMPs) in the Willow Creek subwatershed. According to post-project monitoring results, total suspended solids (TSS) decreased by 60% and total phosphorus decreased by 57% the year following construction (Spooner et al, 2011 as cited in MDEQ, 2013a). The results of a biological survey in 2008 indicated an Acceptable warmwater fish community (-4) and Poor macroinvertebrate scores at both Toles and Kipp Roads (MDEQ, 2009 rev.). Follow-up macroinvertebrate sampling was conducted in 2011 by MDEQ at these sites to continue assessment of BMP performance related to water quality and habitat improvements (MDEQ, 2013a). Results indicated that the macroinvertebrate score at Kipp Road improved from -6 (Poor) to -2 (Acceptable) and the score at Toles Road improved from -3 (Acceptable) to -1 (Acceptable). Although the habitat score decreased at Kipp Road between the sampling events due to increased bank erosion, the site's sinuosity and pool variation slightly improved.

MDEQ sampled the fish community at Rolfe Road in 2011 (MDEQ, 2013a), which scored -3 (Acceptable). This site had few taxa (8 total). The most numerous species in the sample were creek chub and blacknose dace. At this site, Sycamore Creek exhibited greater natural channel morphology channelized.

Farm Animal Survey

An estimated 1,794 large animals were observed in this subwatershed, including 1,687 cows and 107 horses. Large animal density is 37 per square mile. A total of 31 farms hold an average of 58 animals, ranging from one horse to over 600 cows. Four locations were identified that contained at least 100 cows. All four of these facilities are located within one half mile of a stream or drain.

HIT

The Headwaters Sycamore Creek subwatershed is estimated to contribute 0.063 tons of sediment loading per acre per year, for an annual load of 1,975 tons (MSU IWR, 2009). This subwatershed has the fifth highest sediment loading rate out of all subwatersheds in the RCRW.

Water Chemistry/*E. coli*

In 2011 the MDEQ sampled this subwatershed in three locations for nutrient concentrations (MDEQ, 2013a). Ortho-phosphate concentrations were between 0.027 to 0.081 mg/L. Total phosphorus concentrations ranged from 0.035-0.135 mg/L, above the statewide median concentration of 0.032 mg/L, calculated by MDEQ's Water Chemistry Program (Roush, 2013 as cited in MDEQ, 2013a). High total dissolved solids (TDS) concentrations ranging from 510-560 mg/L were also measured (MDEQ, 2013a). While the WQS for TDS is set based on impacts from point sources it still can provide a useful number for comparison to understand the quality of the water. The measured concentration is above the monthly average acceptable concentration of 500 mg/L, but lower than the WQS set for a single data point of 750 mg/L instantaneous concentration. Total Kjeldahl nitrogen concentrations of 0.47 to 0.86 mg/L were measured (MDEQ, 2013a) and are above the ambient water quality criteria recommendations from the U.S. Environmental Protection Agency (EPA) for Ecoregion 7 (US EPA, 2000).

In 2013, eight weeks of DO measurements were taken in the morning and at night at three locations in this subwatershed. Two samples had DO concentrations below 5 mg/L (4.95 and 4.89 mg/L) on Willow Creek. Both measurements were collected in the morning.

Four historic 2000 and 2001 sampling sites in this subwatershed had average *E. coli* concentrations from below 300 to nearly 500 cfu/100 mL (LCHD et al., 2001).

E. coli sampling was conducted by the ICHD in 2009 to 2012 at two sampling locations. Results showed that *E. coli* concentrations from over 500 cfu/100 mL to around 1,000 cfu/100 mL. The majority of weeks exceeded the TBC standard and typically five to 10 weeks exceeded the PBC standard (ICHD, 2012).

Delhi Township has done sampling in this subwatershed. Summer geomeans for *E. coli* largely varied from less than 200 cfu/100 mL to over 800 cfu/100 mL in 2012 and 2011 (Delhi Charter Township, 2012).

Samples were collected from each tributary in 2012, Willow Creek, Sycamore Creek, and the County Drain by the RCRW management team. The Sycamore Creek tributary had a four-week *E. coli* geomean less than the TBC standard. The Willow Creek and County Drain tributaries had *E. coli* geomeans over 700 cfu/100 mL.

2013 *E. coli* monitoring by the ICHD was completed in two locations on the creek and had 22-week summer geomeans of 694 and 942 cfu/100 mL, with 19 and 22 weeks exceeding the TBC standard and 6 and 9 weeks exceeding the PBC standard (ICHD, 2013).

Microbial source tracking was completed in 2013 by the RCRW management team in all three tributaries of the subwatershed: Willow Creek, Sycamore Creek, and the County Drain. Human, bovine, and equine sources of waste were detected in Willow Creek and the Drain. Bovine and equine sources of waste were detected in Sycamore Creek.

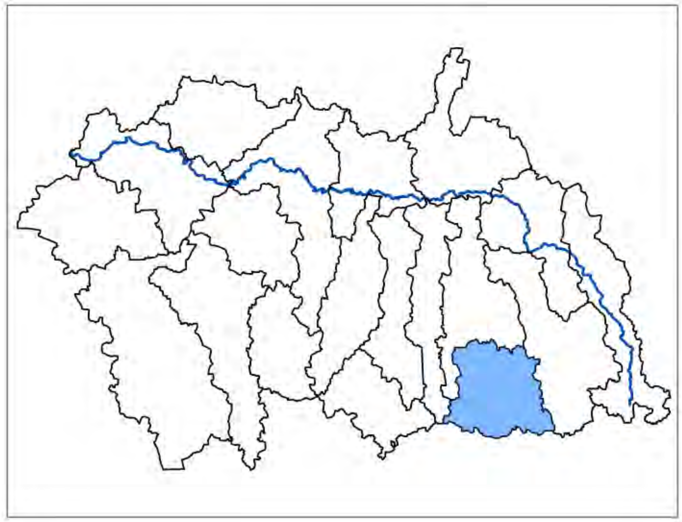
<u>Wetlands</u>
According to MDEQ (2012b), the Headwaters Sycamore Creek subwatershed contains about 3,000 acres of wetland; this number represents a loss of 70% of the wetland that were historically present (10,306 acres) in this area. In addition to the overall loss, the average size of individual wetlands has decreased from 19 acres to 4.5 acres.

<u>Potential Conservation Areas</u>
About 3,584 acres within this subwatershed are listed as areas for conservation. Of these 3,584 acreas, 1,091 are listed as High or Highest Priority (Paskus and Enander, 2008).

4.9 Headwaters West Branch Red Cedar River
This subwatershed (040500040404) is 20.6 square miles in size, contains over 33 miles of stream channel (MDTMB, 2012), and is located primarily in Livingston County. Lameroux Lake is located in the northeast corner of this subwatershed. Iosco Drain No. 2 is the primary tributary in Livingston County and joins the West Branch of the Red Cedar River at the northern boundary of this subwatershed, between Iosco and Odell Roads.

<u>Census and Land Use</u>
According to the 2010 Census, this subwatershed is home to 2,075 people (MDTMB, 2012), living at a density of 101 people per square mile. It is estimated that about 249 septic systems exist at homes within this subwatershed (MDTMB, 2012). The majority of this subwatershed is agricultural land (30%) and shrubland and grassland, including grazing (31%). The remaining land use make-up is wetlands (20%), forest (14%), and developed (5%) (NOAA, 2008).

Biology
Mid-MEAC has sampled a site on Kane Road near the intersection of M-36 since 2005 (Mid-MEAC, 2012). While the area is mainly agricultural, the site is buffered by trees and has vegetated riparian zone. Substrate at the site was noted to be “muddy”. This site typically receives a lower stream score than other Mid-MEAC sites. Sampling in the fall of 2012 resulted in a stream score of 12.6 (Poor), which is the lowest ever recorded at this site. The highest score recorded at this site was 38 (Good) in the fall of 2011.



Farm Animal Survey
The Headwaters West Branch Red Cedar River subwatershed is dominated by small, hobby-type farms. A total of 18 farms were counted with an average size of 26 large animals. However, 300 of the 463 large animals in this subwatershed were found at one location. If this farm is removed from the calculation, the average number of animals at the other 17 farms is only 10. Of the 463 animals, 386 are cows, 57 are horses and the remainder are donkeys and sheep. The average number of large animals per square mile is 22.

HIT
The HIT model estimates that the Headwaters West Branch Red Cedar River subwatershed contributes roughly 0.029 tons of sediment loading per acre per year, for a total loading of 382 tons of sediment per year (MSU IWR, 2009). This subwatershed has the fourth lowest sediment loading rate out of all nineteen subwatersheds.

Water Chemistry/*E. coli*
No recent *E. coli* data has been collected in this subwatershed. Historic *E. coli* sampling from 2000 and 2001 collected just downstream of this subwatershed had average concentrations of just over 500 cfu/100 mL (LCHD et al., 2001).

Historic nutrient data for this subwatershed is available from 2001. The 12-week ammonia as nitrogen average concentration was 0.07 mg/L, higher than the mean Ecoregion concentration of 0.042 mg N/L (Lungdren, 1994 as cited in MDEQ, 2013a). The ortho-phosphorus average concentration was 0.03 mg/L, while the total phosphorus concentration was 0.02 mg/L (LCHD et al., 2001).

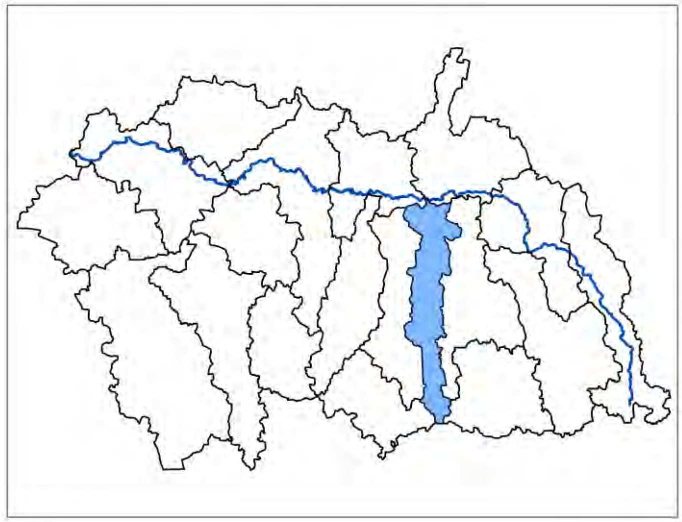
Wetlands
The Headwaters West Branch Red Cedar subwatershed has lost about 40% of the historic 4,596 acres of wetland (MDEQ, 2012b). The remaining 2,759 acres of wetland are, on average (six acres), about one-third the size of the historic wetlands (17 acres).

Potential Conservation Areas
About 625 acres within this subwatershed are listed as areas for conservation. Of these 625 acres, 244 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.10 Kalamink Creek
Kalamink Creek (HUC 040500040406) originates as an outlet from Burden Lake along the eastern border of Ingham County and joins the Red Cedar River near Webberville. The subwatershed contains 17.7 square miles of land and almost 24 miles of stream channel (MDTMB, 2012). Tributaries include Wolter, Stowes, Searles, Monroe and Leach, Holland and Donal Drains.

TMDL

MDEQ ranked this subwatershed as a top priority subgroup in the TMDL area based on their stressor analysis (MDEQ, 2012c). Based on data in the 2014 draft MDEQ Integrated Report, 21 miles of stream channel are impaired for *E. coli* and are included in the TMDL. (AUID 040500040406-01).



Census and Land Use

The Kalamink Creek subwatershed contains about 1,363 people, living at a density of 77 people per square mile, according to the 2010 Census (MDTMB, 2012). About 172 septic systems are known to exist in this subwatershed (MDTMB, 2012). Land use is predominantly agricultural at 50%. The remaining land is shrublands and grasslands, including grazing (20%), developed (11%), forested (9%) and comprised of wetland (10%) (NOAA, 2008).

Biology

In 1991, “good” numbers of macroinvertebrates and fish were found at the creek (MDNR, 1992). Fifteen macroinvertebrate families were documented during the survey. The macroinvertebrate community substantially declined in 2001, when MDEQ only documented four families of insects (MDEQ, 2003). This resulted in a Poor score for the macroinvertebrate community. Factors contributing to the Poor score included a lack of stable habitat and the homogenous nature of the channel.

Mid-MEAC has sampled a site on Kalamink Creek, near the intersection of Elm and Van Orden Roads, south of Webberville since the fall of 2006 (Mid-MEAC, 2012). This wooded area is near the Alchin Farm Cemetery and provides shade to stream. The stream, which has a very muddy substrate, has an abundance of branches and logs that are suitable habitats for some macroinvertebrates. Stream scores have fluctuated but steadily declined. This site received its lowest score ever in the fall of 2012, an 18.4 (Poor).

Farm Animal Survey

The Kalamink Creek subwatershed contains 213 large animals, including about 196 cows, 15 horses and two donkeys. There are 12 animals per square mile and nine farms, with an average of 24 animals per farm. The smallest farms have two animals, while the largest has about 50 cows. One site was identified where a herd of 40 to 50 cattle are grazed on pasture adjacent a stream channel.

HIT

This subwatershed is predicted to contribute 0.038 tons of sediment loading per acre per year by the HIT model (MSU IWR, 2009). An estimated 430 tons of sediment erodes from agricultural overland sources on an annual basis. The subwatershed ranks 12 out of 19 in terms of sediment loading rate for subwatersheds in the RCRW.

Water Chemistry/*E. coli*

Nutrient data was collected in this subwatershed in 2001. Ammonia as nitrogen had a summer 12-week average concentration of 0.07 mg/L, higher than the mean in the Ecoregion of 0.042 mg N/L (Lungdren, 1994 as cited in MDEQ, 2013a). On average the ortho-phosphorus concentration was 0.14 mg/L, while total phosphorus had an average measured concentration of 0.04 mg/L. This is higher than the median statewide total phosphorus concentration of 0.032 mg/L (Roush, 2013 as cited in MDEQ, 2013a; LCHD et al., 2001).

Historic *E. coli* sampling from 2000-2001 was done in Kalamink Creek subwatershed in two locations. The locations had average concentrations of nearly 500 cfu/100 mL and just over 1,000 cfu/100 mL (LCHD et al, 2001).

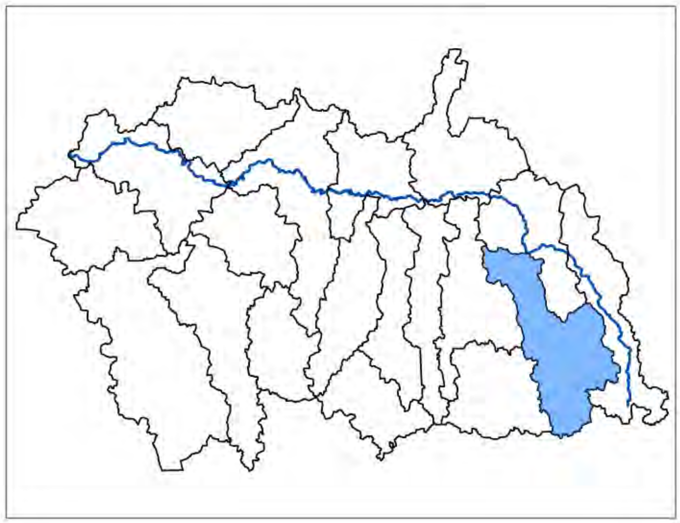
E. coli sampling conducted by the RCRW management team in 2012 over four weeks in the Kalamink Creek subwatershed had an *E. coli* geometric mean just over 400 cfu/100 mL; three weeks exceeded the TBC standard and zero weeks exceeded the PBC standard.

Wetlands
According to MDEQ (2012b) Kalamink Creek contains about 1,234 acres of wetland, a 73% reduction from the 4,461 acres that were historically present. The average size of individual wetlands decreased from 17 acres to 5.2 acres.

Potential Conservation Areas
About 1,751 acres within the Kalamink Creek subwatershed are listed as areas for conservation, of which 476 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.11 Middle Branch Red Cedar River

The Middle Branch of the Red Cedar River subwatershed (HUC 040500040402) is located in western Livingston County. The river flows north and joins the main branch of the Red Cedar River about one half mile south of the Village of Fowlerville and I-96. The subwatershed contains 30 square miles of land and over 50 miles of stream channel (MDTMB, 2012). The headwaters are heavily modified into a geometric drainage network. The major tributary of the Middle Branch is the Marion Iosco Drain.



TMDL
Based on data in the 2014 draft MDEQ Integrated Report, 11 miles of stream channel are impaired for *E. coli* and are included in the TMDL (AUID 040500040402-01).

Census and Land Use
The Middle Branch has a human population of about 4,195 (MDTMB, 2012), living at a density of about 140 people per square mile. About 629 homes are serviced by septic systems (MDTMB, 2012). It is a largely rural subwatershed, with 32% shrubland and grassland, including grazing, 29% of its land in agricultural cover, 17% wetland, 15% forest, and 6% developed (NOAA, 2008).

Biology
Results from a 1991 MDEQ biological survey found the habitat and macroinvertebrate community to be Poor in this subwatershed (MDNR, 1992). The biggest contributing factor for the Poor scores was cited as heavy silt loads from agriculture. Muck deposits were noted to be two to four feet thick.

A site at Sargent Road was surveyed in 2001, and large deposits of fine sediment and silt were found to be negatively affecting the stream habitat (MDEQ, 2003). Macroinvertebrate habitat was limited to sweeping vegetation found on the banks, and no hard substrates were documented. Furthermore, dredging and straightening of the channel had occurred. Stream habitat was rated as Fair (moderately impaired). Tolerant and surface dependent species comprised the macroinvertebrate community. No caddisflies were found and very few mayflies were documented.

In 2011, MDEQ sampled macroinvertebrates at Munsell Road and Mason Road (MDEQ, 2013a). Macroinvertebrates scored Poor (-5) at Mason Road and Acceptable (-4) at Munsell Road. Both sites had channel widths around 20 feet and aquatic vegetation (e.g., *Sparganium*) was present. At Mason Road, the stream was more channelized than at Munsell Road, where the stream had some meanders and a more natural morphology. Both sites were limited in available stable substrate for macroinvertebrate habitat.

Farm Animal Survey
Results of the windshield survey indicate that there are about 498 large animals scattered throughout this subwatershed, including 319 cows, 99 horses, 140 pigs, goats, sheep and donkeys. Animal density was calculated at 19 large animals per square mile. About 40 farms house an average of 14 animals. The smallest farms have one or two animals, while the largest has about 150 cows.

HIT
The Middle Branch Red Cedar River subwatershed is estimated to contribute 0.048 tons of sediment loading per acre per year, according to the HIT model (MSU IWR, 2009). This equates to 922 tons of sediment per year. It ranks 8 out of 19 in terms of sediment loading rate.

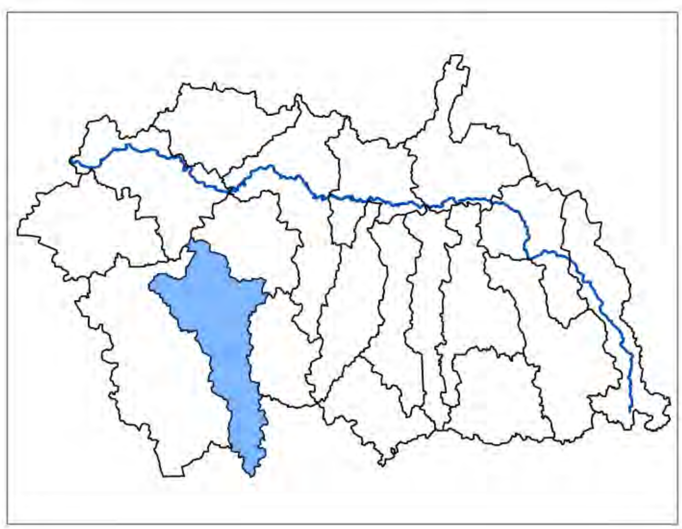
Water Chemistry/*E. coli*
The nutrient contributions to the watershed from the Middle Branch subwatershed were measured in 2001. Ammonia as nitrogen had a 12-week average concentration of 0.11 mg/L, higher than the mean concentrations for the Ecoregion of 0.042 mg N/L (Lungdren, 1994 as cited in MDEQ, 2013a). Ortho-phosphorus had an average concentration of 0.04 mg/L (LCHD et al., 2001).

Historic *E. coli* sampling from 2000 and 2001 in two locations had average summer geometric mean concentrations less than the TBC standard, 300 cfu/100 mL and just over that standard (LCHD et al., 2001).

Four week sampling in 2012 by the RCRW management team had an *E. coli* geometric mean concentration of nearly 1,000 cfu/100 mL. All samples exceeded the TBC standard, and half of the samples exceeded the PBC standard.

Wetlands
This subwatershed has lost a relatively small portion (34%) of its historic wetland area (MDEQ, 2012b). An estimated 3,958 acres of wetland still exist, though the average wetland size has decreased from 25 acres to 8.3 acres.

4.12 Mud Creek



Mud Creek is located east of, and contains a small portion of, the City of Mason. The subwatershed (HUC 040500040505) is 31 square miles in size and has about 36 miles of stream channel (MDTMB, 2012). The main branch of Mud Creek is nearly 11 miles long. Mud Creek joins Sycamore Creek about two miles north of the City of Mason.

TMDL
Mud Creek is included in the proposed TMDL for DO, as indicated by data in the 2014 draft MDEQ Integrated Report (AUID 040500040505-01).

Census and Land Use
According to the 2010 Census, the human population in this subwatershed is 4,594 (MDTMB, 2012), with a density of 148 per square mile. About 654 homes are serviced by septic systems (MDTMB, 2012). Land

within the subwatershed is predominantly used for agriculture (38%). The remaining land use is as follows: 28% shrubland and grassland, including grazing, 14% forest, 13% wetland, and 6% developed (NOAA, 2008).

Biology
In 2011, MDEQ conducted fish surveys at Okemos Road. The fish community scored +3 (Acceptable). Fifty percent of the sample comprised of sunfish, and 11 taxa were documented. Interestingly, a 25-inch northern pike was captured during the survey (MDEQ, 2013b). It was noted that the stream at this site had a straight channel, steep banks, and no tree canopy.

Farm Animal Survey
The Mud Creek subwatershed has an estimated 684 large animals, most of which are cows (590). There are also 66 horses and 28 donkeys, llamas, sheep and goats. There are about 22 large animals per square mile. About 32 farms house an average of 21 animals each. The smallest farms have one or two animals, while the largest has about 300 cows. Most of the farms are small, hobby-type operations with one to ten animals.

HIT
The HIT model estimates that 0.059 tons of sediment loading per acre per year come from the Mud Creek subwatershed, for a total annual loading of 1,171 tons (MSU IWR, 2009). Mud Creek has the sixth highest estimated sediment loading rate.

Water Chemistry/*E. coli*
Nutrient data were measured in one location in Mud Creek in 2011 by the MDEQ (2013a). Nitrogen as ammonia was measured at 0.052 mg/L. Nitrogen as total Kjeldahl nitrogen was measured at 0.76 mg/L. TDS were measured at 510 mg/L and did not exceed the 750 mg/L instantaneous concentration WQS for point sources, but are above the monthly average acceptable concentration of 500 milligrams per liter. Ortho-phosphate as phosphorous was measured as 0.029 mg/L, and total phosphorus was measured as 0.047 mg/L. Total phosphorus is above the statewide calculated median concentration of 0.032 mg/L, determined by MDEQ's Water Chemistry Program (Roush, 2013 as cited in MDEQ, 2013a).

As noted earlier, Mud Creek is included in the proposed TMDL for DO. In 2013, six days of DO data were collected twice a day by the MDEQ (MDEQ, 2013b). This monitoring had four days of DO results below 5 mg/L. Results below 5 mg/L were collected in the morning.

Historic average *E. coli* concentrations of the Mud Creek subwatershed from 2000-2001 were just under 400 cfu/100 mL (LCHD et al., 2001).

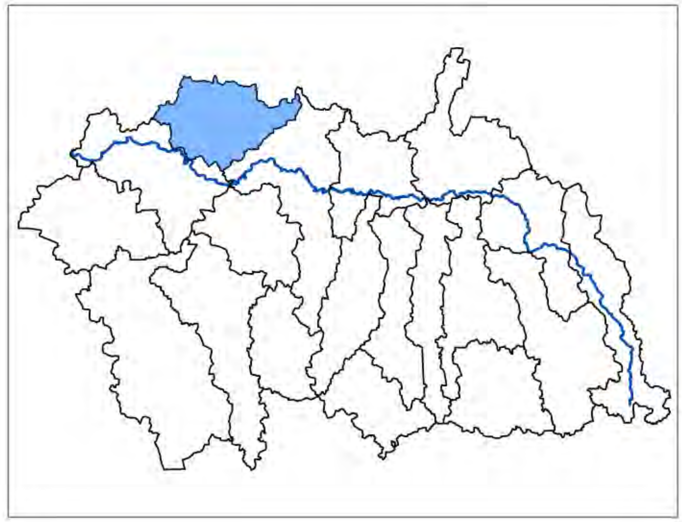
Microbial source tracking data collected by the RCRW management team in 2013 for one day indicated that bovine sources of *E. coli* are present in the subwatershed. *E. coli* sampling was completed in 2013 by the ICD. The ten-week *E. coli* geometric mean concentration upstream in the subwatershed was 1,012 cfu/100 mL and the geometric mean concentration downstream in the subwatershed was 734 cfu/100 mL. In both locations, nine weeks exceeded the TBC standard and two and five weeks exceeded the PBC standard respectively (ICD, 2013).

There are suspected overflow septics in the subwatershed, as reported by stakeholders.

Wetlands
During pre-settlement times, an estimated 6,298 acres of wetland existed in the Mud Creek subwatershed (MDEQ, 2012b). Today, about 2,875 (45%) acres remain. Average wetland size has decreased from 18 acres to six acres.

Potential Conservation Areas
About 4,187 acres within the Mud Creek subwatershed are listed as areas for conservation, of which 1,500 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.13 Pine Lake Outlet



The Pine Lake Outlet subwatershed (HUC 040500040504) is located east of, and contains a small portion of, the City of East Lansing. The subwatershed encompasses 21.4 square miles and Lake Lansing, the largest lake in the RCRW (MDTMB, 2012). The western half of the subwatershed is dominated by residential housing, commercial development and other urban land use. The eastern half is relatively rural in nature.

Census and Land Use

The Pine Lake Outlet subwatershed is home to 21,862 people (MDTMB, 2012), living at a density of 1,020 people per square mile. It is estimated that about 755 septic systems exist in this subwatershed (MDTMB, 2012). Land use within this subwatershed is fairly mixed, with 42% developed, 23% comprised of wetland, 13% forested, 10% shrubland and grassland, including grazing, 9% use for agriculture, and 4% open water (NOAA, 2008).

This subwatershed has a high density of people relative to other areas within the RCRW, however, vegetated banks are found throughout the subwatershed and development tends to be set-back from the creek (MDEQ, 2013a). Due to a large amount of impervious surfaces and a high-density population, storm sewers are believed to contribute nonpoint source pollution and increase flashiness to the outlet. MDEQ (2013a) found that the exceptionally low gradient of the channel has periodically caused the main stem of the Red Cedar River to backup into the Pine Lake Outlet.

Biology

In 2011, MDEQ surveyed macroinvertebrate populations upstream of Okemos Road in the Pine Lake Outlet subwatershed, which scored Poor (-5) (MDEQ, 2013a). About two-thirds of the sample consisted of more tolerant macroinvertebrates: *Oligochaeta* (segmented worms) and *Amphopoda* (scuds). The sample did not include any mayflies. While habitat was scored Good, sedimentation and flashiness were noted as issues of concern. The site did exhibit stable streambanks and high quality riparian vegetative zones. The channel was also incised as a result of past channelization. According to MDEQ (2013a), this site likely exhibited characteristics of a wetland prior to channelization.

Farm Animal Survey

Based upon the windshield survey, it is estimated that 226 large animals are kept in this subwatershed. All animals were observed in the eastern half of the subwatershed and included 200 cows, 24 horses and two donkeys. Animal density was calculated at 11 per square mile. Only seven farms were observed; one farm has about 200 cows, while all other farms are small with one to ten animals. One riding stable was identified and appears to house at least ten horses.

HIT

According to the HIT model, this subwatershed contributes 0.013 tons of sediment loading per acre per year, for a total annual load of 178 tons of sediment (MSU IWR, 2009). It ranks as having the second lowest sediment loading out of all nineteen subwatersheds. It should be noted that the HIT model only estimates sheet erosion coming off agricultural lands. Given that this subwatershed is predominantly developed, a large percentage of the sediment load may not be accounted for by the HIT model.

Water Chemistry/*E. coli*

Nutrient contributions from the Pine Lake Outlet were measured in 2001. Ammonia as nitrogen had a 12-week average of 0.15 mg/L, which is greater than the mean concentration for the Ecoregion of 0.042 mg

N/L (Lungdren, 1994 as cited in MDEQ, 2013a). Ortho-phosphorus had an average concentration of 0.2 mg/L. The average TSS concentration was around 7 mg/L (LCHD et al., 2001).

Data near the confluence of the Pine Lake Outlet with the Red Cedar River have been collected by the ICHD. Data from 2009-2012 at this location typically had geometric means between 300 and 360 cfu/100 mL. On average, half of the weeks exceeded the TBC standard and a few weeks typically exceeded the PBC standard (ICHD, 2012).

No recent *E. coli* monitoring has been done in this subwatershed, with the exception of the beach monitoring at Lake Lansing. No values were reported high enough in 2013 to warrant a beach closure (MDEQ, 2013d).

Wetlands

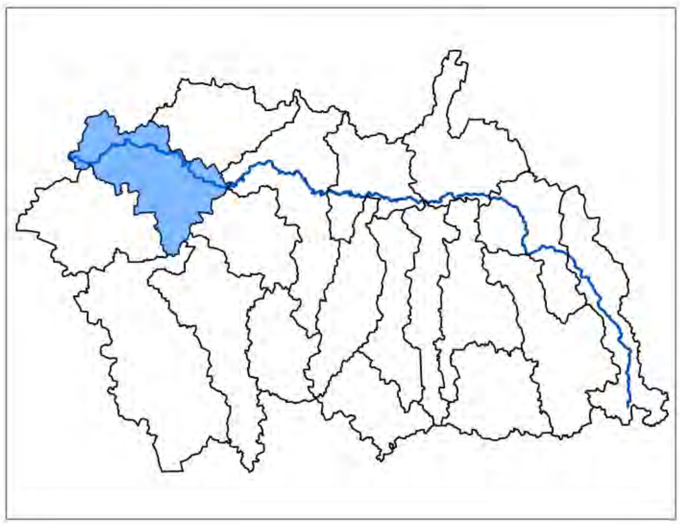
This subwatershed still has about 60% of its historic wetlands, with over 2,900 acres remaining (MDEQ, 2012b). The average wetland size, however, has decreased from 13 acres to about 5.3 acres.

Potential Conservation Areas

About 3,218 acres within this subwatershed are listed as areas for conservation, of which 990 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.14 Red Cedar River

The Red Cedar River subwatershed (HUC 040500040508) contains 28 square miles including much of the City of East Lansing and a small portion of the City of Lansing, as well as MSU and the City of Okemos (MDTMB, 2012). Furthermore, all of the MSU agricultural operations and livestock facilities are located within the subwatershed boundaries. The Red Cedar River flows through this subwatershed, from east to west, and picks up the tributaries of Herron Creek and Smith Drain. Montgomery Drain also enters the Red Cedar River south of the Frandor Shopping Center; this drain is said to contribute polluted water to the river.



TMDL

This subwatershed includes 18 miles of the Red Cedar River that are covered under an *E. coli* TMDL (AUID 040500040508-03). Based on draft 2014 data, an additional 2 miles from AUID 040500040508-02 are included in the TMDL. MDEQ ranked this subwatershed as a top priority subgroup in the TMDL area based on their stressor analysis (MDEQ, 2012c).

A TMDL for DO has been drafted for this subwatershed (AUID 040500040508-02) by the MDEQ (2013b).

Census and Land Use

This is the most densely populated subwatershed in the RCRW area, with 63,433 people (MDTMB, 2012) living at a density of 2,263 per square mile. The majority of these people rely on sanitary sewer, but 461 homes are known to use septic systems (MDTMB, 2012). According to NOAA (2008), 64% of land in the subwatershed is developed, 11% is grassland and shrubland for uses including grazing, 10% is used for agriculture, 7% is forested and 7% is wetland, and 1% is open water.

Biology

Between 2001 and 2003, Latimore (2005) sampled fish and macroinvertebrate communities at several stations along the Red Cedar River near the campus of MSU. A total of 31 species of fish, representing

11 families were documented, with the large majority of the specimens consisting of bluegill, green sunfish and rock bass. In addition to the 31 species listed, common carp and coho and chinook salmon are also known to occur in the river, at least on a seasonal basis. Macroinvertebrates were sampled at 20 stations and all except two were found to be Acceptable based upon P51 scoring criteria; the remaining two sites, above Hagadorn Road and above the dam, were found to be Poor in August 2001. Latimore also noted that a survey of the mussel community on campus was undertaken in 2001 by David Stagliano and Pete Badra of the MNFI. A rich mussel fauna was reported, including several uncommon species.

Since 2006, Mid-MEAC has sampled a site at the mouth of a tributary to the Red Cedar River near the intersection of Dobie and Kinawa Roads in Okemos (Mid-MEAC, 2012). A variety of aquatic habitats were found here, including riffles, runs, woody debris, cobble and pools. The stream score has declined in recent years from a high of 43. In the fall or 2012, a stream score of 22 was recorded.

Mid-MEAC (2012) also sampled two sites on the Red Cedar River near the Frandor Shopping Center for the first time in 2012. One of these sites was located upstream of the Montgomery Drain. This section of the Red Cedar was found to offer a variety of habitats including woody debris from downed trees, cobble, riffles and aquatic plants, but some channelization is present. Gravel and silt comprise the substrate material. This site received a score of 19, which is on the very low end of Fair. Downstream of the Montgomery Drain, the Red Cedar is narrower and shallower than at the upstream site. At this site, woody debris and riffles were present. The outer bank was eroding and the inner berm consisted of gravel. Sand and gravel make up the majority of the substrate. The lowest recorded score of all eight 2012 Mid-MEAC sites was recorded here, an 8 (Poor).

In 2011, MDEQ (2013a) surveyed two locations on the mainstem of the Red Cedar River at Kalamazoo Avenue and Dobie Road. Macroinvertebrate scores were +3 and +4 (both Acceptable). Habitat scores were similar at both sites; the Dobie Road site scored 100 (Marginal) and the Kalamazoo site scored 108 (Good).

As noted earlier, a TMDL for DO is being drafted for this subwatershed (MDEQ (2013b). The Red Cedar River did not attain acceptable DO concentrations in the Lansing area in ten out of 14 sample dates in 2012. Morning DO concentrations were typically lower than evening concentrations.

Erosion Assessment

A 2007 report, “Natural Areas – 2006 River Bank Stabilization Study”, was completed on the MSU campus from Harrison Road upstream to Bogue Street, by Hamilton Anderson Associates, Inc. Of the approximately 8,200 feet of stream assessed (16,400 including both banks), about 5,000 total feet of streambank was determined to be “high priority” for stabilization, indicating severe bank erosion (HAA, 2007). Therefore, for purposes of this WMP, the 2006 data were used to make load calculations, using MDEQ guidance (1999b rev.). The 5,000’ stretch was given an erosion rate of 0.3 feet per year with an estimated average bank height of six feet and soil weight of 0.045 tons/ft^3 to compute an annual loading of 405 tons of sediment per year.

Farm Animal Survey

No farms were identified within the subwatershed boundaries, with exception of those facilities operated by MSU. The animal population includes about 800 cows, 125 horses and 880 pigs and sheep, according to the MDEQ-issued National Pollutant Discharge Elimination System (NPDES) CAFO permit. Subwatershed density of animals is 64 per square mile, though all of the animals are actually located in a relatively small area. Actual density is likely greater than 500 per square mile in the area that contains animals.

HIT

The HIT model predicts that the Red Cedar River subwatershed contributes 0.016 tons of sediment loading per acre per year, for a total annual load of 287 tons of sediment (MSU IWR, 2009). This is the third lowest sediment loading rate out of all nineteen subwatersheds. It should be noted that this figure may not accurately represent how much sediment loading is produced from this subwatershed; the HIT model only accounts for sheet erosion from agricultural lands, and given the large percentage of developed land in this subwatershed, major sources of sediment loading may not be accounted for by this estimation (O'Neil, 2010).

Neighborhood Source Assessment

As part of the planning process, a neighborhood source assessment was conducted to characterize residential areas and to identify pollutants of concern in these areas. This subwatershed contains two relatively distinct types of "neighborhoods"; single-family residential and multi-unit campus housing. Data was collected from the "Shepard Street" and "Walsh Park" neighborhoods, as well as the Spartan Village Apartment complex, using a methodology developed by the Center for Watershed Protection (2005). The single-family neighborhoods are older and well-established with mature trees, dominated by small lots with paved roads, sidewalks and curb and gutter storm drainage. Lawns are well-maintained, but do not appear to receive excessive fertilizer and no permanent irrigation systems were noted. Downspouts typically outlet at the foundation of homes. Surprisingly high proportions of driveways are unpaved and have a natural surface. The major pollutant identified during assessments was sediment, which was evident along sidewalks, driveways and, especially, in curbs and gutters. Additional pollutants noted during surveys included oils and grease, organic matter and trash.

Based upon a tour of the MSU campus, the Spartan Village Apartments and surrounding grounds are typical student housing spaces. These units are multi-story with flat roofs that appear to drain directly to the storm sewers. The surrounding landscape consists of vast stretches of lawn, sidewalks and parking lot areas; very little landscaping exists in the form of shrubs and flowers or mulched areas. The landscape and parking areas are quite well-maintained, though sediment and organic debris were observed in some curb and gutter areas. Primary pollutants in this neighborhood are stormwater runoff and sediment. Some oil spots in the parking areas and trash near the uncovered dumpsters were also observed.

Water Chemistry/*E. coli*

Historic nutrient concentrations on the Red Cedar River as this subwatershed exits the Red Cedar Watershed were measured in 2001. Average total phosphorous concentrations were 0.06 mg/L above the statewide calculated median concentration of 0.032 mg/L (Roush, 2013 as cited in MDEQ, 2013a). Average ortho-phosphorous concentrations were 0.2 mg/L. The average ammonia as nitrogen concentration was 0.24 mg/L, which is greater than the mean concentration of 0.042 mg/L for the Ecoregion (Lungdren, 1994 as cited in MDEQ, 2013a; LCHD et al., 2001).

Nutrient data were measured in Herron Creek in the Red Cedar River subwatershed in 2011 by the MDEQ. Nitrogen as ammonia was measured at 0.126 mg/L, which is much higher than the mean concentration for the SMNIDP Ecoregion of 0.042 mg N/L (Lungdren, 1994 as cited in MDEQ, 2013a). Nitrogen as total Kjeldahl nitrogen was measured at 2.14 mg/L, higher than the 25th percentile Ecoregion comparison concentration of 0.24 mg/L (USEPA, 2000). Total organic carbon (TOC) was measured at 24 mg/L, which is considered high compared to the median TOC concentration of 10 mg/L found in the SMNIDP Ecoregion (Rouch, 2013 as cited in MDEQ, 2013a). Chemical oxygen demand (COD) was measured at 61 mg/L, which was unusually high (MDEQ, 2013a). TDS were measured at 560 mg/L and did not exceed the 750 mg/L instantaneous concentration but were above the monthly average acceptable concentration of 500 milligrams per liter. Ortho-phosphate as phosphorous was measured as 0.071 mg/L and total phosphorus was measured as 0.171 mg/L, which is greater than the statewide calculated median concentrations of 0.032 mg/L, calculated by MDEQ's Water Chemistry Program (Roush, 2013 as cited in MDEQ, 2013a). Also, during this nutrient evaluation, an orange color in the water was seen in this subwatershed and metals concentrations were measured but not found in toxic concentrations (MDEQ, 2013a).

Five sites were sampled in this subwatershed in 2000-2001. One site had a two year summer *E. coli* average of less than 300 cfu/100 mL, two sites had a two year summer average of between 300 and 400 cfu/100 mL, and one site had a two year *E. coli* summer average of over 1,100 cfu/100 mL. All scored medium quality as compared against other sites in the watershed sampled for *E. coli* (LCHD et al., 2001).

MDEQ conducted sampling in 2009 on three sites in this subwatershed. Sixteen-week geometric means were in the high 400's and mid 500's cfu/100 mL concentrations. Over half of the weeks exceeded the

TBC standard and 3 to 5 weeks exceeded the PBC standard. Along the main stem of the Red Cedar River, *E. coli* concentrations increased along the length of this subwatershed. Four significant rain events happened during this sampling effort, and results showed that this subwatershed contributed higher levels of *E. coli* to the watershed in three of the events (MDEQ, 2012c).

Seven sampling sites are located along the main stem of the Red Cedar River through this subwatershed and monitored by the ICHD. The seven monitoring sites from 2009-2012 mostly had summer (19 to 22-week) geometric means less than 400 cfu/100 mL, and some sites had summer geometric means less than the TBC concentration limit of 300 cfu/100 mL. Only one year had a site with a summer geomean over 400 cfu/100 mL. Weeks exceeding TBC and PBC were extremely varied from very few exceedances to over half of the weeks exceeding the TBC standard. Typically, PBC exceedances occurred for four weeks or less amongst the sites (ICHD, 2012). The 22-week summer 2013 geomeans ranged from 194 to 430 cfu/100 mL, with 3 to 11 weeks exceeding the TBC standard and 0 to 5 weeks exceeding the PBC standard (ICHD, 2013).

Wetlands

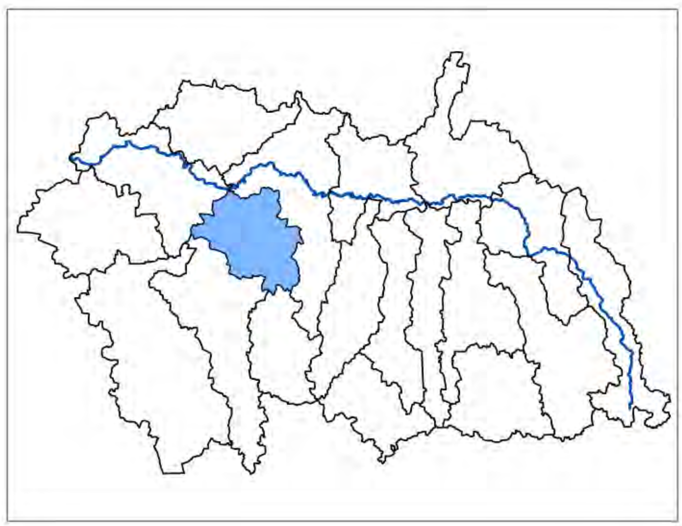
According to MDEQ (2012b), the Red Cedar subwatershed once contained nearly 5,200 acres of wetland. Today, about 1,400 acres, or 26%, of the wetlands remain. The average size of individual wetlands has decreased from 20 acres to less than four acres.

Potential Conservation Areas

About 2,029 acres within this subwatershed are listed as areas for conservation, of which 772 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.15 Sloan Creek

The Sloan Creek subwatershed (HUC 040500040502) contains 19 square miles of land and about 26 miles of stream channel (MDTMB, 2012). Sloan Creek enters the Red Cedar River about 2.5 miles northeast of the City of Okemos, on the north side of I-96. Tributaries to Sloan Creek include Reeves, Cole and Button Drains.



TMDL

Based on data in the 2014 draft MDEQ Integrated Report, 13 miles of stream channel are impaired for *E. coli* and was added to the TMDL. (AUID040500040502-02). MDEQ ranked this subwatershed as a top priority subgroup in the TMDL area based on their stressor analysis (MDEQ, 2012c).

Census and Land Use

The Sloan Creek subwatershed contains a human population of 2,127 (MDTMB, 2012), living at a density of 112 people per square mile. About 393 homes are estimated to be serviced by septic systems (MDTMB, 2012). Agriculture makes up 45% of land use within the subwatershed. The remaining land is roughly 27% grassland and shrubland for uses including grazing, 11% is forested, 9% developed, and 8% is wetland (NOAA, 2008).

Biology

In 2001, the habitat of Sloan Creek was found to be Good (slightly impaired) (MDEQ, 2003). Aquatic habitat included deep and shallow pools, runs and riffles. Compared to other streams in the RCRW, this site had greater amounts of stable habitat and less sedimentation. The macroinvertebrate community was rated as Acceptable, and several families of mayflies and caddisflies were documented.

Farm Animal Survey
This subwatershed has an estimated 3,080 large animals, including 3,000 cows, 40 horses and 40 pigs, sheep, goats and alpacas. Most of the cows are housed at the Mar Jo Lo CAFO, though about 22 smaller farms are also present. Large animal density is estimated to be 174 animals per square mile, the highest of any of the Red Cedar River subwatersheds. Excluding the CAFO, there is an average of 10 animals per farm, and 12 animals per square mile.

HIT
The Sloan Creek subwatershed is estimated to annually contribute 0.053 tons of sediment loading per acre (MSU IWR, 2009). The annual sediment load is estimated at 644 tons. This subwatershed has the seventh highest sediment loading rate of all subwatersheds in the RCRW.

Water Chemistry/*E. coli*
Nutrient contributions from this subwatershed were measured in 2001 (LCHD et al., 2001). Ammonia as nitrogen had an average 13-week concentration of 0.07 mg/L, which is higher than the mean concentration of 0.042 mg/L for the Ecoregion (Lungdren, 1994 as cited in MDEQ, 2013a). The average ortho-phosphorus concentration was 0.05 mg/L. The total phosphorus average concentration was around 0.04 mg/L, which is higher than the statewide calculated median of 0.032 mg/L (Roush, 2013 as cited in MDEQ, 2013a).

Historic *E. coli* sampling in this subwatershed in 2000 and 2001 had an average *E. coli* concentrations around 350 cfu/100 mL (LCHD et al., 2001).

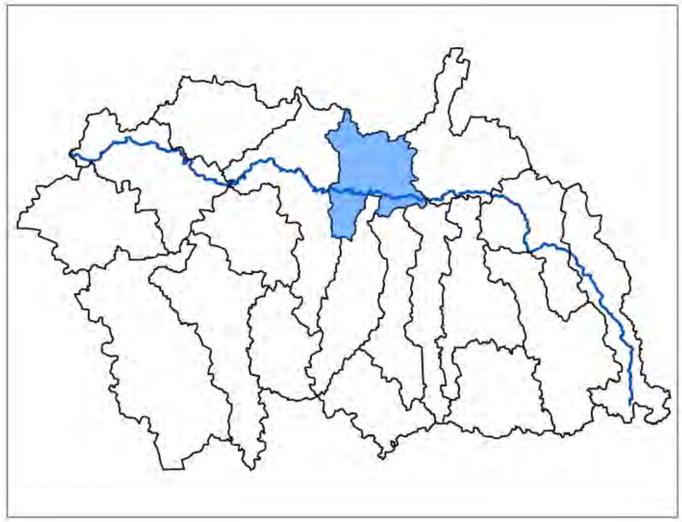
Sampling conducted by the RCRW management team in 2012 over four weeks had an *E. coli* geometric mean concentration of just over 1,000 cfu/100 mL at one location. All samples exceeded the TBC standard, and half of the samples exceeded the PBC standard. It should be noted that 2013 was a very rainy summer and 2012 was a very dry summer.

Microbial source tracking completed for one day in 2013 found human and bovine sources of *E. coli* present at the downstream portion of the subwatershed. Ten weeks of sampling was conducted in 2013 by the ICD in two drains of the Sloan Creek subwatershed. The sites had *E. coli* geometric mean concentrations of 2,172 cfu/100 mL and 2,938 cfu/100 mL. For both sites, all weeks exceeded the TBC standard. One location exceeded the PBC standard for all ten weeks while the other location exceeded the PBC standard for eight weeks (ICD, 2013).

Wetlands
About 68% of the wetlands in this subwatershed have been lost over time (MDEQ, 2012b). Pre-settlement wetland acreage was estimated around 3,196, and 1,023 acres remain. The average size of individual wetlands has decreased from 22 acres to less than four acres.

Potential Conservation Areas
About 2,255 acres within the Sloan Creek subwatershed are listed as areas for conservation, of which 1,054 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.16 Squaw Creek
Squaw Creek is a relatively small, maintained agricultural drain. The subwatershed (HUC 040500040411) encompasses 19 square miles and contains almost 36 miles of stream channel (MDTMB, 2012). The eastern half of the City of Williamston lies within the Squaw Creek subwatershed; much of the remainder of the area is rural. The only tributary to Squaw Creek is Bullett Lake Drain, which enters from the west near Dietz and Moyer Roads. Sullivan Creek is a separate Red Cedar River tributary located within the Squaw Creek subwatershed.



TMDL

This subwatershed contains 29.8 miles of stream with an established TMDL for *E. coli*, including reaches of Squaw and Sullivan Creeks and the Red Cedar River (AUIDs 040500040411-01, 04050004011-02 and 04050004011-03). MDEQ ranked this subwatershed as a top priority subgroup in the TMDL area based on their stressor analysis (MDEQ, 2012c).

Census and Land Use

The 2010 Census indicates that about 2,953 people live in the Squaw Creek subwatershed (MDTMB, 2012), at a density of 156 people per square mile. Septic systems serve approximately 411 homes as a means of wastewater treatment (MDTMB, 2012). The majority of Squaw Creek is used for agriculture (48%). The remaining land area is grassland and shrubland for uses including grazing (23%), wetland (12%), developed (11%), and forested (6%) (NOAA, 2008).

Biology

In 1991, MDEQ rated the fish and macroinvertebrate communities as Good (MDNR, 1992). In 2001, MDEQ found that their survey site had a straightened channel with unstable banks, limiting stable habitat for aquatic biota. These factors contributed to a Fair habitat score and Acceptable macroinvertebrate community (MDEQ, 2003). There appeared to be a substantial decline in stream quality compared to the 1991 survey.

In 2011, MDEQ assessed the macroinvertebrate community and habitat on Sullivan Creek at Perry Road (MDEQ, 2013a). The macroinvertebrate community scored -2 (Acceptable) and received a Good habitat score. The sample comprised of 23 macroinvertebrate taxa; however, two-thirds of the sample were *Amphipoda* (scuds). Riffles were found in the creek with marginal frequency. High quality niche habitat for macroinvertebrates was limited and embedded with sediment.

Farm Animal Survey

Windshield surveys indicated that about 176 large animals live within the Squaw Creek subwatershed. There are 98 cows, 48 horses and 30 donkeys and llamas at 17 farms. The average farm has ten animals and on average, there are nine large animals per square mile. The largest farm observed in the subwatershed has about 60 cattle on a pasture.

HIT

The HIT model estimates that the Squaw Creek subwatershed contributes 0.046 tons of sediment loading per acre per year, which is the ninth highest sediment loading rate for subwatersheds in the RCRW (MSU IWR, 2009). This loading rate equates to an annual load of 559 tons of sediment.

Water Chemistry/*E. coli*

Nutrient contributions from the Squaw Creek subwatershed were measured in 2001. Ammonia as nitrogen had an average concentration of 0.12 mg/L, which is higher than the mean concentration for the Ecoregion of 0.042 mg N/L (Lungdren, 1994 as cited in MDEQ, 2013a). Ortho-phosphorous had an average concentration of 0.1 mg/L (LCHD et al., 2001).

Three sites were sampled in this subwatershed in 2000 and 2001 for *E. coli* and had two year average summer *E. coli* concentrations of around 350, 530, and 630 cfu/100 mL (LCHD et al., 2001).

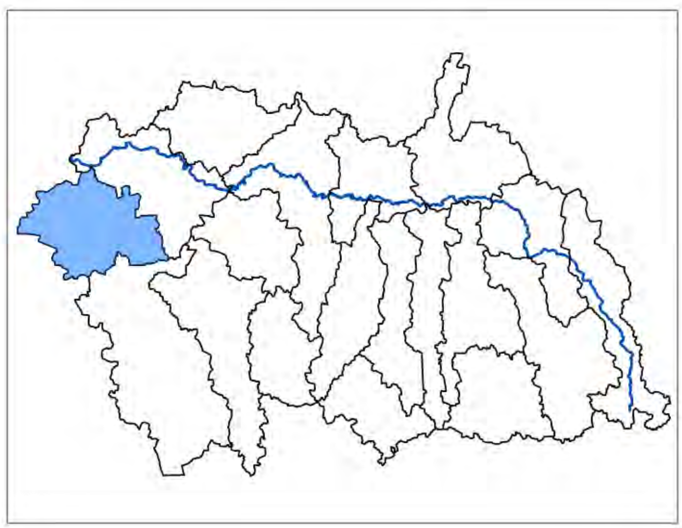
In 2009, MDEQ sampled five locations for *E. coli* in tributaries north of the Red Cedar River and on the Red Cedar River. Four samples had summer geomean concentrations of 500 to almost 640 cfu/100 mL. One sample along the Squaw Creek tributary had a summer geomean of nearly 1200 cfu/100 mL. Tributaries south of the Red Cedar River in this subwatershed were not sampled. Sampling after rain events in this subwatershed at times did not result in an increase in *E. coli* concentrations and at other times did result in an increase in *E. coli* concentrations. The *E. coli* concentrations were higher upstream on the Red Cedar River in this subwatershed than they were downstream (MDEQ, 2012c).

The ICD conducted sampling over ten weeks in 2013 in two drains of the Squaw Creek subwatershed. The two sites had geometric means of 1,115 cfu/100 mL and 1,676 cfu/100 mL. In one location, all weeks exceeded the TBC standard and eight weeks exceeded the PBC standard. In the other location, nine weeks exceeded the TBC standard and four weeks exceeded the PBC standard (ICD, 2013).

Wetlands
According to MDEQ (2012b), this subwatershed contains about 50% of its historic wetlands, with 1,610 acres remaining today. However, the average size of individual wetlands has decreased from 17 to 4.6 acres.

Potential Conservation Areas
About 1,634 acres within the Squaw Creek subwatershed are listed as areas for conservation, of which 671 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.17 Sycamore Creek



Sycamore Creek subwatershed (HUC 040500040507) drains a watershed of approximately 26.1 square miles of land (MDTMB, 2012). The northwestern half of the subwatershed contains a large portion of the City of Lansing. The southeastern half is also heavily developed urban land and includes the City of Holt and the US-127 corridor.

TMDL
Twenty-nine miles of Sycamore Creek and the Banta Drain are included in a TMDL for *E. coli* (AUID 040500040507-01). MDEQ ranked this subwatershed as a top priority subgroup in the TMDL area based on their stressor analysis (MDEQ, 2012c). MDEQ planned to remove this subwatershed from the DO TMDL after collecting additional DO concentrations in a 2013 MDEQ-led summer sampling event. Based on data in the 2014 draft MDEQ Integrated Report, this subwatershed will be removed from the DO TMDL.

Census and Land Use
This is the second-most densely populated subwatershed, with a human population of 52,313 (MDTMB, 2012), living at a density of 2,005 people per square mile. It is estimated that there are 691 septic systems in this subwatershed (MDTMB, 2012). NOAA (2008) indicates that 72% of land within the subwatershed is developed, 6% is shrubland and grasses for uses including grazing, 5% is used for agriculture, 9% is comprised of wetland, 7% is forested, and 1% is open water.

Biology
MDNR (1974) documented negative impacts to Sycamore Creek associated with the discharge from the Mason WWTP.

In 1996, MDEQ conducted fish surveys at nine sites and macroinvertebrate surveys at two sites on Sycamore Creek (MDEQ, 1999a). Results of fish surveys were highly variable, with ratings ranging from Poor to Excellent. It was noted that the fish communities were representative of a relatively balanced warmwater community, despite poor habitat at some stations. Possible factors contributing to degraded fish communities included loss of habitat, high embeddedness and bottom sedimentation. Macroinvertebrates were found to range from Poor to Acceptable at the two sites, which were located upstream and downstream of the Mason WWTP. The upsteam site of the outfall received a higher score, suggesting that the WWTP was having an adverse impact on the biological community.

MDEQ (1999a) also sampled Mud, Rainer and Willow Creeks and Talmadge Drain in 1996. Mud Creek received an Acceptable rating for the fish community, despite a severely impaired rating for habitat. Embeddedness was listed as a limiting factor at this site. The fish community at Talmadge Drain consisted solely of tolerant species and received a Poor fish score. Habitat was found to be moderately impaired, with unstable banks and lack of pools, riffles, runs and bends contributing to degradation. Rainer Creek was found to have Fair habitat and an Acceptable macroinvertebrate community. A fish score was not calculated, but the community was dominated by creek chub and green sunfish, which are known as pollution-tolerant species. In Willow Creek, fish and macroinvertebrate scores ranged from Poor to Acceptable. The Kipp Road site had the highest diversity of fish, with 13 species present. Lack of in-stream habitat, embeddedness, siltation and unsuitable substrate were limiting factors in this stream. Sediment deposition ranging from 8 to 12 inches was reported.

In 2001, MDEQ documented that the macroinvertebrate community was similar both upstream and downstream of the WWTP outfall. The fish community was of higher quality downstream of the outfall, indicating that conditions had improved over time and that the WWTP was not negatively impacting the biological communities of Sycamore Creek (MDEQ, 2003).

Mid-MEAC has sampled Sycamore Creek at Biggie Munn Park, near the intersection of Jolly Road and Aurelius Road in Lansing, since the fall of 2006. Erosion is an issue on the side of the stream that abuts the park’s large grass field as there is no buffer or vegetated riparian zone (Mid-MEAC, 2012). On the other side of the stream, vegetation and trees line the banks. Aquatic habitats present included runs, small pools and woody debris. Stream scores have ranged from 21 to 56, with the most recent score being 24 in 2012. The site consistently rates from Fair to Good.

Farm Animal Survey

No large animals or agricultural facilities were found to exist in this subwatershed.

HIT

The HIT model estimates that this subwatershed contributes 0.009 tons of sediment loading per acre per year and has the lowest overall estimated sediment loading rate in the RCRW (MSU IWR, 2009). Estimated annual load is 150 tons of sediment. It should be noted that the HIT model does not account for urban sources of sediment loading and is likely significantly underestimating the sediment load from this subwatershed.

Neighborhood Source Assessment

Four separate neighborhoods were assessed in Sycamore Creek to determine possible non-point source pollutants and sources as part of this planning project. Most neighborhoods were found to be similar in nature; older, more established areas with relatively small lot sizes (less than 1/4 acre), paved streets with curb and gutter drainage, roof downspouts outletting near the homes and draining to the street, hard-surfaced driveways and maintained lawns. The one neighborhood of exception was a small mobile home park, which had a much greater density of homes but had similar issues otherwise. Pollutants of concern were similar across neighborhoods, with stormwater runoff and sediment observed as the primary issues. Regarding sediment, a surprising amount was found in gutters and on sidewalks, apparently from a variety of sources such as overland runoff, vehicles and, perhaps, winter use for improved traction.

Water Chemistry/*E. coli*
Nutrient contributions from this subwatershed were measured in 2001 (LCHD et al., 2001). Ammonia as nitrogen had a concentration of 0.07 mg/L, which is higher than the mean concentration for the Ecoregion, 0.042 mg N/L (Lungdren, 1994 as cited in MDEQ, 2013a). Ortho-phosphorous had a concentration of 0.06 mg/L.

MDEQ (2003) collected water samples at six locations within the Sycamore Creek subwatershed to analyze nutrients concentrations. Results showed that none of the samples contained levels of nutrients that exceeded the range for reference sites within the Ecoregion. Water samples were also collected up and downstream of the WWTP outfall; these samples contained slightly elevated levels of some metals, nutrients and dissolved solids, but none exceeded WQS.

MDEQ (2013a) collected nutrient samples in this subwatershed in 2011 at three locations for one day. Nitrogen as total Kjeldahl nitrogen ranged from 0.63 to 0.77 mg/L, above the 25^{th} percentile comparison for EPA Ecoregion seven (US EPA, 2000). Phosphate as ortho-phosphate was measured and ranged from 0.040 to 0.045 mg/L. Total phosphorus was measured in concentrations ranging from 0.058 - 0.101 mg/L, above the statewide calculated median concentrations of 0.032 mg/L calculated by MDEQ's Water Chemistry Program (Roush, 2013 as cited in MDEQ, 2013a). TDS concentrations ranging from 550-580 mg/L were measured. No single data point exceeded the 750 mg/L instantaneous concentration, but they were above the monthly average acceptable concentration of 500 milligrams per liter (MDEQ, 2013a).

Sampling was also done in 2000 and 2001 at the confluence before the Red Cedar River for *E. coli*. *E. coli* concentrations averaged around 350 cfu/100 mL (LCHD et al., 2001).

MDEQ conducted sampling in this subwatershed in 2009 upstream of Sycamore Creek's confluence with the Red Cedar River. The summer *E. coli* geometric mean was around 550 cfu/100 mL. *E. coli* concentrations at this location were higher immediately after most rain events (MDEQ, 2012c).

Three sites were also sampled in this subwatershed by Delhi Township farther upstream of the Red Cedar River confluence and in one tributary. The summer geomeans from 2012 and 2011 varied from the high 300's to about 800 cfu/100 mL. Generally, about half of the weeks exceeded the TBC standard in a five to eight week sampling period. Over that same five to eight week sampling period, one to three weeks exceeded the PBC standard (Delhi Charter Township, 2012).

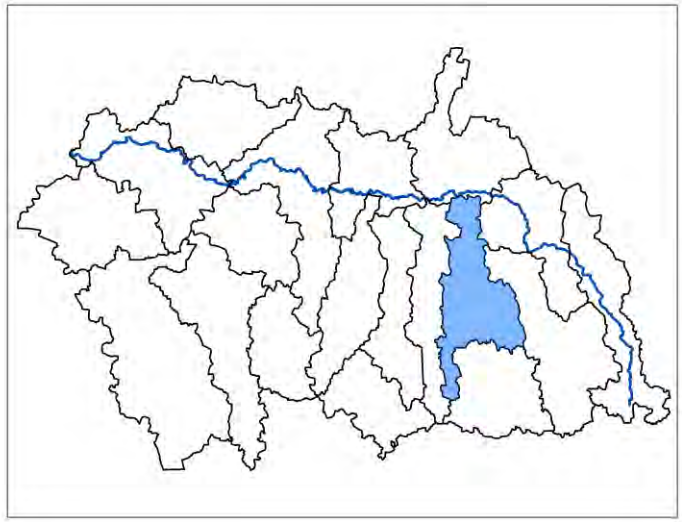
The 22-week summer geomean in 2013 on Sycamore Creek was 393 cfu/100 mL; 14 weeks exceeded the TBC standard and five weeks exceeded the PBC standard (ICHD, 2013). Sampling conducted by the ICHD from 2009-2012 showed varied summer geomean *E. coli* concentrations, ranging from the low 300's in 2012, high 300s in 2011, nearly 1,500 cfu/100 mL in 2010, to the mid-400s in 2009. The summer of 2012 exceeded the TBC standard every week, and the PBC standard almost every week. The other years exceeded the TBC standard about half the time and the PBC standard up to five times (ICHD, 2009-2012).

Beach monitoring is conducted at Hawk Island County Park and Valhalla Park, and no values were reported high enough in 2013 to warrant a beach closure (MDEQ, 2013d).

Wetlands
According to the MDEQ (2012b), the Sycamore Creek watershed historically contained 6,684 acres of wetland. As of 2005, 1,428 acres remain, which is a reduction of 79%. Sycamore Creek has the second largest percentage loss of wetland acreage out of all subwatersheds in the RCRW.

Potential Conservation Areas
About 1,785 acres within the Sycamore Creek subwatershed are listed as areas for conservation, of which 910 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.18 West Branch Red Cedar River



The West Branch of the Red Cedar River (HUC 040500040405) is located on the eastern border of Ingham County and the western border of Livingston County, and drains about 23.3 square miles of land (MDTMB, 2012). The stream enters the Red Cedar River a few miles northeast of the Village of Webberville. About 40 miles of stream channel drain this subwatershed. Tributaries include the McMahon and Lewis Drains.

TMDL

Based on data in the 2014 draft MDEQ Integrated Report, 21 miles of stream channel are impaired for *E. coli* and will be included in the TMDL. (AUID 040500040405-01).

Census and Land Use

This subwatershed is home to 2,497 people (MDTMB, 2012), living at a density of 107 per square mile. It is estimated that about 347 homes are serviced by septic systems (MDTMB, 2012). Land use within the subwatershed is predominantly used for agriculture (41%). The remaining land use is as follows: 23% shrublands and grasslands for uses including grazing, 18% wetland, 11% forested and 6% developed (NOAA, 2008).

Biology

Sampling conducted by MDEQ in 1991 reported a Good fish community, but only Fair macroinvertebrates and habitat. Habitat was heavily impacted by silt (MDNR, 1992).

In 2001, MDEQ conducted a survey at Kane Road, on the West Branch of the Red Cedar (MDEQ, 2003). The macroinvertebrate community was rated as Acceptable and contained several families of mayflies and caddisflies. The habitat was rated as Fair, with siltation and lack of stable habitat limiting the aquatic communities. Streambank erosion was noted as a likely cause of excessive sediment load to this stream.

The West Branch Red Cedar was sampled by MDEQ in 2011 at Grand River Avenue (MDEQ, 2013a). The macroinvertebrate community scored at the high end of Acceptable (+3) and habitat scored Good (149). This was one of the highest rated macroinvertebrate communities of 22 sites sampled during the study. The width of the channel was around 25 feet, and vegetation and trees were present along the riparian areas. Aquatic vegetation including *Sparganium* spp., *Potamageton* spp. and *Elodea* spp. were present along bottom of the stream. It was also determined that sand, silt and organic matter comprised substrate at the site.

Farm Animal Survey

The windshield survey conducted as part of this planning project indicated that there are approximately 19 properties in this subwatershed that house livestock. An estimated 28 cows, 65 horses and 40 sheep were counted. This equates to about six large animals per square mile of land, and an average of seven large animals at each farm. This is the second lowest density of large animals in the RCRW. The number of large animals per farm ranged from one to 40, with a sheep flock of approximately 40 animals being the largest operation.

HIT

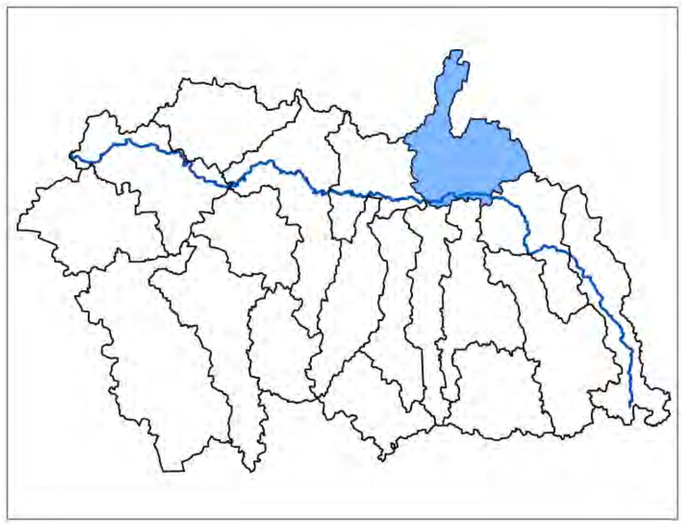
The HIT model estimates that this subwatershed contributes 0.041 tons of sediment loading per acre per year, for a total annual sediment load of 611 tons (MSU IWR, 2009). The West Branch Red Cedar River subwatershed ranks 10 out of 19 subwatersheds in terms of sediment loading rate.

Water Chemistry/*E. coli*
Sampling was conducted in 2012 in this subwatershed at one location by the RCRW management team. The site had a geomean *E. coli* concentration over 800 cfu/100 mL. All four weeks exceeded the TBC standard and three of four weeks exceeded the PBC standard.

Wetlands
The MDEQ (2012b) estimates that historical wetland coverage is around 4,909 acres in this subwatershed, which is 44% greater than what is found today (2,790 acres). Average wetland size has decreased from 13 to six acres.

Potential Conservation Areas
About 1,892 acres within this subwatershed are listed as areas for conservation, of which 755 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

4.19 Wolf Creek



The Wolf Creek subwatershed (HUC 040500040407) encompasses 25.5 square miles and has about 36 miles of stream channel (MDTMB, 2012). Wolf Creek is a maintained drainage ditch with little variation in channel morphology or depth (MDEQ, 2003). The subwatershed also contains the Conway Drain No. 1 and Conway No. 15 Drain, which are direct tributaries to the Red Cedar River located east of Wolf Creek.

TMDL
Based on data in the 2014 draft MDEQ Integrated Report, 24 miles of stream channel are impaired for *E. coli* and will be included in the TMDL (AUIDs 040500040407-01 and 040500040407-02).

Census and Land Use
According to the 2010 Census, there are 2,260 people living in the Wolf Creek subwatershed (MDTMB, 2012), at a density of 89 people per square mile. About 340 homes are serviced by septic systems (MDTMB, 2012). Land use within the subwatershed is approximately as follows: 40% agriculture, 32% shrubland and grassland with grazing uses included, 14% wetland, 8% forest, and 6% developed (NOAA, 2008).

Biology
Wolf Creek was described as a Poor stream in 1991 due to severe degradation including excessive growths of algae and animal waste in the stream (MDNR, 1992). In 2001, MDEQ found very little stable substrate that was available macroinvertebrate habitat. However, the habitat was still rated as Fair (moderately impaired) and the macroinvertebrate community was found to be Acceptable (MDEQ, 2003).

Results of Mid-MEAC sampling indicate that Wolf Creek, at Bell Oak Road, has a variety of habitats for macroinvertebrates, including runs, small pools, riffles and woody debris (Mid-MEAC, 2012). The banks are also vegetated. However, the stream score at this site has steadily declined, and the most recent sampling event in the fall of 2012 produced the lowest stream score that Mid-MEAC has recorded at this site, 16.4 (Poor).

Conway Drain No. 1 was sample by MDEQ (2013a) at Nicholson Road in 2011. The macroinvertebrate community received a -2 (Acceptable) score and a Marginal habitat score. MDEQ also sampled Conway Drain No. 15 at Chase Lake Road, and with a score of -3, the macroinvertebrate community was found to be Acceptable. The habitat at Chase Lake Road scored Good. The Nicholson Road site received a slightly better macroinvertebrate score because the sample had a higher proportion of mayflies and one more mayfly taxa was present. Overall, the Nicholson Road site had five more taxa than the Conway Drain No. 15 site.

Farm Animal Survey
This subwatershed contains the Kubiak Farms CAFO, which houses approximately 1,926 cows. In addition, 321 cows, 111 horses and 23 bison, camels, goats and sheep were observed. Large animal density is 111 animals per square mile including the CAFO, or 21 animals per square mile excluding the CAFO. An additional 22 farms were noted, with an average of 14 animals per farm. It should be noted that it was difficult to decipher which operations were related to the CAFO and if the number of animals observed are included in CAFO permits. One location was identified where about six horses were in the stream channel.

HIT
Wolf Creek is estimated to contribute 0.033 tons of sediment loading per acre per year, according to the HIT model (MSU IWR, 2009). This rate equates to a total of 539 tons of sediment per year. It ranks fourteen out of nineteen in terms of sediment loading rate.

Water Chemistry/*E. coli*
Historic sampling was conducted in 2000-2001 in Wolf Creek along tributaries and the Red Cedar River. Two sites had *E. coli* summer averages below 300 cfu/100 mL, one site had an average concentration around 400 cfu/100 mL, and another site along the Wolf Creek tributary had a geomean of nearly 2,000 cfu/100 mL (LCHD et al., 2001).

In 2001, the Wolf Creek tributary, the Red Cedar River upstream of the Wolf Creek tributary, and the Red Cedar River downstream of the Wolf Creek and Kalamink tributaries were sampled for nutrient concentrations. Ammonia as nitrogen was measured over 12 weeks. The upstream Red Cedar River sampling location had an average concentration of 0.22 mg/L, the Wolf Creek tributary had an average concentration of 1.2 mg/L, and the downstream Red Cedar River sampling location had an average concentration of 0.27 mg/L; all averages are above the Ecoregion median of 0.042 mg N/L (Lungdren, 1994 as cited in MDEQ, 2013a). Ortho-phosphorous concentrations upstream on the Red Cedar River had an average concentration of 0.1 mg/L. The Wolf Creek tributary had an average ortho-phosphorous concentration of 0.27 mg/L, while the downstream tributary had an average concentration of 0.11 mg/L. Upstream total phosphorous concentrations had an average of 0.09 mg/L and downstream total phosphorus concentrations averaged 0.07 mg/L. The Wolf Creek tributary had an average total phosphorous concentration of 0.14 mg/L (LCHD et al., 2001). All measurements are above the statewide calculated median concentration of 0.032 mg/L mg/L respectively (Roush, 2013 as cited in MDEQ, 2013a).

Sampling results on the Red Cedar River in this subwatershed by the ICHD from 2009 to 2012 ranged from below 300 to nearly 500 cfu/100 mL (ICHD, 2009-2012).

The 2013 22-week summer geomean on the Red Cedar River in this subwatershed was 285 cfu/100 mL, with 9 weeks exceeding the TBC standard and one week exceeding the PBC standard (ICHD, 2013). 2012 sampling of *E. coli* along the Wolf Creek tributary by the RCRW management team had the highest measured concentrations in the subwatershed, with a four-week summer geometric sampling mean of around 8,500 cfu/100 mL. Every week exceeded the TBC and PBC standards.

2013 microbial source tracking data was collected in the three major tributaries to the Red Cedar River in the Wolf Creek subwatershed. Human, bovine and equine sources of *E. coli* were present in Wolf Creek and the unnamed tributary in the middle of the subwatershed. Bovine and equine sources of *E. coli* were present in the eastern most tributary of the Wolf Creek subwatershed (ICD, 2013).

Wetlands

The Wolf Creek subwatershed contains about 2,458 acres of wetlands, a 52% reduction from historic wetland coverage (MDEQ, 2012b). The average size of wetlands has decreased from 16 acres to 5.3 acres.

Potential Conservation Areas

About 931 acres within the Wolf Creek subwatershed are listed as areas for conservation, of which 178 acres are listed as High or Highest Priority (Paskus and Enander, 2008).

5. GOALS AND OBJECTIVES OF THE WATERSHED

5.1 Goals for the Red Cedar River Watershed

The goals and corresponding objectives of the watershed management plan (WMP) are described here. Some objectives relate to more than one goal, in addition, several objectives complement one or more goals. Tables 6.1 and 6.2 in Chapter Six directly address the actions needed to make progress towards the goals and objectives listed. Monitoring and evaluating progress towards the goals and objectives is an important component that is described in Chapter Nine.

There are six major project goals of this watershed management planning process:

1. Develop a WMP that is straightforward and available to use by local organizations and community representatives either individually and through collaborative efforts.
2. Restore water quality in the Red Cedar River to support the designated uses of total and partial body contact recreation for the impaired waters listed in Chapter Three (Table 3.2).
3. Restore water quality in the Red Cedar River to support the designated use of other indigenous aquatic life and wildlife and warm water fishery for the impaired waters listed in Chapter Three (Table 3.2).
4. Maintain designated uses that are currently being met through preservation and conservation efforts.
5. Manage the Red Cedar River as an amenity that supports a diversity of native species, residents' ability to use the river corridor to enjoy nature, and is aesthetically pleasing.
6. Manage the watershed to drain stormwater in order to attenuate flooding and minimize the impact of post-settlement development.

5.2 Objectives to Meet the Watershed Goals

The following specific management objectives are outlined as steps to help meet the WMP goals.

Goal 1 corresponding objectives:

- Develop a plan that prioritizes best management practices (BMPs) by specific pollutant, source and cause.
- Develop a plan that provides clear direction on priorities and action items community members and organizations can undertake to improve water quality.
- Encourage communication and collaboration between partnering organizations and stakeholders.
- Establish a method, utilizing adaptive management techniques, to evaluate the progress of watershed plan implementation work, including action items implemented and resulting effects on water quality.

Goal 2 corresponding objectives:

- Increase the amount of BMPs in locations that will lead to measurable improvements in bacteria levels and water quality (e.g., wetland restoration sites).
- Maintain and repair failing septic systems to reduce bacteria loading from human sources.
- Find illicit sewage discharges to surface water and correct to reduce bacteria loading.
- Develop and implement audience-specific information and education campaigns about water quality and BMPs to the target audiences, including landowners, agriculture, local governments, and other applicable stakeholders.
- Work to achieve a balance of agricultural economic success and improved water quality.
- Increase technical support available to the agricultural community to help increase BMP adoption and repair BMPs that are not working properly (e.g. manure management, restricted access, soil conservation techniques, wetland preservation and restoration).
- Increase participation in existing programs such as the Michigan Agricultural Environmental Assurance Program (MAEAP) and the US Department of Agriculture Natural Resources Conservation Service (NRCS) conservation programs.
- Improve land management near the river corridor to address wildlife habitat, stormwater, sediment and pathogen loading.

Goals 2 and 3 corresponding objectives:

- Work with local governments to reduce sedimentation, nutrient, and pathogen loading from urban sources (neighborhoods and municipal property).
- Work with agricultural producers to reduce overland runoff and associated sediment, pathogen and nutrient pollution.
- Work with local drain commissioners to reduce sedimentation from bank erosion.
- Eliminate livestock access to drains and creeks to reduce *Escherichia coli* (*E. coli)*, sediment and nutrient loading.

Other goal 3 corresponding objectives:

- Increase dissolved oxygen levels to the recommended levels listed in the draft total maximum daily load (TMDL) (5 mg/l).
- Work with local governments to reduce and report illegal dumping, illicit discharges and spills in urban areas.
- Work with local governments to reduce pet waste impacts through public educational campaigns and local ordinances.
- Work with local governments, organizations and landowners to encourage and support wetland restoration, low impact development, nutrient management, and green infrastructure.
- Support the implementation recommendations in the draft statewide TMDL for polychlorinated biphenyls (PCBs) and mercury when available.

Goals 4, 5 and 6 corresponding objectives:

- Work closely with local governments to establish sustainable land use planning and management techniques for water quality protection.
- Utilize the MDEQ Landscape Level Wetland Functional Assessment (MDEQ, 2012b) and the Michigan Natural Features Inventory (MNFI) Report (Paskus & Endander, 2008) to identify opportunities for restoration.
- Restore the river's natural flow regime, natural flood attenuation abilities, and some of the watershed's natural wetlands where possible, focusing on critical sites and areas.
- Protect and preserve high quality areas such as wetlands and Potential Conservation Areas as described in Chapter Seven.
- Develop and implement information and education campaigns about water quality BMPs to the community, landowners, agriculture, municipalities, and other applicable stakeholders.
- Obtain support from partnering organizations and identify possible funding sources.

Other goal 6 corresponding objectives:

- Work closely with local governments to establish sustainable land use planning techniques for flood attenuation and stormwater managment; including improved mapping and modeling techniques.
- Promote sustainable green infrastructure developments utilizing native species over traditional development methods.
- Reduce the pollutant impacts of urban stormwater.
- Obtain support from partnering organizations.

6. POLLUTANTS, SOURCES, CAUSES AND BEST MANAGEMENT PRACTICES

Using the information collected through this planning project, a list of all of the pollutants impacting the Red Cedar River Watershed was compiled. This chapter details these pollutants, along with their sources and causes, and recommends best management practices (BMPs) to improve water quality. Actions described in this chapter and in Tables 6.1 and 6.2 relate to the specific goals and objectives described in Chapter Five. For further documentation of specific BMPs beyond what is provided here, consult "BMP Design, Pollutants Controlled Calculation Assistance, and other Technical Manuals" at http://www.michigan.gov/deq/0,4561,7-135-3313_3682_3714-118554--,00.html.

To better understand how to remedy impairments of the watershed from the pollutants described in Chapter Three, the sources and causes of the pollutants must be understood. The *source* is a general description of the original site or living organism discharging the pollution, while the *cause* describes the behavior at a particular location that allows the pollution to be discharged into the waterways.

A summary of the major contributing sources and causes of non-point source (NPS) pollution are listed below in priority order for the watershed. With watershed specific data collected, Table 6.1 was developed to display the pollutants, sources, and causes. Load reduction goals were estimated using a combination of tools including the Spreadsheet Tool for Estimating Pollutant Load (STEPL) model (EPA, 2013a), HIT Model (MSU, 2009), and the Pollutant Controlled Calculation and Documentation for Section 319 Watersheds Training Manual (MDEQ, 1999b). Achieving estimated load reductions using these tools requires that appropriate BMPs and remediation strategies are used. Estimates related to I/E efforts were derived based on an assumed reasonable reduction rate.

The pollutants were also categorized as to whether the pollutant was *known*, that is, confirmed and measured through laboratory data or field assessment; *suspected*, meaning observed or reported by a stakeholder but not measured; or *potential*, where conditions are likely for the pollutant to exist. With knowledge of the sources and causes of the pollutants, specific BMPs are suggested to minimize each pollutants' impact on the watershed. The pollutants, sources, and causes were developed through data collection summarized in Chapter Three, a review of existing reports including the total maximum daily load (TMDL) reports (MDEQ, 2012c; MDEQ, 2013b), and reports from stakeholders from individual and group meetings throughout the planning process. Figure 6.2 displays specific sites, described in more detail below, with known or suspected contributions of pollution from livestock access, improper manure storage, streambank erosion, overland runoff and septic inputs.

Pollutants were ranked watershed-wide based on available data. Overall, *Escherichia coli* (*E. coli)* is ranked as the highest priority pollutant because the high concentrations are the reason for the nonattainment of the partial and full body contact designated uses and the resulting *E. coli* TMDL, which covers a large portion of this watershed. Sediment is ranked as the second highest priority pollutant as it is a leading reason for low dissolved oxygen (DO) concentrations, resulting in the nonattainment of the warmwater fish and other indigenous aquatic life designated uses and has a TMDL for a small portion of this watershed. Many Michigan Department of Environmental Quality (MDEQ) biological reports also attribute the degraded aquatic habitat to sediment. Nutrients are ranked as the third priority pollutant as concentrations were measured above regional comparison concentrations. In individual subwatersheds where the pollutants were not ranked in this *E. coli*, sediment, nutrient priority ranking order, the specific subwatershed pollutant concentrations as compared to the water quality standards (WQS) and the conditions found during the windshield survey were used to prioritize the pollutants. The causes of pollution were ranked in priority order, with known (k) pollutant causes taking priority, followed by suspected (s) and potential (p) causes of pollution. Within the suspected and potential causes of pollution rankings, the largest amounts of pollution the source was estimated to be contributing were ranked as the highest priority.

BMPs are recommended at sites known, suspected, or potentially causing pollution. Though BMPs are encouraged wherever possible in the watershed, due to resource, outreach, and other implementation constraints, priority subwatersheds and critical and priority areas are identified later in this chapter for the implementation of BMPs. Table 6.2 lists BMPs in general categories, corresponding descriptions, pollutants addressed, estimated quantities possible, sources addressed, estimated costs, and measurable milestones for implementation.

How to select a BMP
Where sources of pollution are known, BMPs should be implemented to address the specific source and type of pollution. These sites are designated as critical sites and areas for restoration, and specific BMPs are selected for these sites in Table 6.2.

Where sources of pollution are suspected, additional investigations are recommended and/or BMPs should be implemented. Some site specific BMPs are selected for these sites in Table 6.2. Other sites may implement the most applicable BMP based upon the source and type of pollutant, where general BMP options are listed in the tables below.

Where sources of pollution are potential, BMPS are recommended, with prioritization being for implementation at critical sites and areas for restoration, priority subwatersheds, and priority areas for preservation described at the end of this chapter. Additional investigations, as discussed in Chapter Nine are recommended where feasible and anticipated to better identify more specific pollutants, sources, causes, or the most effective BMPs.

Often more than one BMP is a feasible alternative to address a particular pollutant, source, and cause. In the priority and critical areas, the installer and owner's preferred BMP can be selected from the below list of BMP options, categorized by source and pollutant. More information about each BMP can be found in Table 6.2 to help in the selection. Cost, site conditions, removal efficiency, and preference of the party installing the BMP should all be taken into consideration when selecting the BMP for each individual site.

6.1 Pollutant: *E. coli*
The TMDL report lists potential point sources of *E. coli* to include untreated sewage overflows from wastewater treatment plants (WWTPs), National Pollutant Discharge Elimination System (NPDES) discharges, and storm sewer discharges. It lists potential non-point sources of *E. coli* to include wildlife and pet waste, contaminated overland run-off, agricultural operations, illicit sewer connections from residents or businesses, failing septic systems, dumping of trash, and biosolids and septage land applications (MDEQ, 2013c). In this report, the sources of *E. coli* are categorized by organism producing the *E. coli:* livestock, humans, wildlife, and pets. The causes of *E. coli* specify the reason *E. coli* is reaching a waterway. Findings and observations associated with data collected for this watershed management plan (WMP) corroborate the findings reported in the TMDL. Data in Chapter Three evidenced that water pollution was present during both dry and wet weather events. There were high levels of *E. coli* during dry weather (the absence of rain events). In addition, there were spikes in *E. coli* concentrations measured after wet weather events. Pollution presence during certain weather can be indicative of the source of the pollution. Dry weather sources of *E. coli* can be attributed to such things as leaky septic tanks, wildlife, and regrowth of bacteria. Wet weather sources of *E. coli* are often associated with *E. coli* that is carried with overland runoff, such as manure spread on crops.

Source: Livestock
Livestock manure contains and is a source of *E. coli*. The way the manure is managed can affect the chances of the manure reaching the surface water. Bovine and equine sources of *E. coli* were confirmed in some locations (Figure 6.1) through microbial source tracking done in 2013 as a part of this watershed management planning process. Livestock causes of *E. coli* contributions are listed below and ranked by the relative estimated size of the contribution. Data collected during this planning process were used to make these ranked estimates.

Causes: Livestock E. coli Contributions

Unrestricted livestock access to stream (k and s) - Areas where livestock have direct access to a stream have the potential to collect livestock manure, and consequentially contribute *E. coli* to the stream. Locations where livestock are known or were reported to have access to the stream are shown in Figure 6.2. There are five locations with known or suspected unrestricted livestock access to the stream: Handy Drain No. 5 (Township 4 North, 3 East, Section 33, suspected), Coon Creek (3 N1ES10, suspected); Wolf Creek (4N3ES19, known), Hayhoe Drain (2N1ES25, known), Doan Creek (2N1ES1, known). Doan Creek and Wolf Creek were also analyzed for microbial source tracking evidence of livestock sources, and both had bovine and equine sources of *E. coli*.

<u>Improper application of manure (s)</u> - Livestock manure is frequently spread on crops for use as fertilizer in agricultural areas. The soil conditions, spreading rate, weather, proximity to surface water, groundwater, and drainage all affect the path of the *E. coli* bacteria. Due to the prevalence of cropland in the watershed and observation of land use noted during the windshield survey, it is “suspected” that the over or improper application of livestock manure is the major contributing cause of livestock *E. coli* contributions to the watershed. Contributing to the total manure load are approximately 7,000 non-concentrated animal feeding operation (CAFO) large animals at 352 farms, and 6,500 CAFO animals (Figure 6.3).

<u>Improper storage of manure (s and p)</u> - Livestock manure must be managed. It is left in place or collected, stored, and spread or used for the production of energy, and requires proper handling to prevent *E. coli* bacteria in the manure from reaching groundwater and surface water. For example, Michigan’s generally accepted agricultural management practices (GAAMPs) require storing manure at least 50 feet from a property line, at least 150 feet from a non-farm home, at least 150 feet from surface water, and in such a way that runoff from the manure storage does not enter into surface water or neighboring properties. An appropriate coverage and barrier beneath the manure is also required (MDARD, 2014).

Improper storage and handling of manure poses a risk of impacting the groundwater. Due to conditions recorded by stakeholders it is “suspected” that the improper storage of manure is a major contributing cause of livestock *E. coli* concentrations to the watershed.

Figure 6.3 displays the locations recorded during the windshield survey where larger livestock (e.g., cows, horses, goat, pigs) were present. These locations represent where there may be over or improper application of manure, and improper storage of manure. There are an estimated 352 animal farms (non-CAFO) that have the potential to be improperly storing their manure. Figure 6.4 displays where crops are present in the watershed, and thus where the majority of manure spreading may occur. While all of these locations are not problem areas and many farms abide by approved manure management plans, the data presented are indicative of known sources of *E. coli* (i.e., farm animals). We assume that these locations represent a spectrum of farming practices, ranging from practices that are protective of water quality to egregious and impacting water quality. More specific information about a couple suspected sites indicate higher priority locations for BMP practice implementation. These sites are shown in Figure 6.2. While the Ingham County Fairgrounds were inspected by MDEQ in 2006 and no discharges were occurring (MDEQ, 2012c), it is still being reported as suspected of having improper manure storage practices. Microbial source tracking samples were collected in the Headwaters Sycamore Creek subwatershed, where the Ingham County fairgrounds reside, and bovine and equine sources of *E. coli* were detected. In addition, Fowlerville Fairgrounds has the potential to improperly store manure, and a site in Handy Drain No. 5 (4N3ES33) is also suspected of improperly storing manure.

<u>CAFO manure land spreading resulting in over or improper application of manure (s)</u> - CAFOs are home to a large amount of livestock and thus produce a large amount of manure. Some manure is managed and spread by the CAFO’s under permit of the NPDES program and are not considered non-point sources of pollution themselves. However, some CAFO waste is manifested to other facilities and is spread for fertilizer. Due to the large amount of manure that is produced and manifested, this manure, if not properly applied, can contribute *E. coli* to the surface water.

Figure 6.5 displays the locations of manure spread on CAFO land under NPDES permits. Nonmanifested waste (waste originating from and spread by the CAFO), is spread on 5,376 acres in nine subwatersheds. The CAFOs also produce 6.4 million gallons of manifested liquid waste and 6,558 tons of solid waste (MDEQ, 2012c). The locations where manifested CAFO manure (manure

that originates from a CAFO but not spread by the CAFO), is spread is unknown, but assumed to be closest to the CAFOs.

Livestock holding facilities (p) - Holding facilities concentrate livestock feed and manure, and therefore *E. coli*, in an area. When the facilities are adjacent to a waterway, these nutrients can enter the waterway through runoff. This is a potential source since many holding facilities are present in the watershed, with the Middle Branch subwatershed having the most animal operations.

BMPs to address Livestock E. coli Contributions

The following BMPs are proposed to reduce *E. coli* contributions in the watershed from livestock.

Structural/Vegetative	**Management**
Alternative Water Sources	Agricultural Outreach
Wetland Restoration	Information and Education
Filter and Buffer Strips with Maintenance	Ordinances (e.g. wetland protection, livestock exclusion)
Capture and/or Redirect Runoff	Modify Application Rates and Timing
Contained Manure Storage Areas	Agricultural Management Practices
Exclusion Fencing or Controlled Access	Incentives
Rotating Manure Storage	Wetland Preservation
Cover Crop	Field Tile Management
Tile Line Control Structures	Comprehensive nutrient management plans
	Crop Residue Management

Source: Humans

Human septage contains *E. coli*. Human sources of *E. coli* were confirmed in some locations through source tracking done in 2013 as a part of this watershed management planning process (Figure 6.1). The way human septage is managed and treated can affect the chances of *E. coli* reaching surface water. Human causes of *E. coli* contributions are listed below and ranked by the estimated relative size of the contribution.

Causes: Human E. coli Contributions

Aging septic systems and/or improper maintenance (k) - Homes and businesses that do not have their septage treated through an off-site wastewater treatment system use on-site septic systems. If these systems are not installed, maintained, or replaced properly, human septage can leak from these systems into the ground and surface water without proper treatment. Soil drainage properties are particularly important to consider when installing a septic system. Septic systems may fail if they are installed without proper consideration of their drainage abilities.

Figure 6.6 displays the estimated density of septic systems by subwatershed. It is assumed that 26% of all septic systems are failing in this watershed, based upon recent studies completed by the Barry-Eaton District Health Department (2011). As defined in Article II of the Barry-Eaton Health Department on-site sewage regulation (2007), failing septics include but are not limited to: leaking septic systems; systems that discharge directly to surface water, groundwater, or a conveyance to surface or groundwater; and/or systems with a comprised structure. Using this estimated failure rate, approximately 2,500 septic systems are failing in the watershed. More specifically, stakeholders reported that there are three lakes in the Handy-Howell Drain subwatershed with older subdivisions where septic systems may be failing. Supporting this suspicion, human sources are present in this subwatershed, as confirmed by microbial source tracking.

Stakeholders reported that some older septic systems in the watershed were installed with overflow septic capabilities. These septic systems were plumbed to allow septage to pass through the septic system during times of high flow in the system. Other older septic systems were installed to drain directly to a tile drain meant to drain surface water into the ground and to the nearest open drain or stream. These suspected systems were reported near Lamb and Hagadorn Road in Mud Creek, near

Sherwood and Meridian Roads in Coon Creek, and near Van Atta and Grand River Roads in Coon Creek. Human sources were detected during sampling at the site near Van Atta and Grand River only. However, it should be considered that this was only a one-day microbial source tracking data point, and cannot confirm nor exclude these areas as contributing human sources of *E. coli* from these septic systems with certainty.

Improper connections of septics and stormwater systems (p) - Stakeholders reported suspected older stormwater systems in Dansville and Webberville where septics may have historically been connected directly to the stormwater pipelines. This type of connection would result in human septage reaching the groundwater and surface water prior to treatment. Microbial source tracking was completed downstream of Dansville and human sources were not detected. However, since this was only one data point, this suspicion of improper connections cannot be eliminated with certainty. Figure 6.2 displays suspected illicit septic connections.

Over or improper application of biosolids (p) - Treated septage from WWTPs is applied on land as fertilizer. Biosolid applications are regulated by Residuals Management Programs; pathogens in biosolids are required to be significantly reduced, prior to land application (R 323.2418 of Part 24, Land Application of Biosolids, of the Natural Resources and Environmental Protection Act {NREPA}, 1994 PA 451, as amended, as cited in MDEQ, 2013b). They are suspected to be a potential source of *E. coli* in this watershed (MDEQ, 2012c).

Over or improper application of septage (p) - Septage pumped from septic systems is land applied with oversight by the MDEQ and the local health department. The management of septage is regulated under 2004 Public Act 381, of NREPA (1994 PA 451, as amended, as cited in MDEQ, 2013b). In this watershed, 12 acres are used for septage application. Due to this level of oversight and relative small size of area used for spreading, this cause is considered to contribute minimal amounts of *E. coli*, but may be a source of *E. coli* (MDEQ, 2012c) and should be easily addressed. Figure 6.5 shows the locations of biosolids and septage spreading.

BMPs to address Human E. coli Contributions

The following BMPs are proposed to reduce E. coli contributions in the watershed from humans.

Structural/Vegetative	**Management**
Septic Maintenance, Repairs or Replacement	Septic Outreach and Education
Illicit Connection Repair	Septic Detection Policies
	Illicit Connection Detection
	Information and Education
	Ordinances (e.g. Time of Sale or Transfer)
	Incentives
	Modify Application Rates

Source: Wildlife

Wildlife is considered a source of *E. coli* in this watershed. For this plan, their populations were not counted or estimated as their populations are generally managed by the Michigan Department of Natural Resources (MDNR) and are less manageable through a WMP. However, the causes of wildlife *E. coli* contributions where watershed management could help reduce wildlife *E. coli* contributions to the watershed are reviewed here. Wildlife causes of *E. coli* contributions are listed below and ranked by the size of the contribution.

Causes: Wildlife E. coli Contributions

Improper management of wildlife and zoo animal waste, and illicit connection (k) - Wildlife is reported in the TMDL as a contributing source of *E. coli* to the watershed through illicit connections at Potter Park Zoo (MDEQ, 2012b).

High populations of various wildlife (s) - Wildlife likely contribute *E. coli* to the watershed, but as discussed above, their populations and waste are not addressed in this WMP because they are managed by the MDNR. The feeding of waterfowl leads to unnaturally high concentrations of wildlife and should be discouraged, and the campus of Michigan State University (MSU) was noted during windshield surveys as being a problem area.

Riparian management practices that encourage or attract wildlife (s) - Manicured grass in the riparian zone can attract and encourage wildlife to the water's edge without means of filtering their waste. High habitation rates of Canada geese were noted during the windshield survey and through stakeholder comment in some locations in the watershed. The amount of geese waste reaching the surface water can be managed.

BMPs to address Wildlife E. coli Contributions

The following BMPs are proposed to reduce *E. coli* contributions in the watershed from wildlife.

Structural/Vegetative	**Management**
Shoreline Buffers	Work with zoo
Wetland Restoration	Information and Education
Filter and Buffer Strips with Maintenance	Ordinances (e.g. riparian setback, waterfowl feeding)
	Wetland Preservation
	Incentives
	Discourage feeding of waterfowl

Source: Pets

Pet waste contains and is a source of *E. coli*. Dogs were the only pets considered in this management plan, as dogs and cats are the most common pets. The population of cats was not measured as their waste is typically disposed of in litter boxes and ultimately in landfills (MDEQ, 2012c). Feral populations of cats and dogs were not estimated. The way the dog waste is managed can affect the chances of *E. coli* from the waste reaching the surface water.

Causes: Pet E. coli Contributions

Dog waste not picked up (s) - Dog waste is often left in place on the ground or collected. It is not treated nor spread and used as fertilizer. Collection of dog waste from the ground can help prevent runoff from transporting *E. coli* bacteria present in the waste to the surface water. Picking up dog waste is considered particularly important in the most developed subwatersheds in this watershed as the concentration of dogs is typically higher and the drainage systems are denser, resulting in a reduced likelihood of the dog waste filtering through vegetation.

The most developed and populated subwatersheds are presumed to contribute the highest amounts of dog waste: Sycamore Creek, Headwaters Sycamore Creek, Pine Lake Outlet, and Red Cedar.

BMPs to address Pet E. coli Contributions

The following BMPs are proposed to reduce *E. coli* contributions in the watershed from pets.

Structural/Vegetative	**Management**
Wetland Restoration	Ordinances (e.g. pet waste)
Filter and Buffer Strips with Maintenance	Information and Education
Shoreline Buffers	Wetland Preservation
	Incentives

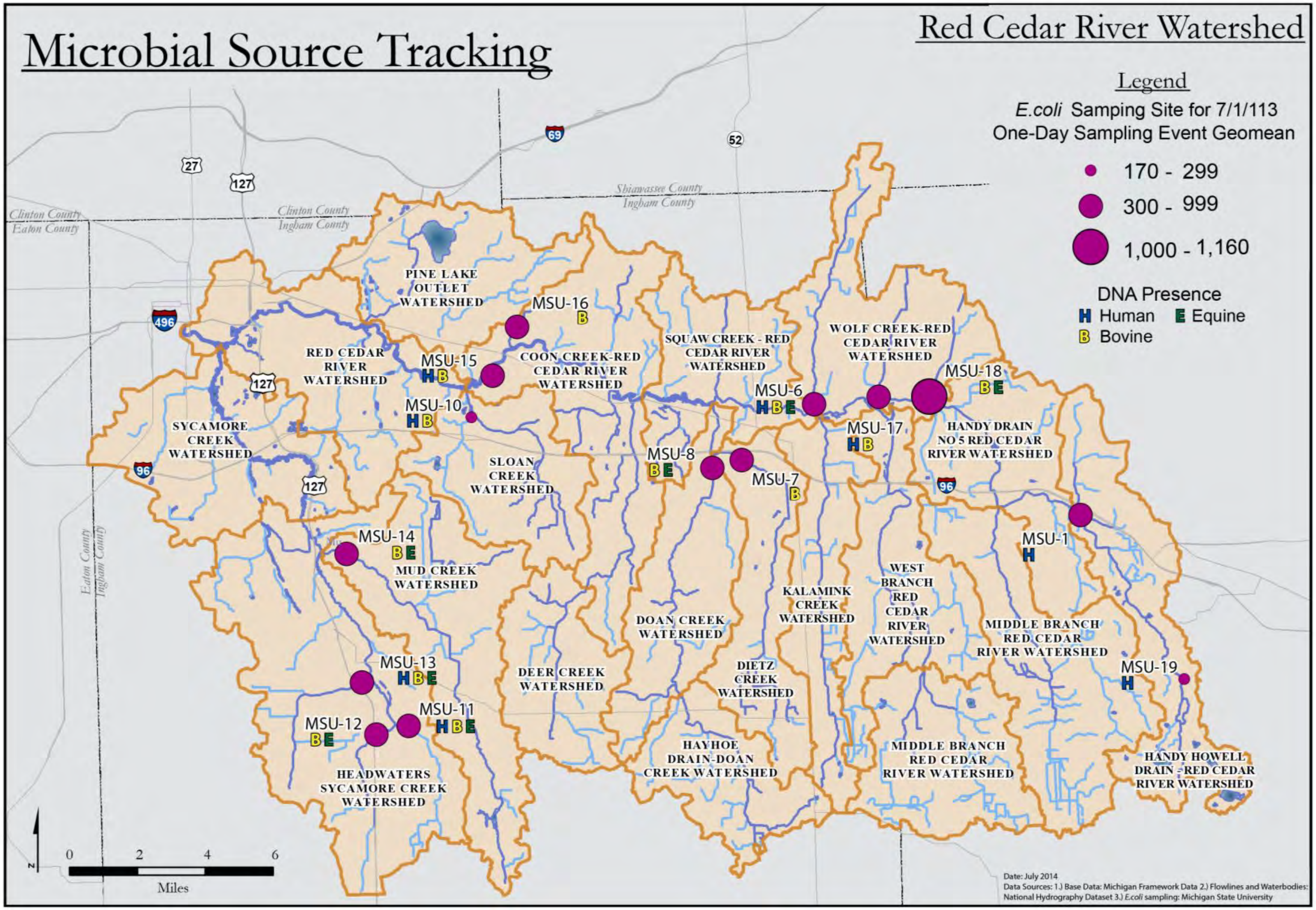


Figure 6.1 Microbial Source Tracking

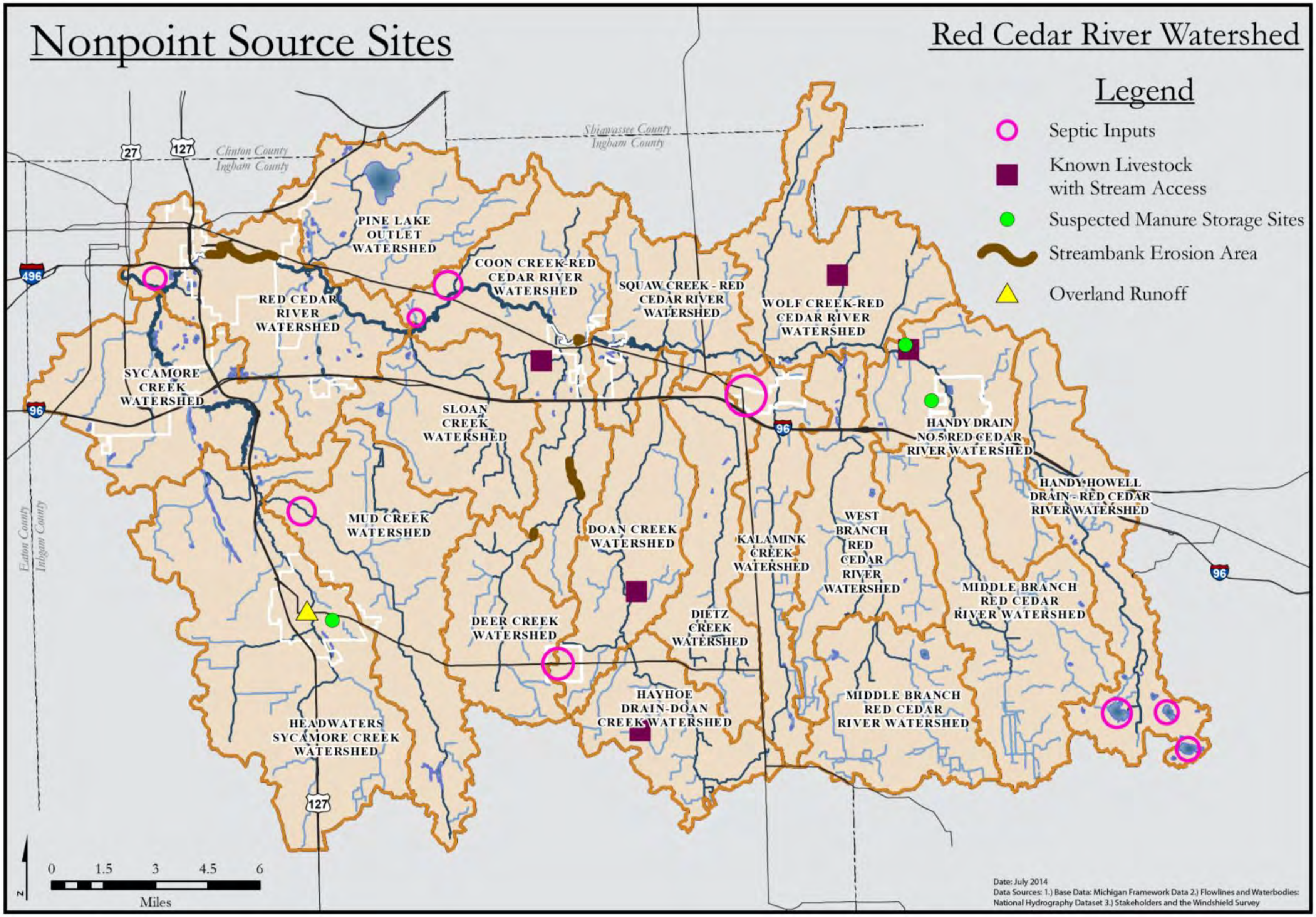


Figure 6.2 Nonpoint source sites

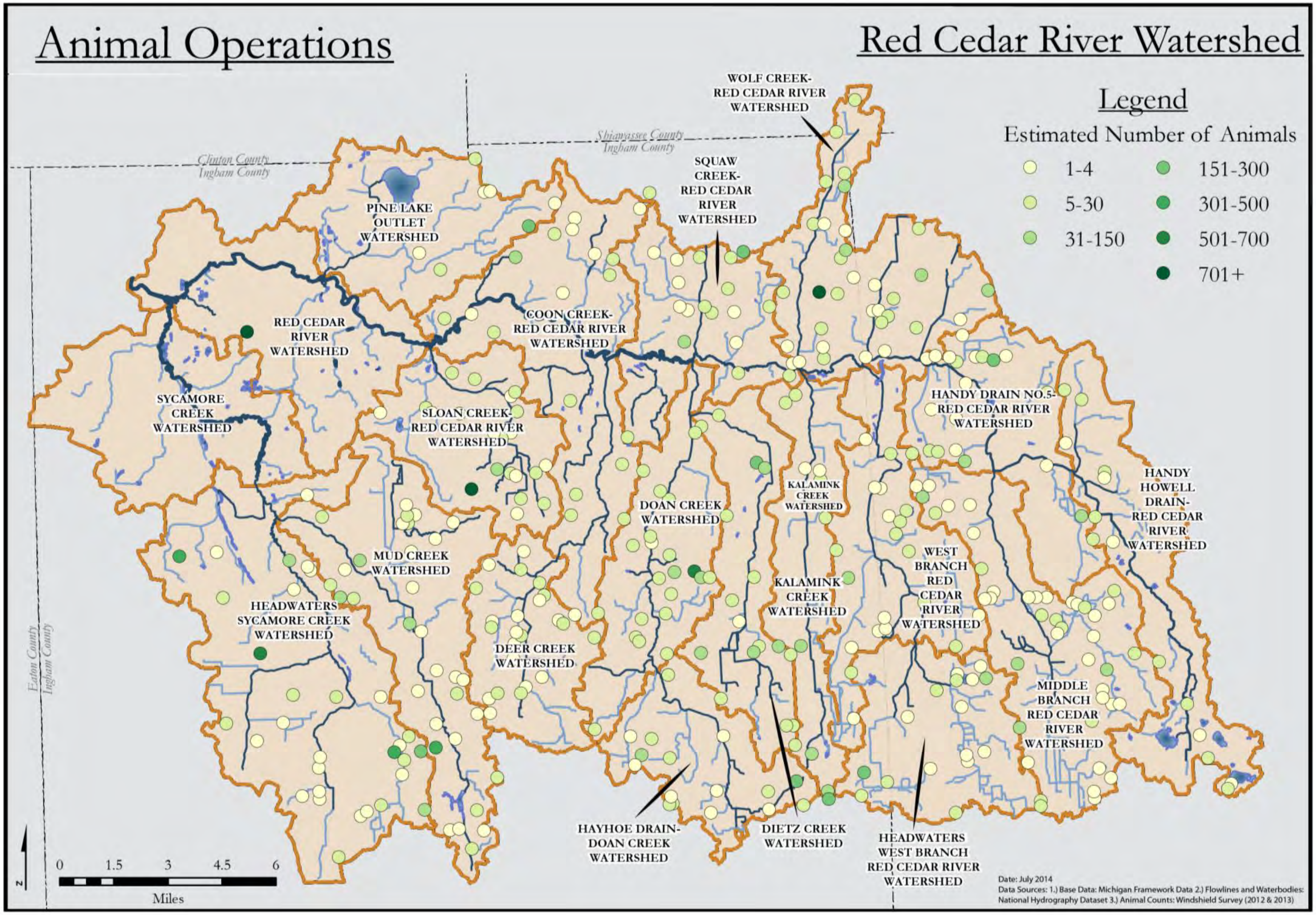


Figure 6.3 Animal Operations

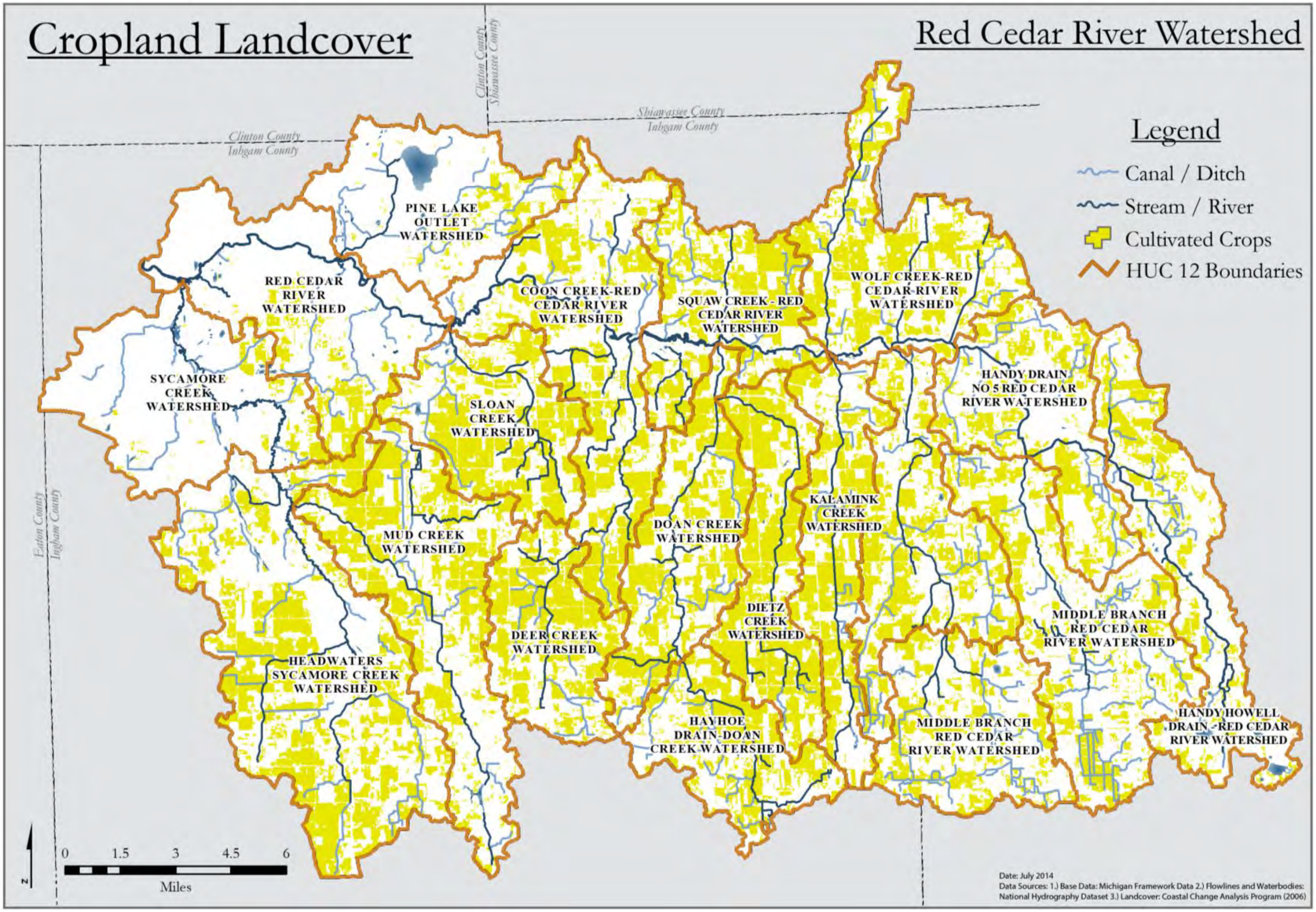


Figure 6.4 Cropland

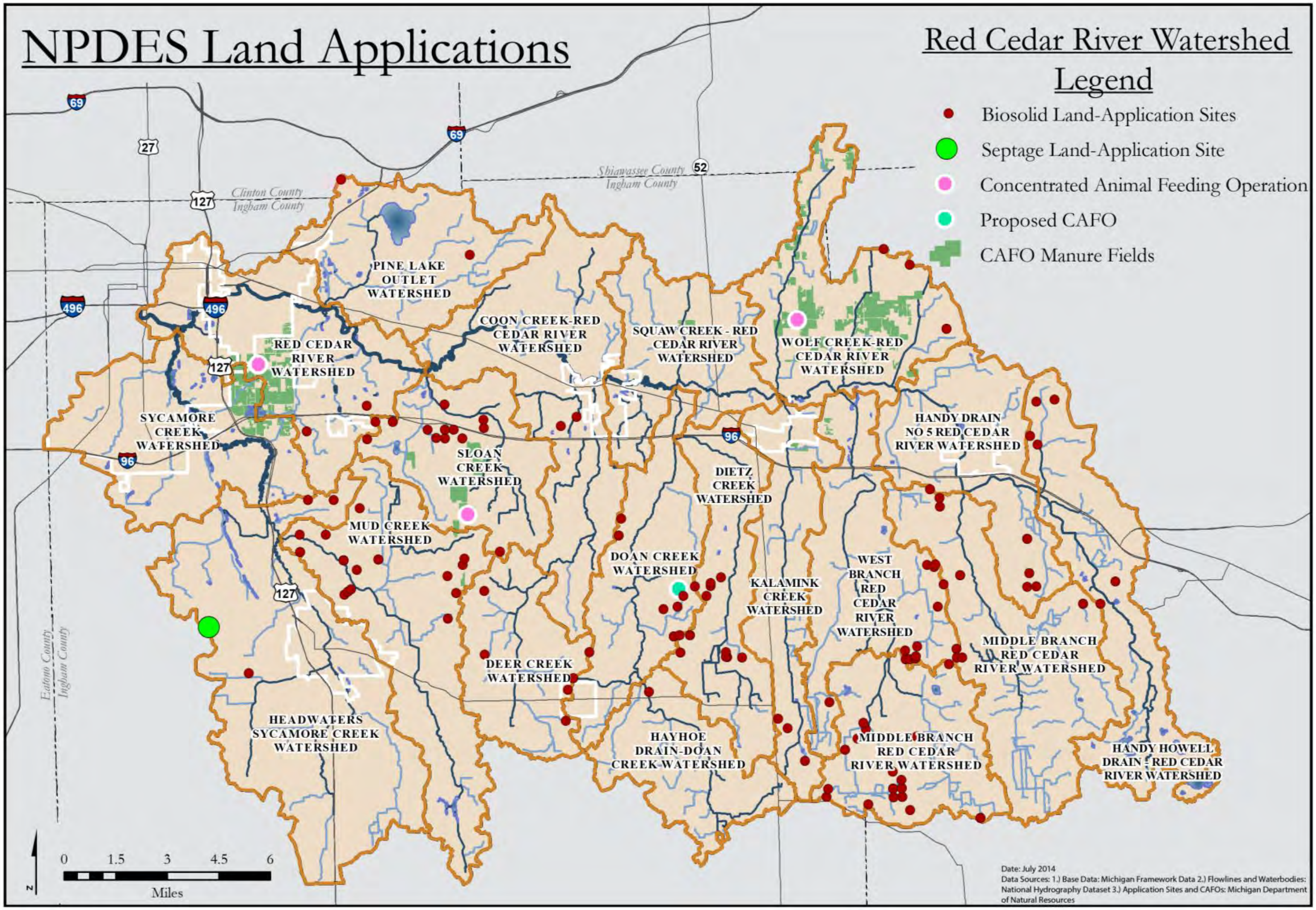


Figure 6.5 Manure Spreading locations under NPDES permits and Biosolid and Septage Land Application Sites

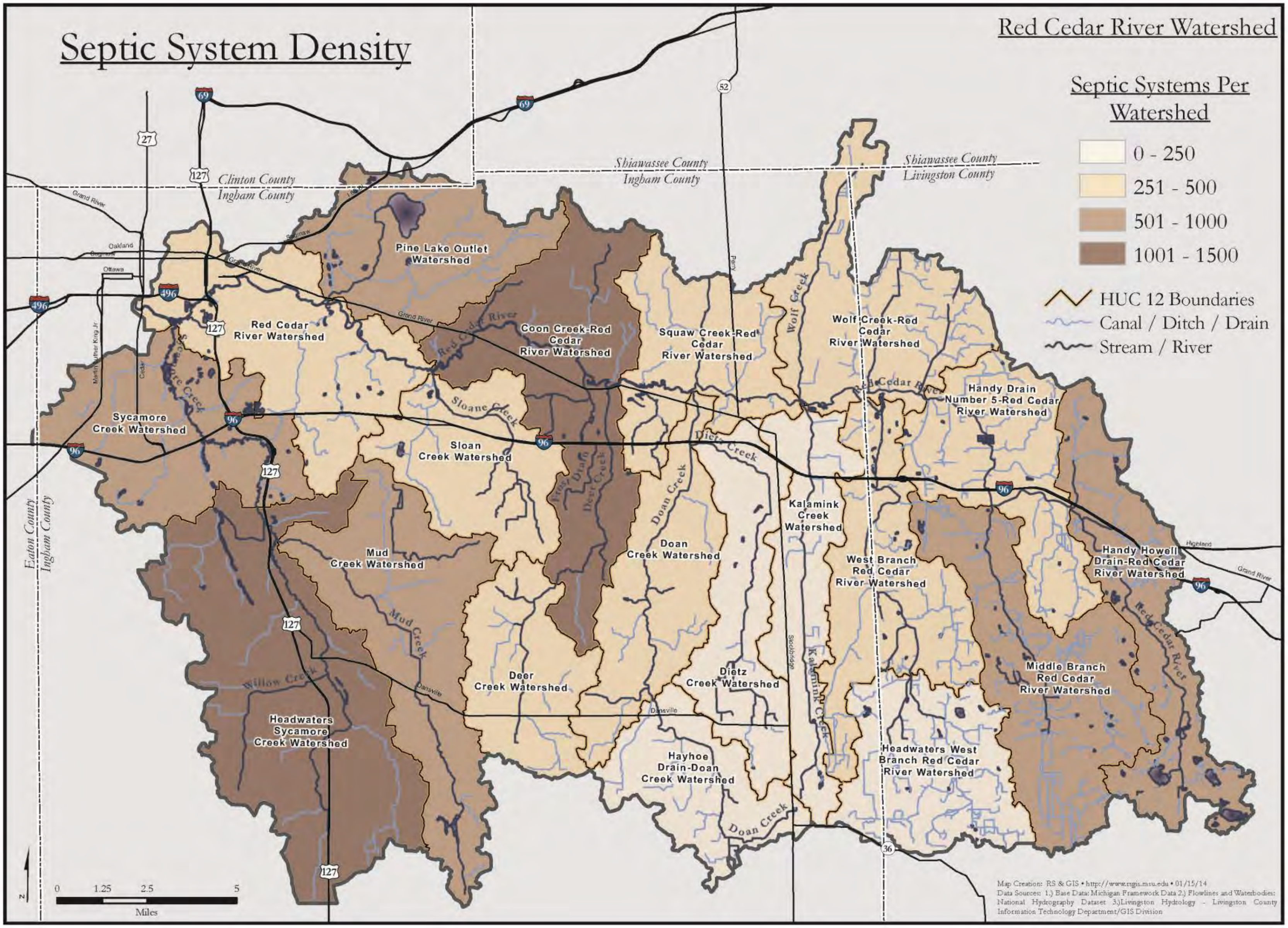


Figure 6.6 Septic System Density by Subwatersheds

6.2 Pollutant: Sediment

Known, suspected and potential nonpoint sources of sedimentation include agricultural fields, construction sites, streambanks, gravel roads and impervious surfaces with excess sediment. Point sources of sedimentation include NPDES permitted sources, such as WWTPs and CAFOs (MEDQ, 2013b).

The DO WQS nonattainment is primarily a result of nutrient and sediment impacts. These suspended solids, which are primarily discharged during high flow conditions, settle on the stream bottom and later have the greatest adverse effect under low flow conditions (MDEQ, 2013b).

Source: Cropland

Cropland can have exposed soil that is at a higher risk of erosion. Most cropland goes through periods of time where vegetation is either not planted, not yet established, or not dense enough to prevent erosion. Eroded soils often travel through runoff to streams and rivers. Cropland causes of sediment contributions are listed below and ranked by the size of the contribution. There are approximately 102,000 acres of cultivated land in the watershed (NOAA, 2008).

Causes: Cropland Sediment

Tillage practices (k) - Different tillage practices disturb the soils to different extents. Some practices leave the ground more susceptible to erosion through runoff by leaving bare soil or little crop residue in the soil. The Natural Resources Conservation Service (NRCS) recommends conservation tillage practices including no-till, mulch-till, and ridge-till (USDA NRCS, 2010).

Figure 6.7 displays results of the High Impact Targeting (HIT) model, which estimates the tons of sediment per acre eroding from crop and agricultural land per year.

BMPs to address Cropland Sediment Contributions

The following BMPs are proposed to reduce sediment contributions in the watershed from cropland.

Structural/Vegetative	**Management**
Cover Crop	Wetland Preservation
Wetland Restoration	Conservation Tillage
Filter and Buffer Strips with Maintenance	Agricultural Management Practices
Streambank Stabilization	Agricultural Outreach
	Information and Education
	Ordinances(e.g. wetland protection)
	Incentives

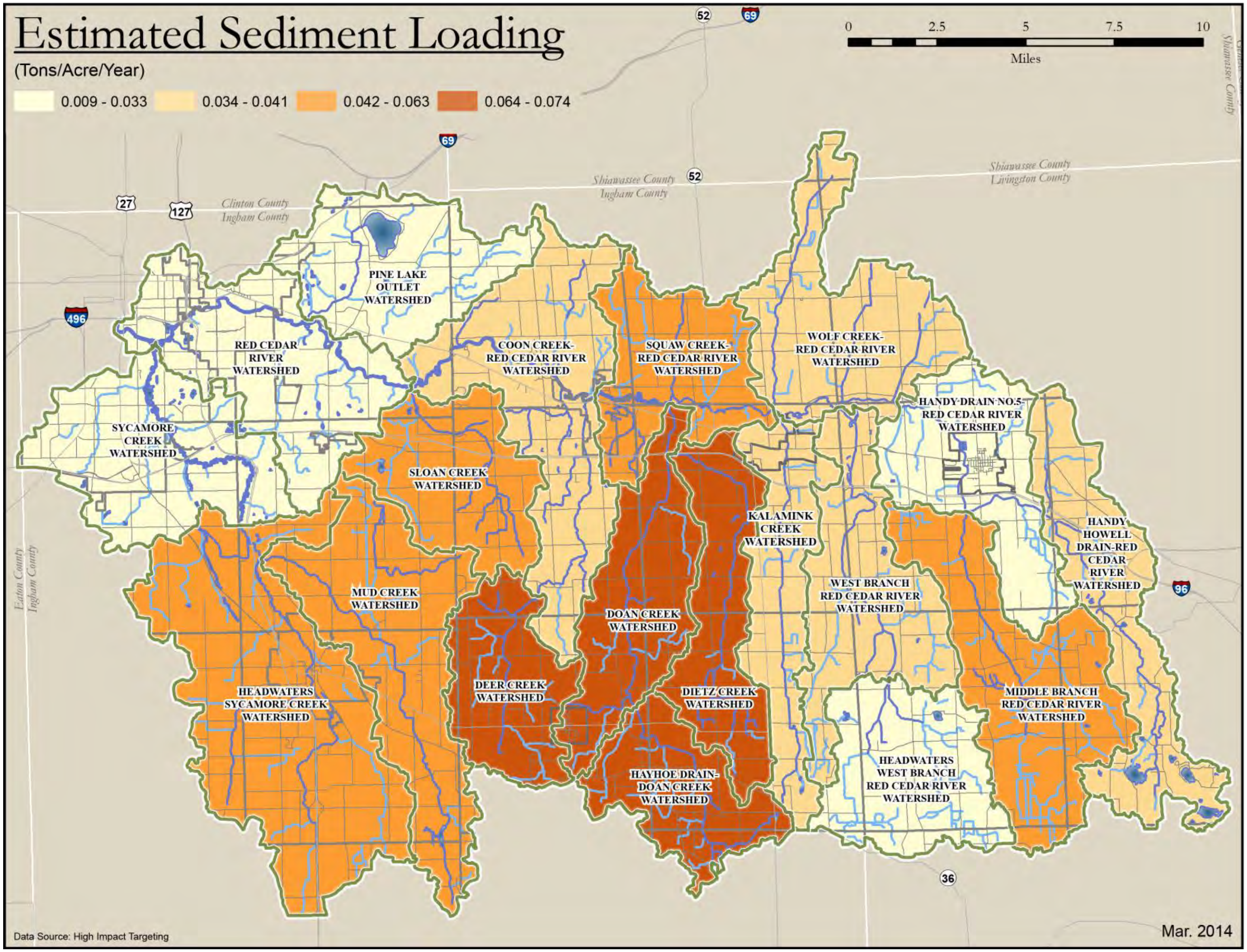


Figure 6.7 HIT modeling results in tons of sediment per acre delivered to surface water per year

Source: Gravel Roads

Gravel roads are areas of bare soil susceptible to erosion. The slope, type of soil, and compaction of the road affect the erosive properties of the soil.

Causes: Gravel Road Sediment

Runoff to roadside ditch or drain (k) - Sediment from the bare soils of the gravel roads observed during the windshield survey gets carried with runoff into roadside ditches or drains, and ultimately into streams and rivers. The transport of road sediments into the drainage network is readily apparent during any precipitation event or snow melt period.

BMPs to address Gravel Road Sediment Contributions

The following BMPs are proposed to reduce sediment contributions in the watershed from gravel roads.

Structural/Vegetative	Management
Pave high erosion areas	Incentives
Filter and Buffer Strips with Maintenance	Wetland Preservation
Wetland Restoration	
Stormwater system devices with pollutant separation capabilities	
Detention or Retention Ponds	
Turnouts	

Source: Streambanks

Unstable streambanks or streambanks lacking vegetation can contribute sediment to creeks and rivers. Streambank causes of sediment contributions are listed below and prioritized by the estimated relative amount of sediment contributions to the creeks and rivers.

Causes: Streambank Sediment

Altered morphology and hydrology including loss of floodplain (k and s) - Modifications to the courses of waterways are often made for farming, residential, and commercial uses of land. These modifications can cause the waterways to change course through erosion, leaving sediment in the waterways. Hydrologic modifications that remove floodplains remove areas from the system that filter sediment from runoff. Areas that are known to have erosion from altered morphology include Doan Creek at Dennis to Holt Road (suspected); three areas of eroded streambank in the Red Cedar subwatershed (known); and an area in the Deer Creek subwatershed (known).

Removal of vegetation (k) - Areas adjacent to waterways that lack vegetation are not protected from erosive streamflows. This flow of water can directly contribute to the erosion of the streambank. The MDEQ reports that 32-73% of each subwatershed's river miles are without substantial natural buffer (MDEQ, 2012c).

Unrestricted livestock access (k) - Areas in this watershed where livestock have direct access to waterways were noted in windshield survey and from stakeholder meetings. Through this direct access to waterways, livestock erode vegetation and soil away from the sides of streambanks and expose streambank areas to erosion. Figure 6.2 shows where unrestricted livestock access locations were found in this watershed.

BMPs to address Streambank Sediment Contributions

The following BMPs are proposed to reduce sediment contributions in the watershed from streambanks.

Structural/Vegetative	Management
Floodplain Restoration	Floodplain Protection
Wetland Restoration	Wetland Preservation
Streambank stabilization	Drain Maintenance
Filter and Buffer Strips with Maintenance	Incentives
Stream Restoration	Information and Education
Exclusion Fencing or Controlled Access	Ordinances
Alternative Water Sources	

Source: Developed Areas

Developed land allows sediment to collect and be conveyed into stormwater systems and into waterways at a quicker rate when compared to that of undeveloped land in its natural state. The impervious surfaces and lack of vegetation causes flashy flows of runoff entering rivers. Developed land causes of sediment contributions are listed below and prioritized by the relative estimated amount of sediment contributions. These areas were noted to be sources of sediment during the neighborhood source assessment (NSA).

Causes: Sediment from Developed Land

Overland runoff (k) - Sediment that collects on impervious surfaces gets carried with runoff into roadside ditches, drains, streams, and rivers. The transport of road sediments into the drainage network is readily apparent during any precipitation event or snow-melt period. The NSA found that sediment from overland runoff is in all developed areas surveyed. A site located at Lansing and Maple Streets in the Headwaters Sycamore Creek subwatershed is suspected to carry sediment from overland runoff on impervious surfaces, as noted by a stakeholder.

Bare soil areas (s) - Areas without vegetative cover are more susceptible to erosion and contributing sediment to waterways.

Unpaved driveways (s) - Unpaved driveways are more susceptible to erosion and contributing sediment to waterways.

BMPs to address Residential Areas Sediment Contributions

The following BMPs are proposed to reduce sediment contributions in the watershed from developed land.

Structural/Vegetative	Management
Floodplain Restoration	Floodplain Protection
Low impact development practices	Street Sweeping
Detention or Retention Ponds	Incentives
Wetland Restoration	Ordinances (e.g. stormwater design standards)
Shoreline Buffers	Information and Education
Stormwater system devices with pollutant separation capabilities	Wetland Preservation

6.3 Pollutant: Nutrients

In this watershed, ammonia as nitrogen, total Kjeldahl nitrogen, total phosphorus, and total organic carbon were nutrients that were found to exceed the target values in data collected by the MDEQ and by stakeholders. Chemical oxygen demand was reported as high by MDEQ (2013a). Nutrient pollution is often associated with agricultural practices, lawn maintenance, and leaking septic systems. Overland nutrient sources of pollution can be transported by sediment through runoff. Similar to *E. coli,* dry weather sources of nutrients can be attributed to such things as leaky septic. Wet weather sources of nutrients are carried with overland runoff, such as fertilizer and manure spread on lawns and crops.

Source: Cropland

Cropland receives periodic inputs of nutrients through chemical fertilizers and manure. Most cropland also goes through periods of time where vegetation is either not planted, not yet established, or not dense enough to prevent erosion, leaving the soil more susceptible to erosion. The eroded soils, and thus the nutrients applied to the soils, are often carried with runoff to streams and rivers. Cropland causes of nutrient contributions are listed below and ranked by the size of the contribution. There are approximately 102,200 acres of cropland in the watershed (NOAA, 2008).

Causes: Cropland Nutrient Contributions

Improper application of manure/fertilizers (s) - Livestock manure and fertilizers are frequently spread on crops for use in promoting plant growth. The soil conditions, spreading rate, weather, proximity to surface water, groundwater, and drainage all affect the path of manure and fertilizer. Due to the conditions recorded during the windshield survey, it is “suspected” that the over or improper application of livestock manure and fertilizers is the major contributing cause of nutrient contributions to the watershed.

Tillage practices (s) - Different tillage practices disturb the soils to different extents. Some practices leave the ground more susceptible to erosion through runoff by leaving bare soil or little crop residue in the soil. Soil that erodes from cropland through runoff can carry nutrients to streams and rivers. The NRCS recommends conservation tillage practices including no-till, mulch-till, and ridge-till (USDA NRCS, 2010).

BMPs to address Cropland Nutrient Contributions

The following BMPs are proposed to reduce nutrient contributions in the watershed from cropland.

Structural/Vegetative	**Management**
Wetland Restoration/Preservation	Information and Education
Cover Crop	Incentives
Filter and Buffer Strips with Maintenance	Ordinances (e.g. wetland protection, riparian setback)
Streambank Stabilization	Tile Line Management
Grassed Waterways	Crop Residue Management
Tile Line Control	Comprehensive nutrient management plans
	Nutrient management plans

Source: Livestock

Livestock food and waste contain nutrients. If the food and waste are not properly managed, the nutrients from them may be transported through overland runoff or drains into waterways.

Causes: Livestock Nutrient Contributions

Unrestricted livestock access to stream (k) - Areas where livestock have direct access to a stream have the potential to contribute livestock manure, sediment from eroded streambanks and consequentially nutrients to the stream. There are five locations with known or suspected unrestricted livestock access to the stream: Handy Drain No. 5 (4N3ES33, suspected), Coon Creek (3N1ES10, suspected); Wolf Creek (4N3ES19, known), Hayhoe Drain (2N1ES25, known), Doan Creek (2N1ES1, known). See Figure 6.2.

Holding facilities adjacent to channel (s) - Holding facilities concentrate the nutrients from livestock feed and manure in an area and when the facilities are adjacent to a waterway, nutrients can enter waterways through runoff. Animal farms are located throughout the watershed, with the highest number being in the Middle Branch subwatershed.

Improper storage of manure (s and p) - Livestock manure that is left in place or collected, stored, and spread or used for the production of energy has the potential to leach nutrients from it. It requires proper handling to prevent nutrients from the manure from reaching groundwater, surface water, and drains. Due to conditions recorded by stakeholders it is “suspected” that the improper storage of manure is a contributing cause of livestock nutrient concentrations to the watershed. These sites are discussed in Section 6.1 and shown in Figure 6.2.

BMPs to address Livestock Nutrient Contributions

The following BMPs are proposed to reduce nutrient contributions in the watershed from livestock.

Structural/Vegetative	**Management**
Contained Manure Storage	Information and Education
Field Tile Management	Ordinances (e.g. livestock exclusion)
Rotating Manure Storage	Incentives
Wetland Restoration/Preservation	Comprehensive nutrient management plans
Exclusion Fencing	Nutrient management plans
Streambank Stabilization	

Source: Human

Human waste including greywater (water that is used for laundering, bathing, or washing) and sewage from houses contains nutrients. If this water is not properly treated it can contribute nutrients to waterways. Source tracking completed in 2013 evidenced human waste sources in the surface water (Figure 6.1).

Causes: Human Nutrient Contributions

Aging septic systems and/or improper maintenance (s) - If septic systems are not installed, maintained, or replaced properly, wastewater can leak from these systems into the ground and surface water without proper treatment. Soils drainage properties are particularly important to consider when installing a septic system. Septic systems may fail if they are installed without proper consideration to their drainage abilities.

Figure 6.6 displays the estimated density of septic systems by subwatershed. It is assumed that 26% of all septic systems are failing in this watershed, based upon recent studies completed by the Barry-Eaton District Health Department (2011). These sites are described in more detail in Section 6.1.

Stakeholders reported that some older septic systems installed in the watershed were installed with overflow septic capabilities. These septic systems were plumbed to allow wastewater carrying nutrients to pass through the septic system during times of high flow in the system. Other older septic systems were installed to outlet directly to a tile drain meant to drain groundwater to the surface water.

Improper connections of septics and stormwater systems (p) - Stakeholders reported suspected older stormwater systems where septics may have historically been connected directly to stormwater pipelines. This type of connection would result in wastewater carrying nutrients to reach the groundwater and surface water prior to treatment. These sites are described in more detail in Section 6.1. Suspected illicit septic connections and improper connections of septics and stormwater systems are displayed in Figure 6.2.

BMPs to address Human Nutrient Contributions

The following BMPs are proposed to reduce nutrient contributions in the watershed from humans.

Structural/Vegetative	**Management**
Septic Maintenance, Repairs or Replacement	Septic Outreach and Education
Illicit Connection Repair	Septic Detection Policies
	Illicit Connection Detection
	Information and Education
	Ordinances (e.g. Time of Sale or Transfer)
	Incentives

Source: Manicured Landscapes

Manicured landscapes often require the application of fertilizers to remain healthy through the seasons. Fertilizer from these landscapes can enter groundwater and surface waters if they are not fully absorbed by the landscaping.

Causes: Nutrient Contributions of Manicured Landscapes

Over or improper application of fertilizers (s) - The soil conditions, spreading rate, weather, proximity to surface water, groundwater, and drainage all affect the path and uptake of fertilizer. Over or improper application of fertilizers is suspected at the following locations: lawns, golf courses, parks, and the three lakes region in the southern part of the Handy-Howell Drain subwatershed.

BMPs to address Manicured landscape Contributions

The following BMPs are proposed to reduce nutrient contributions in the watershed from manicured landscapes.

Structural/Vegetative	**Management**
Low Impact Development	Information and Education Ordinances (e.g. riparian setback, phosphorus fertilizers)

Source: Waterfowl

Waterfowl waste contains nutrients and is often concentrated near surface water. Waterfowl are considered a source of nutrients in this watershed.

Causes: Nutrient Contributions of Waterfowl

Overpopulation of waterfowl (s) - Waterfowl, including Canada geese, often congregate near surface water. Their waste is flushed into the surface water through runoff. Lands adjacent to waterways are suspected locations for where the waterfowl are residing.

BMPs to address Waterfowl Contributions

The following BMPs are proposed to reduce nutrient contributions from the watershed from waterfowl.

Structural/Vegetative	**Management**
Shoreline Buffers	Information and Education Ordinances (e.g. riparian setback, waterfowl feeding) Discourage feeding of waterfowl

Table 6.1 Pollutant, Source, Cause Summary

Pollutant (in priority order)	**Source** (in priority order)	**Cause** (in priority order)	**Goals & Obj**	**Summary of Presence in Watershed**	**Applicable Subwatersheds**	**Proposed BMP(s)**	**Est. Quantity**	**Est. Pollutant Loading**	**Load Reduction Goal**
1. *E. coli* (k)	1. Livestock [bovine (k), equine (k)]	Unrestricted livestock access to stream (k, s)	2, 4, 5	5 locations: Handy Drain No. 5[E] (s, 3N3E4); Coon Creek[C] (s, 3N1ES10); Wolf Creek (k, 4N3ES19); Hayhoe Drain (k, 2N1ES25); Doan Creek[D] (k, 2N1ES1)	Coon Creek[C]; Doan Creek; Wolf Creek, Hayhoe Drain[D]; Handy Drain No. 5[E]	Exclusion fencing or controlled access; alternative water sources	LF fence, 4 controlled crossing and/or 4 water sources		
		Application of manure (s)	2, 4, 5,	14,279 non CAFO large animals; 6,593 CAFO animals; 352 animal farms (non CAFO); Sloan Creek many small farms with poor practices[C]	All; site in Dietz Creek; Sloan	Wetland preservation; wetland restoration; cover crop; conservation tillage; filter and buffer strips with maintenance; agricultural management practices	8,383 acres of wetland to be preserved (2,192 wetland features), 30,311 acres of wetland to restore (813 wetland features), ~102,200 acres of cultivated cropland, 32-73% of each subwatershed's river miles are without substantial natural buffer[A] , ~352 non CAFO animal farms		
		Improper storage of manure (s, p)	2, 4, 5	352 animal farms (non CAFO); Ingham County Fairgrounds (s, stakeholder); Fowlerville Fairgrounds (p); Handy Drain No. 5[A] (s, 3N3E4)	All, Headwaters Sycamore Creek, Handy Drain No. 5	Contained manure storage areas; rotating manure storage	~352 non CAFO animal farms		
		CAFO manure land spreading resulting in over or improper application of manure (s)	2, 4, 5	5,376 acres used for spreading nonmanifested waste at 9 subwatersheds; 6.4 million gallons of manifested liquid waste and 6,558 tons of solid waste[A]	Kalamink, Mud Creek, Red Cedar, Sloan, Squaw, Sycamore Creek, West Branch, Wolf, new CAFO in Doan	Wetland preservation; wetland restoration; cover crop; conservation tillage; filter and buffer strips with waintenance; agricultural management practices	8,383 acres of wetland to be preserved (2,192 wetland features), 30,311 acres of wetland to restore (813 wetland features), 32-73% subwatershed river miles are without substantial natural buffer[A], 5,376 acres used for spreading for nonmanifested waste at 9 subwatersheds; 6.4 million gallons of manifested liquid waste and 6,558 tons of solid waste[A]		
		Livestock holding facilities (p)	2, 4, 5	Middle Branch- many small farms with 2-12 animals; runoff observed; suspected watershed wide	Middle Branch	Filter and buffer strips with maintenance; capture and/or redirect runoff			
	2. Humans (k)	Aging septic systems and/or improper maintenance (k)	2, 4, 5	Estimated 2,472 failing septic tanks (calculated); 3 lakes with older homes with septic systems in Handy-Howell subwatershed[C]	All, Handy-Howell	Septic outreach and education; septic detection policies; septic maintenance, repairs or replacement	Estimated 2,472 failing septic tanks (calculated). ~33 homes on Pleasant Lake, ~90 homes on Triangle Lake, ~50-75 homes Cedar Lake in Handy-Howell subwatershed.		
		Illicit connections (s)	2, 4, 5	3 locations suspected of illicit connections[C]	Coon, Sloan	Septic detection policies; septic maintenance, repairs or replacement; septic outreach and education	~ 3-10 homes in Mud Creek; Subdivision(s) in Coon Creek (nearby Sherwood and Meridian intersection); ~ 6 homes in Coon Creek (nearby (Van Atta and Grand River intersection)		
		Improper connections of septics and old stormwater systems (p)	2, 4, 5	2 locations suspected: Dansville, Webberville[C]	Doan, Kalamink	Illicit connection detection; illicit connection repair; septic outreach and education	2 locations: Dansville, 206 Housing Units; Webberville, Housing Units 573		
		Over or improper application of biosolids (p)	2, 4, 5	64 sites total[B]	All except Sycamore Creek	Ordinances; modify application rates; filter and buffer strips with maintenance	28 waste generators[A]		
		Over or improper application of septage (p)	2, 4, 5	12 acres[B]	Headwaters Sycamore Creek	Ordinances; modify application rates; filter and buffer strips with maintenance; cover crop	1 applicator/ 12 acres		

Pollutant (in priority order)	**Source** (in priority order)	**Cause** (in priority order)	**Goals & Obj**	**Summary of Presence in Watershed**	**Applicable Subwatersheds**	**Proposed BMP(s)**	**Est. Quantity**	**Est. Pollutant Loading**	**Load Reduction Goal**
	3. Wildlife (s)	Improper management of wildlife and zoo animal waste, and illicit connection (k)	2, 4, 5	Potter Park Zoo in Red Cedar[A,C]	Red Cedar	Work with zoo	Potter Park Zoo		
		High populations of various wildlife (s)	2, 4, 5	Geese in Coon Creek[C]; standard baseline populations	All, Coon Creek	Shoreline buffers			
		Riparian management practices that encourage or attract wildlife (s)	2, 4, 5	Water frontage areas	All	Filter and buffer strips with maintenance			
	4. Pets (s)	Dog waste not picked up (s)	2, 4, 5	Estimated 46,403 dogs in the most populated subwatersheds within the Red Cedar River Watershed (calculated)	Sycamore Creek, Headwaters Sycamore Creek, Red Cedar, Pine Lake Outlet	Information and education; ordinances	2 counties, 3 cities, 4 charter townships, 6 townships, MSU		
2. Sediment (k)	1. Cropland (k)	Tillage practices (k)	3, 4, 5	Observed during windshield survey		Information and education	~102,200 acres of cultivated cropland; ~12,800 tons/year	12,801 tons/year[H]	2016: 1,628 tons/year 2018: 3,256 tons/year 2020: 4,885 tons/year 2022: 6,513 tons/year[F]
	2. Gravel roads (k)	Runoff to roadside ditch or drain (k)	3, 4, 5	Rural Subwatersheds with gravel observed during windshield survey	All	Pave high erosion areas	Unknown		
	3. Streambanks (k)	Altered morphology and hydrology including loss of floodplain (k)	3, 4, 5, 6	Observed during windshield survey and existing reports: near Williamston WWTP and golf course in Coon Creek (p); Redig Doan Creek Dennis to Holt Road[C](p); 3 eroded streambank areas in Red Cedar and areas on Deer Creek in Coon Creek[D]	Coon Creek, Doan Creek, Hayhoe Drain, Headwaters Sycamore Creek, Headwaters West Branch, Middle Branch, Mud Creek, Pine Lake Outlet, Red Cedar	Wetlands restoration; wetlands protection; floodplain protection; floodplain restoration, stream restoration, detention or retention ponds; drain maintenance	~ 5,000 linear feet in Deer Creek, ~ 5,000 linear feet in Red Cedar River	808 tons/year (k sources only) [G]	2016: 162 tons/year 2018: 404 tons/year 2020: 566 tons/year 2022: 808 tons/year [I]
		Removal of vegetation (k)	3, 4, 5	TMDL reported	All	Information and education; filter and buffer strips with maintenance; incentives	32-73% of each subwatershed's river miles are without substantial natural buffer[A]		
		Unrestricted livestock access (k, p)	3, 4, 5	5 locations: Handy Drain No. 5[A] (s, 3N3E4); Coon Creek[C] (s, 3N1ES10); Wolf Creek (k, 4N3ES19); Hayhoe Drain (k, 2N1ES25); Doan Creek[D] (k, 2N1ES1)	Coon Creek[C]; Doan Creek; Wolf Creek; Hayhoe Drain[D]; Handy Drain No. 5[E]	Exclusion fencing or controlled access; alternative water sources	Fencing in 4 locations, 4 controlled crossing and/or 4 water sources	80 tons/year (k sources only) [G]	2016: 32 tons/year 2017: 64 tons/year 2018: 80 tons/year [I]
	4. Developed areas (k)	Overland runoff (k, k/s)	3, 4, 5	Lansing & Maple Streets in Headwaters Sycamore Creek (s); all other urban areas (k/s)	Pine Lake Outlet, Red Cedar, Sycamore Creek	Street sweeping; education; stormwater system devices with pollutant separation capabilities	2 Counties, 3 cities, 4 charter townships, 6 townships, MSU	3,720 tons/year [F]	2016: 75 tons/year 2018: 150 tons/year 2020: 225 tons/year 2022: 300 tons/year [I]
		Bare soil areas (s)	3, 4, 5	Watershed Wide	Pine Lake Outlet, Red Cedar, Sycamore Creek	Street sweeping; education; stormwater system devices with pollutant separation capabilities	2 Counties, 3 cities, 4 charter townships, 6 townships, MSU	3,298 tons/year [F]	2016: 75 tons/year 2018: 150 tons/year 2020: 225 tons/year 2022: 300 tons/year [I]
		Unpaved driveways (s)	3, 4, 5	Watershed Wide	Pine Lake Outlet, Red Cedar, Sycamore Creek	Street sweeping; stormwater system devices with pollutant separation capabilities	2 Counties, 3 cities, 4 charter townships, 6 townships, MSU	3,298 tons/year [F]	2016: 75 tons/year 2018: 150 tons/year 2020: 225 tons/year 2022: 300 tons/year [I]

Pollutant (in priority order)	**Source** (in priority order)	**Cause** (in priority order)	**Goals & Obj**	**Summary of Presence in Watershed**	**Applicable Subwatersheds**	**Proposed BMP(s)**	**Est. Quantity**	**Est. Pollutant Loading**	**Load Reduction Goal**
3. Nutrients (s)	1. Cropland (s)	Application of manure/fertilizers (s)	2, 3, 4, 5	~102,200 acres of cultivated cropland		Wetland preservation; wetland restoration; cover crop; conservation tillage; filter and buffer strips with maintenance; agricultural management practices	8,383 acres of wetland to be preserved (2,192 wetland features), 30,311 acres of wetland to restore (813 wetland features), ~102,200 acres of cultivated cropland, 32-73% of each subwatershed's river miles are without substantial natural buffer[A], ~352 non CAFO animal farms	~255 tons P / year ~562 tons N / year [F]	2016: 32 tons P/year 71 tons N/year 2018: 64 tons P/year 142 tons N/year 2020: 96 tons P/year 213 tons N/year 2022: 128 tons P/year 284 tons N/year[F]
		Tillage practices (k)	2, 3, 4, 5	~102,200 acres of cultivated cropland[D]		Information and education	~102,200 acres of cultivated cropland; ~12,800 tons of sediment/year	~255 tons P / year ~562 tons N / year [F]	2016: 26 tons P/year 2016: 56 tons N/year 2018: 52 tons P/year 2018: 112 tons N/year[F]
	2. Livestock (s)	Unrestricted livestock access (k, p)	2, 3, 4, 5	5 locations: Handy Drain No. 5[E] (s, 3N3E4); Coon Creek (s, stakeholder 3N1ES10); Wolf Creek (k, 4N3ES19); Hayhoe Drain (k, 2N1ES25); Doan Creek (k, windshield survey 2N1ES1)	Coon Creek (stakeholder); Doan Creek; Wolf Creek, Hayhoe Drain, (windshield survey) Handy Drain No. 5[E]	Exclusion fencing or controlled access; alternative water sources	Fencing in 5 locations, 5 controlled crossing and/or 5 water sources	~ 80 lbs P / year ~160 lbs N / year (k sites only) [G]	2016: 32 lbs P/year 64 lbs N/year 2017: 64 lbs P/year 128 lbs N/year 2018: 80 lbs P/year 160 lbs N/year [G]
		Holding facilities adjacent channel (s)	2, 3, 4, 5	Middle Branch- many small farms with 2-12 animals; runoff observed; suspected watershed wide	Middle Branch	Filter and buffer strips with maintenance; capture and/or redirect runoff			
		Improper storage of manure (s, p)	2, 3, 4, 5	352 animal farms (non CAFO); Ingham County Fairgrounds (s, stakeholder); Fowlerville Fairgrounds (p); Handy Drain No. 5[E] (s, 3N3E4)	All, Headwaters Sycamore Creek, Handy Drain No. 5	Contained manure storage areas; rotating manure storage	~352 non CAFO animal farms	126 tons P / year 687 tons N / year [F]	2017: 3.4 tons P/year 23 tons N/year 2020: 3.1 tons P/year 17 tons N/year[F]
	3. Humans (s)	Aging septic systems and/or improper maintenance (s)	2, 3, 4, 5	Estimated 2,472 failing septic tanks	All	Septic outreach and education; septic detection policies; septic maintenance, repairs or replacement	Estimated 2,472 failing septic tanks	7,524 lbs P / year 19,213 lbs N / year [F]	2017: 30 lbs P/year 78 lbs N/year 2020: 60 lbs P/year 156 lbs N/year 2023: 76 lbs P/year 194 lbs N/year[F]
		Aging septic systems and/or improper maintenance (s)	2, 3, 4, 5	3 lakes with older homes with septic systems in Handy-Howell[C]	Handy-Howell	Septic detection policies; septic maintenance, repairs or replacement; septic outreach and education	~33 homes on Pleasant Lake, ~90 homes on Triangle Lake, ~50-75 homes Cedar Lake	603 lbs P / year 1,538 lbs N / year [F]	2017: 30 lbs P/year 77 lbs N/year 2020: 60 lbs P/year 154 lbs N/year[F]
		Illicit connections (s)	2, 3, 4, 5	3 locations reported suspected of illicit connections[C]: Mud Creek (1), Coon Creek (2)	Coon, Sloan	Illicit connection detection; illicit connection repair; septic outreach and education	~ 3-10 homes in Mud Creek; Subdivision(s) in Coon Creek (nearby Sherwood and Meridian intersection); ~ 6 homes in Coon Creek (nearby (Van Atta and Grand River intersection)	29 lbs P / year 146 lbs N / year [F]	2017: 2 lbs P/year 7 lbs N/year 2020: 4 lbs P/year 14 lbs N/year[F]
		Improper connections of septics and stormwater systems (p)	2, 3, 4, 5	2 locations (s): Dansville, Webberville[C]	Doan, Kalamink	Illicit connection detection; illicit connection repair; septic outreach and education	2 locations: Dansville, 206 Housing Units; Webberville, Housing Units 573	1,424 lbs P / year 7,119 lbs N / year [F]	2017: 71 lbs P/year 356 lbs N/year 2020: 142 lbs P/year 712 lbs N/year[F]
	4. Streambanks (k)	Altered morphology and hydrology including loss of floodplain (k)	3, 4, 5, 6	Observed during windshield survey and existing reports: near Williamston WWTP and golf course in Coon Creek (p); Redig Doan Creek Dennis to Holt Road[C](p); 3 eroded streambank areas in Red Cedar and areas on Deer Creek in Coon Creek[D]	Coon Creek, Doan Creek, Hayhoe Drain, Headwaters Sycamore Creek, Headwaters West Branch, Middle Branch, Mud Creek, Pine Lake Outlet, Red Cedar	Wetlands restoration; wetlands protection; floodplain protection; floodplain restoration, stream restoration, detention or retention ponds; drain maintenance	~ 5,000 linear feet in Deer Creek, ~ 5,000 linear feet in Red Cedar River	929 Lbs P / year 1,858 Lbs N / year [G]	2016: 232 lbs P/year 2016: 464 lbs N/year 2018: 464 lbs P/year 2018: 929 lbs N/year[I]
	5. Maintained landscapes (s)	Over or improper application of fertilizers (s)	2, 3, 4, 5	Lawns, golf courses, parks, lakes in Handy-Howell subwatershed	All	Ordinances; information and education	Sporadically observed during windshield survey. Many houses on Pine Lake Outlet and Headwaters Sycamore Creek Lakes region have maintained landscapes	38,135 lbs P / year 245,560 lbs N / year[F]	2016: 1,983 lbs P/year 2016: 12,278 lbs N/year 2018: 1,874 lbs P/year 2018: 12,184 lbs N/year [F]
	6. Waterfowl (s)	Overpopulation of waterfowl (s)	2, 3, 4, 5	Water frontage areas	All	Shoreline buffers; information and education; ordinances			

Sources:
A – *E. coli* TMDL (MDEQ, 2012c)
B – MDEQ
C – Stakeholder
D – Windshield survey
E – 2001 Unapproved Red Cedar River Watershed Management Plan
F – STEPL Model
G – Pollutants Controlled Calculation and Documentation for Section 319 Watersheds
H – HIT Model
I – WMP Planning Team Estimate

Table 6.2 Best Management Practices for Pollutants and Sources

Corresponding Goals & Obj	BMP	Description	Pollutant Addressed	Estimated Quantity	Source Addressed	Unit Cost ($)	Per Unit	Total Installed Cost ($)	Timeline/ Duration	Measureable Milestone (0-3 Years)	Unit	Measureable Milestone (4-10 Years)	Unit	10 Year Installed Cost ($)	Potential Parties and Techncial Assistance
3, 5, 6	Low impact development practices	Utilize practices that reduce the impact of development on stormwater (e.g., rain barrels, rain gardens, green roofs, porous pavement)	Sediment	2 counties, 3 cities, 4 charter townships, 6 townships, MSU	Residential Areas, Manicured Landscape	$100,000	Municipality	$1,800,000	1-2 years/municipality. 2017: 2 municipalities 2019:4 municipalities	2 Municipalities	Municipalities	4 Municipalities	Municipalities	$400,000	Mid-MEAC; MGROW; Municipalities; TCRPC
3, 5, 6	Stormwater system devices with pollutant separation capabilities	Capture sediment and other pollutants in developed areas in stormwater systems	Sediment	2 counties, 3 cities, 4 charter townships, 6 townships, MSU	Gravel Roads, Residential Areas	$5,000	Each	$450,000	5/year. 2017: 10 devices 2019: 20 devices 2021: 30 devices 2023: 40 devices	20	Each	40	Each	$200,000	Municipalities; MGROW; TCRPC
3, 4, 5, 6	Pave high erosion areas	Pave areas on gravel or dirt roads with high risk of erosion	Sediment	50 miles	Gravel Roads	$200,000	Mile	$10,000,000	2017: 2 miles 2020: 5 miles	2	Miles	5	Miles	$1,000,000	Municipalities; MGROW; TCRPC
2, 3, 6	Stream restoration	Restore streambanks with engineered materials or natural vegetation to stabilize banks and reduce erosion	Sediment	10,000 linear feet of eroded streambanks	Streambanks	$100	Linear Foot	$1,000,000	Ongoing 2016: 2,000 LF 2018: 5,000 LF 2020: 7,000 LF 2024: 10,000 LF	5,000	Linear Feet	10,000	Linear Feet	$1,000,000	County Drain Commissioners; MGROW; USDA/NRCS; Conservation Districts
3, 5, 6	Detention or retention ponds	Retain water to reduce erosion and flooding and allow sediment to settle out	Sediment	40 Ponds	Gravel Roads, Residential Areas	$20,000	Each	$800,000	2016: 4 ponds 2018: 8 ponds 2020: 12 ponds 2022: 16 ponds	8	Each	16	Each	$320,000	Drain Commissioners; Municipalities
3, 5, 6	Street sweeping	Sweep streets at appropriate times to reduce sediment from entering storm drains and reaching surface water	Sediment	2 counties, 3 cities, 4 charter townships, 6 townships, MSU	Residential Areas	$20,000	Municipality	180,000	2016: 1 municipality 2018: 3 municipalities 2020: 5 municipalities 2022: 7 municipalities	3 Municipalities	Municipalities	7 municipalities	Municipalities	$140,000	MGROW; Municipalities; TCRPC
3, 5, 6	Floodplain restoration	Protect floodplains to preserve habitat and nutrient connectivity between land and water and maintain stream stability	Sediment	~1000 acres	Streambanks, Residential Areas	$2,000	Acre	$2,000,000	Ongoing. 2017: 100 acres 2020: 250 acres	100	Acres	250	Acres	$500,000	MDEQ; USDA/NRCS: Conservation Districts; Livingston Land Conservancy; TCRPC
2, 3, 4, 5, 6	Wetland preservation	Preserve existing wetlands from being removed	*E. coli*; Sediment	51,656 acres (56%) of lost wetlands pre-settlement to 2005 (MDEQ); ***E. coli* related:** 8,383 acres of wetland to be preserved (2,192 wetland features); **Sediment related:** 17,574 acres of wetland to preserve (2,969 wetland features), 20,288 acres of wetland to restore (2,222 wetland features)	Livestock, Wildlife, Pets, Cropland, Gravel Roads, Streambanks, Residential Areas	$3,000	Acre	$25,149,000	Ongoing. 50 acres/year. 2016: 50 acres 2022: 350 acres 2025: 500 acres	100	Acres	500	Acres	$1,500,000	MDEQ; USDA/NRCS: Conservation Districts; Livingston Land Conservancy; TCRPC

Corresponding Goals & Obj	BMP	Description	Pollutant Addressed	Estimated Quantity	Source Addressed	Unit Cost ($)	Per Unit	Total Installed Cost ($)	Timeline/ Duration	Measureable Milestone (0-3 Years)	Unit	Measureable Milestone (4-10 Years)	Unit	10 Year Installed Cost ($)	Potential Parties and Techncial Assistance
2, 3, 5, 6	Wetland restoration	Restore potential wetland areas to wetlands	Sediment	***E. coli* related:** 30,311 acres of wetland to restore (813 wetland features); **Sediment related:** 20,288 acres of wetland to restore (2,222 wetland features)	Livestock, Wildlife, Pets, Cropland, Gravel Roads, Streambanks, Residential Areas	$5,000	Acre	$151,555,000	Ongoing. 2016: 250 acres 2018: 500 acres 2020: 750 acres 2022: 1000 acres	500	Acres	1,000	Acres	$5,000,000	MDEQ; USDA/NRCS: Conservation Districts; Livingston Land Conservancy; TCRPC
2, 3, 5	Conservation tillage	Leave crop residue on the surface to reduce erosion and tillage		~102,200 acres of cultivated cropland; ~12,800 tons/year	Cropland	$300	Acre	$30,660,000	Ongoing. 2016: 13,000 acres 2018: 26,000 acres 2020: 39,000 acres 2022: 51,100 acres	25,550	Acres	51,100	Acres	$15,330,000	MSU-E; USDA/NRCS: Conservation Districts
2, 3	Agricultural management practices (e.g., CNMP, soil testing)	Test manure and soil to help identify appropriate application rates		~352 non CAFO animal farms	Livestock, Cropland	$60	Farm ($20/test and 3 tests/farm)	$21,120	2016: 8 farms 2018: 25 farms 2022: 40 farms 2024: 50 farms	25	Farms	50	Farms	$3,000	MSU-E; USDA/NRCS: Conservation Districts
2, 3	Agricultural outreach	Conduct outreach encouraging the agricultural community to become verified through MAEAP, and/or develop nutrient management plans or use BMPs to address manure storage, composting, and application		~352 non CAFO animal farms	Livestock, Cropland	$500	Indivudal Farm Meetings	$176,000	Ongoing. 25 meetings/year. 2017: 75 meetings 2020: 125 meetings	75	Farm Meetings	125	Farm Meetings	$62,500	MSU-E; USDA/NRCS: Conservation Districts
2, 3, 4, 5	Exclusion fencing or contolled access	Install fencing to exclude livestock from freely accessing the creeks or river or install controlled access for livestock to cross a creek in a small determined area with erosion prevention controls in place		5 locations	Livestock, Streambanks	$3	Linear Foot (with estimated 500 LF per location needed)	$7,500	2016: 2 sites 2017: 4 sites 2018: 5 sites	5	Sites		Sites	$37,500	MSU-E; USDA/NRCS: Conservation Districts
2, 3, 4, 5	Alternative water sources	Install water sources to prevent the need of livestock to access surface water by way of the creek or river		5 locations	Livestock, Streambanks	$3,700	Each	$18,500	2016: 2 sites 2017: 4 sites 2018: 5 sites	5	Sites		Sites	$92,500	MSU-E; USDA/NRCS: Conservation Districts
2, 3, 4, 5	Capture and/or redirect runoff	Collect rainwater from roofs and direct runoff so that it does not transport *E. coli* or sediment across livestock holding or manure storage facilities		~352 non CAFO animal farms	Livestock	$5,000	Farm	$1,760,000	Ongoing. 10 farms/year. 2017: 20 farms 2021: 40 farms 2025: 60 farms	30	Farms	60	Farms	$300,000	MSU-E; USDA/NRCS: Conservation Districts
2, 3, 4, 5	Modify application rates	Test waste and soil and customize application rates accordingly		28 biosolid waste generators; 1 septage generator	Humans, Livestock	$1,000	Plan	$29,000	Ongoing. 2017: 10 plans 2019: 20 plans	10	Plans	20	Plans	$20,000	Municipalities; MDEQ

Corresponding Goals & Obj	BMP	Description	Pollutant Addressed	Estimated Quantity	Source Addressed	Unit Cost ($)	Per Unit	Total Installed Cost ($)	Timeline/ Duration	Measureable Milestone (0-3 Years)	Unit	Measureable Milestone (4-10 Years)	Unit	10 Year Installed Cost ($)	Potential Parties and Techncial Assistance
2, 3, 4, 5	Cover crop	Plant a close growing crop to prevent soil erosion		~102,200 acres of cultivated cropland; ~12,800 tons/year	Cropland, Livestock	$300	Acre	$30,660,000	Ongoing. 2016: 13,000 acres 2018: 26,000 acres 2020: 39,000 acres 2022: 51,100 acres	25,550	Acres	51,100	Acres	$15,330,000	MSU-E; USDA/NRCS: Conservation Districts
2, 3, 4, 5	Filter and buffer strips with maintenance	Plant grass, trees, shrubs, or legumes to reduce soil erosion, trap sediment, and increase infiltration	*E. coli*	32-73% of each subwatershed's river miles are without substantial natural buffer (TMDL)	Livestock, Wildlife, Pets, Cropland, Gravel Roads, Streambanks	$9,000	Mile (50 foot wide buffer)	$1,800,000	Ongoing. 2017: 10 miles 2020: 15 miles 2022: 20 miles 2024: 25 miles	10	Miles	25	Miles	$225,000	MSU-E; USDA/NRCS: Conservation Districts; County Drain Commissioners
2, 3, 4, 5	Information and education	Provide information for residents about behaviors and BMPs that protect water quality (e.g., street sweeping, vegetated ditches)		2 counties, 3 cities, 4 charter townships, 6 townships, MSU	Livestock, Humans, Wildlife, Pets, Cropland, Streambanks, Waterfowl, Residential Areas, Manicured Landscape	$2,000	Per source addressed	$18,000	Ongoing. 2016: 2 sources addressed 2018: 4 sources addressed 2020: 5 sources addressed	4	Sources addressed	5	Sources addressed	$10,000	MGROW; Municipalities; TCRPC; MSU; Conservation Districts
2, 3, 4, 5, 6	Ordinances	Adopt local and statewide policies that protect water quality		2 counties, 3 cities, 4 charter townships, 6 townships, MSU	Livestock, Humans, Wildlife, Pets, Cropland, Streambanks, Waterfowl, Residential Areas, Manicured Landscape	$10,000	Ordinance/per community	$180,000	Ongoing. 2017: 3 communities 2020: 6 communities 2023: 9 communities	3	Communities	9	Communities	$90,000	TCRPC; Municipalities
2, 3, 4, 5, 6	Incentives	Use incentives to adopt conservation practices	Nutrients	3 conservation districts	Livestock, Humans, Wildlife, Pets, Sediment, Cropland, Gravel Roads, Streambanks, Residential Areas	$50,000	Each main county (Ingham/ Livingston)	$100,000	Ongoing. 2017: 1 county 2020: 2 counties	1	County	2	County	$50,000	USDA/NRCS; Consercation Districts; Ingham County Farmland and Open Space Preservation Board; Livingston Land Conservancy
2, 5	Septic outreach and education	Educate residents about proper septic maintenance, signs of failure, improper connections, and local sanitary codes.		5 counties	Humans	$20,000	Each main county (Ingham/ Livingston)	$40,000	Ongoing. 2016: 1 county 2019: 2 counties	1	County	2	County	$20,000	County Health Departments; MGROW; Mid-MEAC; Municipalities; TCRPC
2, 5	Septic detection policies	Adopt policies to contribute to better septic system health. The TMDL suggests using a time-of-sale septic system inspection program like in Barry-Eaton County.		5 counties	Humans	$20,000	Each main county (Ingham/ Livingston)	$40,000	2017: 1 county 2019: 2 counties	1	County	2	County	$20,000	County Health Departments; MGROW; Municipalities; TCRPC
2, 5	Septic maintenance, repairs, or replacement	Septic system monitoring, maintenance, pumping; and septic tank, field, or system repair and/or replacement as necessary		~2,472 failing septics	Humans	$7,500	Each full replacement	$18,540,000	Ongoing. 2017: 10 replacements 2020: 20 replacements 2023: 25 replacements	10	Septic system replacements	25	Septic system replacements	$187,500	County Health Departments; MGROW; Mid-MEAC; Municipalities; TCRPC

Corresponding Goals & Obj	BMP	Description	Pollutant Addressed	Estimated Quantity	Source Addressed	Unit Cost ($)	Per Unit	Total Installed Cost ($)	Timeline/ Duration	Measureable Milestone (0-3 Years)	Unit	Measureable Milestone (4-10 Years)	Unit	10 Year Installed Cost ($)	Potential Parties and Techncial Assistance
2, 5	Illicit connection detection	Locate and address septics that are currently failing or incorrectly connected to surface water	Nutrients; *E. coli*	~5 locations with suspected illicit connections: Mud Creek (~ 3-10 homes possible); Coon Creek near intersection of Sherwood and Meridian (Subdivision(s)); Coon Creek near Van Atta and Grand River (up to ~ 6 homes); Village of Dansville (up to 206 Housing Units); Village of Webberville (up to 573 Housing Units)	Humans	$200	Each	$179,000	Ongoing. 2020: 400 connections 2025: 895 connections		Connections	895		$179,000	County Health Departments; MGROW; Municipalities; TCRPC
2, 5	Illicit connection repair	Repair illicit or leaky septic connections		~2,472 failing septics; ~5 locations with suspected illicit connections	Humans	$7,500	Each		Ongoing. 2017: 10 connections 2020: 20 connections	10	Connections	20	Connections	$18,577,500	County Health Departments
2, 3, 5	Shoreline buffers	In riparian areas, use tall and dense vegetation where possible to discourage geese from congregating		~28 shoreline parks	Pets, Wildlife, Residential Areas	$9,000	Mile	$252,000	2016: 1 mile 2020: 3 miles	1	Miles	3	Miles	$27,000	MGROW; Mid-MEAC; Municipalities; TCRPC
2, 5	Contained manure storage areas	Store manure in the proper spaces to reduce *E. coli* from reaching water bodies and/or groundwater		~352 non CAFO animal farms (est. 30 facilities would need this BMP)	Livestock	$50,000	Each	$1,500,000	2018: 3 farms 2020: 6 farms 2022: 8 farms 2024: 10 farms	3	Farms	10	Farms	$500,000	MSU-E; USDA/NRCS: Conservation Districts
2, 3, 5	Field tile management	Control drainage where manure is applied to artificially drained land.		~102,200 acres of cultivated cropland	Livestock	$10	acre	$1,022,000	Ongoing. 2016: 500 acres 2018: 1000 acres 2020: 1500 acres 2025: 2000 acres	1000	acres	2000	acres	$20,000	MSU-E; USDA/NRCS: Conservation Districts
2, 4, 5	Rotating manure storage	Store manure in a location for an appropriate amount of time to reduce *E. coli* from reaching water bodies and/or groundwater		~316 smaller animal farms	Livestock	$0	Each	$0	Ongoing. 2016: 10 farms 2018: 20 farms 2020: 30 farms 2024: 50 farms	20	Farms	50	Farms	$0	MSU-E; USDA/NRCS: Conservation Districts
2, 4, 5	Work with zoo	Manage manure properly		1 facility	Wildlife	$5,000	Each	$5,000	2016	1	Each			$5000	Potter Park Zoo; City of Lansing

7. STRUCTURAL BMP IMPLEMENTATION PLAN

Through this watershed management planning process, pollutants, with a variety of sources and causes, have been identified across the Red Cedar River Watershed (RCRW), which are known or suspected to be negatively impacting water quality. Best Management Practices (BMPs) that could be implemented to reduce the impact of these pollutants and meet pollutant reduction goals in the highest priority areas are identified in this chapter. This chapter also further defines priority locations for preservation, critical sites and areas for restoration, priority subwatersheds, and corresponding BMPs that align with the pollutants, sources, and causes found at these locations.

Though BMPs are encouraged to be implemented wherever possible in the watershed, due to limited resources, priority subwatersheds, and critical and priority areas have been identified. This chapter includes recommendations for:

- Protecting existing high quality lands or important features
- Restoring Critical Sites
- Restoring Critical Areas
- Subwatershed prioritization for general preservation and restoration activities

7.1 Pollutant Loadings and Reduction Goals to Meet TMDL Goals

Total Maximum Daily Load (TMDL) reports completed by the Michigan Department of Environmental Quality (MDEQ) (2012c, 2013b) address the water bodies currently listed as impaired due to excessive *Escherichia coli* (*E. coli)* pollution and dissolved oxygen (DO) deficiencies and are discussed in detail throughout this WMP.

Because the *E. coli* TMDL is concentration-based rather than load-based, the goal is also equal to 130 *E. coli* per 100 mL as a 30-day geometric mean; 300 *E. coli* per 100 mL as a daily maximum for total body contact recreation (TBC); and 1,000 *E. coli* per 100 mL as a daily maximum for partial body contact (PBC) recreation. As such, reduction goals for this project are based upon the relationship between existing *E. coli* concentrations and the water quality standards (WQS). The goal is to ultimately have all water bodies meet the WQS for *E. coli*.

The MDEQ draft TMDL report for DO identified the Mud Creek subwatershed as impaired due to low levels of DO. The goal is to meet the WQS for DO: a minimum of 5 mg/L of DO for warmwater fisheries. To accomplish this, total suspended solids (TSS) should be reduced by 51%. In the Mud Creek subwatershed, the HIT model (described in Chapter Three) estimates pollutant loading at 1,171 tons/acre/year.

Previous studies of agricultural watersheds suggest that significant reductions in *E. coli* concentrations are possible through implementation of physical BMPs. Horizon (2010) reports 58% reductions as a result of site-specific wetland restoration in the Tyler Creek watershed in Kent County, MI. It is appropriate to assume then, that if enough BMPs are installed on a watershed scale, that large-scale reductions in *E. coli* concentrations are feasible.

The feasible and attainable goals for BMP implementation were determined to be approximately 10% of the practices in 5 years and 20% by 2020. The pollutant loadings should be monitored after BMP implementation so progress toward reduction goals can be evaluated. Implementation schedules and practices should then be adjusted to ensure that the TMDL goals will be met.

7.2 Pollutant Loading and Reduction Goals for Other Pollutants

Targeted reduction values for sediment and nutrients are discussed in this section, even though TMDLs have not been established to address them in the RCRW. Criteria for these other pollutants are compared to values in Table 3.2 and summarized below. Sediment reduction goals are based upon meeting Michigan's WQS for total dissolved solids (TDS), established by Part 4 Rules issued in accordance with Part 31 of NREPA, and an informal target for TSS. Rule 323.1051 states that TDS must not exceed a concentration of 500 milligrams per liter as a monthly average or no more than 750 milligrams per liter at any time, as a result of controllable point sources. Furthermore, while Michigan's WQS do not include numerical limits for TSS, an informal target of 80 mg/L is recommended. The goal is to meet these standards for TDS and TSS.

Nutrient reduction goals are based on data from the EPA Ecoregion VII or the Southern Michigan/ Northern Indiana Drift Plains Ecoregion (SMNIDP). The target for total Kjeldahl nitrogen is 0.24 mg/L, as noted in the U.S. EPA's Ambient Water Quality Criteria Recommendations (2000). The goal for ammonia as nitrogen is 0.042 mg/L, which is the SMNIDP Ecoregion mean concentration (Lungdren, 1994 as cited in MDEQ, 2013a). For total phosphorous, the goal is 0.32mg/L, the median value reported for Michigan from 250 sites between 2005 and 2009. The target for total organic carbon (TOC) is <10 mg/L, derived from the SMNIDP Ecoregion median concentration from 2000-2008 (Roush, 2013 as cited in MDEQ, 2013a). The goal is to meet these concentrations for nitrogen, phosphorus and TOC.

7.3 Priority Areas for Preservation and Protection

Preserving high quality or important lands and features is an important component of watershed planning. Priority Areas within the RCRW were identified using several methods. First, the Michigan Natural Features Inventory (MNFI) evaluated potential conservation areas (PCAs) in a study of Clinton, Eaton, and Ingham Counties (Hyde et al., 2009). The results of the MFNI study were reviewed, and it was determined that the areas scoring in the highest PCA category are those most worthy of protection and are designated as Priority Areas for preservation in this plan.

In addition, for reasons discussed throughout this plan, all existing wetlands should be considered Priority Areas. Many wetlands are currently protected by state or local jurisdictions. It is recommended that all local municipalities consider developing a wetland ordinance with preservation in mind.

Because it has been shown that *E. coli* from livestock operations and sediment from cropland erosion are problems in the watershed, a methodology was developed for identifying the highest priority wetlands for protection. First, a radius was assigned to specific livestock operations based upon the number of animals and the estimated amount of land needed for disposal of manure. The following categories were developed based on the results of the windshield survey:

- 1-4 animals: 1/8 mile radius
- 5-30 animals: 1/4 mile radius
- 31-150 animals: 1/2 mile radius
- 151-300 animals: 3/4 mile radius
- 301-500 animals:1 mile radius
- 501-700 animals: 1 1/2 mile radius
- 701+ animals: 2 mile radius

Using the MDEQ Landscape Level Wetland Functional Assessment (LLWFA) (MDEQ, 2012b), existing wetlands with a pathogen removal function, which are located within these radii, were identified. Next, a buffer was created around the two highest High Impact Targeting (HIT) model categories to identify existing wetlands with a sediment removal function. Using the categories listed above, the existing wetlands that fell within a farm or HIT buffer were identified as the highest priority for wetland protection.

In total, about 17,254 acres of wetland in the RCRW are considered Priority Areas for conservation. The map of those areas is shown in Figure 7.1.

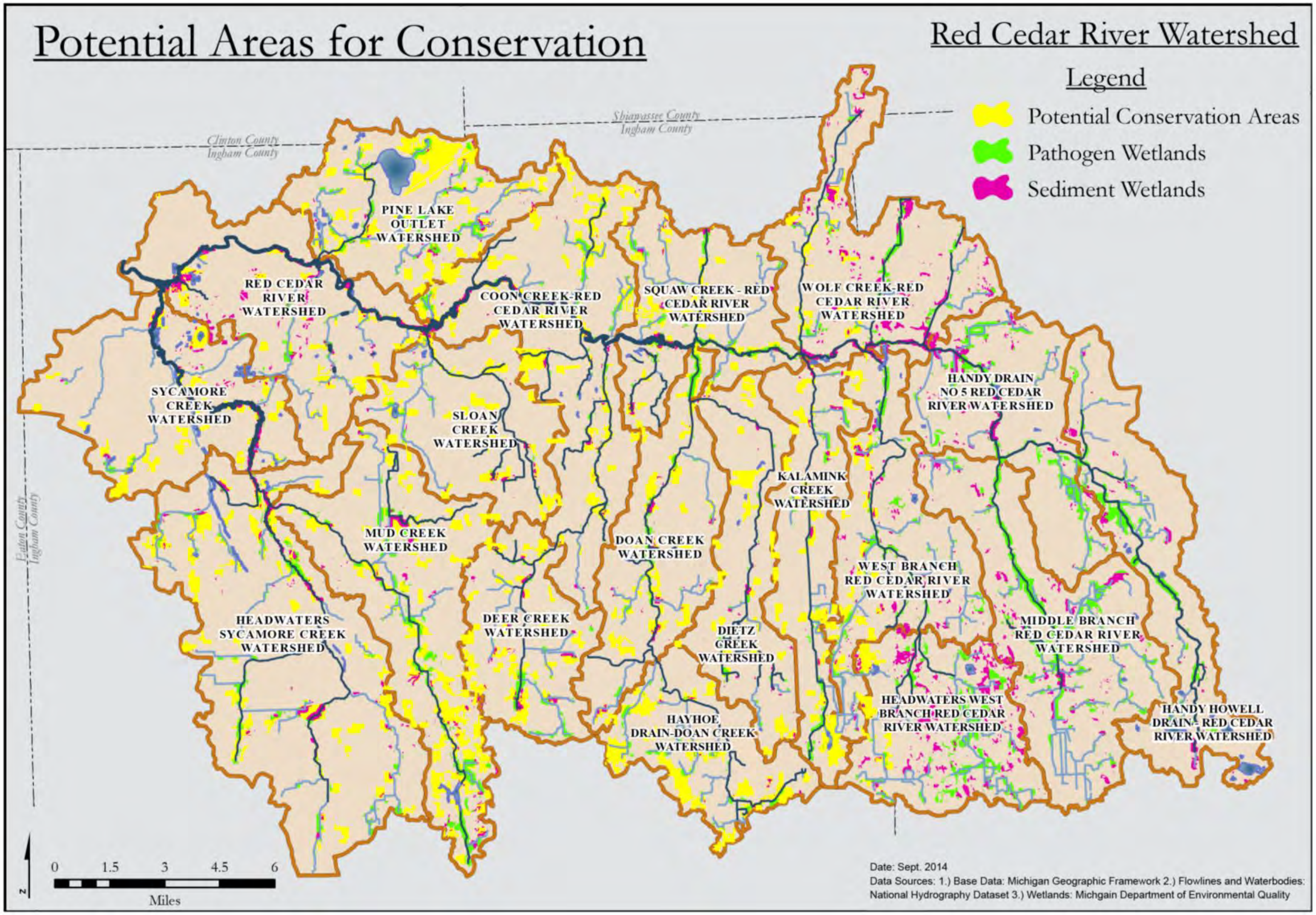


Figure 7.1 Priority Areas for Conservation

7.4 Restoring Critical Sites

Critical sites that have been identified throughout the watershed are summarized in Table 7.1 and shown in the map in Figure 7.2. These sites are considered the highest priority of issues to address in the short term.

These sites are a subset of the sites that were mapped in Chapter Six (Figure 6.2), with known or suspected pollution from livestock access, improper manure storage, streambank erosion, overland runoff and septic inputs. They are sites with known sources of pollution, or with a strong suspicion of pollutant loadings based upon stakeholder input.

Table 7.1. Critical Sites for Restoration

Livestock in the Stream	Overland Runoff from Developed Land	Eroded Streambank	Improper Manure Management	Septic/Sewerage Issues
Wolf Creek (4N3ES19, k)	Lansing and Maple Street in Headwaters Sycamore Creek (s)	3 areas eroded streambanks in Red Cedar (k)	Ingham County Fairground (s)	Potter Park Zoo in Red Cedar (k)
Suggested BMP: Exclusion Fencing and Alternative Water sources or Controlled Access	Suggested BMP: Retrofit and regrade parking lot; Rain gardens	Suggested BMP: Stream Restoration; Streambank Stabilization	Suggested BMP: Contained Manure Storage Areas	Suggested BMP: Work with zoo on maintaining buffers and managing and eliminating zoo animal and wildlife waste contamination
Doan Creek (windshield survey 2N1ES1, k)				Lamb and Hagadorn Roads Intersection in Mud Creek (s)
Suggested BMP: Exclusion Fencing and Alternative Water sources or Controlled Access				Suggested BMP: Illicit Connection Detection and Repair
Hayhoe Drain (2N1ES25, k)		Eroded areas on Deer Creek in the Coon Creek Subwatershed (k)		Van Atta and Grand River in Coon Creek (s)
Suggested BMP: Exclusion Fencing and Alternative Water sources or Controlled Access		Suggested BMP: Stream Restoration; Streambank Stabilization		Suggested BMP: Illicit Connection Detection and Repair

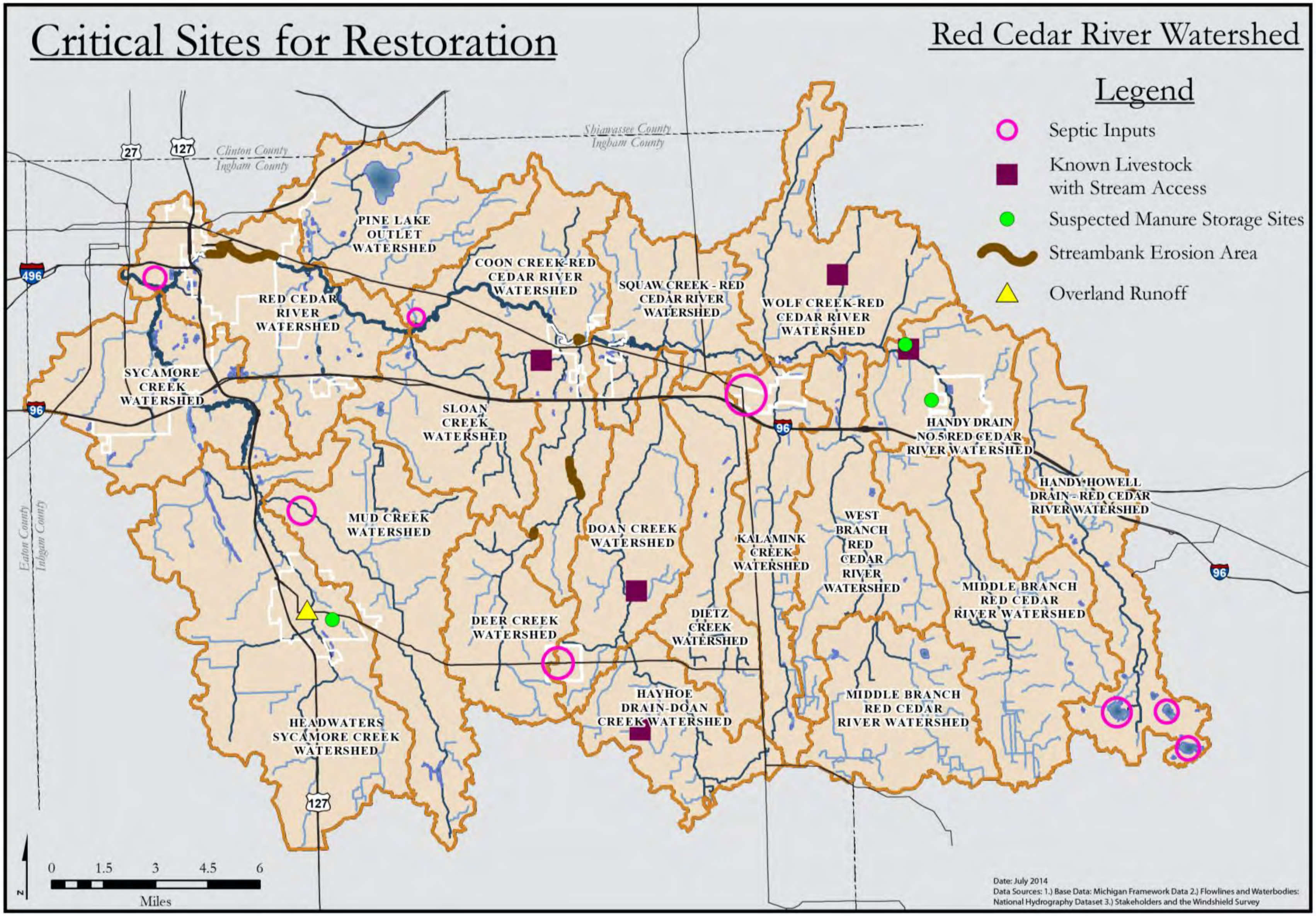


Figure 7.2 Critical Sites for Restoration

7.5 Restoring Critical Areas

The second highest priority for restoration activities are the critical areas outlined below and categorized by pollutant source:

Livestock *E.coli*

As previously discussed, livestock waste is a known overland source of pollution in the watershed. The number of farms and animals at each facility has been estimated. Thus, these areas should be considered for reducing manure inputs (and associated pollutant loading including *E. coli,* nutrients, etc.) to streams and drains within the watershed. Wetland restoration is considered an important BMP since wetlands historically covered much of the watershed, wetlands receive overland flow inputs, and because wetlands are effective systems for *E. coli* removal.

Critical areas for wetland restoration were developed, taking into account the historic and existing wetlands, potential for wetland restoration, livestock demands on the land, and cropland erosion. Similar to methods described earlier for identifying high priority wetlands for protection, the radii around livestock operations were used to identify historic wetlands for restoration. These are the wetlands that have the greatest potential for pathogen removal and are located around the known sources of pollution. The critical areas for wetland restoration are shown in Figure 7.3.

Where wetland restoration is not possible or may not be the most appropriate BMP, buffers or similar BMPs aimed at capturing overland manure runoff should be installed. In addition, other structural and managerial BMPs suggested for livestock pollutant contributions (reviewed in Chapter Six) should be installed.

Cropland

Sediment is a known source of overland pollution in the watershed. Critical areas for sediment pollution from cropland runoff were identified using HIT model results along with the LLWFA. Cropland was determined to be the largest contributor of sediment to the RCRW and its tributaries, and wetland restoration is considered a critical BMP on cropland since wetlands are effective systems for sediment removal.

Where wetland restoration is not possible or may not be the most appropriate BMP, buffers or similar BMPs aimed at reducing and capturing overland sediment should be installed. In addition, other structural and managerial BMPs suggested for cropland sediment pollutant contributions reviewed in Chapter Six should be installed.

Critical areas for wetland restoration were developed, taking into account the historic and existing wetlands, potential for wetland restoration, livestock demands on the land, and cropland erosion. The highest priority wetlands for treating cropland runoff are recommended in this plan to be restorable wetlands located within 500 feet of a stream and within a buffer of the highest two HIT categories. These wetlands are identified, mapped, and considered to be the critical wetland restoration areas for sediment removal and are shown in Figure 7.3.

Urban Sediment

The neighborhood source assessment (NSA) did not identify specific urban areas as being more critical than other urban areas. BMPs to reduce sediment inputs from urban areas should be installed, including those listed in Chapter Six.

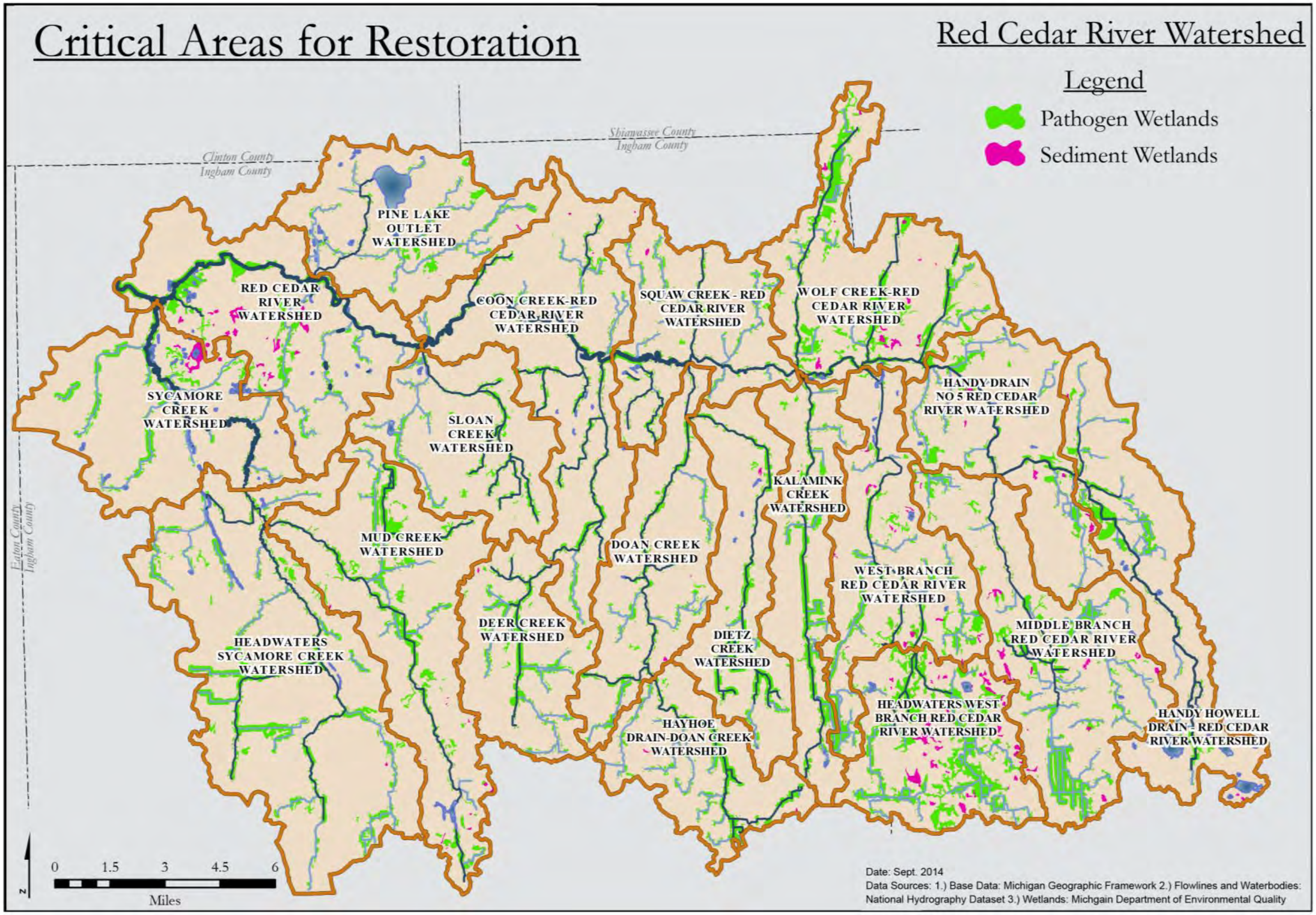


Figure 7.3 Critical Areas for Wetland Restoration

Human *E. coli*
Critical areas for human waste entering the environment from improperly maintained or failing septic or sewer systems were identified using a variety of means, including results of work with scent-trained canines, well and septic records, meetings with health department personnel and personal reports. The results of this information gathering indicate that the following areas should be targeted for BMPs or additional data collection, due to known or suspected pollution from onsite wastewater treatment systems:

Known
Coon Creek
Handy Howell Drain
Headwaters Sycamore Creek
Sloan Creek
Wolf Creek

Suspected
Homes near the intersection of Sherwood and Meridian- Coon Creek
Village of Webberville
Village of Dansville
Triangle Lake
Cedar Lake
Pleasant Lake

Potential (subwatersheds with the highest density of septic systems)
Coon Creek
Headwaters Sycamore Creek
Handy-Howell
Middle Branch
Mud Creek
Sloan Creek
Sycamore Creek
Septic systems in areas with poor soils

To address *E. coli* from human sources in these critical areas, additional source tracking is recommended. In addition, illicit septic connections should be corrected, and septic systems should be maintained, repaired, and/or replaced.

7.6 Subwatershed Prioritization
It was determined that a prioritization of subwatersheds was necessary to help guide future watershed activities due to the large amount of data that exists, the distribution of willing project partners and the various pollutants, sources and causes identified across a very large watershed region. While this is meant to be a prioritization, it does not mean that implementation activities in lower priority subwatersheds are not meaningful or necessary. It is simply meant to be a guide for determining the wisest use of limited funds and resources.

Using the data and information collected and described in this WMP, subwatersheds were prioritized into four tiers from highest piority (Tier I) to lowest priority (Tier IV). Specifically, the following information was used to develop the ranking matrix presented in Table 7.2:

1. Animal density
2. Known or suspected septic problems
3. TMDL priority
4. *E. coli* monitoring results
5. HIT model results
6. Wetland loss
7. Partners interested in developing and implementing BMPs

This tiered list is intended to be updated over time to plan for and implement work in additonal subwatersheds as more funding becomes available. Watershed priority tiers are listed in Table 7.3 and depicted in Figure 7.4.

Table 7. 2 Subwatershed Ranking Matrix

Subwatershed	Animal density (0-10 = 1; 11-30 = 5; 31-100 = 10; 101+ = 15)	Known or suspected Septic (no = 0; yes = 10)	TMDL priority (*E. coli* and DO) (Priority = 10; TMDL = 5; no TMDL = 0)	*E .coli* results (%PBC exceedence) (0-39% = 1; 40-70% = 5; 71-100% = 10)	HIT (Category 1 = 0; Category 2 = 2; 3 = 4; 4 = 6)	Wetland loss (0-30% = 1; 31-70% = 5; 71%+ = 10)	Partner interest (0-2 partners = 1; 3-5 partners = 5; 6+ partners = 10)	TOTAL SCORE	No. of partners	Partners
Sloan Creek	15	10	10	10	4	5	1	55	2	DC, CD
Wolf Creek-Red Cedar River	10	10	5	10	2	10	1	48	2	DC, CD
Red Cedar River	10	10	10		0	5	10	45	7	DC, CD, MSU, Lansing, E. Lansing, Lansing Twp, Meridian Twp
Headwaters Sycamore Creek	10	10	10		4	5	5	44	5	DC, CD, HD, Delhi, Mason
Mud Creek	5	10	10	5	4	5	5	44	3	DC, CD, HD
Middle Branch Red Cedar River	5	10	0	5	4	5	5	34	3	DC, CD, Marion Twp
Coon Creek-Red Cedar River	1	10	5	5	2	5	5	33	5	DC, CD, HD, Williamston, Williamstown Twp
Dietz Creek	10		5	5	6	5	1	32	2	DC, CD
Doan Creek	10		5	5	6	5	1	32	2	DC, CD
Squaw Creek-Red Cedar River	1		10	5	4	5	5	30	4	DC, CD, Williamston, Williamstown Twp
Handy Howell Drain-Red Cedar River	1	10	5	1	2	1	5	25	4	DC, CD, HD, Marion Twp
Kalamink Creek	5		10	1	2	5	1	24	2	DC, CD
Sycamore Creek	1		10	1	0	1	10	23	6	DC, CD, HD, Delhi Twp, Lansing, Lansing Twp
Hayhoe Drain-Doan Creek	5		0		6	10	1	22	2	DC, CD
West Branch Red Cedar River	1		5	10	2	1	1	20	2	DC, CD
Handy Drain No 5-Red Cedar River	5		5		0	5	5	20	4	DC, CD, HD, Marion Twp
Deer Creek	1		0	5	6	5	1	18	2	DC, CD
Headwaters West Branch Red Cedar River	5		5		0	5	1	16	2	DC, CD
Pine Lake Outlet	5		0		0	5	5	15	5	DC, CD, Meridian Twp, Williamston, Williamstown Twp

Table 7.3 Subwatershed Tier Prioritization

Tier I	Tier II	Tier III	Tier IV
Sloan Creek	Middle Branch	Handy Howell	Deer Creek
Wolf Creek	Coon Creek	Kalamink Creek	Headwaters West Branch
Red Cedar River	Dietz Creek	Sycamore Creek	Pine Lake Outlet
Headwaters Sycamore	Doan Creek	Hayhoe Drain	
Mud Creek	Squaw Creek	West Branch	
		Handy Drain No. 5	

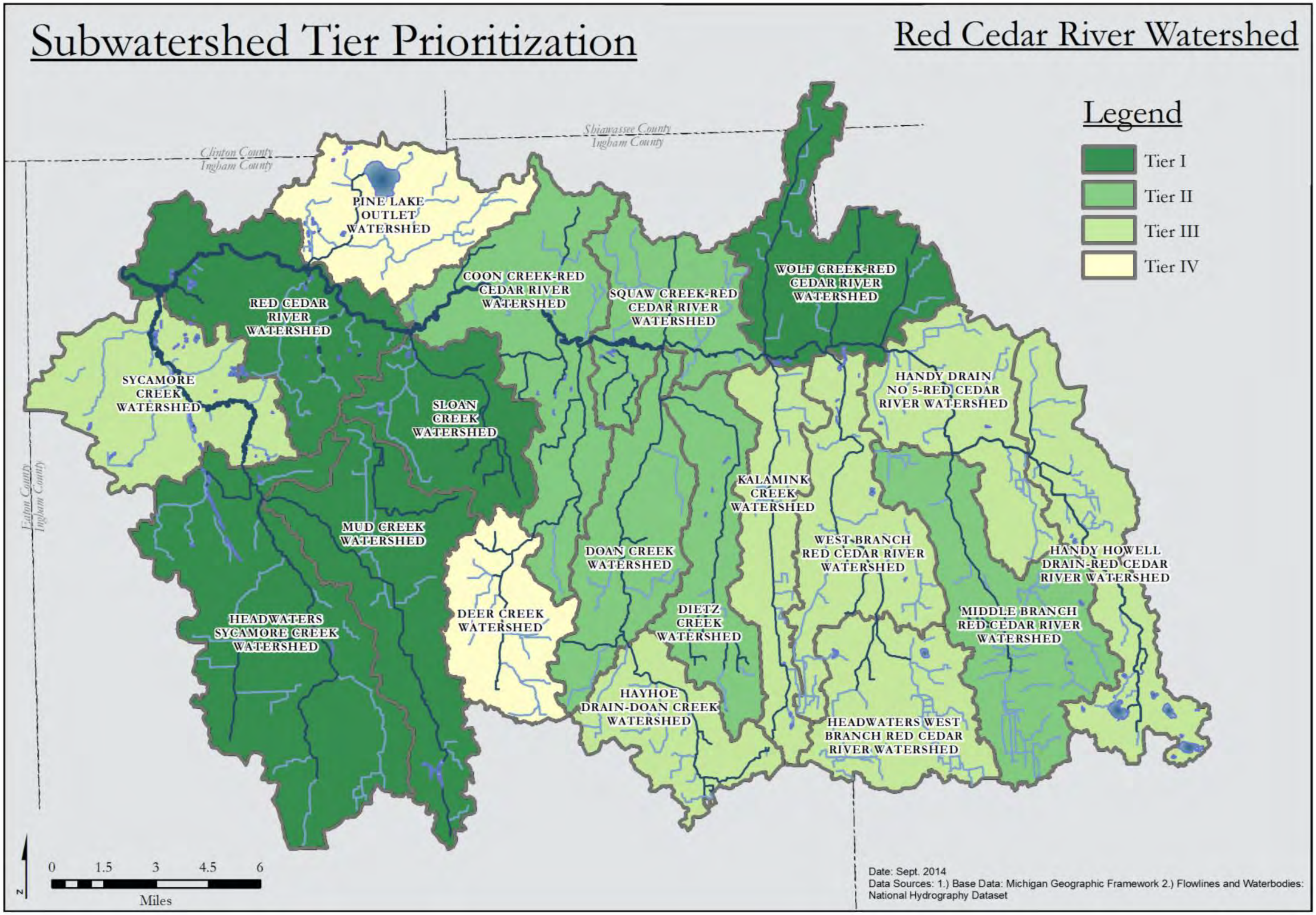


Figure 7.4 Subwatershed Tier Prioritization

7.7 Funding BMPs

A variety of funding sources currently exist for water quality improvements, but opportunities change over time and must be tracked accordingly. This makes it especially important to use all of the funding resources available, rather than continue to rely on one or two particular sources. Examples of financial sources include EPA Section 319 implementation funds, Clean Michigan Initiative, several programs with the United States Fish and Wildlife Service, Great Lakes Basin Program, Sustain Our Great Lakes, the Natural Resources Conservation Service, local governments and private funding provided by foundations.

7.8 Implementation Schedule and Milestones

Table 6.2 in Chapter Six includes short and long-term milestone goals for implementation. However, it is recommended that implementation of this plan begin immediately and is fueled by momentum established during this planning project. Many partners have been identified and are excited to begin implementation of recommendations for measureable water quality improvements.

As progress is made toward the goals and objectives established as part of this planning project, an update to the WMP will be warranted. It is suggested that updates to the WMP are made at least every five years to ensure that information used to make management decisions remains relevant and dependable.

8. INFORMATION AND EDUCATION STRATEGY

This Information and Education (I/E) Strategy has been developed in cooperation with several partner groups, individuals and organizations. The purpose of the I/E Strategy is to document a clear set of goals, objectives and action items that will inform and educate the public about things they can do to help restore the designated uses in the watershed. The I/E Strategy sets a clear path for responsible partners, stakeholder groups and others to follow, and builds upon existing partnerships, programs and activities. This will lead to new opportunities and activities, and ultimately measurable improvements in awareness of water quality issues, with the goal of affecting positive behavioral changes in the watershed.

8.1 Survey Data

An abundance of data that describe the water quality-related knowledge and behavior of existing residents in both the urban and rural areas of the watershed are available. Both the Middle Grand River Watershed Planning project (MGRWP) and the Greater Lansing Regional Committee for Stormwater Management (GLRC) have conducted surveys of residents in the region. Several areas in the Red Cedar River Watershed (RCRW) overlap with those of the MGRWP and the GLRC geographical boundaries; since the population demographics in the RCRW are similar to that of the surveyed populations, it is assumed that both the MGRWP and the GLRC data reflect the public's opinions and beliefs of residents in the RCRW. The analysis of the data and subsequent I/E planning activities related to it have been a collaborative effort among these watershed efforts.

Identifying Target Audiences

Based on the survey data and discussions with various partner organizations within the RCRW, target audiences were identified for the I/E activities. The audiences include three categories: urban, rural residential and agricultural. The MGRWP survey data were collected for each of these audiences, while the GLRC survey focused on urban and rural residential audiences.

Urban Audience

The urban audience includes residents within any village or city limits and the urbanized area in the Lansing vicinity as defined by the US Census Bureau.

Rural Residential Audience

The rural residential audience includes individuals who may have a small amount of property without livestock or farms, or who may live in a subdivision or just outside of one.

Agricultural Audience

The agricultural audience includes those who live outside of the urban area and have livestock or farmland. This includes large producers and those operating smaller animal farms, including individuals who may have only a small number of farm animals.

<u>Middle Grand River Watershed Planning Project Survey Data</u>

In the fall of 2011, the Eaton Conservation District (ECD) conducted a residential survey as part of their MGRWP (ECD, 2012). Some of the key findings are summarized here. Three different surveys were sent to three separate audiences: urban, rural residential and agricultural. Each surveyed group agreed that it is their personal responsibility to help protect water quality. The surveyed groups also agreed that using recommended farm best management practices (BMPs) and yard and lawn care can influence water quality in local rivers and lakes. While the audience is aware of the problem and understands the need for BMPs, less than half of respondents (15% agriculture, 35% rural residential and 45% urban) agreed that they would be willing to pay more to improve water quality.

Michigan State University Extension (MSU-E) was identified as the most trusted resource for all three audiences. Conservation districts, county health departments, and the Michigan Department of Natural Resources were the second most trusted resources from agricultural, rural residential and urban residents, respectively. The survey results indicate that effort is needed to educate stakeholders about the types of water pollution and the specific sources of pollutants. Since there is a high level of agreement about personal responsibility for water resources, behavioral change is more likely to be realized if the importance of specific BMPs is clearly explained to each target audience.

Greater Lansing Regional Committee for Stormwater Management Survey Data
The GLRC completed a statistically valid public education survey in 2006 to develop a baseline representation of knowledge and behavior related to water quality protection and pollution prevention in the urbanized area of the Grand, Red Cedar and Looking Glass River Watersheds (ETC Institute, 2006). Based on these results and the federal stormwater permit requirements, with very limited funding, the GLRC developed a public education campaign. The effectiveness of the campaign was measured with a follow up survey in 2012. The 2012 follow up survey used the same survey instrument and methodology as the 2006 effort, and the data were tabulated across the watersheds to assess changes in knowledge, willingness to change and behavior patterns of citizens in different portions of the watersheds.

GLRC survey results indicate that more than one-third (38% or about 130,000) of area residents had taken some type of action to protect water resources in the past five years and 11% indicated that they “didn’t know” if their household had done anything that would have helped protect water resources. The percentage of residents who indicated their household had taken some type of action to protect water resources increased by 11% from 2006 to 2012, which equates to an increase in the number of people taking action by approximately 38,000 residents.

The survey asked how willing residents are to take certain actions to reduce water pollution. Residents were most willing to dispose of hazardous waste at a community collection day (92%), sweep excess fertilizer/grass clippings into their lawn (90%), change their car washing practices (86%), and use low phosphorus or slow release fertilizer (85%). Residents were least willing to have their soil tested (50%).

The survey also queried residents about their knowledge concerning the connection of stormwater runoff and water resources. Forty-nine percent (approximately 168,000 residents) thought stormwater went directly to lakes/streams without treatment; 17% thought it went to a treatment plant, 12% thought it went to lakes/streams with treatment and 22% indicated that they “did not know.” The percentage of residents who thought that stormwater went to lakes/streams without treatment decreased 7% from 56% in 2006 to 49% in 2012. The GLRC notes that the survey results indicate more public education about stormwater runoff and its impacts on local rivers and lakes is needed.

8.2 Goals and Objectives of I/E Strategy

Goals and objectives are described here are on an overarching level and are directly correlated from the survey data described above. The actions identified in Table 8.1 are specific to each target audience.

General Goals:

- Increase awareness of impairments, caused by pollutants, including *E. coli*, sediment, nutrients and dissolved oxygen levels
- Encourage implementation of BMPs
- Work collaboratively with other watershed groups, agencies and organizations on I/E efforts

General Objectives:

- Use survey results to guide and adapt strategy
- Through stakeholder involvement, establish a point of contact/organizational structure for implementation activities

- Increase availability of information about BMPs and other implementation-related activities

8.3 Developing Messages

The I/E Strategy builds upon existing messages that are currently in place as part of regional educational efforts. Example messages include education pertaining to the following topics:

- Manure storage and application
- Wetland restoration
- Soil conservation methods
- On-site septic system maintenance
- Proper soil management
- Native plantings
- Fertilizer use and application
- Pet waste reduction
- Low impact development techniques
- Rain barrel use and downspout disconnection

8.4 Selecting Delivery Mechanisms and Activities

Delivery mechanisms are a crucial component of the I/E Strategy. Getting the public engaged is a critical first step in changing knowledge and behavior in order to protect and improve water quality. There are several water quality-related education efforts underway in the watershed and surrounding areas. In addition, the survey data identify agencies and partners that have established credibility as a trusted source to local residents. The I/E Strategy aims to use the existing educational efforts and partnerships with trusted sources to create an effective and efficient approach to outreach and education. Delivery mechanisms include:

- Demonstration projects
- Workshops with trusted sources
- Exhibit/display materials
- Print materials (brochures, posters)
- Promotional items
- Social media announcements
- Public access television
- Local radio
- Billboards
- Incentive programs (septic system cleaning coupons)
- Giveaways
- Direct mail
- Community newspapers
- Multi-media
- Special events
- Presentations

8.5 Regional Collaboration and Partnerships

Regional partnerships are a critical component of the I/E Strategy. The watershed management plan (WMP) and implementation of the plan should enhance and strengthen these existing efforts through increased partnerships, funding and evaluation of outreach activities. Geographic areas and municipal boundaries overlap among and between the Middle Grand River Organization of Watersheds (MGROW), the MGRWP and the Red Cedar River WMP boundaries. In recent years, information, education and outreach efforts have been coordinated to increase effectiveness. This cooperative approach will continue in order to strengthen the existing partnerships, with an emphasis on restoring designated uses.

<u>Middle Grand River Organization of Watersheds</u>

There are a number of watershed-based initiatives underway in the larger Middle Grand River Watershed, to which the Red Cedar River is a tributary. These include the MGRWP, GLRC, Friends of the Looking Glass, Friends of the Maple River and the Maple River Implementation Project. Since all of these efforts have similar I/E components, including audiences, pollutants, messages, calls to action, events, clean ups, etc., the Tri-County Regional Planning Commission (TCRPC) has facilitated a regional approach to I/E with the help of the MGROW. MGROW is an umbrella organization that is striving to service the region's watershed groups (listed above) and bring collaborative solutions to the various efforts. MGROW also works to improve recreational opportunities and improve the public perception of our local water resources.

The TCRPC Mid-Michigan Program for Greater Sustainability has offered its support to the work of MGROW, believing that a regional, collaborative approach to I/E is more cost effective and efficient, and will ultimately help to sustain water resources education over the long term. The MGROW educational campaign currently underway seeks to relay to the public that while they might not live directly on the river, what they do affects water quality. Very simple action-oriented language is used to encourage behavior change.

The campaign is titled *Pollution Isn't Pretty*. The website associated with the campaign (pollutionisntpretty.org) is a gateway page linking to all local watershed initiatives including the RCRW Planning project. Since the launch of the campaign in December 2013, several local radio stations and public access television stations have covered its release. This provides regional coverage and helps spread the messages of the campaign and partnerships. Billboards purchased by the GLRC and the ECD have brought awareness to the campaign. These groups continue to promote the campaign through social media, print materials and educational displays. This is a valuable, efficient and effective collaborative project that is included as a foundation of this I/E Strategy.

<u>Middle Grand River Watershed Planning Project I/E Strategy</u>
The MGRWP, the adjacent watershed's nonpoint source planning effort, has also developed an I/E Strategy. The TCRPC has provided input to both the MGRWP and RCRW I/E Committees, as well as coordinated the Regional Education Campaign on MGROW's behalf. This is important as TCRPC can serve as the liaison for these groups with similar demographics, adjoining watershed boundaries, and water quality impairments.

<u>Greater Lansing Regional Committee for Stormwater Management Public Education Plan (PEP)</u>
The GLRC is a guiding body comprised of participating Municipal Separate Storm Sewer System (MS4) communities within the Greater Lansing Region. The committee has been established to guide the implementation of the entire MS4 Stormwater Program for the communities within three identified watersheds: the Grand, Red Cedar and Looking Glass River. The GLRC focuses on the following components of I/E:

- Promote public responsibility and stewardship in the applicant's watershed(s).
- Inform and educate the public about the connection of the MS4 to area waterbodies and the potential impacts discharges could have on surface waters of the state.
- Educate the public on illicit discharges and promote public reporting of illicit discharges and improper disposal of materials into the MS4.
- Promote preferred cleaning materials and procedures for car, pavement, and power washing.
- Inform and educate the public on proper application and disposal of pesticides, herbicides, and fertilizers.
- Promote proper disposal practices for grass clippings, leaf litter, and animal wastes that may enter into the MS4.
- Identify and promote the availability, location, and requirements of facilities for collection or disposal of household hazardous waste, travel trailer sanitary wastes, chemicals, yard wastes, and motor vehicle fluids.

- Inform and educate the public on proper septic system care and maintenance, and how to recognize system failure.
- Educate the public on, and promote the benefits of, green infrastructure and low impact development.
- Promote methods for managing riparian lands to protect water quality.
- Identify and educate commercial, industrial, and institutional entities likely to contribute pollutants to stormwater runoff.

GLRC Members include those municipalities in the urbanized area. Those communities are currently implementing the GLRC PEP. This I/E Strategy for the RCRW includes the activities being conducted by the GLRC PEP and expands them to other geographical areas of the watershed, throughout Ingham and Livingston Counties.

The Grand Learning Network

The Grand Learning Network is a program facilitated by Michigan State University (MSU) to bring place-based education to local school districts through hands-on activities related to water quality and watershed management. The program provides in-depth professional development opportunities to elementary school teachers, who then implement activities in the classroom. Examples of projects include: salmon in the classroom (raising salmon over the school year and releasing them to area waterways), building rain gardens, planting natural prairie lands (from seed the students raised), providing habitat areas at a restored wetland, etc.

Social Media

Both MGROW and the GLRC have been using social media such as Facebook and Twitter to reach local residents. Social media is also a useful way to connect with partners, sharing each other's events, activities and ideas. The team will look to these organizations to share events and information through existing social media channels as the WMP is implemented.

Local Events

There are several recurring, local events that focus on responsible watershed management. This I/E strategy recognizes the importance of these events and will seek to encourage the continuation of them. Some of these local events are included below.

River clean ups provide a unique opportunity to interact with the public. The MSU Fisheries and Wildlife Club conducts annual fall and spring clean ups on the Red Cedar River through campus. The Ingham Conservation District (ICD) conducts an annual clean up on the Sycamore River near Mason. The Lansing Board of Water & Light, in partnership with the Impression 5 Science Museum, conducts an Adopt A River event on the Grand River in downtown Lansing, not far from the Red Cedar confluence.

Each spring the TCRPC Groundwater Management Board's Annual Children's Water Festival is held on the MSU Campus. Over the past 17 years, the festival has had great success with more than 34,000 students (fourth, fifth and sixth graders) from area schools attending. The festival provides a field trip for students, where they learn about the importance of water resources and their role in protecting and conserving it. The students participate in three 25-minute hands-on activities that relate to water resources. They also get to experience Billy B, the "natural science song and dance man" who provides an interactive musical performance based on water stewardship.

The Mid-Michigan Environmental Action Council (Mid-MEAC) Volunteer Stream Monitoring program monitors the macroinvertebrate communities in the Red Cedar River. They conduct a volunteer training day, and spring and fall collection days. A local entomologist and aquatic biologist assist with macroinvertebrate identification. This is a hands-on activity for volunteers and an opportunity to educate them about indicators of water quality.

Other Potential Partners

There are several other programs, organizations and agencies that will be important partners in the implementation of the I/E Strategy. These include, but are not limited to, Trout Unlimited, Project Fish, Salmon in the Classroom, Conservation Districts, and other local, state and federal agencies.

8.6 Implementation of I/E Strategy

The I/E Strategy action items are categorized by short term (1-3 years) and long term (4-7 years) efforts. Implementation of each action will occur according to the time listed in Table 8.1. While the actions listed are specific to I/E, other educational opportunities may arise through other partnerships described in Chapter Nine. Implementation actions are always evolving as new opportunities arise.

For the I/E Strategy, enhancing the *Pollution Isn't Pretty* campaign is an important next step. The existing campaign can be utilized but developing additional materials that address BMPs for rural residential and agricultural audiences is necessary. This will be coordinated with other watershed groups that utilize the campaign.

Table 8.1 I/E Implementation

	Action	Priority (High, Med, Low)	Topics/Pollutant, Source, Cause Link	Delivery Method	Existing Programs	Lead Agency	Other Responsible Partners*	Timeline ST (1-3 yrs)/ LT (4-10 yrs)	Estimated Cost	Evaluation
URBAN	Use social media to expand audience discussion and sharing of information related to water quality.	High	***E. coli***: pet waste; **Sediment:** reducing exposed soil, construction sites; **Nutrients:** fertilizer reduction/management	Twitter, Facebook, Pinterest, Instagram, LinkedIn, etc.	PIP, partner organizations, federal agencies, nonprofits, etc.	MSU, GLRC	All partners with an existing social media/online presence	ST - ongoing	$30,000/year Part time social media/website manager	Likes, followers, shares, discussion/comments, SIDMA** pre/post survey results
URBAN	Co-host 1 event with a trusted partner to increase knowledge about nonpoint source pollution.	High	***E. coli***: pet waste; **Sediment:** reducing exposed soil, construction sites; **Nutrients:** fertilizer reduction/management	Direct contact, trusted partner communication channels, social media	Recycling events, Landscaping for Water Quality and Rain barrel, home energy efficiency workshops	MSU	**DNR, MSUE, USEPA, MDARD, MDEQ,** MEO, Mid-MEAC, GLRC, TCRPC	ST - ongoing	$3,000 for printing, promotional items, etc.	Number of attendees, media coverage of event, assessment of pre/post project, SIDMA pre/post survey results
URBAN	Participate in 3 community events per year to promote water quality BMPs for pet waste reduction and fertilizer management.	High	***E. coli***: pet waste; **Sediment:** reducing exposed soil, construction sites; **Nutrients:** fertilizer reduction/management	Interactive presentation and/or guest speaker, material disbursement , promotional items	Children's Water Festival, Arbor Day, Earth Day MDEQ, Quietwater Symposium, community art/music events and initiatives	MSU	TCRPC, **CD**, MSU, GLRC, **State/Federal gov**, nonprofits, **higher education institutions**	ST - ongoing	$3,000/event	Number of attendees/participants, media coverage of event, assessment of pre/post project, SIDMA pre/post survey results
URBAN	Increase willingness to change the way an individual cares for their lawn/yard to improve water quality.	High	***E. coli***: pet waste; **Sediment:** reducing exposed soil, construction sites; **Nutrients:** fertilizer reduction/management	Social media, newsletters, public presentations, billboard campaign, trusted partner communication channels, promotional items and materials	MI Turfgrass Environmental Stewardship Program, MI Water Stewardship website, PIP, MSUE	MSU	TCRPC, **CD**, GLRC, **State/Federal gov**, nonprofits, **higher education institutions**	ST - ongoing	$40,000 to develop and enhance existing campaign and materials	Increased willingness from GLRC survey results, SIDMA pre/post survey results
URBAN	Increase awareness that pet waste, residential stormwater runoff, roof runoff, stream bank erosion and street erosion are sources of pollution.	High	***E.coli***: pet waste; **Sediment:** reducing exposed soil, construction sites; **Nutrients:** fertilizer reduction/management	Social media, newsletters, public presentations, billboard campaign, trusted partner communication channels, promotional items and materials	PIP	MSU	TCRPC, MSU, **CD**, GLRC, **State/Federal gov**, nonprofits, **higher education institutions**	ST - ongoing	$40,000 to develop and enhance existing campaign and materials	Increased knowledge from GLRC survey results, SIDMA pre/post survey results
URBAN	Identify 3 neighborhood associations (group of the associations) willing to participate in a demonstration project.	Medium	Stormwater management, low impact development techniques	Direct contact, association newsletters/communications, demonstration project itself	Lansing area - Allen, Old Town, South Lansing, Baily, Westside NW	MSU	Municipalities, GLRC, **CD**, Mid-MEAC, human service nonprofits (faith community), Friends/watershed nonprofits	ST	Minimum $5,000/project	Demo project built, number of people reached, assessment of pre/post project, future practice installation
URBAN	Increase awareness of low cost options (i.e. native plants, rain gardens, rain barrels, pervious pavers, downspout disconnect, turf management BMPs, pet waste management), to achieve water quality.	Medium	Stormwater management, low impact development techniques	Social media, newsletters, public presentations, billboard campaign, trusted partner communication channels, promotional items and materials	CD, MSUE programs	MSU	TCRPC, **CD**, MSU, GLRC, **State/Federal gov**, nonprofits, **higher education institutions**	ST - ongoing	$40,000 to develop and enhance existing campaign and materials	Increased awareness from GLRC survey results, SIDMA pre/post survey results
URBAN	Increase willingness to pay more to improve water quality by educating about low cost options.	Medium	***E. coli***: pet waste; **Sediment:** reducing exposed soil, construction sites; **Nutrients:** fertilizer reduction/management	Social media, newsletters, public presentations, billboard campaign, trusted partner communication channels, promotional items and materials, demonstration projects, interactive presentations, community events	CD, MEO, MSUE, MI Water Stewardship website, GLRC	MSU	TCRPC, MSU, **CD**, GLRC, **State/Federal gov**, nonprofits, **higher education institutions**	LT	$40,000 to develop and enhance existing campaign and materials	Increased willingness from GLRC survey results, SIDMA pre/post survey results
URBAN	Use 3 images and/or messages related to scenic beauty and people enjoying water resources when engaging audience. Utilize issues related to public health.	Low	Overall environmental stewardship, connecting people to land and water.	Social media, newsletters, public presentations, billboard campaign, trusted partner communication channels, promotional items and materials	Pure Michigan, MGROW	MSU	TCRPC, MSU, **CD**, GLRC, **State/Federal gov**, nonprofits, **higher education institutions**	ST - ongoing	$1,000 - use existing messages and images	Estimated number of people reached

	Action	Priority (High, Med, Low)	Topics/Pollutant, Source, Cause Link	Delivery Method	Existing Programs	Lead Agency	Other Responsible Partners	Timeline ST (1-3 yrs)/ LT (4-10 yrs)	Estimated Cost	Evaluation
RURAL RESIDENTIAL	Increase willingness to adopt BMPs targeting pollutants.	High	***E. coli***: pet waste, manure management and storage, septic maintenance; **Sediment:** reducing exposed soil, **Nutrients:** fertilizer reduction/management, stormwater management, low impact development techniques, overall stewardship	Social media, newsletters, public presentations, billboard campaign, trusted partner communication channels, promotional items and materials	NRCS - CD programs	MSU	TCRPC, **CD**, GLRC, **State/Federal gov**, nonprofits, **higher education institutions**	LT	$40,000 to develop and enhance existing campaign and materials	Number of BMPs adopted, SIDMA pre/post survey results
	Increase opinion that farm field soil erosion, stream bank soil erosion, improperly maintained septic systems, manure from farm animals, pet waste and residential stormwater runoff are sources of water quality pollution.	High	***E. coli***: pet waste, manure management and storage, septic maintenance; **Sediment:** reducing exposed soil, **Nutrients:** fertilizer reduction/management, stormwater management, low impact development techniques, overall stewardship	Social media, newsletters, public presentations, billboard campaign, trusted partner communication channels, promotional items and materials	PIP, GLRC, CD, NRCS, MDARD, MSUE programs	MSU	TCRPC, MSU, **CD, GLRC, State/Federal gov, nonprofits,** higher education institutions	LT	$40,000 to develop and enhance existing campaign and materials	Increased knowledge from pre/post surveys, social media and website statistics, SIDMA pre/post survey results
	Identify 3 local governments willing to participate in a demonstration project.	Medium	Stormwater management, low impact development techniques	Direct contact, municipal/community newsletters/communications, demonstration project itself	N/A	TCRPC	Local governments, TCRPC, **CD**, nonprofits	LT	Minimum $5,000/project	Demo project built, number of people reached, assessment of pre/post project, future practice installation, SIDMA pre/post survey results
	Hold 3 workshops per year at a conveniently located community facility such as a library, school, township hall, etc. to educate on nonpoint source pollution	Medium	***E.coli***: pet waste, manure management and storage, septic maintenance; **Sediment:** reducing exposed soil, **Nutrients:** fertilizer reduction/management, stormwater management, low impact development techniques, overall stewardship	Interactive presentation and/or guest speaker, material disbursement, promotional items	CD, MSUE programs	MSU	TCRPC, **CD**, GLRC, **State/Federal gov**, nonprofits, **higher education institutions**	ST	$3,000 for printing, promotional items, etc.	Number of attendees, assessment of pre/post workshop, SIDMA pre/post survey results
	Use 3 images and/or messages related to picnicking and family activities when engaging audience in information and education strategies. This could include: family playing near a stream, children and water, safe food as it relates to water quality and *E.coli*, etc.	Medium	Overall environmental stewardship, connecting people to land and water.	Social media, newsletters, public presentations, billboard campaign, trusted partner communication channels, promotional items and materials	PIP, partner organizations, federal agencies, nonprofits, etc.	MSU	TCRPC, **CD**, GLRC, **State/Federal gov**, nonprofits, **higher education institutions**	ST	$1,000 - use existing messages and images	Estimated number of people reached, social media and website statistics, SIDMA pre/post survey results
	Conduct direct mailings focusing on non-point source pollution.	Low	***E.coli***: pet waste, manure management and storage, septic maintenance; **Sediment:** reducing exposed soil; **Nutrients:** fertilizer reduction/management, stormwater management, low impact development techniques, overall stewardship	Direct mail	Community news, utilize tax mailings, postcard	TCRPC	Local governments, TCRPC, nonprofits, **MSUE**	LT	$10,000	Number of residents mailed, website traffic, SIDMA pre/post survey results
	Install 100 educational signs at locations across the watershed.	Low	***E. coli***: pet waste, manure management and storage, septic maintenance; **Sediment:** reducing exposed soil; **Nutrients:** fertilizer reduction/management, stormwater management, low impact development techniques, overall stewardship	Strategic sign placement	GLRC watershed signs	GLRC	GLRC, road commissions	LT	$8,000/100 signs	Number of signs installed, traffic counts

	Action	Priority (High, Med, Low)	Topics/Pollutant, Source, Cause Link	Delivery Method	Existing Programs	Lead Agency	Other Responsible Partners	Timeline ST (1-3 yrs)/ LT (4-10 yrs)	Estimated Cost	Evaluation
AGRICULTURAL	Increase willingness to adopt Best Management Practices.	High	***E. coli***: manure management, storage and application; **Sediment:** reducing exposed soil; **Nutrients:** fertilizer reduction/management, stormwater management, green infrastructure techniques, overall stewardship	Social media, newsletters, public presentations, billboard campaign, trusted partner communication channels, promotional items and materials	PIP, CD, NRCS, MDARD, MSUE programs	MSU	TCRPC, MSU, **CD, State/Federal gov,** nonprofits, higher **education institutions**	LT	$40,000 to develop and enhance existing campaign and materials	Number of BMPs installed, SIDMA pre/post survey, SIDMA pre/post survey results
	Increase awareness about BMP maintenance programs and technical assistance available.	High	***E. coli***: manure management, storage and application; **Sediment:** reducing exposed soil; **Nutrients:** fertilizer reduction/management, stormwater management, green infrastructure techniques, overall stewardship	Direct contact, partner communications	CD, NRSC, MDARD, MSUE projects	MSU, CD	TCRPC, MSU, **CD, State/Federal gov,** nonprofits, higher **education institutions**	LT	$3,000 for printing, promotional items, etc.	Number of people reached, long term assessment of project, future practice installation
	Increase awareness that farm field soil erosion, stream bank soil erosion, improperly maintained septic systems, manure from farm animals, pet waste and residential stormwater runoff are sources of water quality pollution.	High	***E. coli***: manure management, storage and application; **Sediment:** reducing exposed soil; **Nutrients:** fertilizer reduction/management, stormwater management, green infrastructure techniques, overall stewardship	Social media, newsletters, public presentations, billboard campaign, trusted partner communication channels, promotional items and materials	CD, NRCS, MDARD, MSUE programs	MSU, CD	TCRPC, MSU, **CD, State/Federal gov,** nonprofits, **higher education institutions**	LT	$40,000 to develop and enhance existing campaign and materials	Increased knowledge from pre/post surveys, social media and website statistics, SIDMA pre/post survey results
	Identify 3 trusted sources willing to participate in a demonstration project.	Medium	***E. coli***: manure management, storage and application; **Sediment:** reducing exposed soil; **Nutrients:** fertilizer reduction/management, stormwater management, green infrastructure techniques, overall stewardship	Direct contact, partner communications, demo project itself	CD, NRSC, MDARD, MSUE projects	MSU, CD	TCRPC, MSU, **CD, State/Federal gov,** nonprofits, higher **education institutions**	LT	Minimum $20,000/project	Demo project built, number of people reached, assessment of pre/post project, future practice installation
	Hold 3 educational events per year in partnership with a trusted source. For example a farm safety day, cover crop workshop.	Medium	***E. coli***: manure management, storage and application; **Sediment:** reducing exposed soil; **Nutrients:** fertilizer reduction/management, stormwater management, green infrastructure techniques, overall stewardship	Direct contact, partner communications, workshop itself	CD, NRCS, MDARD, MSUE programs	MSU	**DNR, MSUE, USEPA, MDARD, MDEQ,** Mid-MEAC, TCRPC, CD	ST	$3,000 for printing, promotional items, etc.	Number of attendees, pre/post survey, SIDMA pre/post survey results
	Hold 3 peer-peer educational events per year.	Medium	***E. coli***: manure management, storage and application; **Sediment:** reducing exposed soil; **Nutrients:** fertilizer reduction/management, stormwater management, green infrastructure techniques, overall stewardship	Direct contact, social media, newsletters		MSU, CD	TCRPC, MSU, **CD, State/Federal gov,** nonprofits, **higher education institutions**	LT	$3,000/event	Number of attendee, pre-post survey, SIDMA pre/post survey results
	Use 3 images and/or messages related to scenic beauty when engaging audience in information and education strategies. This could include: images of a farm, streams, ditches with native grasses and wildflowers, etc.	Low	Overall environmental stewardship, connecting people to land and water.	Social media, newsletters, public presentations, billboard campaign, trusted partner communication channels, promotional items and materials	Pure Michigan, MGROW	MSU	TCRPC, **CD, State/Federal gov,** nonprofits, **higher education institutions**	ST - ongoing	$1,000 - use existing messages and images	Estimated number of people reached, social media and website statistics

*Bolded partners were identified by the GLRC survey
** Social Indicators Data Management and Analysis System

8.7 MDEQ Funding Acknowledgement

Materials created with MDEQ nonpoint source implementation funding will be labeled as such using the appropriate MDEQ logo.

8.8 Evaluation Measures

Evaluation of the I/E Strategy will help those implementing it to apply adaptive management techniques where needed. To determine progress towards goals of the I/E Strategy, both formative and summative evaluation techniques will be used.

After several components of the I/E strategy have been implemented, a follow-up survey of watershed residents will be considered to assess additional changes in knowledge and behavior. The GLRC surveys and overall evaluation methodology may be used for the larger audience base as described in the evaluation section of the I/E Strategy table. The survey results can then be used to modify the outreach activities as needed. While several surveys have been completed in the region, the entire RCRW lacks a comprehensive survey. Utilizing the Social Indicators Data Management and Analysis Tool (SIDMA) developed specifically for social indicators related to nonpoint source management efforts, additional information for the entire watershed can be achieved. This survey would target the three audiences: urban, rural residential and agriculture.

Additionally, pre- and post- surveys and/or tests will be used as part of workshops and/or hands-on events in order to assess knowledge gain, level of understanding and interest among participants pertaining to different topics. These evaluation techniques allow the project team to assess the effectiveness of outreach programs and change them as needed to more adequately address topics of concern. Conversations and/or focus group discussions with outreach partners will also be used to assess the effectiveness of programs and identify gaps in programming across the watershed. In summary, formative and summative evaluation methods will be used to help provide an understanding of the successes and challenges of the I/E activities, and allow for adaptations as needed.

9. SUSTAINABILITY

Sustainability of the watershed management plan (WMP) and ongoing assessment of structural and managerial best management practices (BMPs) will help to ensure that water quality improvements are realized over the long term. This chapter will address the organizations, partnerships, and jurisdictional programs that exist within the watershed in order to ensure sustainable water resources management into the future. Plans for water quality monitoring activities and opportunities for long-term programmatic changes are also addressed.

9.1 Existing Structure

Management Team

The Red Cedar River Watershed (RCRW) management team consists of the Michigan State University (MSU) Institute of Water Research (IWR); Streamside Ecological Services, Inc.; and the Tri-County Regional Planning Commission (TCPRC). Representatives from these organizations are the authors of this plan, with input from a number of local partners. They have coordinated and guided all efforts related to the planning process and overall WMP development, including stakeholder engagement.

Stakeholders

Stakeholders are a critical component of the watershed management planning process. Stakeholders who participate in the planning process are much more likely to take action and implement projects to improve water quality than those who do not participate. Stakeholders who were contacted as part of this planning process include local industry, local government staff members, elected officials and commissions, civic groups, adjacent watershed groups, conservation districts, county health departments and others. For a complete list of stakeholders see Appendix A.

The management team conducted stakeholder meetings to share information about the planning process and engage participants in the process. The team provided updates on current progress related to data gathering, impairment status, and field investigations. Stakeholders were engaged in the watershed inventory process, sharing their knowledge about areas of the watershed that are potentially contributing to the impairments. This information was then used during field investigations to verify potential critical areas. Stakeholder knowledge of the existing land uses and landowner practices proved valuable as the team reviewed areas to gather additional data and identified critical areas. Stakeholders also identified other partners who would be interested in assisting with planning, and potentially implementing watershed protection projects.

Email updates were provided to stakeholders throughout the watershed planning process related to specific topics of interest and volunteer opportunities. These opportunities included monitoring, field work and educational efforts. The team followed up with several stakeholders, meeting on an individual basis to discuss their role and potential implementation activities listed in the WMP.

Agricultural Committee

The team met with a number of agricultural stakeholders in a two-part process. The first meeting consisted of agricultural service providers including representatives from the following agencies: Eaton Conservation District (ECD), Ingham Conservation District (ICD), Open Space and Farmland Preservation Board, Shiawassee Conservation District (SCD), and the Ingham County Drain Commissioners' office. The purpose of the first meeting was to gather important information about how to connect with land owners, specifically those in the agricultural community. Several avenues and strategies for connecting with the agricultural community were identified. The group also discussed existing programs for improving water quality, reducing nonpoint source pollution and strategies for promoting BMPs.

The second meeting was with agricultural producers in the watershed. This meeting focused on identifying barriers that hinder the use of BMPs to improve water quality. The committee also discussed strategies to overcome these barriers. The producers that participated were candid and provided valuable information that will be used in the implementation strategy to continue to promote and educate landowners about available programs and BMPs to improve and protect water quality. Both meetings had similar recommendations:

- Provide educational materials to landowners via technicians engaged in existing programs. For example, inspectors from drain commissioner offices and the Michigan Agriculture Environmental Assurance Program (MAEAP) technicians; any resource professional that is out in the field already or has established relationships with local landowners.
- Partner with trusted sources at existing events. Utilizing events that landowners and farmers are already attending is an opportunity to reach the target audience in a place they feel comfortable. Examples would be MSU Extension (MSU-E), drain commissioners and conservation districts, conservation non-profits like Ducks Unlimited and businesses such as Greenstone.

In summary, input from the agricultural meetings held suggested that the highest priority way to reduce agricultural pollutant contributions was to provide improved technical resources about conservation practices and programs to the agriculture community. The groups were reluctant to share a most effective and favorite BMP citing that each agricultural facility had different preferences and successes. The stakeholders did give recommendations on improving technical resource education. More specifically, they suggested to:

- Work with high-visible farmers on conservation practices who share knowledge with other farmers.
- Educate the agricultural community about Natural Resources Conservation Service (NRCS) and conservation district programs.
- For local service providers; turnaround time for responding to communication with farmers should be reduced.
- Communication with farmers should be timed to better coordinate with their seasonal workloads.
- Relationships should be rebuilt at the ICD to mend past problems.
- Utilize different modes of communication, but make sure messages provided are clear and concise.
- The appropriate message should be provided to each different agricultural audience (e.g. large commercial farms, hobby farms, horse farms).
- Manure management education is needed for the horse community.
- Messages conveyed should be personal and not formulaic.
- Information provided should be consistent across organizations.
- Create a document that explains all of the agricultural resources in the area.
- Host informational meetings at different venues, such as grain elevators
- Ensure BMPs have maintenance programs and resources to modify them when they are not working properly.
- Encourage resource and knowledge sharing between agricultural stakeholders themselves.

<u>Information and Education (I/E) Committee</u>
The I/E Strategy and associated chapter describes the collaborative outreach efforts that will continue into the future. The team will continue to collaborate with the Middle Grand River Organization of Watersheds (MGROW) to establish longevity of the I/E efforts. By working with adjacent watershed groups and with MGROW as the overarching organization, resources can be disseminated in an efficient and cost-effective manner. Working together to share the pollution prevention message, encouraging residents to value area water resources and helping residents of the region understand that they all play a role in improving and protecting water resources will be beneficial for the RCRW and adjacent watersheds.

<u>Existing Watershed Organizations and Activities (for sustainability)</u>
The IWR at MSU provides timely information for addressing contemporary land and water resource issues through coordinated multidisciplinary efforts. The IWR endeavors to strengthen MSU's efforts in nontraditional education, outreach, and interdisciplinary studies utilizing available advanced technology, and partnerships with local, state, regional, and federal organizations and individuals. Activities include coordinating education and training programs on surface and groundwater protection, land use and watershed management, among others. Since the Red Cedar River Watershed is also home to Michigan State University, the river has been the test subject of many MSU faculty members, students and staff members.

In addition to the research efforts on campus and throughout the watershed, there are other groups working to protect and enhance the river. These include Friends of the Red Cedar (FORC), MGROW, ICD, Livingston Conservation District (LCD), and the Greater Lansing Regional Committee for Stormwater Management (GLRC). Many of these groups and their activities and efforts are described in more detail in Chapter Eight.

MGROW is an outgrowth of Grand River Expedition 2010, and strives to bring together local communities, sub-watershed groups and other stakeholders in the Middle Grand River towards a greater understanding of and stewardship for the river. Geographically, the MGROW project area includes the Maple, Looking Glass, Red Cedar and Middle Grand River Watersheds.

The GLRC, managed by the TCRPC, is a guiding body comprised of communities with municipal separate storm sewer systems (MS4) within the Greater Lansing region. The GLRC guides the implementation of the permitted stormwater program as mandated by the state and federal governments. The GLRC works to meet specific permit requirements within the urbanized area to reduce polluted runoff from reaching the Grand, Red Cedar, and Looking Glass Rivers. Several activities of the GLRC overlap with general watershed management planning activities.

The Middle Grand River Watershed Planning project is managed by the ECD and geographically covers the area on the main channel of the Grand River from Eaton Rapids to the Sunfield area. This adjacent watershed group is developing a WMP based on the same TMDL reports used to drive the efforts of this plan. In addition, GLRC members, MGROW members, and several local units of governments are geographically in both the Red Cedar and Middle Grand River watersheds.

9.2 Local Partners

In addition to the watershed groups listed above, there are several other partners that are important to the implementation of this WMP. These are summarized below.

Tri-County Regional Planning Commission

The TCRPC manages the Mid-Michigan Program for Greater Sustainability (MMPGS). This EPA/HUD funded program is implementing sustainable practices in local communities and working to improve the quality of life in the region which supports economic development and sound environmental practices, creating a walkable, bikeable and overall attractive sustainable region. The sustainability work under this funding includes water resources management through the funding of some MGROW activities. This effort also engages low income, marginalized populations and works to involve them in local land use planning processes. This helps the watershed management planning project reach additional stakeholders, engage civic groups and in general provides a pathway for implementing different land use planning techniques and opportunities with more educated stakeholders. The TCRPC MMPGS also serves MGROW by supporting their regional education campaign described in detail in Chapter Eight. In summary, collaboration with these efforts only enhances the willingness for land use changes to be more related to water resources protection and pollution prevention.

Also managed by the TCRPC, Green Mid-Michigan (GMM); Regional Green Infrastructure Vision is a green infrastructure policy/poster plan that was developed and adopted by the TCRPC and its partners in 2010. After a multi-year planning process GMM provides a benchmark and a vision for the communities in Clinton, Eaton and Ingham Counties when it comes to protecting potential conservation areas, connecting parks and trails across jurisdictional boundaries and for promoting sustainable land use policy. GMM gives communities a snapshot of where future conservation activities should occur, where low impact development would have the largest impact, and where communities can best link their recreation facilities together.

With regard to watershed planning, GMM offers a data set of potential conservation areas (PCAs). PCAs are areas on the landscape that provide critical ecological services, such as maintaining water quality and quantity soil development and stabilization, pollination of crop land, wildlife travel corridors, stopover sites for migratory birds, sources of genetic diversity and floodwater retention. PCAs are an invaluable tool for watershed planning, allowing agencies and governments to understand where the highest quality PCAs are located in our region, so that watershed protection strategies can be applied in the most efficient manner possible.

Of the nine largest PCA hubs in the tri-county region, all but two are affiliated with riparian areas and those remaining two areas are located within the drainage systems of the main watershed in the region. The promotion of low impact development strategies in and around these hubs is critical for watershed protection. The largest PCA hubs are also surrounded by rural land uses and natural areas which face issues such as fragmentation for land development and crop land, and agricultural /livestock impacts.

One of the main ways that the region is implementing the GMM vision is through formal adoption of the poster plan by local jurisdictions. Once GMM is adopted by a community, they can amend their Master Plan to include GMM language and data sets and they can amend zoning codes to more fully support the recommendations of GMM. Over 20 local jurisdictions have adopted the plan.

U.S. Department of Agriculture - Natural Resources Conservation Service
The local NRCS office covers both Ingham and Livingston Counties. The 2014 Farm Bill will streamline key conservation programs over a five year period.   The purpose of the conservation programs is to protect and enhance soil health, farmland, water quality and local wildlife habitat.

Key program changes include:

- **Financial assistance programs:** The Environmental Quality Incentives Program (EQIP) will absorb the Wildlife Habitat Incentive Program. The Conservation Stewardship Program and Agricultural Management Assistance will continue.
- **Easement programs:** The existing easement programs will be merged into a new program called the Agricultural Conservation Easement Program, or ACEP. ACEP includes the former Wetlands Reserve Program, Grasslands Reserve Program and Farm and Ranchlands Protection Program.
- **Partnership programs:** Regional conservation efforts will be part of a new program – the Regional Conservation Partnership Program, (RCPP). Critical conservation areas for this new program will be designated by the Agriculture Secretary and the NRCS will select project areas at the state and national level.

(NRCS website http://www.nrcs.usda.gov/wps/portal/nrcs/main/mi/programs/farmbill/)

The programs offered by NRCS are an important resource that can be shared with agricultural producers and landowners to provide cost-share for natural resources protection, including water quality.

Farm Service Agency
The Farm Service Agency (FSA) administers farm commodity, credit, crop insurance, environmental, conservation, and emergency assistance programs for local farmers and ranchers. Since local farmers comprise the committee that oversees FSA work, this provides potential connection to several farmers in the watershed. WMP implementation will include working with FSA in the future to help farmers understand the economic benefits of watershed planning and implementation efforts.

United States Geological Survey (USGS)
The USGS is a bureau of the Department of the Interior, provides reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. The USGS supports studies on local water quality issues with its National Cooperative Water Program funding that allows a funding match for projects.

Other Federal and State Agencies
There are several other federal and state agencies that are potential partners for the WMP. These include but are not limited to: U.S. Army Corps of Engineers, U.S. EPA, U.S. Fisheries and Wildlife, Michigan Department of Agricultural and Rural Development.

Farm Bureau
The Michigan Farm Bureau represents the agricultural community through several different political and planning efforts. The insurance company represents farmers in the political arena, protecting agriculture to enhance their economic situation.

Conservation Districts
The ICD is the primary conservation district in the watershed. The ICD Executive Director is working diligently to grow the district to a capacity level that could be successful in implementing BMPs in the watershed. Typical programs that the ICD promotes are MAEAP and various NRCS programs. The ICD also works closely with the Upper Grand River Watershed Alliance, which is currently implementing the Upper Grand River WMP. The LCD currently has two part-time technicians; they educate local residents about BMPs and conduct an annual tree sale.

County Health Departments
The Ingham County Health Department (ICHD) Bureau of Environmental Health is an active participant in watershed planning activities. As described in previous chapters, ICHD collects water quality data and contributes to the overall protection and enhancement of the river through clean ups and household hazardous waste collections. They have a Community Surface Water Sampling program that has been in place since 2004. This dataset is provides a historical perspective on levels of *E. coli* in the watershed. ICHD also has a Point of Sale ordinance in place. The ordinance requires that when a home is sold, a well and septic inspection by a certified operator is required. If the well or on-site septic system is not up to public health code (failing), then money must be placed in escrow for repair or replacement before the sale of the property can be finalized. This ensures that failing on-site septic systems will be identified and repaired or replaced, reducing the pollution impact to the local water resources. It is important to remember that this is only for homes that are being sold; failing systems that are not part of a sale can continue to contribute pollution for a significant amount of time.

The Livingston County Department of Public Health Environmental Health Division serves as the local permitting agency for onsite sewage treatment systems. The Livingston County Department of Public Works/Solid Waste department conducts household hazardous waste collections (including electronics), and sells rain barrels and compost bins.

County Drain Commissioners
The role of a county drain commissioner is to manage the county storm drain systems. Both Ingham County and Livingston County Drain Commissioners have participated in the development of the WMP. They are crucial to implementation of the plan and can assist with education of the urban, rural residential and agricultural community. The Ingham County Drain Commissioner has completed successful low impact development projects in the watershed. These include the Tollgate Wetlands (wetland reconstruction with treatment) and Towar Rain Gardens (significant reduction in flooding). These stormwater management projects illustrate the innovation that can happen in the watershed.

Local Units of Government
The local units of government in the RCRW include the following Counties, Cities, Charter and General Law Townships, and Villages:

Counties: Clinton, Eaton, Ingham, Livingston and Shiawassee

Cities: East Lansing, Lansing, Mason and Williamston

Charter Townships: Bath, Delhi, Lansing and Meridian

General Law Township: Antrim, Alaiedon, Aurelius, Bunker Hill, Conway, Cohoctah, Handy, Howell, Ingham, Iosco, Leroy, Leslie, Locke, Marion, Perry, Stockbridge, Unadilla, Vevay, Wheatfield, White Oak and Williamstown

Villages: Dansville, Fowlerville and Webberville

9.3 Local Policy Review of Codes and Ordinances

The team has reviewed all local governments' master planning documents. While most have a natural resource goal listed, several are lacking additional information. Local governments closer to the urban area have more environmentally protective ordinances and land use policies such as wetlands ordinances, overlay districts, etc., while others do not. Ingham County is unique in the fact that there is no county planning and zoning; rather, it is done on a Township level, even if the local unit is a general law township. A detailed spreadsheet listing information related to several different land use planning documents within the local jurisdictions is included as Appendix F.

Local Policy and Regulation Recommendations

Local units of government in the watershed have the opportunity to control land use, essentially prohibiting nonpoint source pollution through implementing BMPs for land use management.

It is important that those having land use authority include language for the protection of natural resources. An overarching statement in the Land Use Master Plan and/or Comprehensive Plan sets the stage for the unit of government to implement specific strategies to do just that, protect natural resources. For the purposes of this plan, the focus is specifically on water quality protection. There are several different avenues that local governments can explore in order to implement and achieve that goal. Depending on the characteristics of the jurisdiction, some strategies are more appropriate than others. The team has reviewed the level of regulatory authority currently in place to protect natural resources within the watershed.

General recommendations for ordinances and/or regulations are listed here and in greater detail in the spreadsheet located in Appendix F. Types of ordinances or regulatory mechanisms that are beneficial to reduce nonpoint source pollution include but are not limited to:

- Pet Waste
- Illicit Discharges
- Greenways/greenbelts
- Woodland Preservation
- Farmland and Open Space/Natural Area Preservation
- Wetland Preservation/Restoration
- Invasive Species Management
- On-Site Septic System Inspections
- Lake Management
- LID/Stormwater Management
- Riparian Setbacks
- Overlay Districts

Through the implementation of the WMP, each local unit government will have the opportunity to make improvements to their local codes and ordinances for natural resource and water quality protection and improvement. Draft ordinances and code language will be shared and discussed in detail with each board and/or commission to offer very specific recommendations that can complement other implementation efforts in the watershed. The TCRPC will lead this effort, working closely with the local conservation districts and MSU.

9.4 Measuring Progress and Monitoring Water Quality

Evaluation Framework

The progress made in achieving the objectives and goals of this plan must be measured. Ultimately, this watershed planning project seeks to realize reductions in bacterial loading throughout the watershed. In addition to chemical, physical and biological monitoring, interim indicators of success can also be used to help assess progress towards meeting watershed goals. These may include programmatic assessments and various social indicators. A formative approach to evaluation should be emphasized, in order to allow for adaptive management as the plan is implemented.

Progress in implementing this WMP can be tracked by monitoring:

- Programmatic assessments
- Social indicators
- BMP tracking
- Water quality monitoring

Programmatic Assessments and Social Indicators
Through the use of participant evaluations at educational events, focus groups and interviews, program assessments can be conducted on an ongoing basis. Likewise, surveys of citizens and stakeholders in the watershed can be used to assess knowledge, opinions and behaviors. Tracking of the implementation of the I/E plan will be measured based on the I/E Strategy (Table 8.1).

BMP Tracking and Interim Measureable Milestones
BMPs selected in this plan to address the watershed impairments and threats are practices known to help improve water quality at the source of the pollutant. Measuring these installed BMPs provides support that measures are being taken to reduce pollutant loading from various causes. Measurable interim milestones are outlined for the implementation of BMPs in Table 6.2. The priority parameters to measure include *E. coli*, dissolved oxygen (DO) and sediment, and nutrients.

Water Quality Monitoring
Direct surface water measurements of *E. coli*, nutrients, and DO/sediment can be used to determine if the watershed is meeting the goals and objectives of this WMP. Because of the existing *E. coli* TMDL and the need to meet the partial and full body contact designated uses in the watershed, *E. coli* will be the highest priority parameter to be measured. DO, nutrients, habitat and macroinvertebrate assemblage will also be sampled in some subwatersheds.

Tracking water quality improvements due to the implementation of BMPs will be the top monitoring priority. Maintaining the water quality where designated uses are currently being met and assessing subwatersheds where the conditions are unknown is a secondary monitoring priority. Due to the limited scale of this watershed inventory and planning project, additional monitoring is recommended to better understand the extent and sources of the pollution in the watershed.

It is proposed that a committee be formed to guide the monitoring effort in the watershed. This working committee should be responsible for coordinating the monitoring activities among multiple organizations. The committee should determine sampling frequencies and parameters to be measured in priority subwatersheds, develop long-term plans to measure BMP effectiveness, and ensure that Quality Assurance Program Plans (QAPPs) are developed and followed for all monitoring efforts.

The proposed water quality monitoring activities are described below and in Table 9.1:

1. Conduct ongoing *E. coli* sampling in partnership with the Ingham County Community Surface Water Sampling Program. The program is a consortium of local units of government and state agencies with an interest in surface water quality and its stewardship. The ICHD Bureau of Environmental Health is currently the administrative agency for the group. Future monitoring may include shifting sampling locations from historic sites to better characterize bacterial inputs from priority tributaries. In addition, wet weather sampling events will be considered for addition to the existing weekly sampling protocol in some subwatershed locations.

2. Further identify human influences through canine source tracking in the eight subwatersheds that were flagged as having known or suspected human sources of bacteria inputs. Activities that will be considered include river corridor investigations featuring canine scent tracking and mapping of septic systems in priority subwatersheds.

3. In partnership with MSU faculty members from the Department of Civil and Environmental Engineering and Biosystems Engineering and the USGS, quantify the relative contributions of

human and animal sources to the total microbial pollution load that is discharged in the highest priority subwatersheds, beginning with the Tier I subwatersheds. Multiple quantitative qPCR *bacteroides* tests will be performed and the ratios indicating relative contribution of pollutant sources will be determined. Determination of these ratios, together with geographic information system (GIS) data, will help to better inform land use decision making in those subwatersheds.

4. Work with jurisdictions within the urbanized area of the watershed to link *E. coli* sampling and microbial source tracking efforts with stormwater permit monitoring requirements. Jurisdictions will be required to monitor for bacteria inputs as part of the *E. coli* TMDL beginning with the 2018 permit issuance. DO sampling may also be required for some jurisdictions.

5. Work with various organizations and the MiCorps program to continue macroinvertebrate assessments across the watershed. Macroinvertebrates have long been used as indicators of water quality and long term assessments can show water quality changes over time.

6. Conduct stream habitat assessments in high priority subwatersheds.

Table 9.1 Proposed Water Quality Monitoring Activities

Subwatersheds	Type of Analysis	Timeline/Frequency	Estimated Cost	Responsible Party
Establish monitoring working committee	N/A	Quarterly Meetings		MSU, USGS, ICHD, MDEQ
Tier I and Tier II subwatersheds	*E. coli* Monitoring	Weekly + wet weather sampling	$75/sampling location	ICHD, MSU, USGS, MDEQ
Sloan, Wolf, Headwaters Sycamore Creek, Mud, Red Cedar, Middle Branch, Coon, Handy Howell	Canine Scent Tracking	Once per tributary or as determined by Monitoring Committee	$6,000	MSU, ICD
Tier I Subwatersheds	Microbial Source Tracking	TBD	$15,000/year	MSU, USGS, ICHD, MDEQ
TBD (to fill data gaps)	Benthic Macroinvertebrates	2x/year	$6,000/year	Mid-MEAC, ICD
TBD (to fill data gaps)	Stream Habitat Assessment	3 year interval	$12,000	Streamside Ecological Services
Mud Creek	Dissolved Oxygen	Weekly	$2,000	MSU, ICD, USGS, MDEQ
TBD	Nutrients	TBD	TBD	MSU

9.5 WMP Implementation Plan and Updates

The planning team is currently made up of individuals from MSU-IWR, TCRPC and Streamside Ecological Services, with input from a number of local partner organizations and agencies. It is anticipated that this team will be responsible for periodic plan updates, although the WMP is written so that anyone within the watershed can actively participate in the implementation of the plan. It is recommended that the WMP be updated every five years to highlight completed, successful implementation projects, and re-assess the condition of the watershed. Updates will include a summary of water quality improvments related to implemented BMPs, changes to TMDL status, and increased responsibility of existing and newly identified project partners. Additional pollutants identified will be addressed.

<u>Criteria Requiring Watershed Management Plan Revision</u>

As BMPs are implemented, water quality sampling results will be assessed in the corresponding subwatersheds to determine whether the practices are resulting in the desired water quality pollutant load reductions. Land use changes will also be tracked as part of this effort. If pollutant load reductions are realized, it can be assumed that the BMPs are effectively achieving the goals of the watershed management plan and TMDLs.

If however, water quality does not improve despite the implementation of the BMPs, additional investigation should be done to determine if new sources and causes are present in the watershed, or if additional BMPs are necessary. The ultimate desired outcome is to meet the goals and objectives of this watershed management plan, by achieving water quality that meets the water quality standards in order to support the designated and desired uses.

REFERENCES

Barry-Eaton District Health Department. (2007). Regulations governing on-site sewage and on-site water supply system evaluation and maintenance in Barry and Eaton County, Michigan. Retrieved from http://www.barryeatonhealth.org/LinkClick.aspx?fileticket=9A24LcI98eQ%3d&tabid=610

Barry-Eaton District Health Department. (2011). *Time of Sale or Transfer Program, the first three years: November 1, 2007 through October 31, 2010*. Retrieved from http://www.barryeatonhealth.org/LinkClick.aspx?fileticket=jqspmiveOnY%3d&tabid=610

Center for Watershed Protection. (2005). *Urban subwatershed restoration manual no. 11, Unified subwatershed and site reconnaissance: A User's manual version 2.0.* Ellicott City, MD: Author. Retrieved from http://www.cwp.org/online-watershed-library/doc_download/65-urban-subwatershed-restoration-manual-series-manual-11-unified-subwatershed-and-site-reconnaissance-a-user-s-manual

Cwikiel, W. (2003). *Michigan wetlands – Yours to protect: A Citizen's guide to wetland protection* (3rd ed.). Petoskey, MI: Tip of the Mitt Watershed Council. Retrieved from http://www.watershedcouncil.org/water%20resources/wetlands/wetland-resources/files/document%201%20citizens%20guide%20to%20wetland%20protection.pdf

Delhi Charter Township. (2012). Historic *E. coli* surface water sampling data, 2009-2012 [Data file]. Available from Delhi Charter Township.

Fishbeck, Thompson, Carr, and Huber Inc. (2010). *Upper Maple River watershed management plan* (MDNRE #2007-0118). Retrieved from http://www.michigan.gov/documents/deq/wrd-nps-upper-maple-wmp_370632_7.pdf

Eaton Conservation District. (2012). *Eaton County natural resource assessment*. Retrieved from http://www.eatoncd.org/uploads/1/6/4/4/16449128/2011resource_assessment_with_appendices.pdf

ETC Institute. (2006). *Greater Lansing regional water quality survey findings report.* Lansing, MI: Greater Lansing Regional Committee. Retrieved from http://www.mywatersheds.org/publications/Other%20PEP_Habitat/Lansing%20Water%20Qual%20Survey%20Final%20Report_Nov%2021.pdf

Higman, P.J. & S. Campbell. (2009). *Meeting the Challenge of Invasive Plants: A Framework for Action*. Retrieved from http://mnfi.anr.msu.edu/reports/2009-11%20Invasives_strategy_final.pdf

Hamilton Anderson Associates, Inc. (HAA) (2007). *Natural areas – 2006 River bank stabilization study* (CP05562/REC ID 58580).

Hyde, D.A., Enander, H.D., Slaughter, B.S., Monfils, M.J., Penskar, M.R., Badra, P.J., & Paskus J.J. (2009). *Significant natural features in the Tri-County Region (Clinton, Eaton and Ingham Counties): Providing ecological information for a green infrastructure plan (Phase 2)* (Report No. 2009-07). Lansing, Michigan: Michigan Natural Features Inventory, Michigan State University Board of Trustees.

Horizon Environmental Corporation (2010). *Tyler Creek Golf Course Weather & Surface Water Monitoring Study Report.*

Ingham Conservation District. (2013). *E. coli* surface water sampling data, collected in 2013 [Data file].

Ingham County Health Department. (2012). Historic *E. coli* surface water sampling data, collected between 2009-2012 [Data file]. Available from Ingham County Health Department.

Ingham County Health Department. (2013). *E. coli* surface water sampling data, collected in 2013 [Data file].

Latimore, J. (2005). *Habitat selection and resilience of stream fishes in the Red Cedar River Watershed, Michigan* (Doctoral dissertation). Michigan State University, Department of Fisheries and Wildlife, East Lansing, MI. Retrieved from http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=http://search.proquest.com.proxy2.cl.msu.edu/docview/305469919?accountid=12598

Latimore, J. (2006). *MiCorps volunteer stream monitoring procedures.* Michigan Clean Water Corps. Retrieved from http://www.micorps.net/streamresources.html

Livingston County Health Department, Livingston County Drain Commission, & Ingham County Drain Commission. (2001). Historic *E. coli* surface water sampling data, collected between 2000 – 2001 [Data file].

Luukkonen, C.L. (2009). *Model refinement and simulation of groundwater flow in Clinton, Eaton, and Ingham Counties, Michigan* (U.S. Geological Survey Scientific Investigations Report 2009–5244). Reston, VA: U.S. Geological Survey. Retrieved from http://pubs.usgs.gov/sir/2009/5244/pdf/sir2009-5244.pdf

Michigan Department of Agriculture and Rural Development. (2014). Generally accepted agricultural and management practices for manure management and utilization. Lansing, MI: Author. Retrieved from http://www.michigan.gov/documents/mdard/2014_MANURE_MANAGEMENT_AND_UTILIZATION_GAAMPs_452812_7.pdf

Michigan Department of Environmental Quality. (1999a). *Biological surveys of Sycamore Creek and select tributaries, Ingham County, Michigan, September 22, 1995; August 22, 1996; and September 13, 1996* (MI/DEQ/SWQ-99/148). Lansing, MI: Author.

Michigan Department of Environmental Quality. (1999b revision). *Pollutants Controlled Calculation and Documentation for Section 319 Watershed Training Manual*. Retrived from http://www.michigan.gov/documents/deq/deq-wb-nps-POLCNTRL_250921_7.pdf

Michigan Department of Environmental Quality. (2003). *A biological survey of the Red Cedar River and selected tributaries, Livingston and Ingham Counties, Michigan. August and September 2001* (Staff Report MI/DEQ/WD-03/025). Lansing, MI: Author.

Michigan Department of Environmental Quality. (2008 revision). Policy and procedures: qualitative biological and habitat survey protocols for wadeable streams and rivers (WB-SWAS-051). http://www.michigan.gov/documents/deq/wb-swas-procedure51_280711_7.pdf

Michigan Department of Environmental Quality. (2009 revision.). *A biological survey of the Red Cedar Watershed and selected tributaries located in Ingham and Livingston County, Michigan, June-August 2008* (Staff Report MI/DEQ/WB-08/088). Lansing, MI: Author.

Michigan Department of Environmental Quality. (2012a). *Application of the Richards-Baker Flashiness Index to gaged Michigan rivers and streams* (MI/DEQ/WRD-12/028). Retrieved from: http://www.michigan.gov/nps

Michigan Department of Environmental Quality. (2012b). Red Cedar River Watershed: Landscape level wetland functional assessment (enhanced NWI).

Michigan Department of Environmental Quality. (2012c). *Total maximum daily load for E. coli in portions of the Red Cedar River and Grand River Watersheds; including Sycamore, Sullivan, Squaw, and Doan Creeks. Ingham, Eaton, Clinton, Jackson, and Livingston Counties.* Retrieved from http://www.michigan.gov/documents/deq/wrd-swas-tmdl-draft-redcedar-grand_391057_7.pdf

Michigan Department of Environmental Quality. (2012d). *Water quality and pollution control in Michigan 2012 Sections 303(d), 305(b), and 314 Integrated Report* (MI/DEQ/WRD-12/001). Lansing, MI: Author.

Michigan Department of Environmental Quality. (2013a). *A biological survey of the Red Cedar Watershed and selected tributaries: Ingham and Livingston Counties, Michigan July and August 2011* (Staff Report MI/DEQ/WRD/-13/009). Lansing, MI: Author.

Michigan Department of Environmental Quality. (2013b). *Draft total maximum daily load for dissolved oxygen in the Grand River, Red Cedar River, and tributaries: Ingham, Eaton, and Clinton Counties.* Retrieved from http://www.michigan.gov/documents/deq/wrd-swas-tmdl-draft-grandredcedar_424646_7.pdf

Michigan Department of Environmental Quality. (2013c). Groundwater statisitics. Retrieved from http://www.michigan.gov/documents/deq/deq-wd-gws-wcu-groundwaterstatistics_270606_7.pdf

Michigan Department of Environmental Quality. (2013d). Historic *E. coli* sample results from Burchfield Park, Hawk Island County Park, Lake Lansing Park South, and Valhalla Park, BeachGuard database [Data files]. Retrieved on December 18, 2013, from http://www.deq.state.mi.us/beach/SearchResults.aspx?instatepark=False&beachtype=Public&countyId=33

Michigan Department of Environmental Quality. (2014). Floodplains. Retrieved January 2014 from http://www.michigan.gov/deq/0,4561,7-135-3313_3684_3725-11255--,00.html

Michigan Department of Natural Resources. (1974). *A biological and sediment chemistry survey of Sycamore, Willow, and Mud Creeks, and Vevay Drain from Mason to Lansing, Ingham County, Michigan, July 2 to November 8, 1973* (Report No. 2290). Lansing, MI: Author.

Michigan Department of Natural Resources. (1992). *A biological survey of the Red Cedar River, Livingston and Ingham Counties, Michigan, June 24-28, 1991* (MI/DNR/SWQ-92-201). Lansing, MI: Author.

Michigan Department of Natural Resources. (2011). *Draft Grand River assessment*. Ann Arbor, MI: MDNR Fisheries Division. Retrieved from http://grandrapidswhitewater.org/documents/

Michigan Department of Technology, Management and Budget, Center for Shared Solutions and Technology Partnerships. (2012). Michigan Geographic Framework v13a, census, groundwater, hydrography and topography data [Data files]. Retrieved June 2013 from http://www.mcgi.state.mi.us/mgdl/

Michigan State University. (2014). Enviro-weather database, MSUHort station 2012-2013 [Data file]. Retrieved on February 19, 2014, from http://enviroweather.msu.edu/

Michigan State University, Institute of Water Research. (2009). High Impact Targeting (HIT) model results for Red Cedar River Watershed [Data file]. Retrieved on October 11, 2013, from www.iwr.msu.edu/hit2

Mid-Michigan Environmental Action Council. (2012). Stream monitoring report: On Mid-MEAC's volunteer stream monitoring program and the status of the Red Cedar Watershed. Retrieved from: http://www.midmeac.org/LinkClick.aspx?fileticket=V0RCZbbfsR4%3d&tabid=1393

National Oceanic and Atmospheric Administration. (2008). NOAA Coastal Change Analysis Program (C-CAP) zone 51 (lower) 2006-era regional land cover data [Data file]. Charleston, SC: NOAA Office for Coastal Management. Retrieved from www.coast.noaa.gov/digitalcoast/data/ccapregional.

Paskus, J. & Endander, H. (2008). Clinton, Eaton, and Ingham Counties potential conservation areas assessment (MFNI 2008-11). Lansing, Michigan: Michigan Natural Features Inventory, Michigan State University Board of Trustees.

O'Neil, G. (2010). Impact Targeting: applying conservation tools to the worst areas for maximum sediment/nutrient reductions. USDA-NRCS Conservation Innovation Grant final report.

Ouyang, D., Bartholic, J., & Selegean, J. (2005). Assessing sediment loading from agricultural croplands in the Great Lakes basin. *Journal of American Science, 1*(2), 14-21.

Southeast Michigan Council of Governments. (2012). SEMCOG 2040 Forecast Database for Livingston County [online spreadsheets]. Retrieved on December 4, 2012 from: http://www.semcog.org/Data/Apps/regional.forecast.cfm

Spicer Group, Inc. & Wetland and Coastal Resources (2009, revision) Cook and Thorburn Drain Watershed Management Plan.

Tetra Tech. (2006). Red Cedar River watershed management plan. Lansing, MI: Greater Lansing Regional Committee on Phase II Nonpoint Source Pollution. Retrieved from http://www.lansingmi.gov/watershed_management_plan

Tri-County Regional Planning Commission. (2012). Tri-County Region Interim Population Projections [pdf]. Retrieved from http://www.tri-co.org/gis.htm

U.S. Department of Agriculture Natural Resources Conservation Service. (2007). Part 630 Hydrology National Engineering Handbook: Chapter 7 Hydrologic Soil Groups (210-VI-NEH) [pdf]. Retrieved from http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=22526.wba

U.S. Department of Agriculture Natural Resources Conservation Service. (2010). Conservation Choices: Your guide to 30 Conservation and Environmental Farming Practices. Lansing, MI: Michigan NRCS.

U.S. Department of Agriculture Natural Resources Conservation Service. (2013). Web Soil Survey Database (SSURGO 2.2). Retrieved on June 28, 2013, from http://datagateway.nrcs.usda.gov/

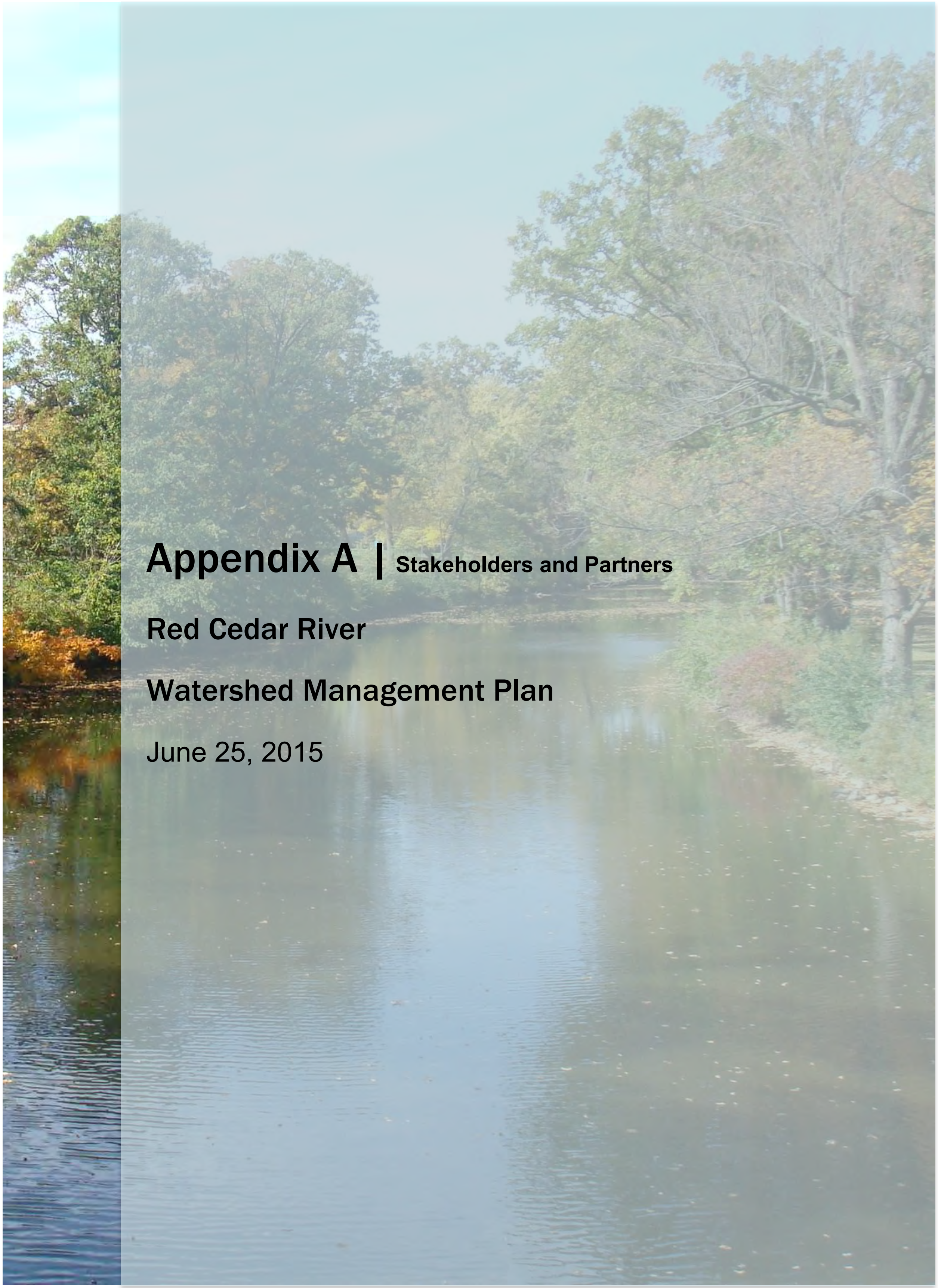
U.S. Environmental Protection Agency. (2000). Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Rivers and Streams in Nutrient Ecoregion VII (EPA 822-B-00-018). Washington, DC: Author. Retrieved from http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/2007_09_27_criteria_nutrient_ecoregions_rivers_rivers_7.pdf

U.S. Environmental Protection Agency. (2008a). Handbook for developing watershed plans to restore and protect our waters (EPA 841-B-08-002). Washington, DC: Author. Retrieved from http://water.epa.gov/polwaste/nps/upload/2008_04_18_NPS_watershed_handbook_handbook-2.pdf

U.S. Environmental Protection Agency. (2008b). Fecal coliform and *E. coli*. Retrieved from: http://www.epa.gov/katrina/fecal.html

U.S. Environmental Protection Agency (2013a). STEPL and Region 5 Model. Retrieved on March 20, 2015, from http://it.tetratech-ffx.com/steplweb/

U.S. Environmental Protection Agency. (2013b). Wetland Definitions. Retrieved on February 5, 2013 from http://water.epa.gov/lawsregs/guidance/wetlands/definitions.cfm



Appendix A | Stakeholders and Partners

Red Cedar River

Watershed Management Plan

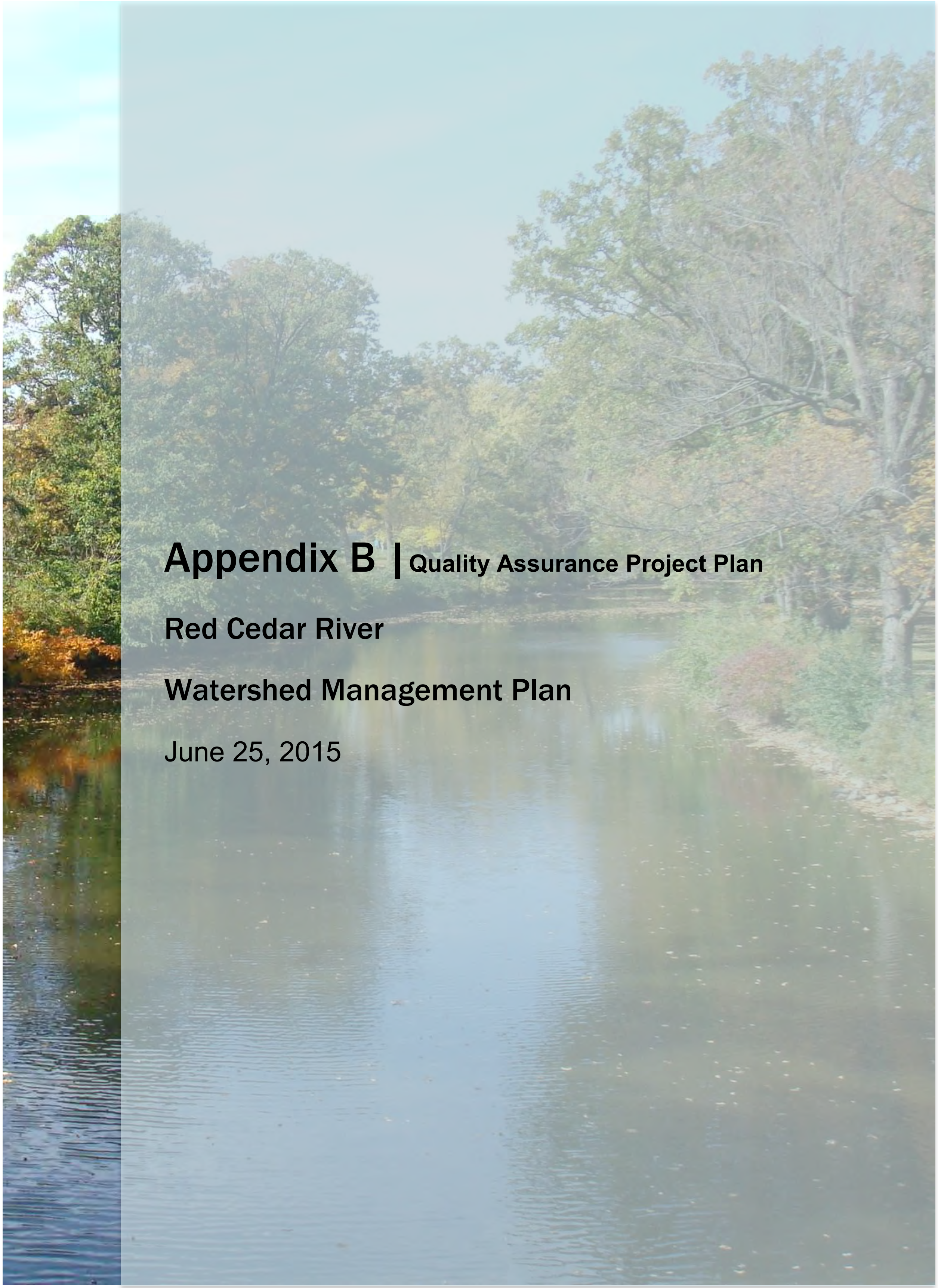
June 25, 2015

SAL	First	Last	TITLE	County	COMPANY	ADDRESS_1	ADDRESS_2	CITY	STATE	ZIP	EMAIL	PHONE
Mr	Tim	Allard	City Manager	Ingham	City of Williamston	City Hall	161 E Grand River	Williamston	MI	48895	manager@williamston-mi.us	655-2774
Ms.	Christe	Alwin			MDEQ						ALWINC@michigan.gov	
Mr	Mike	Atayan	Drain Commissioner	Eaton	Eaton County Drain Commission	1045 Independence Blvd		Charlotte	MI	48813	matayan@eatoncounty.org	517- 543-7500 X1214
Mr	Ken	Baker	DPW Superintendent	Ingham	City of Mason	435 N Jefferson Street		Mason	MI	48854	kenb@mason.mi.us	676-1166 X 203
Dr.	Jon	Bartholic			Michigan State University						bartholi@msu.edu	
Mr	John	Bayless	Administrator	Eaton	City of Grand Ledge	200 E. Jefferson		Grand Ledge	MI	48837	jbayless@grand-ledge.com	517-627-2149
Mr	Jim	Bedford	Chapter President			1804 Wood Stree		Lansing	MI	48912	gairdneri@comcast.net	517-484-5178
Ms	Michelle	Beloskur	Watershed Technician	Ingham	Ingham Conservation District	1031 W. Dexter Trail		Mason	MI	48854	michelle.beloskur@macd.org	517-676-2290
The Honorable	Virgil	Bernero	Mayor	Ingham	City of Lansing	City Hall 9th Floor	124 W Michigan Avenue	Lansing	MI	48933	mayor@lansingmi.gov	483-4141
	Gabriel	Biber		Mid-MEAC							gjbiber@gmail.com	
Ms	Kay	Bodell	Supervisor	Ingham	Onondaga Township	4675 Onondaga Rd		Onondaga	MI	49266	clerk@onondagatownship.org	517- 628-2654
Mr	Matt	Bolang			Livingston County Health Department						mbolang@co.livingston.mi.us	
Mr	Gary	Bozek		Eaton	Delta Charter Township	7710 W Saginaw Hwy		Lansing	MI	48917		323-8540
Mr	Matt	Brinkley	Assistant Planner	Ingham	Lansing Charter Township	3209 W Michigan Ave		Lansing	MI	48917	mbrinkley@lansingtownship.org	485-2272
Mr	Dick	Brown	Deputy Drain Commissioner	Eaton	Eaton County Drain Commission	1045 Independence Blvd		Charlotte	MI	48813	RBrown@eatoncounty.org	517- 543-7500
Mr.	Rick	Brown			Meridian Charter Township	5151 Marsh Road		Okemos	MI	48864	brown@meridian.mi.us	517-853-4568
Mr	Bill	Brunner	City Engineer	Ingham	City of Lansing	124 W Michigan Ave		Lansing	MI	48933	bbrunner@lansingmi.gov	
Mr	Allen	Bryant	Environmental Coordinator	Ingham	Delhi Charter Township	2074 Aurelius Road		Holt	MI	48842	allen.bryant@delhitownship.com	
Ms	Sue	Butler	Supervisor	Eaton	Windsor Charter Township	405 W Jefferson		Dimondale	MI	48821	suebutler227@sbcglobal.net	517-646-7510
Ms	Stacey	Byers		Ingham	Ingham County Ag Preservation Board	121 E. Maple		Mason	MI	48854	stacy@sheridanland.com	
Mr	Donald	Byrd	Village President	Ingham	Stockbridge Village	PO Box 155		Stockbridge	MI	49285	dbyrd@vil.stockbridge.mi.us	517-851-7435
Ms.	Erin	Campbell			TCRPC						ecampbell@mitcrpc.org	
Ms.	Koren	Carpenter			MDEQ						CarpenterK5@michigan.gov	
Mr.	Doug	Carter			Retired - Epxeditions						riverologist@comcast.net	
The Honorable	Leon	Clark	Mayor	Ingham	City of Mason	616 S Jefferson		Mason	MI	48854	LeonC@mason.mi.us	676-3523
Mr.	Thad	Cleary			MDEQ						CLEARYT@michigan.gov	
Mr	Mike	Coddington	Supervisor	Livingston	Howell Township	3525 Byron Road,		Howell	MI	48855	supervisor@howell-mi-twp.org	517- 546-2817
Mr	Martin A	Colburn	City Administrator/City Clerk	Ingham	City of Mason	City Hall - 201 W Ash St		Mason	MI	48854	martyc@mason.mi.us	676-9155
Ms	Carol	Coldburn	President	Ingham	Dansville Village	PO Box 62		Dansville	MI	48819		623-6753
Mr	Don	Cooley	Supervisor	Eaton	Oneida Charter Township	512 Whitney St.		Grand Ledge	MI	48837	dfcooley@aol.com	517-622-8078
	Angie	Cosman		Ingham							dr_cosman@ingham.org	
Mr	Dan	Coss	City Administrator	Clinton	City of DeWitt	414 E Main		DeWitt	MI	48820	dcoss@dewittmi.org	669-2441
Mr	Harold	Curtis	Supervisor	Ingham	Wheatfield Township	1409 Zimmer Rd		Williamston	MI	48895		655-1484 Home

SAL	First	Last	TITLE	County	COMPANY	ADDRESS_1	ADDRESS_2	CITY	STATE	ZIP	EMAIL	PHONE
Mr	Tim	Allard	City Manager	Ingham	City of Williamston	City Hall	161 E Grand River	Williamston	MI	48895	manager@williamston-mi.us	655-2774
Mr	Kathy	Rodgers	Supervisor	Ingham	Lansing Charter Township	3209 W Michigan Ave		Lansing	MI	48917	rodgerskm@lansingtownship.org	485-2272
Mr	Scott	De Vries	City Engineer	Ingham	City of Williamston	161 E Grand River Ave		Williamston	MI	48895	scott.devries@williamston-mi.us	517-655-2774
Ms	Sandra	Diorka	Director of Public Services	Ingham	Delhi Charter Township	2074 Aurelius Road		Holt	MI	48842	sandra.diorka@delhitownship.com	699-3879
Mr.	Erich	Ditschman				1120 Wildwood Drast		East Lansing	MI	48823	erichditschman@gmail.com	
	Susan	Doty		MDEQ							Dotys2@michigan.gov	
Dr.	Erin	Dreelin			Michigan State University						dreelin@msu.edu	
Mr	John	Elsinga	Manager	Ingham	Delhi Charter Township	2074 Aurelius Road		Holt	MI	48842	john.elsinga@delhitownship.com	694-2137
Mr	Troy	Feltman	Superintendent	Clinton	Bath Township	P.O. Box 247		Bath	MI	48808	tfeltman@bathtownship.us	517.641.6728
Mr	Randy	Fox	Councilmember & Mayor Pro-Tem	Ingham	City of Leslie	PO Box 496		Leslie	MI	49251		51-589-8236
Mr	Stuart	Goodrich	Township Supervisor/DDA Director	Ingham	Delhi Charter Township	2074 Aurelius Road		Holt	MI	48842	stuart.goodrich@delhitownship.com	694-0068(H)
Mr	Paul	Griffes	Supervisor	Ingham	Locke Township	5287 E Allen Rd		Webberville	MI	48892	paulgriffes@tds.net	517-468-3372
	Geoff	Habron		MSU							habrong@msu.edu	
Mr.	Jay	Hanks	President		Lansing Oar and Paddle Club						jayhanks@aol.com	
Mr	Phil	Hanses	Drain Commissioner	Clinton	Clinton County Drain Commission	Clinton County Courthouse	100 E State Street, Suite 2300	St. Johns	MI	48879	hansesp@clinton-county.org	989-224-5160
Mr	Scott	Hanshue	Fisheries Management Biologist		MDNR	621 North 10th St		Plainwell	MI	49080	hanshues1@michigan.gov	118
Mr	Bob	Hanvey	Supervisor	Livingston	Marion Township	2877 W. Coon Lake Rd		Howell	MI	48843	supervisor@mariontownship.com	517-546-1588
Mr.	Bill	Haun			Ingham County Health Department						He_haun@ingham.org	
Dr.	Dan	Hayes			Michigan State University						hayesdan@msu.edu	
Mr.	Gary	Haynes	President	Ingham	MGROW	P.O. Box 12211		Lansing	MI	48909	gehaynes@mgrow.org	
Mr	Dallas	Henney	Supervisor	Ingham	Leslie Township	2600 Olds Rd		Leslie	MI	49251	dhenney@cablespeed.com	589-9272
	John	Hesse		MSU							hessej@msu.edu	
The Honorable	Michelle	Hyne	Mayor	Ingham	City of Williamston	161 East Grand River		Williamston	MI	48895	mayor@williamston-mi.us	517-655-2774
Mr	Dean	Johnson	City Engineer	Ingham	City of Lansing	124 W Michigan Ave		Lansing	MI	48933	djohnson@lansingmi.gov	483-4458
Mr	Brian	Jonckheere	Drain Commissioner	Livingston	Livingston County Drain Commissioner	2300 E. Grand River	Suite 105	Howell	MI	48843	BJonckheere@co.livingston.mi.us	517.546.0040
Mr.	Mark	Kieselbach	Director of Community Planning and Development	Ingham	Meridian Charter Township	5151 Marsh Road		Okemos	MI	48864	kieselbach@meridian.mi.us	517.853.4506
Mr	Wayne	Kinne	Supervisor/Assessor	Ingham	Ingham Township	PO Box 238		Dansville	MI	48819	supervisor@inghamtownship.com	517-623-0008
Ms	Ruth	Kline-Robach		Ingham	Michigan State University - IWR	1405 S. Harrison Rd.	Manly Miles Bldg. Rm 101	East Lansing	MI	48823	kliner@msu.edu	355-0224
Ms	Kristi	Klomp	Executive Director		Timberland RC&D	1345 Monroe Ave NW	Suite 243	Grand Rapids	MI	49505	timberlandrcd@gmail.com	616-451-4844
Mr	Walt	Kulasa	Construction Inspector	Eaton	Delta Charter Township	7710 W Saginaw Hwy		Lansing	MI	48917	wkulasa@deltami.gov	
Mr	George	Lahanas	Interim City Manager	Ingham	City of East Lansing	410 Abbot Rd		East Lansing	MI	48823	glahana@cityofeastlansing.com	319-6920
Dr.	Jo	Latimore			Michigan State University						latimor1@msu.edu	
Mr	John	Leonard	President	Ingham	Webberville Village	115 South Main Street	PO Box 389	Webberville	MI	48892	jleonard@villageofwebberville.com	521-3984
Mr	Pat	Lindemann	Drain Commissioner	Ingham	Ingham County	707 Buhl Ave	P.O. Box 220	Mason	MI	48854	patricklindemann@me.com	517- 676-8395
Dr.	David	Long			Michigan State University						long@msu.edu	
The Honorable	Victor W	Loomis Jr	Mayor	Ingham	City of East Lansing	410 Abbot Rd		East Lansing	MI	48823	vloomis@cityofeastlansing.com	517-319-6920
Mr	Steven	Lott	Supervisor	Ingham	Alaiedon Township	916 Lamb Road		Mason	MI	48854	alaiedon@alaiedontwp.com	676-9277

SAL	First	Last	TITLE	County	COMPANY	ADDRESS_1	ADDRESS_2	CITY	STATE	ZIP	EMAIL	PHONE
Mr	Tim	Allard	City Manager	Ingham	City of Williamston	City Hall	161 E Grand River	Williamston	MI	48895	manager@williamston-mi.us	655-2774
Ms.	Luanne	Maisner			Meridian Twp. Parks Dept.						maisner@meridian.mi.us	
Mr	Alec	Malvetis	CSO Program Engineer	Ingham	City of Lansing	124 W Michigan Ave		Lansing	MI	48933	AMalveti@lansingmi.gov	
	Phanikumar	Mantha		MSU							phani@msu.edu	
Mr	Dorwin	Marshall	Supervisor	Ingham	White Oak Township	4591 M-36		Stockbridge	MI	49285		851-7958
Ms	Mickey S	Martin	Supervisor	Ingham	Williamstown Township	4990 N Zimmer Road		Williamston	MI	48895	martinm@williamstowntownship.com	655-3193
Ms	Erin	McDonough	Executive Director	Ingham	MI United Conservation Clubs	P.O. Box 30235		Lansing	MI	48909	emcdonough@mucc.org	517-371-1041
Ms	Susan	McGillicuddy	Supervisor	Ingham	Meridian Charter Township	5151 Marsh Road		Okemos	MI	48864	mcgillicuddy@meridian.mi.us	853-4262
Mr	Rich	Miller	Supervisor	Clinton	City of DeWitt	414 E Main		DeWitt	MI	48820	rmiller@dewittmi.org	669-2441
Mr	William C.	Miller	Supervisor	Livingston	Iosco Township	P.O. Box 1079		Fowlerville	MI	48836	ioscotwp@fnwusers.com	517-223-9545
The Honorable	Michael	Moody	Mayor Pro-Tem	Ingham	City of Williamston	161 E Grand River Ave		Williamston	MI	48895	mmoody@williamston-mi.us	517-655-2774
Ms	Robin C	Naeyaert	Member Liason	Ingham	City of Mason	501 Riverwalk Dr		Mason	MI	48854	robinn@mason.mi.us	676-3620 (H)
Mr	John	Neilsen	Deputy Controller	Ingham	Ingham County	Courthouse	PO Box 319	Mason	MI	48854	jneilsen@ingham.org	676-7211 Linda
Ms.	Kalie	Nye			Michigan State University						kalie.nye@gmail.com	
Ms	Belinda	Peters	County Administrato	Livingston	Livingston County	304 E. Grand River Ave.	Suite 202	Howell	MI	48843	Administration@co.livingston.mi.us	517.546.3669
Ms	Sue	Pigg	Executive Director	Ingham	TCRPC	3135 Pine Tree Rd.	Suite 2C	Lansing	MI	48910	spigg@mitcrpc.org	517-393-0342
Ms	Julie	Powers	Executive Director	Ingham	Mid-MEAC	405 Grove St.		East Lansing	MI	48823	jpowers155@gmail.com	517- 292-3078
Mr	Paul	Pratt	Deputy Drain Commissioner	Ingham	Ingham County Drain Office	707 Buhl		Mason	MI	48854	ppratt@ingham.org	676-8395
Mr	Brian	Ralph	Chief Operations Officer	Ingham	Lansing Public Schools	519 W. Kalamazoo St. 210		Lansing	MI	48933	brian.ralph@lansingschools.net	517.755.3036
Mr	Kenneth	Recker	Commissioner	Livingston	Commissioner	2300 E. Grand River	Suite 105	Howell	MI	48843	livingstoncountydrain@gmail.com	517.546.0040
Mr	Brian	Reed	Administrator	Ingham	City of Leslie	PO Box 496		Leslie	MI	49251	reedb@cityofleslie.org	104
Mr	Gerald	Richards	Township Manager	Ingham	Meridian Charter Township	5151 Marsh Road		Okemos	MI	48864	richards@meridian.mi.us	853-4254
Mr	Michael	Rife	Supervisor	Livingston	Conway Township	8015 N. Fowlerville Rd		Fowlerville	MI	48836	supervisor@conwaytownship.com	517- 223-0358
Ms.	Molly	Rippke			MDEQ						rippkem@michigan.gov	
Mr	Paul	Risner	Supervisor	Ingham	Stockbridge Township	PO Box 837		Stockbridge	MI	49285	Risnerp@frontier.com	517-851-4252
Mr	Bob	Scheuerman	Engineering Administrator	Ingham	City of East Lansing	410 Abbott Rd		East Lansing	MI	48823	bscheue@cityofeastlansing.com	
Mr	Ray	Severy	Public Works	Ingham	Meridian Charter Township	5151 Marsh Road		Okemos	MI	48864	severy@meridian.mi.us	853-4448
Mr	Kip	Miller			MDARD	Constitution Hall	P.O. Box 30017	Lansing	MI	48909	millerk15@michigan.gov	
Mr	Larry	Silsby	Supervisor/Assessor	Ingham	Aurelius Township	1939 Aurelius Rd		Mason	MI	48854	larrys@aureliustwp.org	628-2093
Dr.	George	Silva		MSUE							silvag@msu.edu	
Ms	Jennifer	Silveri	Watershed Stewardship Technician	Eaton	Eaton Conservation District: MI Ag Environmental Assurance Program (MAEAP)	551 Courthouse Dr.	Suite 3	Charlotte	MI	48813	jennifer.silveri@mi.nacdnet.net	517.543.5848 Ext. 5
	Stephanie	Smith									fluker@msu.edu	
Mr	Todd	Sneathen	Works	Ingham	City of East Lansing	410 Abbott Rd		East Lansing	MI	48823	tsneath@cityofeastlansing.com	337-9459
Mr.	Aaron	Snell									snell@streamsideeco.com	
Ms	Andrea	Stay	Executive Director	Eaton	Eaton Conservation District	551 Courthouse Dr.	Suite 3	Charlotte	MI	48813	andrea.stay@mi.nacdnet.net	517- 543-5848 Ext. 5
Mr	Rod	Taylor	Manager	Clinton	DeWitt Charter Township	1401 W Herbison Rd		DeWitt	MI	48820	rtaylor@dewitttwp.org	669-6576
Ms	Karry	Trickey	District Conservationist	Ingham/ Livingston	USDA/NRCS	521 N. Okemos Rd.		Mason	MI	48854	Karry.Trickey@one.usda.gov	
Ms	Rachael	Loucks	Watershed Coordinator	Eaton	Eaton Conservation District	551 Courthouse Dr.	Suite 3	Charlotte	MI	48813	rachael.loucks@macd.org	517-543-5848 ext.5
Mr	Gene	Ulrey	Supervisor	Ingham	Bunker Hill Township	3501 Williams Rd		Leslie	MI	48251		517-589-9886

SAL	First	Last	TITLE	County	COMPANY	ADDRESS_1	ADDRESS_2	CITY	STATE	ZIP	EMAIL	PHONE
Mr	Tim	Allard	City Manager	Ingham	City of Williamston	City Hall	161 E Grand River	Williamston	MI	48895	manager@williamston-mi.us	655-2774
Dr.	Henry	Vaupel	Supervisor	Livingston	Handy Township	135 N. Grand Ave	PO Box 189	Fowlerville	MI	48836	henryvaupel@handytownship.com	517-223-3228
Mr.	Peter	Vincent			MDEQ						vincentp@michigan.gov	
Dr.	Tom	Voice			Michigan State University						voice@msu.edu	
Mr	Ronald	Weesies	Supervisor	Ingham	Vevay Township	780 Eden Rd		Mason	MI	48854	supervisor@vevaytownship.org	676-1764
Mr	Neil R	West	Supervisor	Ingham	Leroy Township	PO Box 416		Webberville	MI	48892	leroytwp@yahoo.com	517-521-3729
Mr	Ted	Westmeier	Director/Health Officer	Livingston	Livingston County Health Department	2300 E. Grand River	Suite 102	Fowlerville	MI	48836	twestmeier@co.livingston.mi.us	517-552-6801
Mr	Jim	Wilson	Director, BEH	Ingham	Ingham County Health Department	5303 S. Cedar St.	P.O. Box 30161	Lansing	MI	48911	jwilson@ingham.org	
Dr.	Lois	Wolfson			Michigan State University						wolfson1@msu.edu	
Mr	Ryan	Wood	Administrator	Clinton	Clinton County	Clinton County Courthouse	100 E State Street, Ste 2100	St Johns	MI	48879	woodr@clinton-county.org	989-224-5120
Mr.	Rob	Zbiciak			MDEQ						Zbiciakr@michigan.gov	
				Livingston	Conservation District	P.O. Box 916		Fowlerville	MI	48836	admin@livingstoncd.org	
Mr.	Paul	Kindel									kindel@msu.edu	



Appendix B | Quality Assurance Project Plan

Red Cedar River

Watershed Management Plan

June 25, 2015

Quality Assurance Project Plan (QAPP)
Red Cedar River Watershed Planning 2012 – 2014

Michigan Department of Environmental Quality tracking code: #2011-0014

August 21, 2012
Version 3

Ruth Kline-Robach 8-23-12

Ruth Kline-Robach, Grantee **Date**
Michigan State University-Institute of Water Research

Kalie Nye 8-23-12

Kalie Nye, Graduate Student **Date**
Michigan State University

8-23-12

Joe Rathbun, **Date**
Nonpoint Source Monitoring Coordinator
Michigan Department of Environmental Quality

8/23/2012

for **Robert Day,** **Date**
Nonpoint Source Unit Chief
Michigan Department of Environmental Quality

Quality Assurance Project Plan (QAPP)
Red Cedar River Watershed Planning 2012 – 2014

Michigan Department of Environmental Quality tracking code: #2011-0014

August 21, 2012
Version 3

Ruth Kline-Robach, Grantee   Date
Michigan State University-Institute of Water Research

Kalie Nye, Graduate Student   Date
Michigan State University

8/22/12
Joe Rathbun,   Date
Nonpoint Source Monitoring Coordinator
Michigan Department of Environmental Quality

Robert Day,   Date
Nonpoint Source Unit Chief
Michigan Department of Environmental Quality

Table of Contents

QAPP Organization and Project Description

Distribution List

Michigan State University

- Ruth Kline-Robach
- Kalie Nye

Michigan Department of Environmental Quality (MDEQ)

- Joe Rathbun, Nonpoint Source Monitoring Coordinator
- Susan Doty, Project Manager
- Thad Cleary, Grand Administrator
- Molly Rippke, Aquatic Biologist

Streamside Ecological Services

- Aaron Snell

Tri- County Regional Planning Commission

- Erin Campbell

Project Organization

The Institute of Water Research at Michigan State University is responsible for grant administrative activities. Together, Michigan State University- Institute of Water Research (MSU-IWR), Streamside Ecological Services (SES), and Tri-County Regional Planning Commission (TCRPC) (the internal project team) will collect and analyze data for use in developing a Watershed Management Plan. Throughout the process, the internal project team will collaborate with the Ingham County Health Department (ICHD) and the Michigan Department of Environmental Quality (MDEQ) project contacts.

Table 1. Red Cedar River Watershed Planning Project Leadership- Internal Project Team

Name and Title	Responsibilities	Contact Information
Ruth Kline-Robach, Outreach Specialist, Michigan State University-Institute of Water Research	Project Coordinator, data analysis	kliner@msu.edu (517) 355-0224
Kalie Nye, Graduate Assistant, Michigan State University	QAPP Development, *E. coli* sampling	nyemicha@msu.edu 517-353-2244
Aaron Snell, Aquatic/Restoration Biologist, Streamside Ecological Services	Technical expertise and data analysis	snell@streamsideeco.com (616) 238-7372
Erin Campbell, Assistant Environmental Planner, Tri-County Regional Planning Commission	Data analysis	ecampbell@mitcrpc.org 517.393.0344 ext. 22

Project Description

Sample data collected under this QAPP will be used in the Red Cedar River Watershed Planning Project. The intent of the Red Cedar River Watershed Planning Project is to develop a plan to restore and protect water quality. To make this task most manageable, the watershed management plan and thus this QAPP will focus on four to eight 12-digit hydrologic unit code (HUC) subwatersheds of the Red Cedar River Watershed.

The Red Cedar River watershed (HUC 04050004) is approximately 294,496 acres (461 sq. miles). The headwaters are located in eastern Livingston County, in the south-central portion of the Lower Peninsula; the river flows in a westerly direction into and across Ingham County. The river meets the Grand River near the Ingham and Eaton County border in downtown Lansing. Land use in the watershed area is as follows: 59% agriculture/bare; 14% residential/commercial/industrial (intensity developed); 13% forest/range; 14% wetland/water.

Portions of the watershed are included in a Draft Total Maximum Daily Loads (TMDL) for *Escherichia coli* (*E. coli*). Portions of the watershed are anticipated to be included in dissolved oxygen (DO), mercury, and polychlorinated biphenyl (PCB) TMDLs.

The Wolf Creek, Dietz Creek, Doan Creek, Squaw Creek, Coon Creek, Headwaters Sycamore Creek, Sycamore Creek, and Red Cedar subwatersheds have *E. coli* TMDLs under development (subwatershed naming from National Hydrography Dataset). TMDLs to address low DO levels are also scheduled for 2012 and 2017 in the Red Cedar River, Mud Creek, Sycamore Creek, Cook and Thorburn Drain from Cedar Lake Upstream, and the Headwaters Sycamore Creek subwatersheds.

The emphasis of this watershed planning effort and this QAPP will be focused on collecting data to address the *E. coli* TMDL and *E. coli* water quality standard (WQS) exceedances in the Red Cedar Watershed. Sampling locations will be selected based on results of previous studies done on the watershed and in areas where there are data gaps. Data sources used in selecting sampling sites include, areas determined to benefit from additional sampling as outlined in the *Total Maximum Daily Load for E. coli in portions of the Red Cedar River and Grand River Watersheds; including Sycamore, Sullivan, Squaw, and Doan Creeks: Ingham, Eaton, Clinton, Jackson, and Livingston Counties* report (MDEQ, 2012), priority areas determined in the 2001 watershed planning work, areas identified as benefiting from additional sampling through *E. coli* transport modeling, and areas of high sedimentation as determined by High Impact Targeting (HIT) modeling results.

Sampling is expected to take place over two sampling seasons. Thirteen sites will be sampled for *E. coli* in the late summer and early fall of 2012. Data collected from this sampling effort will be used in developing an expanded monitoring plan for spring and summer of 2013. The expanded monitoring plan is expected to include additional parameters and different sampling sites. A QAPP addendum or new QAPP will be submitted for that effort.

The Red Cedar Watershed Management Plan is meant to complement the existing stormwater management plan developed by the Greater Lansing Regional Committee for Stormwater Management (GLRC) for the urbanized areas and their municipal separate storm sewer system (MS4) permit requirements. In addition, data will be shared with the Middle Grand River watershed planning project.

Training Requirements/Certification

Persons responsible for sampling *E. coli* under this project and QAPP will have prior *E. coli* sampling experience or will be trained by others with experience in *E. coli* sampling.

Measurement/Data Acquisition

Study Objectives

The objective of the watershed sampling effort is to collect supplemental data to better understand pollutant conditions, sources, and causes. The objective of the 2012 sampling effort is to collect additional *E. coli* data in order to finalize four to eight priority subwatersheds and to identify those tributaries that are contributing higher levels of *E. coli.*

Currently, in most of the subwatersheds listed as impaired, the *E. coli* TMDL reaches extend throughout the majority of the subwatershed. However, the TMDL locations were identified primarily from monitoring data taken from the main branch of the Red Cedar River. This study will assess the *E. coli* concentrations at various locations within certain tributaries of the Red Cedar River.

Study Design Description

Monitoring Location Selection

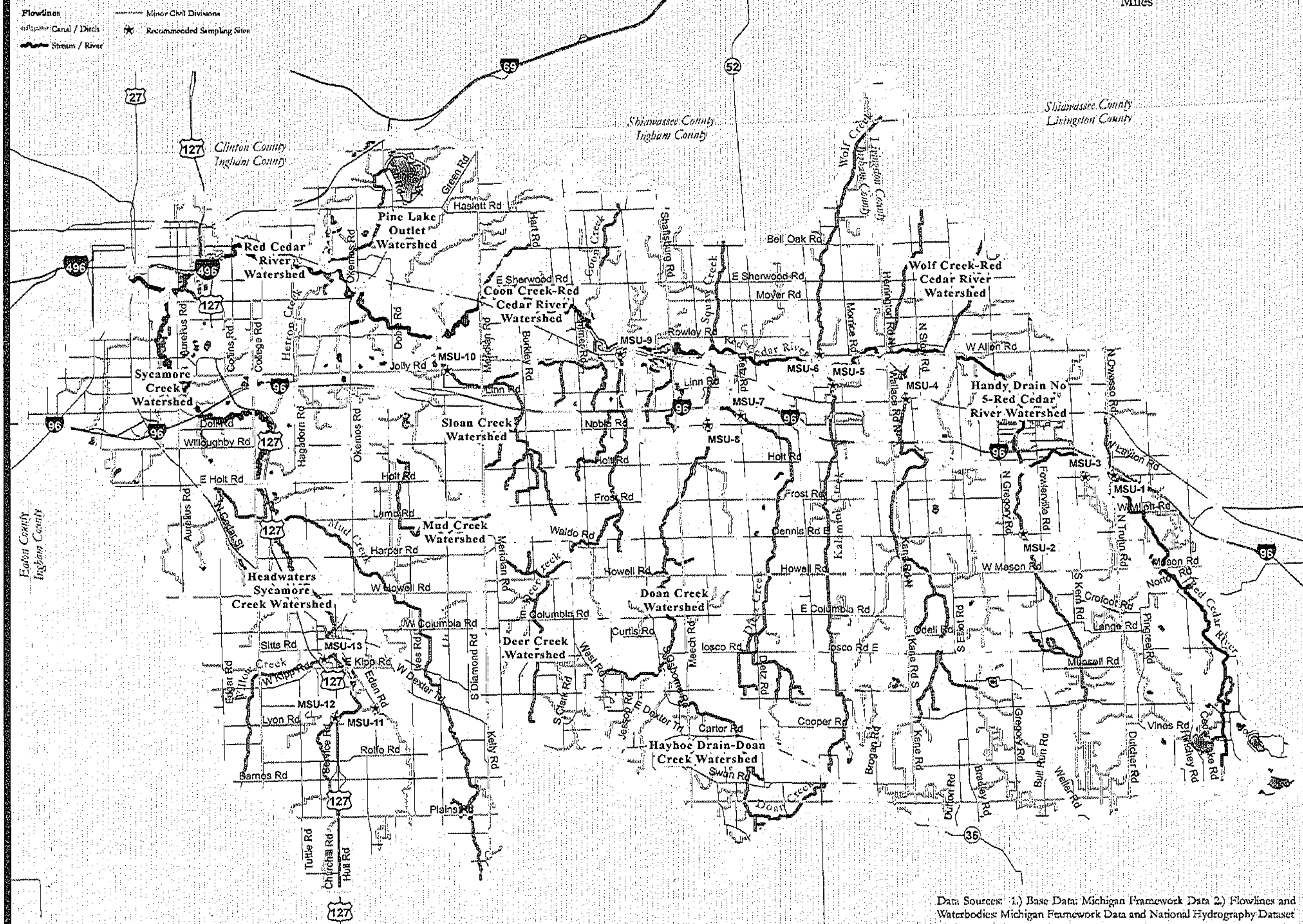
An assortment of existing data has been compiled and reviewed. Sources of that data include past and current monitoring studies, information provided by watershed stakeholders and academicians, and historical watershed planning documents. Additional monitoring sites were selected by reviewing previous studies and by running a HIT sediment model for the watershed. Recommendations from the report entitled *Total Maximum Daily Load for E. coli in Portions of the Red Cedar River and Grand River Watersheds; including Sycamore, Sullivan, Squaw, and Doan Creeks: Ingham, Eaton, Clinton, Jackson, and Livingston Counties* (MDEQ, 2012) and its author Molly Rippke (personal communication, July, 20, 2012) were also considered. Priority areas determined in watershed inventory work conducted in 2001, *E. coli* transport modeling conducted by faculty members at Michigan State University, and through HIT modeling conducted at the MSU-IWR were also incorporated.

The various studies and data sources prioritized the subwatersheds differently, and four to eight priority subwatersheds are not apparent across the various data sources. In addition, there are obvious gaps in the available sampling data. This study will address those gaps by collecting data at locations that have not yet been sampled. In addition, sites prioritized for additional monitoring by Molly Rippke (personal communication, July, 20, 2012) will be included in the 2012 sampling regime. Where possible, the sampling locations will be at road and stream crossings with right-of-way access.

A map of the watershed showing proposed monitoring stations is included as Figure 1.

The study will focus initially on *E. coli* to coincide with the *E. coli* TMDL that was recently written for portions of the watershed. In addition, because of the unusually dry summer season,

Figure 1: QAPP Sampling Locations



temperature and depth of water measurements will be recorded during one sampling event at each sampling location with the intention of correlating *E. coli* results with those parameters and to better compare the 2012 data with the historical data.

Subwatersheds in which *E. coli* samples will be collected include:

- Coon Creek
- Dietz Creek
- Doan Creek
- Handy Drain No. 5
- Handy Howell Drain
- Headwaters Sycamore Creek
- Kalamink Creek
- Middle Branch
- Sloan Creek
- West Branch
- Wolf Creek

Data collected during this sampling effort will be combined with the other available data and reports in order to prioritize four to eight subwatersheds. It is anticipated that the 2013 sampling will focus on potential sources and causes of the impairments in the priority subwatersheds, and will include additional parameters to better understand pollutants and potential sources in the priority subwatersheds.

Sampling Process

Thirteen sites will be sampled weekly for four weeks beginning the week of August 27, 2012. Samples will be collected weekly on Wednesday and Thursday each week. In the event of unexpected challenges, data will be collected as close as possible to the originally scheduled sampling date.

At each *E.coli* sampling location, three samples (left, right, and center) will be collected. The three results will be used to calculate a geometric mean for each sampling location for each week. Temperature and depth of water will be measured and recorded after the *E. coli* samples have been collected each week.

To more easily manage sample data, sample stations will have a unique name. Samples sites will be labeled "MSU-#", and the # will be replaced with their unique sample site number beginning with 1 and increasing numerically. Samples will be numbered and labeled with their own unique sample ID number. The unique name will allow differentiation between other data sets and between sample sites.

Weather conditions on the dates of the sampling events will be recorded using data posted on the Michigan State University Enviro-Weather website East Lansing station (http://www.enviroweather.msu.edu/weather.php?stn=msu). In addition, rainfall amounts in the 48 hours preceding the sampling will be recorded.

If problems with sampling site access arise, a new sampling site will be selected in close proximity to the originally planned site. If field conditions warrant a large deviation from the sampling proposed in this QAPP, we will contact our MDEQ project manager to discuss the changes.

If insufficient water is available at a site to allow for sampling, a site nearby the originally planned site will be used for sample collection. Or if possible, the sediment at the bottom of the stream will be manually dredged, the suspended solids allowed to settle, and water allowed to flow from upstream into the area before the sample is collected.

Data Quality Objectives

Obtaining quality and useful data is necessary to most effectively inform the watershed management planning process. Table 2 below describes measures that will be taken to ensure that data is accurate, precise, comparable to other studies, and representative of field conditions.

Table 2. Red Cedar River Watershed Management Plan Data Quality Objectives

Activity	Accuracy	Precision	Representativeness /Comparability
E.coli sampling	Collect a blank every 20^{th} sample or once per survey, whichever is more frequent Measured value within 25% of known standard concentration Field blanks with a bacteria count of $\leq$ 10 CFU	Collect a field duplicate every 20^{th} sample or once per survey, whichever is more frequent Relative Percent Difference (RPD) of ≤ 25% Duplicate samples exceeding the 25% RPD but still within the same regulatory category will be considered acceptable	Three samples (right, left, center) for each sampling location to generate a geometric mean Use standard sampling and analysis methods
Temperature	Follow Field Protocol included in QAPP Instrument rated for $\pm$1.0 °C	Collect a field duplicate every 20^{th} sample or once per survey, whichever is more frequent Relative Percent Difference (RPD) of ≤ 20%	Same as accuracy
Water Depth	Follow Field Protocol included in QAPP	Same as accuracy	Same as accuracy

The completeness data quality objective (DQO) will be attained by collecting each proposed sample at each of the proposed sampling sites and event times. The dataset will be considered complete if 90% of the data is useable and meets all DQOs. Any problems that arise in sampling will be handled as described in the Sampling Process section above.

Sample/Data Collection and Analysis Procedures

Industry accepted collection and analysis procedures will be followed and are described in detail below. Table 3 below lists the analytical method, detection limit, sample volume, bottle type, preservative, and hold time that will be used for this sampling effort.

Table3. Red Cedar River Watershed Management Plan Sample Collection and Analysis Details

Parameter	**Method**	**Detection Limit**	**Sample Volume (mL)**	**Bottle Type**	**Preserva-tive**	**Hold Time**
E. coli	EPA 1103.1	Lower: 10-10,000 CFU /100 mL OR Upper: 10-1,000,000 CFU /100 mL	100	Plastic Unit 30	Sodium Thiosulfate	6 hours
Temperature	Cole Parmer Remote Probe Thermometer	± 0.1 °C	Not applicable, measured with a field instrument.			
Water Depth	Meter Stick Manual Measurement	1 mm	Not applicable, measured with a field instrument.			

<u>*E. Coli*</u>

Samplers will follow the procedures described in the MDEQ Drinking Water Laboratory EQP 2300 form included in the Appendix. *E. coli* samples will be collected away from the banks and in the stream current. Sampling locations will be chosen that are representative of average stream conditions to be sampled. The laboratory form will be labeled with the date, time, sampler initials, and location-specific sample identification. The bottle will be labeled with the unique sample ID.

Samples will be collected by wading into the stream, from the banks of the stream where the stream is narrow, or from a bridge above the stream. By approaching the sampling site from downstream, walking with caution, and/or by sampling from the banks of the stream, the bottom of the stream will be disturbed as little as possible to avoid including any disturbed sediment from the bottom. If the sediment is disturbed the sampler will wait until the sediment settles to collect the samples. The sampler will face upstream while collecting samples. To collect the sample, the sampler will plunge the bottle into the water with the top facing downward while holding the bottom of the bottle. The bottle will be pushed away from the sampler and upstream. A one inch air gap below the lid will be left, and the cap will be placed on the bottle while avoiding contamination into the cap or bottle from other sources. If the stream is too shallow to plunge the bottle into the water facing downward, the bottle will be pushed into the water on its side, facing downstream until submerged, and turned to face upstream to collect the sample. An extension pole may be used to collect samples in deep water or to collect samples while the sampler stands on the banks of the stream. The sampler will collect the water sample eight to 12 inches below the water's surface or, where the stream is shallow, half-way between the water surface and the bottom of the stream. (United States Environmental Protection Agency Office of Water, 1997). When sampling from the bridge, the sampler will tie a string or rope to the top of the bottle, unscrew the cap carefully and set it aside so that the inside of the cap remains untouched. The sampler will lower the bottle using the rope, bottom first, to the water by gravity. The bottle will be submerged into the stream using stream water to weight and lower the bottle to the appropriate stream depth. Once the bottle is filled, it will be pulled out of the water and up to the bridge. A one inch air gap below the lid will be left, and the cap will be placed on the bottle while avoiding contamination from getting into the cap or bottle from other sources. The bottle will be labeled and placed in the cooler. GPS coordinates and the nearest intersection will be identified and recorded for each sampling location on the field form.

A laboratory supplied EQP 2300 form will be filled out by the sampler or sampling team. Samples will be delivered to the MDEQ Drinking Water Analysis Laboratory at 3350 North M.L. King Blvd., P.O. Box 30270, Lansing, MI 48909, within 6 hours of being collected and between the hours of 8 a.m. to 3 p.m. on Monday - Thursday. The laboratory can be reached at 517-335-8184. Once delivered to MDEQ lab, MDEQ assumes responsibility for the samples and is to follow all approved laboratory practices for sample handling.

During the first week of sampling, samples will be analyzed for the presence of *E. coli* colony forming units (CFUs) in the 10-1,000,000 CFU range using the NPEC_High test method by membrane filtration. Samples that have results from the first week of sampling above 7,500 CFU (25% of 10,000 CFU) will continue to be tested using the NPEC_High method for the remainder of the four week sampling event. Samples that have results below 7,500 CFU will be sampled using the NPEC_Low method for the remainder of the four week sampling event. In the event that sample results from the first week of sampling have not yet been reported by the laboratory before the second week of sampling, the NPEC_High method will be used again for the second week of sampling. In that case, the sampling methods for the third and final weeks of sampling will then be determined by the first and second weeks sampling results using 7,500 CFU as the level triggering the use of the NPEC_High method.

Depth of Water

Depth of water will be collected using a meter stick each week of sampling. Water depth will be measured in the center of the stream at each sampling site. The depth will be measured from the top of the sediment in the bottom of the stream to the water surface and recorded to the nearest centimeter on the field form. The stream flow (high, medium, low) will also be recorded using observations of the stream conditions and any signs of previous water lines for comparison. This measurement may also be taken from the bridge. To measure the depth to water from the bridge, the "tape-down" method will be followed. A measuring tape with a weight on the end will be lowered to the water. The measurement to the bottom of the stream will be measured in relation to a spot on the bridge. The measurement to the surface of the stream will also be measured in relation to the same spot on the bridge and the difference will be calculated and recorded as the depth of water.

Temperature

Temperature will be measured using a Cole Parmer Remote Probe Thermometer and recorded to the nearest tenth of a degree Celsius each week of sampling. Temperature will be measured from near the same location and depth in the stream as where the center *E. coli* sample was collected at each sampling site. The time and temperature will be recorded on the field form. This measurement may also be taken from the bridge. If the temperature is taken from the bridge, after *E. coli* samples have been taken, a rope and bucket will be used to collect water from the stream. The temperature of the water in the bucket will be taken immediately following collection and recorded as the stream temperature.

Any additional notable observations of the stream at each sampling site may also be recorded on the field form.

Quality Control Requirements

Measures will be taken to obtain data of an acceptable quality.

One field blank will be collected for every twenty *E. coli* samples collected or once per trip, whichever is more frequent. Field blanks will be standard *E. coli* sample bottles filled with sterilized water and labeled to indicate they are a field blank (United States Environmental Protection Agency Office of Water, 1997).

In addition, one field duplicate sample will be collected for every twenty *E. coli* samples, or one field duplicate per trip, whichever is more frequent. To fill duplicate samples, a second *E. coli* sample bottle will be filled at the same sample location and time as another *E. coli* sample. The sample will be labeled to indicate it is a duplicate (United States Environmental Protection Agency Office of Water, 1997). Results of field blank and field duplicates tests will be included with the rest of the sample data results.

A field duplicate measurement of temperature will also be collected for every twenty temperature readings, or once per trip, whichever is more frequent. To record a duplicate temperature field measurement, the temperature probe must be removed from the water and allowed to regulate its temperature between temperature readings.

Laboratory quality control measures for *E. coli* samples are detailed in SOP#603 in the appendix. Some of the laboratory quality control measures include method blank control, negative daily control, positive daily control, and initial demonstration of capability. In addition, ongoing precision and recovery measures are taken.

In addition, the person responsible for sampling and data management and/or the project team will:

- Document any changes to the proposed sample collection and analysis procedures;
- Ensure supplies are inspected prior to use;
- Verify the appropriate laboratory analytical procedures and quality control procedures were followed, and take corrective action if necessary; and
- Ensure all data are reviewed, recorded, and archived.

Data Analysis and Interpretation

E. coli sample data collected will be reviewed and compared against historical data, across sampling sites, and against the respective WQS. The daily maximum standards for Total Body Contact (TBC) and Partial Body Contact (PBC), 300 CFU/100mL and 1,000 CFU/100mL respectively, will be the WQS used in this data analysis. The geometric mean of each sampling site on each date will be calculated. Data trends, areas with frequent WQS exceedances, and areas of infrequent WQS exceedances will be of interest during the data interpretation.

The results will be interpreted by the internal project team in consultation with the MDEQ project contacts.

Geometric mean results calculated from the sampling data will be used to rank and prioritize the sites relative to each other and relative to existing data. Sites exceeding both the TBC and PBC standards will be the top priority and will warrant additional investigation and/or monitoring in the area at a later time.

Weather, temperature, and depth of water measurements will be used to help understand *E. coli* results based on known *E. coli* behaviors.

Instrument/Equipment Calibration, Testing, Inspection and Maintenance

Laboratory calibration standards for *E. coli* samples are detailed in SOP#603 in the appendix.

It is assumed that the laboratory meets testing, inspection, and maintenance requirements as it is an MDEQ laboratory.

Supplies Inspection

Samplers will verify laboratory bottles are properly sealed and include the appropriate preservative prior to use.

Data Acquisition Activities not covered by this QAPP

Historical and existing data have been and will be collected for use in the Watershed Management Planning process. Data will be collected from reputable and reliable sources.

GIS data is planned to be collected from TCRPC, Michigan Geographic Data Library (http://www.mcgi.state.mi.us/mgdl/), MDEQ, the National Hydrography Dataset, and the U.S. Department of Agriculture – Natural Resources Conservation Service.

E. coli, macroinvertebrate, dissolved oxygen, and other applicable chemical and biological sample data will be obtained from other studies and organizations where applicable data may be available. Organizations contributing to the data that will be used in this Watershed Management Planning Process include: MDEQ, Delhi Township, Ingham County Health Department, Eaton County Conservation District, Charter Township of Meridian (Lake Lansing Special Assessment Advisory), Ingham County Drain Commissioner, Livingston County Drain Commissioner, and Livingston County Health Department.

Ingham County Health Department and MDEQ data were used in the development of the TMDL by MDEQ so are assumed to be reliable sources of data. Eaton County Conservation District and Delhi Township have an MDEQ approved QAPP. Data collected through work done by the Ingham County Drain Commissioner, Livingston County Drain Commissioner, and Livingston County Health Department are assumed to be reliable as work was completed with guidance from MDEQ. MDEQ is reported to have participated in the project involving data collection for the Township of Meridian (Lake Lansing Special Assessment Advisory) so it is also assumed to be reliable (Progressive AE, 2002).

Data Validation and Reporting

Data Review, Validation, and Verification

The internal project team will review the data at the completion of the four week sampling process.

A review will be conducted to ensure the data collected is complete. Completed EQP 2300 forms and field forms will be reviewed to verify that they were thoroughly filled out. All data collected will be compared against that planned in this QAPP for completeness and methods. *E. coli* data will be reviewed for each set of laboratory results received for reasonableness.

Field blank sample laboratory results will be reviewed to ensure an unacceptable amount of bacteria counts were not recorded in the field blank indicating sampling or equipment errors. (United States Environmental Protection Agency Office of Water, 1997). Bacteria counts in field blanks should be less than or equal to 10 CFUs. An RPD calculation will also be done to verify the *E. coli* CFU amounts are within 25% of known standard amounts used in laboratory spiked samples.

Field duplicate temperature measurement results will be reviewed to ensure precision in field measurements. An RPD calculation will be done to verify this and 20% will be used as an acceptable range.

Field duplicate sample laboratory results will be reviewed to check sampling and laboratory analysis precision. Field duplicate samples should have *E. coli* counts comparable to the original sample *E. coli* counts taken at the same location and time per 100 mL (United States Environmental Protection Agency Office of Water, 1997). An RPD calculation will be done to verify this and 25% will be used as the acceptable range. If field duplicate samples are outside of the acceptable 25% RPD range, but still within the same regulatory category, both exceeding 1,000 CFU/100 mL or both between 300 CFU and 1,000 CFU/mL, the sample data will be considered valid and useful for the purpose of this watershed management planning process.

Any quality control data completed and provided in the results by the laboratory will be reviewed. In the event of a discrepancy, the laboratory or sampler will be contacted to clarify any observed errors. Additional data collection may be required to be collected to fill in any data gaps.

Reconciliation of Data with DQOs

Data deemed acceptable after the review, validation, and verification will be approved as having met the accuracy, precision, comparability, representativeness, and completeness DQOs of the sampling event covered under this QAPP. Data that does not meet these requirements will be discussed in the report developed upon completion of the sampling events.

Additional sampling locations and/or parameters will be considered for the 2013 sampling season in the report developed upon completion of the sampling events.

Data Management

Field forms and laboratory analysis result copies will be stored in a file folder at MSU-IWR. Data will be compiled into a spreadsheet using the United States Environmental Protection Agency STORET chemical data spreadsheet as a template (available from http://www.michigan.gov/deq/0,1607,7-135-3313_3682_3714-152031--,00.html, accessed July 25, 2012). Data will be backed up onto an external drive. Data will be stored as a complete set and will be in one location at the MSU-IWR, stored for five years minimum.

Data Reporting

Data results will be compiled by the internal project team. The results will be compiled into a report at the end of the four week sampling event and submitted to the MDEQ project manager and MDEQ Project Administrator with the project quarterly report.

References

Michigan Department of Environmental Quality Water Resources Division. (July 2012). *Total Maximum Daily Load for E. coli in portions of the Red Cedar River and Grand River Watersheds; including Sycamore, Sullivan, Squaw, and Doan Creeks: Ingham, Eaton, Clinton, Jackson, and Livingston Counties.*

Progressive AE. (March, 2002). *Management Plan for Lake Lansing and Its Watershed.*

United States Environmental Protection Agency Office of Water. (November, 2007). *Volunteer Stream Monitoring: A Methods Manual.* (EPA 841-B-97-003).

Appendix

Standard Operating Procedures

Michigan Department of Environmental Quality Drinking Water Laboratory EQP 2300

Michigan Department of Environmental Quality SOP #603 Escherichia Coli in Water by Membrane Filtration (NPEC)

Field Form

Red Cedar Monitoring Data

BILLING INFORMATION *PLEASE PRINT*

Name	DWL Account Number	
Mailing Address		
City	State	Zip
Check#, if applicable (pay to State of Michigan)	Amount enclosed	

DEQ DRINKING WATER LABORATORY - LANSING
DEPARTMENT OF ENVIRONMENTAL QUALITY

REQUEST FOR WATER ANALYSIS

- **FEE AMOUNTS ON THIS FORM ARE EFFECTIVE JAN. 1, 2010.** Fee amounts are subject to annual changes.
- Sample Collection Instructions are on the back of this form
- **PREPAYMENT OR *APPROVED* DWL CREDIT ACCOUNT NUMBER IS REQUIRED FOR TESTING.**

WSSN (Type I-II Public Water) or Pool Serial Number	Does sample contain chlorine? ☐ Yes ☐ No	**DO NOT SEND CASH!**

SAMPLE SOURCE - *Circle One*
0 - Single Family Dwelling
1 - TYPE I (community, apartment, subdivision, mobile home park, etc., with 25 or more residents year round)
2 - TYPE II (school, industry, restaurant, office, etc., serving 25 or more persons - 60 days or more per year)
3 - TYPE III (all other public supplies, duplex, small office, etc.)
7 - Surface Water (includes bathing beach and wastewater discharge)
8 - Swimming pool or Spa
9 - Other

SAMPLING PURPOSE - *Circle One*
0 - Routine Monitoring
1 - Real Estate Transaction
2 - Repeat Sample
3 - Repair/Construction/New Well
5 - Water Quality Problem
9 - Other

SAMPLE POINT - *Circle One*
1- Public System Well
2- Public System Surface Water
3- Untreated Public Distribution System
4- Treated Public Distribution System
5 - Untreated Private Well
6 - Treated/Softened Private Well
7 - Pressure Tank/Plant Tap
9 - Other

SENDER INFORMATION *PLEASE PRINT* **NOTE: RESULTS WILL BE AUTOMATICALLY COPIED TO LOCAL COUNTY HEALTH DEPARTMENT**

Name	E-mail address	
Mailing Address	Area Code & Phone number	
City	State	ZIP Code

SAMPLE COLLECTION INFORMATION *PLEASE PRINT*

Sample Collector Name	Date Collected	Time Collected	Circle One AM PM

☐ Do **NOT** analyze my sample(s) if received past the EPA specified hold time. (Hold times are indicated on the sample bottle.) **THE DATE AND TIME COLLECTED MUST BE FILLED OUT!**

☐ Analyze my sample(s) even if received beyond the EPA specified hold time.

NOTE: If a selection is not made, your sample(s) will be analyzed. Although samples analyzed beyond hold time typically cannot be used for compliance purposes, the results may still have informational value.

Collector Code *Circle One*: 0 - County Personnel 1- Water Supply Operator 2- DEQ DW staff 3- Private Citizen 4 - DEQ Staff other than DW 6- MDA Staff 9- Other		System/Owner Name	
Collection Site (Street Address)		Township (if known)	Section (if known)
City	County	ZIP Code	Well Number (if more than one)
Sampling Point (kitchen, bath, etc.)		Site Code or Permit Number (if known)	

TESTING REQUEST INFORMATION (REQUIRED)

TEST CODE	REQUIRED UNIT #	DRINKING WATER OR POOL/SPA TEST	FEE	☑
B	30	Water Coliforms (Bacteriology) *30 hour hold time*	$16.00	
R	32	Automated Partial Chemistry, *including Fluoride, Chloride, Hardness, Nitrate, Nitrite, Sulfate, Sodium and Iron*	$18.00	
CAS	36ME	Arsenic	$18.00	
CPB	36ME	Lead	$18.00	
CCUB	36CC	Lead/Copper for corrosion control	$26.00	
CXVO	36VO	Volatile Organic Compounds	$100.00	
TEST CODE	**REQUIRED UNIT #**	**SURFACE OR WASTEWATER TEST (Pond, Lake, Ditch, etc.)**	**FEE**	
NPEC-LO	30	E. coli (Counts 10 - 10,000) *delivery to lab-6 hours*	$15.00	
NPEC-HI	30	E. coli (Counts 10 - 1,000,000) *delivery to lab-6 hours*	$25.00	
NPFC-LO	30	Fecal Coliform (Counts 10 - 10,000) *delivery to lab-6 hours*	$15.00	
NPFC-HI	30	Fecal Coliform (Counts 10 - 1,000,000) *delivery to lab-6 hours*	$25.00	

INSTRUCTIONS:
- Check box next to Test Code(s) of desired analysis.
- Check the UNIT# on bottle to ensure you have the REQUIRED UNIT for desired analysis.
- For other types of testing, enter the TEST CODE, UNIT# (located on the sample bottle) and FEE in the area on the right side of this section.
- Refer to the full Testing Fee Schedule available from county health departments and DEQ Drinking Water Laboratory for other types of testing. **Fee amounts are subject to annual changes.**

TEST CODE	UNIT#	FEE
TOTAL OF ALL FEES »		

EQP 2300 (Front) 12/2011)

Submit White Copy With Sample - Keep Yellow Copy For Your Records

- A form is required for each sample site (Collection Site, Sampling Point, and Date/Time must be the same for all samples with this form).
- **Complete all parts of this form which apply.** Samples not properly identified or not having clear test requests MAY NOT be tested.
- Fill in your email address, if you would like a copy of the report emailed when completed.
- **For additional information contact your local county health department or the Drinking Water Laboratory, (517) 335-8184 or visit our web site: http://www.michigan.gov/deq**

Allow two weeks for results on most testing.

SAMPLE COLLECTION INSTRUCTIONS

UNIT#	INSTRUCTIONS
30	1. **This testing unit contains preservatives in the sample bottle.** Do not rinse the bottle with sample. Do not open the bottle until ready to collect the sample. Do not touch the inside of cap or bottle. 2. If not collecting sample from a tap (lake, pool, etc.), plunge bottle mouth down, move in continuous arc down and back up from water, discard top half-inch or to 100 ml line. 3. If using a sample tap, select a **clean** (disinfect as necessary) faucet and remove such attachments as aerators, dishwasher connectors, etc. Allow water to run for about ten minutes at full flow from the sampling tap. Reduce flow to avoid splashing, and collect the sample directly into the bottle. Do not use an intermediate container. Do not allow water from the outside surface of the faucet to drip into the bottle. **Fill bottle only to the bottom of neck, or to 100 ml line.** 4. Most bacteriological testing has a 30 hour EPA hold time. Samples must be received at the laboratory before the hold time expires. Surface water samples must be received at the laboratory within 6 hours of sampling.
32*, 33* 36AC 36CN, 36HA* 36HB, 36LP 36ME, 36PT	1. **Sample bottle may contain preservative** (refer to unit label on bottle). Do not rinse bottle with sample. Do not open the bottle until ready to collect the sample. Do not touch the inside of cap or bottle. 2. Select a clean faucet and remove such attachments as aerators, dishwasher connectors, etc. Allow water to run for about ten minutes at full flow from the sampling tap. Reduce flow to avoid splashing, and collect the sample directly into the bottle. Do not use an intermediate container. Do not allow water from the outside surface of the faucet to drip into the bottle. **Fill bottle to the bottom of neck.**
36TO* 36VO* 36VO-NP*	1. <u>The sample vials contain preservative</u>. **Tap each vial in upright position to drain preservatives from cap. Do not rinse vial before collection.** 2. Do not open the vial until ready to collect the sample. Do not touch the inside of cap or vial. Select a clean faucet without attachments or leaking stem. Allow water to run for ten minutes at full flow. 3. Reduce flow and collect the sample directly into all vials provided. a. **For 36TO,** fill vial until water rounds at the top of vial. b. **For 36VO,** fill vial HALFWAY. Add 2-3 drops of the provided acid from small dropper bottle. Completely fill vial until water rounds at the top of vial. 4. **Cap and invert to check for air in vial.** THE SEPTA (RUBBER PART INSIDE CAP RING) MUST BE SMOOTH SIDE DOWN IN CONTACT WITH SAMPLE TO AVOID POSSIBLE CONTAMINATION. 5. If air is observed in inverted sample, remove cap, add water **(DON'T DUMP SAMPLE)** and recap as instructed.
36CNa	1. **<u>Enclosed vial contains dilute preservative and caution should be exercised</u>. This testing unit also contains preservatives in the sample bottle. Tap unit in upright position to drain preservatives from cap. Do not rinse bottle before collection.** 2. Do not open the bottle until ready to collect the sample. Do not touch the inside of cap or bottle. 3. Do not rinse the bottle with sample. Select a clean faucet without attachments or leaking stem. Allow water to run for about ten minutes at full flow from the sampling tap. 4. Reduce flow to avoid splashing, and collect the sample directly into the bottle. Do not use an intermediate container. **Fill to 1" below top of bottle. Cap and invert 5 times to mix sample with preservatives. Carefully add all preservative in vial to sample bottle. Cap the sample and mix sample. Rinse vial and return.**
36CC	1. Do not open the bottle until ready to collect the sample. Do not touch the inside of cap or bottle. 2. Select a kitchen or bathroom sink or a faucet from which water is typically drawn for consumption. **Sampling point should not have been used for a minimum of six (6) hours prior to sampling.** Do not flush the sample tap before sample collection. 3. **Samples must be received in the laboratory within 14 days of collection.**

*** NOTE:** Some tests require thermal preservation. If you received your kit with an ice pack, please ensure that **<u>the ice pack</u>** is frozen prior to return shipment to the laboratory.

EFFECTIVE DATE: 05/2009 SOP# 603 REVISION # 5

ESCHERICHIA COLI IN WATER BY MEMBRANE FILTRATION (NPEC)

Table of Contents

1.0 Applicable Analytical Methods

1.1 *Escherichia Coli (E. coli)* in Water by Membrane Filtration Using membrane-Thermotolerant *Escherichia coli* Agar (mTEC), U.S. Environmental Protection Agency, Method 1103.1, 2002.

1.2 *Escherichia Coli (E. coli)* in Water by Membrane Filtration Using membrane-Thermotolerant *Escherichia coli* Agar (mTEC), U.S. Environmental Protection Agency, Method 1103.1, 2005.

2.0 Matrix or Matrices

2.1 Recreational waters.

2.2 Surface waters.

2.3 Source-water or Ground water under the direct influence of Surface waters.

3.0 Method Detection Limits

3.1 Not applicable to this method.

4.0 Scope and Application

4.1 This method describes a membrane filter (MF) procedure for the detection and enumeration of *Escherichia coli* in ambient water. Because the bacteria, is a natural inhabitant only of the intestinal tract of warm-blooded animals, its presence in water samples is an indication of fecal pollution and the possible presence of enteric pathogens.

4.2 The *E. coli* test is used as a measure of ambient recreational water quality. Epidemiological studies have led to the development of criteria which can be used to promulgate recreational water standards based on established relationships between health effects and water quality. The significance of finding *E. coli* in recreational water samples is the direct relationship between the density of *E. coli* and the risk of gastrointestinal illness associated with swimming in the water.

4.3 Since a wide range of sample volumes or dilutions can be analyzed by the MF technique, a wide range of *E. coli* levels in water can be detected and enumerated.

5.0 Method Summary

5.1 The MF method provides a direct count of bacteria in water based on the development of colonies on the surface of the membrane filter. A water sample is filtered through the membrane which retains the bacteria. After filtration, the membrane containing the bacterial cells is placed on a selective and differential medium, m-TEC, incubated at 35 ± 0.5°C for 2 hours +/-.5 hours to resuscitate injured or stressed bacteria, and then incubated in a water bath at 44.5 ± 0.2°C for 22 ± 2 hours. Following incubation, the filter is transferred to a filter pad saturated with urea substrate. After 15 minutes, yellow, yellow-green, or yellow-brown colonies are counted using a magnifying colony counter, if necessary.

6.0 Definitions

6.1 *E. coli* – Those bacteria which produce yellow, yellow-green, or yellow-brown colonies on a filter pad saturated with urea substrate broth after primary culturing on m-TEC medium.

6.2 Colony forming units (CFU) – May consist of single cells or multiple cells in clumps or chains that form single colonies.

7.0 Interferences

7.1 Water samples containing colloidal or suspended particulate material can clog the membrane filter and prevent filtration, or cause spreading of bacterial colonies which could interfere with identification and enumeration of target colonies.

8.0 **Safety**

8.1 Eye protection is required in all designated laboratory areas.

8.2 Laboratory coats are required for all bacteriological testing. Additional Personal Protective Equipment, (PPE), requirements can be found in the Hazard Risk Assessment completed on this work area.

8.3 Be familiar with the laboratory chemical hygiene plan.

8.4 Be familiar with the laboratory safety policy (internal SOP 100)

8.5 Exercise caution when operating the autoclave and the Meker burner.

8.6 Mouth-pipetting is prohibited.

8.7 Observe the normal safety procedures required in a microbiology laboratory while preparing, using, and disposing of cultures, reagents, and materials including disinfecting analytical surfaces and frequent hand washing before performing analysis and when leaving the work area.

9.0 **Equipment and Supplies**

9.1 Micropipetter - to deliver 10 µL volume

9.2 Magnifying Colony Counter

9.3 Hand tally or electronic counting device

9.4 Microscope 1X-2X dissecting

9.5 Pipettes – Disposable, Sterile, Serological TD 10 mL glass and 1mL plastic 2.5% tolerance

9.6 Membrane filter apparatus for 47 mm filters.

9.7 Vacuum system

9.8 Petri dishes, sterile, plastic, 9 x 50 mm with tight fitting lids.

9.9 47 mm Membrane Filters (approved Gelman GN-6 or Millipore HC).

9.10 Absorbent pads, sterile, 47 mm diameter.

9.11 Incubator capable of maintaining constant temperatures of 35.0 ± 0.5°C.

9.12 Waterbath incubator capable of maintaining constant temperatures of 44.5 ± 0.2°C.

9.13 500 mL autoclavable bottles with caps.

9.14 MIELE Dishwasher-using wash cycle "C". (DEQ Method 917 sec 7.1.1-7.1.5)

9.15 PVC conduit tubes with stoppers – for containment of samples in water bath.

9.16 Glassware – graduated cylinders and volumetric flasks.

9.17 Autoclave – To maintain a temperature of 121°C under 15 psi of pressure for required treatment time.

9.18 Packaging paper, gauze. Integrated Sterilization Indicators, external auto clave thermometers.

10.0 Reagents and Standards

10.1 All reagents, solvents, and standards must be Reagent Grade and traceable to the stock inventory tracking log.

10.2 All reagents, solvents, and standards must be labeled with: date received, date opened, expiration date, tracking number, and receiver's initials.

10.3 All prepared reagents and standards must be labeled with: date prepared, expiration date, preparer's initials, and tracking number.

10.4 All standard logbooks must be completely filled out.

10.5 All certificates of analysis must include the stock inventory tracking number that was assigned to the standard.

10.6 Reagent water – Conforming to specifications in: Standard Methods for the Examination of Water and Wastewater (latest edition approved by EPA in 40 CFR Part 136 or 141, as applicable), Section 9020 (Reference 21.3).

10.7 Reverse Osmosis (RO) water - Sterile, endotoxin free water is prepared by autoclaving in 500 ml bottles for 35 minutes at 121°C and 15 psi. Sterility checks are performed using commercially purchased 2X Tryptic Soy Broth (TSB). Batches are checked for sterility by combining 50 ml of RO water with 50 ml of 2X TSB and incubating at 35± 0.5°C for 48 hours. If no growth is observed, the batch of RO water is labeled for use with a BW tracking number, and an expiration date of 6 months from date of production. Quality Control paperwork must be filled out and kept as a record for 7 years.

10.8 Tryptic Soy Broth (TSB) - Commercially purchased, sterile single strength at 5 mL volume in tubes and double strength at 50 mL volume in jars. Confirm broth for sterility by placing media in incubator at 35 ± 0.5°C for 48 hours and observing for signs of growth. Broth is confirmed for support of growth by inoculating media with *E.*

coli (ATCC 25922) and observing for growth after 24 hours. pH verified upon receipt should be 7.3 ± 0.2. Product shelf life is as defined by vendor.

10.9 Sodium Hydroxide reagent grade (NaOH), 1 N – Dissolve 40 g of NaOH pellets in reagent water. Dilute to 1 L with reagent water. Label for use with BW tracking number.

10.10 Stock Phosphate Buffer Solution (PBS) – Dissolve 34.0 g potassium dihydrogen phosphate reagent grade in 500 mL of reagent water, adjust to pH 7.2 ± 0.5 with 1 N NaOH, and dilute to 1 L with reagent water. Sterilize by autoclaving at 121°C (15psi) for 30 minutes. Solution is confirmed for sterility by inoculating 50 mL of 2X TSB with 50 mL of solution, incubating at 35.0°C ± 0.5 for 48 hours and observing for growth. Label for use with a BW tracking number. Solution is stored in the refrigerator until used. Discard the solution if signs of mold or turbidity are observed.

10.11 Magnesium Chloride Solution – Dissolve 81.1 g magnesium chloride, reagent grade ($MgCl_2 \cdot 6H_2O$) in 1 L of reagent water. Sterilize by autoclaving at 121°C (15psi) for 30 minutes. Solution is confirmed for sterility by inoculating 50 mL of 2X TSB with 50 mL of solution, incubating at 35.0 ± 0.5°C for 48 hours and observing for growth. Label for use with a BW tracking number. Solution is stored in a refrigerator until used. Discard the solution if signs of mold or turbidity are observed.

10.12 Buffered Rinse Water – Add 1.25 mL stock phosphate buffer solution and 5.0 mL magnesium chloride solution to 1 L of reagent water. Dispense into containers for use as rinse water. Check for a pH of 7.0+/- 0.2 and record. Sterilize by autoclaving at 121°C, 15 psi for 30 minutes. Batches are checked for sterility by combining 50 mL of buffered rinse water with 50 mL of 2X TSB and incubating at 35.0 ± 0.5°C for 48 hours. If no growth is observed, the batch of rinse water is labeled for use with a BW tracking number Buffered water is stored at room temperature with a shelf life of 6 months.

10.13 Dilution Water Blanks, commercially purchased - Store at room temperature. Dilution water blanks are confirmed for sterility by inoculating 50 mL of 2X TSB with 50 mL Dilution Water Blanks, incubating for 48 hours and observing for growth. pH is recorded upon receipt and should be 7.0 ± 0.2.

10.14 m-TEC agar - Commercially purchased and pre-plated. Plates are stored in a refrigerator until expiration date as defined by the product vendor. pH is verified upon receipt and should be 7.3+/- 0.2. QC requirements for each batch are detailed in Section 12.7

10.15 Urea Substrate medium – Add 10.0 g urea and 0.05 g phenol red to 500 mL reagent water. Stir to dissolve and adjust to pH 3-4 with a few drops of 1N HCl. The substrate solution should be a straw yellow color at this pH and should be stored at 6-8°C for no more than a week.

10.16 Spore Strips - Geobacillus stearothermophilus stored away from light at room temperature. Product shelf life is as defined by vendor.

10.17 Modified TSB - For use with Spore Strips stored away from light at room temperature. Product shelf life is as defined by vendor.

10.18 Control Cultures - The Michigan Department of Community Health (MDCH), Bureau of Laboratory Services, provides the MDEQ, Laboratory Services Section, with some bacteria strains. The laboratory also uses commercially purchased bacterial strains.

10.18.1 Positive Control –
Stock culture of *E-coli* ATCC #25922
E.-coli ATCC #11775 BioBalls (BTF Pty, Sydney, Australia)

10.18.2 Negative Control –
Stock culture of *E. Aerogenes* ATCC #13048
E. Aerogenes ATCC #13048 BioBalls (BTF Pty, Sydney, Australia)
E. faecalis ATCC #19433

11.0 Sample Collection, Preservation, Shipment, and Storage

11.1 Sample containers must be sterile and have a volume of at least 120 mL (Michigan Department of Environmental Quality [MDEQ] Unit 30). They must contain a sufficient amount of sodium thiosulfate to neutralize any disinfectant in the water samples. This is not required if the water is known to be free of disinfectant.

11.2 Ice or refrigerate water samples at < 10°C during transit to the laboratory. Do not freeze samples.

11.3 Sample holding time is 8 hours. Six hours are allowed between collection and initiation of analysis and 2 hours are permitted to set up samples in the laboratory.

12.0 Quality Control (QC)

12.1 Method Blank Control - At the beginning of each analytical batch, filter 50 mL sterile buffered rinse water through a filter and incubate as indicated in Section 14. Data may be rejected if the control is contaminated. The analyst will consult with the Unit Manager to determine if the data are acceptable.

12.2 Prepare the working standard for the negative controls, (*E. aerogenes* ATCC 13048 and E. faecalis 19433) by inoculating one each a tube containing sterile single-strength TSB with culture from the Petri dish containing stock *E. aerogenes and E. faecalis.* The bacteria on the Petri dish may be stressed from refrigeration and the inoculated TSB culture tube should be incubated at 35.0 +/- 0.5 degrees for 2 hours prior to use. Inoculation is performed by transferring a small amount of culture using a sterile loop to the broth and gently swirling it under the liquid media surface.

12.3 Negative Daily Control- (*E. aerogenes* ATCC 13048 and E. faecalis 19433) - At the beginning of each day's analysis, filter a suspension of *E. aerogenes* and E. faecalis and analyze as described in section 14. Suspension will be made by inoculating 2 sterile sample bottles containing 100 mL of sterile R.O. water from negative control working standards, one with 10 uL of viable E-aerogenes and one with10 uL of E. faecalis. Viability of E. aerogenes and E. faecalis will be determined by growth of organism on pre-inoculated non-specific plated media as provided by Michigan Department of Community Health. If the negative control fails to exhibit the appropriate response, reanalyze and/or replace associated media or reagents.

12.4 Prepare the working standard for the positive control, (E. Coli ATCC 29522) by inoculating a tube containing sterile single-strength TSB with culture from the Petri dish containing stock *E-coli.* The bacteria on the Petri dish may be stressed from refrigeration and the inoculated TSB culture tube should be incubated at 35.0 +/- 0.5 degrees for 2 hours prior to use. Inoculation is performed by transferring a small amount of culture using a sterile loop to the broth and gently swirling it under the liquid media surface.

12.5 Positive Daily Control- (*E. coli* ATCC 25922) - At the beginning of each day's analysis, filter a suspension *E. coli* and analyze as is described in section **14**. Suspension will be made by inoculating a sterile sample bottle containing 100mL of sterile R.O. with 10 uL of working standard of E-Coli. Viability of organism will be determined by growth of the organism on pre-inoculated non-specific plated media as provided by Michigan Department of Community Health. If the positive control fails to exhibit the appropriate response, reanalyze and/or replace associated media or reagents.

12.6 Initial Demonstration of Capability (IDOC) - Method performance (initial precision and recovery [IPR]) by each laboratory before the method is used for monitoring field samples. EPA recommends but does not require that IDOC analyses be performed by each analyst. IDOC samples should be accompanied by an acceptable method blank (Section 12.1). The IDOC analyses are performed as follows:

12.6.1 Using four commercially purchased dilution blanks inoculate each from a certified concentration of *E.coli* ATCC #11775. Filter and process each IDOC sample according to the procedures in Section 14 and calculate the number of *E. coli* per 100 mL according to Section 15.

12.6.2 Enter colony count data into the laboratory IDOC template. The template will calculate the percent recoveries of the four analyses, the mean percent recovery and the relative standard deviation (RSD) of the recoveries.

12.6.3 Compare the mean recovery and RSD with the corresponding IPR criteria in Table 1, below. If the mean and RSD for recovery of *E. coli* meet acceptance criteria, system performance is acceptable and analysis of field samples may begin. If the mean or the RSD fall outside of the required range for recovery, system performance is unacceptable. In this event, identify the problem by evaluating each step of the analytical process, media, reagents, and controls, correct the problem and repeat IDOC analyses.

Ongoing precision and recovery (OPR) - To demonstrate ongoing control of the analytical system, the lab will periodically analyze dilution blanks spiked with BioBalls containing E. coli ATCC #11775 per section 14. These will be performed as part of the QC necessary for all new lots of plated media and will include the appropriate method blanks, negative controls and sterility checks. Record results in Excel spreadsheet.

Table 1. Initial Precision and Recovery (IPR and OPR) Acceptance Criteria

Performance test	Lab-prepared spike acceptance criteria	BioBall™ spike acceptance criteria

Initial precision and recovery (IPR) • Mean percent recovery • Precision (as maximum relative standard deviation)	76% - 124% 41%	68% - 96% 25%
Ongoing precision and recovery (OPR) as percent recovery	54% - 146%	58% - 106%

12.7 QC sample – QC controls from an outside source are analyzed monthly.

12.7.1 Where more than one analyst is interpreting cultures in a laboratory, the culture count comparison for all analysts must be organized and evaluated by the Unit Manager for each change in personnel or testing procedures. Analysts must be able to duplicate the counts of other analysts within ± 10%. Document results in Excel spreadsheet.

12.7.2 Analysts must be able to duplicate their own counts on the same sample plate within ± 5%. Document results in Excel spreadsheet.

12.7.3 Proficiency testing – A proficiency sample is analyzed on an annual basis.

12.8 Initial Filter Sterility Check- For each new lot of filters, place 1 filter in 50 ml of 2X TSB using sterile forceps and incubate for 48 hours at 35.0 +/- .5 C. Observe for signs of growth. Lot will be designated sterile if there is no growth after 48 hours. Record results on the filter sterility quality control sheet.

12.9 Media QC Check

12.9.1 A QC check must be performed on each new batch of media using a media sterility check and, as required, *E. coli* bacteria , *E. aerogenes and E. faecalis.*

12.9.1.1 The laboratory will test media sterility by incubating one unit (tube or plate) for each new batch of medium (TSB 1X and 2X, m-TEC) as appropriate and observing for growth. Absence of growth indicates media sterility.

12.9.1.2 For each new batch of plated media, a positive control and negative controls will be performed. The positive control will be made by inoculating a sterile dilution blank with BioBall E-Coli ATCC# 11775. Filter the entire dilution blank and analyze as described in Section 14. The negative controls will be made by inoculating 2 bottles containing 100 mL of sterile RO water with 10 uL of working standards of E. aerogenes ATCC#13048 and E. faecalis ATCC# 19433 respectively. Filter 10 mL of each on separate filters and analyze as described in Section 14. Record results. If media fails to exhibit appropriate responses as expected, reanalyze or replace media as necessary.

12.10 Bottle Check - for each lot of sample bottles.

12.10.1 QC checks must be performed by inoculating 3 separate units containing sterile water with one each of MUG-positive *E. coli* strain, a MUG-negative coliform and a non-coliform bacteria, and analyzing each QC check as described in Section 14 of SOP 602.

12.10.2 Bottles are checked for sterility by adding 25 mL of sterile 2X TSB and incubating bottle at 35.0± 0.5C for 48 hours.

12.10.3 The accuracy of the 100 mL mark of each lot of sample bottles must be checked by weighing an empty bottle, adding water to the 100 mL mark, and reweighing the bottle. The weight should equal 100 g ± 2.5 g (1 mL = 1 g) after subtracting the weight of the empty bottle.

13.0 Calibration and Standardization

13.1 Twice daily, check the temperature of the incubators and water bath at a minimum of four hours apart to insure that they are operating within stated limits. If temperatures are outside limits, take corrective action. The temperatures are recorded on the preventative maintenance (PM) sheet provided.

13.2 The temperature of refrigerators shall be checked and recorded daily to insure operation within stated limits. The temperatures are recorded on the PM sheet provided.

13.3 Thermometers shall be recalibrated at least annually with a NIST certified thermometer or replaced annually with a NIST traceable thermometer.

14.0 Procedure

14.1 Place a sterile membrane filter on the filter base, grid side up, and attach the funnel to the base so that the membrane filter is held between the funnel and the base.

14.2 For samples submitted for surface water testing, shake the sample bottle vigorously at least 25 times to distribute the bacteria uniformly. Sample dilutions will be based on the analysis requested by the submitter. Those samples having a test code of NPEC-Lo will be analyzed with two dilutions, (10 ml and 1 ml). Those samples having a test code of NPEC-Hi will be analyzed using 4 dilutions, (10 ml, 1ml, -1, and -2). See Attachment 22.1 for dilution procedures.

NOTE: When analyzing smaller sample volumes (e.g., < 10 mL), 20-30 mL of PBS or phosphate-buffered dilution water should be added to the funnel or an aliquot of sample should be dispensed into a dilution blank prior to filtration. This will allow even distribution of the sample on the membrane.

14.3 Filter the sample, rinsing the sides of the funnel at least twice with 20–30 mL of sterile buffered rinse water. Turn off the vacuum and remove the funnel from the filter base.

14.4 Use sterile forceps to aseptically remove the membrane filter from the filter base and roll it onto the m-TEC Agar to avoid the formation of bubbles between the membrane and the agar surface. Reseat the membrane if bubbles occur. Run the forceps around the edge of the filter to be sure that the filter is properly seated on the agar. Close the dish, invert and incubate at 35.0 ± 0.5°C for 2 ± .5 hours in the walk in incubator.

14.5 To reuse the filtration apparatus for another sample, aseptically transfer a sterile filter to the base, hold funnel over a flame for 2-5 seconds, and reassemble funnel in place over filter.

14.6 After the 2 hour incubation, transfer the plates to water tight tubes and place in the water bath incubator at 44.5 ± 0.2°C for 22 ± 2 hours.

14.7 At the end of the incubation time, remove the plates from the water bath. Place an absorbent pad in the lid of the Petri dish and saturate the pad with Urea Substrate Medium. Aseptically transfer the membrane from the m-TEC Agar to the absorbent pad and allow to incubate at room temperature for 15-20 minutes.

14.8 After incubation on the urea substrate, count and record the number of yellow, yellow-green, or yellow-brown colonies on the membrane filters. Select plates/dilutions for each sample that contains a colony count of less than or equal to 100 CFU. If for a given test request, (Hi or Lo), the greatest dilution yields a plate with greater than 100 colonies, than the result reported will be >1,000,000 CFU for the "Hi" test and >10,000 CFU for the "Lo" test. Because the initial dilution for all samples is at 10 mL, those samples containing no method appropriate colonies on the plate after incubation will be reported as "<10 CFU/100 mL."

15.0 Calculations

15.1 Select a membrane filter with an acceptable number of colonies and calculate the number of *E. coli* per 100 mL according to the following general formula.

$$E.\ coli \text{ per } 100 \text{ mL} = \frac{\text{Number of } E.\ coli \text{ colonies}}{\text{Volume of sample filtered (mL)}} \times 100$$

	Volume filtered (mL)	# of colonies	Multiplier	= CFU
	10	20	10	200
	1	20	100	2,000
Dilution: 1 mL to 99 mL:	10 (-1)	20	1000	20,000
Dilution: 1 mL to 99 mL:	1 (-2)	20	10000	200,000

(See Attachment 22.1)

16.0 Method Performance

16.1 All growth and recovery media must be checked to assure that the target organisms respond in an acceptable and predictable manner.

16.2 Specificity - The specificity characteristic of a method is usually reported as the percent of false positive and false negative results. The false positive rate reported for mTEC medium averaged 9% for marine and fresh water samples. Less than 1% of the *E. coli* colonies observed gave a false negative reaction. (Section 21.6)

16.3 Upper Counting Limit (UCL) – That colony count above which there is an unacceptable counting error. The error may be due to overcrowding or antibiosis. The UCL for *E. coli* on m-TEC media has been demonstrated by intra-laboratory testing and analyst comparisons to be 100 colonies per filter.

17.0 Pollution Prevention

17.1 Positive samples must be autoclaved for 15 minutes at 121°C, 15 psi, before disposal. The proper performance of the autoclaves are confirmed weekly using the Spore Strip kit and are monitored with each sterilization batch using sterilization integrated indicator strips and independent autoclave thermometers.

17.2 Solutions and reagents should be prepared in volumes consistent with laboratory use to minimize the volume of expired materials to be disposed.

18.0 Data Assessment

18.1 The data must be qualified for data not analyzed within the sample hold time limits.

18.2 Data may be qualified based on analytical results.

18.3 Samples may be qualified by the analyst.

19.0 Corrective Actions

19.1 Data may be rejected if the negative control sample for a sample series tests positive.

19.2 Data may be rejected if the positive control for a sample series is negative or does not yield results as expected.

19.3 Data may be rejected if the incubator or water bath goes outside the stated limits or if the incubation time is incorrect. The analyst will consult with the Unit Manager to determine if the data is acceptable.

20.0 Waste Management

20.1 It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the biohazard and hazardous waste identification rules and land disposal restrictions. It is also the laboratory's responsibility to protect the air, water and land by minimizing and controlling all releases from bench operations. Compliance with all sewage discharge permits and regulations is also required.

20.2 For further information on waste management, consult "The Waste Management Manual for Laboratory Personnel" and "Less is better: Laboratory Chemical Management for Waste Reduction."

21.0 References

21.1 <u>*Escherichia Coli (E. coli)* in Water by Membrane Filtration Using membrane-Thermotolerant *Escherichia coli* Agar (mTEC)</u>, U.S. Environmental Protection Agency, Method 1103.1, 2002.

21.2 <u>*Escherichia Coli* in Water by the Membrane Filter Procedure</u>, U.S. Environmental Protection Agency, Method 1103.1, 1985.

21.3 APHA, 1998. *Standard Methods for the Examination of Water and Wastewater*, 20th Edition. American Public Health Association, Washington D.C.

21.4 Bordner, R., J. A. Winter and P. V. Scarpino (eds.), Microbiological Methods for Monitoring the Environment, Water and Waste, EPA-600/8-78-017. Office of Research and Development, USEPA.

21.5 Test methods for *Escherichia coli* and enterococci in water by the membrane filter procedure, 1985. EPA-600/4-85/076. Environmental Monitoring and Support Laboratory, Cincinnati, USEPA.

21.6 USEPA, 2004. *Results of the interlaboratory Validation of EPA Method 1603 (modified mTEC) for E. coli in Wastewater Effluent.* EPA-821-R-04-020. December 2004.

22.0 Attachment

22.1 Illustration – "Sample Volumes for Filtration and Dilution Preparation."

Signature Page

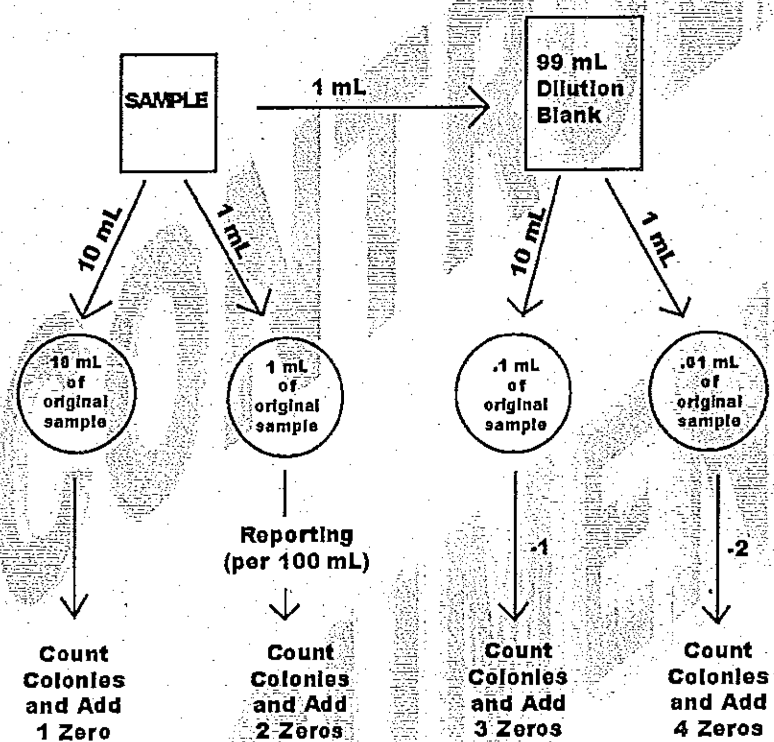
APPROVED BY ____________________ DATE 5/7/09
CHIEF, LABORATORY SERVICES SECTION

APPROVED BY ____________________ DATE 5/8/09
COMPLIANCE OFFICER

APPROVED BY Julie E. Pieper DATE 5/7/09
UNIT MANAGER

APPROVED BY ____________________ DATE 5/7/09
ANALYST

SAMPLE VOLUMES FOR FILTRATION AND DILUTION PREPARATION



RED CEDAR RIVER MONITORING DATA SHEET

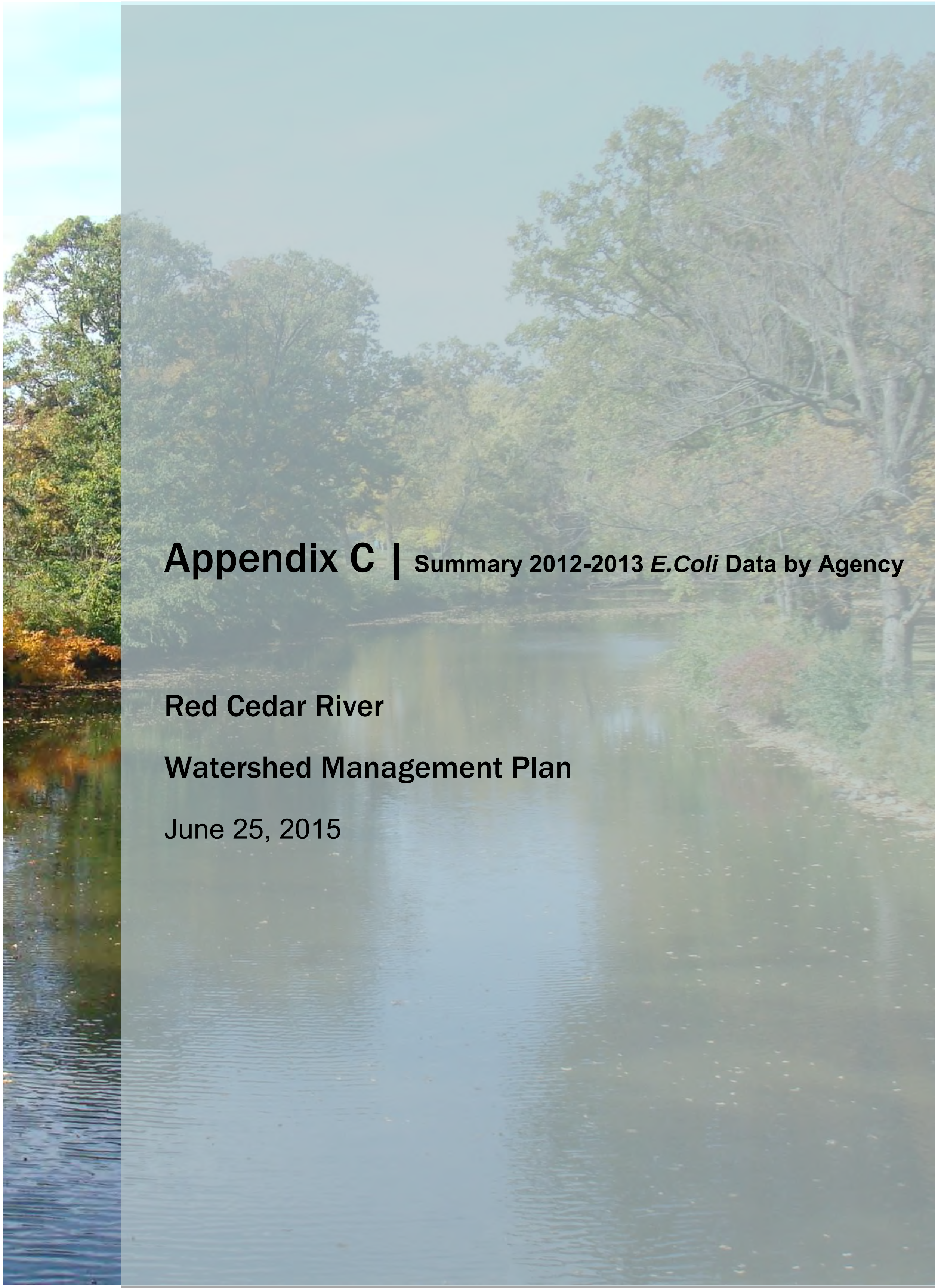
Date :_______/_______/________
Monitor's Name: ____

Past 48 Hour Rain Fall Amount: ______ inches

Current Weather:
☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (Steady) ☐ Storm

Worst Weather in Past 48 hrs.:
☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (Steady) ☐ Storm

Site ID	GPS Coordinates	Location/Nearest Intersection	Stream Flow (High, Medium, Low)	Temperature (0.0°C)	Time	Channel Depth (cm)	Observations
MSU-							
MSU-							
MSU-							
MSU-							
MSU-							
MSU-							
MSU-							
MSU-							
MSU-							
MSU-							
MSU-							
MSU-							
MSU-							
MSU-							



Appendix C | Summary 2012-2013 *E.Coli* Data by Agency

Red Cedar River

Watershed Management Plan

June 25, 2015

Conservation District

Conservation District 2013	# times sampled	Dates	Avg. Geomean	# over TBC	% over TBC	# over PBC	% over PBC	Counts > 10,000
Doan Creek @ Meech Rd	10	June-August 2013	1,315	10	100%	7	70%	
Deer Creek @ Howell Rd	10		1,474	10	100%	6	60%	
Mud Creek @ Hagadorn Rd/Lamb Rd	10		734	9	90%	2	20%	1
Mud Creek @ Dexter Tr	10		1,012	9	90%	6	60%	
Unnamed Trib @ Sherwood Rd near Harris Rd (Squaw Creek)	10		1,115	9	90%	4	40%	1
Unnamed Trib @ Sherwood Rd near Shaftsburg Rd (Squaw Creek	10		1,676	10	100%	9	90%	
Coon Creek near Sherwood Rd/Beeman Rd	10		1,781	10	100%	7	70%	
Unnamed Trib @ Sherwood Rd near Meridian Rd (Coon Creek)	10		1,158	9	90%	5	50%	1
Reeves Drain @ Noble Rd (Sloan Creek)	10		2,938	10	100%	10	100%	2
Cole Drain @ Noble Rd (Sloan Creek)	10		2,172	10	100%	8	80%	2

MSU Data

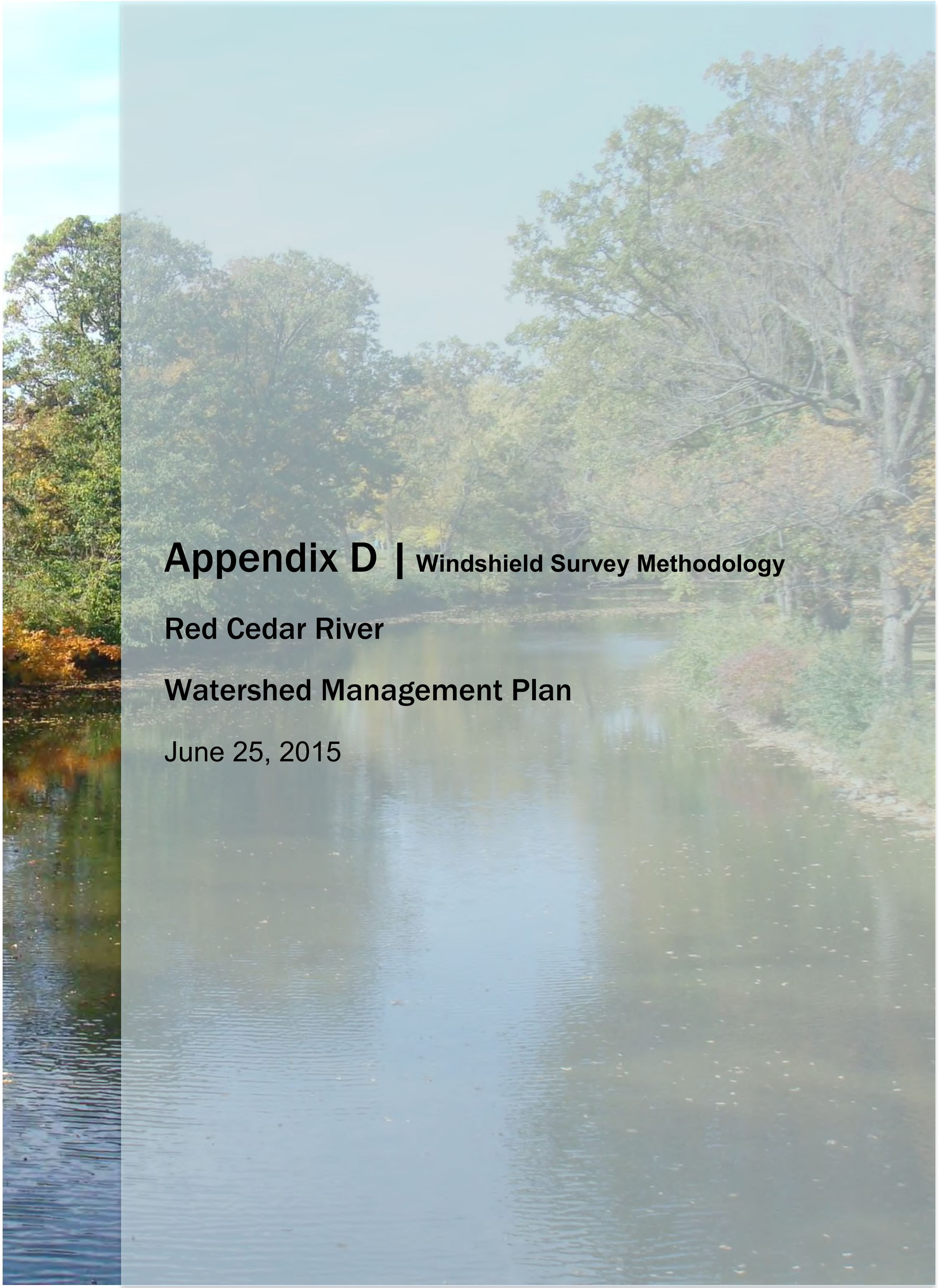
MSU Data- 4 Weeks - 2012	**# times sampled**	**8/29-9/20**	**Avg. Geomean**	**# over TBC**	**% over TBC**	**# over PBC**	**% over PBC**	**Counts > 10,000**
Coon Creek (MSU-9)	4		**408**	2	50%	1	25%	
Dietz Creek (MSU-7)	4		**1,206**	4	100%	2	50%	
Doan Creek (MSU-8)	4		**640**	4	100%	0	0%	
Handy Drain No. 5 (MSU-3)	4		221	1	25%	0	0%	
Handy Howell Drain (MSU-1)	4		**1,085**	4	100%	3	75%	
Headwaters Sycamore Creek (MSU-11)	4		**749**	4	100%	1	25%	
Headwaters Sycamore Creek (MSU-12)	4		214	1	25%	0	0%	
Headwaters Sycamore Creek (Msu-13)	4		**782**	4	100%	1	25%	
Kalamink Creek (MSU-5)	4		**406**	3	75%	0	0%	
Sloan Creek (MSU-10)	4		**1,044**	4	100%	2	50%	
Middle Branch (MSU-2)	4		**968**	4	100%	2	50%	
West Branch (MSU-4)	4		**823**	4	100%	3	75%	
Wolf Creek (MSU-6)	4		**8,539**	4	100%	4	100%	1

MSU Data - 2013 (not included in data summary – one time sampling event)	1-Jul-13
	Geomeans
Handy Howell Drain	316
Wolf Creek	441
Dietz Creek	417
Doan Creek	791
Sloan Creek	266
Headwaters Sycamore Creek	462
Headwaters Sycamore Creek	434
Headwaters Sycamore Creek	739
Mud Creek	522
Coon Creek	343
Coon Creek	818
Wolf Creek	782
Wolf Creek	1,160
Handy Howell Drain	170

Ingham County Health Department Data

Subwatershed	Sample Event Geomean 2013	# TBC Exceedances	% Exceedance	# PBC Exceedances	% Exceedance
ICHD Data					
Coon Creek (S-GR)	216	6 of 22	27%	1 of 22	5%
Coon Creek (S-WIL-B)					
Headwaters Sycamore Creek (S-MA-A)	694	19 of 22	86%	6 of 22	27%
Headwaters Sycamore Creek (S-MA-B)	942	22 of 22	100%	9 of 22	41%
Red Cedar River (S-1)	430	11 of 21	52%	5 of 21	24%
Red Cedar River (S-NK)	282	11 of 22	50%	2 of 22	9%
Red Cedar River (S-HD)	225	7 of 22	32%	0 of 22	0%
Red Cedar River (S-FL)	194	3 of 22	14%	3 of 22	14%
Red Cedar River (S-HR)	210	5 of 22	23%	3 of 22	14%
Red Cedar River (S-KZ)	226	7 of 22	32%	2 of 22	9%
Red Cedar River (S-11)	307	8 of 22	36%	3 of 22	14%
Coon Creek (S-WIL-A)					
Squaw Creek (S-WEB-B)					
Sycamore Creek (S-MH)	393	14 of 22	64%	5 of 22	23%
Wolf Creek (S-WEB-A)	285	9 of 22	41%	1 of 22	5%

Subwatershed	Sample Event Geomean 2012	# TBC Exceedances	% TBC Exceedance	# PBC Exceedances	% PBC Exceedances
ICHD Data					
Coon Creek (S-GR)	277	8 of 20	40%	1 of 20	5%
Coon Creek (S-WIL-B)	280	9 of 20	45%	1 of 20	5%
Headwaters Sycamore Creek (S-MA-A)	745	18 of 20	90%	7 of 20	35%
Headwaters Sycamore Creek (S-MA-B)	660	17 of 20	85%	5 of 20	25%
Red Cedar River (S-1)	320	9 of 20	45%	2 of 20	10%
Red Cedar River (S-NK)	321	11 of 20	55%	2 of 20	10%
Red Cedar River (S-HD)	158	1 of 20	5%	0 of 20	0%
Red Cedar River (S-FL)	120	2 of 19	11%	1 of 19	5%
Red Cedar River (S-HR)	131	1 of 20	5%	1 of 20	5%
Red Cedar River (S-KZ)	140	1 of 20	5%	1 of 20	5%
Red Cedar River (S-11)	80	1 of 20	5%	0 of 20	0%
Coon Creek (S-WIL-A)	**314**	12 of 20	60%	3 of 20	15%
Squaw Creek (S-WEB-B)					
Sycamore Creek (S-MH)	**327**	7 of 20	35%	2 of 20	10%
Wolf Creek (S-WEB-A)	**398**	14 of 20	70%	1 of 20	5%



Appendix D | Windshield Survey Methodology

Red Cedar River

Watershed Management Plan

June 25, 2015

WINDSHIELD AND WALKING ASSESSMENT DESCRIPTIONS

Step 1. Windshield Assessment

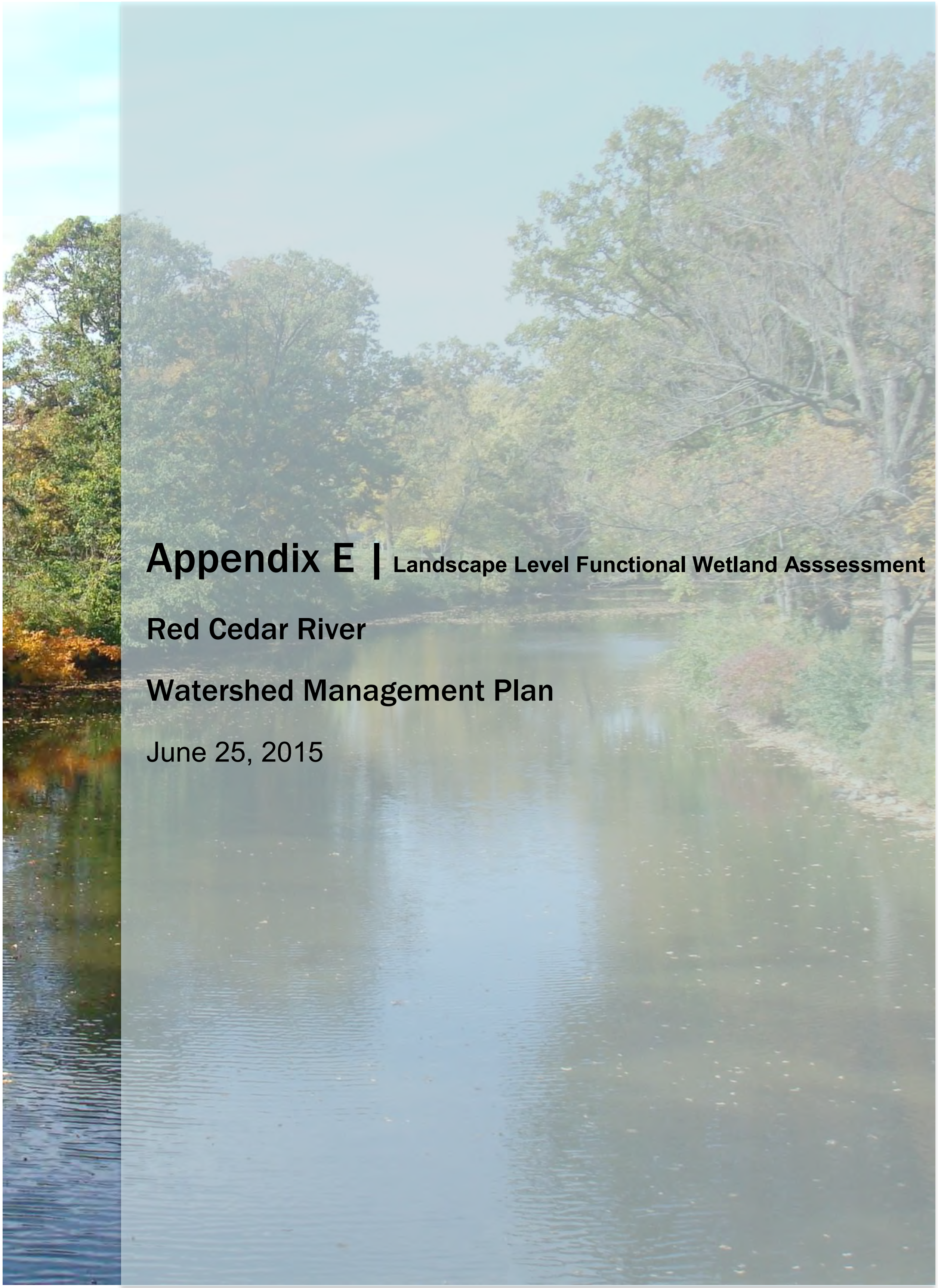
- The entire subwatershed was assessed via windshield survey. Due to the wide open nature of many subwatersheds, large sections of channel could be assessed from the roadway, thereby eliminating the need to traverse on foot.
- If impairments such as sedimentation or streambank erosion were identified during the windshield survey, the channel was assessed on foot. If no impairments were identified, the section of channel was eliminated from further assessment.
- All locations with larger livestock (e.g. cattle, horses, sheep, pigs), were recorded and along with the estimated number of animals. Notes were also recorded relative to proximity to streams or drains, excessive accumulation or storage of manure, etc.
- General notes were recorded including, but not limited to, tillage practices, high quality areas, congregations of waterfowl, etc.

Step 2. Walking Assessment

- Those reaches determined to potentially be impaired during the windshield survey were assessed by foot. Each source of pollution was identified and the location was recorded on field maps. Examples of NPS sites include:
    - eroding streambanks
    - gully erosion on adjacent lands
    - livestock access points and pastures
    - animal holding facilities located adjacent the channel
    - highly maintained golf course properties
    - orchards
    - manure application
    - cropland
    - failing septic systems, cheater pipes, etc
    - Maintained lawns adjacent lakes
    - Open channel with no canopy
- Site-specific data was recorded at each point. At a minimum, enough data was collected to estimate the pollutant load at each site.

Step 3. The cause of pollution was identified for each source documented during Step 2.

- Examples of causes of pollution include:
    - Indiscriminant access to the stream for livestock
    - Altered morphology
    - Altered hydrology
    - Over or improper application of manure
    - Over or improper application of lawn fertilizers and chemicals
    - Lack of riparian buffer adjacent channel
    - Lack of filter strips on erosion-prone cropland
    - Improper grading or drainage at livestock holding facilities
    - Improper maintenance of septic systems



Appendix E | Landscape Level Functional Wetland Asssessment

Red Cedar River

Watershed Management Plan

June 25, 2015

RED CEDAR RIVER WATERSHED

Landscape Level Wetland Functional Assessment

(Enhanced NWI)

Department of Environmental Quality

12-7-2012

RED CEDAR WATERSHED
Wetland Resources Status and Trends

Pre-settlement Wetland conditions

- 92,367 Acres of Wetlands
- 4,749 Polygons
- Average Size – 19 Acres

2005 Wetland Condition

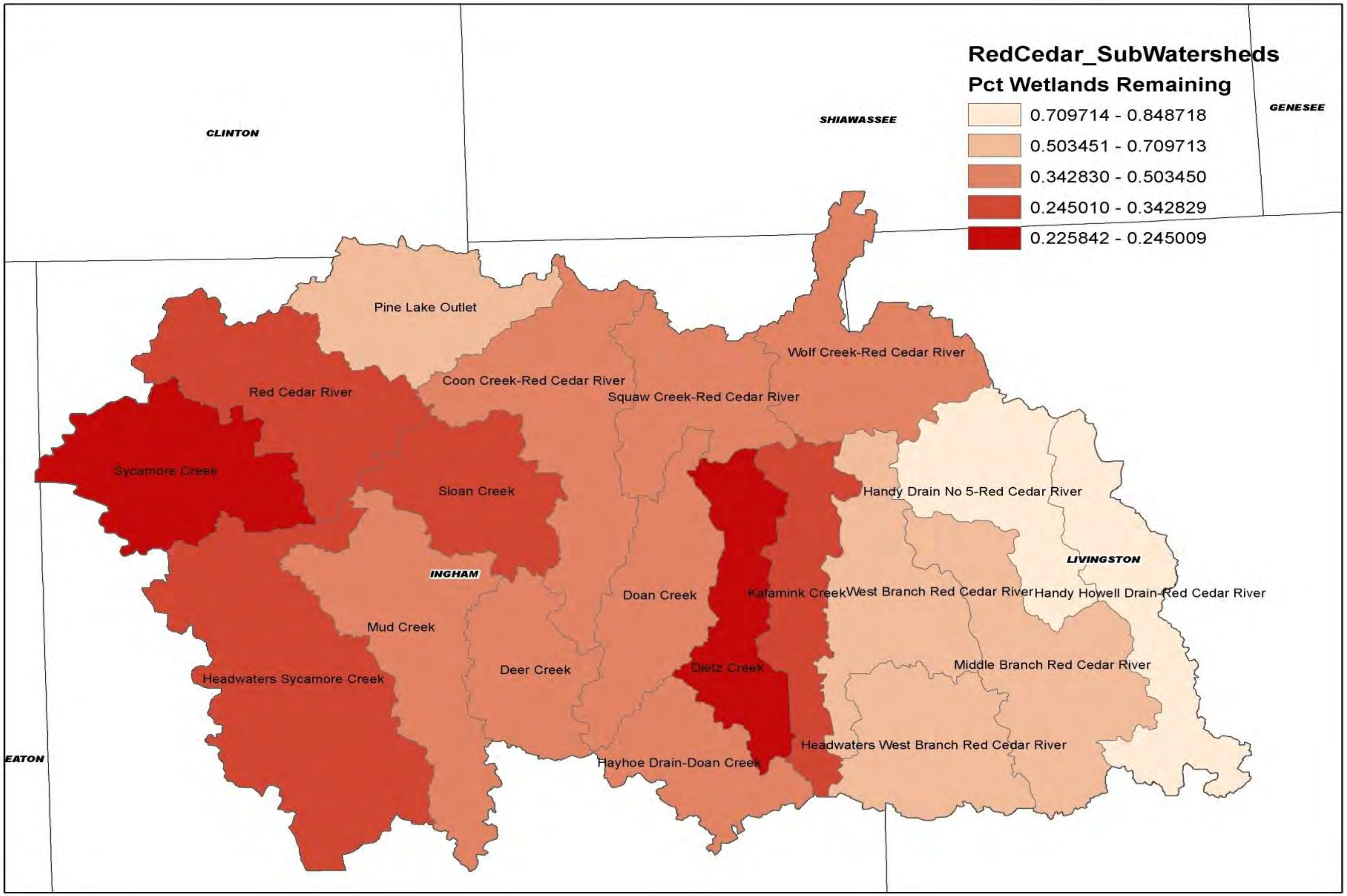
- 40,681 Acres of Wetlands
- 7,225 Polygons
- Average Size – 5.6 Acres

44% OF ORIGINAL WETLAND ACREAGE REMAINS
56% LOSS OF TOTAL WETLAND RESOURCE

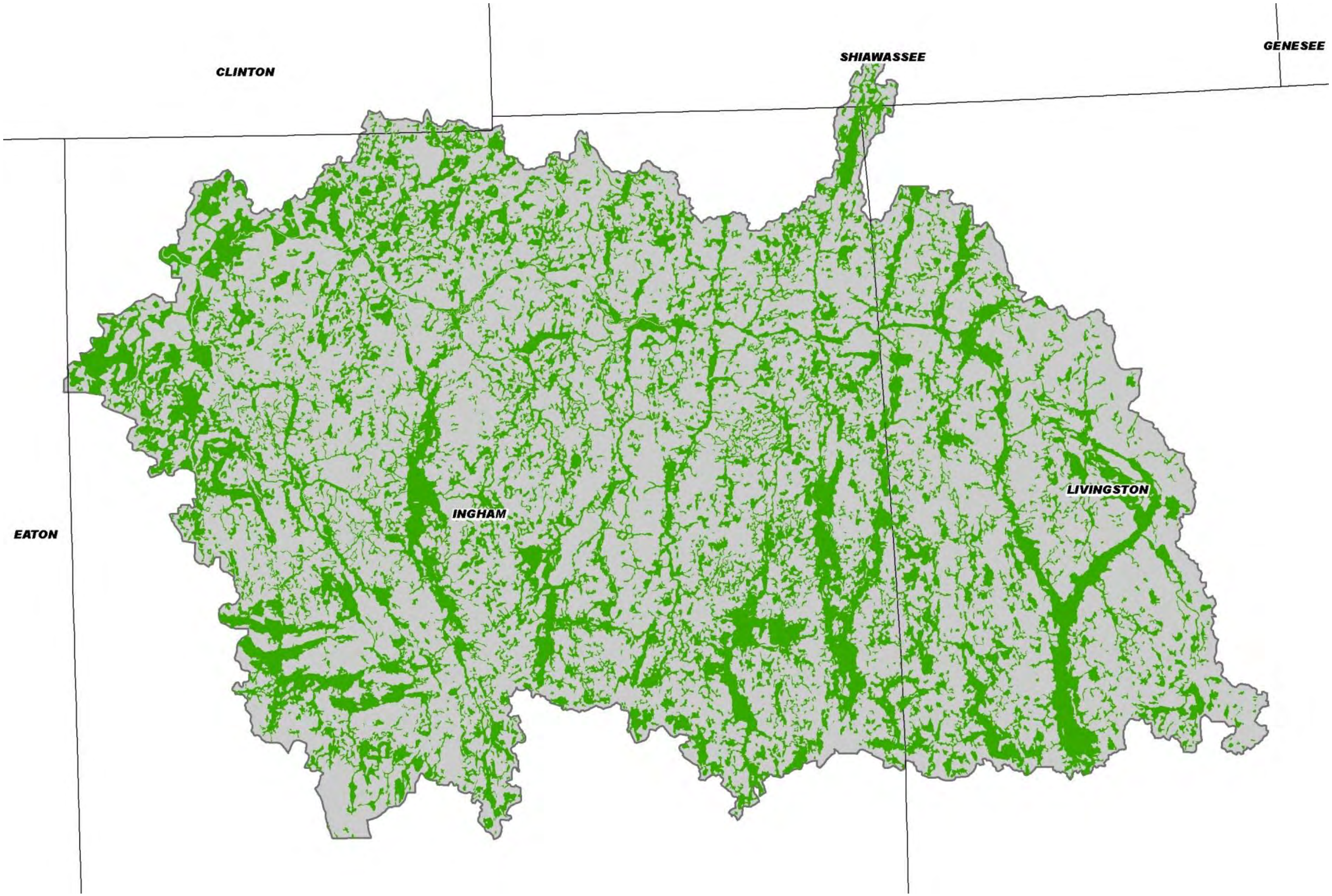
TOTAL ACREAGE LOSS OF:
51,686 ACRES

* These figures exclude open water type wetlands

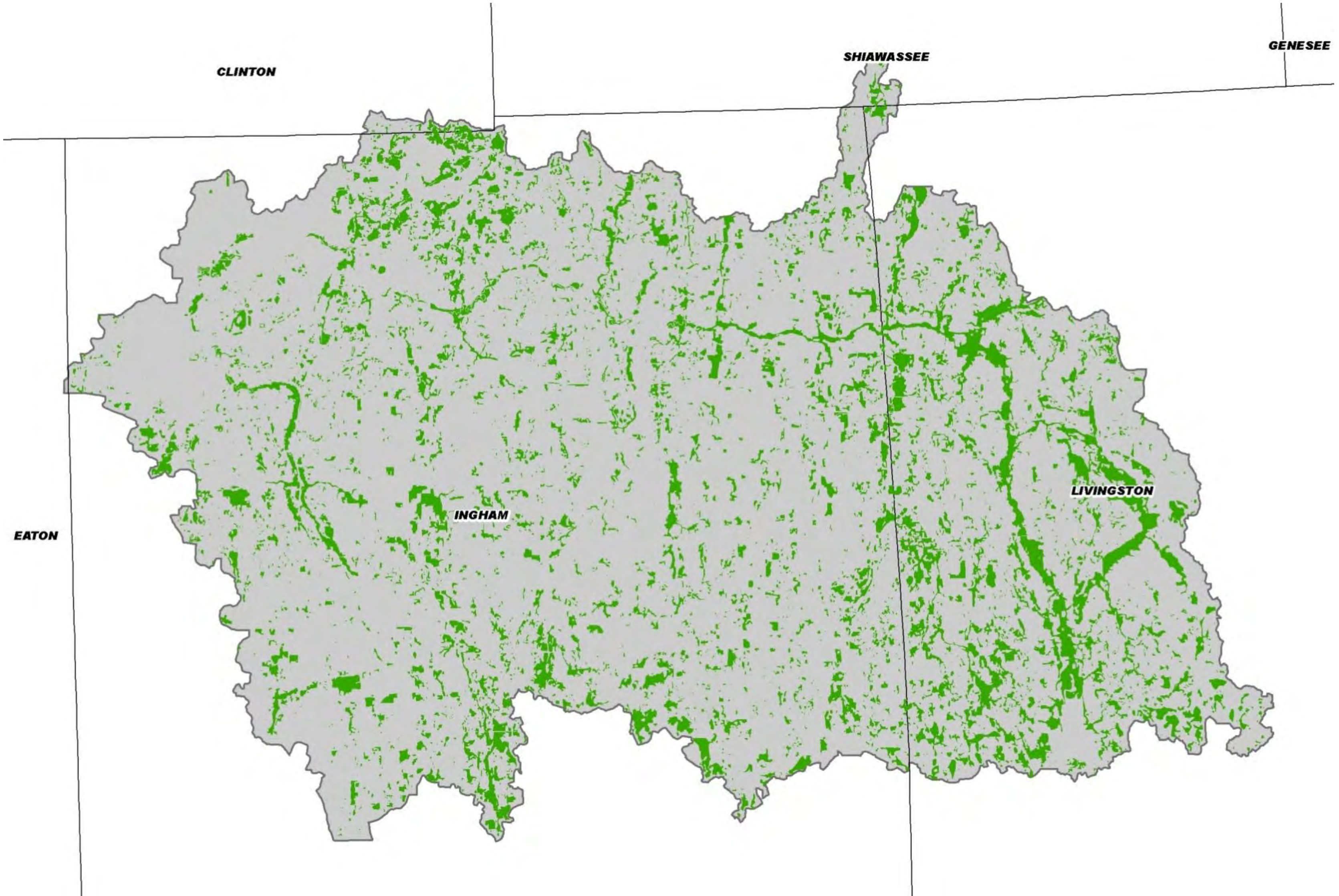
Percentage of Remaining Wetlands



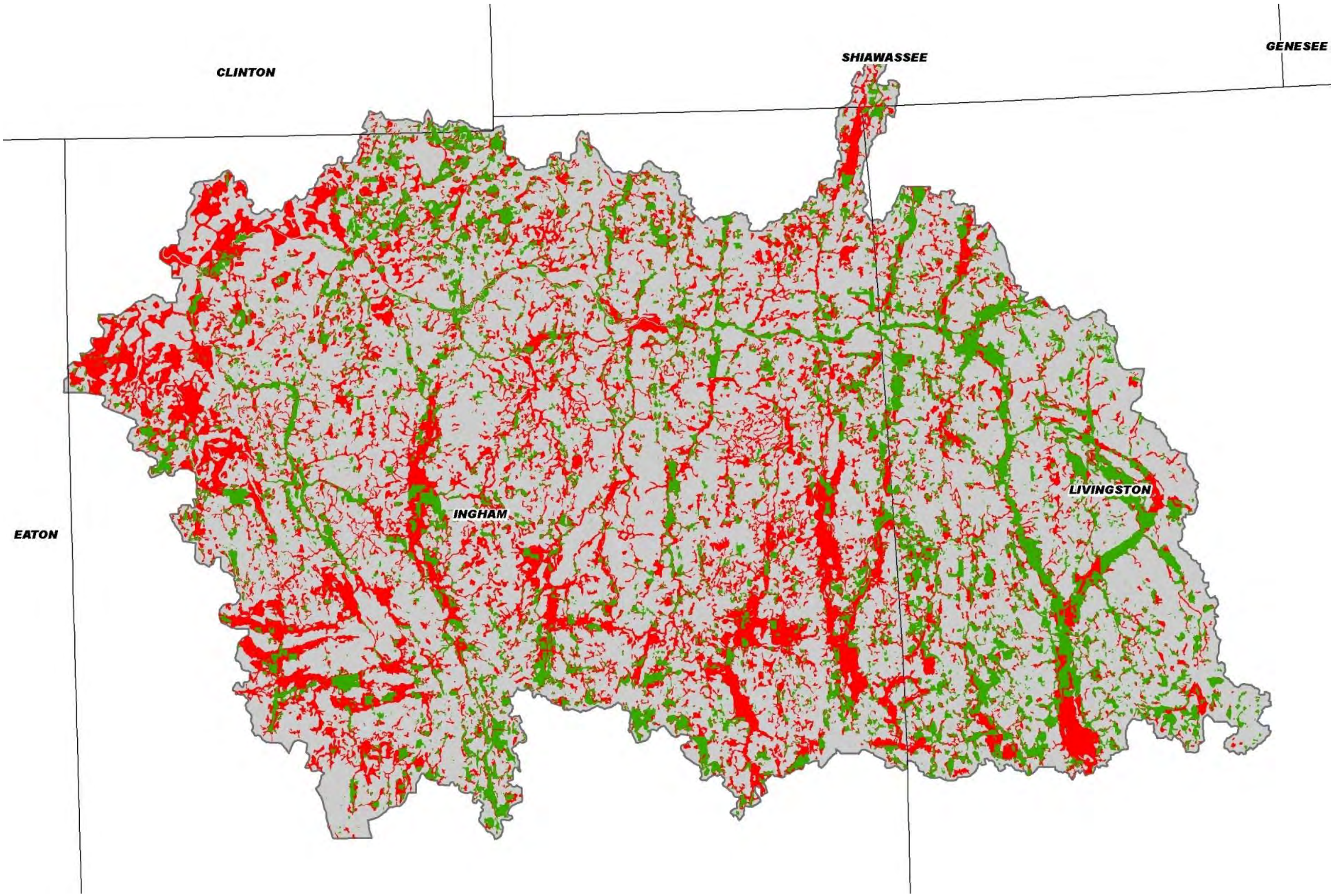
PRE-EUROPEAN SETTLEMET WETLAND COVERAGE



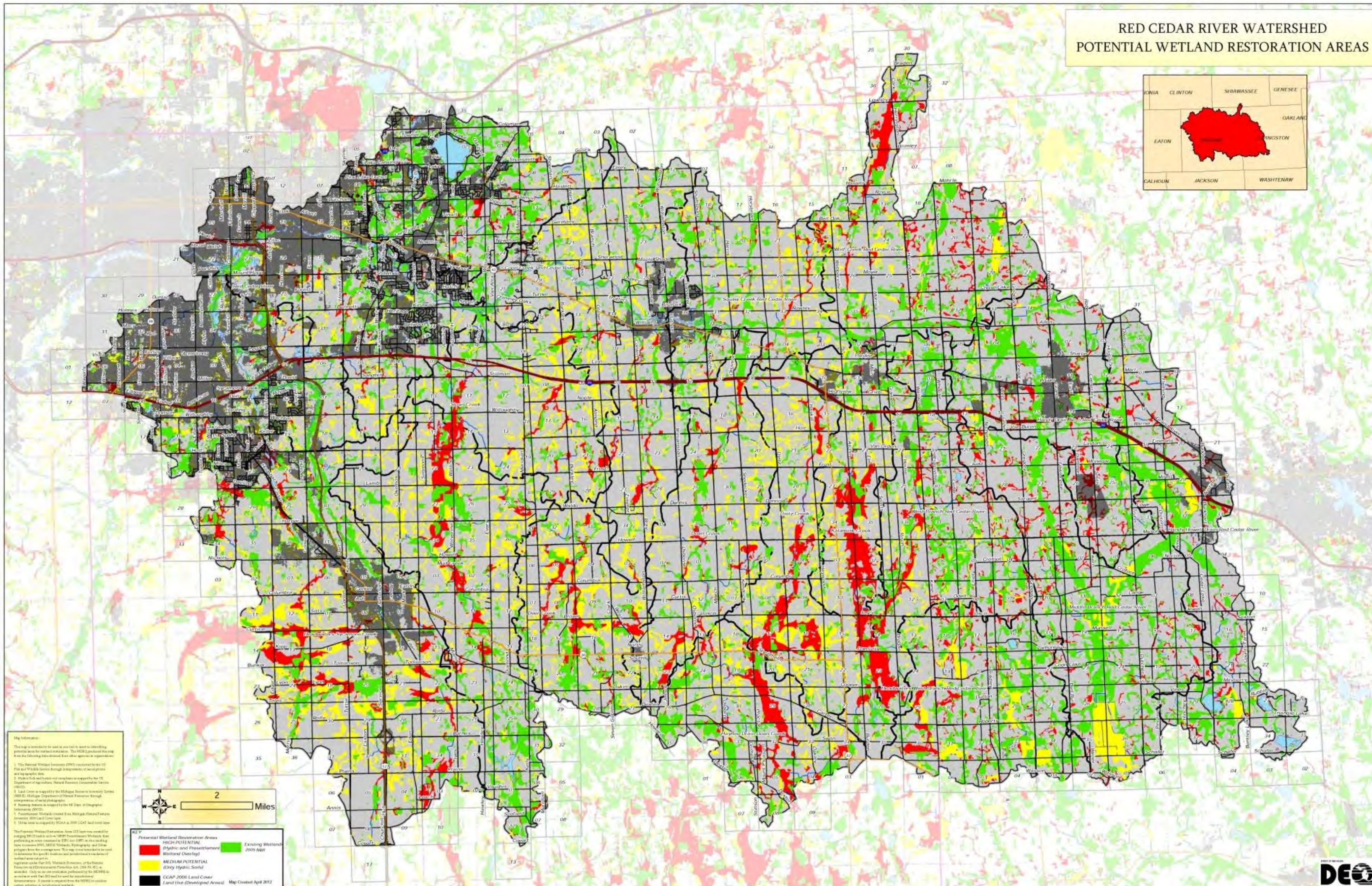
2005 WETLAND COVERAGE



APPROXIMATE WETLAND LOSS PRE-EUROPEAN SETTLEMENT TO 2005



RED CEDAR WATERSHED



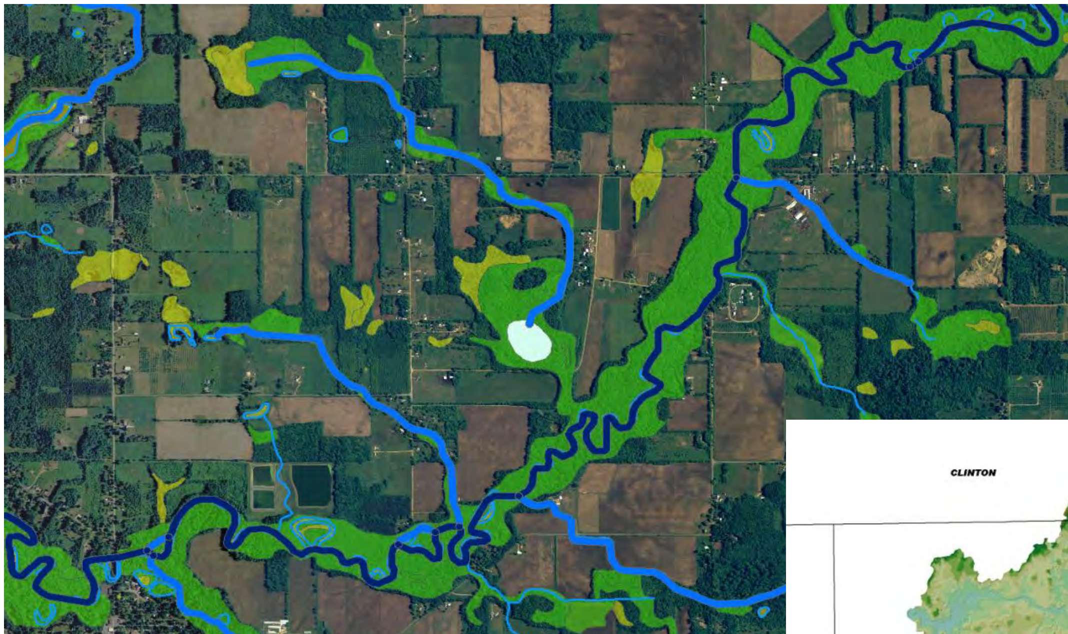
NWI TYPE COMPARISON

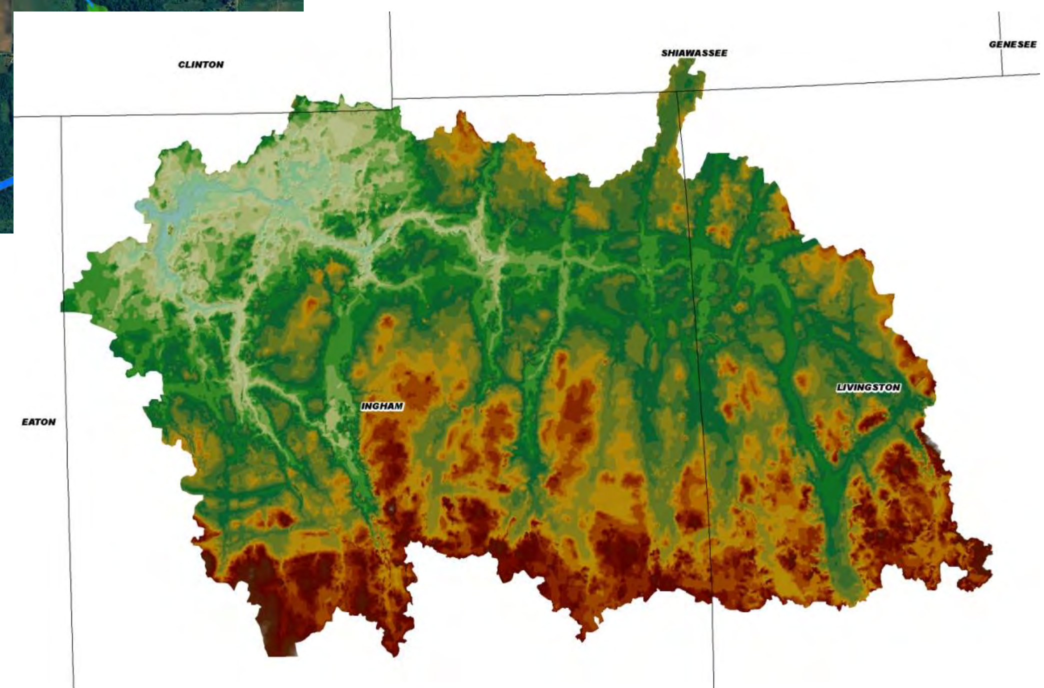
Table 1: Generalized NWI type comparison

Wetland Type	**Pre-European Settlement Acres**	**2005 Acres of Wetlands**	**Net Acres Remaining**
Palustrine Emergent	5,400	13,505*	100%
Palustrine Forested	80,664	21,189**	26%
Palustrine Shrub-Scrub	6,301***	5,787****	91%
Other Palustrine			
Ponds	0*****	1,376	100%
Total	92,365	41,857	45%

*Includes mixed emergent wetland classes and mixed communities where subclasses include Forested and Shrub-Scrub Areas
**Includes mixed forested wetland classes and mixed communities where subclasses include Emergent and Shrub-Scrub Areas
*** Includes mixed Shrub-Scrub/Emergent communities
****Includes mixed shrub-scrub wetland classes and mixed communities where subclasses include Emergent, Forested and Shrub-Scrub
***** Little acreage in ponds due to mapping differences between Pre-Settlement and Current wetland coverage's.

ENHANCING NWI FOR LANDSCAPE-LEVEL WETLAND FUNCTIONAL ASSESSMENT IN THE RED CEDAR RIVER WATERSHED





Using NWI for Functional Assessment

- Lack of hydro-geomorphic (HGM) information
  - No landscape position
  - No landform
  - No water flow direction
  - General pond classification
  - Features important for assessing many functions are lacking
- *Most of these features can be interpreted from the maps*

What information can we extract from NWI?

How many wetlands are there?

What is the size range of wetlands?

What is the average size of a given wetland type?

How many wetlands are in various size classes?

…With HGM information added?

How much and how many

- occur along rivers?
- along streams?
- in lake basins?
- are isolated?
- are sources of streams?
- have inflow but no outflow?
- are connected to other wetlands?
- What types of ponds are there and what is their extent?

Wetland Landscape Positions

- Landscape Position
  - Terrene
  - Lentic
  - Lotic River
  - Lotic Stream

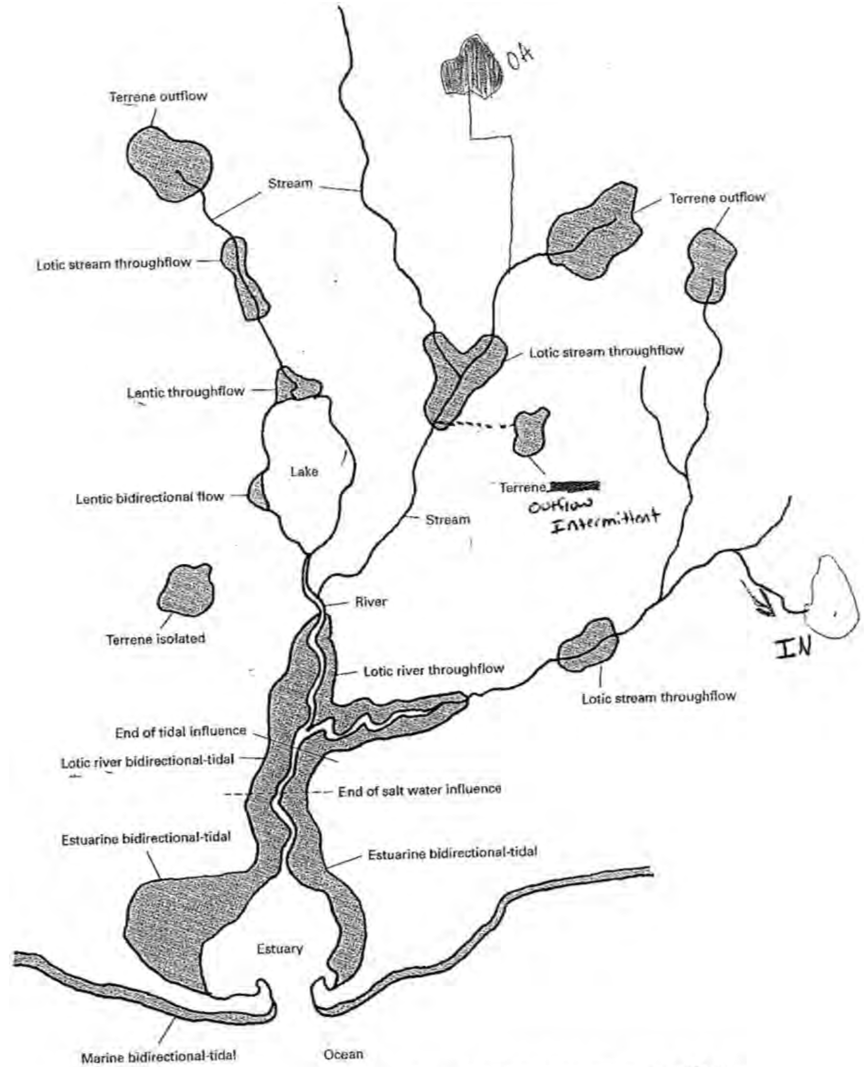


Figure 14.4. Typical wetland landscape positions and water flow paths in the eastern United States.

TERRENE

LENTIC

LOTIC

RIVER

STREAM

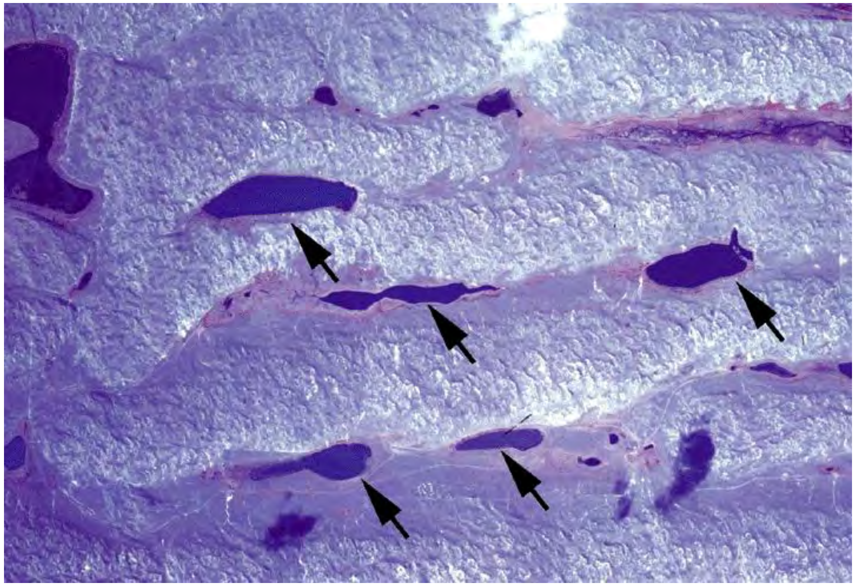
Wetland Landform Types

- Fringe
- Basin
- Flat
- Floodplain
- Slope

FRINGE




BASIN



FLAT

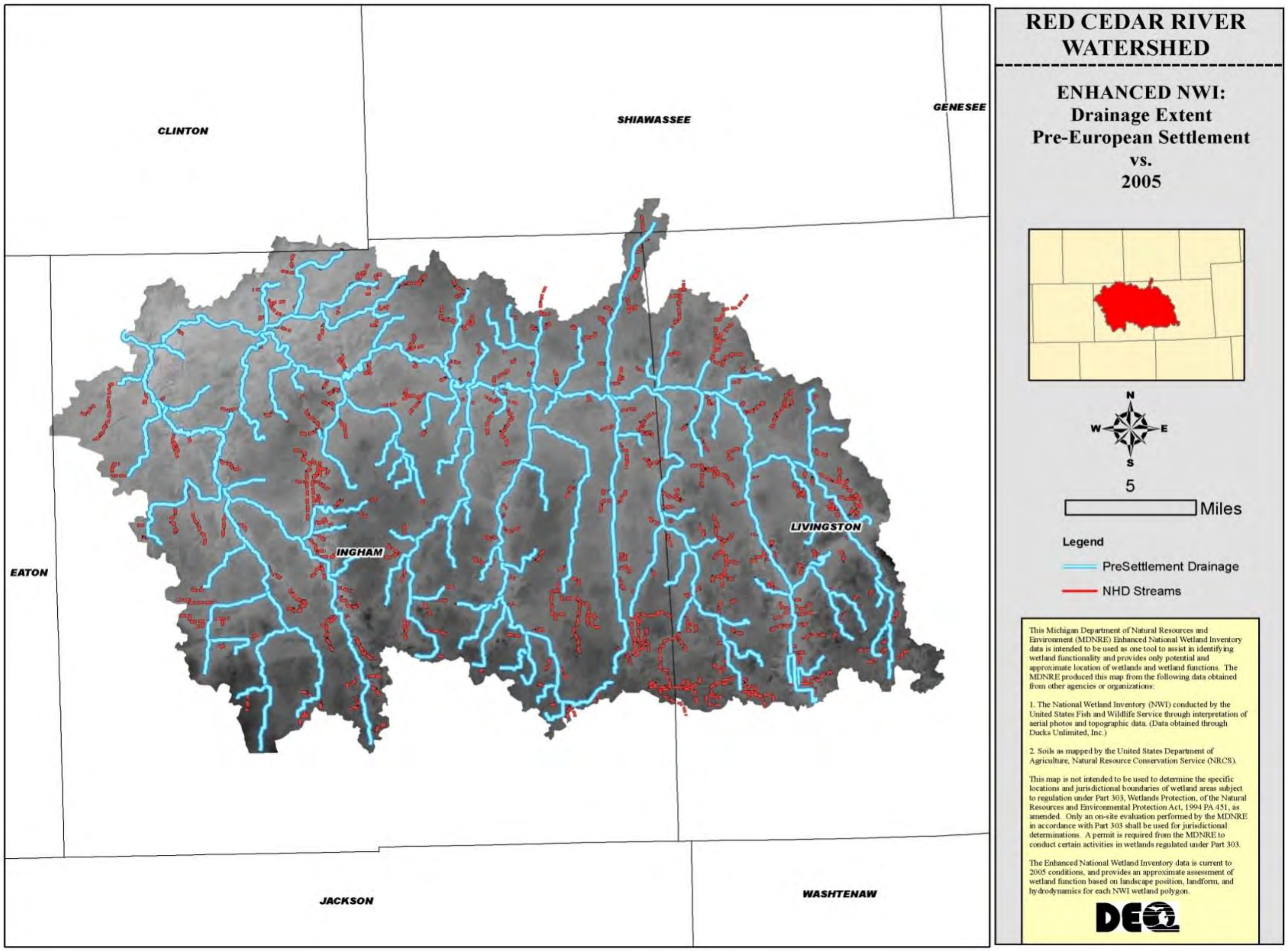
FLOODPLAIN

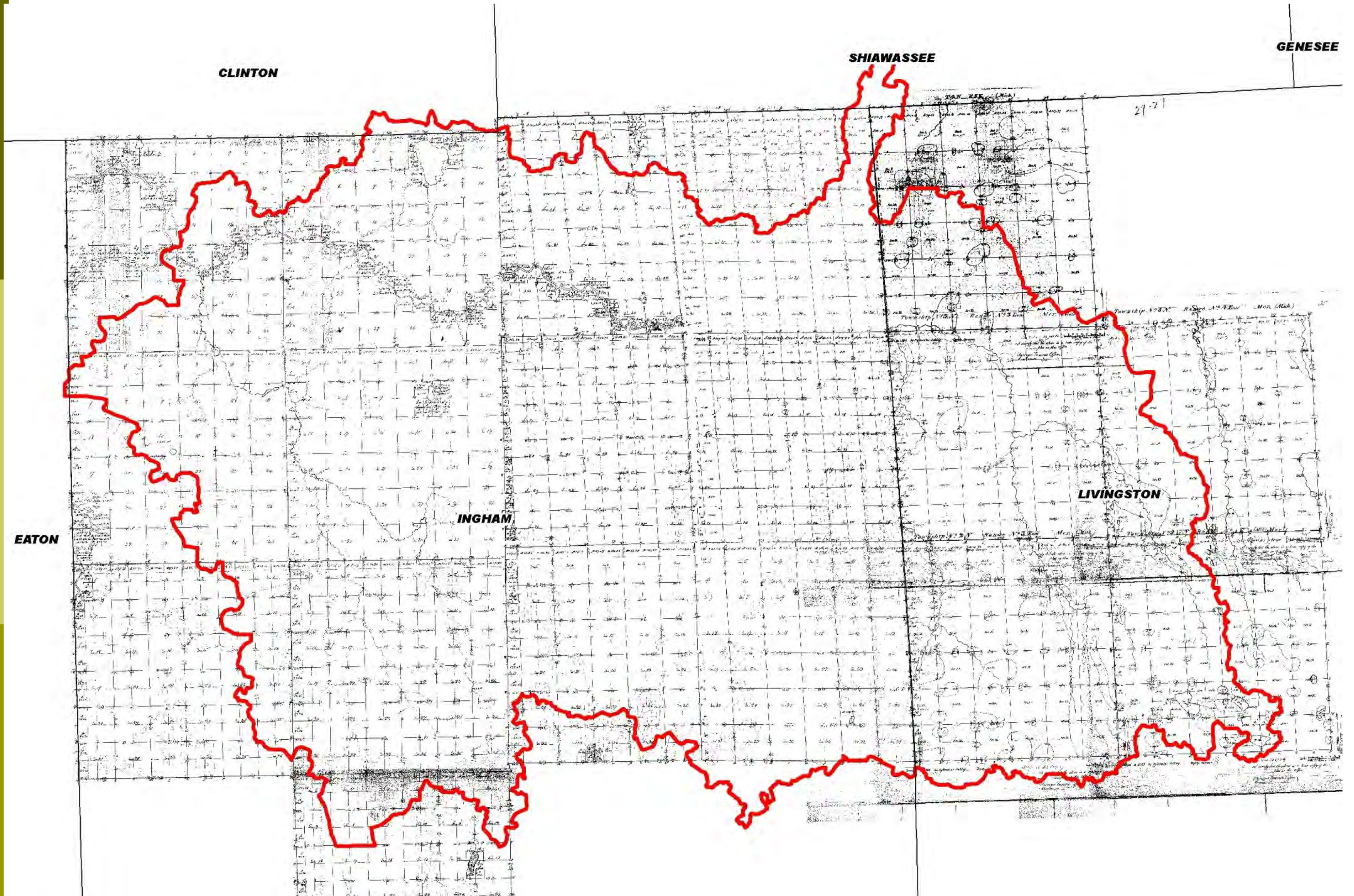
SLOPE

Evaluated Wetland Functions

- Flood Water Storage
- Streamflow Maintenance
- Nutrient Transformation
- Sediment and Other Particulate Retention
- Shoreline Stabilization
- Stream Shading
- Conservation of Rare and Imperiled Wetlands
- Ground Water Influence
- Fish Habitat
- Waterfowl/Waterbird Habitat
- Shorebird Habitat
- Interior Forest Bird Habitat
- Amphibian Habitat
- Carbon Sequestration
- Pathogen Retention

DRAINAGE EXTENT





CLINTON
SHIAWASSEE
GENESEE
EATON
INGHAM
LIVINGSTON

DETAILED FUNCTIONAL COMPARISONS

Table 2: Detailed Functional Comparisons

Function	Potential Significance	Pre-European Settlement Acreage	2005 Acreage	% Change in Acreage
Flood Water Storage	High	30,750.40	20,696.75	-33
	Moderate	52,074.23	2,725.80	-95
	Total	82,824.63	23,422.55	-72
Streamflow Maintenance	High	65,535.45	24,176.88	-63
	Moderate	13,085.83	8,323.47	-36
	Total	78,621.28	32,500.35	-59
Nutrient Transformation	High	35,096.34	30,158.40	-14
	Moderate	57,271.21	10,523.30	-82
	Total	92,367.55	40,681.70	-56
Sediment and Retention of Other Particulates	High	35,090.54	9,901.24	-72
	Moderate	13,010.40	13,522.97	4 *
	Total	48,100.94	23,424.21	-51
Shoreline Stabilization	High	27,608.44	13,453.32	-51
	Moderate	44,325.34	16,464.63	-63
	Total	71,933.78	29,917.95	-58
Fish Habitat	High	72,758.52	8,511.63	-88
	Moderate	7,575.61	16,481.77	118 *
	Total	80,334.13	24,993.40	-69
Stream Shading	High	18,861.10	4,459.50	-76
	Moderate	2,789.30	1,964.60	-30
	Total	21,650.40	6,424.10	-70

* Increases in the moderate & high category in the functions above can be attributed to the mapping differences in the two wetland layers and may not represent the current conditions on the ground.

DETAILED FUNCTIONAL COMPARISONS CONT…

Function	Potential Significance	Pre-European Settlement Acreage	2005 Acreage	% Change in Acreage
Waterfowl/Waterbird Habitat	High	5,933.50	14,230.04	140 *
	Moderate	11,313.20	15,890.60	40 *
	Total	17,246.70	30,120.64	75 *
Shorebird Habitat	High	0.00	56.30	Null
	Moderate	92,367.55	40,482.15	-56
	Total	92,367.55	40,538.45	-56
Interior Forest Bird Habitat	High	9,302.01	8,053.80	-13
	Moderate	77,664.80	18,923.10	-76
	Total	86,966.81	26,976.90	-69
Amphibian Habitat	High	32,684.60	8,038.20	-75
	Moderate	4,692.30	5,384.93	15 *
	Total	37,376.90	13,423.13	-64
Carbon Sequestration	High	3,415.21	6,207.30	82 *
	Moderate	33,961.67	5,056.30	-85
	Total	37,376.88	11,263.60	-70
Ground Water Influence	High	45.40	13.13	-71
	Moderate	12,892.31	7,869.55	-39
	Total	12,937.71	7,882.68	-39
Conservation of Rare & Imperiled Wetlands & Species	High	Null	4,079.21	Null
	Moderate	Null	14,529.90	Null
	Total	Null	18,609.11	Null

* Increases in the moderate & high categories in the functions above can be attributed to the mapping differences in the two wetland layers and may not represent the current conditions on the ground.

FUNCTIONAL ACRES COMPARISON

Table 3: Functional Acres comparison

Function	Pre-European Settlement Functional Acres	2005 Functional Acres	Predicted % of Original Capacity Left	Predicted % Change in Functional Capacity
Flood Water Storage	113,575.03	44,119.30	39	-61
Streamflow Maintenance	144,156.73	56,677.23	39	-61
Nutrient Transformation	127,463.89	70,840.10	56	-44
Sediment and Other Particulate Retention	83,191.48	33,325.45	40	-60
Shoreline Stabilization	99,542.22	43,371.27	44	-56
Fish Habitat	153,092.65	33,505.03	22	-78
Stream Shading	40,511.50	10,883.60	27	-73
Waterfowl and Waterbird Habitat	23,180.20	44,350.68	191	91 *
Shorebird Habitat	92,367.55	40,594.75	44	-56
Interior Forest Bird Habitat	96,268.82	35,030.70	36	-64
Amphibian Habitat	70,061.50	21,461.33	31	-69
Carbon Sequestration	40,792.09	17,470.90	43	-57
Ground Water Influence	12,983.11	7,895.81	61	-39
Conservation of Rare & Imperiled Wetlands & Species	0	22,688.32	100	100

- Increases in the predicted percent change functional capacity in the functions above can be attributed to the mapping differences in the two wetland layers and may not represent the current conditions on the ground.

Frequency of Functions

Pre-Settlement

# of Wetlands	# of Functions	ACRES
10	1	485
14	2	757
613	3	7,891
579	4	1,692
44	5	184
232	6	5,243
716	7	15,200
1,045	8	19,075
611	9	14,724
429	10	13,930
411	11	12,856
66	12	1,709
1	13	2

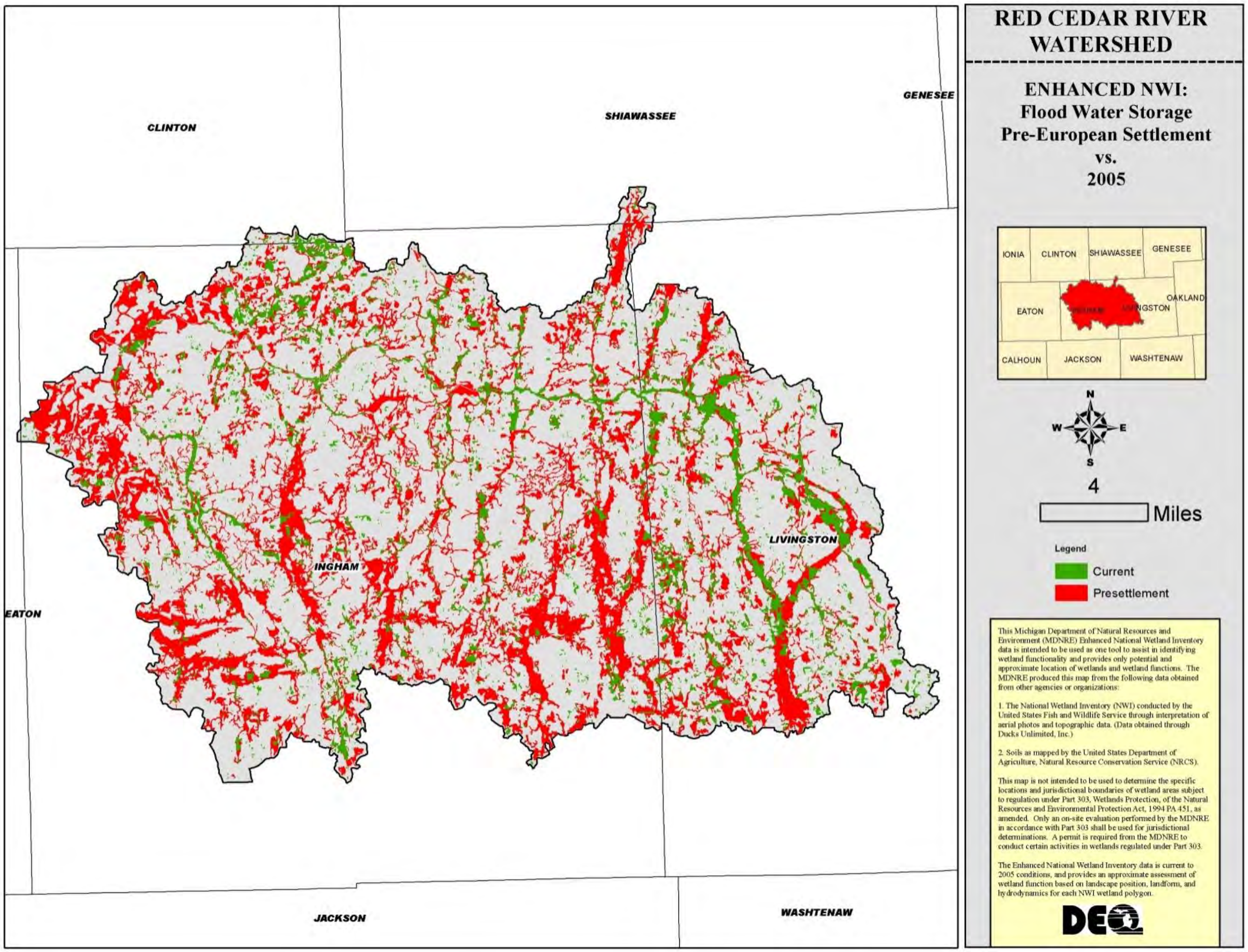
Current

# of Wetlands	# of Functions	ACRES
484	1	570
1,148	2	1,795
575	3	1,854
520	4	1,313
794	5	2,235
465	6	4,682
950	7	5,099
2,086	8	11,182
1,438	9	8,723
436	10	2,158
238	11	1,691
151	12	2,324
16	13	325

FLOOD WATER STORAGE

- This function is important for reducing the downstream flooding and lowering flood heights, both of which aid in minimizing property damage and personal injury from such events.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

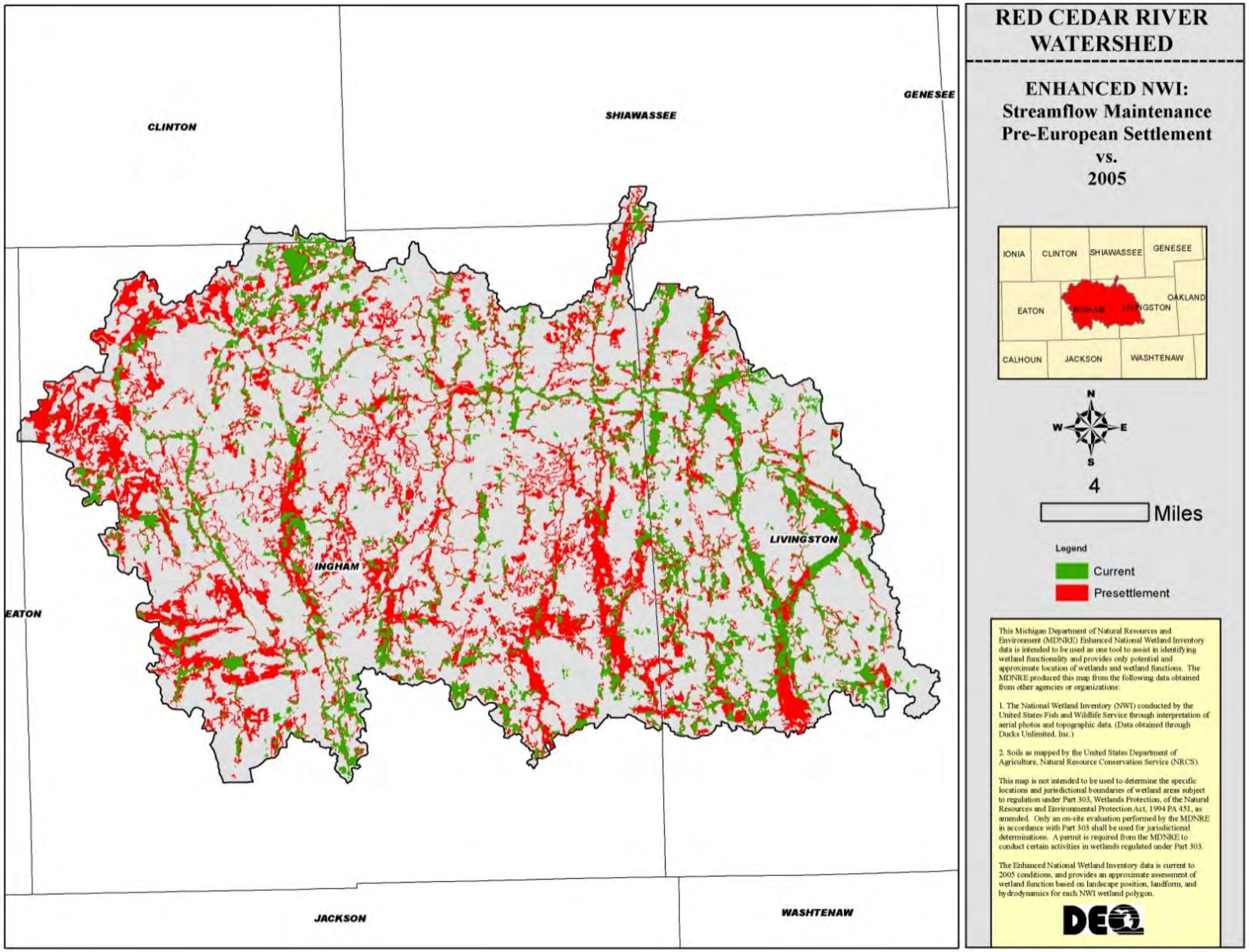
FLOOD WATER STORAGE



STREAMFLOW MAINTENANCE

- Wetlands that are sources of groundwater discharge that sustain streamflow in the watershed. Such wetlands are critically important for supporting aquatic life in streams. All wetlands classified as headwater wetlands are important for streamflow.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

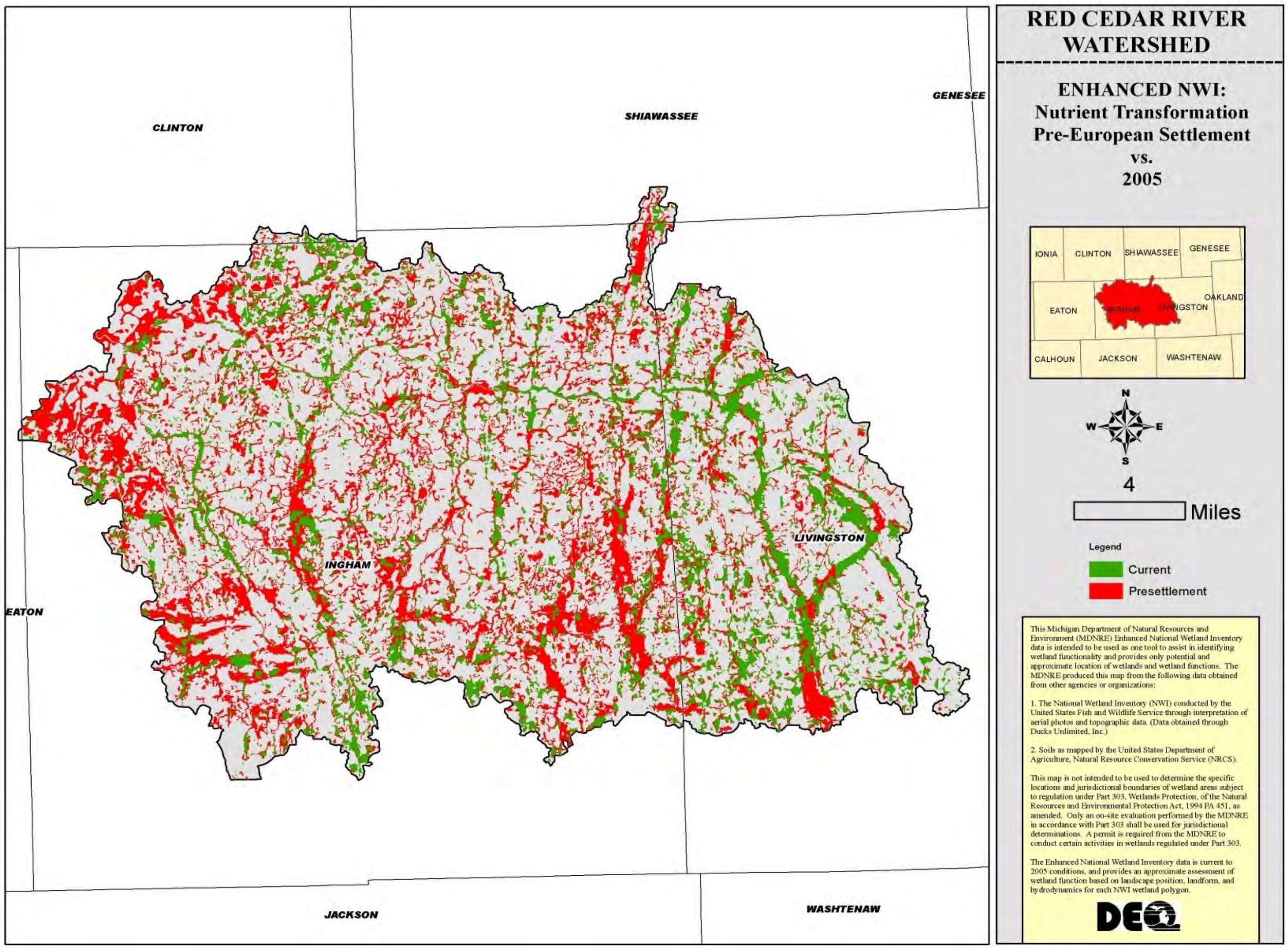
STREAMFLOW MAINTENANCE



NUTRIENT TRANSFORMATION

- Wetlands that have a fluctuating water table are best able to recycle nutrients. Natural wetlands performing this function help improve local water quality of streams and other watercourses.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

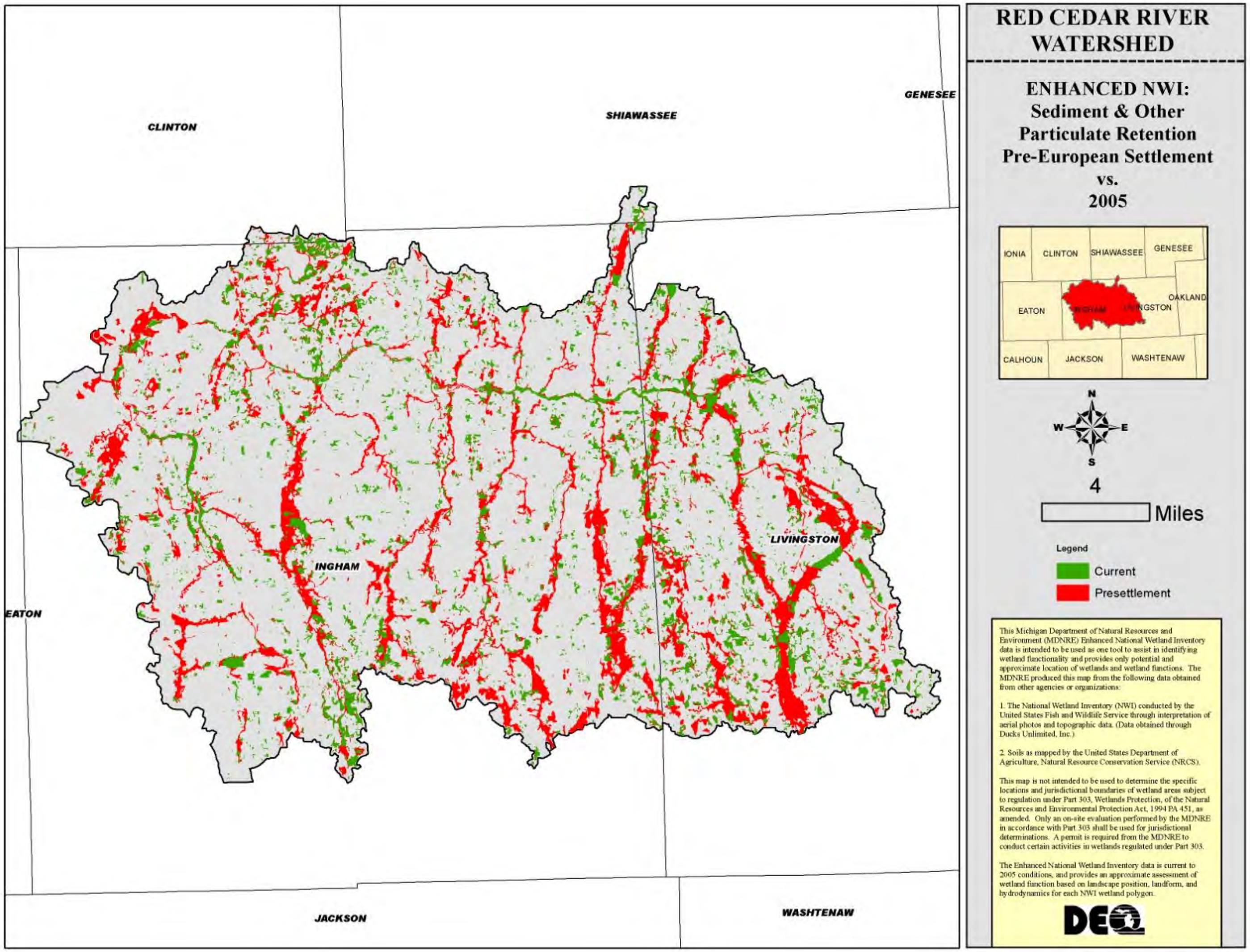
NUTRIENT TRANSFORMATION



SEDIMENT AND OTHER PARTICULATE RETENTION

- This function supports water quality maintenance by capturing sediments with bonded nutrients or heavy metals. Vegetated wetlands will perform this function at higher levels than those of non-vegetated wetlands.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

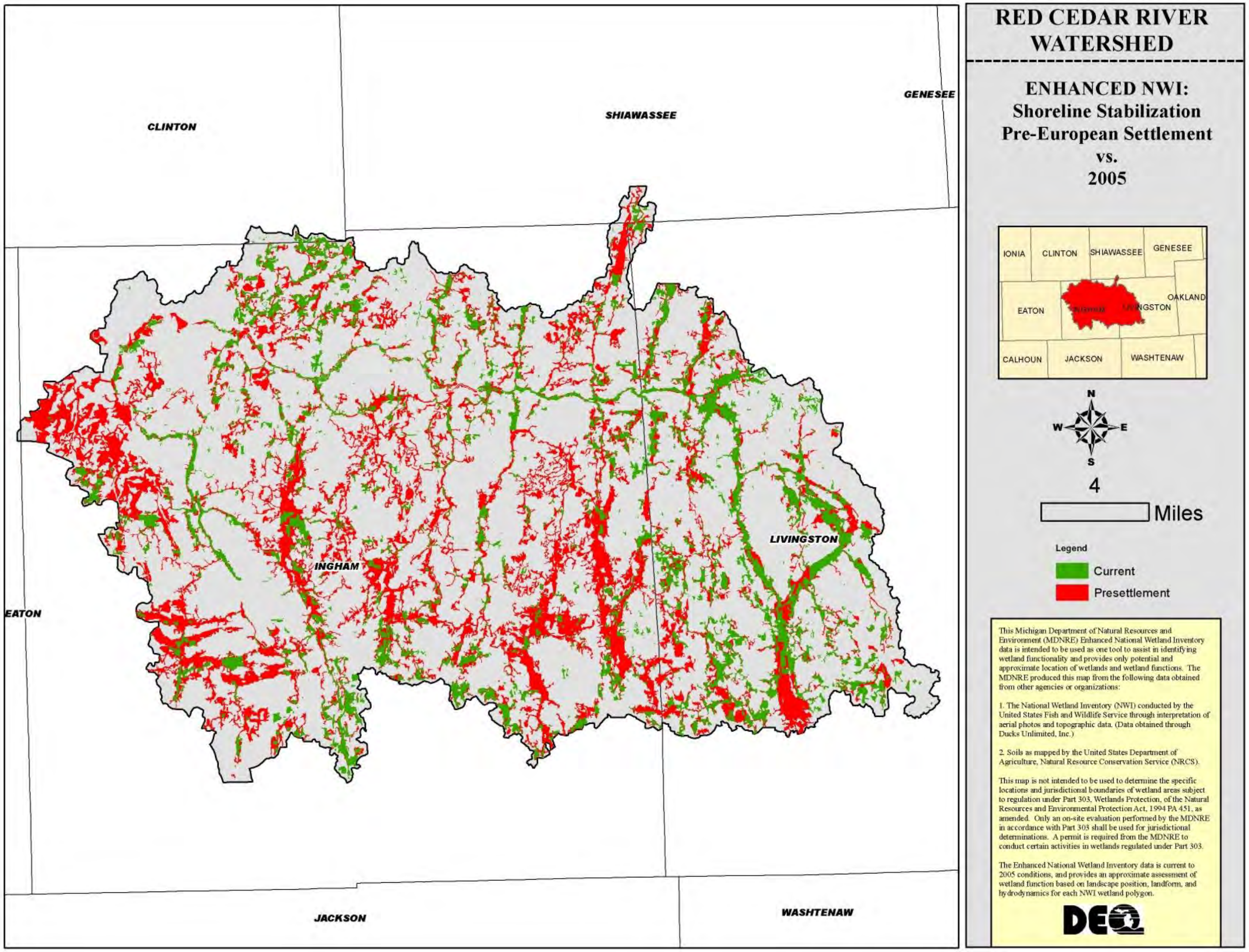
SEDIMENT AND OTHER PARTICULATE RETENTION



SHORELINE STABILIZATION

- Vegetated wetland along all waterbodies (e.g. estuaries, lakes, rivers, and streams) provide this function. Vegetation stabilizes the soil or substrate and diminished wave action, thereby reducing shoreline erosion potential.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

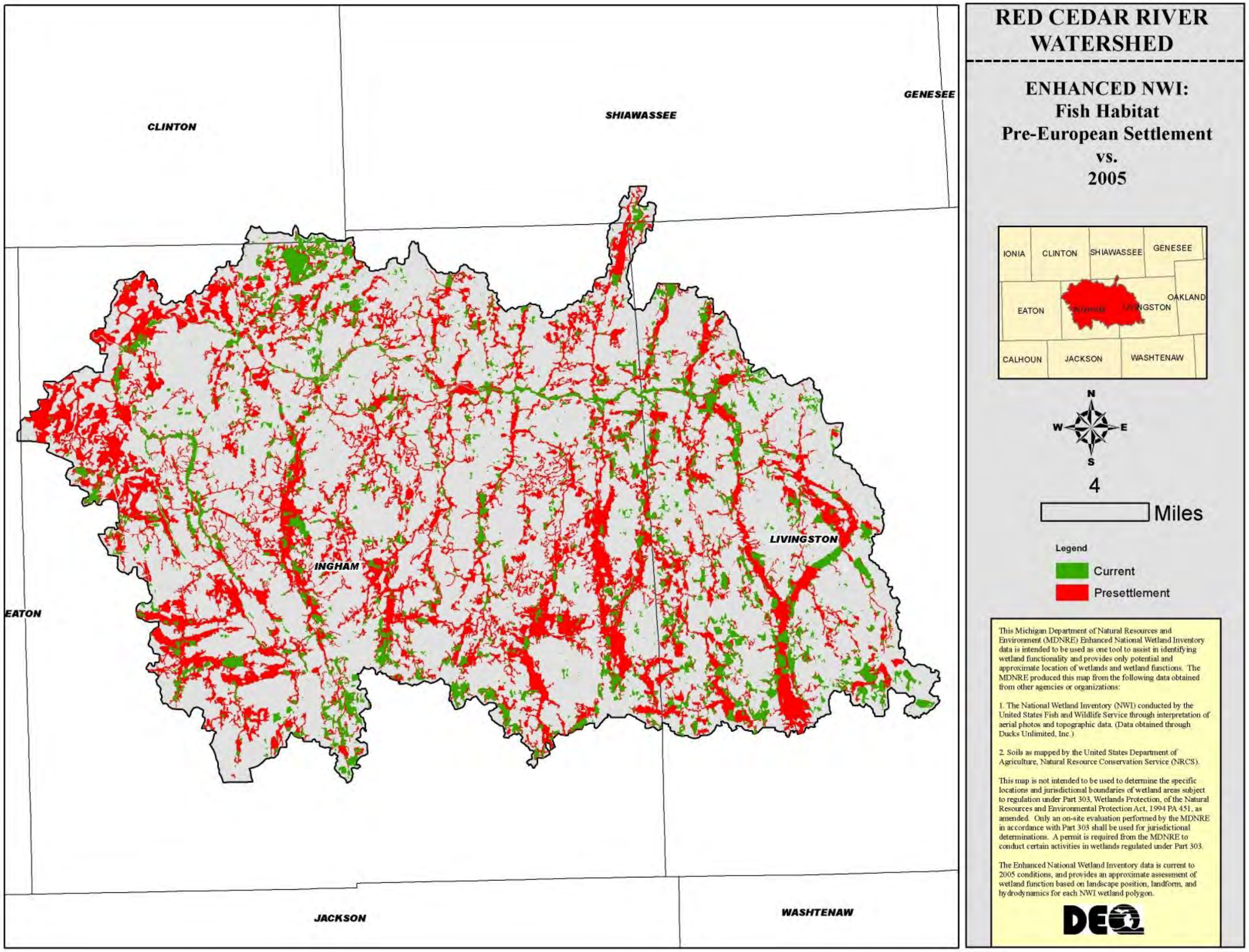
SHORELINE STABILIZATION



FISH HABITAT

- Wetlands that are considered essential to one or more parts of fish life cycles. Wetlands designated as important for fish are generally those used for reproduction, or feeding.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

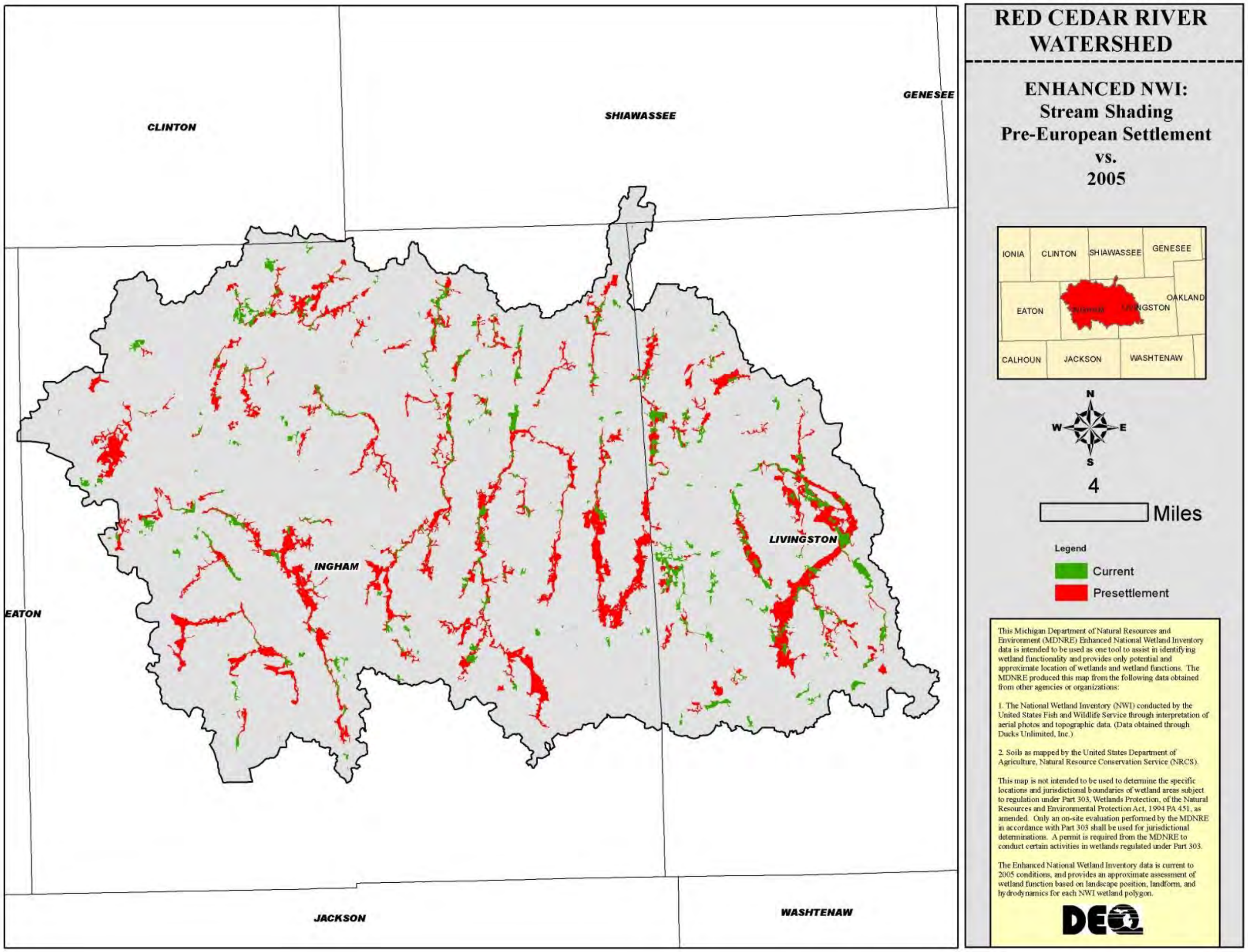
FISH HABITAT



STREAM SHADING

- Wetlands that perform water temperature control due to the proximity to streams and waterways. These wetlands generally are Palustrine Forested or Scrub-Shrub.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

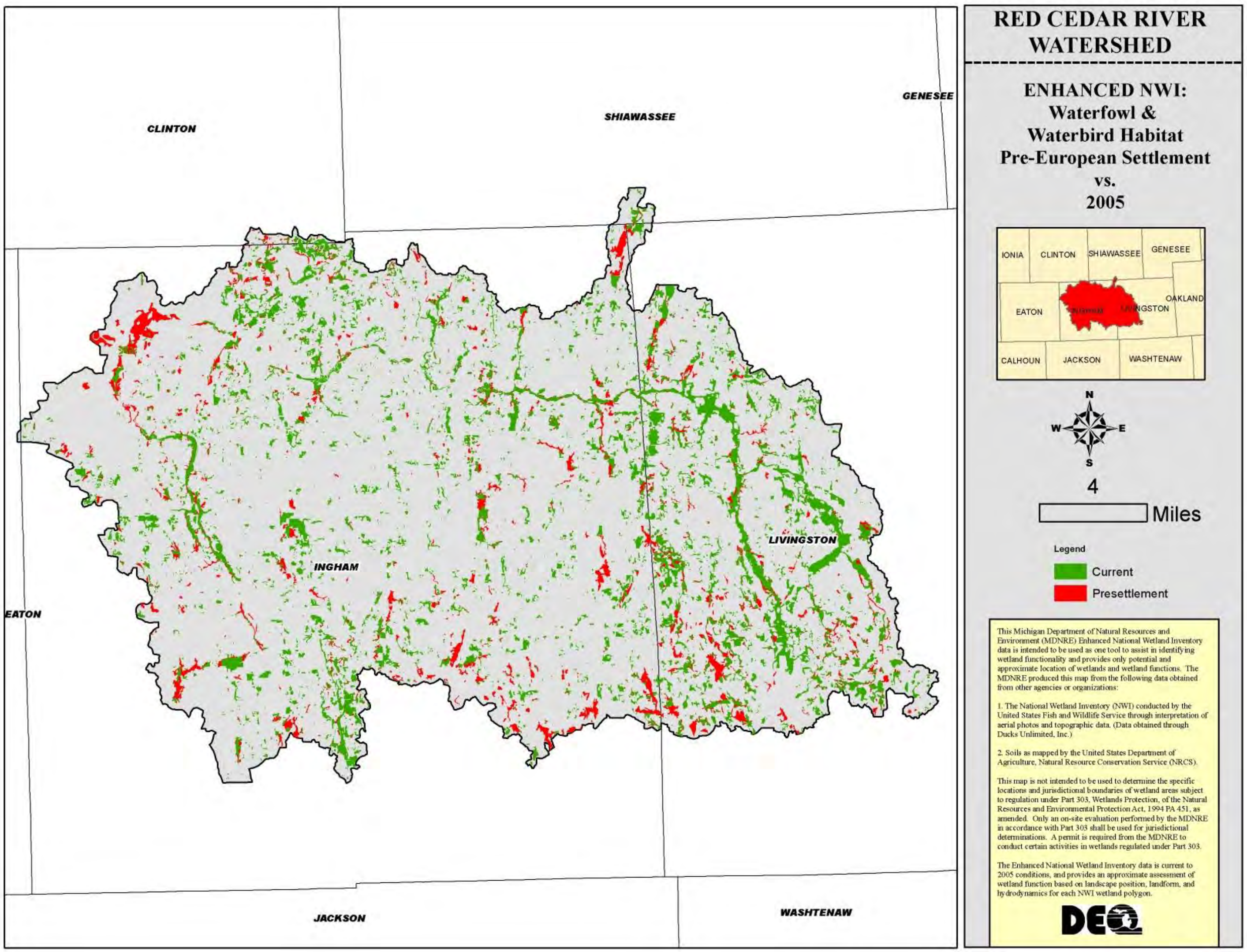
STREAM SHADING



WATERFOWL AND WATERBIRD HABITAT

- Wetlands designated as important for waterfowl and waterbirds are generally those used for nesting, reproduction, or feeding. The emphasis is on the wetter wetlands and ones that are frequently flooded for long periods.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

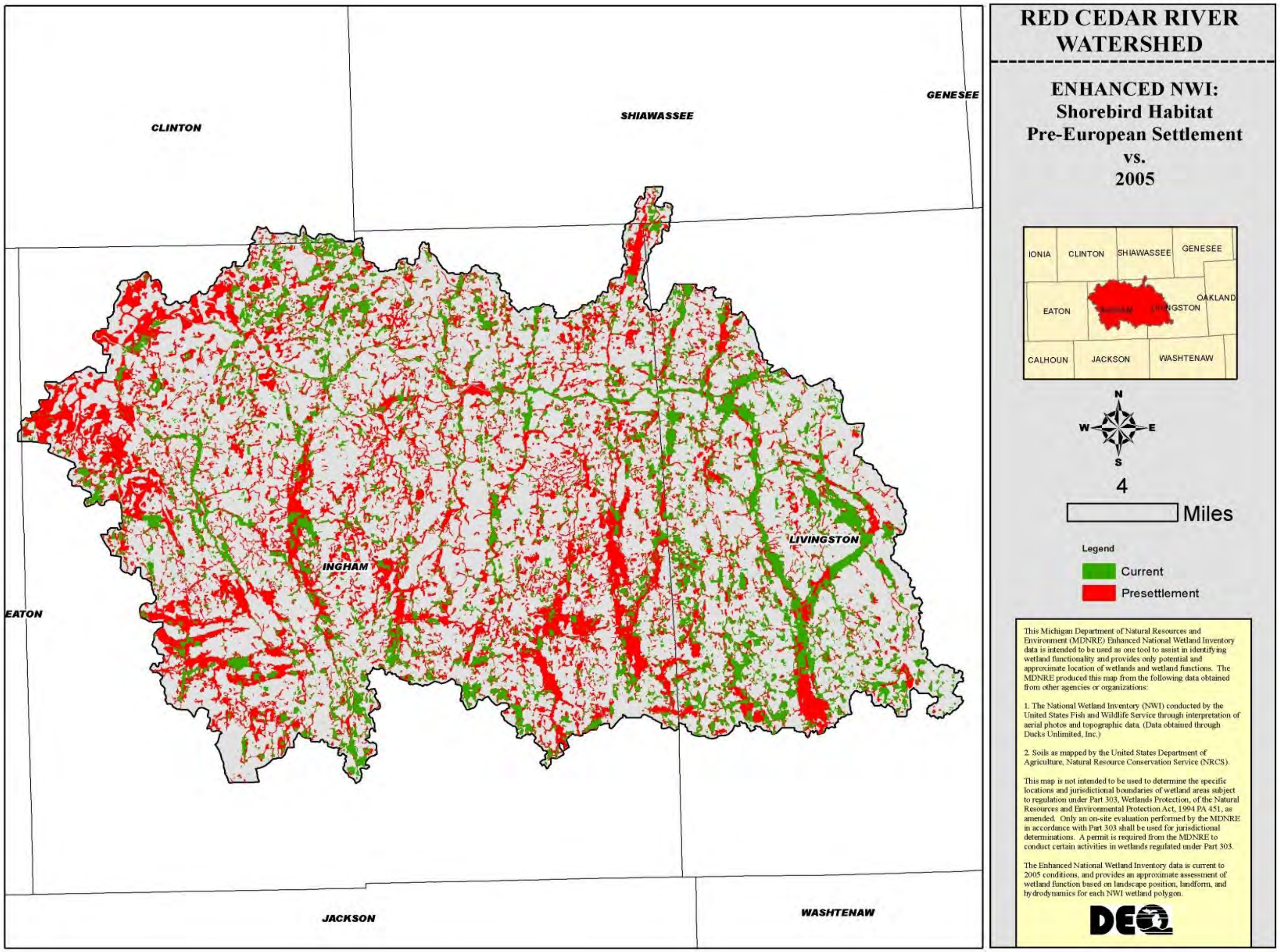
WATERFOWL & WATERBIRD HABITAT



SHOREBIRD HABITAT

- Shorebirds generally inhabit open areas of beaches, grasslands, wetlands, and tundra and undertake some of the longest migrations known. Along their migration pathway, many shorebirds feed in coastal and inland wetlands where they accumulate fat reserves needed to continue their flight. Common species include; plovers, oystercatchers, avocets, stilts, and sandpipers. This function attempts to capture wetland types most likely to provide habitat for these species.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

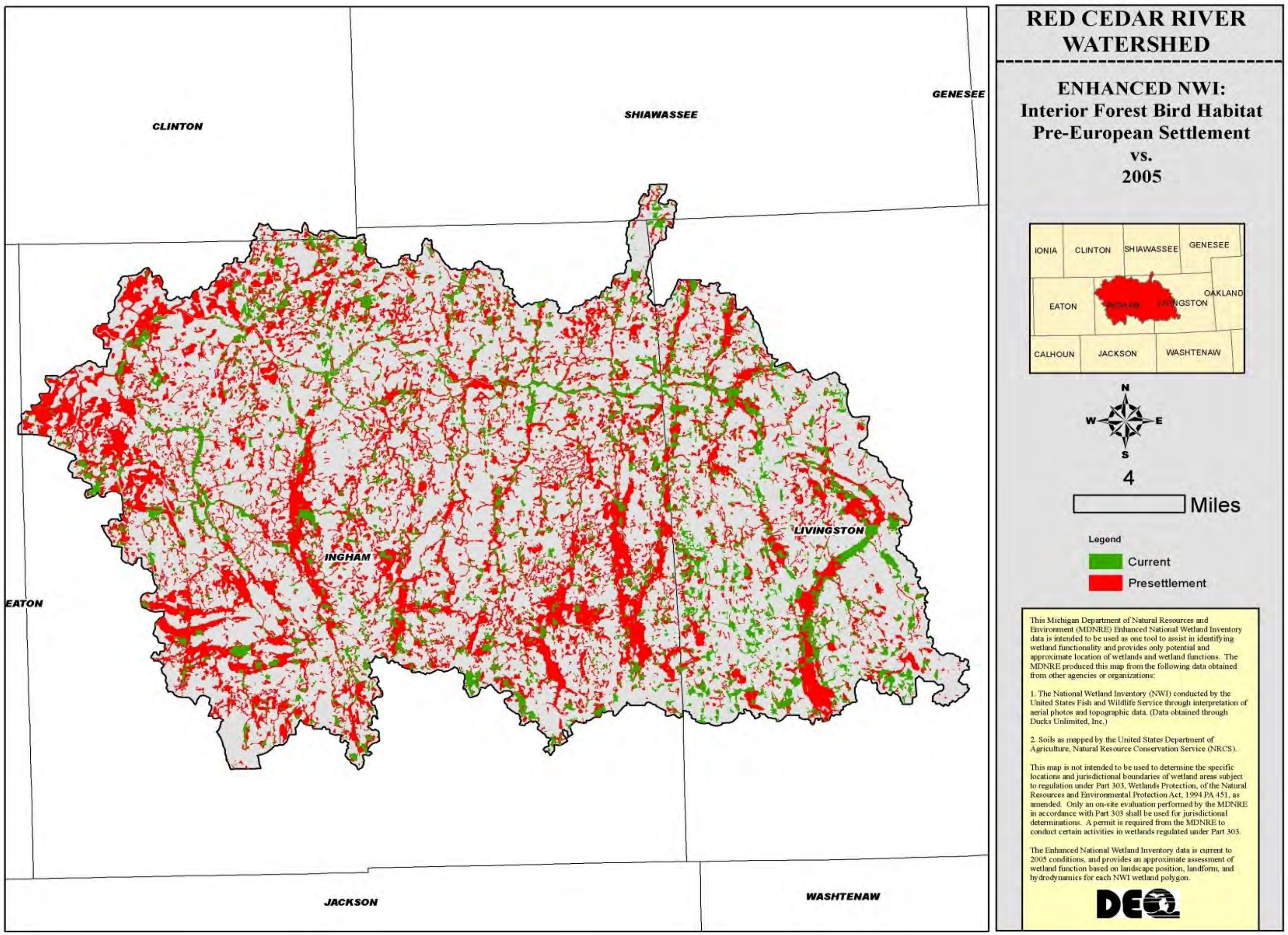
SHORE BIRD HABAITAT



INTERIOR FOREST BIRDS

- Interior Forest Birds require large forested areas to breed successfully and maintain viable populations. This diverse group includes colorful songbirds such as; tanagers, warblers, vireos that breed in North America and winter in the Caribbean, Central and South America, as well as residents and short-distance migrants such as; woodpeckers, hawks, and owls. They depend on large forested tracts, including streamside and floodplain forests. It is important to note that adjacent upland forest to these riparian areas are critical habitat for these species as well. This function attempts to capture wetland types most likely to provide habitat for these species.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

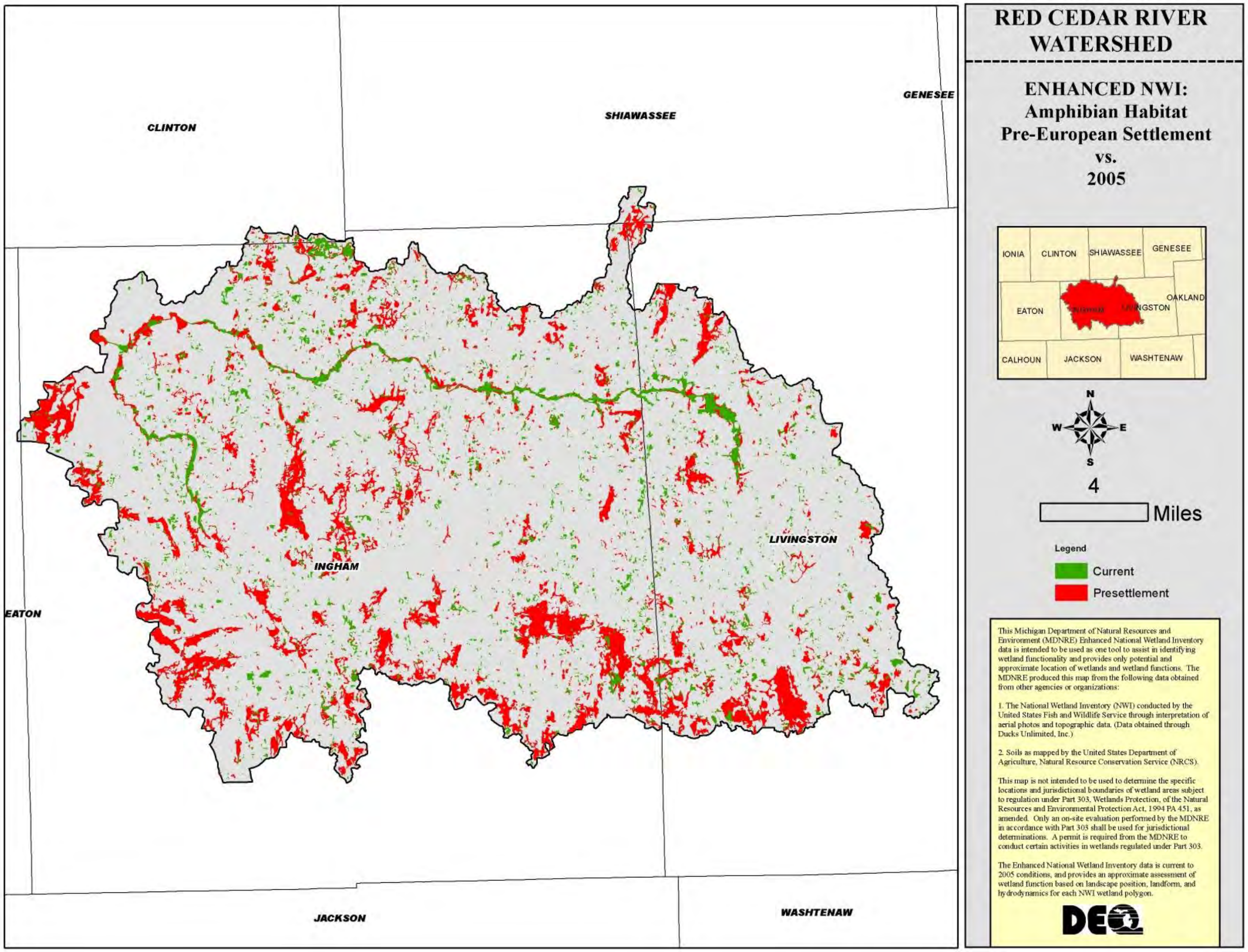
INTERIOR FOREST BIRD HABITAT



AMPHIBIAN HABITAT

- Amphibians share several characteristics in common including wet skin that functions in respiration and gelatinous eggs that require water or moist soil for development. Most amphibians have an aquatic stage and a terrestrial stage and thus live in both aquatic and terrestrial habitats. Aquatic stages of these organisms are often eaten by fish and so for certain species, successful reproduction may occur only in fish-free ponds. Common sub-groups of amphibians are salamanders, frogs, and toads. This function attempts to capture wetland types most likely to provide habitat for these species.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

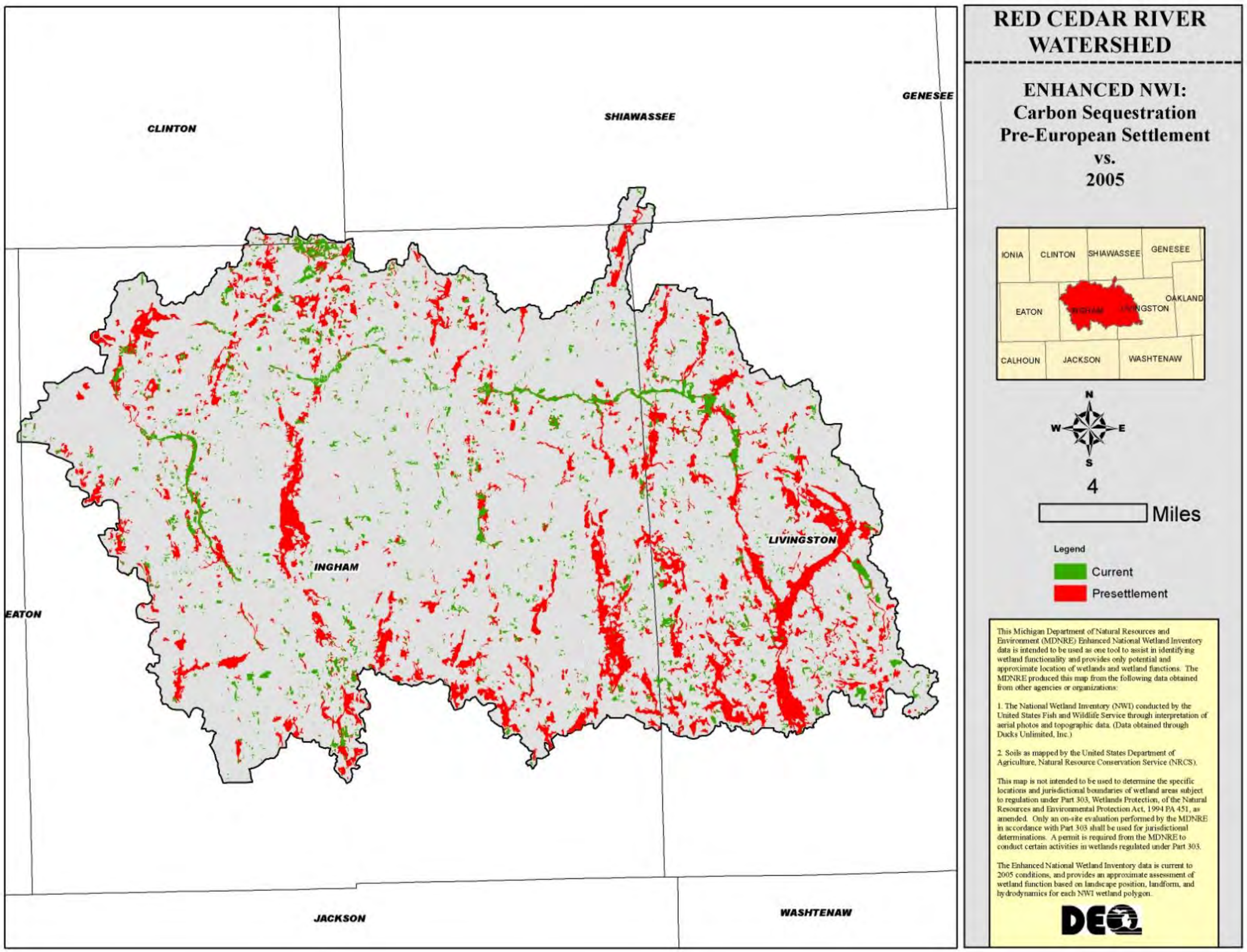
AMPHIBIAN HABITAT



CARBON SEQUESTRATION

- Wetlands are different from other biomes in their ability to sequester large amounts of carbon, as a consequence of high primary production and then deposition of decaying matter in the anaerobic areas of their inundated soils.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

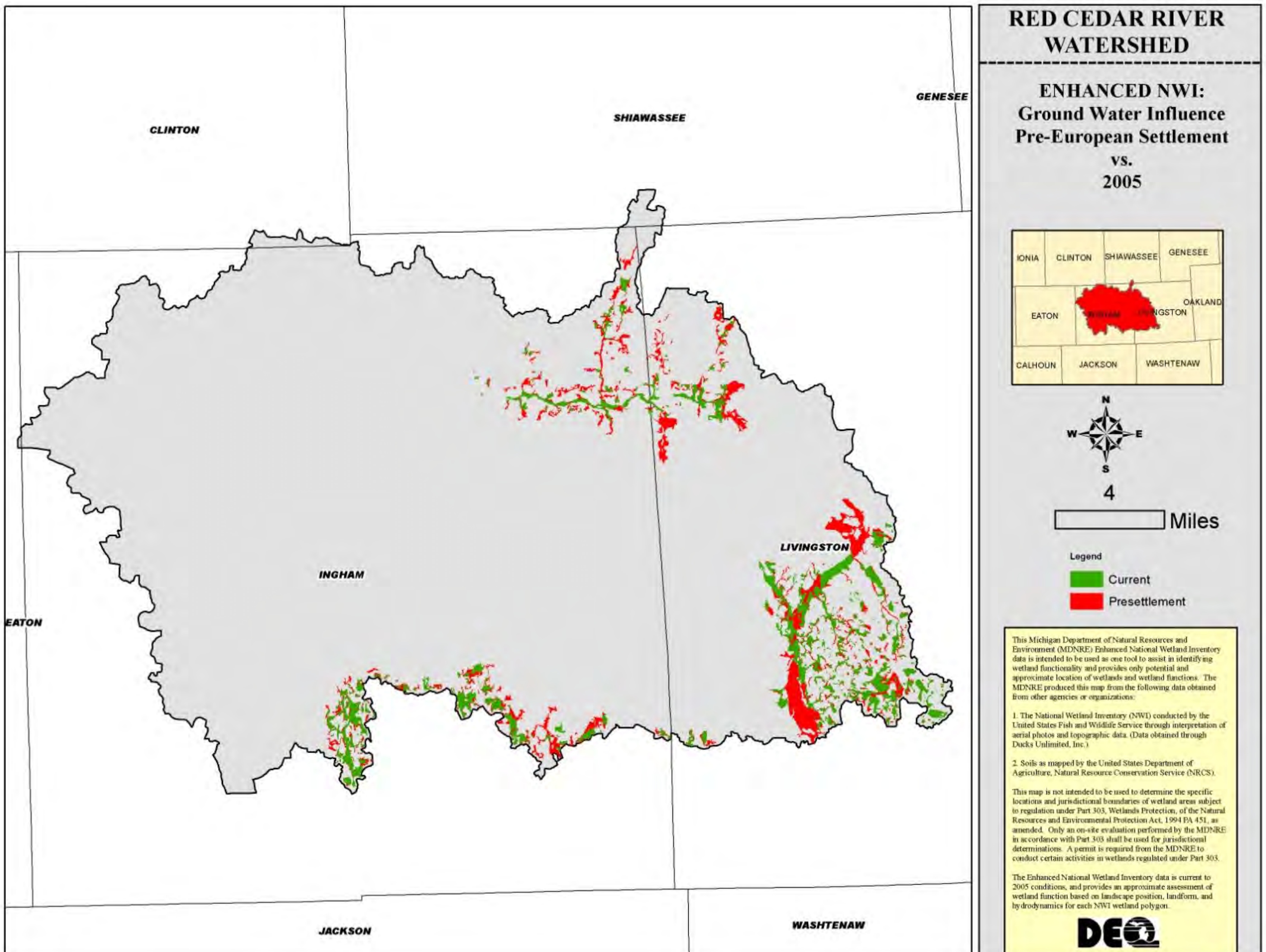
CARBON SEQUESTRATION



GROUND WATER INFLUENCE

- Wetlands categorized as High or Moderate for Groundwater Influence are areas that receive some or all of their hydrologic input from groundwater reflected at the surface. The DARCY (definition of acronym) model was the data source utilized to determine this wetland/groundwater connection, which is based upon soil transmissivity and topography. Wetlands rated for this function are important for maintaining streamflows and temperature control in waterbodies.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

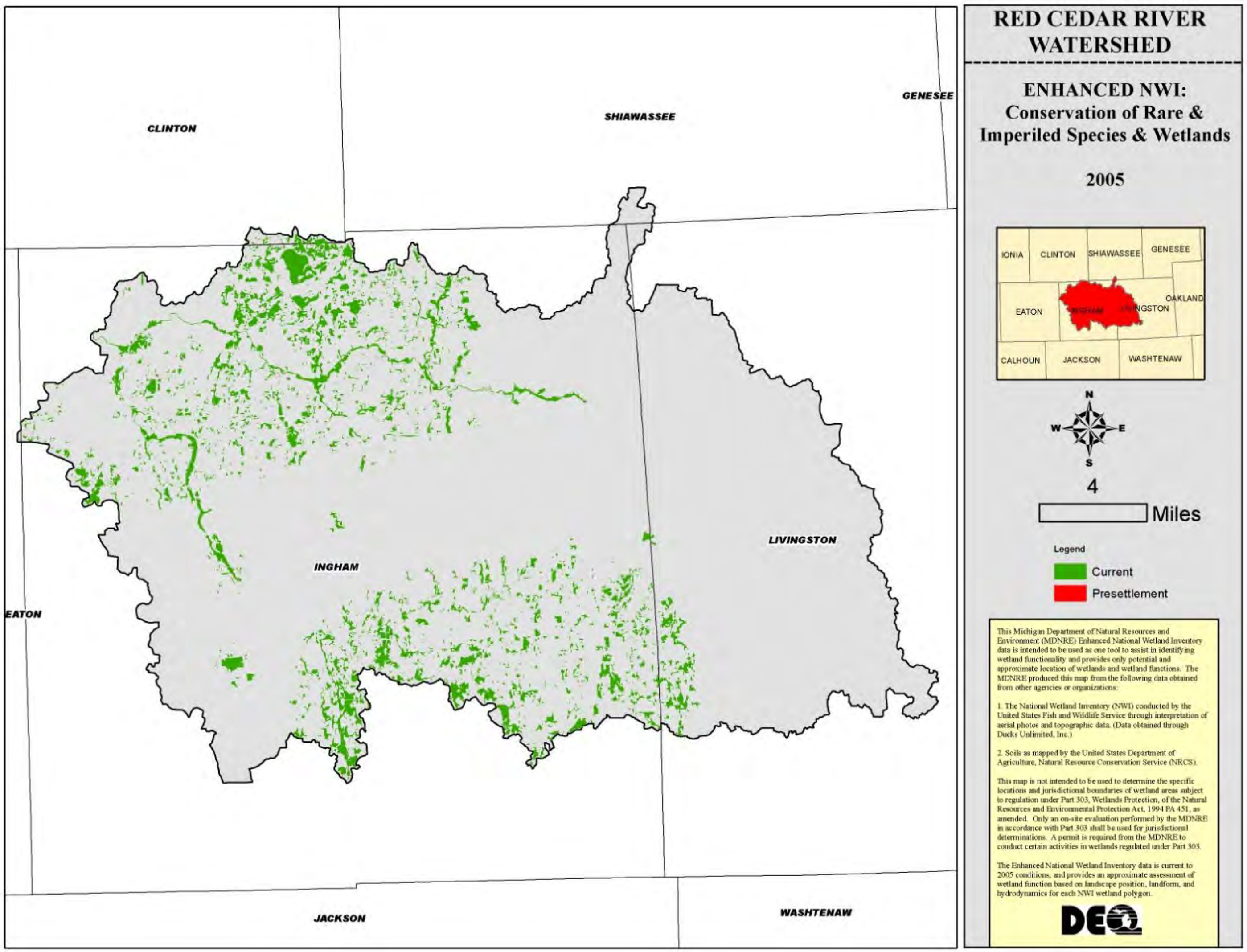
GROUND WATER INFLUENCE



CONSERVATION OF RARE AND IMPERILED WETLANDS & SPECIES

- Wetlands that are considered rare either globally or at the state level. They are likely to contain a wide variety of flora and fauna, or contain threatened or endangered species.
- This function is derived from the Michigan Natural Features Dataset (MNFI) of known sightings of threatened, endangered, or special concern species and high quality natural communities. The model values are reported on a 40 acre polygon grid for the state of Michigan, or a subset of MI. Due to this the dataset should not be used as a comprehensive inventory of Rare and Imperiled wetlands.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in (green) circa 2005.

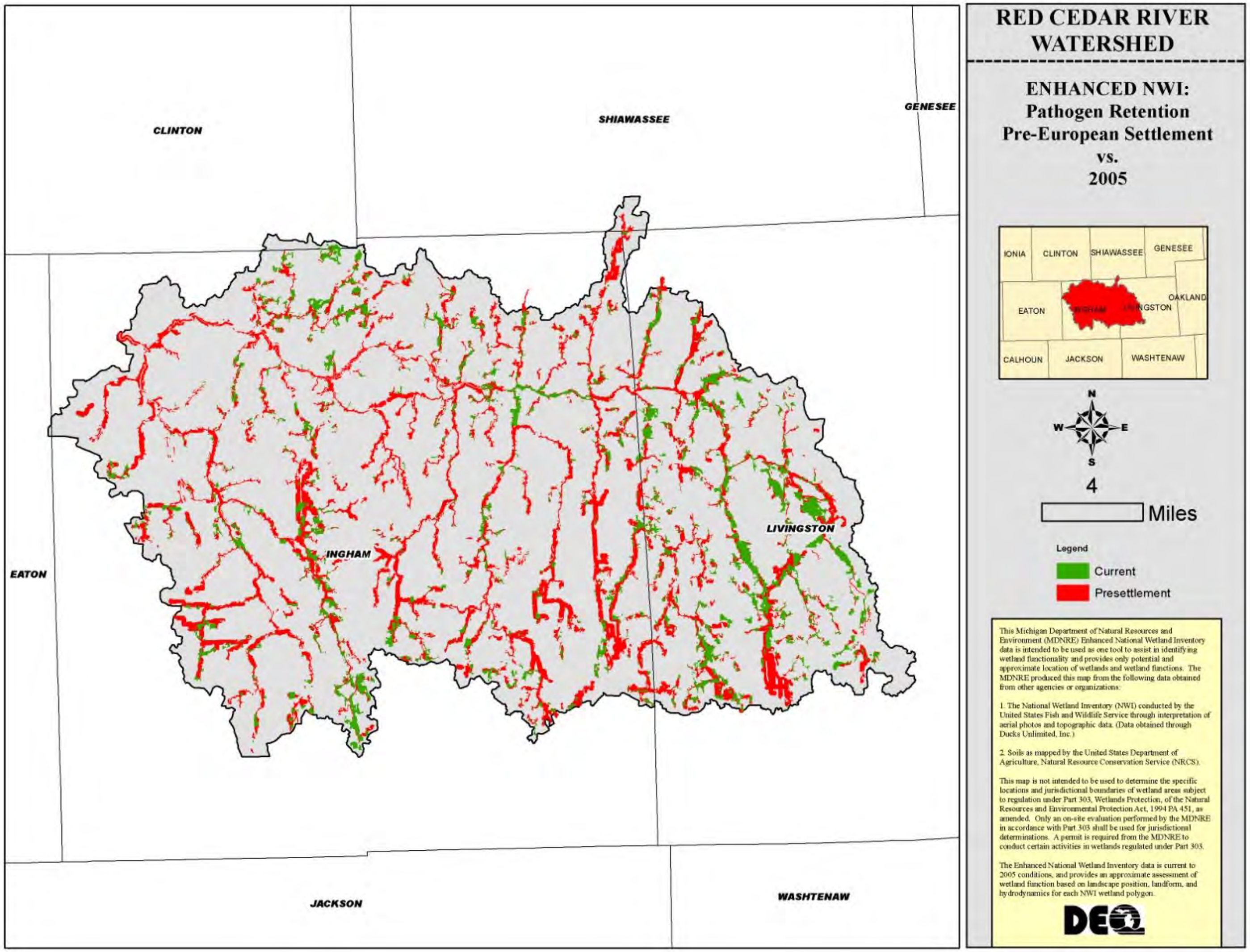
CONSERVATION OF RARE IMPERILED WETLANDS, & SPECIES



PATHOGEN RETENTION

- Wetlands can improve water quality through natural processes of filtration for sedimentation, nutrients and Escherichia coli (E. coli). E. coli is a sub-set of fecal coli forms whose presence in water indicates fecal contamination from warm blooded animals. The presence of E. coli indicates that contamination has occurred, and other harmful pathogens may also be present.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function at a high level are mapped in (green) circa 2005. Wetlands deemed valuable for restoration for this function are mapped in (red).

PATHOGEN RETENTION



Data Limitations and Disclaimer

National Wetlands Inventory Plus (NWI)

- Wetland boundaries determined from Aerial Imagery
- Last updated in 2005
- Obvious limitations to Aerial Photo Interpretation:
  - Errors of Omission (forested and drier-end wetlands)
  - Errors of Comission (misinterpretation of aerials)

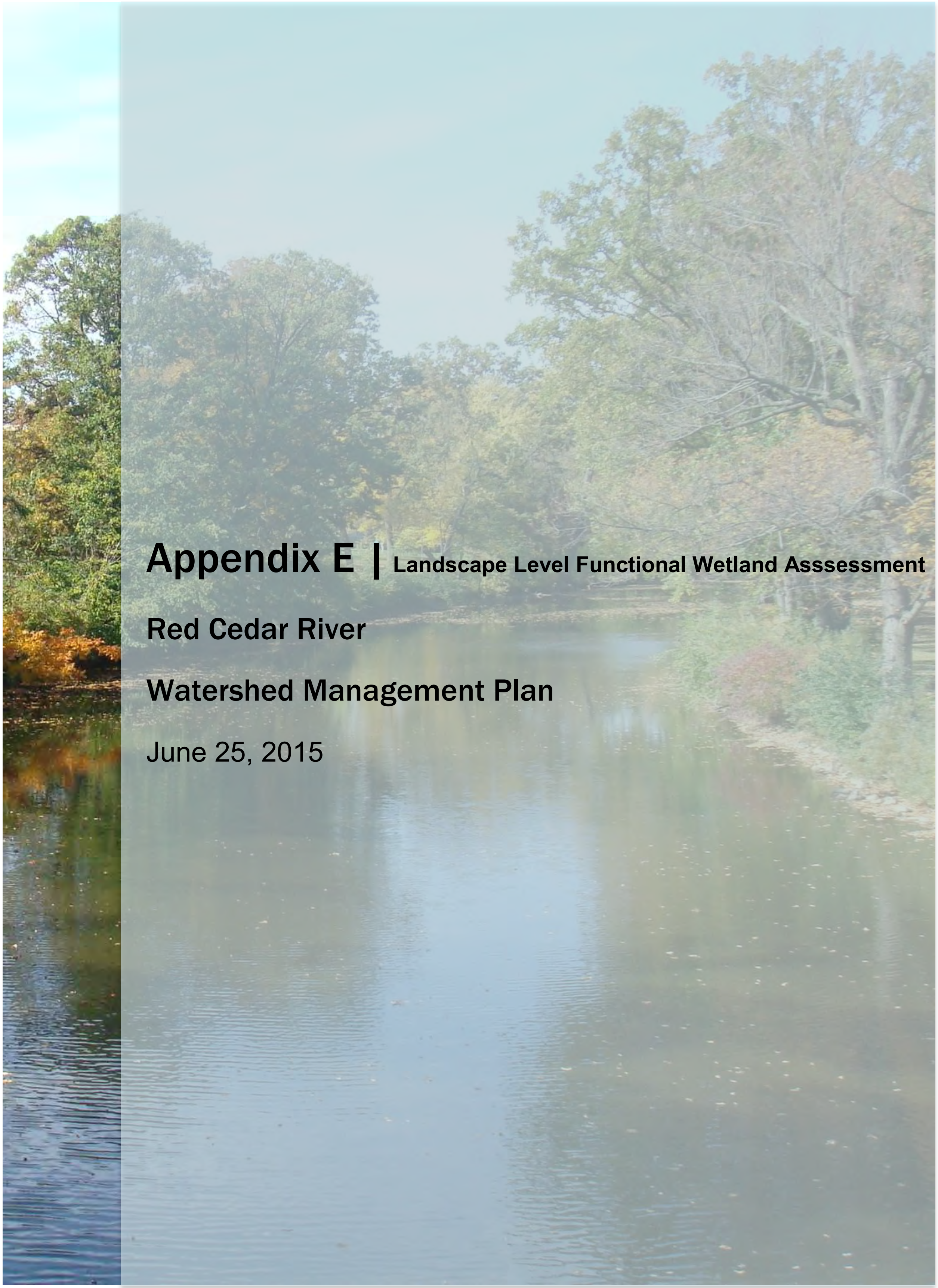
The 2005 NWI data was used in this analysis to report status and trends, as this is currently the best data source available. However, this data may not accurately reflect current conditions on the ground.

Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

Landscape Level Wetland Functional Assessment (LLWFA)

- Source data are a primary limiting factor.
- Wetland mapping limitations due to scale, photo quality, and date and time of year of the photos.

- Functional assessment is a preliminary one based on:
  - Wetland Characteristics interpreted through remote sensing
  - Professional Judgment of various specialists to develop correlations between those wetlands and their functions.
- Watershed-based Preliminary Assessment of wetland functions:
  - Applies general knowledge about wetlands and their functions
  - Develops a watershed overview that highlights possible wetlands of significance
  - Does not consider the condition of the adjacent upland
  - Does not obviate the need for more detailed assessment of various functions
- This analysis is a "Landscape Level" assessment and used to identify wetlands that are likely to perform a given function at a level above that of other wetlands not designated



Appendix E | Landscape Level Functional Wetland Asssessment

Red Cedar River

Watershed Management Plan

June 25, 2015

RED CEDAR RIVER WATERSHED

Landscape Level Wetland Functional Assessment

(Enhanced NWI)

Department of Environmental Quality

12-7-2012

RED CEDAR WATERSHED
Wetland Resources Status and Trends

Pre-settlement Wetland conditions

- 92,367 Acres of Wetlands
- 4,749 Polygons
- Average Size – 19 Acres

2005 Wetland Condition

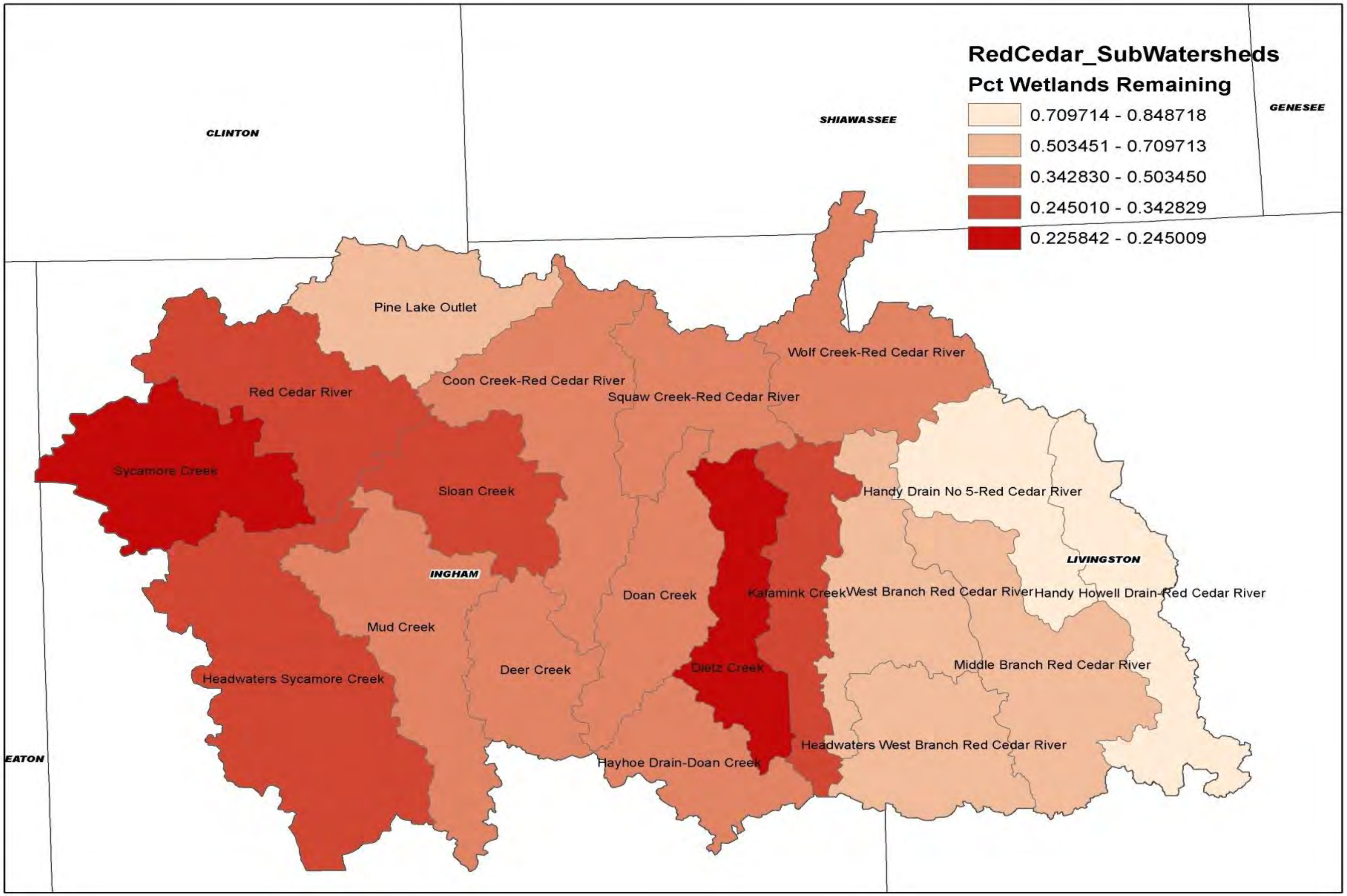
- 40,681 Acres of Wetlands
- 7,225 Polygons
- Average Size – 5.6 Acres

44% OF ORIGINAL WETLAND ACREAGE REMAINS
56% LOSS OF TOTAL WETLAND RESOURCE

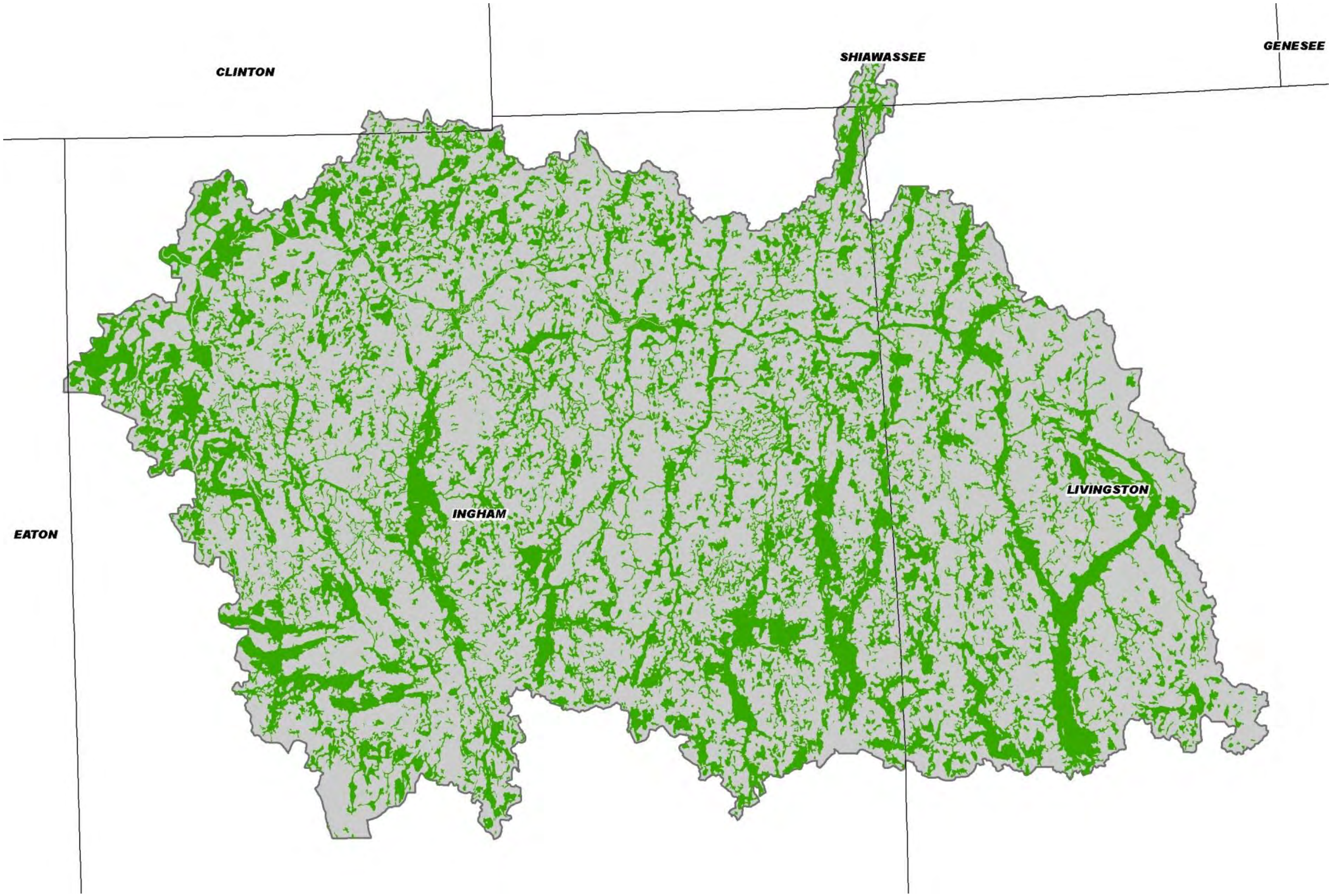
TOTAL ACREAGE LOSS OF:
51,686 ACRES

* These figures exclude open water type wetlands

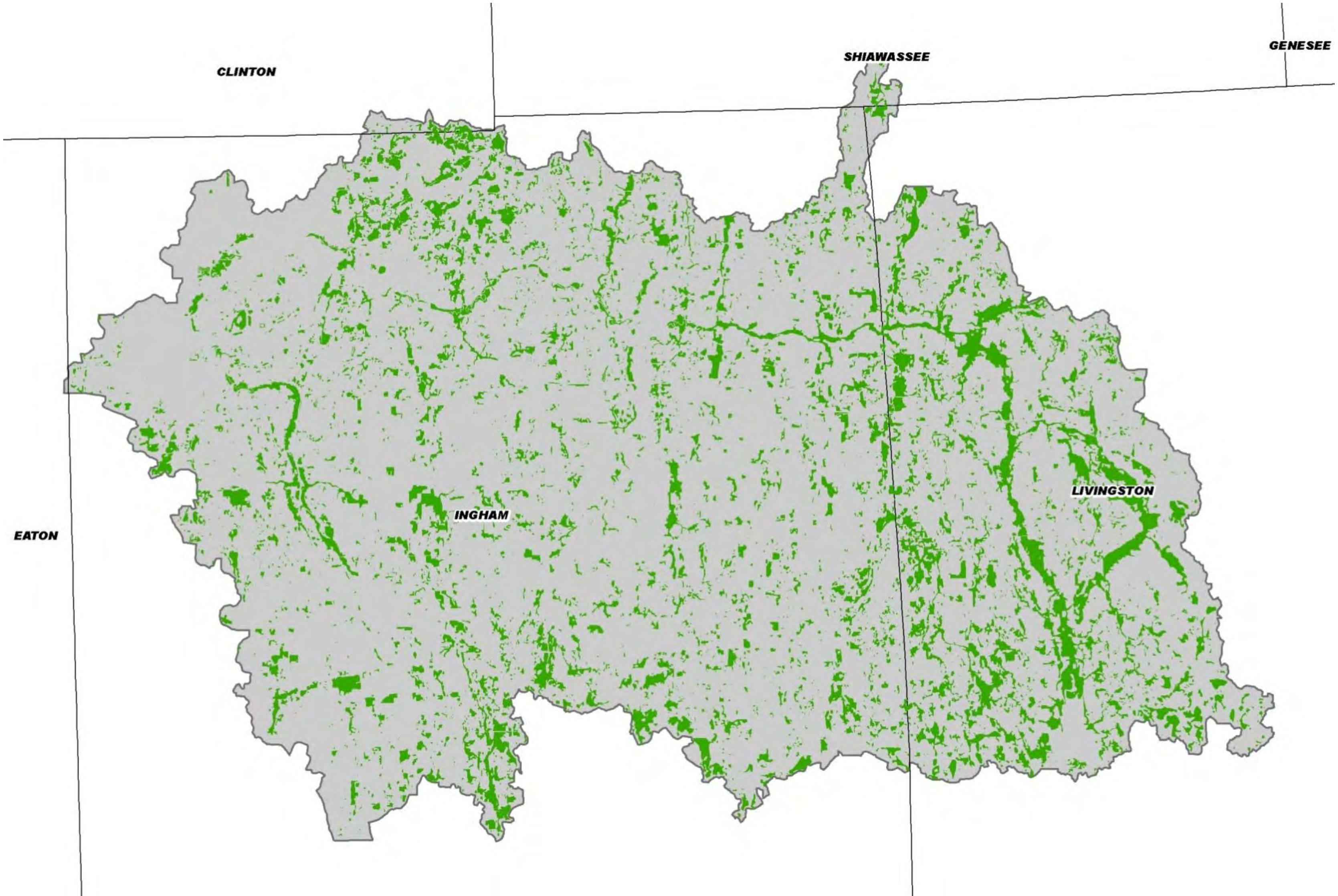
Percentage of Remaining Wetlands



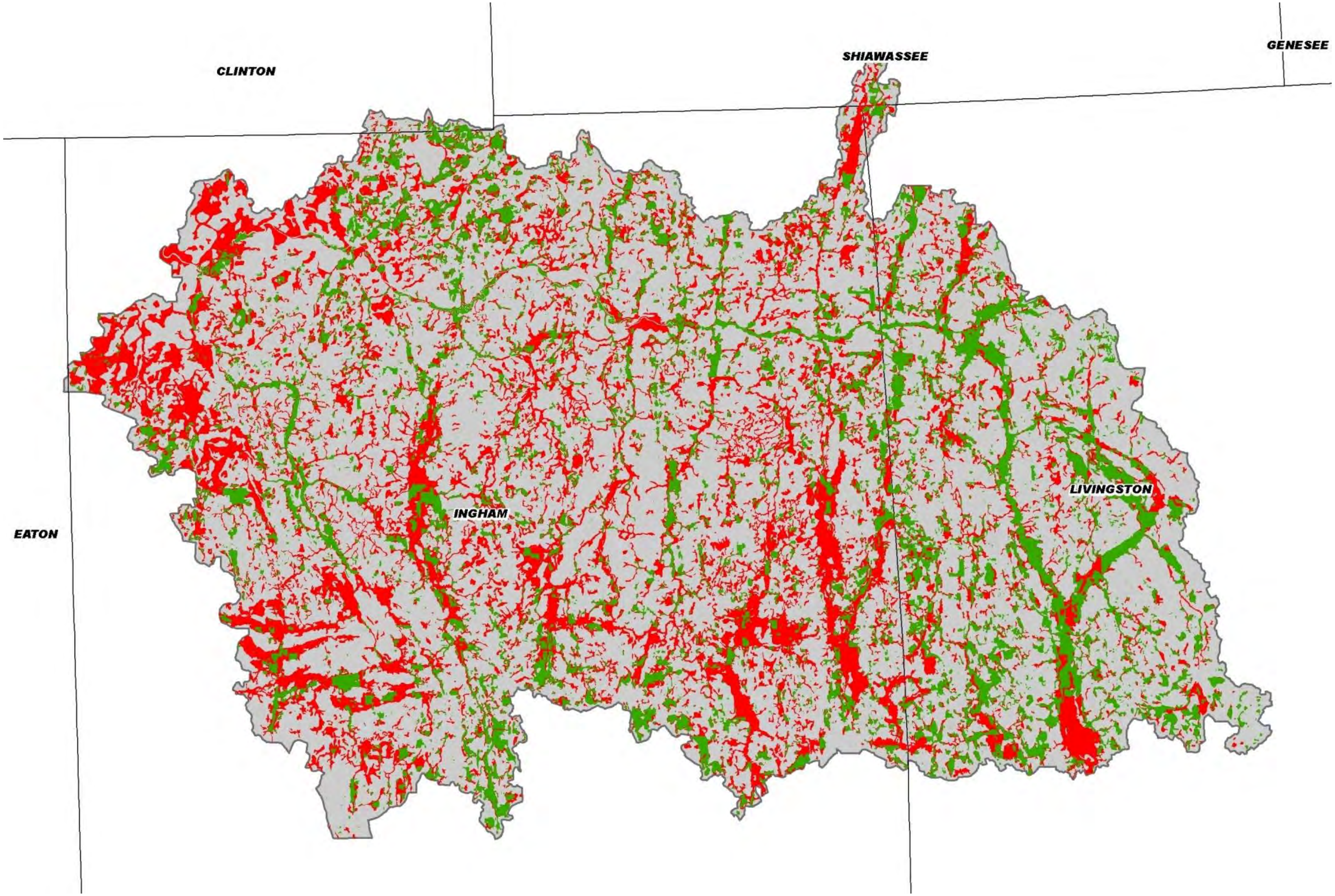
PRE-EUROPEAN SETTLEMET WETLAND COVERAGE



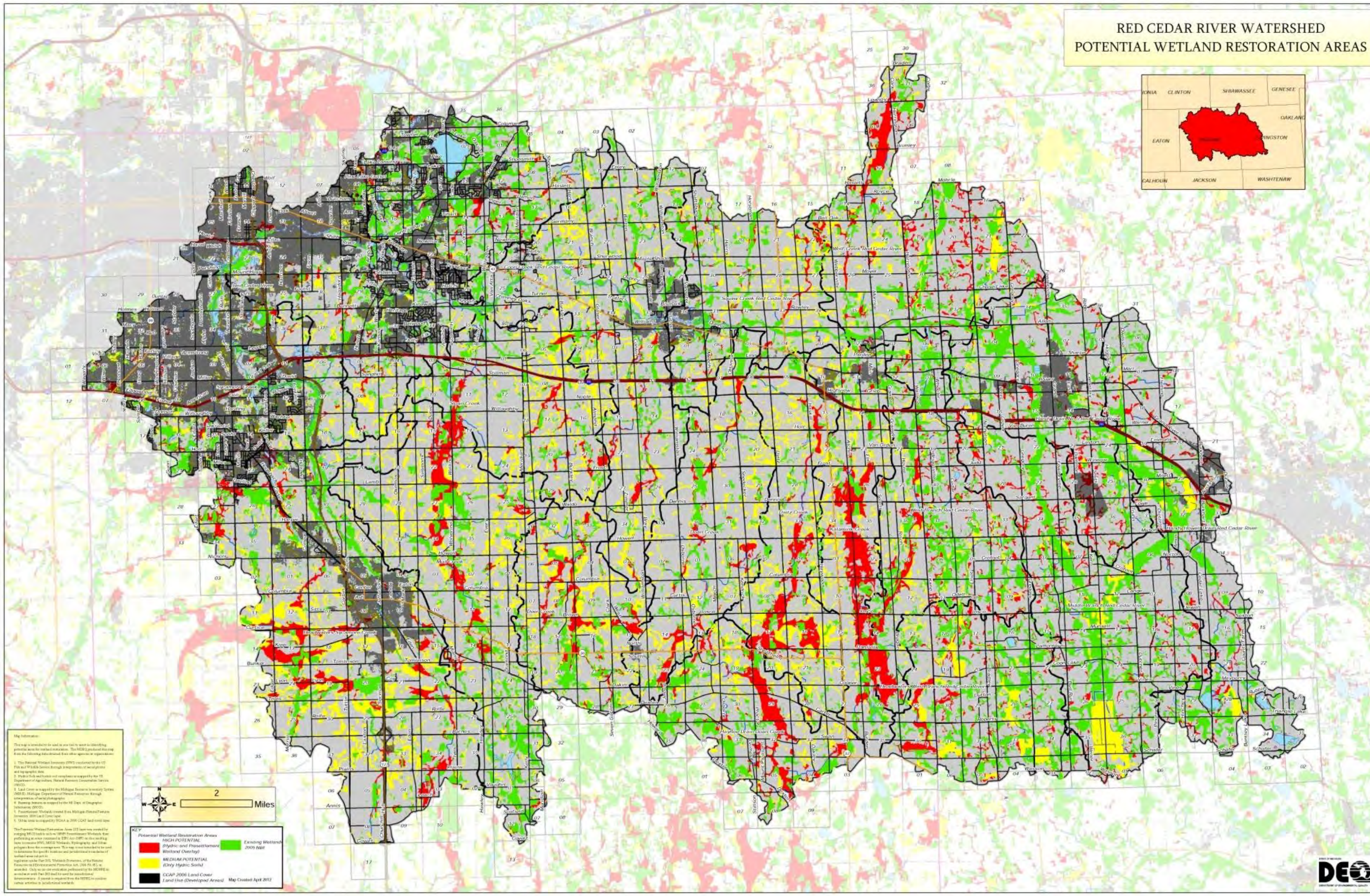
2005 WETLAND COVERAGE



APPROXIMATE WETLAND LOSS PRE-EUROPEAN SETTLEMENT TO 2005



RED CEDAR WATERSHED



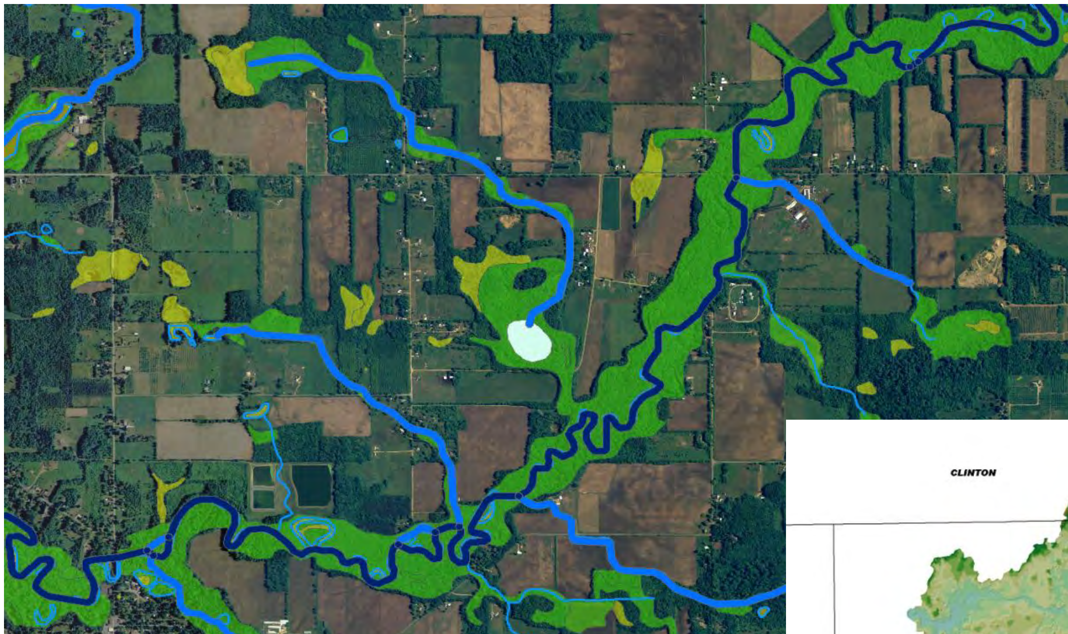
NWI TYPE COMPARISON

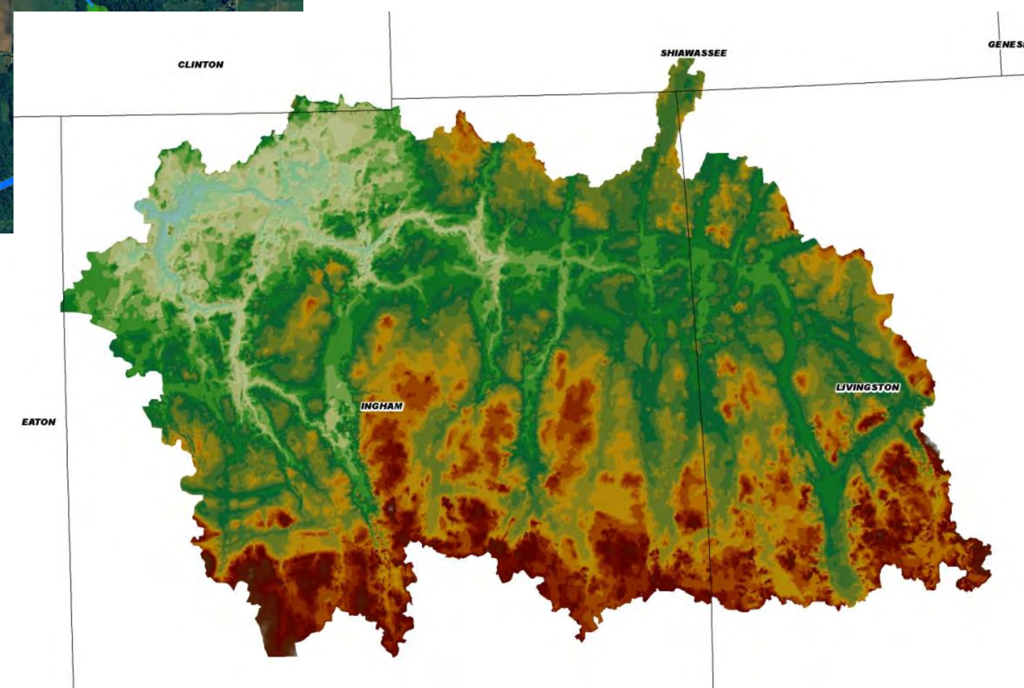
Table 1: Generalized NWI type comparison

Wetland Type	Pre-European Settlement Acres	2005 Acres of Wetlands	Net Acres Remaining
Palustrine Emergent	5,400	13,505*	100%
Palustrine Forested	80,664	21,189**	26%
Palustrine Shrub-Scrub	6,301***	5,787****	91%
Other Palustrine			
Ponds	0*****	1,376	100%
Total	92,365	41,857	45%

*Includes mixed emergent wetland classes and mixed communities where subclasses include Forested and Shrub-Scrub Areas
**Includes mixed forested wetland classes and mixed communities where subclasses include Emergent and Shrub-Scrub Areas
*** Includes mixed Shrub-Scrub/Emergent communities
****Includes mixed shrub-scrub wetland classes and mixed communities where subclasses include Emergent, Forested and Shrub-Scrub
***** Little acreage in ponds due to mapping differences between Pre-Settlement and Current wetland coverage's.

ENHANCING NWI FOR LANDSCAPE-LEVEL WETLAND FUNCTIONAL ASSESSMENT IN THE RED CEDAR RIVER WATERSHED





Using NWI for Functional Assessment

- Lack of hydro-geomorphic (HGM) information
  - No landscape position
  - No landform
  - No water flow direction
  - General pond classification
  - Features important for assessing many functions are lacking
- *Most of these features can be interpreted from the maps*

What information can we extract from NWI?

How many wetlands are there?

What is the size range of wetlands?

What is the average size of a given wetland type?

How many wetlands are in various size classes?

…With HGM information added?

How much and how many

- occur along rivers?
- along streams?
- in lake basins?
- are isolated?
- are sources of streams?
- have inflow but no outflow?
- are connected to other wetlands?
- What types of ponds are there and what is their extent?

Wetland Landscape Positions

- Landscape Position
  - Terrene
  - Lentic
  - Lotic River
  - Lotic Stream

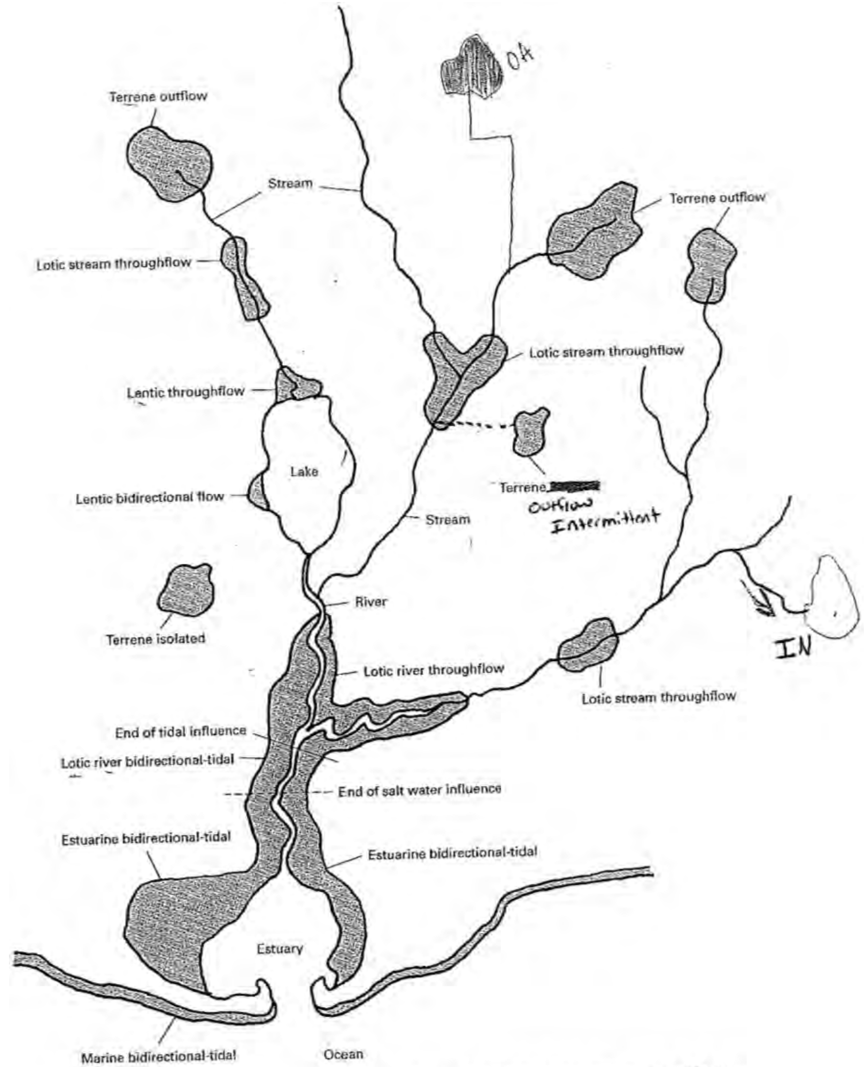


Figure 14.4. Typical wetland landscape positions and water flow paths in the eastern United States.

TERRENE

LENTIC

LOTIC

RIVER

STREAM

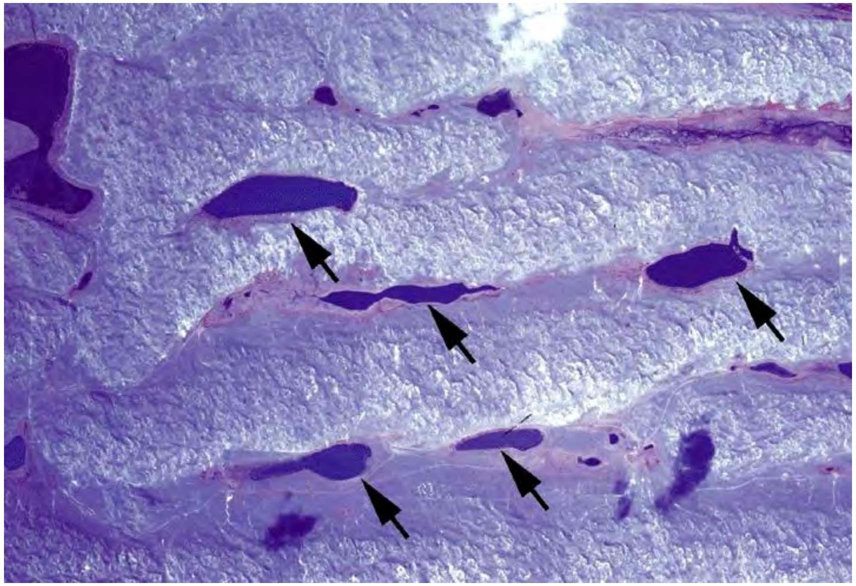
Wetland Landform Types

- Fringe
- Basin
- Flat
- Floodplain
- Slope

FRINGE




BASIN



FLAT

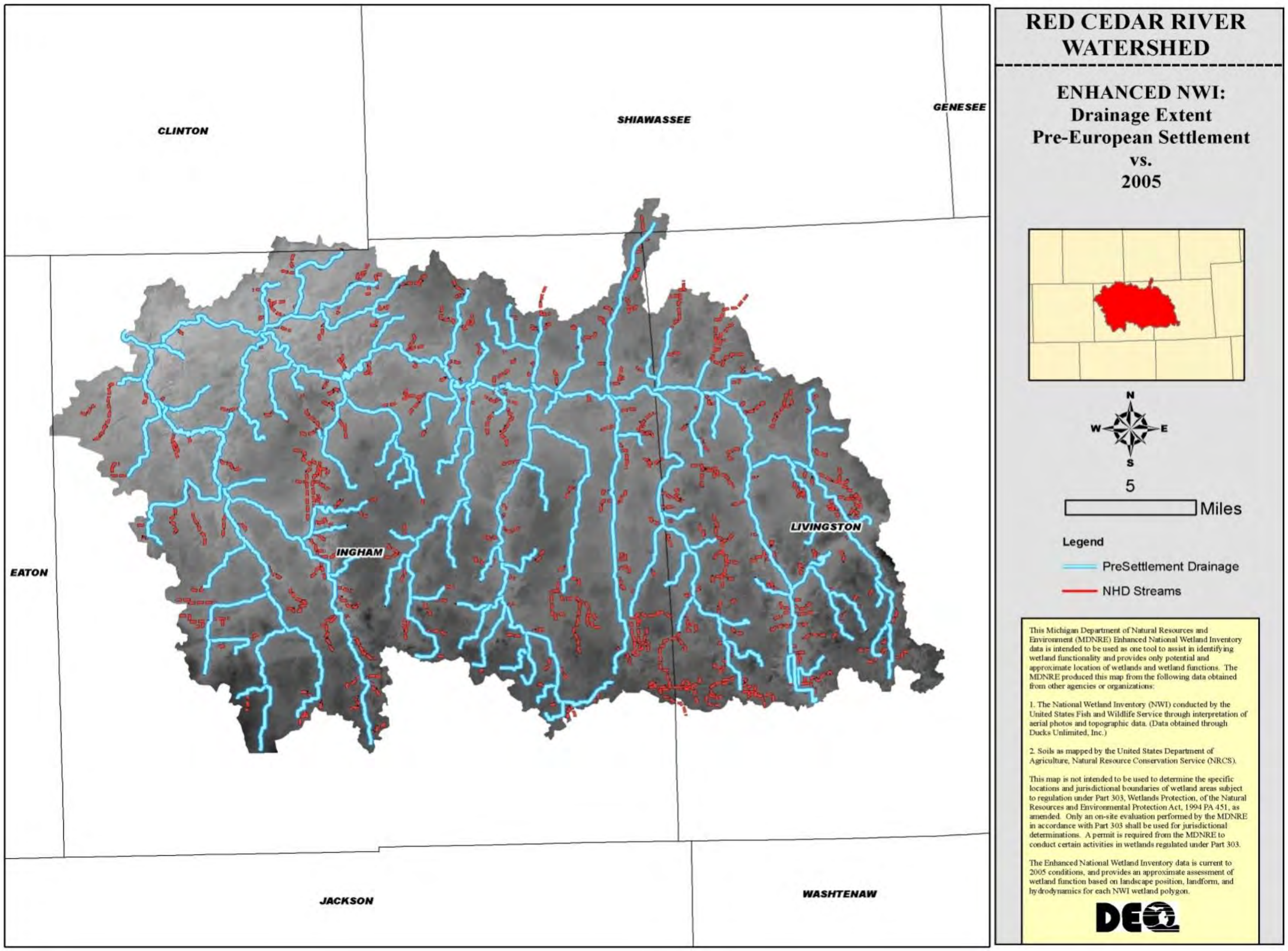
FLOODPLAIN

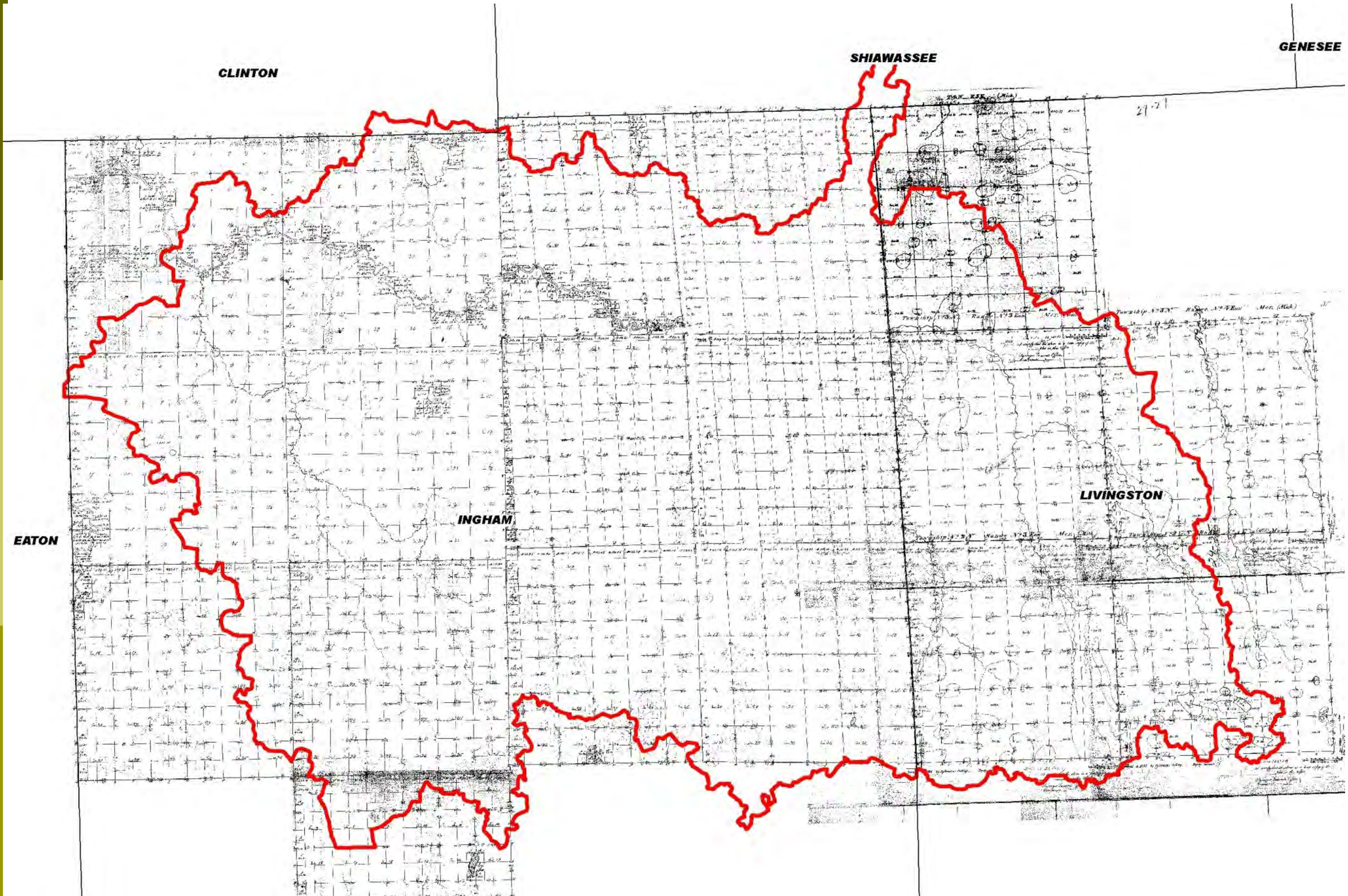
SLOPE

Evaluated Wetland Functions

- Flood Water Storage
- Streamflow Maintenance
- Nutrient Transformation
- Sediment and Other Particulate Retention
- Shoreline Stabilization
- Stream Shading
- Conservation of Rare and Imperiled Wetlands
- Ground Water Influence
- Fish Habitat
- Waterfowl/Waterbird Habitat
- Shorebird Habitat
- Interior Forest Bird Habitat
- Amphibian Habitat
- Carbon Sequestration
- Pathogen Retention

DRAINAGE EXTENT




CLINTON
SHIAWASSEE
GENESEE
EATON
INGHAM
LIVINGSTON

DETAILED FUNCTIONAL COMPARISONS

Table 2: Detailed Functional Comparisons

Function	Potential Significance	Pre-European Settlement Acreage	2005 Acreage	% Change in Acreage
Flood Water Storage	High	30,750.40	20,696.75	-33
	Moderate	52,074.23	2,725.80	-95
	Total	82,824.63	23,422.55	-72
Streamflow Maintenance	High	65,535.45	24,176.88	-63
	Moderate	13,085.83	8,323.47	-36
	Total	78,621.28	32,500.35	-59
Nutrient Transformation	High	35,096.34	30,158.40	-14
	Moderate	57,271.21	10,523.30	-82
	Total	92,367.55	40,681.70	-56
Sediment and Retention of Other Particulates	High	35,090.54	9,901.24	-72
	Moderate	13,010.40	13,522.97	4 *
	Total	48,100.94	23,424.21	-51
Shoreline Stabilization	High	27,608.44	13,453.32	-51
	Moderate	44,325.34	16,464.63	-63
	Total	71,933.78	29,917.95	-58
Fish Habitat	High	72,758.52	8,511.63	-88
	Moderate	7,575.61	16,481.77	118 *
	Total	80,334.13	24,993.40	-69
Stream Shading	High	18,861.10	4,459.50	-76
	Moderate	2,789.30	1,964.60	-30
	Total	21,650.40	6,424.10	-70

* Increases in the moderate & high category in the functions above can be attributed to the mapping differences in the two wetland layers and may not represent the current conditions on the ground.

DETAILED FUNCTIONAL COMPARISONS CONT…

Function	Potential Significance	Pre-European Settlement Acreage	2005 Acreage	% Change in Acreage
Waterfowl/Waterbird Habitat	High	5,933.50	14,230.04	140 *
	Moderate	11,313.20	15,890.60	40 *
	Total	17,246.70	30,120.64	75 *
Shorebird Habitat	High	0.00	56.30	Null
	Moderate	92,367.55	40,482.15	-56
	Total	92,367.55	40,538.45	-56
Interior Forest Bird Habitat	High	9,302.01	8,053.80	-13
	Moderate	77,664.80	18,923.10	-76
	Total	86,966.81	26,976.90	-69
Amphibian Habitat	High	32,684.60	8,038.20	-75
	Moderate	4,692.30	5,384.93	15 *
	Total	37,376.90	13,423.13	-64
Carbon Sequestration	High	3,415.21	6,207.30	82 *
	Moderate	33,961.67	5,056.30	-85
	Total	37,376.88	11,263.60	-70
Ground Water Influence	High	45.40	13.13	-71
	Moderate	12,892.31	7,869.55	-39
	Total	12,937.71	7,882.68	-39
Conservation of Rare & Imperiled Wetlands & Species	High	Null	4,079.21	Null
	Moderate	Null	14,529.90	Null
	Total	Null	18,609.11	Null

* Increases in the moderate & high categories in the functions above can be attributed to the mapping differences in the two wetland layers and may not represent the current conditions on the ground.

FUNCTIONAL ACRES COMPARISON

Table 3: Functional Acres comparison

Function	Pre-European Settlement Functional Acres	2005 Functional Acres	Predicted % of Original Capacity Left	Predicted % Change in Functional Capacity
Flood Water Storage	113,575.03	44,119.30	39	-61
Streamflow Maintenance	144,156.73	56,677.23	39	-61
Nutrient Transformation	127,463.89	70,840.10	56	-44
Sediment and Other Particulate Retention	83,191.48	33,325.45	40	-60
Shoreline Stabilization	99,542.22	43,371.27	44	-56
Fish Habitat	153,092.65	33,505.03	22	-78
Stream Shading	40,511.50	10,883.60	27	-73
Waterfowl and Waterbird Habitat	23,180.20	44,350.68	191	91 *
Shorebird Habitat	92,367.55	40,594.75	44	-56
Interior Forest Bird Habitat	96,268.82	35,030.70	36	-64
Amphibian Habitat	70,061.50	21,461.33	31	-69
Carbon Sequestration	40,792.09	17,470.90	43	-57
Ground Water Influence	12,983.11	7,895.81	61	-39
Conservation of Rare & Imperiled Wetlands & Species	0	22,688.32	100	100

- Increases in the predicted percent change functional capacity in the functions above can be attributed to the mapping differences in the two wetland layers and may not represent the current conditions on the ground.

Frequency of Functions

Pre-Settlement

# of Wetlands	# of Functions	ACRES
10	1	485
14	2	757
613	3	7,891
579	4	1,692
44	5	184
232	6	5,243
716	7	15,200
1,045	8	19,075
611	9	14,724
429	10	13,930
411	11	12,856
66	12	1,709
1	13	2

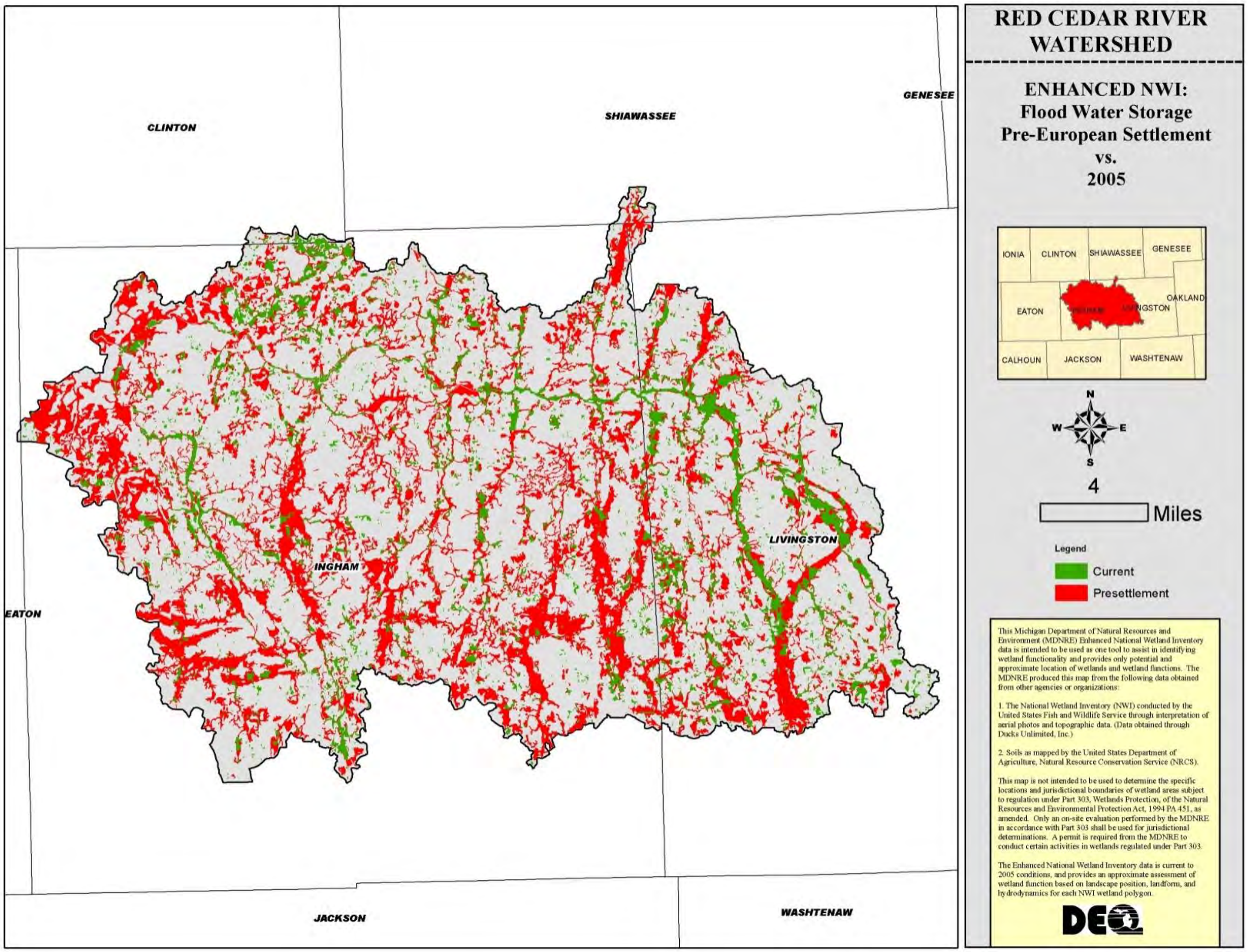
Current

# of Wetlands	# of Functions	ACRES
484	1	570
1,148	2	1,795
575	3	1,854
520	4	1,313
794	5	2,235
465	6	4,682
950	7	5,099
2,086	8	11,182
1,438	9	8,723
436	10	2,158
238	11	1,691
151	12	2,324
16	13	325

FLOOD WATER STORAGE

- This function is important for reducing the downstream flooding and lowering flood heights, both of which aid in minimizing property damage and personal injury from such events.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

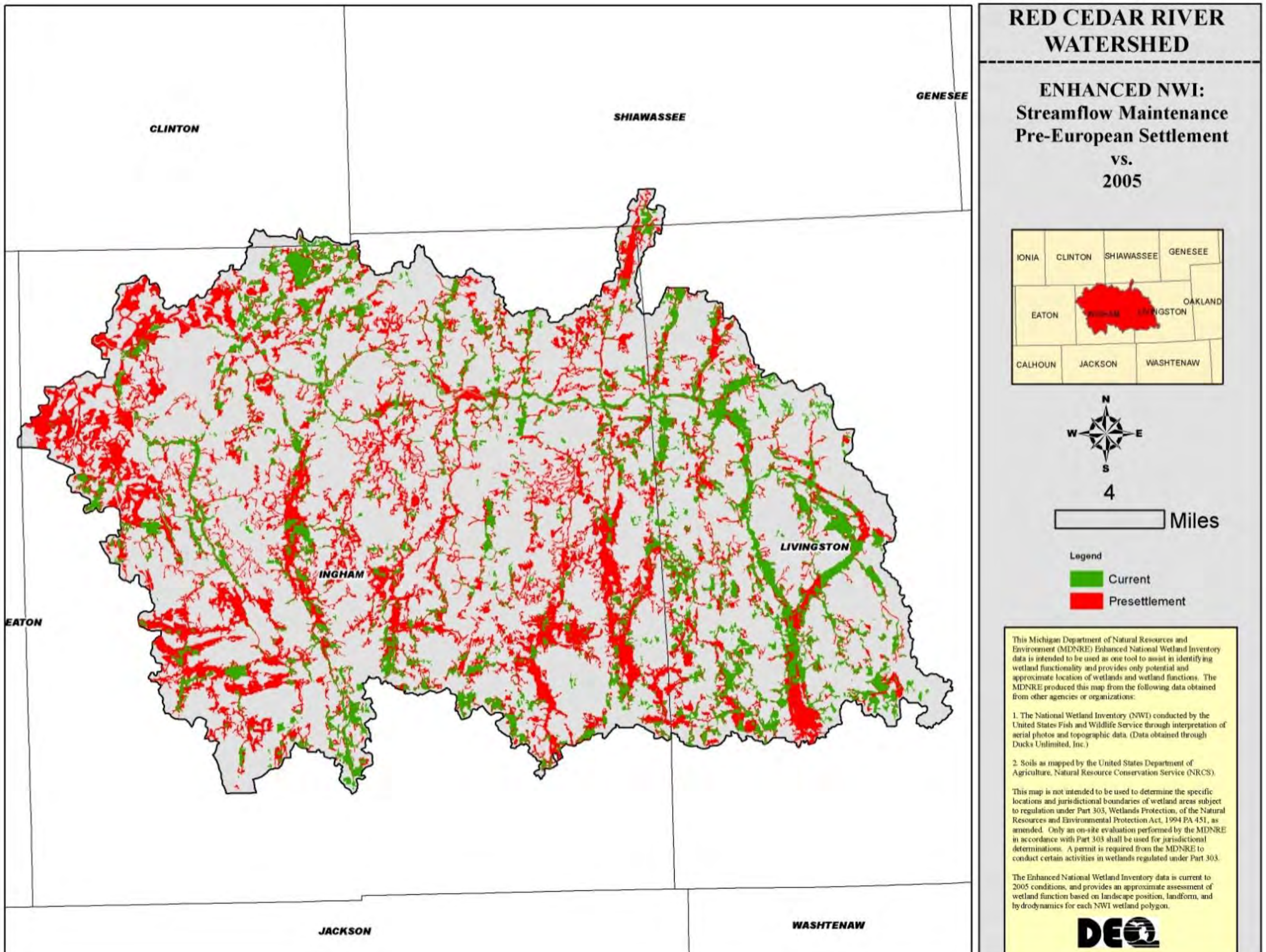
FLOOD WATER STORAGE



STREAMFLOW MAINTENANCE

- Wetlands that are sources of groundwater discharge that sustain streamflow in the watershed. Such wetlands are critically important for supporting aquatic life in streams. All wetlands classified as headwater wetlands are important for streamflow.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

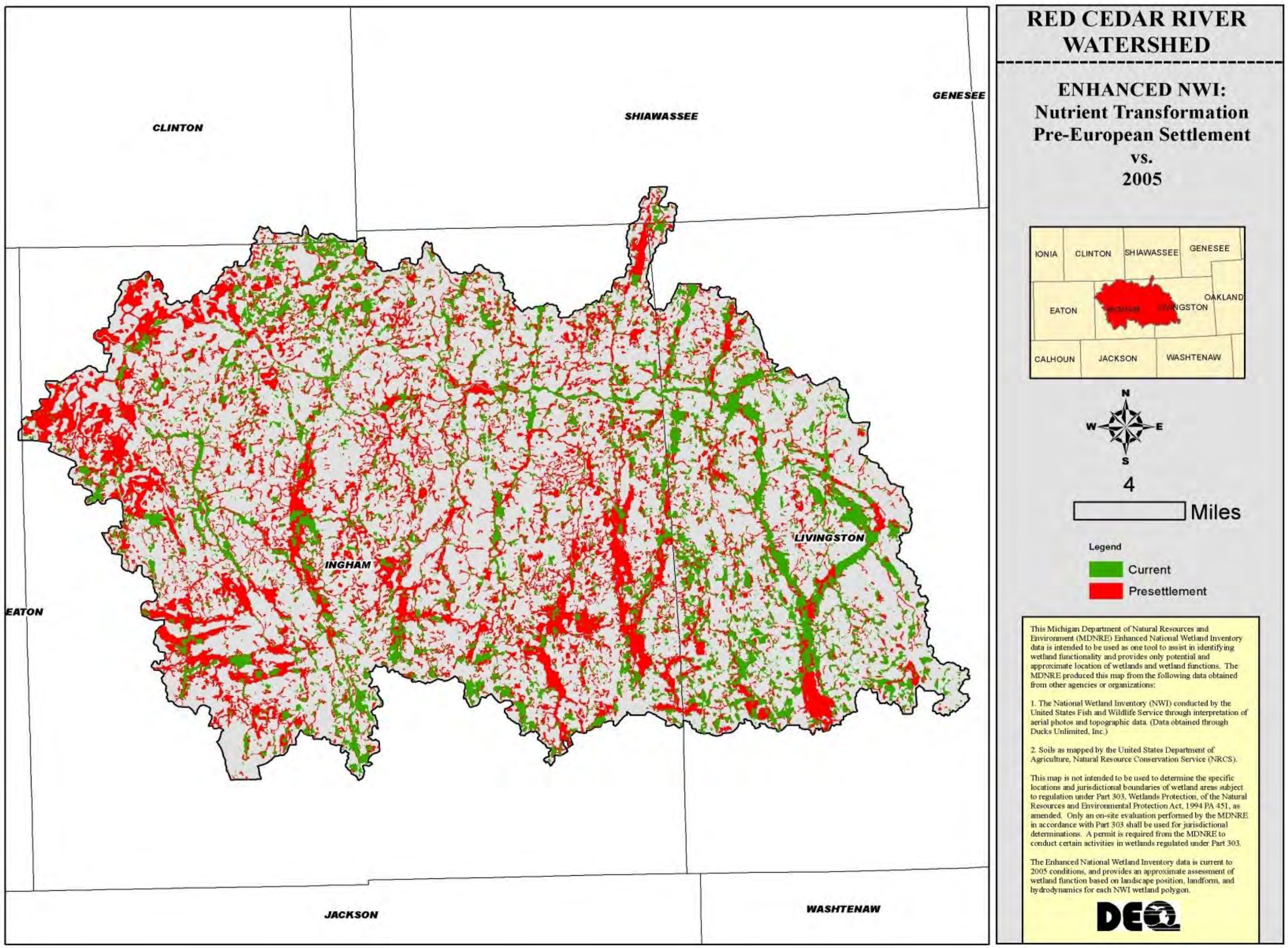
STREAMFLOW MAINTENANCE



NUTRIENT TRANSFORMATION

- Wetlands that have a fluctuating water table are best able to recycle nutrients. Natural wetlands performing this function help improve local water quality of streams and other watercourses.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

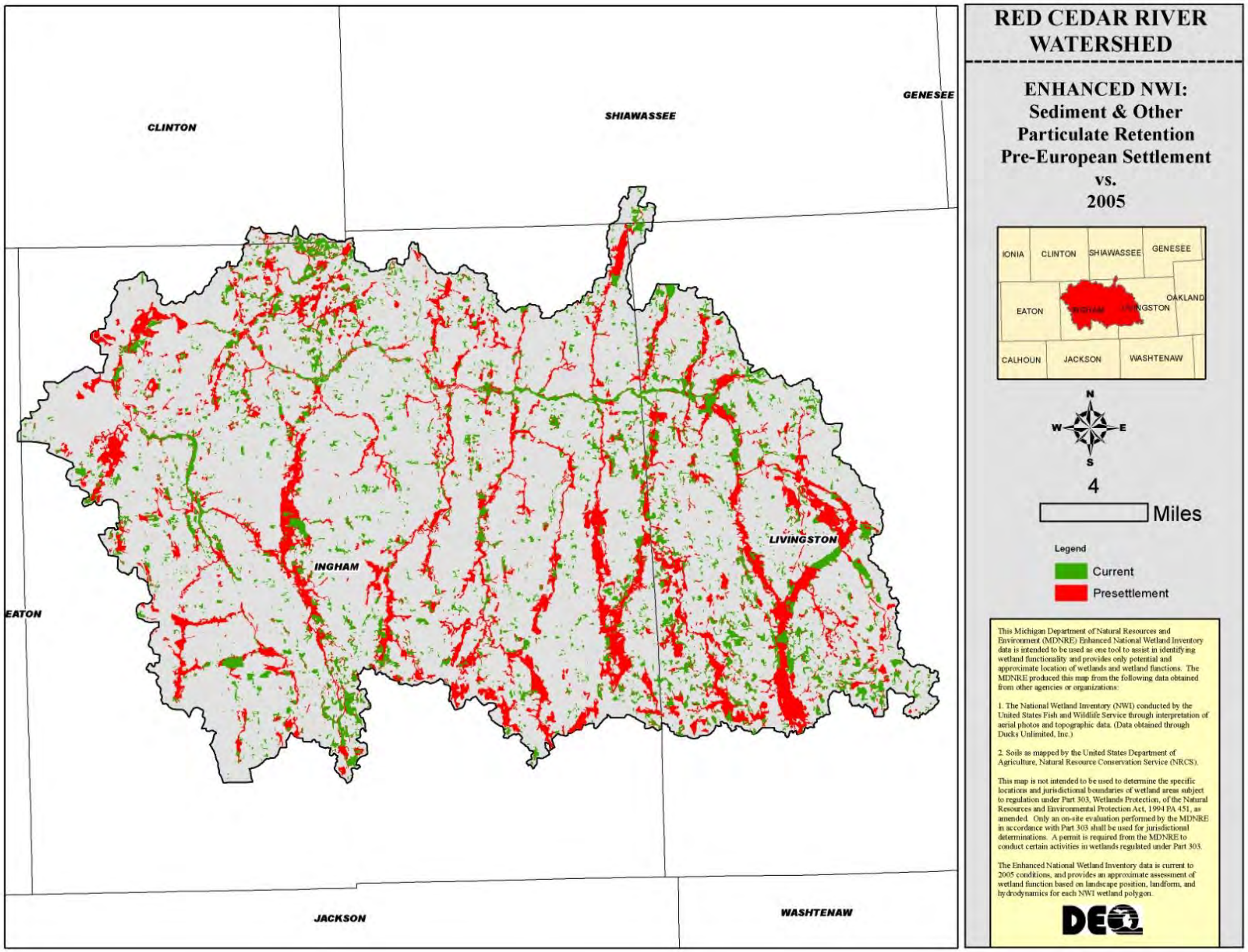
NUTRIENT TRANSFORMATION



SEDIMENT AND OTHER PARTICULATE RETENTION

- This function supports water quality maintenance by capturing sediments with bonded nutrients or heavy metals. Vegetated wetlands will perform this function at higher levels than those of non-vegetated wetlands.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

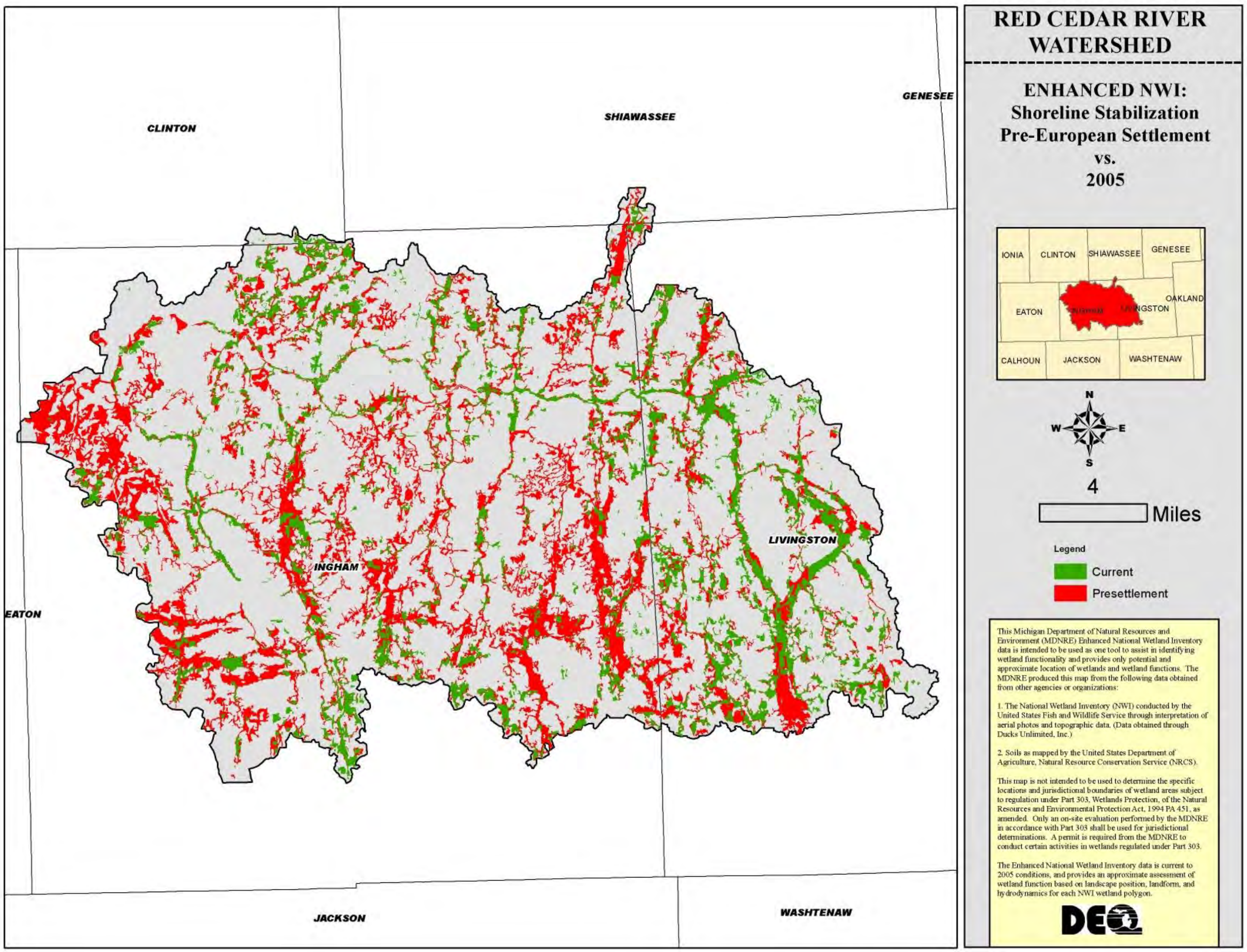
SEDIMENT AND OTHER PARTICULATE RETENTION



SHORELINE STABILIZATION

- Vegetated wetland along all waterbodies (e.g. estuaries, lakes, rivers, and streams) provide this function. Vegetation stabilizes the soil or substrate and diminished wave action, thereby reducing shoreline erosion potential.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

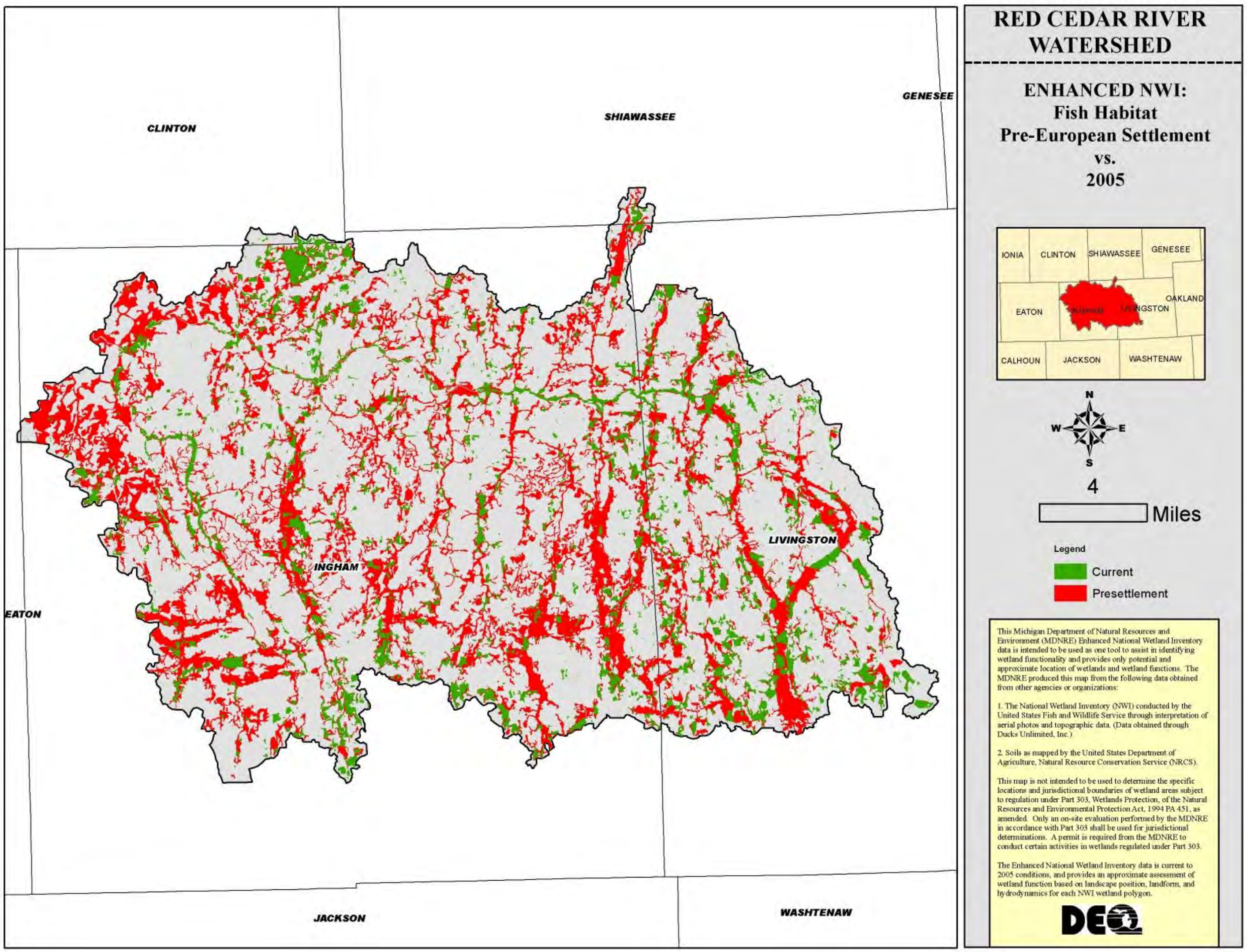
SHORELINE STABILIZATION



FISH HABITAT

- Wetlands that are considered essential to one or more parts of fish life cycles. Wetlands designated as important for fish are generally those used for reproduction, or feeding.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

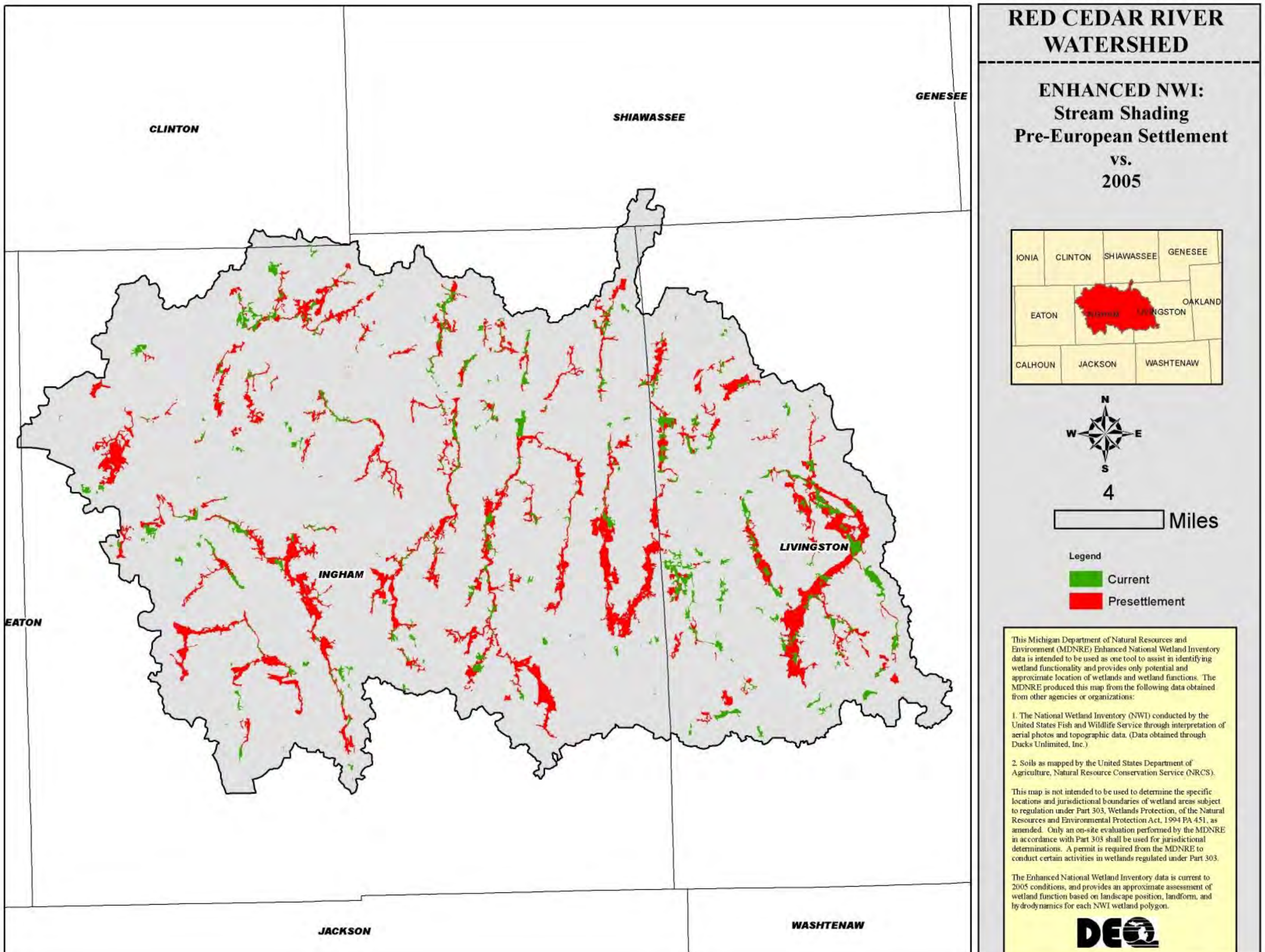
FISH HABITAT



STREAM SHADING

- Wetlands that perform water temperature control due to the proximity to streams and waterways. These wetlands generally are Palustrine Forested or Scrub-Shrub.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

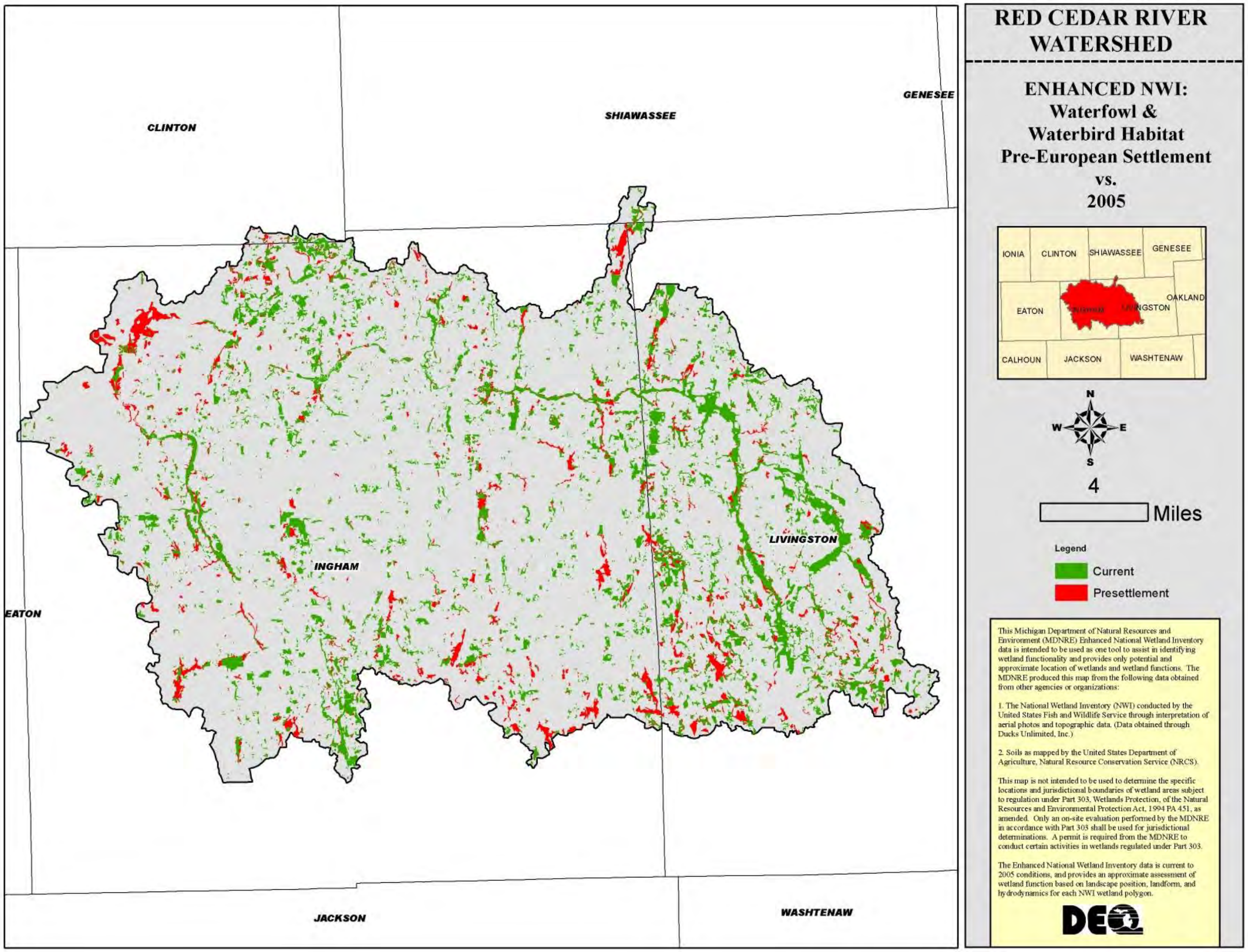
STREAM SHADING



WATERFOWL AND WATERBIRD HABITAT

- Wetlands designated as important for waterfowl and waterbirds are generally those used for nesting, reproduction, or feeding. The emphasis is on the wetter wetlands and ones that are frequently flooded for long periods.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

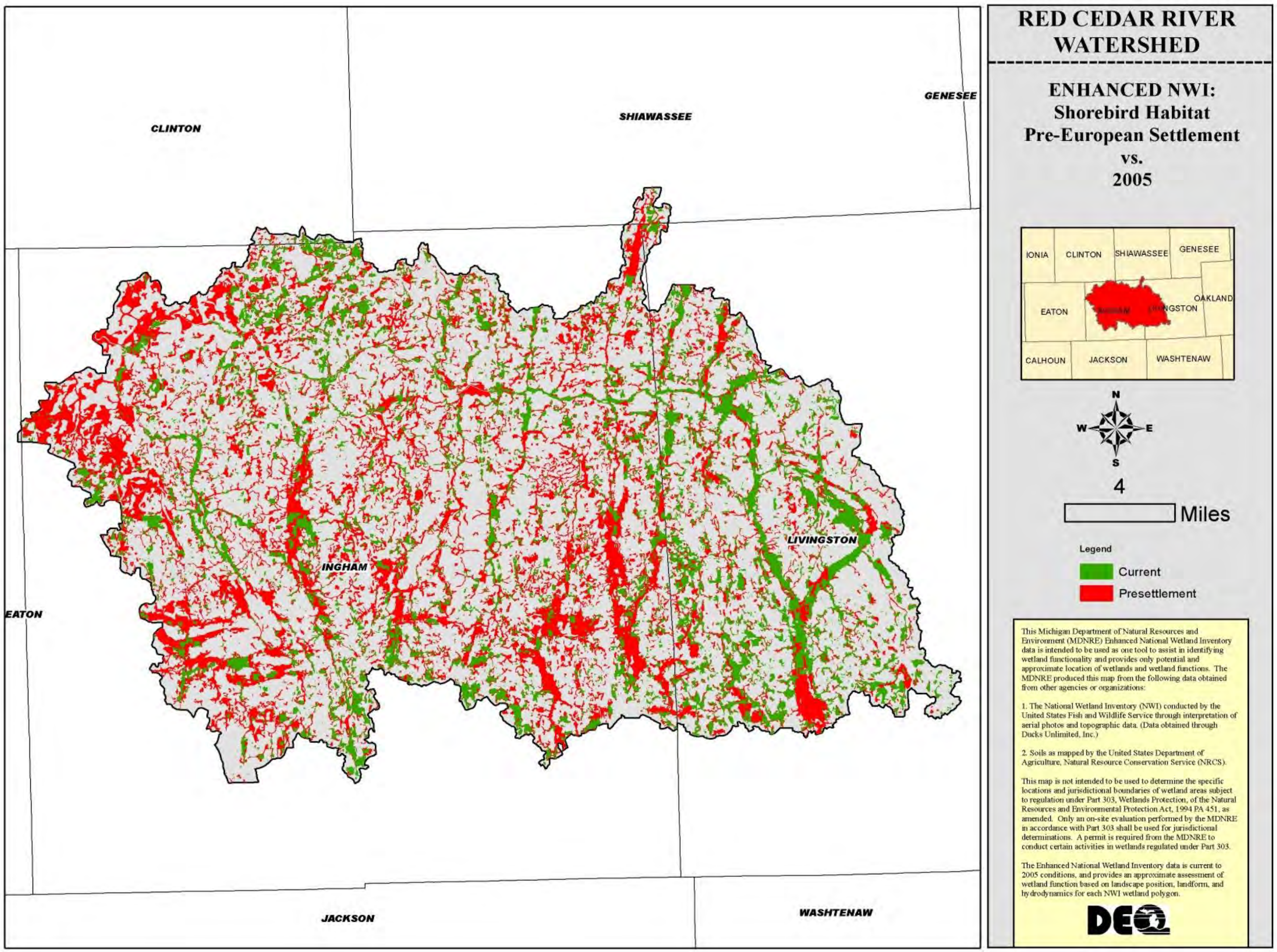
WATERFOWL & WATERBIRD HABITAT



SHOREBIRD HABITAT

- Shorebirds generally inhabit open areas of beaches, grasslands, wetlands, and tundra and undertake some of the longest migrations known. Along their migration pathway, many shorebirds feed in coastal and inland wetlands where they accumulate fat reserves needed to continue their flight. Common species include; plovers, oystercatchers, avocets, stilts, and sandpipers. This function attempts to capture wetland types most likely to provide habitat for these species.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

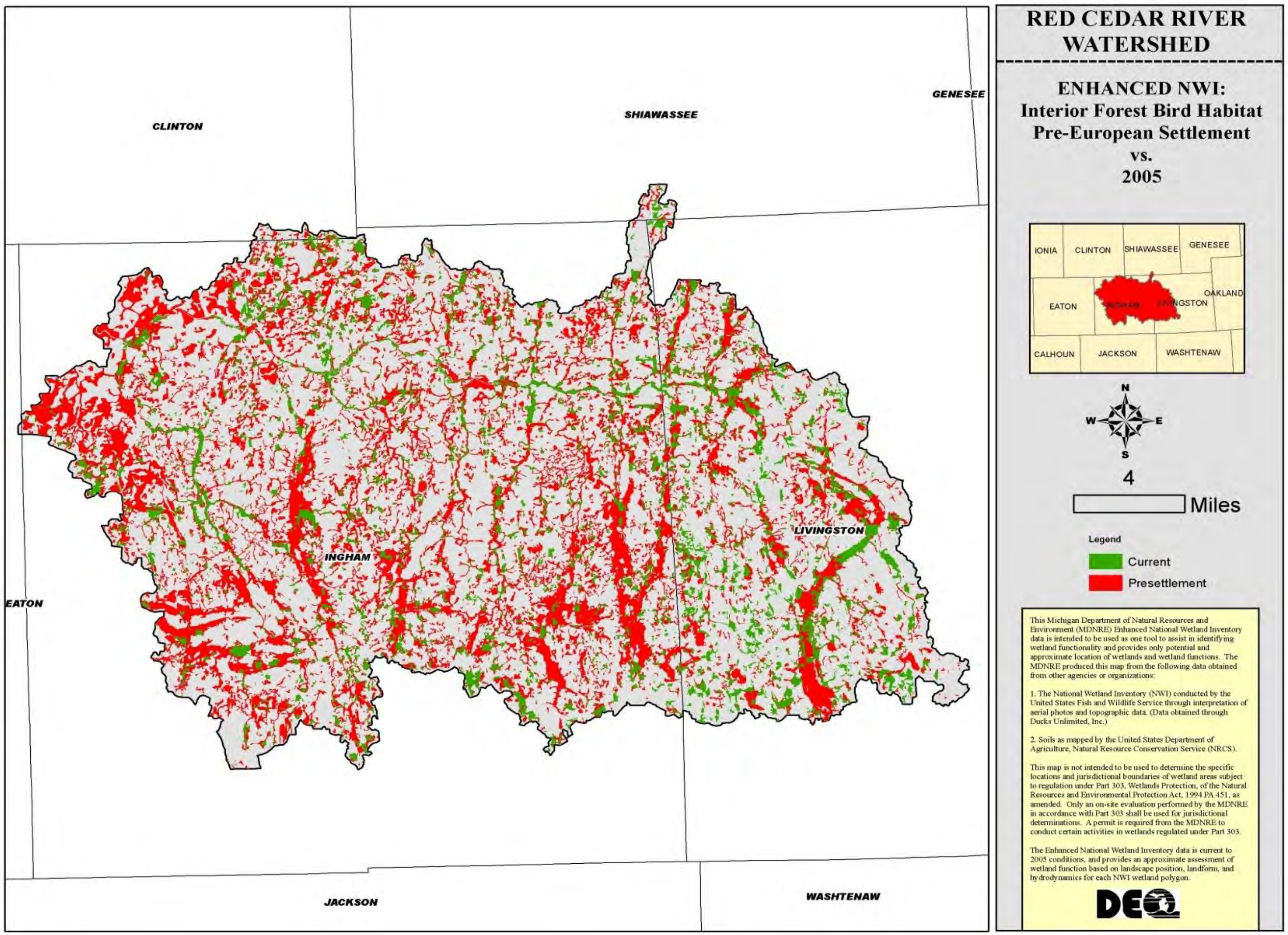
SHORE BIRD HABAITAT



INTERIOR FOREST BIRDS

- Interior Forest Birds require large forested areas to breed successfully and maintain viable populations. This diverse group includes colorful songbirds such as; tanagers, warblers, vireos that breed in North America and winter in the Caribbean, Central and South America, as well as residents and short-distance migrants such as; woodpeckers, hawks, and owls. They depend on large forested tracts, including streamside and floodplain forests. It is important to note that adjacent upland forest to these riparian areas are critical habitat for these species as well. This function attempts to capture wetland types most likely to provide habitat for these species.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

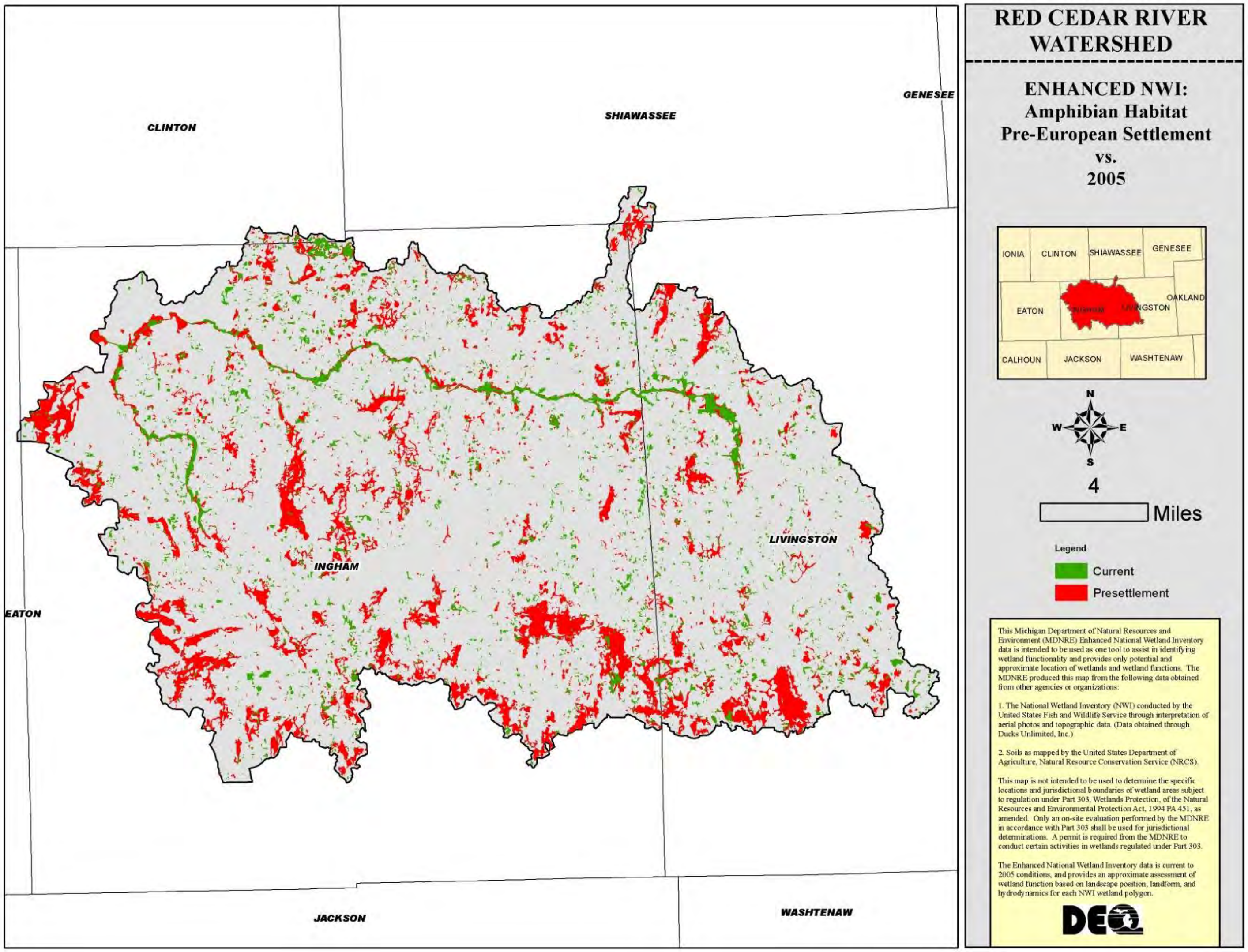
INTERIOR FOREST BIRD HABITAT



AMPHIBIAN HABITAT

- Amphibians share several characteristics in common including wet skin that functions in respiration and gelatinous eggs that require water or moist soil for development. Most amphibians have an aquatic stage and a terrestrial stage and thus live in both aquatic and terrestrial habitats. Aquatic stages of these organisms are often eaten by fish and so for certain species, successful reproduction may occur only in fish-free ponds. Common sub-groups of amphibians are salamanders, frogs, and toads. This function attempts to capture wetland types most likely to provide habitat for these species.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

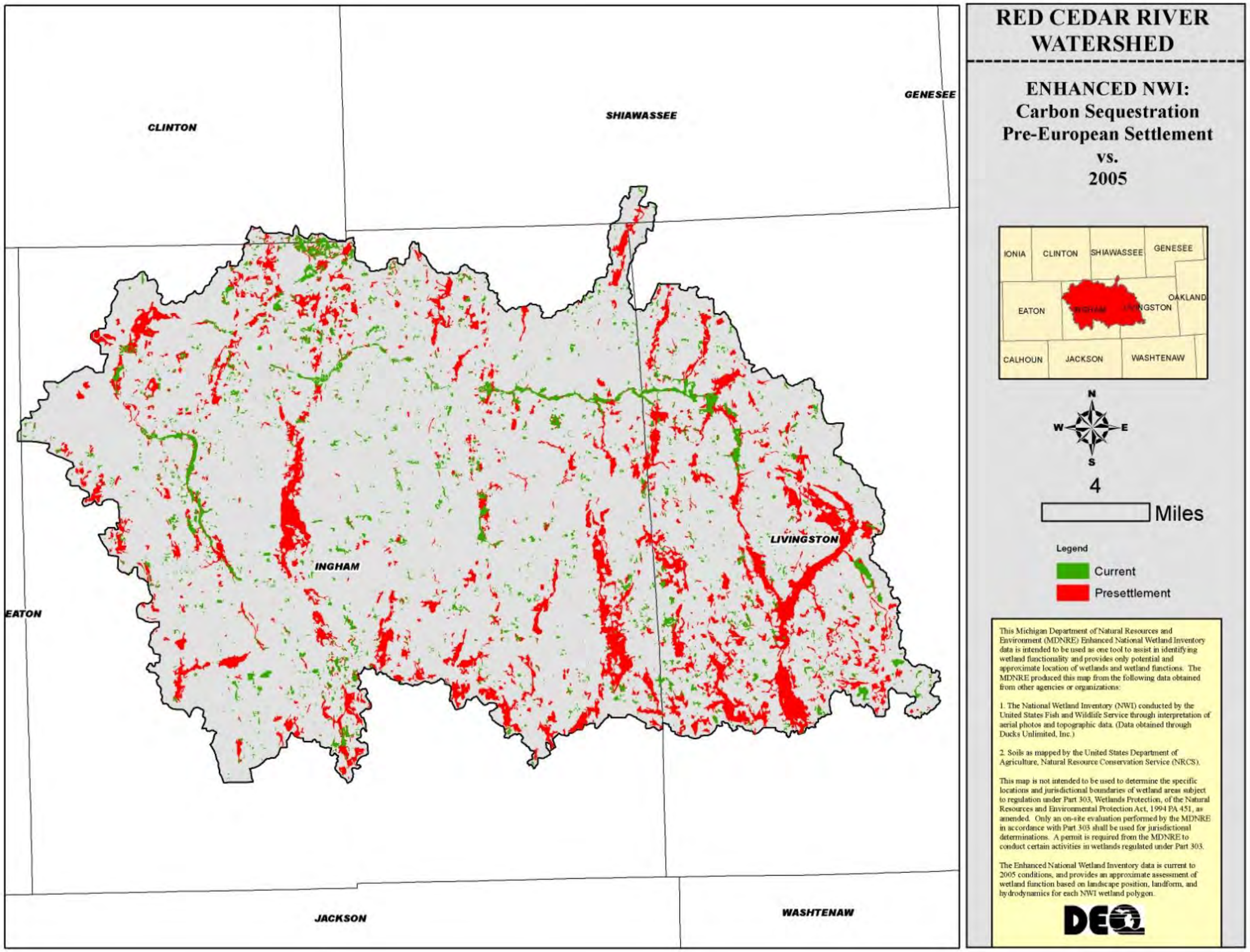
AMPHIBIAN HABITAT



CARBON SEQUESTRATION

- Wetlands are different from other biomes in their ability to sequester large amounts of carbon, as a consequence of high primary production and then deposition of decaying matter in the anaerobic areas of their inundated soils.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

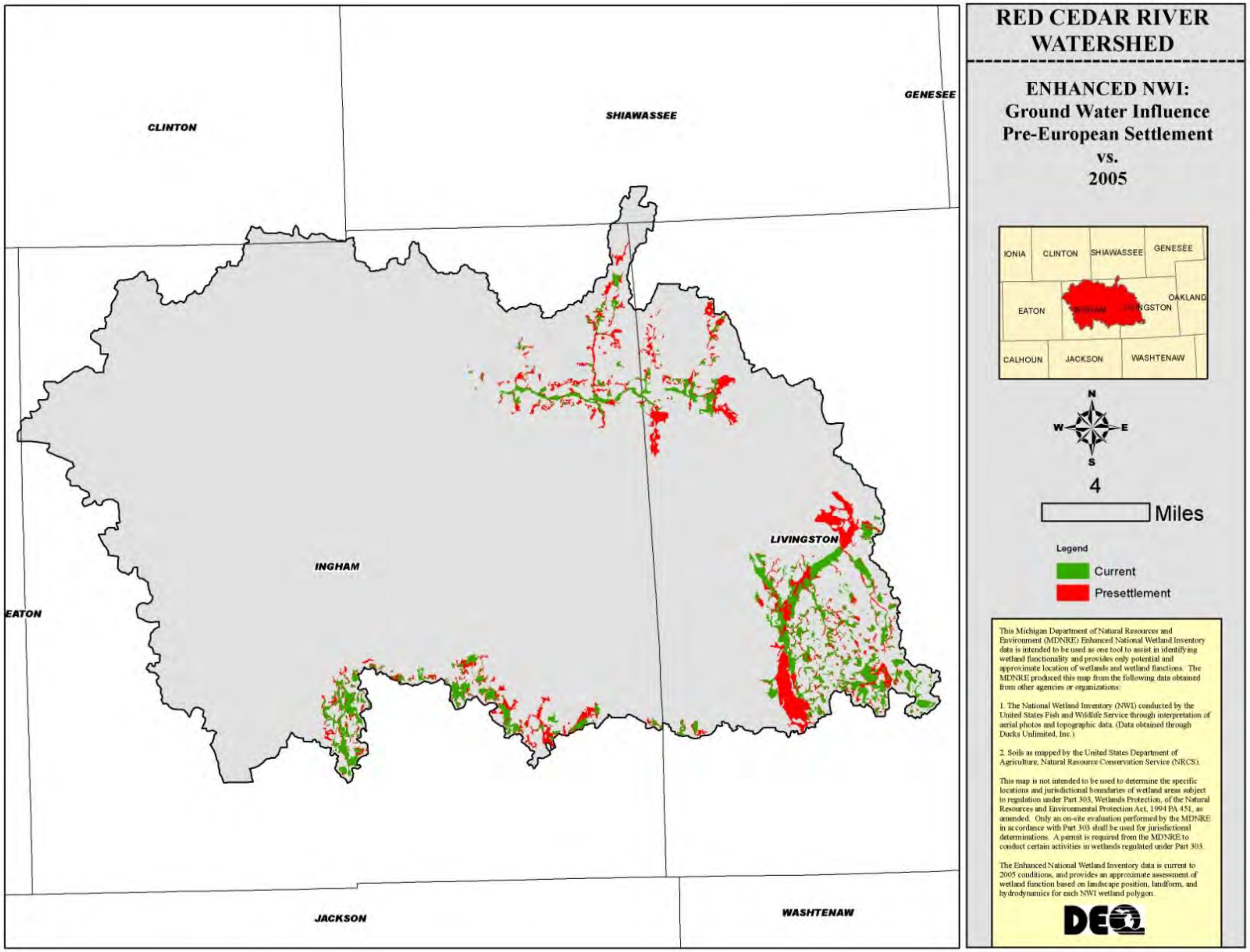
CARBON SEQUESTRATION



GROUND WATER INFLUENCE

- Wetlands categorized as High or Moderate for Groundwater Influence are areas that receive some or all of their hydrologic input from groundwater reflected at the surface. The DARCY (definition of acronym) model was the data source utilized to determine this wetland/groundwater connection, which is based upon soil transmissivity and topography. Wetlands rated for this function are important for maintaining streamflows and temperature control in waterbodies.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in two distinct time periods; Pre-European settlement (red), and wetlands circa 2005 (green).

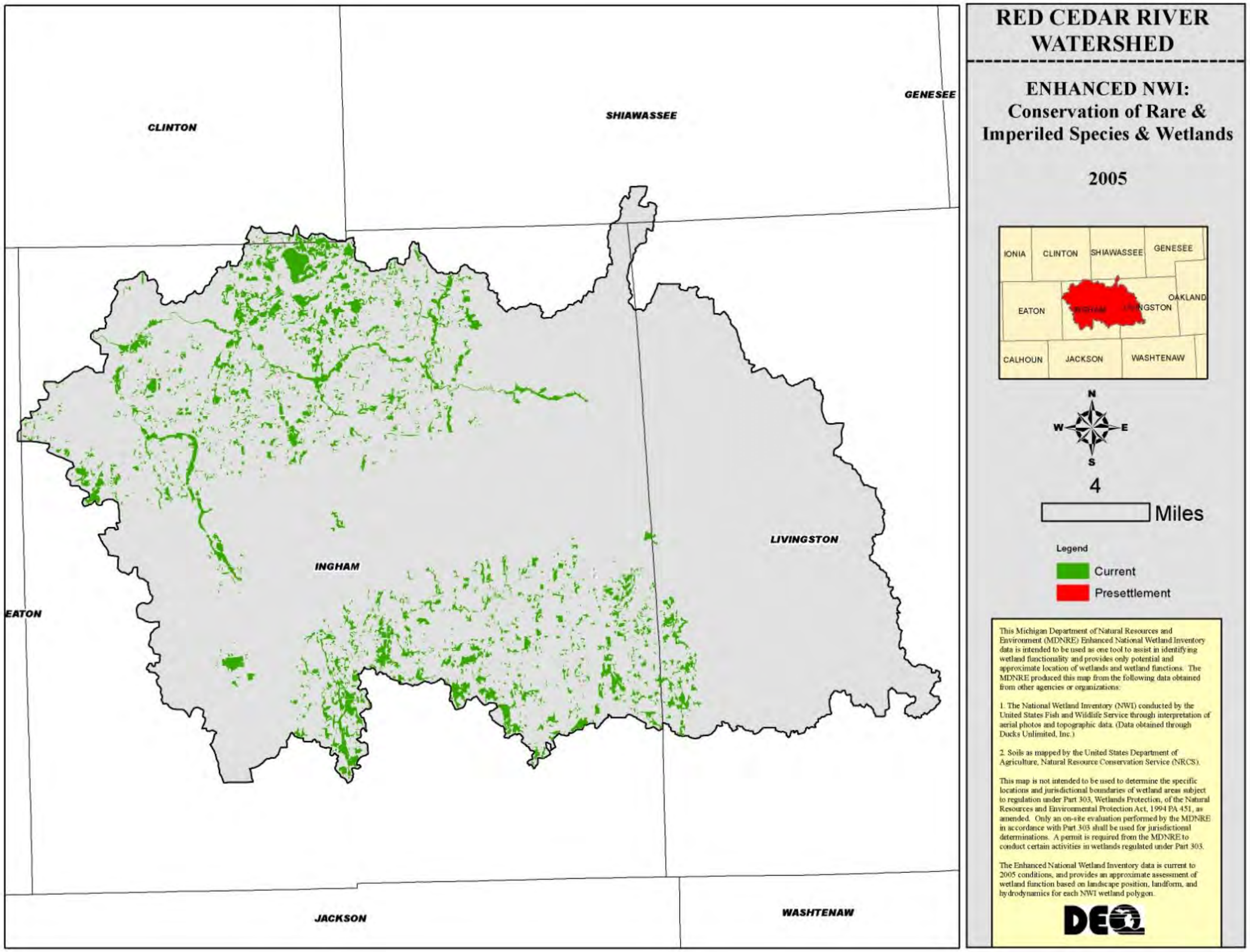
GROUND WATER INFLUENCE



CONSERVATION OF RARE AND IMPERILED WETLANDS & SPECIES

- Wetlands that are considered rare either globally or at the state level. They are likely to contain a wide variety of flora and fauna, or contain threatened or endangered species.
- This function is derived from the Michigan Natural Features Dataset (MNFI) of known sightings of threatened, endangered, or special concern species and high quality natural communities. The model values are reported on a 40 acre polygon grid for the state of Michigan, or a subset of MI. Due to this the dataset should not be used as a comprehensive inventory of Rare and Imperiled wetlands.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function are mapped in (green) circa 2005.

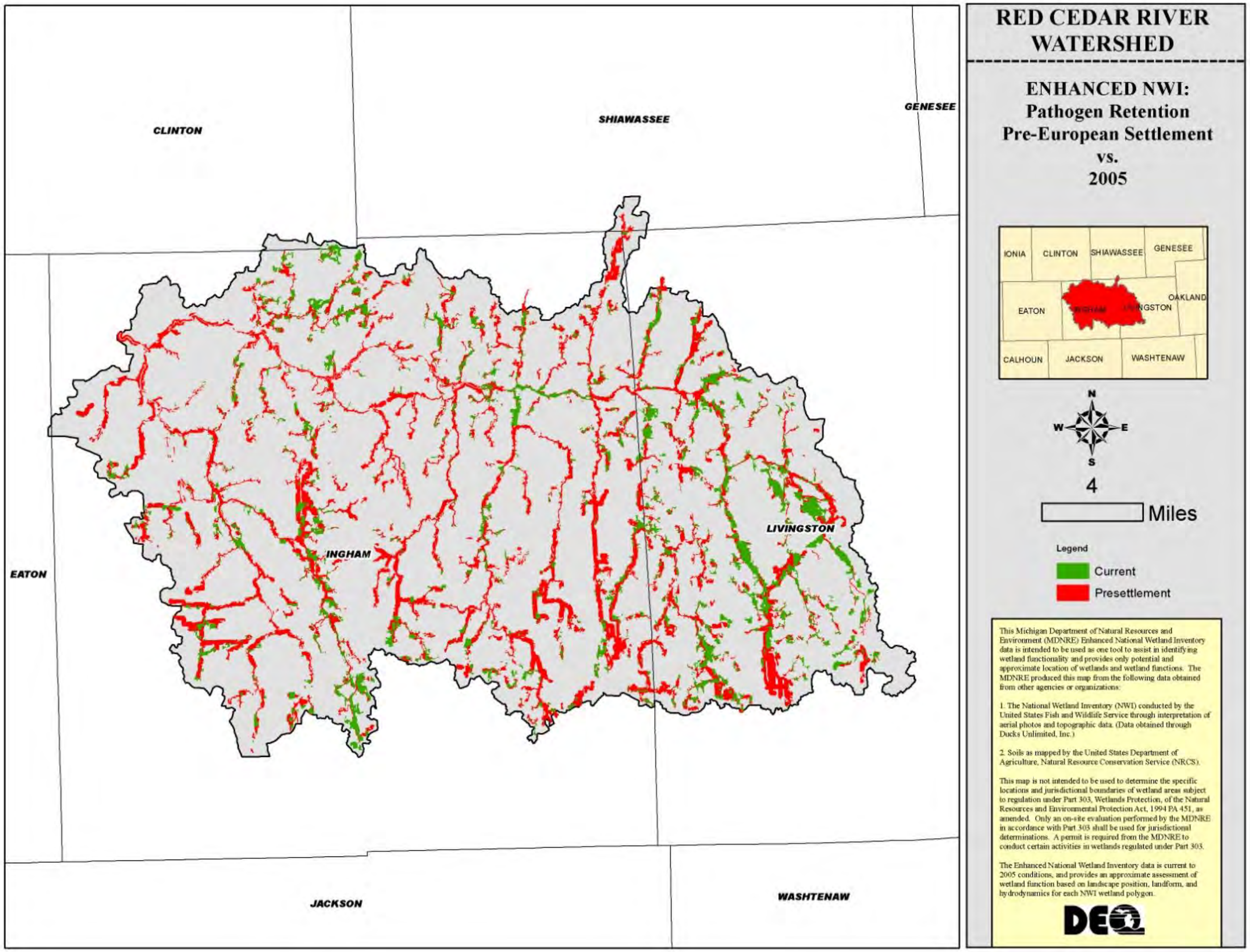
CONSERVATION OF RARE IMPERILED WETLANDS, & SPECIES



PATHOGEN RETENTION

- Wetlands can improve water quality through natural processes of filtration for sedimentation, nutrients and Escherichia coli (E. coli). E. coli is a sub-set of fecal coli forms whose presence in water indicates fecal contamination from warm blooded animals. The presence of E. coli indicates that contamination has occurred, and other harmful pathogens may also be present.
- The following map illustrates wetlands that perform the above ecological service at a level of significance above that of wetlands not designated. Wetlands deemed to be performing this function at a high level are mapped in (green) circa 2005. Wetlands deemed valuable for restoration for this function are mapped in (red).

PATHOGEN RETENTION



Data Limitations and Disclaimer

National Wetlands Inventory Plus (NWI)

- Wetland boundaries determined from Aerial Imagery
- Last updated in 2005
- Obvious limitations to Aerial Photo Interpretation:
  - Errors of Omission (forested and drier-end wetlands)
  - Errors of Comission (misinterpretation of aerials)

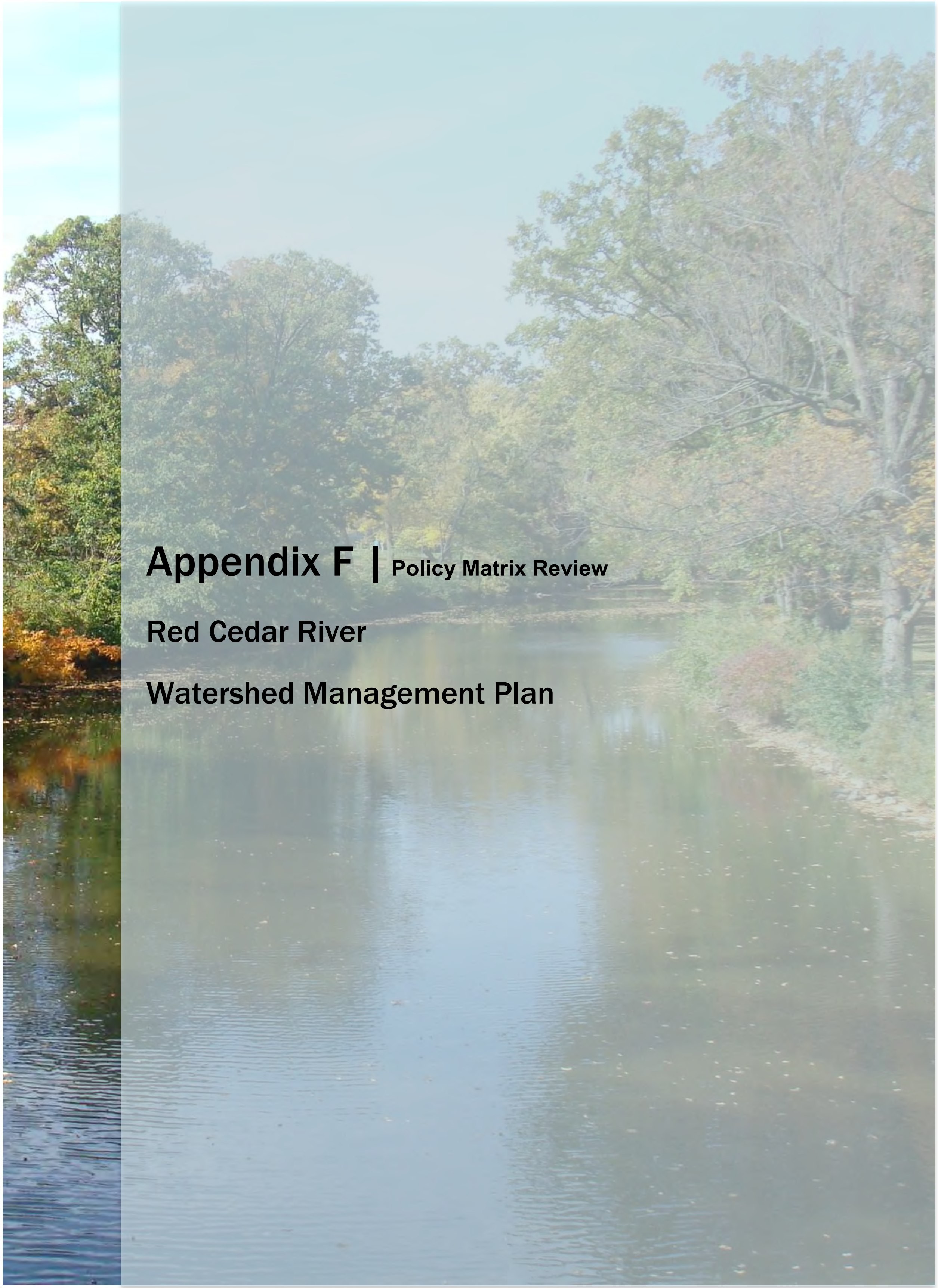
The 2005 NWI data was used in this analysis to report status and trends, as this is currently the best data source available. However, this data may not accurately reflect current conditions on the ground.

Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

Landscape Level Wetland Functional Assessment (LLWFA)

- Source data are a primary limiting factor.
- Wetland mapping limitations due to scale, photo quality, and date and time of year of the photos.

- Functional assessment is a preliminary one based on:
  - Wetland Characteristics interpreted through remote sensing
  - Professional Judgment of various specialists to develop correlations between those wetlands and their functions.
- Watershed-based Preliminary Assessment of wetland functions:
  - Applies general knowledge about wetlands and their functions
  - Develops a watershed overview that highlights possible wetlands of significance
  - Does not consider the condition of the adjacent upland
  - Does not obviate the need for more detailed assessment of various functions
- This analysis is a "Landscape Level" assessment and used to identify wetlands that are likely to perform a given function at a level above that of other wetlands not designated



Appendix F | Policy Matrix Review

Red Cedar River

Watershed Management Plan

Policy Review Criteria	Goal	General Recommendations	Alaiedon Township
Land Use Planning			
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	Adopted 1990 as a twenty year plan (1990-2010)
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	Promote a healthy environment, the Township's natural resources, the quality of the Township's ecosystem and visual environment.
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Amended February 11, 2013
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	Flood Plain shall be defined as established and published by the Corps of Engineers of the U.S. Army. Uses Permitted: Agriculture, parks, playgrounds, golf courses, preserves, trails, and outdoor recreation and conservation or required yard and setback areas.
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.	
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.	Account for existing natural features on and within 300 feet of site including woodlands; wetlands; drainage courses, water bodies, and 100-year flood plain areas; topography less than two-foot contour intervals; soils by type and drainage features. The location of all trees 10" or greater in diameter, measured at five feet (5') above ground surface identified by size and type, source and location of potable water, sewage disposal, and electrical and communication lines. Proposed grading, storm drainage and storm water management plan.
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.	No
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	No

Policy Review Criteria	Goal	General Recommendations	Alaiedon Township
Other Ordinances			Subdivision Regulations, Junk Ordinance.
Agriculture			
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.	GPO Text does address the preservation of agricultural land.
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.	
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.	Open Space Preservation Communities: Encourage residential development to more effectively preserve the Township's natural resources including farmland, sensitive environmental areas, and the Township's rural character by grouping or clustering new homes on smaller lots so the remainder of the site can be preserved open space.
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.	
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.	
Sediment			
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.	Clearing, Grading, and Drainage: In order to protect soil resources, public watercourses, and to provide for adequate drainage of surface water. Restrictions apply to the following: Removal of Topsoil, Drainage/Flow
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	Landscaping and Screening standards to assure that land uses minimize noise, air, and visual pollution; assure adequate buffering between differing uses; prevent soil erosion and soil depletion
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide	

Policy Review Criteria	Goal	General Recommendations	Alaiedon Township
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide	
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide	
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	Driveways shall be graded and drained to prohibit the ponding of water
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide	
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide	
Nutrients			
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.	
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).	See site plan review ordinance Article 14
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.	See site plan review ordinance Article 14

Policy Review Criteria	Goal	General Recommendations	Alaiedon Township
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	No
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.	
Pesticides and Chemicals			
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.	No
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.	Participates in Groundwater Management Board
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.	
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.	
PATHOGENS			
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.	
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.	
Temperature			

Policy Review Criteria	Goal	General Recommendations	Alaiedon Township
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.	
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects.	The Site Plan review process should include woodland preservation criteria.	
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.	
Invasive Species			
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.	
Other			
Other Comments			Participates in Groundwater Management Board

Policy Review Criteria	Goal	General Recommendations	Aurelius Township	Bath Township
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	Adopted December 1999	Comprehensive Plan adopted March, 2011. Prepared by McBride Dale Clarion. Strategic Plan 2009-2020
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	Goal: Natural Resource Management. Includes four policies with supporting objectives	Promote and reinforce open space preservation. Protect environmentally sensitive areas from development. Develop township wide system of open space and conservation greenways.
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Original Ordinance adopted July 20, 1980. Recent updates made in 2011, 2013	Adopted April 11, 2007
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	FEMA participant; No structures shall be erected within the floodplain of the Grand River as established by the U.S. Army Corps of Engineers.	Development restricted or prohibited in or surrounding floodplain for safety reasons, and to prevent flooding adjacent to development
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.		Parks and Rec Plan: Adopted Jan 14, 2013. There are ten (10) Township owned recreation areas or facilities, a total of 85 acres.
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.	Site plans shall demonstrate that as many natural features as possible have been retained, particularly where such features provide a buffer between adjoining properties or help control soil erosion or stormwater.	
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.		
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	No	

Policy Review Criteria	Goal	General Recommendations	Aurelius Township	Bath Township
Other Ordinances			Draft ordinance includes conservation measures including cluster development option, alternative surfacing for overflow parking and a detailed site plan review section. Subdivision control	
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.	Ag Preservation District: Preserve prime soils for agricultural use and to protect viable agricultural enterprises. The district is designed to preserve these areas by prohibiting the intrusion of nonagricultural and incompatible uses into the prime agricultural areas.	
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.		
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.	Overlay Zoning District to provide innovative options for creation of open space residential communities and the promotion of open space preservation consistent with Public Act No. 177 of 2001 (MCL 125.286h)	
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.		
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	Currently provides a building permit information package which could be used as a tool for providing other permit requirement and general BMP information.	
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide		

Policy Review Criteria	Goal	General Recommendations	Aurelius Township	Bath Township
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		Soil erosion control plan (Clinton County Soil Erosion and Sedimentation Control Ordinance).
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide	A minimum of ten percent of the gross parking area shall be devoted to living plant material. Interior areas of parking lots shall contain landscaped areas to effectively disperse expansive paved areas and provide filtering opportunities for stormwater.	
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	*Surfacing:* All parking areas shall be graded to provide adequate storm drainage and provided with a smooth, durable, dustless surface consisting of bituminous, asphalt, concrete, aggregate stone or gravel. The planning commission may approve parking in an unimproved, grassy area for temporary or seasonal uses.	
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.	No local ordinance	Preserve Existing Open Space and Wetlands Green infrastructure for strategically planned natural resources, parks and open spaces, and habitats which maintain and enhance the environment. Additionally, the Township has completed an extensive wetland inventory and will be implementing a wetland regulation ordinance which will add further protection.
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).		Households in Bath Charter Township use personal septic tanks or the public sewer. The public sewer is provided and maintained by the Southern Clinton County Municipal Utilities Authority (SCCMUA) located in Dewitt Township.
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.		

Policy Review Criteria	Goal	General Recommendations	Aurelius Township	Bath Township
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	No	
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.		
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.	Specifically addresses wellhead protection, protection of surface water quality, best management practices through site plan review, cluster development options.	
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.		Participate in the Groundwater Management Board administered through the Tri-County Regional Planning Commission. Review examples of wellhead protection ordinances to determine what should be incorporated into Bath Charter Township Ordinances. Research and develop a potential watershed protection ordinance.
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.		Recycling and Reuse Objective: Bath Township will encourage conservation by promoting recycling and reuse for all businesses and residents.
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.		
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.		
Temperature				

Policy Review Criteria	Goal	General Recommendations	Aurelius Township	Bath Township
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.	Landscaping and Buffering: Reduce the negative effects of... erosion, and sedimentation caused by expanses of impervious and other surfaces which are without vegetation. It is the intent of Landscaping elements can contribute to the processes of air and water purification, groundwater recharge.	Produce a connected system of preserved open spaces, greenways and trails (Master Plan)
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects.	The Site Plan review process should include woodland preservation criteria.		
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.		Preserve the valued natural resources of Bath Township including water resources, floodplains, riparian corridors, wetlands, soils, slopes and tree canopies.(Master Plan)
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.		
Other				
Other Comments			Currently provides a building permit information package which could be used as a tool for providing other permit requirement and general BMP information.	

Policy Review Criteria	Goal	General Recommendations	Bunker Hill Township	Conway Township
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	Prepared by Carlisle Wortman Associates. Adopted October 21, 2003.	Prepared by Planning Commission March 2012
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	Encourage the use of the lands and resources of the Township in accordance with their character and adaptability. Reduce hazards to natural settings... to conserve the resources of the Township.	Goal statement addresses preservation of the township's natural resources and lists open spaces, woodlands, wetlands, agricultural areas, floodplains and visual resources.
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Prepared by Planning Commission with assistance from Carlisle Wortman. Effective 9-11-2011	10/21/1997. Updated to compliment Comprehensive Plan
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	Delineation of Floodplain determined by the Federal Housing Administration, U.S. Army Corps of Engineers, the U.S. Soil Conservation Service. Development shall be prohibited within the one hundred (100) year floodplain of any existing watercourse and/or wetland.	Not Participating/ No local ordinance
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.	Recreation Conservation District regulates development in order to protect the natural resources, natural habitats of wildlife, waterways and water bodies, agricultural capabilities, public and private recreation areas of Bunker Hill Township.	
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	Land Division Ordinance: -No land within Bunker Hill Township shall be divided without the prior review of the Township Assessor for compliance.	
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.	Site plan review includes: 1. Preservation of Natural Environment 4.Surface Water Drainage	Article 14 of zoning ordinance contains specific standards for site plan review related to soils, drainage and watercourses, and natural features
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.	None	No.
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	None	No.

Policy Review Criteria	Goal	General Recommendations	Bunker Hill Township	Conway Township
Other Ordinances			Section 11.06 Required Water Supply/Sanitary Sewerage Facilities Section 11.11 Shoreline Excavation and Dredging	(Article 6) include Preservation of Environmental Quality (6.12) and Landscaping provisions (6.16); Open Space Community (Article 11); Parking (Article 15); and Access Management and Private Road Standards (Article 16).
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.	A primary focus of the Master Plan document is the preservation of agriculture and the rural character of the Township.	The Agricultural Residential District is established to protect lands best suited for agricultural uses, while also designating land area for rural residential.
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.		
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.	Residential Cluster Development: at least fifty (50%) percent of the gross buildable area of the subject property must be perpetually preserved as open space (not including open bodies of water, streams, floodplains and wetlands)	Open Space Community objective: To assure the permanent preservation of open space, agricultural land, rural lands and natural resources.
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.	Stormwater Management: All developments and earth changes subject to review... shall be designed, constructed, and maintained to prevent flooding and protect water quality.	
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide		

Policy Review Criteria	Goal	General Recommendations	Bunker Hill Township	Conway Township
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		Zoning Ordinance has some drainage requirements included which requires equivalent grades for new public or private roads and addresses stormwater runoff. Site plan review section requires detailed grading plan and has drainage standards.
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.	All areas designated as wetlands by the Michigan Department of Environmental Quality are declared to be "Wetlands" in the Township	Preservation of Environmental Quality: A river, stream, watercourse, drainage way or wetland, whether filed or partly filed with water shall not be altered in any way, except when done in conformance with state and federal law and standards.
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).	Sanitary Landfills only to be located in Ag Districts, developed in conformance with The Solid Waste Management Act, or under the jurisdiction of the Michigan Department of Natural Resources, and The Hazardous Waste Act.	Section 6.13 Sanitary Facilities: Articles (A)New Construction. (B) Festivals and (C) Seasonal Use
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.		

Policy Review Criteria	Goal	General Recommendations	Bunker Hill Township	Conway Township
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	The Drain Commission conducts any drainage work unless a signoff from the Drain Commission Office is granted.	Zoning Ordinance has some drainage requirements in it including equivalent grades for new public or private roads and addresses stormwater runoff. Site plan review requires detailed grading plan and has drainage standards.
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.	In order to conserve the lakes, ponds, rivers, streams, water courses and drainage ways in the Township, no such feature shall be altered, or varied from its present existing condition	
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.	None	No.
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.		
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.		
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.		
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.	Discharge of runoff from any site, which may contain oil, grease, toxic chemicals, or other polluting materials, is prohibited.	
Temperature				

Policy Review Criteria	Goal	General Recommendations	Bunker Hill Township	Conway Township
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.	Landscaping, Greenbelts, Buffering, and Screening: Prevent soil erosion and soil depletion and promote sub-surface water retention.	Section 6.16 Required Landscaping and Screening for non-Residential Uses; Greenbelt with minimum width of 15 feet
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects	The Site Plan review process should include woodland preservation criteria.	Encourage the integration of existing woodlands in landscape plans. Existing woodlands mapped in Master Plan Article 3.	
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.		
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.	Encourage an appropriate mixture of plant material, such as evergreen and deciduous trees and shrubs, to protect against insect and disease infestation.	
Other				
Other Comments				

Policy Review Criteria	Goal	General Recommendations	Village of Dansville	Delhi Charter Township
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	Adopted: 1982 Revisions: None	Originally adopted Oct 14, 2002. Amended Sept 24, 2007 and Oct 28, 2013
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	None within Village. The Village of Dansville falls under township ordinances and guidelines.	Preserving environmentally sensitive resources from the impacts of development. Identification of environmentally sensitive areas, participation in organizations focused on water quality, zoning ordinance amendments protect water bodies and open space.
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Adopted: 1977 Revisions: Small revisions; none pertaining to water quality	Originally adopted Oct., 1968. Most recent update: October, 2013
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	Not a FEMA participant	Participating community plus regulations in zoning ordinance.
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.		Parkland and Open Space: An identification of the privately and publicly owned park and open space areas within the Township. Provide recreational opportunities, open space enhancement, and agricultural land uses.
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.	No formal Site Plan Review Text exists, rather requirements for a building permit must be met	Section 3.3 of Zoning Ordinance requires review of Grading/Drainage. Plan and Landscape Plan required only for major projects. No specific standards for approval.
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.	None .	No
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	Whenever possible existing trees on the site shall be preserved. In addition, new landscaping shall be added to enhance the beauty of the development.	No

Policy Review Criteria	Goal	General Recommendations	Village of Dansville	Delhi Charter Township
Other Ordinances			Section 502 A: Removal of Soil, Sand, Gravel and other Materials must meet requirements of soil erosion control standards of Ingham County. Section 502. C: Public or Private Sanitary Landfills or Junk Yards: Uses shall be established and maintained in accordance with State of Michigan Statutes.	Section 6.6: Floodplain Regulations; Section 6.10: Landscape Requirements; Section 6.12: Storm Water Retention Areas and Lakes/Ponds.
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.		To protect agricultural industry for the township, specific areas with adequate farming soils will be protected from development. A series of standards in these areas through a combined effort in Township Zoning Ordinance, Future Land Use Map and Public Infrastructure Boundary.
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.		
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.		Rural and Open Space Emphasis: preserving agricultural operations, natural features for water retention, ground water recharge, plants and habitat (Southern 1/3 of the Township south of McCue and Harper roads)
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.		Very complete text provided for storm water retention areas. Monthly site plan review group meeting including Drain Commissioner in a roundtable review of pending site plans. Application packet available.
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide		

Policy Review Criteria	Goal	General Recommendations	Village of Dansville	Delhi Charter Township
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	Section 403 B: Parking Design and Construction Requirements: Sites no reference to environmental damage control related to erosion or runoff from construction sites.	
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.	None	Wetland Preservation Ordinance regulates all development within wetlands, ensures these important natural resources are not degraded.
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).		88% of homes are serviced by public sewer. Those outside service boundary have private, on-site sewage disposal systems
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.		

Policy Review Criteria	Goal	General Recommendations	Village of Dansville	Delhi Charter Township
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	The Drain Commission conducts any drainage work unless a signoff from the Drain Commission Office is granted.	Drainage plans and site inspection required for all new construction with a full foundation prior to the issuance of a building permit. Drainage requirements mirror those of the County Drain Commissioner.
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.		
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.	None	Yes
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.		
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.		
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.		
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.		
Temperature				

Policy Review Criteria	Goal	General Recommendations	Village of Dansville	Delhi Charter Township
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.		
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects.	The Site Plan review process should include woodland preservation criteria.		
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.		
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.		
Other				
Other Comments				

Policy Review Criteria	Goal	General Recommendations	City of East Lansing	Handy Township
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	2006 Big Picture Comprehensive Plan	Prepared by McKenna Assoc. and adopted September, 1997
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	Protect and enhance water resources by reducing pollution caused by surface runoff and sewer overflows, and by promoting conservation and replenishment of groundwater supplies	Preservation of Natural Features identified as a prevailing objective. Environmental Policies address natural features, pollution control, intergovernmental cooperation and flood-prone areas.
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Adopted Nov 18, 2003 and updated July 9, 2013	November 2011 as Amended
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	Yes. Participating community and local regulations in Chapter 103 of the City Codes.	The flood plain area shall be determined by FEMA, the County Engineer, the U.S. Army Corp of Engineers. No building for human occupancy shall be erected or hereafter occupied, if vacant, in such designated flood plain areas.
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.		
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.	No specific text on Site Plan Review but (5.107 Parking and Landscape Plan) are used as the text basis for a Site Plan Review process.	Site plan must contain proposed storm drainage and identification of significant natural features. Standards include preservation of natural environment and specific surface water drainage standards.
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.	No.	No. But Environmental Protection section of Zoning Ordinance is similar in result.
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	A tree removal/land clearing permit shall be obtained prior to any removal of one or more trees which are four inches in diameter or larger and land clearing of an area of one-half acre or larger.	No. But Environmental Protection section of Zoning Ordinance addresses the tree removal in areas that the Planning Commission may designate as "environmentally sensitive."

Policy Review Criteria	Goal	General Recommendations	City of East Lansing	Handy Township
Other Ordinances			Landscaping standards are found within the parking section.	Section 2.17: Buffers/Greenbelts; Section 2.19: Private Roads; Section 2.22: Floodplain; Section 2.26: Site Condos; Section 2.28: Environmental Protection; Chapter 13: Planned Unit Development; Chapter 15 (2): Parking.
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.		Section 2.28 (D): Preserve current or potential agricultural land based on soil types, elevation. Standards set within site planning
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.		
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.		Open Space Development option requires at least fifty (50%) percent of the area of the subject property must be preserved as open space (not including open bodies of water, streams, floodplains and wetlands)
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.		
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide		

Policy Review Criteria	Goal	General Recommendations	City of East Lansing	Handy Township
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide		Impervious Surface Reduction/Infiltration Enhancement: allowing for reduction in impervious surfaces whenever it finds that such deviations are more likely to meet the intent of impervious surface reduction and infiltration enhancement.
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.	East Lansing Code of Ordinances Chapter 49: The protection of the stability of the city's wetlands	Not freestanding but provisions in Zoning Ordinance Environmental Protection Section 2.28 (G).
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).		
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.		

Policy Review Criteria	Goal	General Recommendations	City of East Lansing	Handy Township
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	The Grading and Soil Erosion Ordinance requires that no increase in the rate of storm water runoff into the Remy-Chandler Drainage Basin will be caused by construction.	Some in Zoning Ordinance as described above in Site Plan Review comments.
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.		In order to conserve or wisely use the lakes, ponds, rivers streams, water courses and drainage ways in the Township, no such feature shall be altered from its present existing condition
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.	A committee is currently developing a wellhead protection plan. A consultant has been hired to assist in the process.	No.
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.		
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.		
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.		
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.		
Temperature				

Policy Review Criteria	Goal	General Recommendations	City of East Lansing	Handy Township
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.		Landscaped greenbelts to be used as buffers between residential and non-residential uses
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects.	The Site Plan review process should include woodland preservation criteria.		
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.		
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.		
Other				
Other Comments			Zoning ordinance has been amended to allow porous paving materials, on-site stormwater retention standards have been developed, floodplain regulations are in place at the local level.	Some zoning district policies include environmental references as well

Policy Review Criteria	Goal	General Recommendations	Howell Township	Ingham Township
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	Prepared by the Planning Commission of Howell Township, Adopted January 2009	Adopted: 1977 Revised: No major additions, only small ones
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	Promote the conservation of unrenewable natural resources, saving of vegetation, wildlife cover, watersheds, areas which periodically flood, features controlling wind or water erosion, wetlands, and areas of topographical... or agricultural significance.	No development on: excessive slopes to prevent erosion, wetlands or marshes, woodlands, poorly drained soils. Promote wises use of natural resources.
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Last Amended and adopted August 26, 2013	Adopted: 1997 Revised September 9, 2011: No major revisions
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	Land subject to periodic flooding shall be used only for agriculture and recreation uses, provided no structures are located within the area subject to flooding.	Not a FEMA participant.
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.	Howell Township recently completed a "Township Recreation Plan 2000 - 2005". The Township Recreation Committee will purchase and develop at least one park site. The Township currently has no parks.	
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.	Existing conditions of the natural environment shall be preserved in their natural state. Minimize tree and soil removal. Planning Commission of Township Board may determine EIS is needed for development.	The landscape shall be preserved in its natural state, by minimizing tree and soil removal, topographic modifications which result in maximum harmony with adjacent areas. Special attention shall be given to proper site surface drainage
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.		None
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	Ordinance stating that existing trees or vegetation on site must be replaced if dead within one year of new development	None

Policy Review Criteria	Goal	General Recommendations	Howell Township	Ingham Township
Other Ordinances				
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.	Section 15.04: Preserve current or potential agricultural land based on soil types, elevation. Standards set within site planning	Sec 306.1 Ag Districts: preserve prime soils for agricultural use and to protect viable agricultural enterprises. It is to be applied to areas which have soils well suited to agricultural activities.
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.		
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.	Open Space Developments shall set aside at least 50% of the total area of a lot or a parcel of land for this purpose. This provision shall apply in all Zoning Districts which permit single and multiple family housing as a principal use in them.	
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.	Detention areas or retention ponds shall be designed as an integral part of the overall site plan and shall be considered a natural landscape feature	
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	Section 20.08: Special attention shall be given to proper site surface drainage so that the flow of surface waters will not adversely affect adjacent and surrounding properties or to public storm drainage system.	
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide		

Policy Review Criteria	Goal	General Recommendations	Howell Township	Ingham Township
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	Soil survey conducted by the Soil Conservation Service for information on soils having: 1. Slight Limitations, 2. Moderate Limitations and 3. Severe Limitations.	
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		404.5 Design and Construction Requirements: Parking areas shall be maintained in a smooth, dust-free condition, and provided with adequate drainage
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.	Section 15.07: All areas as designated on Map No. 6 (Master Plan) Rivers, Creeks, Floodplains, Wetlands, Lakes, Ponds, Streams, Drainage ways and Ridge Lines are and shall be subject to protective provisions	No formal zoning ordinances, but wetlands are referenced in Comprehensive Development Plan on pages 33 and 34.
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).	There are no public sanitary sewers or sewage treatment plant currently existing in Howell Township. Water supply is provided from individual onsite wells. All sewage and other forms of waste water from homes and businesses are treated with use of septic tanks and connecting tile drain fields.	Section 402.11 Any structure erected shall be provided with potable water supply and safe and effective means of waste disposal and treatment.
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.		

Policy Review Criteria	Goal	General Recommendations	Howell Township	Ingham Township
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		Ingham County Drain Commission maintains drainage requirements.
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.	Section 15.05: In order to conserve or wisely use the lakes, ponds, rivers, streams, water courses and drainage ways in the Township, no such feature shall be altered, changed, transformed or otherwise be varied from its present existing condition except as follows: (A)(B)(C)(D)	
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.		None
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.		
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.		
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.		
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.		
Temperature				

Policy Review Criteria	Goal	General Recommendations	Howell Township	Ingham Township
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.		
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects	The Site Plan review process should include woodland preservation criteria.	Master Plan: As a natural resource... from a land use planning perspective... preserve as much of this woodland acreage as possible.	
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.		
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.		
Other				
Other Comments				

Policy Review Criteria	Goal	General Recommendations	Iosco Township	City of Lansing
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	March, 1988. Developed with Livingston County Planning Department	Master Plan Status: Goals and Objectives of the 21st Century (1993) currently beginning revisions
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	preservation of natural resources through cluster housing, protection of floodplain, wetlands and other environmentally sensitive areas, minimizing runoff and erosion.	Environmental Objective part of Community Facilities Goal contains a statement addressing preservation of environmentally sensitive areas.
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Effective Date: February, 1991	Zoning Ordinance Status: Adopted December, 1991 with amendments to district provisions (2000).
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	Not participating/ no local ordinance	FEMA participant. Floodplain Regulations in Zoning Code (Ch. 1288)
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.		The City's parks and recreation master plan identified four top priorities for facility improvements: trails, natural areas, public gardens and nature centers, and recreation programming for special events and festivals.
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		Master Plan Chapter 4: Low-impact stormwater management strategies include, reducing impervious surface area, using rain barrels to collect and reuse rainwater, incorporating rain gardens and native vegetation.
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.	Identify undisturbed areas. Standards are included for soils, for drainage and watercourses and for natural features	Section 1242.04-07 of the Zoning Code address when required, contents, review process and modification provisions. Minimal standards for approval.
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.	No. But "Preservation of Environmental Quality" has a similar result.	No.
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	No.	No.

Policy Review Criteria	Goal	General Recommendations	Iosco Township	City of Lansing
Other Ordinances			Section 723: Preservation of Environmental Quality; Article 9: Planned Residential Development District; Article 16: Parking	Chapter 1280: Planned Residential Development; Chapter 1284: Off-Street Parking; Chapter 1288 Floodplain Control; Chapter 1290: Landscaping, Screening and Buffering.
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.		
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.		Restoring riverbanks and riparian buffers will further protect water quality. Typically, 100 feet of natural land cover is desirable on both sides of a river or stream. Where possible, river and stream channels should be reconnected to naturalized floodplain areas.
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.		Open spaces are identified but primarily to serve as community activity areas.
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.		Managing stormwater throughout the city in ways that increase infiltration (by reducing impervious surface area and providing landscaped areas to store and filter rain water close to its source)
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide		

Policy Review Criteria	Goal	General Recommendations	Iosco Township	City of Lansing
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		Green Street Design objective: Promote the use of low impact development strategies within the street network to minimize stormwater volumes and pollutants by reducing impervious surface and using rain gardens.
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.	No.	No.
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).		
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.		

Policy Review Criteria	Goal	General Recommendations	Iosco Township	City of Lansing
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	No. Standards appear several times in the zoning ordinance to reflect requirements of the Drain Commissioner.	Soil Erosion/Sedimentation regulated through Department of Public Service (Chapter 1218 of Planning Code).
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.		
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.	No.	Yes. Adopted July, 2000. Prepared by Lansing Board of Water and Light
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.		
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.		
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.		
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.		
Temperature				

Policy Review Criteria	Goal	General Recommendations	Iosco Township	City of Lansing
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.		TCRPC has initiated a collaborative effort by identifying green infrastructure conservation priorities and linkages. The City’s existing river-related parks and trails will play an important role in that regional network.
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects	The Site Plan review process should include woodland preservation criteria.		
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.		Areas identified in Figure 5-1 of Master Plan
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.		
Other				
Other Comments				Brownfield Redevelopment Authority in place. Public Service Department oversees combined sewer/storm overflow project. Participates in Groundwater Management Board. City also has River Point Neighborhood Plan (1992)

Policy Review Criteria	Goal	General Recommendations	Lansing Charter Township	Leroy Township
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	Prepared by Tri-County Regional Commission in 1974, updated in 2009	
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	Environment Stewardship: conserve natural resources, improve environmental quality, and reduce the environmental impact of development and other human activities. Objectives: reduce solid waste, implement a recycling program, participate in regional efforts to improve water quality, work with relevant agencies to draft flood plain hazard mitigation plan.	
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Originally adopted August, 1966. Revisions include Planned Development Zone in September, 2000	
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	FEMA Participating Community and Local Floodplain Regulations (Chapter 90 of Zoning Ordinance) New construction, substantial improvements and other development, including fill, shall be prohibited within floodplain	
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.		
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.	Section 85-10 addresses site plan review. Section has been revised to include wellhead protection standards. Procedure includes an informal preapplication conference not prescribed in Zoning Ordinance.	
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.	No	
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	No	

Policy Review Criteria	Goal	General Recommendations	Lansing Charter Township	Leroy Township
Other Ordinances			Section 85-11 PD/Planned Development Zone includes landscape and buffer requirements, and drainage provisions. Chapter 84 Parking and Loading allows for crushed stone or gravel surface material and shared parking. Chapter 90 contains floodplain provisions.	
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.	Natural Resources and Environment: The 425 acres of agricultural land (owned by MSU) in the Township's southeastern-most corner are unlikely change to within the time frame of this master plan.	
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.		
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.		Article 13 and Article 15 of Zoning Ordinance
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.		
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide		

Policy Review Criteria	Goal	General Recommendations	Lansing Charter Township	Leroy Township
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	Prevent soil erosion and sedimentation from occurring as a result of earth-change activities within the township.	
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.	No	
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).		
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.		

Policy Review Criteria	Goal	General Recommendations	Lansing Charter Township	Leroy Township
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	Site Plan Review process of Zoning Ordinance has standards which reflect the standards of the County Drain Commissioner. Reviewed by County Drain Commissioner.	
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.		
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.	Provisions added to Site Plan Review Section	
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.		
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.	Section 24-2 of Zoning Ordinance: Cleanup and abatement of hazardous substance/waste releases shall be the responsibility of the person who produced, used or possessed substance. The Hazardous Waste Management Act of Michigan, part 111 of NREPA, shall apply where appropriate.	
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.	General Motors manufacturing facilities in the Township require remediation of the site for asbestos containing materials (ACM), polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs) throughout demolition process	
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.		
Temperature				

Policy Review Criteria	Goal	General Recommendations	Lansing Charter Township	Leroy Township
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.		
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects.	The Site Plan review process should include woodland preservation criteria.		
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.		
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.		
Other				
Other Comments				

Policy Review Criteria	Goal	General Recommendations	Leslie Township	Locke Township
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	Adopted: September 1999 Revisions: None	Prepared by the Locke Township Planning Commission with assistance from Mark Eidelson and LANDPLAN Inc. Adopted Nov 17, 2004
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	2020 Vision Statement included in Future Land Use Plan: -Encourage City to maintain sewer/water system capacity for future growth. -Promotes and enforces protection of drains/creeks from chemical and bacterial pollution, siltation and warming. -Promotes and enforces best management practices from water erosion.-Requires buffers along edges of streams, drains and wetlands.	Preserve the Township's natural resources including farmland resources, wetlands and woodlands with coordinated future land use strategy and related implementation tools.
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Adopted: 1979 Revisions: Several small, fine tune revisions	Adopted Oct 6, 2005 amended Nov 14, 2006
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	Section 6.6 Floodplain Regulations; Leslie Township Zoning Ordinance: Includes data, delineation, existing and permitted uses, and liability	
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.	The Leslie Community Recreation Plan, dated March 2006, was a successful cooperative planning effort carried out by the City of Leslie, Leslie Township and the Leslie School District.	
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.	Site Plan Review, Site Requirements, Land Division Application, Building Permit Application and Plan Examination	Site Plan Review Account for existing natural features on and within 300 feet of the site (woodlands; wetlands; drainage courses, water bodies, and 100-year flood plain areas), topography, soils by type and drainage features, and a grading, storm drainage and storm water management plan, including soil erosion and sedimentation control measures
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.	No formal adoptions are imposed locally only ones forced by county and state are followed.	
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	None	

Policy Review Criteria	Goal	General Recommendations	Leslie Township	Locke Township
Other Ordinances				
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.		Preserve existing ag areas and those well suited for production. Provide opportunities for development that encourages preservation of open spaces, natural resources and rural character.
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.		
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.		Article 16 of zoning ordinance supports open space developments/clustering.
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.		
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide		

Policy Review Criteria	Goal	General Recommendations	Leslie Township	Locke Township
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide		Zoning Ordinance Article 23.03.D. Off-street parking drainage standards
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.	None	Development on a parcel containing wetlands should only occur on area void of wetland. township may require mitigation measures to replace environmentally sensitive areas harmed by development
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).	Section 6.1.5. Required Water Supply and. Sanitary Sewerage Facilities - No structure shall be erected or altered without a safe, sanitary and potable water supply or without a safe and effective means of collection, treatment, and disposal of human excrement and domestic, commercial, and industrial wastes.	Any building shall be provided with a potable water supply and waste water disposal system. Constructed and maintained with standards of Ingham County Health Department.
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.		

Policy Review Criteria	Goal	General Recommendations	Leslie Township	Locke Township
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	The Drain Commission conducts any drainage work unless a signoff from the Drain Commission Office is granted.	
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.		
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.	None	
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.		
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.		
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.		
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.		
Temperature				

Policy Review Criteria	Goal	General Recommendations	Leslie Township	Locke Township
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.		
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects	The Site Plan review process should include woodland preservation criteria.		
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.		
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.		
Other				
Other Comments			The availability of public sewer, drains, and water should be the key trigger to whether other lands should be rezoned in the future consistent with the 2020 vision of Leslie Township. The 2020 vision provides a clear direction for the future decisions, both short and long term, to achieve the desired result for Leslie Township.	

Policy Review Criteria	Goal	General Recommendations	Marion Township	City of Mason
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	Plan adopted January 25, 2005. New Master Plan adopted 2010 (date not specified)	Prepared by the City of Mason Planning Commission, adopted April 19, 2004.
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	Protect environmentally sensitive areas such as wetlands, groundwater recharge areas, wellhead protection areas, and inland lakes from the harmful effects of incompatible development.	Preserve the City's natural resources through a coordinated future land use strategy and related implementation tools, discourage unnecessary destruction or loss of natural resources, including wetlands
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Prepared by the Livingston County Planning Department--March, 1996	
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	No. But language in Zoning Ordinance section 6.16 (B)	
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.	Marion Township currently contracts public recreational opportunities with the Howell Area Parks and Recreation Authority (HAPRA) program.	
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.	Site plans are required to contain information on natural features; drainage, landscaping; and hazardous materials storage. Ground Water Standards: Protect natural features including water bodies. Stormwater management must be addressed.	
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.	No.	
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	No.	

Policy Review Criteria	Goal	General Recommendations	Marion Township	City of Mason
Other Ordinances			Section. 6.13: Landscaping; Section 6.16: Environmental Performance Standards; Section 6.17 (Infrastructure Concurrency) includes stormwater management; Section 6.21: Shorelines (includes several setback provisions); Section 6.27: Wellhead Protection and Hazardous Substance Overlay Zone;	
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.	Preserve agricultural land, open space, and unobstructed views of fields, pastures, and agricultural buildings. Support the landowner's Right to Farm when proper agricultural practices are followed. Protect drainage ways for agricultural land.	
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.	All principal uses of land adjacent to inland lakes shall meet set back requirements and erosion control devices when located and designed	
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.	Section 6.29 Open Space Preservation: Allow developers to cluster new homes on smaller lots and to provide the home sites with permanently preserved open space.	The residents of Mason have clearly expressed an interest in maintaining the City's small town character. This character is due to open spaces including open fields, farmlands, woodlots, and natural wildlife habitats that surround the City.
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.	Storm water management standards to prevent impact on adjacent land or water bodies. Any required infrastructure requirements must be made previous to development.	Adopt ordinances and policies to fund storm water management. (City Council)
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide		

Policy Review Criteria	Goal	General Recommendations	Marion Township	City of Mason
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	Livingston County Soil Erosion and Sedimentation Ordinance.	
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide	Zoning Ordinance Section 6.19 f. Driveways shall be designed to minimize runoff and erosion.	
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.		Encourage the preservation of open spaces and natural resources (such as woodlands, wetlands, and stream corridors) as part of the land development process
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).	Most Marion Township residents are served by individual septic systems and private wells. Municipal water services are available to township residents in the northern portion of the township. Marion Township is a member of a water authority called MHOG.	Expand sanitary sewer in phases to match development. Replace and upgrade older/underused pipes. Search for new efficiencies.
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.	Septic tanks and associated drain fields for the containment of human or animal wastes shall conform to regulations and standards of the Livingston County Health Department.	

Policy Review Criteria	Goal	General Recommendations	Marion Township	City of Mason
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	No. Refers to standards of the Livingston County Drain Commissioner.	
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.		
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.	Marion Township has two wellhead protection areas within their boundaries.	
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.	Site plans shall address the location and extent of any contaminated soils and/or groundwater on the site. Development shall be prohibited on a site of environmental contamination unless mediated	
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.		
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.	Extensive language regarding polluting materials, containment devices, storage standards and handling	Seeks to address improper clearing and discharging of runoff or wastes in or near important water courses. (City Council, in coordination with the County Drain Commissioner)
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.		
Temperature				

Policy Review Criteria	Goal	General Recommendations	Marion Township	City of Mason
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.	Screening between land uses: 25 foot greenbelt along sides and rear. 50 foot greenbelt adjacent to any public road	
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects.	The Site Plan review process should include woodland preservation criteria.		
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.		
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.		
Other				
Other Comments			Natural Resources Summary of existing environmental features.	

Policy Review Criteria	Goal	General Recommendations	Meridian Charter Township	Stockbridge Township
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	Adopted May 5, 2005	
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	Preserve Open Space and Natural Areas: recharge areas; protecting endangered ecosystems, plants and animals, open spaces linkages	
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Codified Ordinance with regular revisions	January 2009. Revised May 9, 2011
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	The Township's floodplain map was updated in August of 2000 (Map 7-6). The Township monitors construction in the flood prone areas through the zoning ordinance.	
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.	Goal: Develop the Meridian Township park and recreational system to reflect the population characteristics and recreation needs of current and future residents.	
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.	Contains standards for landscape preservation, surface water management, groundwater protection, soil erosion/sedimentation control. Currently being revised to include additional language for wellhead/groundwater protection:	Site Plan Review: Proposed grading and drainage patterns, existing natural and man-made features to be retained or removed, proposed water, sanitary sewer, and storm water catchment and drainage systems.
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.	Meridian Township Green space Plan: When implemented, the Green space Plan will provide a network of green spaces and non-motorized linkages that will protect and connect valued natural resources	
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	No, but is being considered	

Policy Review Criteria	Goal	General Recommendations	Meridian Charter Township	Stockbridge Township
Other Ordinances				
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.		Section 4.07 AR, Agriculture Residential District: to provide for residential building purposes in a pastoral, agricultural, woodland or open land setting, which will remain un-served by public water distribution and wastewater disposal systems in the foreseeable future.
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.		
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.	Township has a land preservation program to protect and enhance open space and natural features.	
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.	Storm water from the majority of the drains flows to the Red Cedar River. System uses natural and man made components. Major open drains displayed in Map 8-3 in Master Plan	
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide	Township has completed three sewer lining projects to reduce “inflow and infiltration” since 1998.	

Policy Review Criteria	Goal	General Recommendations	Meridian Charter Township	Stockbridge Township
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		Off-street parking areas shall be drained so as to dispose of all surface water accumulated without affecting adjacent areas
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.	Adopted 1991. Regulates wetlands larger than 1/4 acre. Includes inventory map.	
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).	The Township contracts with the City of East Lansing for wastewater treatment services.	
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.		

Policy Review Criteria	Goal	General Recommendations	Meridian Charter Township	Stockbridge Township
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	Storm Drainage code includes policy regarding excavation, grades and grading, water quality standards	
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.		
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.	Following approval of the East Lansing/Meridian Wellhead Protection Plan, groundwater protection regulations were incorporated into the site plan review section of the zoning ordinance.	
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.	Protect groundwater recharge areas in the Township: identify important groundwater recharge areas, educate citizens, develop a set of public policies	
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.		
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.		
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.		Unlawful for any person, firm, corporation or other legal entity to pollute, impair or destroy the air, water, soils or other natural resources within the Township
Temperature				

Policy Review Criteria	Goal	General Recommendations	Meridian Charter Township	Stockbridge Township
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.	Township has green space plan to link open and natural areas.	A greenbelt shall be provided, and is an area established at a depth of the required front yard setback, with a number of standards regarding landscaping
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects.	The Site Plan review process should include woodland preservation criteria.		
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.	Conservancy District which is an overlay zone addressing groundwater recharge areas, floodway areas and floodway fringe areas with its boundaries determined on a case by case basis.	Section 4.06 RD, Resource Development District: Established to provide for the arrangement of land uses that are compatible with the conservation and preservation of natural environment.
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.		
Other				
Other Comments			Local effort to close abandoned wells. Requirements for water conservation/lawn sprinkling. Participates in Groundwater Management Board. Very Comprehensive in its Natural Features Inventory	

Policy Review Criteria	Goal	General Recommendations	Unadilla Township	Vevay Township
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.		Adopted May 5, 2004
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	Promote a healthy environment in Unadilla Township as it relates to the Township's natural resources, sensitive ecosystems, the integrity of the Township's land, water, and air	COMMUNITY CHARACTER / ENVIRONMENT GOAL: Preserve the dominant rural character of Vevay Township and the integrity of its environmental resources. Review development in light of impact. Educate the public. Encourage preservation of open spaces. Target key environmental areas for protection.
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Adopted May 13, 1999. Amended Nov 19, 2011	Adopted 6-2-2008. Prepared by LSL Planning
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.		Chapter 10 Zoning Ordinance- Delineation of a Floodplain Overlay District: 1000ft from high water marks and 500ft from the edge of any county drain easement.
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.	C-1: Public Recreation District: protect the quantity and quality of the publicly owned natural resources within Unadilla Township.	Township operates a single recreation site. Township residents are able to use recreational facilities of the Mason and Dansville School Districts, Cities of Mason and Lansing, as well as regional facilities operated by Ingham County and other public agencies.
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		Chapter 11 PUD: Allow clustering of development to preserve common open space, traditional neighborhood design, historic or significant architectural features.
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.		Site Plan Text: See Attached -Business Districts -Planned Shopping Centers -Limited Industrial Districts -General Industrial Districts -Mobile Home Districts
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.		Only state imposed regulations are followed.
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.		Any tree required by this Ordinance to be preserved die, the owner/developer shall replace the tree. A means of protecting site trees against injury during construction shall be provided.

Policy Review Criteria	Goal	General Recommendations	Unadilla Township	Vevay Township
Other Ordinances				
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.	A-1: Farm / Residential District: Provide opportunities for farming in the Township and the retention of land areas in the Township for production of food and fiber... This District is also intended to preserve woodlands and wetlands associated with farms.	Approximately two-thirds of the Township is devoted to agricultural use and farming continues to play a dominant role in the community. Strong support in the community for the preservation of farmland resources.
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.		
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.	Section 18.24 OPEN SPACE PRESERVATION OPTION: Under this option site must meet minimum space preserved, no more than 50% of total land area developed.	To the extent that residential development is accommodated in the Agricultural/Rural Residential Area, patterns that incorporate “clustering” and/or “open space developments.” or the preservation of natural resources, open spaces, rural character are strongly encouraged.
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.	Storm Water Management: New development shall impact adjacent lands or reduce level of stormwater management service	Storm Water Management Policies: New development shall impact adjacent lands or reduce level of stormwater management service. Green infrastructure, or storm water management that places priority on the reliance on natural drainage patterns will be encouraged wherever feasible.
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide		

Policy Review Criteria	Goal	General Recommendations	Unadilla Township	Vevay Township
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.		The Goemaere-Anderson Wetland Protection Act enacted by the state of Michigan in 1979 is closely followed by Vevay Township.
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).	B. Sewage Disposal: Meets standards of Livingston County Public Health Dept. as well as other local, county, state or federal agencies. Service to two dwellings or more constitutes a public system	All on-site sewage disposal and potable water facilities will be in accordance with the standards of the Ingham County Public Health Department, Michigan Public Health Department, and other applicable local, county, state or federal agencies.
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.		

Policy Review Criteria	Goal	General Recommendations	Unadilla Township	Vevay Township
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		Ingham County Drain Commission maintains drainage requirements.
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.		
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.		None
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.	Section 24.06 SURFACE WATER and GROUNDWATER MANAGEMENT and PROTECTION: Requirements set for protection and design standards for facilities that are associated with greater than 100kg/month of hazardous substances.	
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.		
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.		
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.		
Temperature				

Policy Review Criteria	Goal	General Recommendations	Unadilla Township	Vevay Township
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.		
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects.	The Site Plan review process should include woodland preservation criteria.		
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.		Section 62.4 Excavation of Soils and Minerals: Top soil shall not be stripped, excavated or otherwise removed on any premises for sale or for any other use than on the premises on which the top soil was originally located.
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.		
Other				
Other Comments				

Policy Review Criteria	Goal	General Recommendations	Village of Webberville	Wheatfield Township
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	Issued as part of the Zoning Ordinance.	Adopted: 1994 , Revisions: Small revisions and slight adjustments made in 1997
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.		Protect the rural character and environmental integrity of the Township. - Maintain a record of the natural environment including woodlands, wetlands, and water resources, as well as potentially environmentally hazardous areas. - Encourage an environmentally friendly future land use plan.
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Adopted: Aug 24, 2009 Revisions: In the process of adopting wellhead protection ordinances.	Adopted: 1996 - Revisions: Very small revisions made throughout the years
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	A participant of FEMA. Floodplain regulations protect areas of predictable flooding.	Not a FEMA participant.
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.		
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.		Site Plan Application/Site Plan Review Checklist/Site Plan Review Text
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.	None	None.
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	None	Existing trees and other plant growth shall be preserved in areas where disturbance is not necessary. Use of native species is encouraged with landscaping.

Policy Review Criteria	Goal	General Recommendations	Village of Webberville	Wheatfield Township
Other Ordinances				
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.		The following apply to farms: - -Manure Management: manure shall be stored in a manner to minimize runoff -Pesticide Management: pesticide facilities shall have a concrete floor that is sloped to a sump for containment of spills to prevent groundwater contamination.
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.		
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.		
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.		
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide		

Policy Review Criteria	Goal	General Recommendations	Village of Webberville	Wheatfield Township
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.	None	None.
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).	Chapter 51: Webberville Sewer Ordinance	
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.		

Policy Review Criteria	Goal	General Recommendations	Village of Webberville	Wheatfield Township
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	The Drain Commission conducts any drainage work unless a signoff from the Drain Commission Office is granted.	Ingham County Drain Commission maintains drainage requirements.
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.		
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.	None, but the village has gone through public hearings and are awaiting the adoption of new revisions in the next few months.	None.
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.		
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.		The cleanup of hazardous materials shall be the responsibility of the person who produced them. Hazardous materials shall not be disposed of/collected/stored/transported within the village without written approval of the Village President or the Fire Chief.
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.		
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.		
Temperature				

Policy Review Criteria	Goal	General Recommendations	Village of Webberville	Wheatfield Township
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.		
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects.	The Site Plan review process should include woodland preservation criteria.		
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.		
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.		
Other				
Other Comments				Stormwater Management -Existing natural drainage shall be maintained to the maximum extent feasible. -Stormwater management facilities shall be designed in as small an area as possible -Retention areas shall resemble natural features.

Policy Review Criteria	Goal	General Recommendations	White Oak Township	Williamstown Township
Land Use Planning				
Master Plans/Future Land Use Maps	Master Plan and Comprehensive Land Use Plan should state the community's intention for land use, natural resource preservation, and providing infrastructure.	The Master Plan is the first place where natural resource protection should be mentioned in an overarching statement of stewardship.	Adopted: 1992 Revised: None	Adopted 2006. Proposed update April 23, 2013
Environmental Goals/Policies/Objectives	Some goals/policies/objectives for the community should include specifics to environmental health and safety, overall environmental stewardship.	Goals and objectives should be very clear about environmental protection and stewardship. This can be tied to quality of life and economic development.	Provide sufficient areas for future development and growth, protect adjacent natural features.	Preservation of Natural Features. Potable Water & Wastewater Treatment. Farmland Preservation. Green Mixed Used Development Policies / Environmental Policy Statements.
Zoning Ordinance	Zoning Ordinances should enact the rules that support the vision of the Master Plan and Future Land Use Maps.	Be sure that the Zoning Ordinance falls in line with the Master Plan goals and objectives; this is often where disconnects in policy begin.	Adopted: 1995 Revised: Several items currently being revised including communication towers, driveway requirements, and land splits.	Adopted July 9th, 2013
Floodplain Mapping, Overlay District Flood Hazard Mitigation Planning, Floodplain Ordinance	Extent of 100-year floodplain is recognized and provisions to protect or mitigate impacts to the floodplain are adopted.	Floodplain language/maps should be updated to include the most up to date information. Revise zoning maps accordingly.	A participant of FEMA.	FEMA Participant/Floodplain Ordinance adopted 1982. Discourage development in areas that are known to be in the 100-year flood plain.
Recreation Plan	A MDNR approved 5-year Recreation Plan identifies priority lands for acquisition or protection for future recreational use.	Recreation plans should include trails, green space, parks, blue trails, and boating access. Future recreational uses need to incorporate water recreation as a more prominent opportunity.		The Williamstown Township Parks and Recreation Master Plan sets forth the Township goals, objectives, and places for parks and recreation facilities and services. Plan was adopted in 2007 and must be updated to remain eligible for state recreation grants.
Low Impact Development Ordinance - development and division practices	Impacts of development to communities resources are minimized through infiltration and reduction of impervious surfaces.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite		
Development Review Process	Existing and future plans for natural features are illustrated in site plan. Protective measures are included in site plans to ensure that developments preserve natural features and water quality	Site Plan review procedures and checklists should align with all ordinances/policies related to water quality, conservation, stewardship and maintenance.	Section 4.38 Site Plan Review and Approval Procedures	Section 27.02: Site Plan Review/ Plat Approval Process are combined in Section 27 entitled General Procedures and Related Standards.
Natural Features Overlay District	Overlay districts restrict activities in areas of protection based on proposed land use changes.	Be sure that the Zoning Ordinance and Site Plan procedures take an overlay district into account.	Section 4.33 Landscaping Requirements and Plant Materials, Buffer strip and Greenbelt Standards	No, but has been discussed.
Tree Removal Ordinance	When trees are removed from a site for development, they should be replaced/replanted with an appropriate ratio to enhance tree coverage in the community.	The Site Plan review process should include the tree ordinance criteria.	Section 4.33 Landscaping Requirements: All diseased and/or dead material shall be removed within thirty days following Township notification and shall be replaced.	Objective included in Master Plan: Prepare and Adopt a Tree Protection Ordinance.

Policy Review Criteria	Goal	General Recommendations	White Oak Township	Williamstown Township
Other Ordinances			Section 4.19 Building Grades: Land surrounding structures shall be graded to prevent inflow of water on structure	Sec 2.11: Grading Regulations; Sec 2.20: Floodplains; Sec 2.21: Soil Erosion and Sedimentation Control; Article 5: Landscaping and Screening; Article 25: Planned Development
Agriculture				
Agriculture/Farmland Preservation	Master Plans describe importance of agricultural land and rural character in community. Zoning ordinances provide regulations for preserving farmland	Ingham Co. municipalities need to be sure that the Ag/Farmland Preservation program criteria is included in their development procedures; Livingston Co. could consider adopting a similar program.	Article 9 Zoning Ordinance: The Agricultural District is intended to conserve and enhance the low-density character and agricultural use of substantial portions of the Township.	Encourage continued agricultural activity. When reviewing development plans, explore alternative layouts to minimize loss of farmland and conflict with nearby farming operations.
Riparian Ordinance - riparian setbacks	Buffer overlay zones are identified and regulated for stream protection and flood control	Be sure that the Zoning Ordinance and Site Plan procedures take the riparian corridor into account.		
Clustering and Open Space Developments - protect open spaces, natural resource protection	Cluster development is allowed and incentivized. Land conservation techniques are utilized to keep land preserved in perpetuity	Be sure that the Zoning Ordinance and Site Plan procedures allow for cluster/open space development.		The Green Zone Planned Development District (the "Green Zone") is a diverse mixed use zoning district created to guide development of a portion of the Grand River corridor in a sustainable compact design
Street Patterns	Standards are flexible for street length and width, sidewalk locations, and cul-de-sacs to reduce imperviousness	Reduce imperviousness by using the most appropriate street/sidewalk widths while maintaining public safety. Work with the Road Commission to have common goals.		
Conservation Easements and Similar Tools	Use of conservation tools is incentivized to allow developers to realize benefits of protecting resources.	Consider utilizing easements in areas for conservation, work with the TCRPC to review potential conservation areas in depth and incorporate into Master Plan/Zoning documents.		
Sediment				
Storm Water Standards - runoff and water quality	Storm Water Standards and criteria are developed to regulate for flood control, stream protection, and water quality.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite. The handbook covers all topics listed here.		
Engineered Best Management Practices	Designs for water quality are incorporated into designs standards.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Runoff Volume Control	Reduction of runoff volume is incorporated into designs, allowing flexibility in street and development drainage systems.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Minimizing Inflow	Disconnect downspouts and other direct connections to the storm sewer	Use the GLRC Post-Construction Stormwater Control handbook as a guide		

Policy Review Criteria	Goal	General Recommendations	White Oak Township	Williamstown Township
SESC, Construction Management Ordinance	Soil erosion and sedimentation control is identified as an important activity of the County and other enforcing agents.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
	Adequate staff is available to effectively administer and enforce SESC ordinance	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Impervious Surface Reduction - parking lot designs and parking space requirements, alternative materials	Flexibility is allowed for alternative paving materials and requirements	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Parking Lots and Driveways	Alternative parking lots and driveways designs are permitted to reduce imperviousness.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Streets and Access	Reduced street widths and on-street parking requirements are allowed to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Lot Setbacks/Lot Width/Lot Coverage	Relaxed rules for specific dimensions allows more options for developers, such as open space and cluster development designs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Sidewalks	Flexibility is allowed for sidewalks on only one side of the street or the use of alternative pathways and trails to reduce imperviousness	Use the GLRC Post-Construction Stormwater Control handbook as a guide		
Nutrients				
Wetland Preservation	Identification and delineation of wetlands provides support for ordinance and regulations to protect and preserve existing and restored wetlands.	Protection of existing wetlands should a priority in the Master Plan and Zoning ordinance; restoration is a component that should be included for future land use planning.	None	Zoning Ordinance Article 2 Section 2.24 Wetland Buffer Regulations
Sanitary System Standards	Master Plan provides sewer service area that adequately serves the community.	These standards should be updated on a regular schedule as part of the Master Plan update (every five years).	List of provisions, prohibitions and acts requiring permit regarding handling and disposal of waste, and sanitation systems.	According to the Soils Survey, soils over almost the entire Township have moderate or severe limitations with regard to use of septic systems. A lack of public water or sewer is one of the reasons Williamstown was not included in the TCRPC's urban services boundary.
Septic Ordinance	An ordinance regulating the siting, installation, and maintenance of septic systems reduces failures and identifies faulty systems.	Ingham Co. Point of Sale Ordinance should be recognized throughout community specific plans; Livingston Co. could consider similar regulations.		

Policy Review Criteria	Goal	General Recommendations	White Oak Township	Williamstown Township
Local Site Drainage Requirements other than County Drain Commissioner	Reduce polluted runoff from entering municipal drainage systems and BMPs.	Use the GLRC Post-Construction Stormwater Control handbook as a guide to set design criteria for BMPs to manage stormwater onsite	The Drain Commission conducts any drainage work unless a signoff from the Drain Commission Office is granted.	No
Lake Management	Minimize lake access and usage to preserve water quality.	Be sure lake properties are zoned/planned for to protect water quality. This can include setbacks, septic maintenance requirements, native plants, etc.		
Pesticides and Chemicals				
Wellhead Protection Areas	Identify and map wellhead protection areas to preserve groundwater.	Work with the TCRPC to develop a Wellhead Protection Plan which should include recommendations for siting new wells based on land use.	Section 4.49 Wells: All structures associated with a well must be pre-empted by the Michigan Department of Natural Resources, the EPA, or the Ingham County Health Dept.	No
Groundwater Protection	Restrict high-risk land uses in groundwater recharge areas.	Work with the TCRPC to develop a potential contaminant source inventory (already exists in the urban area) to be used in future land use planning.		The Michigan Resource Information System (MIRIS) maps indicate wetlands are scattered throughout the Township, but the greatest concentrations are located along the Red Cedar River and Coon Creek. Development should be restricted in all groundwater recharge and wetlands areas.
Waste Reduction/Recycling	Provide recycle facilities and opportunities for waste removal or reduction	Work to provide recycle and waste reduction opportunities to reduce dumping or spills.		
Preventing Pollution/Housekeeping	Communities should maintain facilities and storage areas to reduce polluted runoff.	Use the GLRC Pollution Prevention and Good Housekeeping Manual to develop a community specific set of standard operating procedures.		
PATHOGENS				
Animal Waste (Pet & Manure)	Educate residents about the availability, location, and requirements of properly disposing of pet waste	Promote the use of BMPs related to animal waste storage and application. Develop a pet waste ordinance for local park and open space areas.		
IDEP Illicit Discharge Ordinance	Map drainage system and outfalls to support IDEP ordinance and inspection program.	Work with the GLRC to develop consistencies related to illicit connections throughout all municipalities.		
Temperature				

Policy Review Criteria	Goal	General Recommendations	White Oak Township	Williamstown Township
Greenways/Greenbelts	Plan for use of greenways and greenbelts to protect watercourses and other resources.	Utilize the TCRPC Green Infrastructure Vision to protection and enhance conservation areas.	Where required, greenbelts shall conform to outlined standards: Width, and minimum landscaping provisions	
Woodland Preservation	Assess individual trees and woodlands to support protection measures of ordinances and standards to minimize tree removal during construction projects.	The Site Plan review process should include woodland preservation criteria.		
Habitat Preservation - Natural Area Preservation/Restoration	Assess natural areas to identify unique and sensitive areas important for ecosystem.	Utilize the TCRPC Green Infrastructure Vision to protect and enhance conservation areas.		Preservation of natural features should be a prevailing objective in all future development. (Rural character, including woodlands and woodlots, wetlands, drainage courses, and rolling topography)
Invasive Species				
Invasive Species Management	Use native and site specific plants to maximize viability and reduce threat of invasive species.	Work with the TCRPC Green Infrastructure Vision and the Conservation District to reduce the risk of invasive species.		
Other				
Other Comments				Developing a local Wetlands Ordinance; Also looking to amend Zoning Ordinance section regarding Agriculture/Commercial zone. Looking at a specific cluster development option in the Ag Commercial Zone which pairs clustering with donation of development rights.