Total Maximum Daily Loads for the Grand River (upper) Watershed

Final Report
Division of Surface Water
January 31, 2013

Photo caption: Rock Creek waterfalls

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Acronyms and Abbreviations

AFG	allowance for future growth
ALU	aquatic life use
AU	assessment unit
AWS	agricultural water supply
BMP	best management practices
BNA	base neutral and acid extractable compounds
BW	bathing water
CAFO	confined animal feeding operation
CFR	Code of Federal Regulations
cfs	cubic feet per second
Corps	United States Army Corps of Engineers
CREP	Conservation Reserve Enhancement Program (USDA program)
CRP	Conservation Reserve Program (USDA program)
CSO	combined sewer overflow
CSP	Conservation Security Program (USDA program)
CWA	Clean Water Act
CWH	coldwater habitat
D.O.	dissolved oxygen
DA	drainage area
DMR	discharge monitoring report
DNAP	Division of Natural Areas and Preserves (part of ODNR)
DOW	Division of Wildlife (part of ODNR)
DSW	Division of Surface Water (part of Ohio EPA)
DSWC	Division of Soil and Water Conservation (part of ODNR)
ECBP	Eastern Corn Belt Plains (ecoregion)
EPA	Environmental Protection Agency, see U.S. EPA
EQIP	Environmental Quality Incentive Plan (USDA program)
EWH	exceptional warmwater habitat
FCA	fish consumption advisory
FFY	federal fiscal year (October 1 to September 30)
FSA	Farm Service Agency
FWPCA	Federal Water Pollution Control Act
gpd	gallons per day
GRP	Grassland Reserve Program (USDA program)
HELP	Huron Erie Lake Plain (ecoregion)
HSTS	home sewage treatment system
HU	hydrologic unit
HUC	hydrologic unit code
I/I	infiltration and inflow
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
IR	Integrated Report
IWS	industrial water supply
kg	kilogram
L	liter
LA	load allocation
LaMP	Lakewide Management Plan
LEC	(Ohio) Lake Erie Commission

LEL	lowest effect level
LEPF	Lake Erie Protection Fund (LEC program)
LRAU	large river assessment unit
LRW	limited resource water
LTCP	long-term control plan
mg	milligram
MGD	million gallons per day
MHP	mobile home park
MIwb	Modified Index of well being
mi^2	square miles
ml	milliliter
MOS	margin of safety
MPN	most probable number
MS4	municipal separate storm sewer system
MWH	modified warmwater habitat
n	number (of data points in a grouping)
NHD	National Hydrography Dataset
NOI	notice of intent
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NRCS	Natural Resource Conservation Service
OAC	Ohio Administrative Code
ODA	Ohio Department of Agriculture
ODH	Ohio Department of Health
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
OEPA	Ohio Environmental Protection Agency
Ohio EPA	Ohio Environmental Protection Agency (preferred nomenclature)
ORC	Ohio Revised Code
ORSANCO	Ohio River Valley Water Sanitation Commission
OSC	on-site coordinator
OSUE	Ohio State University Extension
OWDA	Ohio Water Development Authority
OWRC	Ohio Water Resources Council
PAHs	polyaromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCR	primary contact recreation
PEC	probable effect concentration
PDWS	public drinking water supply
PEC	probable effect concentration
ppb	parts per billion
PS	point source
PTI	permit to install
PTO	permit to operate
PWS	public water supply
QA	quality assurance
QC	quality control
QHEI	qualitative habitat evaluation index
RM	river mile
SCR	secondary contact recreation
SDWA	Safe Drinking Water Act

SEL	severe effect level
SFY	state fiscal year (July 1 to June 30)
SMP	sludge management plan
sq mi	square miles
SRW	state resource water
SSH	seasonal salmonid habitat
SSM	single-sample maximum
SSO	sanitary sewer overflow
STORET	STOrage and RETrieval (a U.S. EPA water quality database)
SWIMS	Surface Water Information Management System
SWCD	Soil and Water Conservation District
TEC	threshold effect concentration
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily load
TOC	total organic carbon
TSS	total suspended solids
ug	microgram
µg	microgram
U.S. EPA	United States Environmental Protection Agency
UAA	use attainability analysis
USACOE	United States Army Corps of Engineers
USC	United States Code
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VOC	volatile organic compound
WAU	watershed assessment unit
WHIP	Wildlife Habitat Incentives Program (USDA program)
WLA	wasteload allocation
WPCLF	Water Pollution Control Loan Fund
WQ	water quality
WQS	water quality standards
WRP	Wetland Reserve Program (USDA program)
WRRSP	Water Resource Restoration Sponsor Program (Ohio EPA program)
WTP	water treatment plant
WWH	warmwater habitat
WWTP	wastewater treatment plant

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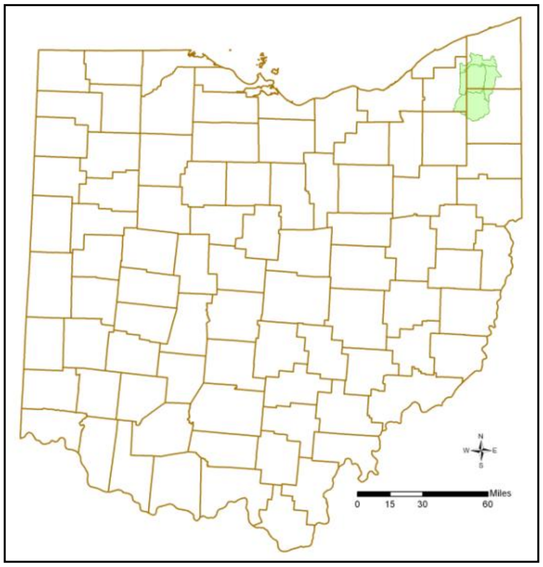
Executive Summary

The Grand River (upper) watershed is located in northeast Ohio extending from north of Warren to south of Rock Creek. This 417.5-square mile watershed area is home to more than 63,300 people and encompasses all or part of six municipalities in Trumbull, Ashtabula, Geauga and Portage counties. The watershed is primarily forested and cultivated crops with 6.3 percent being developed.



Statewide map of the Grand River (upper) watershed with the TMDL project area highlighted.

In 2007, Ohio EPA sampled 57 sites on streams in this watershed. Data collected related to water and sediment quality, aquatic biological communities, and habitat. Ohio's water quality standards were compared with these data to determine if quality criteria for various designated beneficial uses are being met.

Overall the watershed met criteria for the recreation use at 16%, 63% for aquatic life uses and 100% for the public drinking water supply use. The causes of impairments include natural conditions, direct habitat alterations, nutrients, low flow alterations, total dissolved solids and bacteria. Sources of these stressors include natural sources for natural causes, channelization and construction for direct habitat alterations, unsewered areas and a dam or impoundment for nutrients and low flow alterations, unsewered areas and unknown sources for total dissolved solids, and failing home sewage treatment systems, livestock and unknown sources for bacteria.

Total maximum daily loads (TMDL) have been developed for pollutants and stressors that have impaired beneficial uses and precluded attainment of applicable water quality standards. Specific TMDLs that have been developed and are described in this report include:

- Nutrients (total Kjeldahl nitrogen, total phosphorus, ammonia)
- Total dissolved solids
- *E. coli* bacteria

The needed load reductions ranged from 0 to 97% for *E. coli*, 28.0% for total dissolved solids, 9.41 to 93.3% for total phosphorus, 58 to 65% for total Kjeldahl nitrogen and 21.1% for ammonia. Nonpoint sources of the pollutants have been allocated the most significant reductions.

Recommendations for regulatory action resulting from this TMDL analysis include lower effluent limits for total phosphorus, total Kjeldahl nitrogen and ammonia. Nonpoint sources of direct habitat alterations should be addressed by bank and riparian restoration, stream restoration and investigation into dam modification or removal; for nutrients, total dissolved solids and bacteria by tying unsewered areas into sewer systems where feasible and further investigation sources in some locations; and for bacteria by inspecting and replacing or repairing failing home sewage treatment systems and agricultural best management practices. In some cases of natural impairment, wetland restoration and/or conservation easements may improve water quality.

1 INTRODUCTION

The Grand River (upper) watershed is located in northeast Ohio extending from north of Warren to south of Rock Creek. This 417.5-square mile watershed area is home to more than 63,300 people and encompasses all or part of six municipalities in Trumbull, Ashtabula, Geauga and Portage counties. Ohio EPA comprehensively sampled biology, habitat and chemistry in 2007. Non-attainment of aquatic life use criteria tended to result from natural conditions (flow or habitat), nutrients and total dissolved solids. Partial attainment of aquatic life use criteria predominantly resulted from natural conditions (flow or habitat), direct habitat alterations and nutrients and organic enrichment. Impairment by bacteria was widespread throughout the watershed. The most common sources of impairment included natural sources, channelization and sewage discharges in unsewered areas.

1.1 The Clean Water Act Requirement to Address Impaired Waters

The Clean Water Act (CWA) Section 303(d) requires States, Territories, and authorized Tribes to list and prioritize waters for which technology-based limits alone do not ensure attainment of water quality standards. Lists of these impaired waters (the Section 303(d) lists) are made available to the public for comment, then submitted to the U.S. Environmental Protection Agency (U.S. EPA) for approval in even-numbered years. Further, the CWA and U.S. EPA regulations require that total maximum daily loads (TMDLs) be developed for all waters on the Section 303(d) lists. The Ohio EPA identified the Grand River (upper) watershed (assessment units 04110004 01 01 through 01 06; 02 01 through 02 03; 03 01 through 03 05; and 05 01 through 05 02) as impaired on the 2012 303(d) list (Ohio EPA 2012; available at http://epa.ohio.gov/dsw/tmdl/OhioIntegratedReport.aspx).

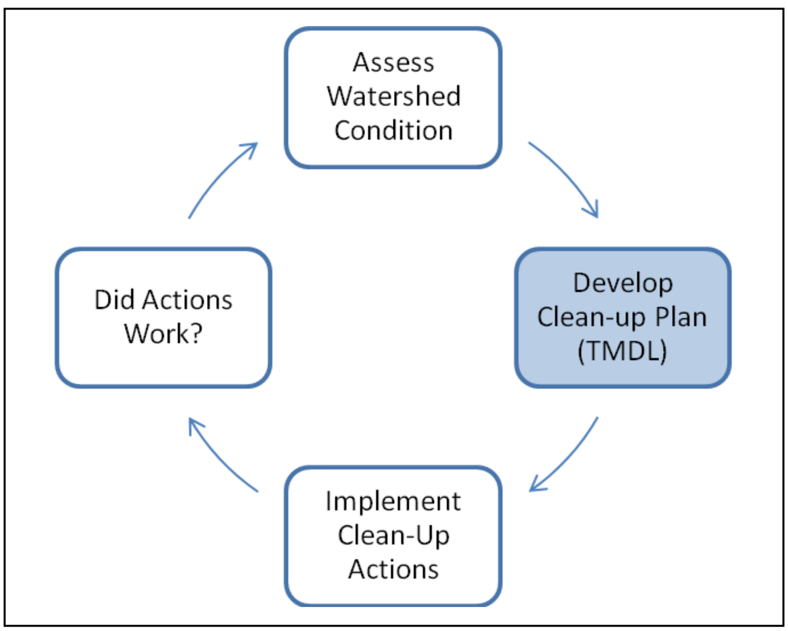


Figure 1-1. Overview of the TMDL project process.

In the simplest terms, a TMDL can be thought of as a cleanup plan for a watershed that is not meeting water quality standards. A TMDL is defined as a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards and an allocation of that quantity among the sources of the pollutant. Ultimately, the goal of Ohio's TMDL process is full attainment of water quality standards (WQS), which would subsequently lead to the removal of the waterbodies from the 303(d) list. Figure 1-1 shows the phases of TMDL development in Ohio.

Table 1-1 summarizes how the impairments identified in the Grand River (upper) watershed are addressed in this TMDL report.

Table 1-1. Summary of impairments in the Grand River (upper) watershed and methods used to address impairments.

Assessment Unit (04110004)	Narrative Description	Causes of Impairment[1]	Action Taken
Headwaters Grand River (04110004 01)			
01 01 *Priority points: 6*	Dead Branch	Insufficient data to assess (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
01 02 *Priority points:11*	Headwaters Grand River	Direct habitat alterations (ALU)	Habitat TMDL
		Bacteria (RU)	Bacteria TMDL
		No impairment (PDWSU)	No action necessary
01 03 *Priority points:6*	Baughman Creek[2]	Natural conditions (flow or habitat) (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
01 04 *Priority points:6*	Center Creek-Grand River	Ammonia (total) (ALU)	TKN[3] TMDL as surrogate
		Total Kjeldahl nitrogen (ALU)	TKN TMDL
		Total dissolved solids (ALU)	TKN TMDL as surrogate
		Organic enrichment (sewage) biological indicators) (ALU)	TKN TMDL as surrogate
		Natural (flow or habitat) (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
01 05 *Priority points:8*	Coffee Creek-Grand River	No impairment (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
01 06 *Priority points:5*	Swine Creek	No impairment (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
Rock Creek (04110004 02)			
02 01 *Priority points:5*	Upper Rock Creek	Insufficient data to assess (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
02 02 *Priority points:7*	Middle Rock Creek	Total dissolved solids (ALU)	TDS TMDL
		Nutrient/eutrophication biological indicators (ALU)	TP[4] TMDL
		Bacteria (RU)	Bacteria TMDL

Assessment Unit (04110004)	Narrative Description	Causes of Impairment[1]	Action Taken
02 03 *Priority points:5*	Lower Rock Creek	Low flow alterations (ALU)	Not addressed
		Nutrient/eutrophication biological indicators (ALU)	TP TMDL
		Total dissolved solids (ALU)	Ammonia TMDL as surrogate
		Ammonia (total) (ALU)	Ammonia TMDL
		Bacteria (RU)	Bacteria TMDL
Phelps Creek-Grand River (04110004 03)			
03 01 *Priority points:5*	Phelps Creek[2]	Natural conditions (flow or habitat)	No action necessary
		Bacteria (RU)	Bacteria TMDL
03 02 *Priority points:9*	Hoskins Creek	Direct habitat alterations (ALU)	Habitat TMDL
		Natural conditions (flow or habitat) (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
03 03 *Priority points:10*	Mill Creek-Grand River	Low flow alterations (ALU)	Not addressed
		Natural conditions (flow or habitat) (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
03 04 *Priority points:10*	Mud Creek	Direct habitat alterations (ALU)	Habitat TMDL
		Bacteria (RU)	Bacteria TMDL
03 05 *Priority points:7*	Plum Creek-Grand River	No impairment (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
Three Brothers Creek-Grand River (04110004 05)			
05 01 *Priority points:8*	Three Brothers Creek-Grand River[2]	Natural conditions (flow or habitat) (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL
05 02 *Priority points:6*	Bronson Creek-Grand River[2]	Natural conditions (flow or habitat) (ALU)	No action necessary
		Bacteria (RU)	Bacteria TMDL

[1] ALU = aquatic life use
RU = recreation use
[2] The category for aquatic life use is 4n (natural causes and sources only).
[3] TKN stands for total Kjeldahl nitrogen.
[4] TP stands for total phosphorus.

1.2 Public Involvement

Public involvement is fundamental to the success of water restoration projects, including TMDL efforts. From the beginning, Ohio EPA has invited participation in all aspects of the TMDL program. The Ohio EPA convened an external advisory group in 1998 to assist the Agency with the development of the TMDL program in Ohio. The advisory group issued a report in July 2000 to the Director of Ohio EPA on their findings and recommendations. The Grand River (upper) watershed TMDL project has been completed using the process endorsed by the advisory group.

Ohio EPA met with the Grand River watershed coordinator (working out of Western Reserve Land Conservancy) to discuss implementation recommendations for Section 6 in November 2011.

Consistent with Ohio♣s current Continuous Planning Process (CPP), the draft TMDL report was available for public comment from September 18 through October 18, 2012. A copy of the draft report was posted on Ohio EPA♣s web page (http://epa.ohio.gov/dsw/tmdl/index.aspx).

Continued public involvement is essential to the success of any TMDL project. Ohio EPA will continue to support the implementation process and will facilitate, to the fullest extent possible, restoration actions that are acceptable to the communities and stakeholders in the study area and to Ohio EPA. Ohio EPA is reluctant to rely solely on regulatory actions and strongly upholds the need for voluntary actions facilitated by the local stakeholders, watershed organization, and agency partners to restore the Grand River (upper) watershed.

1.3 Organization of Report

Chapter 2 gives an overview of water quality standards applicable in the watershed. Chapter 3 gives an overview of the water quality conditions in the watershed. Chapter 4 briefly discusses the methods used to calculate load reductions. Chapter 5 provides the load reduction results. Chapter 6 discusses suggested restoration methods to improve water quality.

More detailed information on selected topics is contained in appendices. Appendix A lists the permitted facilities in the watershed. Appendix B summarizes the findings of the watershed survey. Appendix C is a primer on Ohio's water quality standards. Appendix D contains details of the loading analysis. Appendix E discusses programs and actions available to improve water quality.

Readers may also wish to consult the technical glossary and background information available on Ohio EPA's TMDL Web page (http://epa.ohio.gov/dsw/tmdl/index.aspx).

2 CHARACTERISTICS AND EXPECTATIONS OF THE WATERSHED

The Grand River (upper) watershed is located in northeast Ohio, extending from north of Warren to south of Rock Creek. This 417.5-square mile watershed area encompasses all or part of six municipalities (Orwell, Roaming Shores, Rock Creek, West Farmington, Middlefield and Champion Heights) in Trumbull, Ashtabula, Geauga and Portage counties.

2.1 Watershed Characteristics

The following subsections provide an overview of the characteristics of the Grand River (upper) watershed.

2.1.1 Population and Distribution

According to the 2000 U.S. Census, the total population for the Grand River (upper) watershed was over 63,000 people. The 2010 U.S. Census showed small increases in the populations of Geauga and Portage counties and decreases in the populations of Trumbull and Ashtabula counties. Population concentrations in 2000 were slightly higher in the southern and eastern portions of the watershed (Figure 2-1).

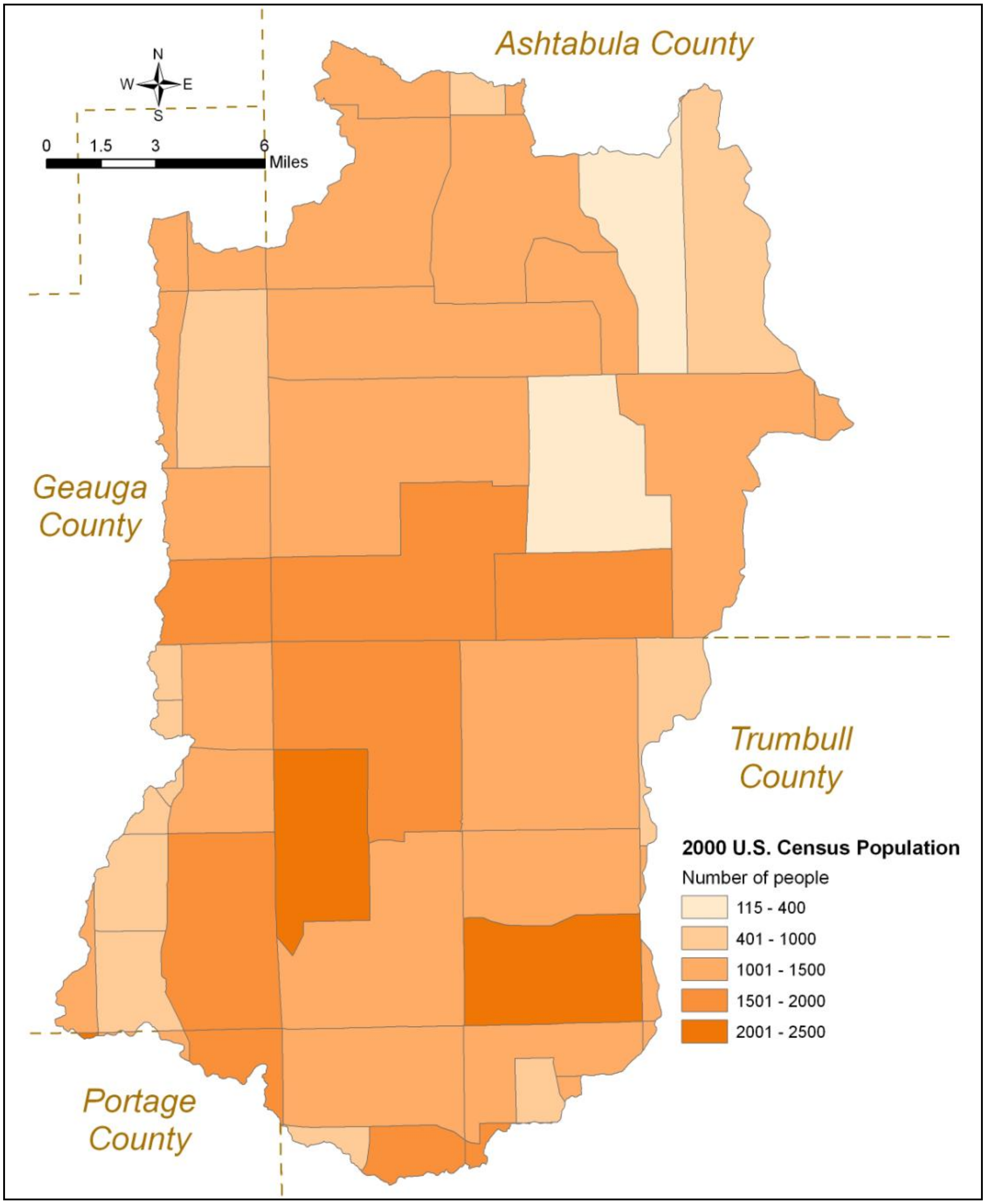


Figure 2-1. Population per block for the Grand River (upper) watershed (source: 2000 U.S. Census).

2.1.2 Land Use

Land use in the Grand River (upper) watershed is dominated by forest (41.5%), cultivated crops and pasture lands (36.1%), and wetlands (8.9%). A large complex of wetlands is located near the center of the watershed (Figure 2-2). Forest and agricultural lands are spread throughout the watershed. Developed land (6.3%) is primarily located in the northern portion of the watershed, near Rock Creek and Roaming Shores, and near West Farmington.

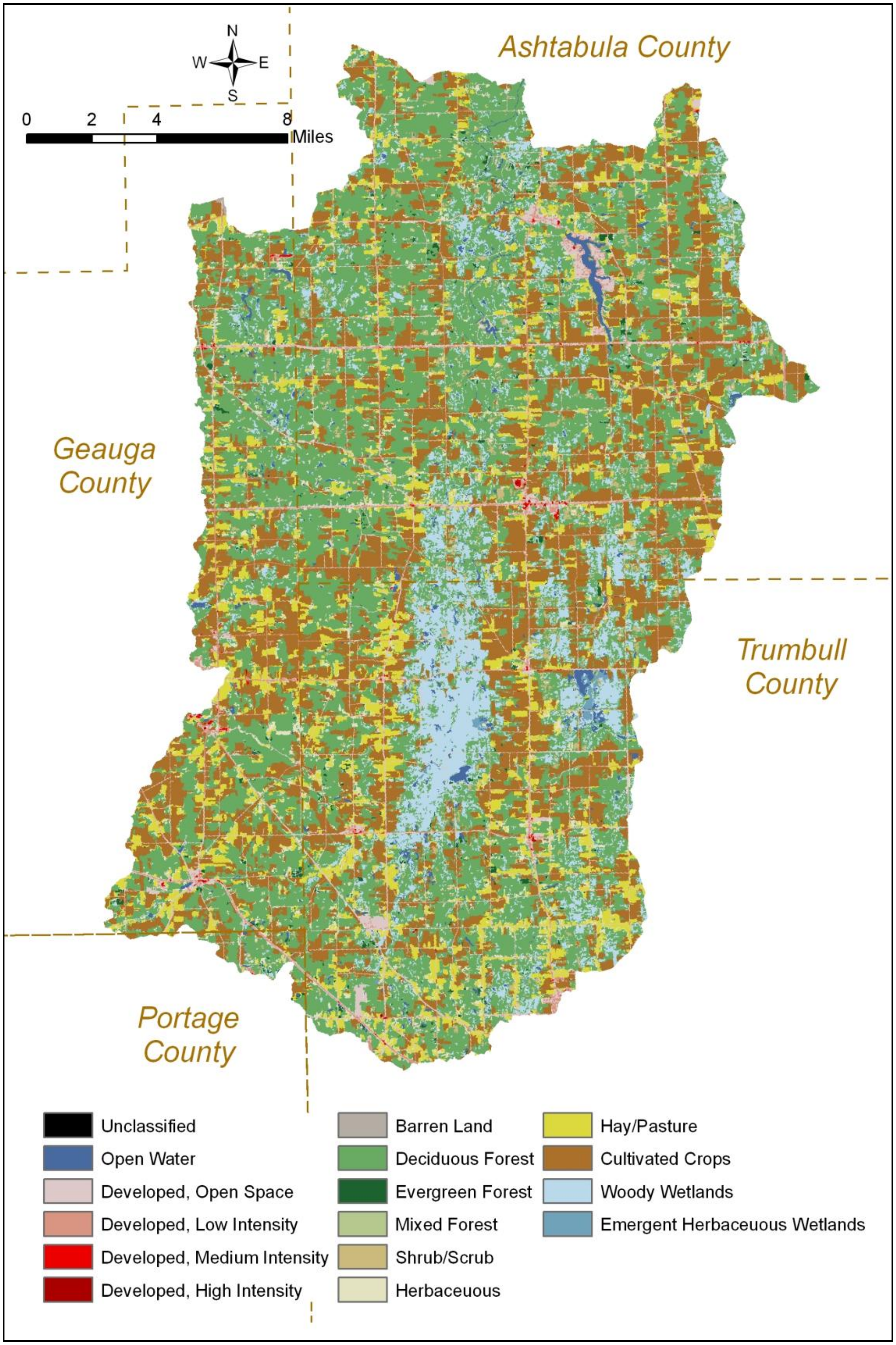


Figure 2-2. Land use in the Grand River (upper) watershed (source: 2006 National Land Cover Dataset).

2.1.3 Point Source Discharges

Industrial and municipal point sources include wastewater treatment plants and factories. Wastewater treatment plants can contribute to bacteria, nutrient enrichment, siltation, and flow alteration problems. Industrial point sources, such as factories, sometimes discharge water that is excessively warm or cold, changing the temperature of the stream. Point sources may contain other pollutants such as chemicals, metals and silt.

NPDES dischargers are entities that possess a permit through the National Pollutant Discharge Elimination System (NPDES). NPDES permits limit the quantity of pollutants discharged and impose monitoring requirements. NPDES permits are designed to protect public health and the aquatic environment by helping to ensure compliance with state and federal regulations. NPDES entities generally discharge wastewater continuously. They primarily affect water quality under average- to low-flow conditions because the potential for dilution is lower. NPDES dischargers located near the origin of a stream or on a small tributary are more likely to cause severe water quality problems because their effluent can dominate the natural stream flow. Appendix A lists the NPDES permittees in the Grand River (upper) watershed.

Municipal wastewater treatment plants are scattered throughout the watershed. Industrial permitted facilities tend to be concentrated around municipal areas such as Middlefield and Orwell. The total design flow of all individual non-storm water facilities is 1.22 million gallons per day (MGD). There are no major dischargers (design flows of more than 1 MGD) in the watershed. There are six industrial facilities, twenty-four municipal wastewater treatment plants, one small sanitary general permit, and four small sanitary dischargers that cannot meet best available demonstrated control technology (BADCT) general permits.

There are no confined animal feeding operations or combined sewer overflows in the watershed. General construction storm water is minimal because of the slower population growth in the watershed.

2.1.4 Public Drinking Water Supplies

Some communities supply public drinking water from ground water (underground aquifers). Other communities supply public drinking water by withdrawing water from surface waters, including lakes and streams. A surface water public drinking water supply for the community of West Farmington is located in the Grand River (upper) watershed. More details are available in Appendix B.

2.2 Water Quality Standards

TMDLs are required when a waterbody fails to meet water quality standards (WQS). Every state must adopt WQS to protect, maintain, and improve the quality of the nation's surface waters. WQS represent a level of water quality that will support the Clean Water Act goal of swimmable and fishable waters. Ohio's WQS, set forth in Chapter 3745-1 of the Ohio Administrative Code (OAC), include three major components: beneficial use designations, criteria and antidegradation provisions. Where criteria have not been developed, the State can develop project-specific targets.

Beneficial use designations describe the existing or potential uses of a waterbody, such as public water supply; protection and propagation of aquatic life; and recreation in and on the water. Ohio EPA assigns beneficial use designations to each waterbody in the state. Use designations are defined in paragraph (B) of rule 3745-1-07 of the OAC and are assigned in rules 3745-1-08 to 3745-1-32. Attainment of uses is based on specific numeric and narrative criteria.

Numeric criteria are estimations of chemical concentrations, degree of aquatic life toxicity, and physical conditions allowable in a waterbody without adversely impacting its beneficial uses. Narrative criteria, located in rule 3745-1-04 of the OAC, describe general water quality goals that apply to all surface waters. These criteria state that all waters shall be free from sludge, floating debris, oil, scum, color and odor-producing materials; substances that are harmful to human or animal health; and nutrients in concentrations that may cause excessive algal growth. Narrative "free froms," also located in rule 3745-1-04 of the OAC, are general water quality criteria that apply to all surface waters. These criteria state that all waters shall be free from sludge, floating debris, oil and scum, color and odor producing materials, substances that are harmful to human, animal or aquatic life, and nutrients in concentrations that may cause algal blooms. Much of Ohio EPA's present strategy regarding water quality based permitting is based upon the narrative free from of "no toxics in toxic amounts." Ohio EPA developed its strategy based on an evaluation of the potential for significant toxic impacts within the receiving waters. Very important components of this evaluation are the biological survey program and the biological criteria used to judge aquatic life use attainment.

Antidegradation provisions describe the conditions under which water quality may be lowered in surface waters. Under such conditions water quality may not be lowered below criteria protective of existing beneficial uses unless lower quality is deemed necessary to allow important economic or social development. Antidegradation provisions are in Sections 3745-1-05 and 3745-1-54 of the OAC.

The following sub-sections describe the applicable water quality standards for the Grand River (upper) watershed. Further details can be found in Appendix C.

2.2.1 Aquatic Life Use

Ohio's WQS have seven subcategories of aquatic life uses (see http://epa.ohio.gov/portals/35/rules/01-07.pdf). Those that apply to the Grand River (upper) watershed are shown in Figure 2-3. The WQS rule contains a narrative for each aquatic life use and the three most commonly assigned aquatic life uses have quantitative, numeric biological criteria that express the minimum acceptable level of biological performance based on three separate biological indices (Table 2-1). The indices measure the health of aquatic communities of both fish and insects.

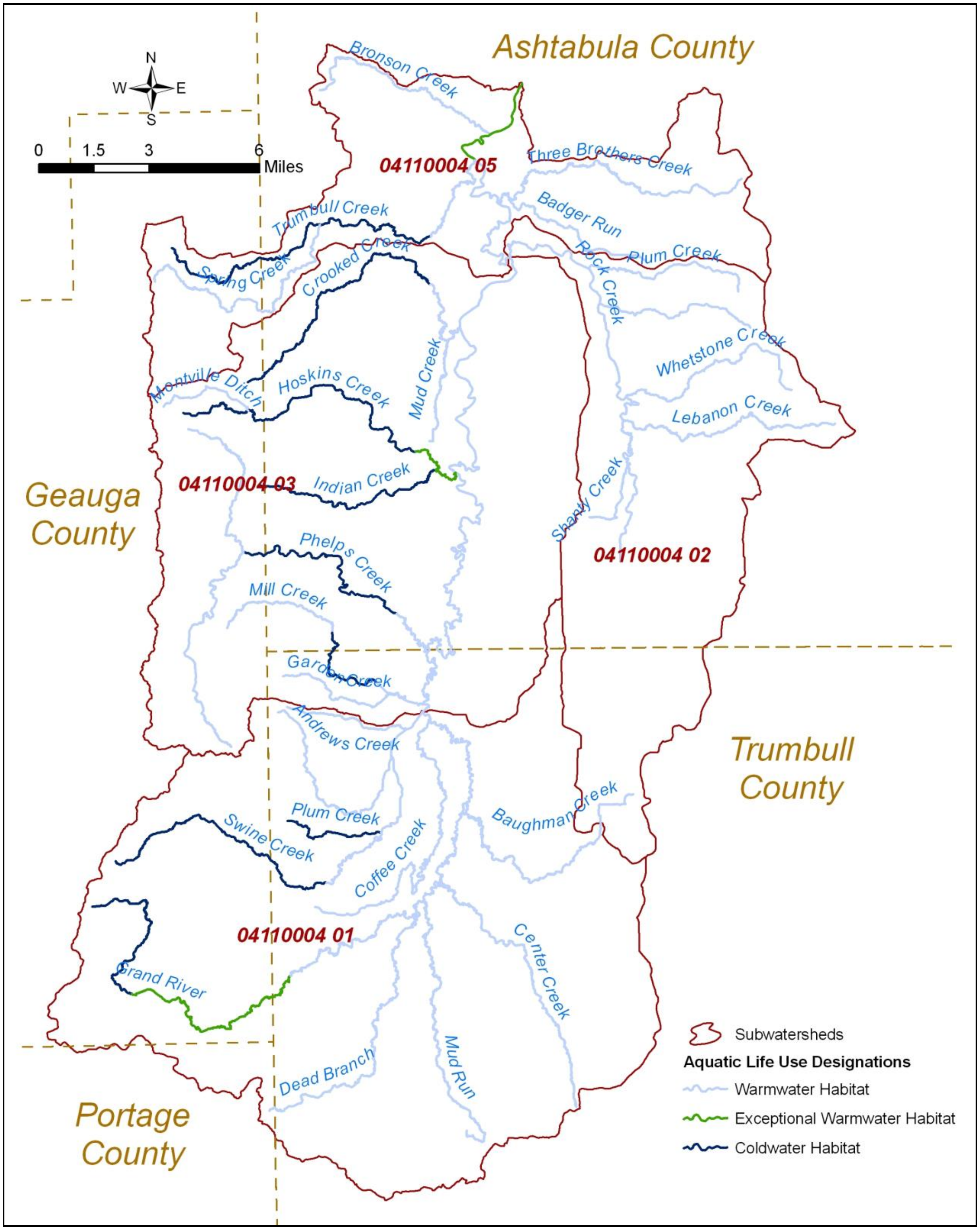


Figure 2-3. Aquatic life use designations in the Grand River (upper) watershed.

Table 2-1. Biological criteria applicable in the Grand River (upper) watershed.

Biological Index[1]	Assessment Method[2, 3]	Biological Criteria for the Applicable Aquatic Life Use Designations[4]	
		Warmwater Habitat	Exceptional Warmwater Habitat
IBI	Headwater	40	50
	Wading	38	50
	Boat	40	48
MIwb	Wading	7.9	9.4
	Boat	8.7	9.6
ICI	All[5]	34	46

[1] IBI stands for Index of Biotic Integrity; MIwb stands for Modified Index of Wellbeing; ICI stands for Invertebrate Community Index.

[2] The assessment method used at a site is determined by its drainage area (DA) according to the following: Headwater: DA ≤ 20 mi^2; wading: DA >20 mi^2 and ≤ 500 mi^2; boat: DA > 500 mi^2

[3] MIwb not applicable to drainage areas less than 20 mi^2.

[4] Coldwater habitats (CWH), limited warmwater habitat (LWH), resource waters (LRW) and seasonal salmonid habitat (SSH) do not have associated biological criteria.

[5] Limited to sites with appropriate conditions for artificial substrate placement.

2.2.2 Recreation Use

Ohio's WQS have three subcategories of recreation uses (bathing waters, primary contact and secondary contact). Uses that apply to the Grand River (upper) watershed are shown in Figure 2-4. Within primary contact there are three classes of streams (A, B and C) that describe the general frequency with which the stream is used for recreation. The WQS rule contains a description of each recreation use and all primary contact recreation classes have numeric criteria that are associated with a statistically-based risk level (Table 2-2).

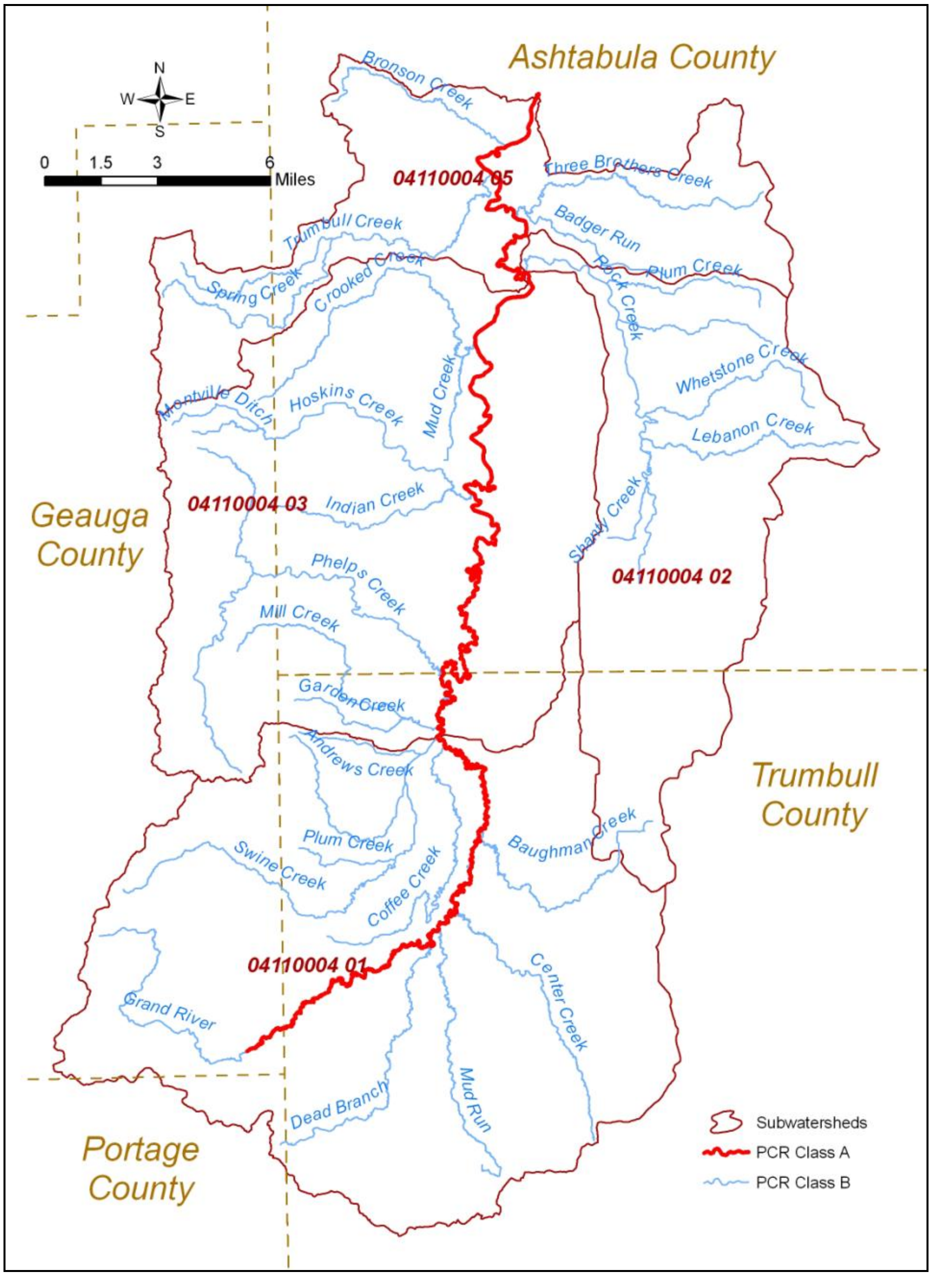


Figure 2-4. Recreation use designations in the Grand River (upper) watershed.

Table 2-2. Recreation use criteria for Ohio.

Recreation Use	*E. coli* (colony forming units per 100 ml)	
	Seasonal Geometric Mean	Single Sample Maximum[1]
Bathing water	126	235[a]
Class A primary contact recreation	126	298
Class B primary contact recreation	161	523
Class C primary contact recreation	206	940
Secondary contact recreation	1030	1030

[1] Except as noted in footnote *a*, these criteria shall not be exceeded in more than ten per cent of the samples taken during any thirty-day period.

[a] This criterion shall be used for the issuance of beach and bathing water advisories.

2.2.3 Public Drinking Water Supply Use

The public drinking water supply use includes surface waters from which public drinking water is supplied. This beneficial use provides an opportunity to strengthen the connection between Clean Water Act and Safe Drinking Water Act (SDWA) activities by employing the authority of the CWA to meet SDWA objectives of source water protection and reduced risk to human health. Criteria associated with this use designation apply within five hundred yards of surface water intakes. The public drinking water supply intake for West Farmington is shown in Figure 2-5. The beneficial use is supported at this location.

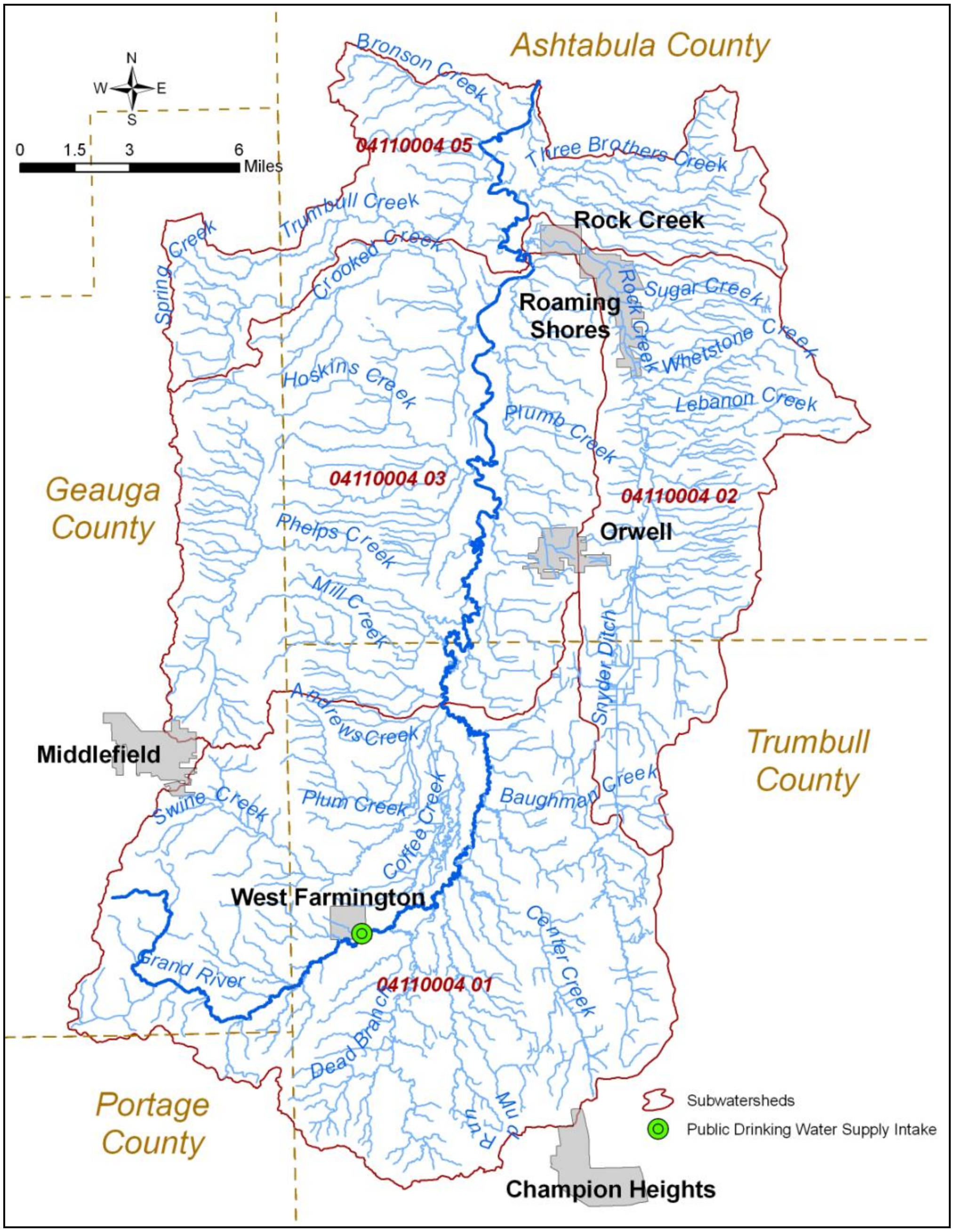


Figure 2-5. Location of the public drinking water supply intake in the Grand River (upper) watershed.

2.2.4 Human Health (Fish Contaminants) Use

Ohio has adopted human health WQS criteria to protect the public from adverse impacts, both carcinogenic and non-carcinogenic, caused by exposure via drinking water (applicable at public water supply intakes) and by exposure in the contaminated flesh of sport fish (applicable in all surface waters). The latter criterion, called the non-drinking water human health criterion, ensures that levels of a chemical in water do not bioaccumulate in fish to levels harmful to people who catch and eat the fish. Ohio measures contaminants in fish tissue and uses the data in two comparisons: (1) to determine if the human health criteria are being violated, thus identifying the water for restoration through a TMDL or other action, or (2) to determine the quantity of sport fish that may be safely consumed. The first comparison can result in the water being identified as impaired on the 303(d) list; the second can result in the issuance of a sport fish consumption advisory.

Three nested subwatersheds had new fish tissue data collected during 2007 (04110004 02 02, 03 05 and 05 02); see this link for details: http://wwwapp.epa.ohio.gov/dsw/ir2012/watershed.php?id=04110004. Two of these nested subwatersheds were attaining human health criteria; the third was not and was impaired by mercury.

Mercury is a ubiquitous contaminant in streams throughout the U.S.; its primary source is thought to be mercury deposited from the atmosphere. Mercury as a surface water pollutant is being addressed in a variety of ways outside of the traditional TMDL process, including limits on mercury emissions from air sources, mercury take-back programs, and legislation prohibiting the sale of most mercury-containing products. Unless there are known or suspected local surface water sources of mercury, mercury is best addressed outside of the individual watershed TMDL framework.

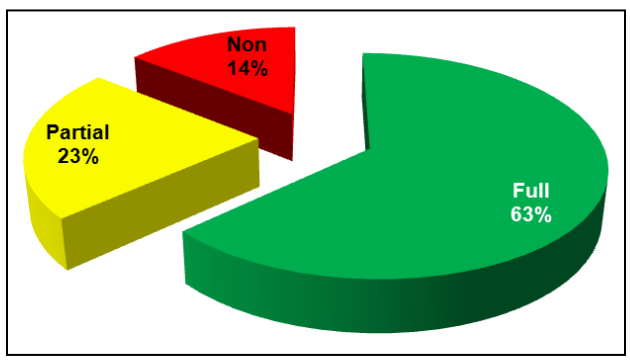
The Grand River (upper) watershed is included in the statewide fish advisory for mercury. Additional advisories specific to the Grand River (upper) watershed exist. Information regarding fish consumption advisories can be found at: http://epa.ohio.gov/dsw/fishadvisory/index.aspx.

3 WATER QUALITY CONDITIONS IN THE WATERSHED

Ohio uses the fish and aquatic insects that live in streams to assess the health of Ohio's flowing waters. Aquatic animals are generally the most sensitive indicators of pollution because they inhabit the water all of the time. A healthy stream community is also associated with high quality recreational opportunities (e.g., fishing and boating).

In addition to biological data, Ohio EPA collects information on the chemical quality of the water, sediment, and wastewater discharges; data on the contaminants in fish flesh; and physical information about streams. Taken together, this information identifies the factors that limit the health of aquatic life and that constitute threats to human health.

Ohio EPA performed a comprehensive water quality study in the Grand River (upper) watershed in 2007. Fifty-seven sites were studied for biological health, 57 sites for water chemistry, 56 sites for recreation use, and three sites for human health (fish contaminants) use; in addition, several samples were collected in the Grand River main stem in 2004. Sites were scattered throughout the watershed. Please refer to Appendix B for more detail.



Non-attainment of aquatic life use criteria tended to result from natural conditions (flow or habitat), nutrients and total dissolved solids. Partial attainment of aquatic life use criteria predominantly resulted from natural conditions, direct habitat alterations, nutrients and organic enrichment. Sixty-three percent of sites with an attainment analysis fully attained water quality standards (WQS); 23% of sites partially attained water quality standards; and 14% are not attaining water quality standards (see the pie chart above). Non-attaining sites are scattered throughout the watershed, but partially attaining sites were focused in the southern and northern portions of the watershed.

The Grand River (upper) watershed TMDL includes four subwatersheds (Figure 3-1). Within each of the four subwatersheds, smaller watersheds are nested (12-digit assessment units). This chapter discusses conditions in each of the subwatersheds with detail added in unique nested subwatersheds. Overall, impairment for aquatic life use was more common in the eastern and northern areas of the watershed. Impairment for recreation use was widespread throughout the watershed. The most common sources of impairment included natural sources, channelization and sewage discharges in unsewered areas.

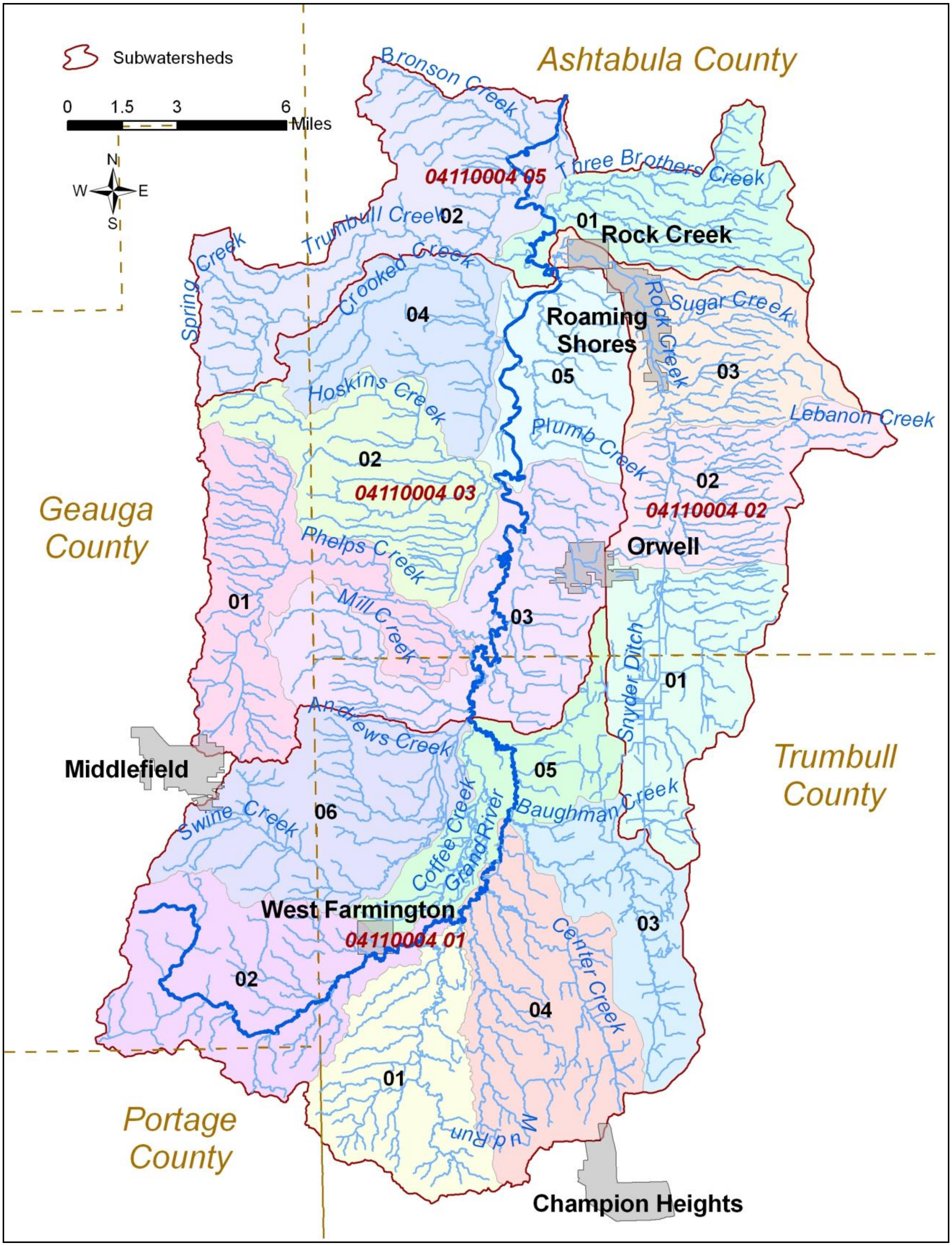


Figure 3-1. Map of the Grand River (upper) watershed.

3.1 Headwaters Grand River (04110004 01)

The Headwaters Grand River subwatershed drains 157 square miles in the southern portion of the watershed (see Figure 3-2). It consists of six nested subwatersheds. The main tributaries to the Grand River include Dead Branch, Center Creek, Deacon Creek, Swine Creek and Coffee Creek. Major causes of impairment include direct habitat alterations, bacteria and natural causes. Those causes are primarily associated with construction and infrastructure changes, livestock and natural sources.

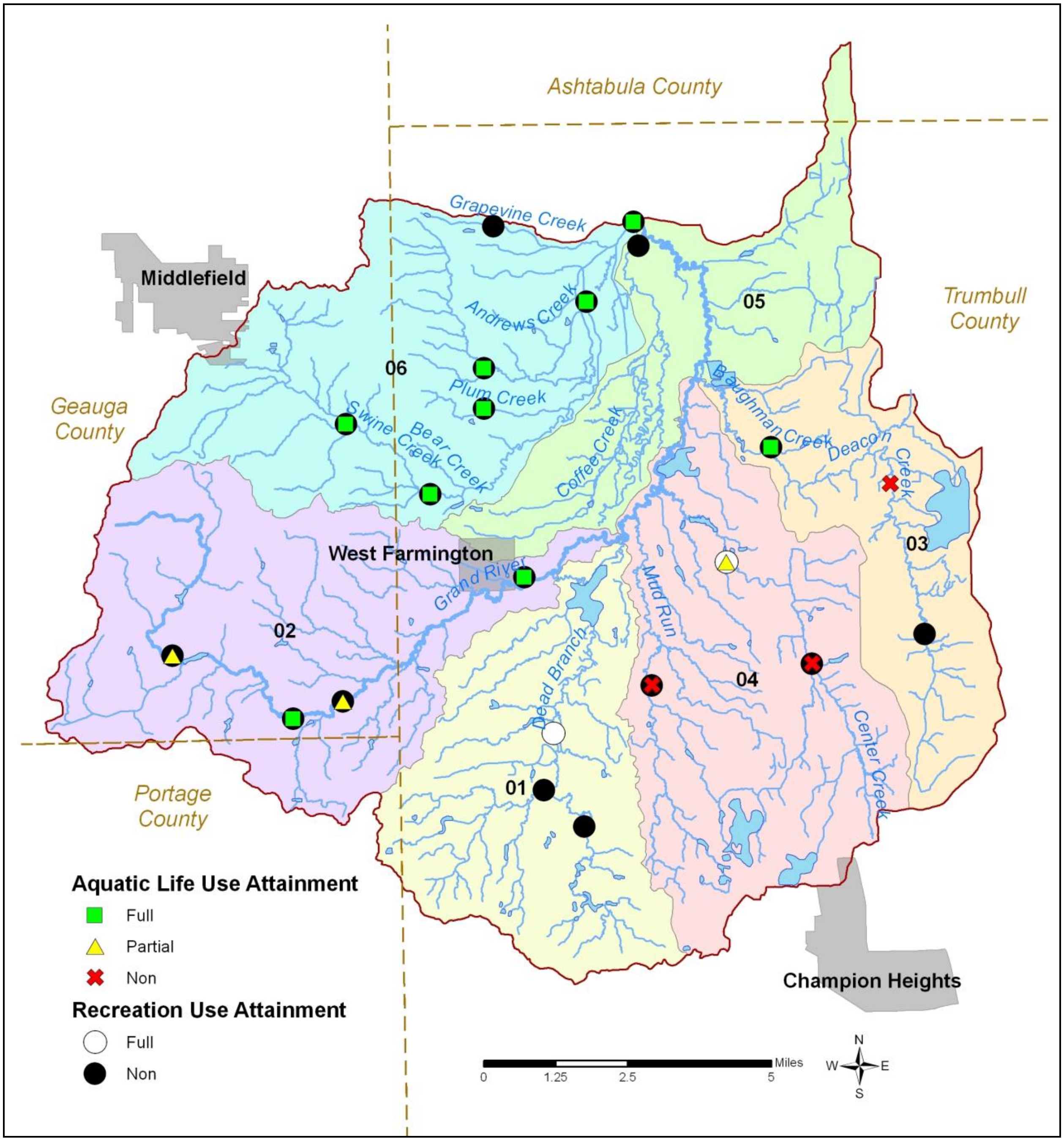


Figure 3-2. Attainment results for the Headwaters Grand River subwatershed.

In most cases, these causes are associated with land uses in the subwatershed (see Appendix C for further information). Figure 3-3 shows land use within the Headwaters Grand River subwatershed.

Within the subwatershed, the Grand River transitions rapidly from a small, upland, coldwater stream to a large, lowland swamp stream. Near the northern subwatershed boundary, at County Line Donley Road, the river begins to support a fauna typical of larger streams and rivers including redhorse suckers and walleye. Because it supports a native population of walleye, sand darters and northern brook lamprey, the river is exceptional. Both Swine and Plumb creeks had stretches of coldwater habitat in the upstream reaches.

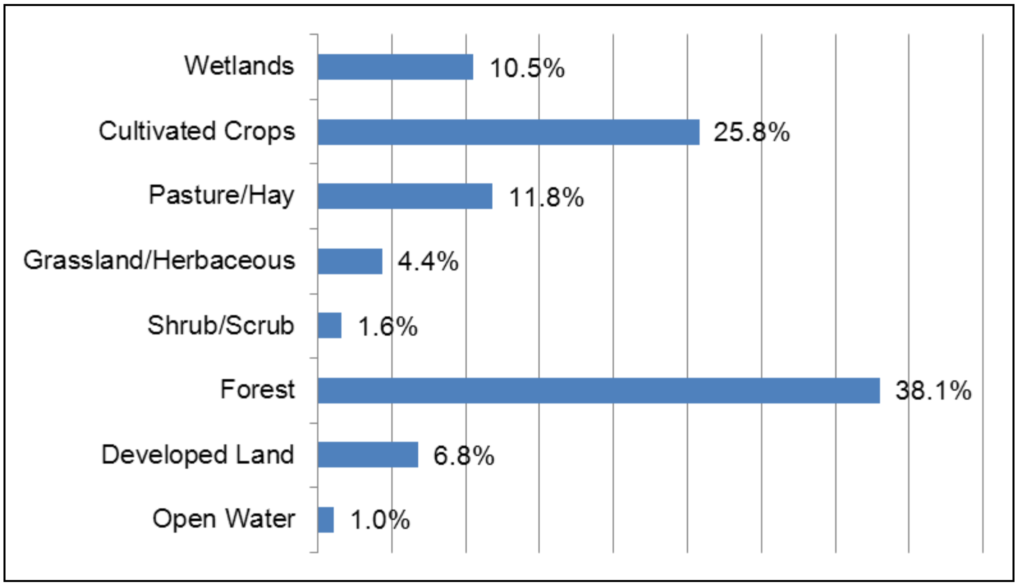


Figure 3-3. Land use in the Headwaters Grand River subwatershed.

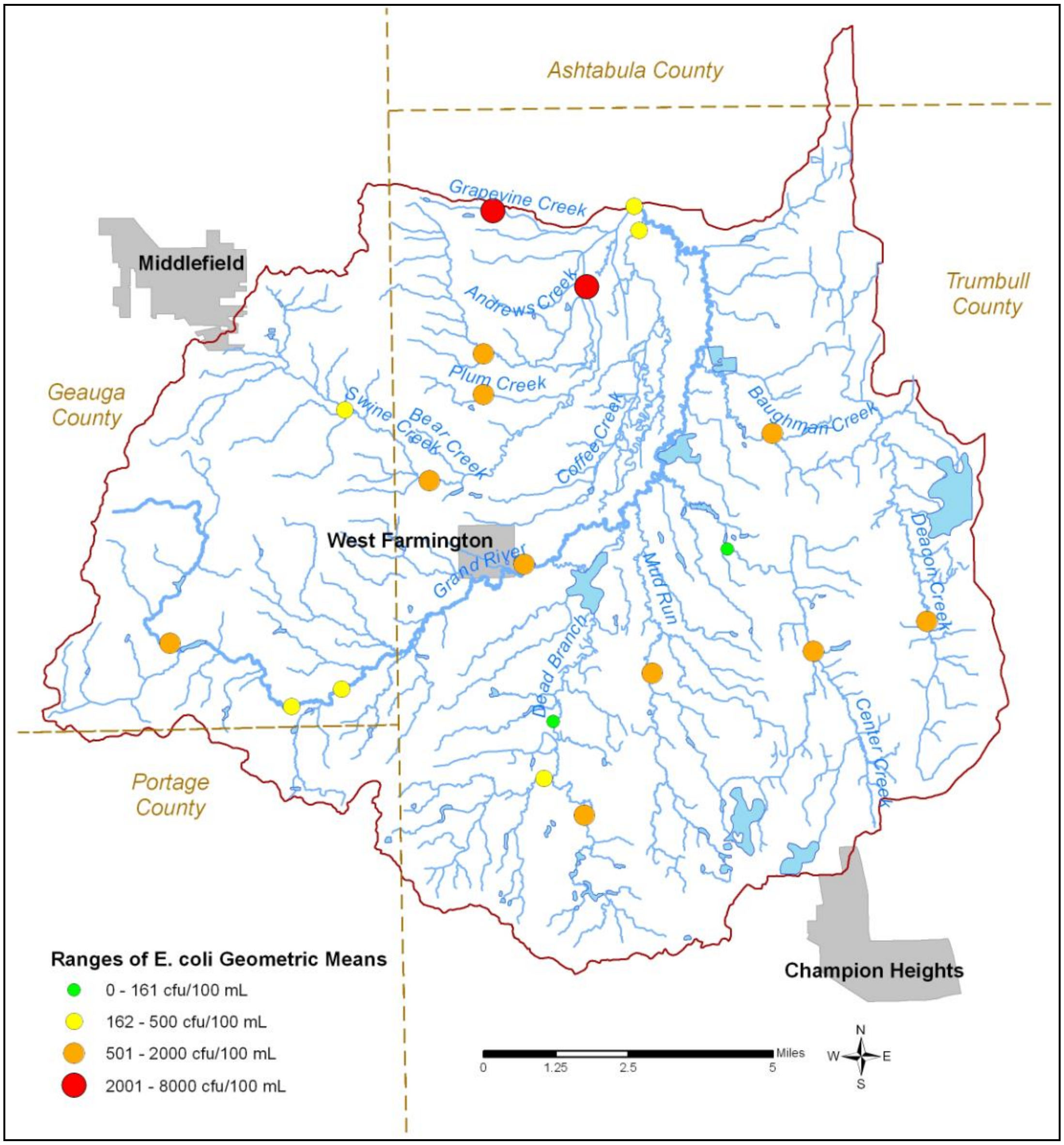


Figure 3-4. Water chemistry results for the Headwaters Grand River subwatershed.

Figure 3-4 shows water chemistry results in the subwatershed. Some of these results aided in identifying causes of aquatic life use impairment. Figure 3-5 shows relative occurrence of causes of aquatic life use impairment in the Headwaters Grand River subwatershed. Figure 3-6 shows the relative occurrence of sources of aquatic life use impairment in the Headwaters Grand River subwatershed.

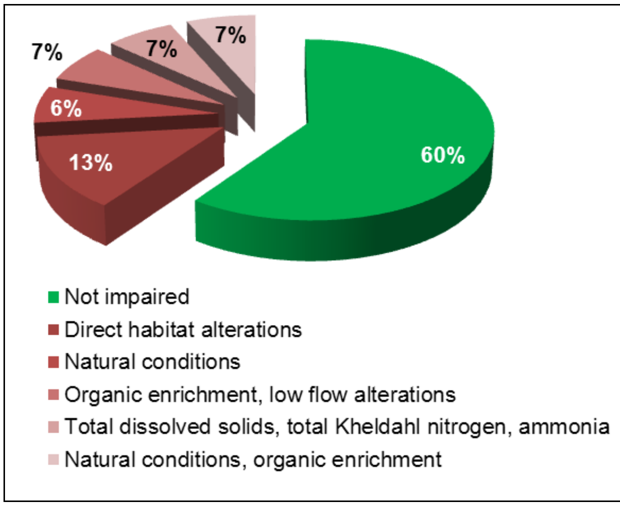


Figure 3-5. Causes of aquatic life use impairment in the Headwaters Grand River subwatershed.

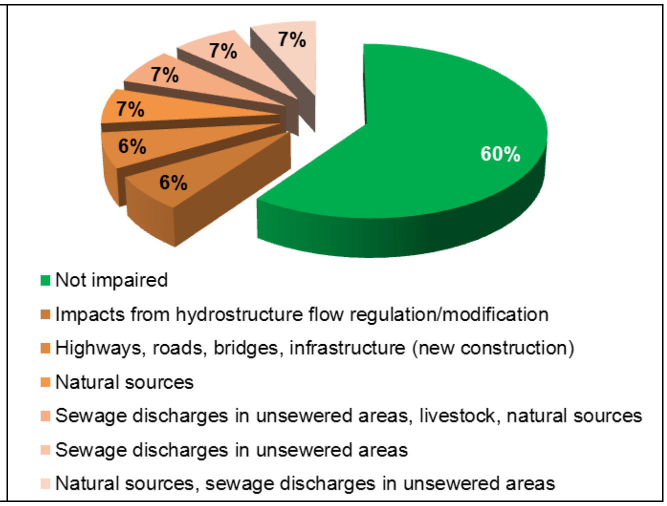


Figure 3-6. Sources of aquatic life use impairment in the Headwaters Grand River subwatershed.

Table 3-1 shows the site-by-site results for each designated beneficial use organized by nested subwatersheds. For more specific information regarding individual site assessment results and supporting chemistry results, please see Appendix B.

Table 3-1. Number of impaired sites, organized by use and nested subwatershed, in the Headwaters Grand River subwatershed.

Nested Subwatershed (04110004 01)		Aquatic Life Use	Recreation Use	Public Drinking Water Supply Use[1]	Human Health Use[1,2]
01 01	# impaired sites (non/partial)	3i[1]	2	N/A	5h
	Index score[3]	N/A	75	N/A	N/A
01 02	# impaired sites (non/partial)	0/2	4	1	5h
	Index score	66.7	42	N/A	N/A
01 03	# impaired sites (non/partial)	1/0	2	N/A	5h
	Index score	50.0	25	N/A	N/A
01 04	# impaired sites (non/partial)	2/1	2	N/A	5h
	Index score	0.0	50	N/A	N/A
01 05	# impaired sites (non/partial)	0/0	2	N/A	5h
	Index score	100.0	63	N/A	N/A
01 06	# impaired sites (non/partial)	0/0	6	N/A	5h
	Index score	100.0	39	N/A	N/A

1 The number shown is the category from Ohio's 2012 303(d) list (Ohio EPA 2012) for the assessment unit.
2 Impairments to the human health use are not being addressed in this TMDL.
3 The index score (between 0 and 100) indicates the relative support of the aquatic life or recreation use in the nested subwatershed. A score of 100 indicates full support of the use.

Overall QHEI scores ranged from 43.5 to 80.5 in the Headwaters Grand River subwatershed. Where the topography is flat, and the substrates are composed primarily of lacustrine silts and clays, habitat quality is generally poor and not conducive to stream faunas typical of the ecoregion. Headwater streams matching this description are found in the lowlands of the subwatershed. The western half of the subwatershed has high relief, and sediments composed of coarse-grained glacial till and sandstone bedrock. Prior to entering the lowlands adjacent to the Grand River main stem, the headwaters on the western side tend to have high gradients, and possess the energy to form well-developed channels through the coarse substrates. Where these streams enter the lowlands, stream gradient drops and substrates become fine-grained, though sandier than streams on the southeastern side of the catchment. Typically, the faunas in these headwaters are not limited by habitat quality.

3.2 Rock Creek (04110004 02)

The Rock Creek subwatershed drains 70.8 square miles in the eastern portion of the watershed (see Figure 3-7). It consists of three nested subwatersheds. The main tributaries to Rock Creek include Snyder Ditch, Lebanon Creek and Whetstone Creek. Major causes of impairment include total dissolved solids, nutrients (including ammonia) and low flow alterations. Those causes are primarily associated with unknown sources and a dam or impoundment.

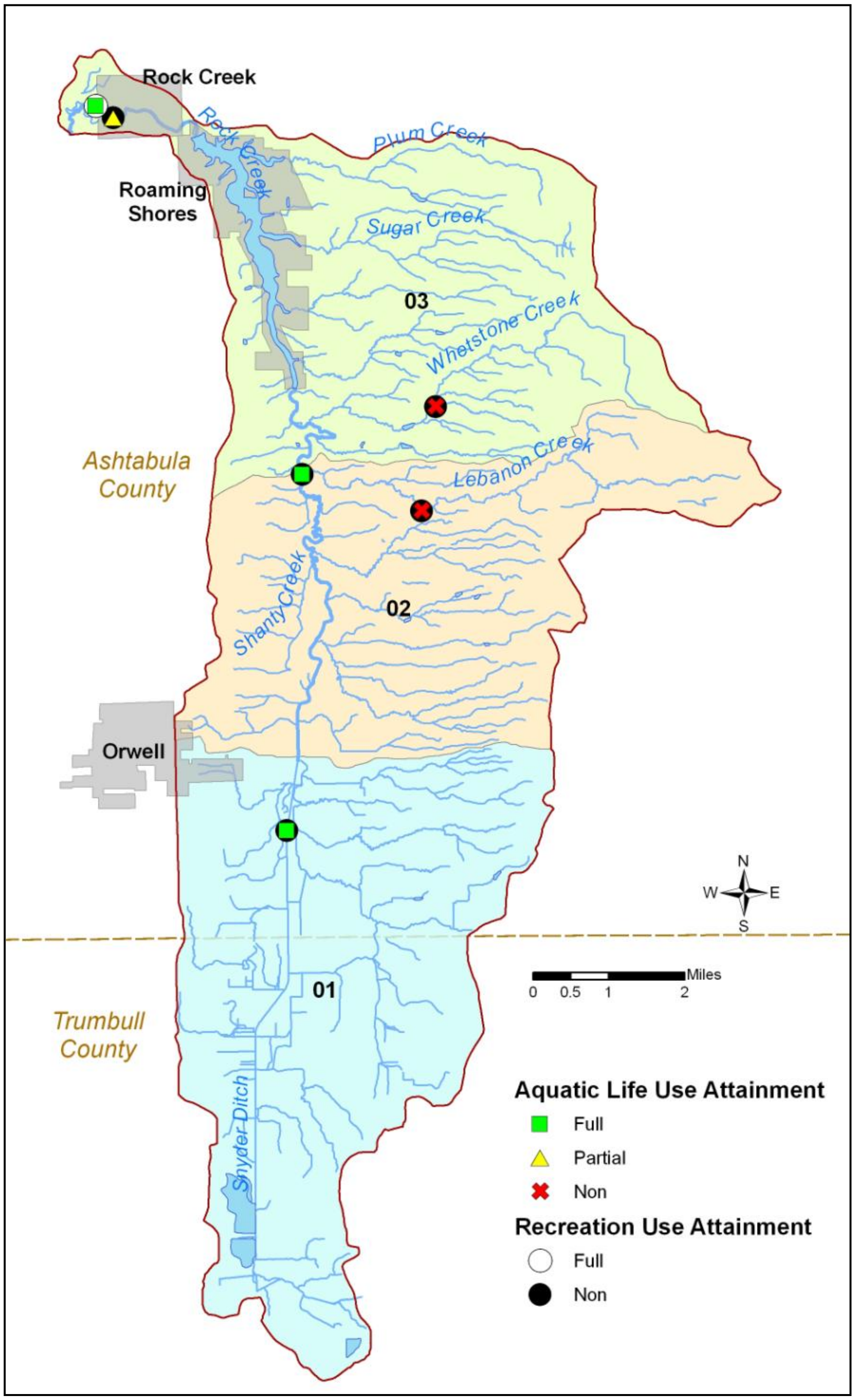


Figure 3-7. Attainment results for the Rock Creek subwatershed.

In most cases, these causes are associated with land uses in the subwatershed (see Appendix C for further information). Figure 3-8 shows land use within the Rock Creek subwatershed.

Most of the tributaries in this subwatershed met or were just below warmwater habitat standards. Snyder Ditch had lower water quality than Rock Creek, Whetstone Creek or Lebanon Creek.

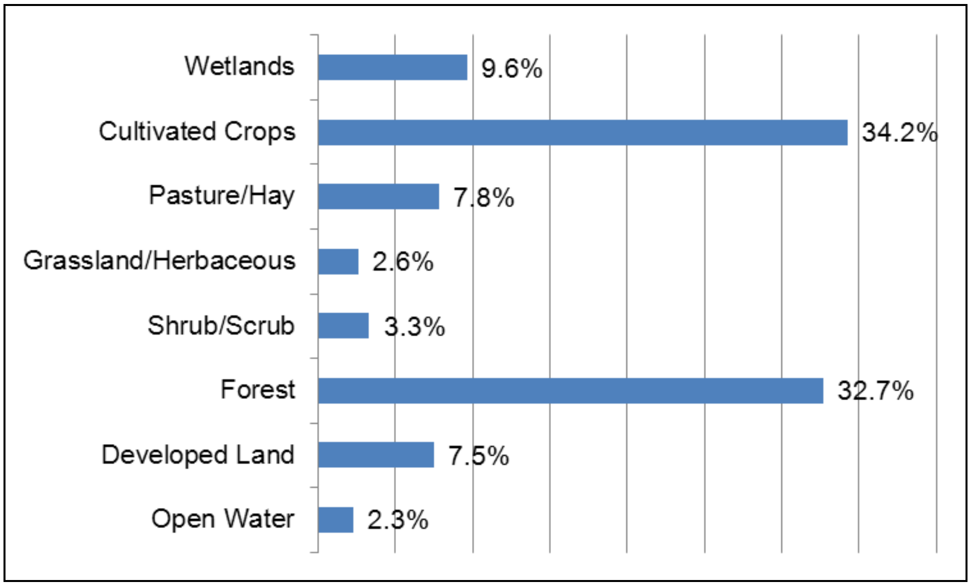


Figure 3-8. Land use in the Rock Creek subwatershed.

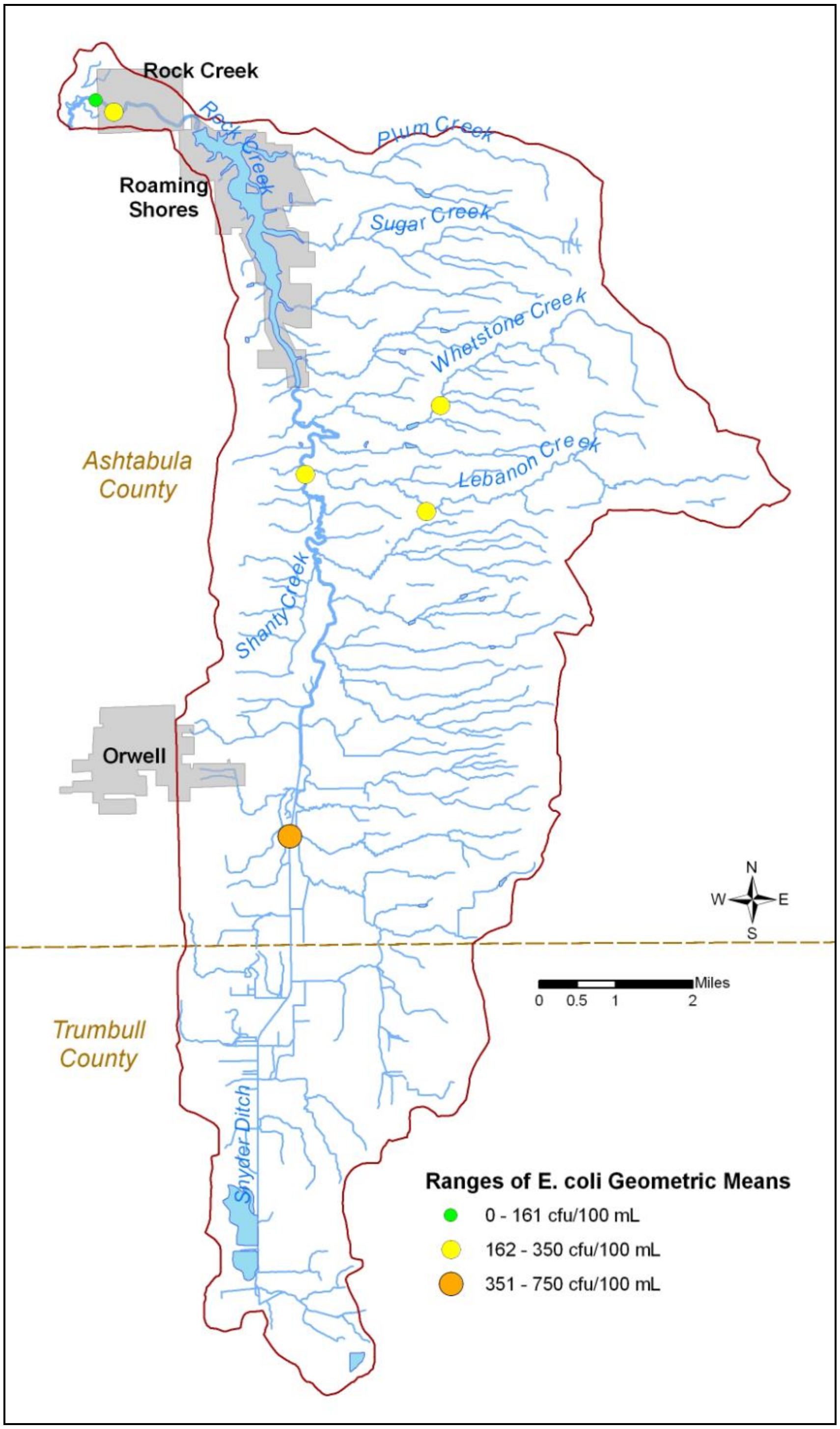


Figure 3-9. Water chemistry results for the Rock Creek subwatershed.

Figure 3-9 shows water chemistry results in the subwatershed. Some of these results aided in identifying causes of aquatic life use impairment. Figure 3-10 shows relative occurrence of causes of aquatic life use impairment in the Rock Creek subwatershed. Figure 3-11 shows the relative occurrence of sources of aquatic life use impairment in the Rock Creek subwatershed. Low flow alterations are addressed in Section D2.4 and in Section 6.3.

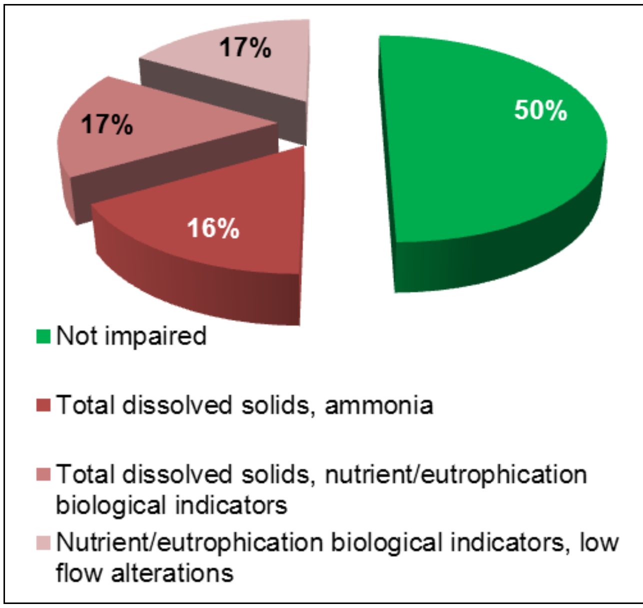


Figure 3-10. Causes of aquatic life use impairment in the Rock Creek subwatershed.

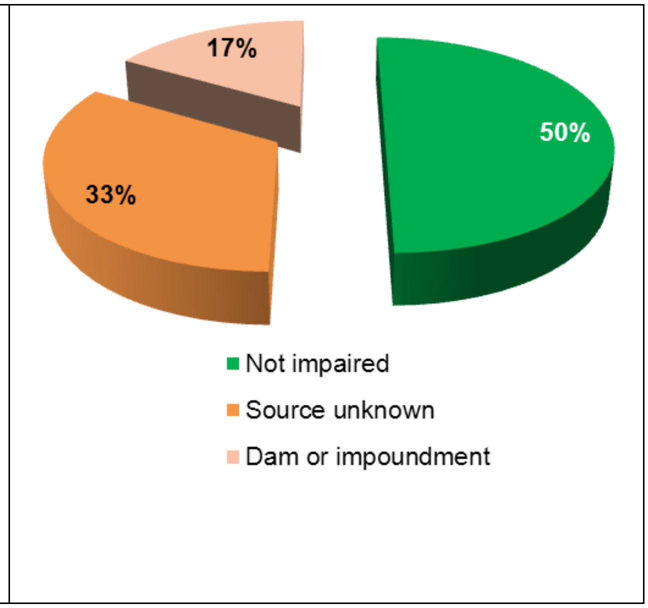


Figure 3-11. Sources of aquatic life use impairment in the Rock Creek subwatershed.

Table 3-2 shows the site-by-site results for each designated beneficial use organized by nested subwatersheds. For more specific information regarding individual site assessment results and supporting chemistry results, please see Appendix B.

Table 3-2. Number of impaired sites, organized by use and nested subwatershed, in the Rock Creek subwatershed.

Nested Subwatershed (04110004 02)		Aquatic Life Use	Recreation Use	Public Drinking Water Supply Use	Human Health Use[1,2]
02 01	# impaired sites (non/partial)	3i[1]	1	N/A	5h
	Index score[3]	N/A	50	N/A	N/A
02 02	# impaired sites (non/partial)	1/0	2	N/A	1
	Index score	50.0	67	N/A	N/A
02 03	# impaired sites (non/partial)	1/1	2	N/A	5h
	Index score	25.0	88	N/A	N/A

[1] The number shown is the category from Ohio's 2012 303(d) list (Ohio EPA 2012) for the assessment unit.
[2] Impairments to the human health use are not being addressed in this TMDL.
[3] The index score (between 0 and 100) indicates the relative support of the aquatic life or recreation use in the nested subwatershed. A score of 100 indicates full support of the use.

Overall QHEI scores ranged from 50.0 to 68.5. Where the topography is flat, and the substrates are composed primarily of lacustrine silts and clays, habitat quality is generally poor and not conducive to stream faunas typical of the ecoregion. Headwater streams matching this description are found in the lowlands of the subwatershed.

3.3 Phelps Creek-Grand River (04110004 03)

The Phelps Creek-Grand River subwatershed drains 132 square miles in the western portion of the watershed (see Figure 3-2). It consists of five nested subwatersheds. The main tributaries to the Grand River include Phelps Creek, Plumb Creek, Hoskins Creek, Mill Creek and Crooked Creek. Major causes of impairment include direct habitat alterations, natural causes and low flow alterations. Those causes are primarily associated with channelization, natural sources and a dam or impoundment.

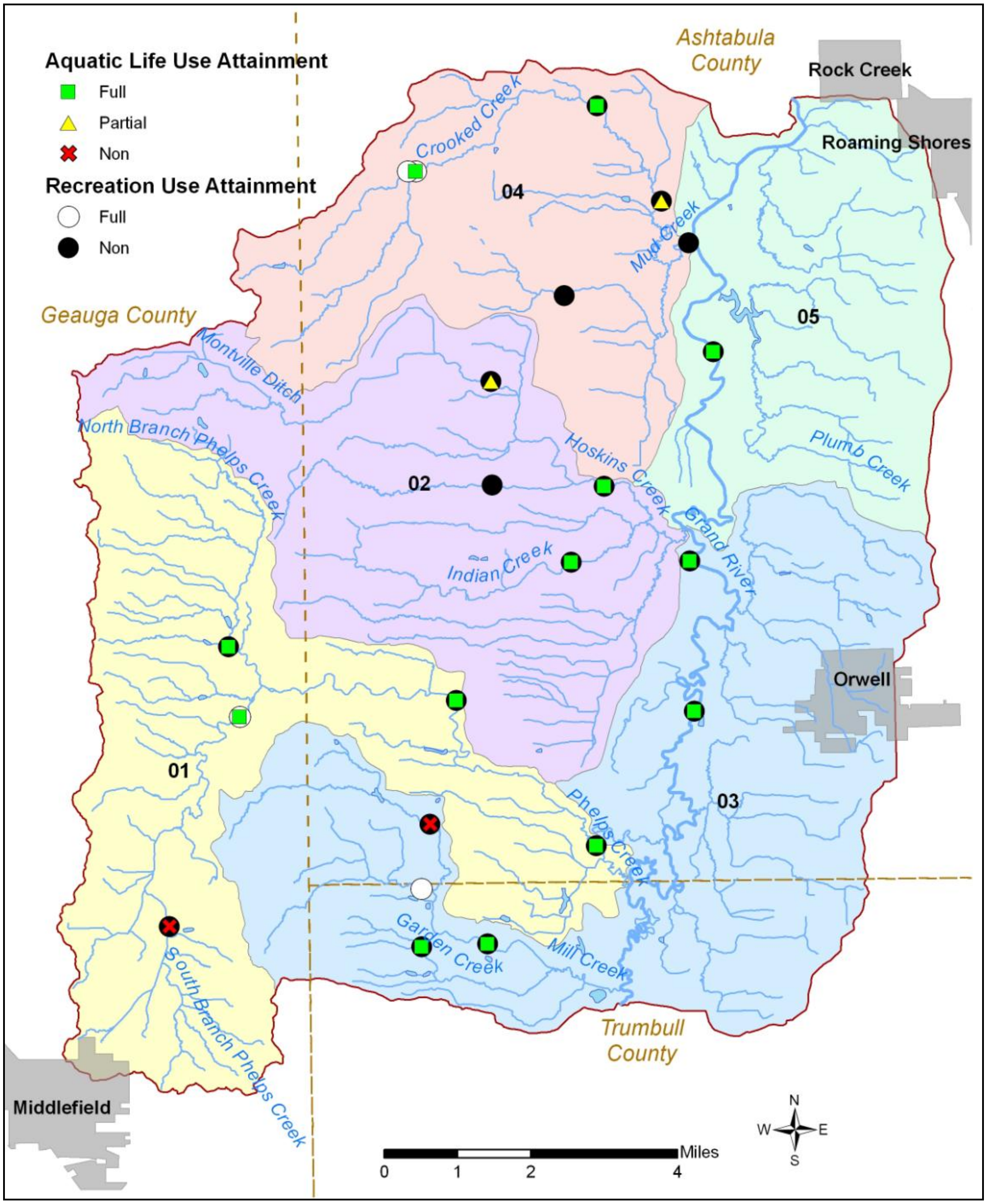


Figure 3-12. Attainment results for the Phelps Creek-Grand River subwatershed.

In most cases, these causes are associated with land uses in the subwatershed (see Appendix C for further information). Figure 3-13 shows land use within the Phelps Creek-Grand River subwatershed. Several tributaries and headwaters were designated as coldwater habitat streams after the 2007 field survey. Where impoundments existed, the altered hydrology from the impoundments tended to cause impairment of the designated aquatic life uses. Low flow alterations are addressed in Section D2.4 and in Section 6.4.

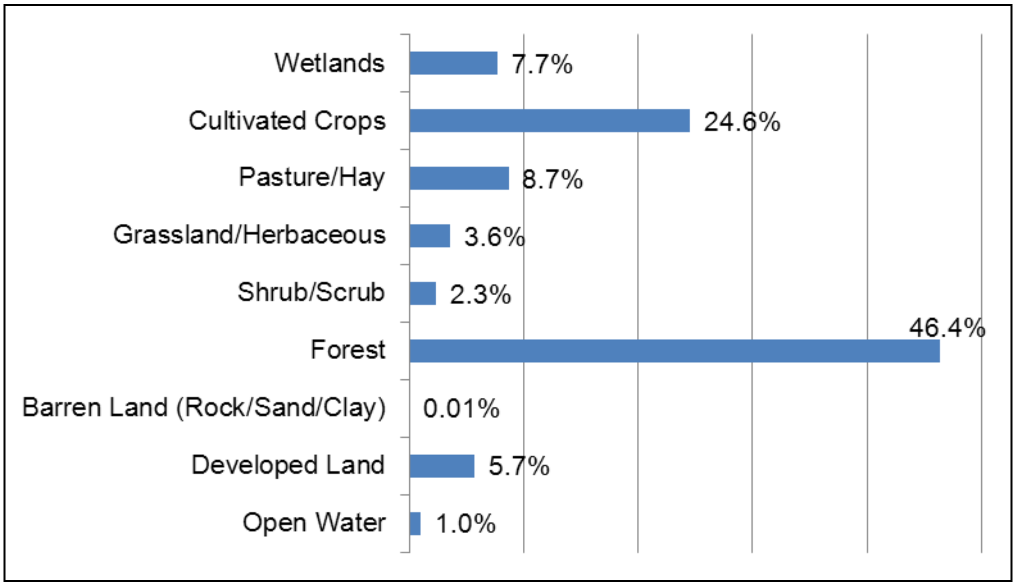


Figure 3-13. Land use in the Phelps Creek-Grand River subwatershed.

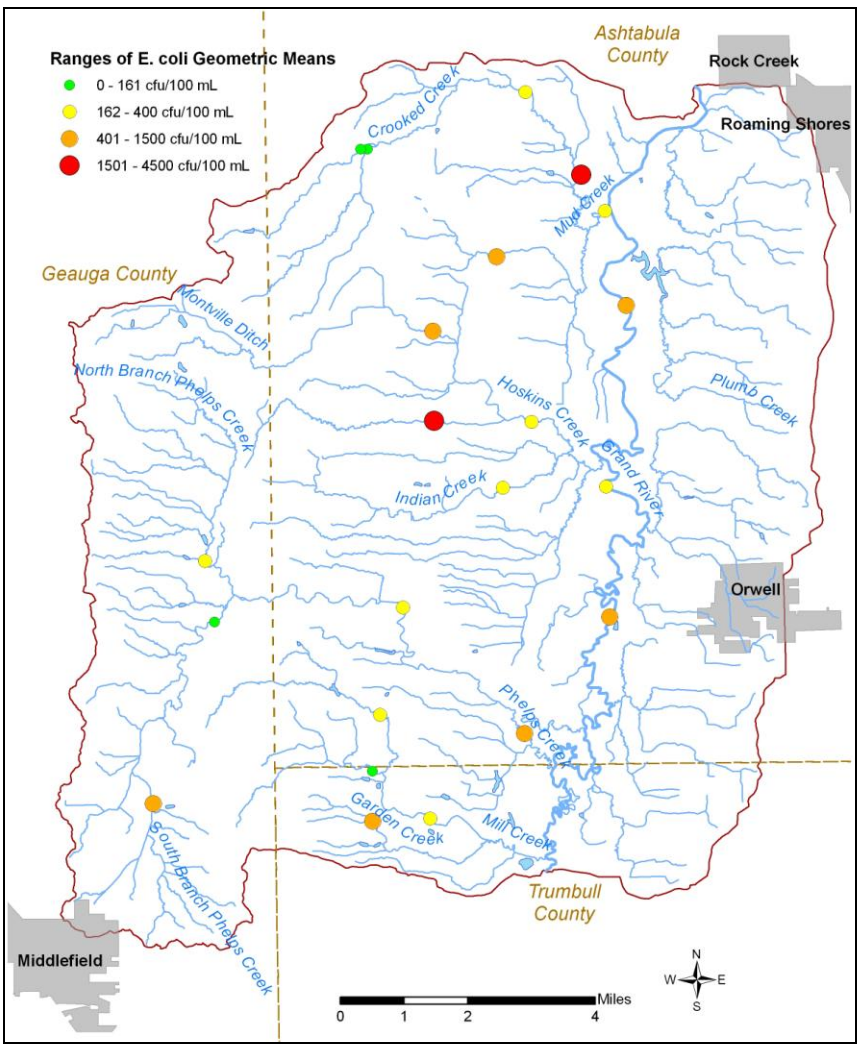


Figure 3-14. Water chemistry results for the Phelps Creek-Grand River subwatershed.

Figure 3-14 shows water chemistry results in the subwatershed. Some of these results aided in identifying causes of aquatic life use impairment. Figure 3-15 shows relative occurrence of causes of aquatic life use impairment in the Phelps Creek-Grand River subwatershed. Figure 3-16 shows the relative occurrence of sources of aquatic life use impairment in the Phelps Creek-Grand River subwatershed.

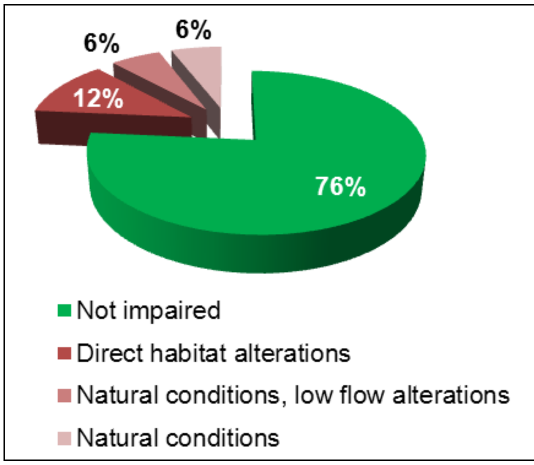


Figure 3-15. Causes of aquatic life use impairment in the Phelps Creek-Grand River subwatershed.

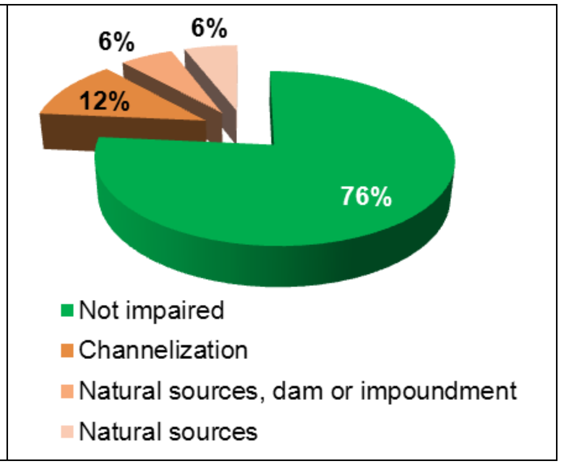


Figure 3-16. Sources of aquatic life use impairment in the Phelps Creek-Grand River subwatershed.

Table 3-3 shows the site-by-site results for each designated beneficial use organized by nested subwatersheds. For more specific information regarding individual site assessment results and supporting chemistry results, please see Appendix B.

Table 3-3. Number of impaired sites, organized by use and nested subwatershed, in the Phelps Creek-Grand River subwatershed.

Nested Subwatershed (04110004 01)		Aquatic Life Use	Recreation Use	Public Drinking Water Supply Use	Human Health Use[1,2]
03 01	# impaired sites (non/partial)	1/0	4	N/A	5h
	Index score[3]	83.3	50	N/A	N/A
03 02	# impaired sites (non/partial)	0/1	4	N/A	5h
	Index score	66.7	44	N/A	N/A
03 03	# impaired sites (non/partial)	1/0	5	N/A	5h
	Index score	83.3	61	N/A	N/A
03 04	# impaired sites (non/partial)	0/1	4	N/A	5h
	Index score	66.7	63	N/A	N/A
03 05	# impaired sites (non/partial)	0/0	1	N/A	5
	Index score	100.0	50	N/A	N/A

1 The number shown is the category from Ohio's 2012 303(d) list (Ohio EPA 2012) for the assessment unit.
2 Impairments to the human health use are not being addressed in this TMDL.
3 The index score (between 0 and 100) indicates the relative support of the aquatic life or recreation use in the nested subwatershed. A score of 100 indicates full support of the use.

Overall QHEI scores ranged from 55.0 to 82.5. The subwatershed has high relief and sediments composed of coarse-grained glacial till and sandstone bedrock. Prior to entering the lowlands adjacent to the Grand River main stem, the headwaters on the western side tend to have high gradients, and possess the energy to form well-developed channels through the coarse substrates. Where these streams enter the lowlands, stream gradient drops and substrates become fine-grained, though sandier than streams on the southeastern side of the catchment. Typically, the faunas in these headwaters are not limited by habitat quality.

3.4 Three Brothers Creek-Grand River (04110004 05)

The Three Brothers Creek-Grand River subwatershed drains 57.7 square miles in the northern portion of the watershed (see Figure 3-17). It consists of two nested subwatersheds. The main tributaries in the Three Brothers Creek-Grand River subwatershed include Three Brothers Creek, Trumbull Creek, Bronson Creek and the Grand River. The only cause of impairment in this subwatershed is natural causes (flow or habitat) from natural sources.

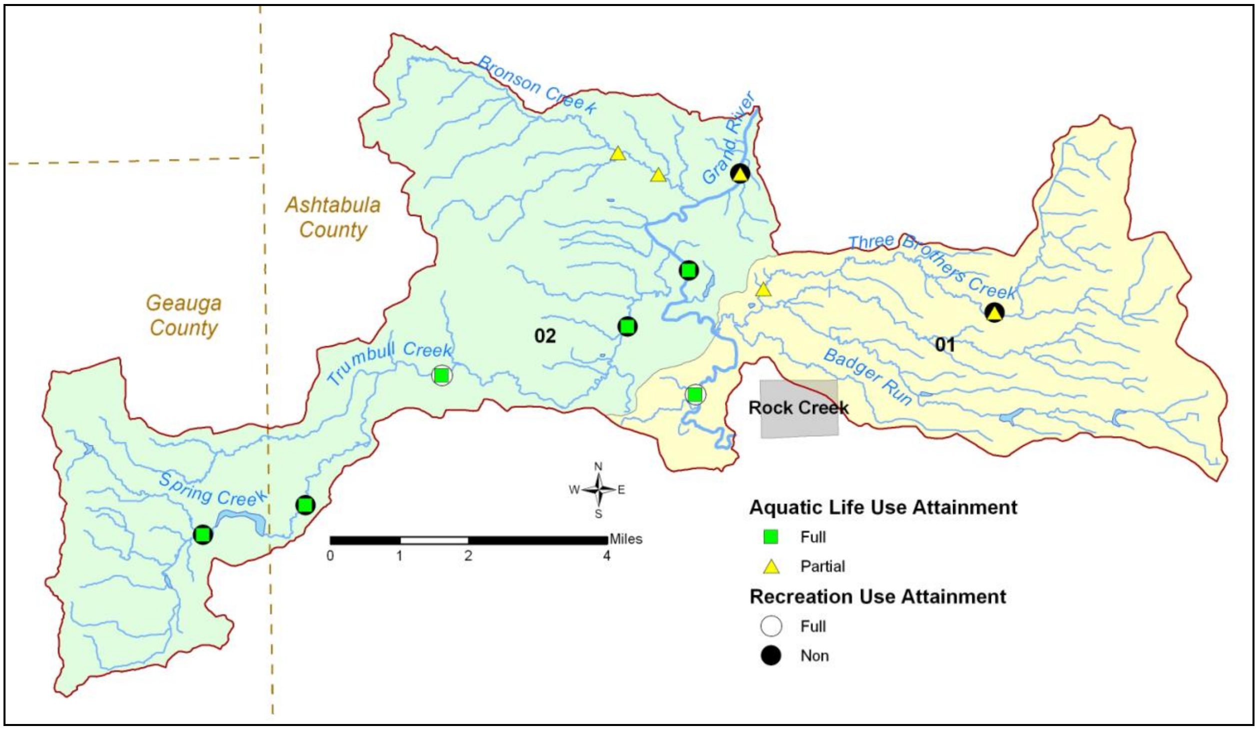


Figure 3-17. Attainment results for the Three Brothers Creek-Grand River subwatershed.

In most cases, these causes are associated with land uses in the subwatershed (see Appendix C for further information). Figure 3-18 shows land use within the Three Brothers Creek-Grand River subwatershed.

The Grand River main stem within this subwatershed is bounded on the south by the confluence with Rock Creek (at river mile [RM] 50.59) and to the north by Mill Creek (RM 41.28). The river transitions from warmwater habitat to exceptional warmwater habitat at Fobes Road (RM 44.7). The Grand River is unique in having populations of walleye, northern pike and muskellunge inhabiting the same reach. The reason these species co-occur is because the habitat is largely intact and the water unpolluted. Several of the smaller tributaries in the subwatershed had bedrock substrates.

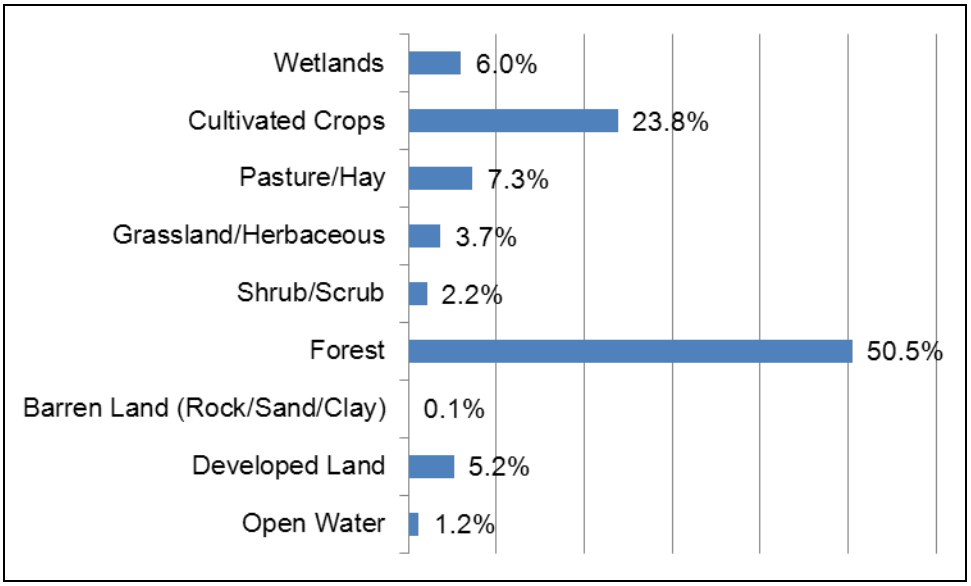


Figure 3-18. Land use in the Three Brothers Creek-Grand River subwatershed.

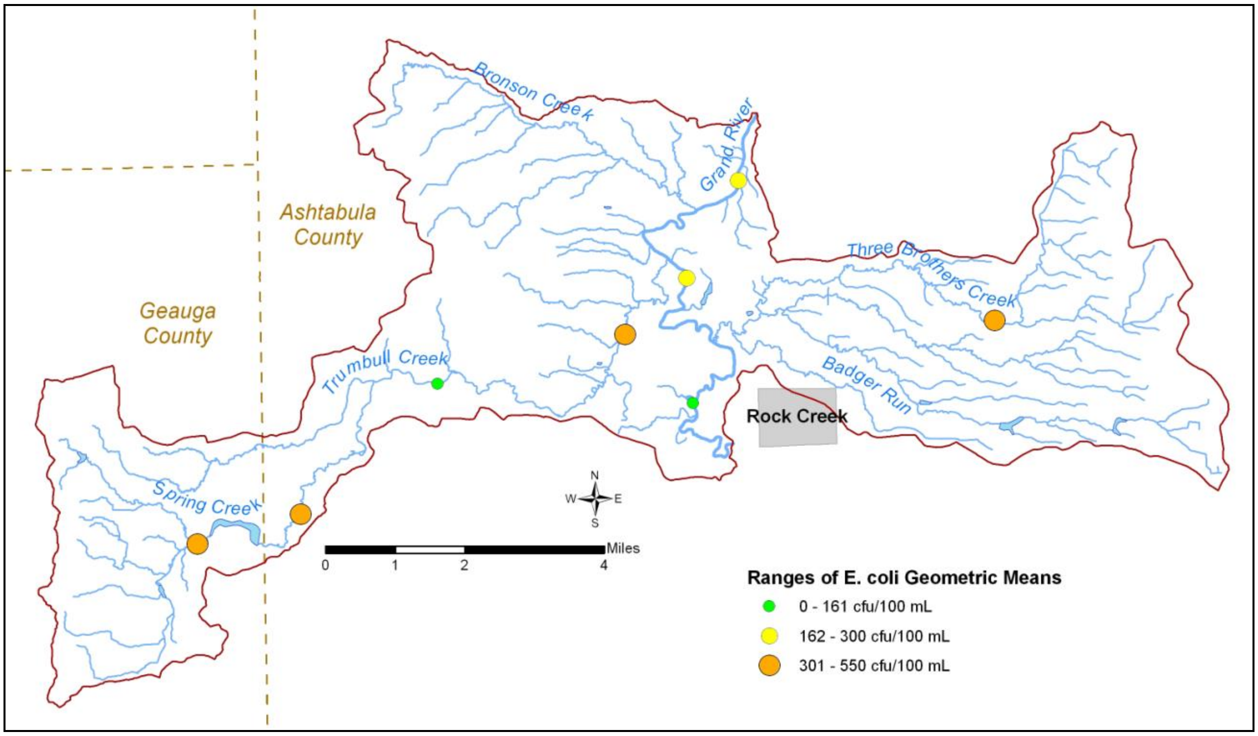


Figure 3-19. Water chemistry results for the Three Brothers Creek-Grand River subwatershed.

Figure 3-19 shows water chemistry results in the subwatershed. Some of these results aided in identifying causes of aquatic life use impairment. Figure 3-20 shows relative occurrence of causes of aquatic life use impairment in the Three Brothers Creek-Grand River subwatershed. Figure 3-21 shows the relative occurrence of sources of aquatic life use impairment in the Three Brothers Creek-Grand River subwatershed.

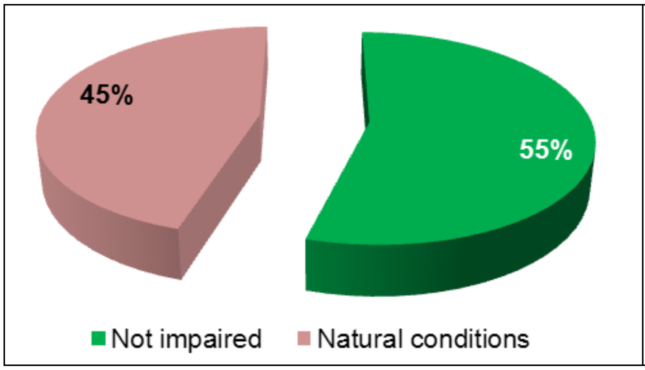


Figure 3-20. Causes of aquatic life use impairment in the Three Brothers Creek-Grand River subwatershed.

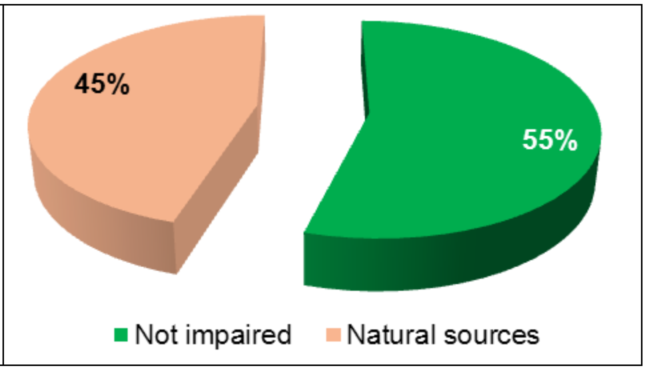


Figure 3-21. Sources of aquatic life use impairment in the Three Brothers Creek-Grand River subwatershed.

Table 3-4 shows the site-by-site results for each designated beneficial use organized by nested subwatersheds. For more specific information regarding individual site assessment results and supporting chemistry results, please see Appendix B.

Table 3-4. Number of impaired sites, organized by use and nested subwatershed, in the Three Brothers Creek-Grand River subwatershed.

Nested Subwatershed (04110004 05)		Aquatic Life Use	Recreation Use	Public Drinking Water Supply Use	Human Health Use[1,2]
05 01	# impaired sites (non/partial)	0/2	1	N/A	5h
	Index score[3]	50.0	75	N/A	N/A
05 02	# impaired sites (non/partial)	0/3	5	N/A	1
	Index score	58.3	63	N/A	N/A

1 The number shown is the category from Ohio's 2012 303(d) list (Ohio EPA 2012) for the assessment unit.
2 Impairments to the human health use are not being addressed in this TMDL.
3 The index score (between 0 and 100) indicates the relative support of the aquatic life or recreation use in the nested subwatershed. A score of 100 indicates full support of the use.

Overall QHEI scores ranged from 59.0 to 77.5. The subwatershed has high relief and sediments composed of coarse-grained glacial till and sandstone bedrock. Prior to entering the lowlands adjacent to the Grand River main stem, the headwaters on the western side tend to have high gradients, and possess the energy to form well-developed channels through the coarse substrates. Where these streams enter the lowlands, stream gradient drops and substrates become fine-grained, though sandier than streams on the southeastern side of the catchment. Typically, the faunas in these headwaters are not limited by habitat quality.

4 METHODS TO CALCULATE LOAD REDUCTIONS

The Grand River (upper) watershed does not support two beneficial uses—aquatic life and recreation. The causes of impairment to aquatic life uses consist of direct habitat alterations, various nutrients, organic enrichment, total dissolved solids, low flow alterations and natural causes. The cause of recreation use impairment is excessive concentrations of an indicator bacterium, *E. coli*. The linkage analysis examines the cause and effect relationships between watershed characteristics and pollutant sources and the effect on the stream biology and evaluates the use of surrogate measures to address the pollutant sources that would result in supporting beneficial uses.

How the identified stressors lead to impaired uses

In freshwater systems, phosphorus is typically the nutrient that is in short supply relative to biological needs, which means that the productivity of aquatic plants and algae can be controlled by limiting the amount of phosphorus entering the water. Large diurnal swings in pH and dissolved oxygen may occur as excessive amounts of nutrients are metabolized by aquatic plants and algae. The range of these swings often exceeds the state water quality criteria established to protect fish and other aquatic organisms in their various life stages. Therefore, the amount of phosphorus currently entering these waters exceeds the seasonal loading capacity and must be reduced if these water quality problems are to be resolved. The sources of phosphorus loading vary depending on the human activities and conditions in a specific watershed (U.S. EPA 2007a).

Though phosphorus can be the limiting factor in the growth of algae, nitrogen is also a critical component, therefore nitrogen is also addressed in this report. Both nitrogen and phosphorus can enter waterways through soil erosion attached to soil particles, dissolved in crop field water via field tiles, failing home sewage treatment systems, and other routes.

Direct linkage

While the Ohio EPA does not currently have statewide numeric criteria for nutrients, potential targets have been identified in a technical report titled *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA 1999). This document, herein referred to as the *Associations* document, provides the results of a study analyzing the effects of nutrients on the aquatic biological communities of Ohio streams and rivers. The study reaches a number of conclusions and stresses the importance of habitat and other factors, in addition to in-stream nutrient concentrations, as having an impact on the health of biological communities. The study also includes proposed total phosphorus target concentrations based on observed concentrations associated with acceptable ranges of expected biological communities. The total P and nitrogen targets used in this report are shown in Table D-4. It is important to note that these nutrient targets are not codified in Ohio's water quality standards; therefore, there is a certain degree of flexibility as to how they can be used in TMDL development.

Ohio's standards also include narrative criteria that limit the quantity of nutrients that may enter state waters. Specifically, OAC Rule 3745-1-04 (E) states that all waters of the state, "…shall be free from nutrients entering the waters as a result of human activity in concentrations that create nuisance growths of aquatic weeds and algae." In addition, OAC Rule 3745-1-04(D) states that all waters of the state, "…shall be free from substances entering the waters as a result of human activity in concentrations that are toxic or harmful to human, animal or aquatic life and/or are rapidly lethal in the mixing zone." Excess concentrations of nutrients that contribute to non-attainment of biological criteria may fall under either OAC Rule 3745-1-04 (D) or (E) prohibitions.

Center Creek (04110004 01 04)
Upstream from Center Creek is Champion Heights, a densely populated, unsewered suburb of the City of Warren. There are approximately 322 unsewered houses, as counted from aerial photography, in the northernmost portion of Champion Heights in an area 0.528 square miles that lies in the Center Creek basin. The impact from these homes is impairing Center Creek at RM 6.25 and RM 3.03. Biology indicated home sewage as a probable source (Ohio EPA 2009): "The riffle habitat was devoid of sensitive EPT and had an unusually high abundance of flatworms (facultative taxa often associated with enrichment effects). Unusually high siltation and algal growths were observed at this station."

The causes listed in Table D-1 for impairments at both sites on Center Creek include ammonia (total), total Kjeldahl nitrogen, total dissolved solids (TDS), organic enrichment (sewage) biological indicators, and natural (flow or habitat – wetlands at RM 3.03). The source of these causes, with the exception of natural causes, is the unsewered housing mentioned above. When HSTS fail, human waste builds in the system and eventually exits to the nearest waterway. Raw or poorly treated waste is high in phosphorus, ammonia (which breaks down into various forms of nitrogen) and TDS.

Total Kjeldahl nitrogen (TKN) is an analytical name for total of ammonia + organic nitrogen (N), so pollution from failing HSTS would generate both ammonia and organic N; using TKN would directly represent this relationship. Nitrogen (as ammonia and/or TKN), solids (as total suspended or total dissolved) and biological oxygen demand are all well documented constituents of home sewage (U.S. EPA 2002). TKN is used as a surrogate for ammonia, TDS and organic enrichment since all parameters have the same source. The impact from the wetlands is not quantified in this report.

Whetstone Creek (04110004 02 03)
Whetstone Creek, a Rock Creek tributary, is impaired due to elevated total dissolved solids, ammonia, and nutrients. The source of ammonia and TDS is not readily evident. However, although they are different parameters, their concentrations increased and decreased in parallel when measured at different times, suggesting a response to a single or related source. Possibilities of sources include failing HSTSs, illegal dumping of brine water or some other type of waste water, high TDS in ground water coming through HSTSs, leaching from an old "toxic dump," or some other unknown source. Ohio EPA did extensive research to determine the source of TDS and ammonia in Whetstone Creek but could not conclusively identify a source. Since additional sampling in 2008 identified significant decreases in TDS and TKN (ammonia was not sampled but is a component of TKN), it seems likely that a one-time spill of some kind or intermittent dumping is the source of both parameters, as indicated by the following text (Ohio EPA 2009):

"…the elevated fecal counts in Whetstone Creek and Lebanon Creek were associated with high TDS and nitrates, as well as ammonia and Kjeldahl nitrogen, suggesting a slug of untreated nitrogenous wastes, possibly from a spill or illegal dumping."

While Ohio EPA cannot conclusively identify a source for ammonia and TDS, it seems probable that the source is the same and that addressing the ammonia in Whetstone Creek (if a source can be identified) will also address the TDS. Therefore, ammonia is used as a surrogate for TDS.

Tables 4-1 and 4-2 indicate how the applicable causes of impairment are addressed in each of the assessment units.

Table 4-1. Summary of causes of impairment and actions taken to address them in assessment units within the 04110004 01 and 02 ten-digit hydrologic units.

	Watershed Assessment Units								
	04110004 01						04110004 02		
Causes of Impairment	**01**	**02**	**03**	**04**	**05**	**06**	**01**	**02**	**03**
Aquatic Life Use									
Direct habitat alterations		D							
Natural conditions (flow or habitat)			N	N					
Ammonia (total)				S					D
Total Kjeldahl nitrogen				D					
Total dissolved solids				S				D	S
Organic enrichment (sewage) biological indicators				S					
Nutrient/eutrophication biological indicators								D	D
Low flow alterations									N
Recreation Use									
E. coli	D	D	D	D	D	D	D	D	D

D – direct	Means that TMDLs are calculated for this parameter
S – surrogate	Means that TMDLs are calculated for a closely related cause and actions to reduce the impact of that cause should be sufficient to address this cause. There is substantial overlap in the sources of the loading of both parameters
N – not addressed	Means that the impairment is not addressed in this report.
Blank	Indicates that the assessment unit is not impaired for this cause.
4B	Means that the 4B option is being used to address impairment.

Table 4-2. Summary of causes of impairment and actions taken to address them in assessment units within the 04110004 03 and 05 ten-digit hydrologic units.

Causes of Impairment	Watershed Assessment Units						
	04110004 03					04110004 05	
	01	02	03	04	05	01	02
Aquatic Life Use							
Natural conditions (flow or habitat)	N	N	N			N	N
Direct habitat alterations		D		D			
Low flow alterations			N				
Recreation Use							
E. coli	D	D	D	D	D	D	D

D – direct	Means that TMDLs are calculated for this parameter
S – surrogate	Means that TMDLs are calculated for a closely related cause and actions to reduce the impact of that cause should be sufficient to address this cause. There is substantial overlap in the sources of the loading of both parameters
N – not addressed	Means that the impairment is not addressed in this report.
Blank	Indicates that the assessment unit is not impaired for this cause.
4B	Means that the 4B option is being used to address impairment.

Further details on modeling methods and analyses are available in Appendix D. An analysis was completed for two dams in nested subwatersheds 02 03 and 03 03 to compare how flows would change in the streams if the dams were modified or removed. See Section D2.4 for details of the analysis.

4.1 Load Duration Curves

In order to determine the magnitude of bacteria impairment and differentiate between types of bacteria sources contributing to impairment, load duration curves (LDCs) were calculated for analyzed sites following the methods described in U.S. EPA's *An Approach for Using Load Duration Curves in the Development of TMDLs* (U.S. EPA 2007b).

Under elevated flow conditions, point sources are assumed to be masked by in-stream dilution, therefore high *E. coli* loading is caused by precipitation washoff or erosion of contaminated land surfaces. Among many possibilities, some typical nonpoint sources of *E. coli* include manure spreading and washoff from livestock feeding operations. Scenarios where high *E. coli* loads exist under mid-range flow conditions, or high loads occur under all conditions, can be attributed to a mixture of point and nonpoint sources. Site investigation using digital mapping, aerial photography or an on-the-ground visit can help further develop priorities for implementation based on the LDC evidence for either point or nonpoint sources of *E. coli*.

It is important to note that the load duration curve method does not enable one to attribute impairment to any particular source; instead it is a tool used to determine the flow conditions under which impairment occurs and the probable types of sources contributing to that impairment.

Five sampling locations were established within the watershed, and these sites were used for further study of the sources of recreation use non-attainment in non-attaining nested subwatersheds. These five sites included two sites on the main stem of the Grand River and three tributary sites on Trumbull, Phelps and Swine Creeks. These five sites included all impaired areas in the watershed. Further details are available in Appendix D.

4.1.1 Justification

Load duration curves can assist in distinguishing between point and nonpoint sources that contribute to *E. coli* loading by highlighting the flow conditions under which impairment occurs. At lower stream flow levels, little to no in-stream dilution of *E. coli* is occurring due to dry conditions lacking runoff. Because of this, any point source *E. coli* contributions to the stream will result in higher concentrations of *E. coli*. If there are a high number of samples under dry weather or low flow conditions that fall above the target curve, there is a likelihood of nearby point sources of *E. coli.* Examples of bacteria point sources include combined sewer overflows (CSOs), municipal separate storm sewer systems (MS4s) or wastewater treatment plants. High bacteria levels under low flow conditions may also indicate concentrated cattle grazing in the stream channel, leaking sewer lines, or failing home sewage treatment systems.

LDCs were used for Whetstone Creek and Lebanon Creek for ammonia and TDS, respectively. This method directly compares actual data to targets, so it is reflective of existing conditions and problems.

4.1.2 Sources of Data

An historical daily flow record was obtained for the USGS Gage 04212100 on the Grand River near Painesville, OH. A long-term water level recorder was installed on the Grand River at Camp Beaumont (G02K52) throughout the 2008 recreation season in order to determine hourly flow rates. Bacteria, nutrient and TDS data were collected in 2007 and 2008 by Ohio EPA.

4.1.3 Target(s)

For a given impaired site, each hydrologic condition (high flows, moist conditions, mid-range conditions, dry conditions or low flows) was assigned a target bacteria loading rate (cfu/day) by multiplying the class A *E. coli* water quality standard, 126 cfu/100 ml, by the median flow of each hydrologic class at that site and a constant, used to convert cubic feet per second to milliliters per day: $T = Q_m * S * C$; where T = target bacteria load, Q_m = median flow for a specific hydrologic class, S = water quality standard (126 cfu/100 ml) and C = a unit conversion constant (cubic feet per second to milliliters per day). Median observed bacteria loads in each hydrologic condition were compared to the median target value in that condition, after incorporating a margin of safety and allowance for future growth, in order to quantify needed reductions.

Water quality standards for ammonia and TDS used in the TMDL calculations are displayed in Table 4-3.

Table 4-3. Ammonia and TDS water quality standards used in TMDLs.

Parameter	Stream	Value (mg/l)	Basis
Ammonia	*Whetstone Creek*		
	In-stream	2.2	WQS based on pH = 7.70, and temp. = 19.67
	Discharger	3	Based on median statewide facility data
Total Dissolved Solids	*Lebanon Creek*		
	In-stream and discharger	1500 (800)	Existing (and potential future) WQS

4.1.4 Calibration and Validation

The LDCs were not calibrated or validated. The uncertainty in the LDCs for *E. coli* was minimized by collecting numerous (~ 13) rounds of water quality samples and 6 to 10 flow measurements over a variety of flow conditions, and by having a station that collected real-time flow data for greater than 1 year. Nevertheless, there is some uncertainty in the long term flow calculations and in the water quality data.

4.1.5 Allowance for Future Growth

The upper Grand River watershed lies within Ashtabula, Geauga, Trumbull and Portage counties. The average population change projection from 2010 to 2020 of the four counties is an increase of 1.4%. In order to ensure recreation use attainment in the future, an allowance for future growth (AFG) factor of 1.4% was applied to each TMDL (ODD 2003).

4.1.6 Seasonality and Critical Conditions

Stream recreation occurs in a variety of forms, from wading to fishing to canoeing, and in a wide range of stream flow conditions. In order to ensure that recreation use is protected whenever recreation might occur, *E. coli* TMDLs are established for all flow conditions during the recreation season (May 1 through October 31), when people are most likely to fish, wade, swim and boat in streams.

In-stream bacteria loads vary by source and can occur across the hydrograph, from washoff of land-deposited bacteria under moist conditions to in-stream livestock and failing HSTS in low flow conditions. Nonpoint sources to which bacteria loads are allocated in the upper Grand River basin include livestock, both manure washoff and in-stream animals, and failing HSTS.

4.2 Mass Balance

The mass balance method was used for Lebanon Creek, Center Creek and Rock Creek for nutrient TMDLs (total Kjeldahl nitrogen and total phosphorus) because the method compares observed data with in-stream targets. Mass balance is an equation that accounts for the flux of mass going into a defined area and the flux of mass leaving the defined area. The flux in must equal the flux out (U.S. EPA 1999).

4.2.1 Justification

The mass balance method was used because it compared observed data with in-stream targets. Because the basins studied are small and have a short time of travel, a more complex loading analysis method was not necessary. This simple mass balance method accounts for point sources and nonpoint sources of nutrients.

4.2.2 Sources of Data

An historical daily flow record was obtained for the USGS Gage 04212100 on the Grand River near Painesville, OH. A long-term water level recorder was installed on the Grand River at Camp Beaumont (G02K52) from May through October 2008 in order to determine hourly flow rates. Water chemistry data were collected in 2007 and 2008 by Ohio EPA.

4.2.3 Target(s)

Existing loads for various parameters related to the cause of impairment for each site were compared to target loads that were derived using either a value from the *Associations* document (Ohio EPA 1999) or a value based on median statewide data from similar facilities with monitoring (see Table 4-4).

Table 4-4. Total Kjeldahl nitrogen and total phosphorus targets used for TMDL calculations.

Parameter	Stream	Value (mg/l)	Basis
Total Kjeldahl Nitrogen	*Center Creek*		
	In-stream	0.4	*Associations* document (Ohio EPA 1999)
	Discharger	1.56	Based on median statewide facility data
Total Phosphorus	*Lebanon Creek*		
	In-stream	0.1	*Associations* document (Ohio EPA 1999)
	Discharger	3	Based on median statewide facility data

4.2.4 Calibration and Validation

The method was not calibrated or validated. There is some uncertainty in the calculated existing loads for parameters, which ultimately are used to determine needed reduction, because the average of only three values was used. More values over a greater time period under varying flow conditions would strengthen the confidence in the conclusions.

4.2.5 Allowance for Future Growth

The Ashtabula County population is projected to increase by 1.4 percent from 2010 to 2030 according to county census data; therefore, the allowance for future growth is set at 1.4%.

4.2.6 Seasonality and Critical Conditions

In the Middle Rock Creek nested subwatershed, the pollutant sources are likely from a mobile home park and unsewered homes. These are sources that tend to have their greatest negative effect during periods of low flow. As a result, the critical condition for nutrients and total dissolved solids is the summer dry period when environmental stress upon aquatic organisms is greatest. It is during this period that water is lowest and these parameters are most concentrated. Samples were taken during this period and are therefore reflective of the critical condition.

In the case of the Lower Rock Creek nested subwatershed, the main issue with elevated in-stream total phosphorus is the increase in algal mass and resulting large dissolved oxygen swings. The critical conditions for algae production occur during summer and early fall when temperatures are hot and flows are low.

4.3 Habitat Alteration (QHEI Analysis)

The Grand River headwaters (RM 94.3), Hoskins Creek (RM 4.88) and Crooked Creek (RM 3.8) were found to be impaired due to direct habitat alterations; therefore, a habitat TMDL was calculated for each.

4.3.1 Justification

Poor habitat quality is an environmental condition, rather than a pollutant load, so development of a load-based TMDL for habitat is not possible. Nonetheless, habitat is an integral part of stream ecosystems and has a significant impact on aquatic community assemblage and consequently on the potential for a stream to meet the biocriteria within Ohio's water quality standards (see below). In addition, U.S. EPA acknowledges that pollutants, conditions or other environmental stressors can be subject to the development of a TMDL to abate those stressors in order to meet water quality standards (U.S. EPA 1991). Thus, sufficient justification for developing habitat TMDLs is established.

The Qualitative Habitat Evaluation Index (QHEI) was developed by the Ohio EPA (Ohio EPA 1989) with one of the objectives being to create a means for distinguishing impacts to the aquatic community from pollutant loading versus poor stream habitat. The design of the QHEI in conjunction with its statistically strong correlation to the biocriteria makes it an appropriate tool for developing habitat TMDLs.

4.3.2 Sources of Data

Habitat metric data are collected during biological sampling in the summer field season. In this case, data were collected by biologists in the summer of 2007.

4.3.3 Targets

The QHEI assigns a numeric value (out of a possible 100) to an individual stream segment (typically 150-200 m in length) based on the quality of its habitat. The actual number values of the QHEI scores do not represent the quantity of any physical properties of the system but provide a means for comparing the relative quality of stream habitat. However, even though the numeric value is derived qualitatively, subjectivity is minimized because scores are based on the presence and absence and relative abundance of unambiguous habitat features. Reduced subjectivity was an important consideration in developing the QHEI and has since been evidenced through minimal variation between scores from various trained investigators at a given site as well as consistency with repeated evaluations (Ohio EPA 1989).

The QHEI evaluates six general aspects of physical habitat that include channel substrate, in-stream cover, riparian characteristics, channel condition, pool/riffle quality, and gradient. Within each of these categories or sub-metrics, points are assigned based on the ecological utility of specific stream features as well as their relative abundance in the system. Demerits (i.e., negative points) are also assigned if certain features or conditions are present which reduce the overall utility of the habitat (e.g., heavy siltation and embedded substrate). These points are summed within each of the six sub-metrics to give a score for that particular aspect of stream habitat. The overall QHEI score is the sum of all of the sub-metric scores.

Since its development the QHEI has been used to evaluate habitat at most biological sampling sites and currently there is an extensive database that includes QHEI scores and other water quality variables. Strong correlations exist between QHEI scores and some its component submetrics and the biological indices used in Ohio's water quality standards such as the Index of Biotic Integrity (IBI). Through statistical analyses of data for the QHEI and the biological indices, target values have been established for QHEI scores with respect to the various aquatic life use designations (Ohio EPA 1999). For aquatic life use designations of warm water habitat

(WWH) and exceptional warm water habitat (EWH) overall QHEI scores of 60 and 75, respectively, are targeted to provide reasonable certainty that habitat is not deficient to the point of precluding attainment of the biocriteria.

One of the strongest correlations found through these statistical analyses described above is the negative relationship between the number of “modified attributes” and the IBI scores. Modified attributes are features or conditions that have low value in terms of habitat quality and therefore are assigned relatively fewer points or negative points in the QHEI scoring. A subgroup of the modified attributes shows a stronger impact on biological performance; these are termed high influence modified attributes.

In addition to the overall QHEI scores, targets for the maximum number of modified and high influence modified attributes have been developed. For streams designated as WWH, there should no more than four modified attributes of which no more than one should be a high influence modified attribute. For EWH streams there should be no more than two modified attributes and zero high influence attributes. Of the three sites impaired for habitat, two are EWH streams and one is designated as WWH. Table D-6 lists modified and high influence modified attributes and provides the QHEI targets used for this habitat TMDL.

Table 4-5. QHEI targets for the habitat TMDL.

	Overall QHEI Score		All Modified Attributes	
			High Influence Modified Attributes	**All Other Modified Attributes**
Range of Possibilities	12 to 100 points		- Channelized or no recovery - Silt/muck substrate - Low sinuosity - Sparse/no cover - Max pool depth < 40 cm (wadeable streams only)	- Recovering channel - Sand substrate (boat sites) - Hardpan substrate origin - Fair/poor development - Only 1-2 cover types - No fast current - High/moderate embeddedness - Ext/mod riffle embeddedness - No riffle
Targets	**WWH**	Overall score ≥ 60	Total number < 2	Total number < 5[1]
	EWH	Overall score ≥ 75	Total number < 0	Total number < 3[1]
TMDL Points if Target Satisfied	+1		+1	+1

[1] Total num. of modified attributes includes those counted towards the high influence modified attributes.

For simplicity, a pass/fail distinction is made telling whether each of the three targets are being met. Targets are set for: 1) the total QHEI score, 2) maximum number of all modified attributes, and 3) maximum number of high influence modified attributes only. If the minimum target is satisfied, then that category is assigned a “1”, if not, it is assigned a “0”. To satisfy the habitat TMDL, the stream segment in question should achieve a score of three.

4.4 Margin of Safety

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

For the *E. coli* LDCs, an implicit MOS is incorporated in various ways, including in the derivation of the *E. coli* water quality criterion and in not considering the die-off of pathogens as part of the TMDL calculations. The implicit MOS is also enhanced by the use of the geometric mean target (which is a seasonal target) to calculate daily loads. In addition, an explicit MOS has been applied as part of all of the bacteria TMDLs by reserving 20% of the allowable load because of the broad fluctuation of *E. coli* concentrations that occurs in nature and the relatively low numbers of data points available for this analysis. The explicit MOS in each allocation is shown in the TMDL allocation tables throughout Section 5.

For nutrient and TDS TMDLs, an explicit margin of safety of 5% is given to the allocations. Because the input values are based on measured values there is a higher level of confidence in them than commonly used assumed or text book values, therefore 5% is an adequate MOS.

There is an implicit margin of safety applied to the habitat and sediment TMDLs based on conservative target values used. The targets from the *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA 1999) are conservative because attainment of aquatic life uses has been demonstrated even when the targets are not met.

5 LOAD REDUCTION RESULTS

Several analyses were completed to address the causes of impairment. Results are summarized in this chapter and organized by assessment unit. Further details are available in Appendix D.

5.1 Dead Branch, Headwaters Grand River, Baughman Creek, Center Creek-Grand River, Coffee Creek-Grand River, Phelps Creek, Hoskins Creek, Mill Creek-Grand River, Plum Creek-Grand River (04110004 01 01 through 06, 03 01, 03 02, 03 03 and 03 05 upstream from river mile 55.6)

Table 5-1 shows the *E. coli* reductions necessary at Grand River at U.S. Route 6. The load duration curve (LDC) created at this site includes all drainage area upstream from the site (at RM 55.6). The largest load allocation reduction (82%) is needed in wet weather flows.

Table 5-1. *E. coli* TMDL table for site on Grand River @ US-6.

Flow regime TMDL analysis					
***E. coli* (billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	0	7	7	0	0
Median sample load	N/A	1,650	123	N/A	N/A
TMDL	**2,960.383**	**380.808**	**71.345**	**26.423**	**13.468**
WLA: total	**4.736**	**4.736**	**4.736**	**4.736**	**4.736**
Bloomfield High School	0.043	0.043	0.043	0.043	0.043
Bridge Lake Farm WWTP	0.016	0.016	0.016	0.016	0.016
Bristol Local School	0.107	0.107	0.107	0.107	0.107
Camp Whitewood	0.038	0.038	0.038	0.038	0.038
Cardinal Local School District	0.029	0.029	0.029	0.029	0.029
End of Commons General Store	0.014	0.014	0.014	0.014	0.014
Geauga Co. Parkman WWTP	0.711	0.711	0.711	0.711	0.711
Glenbeigh Hospital	0.095	0.095	0.095	0.095	0.095
Grand Valley Country Manor	0.095	0.095	0.095	0.095	0.095
Halfway Restaurant	0.001	0.001	0.001	0.001	0.001
Hartsgrove BP	0.002	0.002	0.002	0.002	0.002

Flow regime TMDL analysis ***E. coli* (billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Hartsgrove General Store	0.005	0.005	0.005	0.005	0.005
Kool Lakes Family Campground	0.143	0.143	0.143	0.143	0.143
Middlefield MHP	0.095	0.095	0.095	0.095	0.095
Middlefield Orig. Cheese Coop.	0.049	0.049	0.049	0.049	0.049
Nelson Ledges Estate MHP	0.143	0.143	0.143	0.143	0.143
ODOT Rome Maint. Outpost	0.007	0.007	0.007	0.007	0.007
Orwell WWTP	2.48	2.48	2.48	2.48	2.48
Rigsby Ranch FKA River Pines	0.119	0.119	0.119	0.119	0.119
Shively Land Co. LLC	0.017	0.017	0.017	0.017	0.017
Southington Estates LLC	0.143	0.143	0.143	0.143	0.143
Southington Local Schools	0.095	0.095	0.095	0.095	0.095
Windsor Community Center	0.011	0.011	0.011	0.011	0.011
Trumbull County Commissioners & Others MS4	0.278	0.278	0.278	0.278	0.278
LA	**2,322.146**	**294.599**	**51.362**	**16.053**	**5.871**
MOS: 20%	**592.057**	**76.141**	**14.249**	**5.265**	**2.674**
AFG: 1.4%	**41.444**	**5.33**	**0.997**	**0.369**	**0.187**
Nonpoint (LA) % load reduction required	No Data	**82%**	**58%**	No Data	No Data

Values were adjusted for rounding.

Table 5-2 shows the TMDL results for total Kjeldahl nitrogen for Center Creek.

Table 5-2. Total Kjeldahl nitrogen TMDL results for Center Creek.

	River Mile 6.25 (kg/d)	**River Mile 3.03 (kg/d)**
Existing Average Load	0.1182	0.3183
TMDL	0.0526	0.2210
LA	0.0340	0.0649
WLA	0.0090	0.1419
Trumbull Co. MS4	0.0001	0.0001
Bristol School	N/A	0.1329
Dean Haines Property	0.0089	0.0089
MOS (5%)	0.0026	0.0111
AFG (1.4%)	0.0007	0.0031
Needed Overall Reduction (%)	**55%**	**31%**

Notes:

- Values have been adjusted for rounding.
- The basis for TKN is an analysis of the median value of all Ohio WWTPs and is appropriate for these smaller discharges if they are meeting their ammonia permit of 1.0 mg/l.
- There are no monitoring data for the facilities so the permit flow and concentrations values are used for both the existing and target values; therefore, the values are equal.
- The MS4 area is a very small fraction (0.21%) of the Center Cr. sub-basin; the allocation is taken from the LA.

To satisfy the habitat TMDL, the stream should achieve a target score of three. The scores in Table 5-3 show that neither the Grand River (RM 94.3) nor Hoskins Creek (RM 4.88) meet minimum habitat target of 3, and missed the target by 3 points for the Grand River and 2 points for Hoskins Creek.

Table 5-3. Habitat TMDLs for the Grand River and Hoskins Creek.

		Habitat TMDL						
TMDL Targets	**Use**	**Allocations**			**Subscore**			**TMDL**
	WWH	> 60 = 1 pt	TMDL	< 5 = 1 pt				3 pts
	EWH	> 75 = 1 pt	32	< 3 =1 pt				3 pts
Existing Scores Stream/River (Use) *(Nested Subwatershed)*	River Mile	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Headwaters Grand River (04110004 01)								
Grand River (EWH) *(04110004 01 02)*	94.3	58	1	2	0	0	0	0
Phelps Creek-Grand River (04110004 03)								
Hoskins Creek (EWH) *(04110004 03 02)*	4.88	63.5	2	0*	0	0	1	1

* *The Modified Attributes include the High Influence Attributes, so the total Modified Attributes score is equal to the Modified Attributes score plus the High Influence Attributes score.*

5.2 Swine Creek (04110004 01 06)

Table 5-4 shows the *E. coli* reductions necessary at Swine Creek at Curtis Middlefield Road. The LDC created at this site includes all of the Swine Creek drainage area upstream of the site. The largest load allocation reduction (76%) is needed in wet weather flows.

Table 5-4. *E. coli* TMDL table for site on Swine Creek @ Curtis Middlefield Rd.

Flow regime TMDL analysis *E. coli* **(billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	0	5	9	0	0
Median sample load	N/A	150	18	N/A	N/A
TMDL	**374.808**	**35.446**	**4.932**	**1.359**	**0.490**
WLA	None	None	None	None	None
LA	**294.599**	**27.861**	**3.876**	**1.068**	**0.385**
MOS: 20%	**74.962**	**7.089**	**0.986**	**0.272**	**0.098**
AFG: 1.4%	**5.247**	**0.496**	**0.069**	**0.019**	**0.007**
Nonpoint (LA) % load reduction required	No Data	**76%**	**73%**	No Data	No Data

Values were adjusted for rounding.

5.3 Upper Rock Creek, Middle Rock Creek, Lower Rock Creek, Mud Creek, Plum Creek-Grand River, Three Brothers Creek-Grand River, Bronson Creek-Grand River (04110004 02 01 through 03, 03 04, 03 05 downstream from river mile 55.6, 05 01 and 05 02)

Table 5-5 shows the *E. coli* reductions necessary at Grand River at Camp Beaumont. The LDC created at this site includes all of the drainage area upstream of the site. The largest load allocation reduction (84%) is needed in wet weather flows.

Table 5-5. *E. coli* TMDL table for site on Grand River @ Camp Beaumont.

Flow regime TMDL analysis ***E. coli* (billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	0	6	7	0	0
Median sample load	N/A	4903	166.35	N/A	N/A
TMDL	**5,047.59**	**785.693**	**167.384**	**64.127**	**31.455**
WLA: total	**5.679**	**5.679**	**5.679**	**5.679**	**5.679**
Bloomfield High School	0.043	0.043	0.043	0.043	0.043
Bridge Lake Farm WWTP	0.016	0.016	0.016	0.016	0.016
Bristol Local School	0.107	0.107	0.107	0.107	0.107
Camp Whitewood	0.038	0.038	0.038	0.038	0.038
Cardinal Local School District	0.029	0.029	0.029	0.029	0.029
End of Commons General Store	0.014	0.014	0.014	0.014	0.014
Geauga Co. Parkman WWTP	0.711	0.711	0.711	0.711	0.711
Glenbeigh Hospital	0.095	0.095	0.095	0.095	0.095
Grand Valley Conservation Center	0.095	0.095	0.095	0.095	0.095
Halfway Restaurant	0.001	0.001	0.001	0.001	0.001
Hartsgrove BP	0.002	0.002	0.002	0.002	0.002
Hartsgrove General Store	0.005	0.005	0.005	0.005	0.005
Kool Lakes Family Campground	0.143	0.143	0.143	0.143	0.143
Middlefield MHP	0.095	0.095	0.095	0.095	0.095
Middlefield Orig. Cheese Coop.	0.049	0.049	0.049	0.049	0.049
Nelson Ledges Estate MHP	0.143	0.143	0.143	0.143	0.143
ODOT Rome Maint. Outpost	0.007	0.007	0.007	0.007	0.007
Orwell WWTP	2.48	2.48	2.48	2.48	2.48
Rigsby Ranch FKA River Pines	0.119	0.119	0.119	0.119	0.119
Roaming Shores WWTP	0.763	0.763	0.763	0.763	0.763
Rock Ck. STP	0.033	0.033	0.033	0.033	0.033
Shively Land Co. LLC	0.017	0.017	0.017	0.017	0.017
Southington Estates LLC	0.143	0.143	0.143	0.143	0.143
Southington Local Schools	0.095	0.095	0.095	0.095	0.095

Flow regime TMDL analysis ***E. coli* (billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Windsor Community Center	0.011	0.011	0.011	0.011	0.011
Grand Valley Nature Conservancy	0.095	0.095	0.095	0.095	0.095
Kampf Apartments	0.052	0.052	0.052	0.052	0.052
Trumbull County Commissioners & Others MS4	0.278	0.278	0.278	0.278	0.278
LA	3,961.723	611.874	125.883	44.723	19.043
MOS: 20%	**1,009.518**	**157.139**	**33.477**	**12.826**	**6.291**
AFG: 1.4%	**70.666**	**11**	**2.343**	**0.898**	**0.44**
Nonpoint (LA) % load reduction required	No Data	**84%**	**None**	No Data	No Data

Values were adjusted for rounding.

Table 5-6 shows the total phosphorus TMDL for Lebanon Creek. Table 5-7 shows the TDS TMDL for Lebanon Creek. Table 5-8 shows loading calculations for TDS at the potential future WQS of 800 mg/l. Table 5-9 shows the ammonia TMDL for Whetstone Creek. Table 5-10 shows the total phosphorus TMDL for Rock Creek.

Table 5-6. Total phosphorus TMDL for Lebanon Creek.

	Lebanon Creek (RM 1.93) (kg/d)
Existing Average Load	0.1418
TMDL	0.1343
LA	0.0008
WLA: Kampf Apartments	0.1249
MOS (5%)	0.0067
AFG (1.4%)	0.0019
Needed Overall Reduction (%)	**5.3%**

Table 5-7. Total dissolved solids TMDL for Lebanon Creek at Institute Road (using 1,500 mg/l criterion).

TMDL and duration intervals	**High 0-5%**	**Wet weather 5-40%**	**Normal range 40-80%**	**Dry weather 80-95%**	**Low 95-100%**
Total Maximum Daily Load	**284,194.25**	**38,790.46**	**9,945.33**	**6,238.77**	**5,284.60**
Wasteload Allocation	33.31	33.31	33.31	33.31	33.31
Load Allocation	266,029.34	36,282.32	9,277.51	5,807.42	4,914.13
Margin of Safety: 5%	14,209.71	1,939.52	497.27	311.94	264.23
Allowance for future growth: 1.4%	3,921.88	535.31	137.25	86.10	72.93
Total Load Reduction Required	**NA**	No Data	No Data	**NA**	**28.0%**

Table 5-8. TDS load information at 800 mg/l target for Lebanon Creek at Institute Road.

TMDL and duration intervals	High 0-5%	Wet weather 5-40%	Normal range 40-80%	Dry weather 80-95%	Low 95-100%
Total Maximum Daily Load	151,570.27	20,688.25	5,304.18	3,327.34	2,818.46
Wasteload Allocation	33.31	33.31	33.31	33.31	33.31
Load Allocation	141,866.77	19,335.02	4,932.46	3,081.75	2,605.33
Margin of Safety: 5%	7,578.51	1,034.41	265.21	166.37	140.92
Allowance for future growth: 1.4%	2,091.67	285.50	73.20	45.92	38.89
Total Load Reduction Required	NA	No Data	No Data	NA	61.6%

Table 5-9. Ammonia TMDL for Whetstone Creek at S.R. 46.

TMDL and duration intervals	High 0-5%	Wet weather 5-40%	Normal range 40-80%	Dry weather 80-95%	Low 95-100%
Total Maximum Daily Load	396.90	54.09	13.78	8.67	7.32
Wasteload Allocation	0.00	0.00	0.00	0.00	0.00
Load Allocation	371.58	50.64	12.90	8.11	6.85
Margin of Safety: 5%	19.85	2.70	0.69	0.43	0.37
Allowance for future growth: 1.4%	5.48	0.75	0.19	0.12	0.10
Total Load Reduction Required	**NA**	No Data	No Data	**21.1%**	**NA**

Table 5-10. Total phosphorus TMDL for Rock Creek.

	TMDL (kg/d)				TMDL (mg/l)	Existing Loads (kg/d)		Needed Reduction (kg/d)		Needed Reduction (%)	
	total allocation	total allocation w/ MOS and AFG	Roaming Shores WWTP (WLA)	Rock Creek at SR 45 (LA)	Roaming Shores WWTP (WLA)	Roaming Shores WWTP	Rock Creek at SR 45	Roaming Shores WWTP	Rock Creek at SR 45	Roaming Shores WWTP	Rock Creek at SR 45
win	6.92	6.48	1.94	4.54	3.2	1.94	6.31	NA**	1.77	NA	28.1
spr	6.70	6.27	1.94	4.33	3.2	1.94	4.78	NA**	0.45	NA	9.41
sum	1.97	1.84	1.74	0.10*	2.88	1.94	1.49	0.20	1.39	10.3	93.3
fal	2.81	2.63	1.94	0.69	3.2	1.94	2.14	NA**	1.45	NA	67.8

Notes:

* The total allocation is less than the WLA assuming the WWTP receives its existing average tot P as its discharge limit and assuming there must be some minimal amount for the LA. The WLA was dropped from 1.94 kg/d to 1.74 kg/d in order to give some minimal assimilative capacity (0.10 kg/d) to the LA.

** For total phosphorus both the WLA target and existing conditions assume the same concentration (3.2 mg/l) and the design plant flow for flow, therefore the existing conditions equal the WLA and so no reduction is needed. Any needed reduction is to come from the LA in order to prevent undue burden on the WWTP.

NA indicates that there is a negative needed reduction because existing loads are less than the allocated loads, so no reduction is necessary.

To satisfy the habitat TMDL, the stream should achieve a target score of three. The scores in Table 5-11 show that Crooked Creek (RM 3.8) did not meet the minimum habitat target of 3 and missed the target by 3 points.

Table 5-11. Habitat TMDLs for the Grand River and Crooked Creek.

		Habitat TMDL						
TMDL Targets	**Use**	**Allocations**			**Subscore**			**TMDL**
	WWH	> 60 = 1 pt	TMDL	< 5 = 1 pt				3 pts
	EWH	> 75 = 1 pt	32	< 3 =1 pt				3 pts
Existing Scores Stream/River (Use) *(Nested Subwatershed)*	River Mile	QHEI Score	# of High Influence Attributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Phelps Creek-Grand River (04110004 03)								
Crooked Creek (WWH) *(04110004 03 04)*	3.8	55	6	6*	0	0	0	0

* *The Modified Attributes include the High Influence Attributes, so the total Modified Attributes score is equal to the Modified Attributes score plus the High Influence Attributes score.*

5.4 Phelps Creek (04110004 03 01)

Table 5-12 shows the *E. coli* reductions necessary at Phelps Creek at Windsor Road Extension. The LDC created at this site includes all of the Phelps Creek drainage area upstream of the site. The largest load allocation reduction (83%) is needed in normal flows.

Table 5-12. *E. coli* TMDL table for site on Phelps Creek @ Windsor Rd. Extension.

Flow regime TMDL analysis ***E. coli* (billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	0	7	6	0	0
Median sample load	N/A	211	26	N/A	N/A
TMDL	**758.670**	**46.042**	**4.431**	**1.072**	**0.400**
WLA: total	**0.116**	**0.116**	**0.116**	**0.116**	**0.116**
Camp Whitewood	0.038	0.038	0.038	0.038	0.038
Cardinal Local School District	0.029	0.029	0.029	0.029	0.029
Middlefield Orig. Cheese Coop.	0.049	0.049	0.049	0.049	0.049
LA	**596.198**	**36.073**	**3.367**	**0.726**	**0.198**
MOS: 20%	**151.734**	**9.208**	**0.886**	**0.214**	**0.080**
AFG: 1.4%	**10.621**	**0.645**	**0.062**	**0.015**	**0.006**
Nonpoint (LA) % load reduction required	No Data	**78%**	**83%**	No Data	No Data

Values were adjusted for rounding.

5.5 Bronson Creek-Grand River (04110004 05 02)

Table 5-13 shows the *E. coli* reductions necessary at Trumbull Creek at Riverdale Road. The LDC created at this site includes all of the Trumbull Creek drainage area upstream of the site. The largest load allocation reduction (97%) is needed in high flows.

Table 5-13. *E. coli* TMDL table for site on Trumbull Creek @ Riverdale Rd.

Flow regime TMDL analysis ***E. coli* (billion bacteria/day)**	**High**	**Wet weather**	**Normal range**	**Dry weather**	**Low**
Duration interval	0-5%	5-40%	40-80%	80-95%	95-100%
Samples per regime	1	6	5	1	0
Median sample load	13,937	20.8	14.08	8.020	N/A
TMDL	**473.499**	**33.039**	**3.757**	**0.900**	**0.323**
WLA: total	**0.058**	**0.058**	**0.058**	**0.058**	**0.058**
Great Lakes Medieval Faire	0.053	0.053	0.053	0.053	0.053
Plank Road Tavern	0.006	0.006	0.006	0.006	0.006
LA	**372.112**	**25.910**	**2.895**	**0.649**	**0.196**
MOS: 20%	**94.700**	**6.608**	**0.751**	**0.180**	**0.065**
AFG: 1.4%	**6.629**	**0.463**	**0.053**	**0.013**	**0.005**
Nonpoint (LA) % load reduction required	**97%**	**None**	**73%**	**89%**	No Data

Values were adjusted for rounding.

6 WATER QUALITY IMPROVEMENT STRATEGY

Overall, impairment for aquatic life use was more common in the eastern and northern areas of the watershed. Non-attainment of aquatic life use criteria tended to result from natural conditions (flow or habitat), nutrients and total dissolved solids. Partial attainment of aquatic life use criteria predominantly resulted from natural conditions (flow or habitat), direct habitat alterations and nutrients and organic enrichment. Impairment for recreation use was widespread throughout the watershed. The most common sources of impairment included natural sources, channelization and sewage discharges in unsewered areas.

Tables 6-1 through 6-3 show recommendations involving NPDES permits. Table 6-4 shows an overview of all of the nested subwatersheds that contain sites with partial and non-attainment of aquatic life and recreation uses. Causes of impairment are shown within parentheses following each source that might contribute to that cause. Tables 6-5 through 6-8 each represent a separate subwatershed (see Figure 3-1 for a map). For each nested subwatershed, specific actions are recommended.

Recommendations were developed by Ohio EPA in consultation with local technical stakeholders. In each case, these actions are intended to be inclusive of possible methods to improve water quality in the watershed based on identified causes and sources of impairment. Because Ohio EPA recognizes that actions taken in any individual subwatershed may depend on a number of factors (including socioeconomic, political and ecological factors), these recommendations are not intended to be prescriptive of actions to be taken, and any number or combination might contribute to improvement, whether applied at sites where actual impairment was noted or other locations where sources contribute indirectly to water quality impairment. Further details about individual practices can be found in Appendix E.

6.1 Regulatory Recommendations

Recommendations for NPDES permits are summarized by discharger and nested subwatershed in Tables 6-1 through 6-3. Any suggestions in permit limits reflect calculated TMDLs. Ohio EPA will work with permit holders to accomplish any needed reductions in loadings.

Table 6-1. Recommended implementation actions through the NPDES program for total phosphorus.
Note: Any specific permit condition noted in the table indicates a recommended change from current permit conditions. "No change" means that no change is recommended.

Nested Sub-watershed (04110004)	Entity	Ohio EPA Permit #	Receiving Stream	Design Flow (million gallons per day)	Wasteload Allocation (load)	Wasteload Allocation (concen-tration)	Recommended Permit Conditions		Explanation for Difference
							First Phase	Second Phase	
02 02	Kampf Apartments	3GV00026/ 5PGV0002	Lebanon Creek	0.011	0.1249 kg/d	3.0 mg/l	Monitor 1 time per month	Average monthly limit of 3.0 mg/l	No current data exist to determine existing wasteload
02 03	Roaming Shores WWTP	3PB00068	Rock Creek	0.160	*Winter, spring and fall:* 1.94 kg/d *Summer:* 1.74 kg/d	*Winter, spring and fall:* 3.2 mg/l *Summer:* 2.87 mg/l	*Summer average limits:* 30-day: 1.0 mg/l *Winter:* Monitor 1x per month		Impairment is likely being caused by summer discharges. Therefore, only monitoring is recommended in other seasons.

Table 6-2. Recommended implementation actions through the NPDES program for total Kjeldahl nitrogen.
Note: Any specific permit condition noted in the table indicates a recommended change from current permit conditions. "No change" means that no change is recommended.

Nested Sub-watershed (04110004)	Entity	Ohio EPA Permit #	Receiving Stream	Design Flow (million gallons per day)	Wasteload Allocation (load)	Wasteload Allocation (concen-tration)	Recommended Permit Conditions		Explanation for Difference
							First Phase	Second Phase	
01 04	Bristol Local School	3PT00065	Center Creek	0.0225	0.1329 kg/d	1.56 mg/l	Monitor 1 time per month	Average monthly limit of 1.56 mg/l	No current data exist to determine existing wasteload
01 04	Dean Haines Property	3GV00022	Trib. to Center Cr. at RM 8.38	≤ 0.025	0.0089 kg/d	1.56 mg/l	Monitor 1 time per month	Average monthly limit of 1.56 mg/l	No current data exist to determine existing wasteload

Table 6-3. Recommended implementation actions through the NPDES program for total dissolved solids.
Note: Any specific permit condition noted in the table indicates a recommended change from current permit conditions. "No change" means that no change is recommended.

Nested Sub-watershed (04110004)	Entity	Ohio EPA Permit #	Receiving Stream	Design Flow (million gallons per day)	Wasteload Allocation (load)	Wasteload Allocation (concen-tration)	Recommended Permit Conditions		Explanation for Difference
							First Phase	Second Phase	
02 02	Kampf Apartments	3GV00026/ 5PGV0002	Lebanon Creek	0.011	33.31 kg/d	1,500 mg/l	Monitor 1 time per month	Average monthly limit of 1,500 mg/l	No current data exist to determine existing wasteload

Table 6-4. Recommendations for improving water quality in impaired areas of the Grand River (upper) watershed.

Location Description (10-digit HUC) Location Description (12-digit HUC) Sources (Causes)[1]	Restoration Categories											
	Bank & Riparian Restoration	Stream Restoration	Wetland Restoration	Conservation Easements	Dam Modification or Removal	Levee or Dike Modification or Removal	Abandoned Mine Land Reclamation	Home Sewage Planning and Improvement	Education and Outreach	Agricultural Best Management Practices	Storm Water Best Management Practices	Regulatory Point Source Controls
Headwaters Grand River (04110004 01)												
Dead Branch (01 01)												
Failing HSTS (bacteria)								x	x			
Sediment resuspension (bacteria)			x									
Headwaters Grand River (01 02)												
Impacts from hydrostructure flow regulation/modification (direct habitat alterations)					x							
Highways, roads, bridges, infrastructure (new construction) (direct habitat alterations)	x	x										
Livestock (bacteria)									x	x		
Agricultural land uses (bacteria)									x	x		

Location Description (10-digit HUC) **Location Description (12-digit HUC)** **Sources (Causes)**[1]	**Restoration Categories**											
	Bank & Riparian Restoration	Stream Restoration	Wetland Restoration	Conservation Easements	Dam Modification or Removal	Levee or Dike Modification or Removal	Abandoned Mine Land Reclamation	Home Sewage Planning and Improvement	Education and Outreach	Agricultural Best Management Practices	Storm Water Best Management Practices	Regulatory Point Source Controls
Baughman Creek (01 03)												
Natural sources (natural conditions (flow or habitat))			x	W								
Livestock (bacteria)			x						x	x		
Center Creek-Grand River (01 04)												
Sewage discharges in unsewered areas (total ammonia, TDS, TKN, organic enrichment)								x	x			x
Natural sources (natural conditions (flow or habitat))			x	W								
Failing HSTS (bacteria)								x	x			
Coffee Creek-Grand River (01 05)												
Failing HSTS (bacteria)								x	x			
Livestock (bacteria)									x	x		
Swine Creek (01 06)												
Livestock (bacteria)									x	x		
Rock Creek (04110004 02)												
Upper Rock Creek (02 01)												
Agricultural land uses (bacteria)									x	x		
Middle Rock Creek (02 02)												
Unknown (nutrients/eutrophication, TDS)	Further investigation is recommended.											
Agricultural land uses (bacteria)									x	x		
Unsewered areas (bacteria)								x	x			x
Lower Rock Creek (02 03)												
Unknown (total ammonia, TDS)	Further investigation is recommended.											
Dam or impoundment (low flow alterations, nutrients/eutrophication)					M							
Agricultural land uses (bacteria)									x	x		

Location Description (10-digit HUC) / Location Description (12-digit HUC) / Sources (Causes)[1]	Restoration Categories											
	Bank & Riparian Restoration	Stream Restoration	Wetland Restoration	Conservation Easements	Dam Modification or Removal	Levee or Dike Modification or Removal	Abandoned Mine Land Reclamation	Home Sewage Planning and Improvement	Education and Outreach	Agricultural Best Management Practices	Storm Water Best Management Practices	Regulatory Point Source Controls
Phelps Creek-Grand River (04110004 03)												
Phelps Creek (03 01)												
Natural sources (natural conditions (flow or habitat))			x	W								
Failing HSTS (bacteria)								x	x			
Hoskins Creek (03 02)												
Channelization (direct habitat alterations)	x			x								
Livestock (bacteria)									x	x		
Mill Creek-Grand River (03 03)												
Dam or impoundment (low flow alterations)					x							
Natural sources (natural conditions (flow or habitat))			x	W								
Livestock (bacteria)									x	x		
Mud Creek (03 04)												
Channelization (direct habitat alterations)	x			x						x		
Livestock (bacteria)									x	x		
Plum Creek-Grand River (03 05)												
Livestock (bacteria)									x	x		
Three Brothers Creek-Grand River (04110004 05)												
Three Brothers Creek-Grand River (05 01)												
Natural sources (natural conditions (flow or habitat))			x	W								
Livestock (bacteria)									x	x		
Bronson Creek-Grand River (05 02)												
Natural sources (natural conditions (flow or habitat))			x	W								
Livestock (bacteria)									x	x		

[1] TDS = total dissolved solids; TKN = total Kjeldahl nitrogen; nutrients/eutrophication = nutrient/eutrophication biological indicators; organic enrichment = organic enrichment (sewage) biological indicators

6.2 Headwaters Grand River (04110004 01)

Actions that are likely to improve water quality are marked in Table 6-5Table 6-7 (an “x” marks a recommended action, a “W” marks an actions that will be recommended in the watershed action plan, or WAP). These actions are specific to impairments in nested subwatersheds but, in general, may be applied anywhere within that nested subwatershed to have a positive effect on water quality. More specific actions are discussed below the table.

Table 6-5. Recommended implementation actions in the Headwaters Grand River subwatershed.

Restoration Categories		Specific Restoration Actions	Headwaters Grand River (04110004 01)					
			Dead Branch (01 01)	Headwaters Grand River (01 02)	Baughman Creek (01 03)	Center Creek-Grand River (01 04)	Coffee Creek-Grand River (01 05)	Swine Creek (01 06)
Bank & Riparian Restoration	constructed	Restore streambank using bio-engineering		x				
		Restore streambank by recontouring or regrading						
	planted	Plant grasses in riparian areas						
		Plant prairie grasses in riparian areas		x				
		Remove/treat invasive species		x				
		Plant trees or shrubs in riparian areas		x				
Stream Restoration		Restore flood plain		x				
		Restore stream channel		x				
		Install in-stream habitat structures		x				
		Install grade structures						
		Construct 2-stage channel						
		Restore natural flow		x				
Wetland Restoration		Reconnect wetland to stream	x		x	x		
		Reconstruct & restore wetlands	x		x	x		
		Plant wetland species	x		x	x		
Conservation Easements		Acquire conservation easements			W	W		
Dam Modification or Removal		Remove dams						
		Modify dams						
		Remove associated dam support structures						
		Install fish passage and/or habitat structures						
		Restore natural flow						
Levee or Dike Modification or Removal		Remove levees						
		Breach or modify levees						

Restoration Categories		Specific Restoration Actions	Headwaters Grand River (04110004 01)					
			Dead Branch (01 01)	Headwaters Grand River (01 02)	Baughman Creek (01 03)	Center Creek-Grand River (01 04)	Coffee Creek-Grand River (01 05)	Swine Creek (01 06)
		Remove dikes						
		Modify dikes						
		Restore natural flood plain function						
Abandoned Mine Land Reclamation	treatment	Construct lime dosers						
		Install slag leach beds						
		Install limestone leach beds						
		Install limestone channels						
		Install successive alkalinity producing systems						
		Install settling ponds						
		Install vertical flow ponds						
		Install limestone drains (anoxic and/or oxic)						
		Construct acid mine drainage wetland						
	flow diversion	Repair subsidence sites						
		Reclaim pit impoundments						
		Reclaim abandoned mine land						
		Eliminate stream captures						
		Eliminate mine drainage discharges						
		Restore positive drainage						
		Cover toxic mine spoils						
Home Sewage Planning and Improvement		Develop HSTS plan	x			x	x	
		Inspect HSTS	x			x	x	
		Repair or replace traditional HSTS	x			x	x	
		Repair or replace alternative HSTS	x			x	x	
Education and Outreach		Host meetings, workshops, and/or other events	x	x	x	x	x	x
		Distribute educational materials	x	x	x	x	x	x
Agricultural Best Management Practices	farmland	Plant cover/manure crops		x				
		Implement conservation tillage practices						
		Implement grass/legume rotations						
		Convert to permanent hayland						
		Install grassed waterways						
		Install vegetated buffer areas/strips		x				

Restoration Categories		Specific Restoration Actions	Headwaters Grand River (04110004 01)					
			Dead Branch (01 01)	Headwaters Grand River (01 02)	Baughman Creek (01 03)	Center Creek-Grand River (01 04)	Coffee Creek-Grand River (01 05)	Swine Creek (01 06)
		Install location-specific conservation buffer						
		Install / restore wetlands						
	nutrients / agro-chemicals	Conduct soil testing						
		Install nitrogen reduction practices						
		Develop nutrient management plans						
	drainage	Install sinkhole stabilization structures						
		Install controlled drainage system						
		Implement drainage water management						
		Construct overwide ditch						
		Construct 2-stage channel						
	livestock	Implement prescribed & conservation grazing practices		x	x		x	x
		Install livestock exclusion fencing		x	x		x	x
		Install livestock crossings						
		Install alternative water supplies		x	x		x	x
		Install livestock access lanes						
	manure	Implement manure management practices		x	x		x	x
		Construct animal waste storage structures		x	x		x	x
		Implement manure transfer practices		x	x		x	x
		Install grass manure spreading strips		x	x		x	x
	misc. infrastructure and mgt	Install chemical mixing pads						
		Install heavy use feeding pads						
		Install erosion & sediment control structures						
		Install roof water management practices						
		Install milkhouse waste treatment practices						
		Develop whole farm management plans						
Storm Water Best Management Practices	planning	Develop/implement local ordinances/resolutions						
		Develop local comprehensive land use plans						
	construction	Implement erosion controls						

Restoration Categories		Specific Restoration Actions	Headwaters Grand River (04110004 01)					
			Dead Branch (01 01)	Headwaters Grand River (01 02)	Baughman Creek (01 03)	Center Creek-Grand River (01 04)	Coffee Creek-Grand River (01 05)	Swine Creek (01 06)
	practices	Implement sediment controls						
		Implement non-sediment controls						
	post construction practices	Reduce pollutant(s) through treatment						
		Reduce pollutant(s) through flow/volume management						
	post development/ storm water retrofit	Implement erosion controls						
		Implement sediment controls						
		Implement non-sediment controls						
		Reduce pollutant(s) through treatment						
		Reduce pollutant(s) through flow/volume management						
Regulatory Point Source Controls (includes Storm Water, Sanitary, and Industrial)	planning	Develop long-term control plan (CSOs)						
		Develop/implement local ordinances/resolutions						
		Develop water quality management/208 plans						
	collection and new treatment	Install sewer systems in communities				x		
		Implement long-term control plan (CSOs)						
		Eliminate SSOs/CSOs/by-passes						
	enhanced treatment	Issue permit(s) and/or modify permit limit(s)						
		Improve quality of effluent						
	monitoring	Establish ambient monitoring program						
		Increase effluent monitoring						
	alternatives	Establish water quality trading						
	construction practices	Issue permit(s) and/or modify permit limit(s)						
		Implement erosion controls						
		Implement sediment controls						
		Implement non-sediment controls						
	post construction practices	Issue permit(s) and/or modify permit limit(s)						
		Reduce pollutant(s) through treatment						
		Reduce pollutant(s) through flow/volume management						
	post development/	Issue permit(s) and/or modify permit limit(s)						

Restoration Categories		Specific Restoration Actions	Headwaters Grand River (04110004 01)					
			Dead Branch (01 01)	Headwaters Grand River (01 02)	Baughman Creek (01 03)	Center Creek-Grand River (01 04)	Coffee Creek-Grand River (01 05)	Swine Creek (01 06)
	storm water retrofit	Implement erosion controls						
		Implement sediment controls						
		Implement non-sediment controls						
		Reduce pollutant(s) through treatment						
		Reduce pollutant(s) through flow/volume management						
		Reduce volume to CSOs						

Wetland restoration is possible at the former Camp Chickagami site (owned now by Geauga Park District). There was a dam on the river forming Lake Estabrook; the dam has been removed. Now there's an area that could be a potential for wetland restoration.

Southington has future plans to upgrade the WWTP at the high school. The upgrade would allow the remainder of the town to tie into the WWTP. A feasibility study for the development of a design plan for the construction of an upgraded facility is currently underway. It is unknown at the time of publication when an application for this work will be submitted to Ohio EPA.

The Village of West Farmington has received approval via a permit to install and an NPDES permit (3PA00038, effective March 1, 2012) to install a sewer system. The approved plans for the community call for a de-centralized system that would have three separate treatment units and collection systems. Discharges would be to Coffee Creek, an unnamed tributary to the Grand River and to the Grand River main stem. Installation and operation of the approved systems will eliminate uncontrolled discharges from failing HSTS and help to alleviate the recreation use impairments noted in this area. At present, the village is securing funding for the construction of the wastewater collection and treatment system. Current plans call for construction to begin sometime in 2013.

The dam forming Grand River Lake (RM 97.93) backs up flow on the Grand River for approximate 0.5 miles upstream. The impoundment impacts biological communities. Similar dams on other Ohio rivers create sluggish, monotypic pools, resulting in habitats that support fewer species than natural channels. Dams can act as barriers to fish or mussel migration and impoundment often contributes to excessive fine silt deposition, elevated stream temperatures and reduced oxygen levels. Upstream from the north crossing of U.S. Route 422 (RM 98.95), the stream supports 11 coldwater macroinvertebrates, clearly demonstrating the CWH use. However, the fish community was limited because the reach was bracketed by Grand River Lake downstream and Lake Estabrook (dam at RM 100.3) upstream. The two impoundments isolated the fish community in the free flowing reach between the lakes, and the reach was flow starved during the summer months.

Subsequent to the 2003-2004 water quality survey, the property that included Lake Estabrook was transferred from the Boy Scouts to the Geauga Park District. Based upon the poor condition of the dam and the findings of the Ohio EPA water quality survey, the Park District removed the Lake Estabrook Dam and has restored the former lake bed into a wetland/stream ecosystem. Approximately 0.5 mile of the Grand River, as well as several small primary headwater habitat tributaries, has been restored to a free-flowing condition following the dam removal. The reach of the Grand River downstream from the dam removal project has not yet been re-evaluated to determine how this action benefitted the downstream condition.

It is likely that if the Grand River Lake dam is removed in the future and natural flow were restored, biological communities in the uppermost portions of the Grand River would improve both in the former impoundment and in the upstream and downstream reaches of the Grand River. It is also possible that the exceptional and coldwater communities upstream and downstream of the impoundment would extend into the area of the former impoundment. While funding may be available for such an action (e.g., Section 319), removal of this dam would be dependent on local support. An alternative to removal would be to modify flow through the dam to increase flow at critical conditions (i.e., summer low flows).

The Grand River at Hobart Road was affected by bridge construction that altered channel features and denuded habitat from the riparian zone and stream banks. While some of the natural habitat features may have returned since sampling in 2007, this may be a potential area for stream and/or riparian restoration to restore more natural habitat.

Dead Branch is naturally a wetland-stream complex. Because of this, it is low gradient and has highly erodible soils. Restoring portions of the stream to their natural wetland state would stabilize erosion and help reduce or control the bacteria issues. Biological criteria would likely not be met because Ohio’s WQS are not calibrated to wetland streams.

Center Creek runs through land utilized heavily for agriculture. Addressing manure management practices and failing HSTS along this stream would reduce bacteria entering the stream. If development in Bristol Township increases in the future, the possibility of installing sanitary sewers should be evaluated. Ohio EPA staff members will investigate the Paradise Lake Campground to determine if the plant is still being operated and to help the facility obtain an NPDES permit.

Home sewage treatment systems along State Route 87 to the east of Mesopotamia should be investigated and replaced or repaired where found to be failing. There is a rural community of trailer homes along Combs Road that floods frequently, making it difficult to operate HSTS well.

6.3 Rock Creek (04110004 02)

Actions that are likely to improve water quality are marked in Table 6-6 (an “x” marks a recommended action). These actions are specific to impairments in nested subwatersheds but, in general, may be applied anywhere within that nested subwatershed to have a positive effect on water quality. More specific actions are discussed below the table.

Table 6-6. Recommended implementation actions in the Rock Creek subwatershed.

Restoration Categories		Specific Restoration Actions	Rock Creek (04110004 02)		
			Upper Rock Creek (02 01)	Middle Rock Creek (02 02)	Lower Rock Creek (02 03)
Bank & Riparian Restoration	constructed	Restore streambank using bio-engineering			
		Restore streambank by recontouring or regrading			
	planted	Plant grasses in riparian areas			
		Plant prairie grasses in riparian areas			
		Remove/treat invasive species			
		Plant trees or shrubs in riparian areas			
Stream Restoration		Restore flood plain			
		Restore stream channel			
		Install in-stream habitat structures			
		Install grade structures			
		Construct 2-stage channel			
		Restore natural flow			
Wetland Restoration		Reconnect wetland to stream			
		Reconstruct & restore wetlands			
		Plant wetland species			
Conservation Easements		Acquire conservation easements			
Dam Modification or Removal		Remove dams			
		Modify dams		x	
		Remove associated dam support structures			
		Install fish passage and/or habitat structures			
		Restore natural flow		x	
Levee or Dike Modification or Removal		Remove levees			
		Breach or modify levees			
		Remove dikes			
		Modify dikes			
		Restore natural flood plain function			
Abandoned Mine Land Reclamation	treatment	Construct lime dosers			
		Install slag leach beds			
		Install limestone leach beds			
		Install limestone channels			
		Install successive alkalinity producing systems			
		Install settling ponds			
		Install vertical flow ponds			
		Install limestone drains (anoxic and/or oxic)			
		Construct acid mine drainage wetland			

Restoration Categories		Specific Restoration Actions	Rock Creek (04110004 02)		
			Upper Rock Creek (02 01)	Middle Rock Creek (02 02)	Lower Rock Creek (02 03)
	flow diversion	Repair subsidence sites			
		Reclaim pit impoundments			
		Reclaim abandoned mine land			
		Eliminate stream captures			
		Eliminate mine drainage discharges			
		Restore positive drainage			
		Cover toxic mine spoils			
Home Sewage Planning and Improvement		Develop HSTS plan			
		Inspect HSTS			
		Repair or replace traditional HSTS			
		Repair or replace alternative HSTS			
Education and Outreach		Host meetings, workshops, and/or other events	x	x	x
		Distribute educational materials	x	x	x
Agricultural Best Management Practices	farmland	Plant cover/manure crops	x	x	x
		Implement conservation tillage practices			
		Implement grass/legume rotations			
		Convert to permanent hayland			
		Install grassed waterways			
		Install vegetated buffer areas/strips	x	x	x
		Install location-specific conservation buffer			
		Install / restore wetlands			
	nutrients / agro-chemicals	Conduct soil testing			
		Install nitrogen reduction practices			
		Develop nutrient management plans			
	drainage	Install sinkhole stabilization structures			
		Install controlled drainage system			
		Implement drainage water management			
		Construct overwide ditch			
		Construct 2-stage channel			
	livestock	Implement prescribed & conservation grazing practices			
		Install livestock exclusion fencing			
		Install livestock crossings			
		Install alternative water supplies			
		Install livestock access lanes			
	manure	Implement manure management practices	x	x	x
		Construct animal waste storage structures	x	x	x

Restoration Categories		Specific Restoration Actions	Rock Creek (04110004 02)		
			Upper Rock Creek (02 01)	Middle Rock Creek (02 02)	Lower Rock Creek (02 03)
		Implement manure transfer practices	x	x	x
		Install grass manure spreading strips	x	x	x
	misc. infrastructure and mgt	Install chemical mixing pads			
		Install heavy use feeding pads			
		Install erosion & sediment control structures			
		Install roof water management practices			
		Install milkhouse waste treatment practices			
		Develop whole farm management plans	x		
Storm Water Best Management Practices	planning	Develop/implement local ordinances/resolutions			
		Develop local comprehensive land use plans			
	construction practices	Implement erosion controls			
		Implement sediment controls			
		Implement non-sediment controls			
	post construction practices	Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management			
	post development/ storm water retrofit	Implement erosion controls			
		Implement sediment controls			
		Implement non-sediment controls			
		Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management			
Regulatory Point Source Controls (includes Storm Water, Sanitary, and Industrial)	planning	Develop long-term control plan (CSOs)			
		Develop/implement local ordinances/resolutions			
		Develop water quality management/208 plans			
	collection and new treatment	Install sewer systems in communities		x	
		Implement long-term control plan (CSOs)			
		Eliminate SSOs/CSOs/by-passes			
	enhanced treatment	Issue permit(s) and/or modify permit limit(s)			
		Improve quality of effluent			
	monitoring	Establish ambient monitoring program			
		Increase effluent monitoring			
	alternatives	Establish water quality trading			
	construction practices	Issue permit(s) and/or modify permit limit(s)			
		Implement erosion controls			
		Implement sediment controls			
		Implement non-sediment controls			
	post construction	Issue permit(s) and/or modify permit limit(s)			
		Reduce pollutant(s) through treatment			

Restoration Categories		Specific Restoration Actions	Rock Creek (04110004 02)		
			Upper Rock Creek (02 01)	Middle Rock Creek (02 02)	Lower Rock Creek (02 03)
	practices	Reduce pollutant(s) through flow/volume management			
	post development/ storm water retrofit	Issue permit(s) and/or modify permit limit(s)			
		Implement erosion controls			
		Implement sediment controls			
		Implement non-sediment controls			
		Reduce pollutant(s) through treatment			
		Reduce pollutant(s) through flow/volume management			
		Reduce volume to CSOs			

The source of nutrients and total dissolved solids in Lebanon and Whetstone creeks could not be determined. Further investigation to determine the source of these contaminants is recommended.

The feasibility of modifying the dam release from Lake Roaming Rock should be investigated. A more continuous flow, particularly during summer months when the natural flow is lower, could greatly improve biological performance. As demonstrated in Section D2.4, removing the dam would improve stream flow by a substantial amount during lower summer flows, believed to be sufficient to support aquatic life uses.

Along Dodgeville Road, there are two unincorporated communities where the homes use HSTS, some of which are likely failing. The feasibility of installing sanitary sewers should be investigated.

6.4 Phelps Creek-Grand River (04110004 03)

Actions that are likely to improve water quality are marked in Table 6-7 (an “x” marks a recommended action, a “W” marks an actions that will be recommended in the WAP). These actions are specific to impairments in nested subwatersheds but, in general, may be applied anywhere within that nested subwatershed to have a positive effect on water quality. More specific actions are discussed below the table.

Table 6-7. Recommended implementation actions in the Phelps Creek-Grand River subwatershed.

Restoration Categories		Specific Restoration Actions	Phelps Creek-Grand River (04110004 03)				
			Phelps Creek (03 01)	Hoskins Creek (03 02)	Mill Creek-Grand River (03 03)	Mud Creek (03 04)	Plum Creek-Grand River (03 05)
Bank & Riparian Restoration	constructed	Restore streambank using bio-engineering					
		Restore streambank by recontouring or regrading				x	
	planted	Plant grasses in riparian areas					
		Plant prairie grasses in riparian areas				x	
		Remove/treat invasive species				x	
		Plant trees or shrubs in riparian areas				x	
Stream Restoration		Restore flood plain					
		Restore stream channel					
		Install in-stream habitat structures					
		Install grade structures					
		Construct 2-stage channel					
		Restore natural flow					
Wetland Restoration		Reconnect wetland to stream	x		x		
		Reconstruct & restore wetlands	x		x		
		Plant wetland species	x		x		
Conservation Easements		Acquire conservation easements	W		W	x	
Dam Modification or Removal		Remove dams			x		
		Modify dams			x		
		Remove associated dam support structures					
		Install fish passage and/or habitat structures					
		Restore natural flow					
Levee or Dike Modification or Removal		Remove levees					
		Breach or modify levees					
		Remove dikes					
		Modify dikes					
		Restore natural flood plain function					
Abandoned Mine Land Reclamation	treatment	Construct lime dosers					
		Install slag leach beds					
		Install limestone leach beds					
		Install limestone channels					
		Install successive alkalinity producing systems					
		Install settling ponds					

Restoration Categories		Specific Restoration Actions	Phelps Creek-Grand River (04110004 03): Phelps Creek (03 01)	Hoskins Creek (03 02)	Mill Creek-Grand River (03 03)	Mud Creek (03 04)	Plum Creek-Grand River (03 05)
		Install vertical flow ponds					
		Install limestone drains (anoxic and/or oxic)					
		Construct acid mine drainage wetland					
	flow diversion	Repair subsidence sites					
		Reclaim pit impoundments					
		Reclaim abandoned mine land					
		Eliminate stream captures					
		Eliminate mine drainage discharges					
		Restore positive drainage					
		Cover toxic mine spoils					
Home Sewage Planning and Improvement		Develop HSTS plan	x				
		Inspect HSTS	x				
		Repair or replace traditional HSTS	x				
		Repair or replace alternative HSTS	x				
Education and Outreach		Host meetings, workshops, and/or other events	x	x	x	x	x
		Distribute educational materials	x	x	x	x	x
Agricultural Best Management Practices	farmland	Plant cover/manure crops					
		Implement conservation tillage practices					
		Implement grass/legume rotations					
		Convert to permanent hayland					
		Install grassed waterways					
		Install vegetated buffer areas/strips					
		Install location-specific conservation buffer					
		Install / restore wetlands					
	nutrients / agro-chemicals	Conduct soil testing					
		Install nitrogen reduction practices					
		Develop nutrient management plans					
	drainage	Install sinkhole stabilization structures					
		Install controlled drainage system					
		Implement drainage water management					
		Construct overwide ditch					
		Construct 2-stage channel					

Restoration Categories		Specific Restoration Actions	Phelps Creek-Grand River (04110004 03)				
			Phelps Creek (03 01)	Hoskins Creek (03 02)	Mill Creek-Grand River (03 03)	Mud Creek (03 04)	Plum Creek-Grand River (03 05)
	livestock	Implement prescribed & conservation grazing practices		x	x	x	x
		Install livestock exclusion fencing		x	x	x	x
		Install livestock crossings					
		Install alternative water supplies		x	x	x	x
		Install livestock access lanes					
	manure	Implement manure management practices		x	x	x	x
		Construct animal waste storage structures		x	x	x	x
		Implement manure transfer practices					
		Install grass manure spreading strips					
	misc. infrastructure and mgt	Install chemical mixing pads					
		Install heavy use feeding pads					
		Install erosion & sediment control structures					
		Install roof water management practices					
		Install milkhouse waste treatment practices					
		Develop whole farm management plans					
Storm Water Best Management Practices	planning	Develop/implement local ordinances/resolutions					
		Develop local comprehensive land use plans					
	construction practices	Implement erosion controls					
		Implement sediment controls					
		Implement non-sediment controls					
	post construction practices	Reduce pollutant(s) through treatment					
		Reduce pollutant(s) through flow/volume management					
	post development/ storm water retrofit	Implement erosion controls					
		Implement sediment controls					
		Implement non-sediment controls					
		Reduce pollutant(s) through treatment					
		Reduce pollutant(s) through flow/volume management					
Regulatory Point Source Controls (includes	planning	Develop long-term control plan (CSOs)					
		Develop/implement local ordinances/resolutions					
		Develop water quality management/208 plans					
	collection	Install sewer systems in communities					

Restoration Categories		Specific Restoration Actions	Phelps Creek-Grand River (04110004 03)				
			Phelps Creek (03 01)	Hoskins Creek (03 02)	Mill Creek-Grand River (03 03)	Mud Creek (03 04)	Plum Creek-Grand River (03 05)
Storm Water, Sanitary, and Industrial)	and new treatment	Implement long-term control plan (CSOs)					
		Eliminate SSOs/CSOs/by-passes					
	enhanced treatment	Issue permit(s) and/or modify permit limit(s)					
		Improve quality of effluent					
	monitoring	Establish ambient monitoring program					
		Increase effluent monitoring					
	alternatives	Establish water quality trading					
	construction practices	Issue permit(s) and/or modify permit limit(s)					
		Implement erosion controls					
		Implement sediment controls					
		Implement non-sediment controls					
	post construction practices	Issue permit(s) and/or modify permit limit(s)					
		Reduce pollutant(s) through treatment					
		Reduce pollutant(s) through flow/volume management					
	post development/ storm water retrofit	Issue permit(s) and/or modify permit limit(s)					
		Implement erosion controls					
		Implement sediment controls					
		Implement non-sediment controls					
		Reduce pollutant(s) through treatment					
		Reduce pollutant(s) through flow/volume management					
		Reduce volume to CSOs					

The habitat of Hoskins Creek around the Samco quarry has been modified by channelization activities. Habitat restoration would significantly improve water quality downstream of this area on Hoskins Creek.

A tributary to Hoskins Creek (at river mile 2.45 along Mead Hollow Road) had a high quality assemblage of fish, including mottled sculpin. Land surrounding this stream would be a good candidate for preservation.

There is a small segment of Crooked Creek upstream of Windsor-Mechanicsville Road that has been channelized. The stream should be permitted to recover its natural sinuosity at this location; some riparian restoration may also assist in recovery of the stream's habitat. Upstream of Callender Road, approximately a mile of Crooked Creek runs through an area of pasture in which livestock have free access to the stream. Livestock tend to break down stream banks and cause sedimentation and bacteria issues. Fencing the livestock out of the stream and providing them with alternate water supplies would help the stream to recover. Additionally, planting streamside vegetation to stabilize the stream banks and slow down runoff would improve water quality.

The channelization of Hoskins Creek upstream of U.S. Route 6 has caused biological impairment downstream of U.S. Route 6. Stream bank and riparian restoration may help to stabilize the habitat and reduce the impacts on biology downstream of the channelized area. In addition, setting aside riparian lands in conservation easements would help to preclude further modification of habitat and allow the stream to recover to its natural habitat state.

The impoundment upstream of Wiswell Road on Mill Creek is causing biological impairment downstream of the dam. Removing the dam would improve water quality by restoring natural flows (see Section D2.4 for an analysis of how flows would change). If removal is not supported locally, modification to the flow regime to better mimic natural flows would be an alternative.

6.5 Three Brothers Creek-Grand River (04110004 05)

Actions that are likely to improve water quality are marked in Table 6-8 (an "x" marks a recommended action, a "W" marks an actions that will be recommended in the WAP). These actions are specific to impairments in nested subwatersheds but, in general, may be applied anywhere within that nested subwatershed to have a positive effect on water quality. More specific actions are discussed below the table.

Table 6-8. Recommended implementation actions in the Three Brothers Creek-Grand River subwatershed.

Restoration Categories		Specific Restoration Actions	Three Brothers Creek-Grand River (04110004 05)	
			Three Brothers Creek-Grand River (05 01)	Bronson Creek-Grand River (05 02)
Bank & Riparian Restoration	constructed	Restore streambank using bio-engineering		
		Restore streambank by recontouring or regrading		
	planted	Plant grasses in riparian areas		
		Plant prairie grasses in riparian areas		
		Remove/treat invasive species		
		Plant trees or shrubs in riparian areas		
Stream Restoration		Restore flood plain		
		Restore stream channel		
		Install in-stream habitat structures		
		Install grade structures		
		Construct 2-stage channel		
		Restore natural flow		
Wetland Restoration		Reconnect wetland to stream	x	x

Restoration Categories		Specific Restoration Actions	Three Brothers Creek-Grand River (04110004 05): Three Brothers Creek-Grand River (05 01)	Three Brothers Creek-Grand River (04110004 05): Bronson Creek-Grand River (05 02)
		Reconstruct & restore wetlands	x	x
		Plant wetland species	x	x
Conservation Easements		Acquire conservation easements	W	W
Dam Modification or Removal		Remove dams		
		Modify dams		
		Remove associated dam support structures		
		Install fish passage and/or habitat structures		
		Restore natural flow		
Levee or Dike Modification or Removal		Remove levees		
		Breach or modify levees		
		Remove dikes		
		Modify dikes		
		Restore natural flood plain function		
Abandoned Mine Land Reclamation	treatment	Construct lime dosers		
		Install slag leach beds		
		Install limestone leach beds		
		Install limestone channels		
		Install successive alkalinity producing systems		
		Install settling ponds		
		Install vertical flow ponds		
		Install limestone drains (anoxic and/or oxic)		
		Construct acid mine drainage wetland		
	flow diversion	Repair subsidence sites		
		Reclaim pit impoundments		
		Reclaim abandoned mine land		
		Eliminate stream captures		
		Eliminate mine drainage discharges		
		Restore positive drainage		
		Cover toxic mine spoils		
Home Sewage Planning and Improvement		Develop HSTS plan		
		Inspect HSTS		
		Repair or replace traditional HSTS		
		Repair or replace alternative HSTS		
Education and Outreach		Host meetings, workshops, and/or other events	x	x
		Distribute educational materials	x	x

Restoration Categories		Specific Restoration Actions	Three Brothers Creek-Grand River (04110004 05)	
			Three Brothers Creek-Grand River (05 01)	Bronson Creek-Grand River (05 02)
Agricultural Best Management Practices	farmland	Plant cover/manure crops		
		Implement conservation tillage practices		
		Implement grass/legume rotations		
		Convert to permanent hayland		
		Install grassed waterways		
		Install vegetated buffer areas/strips		
		Install location-specific conservation buffer		
		Install / restore wetlands		
	nutrients / agro-chemicals	Conduct soil testing		
		Install nitrogen reduction practices		
		Develop nutrient management plans		
	drainage	Install sinkhole stabilization structures		
		Install controlled drainage system		
		Implement drainage water management		
		Construct overwide ditch		
		Construct 2-stage channel		
	livestock	Implement prescribed & conservation grazing practices	x	x
		Install livestock exclusion fencing	x	x
		Install livestock crossings		
		Install alternative water supplies	x	x
		Install livestock access lanes		
	manure	Implement manure management practices	x	x
		Construct animal waste storage structures	x	x
		Implement manure transfer practices		
		Install grass manure spreading strips		
	misc. infrastructure and mgt	Install chemical mixing pads		
		Install heavy use feeding pads		
		Install erosion & sediment control structures		
		Install roof water management practices		
		Install milkhouse waste treatment practices		
		Develop whole farm management plans		
Storm Water Best Management Practices	planning	Develop/implement local ordinances/resolutions		
		Develop local comprehensive land use plans		
	construction practices	Implement erosion controls		
		Implement sediment controls		

Restoration Categories		Specific Restoration Actions	Three Brothers Creek-Grand River (04110004 05)	
			Three Brothers Creek-Grand River (05 01)	Bronson Creek-Grand River (05 02)
		Implement non-sediment controls		
	post construction practices	Reduce pollutant(s) through treatment		
		Reduce pollutant(s) through flow/volume management		
	post development/ storm water retrofit	Implement erosion controls		
		Implement sediment controls		
		Implement non-sediment controls		
		Reduce pollutant(s) through treatment		
		Reduce pollutant(s) through flow/volume management		
Regulatory Point Source Controls (includes Storm Water, Sanitary, and Industrial)	planning	Develop long-term control plan (CSOs)		
		Develop/implement local ordinances/resolutions		
		Develop water quality management/208 plans		
	collection and new treatment	Install sewer systems in communities		
		Implement long-term control plan (CSOs)		
		Eliminate SSOs/CSOs/by-passes		
	enhanced treatment	Issue permit(s) and/or modify permit limit(s)		
		Improve quality of effluent		
	monitoring	Establish ambient monitoring program		
		Increase effluent monitoring		
	alternatives	Establish water quality trading		
	construction practices	Issue permit(s) and/or modify permit limit(s)		
		Implement erosion controls		
		Implement sediment controls		
		Implement non-sediment controls		
	post construction practices	Issue permit(s) and/or modify permit limit(s)		
		Reduce pollutant(s) through treatment		
		Reduce pollutant(s) through flow/volume management		
	post development/ storm water retrofit	Issue permit(s) and/or modify permit limit(s)		
		Implement erosion controls		
		Implement sediment controls		
		Implement non-sediment controls		
		Reduce pollutant(s) through treatment		
		Reduce pollutant(s) through flow/volume management		
		Reduce volume to CSOs		

For approximately two river miles upstream of Dawsey Road on Spring Creek, livestock is fairly concentrated and typically has free access to streams. Fencing livestock out of the streams and providing buffers along riparian zones will help to alleviate the influx of bacteria from the dense livestock land use in this area.

Three Brothers Creek is a good candidate for riparian restoration in some areas where forest removal has occurred. The culvert in Camp Beaumont is poorly designed to pass the bankfull flow of the stream and has shown signs of severe erosion over time. Consideration should be given to redesign the culvert to improve habitat and reduce erosion and long-term maintenance costs.

6.6 Reasonable Assurances

The recommendations made in this TMDL report will be carried out if the appropriate entities work to implement them. In particular, activities that do not fall under regulatory authority require that there be a committed effort by state and local agencies, governments, and private groups to carry out and/or facilitate such actions. The availability of adequate resources is also imperative for successful implementation.

When a TMDL is developed for waters impaired by point sources only, the issuance of a NPDES permit(s) provides the reasonable assurance that the wasteload allocations contained in the TMDL will be achieved. This is because 40 C.F.R. 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with the assumptions and requirements of any available wasteload allocation in an approved TMDL.

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, U.S. EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions. To this end, Appendix E discusses organizations and programs that have an important role or can provide assistance for meeting the goals and recommendations of this TMDL. Efforts specific to this watershed are described in this section.

6.6.1 Local Zoning and Regional Planning

The Western Reserve Land Conservancy (WRLC) is currently working on the watershed action plan (WAP) for the Grand River (upper) watershed. The project is funded through a grant from the Ohio Department of Natural Resources and is expected to be completed by the end of 2012. Watershed action plans typically contain recommendations regarding regional planning.

6.6.2 Local Watershed Groups

Grand River Partners, Inc., formerly the local watershed preservation organization, officially merged with the Western Reserve Land Conservancy in December 2009. WRLC is a nonprofit conservation organization dedicated to preserving the natural resources of northern Ohio. It works with landowners, communities, government agencies, park systems and other nonprofit organizations to permanently protect natural areas and farmland, primarily through conservation easements. WRLC's stated mission is to seek to "preserve the scenic beauty, rural character, and natural resources of northern Ohio" (http://www.wrlandconservancy.org/index.html).

WRLC is currently writing a watershed action plan (WAP) for the Grand River (upper) watershed. Many of the implementation recommendations discussed in the Grand River (upper) watershed TMDL report match what will be the recommendations of the WAP.

The Nature Conservancy received a Great Lakes Restoration Initiative grant that is primarily focused on the control of invasive species in protected conservation areas. More information is available at:
http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/ohio/howwework/great-lakes-restoration-initiative-in-ohio.xml.

6.6.3 Other Sources of Funding and Special Projects

Environmental restoration and protection activities within the Grand River (upper) watershed have been largely focused upon wetland creation, enhancement and preservation, as well as stream preservation and protection strategies. Private conservation efforts by several organizations have focused significant resources towards these goals. Collaborative activities among these groups have resulted in a prioritized approach to conservation of the resources. The organizations involved include The Nature Conservancy, the Cleveland Museum of Natural History, the Western Reserve Land Conservancy and the Ohio Wetlands Foundation. The Geauga Park District also has holdings that protect streams and wetlands in the watershed. The dam on the Grand River forming Lake Estabrook was removed in 2009. Figure 6-1 shows the area formerly occupied by Lake Estabrook.

Figure 6-1. The area formerly occupied by Lake Estabrook in Chickagauga Park following dam removal.

6.6.4 Past and Ongoing Water Resource Evaluation

Ohio EPA completed a field survey, sampling biology, habitat, chemistry and fish tissue, in 1995 and 2007. The survey in 2007 added multiple sites that were not sampled in 1995 since the latter survey included sites in the Grand River (lower) watershed as well. According to the 2012 Ohio Integrated Report, the next scheduled sampling will take place in 2019.

ODNR's Scenic Rivers Program does volunteer stream monitoring. The Cleveland Museum of Natural History does biological surveys primarily to monitor rare and endangered species. Most of this work revolves around their conservation holdings, but they also work in various areas and the river itself to monitor changes for these populations.

Recommended Approach for Gathering and Using Available Data

Early communications should take place between the Ohio EPA and any potential collaborators to discuss research interests and objectives. Areas of overlap should be identified and ways to make all parties research efforts more efficient should be discussed. Ultimately, important questions can be addressed by working collectively and through pooling resources, knowledge and data.

6.6.5 Potential and Future Evaluation

It is expected that Ohio EPA, The Nature Conservancy and the Cleveland Museum of Natural History will be the most involved entities evaluating the Grand River (upper) watershed in the future.

6.6.6 Revision to the Improvement Strategy

The Grand River (upper) watershed would benefit from an adaptive management approach to restoring water quality. An adaptive management approach allows for changes in the management strategy if environmental indicators suggest that the current strategy is inadequate or ineffective. Adaptive management is recognized as a viable strategy for managing natural resources (Baydack *et al.* 1999).

If chemical water quality does not show improvement and/or water bodies are still not attaining water quality standards after the improvement strategy has been carried out, then a TMDL revision would be initiated. The Ohio EPA would initiate the revision if no other parties wish to do so.

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