ELK CREEK WATERSHED INVENTORY

May 5, 2017

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ACRONYMS AND ABBREVIATIONS

BCST............................Butler County Stream Team
CRP............................Conservation Reserve Program
CWA.......................... Clean Water Act
CWNS........................ Clean Watersheds Needs Survey
ECW...........................Elk Creek Watershed
EWH...........................Exceptional Warmwater Habitat
EQIP...........................Environmental Quality Improvement Programs
FEMA..........................Federal Emergency Management Agency
GWPP.........................Groundwater Pollution Potential
HSTS...........................Household Sewage Treatment Systems
HUC............................Hydrologic Unit Code
IBI...............................Index of Biotic Integrity
ICI...............................Invertebrate Community Index
LULC...........................Land-Use/Land-Cover
MIWb.........................Modified Index of Well-Being
NLCD..........................National Land Cover Database
NPDES.........................National Pollutant Discharge Elimination System
NPS-IS.........................Nonpoint Source Implementation Strategy
NRCS..........................National Resources Conservation Service
ODNR.........................Ohio Department of Natural Resources
Ohio EPA....................Ohio Environmental Protection Agency
RM.............................River Mile
RUSLE........................ Revised Universal Soil Loss Equation
QHEI.......................... Qualitative Habitat Evaluation Index
SFHA..........................Special Flood Hazard Area
SSA............................ Sole Source Aquifer
SWAP........................ Source Water Assessment and Protection
SWCD........................ Soil and Water Conservation District
SWPPP.......................Stormwater Pollution Prevention Plan
TMDL.........................Total Maximum Daily Load
TVCT.......................... Three Valley Conservation Trust
WAP...........................Watershed Action Plan
WWTP........................Wastewater Treatment Plant
USDA..........................United States Department of Agriculture
US EPA.......................United States Environmental Protection Agency
USGS..........................United States Geological Survey
WRE...........................Wetlands Reserve Easements
WET...........................Whole Effluent Toxicity

EXECUTIVE SUMMARY

The Elk Creek Watershed Inventory is part of a year-long professional service project completed during the 2016-2017 school year by graduate students in Miami University's Institute for the Environment and Sustainability. The client, Butler Soil and Water Conservation District (Butler SWCD), sought a comprehensive understanding of the current conditions in the Elk Creek Watershed (ECW). The inventory will serve as an important step towards watershed management and the protection of water resources in the area.

The United States Environmental Protection Agency (US EPA) established nine minimum elements for improving water quality on a watershed basis. All nine elements must be included in a watershed management plan to secure funding from Section 319 of the Clean Water Act (CWA). To facilitate the implementation of the nine minimum elements, the US EPA produced the *Handbook for Developing Watershed Action Plans to Restore and Protect our Waters*, which outlines the watershed action planning process (US Environmental Protection Agency 2008). One step in this process is the creation of a watershed inventory. The ECW inventory followed these guidelines, as well as the *Guide to Developing Nine-Element Nonpoint Source Implementation Strategic Plans in Ohio,* which was produced by the Ohio Environmental Protection Agency (Ohio EPA) to supplement the Handbook and further address nonpoint source pollution (Ohio Environmental Protection Agency 2016 A). The essential elements to include in a watershed inventory are boundaries, natural features, land use, population characteristics, water quality and watershed conditions, and pollutant sources. The ECW inventory makes use of geographic information systems (GIS) mapping to depict many current conditions in the watershed.

The ECW is located within the Lower Great Miami River Watershed in Southwest Ohio. It is located at the intersection of Butler, Preble, and Montgomery counties, contains six townships and the City of Trenton. The ECW is rural with mostly agriculture (69%) and deciduous forest (20%) making up the land use/land cover. The western portion of the ECW is marked with a higher percentage of agriculture while the eastern portion is a mix of agriculture and forest. Knowledge of water quality in the ECW was greatly aided by the work done by Butler County Stream Team. Their data revealed exceptionally high levels of *Escherichia coli* (*E. coli*) throughout the ECW and significantly higher levels of nitrate in the western portion of the ECW.

The following recommendations were made by the Project Team for Butler SWCD:

1. Monitor Ohio EPA reports relating to water quality, changes in water quality standards, and the status of NPDES and other relevant permits.
2. Collect data that will provide more information about water quality within the ECW, including macroinvertebrate populations as well as livestock populations and home sewage treatment systems' effect on nutrient and *E. coli* concentrations.
3. Work with stakeholders to increase the use of conservation programs offered United States Department of Agriculture, Butler Soil and Water Conservation District, and the Natural Resource Conservation Service.
4. Explore additional funding options including government and private grants for future Butler Soil and Water Conservation District projects.

1 BACKGROUND

1.1 INTRODUCTION

Freshwater is one of the most basic necessities of all life on Earth. It plays a critical role by providing our main source of drinking water, supporting habitat for plants and animals, and presenting opportunities for the enjoyment of nature through recreational activity (Pearlman 2016 A). According to the United States Geological Survey (USGS), only 2.5% of Earth's water supply is freshwater, and only 1.2% of that freshwater is accessible as surface water, making its protection essential for all terrestrial life (Pearlman 2016 A).

Some of the basic regulatory mechanisms for preventing pollution and protecting water quality are derived from the Clean Water Act (CWA). Pollution is classified as either point or nonpoint: point source pollution can be traced back to a discrete location like a factory or a pipe, and nonpoint source pollution is picked up by water as it moves over and through the land (US Environmental Protection Agency 2008). The CWA established the structure for regulating the discharge of pollutants into US waters, and for regulating water quality standards for surface water (US Environmental Protection Agency 2016 A). The CWA requires all states to set water quality standards that include the designated use and water quality criteria for the waters within its borders (33 U.S. Code § 1313 (b)). States are also required to identify waters that are threatened or impaired because they do not meet these standards, as well as create reports regarding water quality (33 U.S. Code § 1313 (d)) (US Environmental Protection Agency 2016 B). These requirements are from two CWA sections commonly known as 303(d) and 305(b).

Under the CWA, point sources of pollution are also regulated through the National Pollutant Discharge Elimination System (NPDES) permitting program, which sets limits on the quality and quantity of water discharged into waterbodies (US Environmental Protection Agency 2016 A). Nonpoint pollution is considerably more difficult to manage, as it cannot be traced back to a single location (US Environmental Protection Agency 2016 C). Amendments to the CWA established Section 319, which provides grant money to territories and Native American tribes to help support, monitor, and assess nonpoint pollution management efforts. To more effectively regulate this

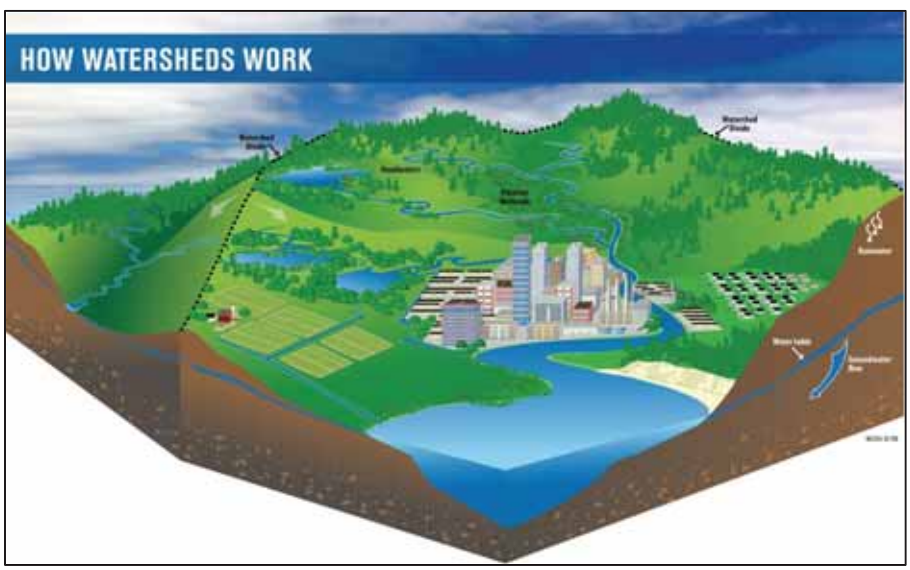

Figure 1.1 A diagram of a watershed. Watersheds are basin-like landforms, where all water flows to a single outflow (Michigan Sea Grant 2017).

type of pollution in surface waters, the US Environmental Protection Agency (US EPA) endorses the use of a watershed approach in which public and private stakeholders develop strategies to manage resources within “hydrologically-defined geographic areas,” also known as watersheds (US Environmental Protection Agency 1996).

1.1.1 What is a Watershed?

A watershed is a basin-like landform defined by highpoints and ridgelines that descend into lower elevations and stream valleys (Figure 1.1) (Pearlman 2016 B). Because of this structure, precipitation flows from the higher elevations into the valley. Watersheds vary in size, from as small as a footprint to all the land that drains into a large body of water like the Gulf of Mexico. Smaller watersheds can be encompassed by larger ones, and are referred to as subwatersheds of the larger system (Figure 1.2). These are organized into hydrologic units by the United States Geological Survey (USGS), each of which is assigned a Hydrologic Unit Code (HUC) (US Geological Survey 2017 A). Hydrologic units are classified into six levels of decreasing geographic area, so lower levels are “nested” within the larger ones. For instance, in Figure 1.2, the Elk Creek Watershed (ECW) is nested within the Lower Great Miami River Watershed, which is within the Great Miami Watershed. The ECW is a HUC 12 and the Lower Great Miami is a HUC 8 (Ohio Environmental Protection Agency 2016 B).

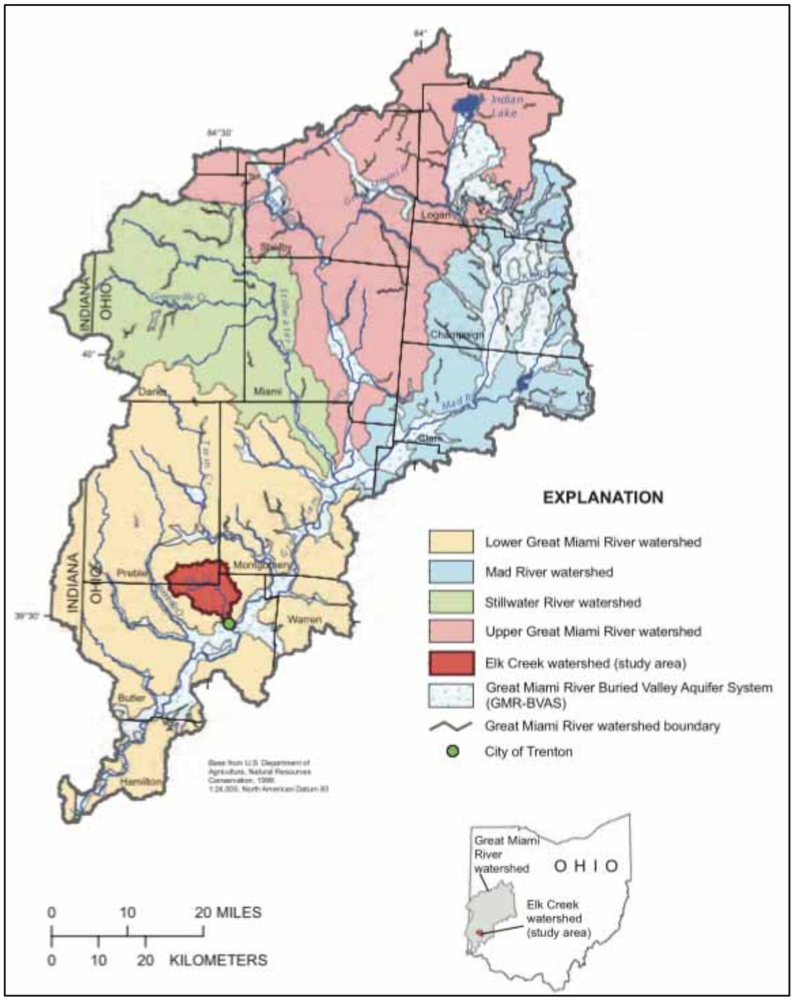

Figure 1.2 The Elk Creek Watershed, a HUC-12 system, nested within the larger Lower Great Miami Watershed, a HUC-8 system (Ohio Environmental Protection Agency 2016 B). Figure from (Pletsch and Schumann 2006).

Land use, land cover, and pollutant contamination affects water quality not only within the watershed in which it occurs, but for all communities downstream. Therefore, when investigating water quality issues, it is essential to consider both the headwaters and the downstream locations (Ohio Environmental Protection Agency 2001). Maintaining natural habitats within a watershed is also important because plant cover and leaf litter provide the natural service of absorbing precipitation, which allows the water to be filtered and released into the system at a sustainable rate. This can help prevent flooding events and erosion that negatively impact water quality throughout the watershed (Ohio Environmental Protection Agency 2001).

1.1.2 Watershed Action Planning

The management of watersheds, as dictated by the CWA and the watershed approach, is accomplished using multijurisdictional watershed action plans (WAPs), which are comprehensive plans for protecting and improving a watershed (Ohio Department of Agriculture 2016). One of the biggest benefits of having a WAP in place is that districts can use the plan to apply for state and federal funding, especially through CWA Section 319 grant programs (US Environmental Protection Agency 2008).

To effectively improve water quality on a watershed level, the US EPA has identified nine minimum elements that must be included in a WAP (see text box). The focus of these elements is to assist in the reduction of nonpoint source pollution. It recommends that all existing and future plans to improve water quality include these elements, and all nine must be included to receive project funding from CWA Section 319 (US Environmental Protection Agency 2008).

To facilitate and guide watershed planning, the US EPA produced the *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (US Environmental Protection Agency 2008). This handbook outlines the entire WAP process, from describing the basis of the watershed approach to implementation and evaluation.

Nine Minimum Elements

a) An identification of the causes and sources… that will need to be controlled to achieve the load reductions estimated in this watershed-based plan.

b) An estimate of the load reductions expected for the management measures described under paragraph (c)…

c) A description of the non-point… measures (solutions) that will need to be implemented to achieve the load reductions estimated under paragraph (b) above and an identification… of the critical areas in which those measures will be needed to implement this plan.

d) An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon…

e) An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

f) A schedule for implementing the NPS management measures identified… that is reasonably expeditious.

g) A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

h) A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards and, if not, the criteria for determining whether this… plan needs to be revised…

i) A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h)… (Ohio Environmental Protection Agency 2016 A)

1.1.3 Watershed Management in Ohio

Ohio has used and led in the development of watershed-based planning for decades (Ohio Environmental Protection Agency 2016 A). Several programs and guidebooks have been created to assist with developing WAPs in Ohio, and between 2004 and 2015 the Ohio Watershed Coordinator Grant Program endorsed 65 WAPs. However, in 2013, new Section 319 program guidance was issued — the US EPA stated that starting in fiscal year 2017, only projects with Nine-Element plans would receive funding through Section 319 grant programs (Ohio Environmental Protection Agency 2016 A). The purpose of the new guidance is to more effectively regulate nonpoint source pollution. Ohio WAPs were reviewed in preparation for the change to ensure continued funding, and two key issues were identified:

1. Critical areas identified in WAPs were too large — each area should be associated with an individual water quality issue or pollution issue within a HUC-12.
2. The nine minimum elements of a WAP should be implemented on a HUC-12 level, whereas Ohio had been implementing them at a HUC-10 level.

In summary, Ohio WAPs were too coarse in scale in both critical areas and implementation of the nine minimum elements. It was also concluded that the nine elements were not clear enough in Ohio WAPs, and should be obvious throughout. To ensure continued funding, the Ohio EPA produced the *Guide to Developing Nine-Element Nonpoint Source Implementation Strategic Plans in Ohio* to supplement existing guidance on WAPs (Ohio Environmental Protection Agency 2016 A). This document describes the process of creating Nonpoint Source Implementation Strategic (NPS-IS) plans, which are designed to supplement WAPs or serve as independent project plans to regulate nonpoint source pollution.

1.1.4 Watershed Inventories

One of the first steps in developing an effective WAP or NPS-IS plan is to compile an inventory of information already available on the watershed in question, which is outlined in Chapter 5 of the *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (US Environmental Protection Agency 2008). Chapter 5 outlines five categories that form the foundation for a basic understanding of any watershed:

1. Physical and natural features
2. Land use and population
3. Water body and watershed conditions
4. Pollutant sources (point and nonpoint sources)
5. Water quality data

Compiling a watershed inventory provides insight on activities within the watershed that impact the overall water quality, and provides baseline data that can help measure the success of restoration efforts. Inventories can also be used to inform the public and educate residents and stakeholders about potential water quality problems and solutions (US Environmental Protection Agency 2008).

1.2 PROJECT DESCRIPTION

1.2.1 Butler Soil and Water Conservation District

In Ohio, watershed management occurs through the Division of Soil and Water Conservation of the Ohio Department of Agriculture (Ohio Department of Agriculture 2017 A). The Divison of Soil and Water Conservation provides guidance and support to local Soil and Water Conservation Districts, which are "independent political subdivisions of state government" that provide technical assistance to land users in the areas they serve (Ohio Department of Agriculture 2017 A).

Butler Soil and Water Conservation District (Butler SWCD) is one such district. Located in Butler County in Southwest Ohio, the goals of Butler SWCD are to reduce soil erosion, improve water quality, and educate the residents of Butler County on the best practices for maintaining a healthy watershed (Butler Soil and Water Conservation District 2016 A). Key issues for Butler SWCD include erosion, drainage, farm conservation programs, development, ponds, and education. The major watershed that falls within Butler County is the Lower Great Miami Watershed (a HUC-8 system) (Figure 1.2), which includes the ECW (a HUC-12 system).

1.2.2 Problem Definition

Butler SWCD is responsible for offering technical assistance and educating residents and business owners about effective methods to reduce soil erosion and improve water quality. To do this, Butler SWCD must understand the issues impacting current waterways and use this information for effective watershed management. Currently, there is no comprehensive inventory of one of the regional waterways, Elk Creek.

1.2.3 Project Scope

Butler Soil and Water Conservation District requested assistance in the creation of a watershed inventory for the ECW. The watershed inventory will follow the guidelines established in Chapter 5 of the US EPA *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (US Environmental Protection Agency 2008). The inventory also uses the *Guide to Developing Nine-Element Nonpoint Source Implementation Strategic Plans in Ohio* as guidance, which provides insights about how the inventory could be used for regional management efforts going forward (Ohio Environmental Protection Agency 2016 A). If not enough information about the ECW is present to comply with the guidelines in either document, the areas that require further investigation will be documented and acknowledged. Ultimately, the ECW inventory should be able to inform a WAP or NPS-IS plan, which can be used by stakeholders to manage and improve water quality in the ECW.

The ECW is 47.62 square miles in area (Figure 1.3). The watershed is located within the larger Lower Great Miami Watershed, which feeds into the Great Miami River, the Ohio River, the Mississippi River, and the Gulf of Mexico (Figure 1.2). Therefore, the water quality of the ECW will affect the water in each of the larger watersheds downstream, which is why an inventory of the ECW is essential for a regional watershed action plan.

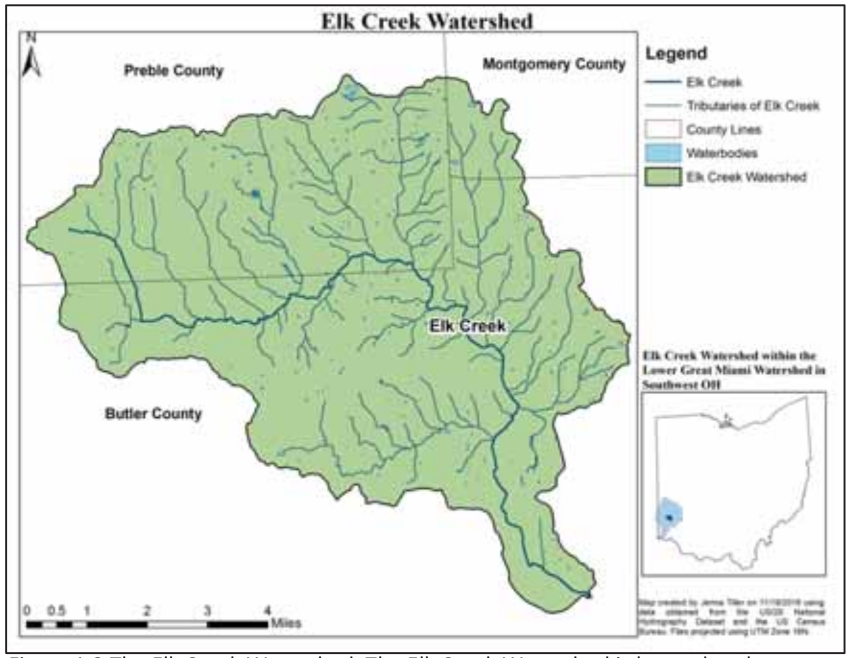

Figure 1.3 The Elk Creek Watershed. The Elk Creek Watershed is located at the intersection of Butler, Preble, and Montgomery counties in Southwest Ohio.

1.2.4 Project Goal

The goal of this project is to compile a watershed inventory for the ECW in compliance with Chapter 5 of the US EPA's *Handbook for Developing Watershed Action Plans to Restore and Protect our Waters* (US Environmental Protection Agency 2008) and the *Guide to Developing Nine-Element Nonpoint Source Implementation Strategic Plans in Ohio* (Ohio Environmental Protection Agency 2016 A) for the client, Butler SWCD.

1.2.5 Objectives

1. Identify the political boundaries and population characteristics in the ECW
2. Describe the natural features of the ECW, including water resources, geology and soils, habitat, and biotic environment
3. Determine the land-use and its potential impacts on the water quality of Elk Creek
4. Identify potential point and nonpoint pollution sources in the ECW
5. Assess watershed conditions through water quality data and previous reports
6. Generate maps and figures to display data
7. Compile information into a report that fulfils US and Ohio EPA requirements

The subsequent sections of this report form the inventory of the ECW. The population and demographics of the inhabitants of the ECW are covered in Section 2, the natural features are described in Section 3, and Section 4 pertains to land use and management. Section 5 outlines the relevant water quality standards that apply to the ECW, Section 6 describes known and potential sources of pollution, and Section 7 contains an evaluation of the current and historic water quality in the ECW. Recommendations on monitoring reports and standards, collecting data, stakeholder participation, and increasing conservation efforts through funding options are outlined in Section 8.

2 POLITICAL BOUNDARIES AND DEMOGRAPHICS

2.1 POLITICAL BOUNDARIES

Knowledge of the political boundaries and land ownership characteristics in a watershed can provide stakeholder information and potential pollutant source information, which may aid in the implementation of a WAP or NPS-IS plan (US Environmental Protection Agency 2008).

The ECW is located at the intersection of Butler, Montgomery, and Preble counties, and crosses through six townships and the City of Trenton (Figure 2.1). There are also seven populated places within the ECW, which are cities and towns identified in the USGS Geographic Names Information System: Astoria, Beechwood, Greenbush, Jacksonburg, Miltonville, West Elkton, and the City of Trenton (US Geological Survey 2017 B). While Trenton’s urban center is not within the ECW, its urban areas extend into the southernmost portion of the watershed, so it is included as a populated place in this inventory. Urban areas are defined as land that is used extensively for commercial, industrial, transportation, communications and utilities purposes (US Geological Survey 2016 A).

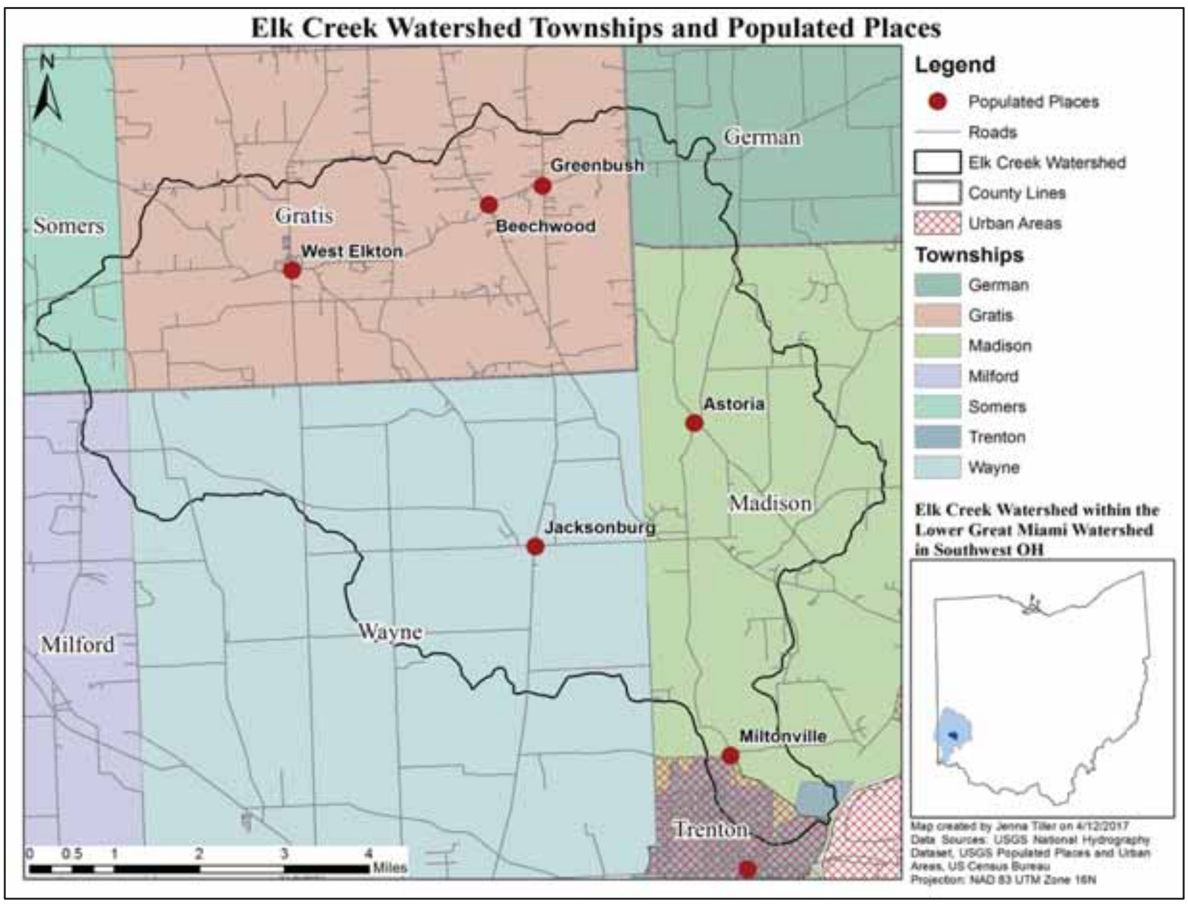

Figure 2.1 Township and towns within the Elk Creek Watershed. This demonstrates that there is a small number of populated places in the watershed. Trenton is shown in the lower right edge of the map with some of its city boundaries in the southeast region of the watershed.

2.2 DEMOGRAPHICS

Human actions are often the leading cause of environmental change, so understanding the demographics, or characteristics of a given population, is essential when developing environmental management plans (Boberg 2005). Based on the 2010 US Census, the total population of the six townships that intersect the ECW and Trenton is 45,139, but this is not specific to the watershed (Table 2.1). Figure 2.2 shows population density within the ECW.

Table 2.1 Populations of Ohio townships that have areas within the Elk Creek Watershed (US Census Bureau 2012 A). The combined population of the townships and Trenton is 45,139, but since none have a majority of their area within the ECW, the actual population of the ECW is likely much lower. See Appendix A.1 for calculations and B for more population characteristics. *The percentage of each township that is within the Elk Creek Watershed was calculated by the Project Team.

County	Township	Populated Places within Township	Total Township Population (2010)	*Percent of Township within the ECW
Butler	Madison	Astoria, Miltonville	8,448	24.70%
	Milford	None	3,550	1%
	Wayne	Jacksonburg	4,443	33.70%
	City of Trenton**	Trenton**	11,869**	1.5**
Preble	Gratis	W. Elkton, Greenbush Beechwood	4,408	34%
	Somers	None	3,992	2.20%
Montgomery	German	None	8,429	3%

**The City of Trenton is not classified as a township.

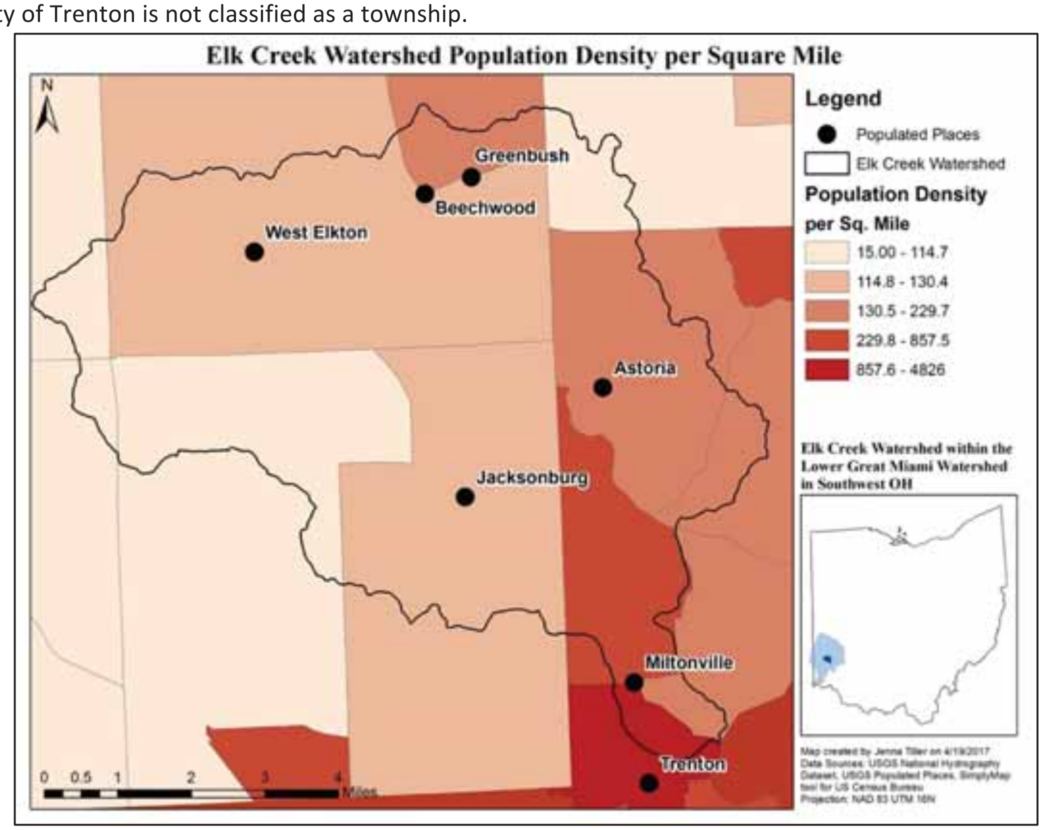

Figure 2.2 2016 population density of townships and cities within the Elk Creek Watershed. Population density is measured in people/sq mile using US Census Block Groups. The population density is and highest near Trenton.

3 NATURAL FEATURES

The natural features of a watershed not only define the watershed boundary, but influence the hydrology, water resources, land use, and pollutant loading (US Environmental Protection Agency 2008).

3.1 SURFACE WATER RESOURCES

3.1.1 Climate

The volume and rate of precipitation determines the amount of water flowing into the system, and air temperature, which influences water temperature, can determine which organisms inhabit the stream (Pearlman 2016 B). The ECW is located in a temperate climate with a peak precipitation in spring with 12.95 inches on average, and average seasonal temperatures ranging from 32.0 °F to 73.3 °F (Table 3.1) (National Centers for Environmental Information 2016).

Table 3.1 Climate normals collected from Hamilton, Ohio between 1981 and 2010 (National Centers for Environmental Information 2016). The average annual precipitation is 42.91 inches and the average temperature is 53.3 F. Spring and summer produce the most rain and the average temperature peaks in the summer at 73.3 F.

Season	**Precipitation (in)**	**Temperature (°F)**
Annual	42.91	53.3
Winter	8.70	32.0
Summer	11.84	73.3
Spring	12.95	52.8
Autumn	9.42	54.5

3.1.2 Tributaries

Elk Creek has three named tributaries, Clear Creek, Denny Creek, and Dry Run, within the USGS Geographic Names Information System (Figure 3.1) (US Geological Survey 2017 B). None of these are classified as subwatersheds of Elk Creek because the ECW is a HUC-12 system, the smallest delineated system by the USGS (US Geological Survey 2017 A).

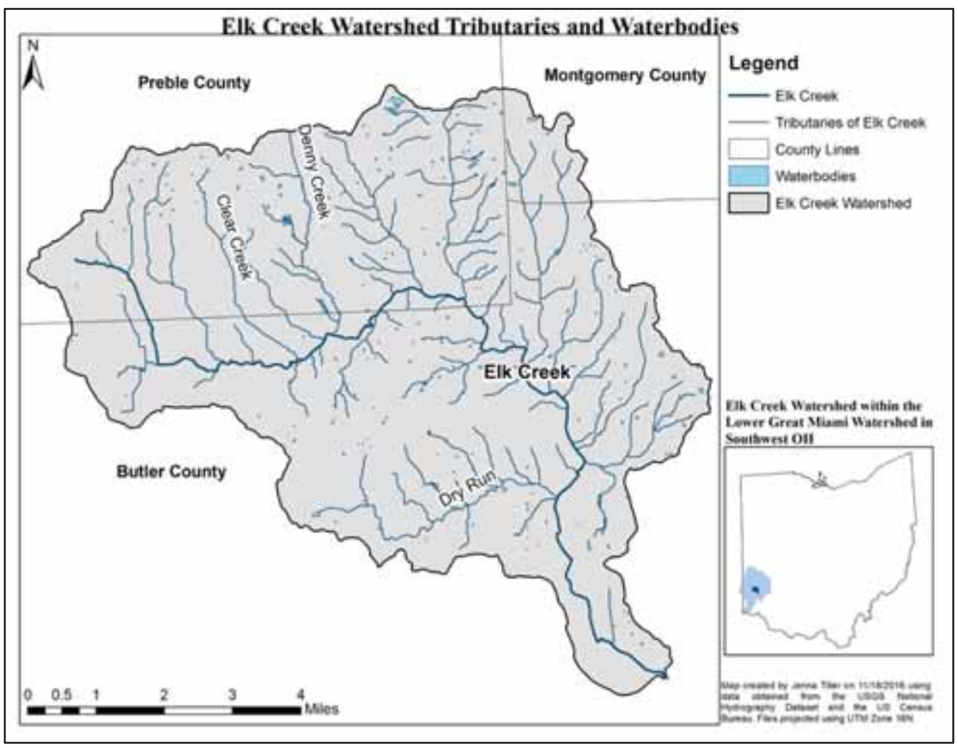

Figure 3.1 Named tributaries of the Elk Creek Watershed. The three named tributaries are Clear Creek, Denny Creek, and Dry Run.

3.1.3 Flood Frequency and 100-Year Floodplain

Flooding is a temporary covering of the land surface by flowing water from any source, including streams, runoff, and natural disasters. Excluded from the definition is shallow or flowing water not associated with a precipitation event or snowmelt, as well as permanent standing water. Flood frequency is how often a flood event occurs in a given area (Soil Survey Division Staff 1993).

In the ECW, flooding is occurs more commonly along Elk Creek, with frequencies ranging from occasional (5-50% chance in any given year) to frequent (over 50% chance in any given year) (Figure 3.2). A majority of the ECW has no reasonable possibility of flooding, and has a flood frequency of "none" (Soil Survey Division Staff 1993).

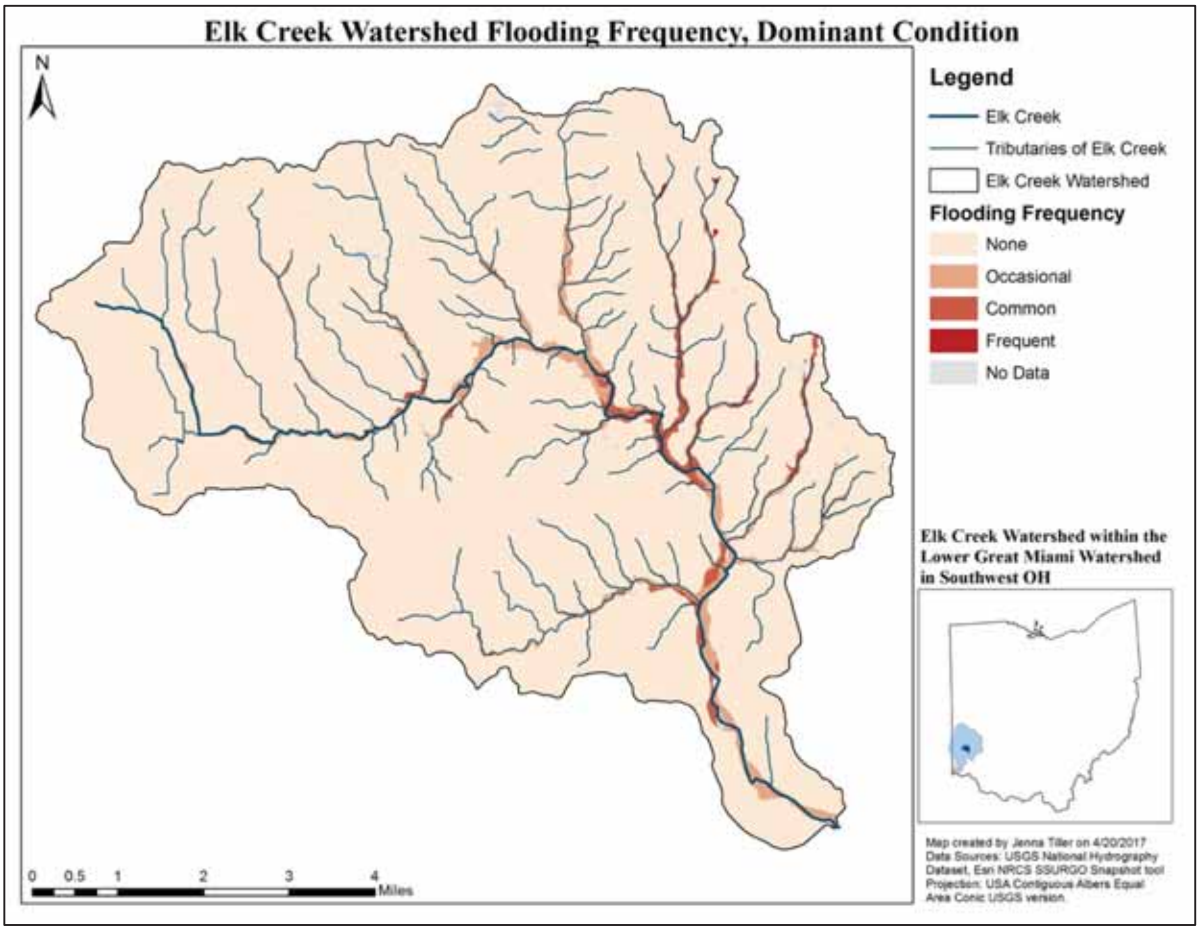

Figure 3.2 Flooding frequency in the Elk Creek Watershed. There is no flooding for majority of the Elk Creek Watershed. Flooding that is considered frequent or common occurs along many sections of land close to the creek.

Special Flood Hazard Areas (SFHA) are defined by the Federal Emergency Management Agency (FEMA) as areas with a 1% or greater chance of being inundated by a flood event in a given year, also known as a 100-year flood (Federal Emergency Management Zones 2017). These zones are significant because flood insurance and development plans are based off the 100-year flood zone.

In the ECW, the only populated place with SFHA is Miltonville (Figure 3.3). Most of the SFHA are located along the main body of Elk Creek.

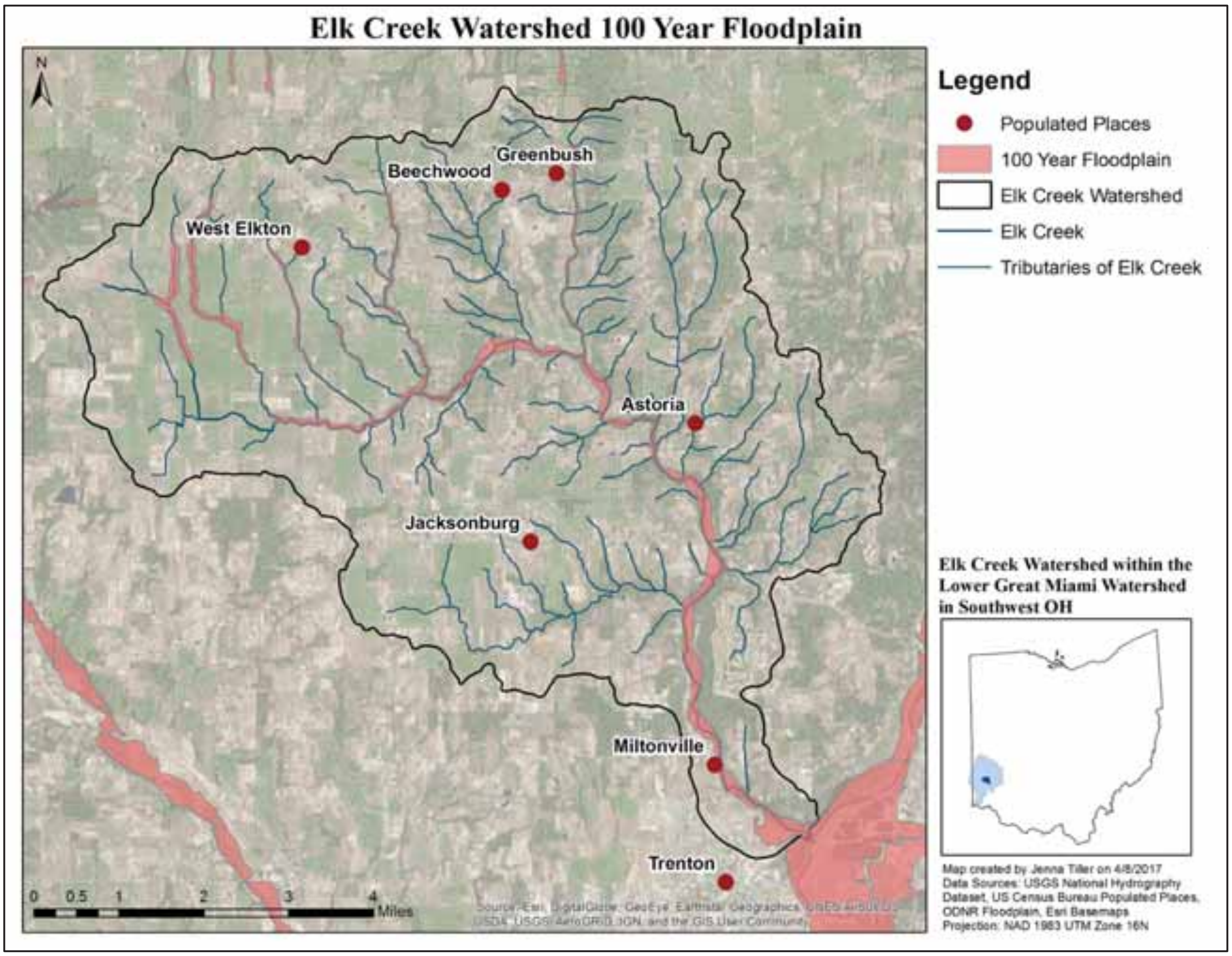

Figure 3.3 The 100-year floodplain zones in the Elk Creek Watershed. The 100-year floodplain is mostly located along the main body of Elk Creek, and Miltonville is the only populated place within the 100-year floodplain.

3.2 GROUNDWATER RESOURCES

For many communities in the ECW, drinking water is provided by groundwater resources (Pletsch and Schumann 2006). Groundwater is defined as water below the land surface that fills the spaces between soil, sediments, or rocks. According to the Ohio EPA, almost four million people in Ohio rely on groundwater through public water systems, and more than 700,000 people have private groundwater wells (Ohio Environmental Protection Agency 2014 A).

Groundwater formations that can yield significant quantities of water to wells and springs are called aquifers, and can be classified as either consolidated or unconsolidated (Ohio Environmental Protection Agency 2014 A). The groundwater in consolidated aquifers moves through the fractures and pore spaces of consolidated rock, which is well-formed and solid. Unconsolidated aquifers are in loose sediment, such as sand and gravel (US Geological Survey 2016 B). These aquifers are often more productive, because water can flow more easily through the spaces between the grains.

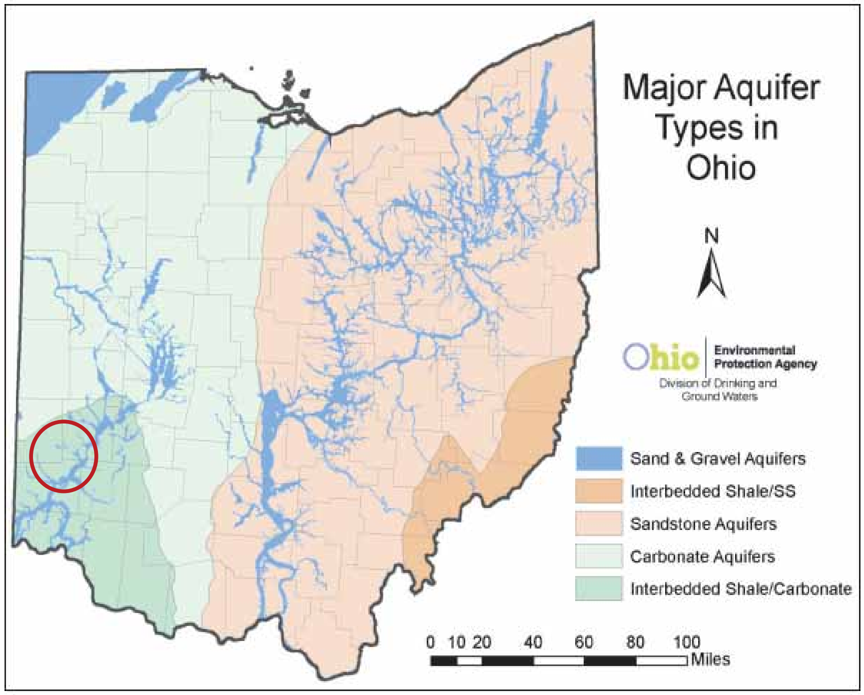

Figure 3.4 Major aquifer types in Ohio. The major types of aquifers in the state of Ohio are sand and gravel, interbedded shale/sandstone, sandstone, carbonate, and interbedded shale/carbonate (Ohio Environmental Protection Agency 2014 B). Southwest Ohio is dominated by interbedded shale/carbonate aquifer.

Ohio has three primary types of aquifers: sand and gravel aquifers (unconsolidated), sandstone bedrock (consolidated), and carbonate bedrock (consolidated) (Figure 3.4) (Ohio Environmental Protection Agency 2014 B). Southwest Ohio is dominated by interbedded shale/carbonate consolidated aquifers, which are often not productive enough for water wells (Figure 3.4) (Ohio Environmental Protection Agency 2014 A). In Ohio, unconsolidated aquifers are primarily defined by glacial sediment and activity. The ECW contains both consolidated and unconsolidated aquifers.

3.2.1 Consolidated Aquifers

The consolidated aquifers in the ECW are named by their geologic age of deposition: Silurian and Ordovician (Figure 3.5). In the ECW, these coincide directly with the type of bedrock present, as discussed in later in Section 3.3.1 (Figure 3.11). Neither type of aquifer have yields productive enough for water wells.

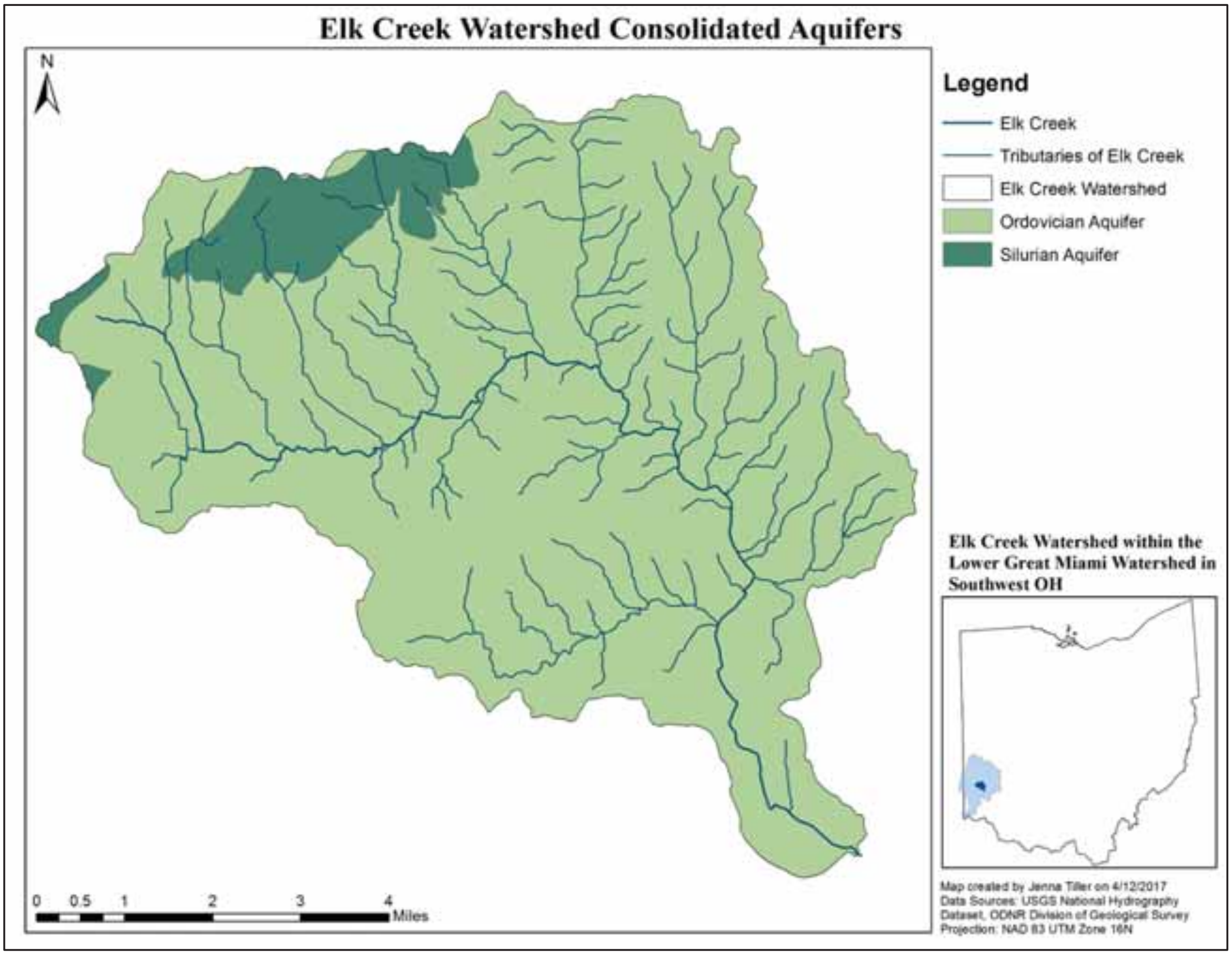

Figure 3.5 Consolidated aquifer types in the Elk Creek Watershed. The two consolidated aquifers in the Elk Creek Watershed are Ordovician and Silurian.

3.2.2 Unconsolidated Aquifers

In Ohio, unconsolidated aquifers can be identified by both their glacial setting and location. The ECW contains buried valley, ground moraine, end moraine, thin upland, alluvial, and complex unconsolidated aquifers, which are associated with Oxford, Trenton, Camden, and the Great Miami River (Figure 3.6) (Ohio Department of Natural Resources 2017 A).

"Buried Valley: Thick drift filling previously existing valley incised into bedrock…. Predominantly contains fines… and sand and gravel. Modern streams commonly overlie these features. Yields are typically 100 gpm or greater.
Ground Moraine: Moderately thick drift (25-100ft) composed primarily of till. Yields are obtained from thin, interbedded lenses of sand and gravel…
End Moraine: …Water is obtained from thin, interbedded lenses of sand and gravel…. They often function as local drainage divides.
Thin Upland: Areas of thin drift (<25 ft). Drift typically is comprised of weathered till, commonly lacks sand and gravel lenses capable of sustaining yields. Underlying bedrock is close to surface and is usually the aquifer…
Alluvial: Areas containing modern streams not associated with major buried valley systems… Drift is typically <100 ft.
Thick Drift Complex: Areas of thick drift (usually >100ft). Drift typically comprised of thick accumulations of glacial till (and lacustrine). Water is obtained from thin, interbedded lenses of sand and gravel. Areas may consist of a combination of settings such as end moraine overlying a buried valley…" (Ohio Department of Natural Resources 2017 A)

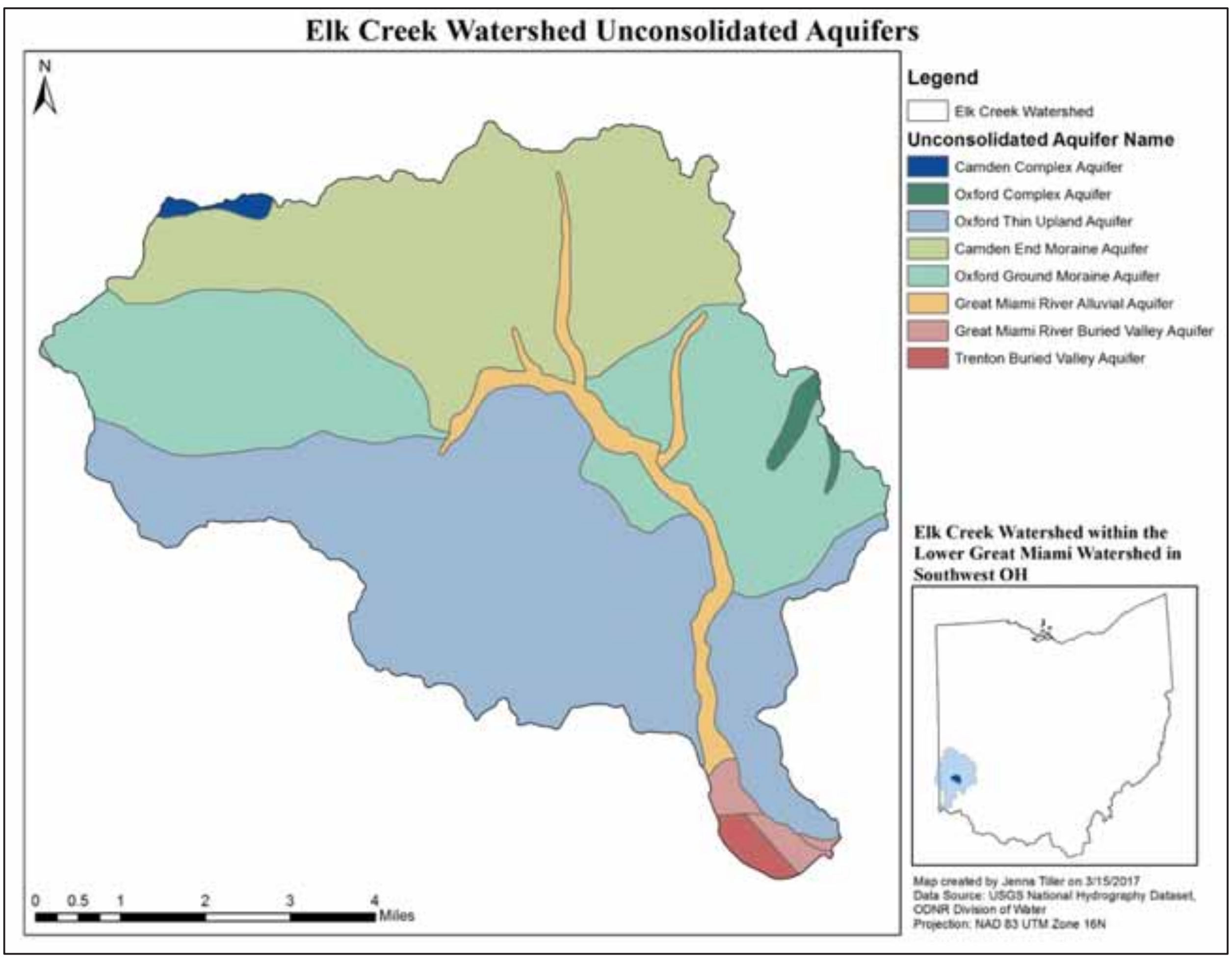

Figure 3.6 Unconsolidated aquifers in the Elk Creek Watershed. Unconsolidated aquifers are named both by their location and glacial setting. There are eight types of unconsolidated aquifers in the Elk Creek Watershed.

3.2.3 Sole Source Aquifers

Sole Source Aquifers (SSA) are aquifers that provide at least 50% of the drinking water to the areas above it. All federally funded projects that could impact a SSA must be reviewed by US EPA to ensure that the SSA will not be put at risk (US Environmental Protection Agency 2017 A). Southwest Ohio contains the Greater Miami SSA, which extends into the southeastern branch of the ECW near where it discharges into the Great Miami River. The full Greater Miami SSA can be seen in Figure 3.7 (Ohio Environmental Protection Agency 2006 A).

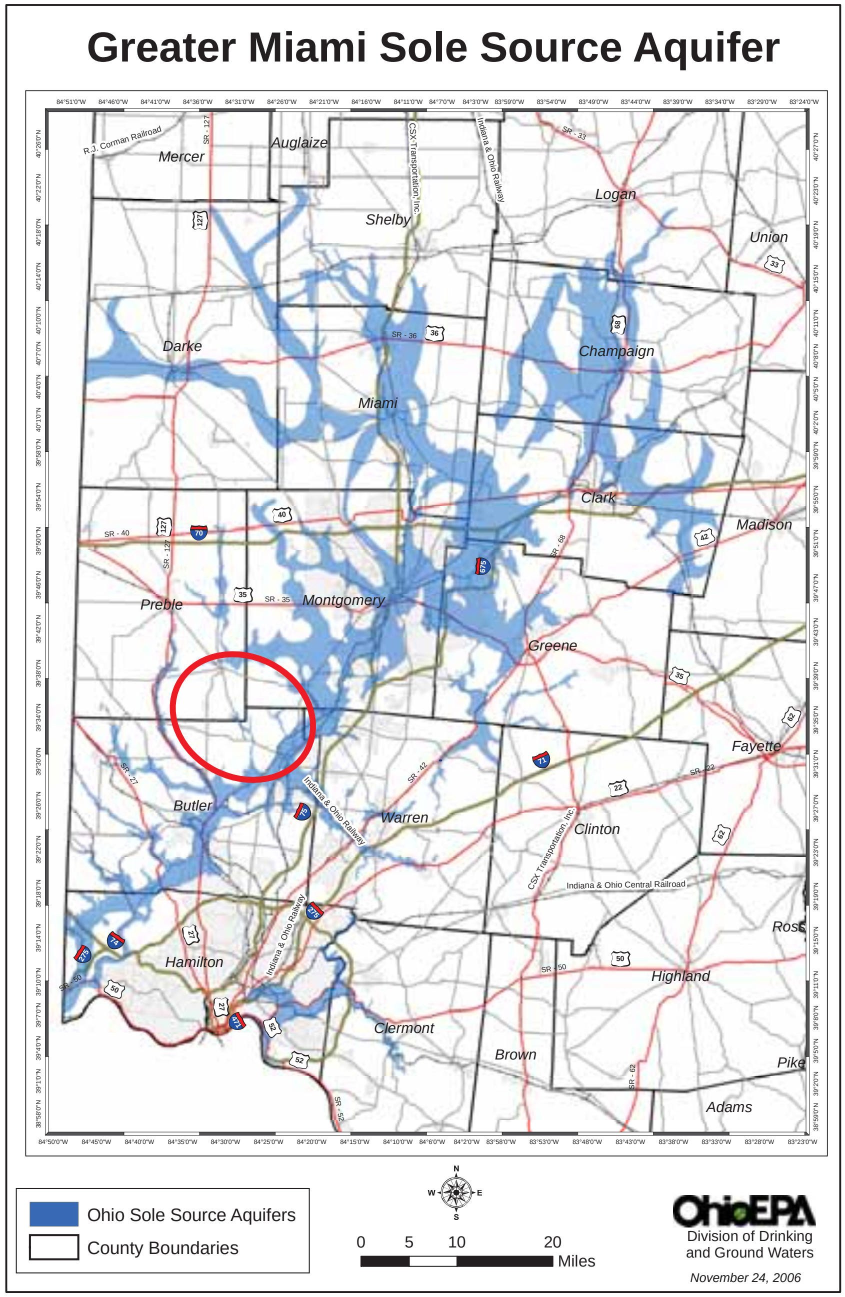

Figure 3.7 The Greater Miami Sole Source Aquifer identified in blue. The approximate location of the Elk Creek Watershed is symbolized by the red circle (Ohio Environmental Protection Agency 2006 A).

In Ohio, drinking water sources are also protected using Source Water Assessment and Protection (SWAP) program, which includes a comprehensive assessment of potential risks and protection measures for a defined area (Ohio Environmental Protection Agency 2016 C). Between Butler, Preble, and Montgomery counties, there are 16 "Public Water Systems with Endorsed Drinking Water Source Protection Plans," (Ohio Environmental Protection Agency 2016 D) and 18 "Non-Municipal Public Water Systems that have approved Drinking Water Source Protection Checklists" (Ohio Environmental Protection Agency 2016 E).

The only Source Water Protection Areas in the ECW are in Trenton, Ohio, and were determined to be "substantially implemented" in 2009 (Figure 3.8) (City of Trenton, Ohio 2009).

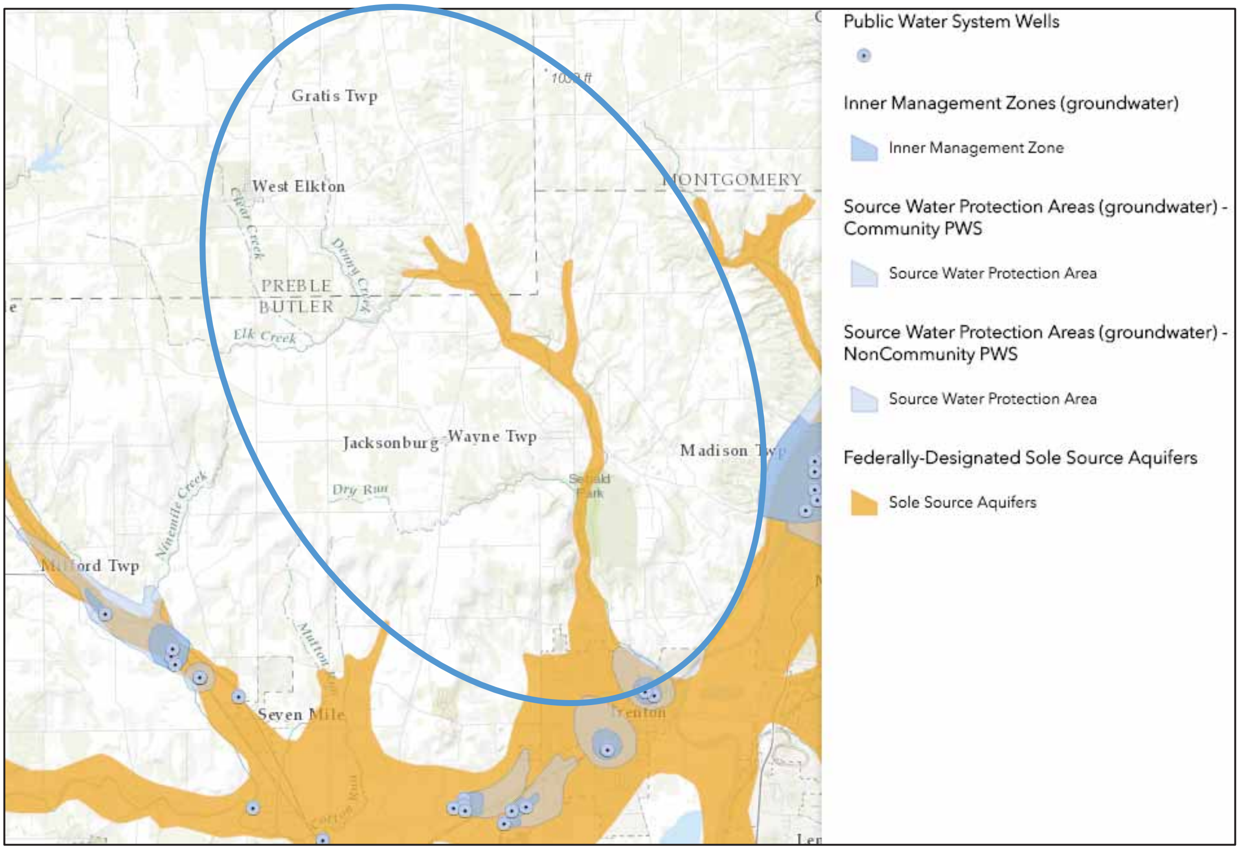

Figure 3.8 Source Water Protection Areas near the Elk Creek Watershed in Trenton, Ohio (Ohio Environmental Protection Agency 2016 F). These areas are designed to protect drinking water sources in Ohio.

Nitrate Study

The USGS completed a nitrate study in 2003-2004 in cooperation with the Miami Valley Conservancy District in response to reports that drinking water wells near Trenton, Ohio had nitrate concentrations exceeding federal standards for drinking water (Pletsch and Schumann 2006). Six surface water and 38 groundwater samples were collected, and two of the groundwater samples had nitrate values exceeding federal standards. In general, lower nitrate values were found in the headwaters of Elk Creek, and higher values were found in the lower watershed near Trenton (Figure 3.9). The conclusion of the report is that soil organic matter and ammonia fertilizer are the primary contributing factors to high nitrate in drinking water wells.

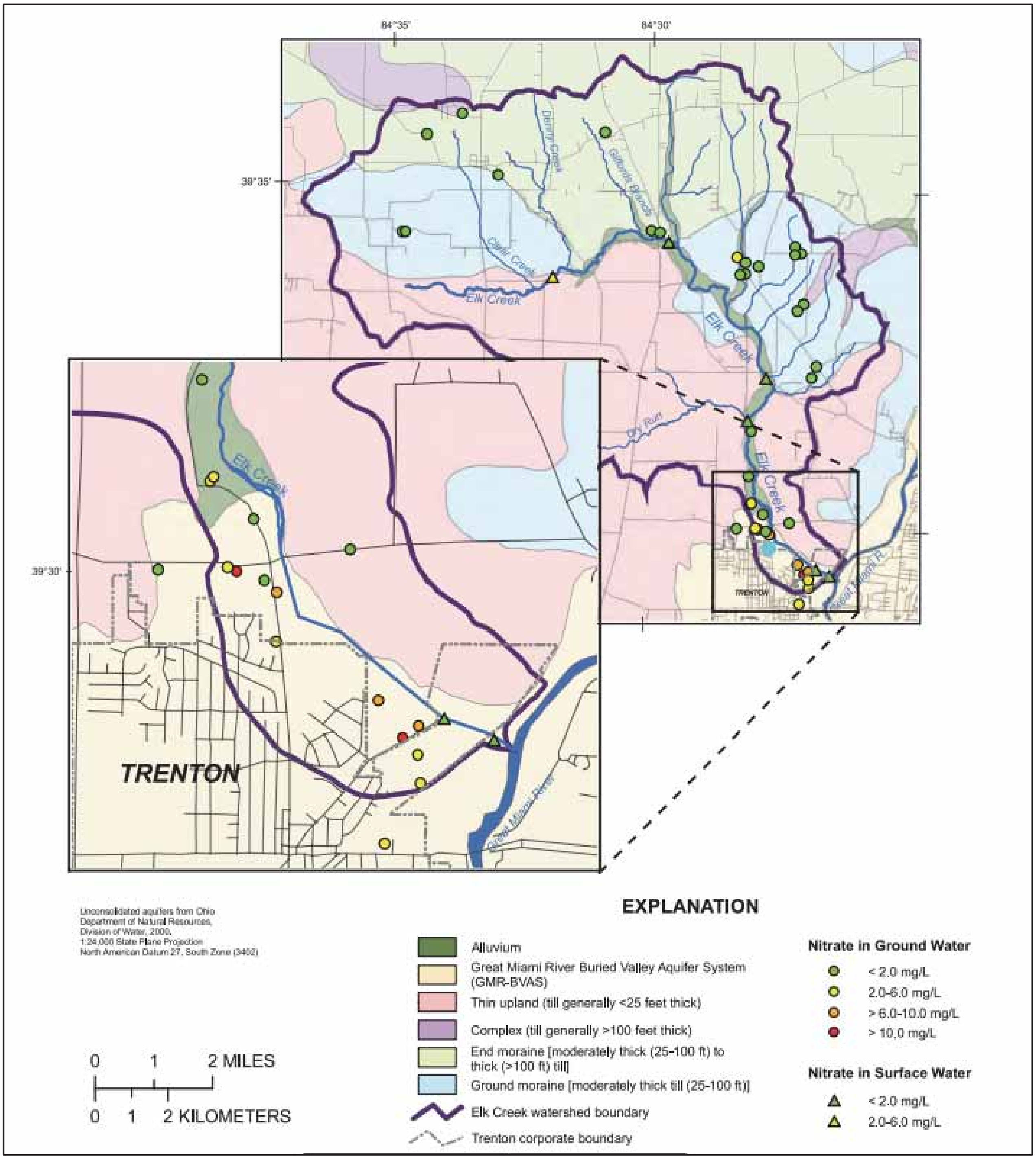

Figure 3.9 Nitrate sampling points and the associated amount of nitrate in the Elk Creek Watershed (Pletsch and Schumann 2006). The highest concentrations of nitrates are found in groundwater wells near Trenton, Ohio, identified by the red dots.

3.2.4 Groundwater Pollution Potential

Monitoring groundwater quality is an important aspect of land management due to its significance as a primary source of water used for drinking, industry, and agriculture in many communities (Ohio Department of Natural Resources, University of Cincinnati 1991). One method for evaluating the relative susceptibility of an area to groundwater pollution is the groundwater pollution potential (GWPP) index, which is determined by examining a range of soil and geologic characteristics (see Appendix C for a full explanation of the method used to calculate the GWPP).

In the ECW, GWPP is highest along the main body of Elk Creek and just north of Trenton, with the northern and northwestern headwaters having the lowest GWPP (Figure 3.10). This is significant because the areas most susceptible to groundwater pollution are where the region's primary drinking water source, the Greater Miami SSA, is located (Figure 3.7) (Figure 3.8).

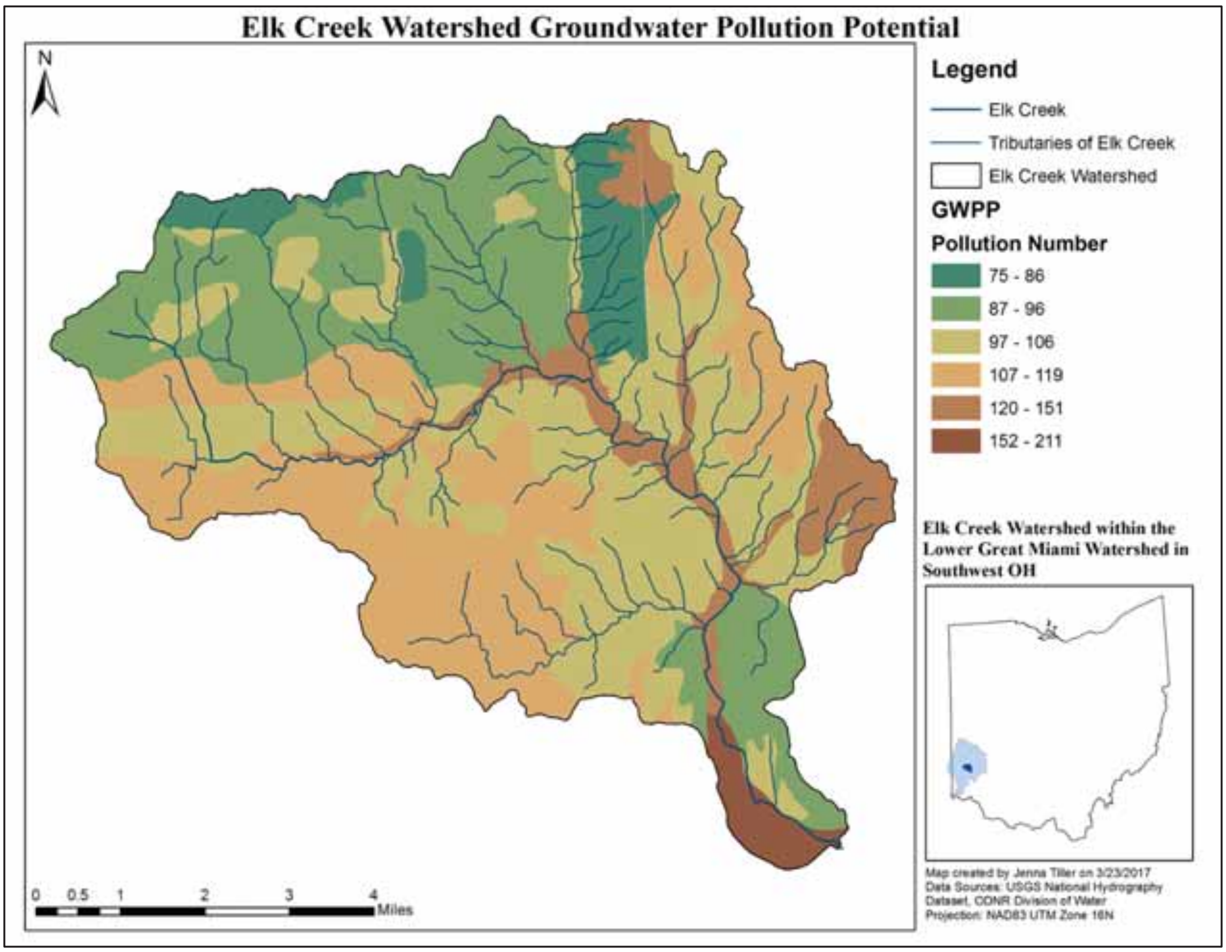

Figure 3.10 Groundwater pollution potential in the Elk Creek Watershed. Larger numbers indicate higher pollution potential. (Ohio Department of Natural Resources, University of Cincinnati 1991). The southern portion near Trenton, and easternmost portion of the Elk Creek Watershed have the highest potential for pollution.

3.3 GEOLOGY AND SOILS

Geology and soils influence the physical characteristics and shape of the watershed, water flow regime, runoff and erosion patterns, and the type of vegetation and wildlife that can be supported in any given area (US Environmental Protection Agency 2008). Therefore, they are important aspects of any watershed analysis and management.

3.3.1 Bedrock Age and Type

The solid, consolidated material under the soil and glacial till is the bedrock (Ohio History Central 2016). In addition to providing information about the history of an area, bedrock can also influence the presence of aquifers, groundwater, mineral and fossil fuel resources, and soil formation and vegetation (Ohio History Central 2016).

The two main types of bedrock in the ECW are Ordovician (488 - 444 million years old) and Silurian (444 - 416 million years old), with alternating bands of limestone and shale that were deposited in a warm, shallow sea environment (Ohio History Central 2016). Most of the ECW is Ordovician shale, with small areas of Ordovician limestone and Silurian shale (Figure 3.11).

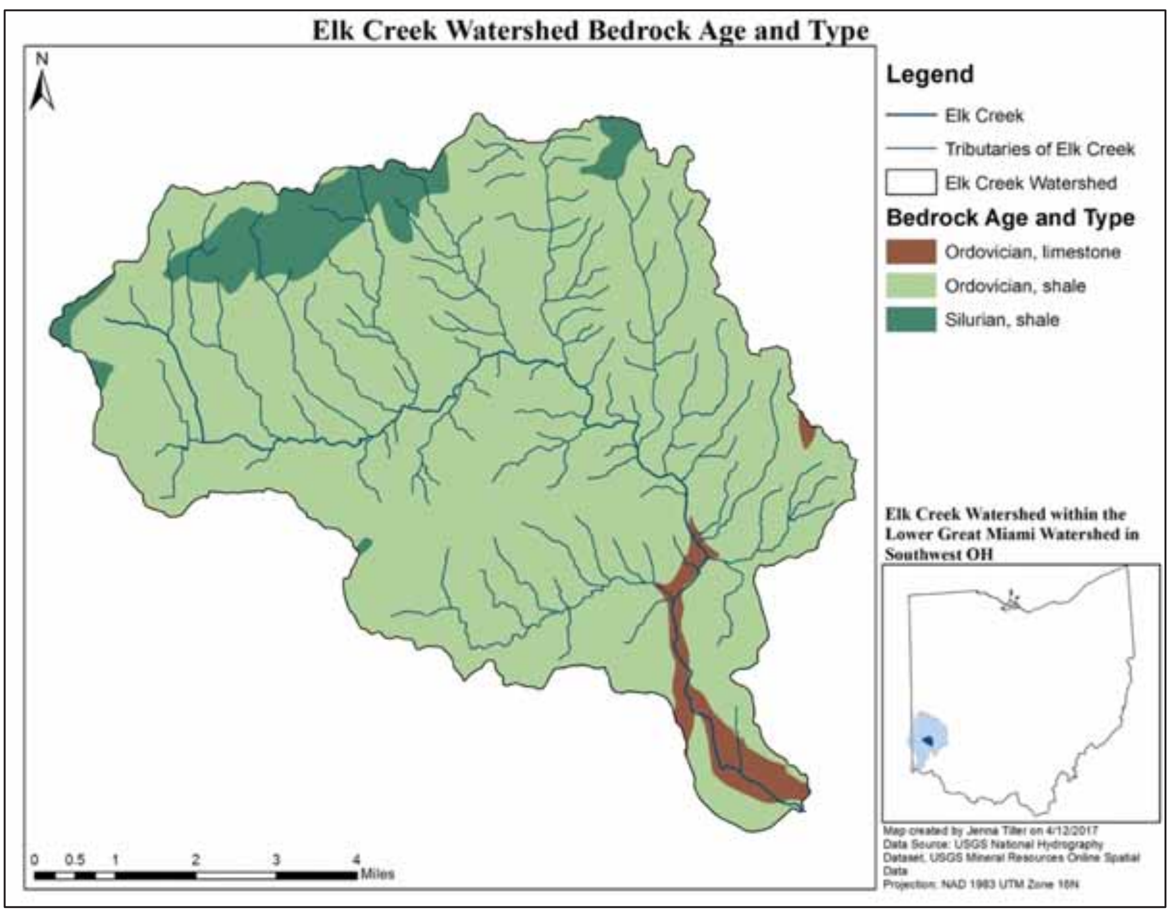

Figure 3.11 Bedrock age and type in the Elk Creek Watershed. Majority of the Elk Creek Watershed is shale from the Ordovician age. There is also Silurian shale in the northwestern portion and Ordovician limestone in the southeastern portion of the Elk Creek Watershed.

3.3.2 Surficial Deposits

Over the last 1.6 million years, Ohio has had a dramatic glacial environment on multiple occasions (Ohio Department of Natural Resources 2005 A). The two primary glacial episodes were the Illinoian (older) and Wisconsinian (newer). As glaciers advanced across the state, they dragged rock, soil, and gravel along with them — and as the glaciers began to recede, this material was deposited as moraines, which can have economic importance depending on the type of deposit. Potential economic uses include sand and gravel, mineral resources, and peat. Southwest Ohio is dominated by Wisconsinian deposits interspersed with Illinoian ground moraine (Figure 3.12) (Ohio Department of Natural Resources 2005 A).

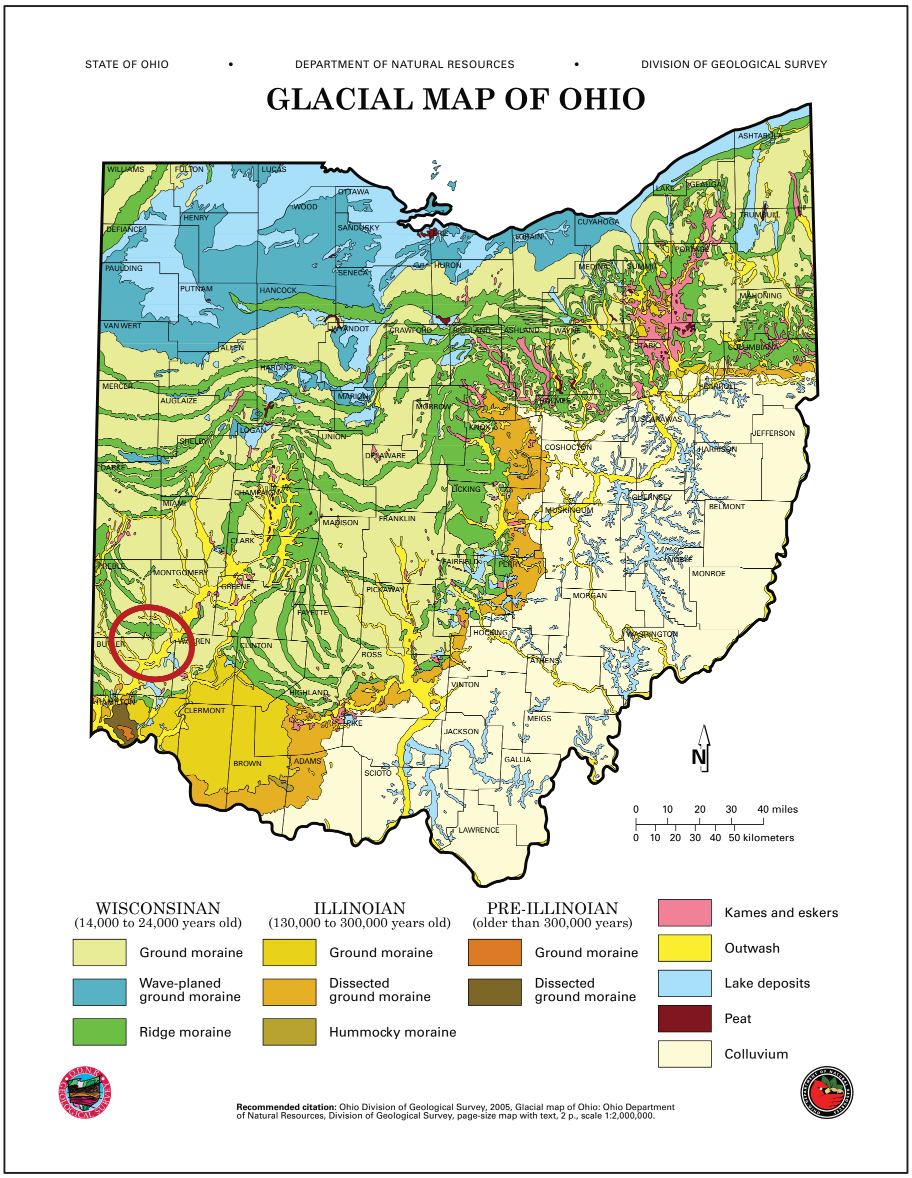

Figure 3.12 Glacial deposits in Ohio. The location of the Elk Creek Watershed is approximated by the red circle. Southwest Ohio is predominantly Wisconsinan (Ohio Department of Natural Resources 2005 A).

3.3.3 Soil Order

> "*Alfisols*: Alfisols are in semiarid to moist areas. These soils… can hold and supply moisture and nutrients to plants. They are formed primarily under forest or mixed vegetative cover and are productive for most crops.
> *Entisols*: Entisols occur in areas of recently deposited parent materials or in areas where erosion or deposition rates are faster than the rate of soil development…
> *Inceptisols*: Inceptisols… generally exhibit only moderate degrees of soil weathering and development. Inceptisols have a wide range in characteristics and occur in a wide variety of climates.
> *Mollisols*: Mollisols… have a dark colored surface horizon relatively high in content of organic matter. The soils are base rich throughout and therefore quite fertile…" (US Department of Agriculture 2016 A)

The USDA classifies soils based on dominant characteristics such as moisture, susceptibility to erosion, and organic content (US Department of Agriculture 2016 A).

The ECW contains Alfisols, Entisols, Inceptisols, and Mollisols (Figure 3.13). A majority of the ECW is the Alfisols soil order, which are productive for most crops. The western and southwestern portion of the watershed features large areas of Mollisols, which are a highly fertile soil with high organic content. Inceptisols and Entisols are found primarily in areas directly adjacent to Elk Creek and its tributaries.

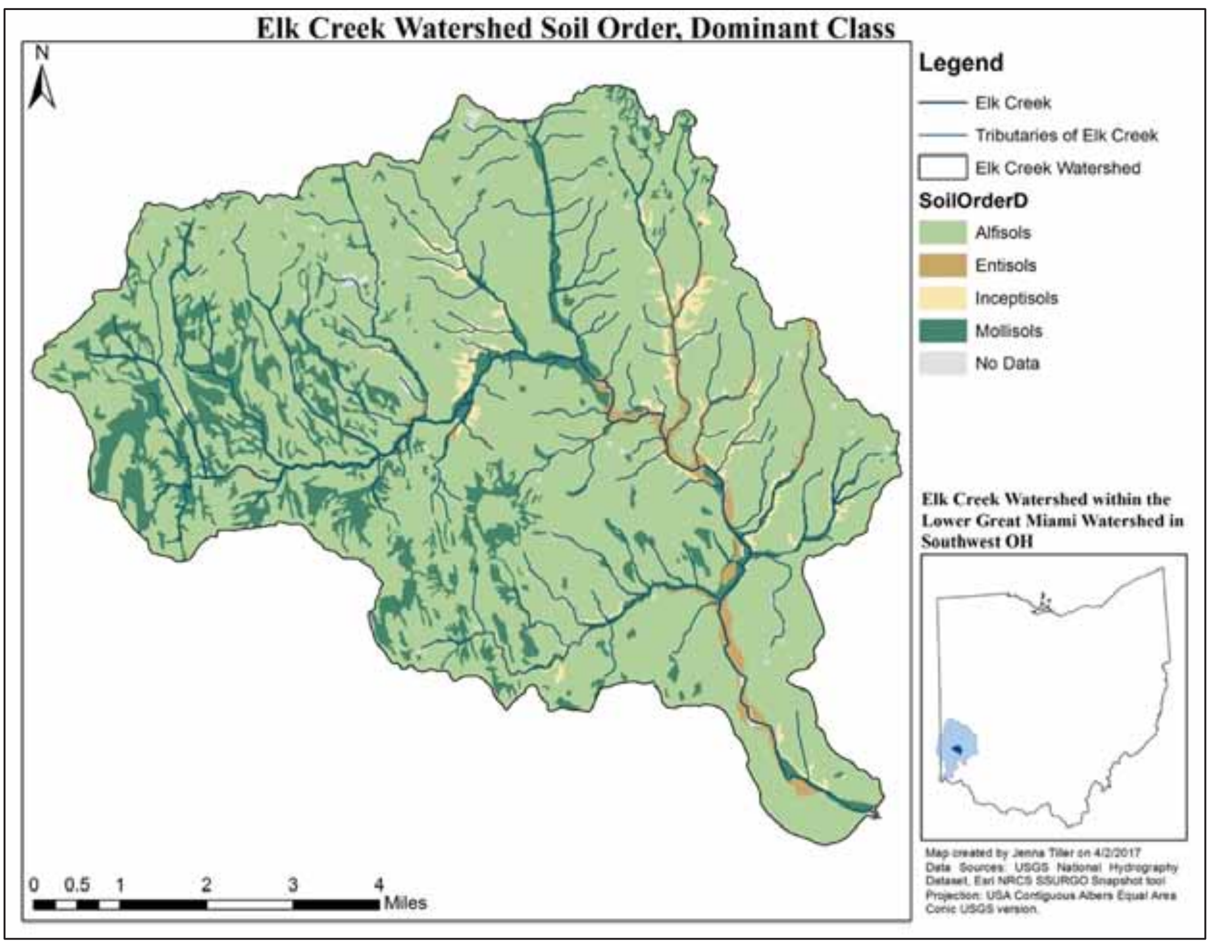

Figure 3.13 Soil orders in the Elk Creek Watershed. The most predominant order is Alfisols, followed by Mollisols. There are smaller amounts of Entisols and Inceptisols.

3.3.4 Topography

Topography is the shape and elevation of the surface of the land, and is the main determining factor of the natural boundaries of a watershed. Higher elevations form the natural barrier that cause water to drain to one outflow (usually at a lower elevation), forming streams and rivers as it flows over the land (Pearlman 2016 B).

The ECW ranges from approximately 190 meters to 340 meters above sea level. The lowest elevations are found along Elk Creek and to the south, and the higher elevations are around the northern headwaters (Figure 3.14).

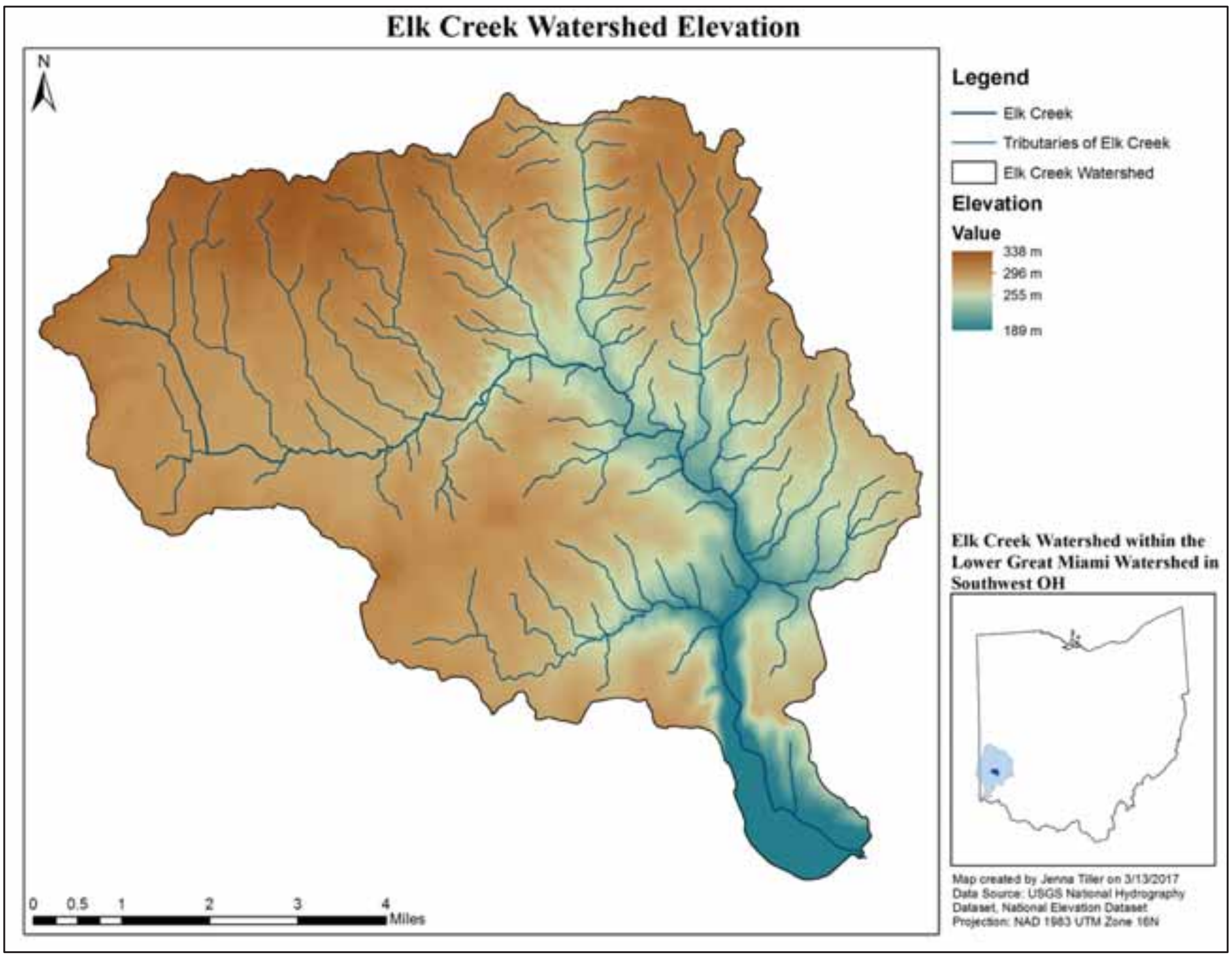

Figure 3.14 Elevation (in meters) above sea level in the Elk Creek Watershed. The southeastern tip of the Elk Creek Watershed is at the lowest elevation, around 189 meters. The highest elevation is on the northwestern side at approximately 338 meters.

3.3.5 Slope Gradient

The US Natural Resource Conservation Service (NRCS) defines slope gradient as a measure of the inclination of the land surface away from horizontal (Soil Survey Division Staff 1993). It is measured as a percentage of the distance in elevation versus the distance between two points, so a difference in elevation of 1 meter over 100 meters horizontally is a slope gradient of 1%. High slope gradients, which represent steep terrain, often correspond with higher levels of runoff and erosion, which can negatively impact habitat through streambank erosion and water quality through increased nutrient runoff and sediment loading.

Based on NRCS slope classifications, most of the ECW is nearly level to gently sloping, so the terrain is fairly even (Figure 3.15). High slope gradients are more commonly found in the central and northern portions of the watershed.

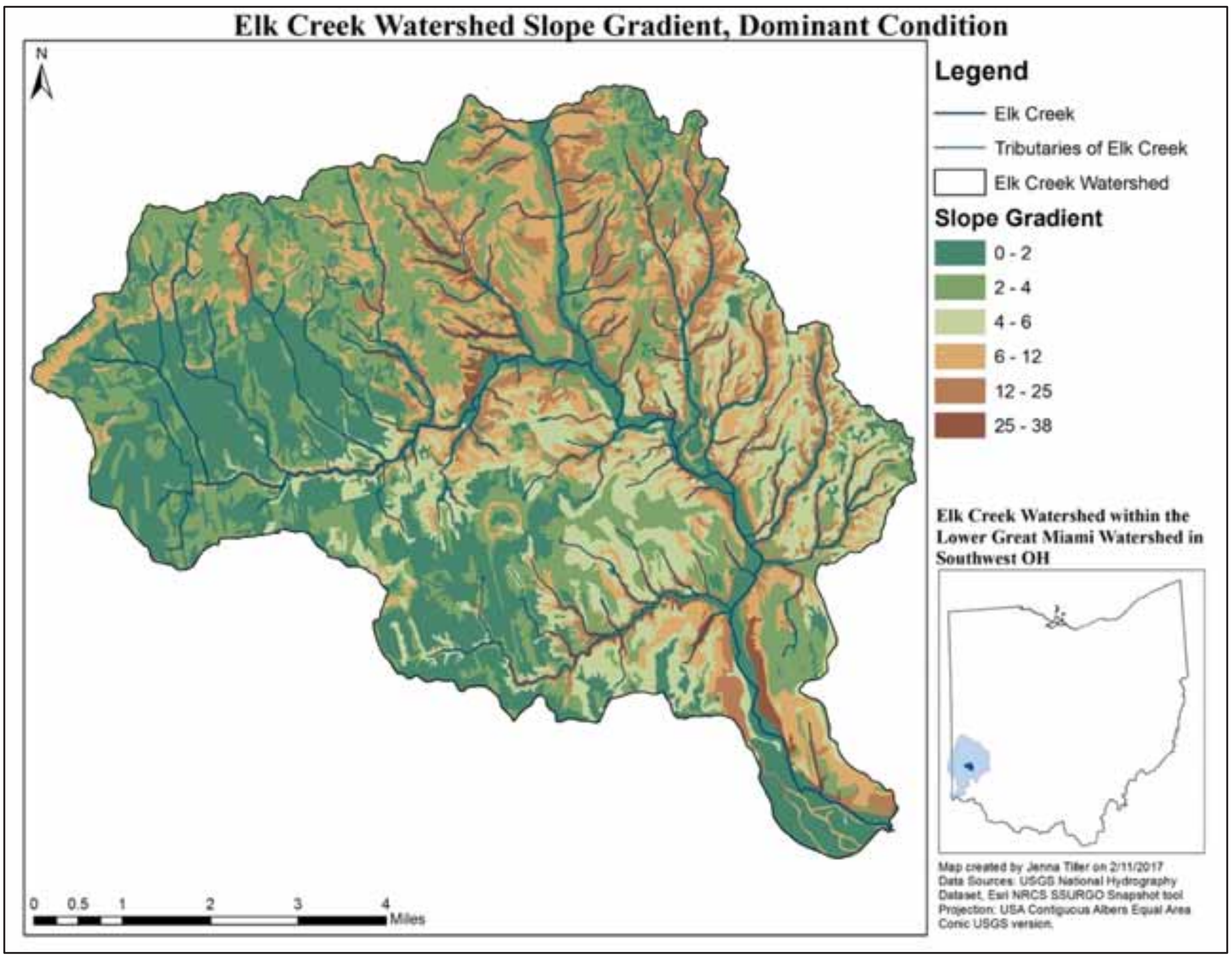

Figure 3.15 Slope gradient in the Elk Creek Watershed. Slope gradient is a measure of the inclination of the land surface away from horizontal (Soil Survey Division Staff 1993). The slope gradient in the Elk Creek Watershed is highest in the central and northern portions of the watershed and is lowest in the western portion.

3.3.6 Drainage Class

Drainage class is an indicator of how well water drains from the soil. Areas with high drainage are likely to be dry and coarse, while poorly drained areas are more likely to have ponding or pooling water and consistently high soil moisture, which can inhibit vegetation growth. This also has implications for runoff — areas with poor drainage are more likely to become saturated during a precipitation event, which could contribute to runoff depending on the slope of the area. Drainage classes are broken into categories ranging from excessively drained to very poorly drained, as described in the USDA NRCS *Soil Survey Manual*, Chapter 3 (Soil Survey Division Staff 1993).

The ECW is classified as well drained for most its area (Figure 3.16). However, the western/southwestern parts of the watershed (which are also its headwaters) are characterized by higher proportions of somewhat poorly drained and very poorly drained areas.

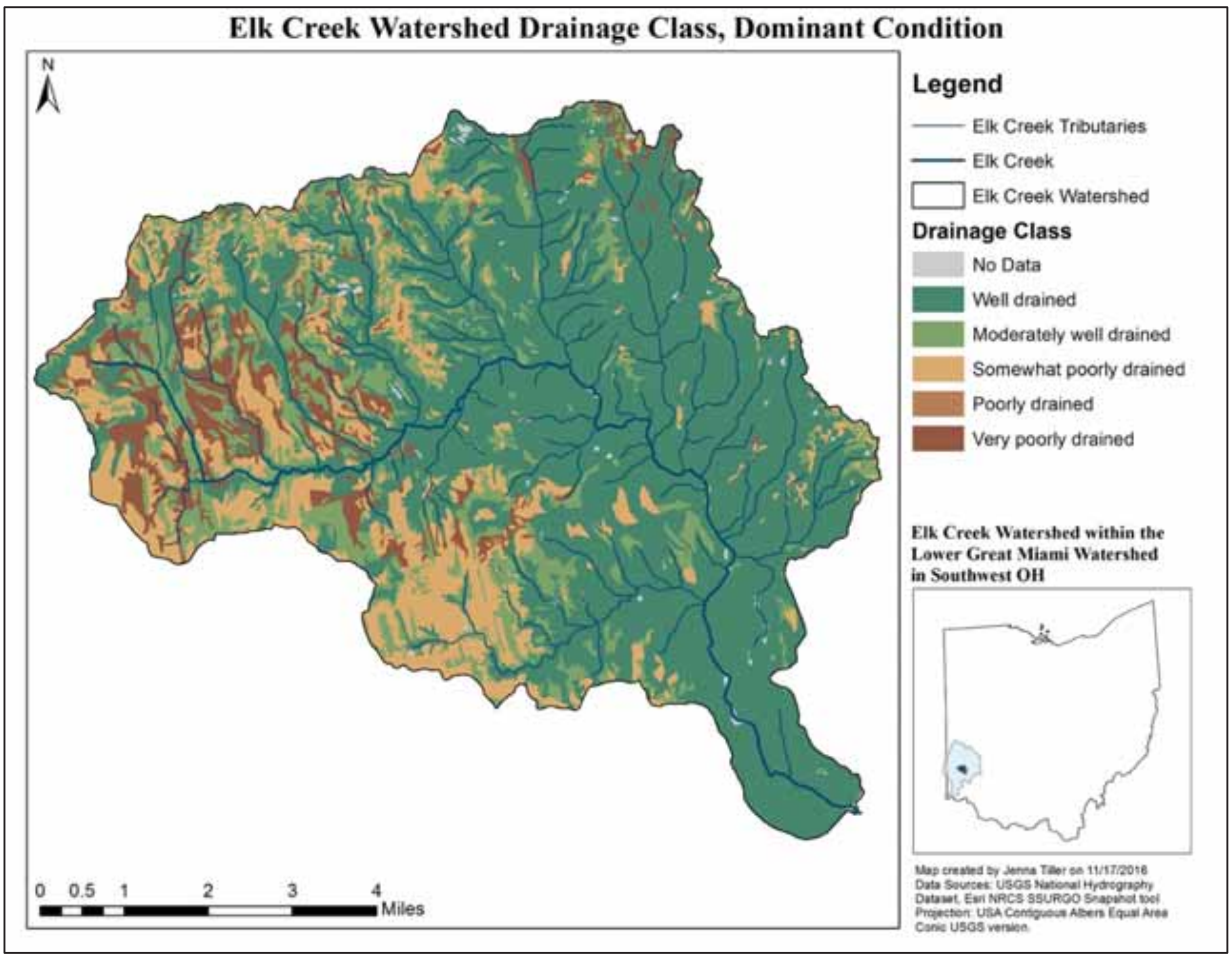

Figure 3.16 Drainage class in the Elk Creek Watershed. Drainage class is an indicator of how well water drains from the soil (Soil Survey Division Staff 1993). The eastern half of the Elk Creek Watershed is well-drained, while the western portion is characterized by soils ranging from somewhat poorly drained to very poorly drained.

3.3.7 Surface Runoff

Surface runoff is defined as the loss of water from an area due to flow over the surface of the land, and is largely dependent on the slope gradient, drainage, and infiltration regimes of an area (Soil Survey Division Staff 1993). Areas with steeper slope have higher runoff than flat areas, and soils that absorb water well have lower runoff than more impermeable soils. The NRCS classifies runoff into six classes based on slope and saturated hydraulic conductivity, which is a measure of soil permeability.

The eastern portion of the ECW is dominated by high runoff, although the classes vary widely from very high to negligible along the creek itself (Figure 3.17). The western part of the watershed is mostly medium and low runoff, with some areas of negligible runoff in the western-most headwaters of Elk Creek. This trend corresponds most directly with slope gradient, as the western part of the watershed has the lowest slope gradient.

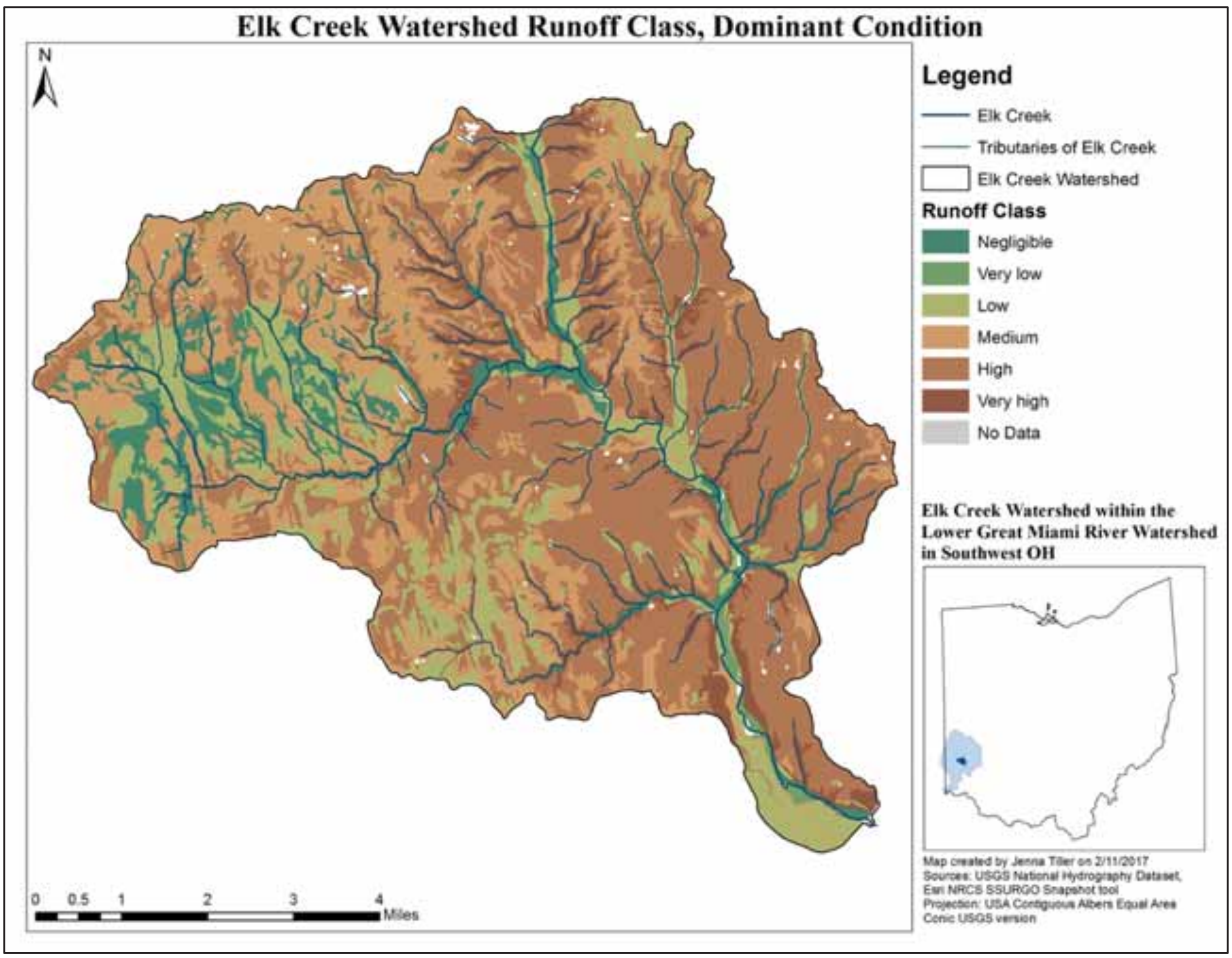

Figure 3.17 Runoff class in the Elk Creek Watershed. Surface runoff is defined as the loss of water from an area due to flow over the surface of the land, and is largely dependent on the slope gradient, drainage, and infiltration regimes of an area (Soil Survey Division Staff 1993). The eastern portion of the ECW is dominated by high runoff and western part of the watershed is mostly medium and low runoff, with some areas of negligible runoff in the western-most headwaters of Elk Creek.

3.3.8 Hydrologic Soil Group

Another way to investigate soil characteristics is through hydrologic soil groups, which are defined by the NRCS and incorporate both runoff and infiltration (Soil Survey Division Staff 1993). The groups range from A (low runoff, high infiltration) to D (high runoff, very low infiltration), and combination groups are given to wet soils that could be adequately drained—the first letter is the drained condition and the second is the undrained.

Much of the ECW is slow infiltration (group C), but the western and southwestern edges are predominantly B/D and C/D, which means they naturally have very low infiltration (Figure 3.18).

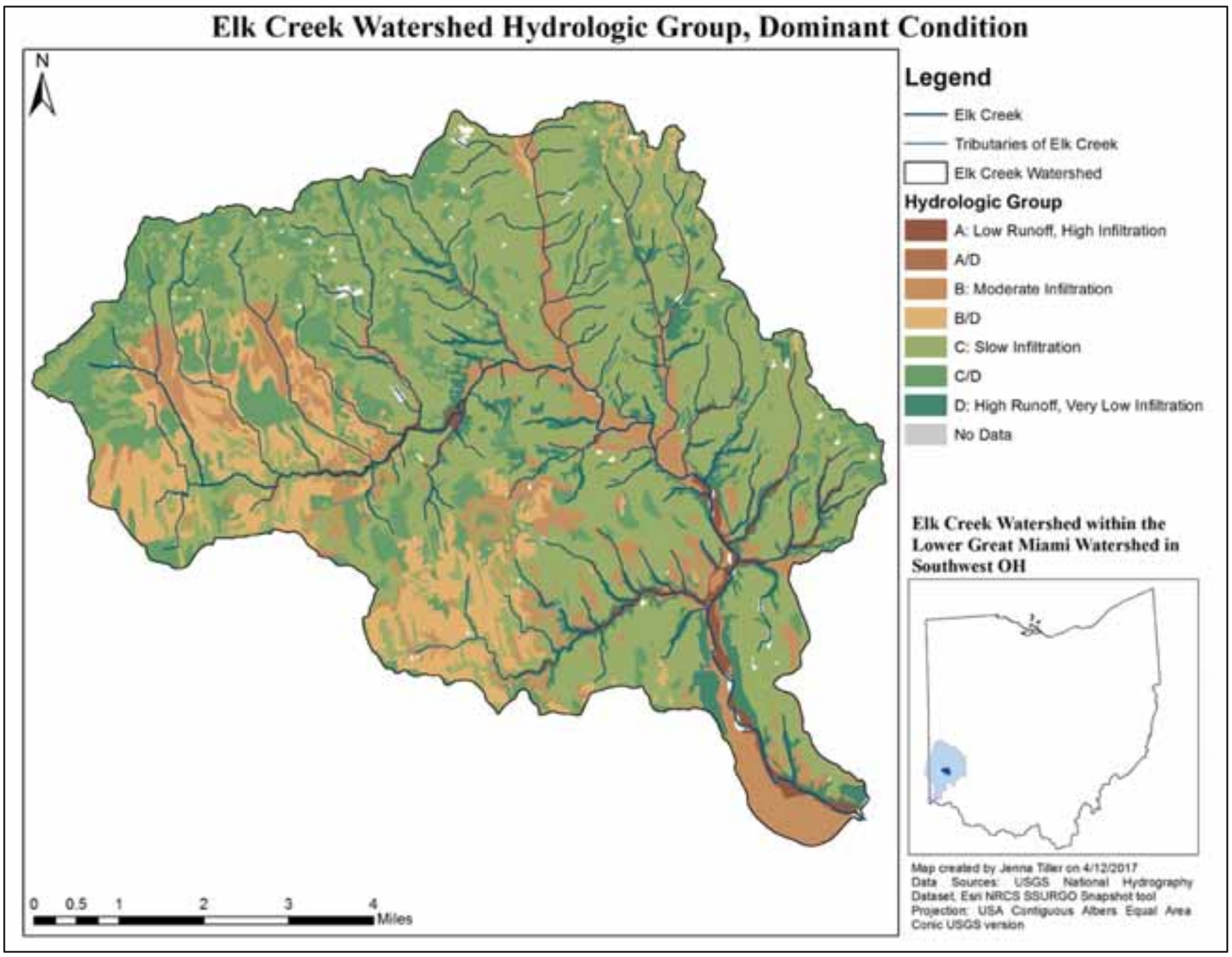

Figure 3.18 Hydrologic group, dominant condition in the Elk Creek Watershed. Hydrologic soil groups are defined by the Natural Resources Conservation Service and incorporate both runoff and infiltration (Soil Survey Division Staff 1993). Much of the Elk Creek Watershed is slow infiltration (group C), but the western and southwestern edges are predominantly B/D and C/D, which means they naturally have very low infiltration.

3.3.9 Estimated Average Annual Soil Loss

Soil erosion is a natural process, but when it occurs at an accelerated rate, it can impact agriculture, water quality, and infrastructure (Kertis and Iivari 2006). Erosion increases the amount of nutrients, sediment, and pesticides in waterways and can harm the health of both aquatic organisms and humans. The Project Team estimated average annual soil loss using Revised Universal Soil Loss Equation (RUSLE) (US Department of Agriculture 2016 B). RUSLE was developed by the USDA and is used by many government agencies to assess soil loss and erosion. The equation and methods of calculating each factor of average annual soil loss are in Appendix A.2.

The RUSLE output indicated low soil loss in the majority of the ECW, but higher soil loss on spots along Elk Creek, especially in the southern portion of the ECW near Elk Creek MetroPark (Figure 3.19). The highest estimated annual soil loss calculated was approximately 90 tons/acres/year.

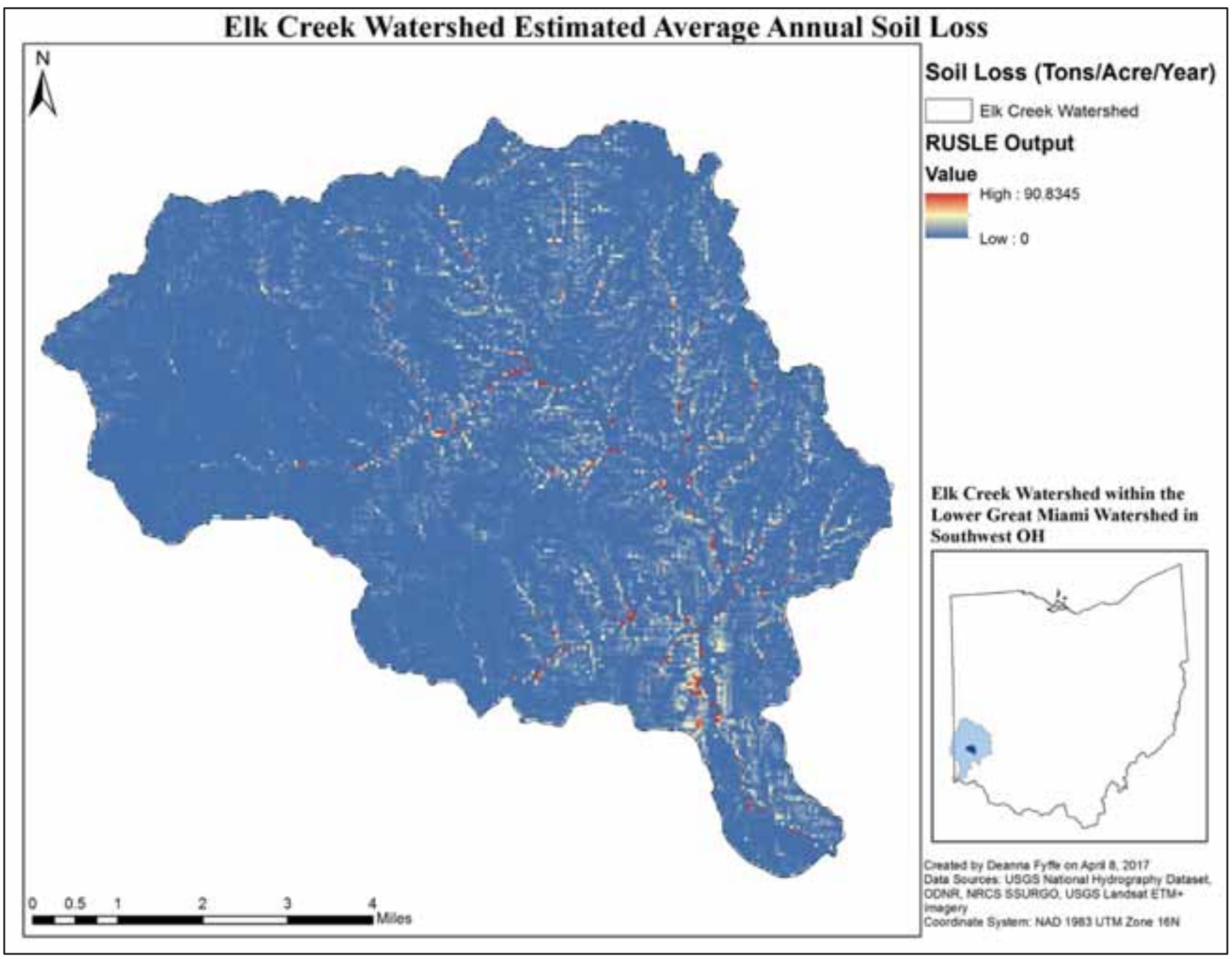

Figure 3.19 Estimated average annual soil loss (tons/acre/year) using the Revised Universal Soil Loss Equation in the Elk Creek Watershed. The equation output indicated increased soil loss in the southern portion of the Elk Creek Watershed, specifically near Elk Creek MetroPark.

3.3.10 Hydric Classification

Hydric soils are formed in saturated conditions, which result in an anaerobic environment in the upper parts of the soil (US Department of Agriculture 2016 C). Hydric soils are notable because they are an indicator of favorable conditions for wetlands, as they correspond to the naturally moist soil conditions that characterize wetland habitat and can support wetland vegetation (US Fish and Wildlife Service 2017).

The ECW is dominated by non-hydric soils. However, there are higher incidences of hydric soils in the western and northeastern-most portions of the watershed, indicating that these sections are potentially suitable for wetland habitat (Figure 3.20)

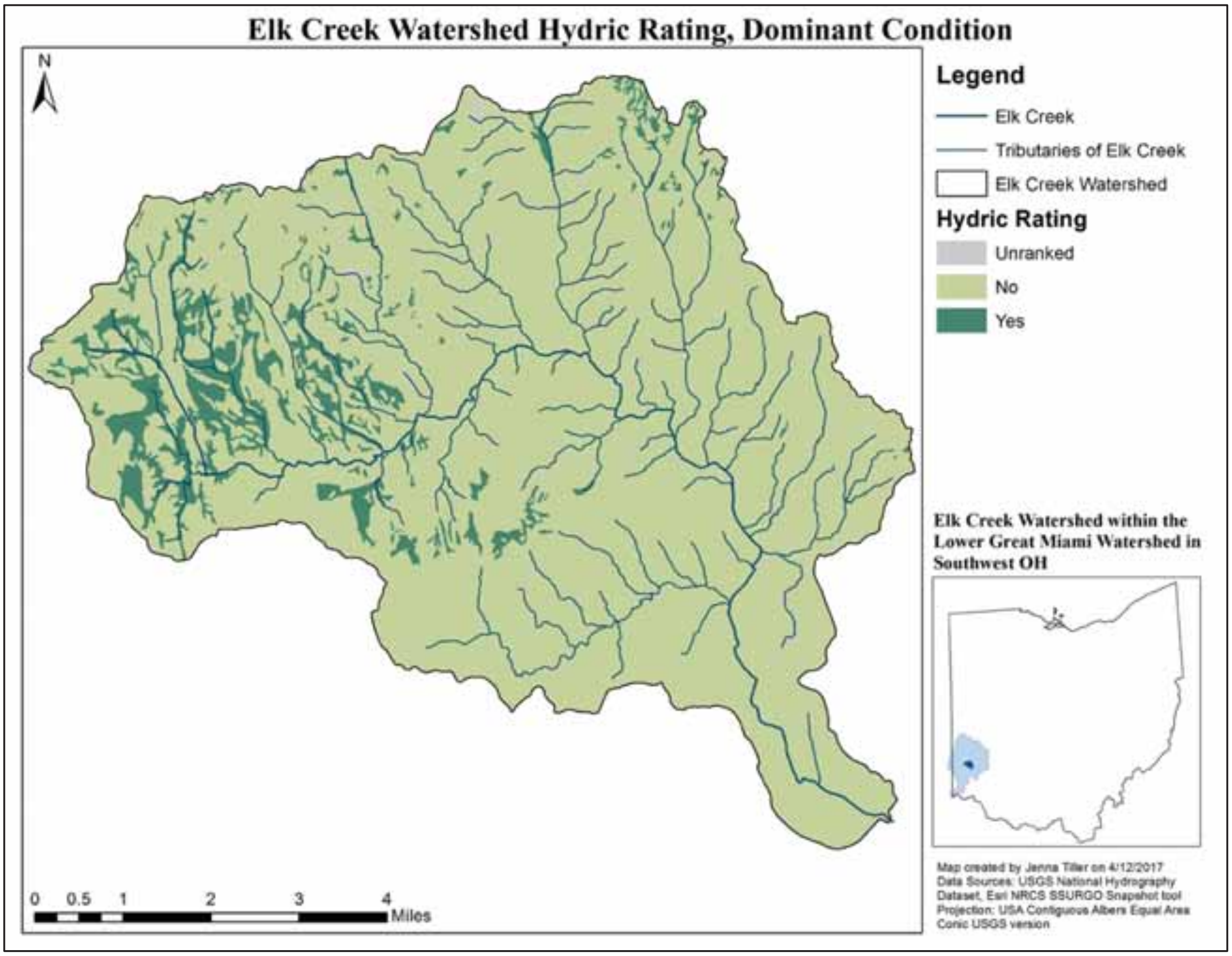

Figure 3.20 Hydric ratings in the Elk Creek Watershed. Hydric soils are formed in saturated conditions, which results in an anaerobic environment in the upper parts of the soil (US Department of Agriculture 2016 C). The Elk Creek Watershed is dominated by non-hydric soils, but there are higher incidences of hydric soils in the western and northeastern-most portions of the watershed.

3.4 HABITATS

When assembling a watershed inventory, it is important to identify and evaluate habitats and their conditions, because maintaining biological integrity is essential to preserving water quality and providing a suitable environment for terrestrial and aquatic organisms (US Environmental Protection Agency 2008). An understanding of the habitats in a watershed provides a baseline to measure the effectiveness of conservation efforts. It can also inform areas for conservation, protection, and restoration to manage and maintain high-quality wildlife and aquatic habitats (US Environmental Protection Agency 2008). Improper management, a decline in habitat quality, or the loss of natural habitat can result in a decline in water quality, as healthy and robust ecosystems can provide a natural filtering system for pollutants (Ohio Environmental Protection Agency 2016 B).

3.4.1 Forest Habitat

The amount of forests within a watershed, especially the concentration of trees bordering the waterways, directly correlate to the water quality and health of aquatic organisms (US Department of Agriculture Forest Service Northeastern Area 2016).

The ECW contains three forest habitat types: deciduous, evergreen, and mixed forests. The National Land Cover Database (NLCD) defines forests as areas with a minimum of 5-foot tall trees comprising 20% of vegetation (Anderson, et al. 2016). A forest is defined as deciduous if at least 75% of the trees simultaneously lose their foliage during seasonal changes. Inversely, evergreen forests have 75% of the trees maintaining their foliage during seasonal changes. Mixed forests contain less than 75% of deciduous or evergreen forests.

In the ECW, forest habitat covers approximately 22% of the land area. This includes 19.5% deciduous forest, and 1% each of evergreen and mixed forest. The team calculated land use percentages using data from the NLCD (see Appendix A.3 for methods). Most of the forested areas in the ECW are in the eastern half along the main body of Elk Creek (Figure 3.21).

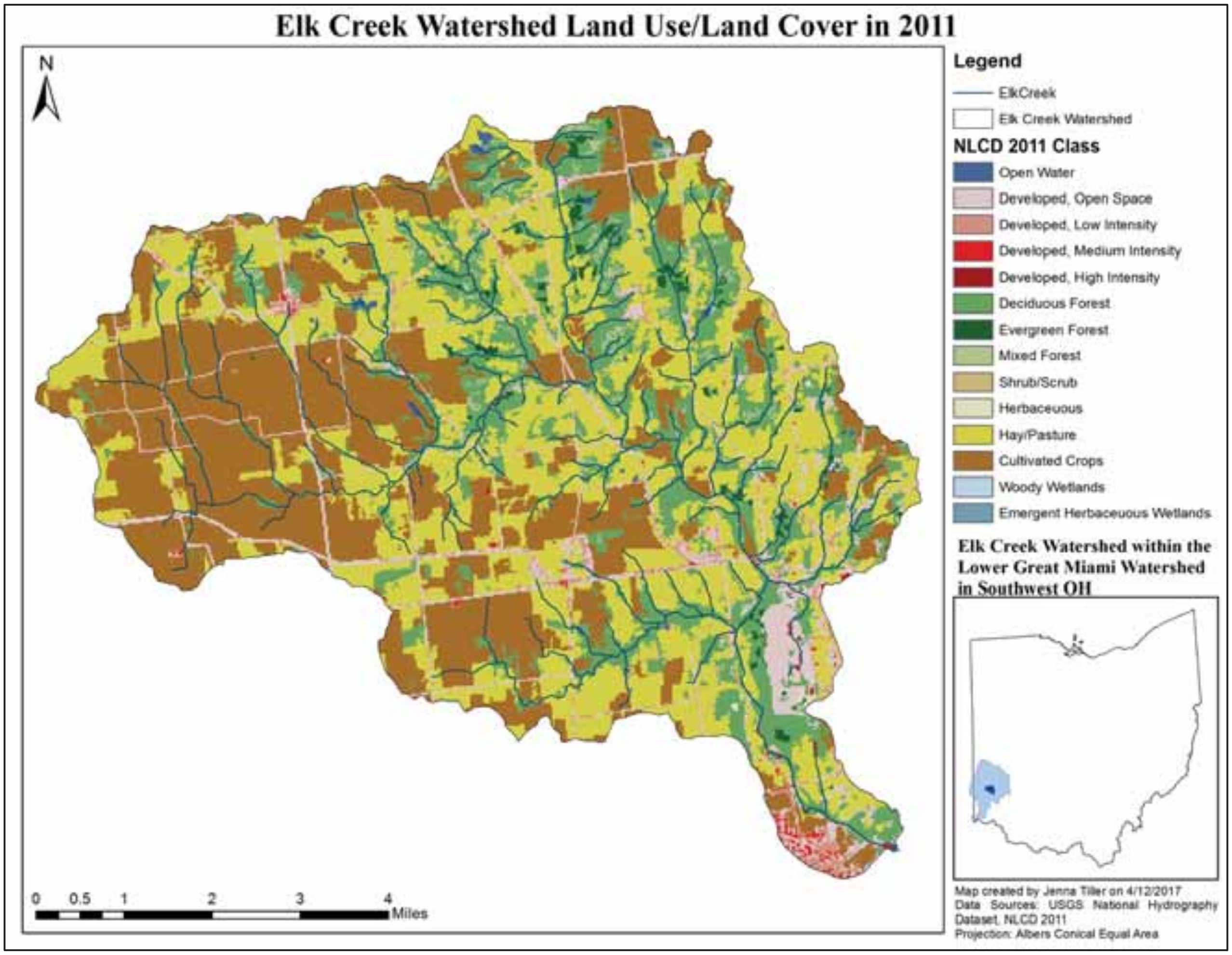

Figure 3.21 Forested areas in the Elk Creek Watershed. Forested areas are various shades of green, and are found primarily along the body of Elk Creek in the eastern half of the watershed.

3.4.2 Wetlands Habitat

Wetlands are a complex ecosystem which provide ecosystem services such as water purification, flood protection, shoreline stabilization, groundwater recharge, and streamflow maintenance depending on the type of wetland (US Geological Survey 1999). They are generally very productive ecosystems and can be home to many native flora and fauna, including endangered species. Disappearance of wetland habitat causes stress on local water bodies and groundwater because of the important ecosystem services they provide (Natural Resources Conservation Service 2017 A).

Historically, wetlands covered 8.74% of the land area in the ECW. Currently, wetland habitats only account for 0.14% of the land area (Ohio Environmental Protection Agency 2016 B). Wetland habitats in the ECW are fragmented and surrounded by residential areas and farm fields, which can degrade the habitat through pollution and disturbance and can also decrease habitat suitability for many wildlife species (Ohio Department of Natural Resources 2015 A). Wetland habitat is concentrated in the eastern portion of the ECW; and in the western half there are large spans where no wetlands are present (Figure 3.22). This may be attributed to the highly agricultural nature of this area (Section 4.1), as wetlands are frequently drained or filled for development and agriculture (Natural Resources Conservation Service 2017).

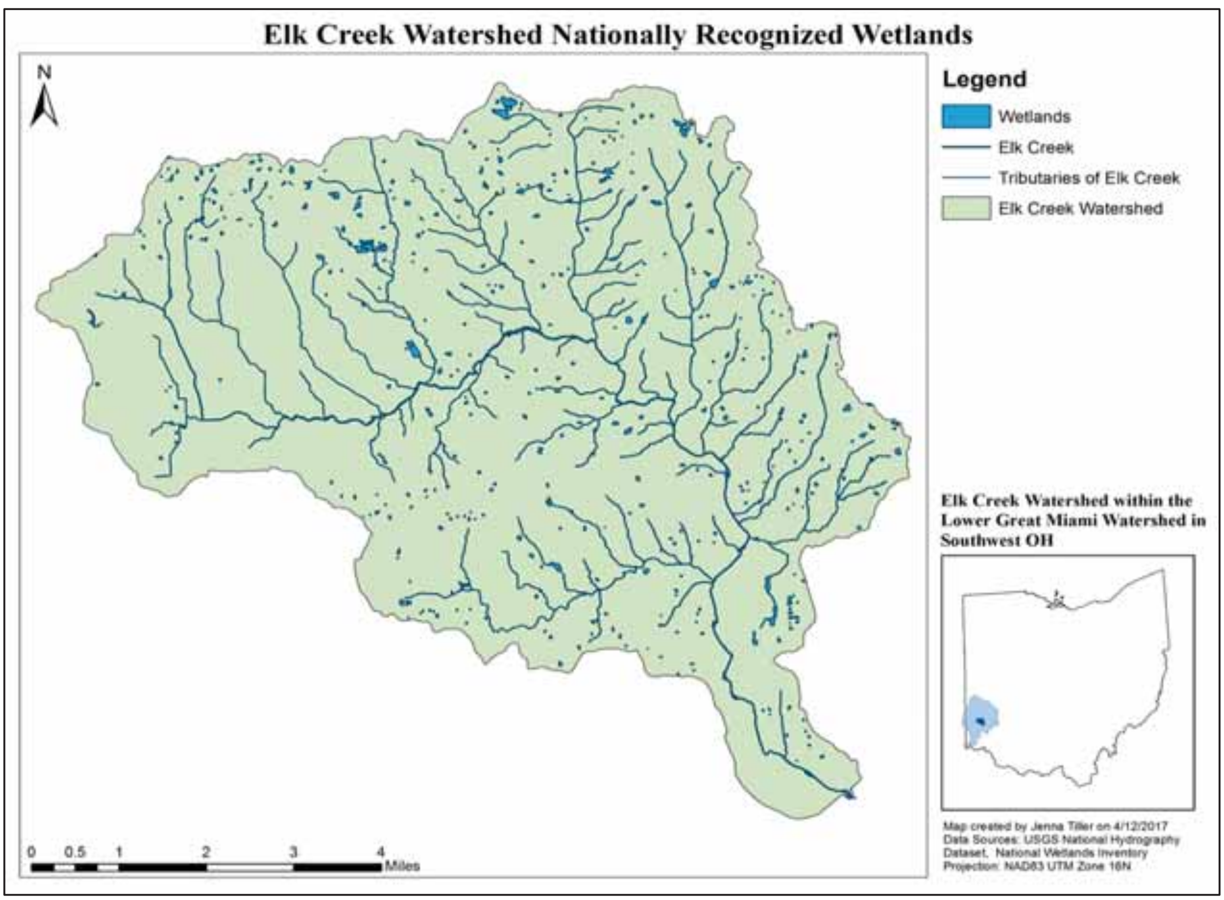

Figure 3.22 Wetlands in the Elk Creek Watershed as identified in the National Wetlands Inventory. Wetland habitat is primarily concentrated in the eastern portion of the ECW, and in the western half there are large areas where no wetlands are present.

3.4.3 Habitat Indicators (QHEI)

The Qualitative Habitat Evaluation Index (QHEI) was developed by the Ohio EPA to evaluate the physical habitat of streams and rivers in Ohio. The Ohio EPA uses QHEI to evaluate habitat characteristics that are crucial to healthy fish communities (Ohio Environmental Protection Agency 2006 B). The QHEI uses both empirical and quantitative data to determine an overall quality of the habitat. The index is based on six principal metrics:

1) Substrate type and quality
2) Instream cover
3) Channel morphology
4) Riparian zone and bank erosion
5) Pool quality and riffle quality
6) Map gradient

The individual scores for each metric are summed for a final QHEI score ranging from 0 to 100. Typical scores are between 20 and 100. QHEI varies from other water quality data collection methods by evaluating characteristics of a stream segment rather than a single sampling site (Ohio Environmental Protection Agency 1997).

Scores greater than 60 generally signify the presence of warm water faunas. Scores greater than 75 indicate habitat conditions that can support exceptional warmwater fauna (Ohio Environmental Protection Agency 1997).

The Project Team obtained QHEI scores for Elk Creek from biological assessments performed by the Ohio EPA. The QHEI scores for River Mile (RM) 3.7 were 91.5 in 1987, 84 in 1995, and 64.5 in 2010 (Table 3.2). In 2010 the QHEI was also measured at two additional RMs. The scores were 64 for RM 10.10 and 58 for RM 1.49. The drop in score for RM 3.7, and the fact that all scores in 2010 were below the 75 generally associated with exceptional warmwater habitat, could indicate a decline in the physical habitat, which may affect the ECW's designation as an exceptional warmwater habitat.

Table 3.2 QHEI scores for Elk Creek from 1987, 1995 and 2010 assessments by the Ohio EPA. River Mile 3.7 was evaluated in 1987 and 1995, and 2010, but RM 10.10 and 1.49 were only evaluated in 2010. (Ohio Environmental Protection Agency 1997) (Ohio Environmental Protection Agency 2012 A). *The 1987 score was found in Table 6 on page 216 of the 1995 report.

Year	River Miles	QHEI Scores
1987*	3.7*	91.5*
1995	3.7	84.0
2010	10.10	64.0
	3.7	64.5
	1.49	58.0

3.5 BIOTIC ENVIRONMENT

Understanding the distribution and composition of species in a watershed allows for the identification of areas for protection and conservation in watershed planning. Of particular importance are threatened or endangered species, which have additional legal protection under Ohio law (ORC 1531-25). The list of state-listed threatened and endangered wildlife species is managed by the Ohio Department of Natural Resources (ODNR) Division of Wildlife (Ohio Department of Natural Resources 2017 B). Ohio's list of threatened and endangered plant species is maintained by the ODNR Division of Natural Areas and Preserves (Ohio Department of Natural Resources 2017 C). Another resource for identifying potential species is the USGS Gap Analysis Program, which uses modeling to predict species and habitat distributions to identify whether they are being properly managed and represented (US Environmental Protection Agency 2008).

Knowledge of the distribution and presence of invasive species is also an important part of land management. Species are considered invasive when they reproduce and overtake a habitat at a faster rate than the native flora and fauna (Ohio Invasive Plants Council 2010). The first step in habitat restoration is often the removal of invasive species before they eliminate important native species.

3.5.1 Wildlife and Plant Species

The Project Team obtained lists of state-listed threatened and endangered species by county, but information about species found within the ECW was not available. Within Butler, Preble and Montgomery counties, there are seven threatened and eight endangered wildlife species (Table 3.3) (Table 3.4), as well as 12 threatened and two endangered plant species (Table 3.5) (Table 3.6) (Appendix D.1).

There are more than 700 non-native species in the state of Ohio, many of which are invasive (Ohio Invasive Plants Council 2010). Lists of county- and state-listed endangered species can be found in Appendix D.2.

Threatened Wildlife Species

Table 3.3 Threatened wildlife species in Butler, Preble and Montgomery counties (Ohio Department of Natural Resources 2016 A) (Ohio Department of Natural Resources 2016 B) (Ohio Department of Natural Resources 2016 C). In total, there are seven threatened wildlife species in at least one of the three counties.

Species	Scientific Name	Butler	Preble	Montgomery
Black-crowned Night-heron	*Nycticorax nycticorax*	X		X
Sloan's Crayfish	*Orconectes sloanii*	X	X	X
Kirtland's Snake	*Clonophis kirtlandii*	X	X	X
Bigeye Chub	*Notropis amblops*		X	
Least Bittern	*Ixobrychus exilis*	X		
Tonguetied Minnow	*Exoglossum laurae*	X		
Podhorn	*Uniomerus tetralasmus*			X

Endangered Wildlife Species

Table 3.4 Endangered wildlife species in Butler, Preble, and Montgomery counties (Ohio Department of Natural Resources 2016 A) (Ohio Department of Natural Resources 2016 B) (Ohio Department of Natural Resources 2016 C). In total, there are eight endangered wildlife species in at least one of the three counties.

Species	Scientific Name	Butler	Preble	Montgomery
Cave Salamander	*Eurycea lucifuga*	X		
Eastern Snuffbox	*Epioblasma triquetra*			X
Indiana Bat	*Myotis sodalis*	X	X	X
Plains Clubtail	*Gomphus externus*	X		X
Rayed Bean	*Villosa fabalis*	X		
Upland Sandpiper	*Bartramia longicauda*	X		X
Blue Corporal	*Ladona deplanata*	X		
Seepage Dancer	*Argia bipunctulata*			X

Threatened Plant Species

Table 3.5 Threatened plant species in Butler, Preble, and Montgomery counties (Ohio Department of Natural Resources 2016 A) (Ohio Department of Natural Resources 2016 B) (Ohio Department of Natural Resources 2016 C). In total, there are 12 threatened plant species in at least one of the three counties

Species	Scientific Name	Butler	Preble	Montgomery
Carolina Witlow-grass	*Draba reptans*			X
Downy White Beard-tongue	*Penstemon pallidus*			X
Dwarf Bulrush	*Lipocarpha micrantha*			X
Hairy Mountain-mint	*Pycnanthemum verticillatum var. pilosum*			X
Inland Rush	*Juncus interior*			X
Midland Sedge	*Carex mesochorea*	X	X	X
Missouri Gooseberry	*Ribes missouriense*	X		
Smooth Beard-tongue	*Penstemon laevigatus*			X
Soft-leaved Arrow-wood	*Viburnum molle*	X	X	X
Tansy Mustard	*Descurainia pinnata*			X
Timid Sedge	*Carex timida*	X		
Wood's-hellebore	*Melanthium woodii*			X

Endangered Plant Species

Table 3.6 Endangered plant species in Butler, Preble, and Montgomery counties (Ohio Department of Natural Resources 2016 A) (Ohio Department of Natural Resources 2016 B) (Ohio Department of Natural Resources 2016 C). In total, there are two endangered plant species in at least one of the three counties.

Species	Scientific Name	Butler	Preble	Montgomery
Snowy Campion	*Silene nivea*	X		
Plains Muhlenbergia	*Muhlenbergia cuspidata*			X

3.5.2 Gap Analysis

Gap analysis is a method of identifying how native "ordinary" species and their communities are represented in land management and conservation plans (US Environmental Protection Agency 2008). "Ordinary" species are those that are not rare, threatened, or endangered. The purpose of Gap analysis is to provide information about the distributions of species and their habitats to promote informed decision-making in land management, policy, and planning. In the US, Gap analysis is carried out through the USGS Gap Analysis Program (GAP), which uses statistical and GIS modeling to generate spatial data and potential distribution models (US Environmental Protection Agency 2008).

The USGS GAP maintains four datasets: Land Cover, Protected Areas, Species Data, and the Aquatic Gap (US Geological Survey 2013). All four are viewable on the official USGS GAP website and have a sophisticated series of data and map viewers that allow users to zoom in to their area of interest to view the specific data of interest. For more information on the data available through USGS GAP, please refer to Appendix D.3.

The USGS collaborated with The Ohio State University and the ODNR Division of Wildlife on the gap analysis in Ohio. Their efforts were divided into terrestrial and aquatic settings. Aquatic Gap examines whether species and habitats are properly represented in areas that manage for their persistence, whether species and habitats are under-represented in any areas, and which species and habitats may be at risk (US Environmental Protection Agency 2008). The Aquatic Gap for the state of Ohio, published in 2006, predicts that the ECW is home to 77 native fish species, 27 native freshwater bivalve species, and eight native crayfish species (Table 3.7) (Table 3.8) (Table 3.9) (US Geological Survey 2007 A) (US Geological Survey 2007 B) (US Geological Survey 2007 C) (Covert, Kula and Simonson 2007).

Table 3.7 Predicted native crayfish in the Elk Creek Watershed (US Geological Survey 2007 A). This species list was developed based on a USGS model which was based on 4,469 crayfish sample locations, physical habitat type, and variables indicating the major drainage basins and Omernik's Level III ecoregion (Covert, Kula and Simonson 2007) There are 7 predicted native crayfish species in the Elk Creek Watershed.

Common Name	Scientific Name
Little brown mudbug	*Cambarus thomai*
Ohio crawfish	*Cambarus sp. A*
Ortmann's mudbug	*Cambarus ortmanni*
Paintedhand mudbug	*Cambarus sp. B*
Papershell crayfish	*Orconectes immunis*
Rusty crayfish	*Orconectes rusticus*
Sloan's crayfish	*Orconectes sloanii*

Table 3.8 Predicted native fish in the Elk Creek Watershed (US Geological Survey 2007 B). This species list was developed based on a USGS model which was based on 5,686 fish sample locations, physical habitat type, and variables indicating the major drainage basins and Omernik's Level III ecoregion (Covert, Kula and Simonson 2007). There are 77 predicted native fish species in the Elk Creek Watershed.

Species	Scientific Name
American brook lamprey	*Lampetra appendix*
Banded darter	*Etheostoma zonale*
Bigeye chub	*Notropis amblops*
Black bullhead	*Ameiurus melas*
Black crappie	*Pomoxis nigromaculatus*
Black redhorse	*Moxostoma duquesnei*
Blacknose dace	*Rhinichthys atratulus*
Blackside darter	*Percina maculata*
Bluegill	*Lepomis macrochirus*
Bluntnose minnow	*Pimephales notatus*
Brindled madtom	*Noturus miurus*
Brook silverside	*Labidesthes sicculus*
Brook stickleback	*Culaea inconstans*
Brown bullhead	*Ameiurus nebulosus*
Central mudminnow	*Umbra limi*
Central stoneroller	*Campostoma anomalum*
Channel catfish	*Ictalurus punctatus*
Creek chub	*Semotilus atromaculatus*
Creek chubsucker	*Erimyzon oblongus*
Emerald shiner	*Notropis atherinoides*
Fantail darter	*Etheostoma flabellare*
Fathead minnow	*Pimephales promelas*
Freshwater drum	*Aplodinotus grunniens*
Gizzard shad	*Dorosoma cepedianum*
Golden redhorse	*Moxostoma erythrurum*
Golden shiner	*Notemigonus crysoleucas*
Grass pickerel	*Esox americanus v.*
Green sunfish	*Lepomis cyanellus*
Greenside darter	*Etheostoma blennioides*
Hornyhead chub	*Nocomis biguttatus*
Johnny darter	*Etheostoma nigrum*
Largemouth bass	*Micropterus salmoides*
Least darter	*Etheostoma microperca*
Logperch	*Percina caprodes*
Longear sunfish	*Lepomis megalotis*
Longnose gar	*Lepisosteus osseus*
Mimic shiner	*Notropis volucellus*
Mottled sculpin	*Cottus bairdi*
Muskellunge	*Esox masquinongy*

Species	Scientific Name
Northern hogsucker	*Hypentelium nigricans*
Northern pike	*Esox lucius*
Orangespotted sunfish	*Lepomis humilis*
Orangethroat darter	*Etheostoma spectabile*
Pumpkinseed	*Lepomis gibbosus*
Quillback	*Carpiodes cyprinus*
Rainbow darter	*Etheostoma caeruleum*
Redfin shiner	*Lythrurus umbratilis*
Redside dace	*Clinostomus elongatus*
River chub	*Nocomis micropogon*
Rockbass	*Ambloplites rupestris*
Rosefin shiner	*Lythrurus ardens*
Rosyface shiner	*Notropis rubellus*
Sand shiner	*Notropis stramineus*
Shorthead redhorse	*Moxostoma macrolepidotum*
Silver chub	*Macrhybopsis storeriana*
Silver redhorse	*Moxostoma anisurum*
Silver shiner	*Notropis photogenis*
Silverjaw minnow	*Notropis buccatus*
Smallmouth bass	*Micropterus dolomieui*
Southern redbelly dace	*Phoxinus erythrogaster*
Spotfin shiner	*Cyprinella spiloptera*
Spotted bass	*Micropterus punctulatus*
Spotted sucker	*Minytrema melanops*
Steelcolor shiner	*Cyprinella whipplei*
Stonecat madtom	*Noturus flavus*
Striped shiner	*Luxilus chrysocephalus*
Suckermouth minnow	*Phenacobius mirabilis*
Tadpole madtom	*Noturus gyrinus*
Tonguetied minnow	*Exoglossum laurae*
Trout-perch	*Percopsis omiscomaycus*
Variegate darter	*Etheostoma variatum*
Walleye	*Stizostedion vitreum v.*
White bass	*Morone chrysops*
White crappie	*Pomoxis annularis*
White sucker	*Catostomus commersoni*
Yellow bullhead	*Ameiurus natalis*
Yellow perch	*Perca flavescens*

Table 3.9 Predicted native freshwater bivalve species in the Elk Creek Watershed (US Geological Survey 2007 C). This species list was developed based on a USGS model which was based on 2,899 freshwater bivalve sample locations, physical habitat type, and variables indicating the major drainage basins and Omernik's Level III ecoregion (Covert, Kula and Simonson 2007) There are 27 predicted native freshwater bivalve species in the Elk Creek Watershed.

Common Name	Scientific Name
Black sandshell	*Ligumia recta*
Clubshell	*Pleurobema clava*
Creek heelsplitter	*Lasmigona compressa*
Creeper	*Strophitus undulates*
Cylindrical papershell	*Anodontoides ferussacianus*
Elktoe	*Alasmidonta marginata*
Fatmucket	*Lampsilis radiata*
Fluted shell	*Lasmigona costata*
Fragile papershell	*Leptodea fragilis*
Giant floater	*Pyganodon grandis*
Kidneyshell	*Ptychobranchus fasciolar*
Lilliput	*Toxolasma parvus*
Long fingernailclam	*Musculium transversum*
Paper pondshell	*Utterbackia imbecillis*
Plan pocketbook	*Lampsilis ventricosa*
Rainbowshell	*Villosa iris*
Rayed bean	*Villosa fabalis*
Ridgedback peaclam	*Pisidium compressum*
Salamander mussel	*Simpsonaias ambigua*
Slippershell mussel	*Alasmidonta viridis*
Spike	*Elliptio dilatata*
Striated fingernailclam	*Sphaerium striatinum*
Threehorn wartyback	*Obliquaria reflexa*
Threeridge	*Amblema plicata*
Wabash pigtoe	*Fusconaia flava*
Wavyrayed lampmussel	*Lampsilis fasciola*
White heelsplitter	*Lasmigona complanata*

4 LAND USE IN THE ECW

Understanding the types of land-use and land-cover (LULC) within a watershed is essential for effective watershed management because different LULC classes correspond with varying levels of impact on water quality conditions (US Environmental Protection Agency 2008). For example, agricultural practices may impact water quality by increasing nutrients from fertilizer applications, fecal coliforms from livestock, and sediment loads from runoff (US Environmental Protection Agency 2017 B). Additionally, impervious surfaces associated with urban and suburban development can result in higher levels of surface water runoff traveling at a faster speed compared to areas with forest cover. The pollutants collected along the way and higher volume can cause flooding, erosion and a decrease in water quality (Cotrone 2017) (US Environmental Protection Agency 2017 B).

4.1 CURRENT LAND-USE/LAND-COVER

Information on LULC in the United States is contained in the National Land Cover Database (NLCD). The NLCD, maintained by a consortium, categorizes land use into 16 classes, 14 of which are found in the ECW (Multi-Resolution Land Characteristics Consortium 2016). LULC classes include types of natural and developed terrestrial environments as well as water bodies. Developed land is broken down into open space, low intensity, medium intensity, and high intensity (see Text Box).

> **Developed, open space** is predominantly vegetative grasses with less than 20% of impervious surfaces. **Low, medium**, and **high intensity development** occurs with more than 20% impervious surface. (Anderson, et al. 2016)

The total land of the ECW is 47.62 square miles (30,521.6 acres) (Ohio Environmental Protection Agency 2016 B). Most of the land in the ECW is agricultural (69%), which includes hay/pasture (35%) and cultivated crops (34%) (Table 4.1). There are three forest types present (evergreen forest, mixed forest, and deciduous forest), and together they comprise approximately 22% of the land in the ECW. All classes of developed land make up approximately 9% of the LULC. All other LULC classes comprise less than 1% of the land in the ECW (Table 4.1).

The western region of the ECW is predominantly cultivated crops, while the eastern region has higher incidences of forested habitat and hay and pasture (Figure 4.1). Most of the developed land is found in the southern part of the watershed, where Elk Creek MetroPark and Trenton are located.

Table 4.1 Land-use/land-cover in the Elk Creek Watershed in acreage and percentage. Most of the land is hay/pasture, cultivated crops, and deciduous forest. Calculated by Jenna Tiller from NLCD 2011 data (See appendix A.3 for methods).

Land Use	Acres	Percent
Hay/Pasture	10,631.1	34.88%
Cultivated Crops	10,221.3	33.54%
Deciduous Forest	5,969.3	19.59%
Developed, Open Space	2,091.6	6.86%
Developed, Low Intensity	616.7	2.02%
Mixed Forest	324.5	1.06%
Evergreen Forest	299.8	0.98%
Open Water	98.5	0.32%
Shrub/Scrub	70.9	0.23%
Developed, Medium Intensity	79.4	0.26%
Herbaceous	46.3	0.15%
Woody Wetlands	12.5	0.04%
Emergent Herbaceous Wetlands	11.1	0.04%
Developed, High Intensity	5.8	0.02%

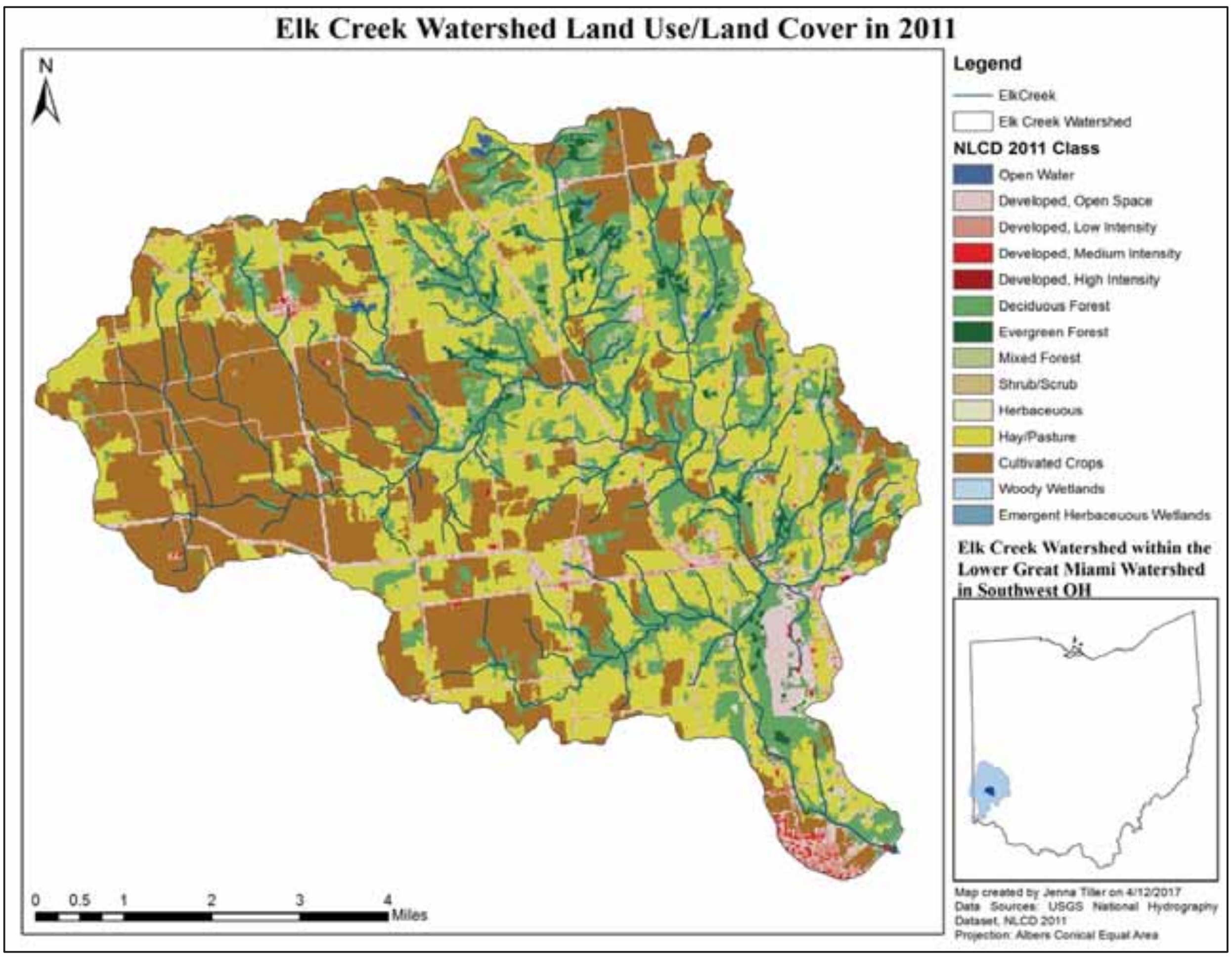

Figure 4.1 Land-use/land-cover in the Elk Creek Watershed. The area is predominantly agricultural (69%), followed by forest (22%) and developed land (9%). All other classes make up 1% of the Elk Creek Watershed.

4.1.1 Changes in Land Use/Land Cover

To determine recent changes in LULC, the team compared NLCD data from 2001 and 2011 (see Appendix A.4 for methods). The biggest change was a decrease in hay/pasture by 271.1 acres, which is approximately 0.1% of the ECW (Figure 4.2). This was accompanied by an increase in cultivated crops (120.7 acres) and developed open space (89.4 acres). Medium and low intensity developed land also increased by small amounts. A continuation of this trend could have implications on Elk Creek's water quality because cultivated crops and urban-developed land contribute to nutrient loading (such as nitrogen and phosphorus), which has negative impacts on water quality when in excess (US Environmental Protection Agency 2017 B).

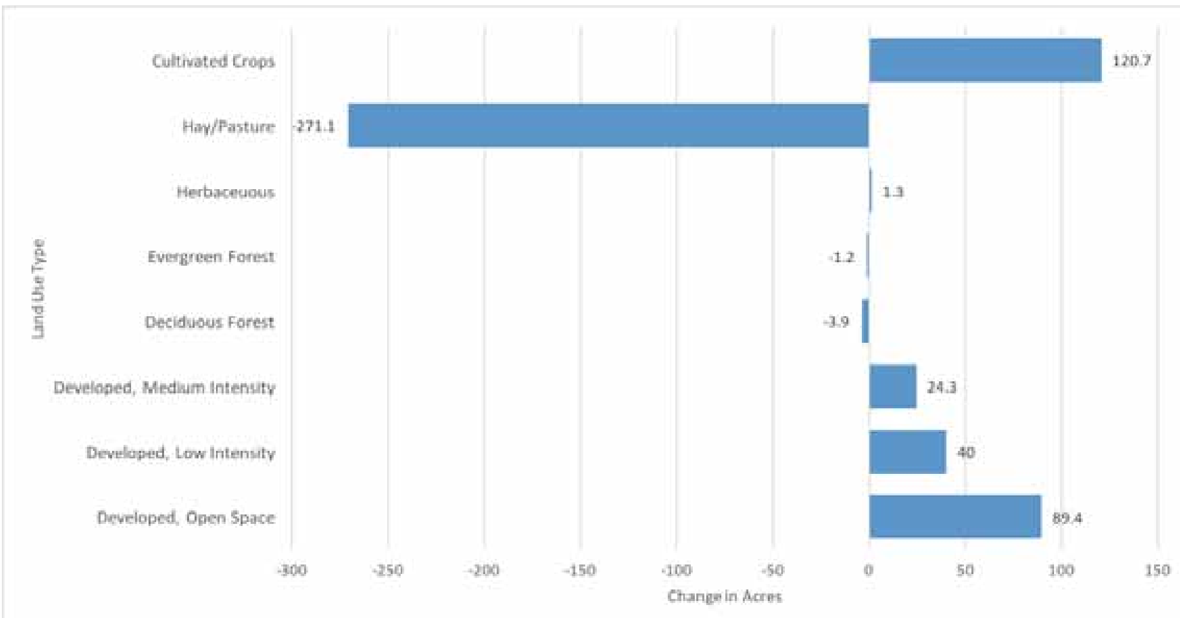

Figure 4.2 Changes in land-use/land-cover in the Elk Creek Watershed between 2001 and 2011. The largest change was a decrease in hay/pasture accompanied by an increase in cultivated crops and developed land of varying intensities. Calculations performed by team based on NLCD data (Appendix A.4).

4.2 LAND MANAGEMENT PRACTICES

4.2.1 Agriculture

Acreage of farmland was obtained at the county level from the US Department of Agriculture and the US Census Bureau. Out of the three counties that the ECW is in, Preble County has the highest acreage of farmland, followed by Butler and then Montgomery (Table 4.2).

Table 4.2 Number and acreage of farmland in Butler, Preble and Montgomery counties. According to the USDA and US Census Bureau data, Preble County has a greater number of farms and higher percentage of farmland. Based on these data, the team calculated that 82% of Preble County, 48.9% of Butler County, and 42% of Montgomery County is farmland. * (US Department of Agriculture 2012 A) ** (US Census Bureau 2015 A) ***(Calculated by Project Team).

County	Number of Farms*	Acres of Farmland*	Acres/County**	% Farmland***
Butler	865	146,054	298,920	48.9%
Preble	1,088	224,243	271,438	82.6%
Montgomery	770	124,105	295,393	42.0%

Table 4.3 Acerage of the crop types in Elk Creek Watershed. Soybeans are the most abundant followed by corn and winter wheat. *Calculated by Project Team – Appendix A.3.

Crop	Acres in ECW
Soybeans	5316.341
Corn	4968.738
Winter Wheat	537.972
Other Hay/Non-Alfalfa	319.803
Alfalfa	161.014
Winter wheat and soybeans	36.250
Oats	1.557
Fallow/Idle Cropland	0.890
Speltz	0.222

In addition to the NLCD data used for LULC analysis (Figure 4.1), the USDA generates Cropscape data, which breaks agricultural land down into specific crop types. According to the metadata from the Cropscape 2015 data analyzed by the team, the emphasis of Cropscape is crop-specific land-cover categories. Figure 4.3 relies on Cropscape to present a more specific breakdown of crop types. See Appendix A.5 for a description of Cropscape calculations.

The Cropscape map for the ECW indicates that the agricultural land is primarily corn and soybean cultivated crops as well as grass/pasture (Figure 4.3) (Table 4.3). There are also smaller amounts of alfalfa and winter wheat (Table 4.3).

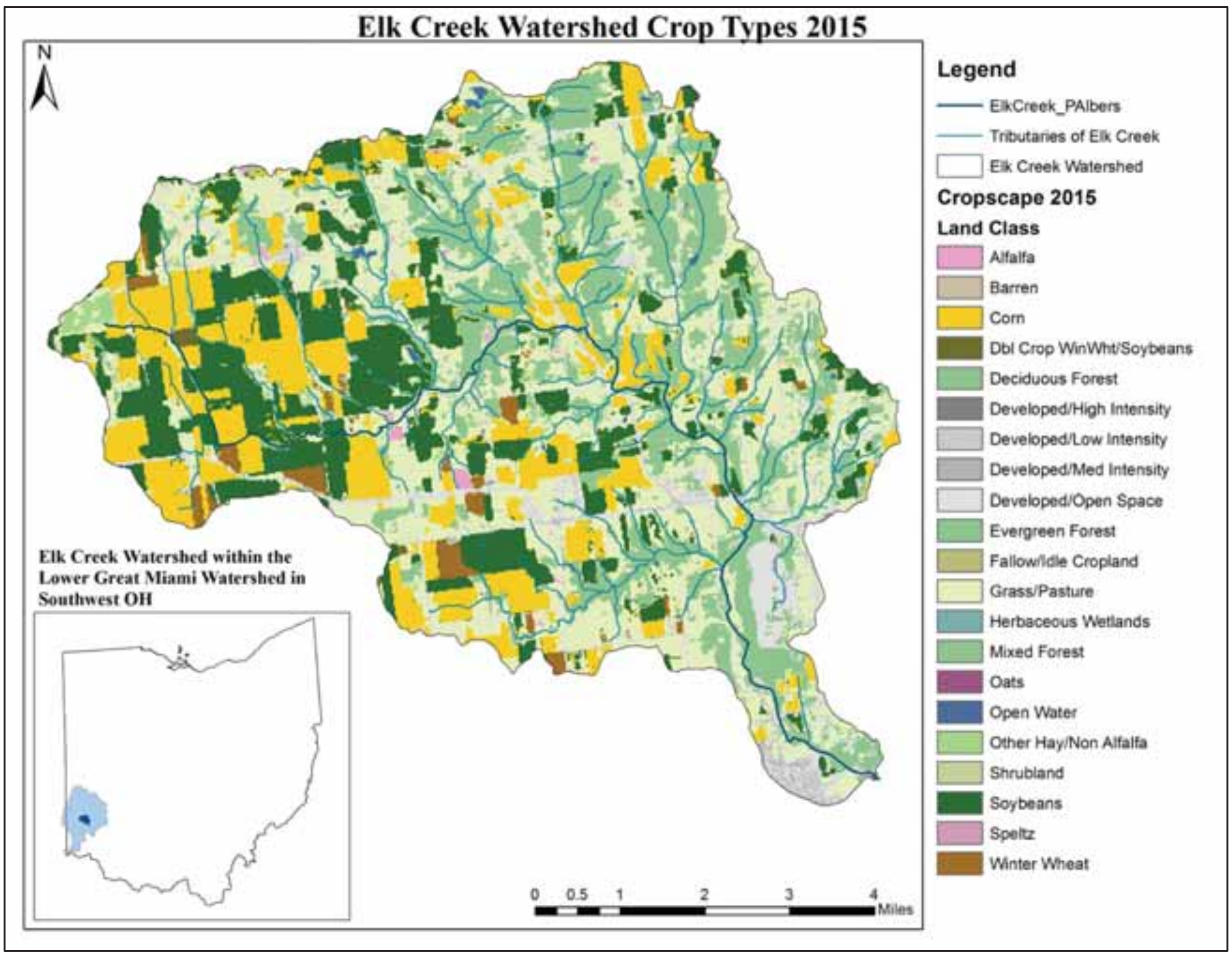

Figure 4.3 Crop Types in the Elk Creek Watershed. Based on team calculations using Cropscape 2015 data, the most abundant cultivated crop in the Elk Creek Watershed is soybeans, followed by corn and winter wheat.

4.2.2 Recreation and Conservation

MetroParks of Butler County:

The MetroParks of Butler County strives to conserve land and provide educational and recreational opportunities to the people of Butler County (MetroParks of Butler County 2016). MetroParks of Butler County has a focus on conservation, and works to keep most of its property undeveloped.

Elk Creek MetroPark, owned by the MetroParks of Butler County, is currently the largest park in the ECW (Barkley 2015). Elk Creek MetroPark is located in the southern part of the ECW and is comprised of the former Sebald Park and Weatherwax Golf Course property. According to Matt Latham, Park Planner/Project Manager for MetroParks of Butler County, there are plans to conduct mitigation work near the entrance bridge to the former Sebald Park to protect the infrastructure from erosion and prevent sedimentation in the creek (Latham 2016). Sebald Park was managed by the MetroParks of Butler County and was approximately 352 acres (MetroParks of Butler County 2016). Weatherwax Golf Course was purchased by the MetroParks of Butler County on September 23, 2015, adding approximately 400 acres to the park. The MetroParks of Butler County plans to convert the site into natural habitat (McCrabb 2015).

City of Trenton:

Trenton Community Park is located on the northwest side of Trenton (Trenton Community Park 2017). The park offers a playground with basketball courts, outdoor shelters, and extensive greenspace.

West Elkton Village:

West Elkton Community Park, owned by the City of West Elkton, is a small park with baseball diamonds and walking paths (West Elkton Village 2017). The park has open green space for recreation and extracurricular activities.

Clean Sweep of the Great Miami – Great Miami River Cleanup

The Great Miami River Cleanup is a volunteer-based effort to improve water quality conditions through litter reduction (Clean Sweep of the Great Miami River 2015). The entire Great Miami River is cleaned once a year. In July 2016, 422 volunteers participated in a Clean Sweep event from Indian Lake to the Ohio River resulting in the collection of 17.3 tons of litter (Clean Sweep of the Great Miami River 2016). Another Clean Sweep event on October 22, 2016 included locations in the ECW in Madison Township and at the Trenton Community Park. The results for this cleanup have not been posted yet.

Butler County Stream Team

The Butler County Stream Team (BCST) is an organization that gathers, analyzes, and reports water quality data with a dual goal of educating residents on water quality issues (Butler County Stream Team 2016 A). Samples from water bodies in Butler County are analyzed for bacteria, nitrates, total phosphorus, total dissolved solids, pH, conductivity, and turbidity. This is accomplished through a collaborative effort between volunteers, the Miami University Institute for the Environment and Sustainability, the Butler County Stormwater District, and the Butler SWCD. *E coli* and nitrate data from BCST sampling sites in the ECW were analyzed for this inventory. Results are included in Section 7.

Three Valley Conservation Trust - Headwaters Preservation Project

The Three Valley Conservation Trust (TVCT) works to preserve land and ecosystems for future generations through land easements and partnerships with land owners and community members in the region (Three Valley Conservation Trust 2017). One of their projects is the Headwater Preservation Project, which is a 270-acre easement and covers over one mile of the ECW, including forests and streams (see Appendix D.3 for more information on the property) (Ohio Public Works Commission 2016).

Historical and Cultural Information

Several historical markers and sites are within the boundaries of the ECW. For more information on these sites, refer to Appendix E.

4.2.3 Stormwater Pollution Prevention Plans

Stormwater Pollution Prevention Plans (SWPPP) are used to develop and implement programs that address runoff from development and industry (Ohio Environmental Protection Agency 2017 A). As required by Ohio law, a construction project requires a permit if it affects more than one acre of land, and a SWPPP is needed to receive a permit.

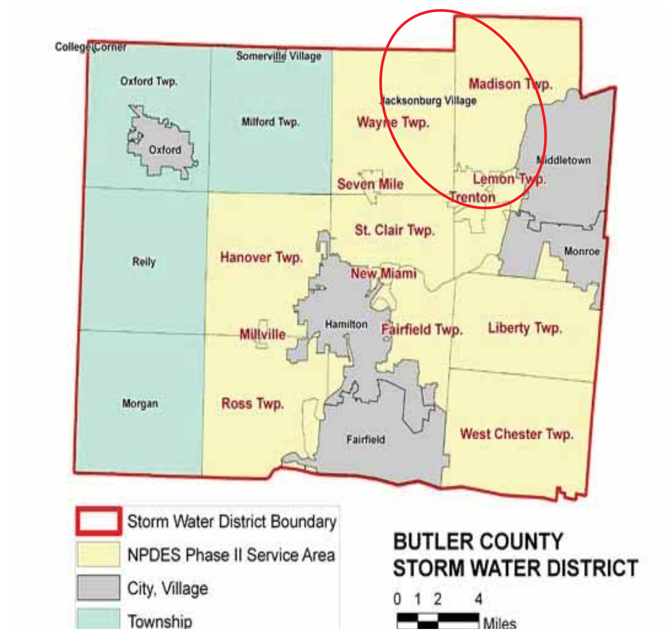

Figure 4.4 Butler County Storm Water District locations within the Elk Creek Watershed. Milford, Wayne, Madison, and the City of Trenton are listed under NPDES Phase II Service area (Butler County Storm Water District 2003)

Butler County Storm Water District drafted a Stormwater Management Plan (SWMP) in 2003 (Butler County Storm Water District 2003). The permit covers 45% of Butler County and affects 132,000 residents, including some of the townships that are in the ECW (Figure 4.4). The Storm Water Management Program identifies six minimum control measures that address stakeholder participation and education, illicit discharge detection and elimination, construction and post-construction site runoff, and pollution prevention. Butler County Storm Water District is responsible for the southern half of the ECW, and handles the storm water planning for the City of Trenton (Butler County Storm Water District 2003). Montgomery and Preble counties did not list any SWPPP on their websites. Both were contacted by the Project Team, but no SWPPP were identified.

5 WATER QUALITY STANDARDS

5.1 OHIO WATER QUALITY STANDARDS

The CWA § 303(c) requires that states generate their own water quality standards (33 U.S. Code § 1313 (c)). Ohio uses ambient standards that define a maximum amount of various pollutants acceptable for each designated use of the water (Ohio Environmental Protection Agency 2015 A). The Ohio standards include the following four components, which combined help ensure the water quality is sufficient for recreational, human, and aquatic life uses:

1. **Beneficial use designations:** current or prospective uses for bodies of water. A water body can have more than one designated use, and the uses are assigned for each individual tributary in a larger drainage basin. The type of aquatic life habitat, water supply use, and recreational use are individually identified for each water body (OAC 3745-1).
2. **Narrative "free-froms":** require the water be free from certain conditions introduced by human activity. Specifically, they must be free from suspended solids, floating debris, materials that change the color or odor of the water, substances in toxic concentrations, and sewage (OAC 3745-1).
3. **Numeric criteria:** include chemical criteria, biological criteria, and Whole Effluent Toxicity levels. These criteria determine the maximum amount of chemicals or toxins allowable in the water body without affecting the beneficial use designations (OAC 3745-1).
4. **Anti-degradation provisions:** require assessment of potential negative impacts of any increased activity on a body of water. If the activity provides important economic or social development, the activity may be allowed even though it may pollute the water (OAC 3745-1).

5.2 WATER QUALITY STANDARDS FOR ELK CREEK

The beneficial uses of Elk Creek are exceptional warmwater habitat, agricultural water supply, industrial water supply, and primary contact recreation use (Class B) (Ohio Environmental Protection Agency 2012 A). Class B recreation indicates which recreational activities are acceptable for the stream—specifically swimming, canoeing, and kayaking. The beneficial uses of Elk Creek have not changed since 1985, and they were most recently reviewed and confirmed on February 17, 2017 (OAC 3745-1)**.** Each designated use comes with its own set of numeric criteria standards which must be maintained for Elk Creek to remain acceptable for its designations (Table 5.1).

Table 5.1 Numeric criteria for the Elk Creek Watershed based on its four designated uses. Elk Creek aquatic use is exceptional warmwater habitat. Elk Creek is not designated as a public drinking water supply but is designated for agricultural and Industrial water use. The recreational designation is primary contact, which includes swimming and boating

Use Designation	Use Designation Meaning	Numeric Criteria
Exceptional Warmwater Habitat	Elk Creek was determined to have a highly or exceptionally diverse aquatic community of warmwater habitat organisms (Ohio Environmental Protection Agency 2012 A). The aquatic life use designation for the majority of streams in the Lower GMR watershed in 2010 was Warmwater Habitat. Only the ECW has the exceptional warmwater habitat (EWH) designation.	**Biological**: The ECW must attain an Index of Biotic Integrity score of 48 – 50 and a Modified Index of Well-Being score 9.4 - 9.6 depending on the site being evaluated (OAC 3745-1)**.** Additionally, exceptional warmwater habitats must achieve an Invertebrate Community Index of 46 which is considered "good."
		Chemical: The ECW must comply to certain statewide criteria set for the entire state of Ohio in order to protect aquatic life (OAC 3745-1)**.** Additionally, it has criteria regarding the maximum and 30-day-average total ammonia-nitrogen concentration allowed based on pH and temperature of the water. The Ohio EPA is in the process of detailing nitrate and phosphorus standards for warm water habitats and exceptional warm water habitats (Jamesson, et al. 2014).
		Whole Effluent Toxicity (WET): WET is determined by investigating the effects of effluent outflow on aquatic plants, vertebrates, and invertebrates. However, the NPDES permits in the ECW have a relatively small discharge flow, so Elk Creek does not have WET criteria (Appendix F.1).
Agricultural Water Supply	Water from Elk Creek can be used for irrigation and livestock watering without treatment	In order to be suitable for agricultural water supply use, the ECW must have average concentrations of fluoride, nitrates, nitrites, and certain metals below designated values (Appendix F.2) (OAC 3745-1).
Industrial Water Supply	Water from Elk Creek can be used for industrial purposes with or without treatment	No criteria (Ohio Environmental Protection Agency 2004).
Primary Contact Recreation (Class B)	Elk Creek is deemed suitable for activities such as swimming, canoeing, kayaking, and others that include direct contact.	Elk Creek is required to have a maximum monthly average of 126 *E. coli* colonies per 100 mL and must maintain the statistical threshold value of 410 *E. coli* colonies per 100 mL (Appendix F.3) (OAC 3745-1). In other words, no more than 10% of the samples taken in a 90-day period may be over 410 *E. coli* colonies per 100 mL.

5.3 WATER QUALITY REPORTS

As mentioned in Section 1 of this inventory, Section 303(d) of the CWA requires that states create a list of impaired waters, and Section 305(b) requires states to create biennial water quality reports. Ohio combines the CWA § 303(d) and CWA § 305(b) reports into the *Ohio Integrated Water Quality Monitoring and Assessment Report,* which identifies waters that are not meeting water quality standards (Ohio Environmental Protection Agency 2016 B). If the water quality is deemed impaired, the states must develop a Total Maximum Daily Load (TMDL) for that waterbody, which is the maximum amount of a pollutant that can enter the waterbody (US Environmental Protection Agency 2017 C). An explanation of the TMDL report process can be found in Appendix F.4.

The Ohio EPA *2016 Integrated Report* indicates that Elk Creek had attained the recreational designation, but was considered impaired for aquatic life and human health (Table 5.2) (Ohio Environmental Protection Agency 2016 B). The cause of impairment for aquatic life was the result of natural causes and did not warrant a TMDL. However, the impairment related to human health was not due to natural causes and was therefore significant enough to warrant a TMDL. The TMDL is currently being prepared (Ohio Environmental Protection Agency 2016 B).

Table 5.2 Ohio EPA water quality monitoring & assessment findings by designated uses for Elk Creek (Ohio Environmental Protection Agency 2016 B). The category designations and explanations can be found on pages L1-44 and L-2 respectively of the Ohio EPA *2016 Integrated Report.* The recreational use for Elk Creek was in full attainment, but aquatic life and human health uses were both impaired for different reasons.

Elk Creek Designated Uses and Status		
Designated Use	**Status**	**TMDL Needed?**
Recreational	Full Use Attainment	No – the historical data used indicated recreational use was supported by current conditions
Aquatic Life	Impaired	No – the impairment is due to natural causes*
Human Health	Impaired	Yes – fish tissue assessment determined a risk to human health

*According to the Ohio EPA, the lower 4 miles of Elk Creek were bulldozed straight decades ago, but have since been filled with gravels and cobbles from glacial till and alluvial deposits (Ohio Environmental Protection Agency 2012 A). The pool depths were greater than 1.0 m in 1995 and were less than 0.7 m in 2010. This prevented large fish from being able to live in this portion of Elk Creek in 2010, causing the impairment. However, the US EPA reported conflicting results on their website regarding the TMDLs needed (Appendix F.5). Specifically, the US EPA claimed a TMDL was needed for the aquatic life use of Elk Creek in addition to the TMDL required for human health use.

6 POLLUTION SOURCES

6.1 POINT SOURCE POLLUTION

A point source of pollution is defined as any single source of direct discharge of pollution into the environment (National Oceanic and Atmospheric Administration 2008). The CWA established the National Pollutant Discharge Elimination System (NPDES) which states that no person may discharge pollutants from a point source into waters of the US without a permit (33 U.S. Code § 1342). The permits define effluent limits as well as monitoring and reporting requirements (US Environmental Protection Agency 2016 D).

Classification of NPDES Permits

1. Individual permits are site specific to the application by the discharger (US Environmental Protection Agency 2016 E).

2. Municipal sites collect sewage and wastewater from homes or businesses and treat the polluted water before it is discharged into a local water source (US Environmental Protection Agency 2016 F).

3. Minor/major industries are classified as such by the state directors (OAC 3745-39-04)

4. Publicly owned treatment works must have in place ways to determine the type of pollutant that occurs in any significant amount and a way to mitigate the pollutants effect on the environment (33 U.S. Code § 1342).

As of April 29, 2017, the ECW had three active NPDES permitted sites (Figure 6.1). All three are classified as individual, municipal, minor, and public under their NPDES permits.

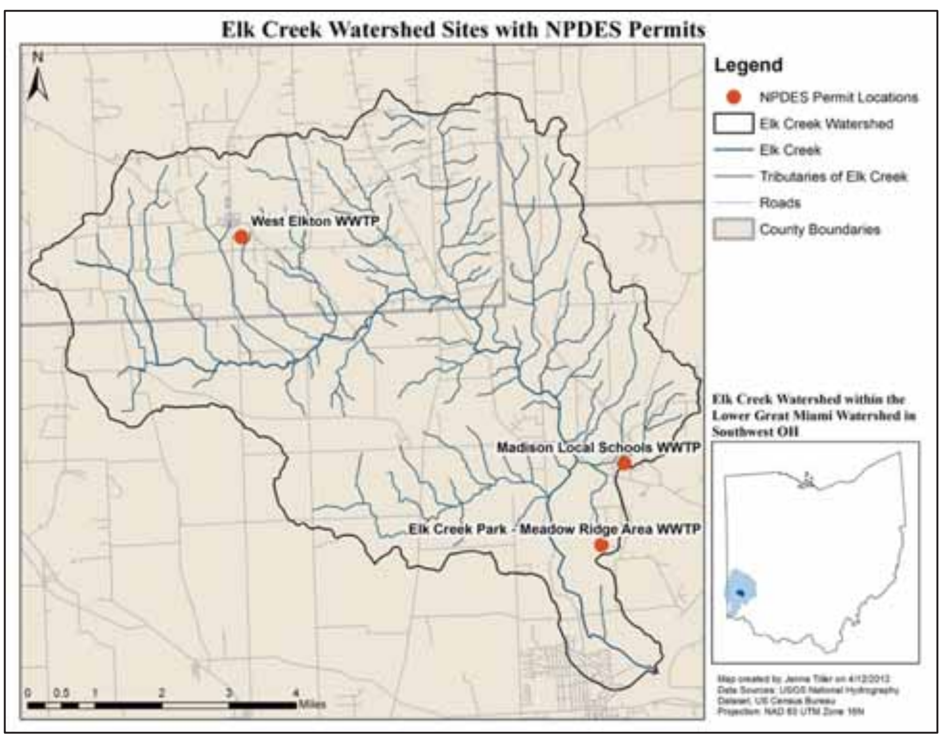

Figure 6.1 Locations of the NPDES Permits in the Elk Creek Watershed. There is one in the northwestern, Preble County portion of the Elk Creek Watershed and two in the southeastern, Butler County portion.

6.1.1 NPDES Permit Compliance

The three NPDES permits within the ECW are the West Elkton/Preble County Sanitary District No. 3 Wastewater Treatment Plant (WWTP), the Madison Local Schools WWTP, and the Elk Creek Park – Meadow Ridge Area WWTP (formerly Weatherwax Golf Course WWTP). The effluent limits for each permit are in Appendices G.1, G.2, and G.3, respectively. All three NPDES permits within the ECW have been found in non-compliance of their NPDES permits at some point over the last 3 years.

The West Elkton WWTP NPDES permit was out of compliance for 3 of the 13 quarters during the July 1, 2014 - September 30, 2016 reporting period (Table 6.1). The permit is set to expire on July 31, 2019 (Ohio Environmental Protection Agency 2014 C).

Table 6.1 Three-year non-compliance details of the West Elkton/Preble County Sanitary District No. 3 Wastewater Treatment Plant NPDES permit. They have been found in non-compliance for late reporting and exceeding limits for total nitrogen-ammonia (as N) and carbonaceous Biological Oxygen Demand (BOD) (Ohio Environmental Protection Agency 2014 C) (US Environmental Protection Agency 2014 A).

Period of Non-Compliance for West Elkton/Preble County Sanitary District No. 3 WWTP		**Reason for Non-Compliance**
Number of Quarters	**Dates**	
1	April 1 – September 30, 2014	Exceeding discharge limits of total nitrogen-ammonia (as N) by 7%
1	October 1 – December 31, 2014	Late reporting
1	July 1, 2016 – September 30, 2016	Exceeding discharge limits of the carbonaceous BOD test by 144%

The Madison Local Schools WWTP NPDES permit was out of compliance for late reporting 7 quarters in a row between October 1, 2014 and June 30, 2016 (Table 6.2). Prior to that, Madison Local Schools self-reported a violation of total nitrogen – ammonia (as N) concentration (Pohlman 2007). The discharge had 1.4 mg/L while their permit limits the concentration to 1.0 mg/L. The current permit is set to expire on April 30, 2019 (Ohio Environmental Protection Agency 2014 D).

Table 6.2 Three-year non-compliance details of the Madison Local Schools Wastewater Treatment Plant NPDES permit. The permit has been out of compliance for late reporting (Ohio Environmental Protection Agency 2014 D) (US Environmental Protection Agency 2014 B).

Period of Non-Compliance for Madison Local Schools WWTP		**Reason for Non-Compliance**
Number of Quarters	**Dates**	
7	October 1, 2014 – June 30, 2016	Late reporting

The third NPDES permit is for the Elk Creek Park – Meadow Ridge Area WWTP, which was formerly operated by Weatherwax Golf Course. When the site was under ownership of Weatherwax Golf Course, the permit was found in non-compliance for exceeding limits on *E. coli*, total nitrogen – ammonia (as N), and total suspended solids (Table 6.3).

According to Matt Latham, Park Planner/Project Manager for MetroParks of Butler County, the park will continue to maintain the Weatherwax Golf Course WWTP NPDES permit for the purposes of the Elk Creek Park – Meadow Ridge Area WWTP (Latham 2017). No changes to the building site are expected. The Elk Creek Park – Meadow Ridge Area WWTP permit is set to expire on December 31, 2017 (Ohio Environmental Protection Agency 2012 B).

Table 6.3 Three-year non-compliance details of the Weatherwax Golf Course Wastewater Treatment Plant NPDES permit. They have been found in non-compliance for *E. coli*, total nitrogen-ammonia, and total suspended solids (Ohio Environmental Protection Agency 2012 B) (US Environmental Protection Agency 2014 C).

Period of Non-Compliance for former Weatherwax Golf Course WWTP		**Reason for Non-Compliance**
Number of Quarters	**Dates**	
1	April 1 – June 30, 2014	Exceeding permit limitations on *E. coli*, and total nitrogen – ammonia (as N)
1	October 1 – December 31, 2014	Exceeding total suspended solids by 17%

6.2 NONPOINT SOURCE POLLUTION

Nonpoint sources of pollution are indirect discharges of polluting material into the environment, usually in the form of runoff (US Environmental Protection Agency 2016 C). These sources of pollution are addressed in the CWA, and are managed in accordance with best management practices established by each state (33 U.S. Code § 1329). The most common sources of nonpoint source pollutants in Ohio are related to land use (fertilizers, chemical herbicides/pesticides, animal manure), stormwater runoff (road salts, oil, debris), and failing on-site sewage treatment systems (OKI Regional Council of Governments 2017).

6.2.1 Livestock Inventory

Livestock plays an important role in health of the watershed because large amounts of livestock create animal waste that contributes to nutrient loading and increased eutrophication in waterbodies (US Environmental Protection Agency 2017 D). However, are also an important element of many rural economies (Sansoucy 1995). In the counties that the ECW is within, hogs and pigs make up most of the livestock, followed by cattle and calves (Table 6.4). There are no concentrated animal feeding operations located within the ECW.

Table 6.4 County-level data on abundance of livestock types. The predominant livestock type is hogs and pigs, with 68,799 in all three counties, followed by cattle and calves, with 39,655 in all three counties (US Department of Agriculture 2012 B) (US Department of Agriculture 2012 C) (US Department of Agriculture 2012 D) (US Department of Agriculture 2012 E) (US Department of Agriculture 2012 F) (US Department of Agriculture 2012 G). *Total number calculated by Project Team.

Types of Livestock		Butler	Montgomery	Preble	*Total
Cattle and Calves	Cows and Heifers that Calved	4721	1,274	3629	9624
	Beef cows	4271	799	3020	8090
	Milk cows	450	475	609	1534
	Other cattle	8631	7,294	14106	30,031
	Total Cattle and Calves	13352	8,568	17,735	39,655
Hogs and Pigs		10502	7,112	51,185	68,799
Horses		1825	1,605	1259	4689
Poultry	Number of Poultry Farms	96	125	135	356
	Layers	2542	4023	4290	10,855
	Pullets for Laying Flock Replacement	106	491	650	1247
	Broilers and Other Meat-Type	937	1937	1221	4095
	Turkeys	80	165	0	245
	Duck, Geese, and Other (farms)	10	33	34	77

6.2.2 Fertilizer Data

Fertilizers are used to promote plant growth and commonly include a mix of primary and secondary nutrients (see text box) (The Ohio State University 2017). Nitrogen, phosphate, and potash (potassium) are the three primary nutrients used, and sulfur is used as a secondary nutrient. The USDA monitors the amount of all four nutrients applied as fertilizer for various crops. The amount and type of fertilizer applied depends on crop type as well as soil types and conditions.

Primary Nutrients:
Nutrients most essential to plant development

Secondary Nutrients:
Nutrients necessary for plant production at lower levels

Table 6.5 Most abundant crop types by acreage in the Elk Creek Watershed. Soybeans are the most abundant followed by corn and then winter wheat. *Calculated by Project Team – Appendix A.5.

Crop	Acreage in the ECW
Soybeans	5,299.0
Corn	4,953.6
Winter Wheat	537.3

Statewide fertilizer application rates are reported by the USDA. To estimate fertilizer application (lbs/year) in the ECW, the Project Team used the application rates determined by the USDA and the Cropscape estimates of the number of acres of the top three crop types in the ECW: soybeans, corn, and winter wheat (Table 6.5).

Based on these calculations using the most recent fertilizer data available, the team estimated that 2.75 million pounds of fertilizer are applied in the ECW annually for soybeans, corn, and winter wheat (Table 6.6). Based on these estimations, the type of fertilizer that was applied in the highest abundance over all three crops was potash, and corn required the highest amount of total fertilizer. The team estimated corn crops have approximately 8.7 times as much nitrogen fertilizer applied when compared to soybean crops and 18.7 times as much when compared to winter wheat crops in the ECW.

Table 6.6 Estimated quantity of fertilizer applied in Elk Creek Watershed in pounds per year based on statewide data of fertilizer application. * Calculated by Project Team, see Appendix A.6 for methods.

Crop**	Amount Fertilizer Applied (lbs/year) in the ECW*				
	Nitrogen	Phosphate	Potash	Sulfur	Total
Corn	765,682.5	369,674.1	464,577.0	44,718.6	1,644,652.3
Soybean	87,719.6	269,006.8	543,861.6	90,377.8	990,965.9
Winter Wheat	40,885.9	30,180.2	40,832.1	8,069.6	119,967.8
Total	894,288.0	668,861.2	1,049,270.7	143,166.0	2,755,585.9

**Corn fertilizer data is from 2010 while soybean and winter wheat fertilizer data is from 2015.

Manure Applied as Fertilizer

Animal manure can be efficiently disposed of by being used as a crop fertilizer (Lory, Massey and Joern 2016). However, because it is a natural source, the nutrients in manure are often imbalanced for efficient crop growth. Specifically, over 60% of the nutrients in manure are present in amounts exceeding what crops can use. This may result in higher nutrient runoff than fertilizer (Lory, Massey and Joern 2016). Although used less than synthetic fertilizer, manure is still used in Butler, Preble, and Montgomery counties (Table 6.7).

Table 6.7 County-level manure application data for Butler, Preble and Montgomery counties in 2012 (US Department of Agriculture 2012 H). Preble County had the most farms using manure as fertilizer and the most acres treated with manure followed by Butler and then Montgomery counties.

Data	Butler	Preble	Montgomery
Number of farms using manure as fertilizer	176	219	92
Acres treated with manure as fertilizer	7,279	10,181	3,780

6.2.3 Household Sewage Treatment Systems

Household sewage treatment systems (HSTS) are any sewage treatment system that receives sewage from a single-family, two-family, or three-family dwelling (OAC 3718-01). These systems provide for both the disposal and treatment of sewage (Ohio Department of Health 2008 A). The most recent information the team could obtain about total number of HSTS in Ohio is that in 2009, Ohio had more than 1 million HSTS (Ohio Department of Health 2009).

In perfect conditions with proper maintenance, HSTS are meant to last between 30 and 40 years (Ohio Department of Health 2008 B). In 2008, the most cited reasons for HSTS failure in Ohio were old age, improper siting/design for site limitations or conditions, system abuse, and general lack of proper maintenance (Ohio Department of Health 2008 B). If not properly maintained, HSTS can pose significant health and environmental risks. Failures in HSTS may contribute *E. coli*, *Salmonella*, *Shigella*, polio, hepatitis, and *Cryptosporidium* to soil and water contamination (Ohio Department of Health 2017).

Clean Watersheds Needs Survey 2008 and 2012

The US EPA coordinates with states to submit to Congress an estimate of the capital costs required to meet water quality goals established by the CWA, particularly in regard to nonpoint source pollution (33 U.S. Code §1375) (US Environmental Protection Agency 2016 G). One way these estimates are made is through the Clean Watersheds Needs Survey (CWNS), which is completed in cooperation with local health departments and soil and water conservation districts.

To gather information for the CWNS as well as for other data reporting needs, Ohio conducts a survey every four years about HSTS (Ohio Department of Health 2013 A). Counties are asked to submit their responses to the Ohio Department of Health and the Ohio EPA (Ohio Department of Health 2013 A). However, not all counties submit reports during each survey period. Butler County's most recent report was submitted in 2008, while Preble and Montgomery counties both submitted reports in 2012. Based on the four-year gap between surveys, another was scheduled to be conducted in 2016, but the data was not available at the time this watershed inventory was written.

One piece of information collected in this survey was the failure rates of HSTS. The HSTS failure rate estimates in Ohio were reported to be 193,899 in 2012 and 250,000 in 2008 (Ohio Department of Health 2013 A). The results of the 2008 and 2012 Ohio surveys were not detailed enough to allow the team to estimate the number of HSTS in the ECW. However, the HSTS information for each county and township that composes the ECW are reported in Table 6.8. Note that survey methods were slightly different between 2008 and 2012. In the 2012 survey, counties were not asked to define "failing systems," and although they provided examples of failing systems to the state, areas of need were left largely to the county's discretion.

HSTS Findings by County and Township, Summary

Table 6.8 Home Sewer Treatment System reporting for Butler, Preble, and Montgomery counties. Information compiled from survey responses by county from state CWNS. Emailed responses from Andy Thomas (Ohio Department of Health), and Thomas Hut (Ohio Department of Health, Supervisor, Montgomery County), (Ohio Department of Health 2008 A), and (Ohio Department of Health 2013 B).

Characteristic	Butler County (2008)		Preble County (2012)		Montgomery County (2012)
Townships(s)	Madison	Combined Townships (Wayne, Milford, Oxford, Ross, Morgan, Reilly, Lemon, and Liberty)	Gratis	Somers	Entire County
Total Existing Systems (All Types)	930	46,250	1,370	787	18,200
Total Currently Failing (All Types)	10	2712	50	35	260
Main Reasons for Failure	80% Old Age 40% Soil Limitations 50% Site Limitations	80% Old Age 20% Soil Limitations 40% Design Issues	60% Old Age 15% Soil Limitations 20% System Owner Abuse	60% Old Age 10% Soil Limitations 10% System Owner Abuse	75% Old Age 20% Soil Limitations 20% Site Limitations
Main Solutions (% Replacement / % Alteration)	75% / 25%	N/A	N/A	N/A	55% / 40%
Basis of Survey	Estimate based on census data and general county knowledge	Estimate based on census data and general county knowledge	N/A	N/A	Estimated using alteration/replacement permit data and/or complaints

7 WATER QUALITY DATA

7.1 WATER QUALITY DATA SOURCES

The water quality data for the ECW used in this section was collected from four different sources. These sources include a Miami University report on nonpoint pollution, Ohio EPA Biological Assessments, a USGS study of nitrate in groundwater, and BCST data (Table 7.1). The studies used provide sporadic data from 1992 to 2016. Together, they give a more comprehensive look at how certain aspects of water quality in Elk Creek have changed over the last few decades.

Table 7.1 Water quality data sources used in the Elk Creek Watershed Inventory. Four sources were used: Miami University, the Ohio EPA, the USGS, and the Butler County Stream Team (BCST). The Miami University collected nitrate data in 1992 and 1993. The Ohio EPA has completed three biologic and water quality assessments since the 1980's which provide data on IBI, ICI, MIWb, QHEI, and *E. coli*. The USGS provided data on nitrate concentrations in groundwater wells in the Elk Creek Watershed in 2003 and 2004. The 2015 and 2016 BCST data was analyzed by the team to assess trends in nitrate and *E. coli* concentrations.

Source	Years of Data Collection	Purpose of Studies	Data Presented in the ECW Inventory
Miami University	1992-1993	To investigate sources and results of nonpoint pollution in Elk Creek (Farmer, et al. 1993)	Nitrate
Ohio EPA	1987,1995, and 2010	To evaluate biologic and water quality of the Lower Great Miami River and selected tributaries (Ohio Environmental Protection Agency 1997) (Ohio Environmental Protection Agency 2012 A)	IBI, ICI, MIWb, *E. coli*
United States Geological Survey	2003-2004	To evaluate level of nitrate in groundwater used for drinking supply (Pletsch and Schumann 2006)	Nitrate
Butler County Stream Team*	2015-2016	To monitor local water quality	Nitrate, *E. coli*

*Data was obtained directly from Tera Ratliff, Research Associate and Lab Manager (Center for Aquatic and Watershed Sciences Laboratory), and the BCST Graduate Assistant Kate Moran.

The Ohio EPA conducts a biological and water quality study on the Lower Great Miami River and selected tributaries every 15 years. The Ohio EPA study published in 1997 had one sample site at Elk Creek RM 3.70, and their study published in 2012 had two additional sample sites at RM 10.10 and RM 1.49 (Ohio Environmental Protection Agency 1997) (Ohio Environmental Protection Agency 2012 A). Both the BCST and the Ohio EPA collect samples at RM 3.70 and RM 1.50 of Elk Creek, but have different sampling sites farther upstream (Figure 7.1). The 1992-1993 Miami University sampling sites could not be accurately identified due to a lack of spatial data in their report.

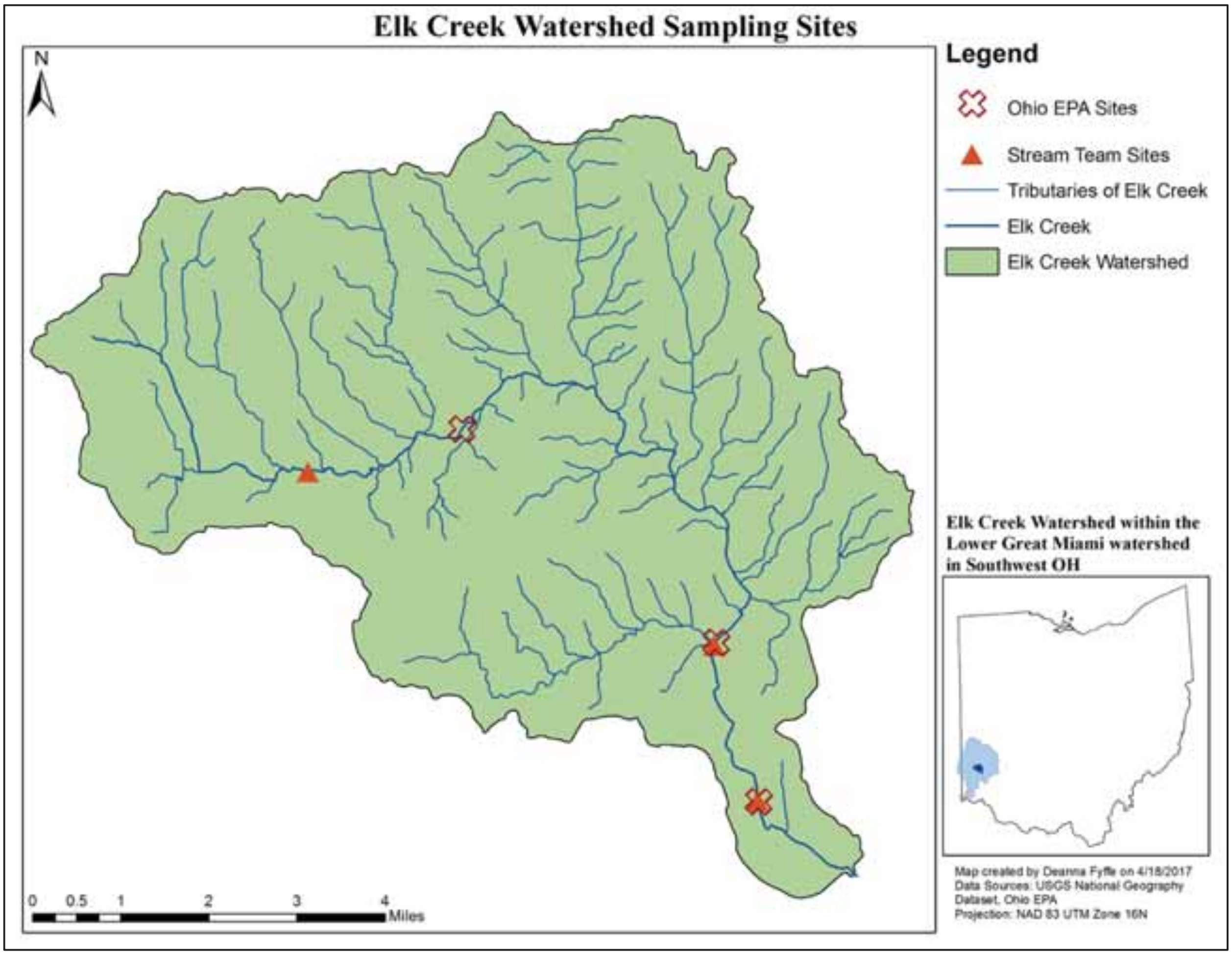

Figure 7.1 Water sample collection sites for the Ohio Environmental Protection Agency (Ohio EPA) and the Butler County Stream Team (Stream Team). The two entities have sampling sites near RM 1.50 and RM 3.60/3.70. Upstream, the Ohio EPA samples at RM 10.10 and Stream Team samples at RM 12.4.

7.2 BIOLOGICAL DATA

The Ohio EPA collects biological data through three different methods: Index of Biotic Integrity (IBI), Modified Index of Well-Being (MIWb), and Invertebrate Community Index (ICI). The IBI and MIWb are based on fish, and ICI is based on macroinvertebrates.

The IBI method determines water quality based on the type and abundance of fish species present in the waterbody (Ohio Environmental Protection Agency 1987 A). The three main categories of variables investigated are species richness and composition, trophic composition, and fish abundance and condition. The maximum score for the IBI is a 60, which indicates the water body has conditions that are untouched by anthropogenic sources. The current IBI score requirement for exceptional warmwater habitats (EWH) is 48 – 50 (Table 7.2).

The MIWb incorporates four fish measures—number of individuals, biomass, and an index based on both abundance and weight (Shannon Diversity Index)—into an equation to reach a single output (Ohio Environmental Protection Agency 1987 B). Fish species that are exotic, highly tolerant of poor water quality, or a hybrid are excluded from the biomass calculation because they commonly skew the calculation to be non-representative of the community present. However, they are used in the Shannon Diversity Index calculations. The conceptual identification of a community as being exceptional, good, fair, or poor is determined by a combination of qualitative and quantitative information (Appendix H.1). The current MIWb score requirement for an EWH is 9.4 – 9.6 (Table 7.2).

ICI is similar to IBI, except it measures macroinvertebrate communities rather than fish communities (Ohio Environmental Protection Agency 1987 B). It uses similar methods and also determines the relative water quality of the water body. IBI is usually preferred over ICI due to the longer lifespan of fish, better represents changes over time. The highest score for ICI is also 60, and the current ICI score requirement for an EWH is 46 (Table 7.2).

Table 7.2 Biological index score requirements to maintain an exceptional warmwater habitat (EWH) (OAC 3745-1). An EWH indicates a highly or exceptionally diverse aquatic community of warmwater habitat organisms (Ohio Environmental Protection Agency 2012 A). IBI scores should be equal to or greater than 48-50, the MIWb scores equal to or greater than 9.4-9.6, and ICI scores of at least 46.

Index	Score Criteria for EWH
IBI	48 – 50
MIWb	9.4 – 9.6
ICI	46

The Ohio EPA calculated IBI, ICI, and MIWb scores were calculated for Elk Creek in 1995 and 2010. Data collected in 1995 for a water quality study of Elk Creek indicated an exceptional macroinvertebrate community and a good biological community overall, but the data was only collected for one site at RM 3.70 (Table 7.3) (Ohio Environmental Protection Agency 1997). This study also indicated elevated amounts of metals in the sediment, but the creek was otherwise of prime water quality based on the biological data. Its designation as an EWH was fully supported.

Table 7.3 Ohio EPA Elk Creek biological data index scores in 1995 (Ohio Environmental Protection Agency 1997) The IBI score for Elk Creek in 1995 indicated very good water quality, the MIWb score indicated marginal water quality, and the ICI score indicated exceptional water quality.

Index	Score	Meaning
IBI	46	Very Good
MIWb	9.0	Marginal
ICI	52	Exceptional

The Ohio EPA added two sample sites for the 2010 study. The ICI data was only collected for one site, MIWb data was collected for two sites, and IBI data was collected for all three sites. Overall, the 2010 data indicated similar biologic conditions to 1995 (Table 7.3) (Table 7.4). The decrease in MIWb scores between 1995 and 2010 were result of the absence of large fish species in 2010 that were present in 1995 (Ohio Environmental Protection Agency 2012 A). However, this was due to a natural decrease in pool depth rather than anthropogenic causes. The Ohio EPA determined that Elk Creek complied with biological criteria for an EWH and 100% of the creek was attaining its beneficial use designations.

Table 7.4 Ohio EPA Elk Creek biological data index scores in 2010 (Ohio Environmental Protection Agency 2012 A) The IBI score for Elk Creek in 1995 indicated very good water quality, the MIWb score indicated marginal water quality, and the ICI score indicated exceptional water quality.

Site	IBI		MIWb*		ICI	
	Score	**Meaning**	**Score**	**Meaning**	**Score**	**Meaning**
RM 10.10	50	Exceptional	–	–	–	–
RM 3.70	46	Marginal	7.9	Fair	–	–
RM 1.49	48	Good	8.1	Fair	46	Exceptional

*Two Ohio EPA sources had conflicting MIWb data. Specifically, the scores published in the 2012 biological and water quality investigation were different from the numbers presented on the Ohio EPA website for the *2016 Integrated Report,* which claimed the fish assessment data was collected in 2010 (Appendix H.2) (Appendix H.3). For the purpose of this inventory, the data from the 2012 biological and water quality report is presented.

7.3 CHEMICAL DATA

7.3.1 Historical and Current Nitrate Conditions

Nitrate (NO_3^-) is commonly found in stormwater, wastewater, and agricultural runoff (US Environmental Protection Agency 2016 H). Ingestion of nitrate through food or water can be converted to nitrite in the body and cause hemoglobin to inefficiently distribute oxygen throughout the bloodstream, a disease called methemoglobinemia (Agency for Toxic Substances and Disease Registry 2015). Moreover, an abundance of nitrates and phosphorus, known as eutrophication, can cause toxic algal blooms and hypoxia (US Environmental Protection Agency 2016 H). The effects can create economic impacts such as a decrease in tourism, increased drinking water costs, and real estate losses in addition to affecting environmental and human health.

Elk Creek is not a public drinking water supply, and there are currently no standards for nitrate concentrations in non-drinking water sources. The agricultural use has a standard for nitrate+nitrite, but no standard for nitrate alone (Appendix F.2). The maximum contaminant level for nitrate in drinking water is 10 mg/L (Ohio Environmental Protection Agency 2010). Table 7.5 summarizes three studies investigating nitrate-N concentrations in Elk Creek.

Table 7.5 Maximum and average nitrate-N concentrations for three different time periods. Data was collected by Miami University in 1992-1993, USGS in 2003-2004, and the Butler County Stream Team (BCST) in 2015-2016. Miami University and the BCST assessed surface water and the USGS assessed groundwater. Miami University found relatively low nitrate-N concentrations. The USGS found a maximum nitrate-N concentration of 11 mg/L, which is above the drinking water standard of at or below 10 mg/L. The BCST found a maximum nitrate-N concentration to be close to the drinking water standard, but the average concentration was much lower. * (Farmer, et al. 1993) ** (Pletsch and Schumann 2006), ***Butler County Stream Team, ****Calculated by Project Team using data from reports and BCST.

Source	Years of Data Collection	Type of Water	Nitrate-N Concentration	
			Maximum (mg/L)****	Average (mg/L)****
Miami University *	1992-1993	Surface	3.7	1.4
United States Geological Survey**	2003-2004	Ground	11.0	4.4
Butler County Stream Team***	2015-2016	Surface	9.5	2.6

In the 2006 USGS study, the maximum and average nitrate-N concentrations in groundwater wells were provided as well as the median concentrations for wells in the upper and lower watersheds. The upper watershed had a median value of 0.06 mg/L, and the lower watershed had a median value of 4.2 mg/L. The USGS determined that nitrate levels were likely due to soil organic matter and ammonia fertilizer (Pletsch and Schumann 2006).

BCST data from 2015 and 2016 were used by the Project Team to represent current concentrations (Table 7.5, Table 7.6). There are three surface water sample sites within the watershed: one in the upper watershed (RM 12.4 off SR 503) and two in the lower watershed (RM 1.5 at Howe Rd and RM 3.6 at Elk Creek MetroPark entrance). It should be noted that BCST data cannot be used for regulatory purposes, but can be used to investigate water quality trends and provide insight on water quality in areas where the Ohio EPA may not have the resources to sample frequently (Butler County Stream Team 2016 B).

Table 7.6 Butler County Stream Team (BCST) nitrate-N concentration data by sample location. The sample site at RM 12.4 was associated with nitrate-N concentrations that were significantly higher than the other two sites. Data source is the Butler County Stream Team. All values calculated by Project Team using raw data from BCST.

Location	Maximum	Average
RM 12.4	9.45	4.46
RM 3.6	6.37	1.98
RM 1.5	5.88	1.76

The upper watershed site at RM 12.4 had the highest average concentration of nitrate at 4.5 mg/L (Table 7.6). The nitrate-N concentration ranges at RM 12.4 were also higher than those at the other two sites (Figure 7.2). The nitrate concentrations at RM 12.4 are significantly different from those at the other two sites (Appendix A.7). However, nitrate concentrations at RM 3.6 and RM 1.5 are not statistically significant from each other. The sample site at RM 12.4 is in a predominantly agricultural area.

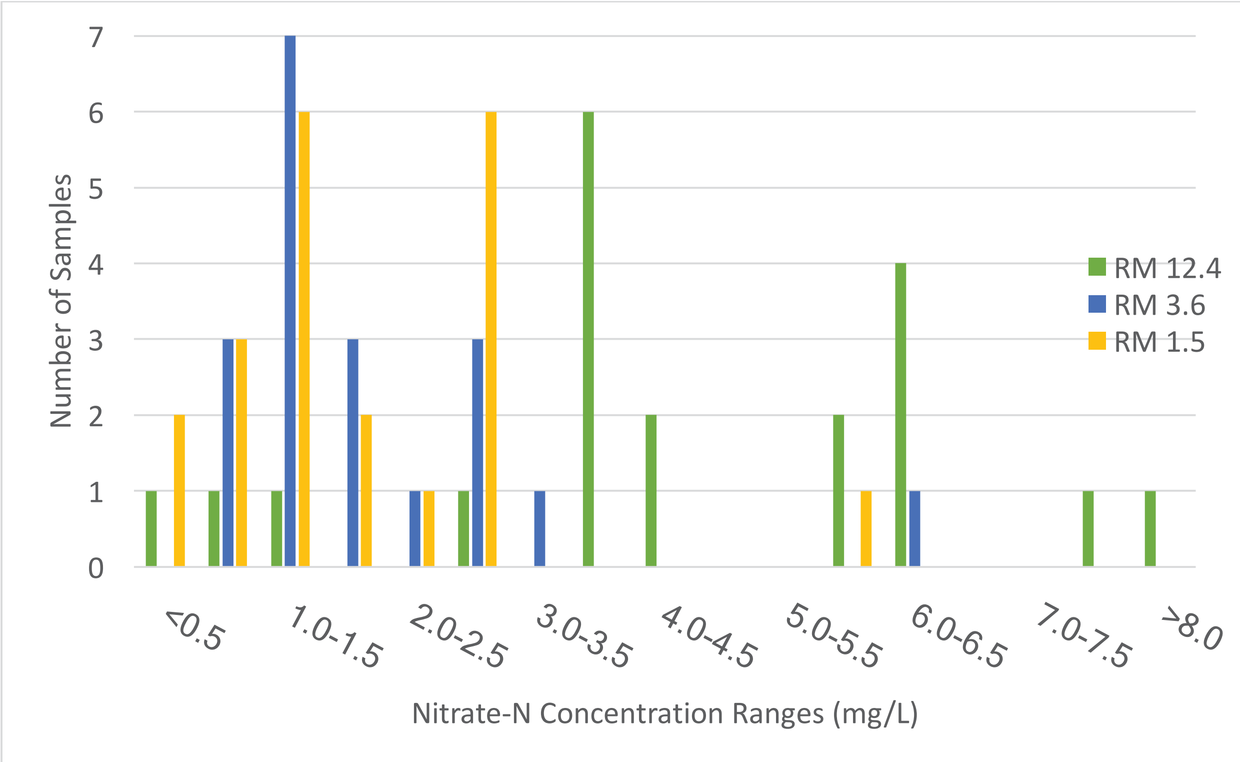

Figure 7.2 Number of samples with nitrate-N concentrations by location. The distribution of the samples from RM 3.6 and 1.5 are similar, peaking at 1.0 – 1.5 mg/L. The samples from RM 12.4 peak at 3.0 – 3.5 mg/L and having a maximum concentration above 8.0 mg/L Data source is the Butler County Stream Team. All values calculated by Project Team – Appendix A.8.

To comply with EWH chemical criteria, ammonia-nitrogen concentrations must be below a designated number based on pH and temperature. BCST does not collect ammonia data, so there is no current information on whether Elk Creek is within the ammonia-nitrogen limits. In 2003-2004, the ammonia-nitrogen concentration in all samples collected from the ECW by the USGS were within the standards set (Pletsch and Schumann 2006).

7.3.2 Agricultural Use Standards

Some of the chemical standards for agricultural use of a water body were investigated in Elk Creek by the Ohio EPA (Ohio Environmental Protection Agency 2012 A). Two elements were not investigated: beryllium and fluoride. Of the other elements subject to agricultural standards, only iron was above the standard in the ECW. For agricultural purposes, iron's total recoverable form should be at or below 5,000 µg/L (Appendix F.2). In 2012, iron's total form was found to be 23,700 mg/kg in Elk Creek.

7.4 MICROBIOLOGICAL DATA

Levels of *E. coli* serve as a standard for recreational waters in order to prevent illness. *E. coli* is a pathogen that can cause severe gastrointestinal, respiratory, urinary, and other illnesses (Centers for Disease Control and Prevention 2015).

The 2012 Ohio EPA study found Elk Creek to be in full attainment of its designation as a Class B source of recreation (Ohio Environmental Protection Agency 2012 A). The Ohio EPA cited this attainment to being result of less urbanized surrounding communities. The 15 samples they took had a mean *E. coli* concentration of 93 cfu/100 mL and a maximum concentration of 1,300 cfu/100mL. The mean of 93 cfu/100 mL is below the standard of 126 cfu/100 mL, and there is no requirement for a one-sample maximum.

However, BCST data from the last two years suggest Elk Creek may not be attaining the standards set for primary contact recreation use. One standard for primary contact recreation is that the watershed must have less than 10% of samples collected in a 90-day period above 410 *E. coli* colonies per 100 mL.

For all 3-month periods in 2015 or 2016, Elk Creek's water had greater 10% of samples with *E. coli* concentrations higher than 410 *E. coli* colonies per 100 mL (Table 7.7). The lowest percentage of samples above 410 colonies/100 mL was September through November of 2015, where 14% of samples were above the standard. All other 3-month periods had at least 20% of samples above the standard.

The Ohio EPA *E. coli* standard applies for 90-day periods. However, BCST only collects samples on the second Saturday of each month March through November. Therefore, the data available was not for exact 90-day periods. The time frame within the 3-month periods varied from 84 days to 97 days, and up to 7 samples were collected in a 3-month period.

Table 7.7 Percentage of Butler County Stream Team (BCST) water samples above 410 colonies per 100 mL in Elk Creek for 2015 and 2016. The lowest percentage of samples below the threshold was 14% in September – November 2015 and the highest percentage was 88% in July – September 2015. The 2016 data ranged between 22% and 50% of samples above the threshold. Data source is raw data from the BCST. All values calculated by Project Team, see Appendix A.8 for methods.

3-Month Period	Percentage of Samples Above 410 Colonies per 100 mL	
	2015	2016
March - May	50%	20%
April – June	25%	29%
May – July	50%	50%
June – August	70%	22%
July – September	88%	50%
August – October	50%	36%
September – November	14%	36%

In the last two years, only two months, October 2015 and November 2016, had *E. coli* concentrations that achieved the monthly average standard of 126 colonies/100 mL (Figure 7.3). September 2016 had the highest average concentration at approximately 7,273 colonies/100mL.

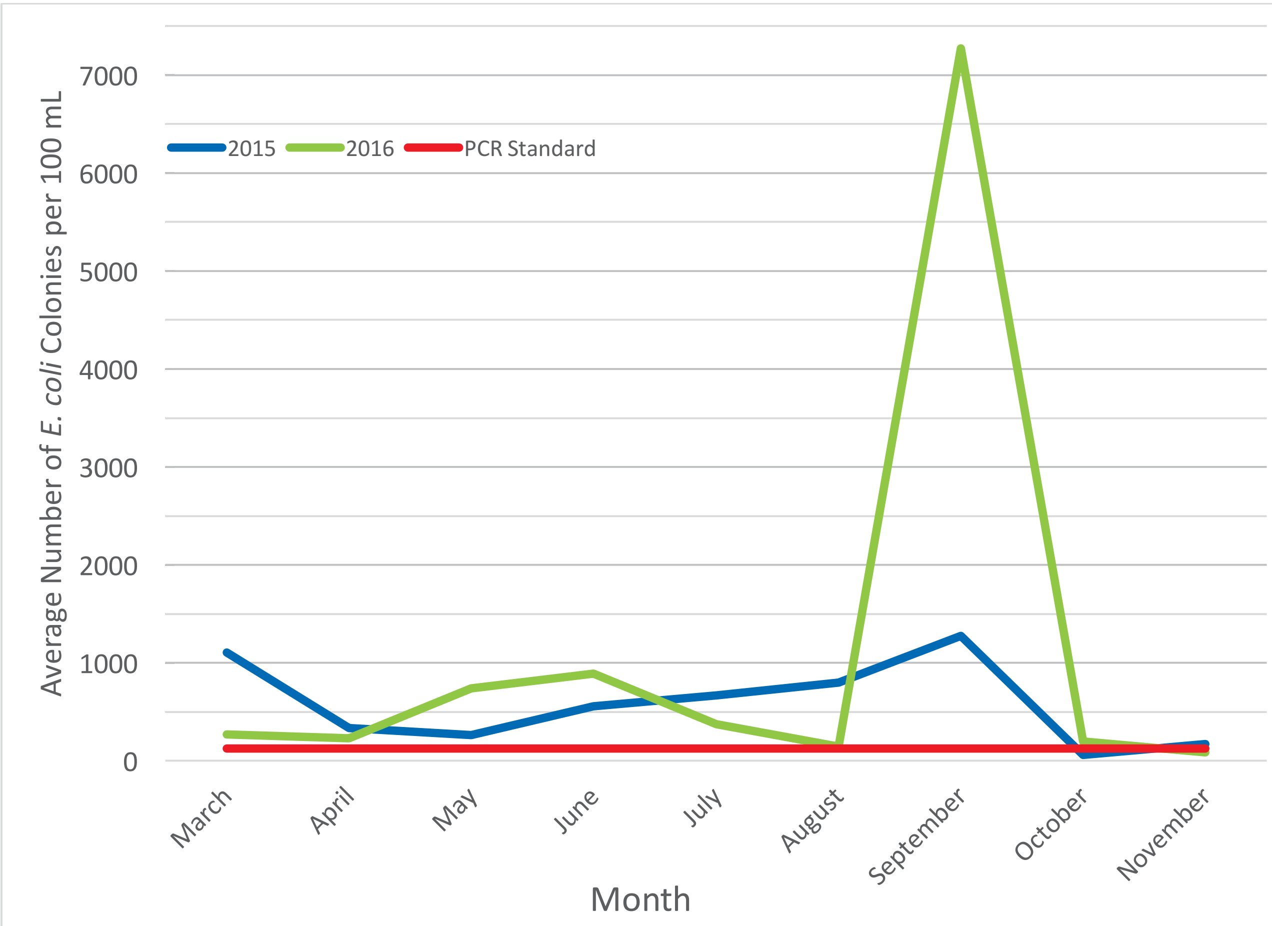

Figure 7.3 Average number of *E. coli* colonies per 100 mL in Elk Creek for 2015 and 2016. For each of the two years, September had the highest monthly average. The average concentration from September 2016 was the highest at approximately 7,273 colonies/100mL. Data source is the Butler County Stream Team. All values calculated by Project Team, see Appendix A.8 for methods.

8 RECOMMENDATIONS

The ECW is a sparsely populated watershed with Trenton having the largest population density. LULC in the area is predominately agricultural. The designated uses of the ECW are exceptional warmwater habitat, agricultural water supply, industrial water supply, and primary contact recreation. The highest potential for soil loss is near Elk Creek MetroPark. In the ECW, there are three active NPDES permits and the potential for nonpoint pollution from HSTS failures and runoff from fertilizer and livestock. According to BCST data, Elk Creek has high nitrate-N at the sample site in the western portion and *E. coli* levels above recreation standards at all three sample sites.

Based on the information and data presented in this inventory, the Project Team proposes a set of recommendations for Butler SWCD.

1) **Monitor Ohio EPA reports relating to water quality, changes in water quality standards, and the status of NPDES and other relevant permits.**
   a) **Total Maximum Daily Load (TMDL):** The biological assessment of Elk Creek conducted in 2010 by Ohio EPA determined the beneficial use designation for human health was impaired because of contaminants found in fish tissue (Ohio Environmental Protection Agency 2016 F). According to the Ohio EPA, a TMDL report is being prepared and is projected to be submitted to the US EPA by 2018 (Ohio Environmental Protection Agency 2016 B). However, in 2015, the Ohio Supreme Court ruled that the TMDL process is considered rulemaking, and therefore the Ohio EPA must adhere to Ohio Revised Code rulemaking procedures, including public notice, comments and a public hearing prior to a rule being adopted (Schirra 2017). The TMDL process, and impact of the Ohio Supreme Court ruling, should be monitored.
   b) **Ohio Nutrient Standards:** The Ohio EPA has been working for many years on developing nitrate and phosphorus standards to protect warmwater habitats and exceptional warmwater habitats (Wilson 2016). Once finalized, the nitrate and phosphorus data analyzed by Butler County Stream Team should be reassessed to determine if the samples collected from Elk Creek are within the set standards.
   c) **National Pollutant Discharge Elimination (NPDES) Permits:** The NPDES Permits for West Elkton/Preble County Sanitary District No. 3 and Local Madison Schools WWTP expire in 2019 (Ohio Environmental Protection Agency 2014 D) (Ohio Environmental Protection Agency 2014 D). The Elk Creek Park - Meadow Ridge Area WWTP permit expires on December 31, 2017 (Ohio Environmental Protection Agency 2012 B). Potential changes in permits should be monitored in case of changes to effluent limits (US Environmental Protection Agency 2010).

2) **Collect data that will provide more information about water quality within the ECW, including macroinvertebrate populations as well as livestock populations and home sewage treatment systems' effect on nutrient and *E. coli* concentrations.**
   a) The last time macroinvertebrate and fish data were collected was in 2010 for the Ohio EPA's Biological and Water Quality Study of the Lower Great Miami River and Select Tributaries. The macroinvertebrate community was determined to be "exceptional" and the fish community ranged from "good" to "exceptional" (Ohio Environmental Protection Agency 2012 A). The next Ohio EPA survey of the ECW will be in 2025 (Ohio Environmental Protection Agency 2016 B). A study prior to 2025 by the Butler SWCD may prove useful to provide more information on water and habitat quality.
   b) The livestock data collected for this report were only available at the county level. Investigating livestock populations within the ECW could provide additional information about potential impacts on water quality. Livestock may contribute to high amounts of nitrogen within the watershed (Pelletier and Tyedmers 2010). If livestock populations within the ECW have access to the creek, the water quality may be negatively impacted (Renwick et al. 2008).
   c) Home sewage treatment system (HSTS) failures may contribute to water contamination by the bacteria *E. coli* (Ohio Department of Health 2017). Most recent data of HSTS was only available at the township and county level. A watershed specific survey of HSTS could provide a more accurate picture of the impact that HSTS may have on Elk Creek.

3) **Work with stakeholders to increase the use of conservation programs offered by the Butler Soil and Water Conservation District (Butler SWCD), the United States Department of Agriculture (USDA), and the Natural Resource Conservation Service (NRCS). A list of potential stakeholders in the ECW can be found in Appendix K.**
   a) These conservation programs offered by Butler SWCD and the USDA Farm Service Agency could enable stakeholders to participate in protecting water quality and water resources.
      i) **Conservation Reserve Program (CRP)**: a cost share program for producers to protect the local waterbody from sediment and nutrient loading by increasing the amount of long term vegetation in sensitive lands, such as highly erodible soils, by planting trees and grasses (Butler Soil and Water Conservation District 2016 B).
      ii) **Environmental Quality Improvement Programs (EQIP) Animal Waste Facility**: offers a variety of farm resource management, but predominantly deals with water quality concerns on livestock farms. This program could be used to help reduce potential impacts of *E. coli* and nitrogen in the ECW (Butler Soil and Water Conservation District 2016 B).
      iii) **EQIP Forestry:** includes the removal of invasive species, crop tree release, and tree planting which will help preserve and increase forest habitat in the ECW (Butler Soil and Water Conservation District 2016 B). Crop tree release is a method for thinning forestry so that the most important species are not competing for the same resources (water, sunlight) (Ohio Department of Natural Resources 2017).

iv)

b) Assessment of soils indicate this area is potentially suitable for wetlands (Section 3.3.10), yet GIS land-use/land-cover analysis indicates very few wetlands (Section 3.4.2). Wetlands can aid in water purification, flood prevention, and shoreline stabilization (US Environmental Protection Agency 2017 I).
    i) **Wetlands Reserve Easements (WRE)**: offered by NRCS and provides technical and financial support to landowners to protect, enhance and restore wetlands on their property (Natural Resources Conservation Service 2017 B). The goal is to create the greatest wetland functions and values, along with optimum wildlife habitat. Wetlands protect biological diversity of fish and wildlife species, including threatened and endangered species (US Geological Survey 1999).

4) **Explore additional funding options including government and private grants for future Butler SWCD projects. See Appendix L for a more detailed description of the grants and other opportunities for grant funding.**
    a) In the past, Butler SWCD secured grant funding through the Ohio EPA Surface Water Improvement Fund (SWIF) Grant, Five Star and Urban Waters Restoration Grant, and the Nutrient Reduction Outreach Grant (Butler Soil and Water Conservation District 2016 B).
    b) The Elk Creek Watershed Inventory is designed to comply with WAP and NPS-IS plans, which are required to secure CWA Section 319 grant funds.
    c) Non-profits could be an avenue for future funding and partnerships in addition to state and federal grants. See Appendix L for more potential funding opportunities.

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APPENDICES

APPENDIX A: METHODS AND CALCULATIONS

Appendix A.1: Demographics:
Data: US Census Bureau Township boundaries
Software: ArcMap 10.4
Methods:

1. Calculated geometry, area in acres for the 6 townships (plus Trenton) that intersect the watershed
2. Clipped the townships to the watershed boundary, calculated geometry area in acres for each of the 7 townships — this gives area in Acres (US) for only the areas within the watershed boundary
3. Divided #acres in watershed/ # acres to calculate percent of area within watershed

Appendix A.2: Estimated Average Annual Soil Loss
Data: Ohio Department of Natural Resources, NRCS SSURGO, USDA National Elevation Dataset, Landsat ETM+ Imagery,
Software: ArcMap 10.4, ENVI
Methods:

1. To compute estimated average annual soil loss, the Project Team used the RUSLE equation, which states:

   A = R x K x L x S x C x P

   Where: A = average annual soil loss (tons per acre per year)
   R = rainfall-runoff erosivity factor
   K = soil erodibility factor
   L = slope length factor
   S = slope steepness factor
   C = cover-management factor
   P = supporting practices factor
2. Computation of individual factors:
   a. R factor
      i. The R factor was acquired from the Ohio Department of Natural Resources and was determined by county (ODNR, 2000). The R factor is based on the amount of precipitation and the intensity of storms. Butler County has an R factor of 150 while Montgomery and Preble counties have an R factor of 140. The R factors were joined to a spatial dataset of Ohio counties downloaded from The National Map.
   b. K factor
      i. The data for the K factor was obtained from SSURGO, a soil survey database created by the National Resources Conservation Service of the United States Department of Agriculture. In the SSURGO dataset, the K factor was an attribute named “kffact”. This feature was converted to a raster.

c. LS factor
    i. Due to their relatedness, the L and S factors are combined into one raster. The fill tool was used on the DEM raster to make it depressionless, then the flow direction and flow accumulation tools were used to generate a final output of a flow accumulation raster. Slope was calculated using the DEM in the slope tool. The slope and flow accumulation outputs were used in the following equation in the raster math tool:
        1. LS = Power(FlowAccumulation * resolution / 22.1, 0.4) * Power(Sin(Slope * 0.01745) / 0.09, 1.4) * 1.4

d. C factor
    i. The C factor was calculated using both ENVI and ArcGIS software. In ENVI, the Landsat ETM+ imagery was converted to NDVI values using the NDVI tool. The NDVI output was exported to ArcMap where it was clipped and used in raster math with the equation:
        1. C = (- NDVI + 1) / 2

e. P factor
    i. The P factor is a numerical representation of conservation practices in the study area. Since the effectiveness of conservation practices and their locations in the ECW are unknown, the P-value was assumed to be 1. The value of 1 signifies no conservation practices.

f. A factor (final output)

Raster math was used to multiply all individual factors to generate the final A factor output

Appendix A.3: Acres for Land Use:

Data: NLCD 2011
Software: ArcMap 10.4
Methods:

1. Extract by Mask to the ECW boundary: this clips the NLCD raster data to the extent of the watershed
2. Calculated area in linear units: created new field called Area, multiplied the Count of each land cover class (number of pixels) by 900, which is the real-world area (in meters) of each pixel
3. Calculated area in acres: created new field called Area_Acres, multiplied the Area field by the conversion factor from square meters to acres.

Appendix A.4: Change in LULC

Data: NLCD 2001, NLCD 2011
Software: ArcMap 10.3, Microsoft Excel
Methods:

1. Steps of Appendix A.2
2. Calculated change: subtracted 2001 acreage values from the 2011 acreage values for each individual LULC class

Appendix A.5 Cropscape Acres:
Data: Cropscape 2015
Software: ArcMap 10.4
Methods:

1. Extract by Mask to the ECW boundary: this clips the Cropscape raster data to the extent of the watershed
2. Calculated area in linear units: created new field called Area, multiplied the Count of each land cover class (number of pixels) by 900, which is the real-world area (in meters) of each pixel
3. Calculated area in acres: created new field called Area_Acres, multiplied the Area field by the conversion factor from square meters to acres

Appendix A.6: Fertilizer Application
Data: NASS Quick Stats (National Agricultural Statistics Service 2015)
Software: Microsoft Excel
Methods:

1. Calculated lbs/acre/year fertilizer applied: multiplied the average amount of fertilizer applied (lbs/acre/application) by the average number of applications per year.
2. Calculated lbs/year fertilizer applied: multiplied lbs/acre/year fertilizer applied output by the acreage of each crop calculated in Appendix A.3
3. This was repeated for three crop types (corn, soybean, and winter wheat) and four fertilizers (nitrogen, phosphate, potash, and sulfur).

Appendix A.7: Nitrate-N Concentration Significance Calculations
Data: Butler County Stream Team
Software: Microsoft Excel
Methods:

1. Determined if any Butler County Stream Team sample sites had nitrate-N concentrations that were statistically significant from the other sites:
    a. Used a two-sample t-test assuming unequal variances in excel to determine if the nitrate concentrations at two sample sites were statistically significant from each other. This analysis used an alpha of 0.05.
    b. Results:

Sites Compared	T-statistic	p-value	Statistically significant from each other?
RM 12.4 vs. RM 1.5	4.316516063	6.79426E-05	Yes
RM 12.4 vs. RM 3.6	3.327575838	0.000994658	Yes
RM 1.5 vs. RM 3.6	0.985354874	0.165261839	No

Appendix A.8: *Escherichia coli* Concentration Calculations
Data: Butler County Stream Team
Software: Microsoft Excel
Methods:

1. Calculated the average number of *E. coli* colonies per 100mL of sample per month: took the average for all samples collected each month by adding all values together and dividing by the number of samples
2. Calculated the percentage of samples above PCR limit for a 90-day period:
    a. Sectioned the year into three 90-day periods
        i. March-May
        ii. June-August
        iii. September-November
    b. Counted the number of samples above 410 *E. coli* colonies per 100mL and divided by the total number of samples collected in that 90-day period to determine the percentage of samples above the PCR limit of 410 *E. coli* colonies per 100mL.

APPENDIX B: DEMOGRAPHIC INFORMATION

Appendix B.1: Population Statistics of Ohio townships for the Elk Creek Watershed (US Census Bureau 2012 A), (US Census Bureau 2015 B), (City-Data 2017), (See Appendix A)

Township Populations

County	Township	Population (2010)	Households (2010 US Census)	Median Age (2010 US Census)	Population Density (ACS 5-yr Survey) (Average Pop Per Sq Mile)	Non-Family Household Median Income (ACS 5-yr Survey) (in dollars)	Family Median Income (ACS 5-yr Survey) (in dollars)	*Educational Attainment % Highschool-Equivalent or less
Butler	Madison	8,448	3,112	42.1	236.2	40,179	64,966	57.6
	Milford	3,550	1,267	42.2	96.6	39,531	63,320	59.9
	Wayne	4,443	1,625	44	121.4	33,839	66,289	63.3
	**City of Trenton	11,869	4,160	32.2	2,600.90	40,618	60,147	56
Preble	Gratis	4,408	1,634	41.5	120.6	33,854	68,000	68.8
	Somers	3,992	1,564	39.2	111.9	30,188	54,388	74.9
Montgomery	German	8,429	3,259	40.4	221.9	38,375	72,659	54.6
Total/Average		33,270	2,076.80	41.6	151.4	35,994.33	64,937	63.2

*City-data.com does not guarantee the accuracy or timeliness of any information on this site. Use at your own risk.

**Not included in Total/Average calculation

Population by township

Townships			Age Groups				
	Total Population	Average Age	17 and Under	18 to 24	25 to 44	45 to 59	60 and above
Madison	8,448	42.1	1,984	622	1,982	2,089	1,771
Milford	3,550	42.2	881	262	780	929	698
Trenton	11,869	32.2	3,684	962	3,639	2,025	1,559
Wayne	4,443	44	1,025	342	932	1,227	917
German	8,429	40.4	2,107	600	2,075	1,957	1,690
Gratis	4,408	41.5	989	356	1,070	1,110	883
Somers	3,992	39.2	1,011	324	955	921	781
Total	45,139	40.2	11,681	3,468	11,433	10,258	8,299

Townships	Age and sex			
	All ages		65 and over	% of total Population
Madison	Female	Males per 100 females	Total	65 and over
Milford	4,241	99.2	1,239	14.7
Trenton	1,787	98.7	467	13.2
Wayne	6,100	94.6	1,114	9.4
German	2,189	103	626	14.1
Gratis	4,305	95.8	1,159	13.8
Somers	2,158	104.3	617	14
	2,036	96.1	525	13.2
Total	22,816		5,747	

Family Household

Townships	Total households	Family Households					
		Total		Husband-wife Family		Female householder, no husband present	
		Number	% with own children under 18 yrs	Number	% with own children under 18 yrs	Total	% with own children under 18 yrs
Madison (B)	3,112	2,469	37.7	1,998	34.9	296	44.6
Milford (B)	1,267	1,005	41.4	847	39.2	92	55.4
Trenton (B)	4,160	3,258	54.1	2,371	49.7	627	67
Wayne (B)	1,625	1,280	36.5	1,091	34.9	112	42.9
Gratis (P)	1,634	1,277	34.8	1,038	32.9	146	39
Somers (P)	1,564	1,103	40.6	825	34.1	189	59.3
German (M)	3,259	2,480	42.4	1,968	37.5	349	61
Total	16,621	12,872	287.5	10,138	263.2	1811	369.2

Townships	Nonfamily households			Average Size	
		Householder living alone			
	Total	Total	65 years & older	Households	Families
Madison (B)	643	511	223	2.71	3
Milford (B)	262	224	92	2.75	3.1
Trenton (B)	902	710	264	2.85	3.18
Wayne (B)	345	268	122	2.73	3.06
Gratis (P)	357	294	123	2.69	3.03
Somers (P)	461	390	170	2.55	3.02
German (M)	779	663	271	2.57	2.96
Total	3749	3060	1265	2.69	3.05

Race by township

Townships	Total Population	White	Black or African American	American Indian and Alaska Native	Asian	Native Hawaiian and Other Pacific Islander	Some other Race	Two or More Races	Hispanic or Latino (or any race)
Madison (B)	8,448	8,271	50	8	20	3	11	85	43
Milford (B)	3,550	3,449	10	5	7	0	0	79	21
Trenton (B)	11,869	11,418	115	18	57	2	35	224	198
Wayne (B)	4,443	4,354	17	12	6	1	5	48	32
Gratis (P)	4,408	4,330	16	14	5	0	6	37	12
Somers (P)	3,992	3,941	2	14	3	0	4	28	28
German (M)	8,429	8,247	70	14	32	1	11	54	88
Total	45,139	44,010	280	85	130	7	72	555	422

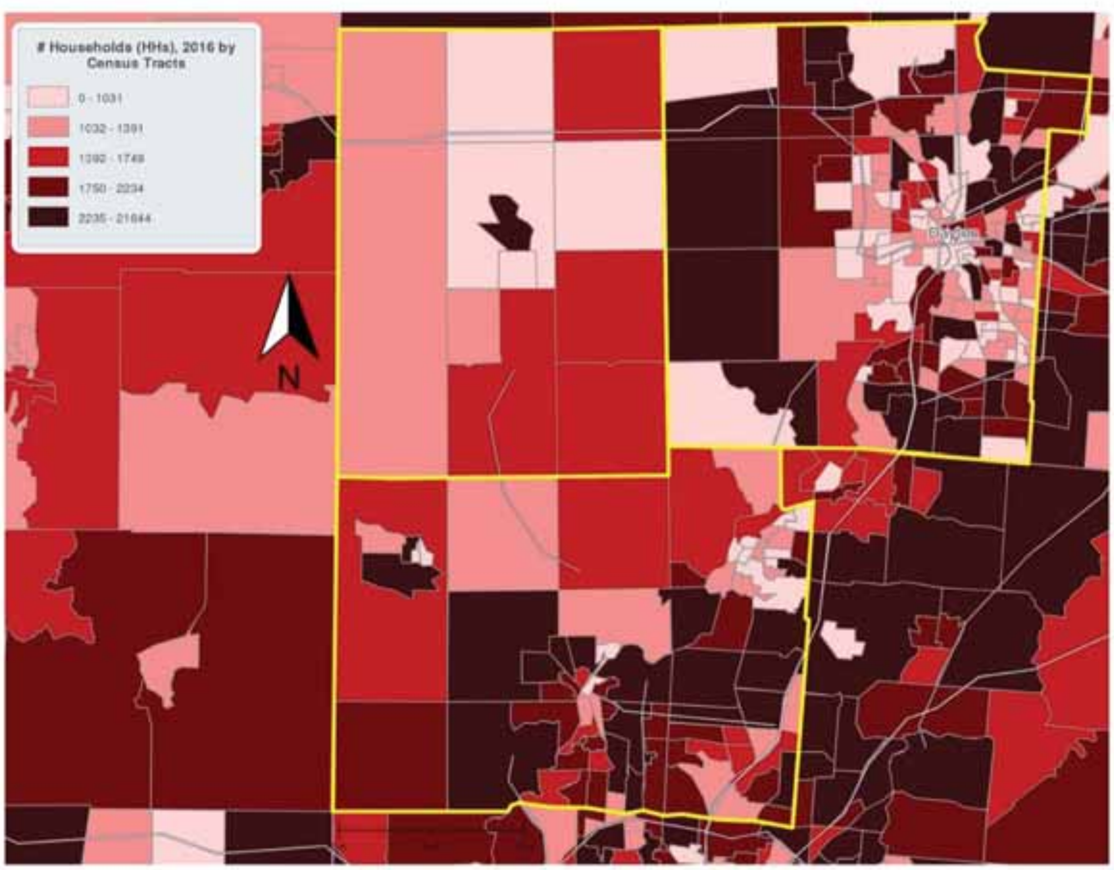
Appendix B.2: Population Graphics

Census tracts were used to display the most detailed information possible for Butler, Preble, and Montgomery counties. Census tracts are small and relatively stable subdivisions of counties, townships or similar (US Census Bureau 2012 B).

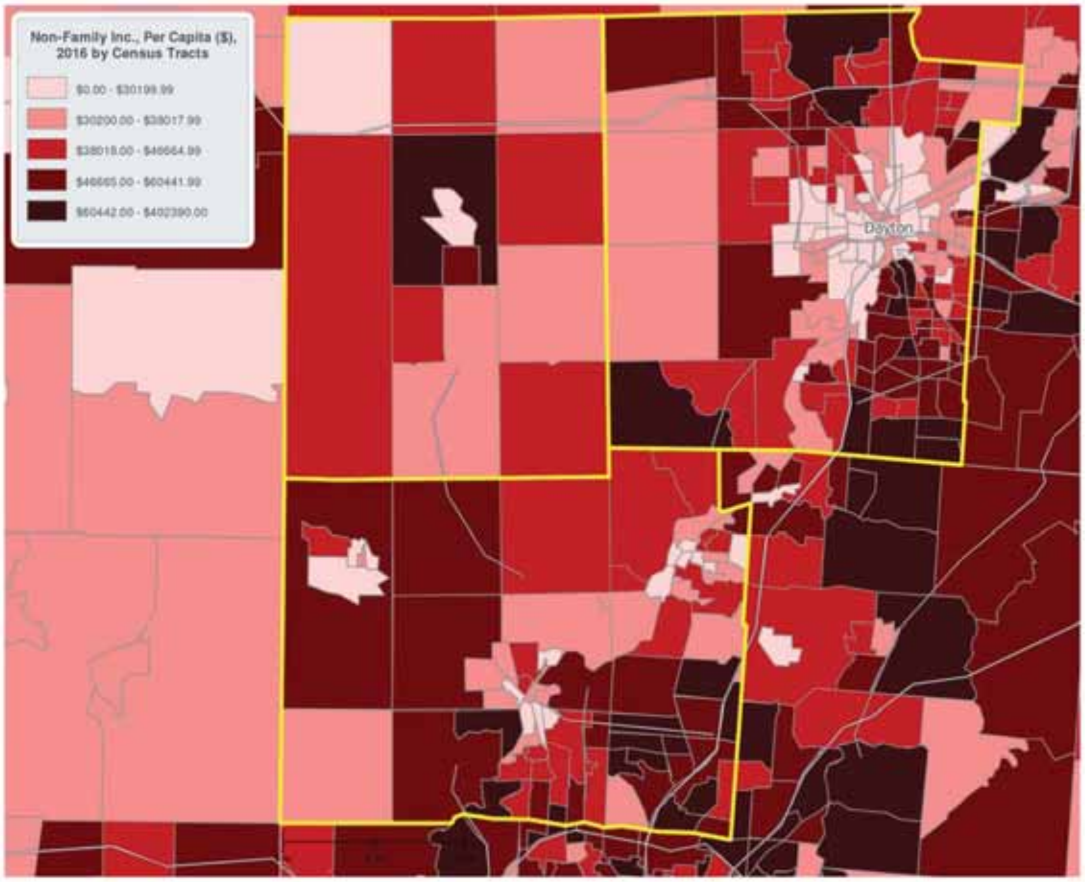
German Township (Montgomery County) has the fewest number of households and least dense population on average within the ECW (Figure 2.2 and 2.3).

The number of households (Figure 3) appears to be consistent across all areas within the ECW. However, apart from the City of Trenton, population density and total population seems the highest in Madison township (Butler County).

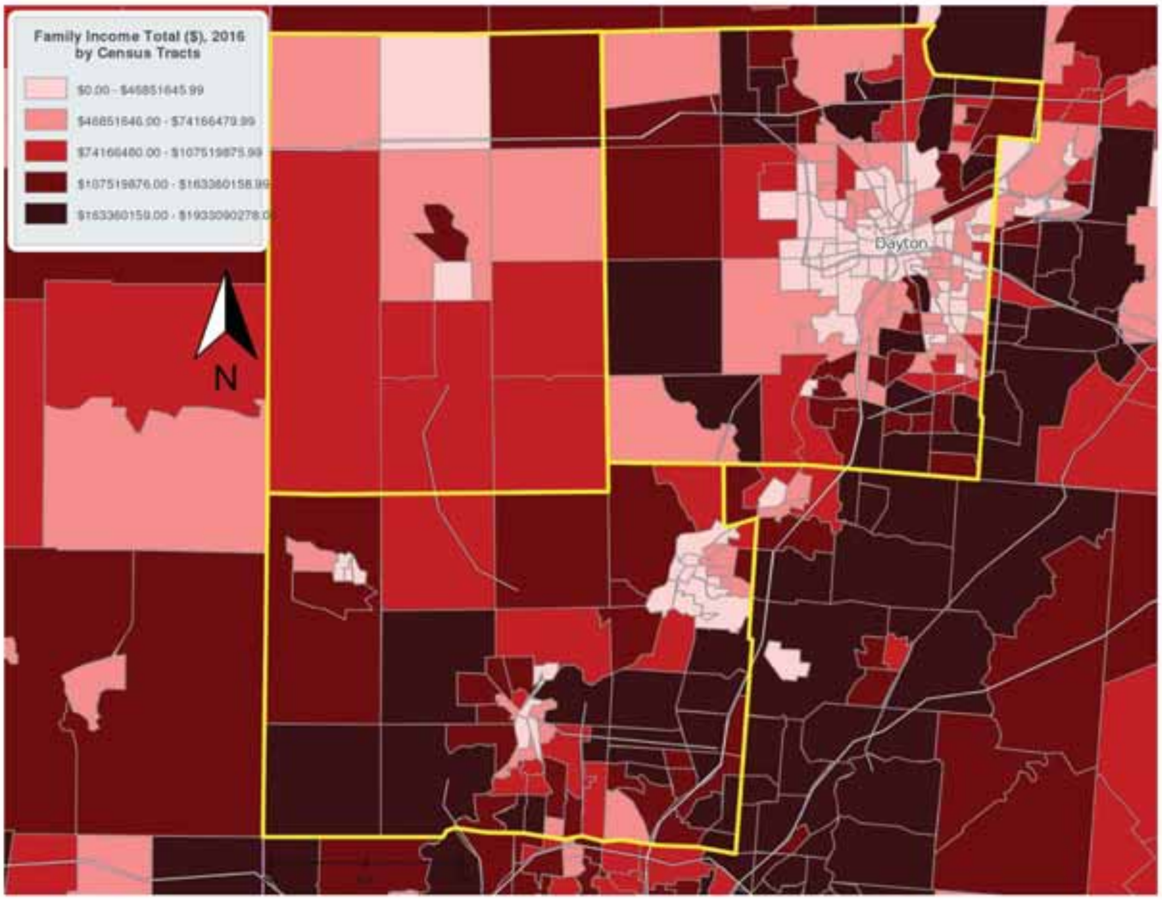
Wayne, Madison, and Gratis townships, which make up a majority of the ECW, are very similar in population characteristics. Family Median Income is slightly higher in Madison and Wayne townships.



Number of Households 2016 by Census Tract Butler, Preble, and Montgomery County. Made by James Crumpler on 03/23/2017 using data obtained from SimplyMap.com



Non-Family Income Per Capita ($) 2016 by Census Tract Butler, Preble, and Montgomery County. Made by James Crumpler on 03/23/2017 usingdata obtained from SimplyMap.com



Family Income Per Capita 2016 by Census Tract Butler, Preble, and Montgomery County. Made by James Crumpler on 03/23/2017 using data obtained from SimplyMap.com

APPENDIX C: DRASTIC METHOD OF GROUNDWATER POLLUTION POTENTIAL

The following is taken from the document *Ground Water Pollution Potential of Butler County, OH,* and explains how the DRASTIC method is used to evaluate the vulnerability of groundwater to pollution (Ohio Department of Natural Resources, University of Cincinnati 1991).

"The system chosen for implementation of a ground water pollution potential mapping program in Ohio, DRASTIC, was developed by the National Water Well Association for the United States Environmental Protection Agency. A detailed discussion of this system can be found in Aller et al. (1987).

The DRASTIC mapping system allows the pollution potential of any area to be evaluated systematically using existing information. The vulnerability of an area to contamination is a combination of hydrogeologic factors, anthropogenic influences and sources of contamination in any given area. The DRASTIC system focuses only on those hydrogeologic factors which influence ground water pollution potential. The system consists of two major elements: the designation of mappable units, termed hydrogeologic settings, and the superposition of a relative rating system to determine pollution potential.

The application of DRASTIC to an area requires the recognition of a set of assumptions made in the development of the system. DRASTIC evaluates the pollution potential of an area assuming a contaminant with the mobility of water, introduced at the surface, and flushed into the ground water by precipitation. Most important, DRASTIC cannot be applied to areas smaller than one-hundred acres in size, and is not intended or designed to replace site-specific investigations.

Hydrogeologic Settings and Factors

To facilitate the designation of mappable units, the DRASTIC system used the framework of an existing classification system developed by Heath (1984), which divides the United States into fifteen ground water regions based on the factors in a ground water system that affect occurrence and availability.

Within each major hydrogeologic region, smaller units representing specific hydrogeologic settings are identified. Hydrogeologic settings form the basis of the system and represent a composite description of the major geologic and hydrogeologic factors that control ground water movement into, through and out of an area. A hydrogeologic setting represents a mappable unit with common hydrogeologic characteristics, and, as a consequence, common vulnerability to contamination (Aller et al., 1987).

…Inherent within each hydrogeologic setting are the physical characteristics which affect the ground water pollution potential. These characteristics or factors identified during the development of the DRASTIC system include:

D - Depth to Water
R - Net Recharge
A - Aquifer Media
S - Soil Media
T - Topography
I - Impact of the Vadose Zone Media
C - Conductivity (Hydraulic) of the Aquifer

These factors incorporate concepts and mechanisms such as attenuation, retardation and time or distance of travel of a contaminant with respect to the physical characteristics of the hydrogeologic setting. Broad consideration of these factors and mechanisms, coupled with existing conditions in a setting, provide a basis for determination of the area's relative vulnerability to contamination.

Depth to water is considered to be the depth from the ground surface to the water table in unconfined aquifer conditions or the depth to the top of the aquifer under confined aquifer conditions. The depth to water determines the distance a contaminant would have to travel before reaching the aquifer. The greater the distance the contaminant has to travel the greater the opportunity for attenuation to occur or restriction of movement by relatively impermeable layers.

Net recharge is the total amount of water reaching the land surface that infiltrates into the aquifer measured in inches per year. Recharge water is available to transport a contaminant from the surface into the aquifer and also affects the quantity of water available for dilution and dispersion of a contaminant. Factors to be included in the determination of net recharge include contributions due to infiltration of precipitation, in addition to infiltration from rivers, streams and lakes, irrigation and artificial recharge.

Aquifer media represents consolidated or unconsolidated rock material capable of yielding sufficient quantities of water for use. Aquifer media accounts for the various physical characteristics of the rock that provide mechanisms of attenuation, retardation and flow pathways that affect a contaminant reaching and moving through an aquifer.

Soil media refers to the upper six feet of the unsaturated zone that is characterized by significant biological activity. The type of soil media can influence the amount of recharge that can move through the soil column due to variations in soil permeability. Various soil types also have the ability to attenuate or retard a contaminant as it moves throughout the soil profile. Soil media is based on textural classifications of soils and considers relative thicknesses and attenuation characteristics of each profile within the soil.

Topography refers to the slope of the land expressed as percent slope. The amount of slope in an area affects the likelihood that a contaminant will run off from an area or be ponded and ultimately infiltrate into the subsurface. Topography also affects soil development and often can be used to help determine the direction and gradient of ground water flow under water table conditions.

The impact of the vadose zone media refers to the attenuation and retardation processes that can occur as a contaminant moves through the unsaturated zone above the aquifer. The vadose zone represents that area below the soil horizon and above the aquifer that is unsaturated or discontinuously saturated. Various attenuation, travel time and distance mechanisms related to the types of geologic materials present can affect the movement of contaminants in the vadose zone. Where an aquifer is unconfined, the vadose zone media represents the materials below the soil horizon and above the water table. Under confined aquifer conditions, the vadose zone is simply referred to as a confining layer. The presence of the confining layer in the unsaturated zone significantly impacts the pollution potential of the ground water in an area

Hydraulic conductivity of an aquifer is a measure of the ability of the aquifer to transmit water, and is also related to ground water velocity and gradient. Hydraulic conductivity is dependent upon the amount and interconnectivity of void spaces and fractures within a consolidated or unconsolidated rock unit. Higher hydraulic conductivity typically corresponds to higher vulnerability to contamination. Hydraulic conductivity considers the capability for a contaminant that reaches an aquifer to be transported throughout that aquifer over time.

Weighting and Rating System

DRASTIC uses a numerical weighting and rating system that is combined with the DRASTIC factors to calculate a ground water pollution potential index or relative measure of vulnerability to contamination. The DRASTIC factors are weighted from 1 to 5 according to their relative importance to each other with regard to contamination potential (Table 1). Each factor is then divided into ranges or media types and assigned a rating from 1 to 10 based on their significance to pollution potential (Tables 2-8). The rating for each factor is selected based on available information and professional judgement. The selected rating for each factor is multiplied by the assigned weight for each factor. These numbers are summed to calculate the DRASTIC or pollution potential index.

Once a DRASTIC index has been calculated, it is possible to identify areas that are more likely to be susceptible to ground water contamination relative to other areas. The higher the DRASTIC index, the greater the vulnerability to contamination. The index generated provides only a relative evaluation tool and is not designed to produce 7 absolute answers or to represent units of vulnerability. Pollution potential indexes of various settings should be compared to each other only with consideration of the factors that were evaluated in determining the vulnerability of the area."

APPENDIX D: BIOTIC ENVIRONMENT

Appendix D.1: Endangered and Threatened Species Information Reported by County (Ohio Department of Natural Resources 2016 A) (Ohio Department of Natural Resources 2016 B) (Ohio Department of Natural Resources 2016 C)

Preble County

Scientific Name	Common Name	Last Observed	State Status	Federal Status
Carex mesochorea	Midland Sedge	1988-06-07	T	
Clonophis kirtlandii	Kirtland's Snake	1970-07-10	T	
Etheostoma microperca	Least Darter	2005-08-05	SC	
Myotis sodalis	Indiana Bat	2004-02-07	E	FE
Notropis amblops	Bigeye Chub	1986-09-02	T	
Orconectes sloanii	Sloan's Crayfish	2005-09-19	T	
Ptychomitrium drummondii	Drummond's Ptychomitrium	1981-10-16	X	
Triphora trianthophora	Three-birds Orchid	2014-08-15	P	
Viburnum molle	Soft-leaved Arrow-wood	2004-08-24	T	

Ohio Division of Wildlife
Ohio Natural Heritage Database
Date Accessed: March 6, 2015
Status based on 2016 Rare Animal List
and 2014-15 Rare Plant List.

Status:
EX = Extinct
X = Extirpated
E = Endangered
T = Threatened
P = Potentially Threatened
SC = Species of Concern
SI = Special Interest

List Created: July 2016

Butler County

Scientific Name	Common Name	Last Observed	State Status	Federal Status
Arabis pycnocarpa var. adpressipilis	Southern Hairy Rock Cress	1965-04	P	
Arabis pycnocarpa var. pycnocarpa	Western Hairy Rock Cress	1990-05-03	X	
Bartramia longicauda	Upland Sandpiper	1987-07-06	E	
Bromus kalmii	Prairie Brome	2013-07-01	P	
Carex mesochorea	Midland Sedge	2005-06-05	T	
Carex timida	Timid Sedge	2011-06-14	T	
Clonophis kirtlandii	Kirtland's Snake	1991-10-25	T	
Cyperus acuminatus	Pale Umbrella-sedge	2014-09-19	P	
Echinodorus berteroi	Burhead	2014-09-19	P	
Eurycea lucifuga	Cave Salamander	1989-06-14	E	
Exoglossum laurae	Tonguetied Minnow	1975-08-27	T	
Gomphus externus	Plains Clubtail	1995-10-31	E	
Ixobrychus exilis	Least Bittern	1991-06	T	
Ladona deplanata	Blue corporal	2000-05-19	E	
Myotis sodalis	Indiana Bat	1988-08-03	E	FE
Nycticorax nycticorax	Black-crowned Night-heron	1990-07-15	T	
Orconectes sloanii	Sloan's Crayfish	2005-09-13	T	
Porzana carolina	Sora Rail	1990-07	SC	
Ribes missouriense	Missouri Gooseberry	2013-07-01	T	
Salix caroliniana	Carolina Willow	1991-06-02	P	
Silene nivea	Snowy Campion	2013-07-01	E	
Viburnum molle	Soft-leaved Arrow-wood	2013-07-01	T	

Ohio Division of Wildlife
Ohio Natural Heritage Database
Date Accessed: March 6, 2015
Status based on 2016 Rare Animal List
and 2014-15 Rare Plant List.

Montgomery County

Scientific Name	Common Name	Last Observed	State Status	Federal Status
Accipiter striatus	Sharp-shinned Hawk	1983-03	SC	
Alasmidonta marginata	Elktoe	2010-07-23	SC	
Ammocrypta pellucida	Eastern Sand Darter	1995-07-12	SC	
Arabis pycnocarpa var. adpressipilis	Southern Hairy Rock Cress	1986-07	P	
Argia bipunctulata	Seepage Dancer	2004-08-15	E	
Bartramia longicauda	Upland Sandpiper	1982-08-20	E	
Caprimulgus carolinensis	Chuck-will's-widow	1983-05-16	SI	
Carex timida	Timid Sedge	2004-06-07	T	
Cistothorus platensis	Sedge Wren	1986-10-01	SC	
Clonophis kirtlandii	Kirtland's Snake	1985-06-10	T	
Descurainia pinnata	Tansy Mustard	1967-04-29	T	
Draba reptans	Carolina Whitlow-grass	2014-04-11	T	
Epioblasma triquetra	Snuffbox	1987-10-19	E	FE
Etheostoma microperca	Least Darter	2005-08-29	SC	
Gentianopsis procera	Small Fringed Gentian	2004-08-14	P	
Gomphus externus	Plains Clubtail	1992-09-15	E	
Juncus interior	Inland Rush	1992-07-29	T	
Juncus secundus	One-sided Rush	2003-06-27	P	
Lampsilis fasciola	Wavy-rayed Lampmussel	1987-10-19	SC	
Lipocarpha micrantha	Dwarf Bulrush	1999-08-07	T	
Lota lota	Burbot	1963-07-13	SC	
Melanthium woodii	Wood's-hellebore	2003-06-27	T	
Moxostoma carinatum	River Redhorse	1987-08-18	SC	
Muhlenbergia cuspidata	Plains Muhlenbergia	2013-06-27	E	
Nyctanassa violacea	Yellow-crowned Night-heron	1985-09	SI	
Opheodrys aestivus	Northern Rough Greensnake	1967-08-28	SC	
Orconectes sloanii	Sloan's Crayfish	2005-09-14	T	
Penstemon laevigatus	Smooth Beard-tongue	1962-06-15	T	

Montgomery County

Scientific Name	Common Name	Last Observed	State Status	Federal Status
Penstemon pallidus	Downy White Beard-tongue	1986-06-05	T	
Poa saltuensis ssp. languida	Weak Spear Grass	1977-05-13	P	
Pycnanthemum verticillatum var. pilosum	Hairy Mountain-mint	2005-08-07	T	
Taxidea taxus	Badger	2011-04-27	SC	
Uniomerus tetralasmus	Pondhorn	1976-02	T	
Viburnum molle	Soft-leaved Arrow-wood	2005-05-05	T	
Viburnum rufidulum	Southern Black-haw	2004-09-03	P	
Villosa fabalis	Rayed Bean	1987-10	E	FE

Ohio Division of Wildlife
Ohio Natural Heritage Database
Date Accessed: March 6, 2015
Status based on 2016 Rare Animal List
and 2014-15 Rare Plant List.

Status:
EX = Extinct
X = Extirpated
E = Endangered
T = Threatened
P = Potentially Threatened
SC = Species of Concern
SI = Special Interest

List Created: July 2016

Appendix D.2 Invasive Species, listed by County or State

Invasive plant species in Butler, Preble, and Montgomery counties (Ohio Invasive Plants Council 2010). In total, there are 22 invasive plant species in at least one of the three counties.

Species	Scientific Name	Butler	Preble	Montgomery
Amur honeysuckle	*Lonicera maackii*	X	X	X
Autumn-olive	*Elaeagnus umbellata*	X	X	X
Canada thistle	*Cirsium arvense*	X		X
Common buckthorn	*Rhamnus cathartica*			X
Common teasel	*Dipsacus fullonum*	X	X	X
Common reed grass (Phragmites)	*Phragmites australis* ssp. *australis*			X
Cut-leaved teasel	*Dipsacus laciniatus*	X	X	
Garlic mustard	*Alliaria petiolata*	X	X	X
Japanese honeysuckle	*Lonicera japonica*	X	X	X
Japanese knotweed	*Fallopia japonica*		X	X
Morrow bush honeysuckle	*Lonicera morrowii*	X		X
Multiflora rose	*Rosa multiflora*	X	X	X
Narrow-leaved cattail	*Typha angustifolia*	X	X	X
Hybrid cattail	*Typha x glauca*	X		
Purple loosestrife	*Lythrum salicaria*	X	X	
Reed canary grass	*Phalaris arundinacea*	X		
Russian-olive	*Elaeagnus angustifolia*			X
Smooth brome	*Bromus inermis*	X	X	X
Tatarian bush honeysuckle	*Lonicera tatarica*			X
Tree-of-heaven	*Ailanthus altissima*	X	X	X
White sweet clover	*Melilotus alba*	X	X	X
Yellow sweet clover	*Melilotus officinalis*	X		X

Some of Ohio's top Aquatic Invasive Species (Ohio Department of Natural Resources 2017 D)

Species		Scientific Name
Asian carp	Bighead carp	*Hypophthalmichthys nobilis*
	Silver carp	*Hypophthalmichthys molitnix*
	Black carp	*Mylopharyngodon piceus*
	Diploid (fertile) grass carp	*Ctenopharyngodon idella*
Curlyleaf pondweed		*Potamogeton crispus*
Hydrilla		*Hydrilla verticillata*
Round goby		*Apollonia melanostomus*
Ruffe		*Gymnocephalus cernuus*
Red swamp crayfish		*Procambarus clarkia*
Sea lamprey		*Petromyzon marinus*
White perch		*Morone americana*
Zebra mussel		*Dreissena polymorpha*

The above list from ODNR only includes the major aquatic invasive species. A comprehensive list can be found through the USGS Nonindigenous Aquatic Species database at the following link:
https://nas.er.usgs.gov/queries/SpeciesList.aspx?Group=&Sortby=1&state=OH

State-Listed Insects and Diseases (Ohio Department of Natural Resources 2017 E)

Species	Scientific Name
Asian longhorned beetle	*Anoplophora glabripennis*
Emerald ash borer	*Agrilus planipennis*
Gypsy moth	*Lymantria dispar dispar*
Hemlock woolly adelgid	*Adelges tsugae*
Walnut twig beetle	*Pityophthorus juglandis*

Appendix D.3 USGS GAP Analysis Methods

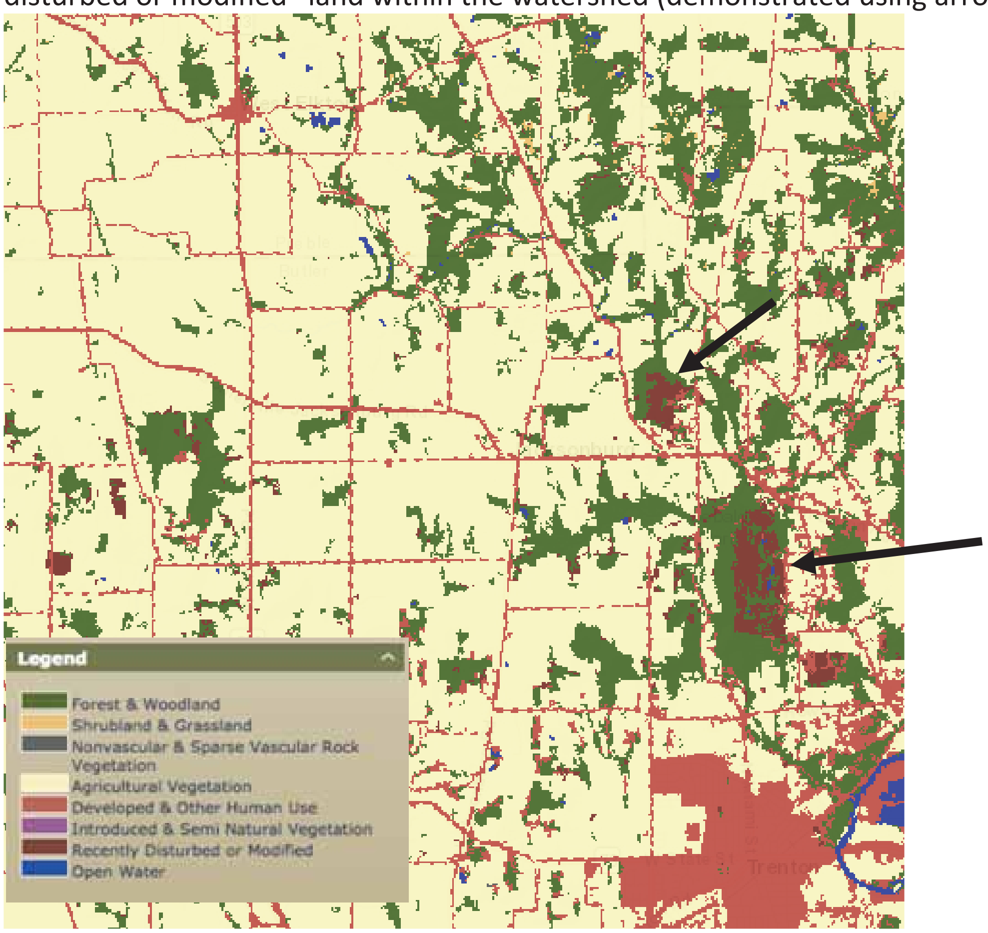
*Three Valley Conservation Trust project information can be found in the Protected Areas section of this appendix

USGS GAP data is maintained in four datasets that can be accessed from the following link: https://gapanalysis.usgs.gov/data/

Land Cover Viewer

A description of the GAP Analysis Land Cover Viewer can be found at the link below. The interactive viewer itself is launched using the blue "Launch Land Cover Viewer" button on the right side of the page. The map allows the user to zoom in to an area of interest and select how they would like to view the land cover data.
https://gapanalysis.usgs.gov/gaplandcover/viewer/

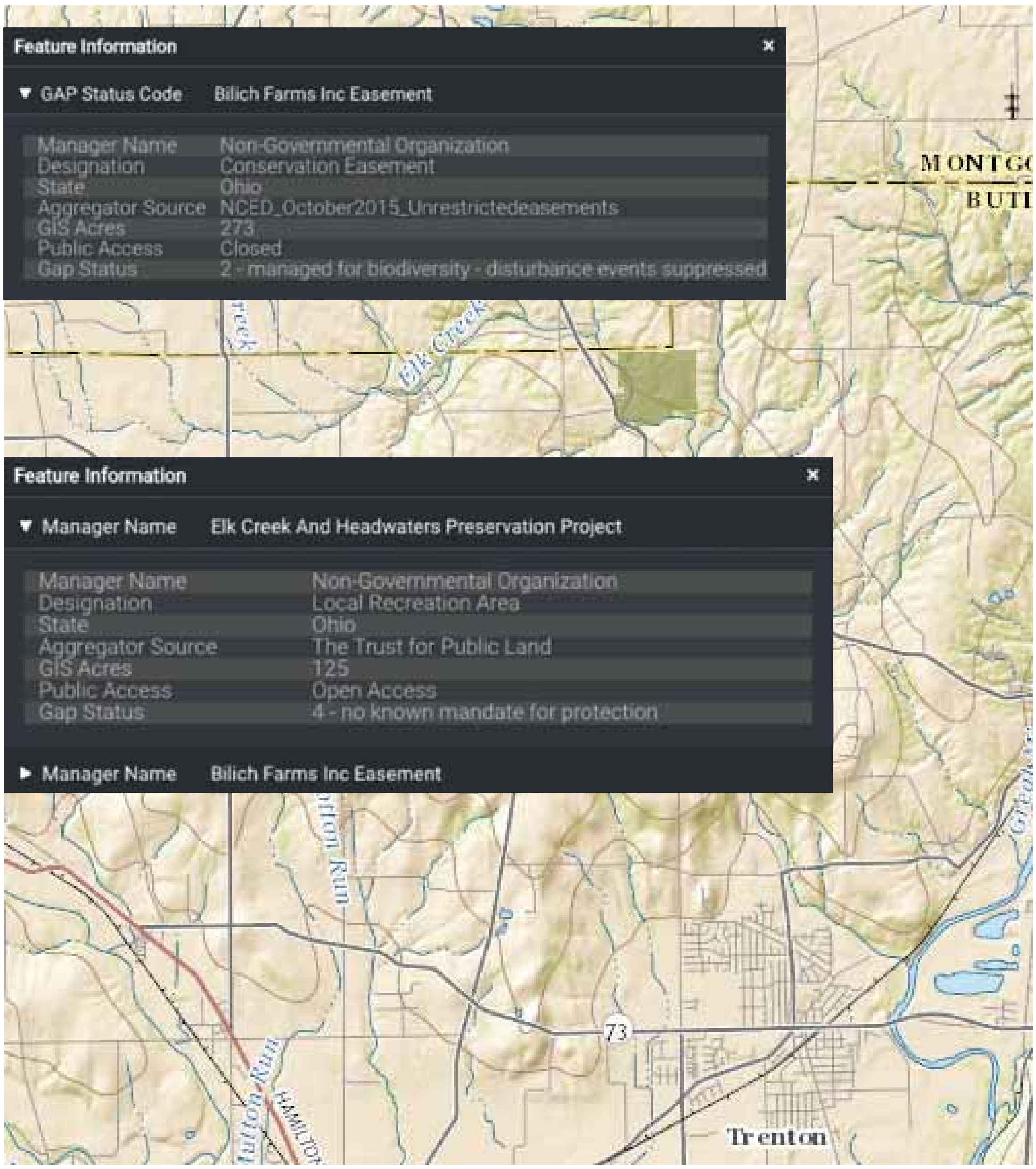
The screenshot below was taken from the Land Cover Viewer showing the approximate location of the ECW and the GAP data on Land Cover. It shows two relatively large area of "recently disturbed or modified" land within the watershed (demonstrated using arrows).



Protected Areas

A description of the GAP Analysis Protected Areas Viewer can be found at the link below. The interactive viewer itself is launched using the blue "Launch Protected Areas Viewer" button on the right side of the page. The map allows the user to zoom in to an area of interest and view different layers of data, including protected areas and management type.
https://gapanalysis.usgs.gov/padus/viewer/

The screenshot below was taken from the Protected Areas Viewer showing the approximate location of the ECW and the GAP Status Code, which is one layer of data on the map. It shows two protected areas in the ECW, which are adjacent to each other — the team could not identify a boundary between the two.



Species Viewer

A description of the GAP Analysis Species Viewer can be found at the link below. The interactive viewer itself is launched using the blue "Launch Species Viewer" button on the right side of the page. The map allows the user to zoom in to an area of interest and filter the species list, select a species of interest, and build a map to view the species distribution.
https://gapanalysis.usgs.gov/species/viewer/

Aquatic GAP

A description of the Aquatic GAP program can be found at the link below.
https://gapanalysis.usgs.gov/aquatic-gap/

To gather the data for this inventory, the team relied on the Ohio Aquatic GAP report published in 2006. More information on the Ohio Aquatic Gap Analysis can be found at the following links:
Project Abstract: https://pubs.usgs.gov/of/2006/1385/
Fact Sheet: https://oh.water.usgs.gov/reports/pdf.rpts/fs.01-093.pdf

APPENDIX E: HISTORICAL AND CULTURAL INFORMATION

Preble County Historical Society is located in Eaton, Ohio. Preble County Historical Society was created in 1971 with the intention of preserving the history of Preble County. This is accomplished through 11 acres of educational museum which includes several 19th century farm structures like barns and farmhouses (The Preble County Historical Society 2017). The property also contains leased farms and natural features like creeks, grasslands, and forest.

Within the Preble County Historical Society's reserve is Aukerman Creek. It is located north of the ECW and is in the Twin Creek Watershed (Preble County Historical Society 2017). Aukerman Creek has extremely high erosion levels and mass wasting with the potential of impacting infrastructure. In 2014, the erosion rate was 1.04 tons per linear feet per year. Erosion causes problems for macroinvertebrates because of the resulting high soil deposition in the creek. Preble County History Society received a grant from the Surface Water Improvement Fund (SWIF) in 2014 (Ohio Environmental Protection Agency 2014 E). The SWIF grant provides aid for projects in water quality impairment and threatened aquatic life. The group was awarded $107,818 for the restoration called the Aukerman Creek Stream Restoration. It resulted in a restoration of 500 linear feet of stream channel. Along with planting one acre of native plant species, the project also resulted in an installed erosion control structure and in-stream habitat structures.

While this restoration project is not located in the Elk Creek Watershed, it is an example for stakeholders to use if they are interested in implementing a restoration project in the ECW. It should also be noted that while Aukerman Creek does not flow into the ECW, if there were a project implemented in the ECW, it would impact watersheds beyond its own boundaries.

The Historical Marker Database

The Historical Marker Database is a volunteer-based organization, with members from all over the United States (The Historical Marker Database 2017). These members, along with the public, create informational web pages from historical markers that become an online catalog. The web pages include historical data, photos, marker locations, and maps.

Bambo Harris Grist Mill

The Bambo Harris Grist Mill plaque was erected by the Madison Township Board of Trustees (Fischer 2010 A). Bambo Harris was a freed slave that created and run Miltonville's grist mill. The grist mill, a mill for grinding grain, was located on Elk Creek and was water-driven. Along with the plaque, they are three millstones as way of educating people about grist mills.

The Elk Creek Baptist Church and Cemetery

In 2003, The Trenton Historical Society, The Trenton Lion's Club, and the Ohio Historical Society erected The Elk Creek Baptist Church and Cemetery plaque. The Elk Creek Baptist Church was the first church in Trenton, Ohio in 1802 (Fischer 2010 B). The funding for the Elk Creek Baptist Church and cemetery was donated by the Village of Trenton's founder, Michael Pearce. Both

Pearce and his wife are buried at the cemetery (now called Pioneer Cemetery). The Church was demolished in 1924.

The Village of Miltonville

In 1996, The Village of Miltonville received a Historical Marker by the Trenton Historical Society and the Ohio Historical Society (Fischer 2010 C). North of Trenton and south of Elk Creek Park (formerly Sebald Park), the Miltonville Marker is located at the intersection of Elk Creek Road and Howe Road. Miltonville is situated on the banks of Elk Creek and was founded by George Bennett, Theophilus Eaglesfield, and Richard V. V. Crane in 1816. The town had two grist mills and a three-story brick inn (Eagle's Tavern) which was the first in the area. Miltonville was also known for vineyards, wineries, pottery factories, and a brickyard. There is also an Indian Burial ground located on Elk Creek near Miltonville.

The Village of Trenton

The Village of Trenton plaque is on the other side of the previously mentioned Elk Creek Baptist Church and Cemetery plaque from 2003. It is located at the intersection of State Street and Miami Street/Hamilton Road. Trenton was founded in 1801 by Michael Pearce and named after Pearce's hometown, Trenton, New Jersey (Fischer 2010 B). The original settlement was English European but later saw an influx of German immigrants in 1840. The town became known for its farming. As time went on, the town became more urbanized when a franchise created interurban electric traction cars along with the growth of several other industries in energy, materials, and food.

APPENDIX F: WATER QUALITY STANDARDS

Appendix F.1: Whole Effluent Toxicity Standards for the Elk Creek Watershed

From: walter.ariss@epa.ohio.gov
Subject: RE: NPDES/Whole Effluent Toxicity Question
Date: February 22, 2017 at 3:26 PM
To: Deanna fyffedl@miamioh.edu

Deanna,
These three plants have a relatively small discharge flow. Preble Co and Madison local are 25,000 gpd and 24,000 gpd respectively in design flows. Elk Creek is extremely small at 2500 gpd. Plants of this size are not required to submit whole effluent toxicity (WET) testing as part of their NPDES permit applications. If our agency had reason to believe that a potential for WET existed in the receiving stream due to the point source impact from these permittees we could require testing. Plants of this size treat residential sewage almost exclusively, with very little or no commercial or industrial flows that tend to contribute metals and dissolved solids that can lead to WET issues. We continually monitor for toxicity characteristics in our receiving streams through our biological and water quality monitoring program.

Major WWTPs (those with 1 MGD and greater in design flow) are required to submit WET testing results with their permit applications as required by the Clean Water Act. We include this requirement as a condition in the effluent tables of the major NPDES permits with a frequency of 1/year testing. We look at the test results each time the permit is renewed to determine if toxicity limits are needed or if the continuation of monitoring is appropriate.

If you have any specific questions regarding why WET testing is not required you can feel free to give me a call at 614-644-3075.
Thanks, Walter

From: Deanna [mailto:fyffedl@miamioh.edu]
Sent: Wednesday, February 22, 2017 1:35 PM
To: Ariss, Walter <Walter.Ariss@epa.ohio.gov>
Subject: Re: NPDES/Whole Effluent Toxicity Question

Walter,

Thank you, that would be very helpful. These are the three NPDES permits we are concerned with:

1. Preble Co Sanitary Dist No 3 WWTP (Preble County)
    - US EPA ID: OH0134082
    - Ohio EPA ID: 1PL00005*CD
2. Madison Local Schools WWTP (Butler County)
    - US EPA ID: OH0123251
    - Ohio EPA ID: 1PT00084*DD
3. Elk Creek Park - Meadow Ridge Area (Butler County)
    - US EPA ID: OH0132268
    - Ohio EPA ID: 1PZ00105*DD

Appendix F.2: Water Quality Standards for Agricultural Use (OAC 3745-1)

3745-1-07

Table 7-12. Statewide water quality criteria for the protection of agricultural uses.

Chemical	Form[1]	Units[2]	OMZA[3]
Arsenic	TR	µg/l	100
Beryllium	TR	µg/l	100
Cadmium	TR	µg/l	50
Total chromium	TR	µg/l	100
Copper	TR	µg/l	500
Fluoride	T	µg/l	2,000
Iron	TR	µg/l	5,000
Lead	TR	µg/l	100
Mercury	TR	µg/l	10
Nickel	TR	µg/l	200
Nitrates + nitrites	T	mg/l	100
Selenium	TR	µg/l	50
Zinc	TR	µg/l	25,000

[1] T = total; TR = total recoverable.
[2] mg/l = milligrams per liter (parts per million); µg/l = micrograms per liter (parts per billion).
[3] OMZA = outside mixing zone average.

Appendix F.3: Water Quality Standards for Primary Contact Recreation (OAC 3745-1)

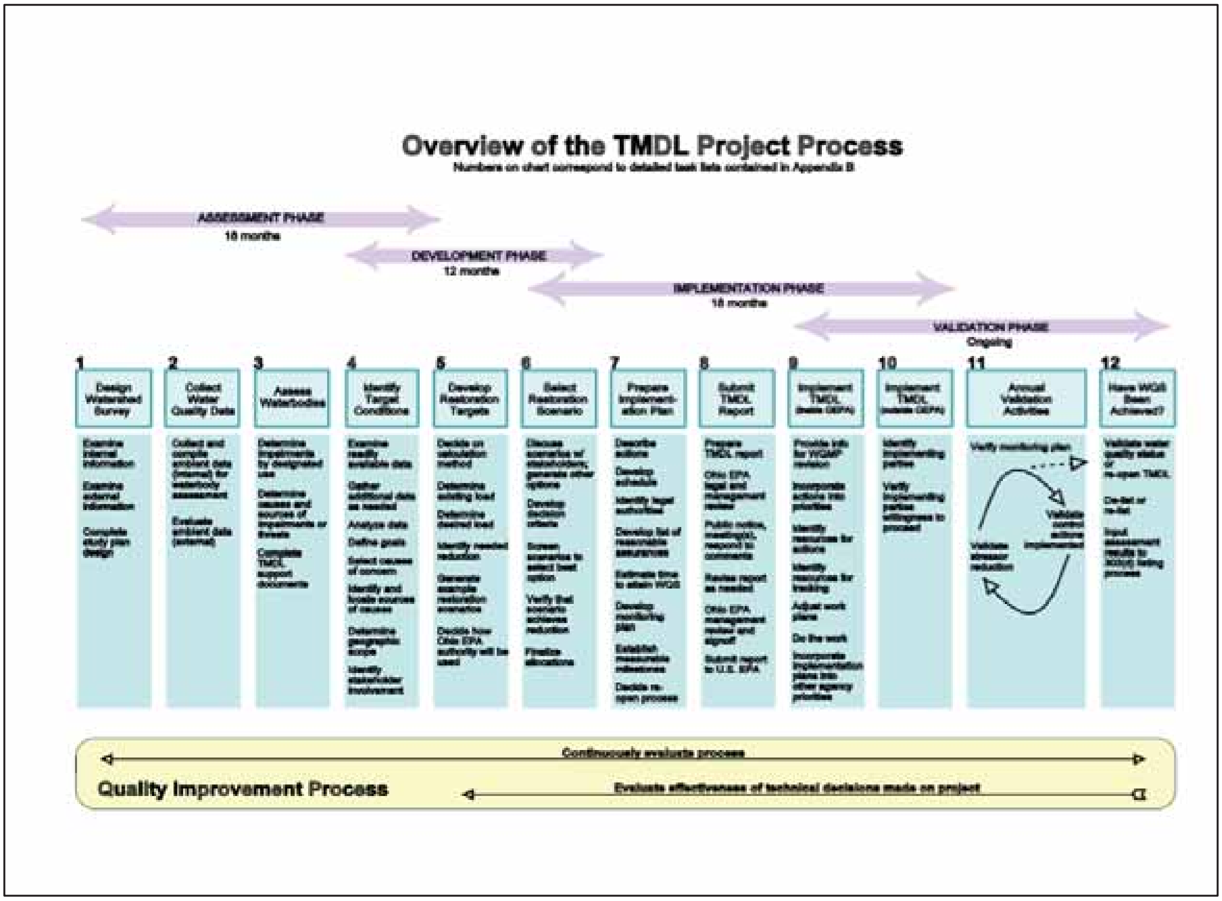
3745-1-07

Table 7-13. Statewide numerical criteria for the protection of recreation uses. These criteria apply inside and outside the mixing zone at all times during the recreation season.

Recreation use	E. coli (colony counts per 100 ml)	
	90-day geometric mean	Statistical threshold value[1]
Bathing water	126	410[a]
Primary contact recreation	126	410
Secondary contact recreation	1030	1030

[1] These criteria shall not be exceeded in more than ten per cent of the samples taken during any ninety-day period.
[a] A beach action value of 235 E. coli colony counts per 100 ml shall be used for the purpose of issuing beach and bathing water advisories.

Appendix F.4: TMDL Project Process (Ohio Environmental Protection Agency 2017 C)



Appendix F.5: US Environmental Protection Agency Webpage on the Elk Creek Watershed Impairments (US Environmental Protection Agency 2017 E)

Causes of Impairment for Reporting Year 2010

Description of this table

Cause of Impairment	Cause of Impairment Group	Designated Use(s)	State TMDL Development Status
Cause Unknown	Cause Unknown	Human Health Use	TMDL needed
Flow Alteration(s)	Flow Alteration(s)	Aquatic Life Use	TMDL needed
Nutrients	Nutrients	Aquatic Life Use	TMDL needed
Priority Organics Compounds	Toxic Organics	Aquatic Life Use	TMDL needed
Salinity/Total Dissolved Solids/Chlorides	Salinity/Total Dissolved Solids/Chlorides/Sulfates	Aquatic Life Use	TMDL needed

APPENDIX G: NPDES PERMITS

Appendix G.1 West Elkton/Preble County Sanitary District No. 3 WWTP NPDES Permit Effluent Limitations (Ohio Environmental Protection Agency 2014 C)

Part I, A. - FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. During the period beginning 12 months after the permit effective date and lasting until the permit expiration date, the permittee is authorized to discharge in accordance with the following limitations and monitoring requirements from the following outfall: 1PL00005001. See Part II, OTHER REQUIREMENTS, for locations of effluent sampling.

Table - Final Outfall - 001 - Final

Effluent Characteristic	Discharge Limitations							Monitoring Requirements		
	Concentration Specified Units				Loading* kg/day					
Parameter	Maximum	Minimum	Weekly	Monthly	Daily	Weekly	Monthly	Measuring Frequency	Sampling Type	Monitoring Months
00010 - Water Temperature - C	-	-	-	-	-	-	-	1/Day	Grab	All
00300 - Dissolved Oxygen - mg/l	-	6.0	-	-	-	-	-	1/Week	Grab	All
00400 - pH - S.U.	9.0	6.5	-	-	-	-	-	1/Week	Grab	All
00530 - Total Suspended Solids - mg/l	-	-	18	12	-	1.71	1.14	1/Week	Composite	All
00610 - Nitrogen, Ammonia (NH3) - mg/l	-	-	4.5	3.0	-	0.43	0.28	1 / 2 Weeks	Composite	Winter
00610 - Nitrogen, Ammonia (NH3) - mg/l	-	-	1.5	1.0	-	0.14	0.10	1 / 2 Weeks	Composite	Summer
00625 - Nitrogen Kjeldahl, Total - mg/l	-	-	-	-	-	-	-	1/2 months	Composite	Bimonthly
00630 - Nitrite Plus Nitrate, Total - mg/l	-	-	-	-	-	-	-	1/2 months	Composite	Bimonthly
00665 - Phosphorus, Total (P) - mg/l	-	-	-	-	-	-	-	1/Month	Composite	All
01350 - Turbidity, Severity - Units	-	-	-	-	-	-	-	1/Day	Estimate	All
31648 - E. coli - #/100 ml	-	-	362	161	-	-	-	1/Month	Grab	Summer
50050 - Flow Rate - MGD	-	-	-	-	-	-	-	1/Day	Continuous	All
70300 - Residue, Total Filterable - mg/l	-	-	-	-	-	-	-	1/2 months	Composite	Bimonthly
80082 - CBOD 5 day - mg/l	-	-	15	10	-	1.42	0.95	1/Week	Composite	All

Notes for station 1PL00005001:

* Effluent loadings based on average design flow of 0.025 MGD.

Appendix G.2: Local Madison Schools WWTP NPDES Permit Effluent Limitations (Ohio Environmental Protection Agency 2014 D)

Part I, A. - FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. During the period beginning 24 months after the permit effective date and lasting until the permit expiration date, the permittee is authorized to discharge in accordance with the following limitations and monitoring requirements from the following outfall: 1PT00084001. See Part II, OTHER REQUIREMENTS, for locations of effluent sampling.

Table - Final Outfall - 001 - Final

Effluent Characteristic	Discharge Limitations							Monitoring Requirements		
	Concentration Specified Units				Loading* kg/day					
Parameter	Maximum	Minimum	Weekly	Monthly	Daily	Weekly	Monthly	Measuring Frequency	Sampling Type	Monitoring Months
00010 - Water Temperature - C	-	-	-	-	-	-	-	1/Week	Grab	All
00300 - Dissolved Oxygen - mg/l	-	6.0	-	-	-	-	-	1/Week	Grab	All
00400 - pH - S.U.	9.0	6.5	-	-	-	-	-	1/Month	Grab	All
00530 - Total Suspended Solids - mg/l	-	-	18	12	-	1.6	1.1	1/Month	Grab	All
00610 - Nitrogen, Ammonia (NH3) - mg/l	-	-	1.5	1.0	-	0.137	0.091	1/Month	Grab	Summer
00610 - Nitrogen, Ammonia (NH3) - mg/l	-	-	4.5	3.0	-	0.41	0.27	1/Month	Grab	Winter
00625 - Nitrogen Kjeldahl, Total - mg/l	-	-	-	-	-	-	-	1/Quarter	Grab	Quarterly
00630 - Nitrite Plus Nitrate, Total - mg/l	-	-	-	-	-	-	-	1/Quarter	Grab	Quarterly
00665 - Phosphorus, Total (P) - mg/l	-	-	-	-	-	-	-	1/Quarter	Grab	Quarterly
01350 - Turbidity, Severity - Units	-	-	-	-	-	-	-	1/Day	Estimate	All
31648 - E. coli - #/100 ml	-	-	284	126	-	-	-	1/Month	Grab	Summer
50050 - Flow Rate - MGD	-	-	-	-	-	-	-	1/Day	Estimate	All
50060 - Chlorine, Total Residual - mg/l	0.019	-	-	-	-	-	-	1 / 2 Weeks	Grab	Summer
80082 - CBOD 5 day - mg/l	-	-	15	10	-	1.4	0.91	1/Month	Grab	All

Notes for station 1PT00084001:
* Effluent loadings based on average design flow of 0.024 MGD.
- Total residual chlorine - See Part II, Item H.

Appendix G.3 Elk Creek Park-Meadow Ridge Area (Formerly Weatherwax Golf Course) WWTP NPDES Permit Effluent Limitations (Ohio Environmental Protection Agency 2012 B)

Part I, A. - FINAL EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. During the period beginning on the effective date of the permit and lasting until the expiration date of the permit, the permittee is authorized to discharge in accordance with the following limitations and monitoring requirements from the following outfall: 1PZ00105001. See Part II, OTHER REQUIREMENTS, for locations of effluent sampling.

Table - Final Outfall - 001 - Final

Effluent Characteristic	Discharge Limitations							Monitoring Requirements		
	Concentration Specified Units				Loading* kg/day					
Parameter	Maximum	Minimum	Weekly	Monthly	Daily	Weekly	Monthly	Measuring Frequency	Sampling Type	Monitoring Months
00056 - Flow Rate - GPD	-	-	-	-	-	-	-	1/Day	Total Estimate	All
00300 - Dissolved Oxygen - mg/l	-	6.0	-	-	-	-	-	1/Quarter	Grab	Quarterly
00400 - pH - S.U.	9.0	6.5	-	-	-	-	-	1/Quarter	Grab	Quarterly
00530 - Total Suspended Solids - mg/l	-	-	18	12	-	0.17	0.11	1/Quarter	Grab	Quarterly
00610 - Nitrogen, Ammonia (NH3) - mg/l	-	-	4.5	3.0	-	0.043	0.028	1/Quarter	Grab	Winter-Qtrly
00610 - Nitrogen, Ammonia (NH3) - mg/l	-	-	1.5	1.0	-	0.014	0.0095	1/Quarter	Grab	Summer - Qtrly
01350 - Turbidity, Severity - Units	-	-	-	-	-	-	-	1/Week	Estimate	All
31648 - E. coli - #/100 ml	-	-	284	126	-	-	-	1/Quarter	Grab	Summer - Qtrly
80082 - CBOD 5 day - mg/l	-	-	15	10	-	0.14	0.095	1/Quarter	Grab	Quarterly

Notes for station 1PZ00105001:
* Effluent loadings based on average design flow of 0.0025 MGD.
- Operator Requirements - See Part II, Item A.
- Turbidity - See Part II, Item E.
- WWTP Outfall Sign - See Part II, Item M.

APPENDIX H: WATER QUALITY

Appendix H.1: Modified Index of Well-Being Narratives (Ohio Environmental Protection Agency 1987 B)

Table 3. Conceptual response of fish community structural and functional attributes as portrayed by modified Index of Well-Being (I_{wb}). Narrative descriptions of fish community condition for good, fair, poor, and very poor ranges are indicated.

Category	--- MEETS CWA GOALS ---		------ DOES NOT MEET CWA GOALS ------		
	"Exceptional"	"Good"	"Fair"	"Poor"	"Very Poor"
1.[a]	Exceptional, or unusual assemblage of species	Usual association of expected species	Some expected species absent, or in low abundance	Many expected species absent, or in low abundance	Most expected species absent
2.	Sensitive species abundant	Sensitive species present	Sensitive species absent, or in very low abundance	Sensitive species absent,	Only most tolerant species remain
3.	Exceptionally high species richness	High species richness	Declining species richness	Low species richness	Very low species richness
4.[b]	Composite index Greater than 9.5	Composite index Greater than 7.4 - 8.6[b], Less than 9.4	Composite index Greater than 5.3 - 6.3[b], Less than 7.4-8.6[b]	Composite index Greater than 4.5 - 5.0[b], Less than 5.3-6.3[b]	Composite index Less than 4.5 or 5.0[b]
5.	Outstanding recreational fishery		Tolerant species increasing, beginning to predominate	Tolerant species predominate	Community organization lacking
6.	Species with an endangered, threatened, or special concern status are present				

[a] Conditions: Categories 1, 2, 3 and 4 (if data is available) must be met <u>and</u> 5 <u>or</u> 6 must <u>also</u> be met in order to be designated in that particular class.

[b] encompasses range of ecoregional values; area of insignificant departure is -0.5 from ecoregional criterion.

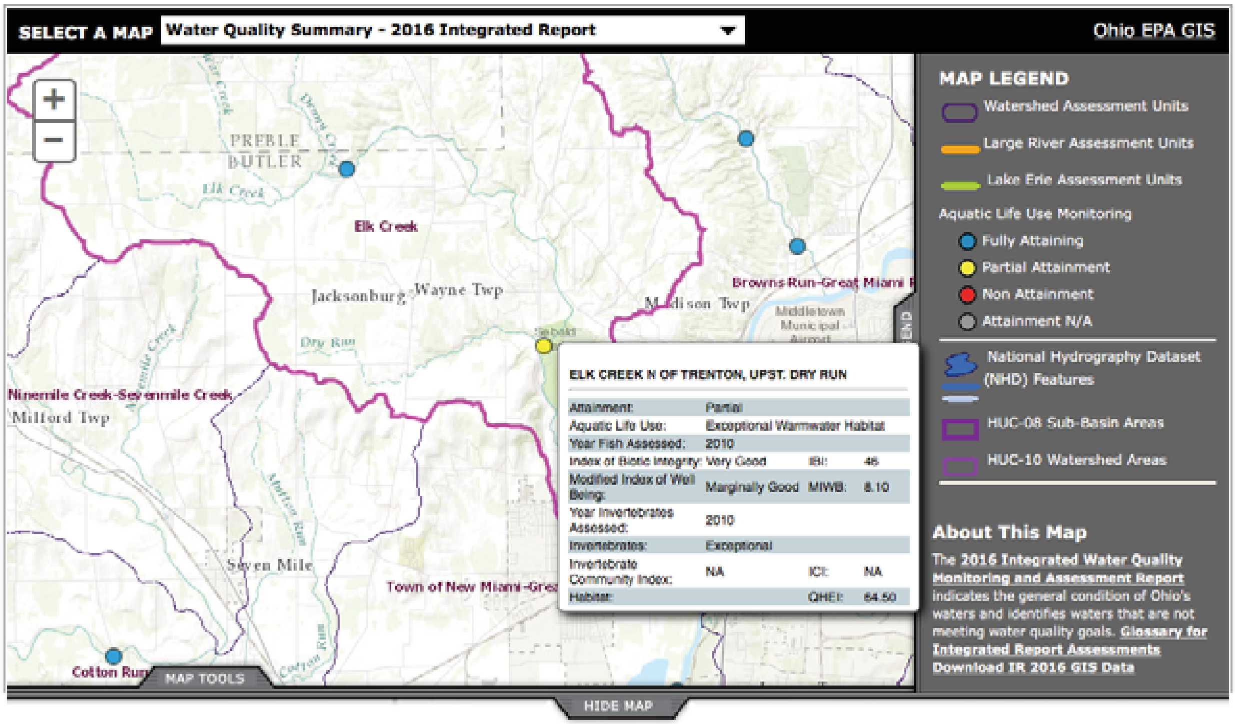
Appendix H.2: Ohio EPA Biological Data for the Elk Creek Watershed Stated in the Report
(Ohio Environmental Protection Agency 2012 A)

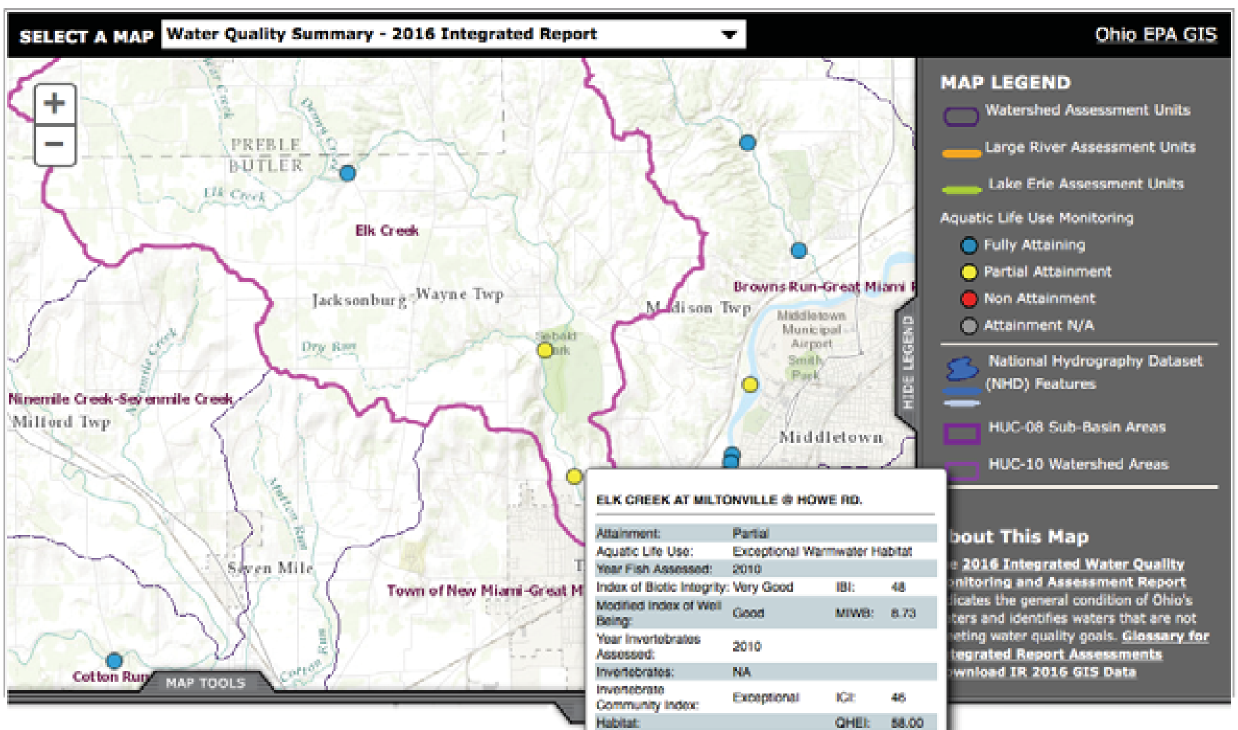
EAS/2012-5-7 Lower Great Miami River TSD May 12, 2012

Table 1. Site-level condition assessments for the Great Miami River and its tributaries based on biological indicators sampled during 2010. Where the biological indicators demonstrate less than full attainment of the designated beneficial aquatic life use, causes and sources are noted. For a given site, the most proximate cause is listed first. Cells with scores within the range of non-significant departure of WWH are shaded gray; those with scores significantly less than the applicable biocriteria are shaded yellow and orange (i.e., corresponding to the Fair and Poor narrative ranges). Biocriteria for the Eastern Cornbelt Plains Ecoregion apply to all assessments units except for the Taylor Creek subwatershed, where the Interior Plateau criteria apply.

Assessment Unit	STORET	RM	ICI[b]	IBI	MIWb[a]	ATTAINMENT	Causes[c]	Sources
	H09P06	9.75	G	44		FULL		
	H09S04	7.08	36	50		FULL		
	203509	5.80	NA	42	8.7	(FULL)		
	Little Bear Creek 14-030-000							
	H09P07	1.01	G	48		FULL		
050800020402	Bear Creek 14-029-000							
	H09S01	0.24	54	43	8.7	FULL		
050800020403	Clear Creek 14-024-000							
	203516	11.10	G	52		FULL		
	H09W49	7.57	42	48	8.8	FULL		
	H09W50	6.90	36	46	8.3	FULL		
	203513	2.50	46	53	9.7	FULL		
	300812	0.77	44	48	9.0	FULL		
050800020701	Elk Creek 14-022-000 Verified Exceptional Warmwater Habitat							
	300944	10.10	E	50		FULL		
	H09W89	3.70	E	46	7.9	Partial	Natural – stream has aggraded since being channelized; pool depths were > 1 m prior to 1995; pool depths measured in 2010 were < 0.7 m	
	H09P01	1.49	46	48	8.7	Partial	Natural – stream has aggraded since being channelized; pool depths were > 1 m prior to 1995; pool depths measured in 2010 were < 0.7 m	

Appendix H.3: Ohio EPA Biological Data for the Elk Creek Watershed Stated on their Website
(Ohio Environmental Protection Agency 2016 G)





APPENDIX I: AREAS OF CONCERN AND SUMMARY TABLE

Elk Creek Watershed Inventory

For: Butler Soil and Water Conservation District

By: Miami University Institute for the Environment and Sustainability

Project Team: JJ Crumpler, Michael Doust, Deanna Fyffe, Savannah Pocisk & Jenna Tiller

Introduction

A watershed is a basin-like landform defined by highpoints and ridgelines that descend into lower elevations and stream valleys.[1] The management of water resources is accomplished using multijurisdictional watershed action plans (WAPs), which are comprehensive plans for protecting water quality and improving conditions in a watershed.[2] One of the first steps to creating a WAP is to compile a watershed inventory of physical and natural features, land use, population, watershed conditions, pollutant sources, and water quality data. WAPs often address water quality concerns such as elevated levels of nutrients, bacteria, and chemicals.

Problem Definition

Butler Soil and Water Conservation District (Butler SWCD) is responsible for offering technical assistance and educating residents and business owners about effective methods to reduce soil erosion and improve water quality.[3] To do this, Butler SWCD must understand the issues impacting current waterways, and use this information to develop a WAP. Currently, there is no comprehensive inventory of biological, geological, and cultural elements of one of the regional waterways, Elk Creek Watershed (ECW).

Objectives

- Describe ECW boundaries and population characteristics
- Determine natural features and land use
- Identify potential point and nonpoint pollution sources
- Assess current and historical ECW water quality
- Generate maps and figures to display our data
- Determine areas of concern to aid in the watershed planning process
- Compile the gathered information into a report following US EPA requirements

Methods

- Reviewed past research on ECW
- Contacted stakeholders about current projects
- Used geographic information systems to generate maps representing characteristics of ECW
- Collected and interpreted data on land-use/land-cover from the United States Department of Agriculture
- Identified potential pollution sources
- Performed statistical analysis on water quality data from Butler County Stream Team regarding nitrate and *E. coli*

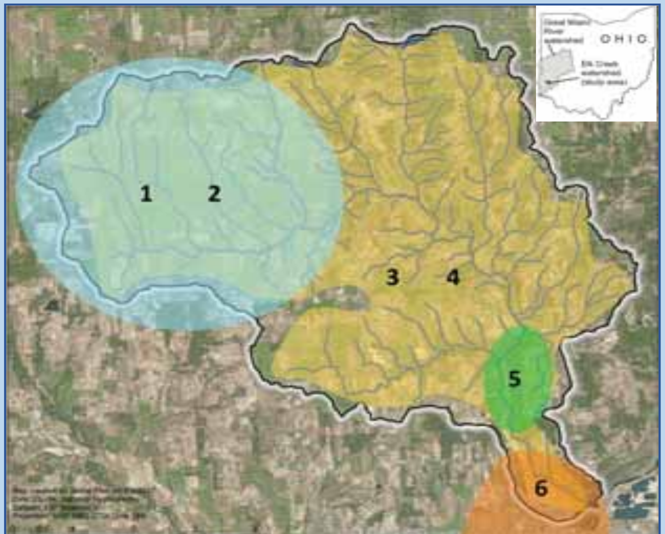


Figure 1: Areas of Concern in Elk Creek Watershed

Table 1: Beneficial Use Designations of Elk Creek [4]

Beneficial use designations are determined by the Ohio EPA based on water quality assessments. They describe the current or prospective uses of water bodies, including the type of aquatic life habitat, water supply use, and recreational use.

Use	Meaning
Exceptional Warmwater Habitat (EWH)	Highly or exceptionally diverse aquatic community of warmwater habitat organisms. Elk Creek is the only EWH in the Lower Great Miami River Watershed.
Agricultural and Industrial Water Supply	Water can be used for agricultural and industrial purposes with or without treatment. Elk Creek is not designated as a public drinking water supply.
Primary Contact Recreation	Suitable for activities such as swimming, canoeing, kayaking, and others that include direct contact.

Results – Areas of Concern

1	There are statistically significant concentrations of nitrate-N that are higher than the rest of ECW. Nitrate in surface water can contribute to nutrient pollution, which can diminish oxygen in a waterbody and impact biodiversity.[5]
2	Assessment of soils indicate this area is highly suitable for wetlands, yet GIS land-use/land-cover analysis indicates very few wetlands. Wetlands can aid in water purification, flood prevention, and shoreline stabilization.[6]
3	Butler County Stream Team samples indicate *E. coli* concentrations above water quality standards for recreation throughout the entire ECW. *E. coli* commonly causes gastrointestinal, respiratory, and urinary diseases in humans.[7]
4	Assessments of the physical habitat using the Qualitative Habitat Evaluation Index (QHEI) at River Mile 3.70 went from 91.5 (excellent) in 1987 to 64 (good) in 2010.[4] QHEI scores above 75 usually correspond with Exceptional Warmwater Habitat, indicating a possible threat to EWH designation.[8]
5	GIS analysis by the team indicated a high potential for annual average soil loss near Elk Creek Park – Meadow Ridge Area. Soil erosion can increase the amount of nutrients, sediment, and pesticides in waterways.[9]
6	There have been high nitrate concentrations in groundwater near Trenton.[10] Nitrate impacts human health and can be lethal to young children.[11]

Recommendations

- Monitor future Ohio EPA biological assessments, Ohio nutrient standards currently being developed, and changes to point source pollution permits
- Collect data on livestock populations and home sewage treatment systems' effect on nutrient and *E. coli* concentrations in ECW
- Work with stakeholders to increase the use of conservation measures offered by Butler SWCD and the National Resources Conservation Service in ECW
- Explore additional funding options for future Butler SWCD conservation projects in order to maintain the EWH use designation.

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Watershed Inventory Sections		Summary	Page Number(s) in Report
Political Boundaries and Demographics			
Political Boundaries and Demographics	Political Boundaries	ECW is located at the intersection of Butler, Preble, and Montgomery counties. There are six townships: Gratis, Somers, German, Madison, Wayne, and Milford	7
		There are seven populated places: Astoria, Beechwood, Greenbush, Jacksonburg, Miltonville, West Elkton, and the City of Trenton	7
	Population Statistics/Demographics	Townships within the ECW have a total population of approximately 33,270, with the highest concentration in the City of Trenton	8
Natural Features			
Surface Water Resources	Climate and precipitation	Elk Creek is dominated by a mostly temperate climate with four distinct seasons. Spring and summer have the most precipitation, receiving 12.95 and 11.84 inches on average. The winter season has an average temperature of 32.0 F, and summer has an average temperature of 73.3 F	9
	Tributaries	Elk Creek Watershed contains Elk Creek, Dry Run, Denny Creek, and Clear Creek. None of these tributaries are classified as a subwatershed of Elk Creek	9
	Flood Frequency	The majority of the ECW has no reasonable possibility of flooding (Figure 3.2). However, the chance of flooding in some tracts of land surrounding the larger branches of the Elk Creek is characterized occasional (5-50% chance in any given year) to frequent (over 50% chance in any given year).	10
	100-Year Floodplain	In the ECW, the only populated place with Special Flood Hazard Areas is Miltonville. Most of the SFHA are located along the main body of Elk Creek.	11
Groundwater Resources	Consolidated Aquifers	Consolidated Aquifers in ECW- Ordovician Aquifer; Silurian Aquifer	13
	Unconsolidated Aquifers	Unconsolidated Aquifers in ECW- Camden Complex Aquifer, Oxford Complex Aquifer, Oxford Thin Upland Aquifer, Camden End Moraine Aquifer, Oxford Ground Moraine Aquifer, Great Miami River Alluvial Aquifer, Great Miami River Buried Valley Aquifer, Trenton Buried Valley Aquifer	14
	Sole Source Aquifers	Sole Source Aquifers in ECW- Southwest Ohio contains the Greater Miami SSA, which extends into the southeastern branch of the ECW near where it discharges into the Great Miami River	15
		The USGS completed a Nitrate study in 2003-2004 in cooperation with the Miami Valley Conservancy District due to reports that drinking water wells near Trenton, Ohio in the southeast ECW had nitrate concentrations exceeding federal standards. In general, lower nitrate values were found in the headwaters of Elk Creek, and higher values were found in the lower watershed near Trenton. The conclusion of the report is that soil organic matter and ammonia fertilizer are the primary contributing factors to high nitrate in drinking water wells.	16-17
	Groundwater Pollution Potential (GWPP)	In the ECW, GWPP is highest along the main body of Elk Creek and just north of Trenton, with the northern and northwestern headwaters having the lowest GWPP	18
Geology and Soils	Bedrock Type and Age	A majority of the ECW is Ordovician shale, with small areas of Ordovician limestone and Silurian shale	19

Watershed Inventory Sections		Summary	Page Number(s) in Report
	Surficial Deposits	Elk Creek is located in southwest Ohio, which is dominated by Wisconsinian deposits interspersed with Illinoian ground moraine	20
	Soil Orders	The ECW contains Alfisols, Entisols, Inceptisols, and Mollisols. A majority of the ECW is the Alfisol soil order, and the western and southwestern portion of the watershed features large areas of Mollisols	21
	Topography and Elevation	The ECW ranges from approximately 190 meters to 340 meters above sea level, with the lowest elevations found along Elk Creek and to the south and the higher elevations around the northern headwaters	22
	Slope Gradient	Most of the ECW is nearly level to gently sloping, and high slope gradients are more commonly found in the central and northern portions of the watershed	23
	Drainage Class	The ECW is classified as Well Drained for most its area, but the western/southwestern parts of the watershed are characterized higher proportions of Somewhat Poorly Drained and Very Poorly Drained areas	24
	Surface Runoff	The eastern portion of the ECW is dominated by high runoff, and the western part of the watershed is mostly medium and low runoff, with some areas of negligible runoff in the western-most headwaters of ECW	25
	Hydrologic Group	Much of the ECW is slow infiltration (group C), but the western and southwestern edges are predominantly B/D and C/D, which means they naturally have very low infiltration	26
	Estimated Average Annual Soil Loss	The RUSLE output indicated increased soil loss in the southern portion of the ECW, specifically near Elk Creek Park – Meadow Ridge Area	27
	Hydric Classification	The ECW is dominated by non-hydric soils, but there are higher incidences of hydric soils in the western and northeastern-most portions of the watershed	28
Biological Features	Forest Habitat	The total forest habitat covers approximately 22% of the land area in ECW, 19.5% of which is deciduous forests	29
	Wetlands Habitat	Historically, wetlands covered 8.74% of the land area in the ECW. Currently, wetland habitats only account for 0.14% of the land area	31
	QHEI	The QHEI scores for River Mile 3.7 in Elk Creek were 91.5 in 1987, 84 1995, and 64.5 in 2010. The scores for two additional River Miles in 2010 were 64 for RM 10.10 and 58 for RM 1.49.	32
	Threatened and Endangered Species – wildlife and plants	In three counties which ECW resides, there are 7 threatened and 8 endangered wildlife species as well as 12 threatened and 2 endangered plant species as well as 12 threatened and 2 endangered plant species.	33-34
	Predicted Native Species - fish, mussles, and crayfish	USGS models of potential distribution suggest that ECW is home to 77 native fish species, 27 native muscle species, and 8 native crayfish species	35-37
Land Use			
Current Land-Use/Land-Cover (acres and percent)	Total land	ECW is 47.62 square miles (30,521.6 acres)	42
	Primary land use	A majority of the land in the ECW is agricultural, which includes Hay/Pasture and Cultivated Crops (21,059.9 acres; 69%)	38
	Hay/Pasture	10,631.1 acres; 34.88%	39

Watershed Inventory Sections		Summary	Page Number(s) in Report
	Cultivated Crops	10,221.3 acres; 33.54%	39
	Deciduous Forest	5,969.3 acres; 19.59%	39
	Developed, Open Space	2,091.6 acres; 6.86%	39
	Developed, Low Intensity	616.7 acres; 2.02%	39
	Mixed Forest	324.5 acres; 1.06%	39
	Evergreen Forest	299.8 acres; 0.98%	39
	Open Water	98.5 acres; 0.32%	39
	Shrub/Scrub	70.9 acres; 0.23%	39
	Developed, Medium Intensity	79.4 acres; 0.26%	39
	Herbaceous	46.3 acres; 0.15%	39
	Woody Wetlands	12.5 acres; 0.04%	39
	Emergent Herbaceous Wetlands	11.1 acres; 0.04%	39
	Developed, High Intensity	5.8 acres; 0.02%	39
	Changes in Land Use	The biggest change was a decrease in hay/pasture by 271.1 acres, approximately 0.1% of the ECW	40
		The second largest change was an increase in cultivated crops (120.7 acres) and developed open space (89.4 acres)	40
Current Crop Data (acres)	Soybeans	5316.341	41
	Corn	4968.738	41
	Winter Wheat	537.972	41
	Other Hay/ Non-Alfalfa	319.803	41
	Alfalfa	161.014	41
	Double Crop (winter wheat and soybeans)	36.250	41
	Oats	1.557	41
	Fallow/Idle Cropland	0.890	41
	Speltz	0.222	41
Land Management Practices	Agriculture	Preble county has the highest acreage of farmland, followed by Butler and then Montgomery	40
		Total Farm Acreage per county- 224,243 acres in Preble; 146,054 acres in Butler; 124,105 in Montgomery	40

Watershed Inventory Sections		Summary	Page Number(s) in Report
	Recreation and Conservation	***Elk Creek MetroPark*** - Sebald Park was the largest public park in the watershed, and represented a large portion of the developed land in the ECW. Weatherwax Golf Course, located to the right of what used to be Sebald Park, was purchased by the MetroParks of Butler County on September 23, 2015. Weatherwax Golf Course, located to the right of what used to be Sebald Park, was purchased by the MetroParks of Butler County on September 23, 2015.	42
		City of Trenton - Trenton Community Park is located on the northwest s	42
		West Elkton Village - West Elkton Community Park, a community park owned by the City of West Elkton, is small park that offers baseball diamonds and walkable paths. The park has open green space for recreation and extracurricular activities.	42
		Clean Sweep of the Great Miami (Great Miami River Cleanup) - The cleanup stretched from Indian Lake to the Ohio River. On October 22nd, they had cleanup site locations in the ECW in Madison Township and at the Trenton Community Park. The results for this cleanup have not been posted yet. However, their previous July 2016 cleanup from Indian Lake to Franklin had 422 volunteers that resulted in a collection of 17.3 tons of litter.	42
		Butler County Stream Team - BCST has three sample sites within the ECW. The samples are tested for bacteria, nitrates, total phosphorus, total dissolved solids, pH, conductivity, and turbidity.	42
		Three Valley Conservation Trust - One of their projects is the Headwater Preservation Project, which is in the ECW. The Headwater Preservation Project consists of 270-acre easement and covers over one mile of Elk Creek including forests and streams.	43
		Historical and Cultural Information - Several historical markers and sites are within the boundaries of the ECW.	43; Appendix E
	Stormwater Pollution Prevention Plans	Butler County Storm Water District created Stormwater Management Plan (SWMP) that was drafted in 2003 (Butler County Storm Water District 2003). The permit covers 45% of Butler County, which includes two of the townships, Madison and Wayne, within the ECW.	43
		Montgomery and Preble County did not list any SWPPP on their websites and both were contacted but were not able to find Stormwater Pollution Prevention Plans. Butler County handles the storm water planning for the City of Trenton.	43
Water Quality Standards			
Beneficial Use Designations	Recreational	Primary Contact Recreation Class B	44
	Aquatic	Exceptional Warmwater Habitat	45
	Human Health	Agriculture and Industry Water Supply	45
Applicable Standards	Exceptional Warmwater Habitat	**Biological:** The ECW must attain an Index of Biotic Integrity score of 48 – 50 and a Modified Index of Well-Being score 9.4 - 9.6 depending on the site being evaluated (OAC 3745-1). Additionally, exceptional warmwater habitats must achieve an Invertebrate Community Index of 46 which is considered “good.”	45

Watershed Inventory Sections		Summary	Page Number(s) in Report
		Chemical: The ECW must comply to certain statewide criteria set for the entire state of Ohio in order to protect aquatic life (OAC 3745-1). Additionally, it has criteria regarding the maximum and 30-day-average total ammonia-nitrogen and based on pH and temperature. The Ohio EPA is in the process of detailing nitrate and phosphorus standards for warm water habitats and exceptional warm water habitats	45
		Whole Effluent Toxicity (WET): WET is determined by investigating the effects of effluent outflow on aquatic plants, vertebrates, and invertebrates. However, The NPDES permits in the ECW have a relatively small discharge flow, so Elk Creek does not have WET criteria	45
	Agricultural Supply	In order to be suitable for agricultural water supply use, the ECW must have average concentrations of fluoride, nitrates, nitrites, and certain metals below designated values	45
	Industrial Water Supply	No criteria	45
	Primary Contact Recreation (Class B)	Elk Creek is required to have a maximum monthly average of 126 E. coli colonies per 100 mL and must maintain the statistical threshold value of 410 E. coli colonies per 100 mL (Appendix H.3). In other words, no more than 10% of the samples taken in a 90-day period may be over 410 colonies per 100 mL.	45
Attainment Status	Recreational	Ohio EPA determined Elk Creek to be in full attainment for recreational use in 2010	46
	Aquatic	Ohio EPA determined Elk Creek to be impaired in 2010 due to natural cause of stream channalization after being bulldozed straight decades ago	46
	Human Health	Ohio EPA determined Elk Creek to be impaired for human health use in 2010 as determined by fish tissue analysis	46
Pollution Sources			
Point Source Pollution	West Elkton	In non-compliance April 1 -September 30, 2014 for exceeding discharge limits of Nitrogen, Ammonia by 7% over their NPDES permit (Appendix C). October 1-December 31, 2014 for late reporting. July 1, 2016-September 30, 2016, was reported in non-compliance for exceeding discharge limits of the Carbonaceous BOD test by 144% over their permitted allocation	48
		Set to expire on July 31, 2019	48
	Madison Schools	In non-compliance October 1, 2014-June 6, 2016 for submitting late reports to the EPA. In 2007 Madison Local Schools WWTP self-reported a permit violation with a discharge of 1.4 mg/l Nitrogen, Ammonia which exceeded their permitted limit of 1.0 mg/l Nitrogen, Ammonia/month (Appendix A).	48
		Set to expire on April 30, 2019	48
	Elk Creek Park- Meadow Ridge Area	In non-compliance April 1-June 30, 2014 and October 1-December 31, 2014, for exceeding permit limitations on E. Coli, Nitrogen, Ammonia, and Total Suspended Solids (Figure 6.3). (Appendix D).	49

Watershed Inventory Sections		Summary	Page Number(s) in Report
		Set to expire on December 31, 2017	49
Nonpoint Pollution	Livestock Inventory	Hogs and pigs make up most of the livestock in the counties that make up the ECW: Total Population 68,799	49-50
		Cattle and calves comprise the second highest livestock population in the counties that make up the ECW: Total Population 39,655	50
	Fertilizer	Total - estimated 2,755,585.9 lbs/yr of fertilizer (894,288.0 lbs/yr of nitrogen, 668,861.2 lbs/yr of phosphate, 1,049,270.7 lbs/yr of potash, and 143,166.0 lbs/yr of sulfur)	51
		Corn - estimated a total of 1,644,652.3 lbs/yr applied for corn crops in ECW (765,682.5 lbs/yr nitrogen, 369,674.1 lbs/yr of phosphate, 464,577.0 lbs/yr of potash, and 44,718.6 lbs/yr of sulfur)	51
		Soybean - estimated a total of 990,965.9 lbs/yr applied for soybean crops in ECW (87,719.6 lbs/yr nitrogen, 269,006.8 lbs/yr of phosphate, 543,861.6 lbs/yr of potash, and 90,377.8 lbs/yr of sulfur)	51
		Winter Wheat - estimated a total of 119,967.8 lbs/yr applied for winter wheat crops in ECW (40,885.9 lbs/yr nitrogen, 30,180.2 lbs/yr of phosphate, 40,832.1 lbs/yr of potash, and 8,069.6 lbs/yr of sulfur)	51
	Manure as Fertilizer (2012)	Bulter - 176 farms and 7,279 acres treated	51
		Montgomery - 92 farms and 3,780 acres treated	51
		Preble - 219 farms and 10,181 acres treated	51
	Household Sewage Treatment Systems	Butler County (2008): Eight combined townships - 46,250 HSTS; Madison Township - 930 HSTS	53
		Montgomery County (2012) - 18,200 HSTS	53
		Preble County (2012): Gratis Township - 1,370 HSTS; Somers Township - 787 HSTS	53
Water Quality Data			
Biological Data	Data Sources	Ohio EPA	54
	IBI	The IBI score at RM 3.70 was 46 in both 1995 and 2010. The IBI score was 50 at RM 10.10 and 48 at RM 1.49 in 2010.	54
	ICI	The ICI score was 52 in 1997 and 46 in 2010.	56
	MIWb	At RM 3.70, the MIWb score was 9.0 in 1997 and 7.9 in 2010. At RM 1.49, the MIWb score was 8.1	57
Chemical Data	Data Sources	Miami University, United States Geological Survey, Butler County Stream Team	58
		Miami University (1992-1993) - maximum nitrate-N in surface water was 3.7 mg/L and average was 1.4 mg/L	59
		USGS (2003-2004) - maximum nitrate-N in groundwater was 11.0 mg/L and average was 4.4 mg/L	59
	Nitrate-N	Butler County Stream Team (2015-2016) - maximum nitrate-N in surface water was 9.5 mg/L and average was 2.6 mg/L. The sample site at RM 12.4 had statistically significant nitrate-N concentrations when compared to the other two sites through t-tests.	59

Watershed Inventory Sections		Summary	Page Number(s) in Report
	Agricultural Use	Ohio EPA - iron concentration was found to be above the standard for agricultural use. All other standards were met aside from the two not tested (berullium and fluoride)	59
Microbiological Data	Data Sources	Ohio EPA, Butler County Stream Team	60
	Escherichia coli	Ohio EPA found Elk Creek to be in full attainment for E. coli standards in 2010. Butler County Stream Team samples indicate the monthly average for E. coli concentrations have only been within the standard twice in the last two years. Additionally, 3-month averages for their samples have not been within a 10% threshold of 410 colonies per 100mL at all in 2015 or 2016	60-61

APPENDIX J: NUTRIENT STANDARDS

Email from Rick Wilson, Environmental Specialist for the Ohio EPA Division of Surface Water, regarding the effort to establish nitrogen and phosphorus standards for exceptional warmwater habitats.

From: Pocisk, Savannah pociskad@miamioh.edu
Subject: Fwd: FW: Elk Creek Watershed Inventory Inquiry
Date: April 30, 2017 at 2:55 PM
To: Deanna Fyffe fyffedl@miamioh.edu

SP

On Tue, Oct 25, 2016 at 2:15 PM, Rick.Wilson@epa.ohio.gov <Rick.Wilson@epa.ohio.gov> wrote:

Good afternoon Ms. Savanna, Deanna, and Suzanne:

Establishing nutrient concentration water quality standards for N and P to protect designated use warm water habitat or exceptional warm water habitat is something our agency has been working on for years(but it is a political football to some degree)....pitting ag interests (nonpoint source) versus urban interests (point sources).

One of the best documents I can suggest on this topic is link to below:

Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams

Ohio EPA Technical Bulletin MAS/1999-1-1 http://www.epa.state.oh.us/portals/35/documents/assoc_load.pdf

Here is a report from a committee that was established to make headway on establishing nutrient criteria in rule...

http://epa.ohio.gov/Portals/35/wqs/nutrient_tag/Proposed_Final_SNAP.pdf

This is good stuff....I hope it's helpful.

Let me know if you have additional questions.

:)

~rick

Rick Wilson, Environmental Specialist
Ohio EPA | **Division of Surface Water**
Surface Water Improvement and Nonpoint Source-§319 program
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APPENDIX K: STAKEHOLDERS IN THE ELK CREEK WATERSHED

The ECW has several stakeholders that aid in is monitoring, assessing, and helping improve the quality of the watershed.

Butler County Health Department
Butler County Health Department focuses its mission on improving the quality of life for Butler County residents through their focus on human health, disease prevention, and environment (Butler County Health Department 2017 A). Butler County Health Department provides environmental services to address any environmental degradation that would impact human health (Butler County Health Department 2017 B). They offer bonds for sewage installers and septage haulers. Further resources are available for septic permits and sewage treatments. They also offer private water resource system permits and information on private well upkeep.

Butler County Storm Water District
Butler County Storm Water District formed under the Environmental Protection Agency's Clean Water Act. The District evaluates and monitors all residential, commercial, and agricultural storm water runoff (Butler County Storm Water District 2017). The figure below shows the locations in Butler County. Butler County Storm Water District. Several of these townships are in the ECW: Milford, Wayne, Madison, and Trenton City.

Butler Soil and Water Conservation District
As mentioned in Section 1.2 Project Description, Butler Soil and Water Conservation District focus on maintaining the health of Butler County's soil and water through conservation and education (Butler Soil and Water Conservation District 2016 A). Some of their conservation measures focus on soil erosion, wildlife, and water quality. The education efforts are geared to both private land owners and the public.

MetroParks of Butler County
The Parks have 10 locations throughout Butler County that not only provide recreational and education activities but provide conservation efforts as well. They work to protect drinking water sources, watersheds, wildlife habitat, birding areas, and animal diversity (MetroParks of Butler County 2017). The MetroParks of Butler County purchased the Weatherwax Golf Course and will add it to Sebald Park.

Miami Conservancy District
MCD was created in 1922 after the Great Flood of 1913 in Dayton, Ohio. The first task was to create a flood plan to protect the area. Since then, MCD work on research and education around the Great Miami River (Miami Conservancy District 2009).

Montgomery Soil and Water Conservation District (MSWCD)
In 1949, beginning with Ohio Conservation District Law, farmers created the MSWCD for Montgomery county to (Montgomery Soil and Water Conservation 2017). The MSCWD is run by a board of supervisors who server three year terms and have seven staff members.

Ohio Department of Agriculture

The Ohio Department of Agriculture works to protect Ohio's food supply including animal and plant health as well as increase farmer economic welfare (Ohio Department of Agriculture 2017 B). The Butler, Montgomery, and Preble Soil and Water Conservation districts are now managed under the Ohio Department of Agriculture (Ohio Department of Agriculture 2017 A). In January 2016, Soil and Water Conservation Districts were transferred from the Department of Natural Resources to the Department of Agriculture.

Ohio Environmental Protection Agency

The Ohio EPA creates standards and collects data on environmental quality including pollution, water quality, waste management, and biology to protect the environment (Ohio Environmental Protection Agency 2017 B). Beyond this, the Ohio EPA offers environmental education, environmental financial assistance, and legal services.

Public Health - Dayton & Montgomery County

Public Health - Dayton & Montgomery County works for the protection of air, food, and drinking water (Public Health – Dayton & Montgomery County 2017). They focus on adapting and changing their practices to implement new strategies to continue to meet the needs of Montgomery County residents. Along with the residents, they work with a variety of other stakeholders like schools and hospitals.

Preble Soil and Water Conservation District (PSWCD)

PSWCD was created in 1949 by landowners interested in conserving water and soil resources. The District is run by five elected supervisors who work with landowners, government agencies and other organizations to develop policies and programs that protect soil and water resources in the county (Preble Soil and Water Conservation District 2017).

Three Valley Conservation Trust (TVCT)

TVCT was founded in 1993 as a member/contributor funded, non-profit land trust that preserves streams and land through agriculture easements (Three Valley Conservation Trust 2017). As of July 2015, TVCT was responsible for protecting, maintaining, and monitoring over 20,000 acres on 168 properties (since July 2015) Properties are found in the Four Mile Creek watershed, the Twin Creek watershed, portions of the Whitewater River watershed (Butler and Preble counties), Elk Creek Watershed, and all the land in Butler County drained by eastern tributaries of the Great Miami River.

APPENDIX L: POTENTIAL SOURCES OF FUNDING

Compiled from: (ODNR 2005 B), (National Fish and Wildlife Foundation 2017), (Ohio Environmental Protection Agency 2003), (Ohio Environmental Protection Agency 2015 B), (Ohio Environmental Protection Agency 2016 H), (Ohio Department of Agriculture 2017 C), (Ohio Department of Natural Resources 2015 B) (Ohio Department of Natural Resources 2015 D), (Ohio Department of Natural Resources 2017 F), (US Environmental Protection Agency 2017 F), (US Environmental Protection Agency 2017 G), (US Environmental Protection Agency 2017 H)

Name	Link	Description	General Application Period
*Surface Water Improvement Fund (SWIF)	http://www.epa.ohio.gov/dsw/nps/swif.aspx	The Surface Water Improvement Fund was created in 2008 and authorizes the Ohio Environmental Protection Agency to provide grant funding to applicants such as local governments, park districts, conservation organizations and others.	Currently unavailable
*Five Star and Urban Waters Restoration	http://www.nfwf.org/fivestar/Pages/home.aspx	Projects seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development.	January deadline
Ohio Department of Agriculture Watershed Coordinator Grant Program	http://water.ohiodnr.gov/portals/soilwater/pdf/watersheds/Coordinator program overview.pdf Contact ODA Soil and Water Conservation at dswc@agri.ohio.gov (614) 265-6610	The Ohio Watershed Coordinator Program, administered by ODNR, Division of Soil & Water Conservation, provides funding to foster permanent positions in local units of government, non-profit organizations or other organizations to prepare and implement a state endorsed Watershed Action Plan (WAP) to restore or protect a water resource. Provides up to $35,000 per year for up to four years to support local employment of "watershed coordinators."	Applications accepted annually

Nature Works Program	https://ohiodnr.gov/portals/realestate/pdfs/grants/natureworks/natureworks-procedural-guide.pdf	This money assists local governments with community parks and recreation projects. There are three types of NatureWorks local grants: Parks, Boating, and Nonpoint Source.	May 1st deadline
Land and Water Conservation Fund	http://realestate.ohiodnr.gov/outdoor-recreation-facility-grants	The Land and Water Conservation Fund (LWCF) grant program provides up to 50% reimbursement assistance for state and local government subdivisions (townships, villages, cities, counties, park districts, joint recreation districts, and conservancy districts) to for the acquisition, development, and rehabilitation of recreational areas.	November 15 deadline
Ohio Environmental Education Fund (OEEF)	http://epa.ohio.gov/Portals/42/documents/2015GeneralGrantGuidelines.pdf	Mini grants $500 - $5,000 and General Grants $5,000 - $50,000. Education projects targeting pre-school through university students and teachers, the general public and the regulated community. Ten percent cash or in-kind match required.	Typically available in Spring and Fall
Water Pollution Control Loan Fund	http://epa.ohio.gov/Portals/29/documents/WPCLF.pdf	Ohio's Water Pollution Control Loan Fund (WPCLF) offers assistance opportunities (direct and indirect loans) for qualifying point source projects (including planning, design, and construction loans) that will be owned by public entities.	Not applicable
US Environmental Protection Agency Clean Water State Revolving Fund	https://www.epa.gov/cwsrf	The Clean Water State Revolving Fund (CWSRF) program is a federal-state partnership that provides communities a permanent, independent source of low-cost financing for a wide range of water quality infrastructure projects.	Not applicable
US Environmental Protection Agency Wetland Program Development Grant	https://www.epa.gov/wetlands/wetland-program-development-grants - about	WPDGs provide eligible applicants an opportunity to conduct projects that promote the coordination and acceleration of research, investigations, experiments, training, demonstrations, surveys and studies relating to the causes, effects, extent, prevention, reduction and elimination of water pollution.	Typically available in Spring
*Butler Soil and Water Conservation District has received funding from the sources in the past			