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Ohio Environmental Protection Agency

Total Maximum Daily Loads for the Upper Mahoning River Watershed

Final Report
August 17, 2011

John R. Kasich, Governor
Mary Taylor, Lt. Governor
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Photo caption: Upper Mahoning River at the Lake Milton spillway in Mahoning County, Ohio

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Acronyms and Abbreviations

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
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)
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
MOR	monthly operating report
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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Project leader	Bill Zawiski
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Executive Summary

The upper Mahoning River watershed is located in parts of Columbiana, Mahoning, Portage, Stark, and Trumbull counties. This 541 square mile watershed is home to an estimated 155,000 people. Municipalities in the watershed include Alliance, Ravenna, Newton Falls, Sebring, Champion Heights, Windham, Garrettsville, South Canal, Craig Beach, Hiram, Atwater, Beloit, Maple Ridge, and Limaville. There are over 40 square miles of lakes, reservoirs, and ponds in the watershed with four large reservoirs accounting for well over half of that area. In 2006, Ohio EPA assessed the aquatic life uses and recreation uses in the watershed.

Sixty-two percent of the 73 sites surveyed (45 sites) had some degree of aquatic life use impairment. Primary causes of this impairment were excessive amounts of fine sediment in bed material, nutrient rich conditions, poor habitat quality, and alterations to normal stream flow conditions. Management practices and other human activities related to these water quality stressors include row crop production, maintenance of agricultural drainage infrastructure (especially channel maintenance), waste water discharges, presences of dams and/or artificial regulation of river flows, and discharges related to home septic systems.

Ninety-five percent (70 sites) of the 74 sites assessed for recreation use attainment did not meet standards. Primary sources of bacteria are improperly functioning home septic systems, non-compliant waste water treatment systems, and manure from livestock and/or wildlife. However, home septic systems are believed to be the predominant source in the basin.

TMDLs were prepared for total phosphorus, habitat, siltation, and *E. coli* bacteria. Total phosphorus TMDLs were developed to address nutrient impaired sites located in the headwaters of the Mahoning River, Eagle Creek, and the portion of Deer Creek that drains to the Walborn and Deer Creek reservoir system. The overall reductions in total phosphorus needed were 41, 71, and 79 percent for the headwater of the Mahoning River, Deer Creek, and Eagle Creek, respectively. In all cases the majority of the load reduction is to come from point sources, crop and livestock production areas, and urban areas.

Sediment and habitat TMDLs were developed using scores from the qualitative habitat evaluation index (QHEI) to enumerate the degree of improvement needed in the system. For sediment, scores deviating from the target ranged from zero to 69 percent with an average of 31 percent.

E. coli bacteria TMDLs were developed to address pervasive recreation use impairment. The overall average reduction in *E. coli* loading from existing conditions was 80 percent.

Allocations for several regulated waste water treatment facilities indicated that total phosphorus reductions are needed. Recommendations to address nonpoint sources of pollution include locating and correcting failing home septic systems, implementing several types of row crop production related conservation practices, and land retirement with streamside buffers, wetlands, and strategically placed filter strips in crop fields.

1 INTRODUCTION

The upper Mahoning River watershed is located in northeastern Ohio. In 2006 Ohio EPA assessed the aquatic life uses and recreation uses in the watershed, finding both uses to be impaired. The primary causes of impairment in the upper Mahoning River watershed are nutrient enrichment, flow alteration (particularly dams), fine sediment loading, poor habitat, organic enrichment, and pathogens. Nutrient enrichment and organic enrichment are closely tied to each other in this watershed. A number of wastewater treatment plants in the watershed contribute nutrients and other contaminants. Agricultural runoff is the main watershed-wide source of nutrients. Runoff from both urban and suburban land is also an important source of nutrients and a cause of habitat degradation in the watershed. TMDLs were calculated for total phosphorus and habitat/siltation to address aquatic life use impairments and *E. coli* bacteria to address recreation use impairments.

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 drafted and made available to the public for comment, then a final list is 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 upper Mahoning River watershed (assessment units 0503010301 01 through 03, 0503010302 01 through 04, 0503010303 01 through 06, and 0503010304 01 through 06) as impaired on the 2010 303(d) list (Ohio EPA, 2010, available at http://www.epa.state.oh.us/dsw/tmdl/2010IntReport/2010OhioIntegratedReport.aspx).

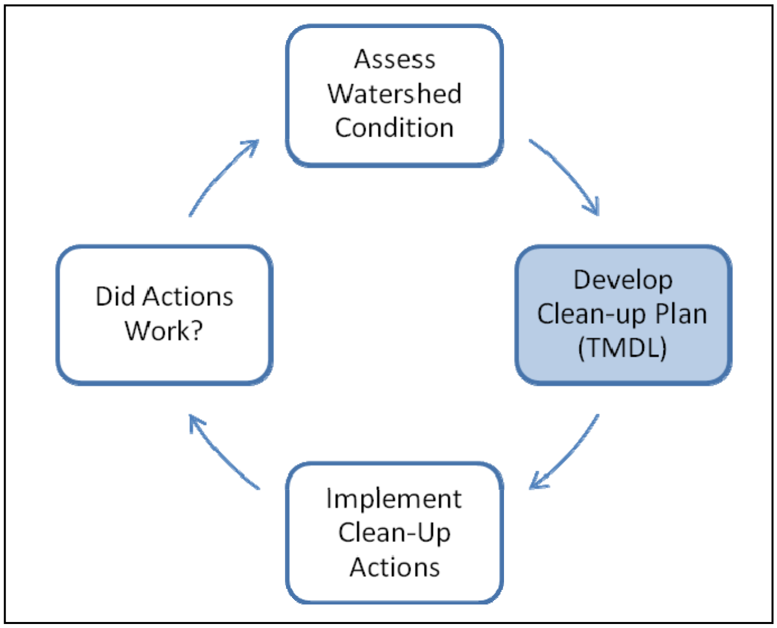

Figure 1-1. Overview of the TMDL project process.

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 upper Mahoning River watershed are addressed in the TMDL report.

Table 1-1. Summary of impairments in the upper Mahoning River watershed and methods used to address them.

Assessment Unit	Narrative Description	Causes of impairment	Action Taken[1, 2]
05030103 01 01	Beaver Run-Mahoning River	Nutrients	Total phosphorus TMDL
		Sedimentation / siltation	QHEI TMDL
Priority Points 5		*E. coli*	LDC TMDL - *E. coli*
05050103 01 02	Beech Creek	Habitat alterations	QHEI TMDL
		Nutrients	Not addressed
		Sedimentation / siltation	QHEI TMDL
Priority Points 6		*E. coli*	LDC TMDL - *E. coli*
05030103 01 03	Fish Creek-Mahoning River	Alteration in streamside / littoral cover	QHEI TMDL
		Habitat alterations	QHEI TMDL
		Fish kills	Not addressed
		Nutrients	Total phosphorus TMDL
		Flow alterations	QHEI TMDL
		Sedimentation / siltation	QHEI TMDL
Priority Points 8		*E. coli*	LDC TMDL - *E. coli*
05030103 02 01	Deer Creek	Nutrients	Total phosphorus TMDL
		Flow alterations	QHEI TMDL
Priority Points 8		*E. coli*	LDC TMDL - *E. coli*
05030103 02 02	Willow Creek	Alteration in streamside / littoral cover	QHEI TMDL
		Nutrients	Total phosphorus TMDL
		Sedimentation / siltation	QHEI TMDL
Priority Points 8		*E. coli*	LDC TMDL - *E. coli*
05030103 02 03	Mill Creek	Natural	None
		Nutrients	Not addressed
		Flow alterations	QHEI TMDL
		Sedimentation / siltation	QHEI TMDL
Priority Points 4		*E. coli*	LDC TMDL - *E. coli*
05030103 02 04	Island Creek-Mahoning River	Nutrients	Not addressed
		Sedimentation / siltation	QHEI TMDL
Priority Points 6		*E. coli*	LDC TMDL - *E. coli*
05030103 03 01	Kale Creek	Habitat alterations	QHEI TMDL
		Natural	None
		Dissolved Oxygen	Not addressed
		Sedimentation / siltation	QHEI TMDL
		Turbidity	Not addressed (or QHEI)

Assessment Unit	Narrative Description	Causes of impairment	Action Taken[1, 2]
Priority Points 6		*E. coli*	LDC TMDL - *E. coli*
05030103 03 02	Headwaters West Branch Mahoning River	Nutrients	Not addressed
		Organic enrichment	Not addressed
		Sedimentation / siltation	QHEI TMDL
Priority Points 9		*E. coli*	LDC TMDL - *E. coli*
05030103 03 03	Barrel Run	Flow alteration	QHEI TMDL
Priority Points 8		*E. coli*	LDC TMDL - *E. coli*
05030103 03 04 *Priority Points 3*	Kirwan Reservoir-West Branch Mahoning River	*E. coli*	LDC TMDL - *E. coli*
05030103 03 05	Town of Newton Falls-West Branch Mahoning River	Habitat alterations	QHEI TMDL
		Flow alterations	QHEI TMDL
		Sedimentation / siltation	QHEI TMDL
Priority Points 8		*E. coli*	LDC TMDL - *E. coli*
05030103 03 06	Charley Run Creek-Mahoning River	Flow alterations	QHEI TMDL
Priority Points 9		*E. coli*	LDC TMDL - *E. coli*
05030103 04 01	Headwaters Eagle Creek	Natural	Not addressed
Priority Points 5		*E. coli*	LDC TMDL - *E. coli*
05030103 04 02 *Priority Points 5*	South Fork Eagle Creek	*E. coli*	LDC TMDL - *E. coli*
05030103 04 03	Camp Creek-Eagle Creek	Nutrients	Total phosphorus TMDL
		Sedimentation / siltation	QHEI TMDL
Priority Points 8		*E. coli*	LDC TMDL - *E. coli*
05030103 04 04	Tinkers Creek	Habitat alterations	QHEI TMDL
		Nutrients	Total phosphorus TMDL
		Sedimentation / siltation	QHEI TMDL
Priority Points 6		*E. coli*	LDC TMDL - *E. coli*
05030103 04 05 *Priority Points 5*	Mouth Eagle Creek	*E. coli*	LDC TMDL - *E. coli*
05030103 04 06	Chocolate Run-Mahoning River	Habitat alterations	QHEI TMDL
		Nutrients	Not addressed
		Flow alterations	QHEI TMDL
		Sedimentation / siltation	QHEI TMDL
Priority Points 8		*E. coli*	LDC TMDL - *E. coli*

[1] QHEI refers to the Qualitative Habitat Evaluation Index
[2] LDC refers to the load duration curve method of TMDL development

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 upper Mahoning River watershed TMDL project has been completed using the process endorsed by the advisory group.

The initial upper Mahoning River TMDL stakeholders public meeting was held on April 18, 2008. The meeting was held in conjunction with the Mahoning River Consortium's general meeting.

Consistent with Ohio's current Continuous Planning Process (CPP), the draft TMDL report was available for public comment from June 15 through July 18, 2011. A summary of the one set of comments that were received and the associated responses is included in Appendix F to this final report.

Continued public involvement is critical 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 upper Mahoning River watershed.

1.3 Organization of Report

Chapter 2 gives an overview of the characteristics of the watershed that are meaningful in terms of impacting water quality, particularly attributes that effect hydrology and nonpoint source pollution potential. The second half of Chapter two reviews the designated uses in the watershed and the associated water quality goals that correspond to sustaining those uses. Chapter 3 discusses the results of the initial water quality assessment and the causes and associated sources of impairment identified. Chapter 4 describes the areas of the watershed for which additional analysis was performed to quantify overall pollutant loading as well as determining the individual contributions from all of the relevant sources. Chapter 5 presents the results of the loading analysis which includes the allocations to point and nonpoint sources of pollution and the pollutant loading reductions needed to meet water quality goals. Chapter 6 presents initial recommendations for improving water quality and meeting the target identified earlier in the report. Point source load reductions are discussed in terms of implementing limits to effluent concentrations in NPDES permits. Nonpoint source reductions are discussed in terms of what is known from the water quality analyses and general watershed data based on remote sources of information (e.g., aerial photography, soil survey data) and management options that are in accordance with those conditions.

2 CHARACTERISTICS AND EXPECTATIONS OF THE WATERSHED

The upper Mahoning River basin extends from the confluence of Duck Creek (about 100 feet below the Leavittsburg dam at river mile 45.57) upstream to the headwaters located in western Columbiana County. The flow of the river originates from a wetland (Watercress Marsh) in Butler Township, Columbiana County. The upper Mahoning River basin is located in six counties: Columbiana, Stark, Mahoning, Trumbull, Portage, and Geauga (Figure 2-1). In the nationwide numbering system for watersheds (similar to postal codes)[1], the entire Mahoning River watershed is assigned the 8-digit number 05030103 (indicating that it eventually flows into the Gulf of Mexico via the Mississippi and Ohio Rivers). The Mahoning River watershed is further subdivided into eight 10-digit areas. The upper Mahoning River study area is comprised of the four most upstream 10-digit sub-watersheds as follows:

- Headwaters to Mahoning River (05030103 - 01)
- Deer Creek – Mahoning River (05030103 - 02)
- West Branch Mahoning River – Mahoning River (05030103 - 03)
- Eagle Creek – Mahoning River (05030103 - 04)

The four 10-digit subwatersheds are further subdivided into 19 12-digit subwatersheds. Ohio has adopted the 12-digit watershed size as the assessment unit for 305(b) and 303(d) reporting. This report will discuss the watershed at the 10 and 12 digit scales.

2.1 Watershed Characteristics

The following subsections provide an overview of characteristics of the upper Mahoning River watershed that affect water quality.

2.1.1 Population and Distribution

Based on 2000 census data (U.S. Census Bureau, 2005) the population of the upper Mahoning River watershed is approximately 155,000 with about 62,000 homes. The largest municipality is Alliance with a population of over 23,000 followed by Ravenna (over 12,000) which is partially in the watershed and then Newton Falls (over 5,000). Other population centers include Beloit, Craig Beach, Garrettsville, Hiram, Limaville, Newton Falls, Sebring, and Windham. Figure 2-2 is a map of the U.S. census blocks with their associated population densities and the municipalities found in the project area. Table 2-1 shows basic demographic statistics for the municipalities in the watershed. There are no indications of upcoming population growth in this part of Ohio.

[1] The numbers are referred to as hydrologic unit codes (HUCs). Each pair of numbers is meaningful; 8-, 10-, and 12-digit codes are also referred to as 4th-, 5th-, and 6th-level codes.

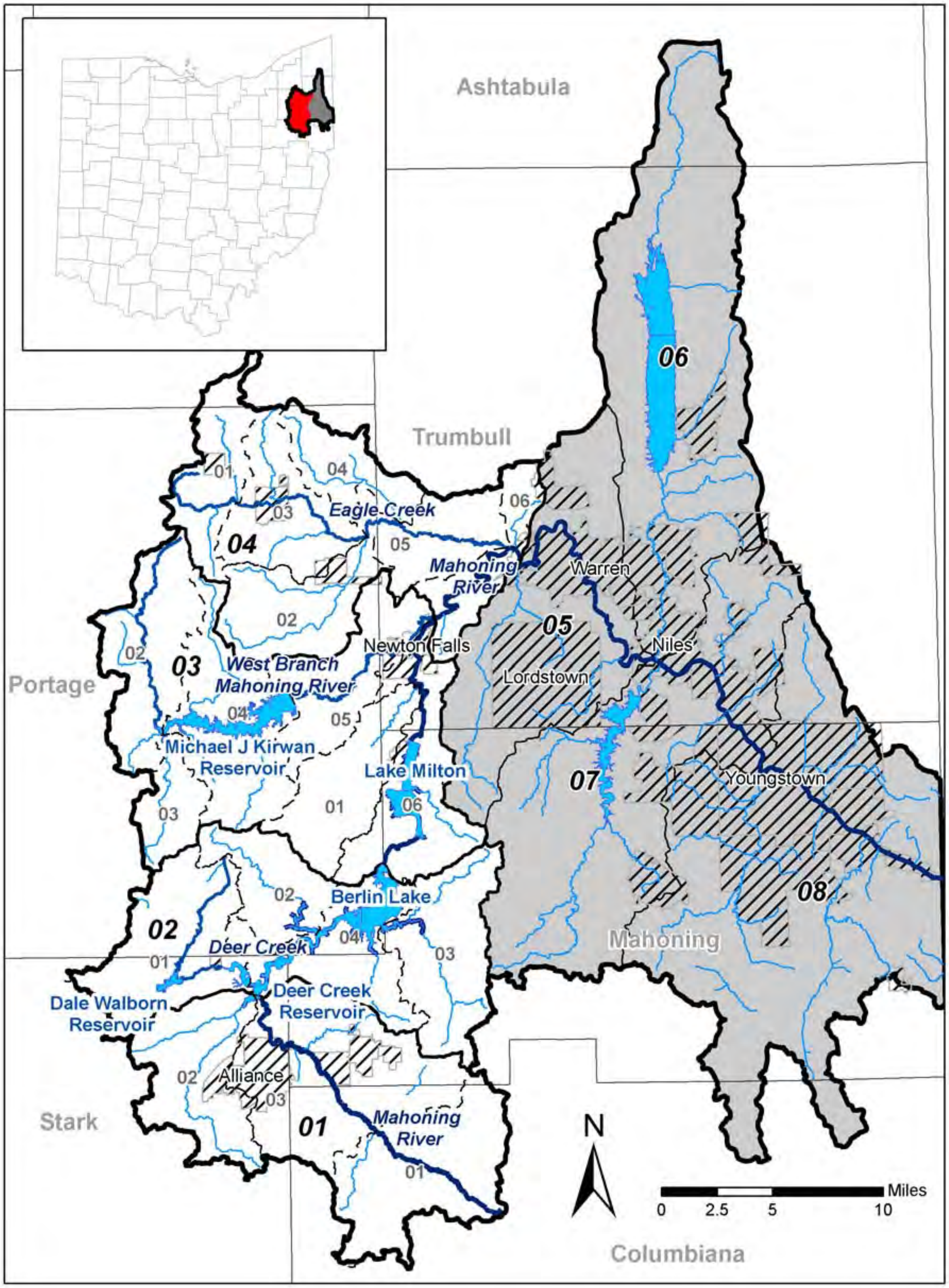

Figure 2-1. Map of the upper Mahoning River watershed showing 12 digit HUC assessment units.

Table 2-1. Municipalities in the upper Mahoning River TMDL watershed area.

Municipality	Population[1]	Area (square mile)	Population density[1] (population per sq mi)
Alliance	23,229	8.76	2,651
Ravenna	12,046	5.42	2,224
Newton Falls	5,043	2.36	2,139
Sebring	4,912	2.06	2,385
Champion Heights	4,646	3.40	1,365
Windham	2,822	2.13	1,328
Garrettsville	2,287	2.53	903
South Canal	1,347	1.66	812
Craig Beach	1,233	1.69	730
Hiram	1,210	0.91	1,331
Beloit	1,030	0.77	1,340
Maple Ridge	917	2.01	456
Limaville	201	0.27	736

[1] Based on U.S. Census Bureau 2000 census data.

2.1.2 Land Use

Overall, the predominant land use in the Upper Mahoning River basin is forest, accounting for 37 percent of the project area, followed by cropland (23 percent) and pasturelands (17 percent). The northern portion the project area, has the highest proportion of forest and lowest for agricultural uses; however the opposite is true in the southern portion of the watershed (see Table 2-2, where the southern 01 HUC has a much lower percentage than the northern 04 HUC). Twelve percent of the project area has some level of land development ranging from high to low intensity. Shrub and grassland account for about four percent of the area while wetlands and open water each are about three percent of the area. Figure 2-3 is a map of the land covers based on satellite imagery and subsequent interpretations made for the National Land Cover Database (2001). Table 2-2 shows the percent each cover class accounts for in each of the four ten-digit HUCs and the respective total land area.

Table 2-2. Land use percentages in the basin

Land Cover Class	Ten-digit HUCs			
	01	02	03	04
Forest	24%	35%	43%	46%
Cultivated Crop	30%	26%	16%	20%
Pasture/Hay	21%	21%	16%	10%
Developed	20%	7%	11%	11%
Grassland	2%	2%	5%	4%
Wetlands	2%	2%	2%	6%
Open Water	1%	6%	5%	1%
Scrub/Shrub	0%	0%	1%	2%
Barren Land	0%	0%	0%	0%
TOTAL AREA (acres)	**82,714**	**75,983**	**106,957**	**81,247**

2.1.3 Soils, Geology and Topography

The bedrock geology of the Mahoning River in Ohio consists of layered sedimentary rocks that represent former sands, silts, and mud, deposited 280 million to 400 million years ago. Rocks exposed in the watershed are primarily from Mississippian and Pennsylvanian Age systems. Rocks of the Mississippian system, including thick shale, sandstone, and interbedded shale and sandstone, are exposed over most of Trumbull County. Rocks of the Pennsylvanian system, composed of a sequence of sandstones, shale, siltstones, coal, clay, and limestone, are exposed throughout Mahoning County. The entire watershed was at one time covered by glaciers, with the last major advance being about 20,000 years ago. The glaciers scoured and eroded the soils and bedrock as they advanced and accumulated an unsorted mixture of clay, sand, and gravel. This material was deposited in front of the ice sheet or left behind when the glaciers melted.

Soils in the project are generally poorly drained where 62 percent are classified as ranging from somewhat poorly drained to very poorly drained and where 16 percent is poorly or very poorly drained (Figure 2-4). However, slopes in the watershed tend to be moderate to steep with 62 percent of the soils having an average slope of 4 percent or more and 13 percent have slopes exceeding 9 percent. Thirty-eight percent of the soils are flat with a slope of 1 percent or less. The steepest elevations are in the southeastern and northwestern extremes of the project area corresponding to the headwaters of the Mahoning River and Eagle Creek respectively. The area surrounding the Michael J. Kirwan Reservoir on the West Branch of the Mahoning River is another area of relatively high relief. These are also areas where soil drainage is at its best. Figure 2-5 is a digital elevation model of the project area.

There are a large proportion of the soils that are classified as hydric (7 percent) or partially (41 percent) hydric (i.e., indicating former wetlands). Forty-one percent are classified as not hydric and on 12 percent hydric determinations are not made.

2.1.4 Point Sources - Waste Water and Storm Water

There are currently 74 individual NPDES discharge permits within the watershed and four general permits for wastewater. A list of NPDES permits in the study area is included as Appendix A. There are three clusters of municipalities in the study area which require NPDES coverage for separate storm sewer systems. Each cluster has general coverage for multiple municipalities and are listed under respective umbrella names of Alliance, Akron, and Mahoning County. None of the clusters overlap with areas for which TMDLs are calculated.

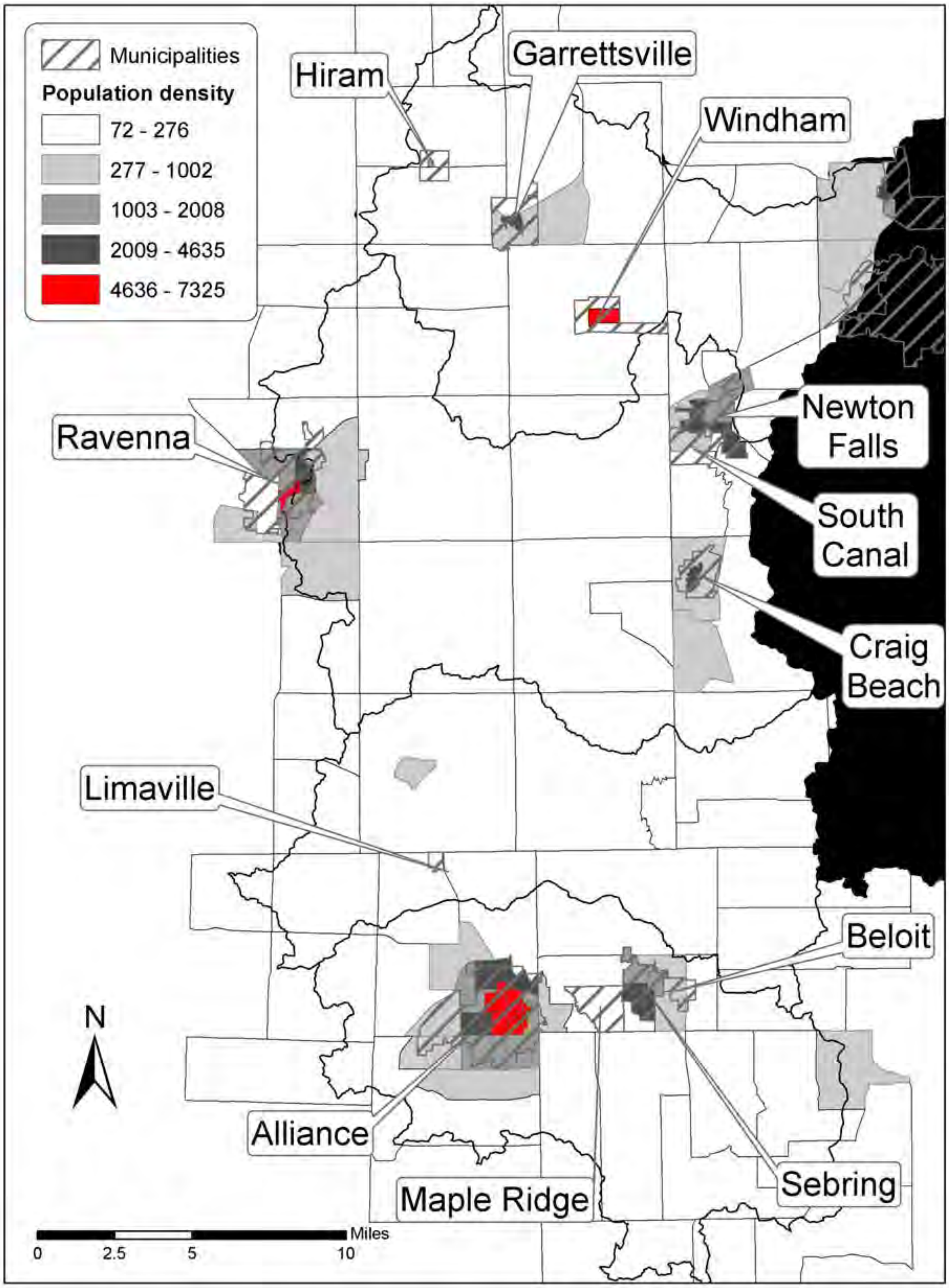

Figure 2-2. Population densities based on census block information in the upper Mahoning River watershed.

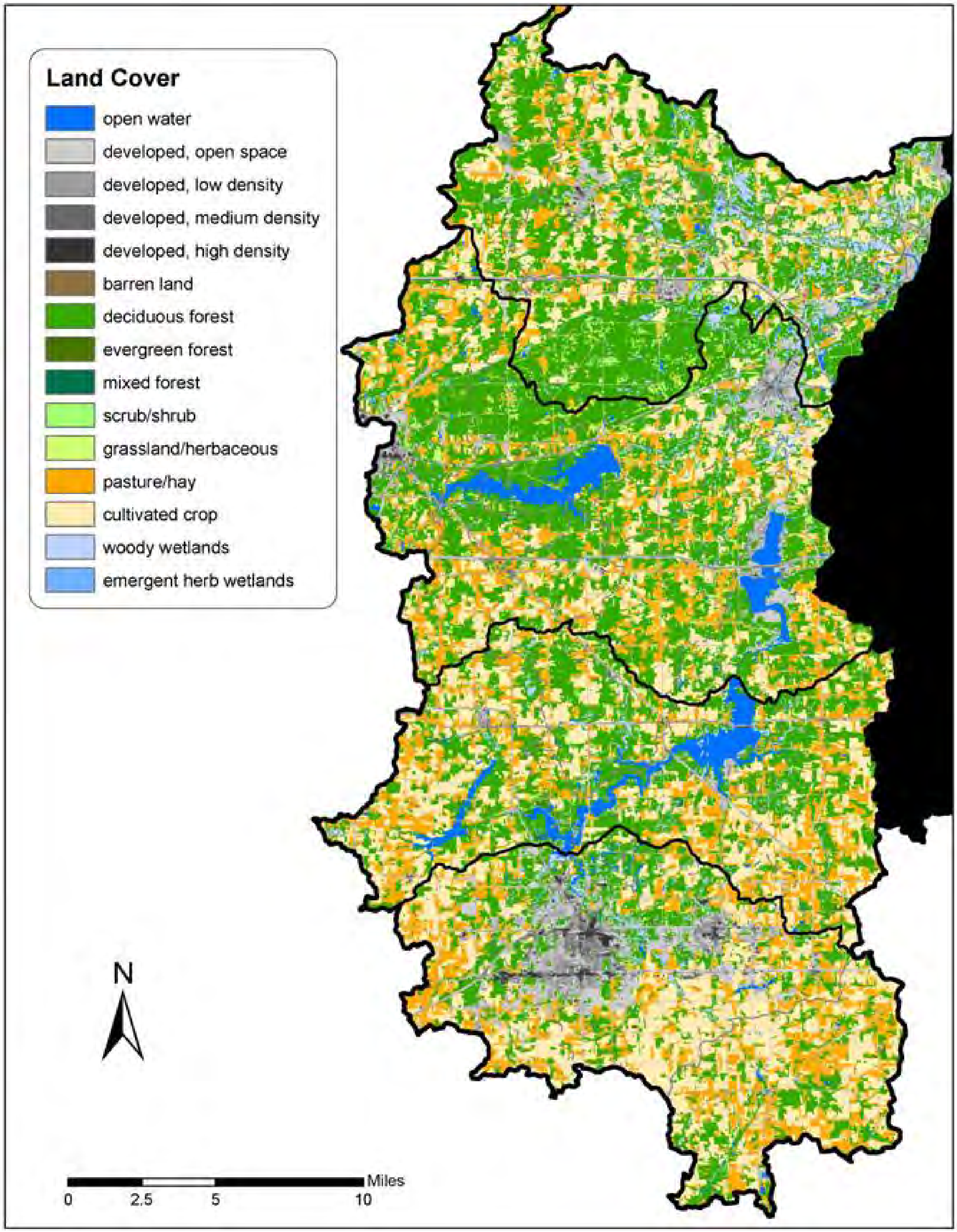

Figure 2-3. Land covers in the upper Mahoning River watershed.

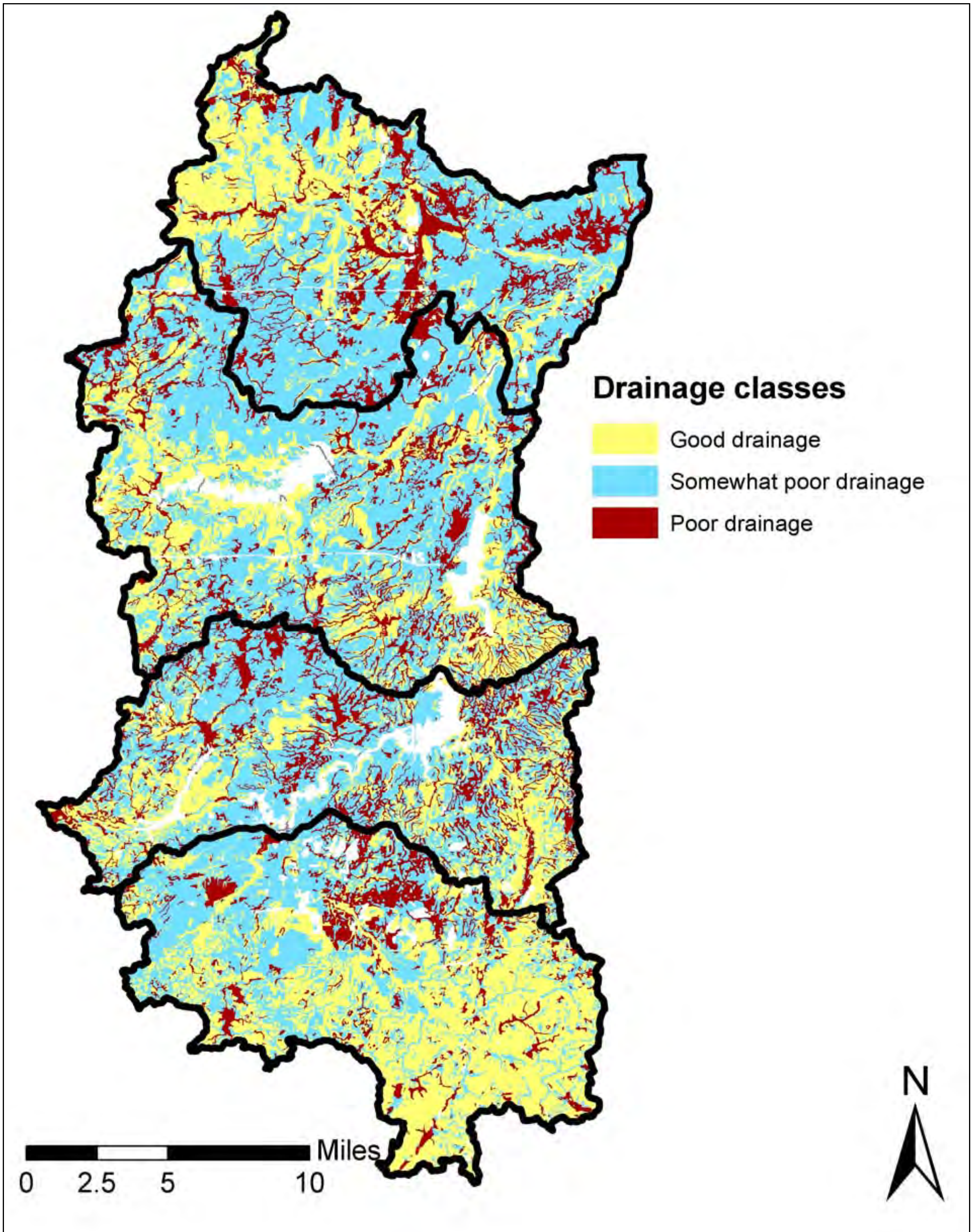

Figure 2-4. Soil drainage classifications in the upper Mahoning River watershed.

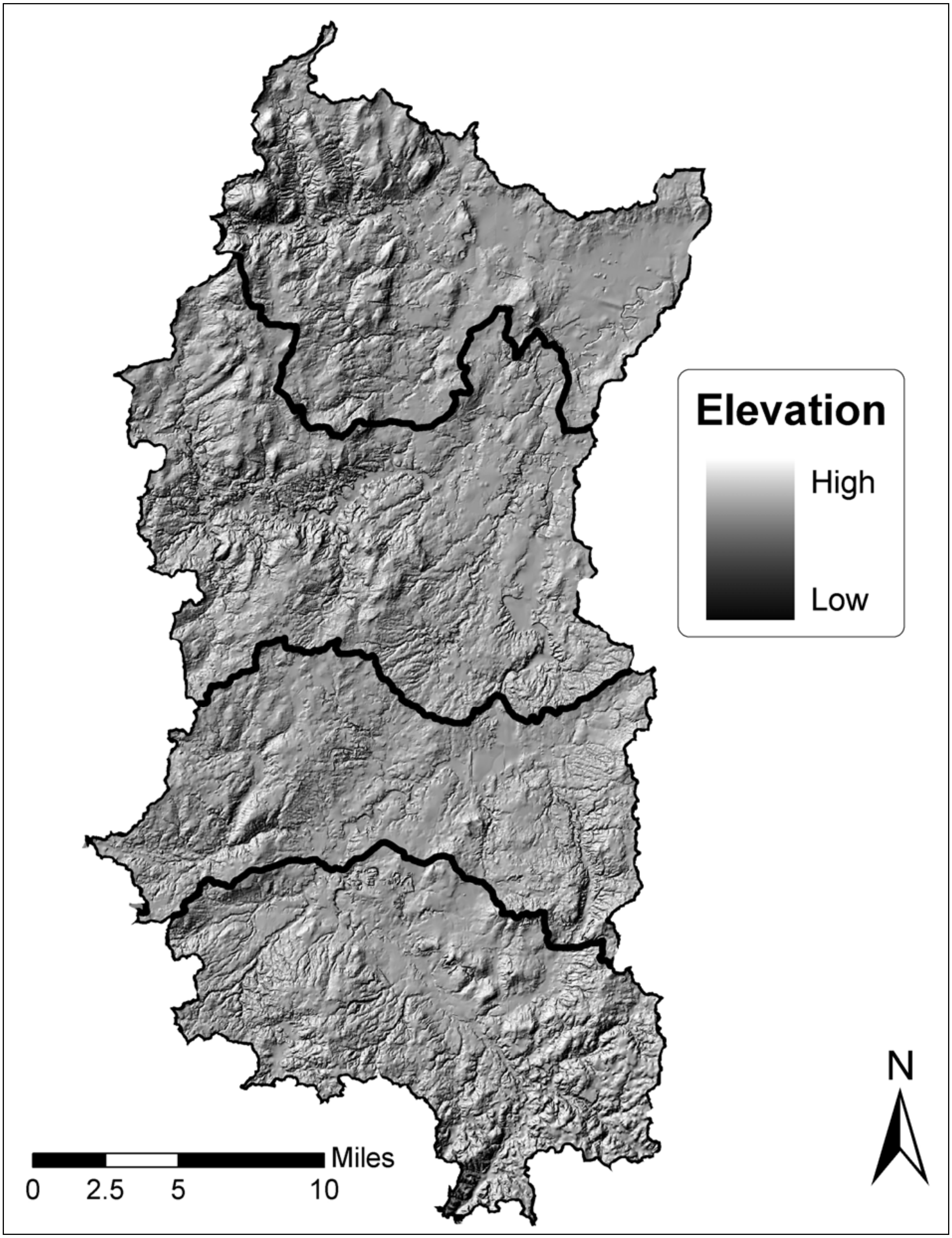

Figure 2-5. Representation of the topographic relief of the upper Mahoning River watershed.

2.2 Water Quality Standards and Targets

Under the Clean Water Act, every state must adopt water quality standards to protect, maintain and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the goal of "swimmable/fishable" waters. Table 2-3 provides a brief description of Ohio's water quality standards. Further information is available in Chapter 3745-1 of the Ohio Administrative Code (OAC) (http://www.epa.state.oh.us/dsw/wqs/criteria.aspx).

Table 2-3. Water Quality Standards Summary

WQS Components	Examples of:	Description
Beneficial Use Designation	1. Water supply •Public (drinking) •Agricultural •Industrial 2. Recreational contact 3. Aquatic life habitats (partial list): •Exceptional Warmwater (EWH) •Warmwater (WWH) •Modified Warmwater (MWH) •Limited Resource Water (LRW) •Cold Water Habitat (CWH)	Designated uses reflect how the water is potentially used by humans and how well it supports a biological community. Every water in Ohio has a designated use or uses; however, not all uses apply to all waters (they are water body specific). Each use designation has an individual set of numeric criteria associated with it, which are necessary to protect the use designation. For example, a water that was designated as a drinking water supply and could support exceptional biology would have more stringent (lower) allowable concentrations of pollutants than would the average stream. Recreational uses indicate whether the water can be potentially used for swimming or if it may only be suitable for wading.
Numeric Criteria	1. Chemical	Represents the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody. Laboratory studies of organism's sensitivity to concentrations of chemicals exposed over varying time periods form the basis for these.
	2. Biological *Measures of fish health:* • Index of Biotic Integrity • Modified Index of Well Being *Measure of macroinvertebrate health:* • Invertebrate Community Index	Indicates the health of the instream biological community by using these 3 indices (measuring sticks). The numeric biological criteria (biocriteria) were developed using a large database of reference sites.
	3. Whole Effluent Toxicity (WET)	Measures the harmful effect of an effluent on living organisms (using toxicity tests).
	4. Bacteriological	Represents the level of bacteria protective of the potential recreational use.
Narrative Criteria (Also known as the "free froms")	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, nutrients in concentrations that may cause algal blooms, and free from a public health nuisance.	
Antidegradation Policy	This policy establishes situations under which the director may allow new or increased discharges of pollutants, and requires those seeking to discharge additional pollutants to demonstrate an important social or economic need. Refer to http://www.epa.state.oh.us/dsw/wqs/wqs.html for more information.	

The Water Quality Standards designations applicable to the upper Mahoning River watershed contained in Ohio Administrative Code Chapter 3745-1-25 are included as Appendix B.

2.2.1 Recreation Uses

Recreational use designations are defined in Section 3745-1-07 of the OAC. Water quality criteria are established to protect recreational water uses by limiting risk for human illness due to exposure to pathogenic microorganisms. Pathogenic organisms include bacteria, viruses, and protozoa. Criteria are set for concentrations of *E. coli* in surface waters. *E. coli* bacteria typically are not pathogenic organisms; however, if their numbers exceed a threshold value it becomes increasingly probable that pathogenic organisms are present in sufficient numbers to threaten public health.

There are three recreational use designations applicable to stream segments in the upper Mahoning River watershed, Primary Contact Recreation (PCR), Classes A and B, and Secondary Contact Recreation (SCR). SCR is applied to waters suitable for partial-body contact recreation such as wading. PCR is applied to waters suitable for full-body contact such as swimming and canoeing. Ohio EPA assigns the PCR use designation to a stream unless it is demonstrated through use attainment analysis that the combination of remoteness, accessibility, and depth makes full-body contact recreation by adults or children unlikely. In those cases, the SCR designation is assigned.

PCR is divided in to three subcategories, classes A, B and C. Waterbodies in each of these classes are able to support the same types of water activities; however, distinctions are made based on the frequency or intensity of such activities. Class A PCR reflects the greatest use of the waterbody for recreation while B to C reflect progressively less frequent recreation activities. For waterbodies throughout Ohio, PCR class B is the most prevalent use assigned.

Attainment of the recreation use designation is evaluated by comparison to bacteriological numeric and narrative criteria. Ohio currently has bacteriological criteria for *E. coli*. Bacteriological criteria apply outside the mixing zone of permitted discharges and during the defined recreation season (May 1st through October 30th). The concentration values of *E. coli* are based on the geometric mean of at least two samples collected at a single site within the same recreational season. If only one sample is available, the single sample maximum concentration can be used to determine if water quality standards are met, otherwise when more than one sample is available attainment is exclusively predicated on the geometric mean value. Table 2-4 shows the *E. coli* water quality criteria for recreation uses.

There are 255 stream miles designated as Class B PCR while 1.9 miles are designated SCR. One hundred six miles are designated as PCR Class A, the most protective PCR designation due to the high level of recreation associated with the reservoirs that are in the basin. Figure 2-6 is a map of the respective recreation use designations in the TMDL project area.

Table 2-4. Quality criteria for recreation use designations.

Recreation use	*E. coli* (colony counts per 100 ml)	
	Seasonal geometric mean	Single sample maximum
Bathing water	126	235
Class A primary contact recreation	126	298
Class B primary contact recreation	161	523
Class C primary contact recreation	206	940
Secondary contact	1030	1030

2.2.2 Aquatic Life Uses

In the upper Mahoning River basin study area, the aquatic life use designations that currently apply to its segments are Warmwater Habitat (WWH) and Cold Water Habitat (CWH). Waters designated as WWH are capable of supporting and maintaining a balanced integrated community of warmwater aquatic organisms, while those designated CWH these are waters which support trout stocking and management under the auspices of the Ohio department of natural resources, division of wildlife and/or these are waters capable of supporting populations of native coldwater fish and associated vertebrate and invertebrate organisms and plants on an annual basis. In the TMDL project area over 347 miles are designated in rule as WWH, while over 16 miles are designated CWH. Figure 2-7 is a map showing the distribution of aquatic life uses throughout the TMDL project area.

Attainment of WQS is measured utilizing both biological communities and chemical sample analysis. Attainment benchmarks from these least impacted areas are established in the WQS in the form of "biocriteria," which are then compared to the measurements obtained from the study area. If measurements of a stream do not achieve the three biocriteria (fish: Index of Biotic Integrity (IBI) and modified Index of Well-being (MIwb); aquatic insects: Invertebrate Community Index (ICI)) the stream is considered in "non attainment". If the stream measurements achieve some of the biological criteria, but not others, the stream is said to be in "partial attainment." A stream that is in "partial attainment" is not achieving its designated aquatic life use, and requires a TMDL, whereas a stream that meets all of the biocriteria benchmarks, is in “full attainment.” A more detailed explanation of Ohio’s biocriteria can be found in the Ohio EPA publication *The Role of Biological Criteria in Water Quality Monitoring, Assessment, and Regulation* (Ohio EPA, 1995). The criteria for the individual biological metrics applicable to the TMDL project area is found in Table 2-5.

Table 2-5. Biological criteria applicable to rivers and streams throughout Ohio for three aquatic life use designations. Criteria are established based on ecoregion and assessment method.

Ecoregion	Biological Index	Assessment method[2, 3]	Biological criteria for the applicable aquatic life use designations[1]		
			WWH	EWH	MWH[4]
Erie-Ontario Lake Plains (EOLP)	IBI	Headwater	40	50	24
		Wading	38	50	24
		Boat	40	48	24 / 30
	MIwb	Wading	7.9	9.4	6.2
		Boat	8.7	9.6	5.8 / 6.6
	ICI	All[5]	34	46	22

1. Cold water habitats (CWH), limited warmwater habitat (LWH), resource waters (LRW) and seasonal salmonid habitat (SSH) do not have associated biological criteria.
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. Bio-criteria depend on type of MWH. MWH-C (due to channelization) is listed first, MWH-I (due to impoundment) is listed second, and MWH-A (mine affected) is listed third (only applicable in the WAP).
5. Limited to sites with appropriate conditions for artificial-substrate placement.

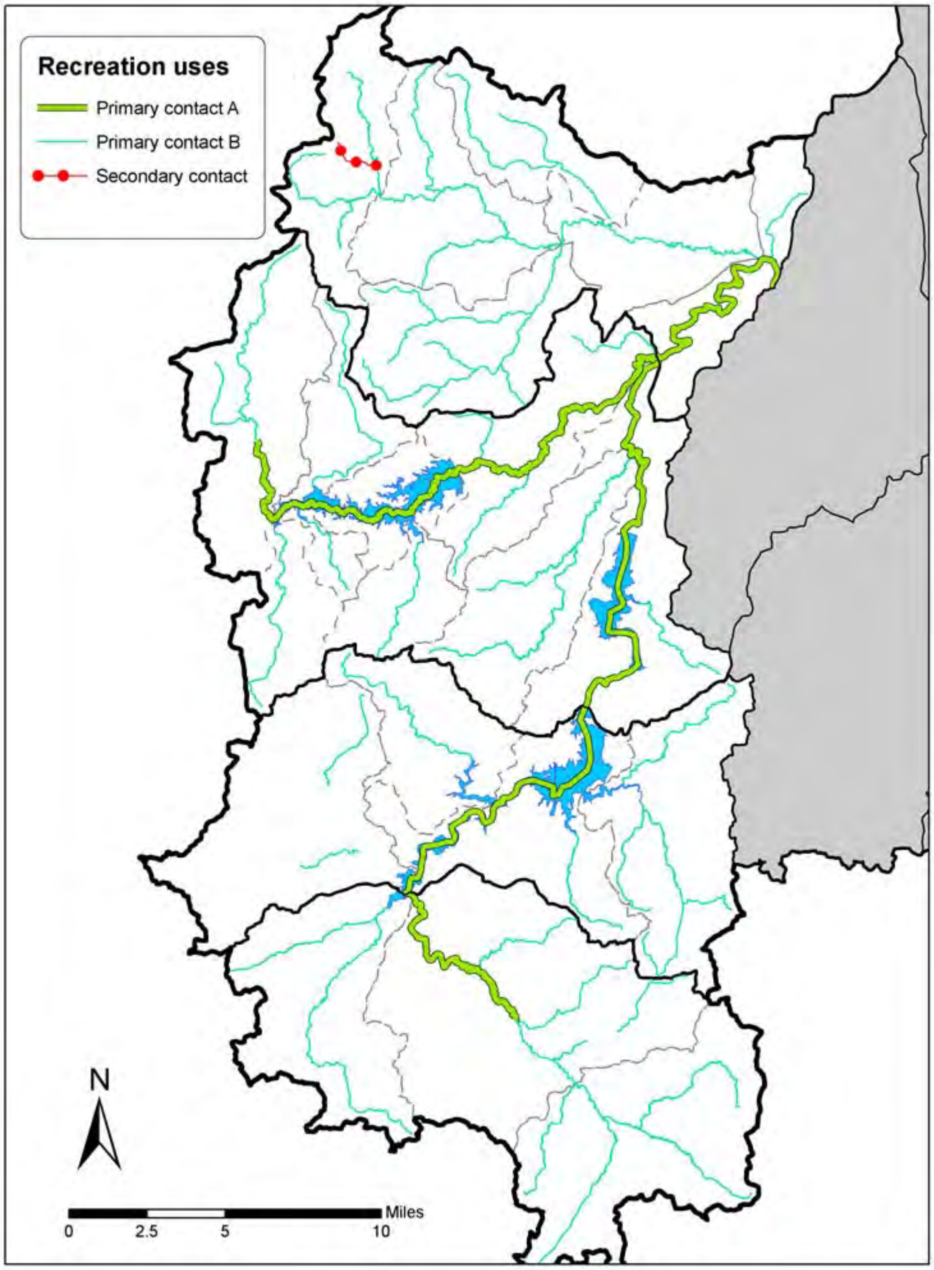

Figure 2-6. Map of the various categories of recreation use designated to streams in the upper Mahoning River watershed.

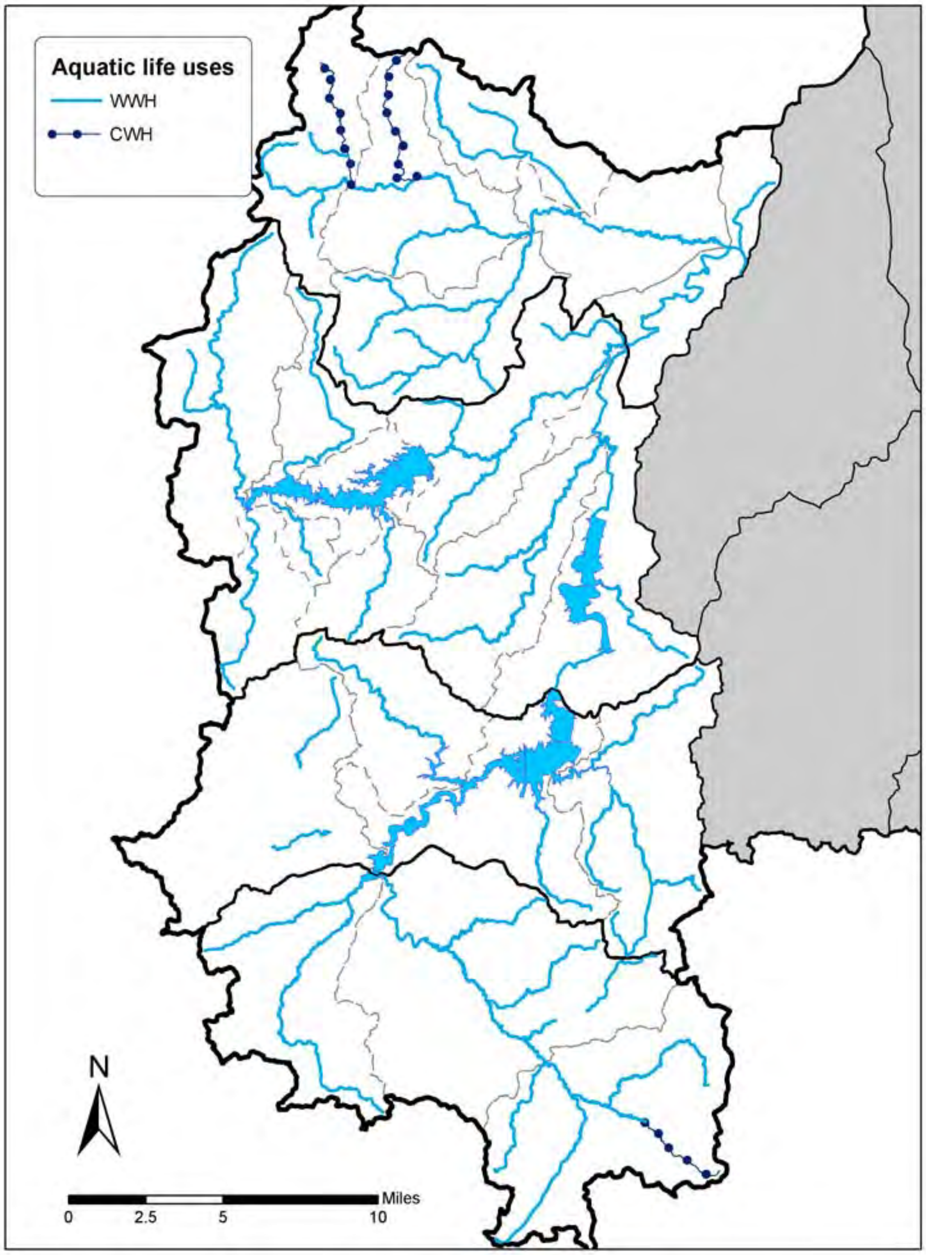

Figure 2-7. Map of the various categories of aquatic life use designated to streams in the upper Mahoning River watershed.

2.2.3 Public Drinking Water Supply Use

The public drinking water supply (PDWS) 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. There are numerous chemical constituents for which concentration criteria have been established; however, the most commonly sampled pollutants in assessing PDWS attainment (selected based on the historic pollution patterns) are nitrates and atrazine (an organo-phosphate pesticide in the triazine family). Rules 3745-1-32 and 34 list the criteria for PDWS.

There are five surface water public drinking water supplies in the upper Mahoning River watershed project area with a total of seven intake locations. Figure 2-8 is a map showing the locations of these public water supplies. Four of the five public water supplies (PWS) in this TMDL study area are meeting their use based on the applicable criteria. The PWS associated with the Mahoning Valley Sanitary District (in the 12-digit HUC 02-04) did not have enough water quality data to determine its use attainment status.

2.2.4 Human Health Use (Fish Tissue)

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 is called the non-drinking water human health criterion. The purpose of that criterion is to ensure levels of a chemical in water do not bioaccumulate in fish to levels harmful to people who catch and eat the fish.

There are four assessment units that were listed in the 2010 Integrated Report as impaired for human health uses for fish consumption. These are:

- Fish Creek-Mahoning River (05030103 01 03)
- Deer Creek (05030103 02 01)
- Island Creek-Mahoning River (05030103 02 04)
- Charley Run Creek-Mahoning River (05030103 03 06)

Three reservoirs are found to likewise be impaired, namely Lake Milton, Berlin Reservoir, and Deer Creek Reservoir while the Kirwan Reservoir met the criteria for human health. No TMDLs are developed to address human health use impairments.

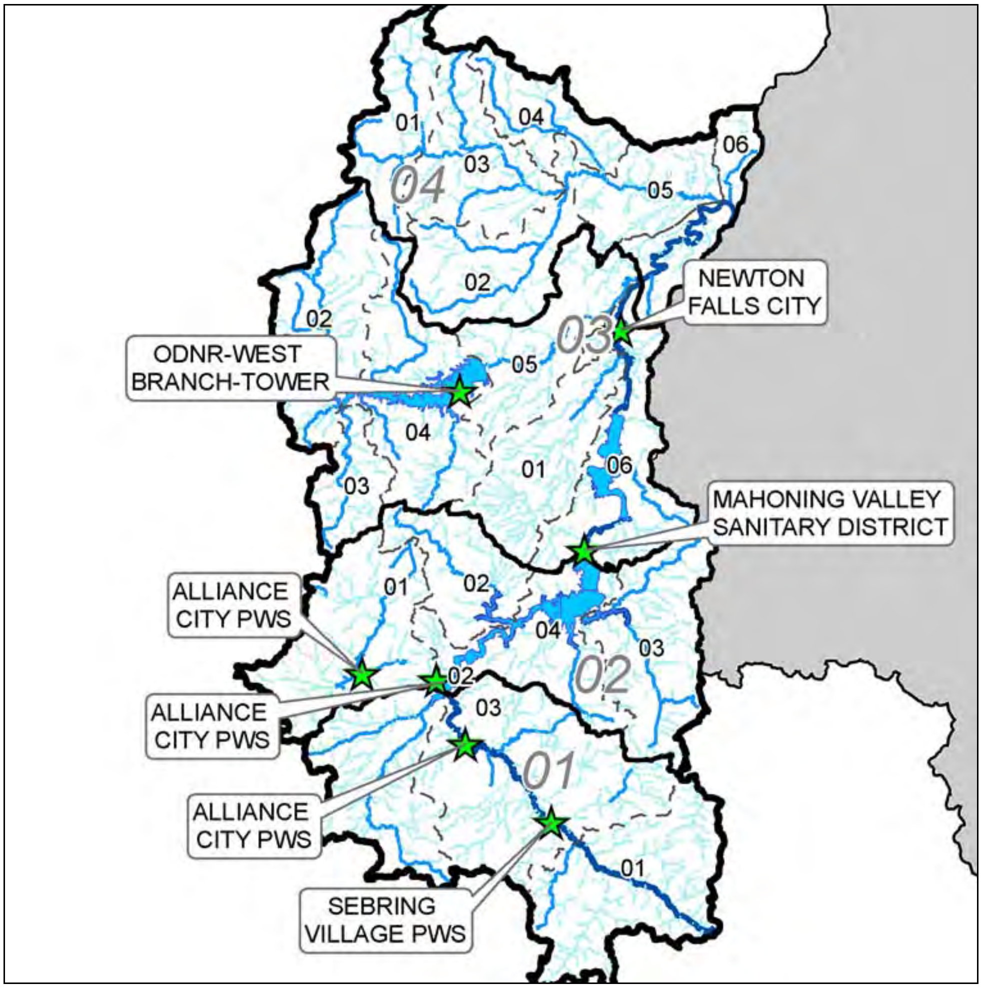

Figure 2-8. Map of surface water intakes in the upper Mahoning River watershed.

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 upper Mahoning River watershed in 2006. Seventy-three sites were studied for biological health, 76 sites for water chemistry, 74 sites for recreation use, and six sites for human health (fish contaminants) use. Sites were scattered throughout the watershed. Please refer to Appendix B for more detail.

The upper Mahoning River watershed TMDL includes 19 subwatersheds. 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. To report on the health of large rivers, Ohio EPA developed a special definition for the area beginning at the point where a river drains more than approximately 500 square miles and extending to the mouth. At this size, rivers generally are impacted more by the character of and activity in the accumulated drainage area and less by what is happening adjacent to the channel (i.e., on the stream bank).

3.1 Aquatic Life and Recreation Use Attainment Status

In terms of aquatic life uses, twenty-eight (38%) of the evaluated sites fully met the existing or recommended life use. Seventeen (23%) of the sites partially met and twenty-eight (38%) of the sites were not attaining their designated or recommended use. Only four (5%) of the sites surveyed met the recreation use criteria while the remaining 70 sites did not meet standards.

The remainder of this section presents the results of the water quality assessment for aquatic life and recreation uses by the respective 10-digit assessment units. Figure 3-1 is a group of pie charts showing the respective aquatic life use attainment statuses for each of the ten digit HUCs while Figure 3-2 is the same for recreation uses. Figure 3-3 shows recreation use attainment for sites along the larger streams in the project area and therefore the ones more likely to be used for recreation.

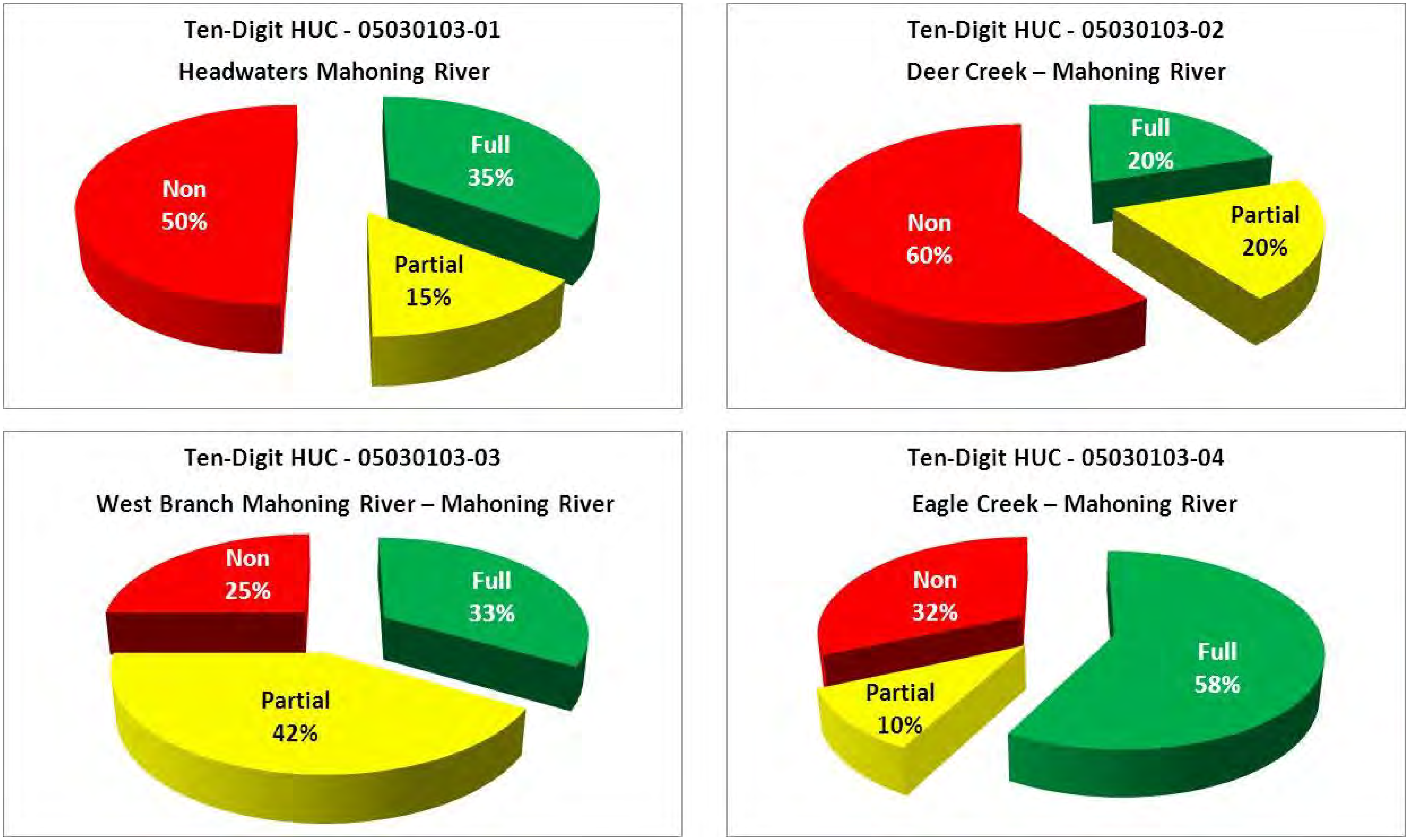

Figure 3-1. Aquatic life use attainment for each of the four ten digit HUCs in the TMDL project area. Proportions are based on the number of sites assessed in that area.

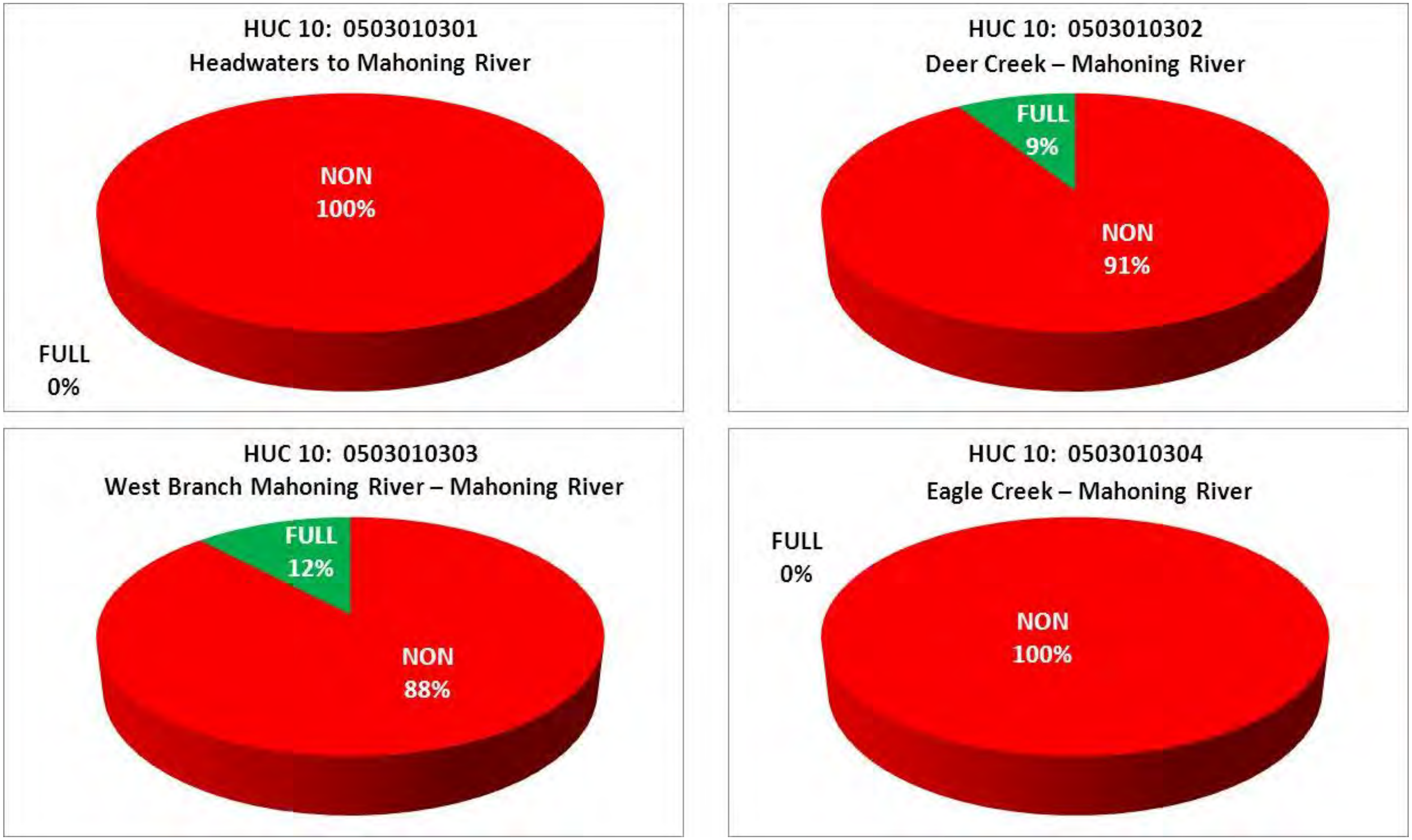

Figure 3-2. Recreation use attainment for each of the four ten digit HUCs in the TMDL project area. Proportions are based on the number of sites assessed in that area.

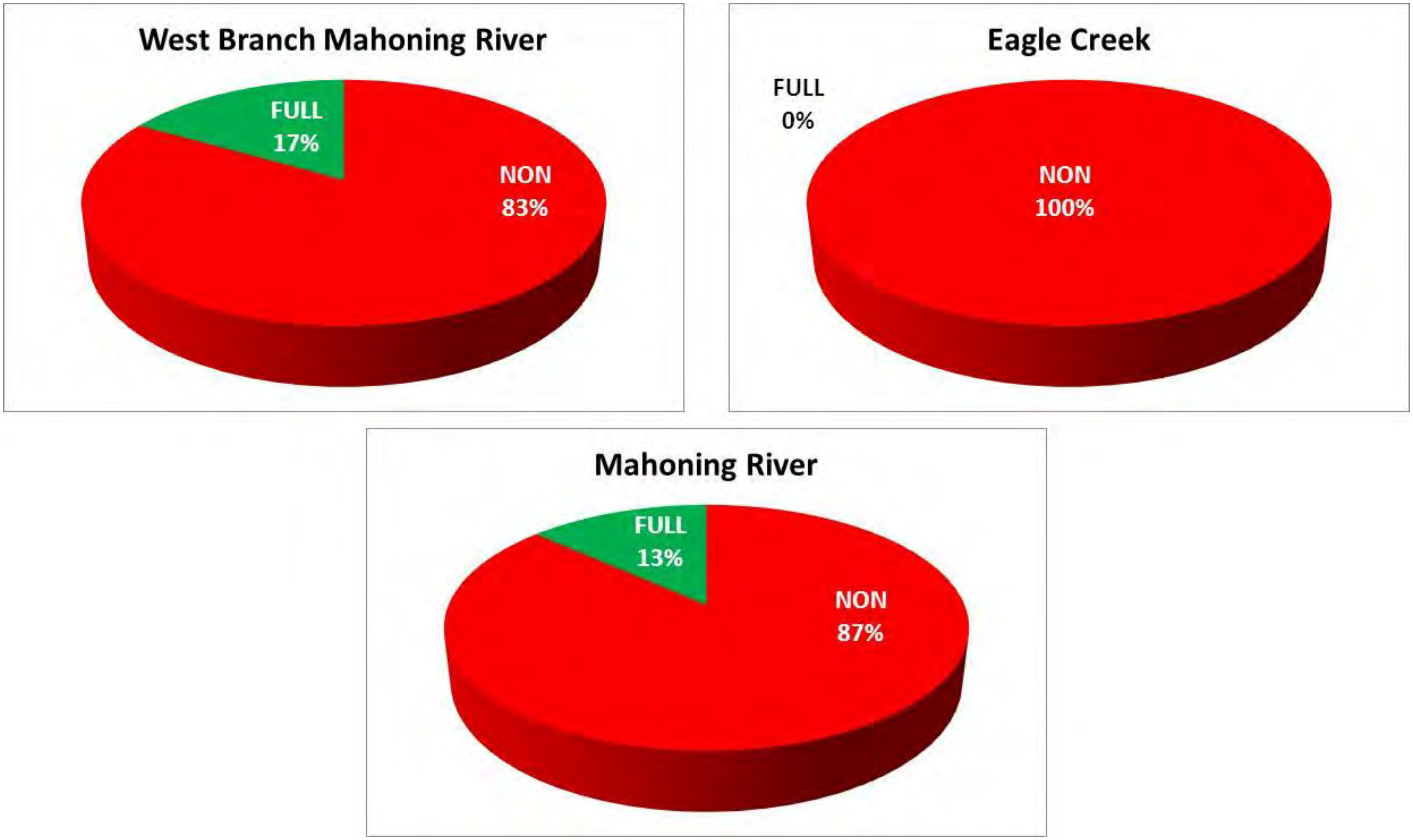

Figure 3-3. Recreation use attainment for largest stream in the project area. Proportions are based on the number of sites assessed in that area.

3.1.1 Mahoning River – Headwaters to Below Beech Cr. (05030103-01)

This part of the project area includes the headwaters of the Mahoning River and several small tributary streams including Beaver Run, Fish Creek and Beech Creek. Seven out of 20 sites (35 percent) surveyed fully meet aquatic life use criteria; however 50 percent meet none of the criteria and 15 percent met some but not all of the criteria (Figure 3-4). The majority of the impairment was found on the mainstem of the Mahoning River, Fish Creek and Naylor Ditch in the areas in and around Alliance, Maple Ridge, Sebring, and Beloit. Recreation uses were impaired at all 21 sites (100 percent) surveyed in this ten digit HUC. Aquatic life and recreation use attainment for HUC -01 is presented in Figure 3-4 while causes and sources of aquatic life use impairment are in presented in the maps associated with Figures 3-5 and 3-6. The bar chart in Figure 3-7 is the site by site geometric mean of the *E. coli* concentrations within the ten-digit HUC. The numbers after the stream name on the x-axis indicate the river mile in which the sample was taken. The standard deviation for each of the component 12-digit HUCs and the applicable water quality criteria are shown on the graph as horizontal lines.

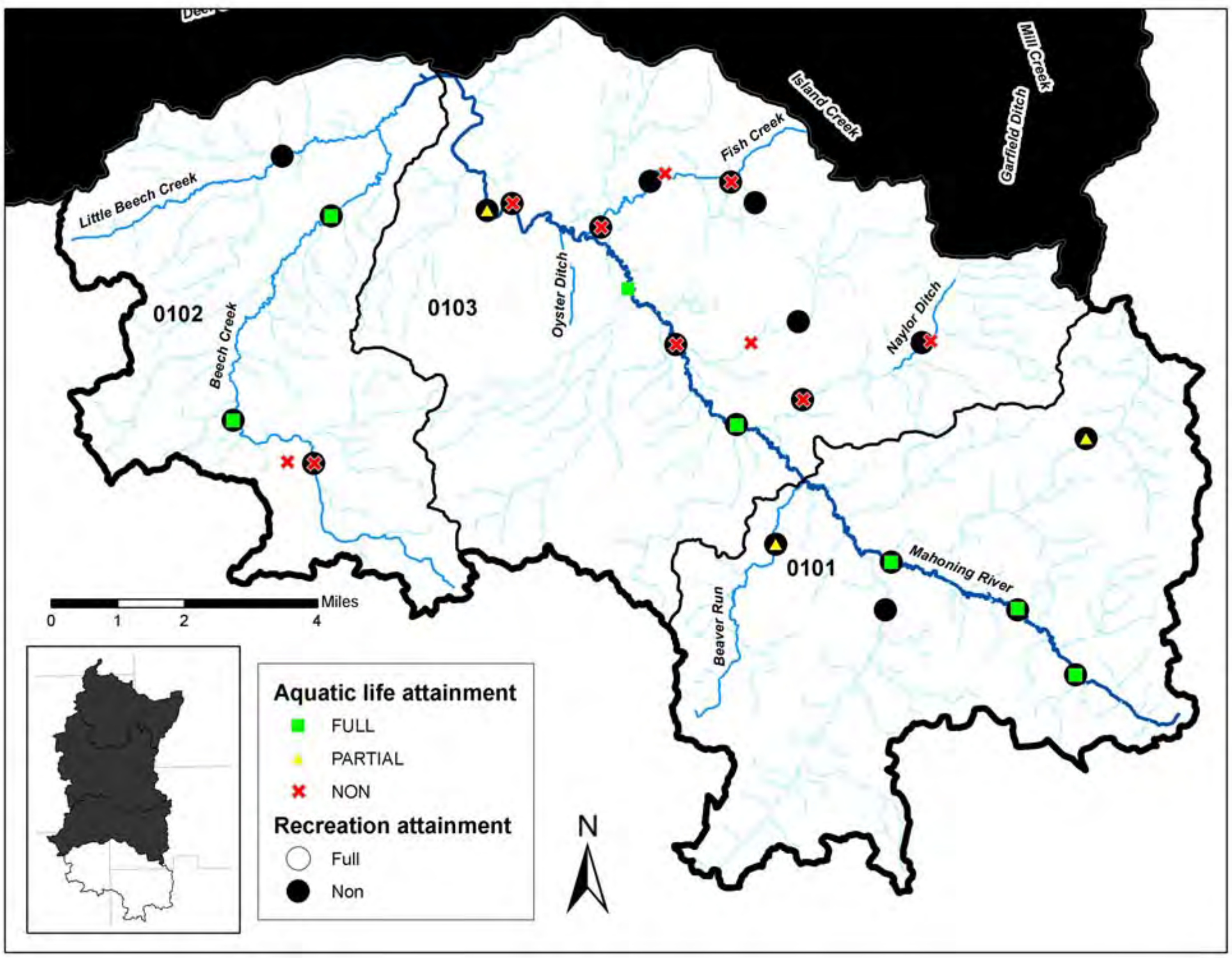

Figure 3-4. HUC 05030103-01 aquatic life and recreation use attainment.

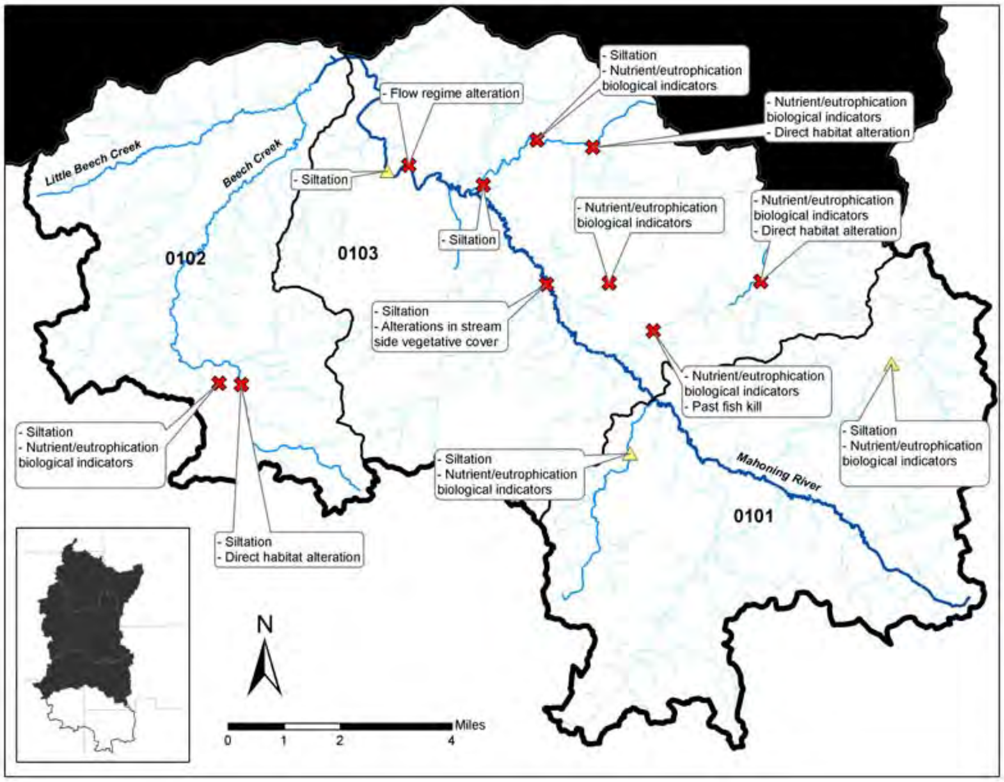

Figure 3-5. Map of the causes of aquatic life use impairment in HUC 05030103-01.

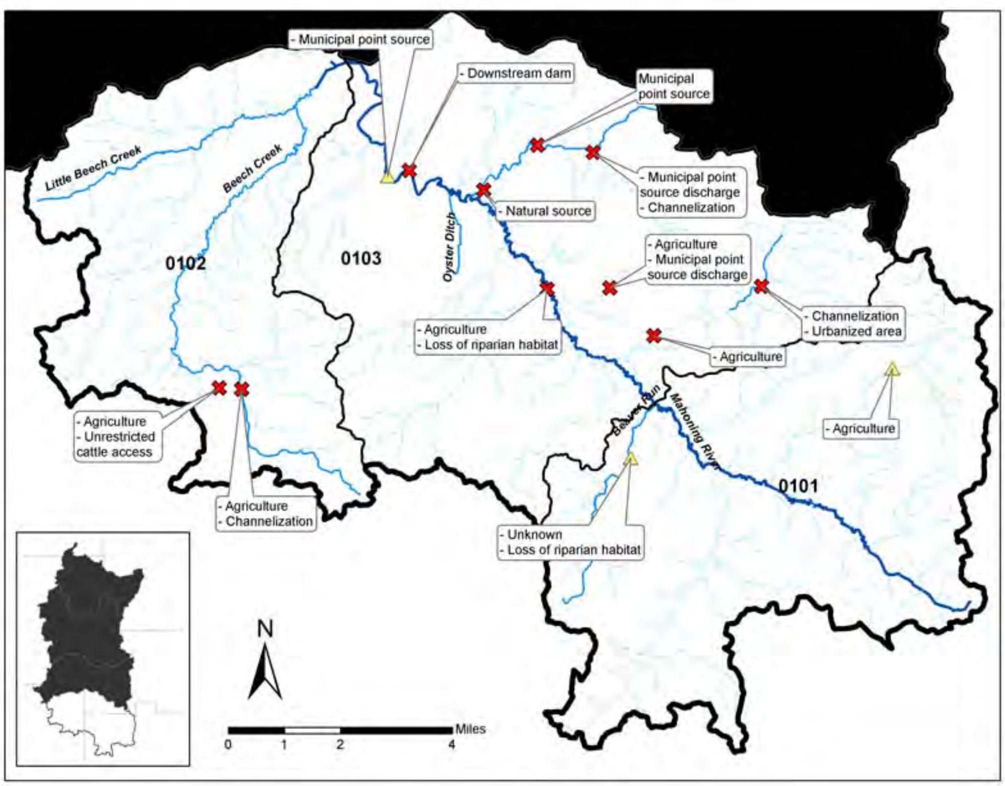

Figure 3-6. Map of the sources of aquatic life use impairment in HUC 05030103-01.

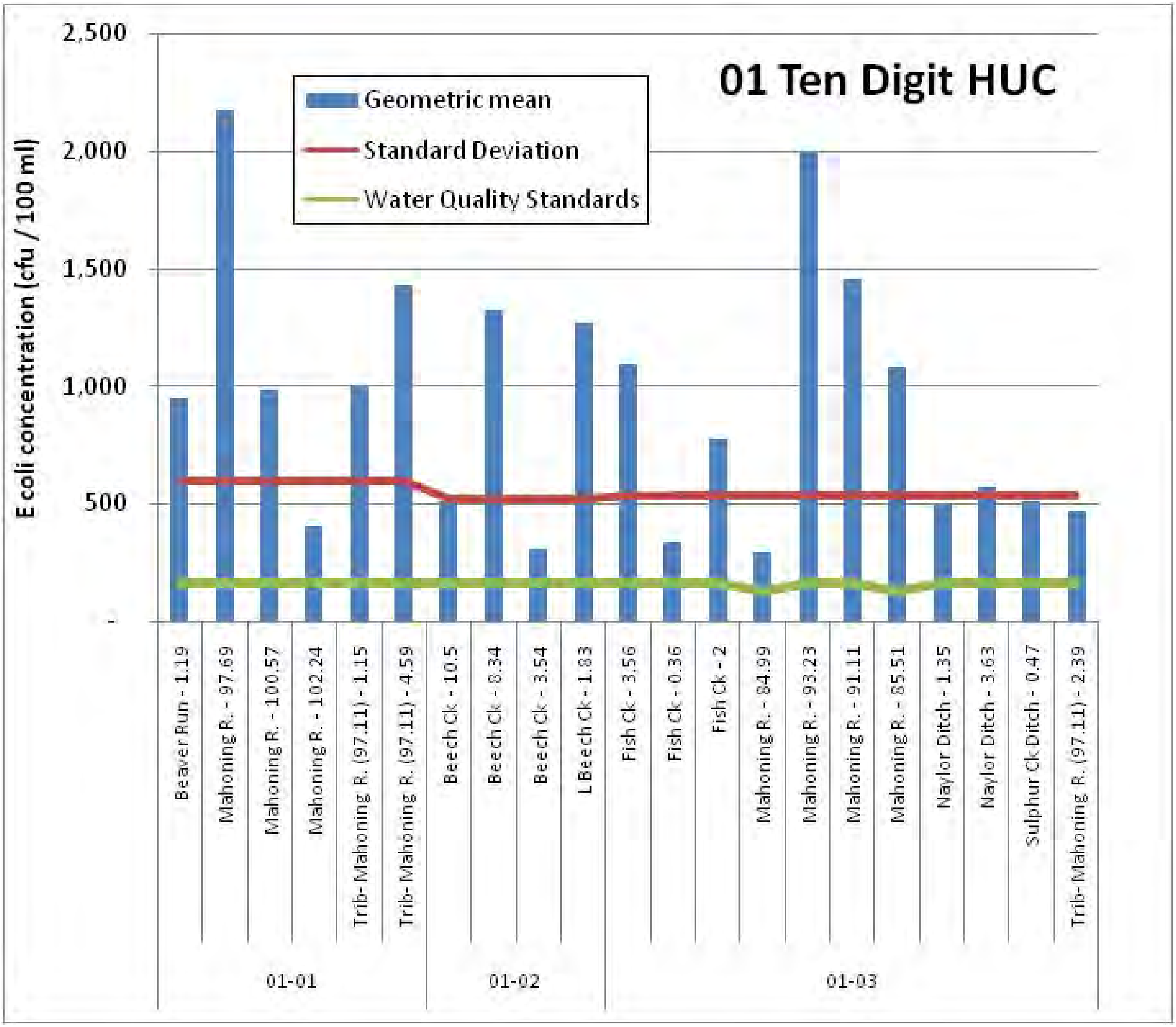

Figure 3-7. Site by site geometric mean for *E. coli* concentrations for the HUC 05030103-01 watershed.

3.1.2 Deer Creek – Mahoning River (05030103 - 02)

In this part of the project area the Mahoning River is impounded to form Berlin Reservoir. Significant tributary streams include Deer Creek (and associated Dale Walborn and Deer Creek Reservoirs), Mill Creek, Willow Creek, and Island Creek. Two out of 10 sites (20 percent) surveyed fully meet aquatic life use criteria; however 60 percent meet none of the criteria and 20 percent met some but not all of the criteria (Figure 3-8). Non attainment was found in each of the large tributaries to the east of the reservoir (12-digit HUCs 02-03 and 02-04) including Garfield Ditch, Mill Creek, Turkey Broth Creek and Island Creek. Willow Creek was also in non attainment and Deer Creek was in partial attainment for aquatic life use downstream of the dam for the Walborn Reservoir. Recreation uses were impaired at 10 sites (91 percent) of the 11 sites surveyed in this ten digit HUC. Aquatic life and recreation use attainment for HUC -02 is presented in Figure 3-8 while causes and sources of aquatic life use impairment are in presented in the maps associated with Figures 3-9 and 3-10. The bar chart in Figure 3-11 is the site by site geometric mean of the *E. coli* concentrations within the ten-digit HUC. The numbers after the stream name on the x-axis indicate the river mile in which the sample was taken. The standard deviation for each of the component 12-digit HUCs and the applicable water quality criteria are shown on the graph as horizontal lines.

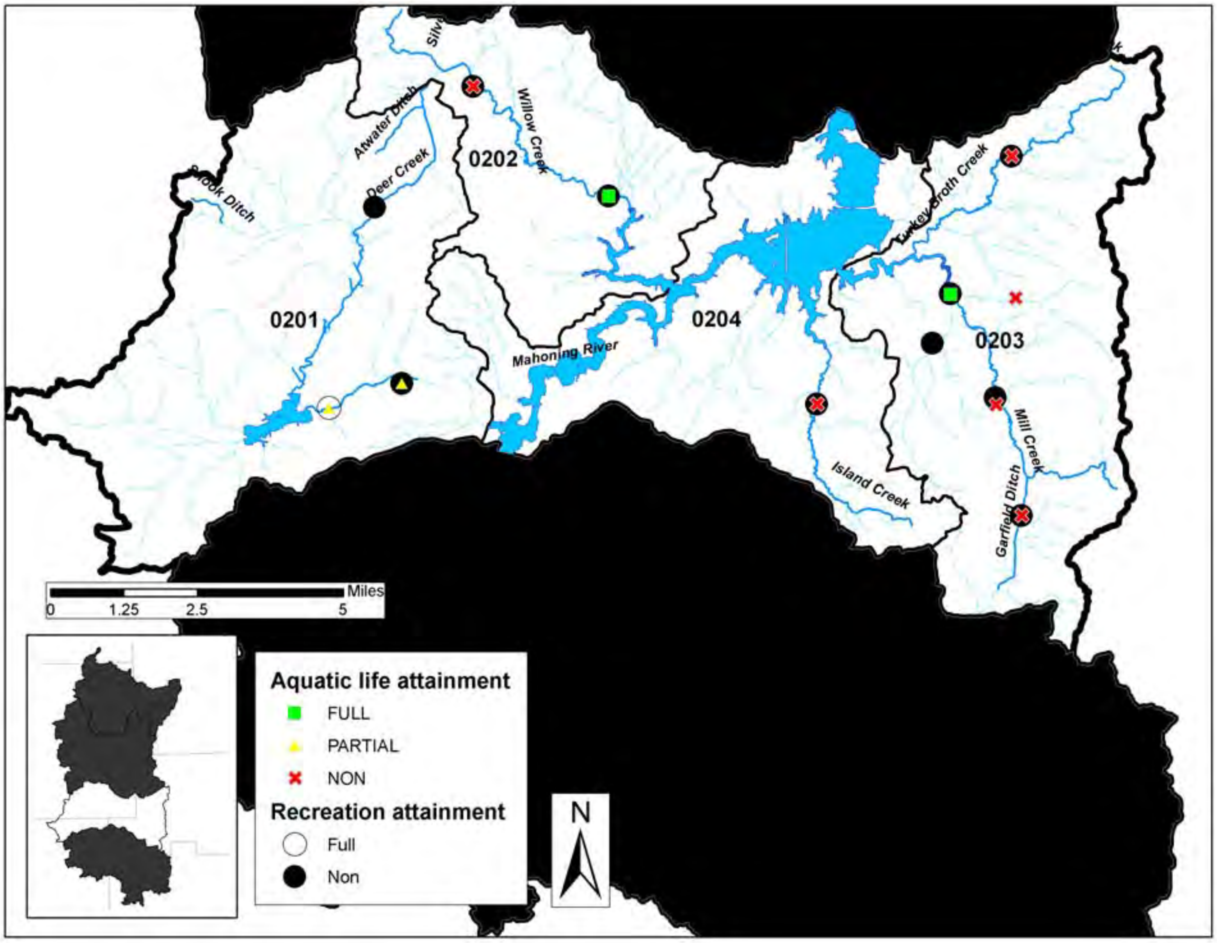

Figure 3-8. HUC 05030103-02 aquatic life and recreation use attainment.

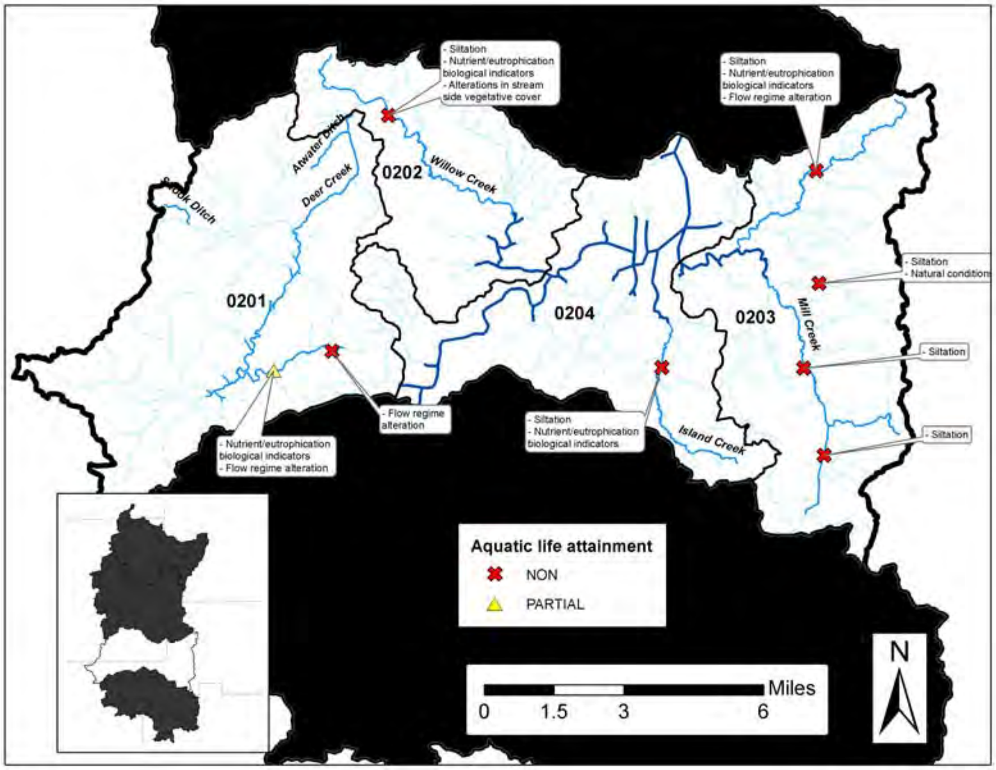

Figure 3-9. Map of the causes of aquatic life use impairment in HUC 05030103-02.

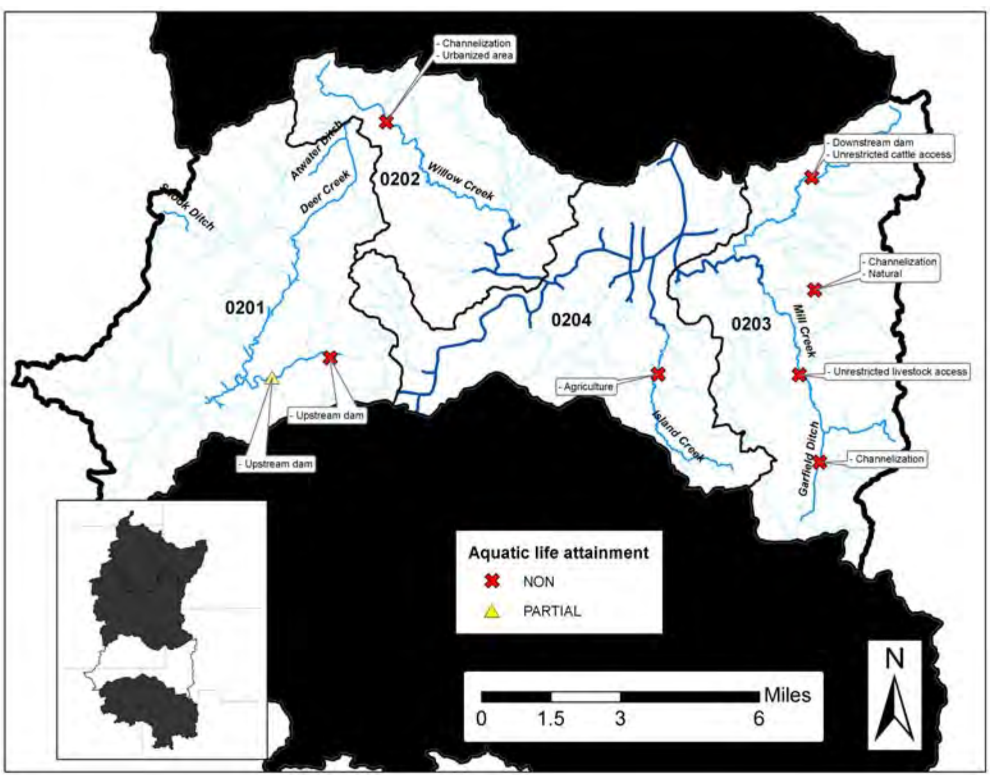

Figure 3-10. Map of the sources of aquatic life use impairment in HUC 05030103-02.

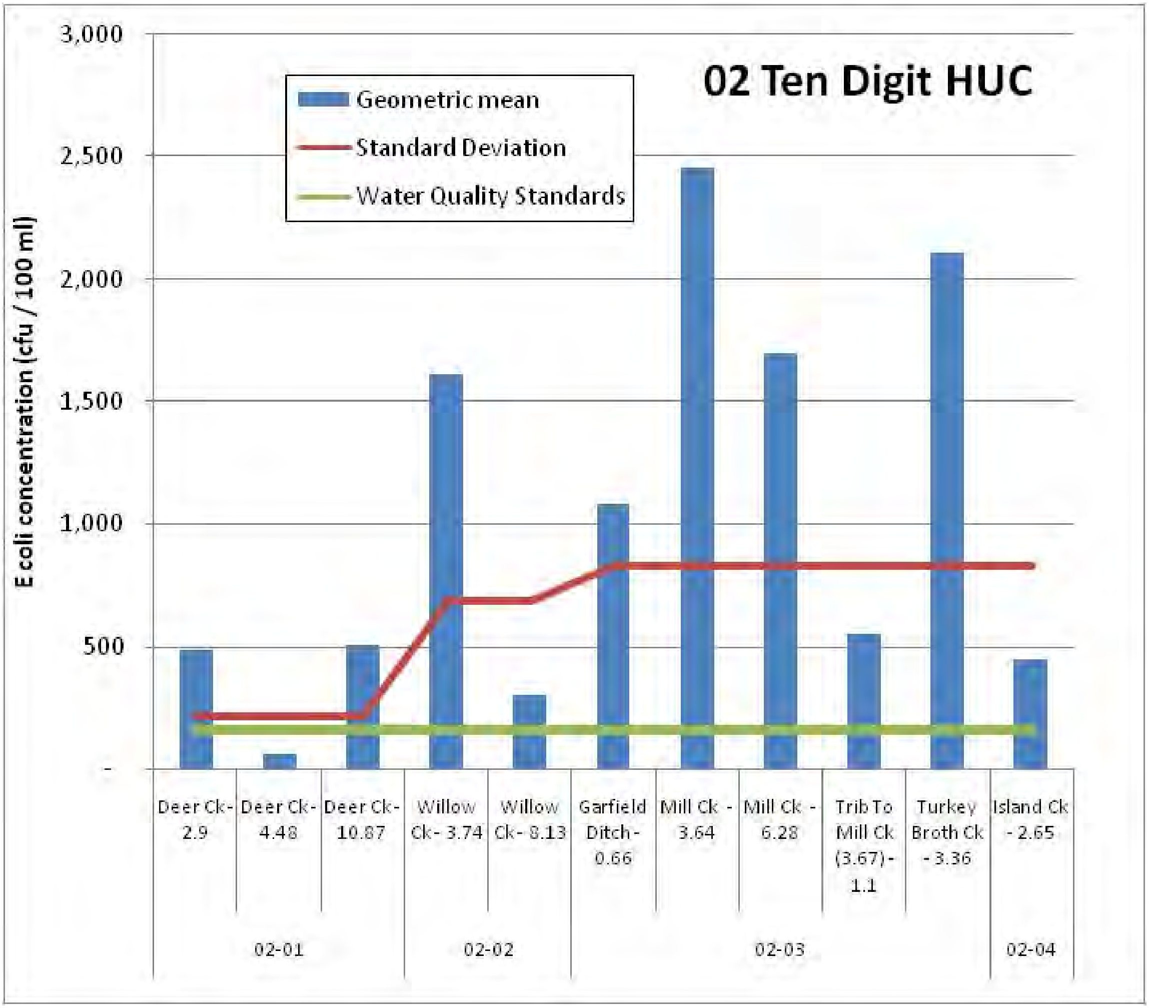

Figure 3-11. Site by site geometric mean for *E. coli* concentrations for the HUC 05030103-02 watershed.

3.1.3 West Branch Mahoning River – Mahoning River (05030103 - 03)

In this part of the project area the Mahoning River is mostly impounded to form Lake Milton about two river miles down from the Berlin Reservoir dam (the terminus of the 02 ten digit HUC watershed). The most significant tributary stream is the West Branch of the Mahoning River (and associated Michael J. Kirwan Reservoir) which joins the Mahoning River just downstream of Newton Falls and marks the terminus of this ten digit watershed. Only two other named tributaries directly enter the Mahoning River, Kale Creek and Charley Run Creek (which was not sampled). Significant tributaries to the West Branch include Silver Creek, Bixon Creek and Barrel Run entering from the south and Harmon Brook and Hinkley Creek entering from the north.

Eight of the 24 sites surveyed (33 percent) fully meet aquatic life use criteria; however 25 percent meet none of the criteria and 42 percent met some but not all of the criteria (Figure 3-12). The majority of the impairment was found on Kale Creek where two sites were in non attainment and three in partial. The mainstem of the Mahoning River is impaired downstream of the Berlin and Lake Milton dams with respective partial and non attainment statuses. Partial attainment was also found on the mainstem in Newton Falls. Three tributaries to the West

Branch were in partial attainment, Barrel Run and Harmon Brook above the reservoir and an unnamed tributary downstream of the reservoir. The West Branch was in partial attainment just down from the dam and in non attainment where it is pooled from the influence of the dam on the mainstem of the Mahoning River in Newton Falls. Recreation uses were impaired at 22 sites (88 percent) of the 25 sites surveyed in this ten digit HUC. Aquatic life and recreation use attainment for HUC -03 is presented in Figure 3-12 while causes and sources of aquatic life use impairment are in presented in the maps associated with Figures 3-13 and 3-14. The bar chart in Figure 3-15 is the site by site geometric mean of the *E. coli* concentrations within the ten-digit HUC. The numbers after the stream name on the x-axis indicate the river mile in which the sample was taken. The standard deviation for each of the component 12-digit HUCs and the applicable water quality criteria are shown on the graph as horizontal lines.

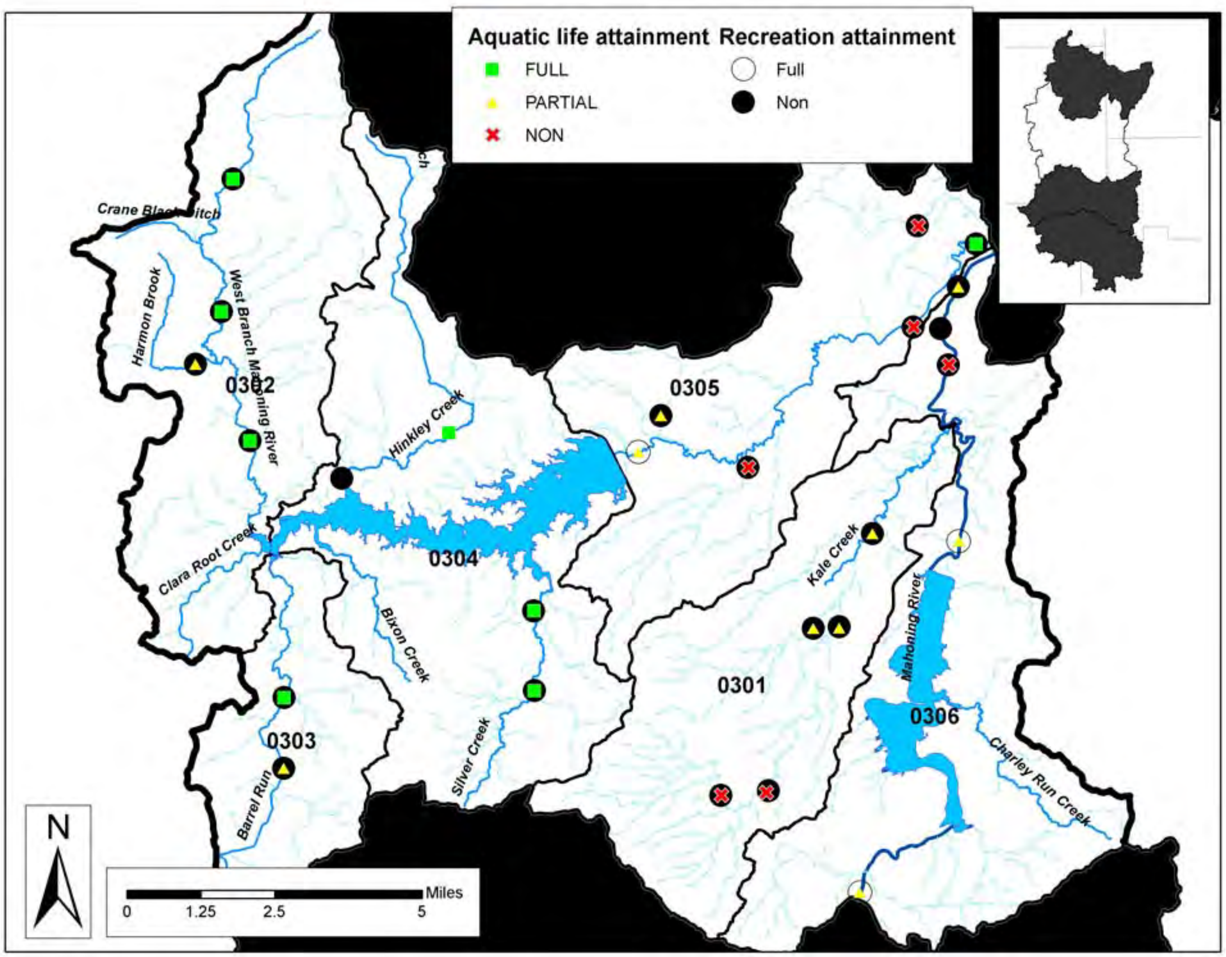

Figure 3-12. HUC 05030103-03 aquatic life and recreation use attainment.

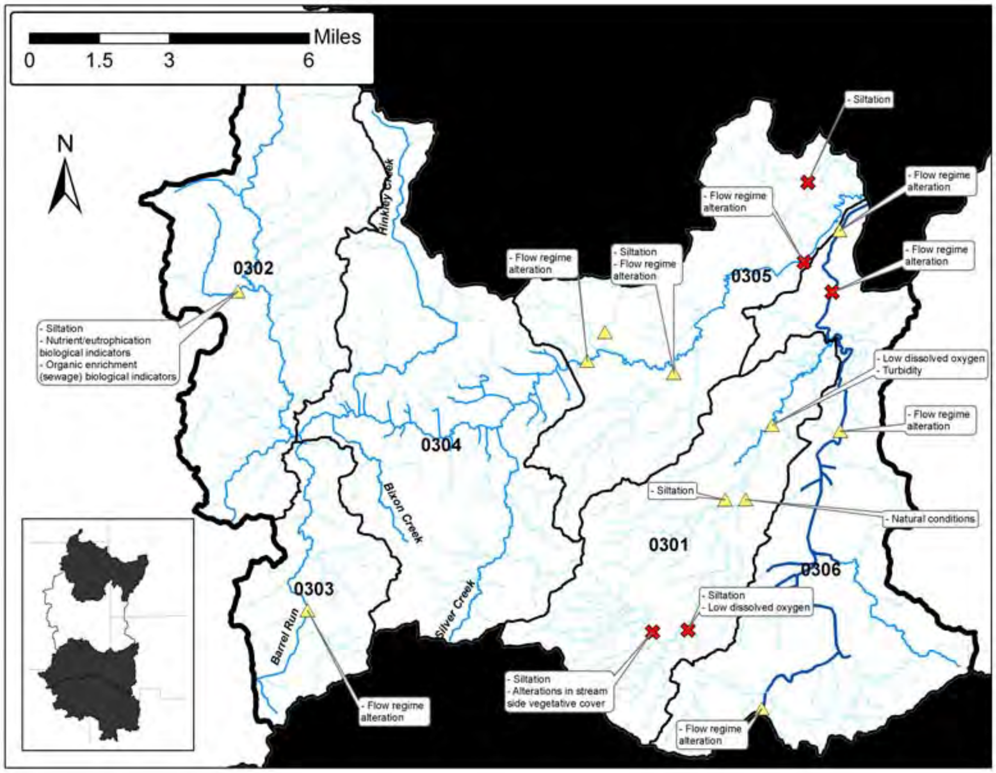

Figure 3-13. Map of the causes of aquatic life use impairment in HUC 05030103-03.

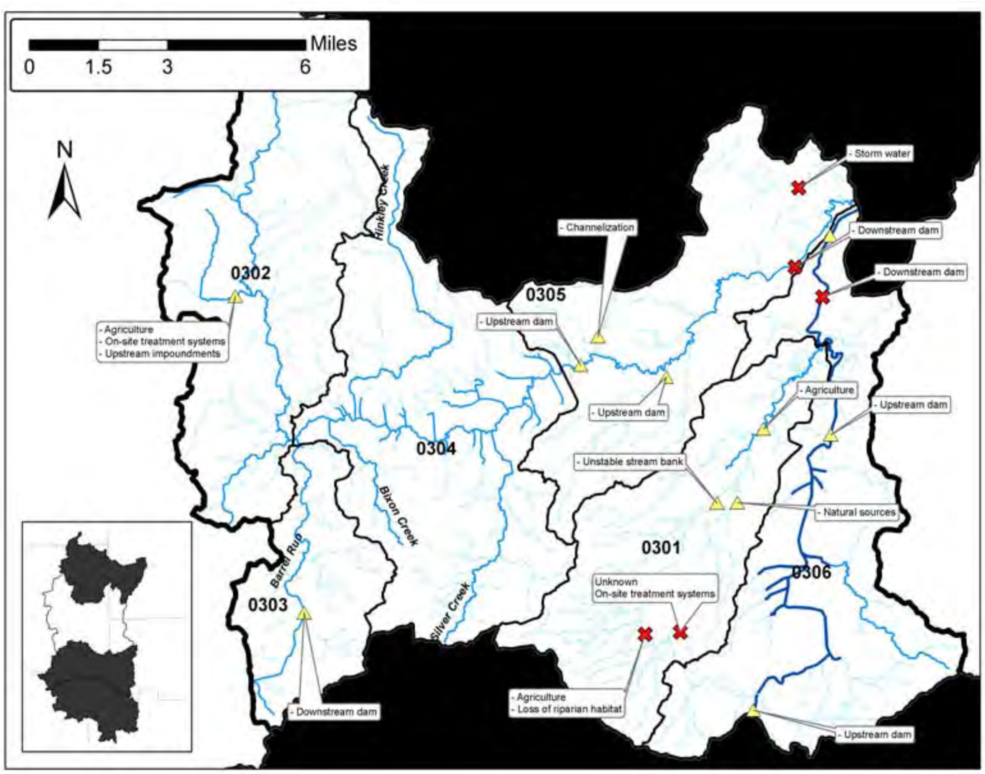

Figure 3-14. Map of the sources of aquatic life use impairment in HUC 05030103-03.

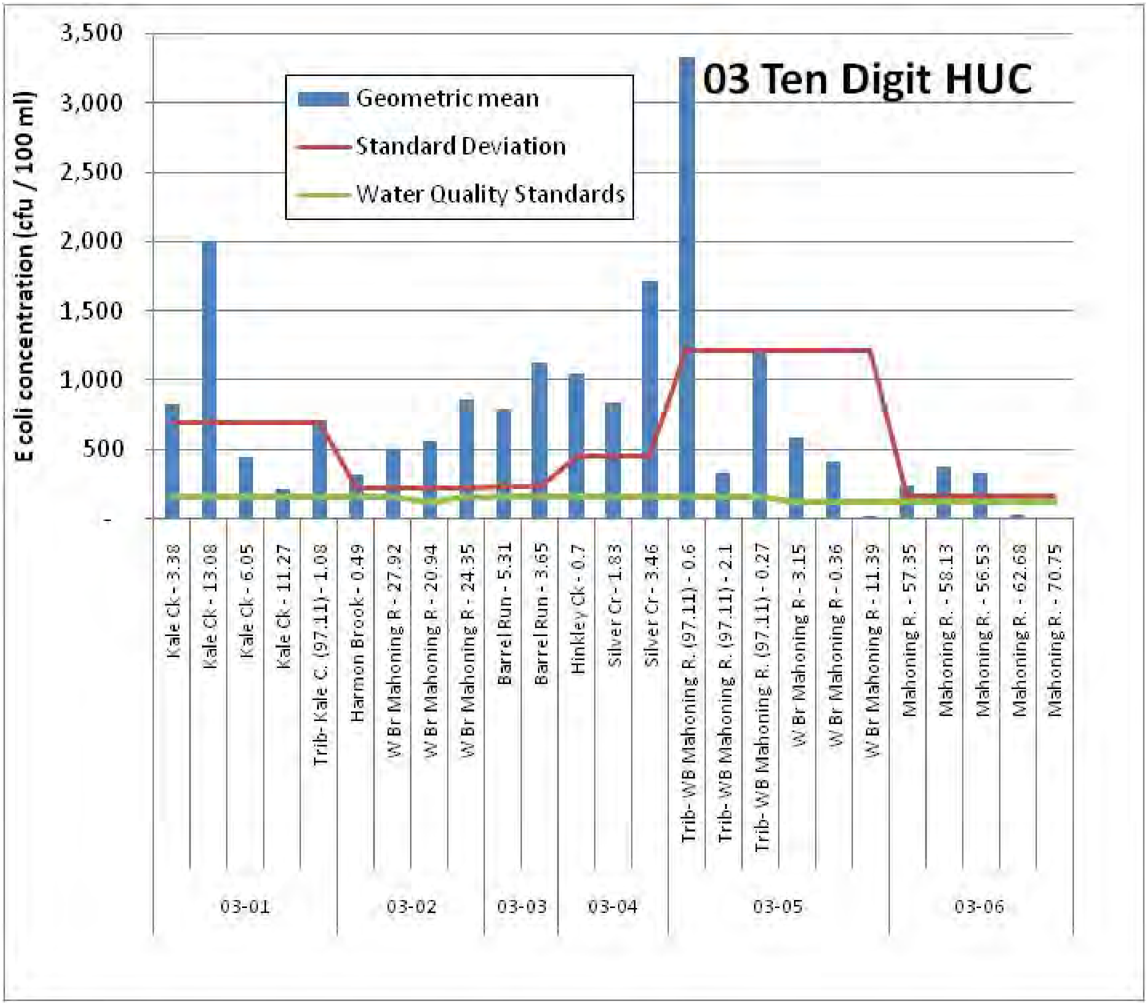

Figure 3-15. Site by site geometric mean for *E. coli* concentrations for the HUC 05030103-03 watershed.

3.1.4 Eagle Creek – Mahoning River (05030103 - 04)

This part of the project area primarily consists of Eagle Creek and its tributary streams and nine miles of the mainstem of the Mahoning River. Significant tributaries to Eagle Creek include Silver Creek, Camp Creek, and Tinker Creek entering from the north and Black Creek, Mahoning Creek, and South Fork Eagle Creek (with Sand Creek as a tributary) from the south.

Nine out of 16 sites (56 percent) surveyed fully meet aquatic life use criteria; however, 31 percent meet none of the criteria and 13 percent met some but not all of the criteria (Figure 3-16). The majority of the impairment was found on the mainstem of the Mahoning River where two sites in the Leavittsburg area were in non attainment while one site downstream from Newton Falls is in partial attainment. Tinker Creek was also impaired with one site in non-attainment and one in partial attainment. One site on Mahoning Creek was also in non attainment. Recreation uses were impaired at 18 sites (100 percent) of the 18 sites surveyed in this ten digit HUC. Aquatic life and recreation use attainment for HUC -03 is presented in Figure 3-16 while causes and sources of aquatic life use impairment are in presented in the maps associated with Figures 3-17 and 3-18. The bar chart in Figure 3-19 is the site by site geometric mean of the *E. coli* concentrations within the ten-digit HUC. The numbers after the stream name on the x-axis indicate the river mile in which the sample was taken. The standard deviation for each of the component 12-digit HUCs and the applicable water quality criteria are shown on the graph as horizontal lines.

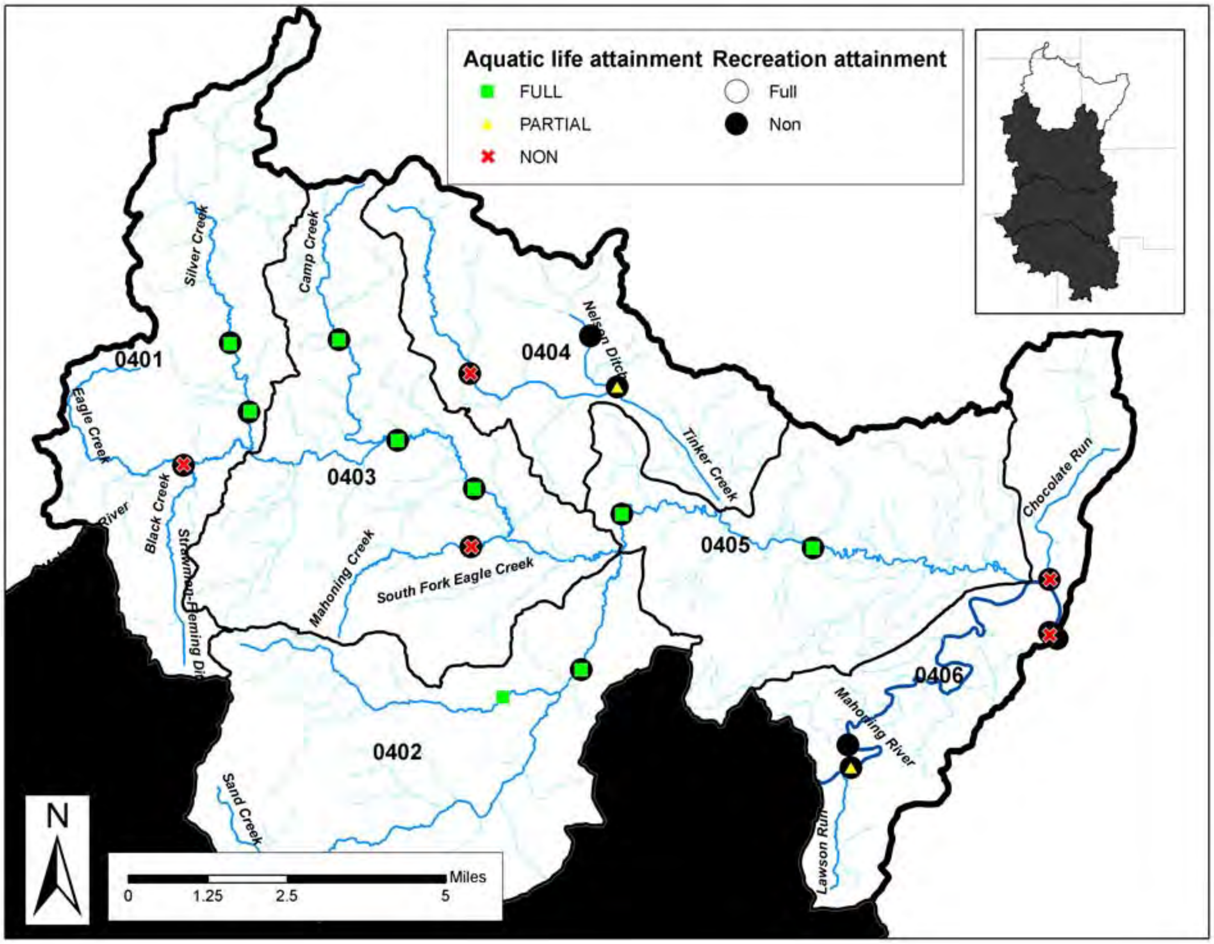

Figure 3-16. HUC 05030103-04 aquatic life and recreation use attainment

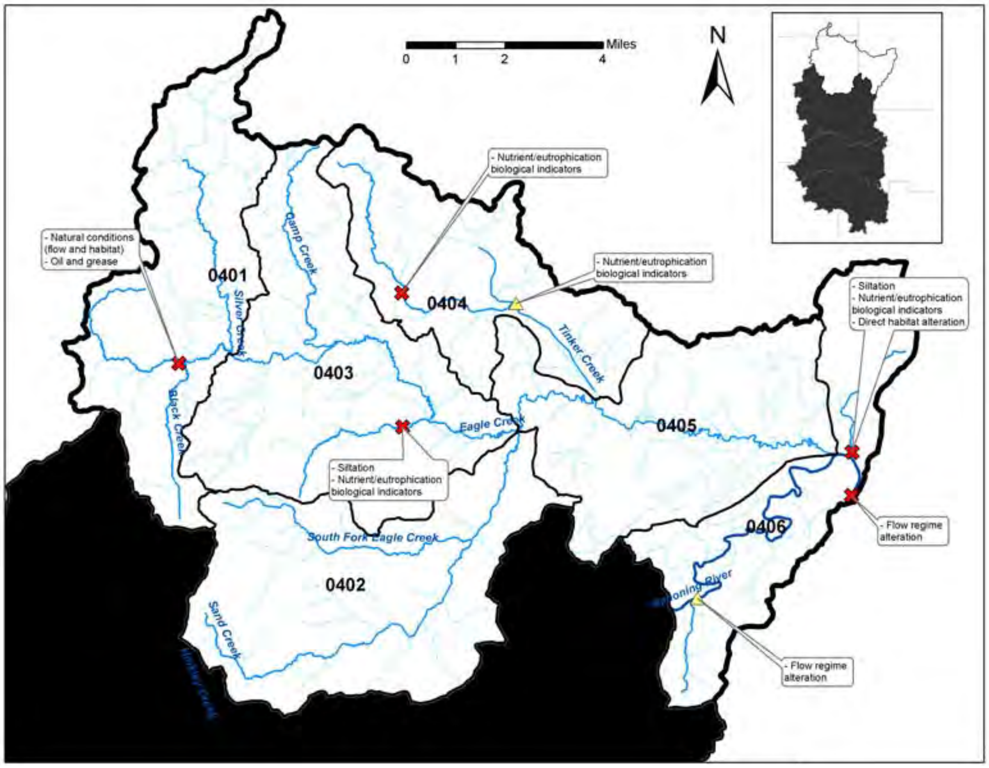

Figure 3-17. Map of the causes of aquatic life use impairment in HUC 05030103-04.

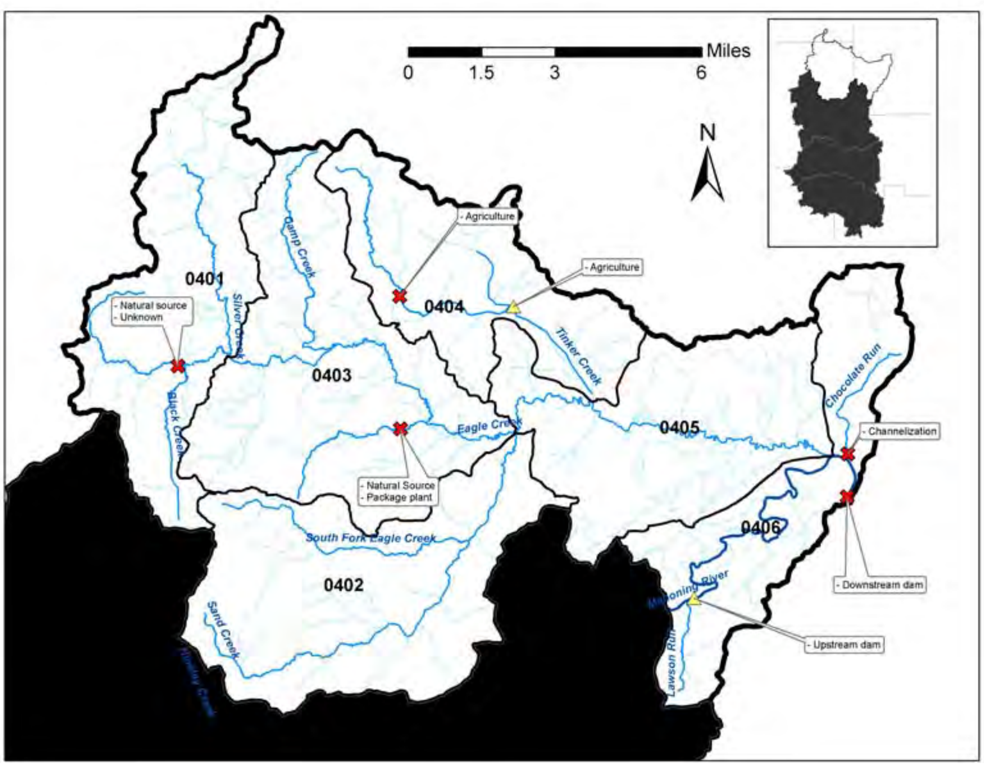

Figure 3-18. Map of the sources of aquatic life use impairment in HUC 05030103-04.

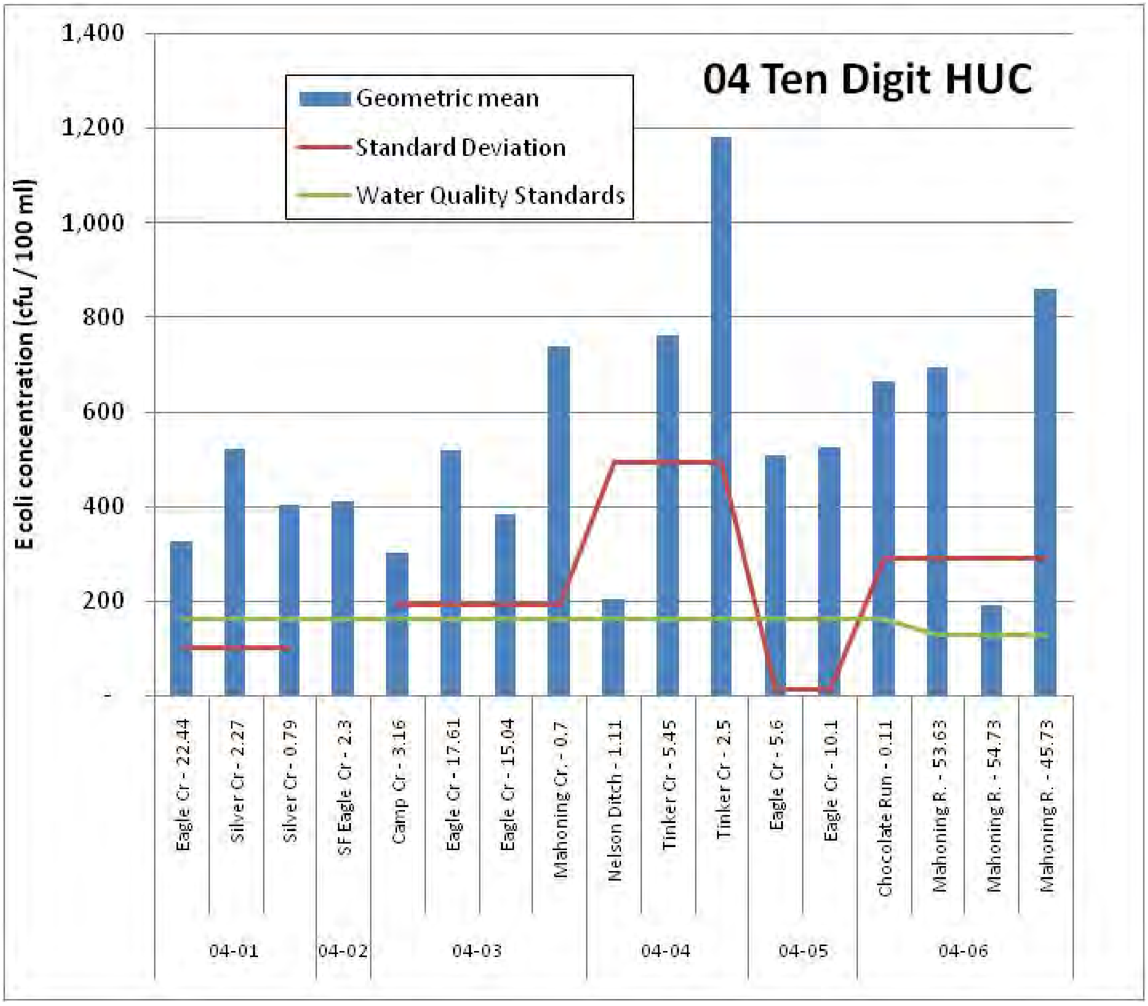

Figure 3-19. Site by site geometric mean for *E. coli* concentrations for the HUC 05030103-04 watershed.

3.2 Summary of the Causes and Sources of Aquatic Life and Recreation Use Impairments

Sixty-one percent of the sites survey failed to meet standards for aquatic life uses and 95 percent did not meet recreation use standards. Based on the results of this water quality survey, and compared to other watersheds in the state, the upper Mahoning River is of relatively fair to poor quality (statewide average is nearly 20 percent higher in terms of number of sites attaining ALUs and 13 percent higher in terms of assessment units meeting recreation use standards, see the 2010 Integrated Report). However, it is also important to note that these water quality surveys are extensive but not comprehensive therefore, there are several small tributary streams that were not directly monitored. Coverage tends to be around five survey sites per HUC 12 watershed (approximately 20 to 25 square mile area) where there is on average 50 miles of streams in such an area. Nonetheless, it is reasonable to extrapolate the results of the sites that were surveyed to the rest of the watershed assuming that the level of impairment and perhaps more importantly, the causes and sources of impairment, occur in similar proportion to areas that are not assessed. This is especially the case for sources of impairment related to land management such as polluted runoff or channel maintenance in small agricultural streams.

Impaired recreation uses

Recreation use impairment was pervasive in the study area and the magnitude at which measured *E. coli* concentrations exceeded the water quality standards was on average well over five times greater (median value showed to be 3.6 times greater). In terms of the concentration values there is a statistically significant negative correlation between drainage area and *E. coli* concentration, although the strength of the correlation is low (R^2 value = 0.054). There were; however, no statistically significant differences between the ten-digit HUCs in terms of pooled *E. coli* concentration values ($p > 0.1$). The means for the respective HUCs were 926, 1,027, 756, and 542 colony forming units per 100 ml of sample for the ten-digit HUCs ending in 01, 02, 03, and 04 respectively. For perspective, the water quality standard for the majority of sites was 161 colony forming units per 100 ml of sample and 126 colony forming units per 100 ml of sample for sites on streams designated as PCR-A (reflecting higher recreation activity and opportunity)

One of the more substantial problems identified as loading bacteria to streams in the project area is inadequately treated sewage from decentralized home sewage treatment systems. In fact, 75 percent of the systems are estimated to be in some state of compromised functionality for modeling purposes of this report (see Section 4-1-1) which is justified through years of professional experience in dealing with these types of systems. The majority of the recreation use impairments stem from this type of source; however, a relatively small proportion of the aquatic life use impairments are due to poorly operating septic systems. Cropland is also believed to have widespread impact on bacteria loading and together with poorly functioning home septic systems accounts for nearly 80 percent of the sources that have been documented as the reason for the impaired recreation uses. Waste water collection (i.e., CSOs from Newton Falls and inadequately treated waste water from small plants in the upper watershed) and treatment and urban runoff account for the remaining 20 percent of the source burden.

Impaired aquatic life uses

Excess fine sediment in the bed material, eutrophic conditions brought on elevated nutrient concentrations, and unnatural stream flow conditions together accounted for 75 percent of the causes of aquatic life use impairment and should be the focus of restoration initiatives in the project area. Poor habitat quality was also an important impact and accounts for well over ten percent of the cause burden. Naturally occurring limitations to the stream system, low dissolved oxygen and enrichment from organic materials turbidity and past fish kills are all also responsible for a minor proportion of the overall causes of aquatic life use impairments. Figure 3-22 is a bar chart of the distribution of the causes of aquatic life use impairments.

Excessive amounts of fine sediment in the channel were found at 30 percent of all sites surveyed. In most cases this was derived from soil losses on cropland and from stream bank erosion due to management of the stream corridor to facilitate land drainage (i.e., channelization or removal of riparian vegetation). In fact, six of the 23 sites where sediment is a problem have been impacted by cropland soil losses. Another 6 sites (only one of which overlaps those where cropland is listed) have channelization listed as the source of sediment and three where unstable banks or riparian vegetation removal is blamed. At four of the 23 sites livestock with stream access trample banks leading to substantial erosion and sedimentation. Urbanization in which storm flows and land disturbance leads to watershed sources of fine sediment as well as significant channel erosion accounts for two of the sites and natural sources at one site.

Nutrients are also significant pollutants in the watershed where 30 percent (18 sites) of all of the sites were impacted. The dominant source is cropland where both runoff and subsurface drainage are the likely pathways for dissolved and particulate forms of nutrients. Ten percent of all sites and nearly 40 percent of the nutrient impacted sites were affected by cropland. Municipal waste water discharges was also a significant source where six percent of all sites were thus impacted. Less significant sources of nutrients include livestock (three percent of all sites), urban areas (three percent of all sites), and home septic systems (one percent of all sites). Figures 3-20 and 3-21 contain diagrammatic representations of the upper Mahoning River and concentrations of phosphorus and nitrate, respectively. In terms of nutrients, home septic systems have a relatively small impact in comparison to cropland sources. In fact, nutrient loading in the Eagleville Creek TMDL area (see Section 4.4.3) which spans 97.7 square miles, home septic systems are estimated to contribute less than one percent of the total phosphorus loading (cropland is approximately 95 percent of the total phosphorus loading).

Flow alteration is a considerable problem for aquatic life uses in the upper Mahoning River watershed (impacting 20 percent of all sites) due the unusually high density of both large and lowhead dams. Three reservoirs exercise substantial controls over stream flow in the Mahoning River and the West Branch Mahoning River. There are also two smaller reservoirs that occur in series on Deer Creek. Such control on stream flow makes it necessarily difficult for fishes and other aquatic organisms to respond to hydrologic cues that are associated with a natural flow regime. Seven sites (10 percent of all sites) are thus affected. Eight sites (11 percent) have been impacted by flow alteration resulting from dam backwaters (especially lowhead dams). In this case again hydrologic cues are altered, but more substantial impacts is loss of flow variability affecting many organisms that are adapted for faster stream current as well as the degradation of habitat quality.

In combination, the degradation of stream habitat and the loss of tree cover and other protective riparian vegetation is a problem at 11 percent of all sites. The majority of this impairment is due to channelization (nine percent of all sites). Among all of the other causes of impairment that are listed, they all range from one to three percent of all sites in their individual impacts. The range for the remaining sources is one to seven percent. These remaining causes include organic enrichment and low dissolved oxygen, natural limitations of the stream (habitat or flow), and turbidity while sources include storm water run off from roads and other developed areas. Figure 3-22 shows the distribution of the major causes of aquatic life use impairment and Figures 3-23 and 3-24 show the distribution of the major sources of stress on aquatic life and recreation uses respectively, in the upper Mahoning River watershed.

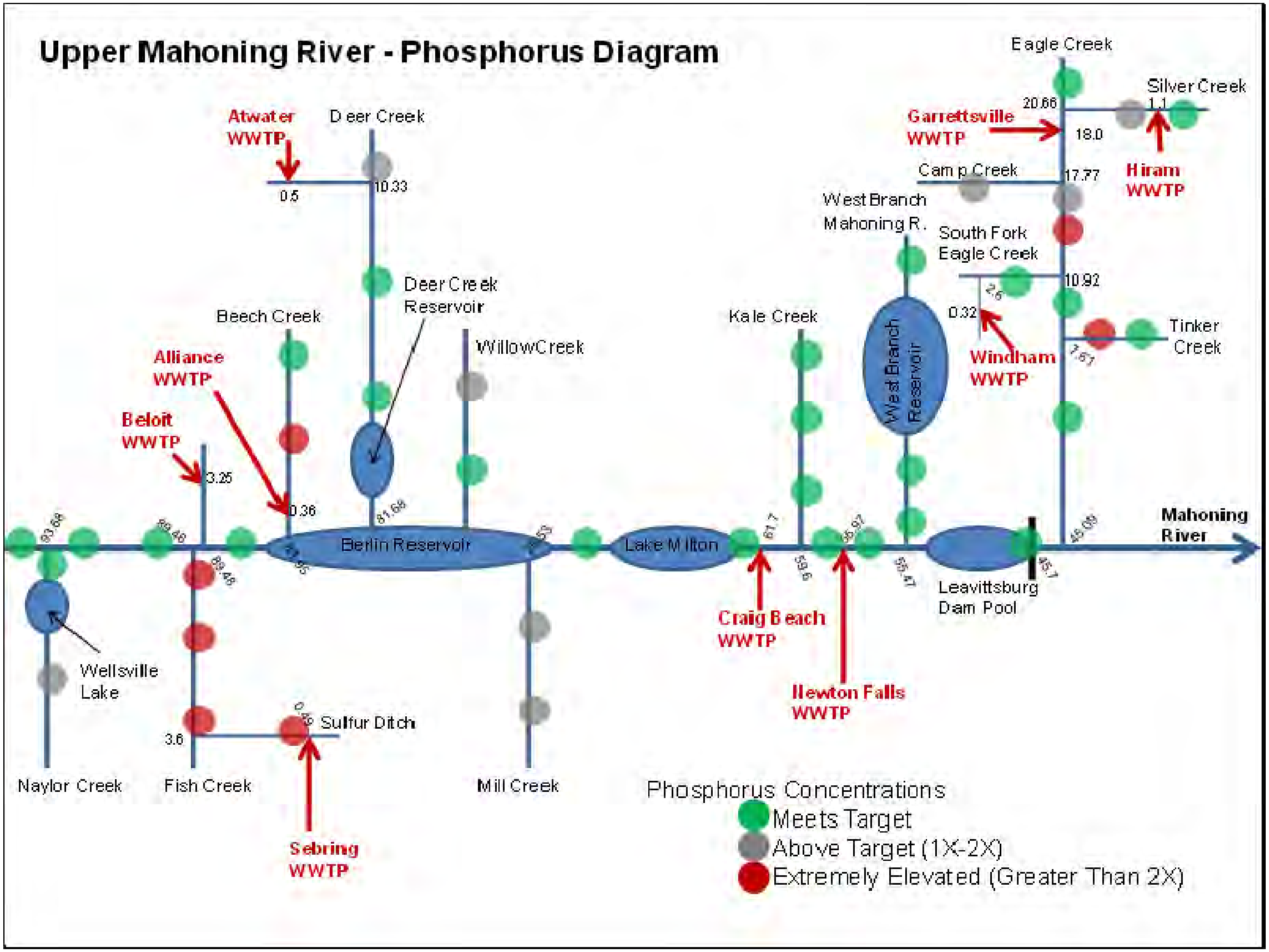

Figure 3-20. Phosphorus concentrations in the upper Mahoning River watershed.

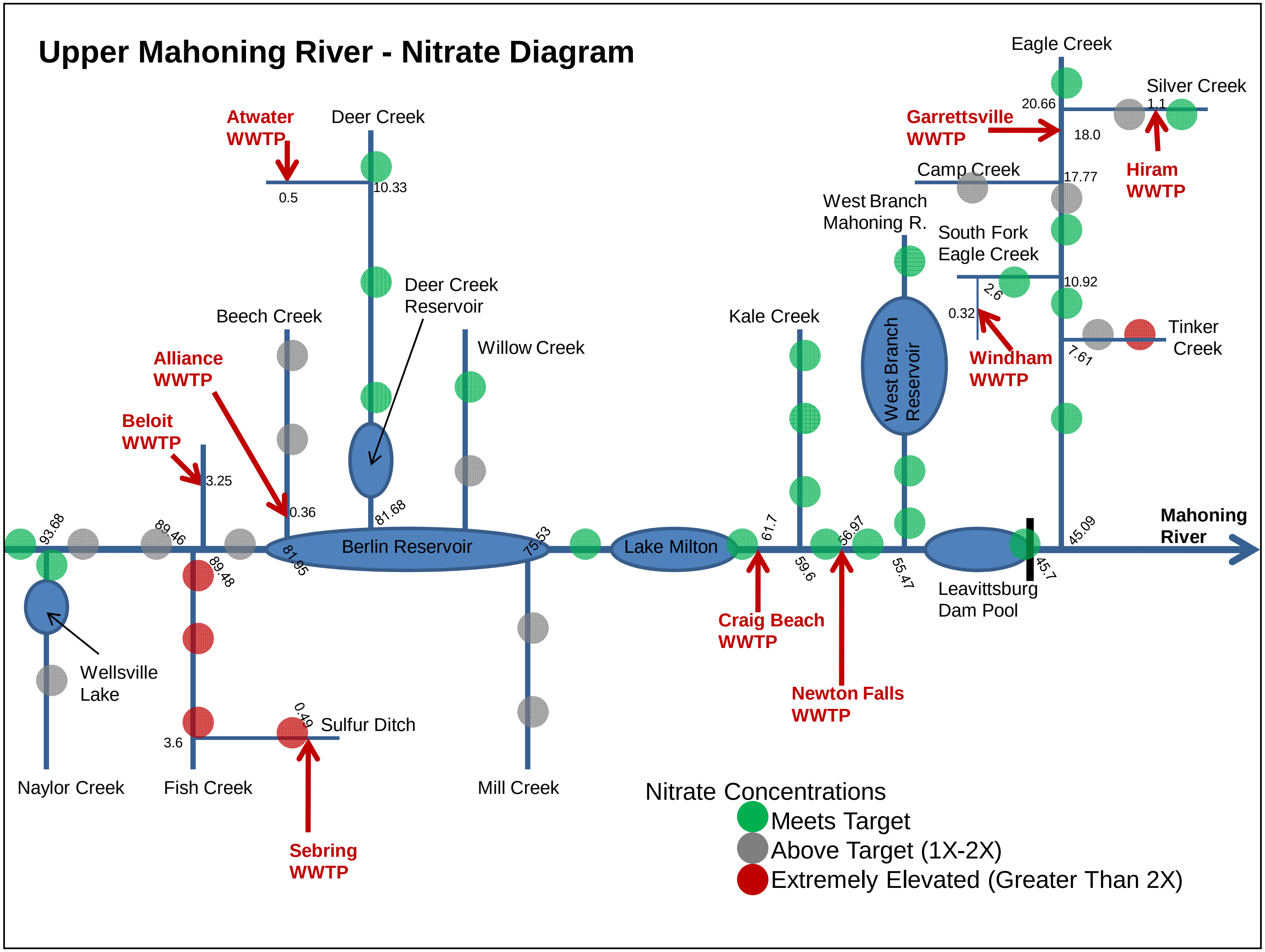

Figure 3-21. Nitrate concentrations in the upper Mahoning River watershed.

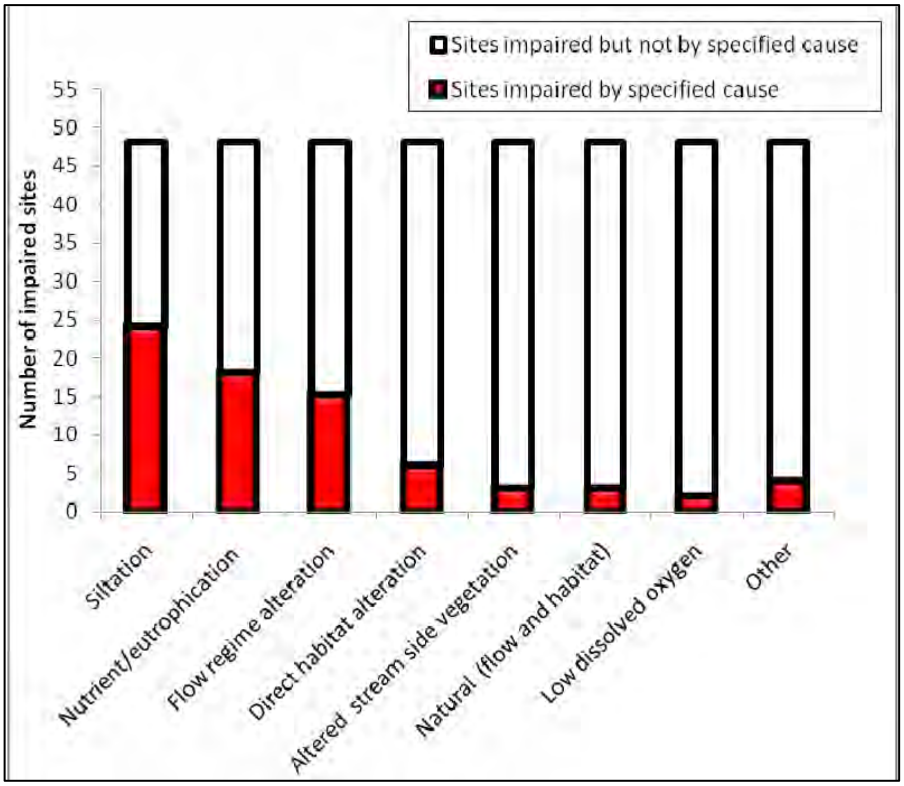

Figure 3-22. Distribution of causes of impairment for ALU impaired sites.

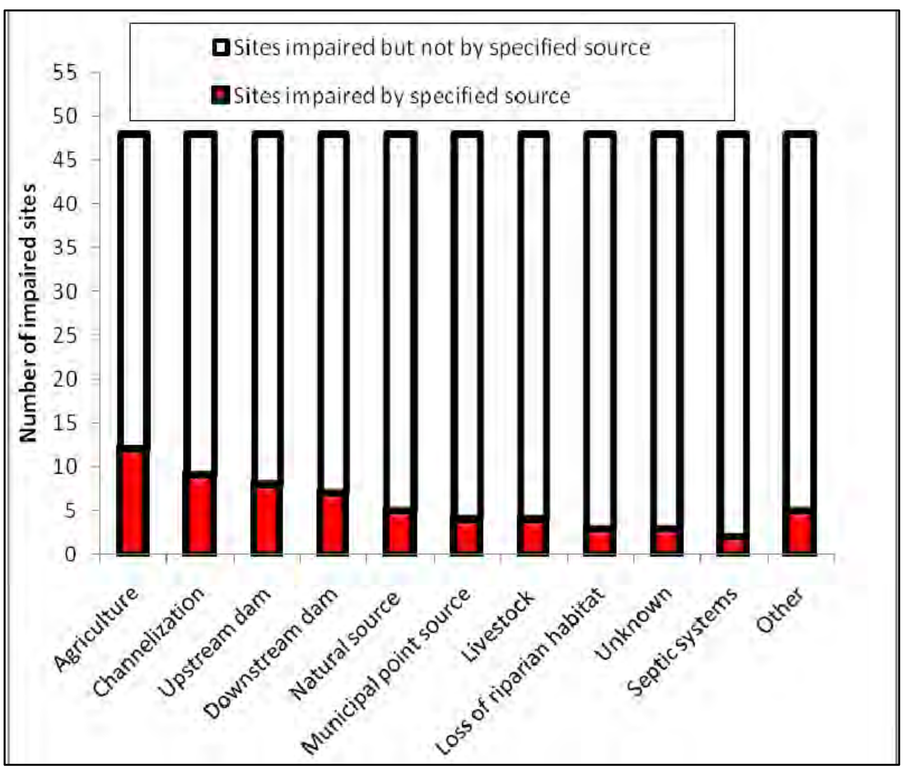

Figure 3-23. Distribution of sources of impairment for ALU impaired sites.

3.3 Statistical Strength of Relationship between Biological Communities and Habitat

To further illustrate the relationship between the river and stream fish and macroinvertebrate communities and habitat quality, correlation and multivariate statistical analyses of the upper Mahoning 2006 survey data were carried out. The results (Table 3-1) confirm statistically significant correlations between biological communities and some habitat components where substrate and riffles are strongly associated with both macroinvertebrate and fish community scores. Fish also are influenced by pools and macroinvertebrates by channel quality, which is consistent with the published literature.

Multivariate statistical analysis techniques assist with data visualization. As in the correlation analysis, individual habitat metric scores were used in the analysis without any biological scores. The specific method used here was a Principal Components Analysis, a procedure designed to evaluate complex data sets and simplify them. Table 3-1 presents results from the PCA analysis. The PCA analysis appears to separate non attaining sites from those in partial and full attainment along the axis labeled Principal Component 1. An interpretation of this graph leads one to visualize a separation, in this case due to habitat, among sites. This indicates that there is a definite connection between habitat quality and aquatic life use attainment status.

Table 3-1. Correlation analysis between habitat features (QHEI metrics) and biological indices.

	substrate	cover	channel	riparian	pool	riffle	gradient	DA(mi^2)	IBI
cover	**0.39**								
	0.001								
channel	**0.441**	**0.486**							
	0	**0**							
riparian	-0.029	**0.333**	**0.388**						
	0.811	**0.005**	**0.001**						
pool	**0.306**	**0.591**	**0.244**	0.11					
	0.01	**0**	**0.043**	0.369					
riffle	**0.777**	**0.456**	**0.465**	0.125	**0.307**				
	0	**0**	**0**	0.306	**0.01**				
gradient	**0.247**	0.001	0.256	-0.098	0.053	0.232			
	0.041	0.996	0.034	0.424	0.665	0.055			
DA(mi2)	0.034	0.15	-0.188	0.131	**0.312**	-0.069	-0.204		
	0.779	0.22	0.122	0.284	**0.009**	0.575	0.093		
IBI	**0.494**	0.222	**0.299**	0.1	**0.323**	**0.394**	0.024	0.089	
	0	0.067	**0.013**	0.412	**0.007**	**0.001**	0.845	0.466	
ICI	**0.609**	0.195	**0.394**	0.055	**0.292**	**0.52**	0.212	-0.127	**0.6**
	0	0.109	**0.001**	0.651	**0.015**	**0**	0.081	0.299	**0**

Top - Pearson correlation
Bottom - P-Value

P-Values<0.05 in bold

Blue highlighted cells are biological correlations

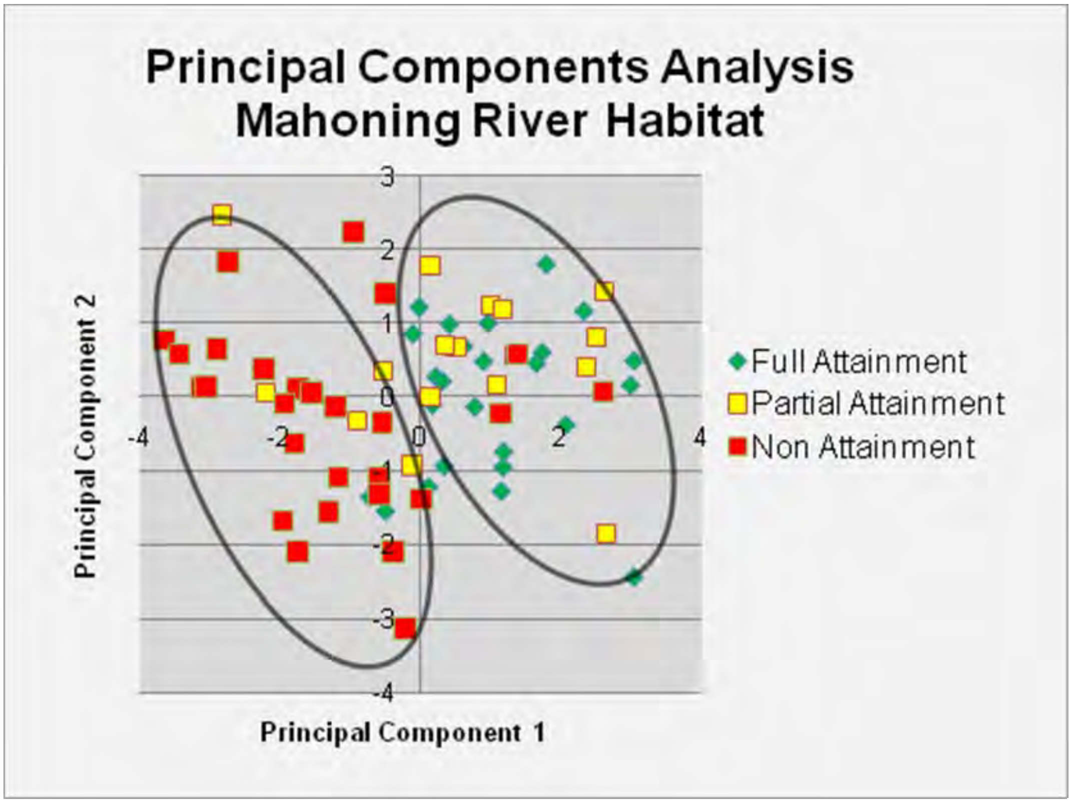

Figure 3-24. PCA for habitat scores in the upper Mahoning River basin.

4 METHODS TO CALCULATE LOAD REDUCTIONS

This section discusses the methods used in developing TMDLs and allocations in the upper Mahoning River project area. Tables 4-1 and 4-2 outline which causes of impairment will be addressed through the development of a TMDL for the particular assessment areas. This section is organized based on the technical methods and/or rationale used for the following:

- Establishing appropriate water quality targets
- Estimating existing conditions such as pollutant concentrations and habitat quality and the respective contributions from the relevant sources
- Allocating the TMDLs to these sources
- Miscellaneous considerations that are also a part of TMDL development.

A more comprehensive discussion of the methods can be found in Appendix D.

Table 4-1. Summary of causes of impairment and actions taken to address them in assessment units within the 05030103- 01 and 05030103- 02 ten-digit hydrologic units.

	Watershed Assessment Units						
	05030103 - 01			05030103 - 02			
Causes of Impairment	**01**	**02**	**03**	**01**	**02**	**03**	**04**
Aquatic Life Use							
Sedimentation / siltation	D	D	D		D	D	D
Nutrient / eutrophication biological indicators	D	N	D	D	D	N	N
Direct habitat alterations		D	D				
Other flow regime alterations			D	D		D	
Alterations in stream-side or littoral vegetative covers			D		D		
Natural conditions						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.

Table 4-2. Summary of causes of impairment and actions taken to address them in assessment units within the 05030103- 03 and 05030103- 04 ten-digit hydrologic units.

	Watershed Assessment Units											
	05030103 - 03						05030103 - 04					
Causes of Impairment	**01**	**02**	**03**	**04**	**05**	**06**	**01**	**02**	**03**	**04**	**05**	**06**
Aquatic Life Use												
Sedimentation / siltation	D	D	D		D				D	D		D
Nutrient / eutrophication biological indicators		N							D			N
Organic enrichment (sewage) biological indicators		N										
Oxygen, dissolved	N											
Turbidity	N											
Direct habitat alterations	D				D					D		D
Natural conditions (flow or habitat)	N						N					
Other flow regime alterations			D		D	D						D
Recreation Use												
E. coli	D	D	D	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.

4.1 Generalized Watershed Loading Function (GWLF) and Hydrograph Proportioned Daily Loads

Phosphorus TMDLs were developed for two watersheds (Figure 4-1) within the upper Mahoning Watershed using the Generalized Watershed Loading Functions (GWLF) watershed model (Haith et al., 1992). The purpose of the modeling effort was to determine the nutrient loads from each significant source category (specifically agricultural runoff, septic systems, and point source dischargers) as well as the acceptable TMDL for total phosphorus. Ultimately, the GWLF output coupled with point source data were used to predict nutrient loads and hydraulic discharges of the stream reaches.

GWLF is a mid-range watershed model that provides monthly output of average nutrient concentrations and daily output for simulated stream flow at a geographical point defined by the user. This model does not simulate fate and transport processes within the stream system itself. Additionally, daily loads were developed by hydrograph proportioning of the monthly load (i.e., based on average monthly total phosphorus concentration, daily flow values, and total monthly flow volume) over a sliding monthly time period. This method presumes a steady loading rate proportioned to the stream flow which, effectively equalizes the total phosphorus concentration of the entire flow regime.

GWLF provides a simulation of precipitation-driven runoff and sediment delivery. Solids load, runoff, and ground water seepage are used to estimate particulate and dissolved phase pollutant delivery to a stream, based on pollutant concentrations in soil, runoff, and ground water (USEPA, 2006). GWLF simulates runoff and stream flow by a water-balance method, based on measurements of daily precipitation and average temperature. Precipitation is partitioned into direct runoff and infiltration using a form of the Natural Resources Conservation Service's (previously Soil Conservation Service [SCS]) Curve Number method (SCS, 1986). The Curve Number determines the amount of precipitation that flows off directly from various land uses and soil types, adjusted for antecedent soil moisture based on total precipitation in the preceding five days.

GWLF requires three input files to simulate runoff and pollutant loads from each subwatershed. The weather file contains daily values of precipitation and average temperature. The nutrient file contains nitrogen and phosphorus concentrations of groundwater and runoff as well as build-up/wash off rates from urban areas. The transport file contains land use areas and parameters for estimating runoff, erosion, and evapotranspiration.

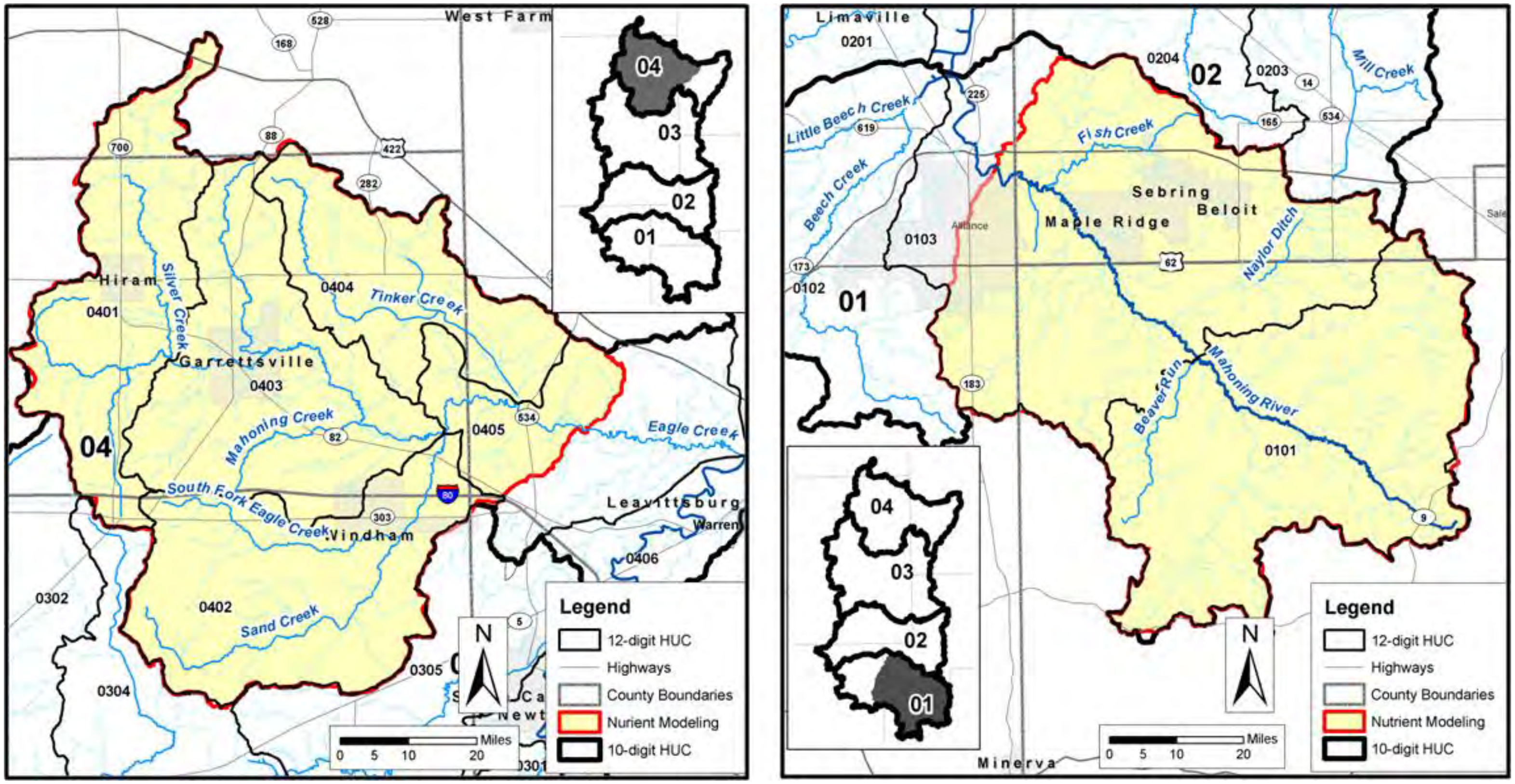

Figure 4-1. Two areas where total phosphorus TMDL were developed using GWLF. The map on the left show the area draining to the Alliance gage while the right is for the Phalanx Station gage.

4.1.1 Sources of Data

GWLF uses daily values of precipitation, average temperature, and evapotranspiration rates to estimate a water budget in the system. A ten year record of weather data from the National Midwest Regional Climate Center stations named Berlin Lake (330639) for the Upper Mahoning River upstream Alliance and Hiram (333780) for Eagle Creek upstream Phalanx Station gage were used as GWLF input. The weather station in which the Thiessen polygon covered the majority for the drainage area of the respective gage was chosen as the appropriate meteorological data source.

The GWLF model uses the curve number method to estimate runoff from each land use area. Curve numbers are determined based on land cover type and the hydrologic soil groups in the area modeled. Land cover was determined from the National Land Cover Dataset (NLCD) which, was compiled from Landsat ™ satellite imagery acquired between 1991 and 1993. No significant changes in land use in these watersheds have occurred since the land use data was collected; therefore, no adjustment to this GIS coverage was attempted. Area weighted curve numbers were developed for each subwatershed based on the NLCD land use and the associated soil hydrologic groups in the STATSGO database (NRCS, 2002).

An estimation of population served by septic systems is required to generate septic system nutrient loading rates. Nutrient loading rates are affected by the number of septic systems that are either failing or operating properly. The total number of home sewage treatment systems (HSTS) was determined via GIS analysis of census data, where the number in each 14-digit HUC[1b] is estimated based on 1990 and 2000 census demographic information and adjusted to conditions expected in 2006 from population trends provided by the Ohio Department of Development. GWLF defines failing systems as ponded, short circuited, and directly discharging. For the Upper Mahoning Basin, 25% of the systems were considered ponded, 25% short-circuited, and 25% direct discharge. This estimation was made based on experience and best professional judgment. HSTS pollutant loads are estimated as the product of the number of persons served by failing systems in each subwatershed, a per capita wastewater flow-rate and representative wastewater-quality information. Failure rates are assumed based on the average rate found in documented studies.

Groundwater nutrient concentrations were based on baseflow measurements reported in the GWLF manual for various levels of forested and agriculturally developed watersheds. Completely forested watersheds have values of 0.07 mg-N/L and 0.012 mg-P/L. Primarily agricultural watersheds have values of 0.71 mg-N/L and 0.104 mg-P/L. Intermediary values are also reported. Because the overwhelming majority of the land use for the watersheds studied were forest, concentrations for primarily forested areas were used as 0.34 mg-N/L and 0.013 mg-P/L.

The Ohio EPA point source database was used to determine the permitted point source discharges existing in the Alliance and Phalanx Station USGS gage drainages. Minimal data to characterize the phosphorus loadings from the wastewater treatment plants in the Upper Mahoning drainage was available. Therefore, estimations of concentrations for the point source dischargers were completed. Loading is then calculated by multiplication of the flow and concentration with unit conversion.

[b] The HUC numbering system was updated in 2008. Older 14-digit HUCs are approximately equal to today's 12-digit HUCs.

4.1.2 Water Quality Targets

Currently, Ohio does not have numeric water quality standards for total phosphorus. However, targets developed from biological attainment correlation to total phosphorus are provided in the Ohio EPA document entitled *Association Between Nutrients, Habitat and the Aquatic Biota in Ohio Rivers and Streams , Ohio EPA Technical Bulletin MAS/1999-1-1* (commonly referred to as the Associations Document). The document proposes instream total phosphorus concentration targets for warmwater habitat streams separated by size class as the following: headwater streams equal 0.08 mg/L; wadeable streams equal 0.10 mg/L; and boatable streams up to 1000 mi^2 drainage equal 0.17 mg/L. Table 4-3 illustrates the targets used for each of the classes of streams in the TMDL project area including those designated as exceptional warmwater habitat.

Table 4-3. Total phosphorus targets applicable to the upper Mahoning watershed.

Watershed size	EWH	WWH
Headwaters (drainage area < 20 mi^2)	-	0.08
Wadable (drainage area ≥ 20 mi^2 < 200 mi^2)	-	0.10
Small Rivers drainage area ≥ 200 mi^2 < 1000 mi^2)	0.10	-
Large Rivers (drainage area > 1000 mi^2)	0.15	-

4.1.3 Selection of Method

The GWLF model was chosen because of its widespread use in TMDLs and its ability to simulate the important processes of concern, specifically hydrology and nutrient export from the landscape to surface waters. To convert GWLF's monthly pollutant loads to daily loads, hydrograph proportioning on a sliding monthly scale was developed from the model output data for the two drainages modeled, 30 day discharge values centered in time around the date in question were summed to obtain a sliding scale 30 day discharge. The daily discharge of this drainage was then divided by the 30 day discharge. The resulting unitless factor was multiplied by the monthly load representing the day in question time frame. The result is the daily total phosphorus load. Equation 1 provides the hydrograph proportioned daily load for given day (represented as ***i***) for a given GWLF monthly load increment (identified as ***j***).

Equation 1 $$DailyLoad_i = monthlyload_j \bullet \frac{DailyDischarge_i}{\sum_{i=-14}^{+15} DailyDischarge_i}$$

This method assumes that loading is directly proportional to daily discharge. In essence, water quality of the stream is considered steady state for the monthly timeframe given by GWLF. Error could be created by this assumption; however, the explicit margin of safety and the seasonal conglomeration of daily loads for analysis may mitigate this issue.

4.1.4 Calibration of the Model

Calibration refers to the adjustment or fine-tuning of modeling parameters to produce output that approximates values observed in the field. Hydrologic calibration precedes water quality calibration because runoff is the primary transport mechanism by which nonpoint pollution occurs. Once the hydrology was calibrated, nutrient results were compared to sample values collected by Ohio EPA at these locations.

Calibration entails several iterations of parameter adjustment and evaluation of the model output versus the field observations until reaching an acceptable correspondence between the two. Hydrologic calibration is typically based on ten years of simulation to evaluate parameters under a variety of climatic conditions, while water quality calibration usually spans only the time period in which measured water quality data exists for the watershed. A 23 year USGS gage record of actual flow from Eagle Creek and 13 years from the Mahoning Gage at Alliance drainage and two seasons of chemistry results from the Mahoning River basin survey were used to calibrate and compare model results.

GWLF input parameters were assigned based on available monitoring data, default parameters suggested in the GWLF User's Manual (Haith et al., 1992), and the meteorological record from the Midwest Regional Climatic Center weather stations at Berlin Lake (330639) for the upper Mahoning River upstream Alliance and Hiram (333780) for Eagle Creek upstream Phalanx Station gage. Default values were used for many parameters due to a lack of local data and to ensure the modeling results are consistent with previously validated studies. Experience and sensitivity analysis have proven these defaults to be acceptable values for most Ohio watersheds.

Hydrology Calibration
Evapotranspiration was the chosen variable of calibration for the hydrology model developed for the upper Mahoning River at the USGS Mahoning Gage at Alliance. This USGS stage gage at Alliance was no longer rated after 1993; therefore, calibration was completed using daily stream discharge values for the 10 year period of 1984 to 1993. This choice is acceptable since no significant land use changes occurred in the watershed from 1993 to 2001 (i.e., based on comparisons of NLCD 1994 and 2001). Figure 4-2 provides the trend of monthly total simulated flow in centimeters and actual USGS gage flow for the watershed area. Once discharge was properly calibrated, modeling was completed for the ten year period from 1998 to 2007. Figure 4-2 also compares the known monthly flow volumes observed (green line) at the gage to the calibrated GWLF estimates (red line). GWLF was calibrated by adjusting the evapotranspiration in an iterative approach until the covariance was maximized and the predicted/observed statistic was most nearly the value of one. Fourteen calibration runs were completed to obtain an r^2 value of 0.46 and predicted/observed of 1.06.

Nutrient Calibration
During the 2006 and 2007 survey season of the upper Mahoning watershed, Ohio EPA obtained 11 samples from the Mahoning River at the Alliance gage and 14 samples of Eagle Creek at the Phalanx Station gage which were analyzed for total phosphorus. This data was utilized to compare the GWLF ten year model run results to actual nutrient data. GWLF simulates the average monthly concentration for the modeled timeframe. Field data is collected as daily grab samples. Therefore, true calibration could not be completed, but comparison of the average monthly concentrations and the daily values could be accomplished as a basis for model adjustment and increase precision.

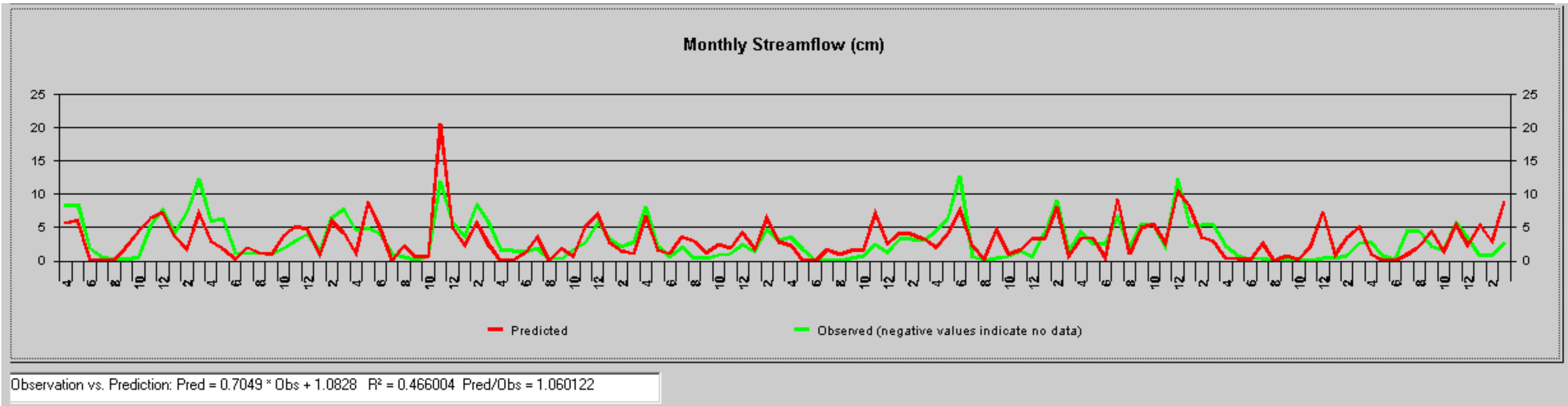

Figure 4-2. Mahoning River at Alliance Gage hydrology simulation result after calibration (Gross Monthly Flow, r^2 = 0.466004, Predicted/Observed = 1.060122).

4.1.5 Margin of Safety and Other Considerations

An explicit margin of safety of five percent of the calculated TMDL was used. Five percent represents a reasonable margin of error in light of the predicted versus actual hydrology ratio being close to one and the fact that a well established and widely accepted mid range watershed model was used. The calibration for water quality presented nothing that warrants an explicit MOS that is higher than what is (see Figures D-7, D-8, and D-9 in Appendix D), and has up to now, been widely used in nutrient TMDLs.

The critical condition for nutrients loading is the growing season particularly when flows are low. In Ohio, this is most manifest in mid to late summer and early fall. Low flows have limited potential to dilute nutrient loads and the slow flow velocities and lower stream power better foster accumulation of filamentous and/or other types of algae. Nutrients impact the aquatic community by increasing algae and plant production leading to wide oscillations in diurnal dissolved oxygen concentrations and seasonal low concentrations when this plant material dies and is consumed by microbes (creating tremendous respiration in the system). The daytime/nighttime swings in dissolved oxygen concentrations is also believed to cause significant stress on aquatic life.

The most relevant nonpoint sources of phosphorus are seasonally loaded to the system. Fertilized cropland typically yields its highest loading when precipitation is high and crop cover is low, corresponding to spring and early summer. Livestock will have direct contact with streams in the warmer months, and their impact is most severe when flow are low (low dilution) corresponding to late summer and early fall. Loading from non-discharging home septic systems is precipitation driven whereas direct discharging systems and other point sources typically discharge at a constant rate throughout the year.

However, as phosphorus readily attaches to sediment, detachment of adsorbed phosphorus in bottom sediments can lead to elevated instream concentrations regardless of the magnitude of short-term loads. As a result, it is the long-term, or chronic, phosphorus load that is directly related to the degradation of water quality. For this reason phosphorus TMDLs are developed to address nutrient loading during all times of the year and therefore, apply to all conditions, rather than a single critical condition.

4.2 Generalized Watershed Loading Function (GWLF) and BATHTUB

The Walborn Reservoir on Deer Creek is listed as the source of eutrophic conditions in the stream resulting in partial attainment of aquatic life uses at river mile 4.48 (approximately 0.3 river miles downstream from the dam). Reservoirs often create this impact on the downstream receiving waters since nutrients accumulate and waters reside in the reservoirs for extended periods fostering abundant algae growth. In essence the reservoir acts as a growing chamber. A substantial amount of the algae is exported downstream through top dam releases and that material impacts the aquatic community by degrading habitat (e.g., filling void spaces in the substrate) and creating oxygen stress that is typical of other nutrient enrichment situations.

In addressing such impairment, it is important that the lakes are not over-productive, which is indicated by a lake’s trophic status (i.e., eutrophic or hyper-eutrophic). The trophic status within the reservoir was estimated using the U.S. Army Corps of Engineers’ BATHTUB model and the Carlson's Trophic State Index. However, the overall purpose of the modeling was to determine the nutrient loading from each significant source category (specifically point source dischargers, failing septic systems, and agricultural runoff) so that load reductions can be properly allocated to them. The watershed model, GWLF, was used to determine the relative contributions from these most relevant nutrient sources, which will inform appropriate abatement planning and subsequent actions. Since GWLF was the same watershed loading model used to address stream impairments within the 01 and 04 ten digit HUCs (Section 4.1) the discussion of the methods regarding GWLF will be somewhat limited here, and the reader should refer to Section 4.1 and the report appendices for more details.

BATHTUB is a steady-state one dimensional model that incorporates several empirical equations of nutrient settling, diffusive flux, and algal growth to predict nutrient and chlorophyll *a* concentrations in the water column as well as Secchi disk transparency. Model output includes in lake concentrations of total phosphorus, chlorophyll a, and total nitrogen and secchi depth. Output is affected by meteorological conditions, water body characteristics, hydraulic characteristics, and nutrient loadings. This model has three primary inputs: global inputs, lake morphology, and watershed loading. Compared to other reservoir models, BATHTUB requires a moderate amount of site-specific data to configure and calibrate. Input data include atmospheric deposition of nutrients, tributary flows and concentrations, and global parameters such as evaporation rates and annual average precipitation.

Loading Capacity Determination

Loading capacity of total phosphorus was determined by developing load response curves from BATHTUB's advance user mode. The total phosphorus load and corresponding reservoir response to loading was modeled for a ten year period (1999-2008). For the combined reservoir system, GWLF results provided a total phosphorus monthly loading into the system for the model period. Subsequently the BATHTUB load response model results were analyzed graphically to determine the reduced influent loading required to obtain the seasonal median in-lake concentrations as listed in Ohio's proposed Lake Habitat Criteria (see Table 4-5).

Table 4-4 summarizes the methods used to estimate existing conditions, the loading capacity and allocations to the various nutrient sources for the TMDLs related to the Dale Walborn Reservoir.

Table 4-4. Summary of nutrient TMDL development.

Development step	Source	Method
Existing load	surface runoff	GWLF nutrient modeling and field data comparison
	ground-water	GWLF nutrient modeling
	point source	Product of discharger permit limit and the design flow of the facility is used to determine phosphorus loading
	HSTS	Population served by failing HSTS estimated via GIS and county Health Departments. Phosphorus load based upon population estimate and a per capita loading rate.
Calculation of loading capacity	-	Product of the annual discharge volume from each sub-basin (GWLF hydrology) and the phosphorus target concentration.
Allocation	surface runoff	LA is equal to the sum of all WLAs and the MOS subtracted from the assimilative capacity.
	point sources	Product of design flow rate and technology based effluent limitation Total P of 1.0 mg /l (or less depending on plant type).
	natural runoff	The expected background phosphorus load is determined based on running GWLF considering all lands to be unmanaged.
	HSTS	Septic systems are allocated a phosphorus load of zero.
	MS4	MS4s allocations are the product of the percentage of the sub-basin area occupied by MS4s and the sub-basin surface runoff allocation.
	MOS	Five percent of the assimilative capacity is reserved for the margin of safety.

4.2.1 Sources of Data

A ten year record of weather data from the National Midwest Regional Climate Center stations named Louisville (#34728), Berlin (#330639), and Ravenna (#336949) were used as GWLF input. Additional data from these stations was utilized for the BATHTUB model. The average temperature of the daily average temperature readings were used as well as a weighted average rainfall utilizing the Thiessen polygon method. Solar radiation and barometric pressure were obtained from the Ohio Agricultural Research Development Center (OARDC) station in Wooster, Ohio. Seasonal lake evaporation was calculated using Penman's equation with a standard pan coefficient of 0.78, in conjunction with OARDC data.

With regard to nutrients, much of the data for the GWLF model were acquired from the same sources as described in Section 4.1.1. Daily per capita mass loading rates and plant uptake rates for normal and failing systems were set to GWLF default values. Using the default parameters suggested by the manual allows for an estimation of pollutant loading relative to other sources in the watershed. An overall failure rate of 75% allotted as 25% ponded, 25% short-circuited, and 25% straight pipe for GWLF usage. These values were used to simulate the failed and normally functioning systems within the watersheds and were developed by best professional judgment. Because site-specific data were not available, soil nutrient concentrations are based on spatial distributions provided in the GWLF manual. Both the soil nitrogen and soil phosphorus concentrations were set to the average of the suggested range for the geographic area during model calibration. The soil nitrogen concentration is estimated to be 1400 mg/kg and the soil phosphorus concentration is estimated to be 1320 mg/kg.

Four municipal wastewater dischargers and one industrial point source discharger are permitted to discharge within the Deer Creek Reservoir watershed. The average total phosphorus loads were utilized in modeling nutrient inputs into the reservoirs.

The BATHTUB model requires basic lake morphometric data to assess residence time, net flow rate, and potential euphotic depth. Morphometric data was collected from on-site sampling, GIS analysis, and the Ohio Department of Natural Resources dam safety inventory database. Because the lakes are spatially close, the two reservoirs were modeled as one waterbody with two segments with a channel connection. The model was developed assuming normal pool elevation throughout the growing season.

Profile and water chemistry of Deer Creek was taken at this location because of the near-dam and deepest pool location. From the limnology work completed at this location in 2007 and 2008, Deer Creek reservoir was found to be thermally stratified because significant temperature change of greater than 1^{o}C for 1 meter of depth change occurred during the sampling season. For BATHTUB, the mean thermocline depth and metalimnion thickness is required for data input.

4.2.2 Water Quality Targets

Ohio EPA has released for public review proposed Lake Criteria rules in the Ohio Administrative Code (OAC Rule 3745-1-43). Target values for modeling purposes of these parameters were drawn directly from the proposed Lake Habitat Criteria (OAC Rule 3745-1-43). Table 4-5 is a copy of the appropriate portion of this proposed rule pertaining to criteria used as target endpoints in this modeling effort.

4.2.3 Selection of Method

The GWLF model was selected for reasons stated in Section 4.1.2. The BATHTUB model was selected because it addresses the parameters of concern and does not have extensive data requirements. It also can be used in conjunction with the non-point source loads calculated by GWLF. The BATHTUB model has been used previously for reservoir TMDL applications.

4.2.4 Calibration and Validation of Model

GWLF was used to predict nutrient loads and hydraulic flows received by the reservoirs for the 10 year period from 1999 to 2008. To calibrate the hydrology and nutrients for the lake watersheds, GWLF modeling was initially calibrated for the watershed upstream of the USGS stage gage of the Mahoning River in Alliance, Ohio (See Section 4.1 and Appendix D). A calibration to this location was necessary because significant water quality and discharge data was available for the USGS gage site. Hydrologic and water quality data of Deer Creek entering the reservoirs was spot checked for comparison purposes once in 2007 and three times in 2008. The parameter values from calibration of the Mahoning River gage site were used in the lake watersheds, which is reasonable because of the nearness and similar characteristics of the two watersheds, such as land use, geology, and meteorological conditions.

The BATHTUB model allows calibration by total phosphorus, total nitrogen and/or chlorophyll *a,* and all three parameters were used. In 2007 and 2008 the Deer Creek Reservoir was sampled as part of Ohio EPA's Inland Lake Program. In-lake depth integrated sampling of the stratified zones as well as water quality at each inlet and outlet for the Deer Creek Reservoir was collected during the visits; however, similar sampling was not completed on Dale Walborn Reservoir. For this reason some of the data collected at the Deer Creek Reservoir was extrapolated for use in modeling the trophic status of the Dale Walborn Reservoir which may be a source of error in the modeling. Despite the need to extrapolate data from the Deer Creek Reservoir, data specific to the Dale Walborn Reservoir was also collected in 2008, including depth profiles and Secchi disk transparency. In the end, drainage specific information, model specific morphometric characteristics, water quality input data, and model calibration data were collected for both lakes.

To isolate various sources of nutrients and collect calibration and model input data, each inlet and outlet of Deer Creek Reservoir was sampled during the dates when lake sampling events occurred. Both water chemistry and flow data was collected at each of these locations as well as at the drinking water raw intake. Bracket sampling of inflow and discharge streams of Dale Walborn Reservoir was not completed in this study; therefore, the modeling results of influent and effluent concentrations of model parameters could not be verified for accuracy.

4.2.5 Margin of Safety and Other Considerations

Both implicit and an explicit margin of safety is used in the TMDL analysis for total phosphorus for the Dale Walborn and Deer Creek Reservoir systems. The conservative assumptions regarding the total phosphorus loading from the upstream NPDES facilities provides a considerable margin of safety since several dischargers are averaging about half of their design flow, and the design flow is the discharge value used in calculating the loading. Also, there is no accounting for the decay of total phosphorus from the point sources loads or other watershed loading despite considerable distance between the outfalls and the reservoir system. An explicit margin of safety of 5% is provided for the proposed reduction of influent total phosphorus to the combined lake system of Dale Walborn and Deer Creek Reservoirs. Five percent provides a reasonable level of assurance that the resulting allocations will meet water quality standards.

For lakes with low phosphorus residence times, the recommended critical condition is the period of increased sunlight, temperature and algal growth from May through September. Due to the effects of settling, the phosphorus residence time is often somewhat longer than hydraulic residence times.

4.3 Habitat Alteration and Sediment Method

Twenty-four sites (32% of all sites) are listed as impaired due to sedimentation while six (8% of all sites) are impaired due to poor habitat quality (two sites are impaired by both). Target scores of the Qualitative Habitat Evaluation Index (QHEI) are developed to determine the deviation between actual QHEI scores and those that are statistically associated with the attainment of aquatic life use. The targets that are developed are the TMDLs and the allocations are represented as the deficit between the actual scores and the target. Both are applied on a site-by-site basis.

The QHEI is an index to evaluate stream habitat quality. The index has six metrics (e.g., substrate quality) each of which is further divided by sub-metrics which often account for discrete habitat features (e.g., a specific size class of substrate). Based on a visual assessment of the study reach (typically 150-200 meters in length), a numeric value is assigned to indicate the quality of its habitat. This is determined by the sum of the scores for each of the metrics. The number values do not represent the quantity of any physical properties of the system but solely provide a means for comparing the quality of stream habitat between various locations.

Table 4-5. Targets based on Ohio's proposed Lake Habitat Criteria.

Parameter Lake type	Form[1]	Units[2]	Statewide criteria	Ecoregional criteria				
				ECBP	EOLP	HELP	IP	WAP
Ammonia	T	mg/l	Table 43-4	--	--	--	--	--
Chlorophyll a[3]								
Dugout lakes	T	µg/l	8.0	--	--	--	--	--
Impoundments	T	µg/l	--	9.5	9.5	9.5	9.5	6.2
Natural lakes	T	µg/l	9.5	--	--	--	--	--
Upground reservoirs	T	µg/l	6.0	--	--	--	--	--
Dissolved oxygen[4] All lake types	T	mg/l	5.0 OMZM 6.0 OMZA	--	--	--	--	--
Nitrogen[3]								
Dugout lakes	T	µg/l	450	--	--	--	--	--
Impoundments	T	µg/l	--	815	790	815	815	350
Natural lakes	T	µg/l	650	--	--	--	--	--
Upground reservoirs	T	µg/l	1,150	--	--	--	--	--
pH								
All lake types	--	s.u.	a	--	--	--	--	--
Phosphorus[3]								
Dugout lakes	T	µg/l	24	--	--	--	--	--
Impoundments	T	µg/l	--	32	32	32	32	13
Natural lakes	T	µg/l	32	--	--	--	--	--
Upground reservoirs	T	µg/l	24	--	--	--	--	--
Secchi disk transparency[5]								
Dugout lakes	--	m	1.35	--	--	--	--	--
Impoundments	--	m	--	1.04	1.04	1.04	1.04	2.38
Natural lakes	--	m	1.04	--	--	--	--	--
Upground reservoirs	--	m	2.68	--	--	--	--	--
Temperature								
All lake types	--	--	b	--	--	--	--	--

1 T = total.
2 m = meters; mg/l = milligrams per liter (parts per million); µg/l = micrograms per liter (parts per billion); s.u. = standard units.
3 These criteria apply from May through October in the epilimnion of stratified lakes and throughout the water column in unstratified lakes.
4 For dissolved oxygen, OMZM means outside mixing zone minimum and OMZA means outside mixing zone minimum twenty-four-hour average. The dissolved oxygen criteria apply in the epilimnion of stratified lakes and throughout the water column in unstratified lakes.
5 These criteria apply as minimum values from May through October.
a pH is to be 6.5-9.0, with no change within that range attributable to human-induced conditions.
b At no time shall the water temperature exceed the average or maximum temperature that would occur if there were no temperature change attributable to human activities.

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. Objectivity 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 (Rankin, 1989).

The six general aspects of physical habitat that the QHEI evaluates are channel substrate, instream cover, riparian characteristics, channel condition, pool/riffle quality, and gradient. Points assigned to the sub-metrics of each of the six categories are based on their ecological utility as well as their relative abundance in the system. Demerits (i.e., negative points) are also assigned if certain habitat 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 metrics to give a score for that particular aspect of stream habitat. The overall QHEI score is the sum of all of the metric scores.

The targets that are established (see Section 4.3.2) are the sediment and habitat TMDLs and allocations themselves. For each site, the difference between the target and the actual score is calculated and presented as the amount of improvement that is needed (expressed by a percentage) to reestablish a healthy aquatic community that would meet the biocriteria. Targets for habitat are established based on the overall QHEI score, the number of modified attributes and the number of high influence modified attribute. Targets for sediment are based on the sum total of three QHEI metrics, namely, substrate, channel, and riparian, each of which have established targets.

4.3.1 Selection of Method

For decades the Ohio EPA has used the QHEI to help understand the causes of aquatic life use impairment as well as in assigning appropriate aquatic life uses to stream segments. The strong correlation between the paired scores of the QHEI and the Index of Biotic Integrity (IBI), an important biometric in Ohio's water quality standards, supports the idea that the QHEI is assessing aspects of the stream system that are relevant to biological performance. The reliability that the QHEI demonstrates in predicting biological performance (the basis for aquatic life use attainment) as well as the relative ease of its application is the reason it is selected as the basis for the sediment and habitat TMDLs.

4.3.2 Water Quality Targets

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 sub-metrics 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 the aquatic life use designation of warm water habitat (WWH) an overall QHEI score of 60 is targeted to provide reasonable certainty that habitat is not deficient to the point of precluding attainment of the biocriteria. An overall score of 75 is targeted for streams designated as exceptional warm water habitat (EWH) and a minimum score of 45 is targeted for modified warm water habitat (MWH) streams.

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 sub-group 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. Table 4-6 lists modified and high influence modified attributes and provides the QHEI targets used for this habitat TMDL. 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.

Table 4-6. QHEI targets for the habitat TMDL that are applicable to warmwater habitats.

	QHEI categories	**Modified attributes**	
		High influence	**Moderate modified attributes**
Range of Possibilities	QHEI score	- 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
Target	Overall score >= 60	Total number < 2	Total number < 5[a]
TMDL Points Assigned if Target is Satisfied	+ 1	+ 1	+ 1

[a] Total number of modified attributes includes those counted towards the high influence modified attributes.

Sediment TMDL Targets and the Qualitative Habitat Evaluation Index (QHEI)
In terms of sediment, although in of itself it can be damaging to the aquatic community, its negative impact is typically restricted to the fact that it degrades stream habitat. Specifically, sediment fills in void spaces that occur between larger substrates such as cobbles and gravels rendering those spaces inaccessible to organisms. The function of the substrate also decreases because flow of water through these spaces is limited, and with it dissolved oxygen and nutrition sources. For these reasons it is appropriate to develop sediment TMDLs using an index for habitat quality.

The QHEI is also used in developing the sediment TMDL for this project. Numeric targets for sediment are based upon metrics of the QHEI. Although the QHEI evaluates the overall quality of stream habitat, some of its component metrics consider particular aspects of stream habitat that are closely related to and/or impacted by the sediment delivery and transport processes occurring in the system.

The QHEI metrics used in the sediment TMDL are the substrate, channel morphology, and bank erosion and riparian zone. Table 4-7 lists targets for each of these metrics.

- The substrate metric evaluates the dominant substrate materials (i.e., based on texture size and origin) and the functionality of coarser substrate materials in light of the amount of silt cover and degree of embeddedness. This is a qualitative evaluation of the amount of excess fine material in the system and the degree to which the channel has assimilated (i.e., sorts) the loading. Higher levels of mud/muck/silt, that cover the substrate have significant negative impacts on the fish community, impacting the reproduction, feeding, and overall health of the biotic community.
- The channel morphology metric considers sinuosity, riffle, and pool development, channelization, and channel stability. Except for stability each of these aspects are directly related to channel form and consequently how sediment is transported, eroded, and deposited within the channel itself (i.e., this is related to both the system's assimilative capacity and loading rate). Stability reflects the degree of channel erosion which indicates the potential of the stream as being a significant source for the sediment loading. Excessive sedimentation fills in the pools and covers up the riffles, resulting in a more uniform, flat stream bed, severely impacting the feeding and reproductive habitat in the stream.
- The bank erosion and riparian zone metric also reflects the likely degree of instream sediment sources. The evaluation of floodplain quality is included in this metric which is related to the capacity of the system to assimilate sediment loads. Specifically, floodplains sort the sediment load during floods where heavier, coarse substrates tend to remain in the main channel whereas fine-grained, lighter sediment can occupy the floodplain areas and subsequently be deposited as the flow recedes after the storm event. If the floodplain is inaccessible or truncated, then removal of this sediment from main channel is hindered which will likely degrade habitat and water quality.

Each of these factors (substrate, channel, riparian) influences the degree to which siltation affect a stream, and cumulatively serves as its numeric target. Table 4-7 shows what these targets are.

Table 4-7. QHEI targets for the sediment TMDL that are applicable to warmwater habitats.

Sediment TMDL =	**Substrate**	**+**	**Channel Morphology**	**+**	**Riparian Zone/Bank Erosion**	
For WWH >=	13	+	14	+	5	>= 32

4.3.3 Margin of Safety and Other Considerations

A margin of safety is implicitly incorporated into the sediment and habitat TMDLs through the use of conservative target values. The target values are developed though a comparison of paired IBI and QHEI evaluations. Using an IBI score of 40 as representative of the attainment of WWH, individual components of the QHEI are analyzed to determine their magnitude at which WWH attainment is probable. Attainment does, however, occur at levels lower than the established targets. The difference between the habitat and sediment targets and the levels at which attainment actually occurs is an implicit margin of safety.

Habitat is generally a static condition of a stream. Exceptions include major modifications made by humans (or some animals like beavers) or changes in the hydrology or sediment loading of the watershed (again, typically a man made situation). Since habitat is relatively static, seasonality has little meaning. Specifically, absent a major disturbance, habitat quality does not change across the seasons but rather over much longer timescales. Finally, there is no seasonal "loading" associated with habitat but instead habitat evolves through changes in morphology and riparian vegetation. However, in terms of sediment, seasonality does have meaning. For example, agricultural areas yield the highest loads when fields have minimal vegetative cover and runoff events occur. This corresponds to the springtime pre-plant season. In-stream sources of sediment from bed or bank erosion are also seasonally loaded when flows are highest and banks are saturated (making them more susceptible to erosion – slip failure). Again the spring is an important time for this but also the mid to late fall.

The concept of critical condition has more meaning for habitat. There are times of the year when poor habitat quality is particularly detrimental to the aquatic community, especially summer low flows. Low flow conditions stress the community and competition for space occurs. Under these conditions the greatest threat is a drying of the stream where most aquatic species can survive for only a short period. The availability of a sufficient amount of water is affected by the quality of the stream habitat. Coarse bed substrates are often areas of water storage, and when they are not embedded with fine sediments (a manifestation of degraded habitat) they are accessible to small aquatic species. Deep pools also act as reservoirs when water becomes scarce. A well intact riparian corridor will mitigate low flow conditions by reducing direct sunlight thereby keeping water temperatures lower than what they may otherwise be (this helps sustain dissolved oxygen concentrations, mitigates excessive increases in metabolic rates and reduces water loss through pan evaporation).

4.4 Load Duration Curves – Pathogens

Bacteria load reductions were determined through the use of load duration curves. This approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream by taking the following steps:

1. Generate a flow frequency table and plotting the data points to form a curve. The data reflect a range of natural occurrences from extremely high flows to extremely low flows. The flow record only includes data acquired from May through the end of October for each year analyzed.

2. Translate into a load duration (or TMDL) curve by multiplying each flow value by the water quality standard/target for a particular contaminant, then multiplying by a conversion factor. The resulting points are plotted to create a load duration curve (LDC).

3. Convert water quality samples to loads by multiplying the sample concentration by the average daily flow on the day the sample was collected. Then, the individual loads are plotted as points on the TMDL graph and can be compared to the water quality standard/target, or LDC.

4. Points plotting above the curve exceed the water quality standard/target and the daily allowable load. Those plotting below the curve represent compliance with standards and the daily allowable load. Further, it can be determined which types of flows contribute loads above or below the water quality standard/target (e.g., high flows versus low flows).

5. The area beneath the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards/targets.

6. The final step is to determine where reductions need to occur. Those exceedences at the right side of the graph occur during low flow conditions, and significant sources might include septic systems, illicit sewer connections, or animals depositing waste directly to the stream; exceedences on the left side of the graph occur during higher flow events, and potential sources include a variety of activities related to runoff.

Using the LDC approach allows Ohio EPA and local planners to determine which implementation practices are most effective for reducing loads based on flow regime. If loads are significant during wet weather events, implementation efforts can target those BMPs that will most effectively reduce storm water runoff.

Table 4-8 shows the bacteria sample sites and their drainage area that were used to address recreation use impairment in all assessment units (i.e., HUC 12 subwatersheds) that are impaired. In order to calculate the load duration curve, each site's full flow duration interval must be calculated. To determine the load duration curve for each LDC site, stream flows are extrapolated to two USGS gages (station # 03086500 Mahoning River at Alliance, OH and station # 03093000 Eagle Creek at Phalanx Station). A simple drainage area ratio of the LDC site to the USGS gage is applied to the gage flows to determine the LDC site's flows. The actual gage site is a sentinel site and no drainage area ratio is required for this site.

Table 4-8. Bacteria sampling site locations where load duration curves represent the upstream loading to account for all of the associated location with recreation use impairment.

12-Digit HUC	STORET Number	Stream Name	Road Intersection or Other Geographic Reference to Site Location	River Mile	Drainage Area (sq. miles)
050301030101	N01K24	Beaver Run	Center Road	1.19	4.8
050301030101	N01K26	Mahoning River	Georgetown-Damascus Road	97.69	19.8
050301030101	N01K25	Trib. To Mahoning River (97.11)	Georgetown Road	1.15	4.3
050301030102	N01K14	Beech Creek	Vine Street	3.54	17.4
050301030102	N01K13	Little Beech Creek	Lane off State Route 619	1.83	9.0
050301030103	N01S12	Mahoning River	Gaskill Drive at Alliance	84.99	90.0
050301030201	300025	Deer Creek	Atwater Road	2.90	30.1
050301030201	N01K12	Deer Creek	Waterloo Road	10.87	3.5
050301030202	300062	Willow Creek	Notman Road	3.74	7.2
050301030203	300061	Mill Creek	Leffingwell Road	3.64	19.1
050301030203	N01K01	Turkey Broth Creek	State Route 534	3.36	4.9
050301030204	N01K06	Island Creek	12Th St Road	2.65	4.2
050301030301	N02W07	Kale Creek	Canal Road (Newton Falls County Line Road)	3.38	21.9
050301030302	300022	West Branch Mahoning River	Newton Falls Road at USGS Gage	20.94	21.8
050301030303	N02K23	Barrel Run	Tallmadge Road	3.65	10.2
050301030304	N02K22	Hinkley Creek	State Route 5	0.70	10.8
050301030304	N02K20	Silver Creek (Trib To West Branch Mahoning River)	Calvin Road	1.83	9.3
050301030305	N02P12	West Branch Mahoning River	County Road 114A South of Newton Falls	0.36	103.0
050301030306	N02S12	Mahoning River	Downstream of Dam Downstream WWTP at Newton Falls	56.53	307.0
050301030401	N02S02	Eagle Creek	State Route 700 Upstream of Garrettsville	22.44	5.2
050301030401	N02S03	Silver Creek	State Route 82 Near Hiram	0.79	11.2
050301030402	N02K06	South Fork Eagle Creek	State Route 303 at Windham	2.30	23.5
050301030403	N02K09	Mahoning Creek	Downstream PM Estates MHP	0.70	3.7
050301030403	N02K10	Eagle Creek	Hopkins Road	15.04	36.0
050301030404	N02K02	Tinker Creek	Nicholson Road	2.50	11.2
050301030405	N02P08	Eagle Creek	Gage near County Road 114 Downstream Garrettsville	5.60	97.6
050301030406	N03S64	Mahoning River	Upstream Dam at Leavittsburg	45.73	542.0
050301030603	602280	Mahoning River	Leavitt Road at Leavittsburg	45.51	575.0

The load duration curves are grouped into five flow regimes noted with vertical lines and labels. These regimes are defined as the following:

High flow zone:	Stream flows in the 0 to 5 exceedance percentile range; these are related to flood flows.
Wet weather zone:	Flows in the 5 to 40 exceedance percentile range; these are flows in wet weather conditions.
Normal range zone:	Flows in the 40 to 80 exceedance percentile range; this are the median stream flow conditions.
Dry weather zone:	Flows in the 80 to 95 exceedance percentile range; these are related to dry weather flows.
Low flow zone:	Flows in the 95 to 100 exceedance percentile range; related to drought conditions.

Figure 4-8 is an example load duration curve to provide explanation of the various symbols used in the curve. The symbols are as follows: 1) water quality samples on the LDC curves are noted as diamonds; 2) samples taken when storm flow is greater than 50% of the flow are noted with the diamond with a red dot in the center (noted as ">50% SF in the figures legend), this flow condition is determined using the sliding-interval method for streamflow hydrograph separation contained in the USGS HYSEP program (Sloto, 1996) 3) box plots are shown for each flow regime with data where the center line of these boxes represents the median *E. coli* load for that flow regime, the top and bottom of the boxes represents the 75th and 25th percentiles, respectively, and the upper and lower vertical bar tails are the maximum and minimum observed loads, respectively.

All of the area beneath the TMDL curve is considered the *E. coli* loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards/targets. The final step to create an LDC, is to determine where reductions need to occur. Samples in exceedance at the right side of the graph occur during low flow conditions, and significant sources might include wastewater treatment plants, malfunctioning home sewage treatment systems, illicit sewer connections and/or animals depositing waste directly to the stream. Any exceedance on the left side of the graph occurs during higher flow events and potential sources are likely land uses or management practices such as manure spreading or livestock production. These supply bacteria that are washed off upland areas with runoff. The LDC approach helps determine which implementation practices are most effective for reducing loads. Table 4-9 shows various pollutant sources and the loads they are associated with.

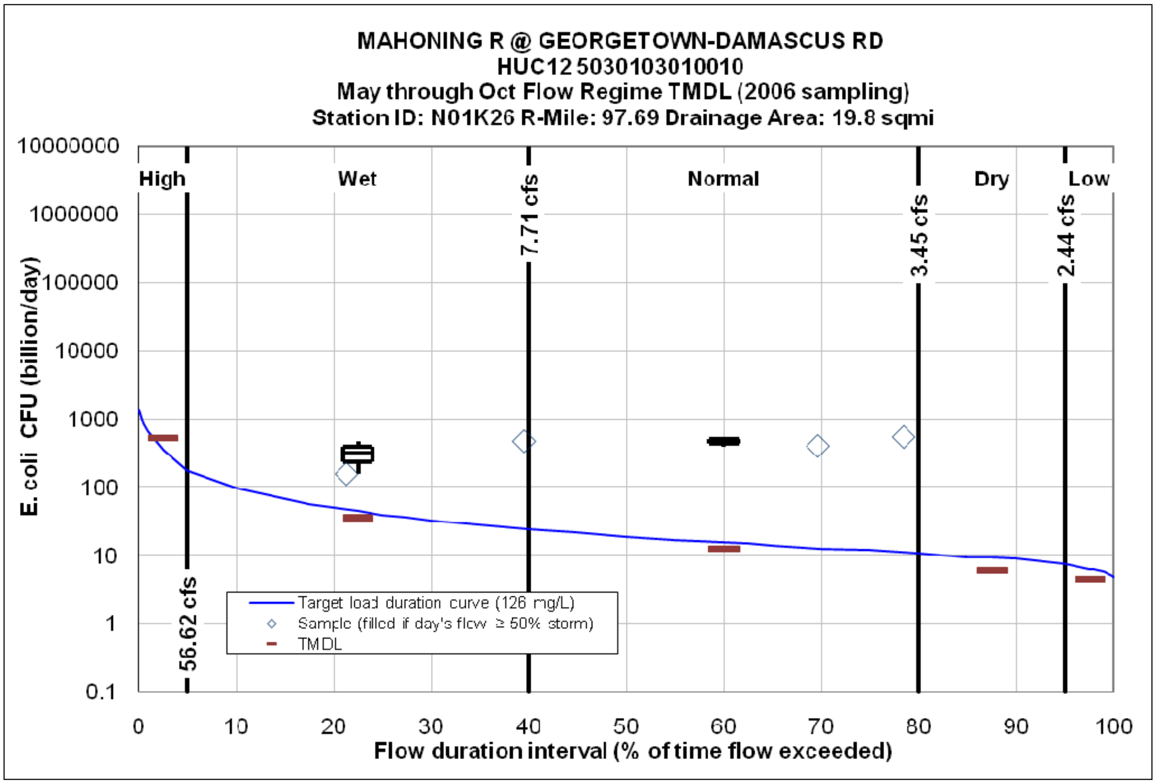

Figure 4-3 Load duration curve for *E. coli* bacteria at sample location N01K26 on the Mahoning River at river mile 97.69 within the 01-01 twelve digit HUC.

Table 4-9. Load duration curve flow zones and typical contributing sources.

Contributing Source Area	Duration Curve Zone				
	High	Wet weather	Normal	Dry	Low
Point source				M	H
Livestock direct access to streams				M	H
Home sewage treatment systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Storm water: Impervious		H	H	H	
Combined sewer overflow (CSO)	H				
Storm water: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			

H = high influence; M = moderate influence; L = low influence

4.4.1 Selection of Method

This method was selected to assess pathogen loading based on much of the same reasoning provided in Section 4.1.1. This method is appropriate since the sources of bacteria in Ohio streams can be differentiated by stream flow regime. The main advantage of the use of LDCs is the ability to discriminate loading based on flow. The main shortcoming of this method is the lack of differentiation between various loading sources that may occur under the same flow regime (such as cows in stream and poorly operating home sewage treatment systems). Additionally, alternatives methods to LDCs are mostly unreliable or prohibitive in terms of needed staff and funding resources to use them. For example, modeling bacteria in a dynamic, watershed manner, such as TP in this report, occurs in some studies in order to best determine bacteria sources but using methods such as this is time consuming and has been found by Ohio EPA to often yield similar results as those generated through simpler methods. More complicated modeling would also require more bacteria data than what is normally collected during routine surveys for calibration.

4.4.2 Water Quality Targets

Elevated bacteria loading is the cause of recreational use impairment for most streams in the upper Mahoning River watershed. TMDL numeric targets for *E. coli* bacteria are derived from bacteriological water quality standards. The criterion for *E. coli* specified in §OAC 3745-1-07 are applicable outside the mixing zone and vary for waters that are classified as primary contact recreation (PCR). The Mahoning River starting from US 62/ Bandy Road (river mile 91.11) throughout the remainder of the project area and the West Branch Mahoning River from McCormick Road (river mile 21.8) to its confluence with the Mahoning River are designated Class A streams. The remainder of streams assessed in this watershed is Class B primary contact recreation streams. For Class A streams the standard states that the geometric mean of more than one *E. coli* sample taken in each recreational season (May through October) shall not exceed 126 colony forming units (cfu) per 100 ml. The standard for Class B streams states that the geometric mean of more than one *E. coli* sample taken in each recreational season shall not exceed 161 cfu per100 ml.

TMDLs are created for watersheds that drain to an assessment site that is not meeting the recreational use criterion described in the paragraph above.

4.4.3 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).

An explicit 20% margin of safety was chosen based on an evaluation of a large data set and model results for the Paint Creek watershed in Ohio (Ohio EPA 2011). The target TMDL concentration with a 20% MOS normalized to the flow regimes, especially in the middle flow ranges, resulted in a seasonal geometric mean that did not exceed the water quality standard but was not unreasonably far below the standard (i.e. too stringent). In the high flow regimes, the 20% MOS is less conservative, but should still provide an adequate level of protection considering the likely reduction in recreation use during the highest flows and the variability of the flows and concentrations.

An implicit MOS is incorporated by 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.

4.4.4 Allowance for Future Growth

In order to account for all expected future growth in the watershed, an additional flow consideration must be taken into account for several LDC sites in the upper Mahoning River watershed. Most permitted public waste water treatment facilities in the watershed do not currently discharge at their full permitted design flow. Because of this the additional flow must be added into the flow duration curve. Since this flow is expected no matter what the flow regime of the stream, the missing flow is added across all flow conditions.

Dischargers with NPDES permits that currently require disinfection (mostly WWTPs), are given a WLA of the product of their design flow, the target *E. coli* concentration and a conversion factor. Since these facilities operate no matter what the stream flow, their WLA is the same for all five flow regimes.

4.4.5 Seasonality and Critical Conditions

The critical condition for pathogens is the summer dry period when flows are lowest, and thus the potential for dilution is the lowest. Growth rates are higher and mortality rates lower in the warmer months further making this a critical time of the year for bacteria contamination. Likewise, summer is the period when the probability of recreational contact is the highest. For these reasons recreational use designations are only applicable in the period May through the end of October. Pathogen TMDLs are developed for the same time period in consideration of the critical condition, and for agreement with Ohio WQS.

The existing loads of *E. coli* from home sewage treatment systems or direct manure deposits from livestock are given a zero allocation because 1) properly functioning septic systems should not discharge pollutants and 2) proper livestock management should preclude such intense pollution of surface waters. The runoff loads are divided between runoff from MS4 areas and non-MS4 areas. Since runoff from MS4s is regulated by Ohio EPA, this allocation is considered a WLA. The non-MS4 runoff is a LA. This division is carried out simply by applying the land area ratio of each type (MS4 and non-MS4) to the remaining *E. coli* load allowed for each TMDL. Specific MS4s are subdivided and identified.

5 WATERSHED ANALYSIS, LOADING CAPACITY, AND ALLOCATIONS

This section of the report presents the results of the TMDL analyses using methods that are described in Chapter 4. These methods are to quantify watershed specific water quality restoration goals and allocate pollutant loading to address the impairments presented in Chapter 3. The four parameters causing water quality impairments that were evaluated are:

- Pathogens (using *E. coli* bacteria only)
- Nutrients (using total phosphorus only)
- Sediment (using the QHEI only)
- Habitat (using the QHEI only)

These results are organized according to the four 10-digit HUCs. Within each of these sections, the results of the analyses for the applicable water quality parameters constitute their own subsections. For *E. coli* and total phosphorus the existing loads, TMDLs, load and wasteload allocations, explicit margin of safety, and load reductions are presented in a series of tables. For the sediment and habitat TMDLs, the score of the total QHEI and its individual metrics are presented along with any deficits in reaching the target for all sites sampled for biology. The sites for which sediment and habitat TMDLs are developed are denoted as bold italics and bold underline, respectively.

Figure 5-1 is a map of the entire project area with the site locations in which load duration curves are developed to generate TMDLs for *E. coli* bacteria. Recreation uses were impaired at nearly all of the 74 sites assessed, and every twelve digit-HUC requires TMDLs be developed. The majority of the sites selected for load duration curve development are located on tributary streams and as near as possible to the outlet of a twelve-digit HUC; however, in many cases sites are selected well within the twelve-digit HUC to address more localized bacteria loading. In all, the sites ranged from 3.5 to 542 square miles in contributing drainage area but only three of which exceeded 100 square miles in drainage area. The mean drainage area was 53.03 square miles and the median, 25^{th} and 75^{th} percentiles are 11.20, 6.20, and 28.67 square miles, respectively. The primary relevance of drainage area in load duration curves is related to the dilution potential of the stream flow as well as the relatively lower impact runoff loading has over stream segments with larger contributing drainage areas.

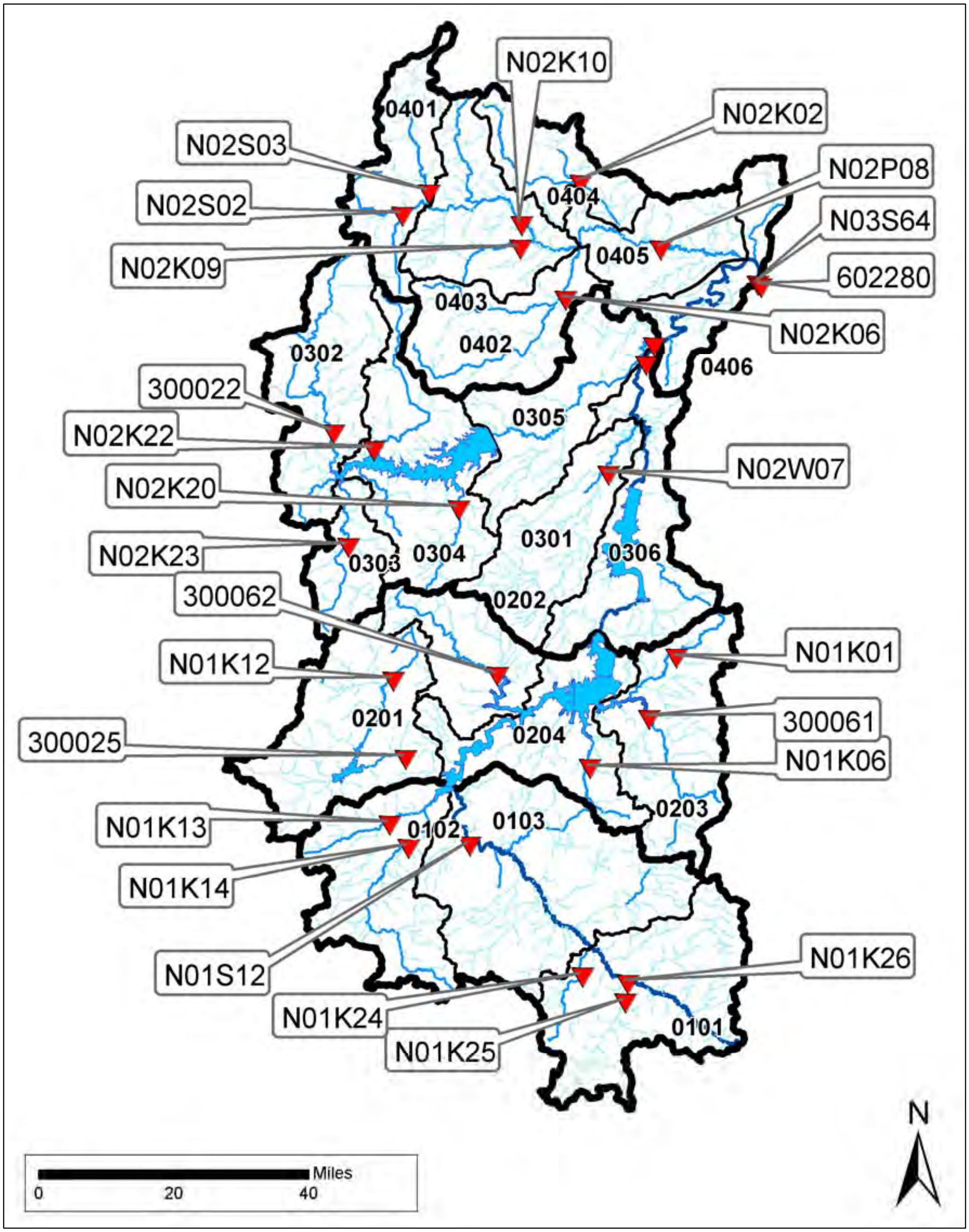

Figure 5-1. Locations where load duration curves are developed for *E. coli* bacteria (identified by STORET number).

5.1 Mahoning River – Headwaters to Below Beech Cr. (05030103-01)

TMDLs were developed in these three 12-digt HUCs for bacteria (*E. coli*), sediment and habitat (QHEI), and nutrients (total phosphorus). The results are presented for the applicable assessment units (i.e., 12-digit HUCs) in the following sub-sections.

5.1.1 *E. coli* Bacteria (HUCs 01-01, 01-02, and 01-03)

Tables 5-1, 5-3, and 5-5 provide the *E. coli* allocations for each flow interval in the load duration curves for sampling sites located in the 01, 02, and 03 twelve-digit HUCs, respectively. Tables 5-2, 5-4, and 5-6 show the wasteload allocations for NPDES permitted facilities within the 01, 02 and 03 twelve digit HUCs, respectively.

Four samples were taken at each site in this ten-digit HUC. Collection occurred under conditions reflective of wet weather (two samples) and mid-range summer (two samples) flows. The exception is the one site located in the 01-03 twelve-digit HUC which had five samples taken during the recreation season, but under similar flow conditions as the others. None of the samples collected throughout the ten-digit HUC (i.e,, 25 in all) were estimated to have more than 50 percent storm runoff contribution, suggesting that a number of days had separated the last storm event and the day of collection. All of the samples collected fell between the calculated twentieth and eightieth exceedance percentiles of flow with a fairly even distribution across flow conditions within that range. The magnitude by which the loads exceeded the target (i.e., the TMDL) ranged from about 4 to 10 times for wet weather flow conditions and about 2 to 37 times for mid-range summer flow conditions.

Nonpoint sources of bacteria represent a vastly greater proportion of the overall loading. In fact, in this ten-digit HUC, under each flow condition the average allocation to nonpoint sources was over 90 percent of the TMDL compared to a range of zero to nine percent for point sources. The point sources are allocated their loading according to their design flow discharge rate times the appropriate *E. coli* concentration according to Ohio's water quality standards. Based on the overwhelming contributions from nonpoint sources and the patterns that can be observed from the load duration curves, it seems that direct loading from livestock and/or direct discharges from home septic systems are occurring (i.e., elevated *E. coli* concentration under lower flows). However, it is also likely that runoff driven loading is important in that loads remain high even under higher flow conditions where the dilution potential is substantially greater (i.e., there must be a commensurate increase in loading to sustain the higher concentrations). Although storm flows did not constitute more than half of the stream flows, *E. coli* may persist in the system and undergoing re-suspension for flows that are high enough to disturb fine substrate materials.

Table 5-1. *E. coli* TMDLs for the 05030103-01-01 12-digit HUC.

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N01K26 - Mahoning River (RM 97.69; Drainage area = 19.14 square miles)					
Samples Collected		2	2		
Sample Median Load		310	466		
NPDES Point Source Existing Load	0.15	0.15	0.15	0.15	0.15
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	103.7	7.1	2.5	1.2	0.9
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	No Data	88.5%	97.3%	No Data	No Data
LA (Non-Point Allocation)	518.33	35.48	12.38	5.87	4.36
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	25.92	1.78	0.63	0.30	0.23
WLA (NPDES Point/MS4 permits)	0.15	0.15	0.15	0.15	0.15
TMDL minus (MOS + Future Growth)	518.48	35.64	12.53	6.02	4.51
N01K25 - Tributary to Mahoning River at RM 97.11 (RM 1.15; Drainage area = 4.30 square miles)					
Samples Collected		2	2		
Sample Median Load		89	14		
NPDES Point Source Existing Load	0.12	0.12	0.12	0.12	0.12
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	28.8	2.0	0.7	0.3	0.3
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	No Data	88.9%	75.0%	No Data	No Data
LA (Non-Point Allocation)	143.76	9.77	3.38	1.55	1.14
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	7.19	0.49	0.17	0.08	0.06
WLA (NPDES Point/MS4 permits)	0.12	0.12	0.12	0.12	0.12
TMDL minus (MOS + Future Growth)	143.88	9.89	3.50	1.67	1.26
N01K24 - Beaver Run (RM 1.19; Drainage area = 4.80 square miles)					
Samples Collected		2	2		
Sample Median Load		50	29		
NPDES Point Source Existing Load	0.00	0.00	0.00	0.00	0.00
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	32.1	2.2	0.8	0.4	0.3
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	No Data	77.7%	86.6%	No Data	No Data
LA (Non-Point Allocation)	160.62	11.06	3.88	1.89	1.42
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	8.03	0.55	0.19	0.09	0.07
WLA (NPDES Point/MS4 permits)	0.00	0.00	0.00	0.00	0.00
TMDL minus (MOS + Future Growth)	160.62	11.06	3.88	1.89	1.42

Table 5-2. *E. coli* wasteload allocations for the 05030103-01-01 12-digit HUC.

Regulated point source	NPDES OEPA ID	Exist Flow Avg MGD	Design Flow Avg MGD	Conc Limit	WLA
Timashamie Family Campground	3PR00305	0.0039	0.0250	161.0	0.15
Paradise Lake Park Campground	3PR00325	0.02	0.02	161	0.12

Table 5-3. *E. coli* TMDLs for the 05030103-01-02 12-digit HUC.

E. coli TMDL Allocation (billion/day)	Higher Flows	Wet Weather	Mid-Range Summer	Dry Weather	Low
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N01K13 - Little Beech Cr. (RM 1.83; Drainage area = 9.00 square miles)					
Samples Collected		2	2		
Sample Median Load		140	64		
Point Source Load	0.21	0.21	0.21	0.21	0.21
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	47.1	3.2	1.1	0.5	0.4
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	No Data	88.4%	91.1%	No Data	No Data
LA (Non-Point Allocation)	235.48	15.99	5.48	2.52	1.83
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	11.78	0.81	0.28	0.14	0.10
WLA (NPDES Point/MS4 permits)	0.21	0.21	0.22	0.22	0.22
TMDL minus (MOS + Future Growth)	**235.69**	**16.20**	**5.70**	**2.74**	**2.05**
N01K14 - Beech Cr. (RM 3.54; Drainage area = 17.40 square miles)					
Samples Collected		2	2		
Sample Median Load		310	69		
Point Source Load	0.14	0.14	0.14	0.14	0.14
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	91.1	6.3	2.2	1.1	0.8
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	No Data	89.9%	84.1%	No Data	No Data
LA (Non-Point Allocation)	455.50	31.18	10.85	5.13	3.83
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	22.78	1.57	0.55	0.26	0.20
WLA (NPDES Point/MS4 permits)	0.14	0.14	0.14	0.14	0.14
TMDL minus (MOS + Future Growth)	**455.65**	**31.32**	**11.00**	**5.28**	**3.97**

Table 5-4. *E. coli* wasteload allocations for the 05030103-01-02 12-digit HUC.

Regulated point source	NPDES OEPA ID	Exist Flow Avg MGD	Dgn Flow Avg MGD	Conc Limit cfu/100mL	WLA billion/day
Stark County Village Green Allot STP	3PG00087	0.0275	0.0200	126.0	0.10
Trilogy Alliance	3IN00347	0.0180	0.0000	0.0	0.00
Washington Elementary School	3PT00101	0.0050	0.0080	161.0	0.05
Marlington Local Schools	3PT00045	0.0213	0.0450	126.0	0.21

Table 5-5. *E. coli* TMDLs for the 05030103-01-03 12-digit HUC.

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N01S12 - Mahoning River (RM 84.99; Drainage area = 90.00 square miles)					
Samples Collected		3	2		
Sample Median Load		634	77		
NPDES Point Source Existing Load	8.57	8.57	8.57	8.57	8.57
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	471.3	32.4	11.4	5.5	4.1
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	No Data	74.5%	26.0%	No Data	No Data
LA (Non-Point Allocation)	2,348.11	153.41	48.30	18.73	11.90
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	117.83	8.10	2.84	1.37	1.02
WLA (NPDES Point/MS4 permits)	8.57	8.57	8.57	8.57	8.57
TMDL minus (MOS + Future Growth)	2356.68	161.98	56.87	27.30	20.47

Table 5-6. *E. coli* wasteload allocations for the 05030103-01-03 12-digit HUC.

Regulated point source	**NPDES OEPA ID**	**Exist Flow Avg MGD**	**Design Flow Avg MGD**	**Conc Limit cfu/100mL**	**WLA billion/day**
Paradise Lake Park Campground	3PR00325	0.0200	0.0200	161.0	0.12
Timashamie Family Campground	3PR00305	0.0039	0.0250	161.0	0.15
Knox Elementary School - West Branch	3PT00123	0.0019	0.0070	126.0	0.03
Sebring WTP	3IV00182	0.0487	0.0500	0.0	0.00
West Branch Nursing Home LLC	3PR00458	0.0118	0.0118	126.0	0.06
Damascus WWTP	3PA00037	0.0547	0.0080	126.0	0.04
Country Squire Estates Ltd	3PV00130	0.0300	0.0100	126.0	0.05
Beloit WWTP	3PB00005	0.0689	0.1900	126.0	0.91
Tecumseh Village MHP	3PV00023	0.0019	0.0125	126.0	0.06
Sebring Landfill Facility	3IN00351	0.0180	0.0000	0.0	0.00
BP Amoco Oil Corp Bulk Plant Alliance	3IN00287	0.0009	0.0000	0.0	0.00
Sebring WWTP	3PC00011	0.7469	1.5000	126.0	7.15
Central Waste Inc	3IN00313	0.0045	0.0000	0.0	0.00
Alliance Tubular Products Co	3ID00043	1.7000	0.0694	0.0	0.00

5.1.2 Sediment and Habitat (HUCs 01-01, 01-02, 02-03)

Poor habitat quality is impairing aquatic life at three sites and sediment is at four sites. Deficits range from 20 to 50 percent for the overall QHEI scores for sites impaired by habitat only and the substrate and riffle metrics were generally the most problematic. For sediment, the deficits are fairly case specific and no metric showed to be more problematic than the others. Table 5-7 shows the results of TMDLs developed to address aquatic life impairments caused by fine sediment and poor habitat quality using the QHEI.

Table 5-7. Sediment and Habitat TMDLs for the 05030103-01 10-digit HUC based on QHEI metrics and modified attributes.

Stream/River (Use)	River Mile[1]	Aquatic Life Use Attainment	Applicable TMDLs - Listed Cause[2] (B = bedload; H = habitat)	Bedload TMDL						Habitat TMDL						
				Allocations			TMDL			Allocations			Subscore			TMDL
				≥13	≥14	≥5	≥32			≥60 = 1pt	<2 = 1pt	<5 = 1pt				3
				QHEI Categories												
				Substrate	Channel	Riparian	Total Bedload Score	% Deviation fromTarget[3]	Metrics with Substantial Deviation[4] (S = substrate; C = channel; R = riparian)	QHEI Score	# High Influence Atributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Mahoning River (WWH)	102.24[H]	Full		17	14.5	3.5	35	-9%	---	62	1	1	1	0	1	**2**
	100.57[H]	Full		13	17.5	6.5	37	-16%	---	74.5	0	4	1	1	0	**2**
	97.69[H]	Full		15.5	16.5	2.5	34.5	-8%	---	75.5	0	3	1	1	1	**3**
	93.23[W]	Full		11	6	3.5	20.5	**36%**	---	57.5	1	4	0	0	0	0
	91.11[W]	Non	B / H	1	5	4	10	**69%**	S / C	33	3	6	0	0	0	0
	85.51[B]	Non	H	6.5	14	8.5	29	**9%**	S	55	1	6	0	0	0	0
	84.80[W]	Partial	B	15	7	4.5	26.5	**17%**	C	60.5	1	5	1	0	0	**1**
Beech Creek (WWH)	**10.50[H]**	Non	B / H	0.5	6.5	5	12	**63%**	S / C	31	5	6	0	0	0	0
	8.34[H]	Full		11.5	14	5.5	31	**3%**	---	65	0	5	1	1	0	**2**
	3.54[H]	Full		11	14	6.5	31.5	**2%**	---	60.5	1	5	1	0	0	**1**
Little Beech Creek (WWH)	**1.83[H]**	Non	B	11	6	1.5	18.5	**42%**	C / R	39.5	3	5	0	0	0	0
Fish Creek (WWH)	**3.56[H]**	Non	H	4.5	12	6.5	23	**28%**	S	49	2	6	0	0	0	0
	2.00[H]	Non	B	5.5	12	7	24.5	**23%**	S	56.5	2	5	0	0	0	0
	0.36[H]	Non	B	0	12	8.5	20.5	**36%**	S	42.5	1	6	0	0	0	0
Beaver Run (WWH)	1.19[H]	Partial	B	12.5	16	6.5	35	-9%	---	70.5	0	4	1	1	0	**2**

Stream/River (Use)	River Mile[1]	Aquatic Life Use Attainment	Applicable TMDLs - Listed Cause[2] (B = bedload; H = habiteat)	Bedload TMDL						Habitat TMDL						
				Allocations			TMDL	% Deviation fromTarget[3]	Metrics with Substantial Deviation[4] (S = substrate; C = channel; R = riparian)	Allocations			Subscore			TMDL
				≥13	≥14	≥5	≥32			≥60 = 1pt	<2 = 1pt	<5 = 1pt				3
				QHEI Categories												
				Substrate	Channel	Riparian	Total Bedload Score			QHEI Score	# High Influence Atributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Naylor Creek (WWH)	**3.63[H]**	Non	H	6	5.5	3.5	15	**53%**	S / C	39	4	5	0	0	0	0
	1.35[H]	Non		5	10.5	4	19.5	**39%**	---	45.5	2	5	0	0	0	0
Trib. to Mahoning R. (RM 91.21) (WWH)	2.39[H]	Non		7	12	7	26	**19%**	---	54	2	5	0	0	0	0
Tributary to Mahoning River (RM 98.71) (WWH)	4.59 [H]	Partial	B	14.5	10.5	5	30	**6%**	C	62	2	5	1	0	0	**1**

1 H – Headwater site, W – Wading site, B – Boat site
2 Habitat TMDLs applicable to sites (i.e., indicated by river mile) with orange highlight and bold font; sediment TMDLs applicable to sites (i.e., indicated by river mile) that are have bold, underline font and are left aligned in the cell.
3 Causes for which habitat TMDLs are developed include: habitat alteration; flow alteration; alteration in streamside vegetation.
4 Negative values shown in light grey indicate where the minimum target is exceeded.
5 Deviations more than 20 to 25 percent of the target value are considered substantial. Deviations are not considered for sites that are not listed as impaired for sediment and/or habitat.

5.1.3 Total Phosphorus (HUCs 01-01 and 01-03)

Nutrients caused aquatic life uses impairments at nine sites in this 10-digit HUC. To address this, a watershed model was used for the entire 01-01 and part of the 01-02 twelve digit HUCs. Other nutrient impaired sites were not addressed. Table 5-8 shows the estimated nutrient loading per land use type and other sources in the watershed.

Based on the watershed model, cropland is the largest source of total phosphorus to the watershed area producing 96% of the total load. All other sources are minimal in comparison and point sources comprise only 0.1% of the total phosphorus load (all combined waste water design volume is about three percent of the average stream flow in the Mahoning River at the Alliance stream gage – see Table 5-11 for design discharge).

Figure 5-2 presents the seasonally grouped data for the Mahoning River at Alliance gage. Ten years of total phosphorus existing daily loads and TMDL values were grouped into seasonal categories. Seasons were grouped as follows: Spring – March, April, May; Summer – June, July, August; Autumn – September, October, November; Winter – December, January, February. Seasonally grouped daily values for existing loads and TMDLs were graphed in bar and whisker charts. Inter-quartile ranges and median are provided on these graphs. In addition, the 95th percent confidence interval of the median area presented as additional boxes within the inter-quartile range area. Data that fell outside the standard statistical 1.5 inter-quartile range test were eliminated from the data sets as outliers.

Table 5-9 provides the median loads and the corresponding median TMDLs for each season. The need for load reduction was determined by a hypothesis test such that if the median of the existing load fell within the 95% confidence interval of the TMDL data set, no reduction in load was proposed. A null value for the hypothesis test indicates that the data sets are equivalent. If the median of the existing loading was higher than the TMDL‘s 95% confidence interval range of the median, reduction percentages and allocations are provided. Reductions were calculated by equating medians of the existing load and TMDL datasets assuring the translated data sets would be statistically similar with median hypothesis test.

The spring and summer seasons require reductions in total phosphorus of 44% and 96%, respectively. The median values for the existing total phosphorus load in autumn and winter fell within the 95% confidence interval of the median TMDL therefore no load reductions are required.

To ensure point source discharges are allocated appropriate load reductions, effluent limits were set to 1 mg/L total phosphorus for facilities with a designed discharge capacity of 150,000 gallons per day or greater. Overall, point source loads comprise a small percent of the total phosphorus load; therefore, reductions beyond 1 mg/L would not have a significant impact for total load reductions in the watershed. Table 5-11 indicates this proposed concentration limit and associated discharge load allocated to the respective point sources. These limits are proposed only during seasons in which loads reductions are needed to meet TMDL goals (i.e., spring and summer).

Other allocations were determined by fractioning the total TMDL load into allotments by equalizing percent reductions for each source besides point source dischargers and septic systems. A one hundred percent reduction is expected for failing septic systems for each season. In addition, it is impractical to expect reductions from land types that consist of surface water, forest, wetland, and groundwater sources; therefore, no reductions were proposed for these sources.

Overall, source reductions of non-point sources are 43.0% and 99.3% for spring and summer loads, respectively. These reductions are projected to allow the water quality to meet TMDL targets. For point source loads, 14% is proposed for both spring and summer within this watershed. Because of seasonal variation in the source loads, crop land is reduced in magnitude as shown in Table 5-10. All source reduction percentages and loads can be viewed in Table 5-10 for the Mahoning River at Alliance gage.

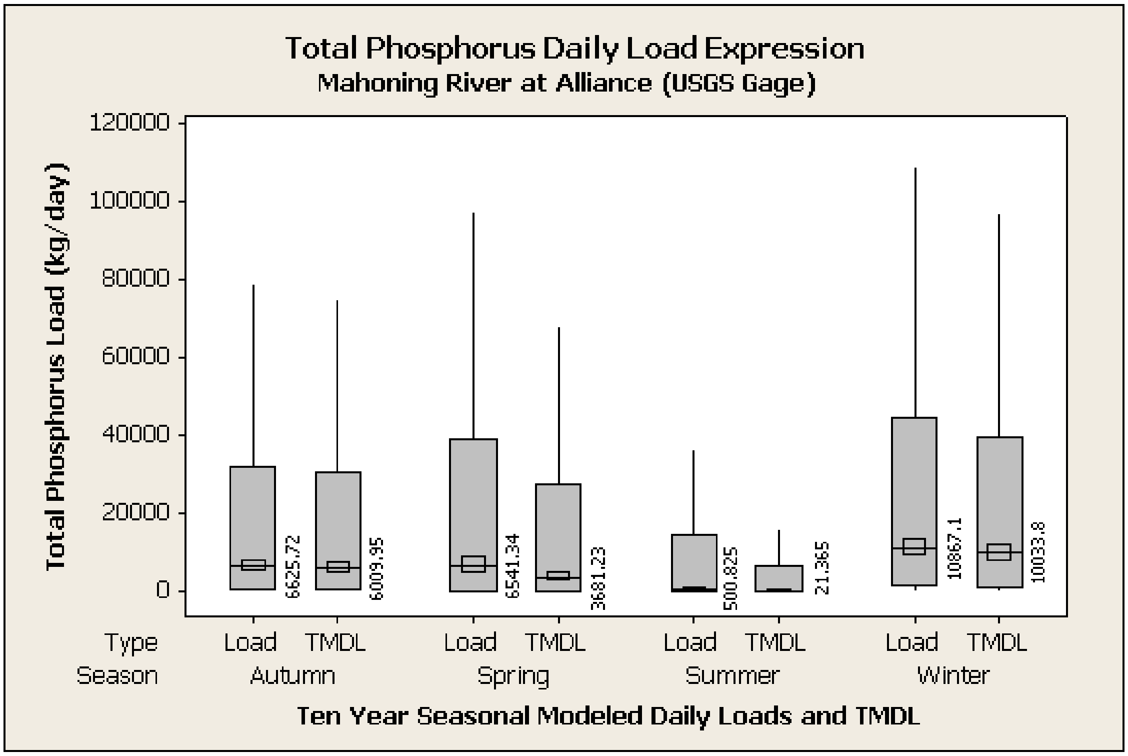

Figure 5-2. Mahoning River at Alliance Gage Daily Load and TMDL Modeled over 10 years for Total Phosphorus (median 95% confidence interval range and values are presented).

Table 5-8. Total annual loads and pollutant yields per the significant sources within the GWLF modeled area that employs the Alliance gage on the Mahoning River (HUCs 01 and 03).

Source	Area (ha)	Total P (kg/d)	kg/ha/day	lb/ac/day	% of Total
Cropland	7,701	13,942	1.811	1.615	96%
Urban	4,178	197	0.047	0.042	1%
Septic Systems	na	95	na	na	1%
Pasture	5,065	67	0.013	0.012	0.5%
Forest	5,368	50	0.009	0.008	0.3%
Water	175	32	0.185	0.165	0.2%
Other_Urban	760	25	0.034	0.030	0.2%
Point Source	na	21	na	na	0.1%
Wetland	3	18	5.925	5.286	0.1%
Groundwater	na	-	na	na	0.0%
TOTAL	**23,250**	**14,449**	**0.621**	**0.550**	**100%**

Table 5-9. Median Existing and TMDL Loads with reductions needed for the Mahoning River and tributaries at the Alliance Gage Daily Load and TMDL Modeled over 10 years for Total Phosphorus.

Season	Median Existing Daily Load (kg/d)	Median TMDL (kg/day)	TMDL MOS (%)	Total Reduction	
				(kg/d)	Percent
Spring	6,541	3,681	5%	2,860	44%
Summer	500	21	5%	479	96%
Autumn	6,625	6,009	0%	-	0%
Winter	10,867	10,033	0%	-	0%

Table 5-10. Allocations and percent reductions for total phosphorus by source within the GWLF modeled area that employs the Alliance gage on the Mahoning River (HUCs 01 and 03).

Source	Spring Load					Summer Load				
	Total P (kg/d)	Allocation (kg/d)	MOS (%)	Reduction (%)	Total Reduction (kg/d)	Total P (kg/d)	Allocation (kg/d)	MOS (%)	Reduction (%)	Total Reduction (kg/d)
Water	14.5	14.5	0%	0%	-	0.9	0.9	0%	0%	-
Urban	88.2	50.0	5%	46%	40.7	5.3	0	5%	100%	5.2
Other_Urban	11.4	6.5	5%	46%	5.3	0.7	0	5%	100%	0.7
Forest	22.4	22.4	0%	0%	-	1.3	1.3	0%	0%	-
Pasture	30.1	17.1	5%	46%	13.9	1.8	0	5%	100%	1.8
Cropland	6,249.9	3,543.9	5%	46%	2,883.2	373.3	0.1	5%	100%	373.2
Wetland	8.2	8.2	0%	0%	-	0.5	0.5	0%	0%	-
Groundwater	-	-	0%	0%	-	0	-	0%	0%	-
Point Source	21.4	18.5	5%	18%	2.9	21.4	18.5	5%	18%	2.8
Septic Systems	95.0	-	5%	100%	95.0	95.0	-	5%	100%	95.0
TOTAL	**6,541**	**3,681**		**44%**	**3041**	**500**	**21.4**		**95.7%**	**478.8**

Table 5-11. Existing and proposed loading information, including wasteload allocations, for NPDES dischargers within the GWLF modeled area that employs the Alliance gage on the Mahoning River (HUCs 01 and 03).

Permit Number	Facility	Design Flow (mgd)	Existing Total Phosphorus Effluent Concentration (mg/l)	Existing Total Phosphorus Load (kg/day)	Proposed Total Phosphorus Effluent Concentration (mg/l)	Proposed Total Phosphorus Load - WLA (kg/day)
3PV00023	Tecumseh Village MHP	0.0125	3*	0.142	3	0.142
3PR00196	Dairy Kool	0.0011	3*	0.012	3	0.012
3PA00037	Damascus WWTP	0.08	3*	0.909	3	0.909
3IN00313	Central Waste Inc***	2.73	0.033	0.341	3	0.341
3PB00005	Beloit WWTP	0.190	3*	2.158	1	0.719
3PC00011	Sebring WWTP	1.50	3*	17.035	1	5.678
3PR00458	West Branch Nursing Home, LLC	0.012	3*	0.133	3	0.133
3PV00112	Arew Mobile Park	0.004	3*	0.045	3	0.045
3PR00305	Timashamie Family Campground	0.025	3*	0.284	3	0.284
3PR00325	Paradise Lake Park Campground STU 1	0.020	3*	0.227	3	0.227
3PT00123	Knox Elementary School - West Branch	0.0070	3*	0.079	3	0.079
TOTAL		**4.578**	**na**	**21.365**	**na**	**8.569**

* Estimate for facilities for which no data exists.

*** Average discharge flow from sedimentation basin utilized for loading calculation.

5.2 Deer Creek - Mahoning River (05030103-02)

TMDLs were developed in these four 12-digt HUCs for bacteria (*E. coli*), sediment and habitat (QHEI), and nutrients (total phosphorus). The results are presented for the applicable assessment units (i.e., 12-digit HUCs) in the following sub-sections.

5.2.1 *E. coli* Bacteria (HUCs 02-01, 02-02, 02-03, and 02-04)

Tables 5-12, 5-14, 5-15, and 5-17 provide the *E. coli* allocations for each flow interval in the load duration curves for sampling sites located in the 01, 02, 03, and 04 twelve-digit HUCs, respectively. Tables 5-13 and 5-16 show the wasteload allocations for NPDES permitted facilities within the 01 and 03 twelve digit HUCs, respectively. In this case the other 12-digit HUCs within this 10-digit HUC do not have NPDES facilities that are sources of *E. coli* bacteria.

Water samples were collected at least once during conditions reflective of three of the five flow regimes, corresponding to a range from about the tenth percentile to the eighty-fifth percentile. Three sites each had one collection taken under higher flows where flow exceedance is less than five percent of the stream flow dataset. No collection was made under low conditions (i.e., flow exceedance occurs for 95 percent or more of the instances within the stream flow dataset). Like the sample collection that was done in the 01 ten-digit HUC, the samples reflect a fairly even distribution across the range of flows. Of the 47 samples collected nine are likely to have had more than 50 percent of its flow attributable to storm water contributions.

Samples collected during wet weather type flows (fifth to fortieth exceedance percentiles) exceeded target conditions by far by the highest magnitude. Some calculated loads are well over 500 times the target load, and the exceedances averaged 136 times the target load. Mid-range summer flow conditions (i.e., fortieth to eightieth exceedance percentile) showed the second highest level of exceedance with a maximum of 144 times greater than the target loads and an average of 52 times greater. Again, like the 01 ten-digit HUC, nonpoint sources are almost entirely responsible for the loading to streams as evidenced by very small wasteload allocations relative to the TMDL load (wasteload allocations are calculated by the design discharge capacity times the water quality standard). Every flow interval from the load duration curve has allocations of greater than 95 percent of the TMDL for nonpoint sources alone.

Interpretation of this data suggests that runoff driven loading has greater relevance in the 02 ten-digit HUC than it did in the 01 ten-digit HUC. And since all flow regimes are well represented with sample collection in this dataset, this cannot be attributed to skewed sampling protocols. Samples collected where runoff is estimated to be greater than 50 percent (three sites) showed a greater exceedance of the target than when runoff was less than 50 percent. If bacteria loaded by runoff events persists substantially in the system (e.g., in the fine bed sediments), then conservation that limits transport should be the highest priority in the 02 ten-digit HUC. Sources that leave enteric bacteria residues on the landscape that are susceptible to runoff include pasture, fields with manure and sludge applied, and wildlife wastes, especially within the riparian zone. However, the strong signature of runoff derived bacteria should not discount the fact that persistent and discrete sources of bacteria are also causing an impact in this ten-digit HUC. Directly discharging home septic systems and livestock with stream access are possible candidates for this loading and efforts to abate such sources are reasonable expenditures of conservation resources.

Table 5-12. *E. coli* TMDLs for the 05030103-02-01 12-digit HUC.

E. coli **TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
300025 - Deer Cr. (RM 2.90; Drainage area = 33.84 square miles)					
Samples Collected	1	3	5	1	
Sample Median Load	2,819	3,085	42	25.4	
NPDES Point Source Existing Load	1.11	1.11	1.11	1.11	1.11
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	157.6	10.8	3.8	1.8	1.4
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	72.0%	98.2%	54.2%	63.9%	No Data
LA (Non-Point Allocation)	787.07	53.07	17.93	8.04	5.75
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	39.41	2.71	0.95	0.46	0.34
WLA (NPDES Point/MS4 permits)	1.11	1.11	1.11	1.11	1.11
TMDL minus (MOS + Future Growth)	788.18	54.18	19.04	9.15	6.86
N01K12 - Deer Cr. (RM 10.87; Drainage area = 3.50 square miles)					
Samples Collected		1	2	1	
Sample Median Load		120	54	7.4	
NPDES Point Source Existing Load	0.00	0.00	0.00	0.00	0.00
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	18.3	1.3	0.4	0.2	0.2
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	No Data	94.7%	95.9%	85.4%	No Data
LA (Non-Point Allocation)	91.67	6.31	2.22	1.09	0.81
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	4.58	0.32	0.11	0.05	0.04
WLA (NPDES Point/MS4 permits)	0.00	0.00	0.00	0.00	0.00
TMDL minus (MOS + Future Growth)	91.67	6.31	2.22	1.09	0.81

Table 5-13. *E. coli* wasteload allocations for the 05030103-02-01 12-digit HUC.

Regulated point source	**NPDES OEPA ID**	**Exist Flow Avg MGD**	**Design Flow Avg MGD**	**Conc Limit**	**WLA**
Pelican Grove Campground	3PR00373	0.0006	0.0008	126	0.004
Buckeye Packaging Co Inc	3PR00259	0.0013	0.0035	161	0.021
Custom Poly Bag Inc	3PR00389	0.0016	0.0015	161	0.009
Atwater WWTP	3PH00033	0.1074	0.2000	126	0.954
Waterloo K-12 Campus	3PT00079	0.0058	0.0200	161	0.122
Evrol LLC Atwater Terminal	3IG00025	0.0001	0.0001	0	0

Table 5-14. *E. coli* TMDLs for the 05030103-02-02 12-digit HUC.

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
300062 - Kale Cr. (RM 3.38; Drainage area = 7.20 square miles)					
Samples Collected	1	5	5	2	
Sample Median Load	4,551	975	27	28.6	
NPDES Point Source Existing Load	0.00	0.00	0.00	0.00	0.00
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	37.7	2.6	0.9	0.4	0.3
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	95.9%	98.7%	82.9%	92.3%	No Data
LA (Non-Point Allocation)	188.54	12.97	4.56	2.19	1.65
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	9.43	0.65	0.23	0.11	0.08
WLA (NPDES Point/MS4 permits)	-	-	-	-	-
TMDL minus (MOS + Future Growth)	188.54	12.97	4.56	2.19	1.65

Table 5-15. *E. coli* TMDLs for the 05030103-02-03 12-digit HUC.

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
300061 - Mill Cr. (RM 3.38; Drainage area = 19.10 square miles)					
Samples Collected	1	3	6	1	
Sample Median Load	35,775	18,385	88	84.3	
NPDES Point Source Existing Load	0.00	0.00	0.00	0.00	0.00
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	100.0	6.9	2.4	1.2	0.9
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	98.6%	99.8%	86.2%	93.1%	No Data
LA (Non-Point Allocation)	500.16	34.38	12.08	5.80	4.37
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	25.01	1.72	0.60	0.29	0.22
WLA (NPDES Point/MS4 permits)	-	-	-	-	-
TMDL minus (MOS + Future Growth)	500.16	34.38	12.08	5.80	4.37
N01K01 - Turkey Broth Cr. (RM 3.36; Drainage area = 4.90 square miles)					
Samples Collected		1	3	1	
Sample Median Load		1,218	571	7.7	
NPDES Point Source Existing Load	0.15	0.15	0.15	0.15	0.15
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	32.8	2.3	0.8	0.4	0.3
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	No Data	99.1%	99.3%	74.9%	No Data
LA (Non-Point Allocation)	163.81	11.13	3.82	1.78	1.30
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	8.20	0.56	0.20	0.10	0.07
WLA (NPDES Point/MS4 permits)	0.15	0.15	0.15	0.15	0.15
TMDL minus (MOS + Future Growth)	163.96	11.28	3.97	1.92	1.45

Table 5-16. *E. coli* wasteload allocations for the 05030103-02-03 12-digit HUC.

Regulated point source	**NPDES OEPA ID**	**Exist Flow Avg MGD**	**Design Flow Avg MGD**	**Conc Limit**	**WLA**
Western Reserve High School	3PT00143	0.0019	0	161.000	0.146268

Table 5-17. *E. coli* TMDLs for the 05030103-02-04 12-digit HUC.

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N01K06 - Island Cr. (RM 2.65; Drainage area = 4.20 square miles)					
Samples Collected		1	2	1	
Sample Median Load		181	346	0.2	
NPDES Point Source Existing Load	0.00	0.00	0.00	0.00	0.00
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	22.0	1.5	0.5	0.3	0.2
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	No Data	95.8%	99.2%	None	No Data
LA (Non-Point Allocation)	109.99	7.57	2.66	1.28	0.96
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	5.50	0.38	0.13	0.06	0.05
WLA (NPDES Point/MS4 permits)	-	-	-	-	-
TMDL minus (MOS + Future Growth)	109.99	7.57	2.66	1.28	0.96

5.2.2 Sediment and Habitat (HUCs 02-01, 02-02)

Sediment is impairing aquatic life at five sites and one site is impacted by loss of stream-side vegetation. Deficits range from zero to 95 percent for the substrate metric, zero to 38 percent for the riparian metric, and zero to 48 percent for the channel metric. Table 5-18 shows the results of TMDLs developed to address aquatic life impairments caused by fine sediment and poor habitat quality using the QHEI.

Table 5-18. Sediment and Habitat TMDLs for the 05030103-02 10-digit HUC based on QHEI metrics and modified attributes.

Stream/River (Use)	River Mile[1]	Aquatic Life Use Attainment	Applicable TMDLs – Listed Cause[2] (B = bedload; H = habiteat)	Bedload TMDL						Habitat TMDL						
				Allocations			TMDL	% Deviation fromTarget	Metrics with Substantial Deviation[3] (S = substrate; C = channel; R = riparian)	Allocations			Subscore			TMDL
				≥13	≥14	≥5	≥32			≥60 = 1pt	<2 = 1pt	<5 = 1pt				3
				QHEI Categories												
				Substrate	Channel	Riparian	Total Bedload Score			QHEI Score	# High Influence Atributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Mill Creek (WWH)	8.75[H]	Non		0.5	5	6	11.5	**64%**	S / C	39.5	3	5	0	0	0	0
	6.28[H]	Non	B	9.5	12.5	4.5	26.5	**17%**	S	56.5	2	4	0	0	0	0
	3.64[H]	Full		16.5	16.5	5	38	-19%	---	74	0	3	1	1	1	**3**
Turkey Broth Creek (WWH)	**3.36[H]**	Non	B / H	0.5	7	4	11.5	**64%**	S / C	35.5	4	5	0	0	0	0
Island Cr (WWH)	**2.65[H]**	Non	B	1	13	5.5	19.5	**39%**	S	43.5	1	5	0	0	0	0
Willow Creek (WWH)	**8.13[H]**	Non	B / H	6	6.5	5.5	18	**44%**	S / C	34	4	6	0	0	0	0
	3.74[H]	Full		4	12	8.5	24.5	**23%**	S	54.5	1	6	0	0	0	0
Deer Creek (WWH)	**4.48[W]**	Full	H	15	7.5	5.5	28	**13%**	C	67	1	6	1	0	0	**1**
	2.90[W]	Partial	H	15.5	15	7	37.5	-17%	---	79.5	0	4	1	1	0	**2**
Garfield Ditch (WWH)	**0.66[H]**	Non	B													
Tributary to Mill Cr at RM 3.67 (WWH)	**1.10[H]**	Non		14	8	3.5	25.5	**20%**	C	54.5	3	4	0	0	0	0

1 H – Headwater site, W – Wading site, B – Boat site

2 Habitat TMDLs applicable to sites (i.e., indicated by river mile) with orange highlight and bold font; sediment TMDLs applicable to sites (i.e., indicated by river mile) that are have bold, underline font and are left aligned in the cell.

3 Causes for which habitat TMDLs are developed include: habitat alteration; flow alteration; alteration in streamside vegetation.

4 Negative values shown in light grey indicate where the minimum target is exceeded.

5 Deviations more than 20 to 25 percent of the target value are considered substantial. Deviations are not considered for sites that are not listed as impaired for sediment and/or habitat.

5.2.3 Total Phosphorus (HUCs 02-01 and 02-02)

Phosphorus reductions are needed to address eutrophic conditions in the Dale Walborn / Deer Creek reservoir systems as well as in-stream eutrophic conditions separate from this reservoir complex. The TMDLs and allocations for each of these environmental settings are different in terms of how the eutrophic conditions impact the aquatic community of the streams as well as the methods used to determine the allowable loading. The results of the analyses performed for the reservoir systems (i.e., BATHTUB – GWLF combination) are presented first followed by the load duration curves generated for the stream sites.

Reservoir Systems (Dale Walborn and Deer Creek)

Total Phosphorus
The median in-lake concentration of 32 ug/L (mg/m^3) corresponded to a ten year loading limit of 1,164,062 kg. The BATHTUB results comprise an entire years loading, therefore, the daily loading limit of total phosphorus to the combined lake system was found to be 319 kg/d (i.e., 1,164,062 kg-TP / 10 years / 365 days per year).

Total Nitrogen
The mean load response indicates an increase or decrease of total phosphorus loading will not influence the total nitrogen concentration of the mixed layer. Because the median total nitrogen concentration of the model results was within proposed Ohio's Lake Habitat Criteria, reduction estimates and allocations are not proposed for total nitrogen.

Chlorophyll a
The median in-lake concentration of 9.5 ug/L (mg/m^3), corresponded to a ten year loading limit of 203,125 kg. The BATHTUB results comprise an entire years loading, therefore, the daily loading limit of total phosphorus to the combined lake system was found to be 56 kg/d.

Secchi Disk Transparency
Using the mean Secchi disk transparency of at least 1.04 meters (as required by the proposed Ohio Lake Habitat Criteria) a ten year loading limit of 210,937 kg of total phosphorus was determined. The BATHTUB results comprise an entire years loading, therefore, the daily loading limit of total phosphorus to the combined lake system was found to be 58 kg/d.

A total reduction in the influent total phosphorus load to the combined lake system including the 5% margin of safety must be 70.8%.

Table 5-19 shows the in-lake response for the combined Dale Walborn and Deer Creek Reservoir system to a fixed total phosphorus external loading rate. Response variables presented are the in-lake ambient concentrations (and equivalent loads) of chlorophyll a, total phosphorus, and total nitrogen. Secchi depths are also presented in Table 5-19 that are the simulated response to the fixed total phosphorus load. Allocations for the sources of external loading of total phosphorus are presented in Table 5-20. Reductions of 86.1% of total phosphorus loading are required for urban runoff, pasture runoff, and cropland runoff. Reductions of 100% and 57.9% are required for failing home sewage treatment systems and point source discharges, respectively. No reductions are proposed for forested area runoff, direct stream/lakewater atmospheric loadings, and wetland loadings because they are non-anthropogenic loadings. No reduction of nitrogen is proposed because the BATHTUB modeling results indicate total nitrogen mean values fall within the median total nitrogen limits in the proposed Ohio Lake Habitat Criteria rule.

Proposed individual point source limits and loadings are presented in Table 5-21. A reasonable total phosphorus limit of 1.0 mg/L and the corresponding loading limits are provided on the table and previous allocations

Table 5-19. Existing Daily Load and Allowable Daily Load during Lake Growing Season for Ohio's Lake Habitat Criteria Attainment (Deer Creek and Dale Walborn Spatial Average water quality).

Modeled Response Parameter	Modeled Contaminant	10 Year Seasonal Mean Daily Modeled Contaminant Influent Load*	10 Year Modeled Concentration Load Response in Mixed Layer	Ohio EPA Proposed Mixed Layer WQ Standard Concentration	Allowable Influent Contaminant Load*	Margin of Safety		Required Reduction
Chlorophyll *a*	Phosphorus, Total	181 kg/day	27.4 ug/L	9.5 ug/L	56 kg/day	5%	3 kg/day	70.80%
Secchi Transparency	Phosphorus, Total	181 kg/day	0.7 m	1.04 m	58 kg/day	5%	3 kg/day	69.70%
Phosphorus, Total	Phosphorus, Total	181 kg/day	30 ug/L	32 ug/L	319 kg/day	5%	16 kg/day	0.00%
Nitrogen, Total	Phosphorus, Total	181 kg/day	672.8 ug/L	790 ug/L	181 kg/day	5%	9 kg/day	0.00%
Limiting Load and % Reduction	**Phosphorus, Total**				**56 kg/day**	**5%**	**3 kg/day**	**70.80%**

*Daily Loads for BATHTUB modeling season of May to September

Table 5-20. Modeled Total Phosphorus Existing Load and TMDL Point and Non-Point Source Loads (kg/day) during Growing Season (May-September).

Reservoir		Water	Urban	Forest	Pasture	Cropland	Wetland	Home Sewage Treatment Systems	Point Sources	5% Margin of Safety	Total Maximum Daily Load
Deer Creek and Dale Walborn Reservoirs	Existing	2.16	0.68	0.52	0.72	148.23	25.51	0.61	2.46	---	181
	Allocation	2.16	0.09	0.52	0.1	20.04	25.51	0	1.61	2.78	53
	% Reduction	0.00%	86.10%	0.00%	86.10%	86.10%	0.00%	100.00%	57.90%	---	70.80%

Table 5-21. Deer Creek Reservoir Watershed Point Source Discharge Total Phosphorus proposed Limit and Resulting Waste Load.

NPDES Permit Number	Type	Size	Facility Name	County	Total Phosphorus Concentration			Total Phosphorus Load	
					Existing (mg/L)	Proposed (mg/L)	Design Flow (mgd)	Existing (kg/d)	Proposed (kg/d)
3PR00389	Public	Minor	Custom Poly Bag Inc	Stark	3**	3.0	0.0015	0.017	0.017
3PT00079	Public	Minor	Waterloo K-12 Campus	Portage	3**	3.0	0.0200	0.227	0.227
3PH00033	Public	Minor	Atwater WWTP	Portage	2.14	1.0	0.2000	1.620	0.757
3IG00025	Industrial	Minor	Evrol LLC Atwater Terminal*	Portage	3**	3.0	0.0500	0.568	0.568
3PR00259	Public	Minor	Buckeye Packaging Co Inc	Stark	3**	3.0	0.0032	0.036	0.036

* Maximum daily flow in lieu of design flow
** Estimated because lack of historic data

5.3 West Branch Mahoning River - Mahoning River (05030103-03)

TMDLs were developed in these six 12-digt HUCs for bacteria (*E. coli*), sediment and habitat (QHEI), and nutrients (total phosphorus). The results are presented for the applicable assessment units (i.e., 12-digit HUCs) in the following sub-sections.

5.3.1 *E. coli* Bacteria (HUCs 03-01, 03-02, 03-03, 03-04, 03-05, and 03-06)

Tables 5-22, 5-24, 5-25, 5-26, 5-28, and 5-30 provide the *E. coli* allocations for each flow interval in the load duration curves for sampling sites located in the 01, 02, 03, 04, 05, and 06 twelve-digit HUCs, respectively. Tables 5-23, 5-27, 5-29, and 5-31 show the wasteload allocations for NPDES permitted facilities within the 01, 04, 05, and 06 twelve digit HUCs, respectively. In this case the other 12-digit HUCs within this 10-digit HUC do not have NPDES facilities that are sources of *E. coli* bacteria.

Water samples were collected at least once during conditions reflective of four highest flow regimes, but none were collected during low flows (ninety-fifth to one hundredth exceedance percentiles). A total of 42 samples were collected and three of the six sites each had ten samples collected while the other three sites each had four samples collected. Like the 01 and 02 ten-digit HUC watersheds, the samples represented a fairly even distribution across the flow regimes. Eleven of the 42 samples are estimated to have had more than 50 percent of the flow as storm water.

The highest flows regimes showed the greatest magnitude by which the target loads were exceeded. However, the dry flow conditions (eightieth to ninety-fifth exceedance percentiles) also showed significant exceedance of the target while the mid-range summer flows (fortieth to eightieth exceedance percentiles) exceeded the targets by the smallest margin (average of 4.4 and median of 2.2 times greater than target). Overall, this ten-digit HUC showed the second highest magnitude by which the targets were exceeded, being second only to the 02 ten-digit HUC with an average exceedance of 25.3, 13.9, 4.4, and 9.6 times larger than target for the top four flow regimes, respectively.

Nonpoint sources dominate the loading in this ten-digit HUC, just like all of the others in this TMDL project area. Two sites showed particularly high loading under dry weather flow conditions, specifically the site on Barrel Run (NO2K23) and the one on Silver Creek (NO2K20). The high loading under dry flow conditions indicates discrete discharges occurring outside of runoff events. Based on aerial photography and GIS data, the most probable sources are the several homes in the area which are likely to have issues with improperly functioning home septic systems. Specifically the areas south of Tallmadge Roads and between the intersection with Industry and Stroup Roads (for the Barrel Run issue) and the area where Tallmadge Road intersects Alliance Road (for the Silver Creek issues).

Table 5-22. ***E. coli*** **TMDLs for the 05030103-03-01 12-digit HUC.**

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Rec Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N02W07 - Island Cr. (RM 2.65; Drainage area = 21.90 square miles)					
Samples Collected	1	3	5	1	
Sample Median Load	38,456	501	24	32.9	
NPDES Point Source Existing Load	0.01	0.01	0.01	0.01	0.01
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	114.7	7.9	2.8	1.3	1.0
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	98.5%	92.1%	42.1%	79.8%	No Data
LA (Non-Point Allocation)	573.47	39.42	13.82	6.65	4.97
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	28.67	1.97	0.69	0.33	0.25
WLA (NPDES Point/MS4 permits)	0.01	0.01	0.01	0.01	0.01
TMDL minus (MOS + Future Growth)	573.48	39.43	13.84	6.66	4.98

Table 5-23. ***E. coli*** **wasteload allocations for the 05030103-03-01 12-digit HUC.**

Regulated point source	**NPDES OEPA ID**	**Exist Flow Avg MGD**	**Design Flow Avg MGD**	**Conc Limit**	**WLA**
Nemenz Little Village Shoppe Inc	3PR00190	0	0.003	126	0.012067

Table 5-24. ***E. coli*** **TMDLs for the 05030103-03-02 12-digit HUC.**

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
300022 - Headwaters West Branch Mahoning River (RM 20.94; Drainage area = 21.80 square miles)					
Samples Collected	2	2	5	1	
Sample Median Load	14,017	1,818	36	51.6	
NPDES Point Source Existing Load	0.00	0.00	0.00	0.00	0.00
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	114.2	7.8	2.8	1.3	1.0
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	95.9%	97.8%	62.2%	87.2%	No Data
LA (Non-Point Allocation)	570.84	39.24	13.79	6.63	4.98
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	28.54	1.96	0.69	0.33	0.25
WLA (NPDES Point/MS4 permits)	-	-	-	-	-
TMDL minus (MOS + Future Growth)	570.84	39.24	13.79	6.63	4.98

Table 5-25. *E. coli* TMDLs for the 05030103-03-03 12-digit HUC.

E. coli **TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N02K23 - Barrel Run (RM 3.65; Drainage area = 10.20 square miles)					
Samples Collected	1	1	1	1	
Sample Median Load	1,833	96	126	65.2	
NPDES Point Source Existing Load	0.00	0.00	0.00	0.00	0.00
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	68.3	4.7	1.7	0.8	0.6
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	81.4%	75.5%	93.5%	93.9%	No Data
LA (Non-Point Allocation)	341.31	23.48	8.26	3.97	2.99
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	17.07	1.17	0.41	0.20	0.15
WLA (NPDES Point/MS4 permits)	-	-	-	-	-
TMDL minus (MOS + Future Growth)	341.31	23.48	8.26	3.97	2.99

Table 5-26. *E. coli* TMDLs for the 05030103-03-04 12-digit HUC.

E. coli **TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N02K20 - Silver Cr. (RM 1.83; Drainage area = 9.30 square miles)					
Samples Collected	1	1	1	1	
Sample Median Load	3,232	74	20	62.9	
NPDES Point Source Existing Load	0.39	0.39	0.39	0.39	0.39
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	48.7	3.3	1.2	0.6	0.4
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	92.5%	77.5%	70.5%	95.5%	No Data
LA (Non-Point Allocation)	243.14	16.36	5.51	2.45	1.73
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	12.18	0.84	0.29	0.14	0.11
WLA (NPDES Point/MS4 permits)	0.39	0.39	0.39	0.39	0.39
TMDL minus (MOS + Future Growth)	243.53	16.75	5.89	2.84	2.12

Table 5-27. *E. coli* wasteload allocations for the 05030103-03-04 12-digit HUC.

Regulated point source requirements	**NPDES OEPA ID**	**Exist Flow Avg MGD**	**Design Flow Avg MGD**	**Conc Limit**	**WLA**
ODOT Rest Area 04-35 WWTP	3PP00033	0.0037	0.0200	126	0.095
Southeast High School	3PT00016	0.0153	0.0500	126	0.238
The Diamond Lodge	3PR00505	0.0100	0.0100	126	0.048
Gionino's Pizza	3PR00390	0.0002	0.0015	126	0.007

Table 5-28. *E. coli* TMDLs for the 05030103-03-05 12-digit HUC.

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N02P12 - West Branch Mahoning River (RM 0.36; Drainage area = 103.00 square miles)					
Samples Collected	2	2	5	1	
Sample Median Load	100,923	2,183	101	96.8	
NPDES Point Source Existing Load	1.57	1.57	1.57	1.57	1.57
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	539.4	37.1	13.0	6.2	4.7
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	97.3%	91.5%	35.4%	67.7%	No Data
LA (Non-Point Allocation)	2,695.51	183.81	63.51	29.67	21.86
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	134.85	9.27	3.25	1.56	1.17
WLA (NPDES Point/MS4 permits)	1.57	1.57	1.57	1.57	1.57
TMDL minus (MOS + Future Growth)	2697.08	185.38	65.08	31.25	23.43

Table 5-29. *E. coli* wasteload allocations for the 05030103-03-05 12-digit HUC.

Regulated point source	**NPDES OEPA ID**	**Exist Flow Avg MGD**	**Design Flow Avg MGD**	**Conc Limit**	**WLA**
ODOT Rest Area 04-35 WWTP	3PP00033	0.0037	0.020	126	0.095
Southeast High School	3PT00016	0.0153	0.050	126	0.238
The Diamond Lodge	3PR00505	0.0100	0.010	126	0.048
Gionino's Pizza	3PR00390	0.0002	0.002	126	0.007
Maple Del Manor MHP	3PV00034	0.0267	0.040	126	0.191
Crest Rubber Co	3IR00015	0.1082	0.001	0	0
Countryside Estates	3PG00120	0.0263	0.035	126	0.167
Country Acres Campground 1	3PR00234	0.0027	0.010	126	0.048
Leisure Lake Park	3PR00265	0.8174	0.038	126	0.179
ODNR Beach Area W Branch SP	3PP00010	0.0039	0.100	126	0.477
Arnies West Branch Steak House	3PR00174	0.0008	0.003	126	0.016
Jolly Time MHP	3PV00085	0.0005	0.002	126	0.011
KMV III Ltd DBA Hamlet MHP	3PV00041	0.0164	0.020	126	0.095

Table 5-30. ***E. coli*** **TMDLs for the 05030103-03-06 12-digit HUC.**

E. coli **TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N02S12 - Mahoning River (RM 56.53; Drainage area = 307.00 square miles)					
Samples Collected	1	1	1	1	
Sample Median Load	34,210	2,370	340	323.2	
NPDES Point Source Existing Load	58.62	58.62	58.62	58.62	58.62
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	1607.8	110.5	38.8	18.6	14.0
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	76.5%	76.7%	43.0%	71.2%	No Data
LA (Non-Point Allocation)	7,980.23	493.89	135.31	34.47	11.19
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	401.94	27.63	9.70	4.65	3.49
WLA (NPDES Point/MS4 permits)	58.62	58.62	58.62	58.62	58.62
TMDL minus (MOS + Future Growth)	8038.85	552.52	193.94	93.10	69.82

Table 5-31. ***E. coli*** **wasteload allocations for the 05030103-03-06 12-digit HUC.**

Regulated point source	**NPDES OEPA ID**	**Exist Flow Avg MGD**	**Design Flow Avg MGD**	**Conc Limit**	**WLA**
Alliance WWTP	3PD00000	5.2550	7.5000	126	35.77
Newton Falls STP	3PD00015	1.1084	1.5000	126	7.15
Sebring WWTP	3PC00011	0.7469	1.5000	126	7.15
Craig Beach WWTP	3PH00030	0.5271	1.0000	126	4.77
Atwater WWTP	3PH00033	0.1074	0.2000	126	0.95
Beloit WWTP	3PB00005	0.0689	0.1900	126	0.91
Alliance Tubular Products Co	3ID00043	1.7000	0.0694	0	0.00
Modern Management Solutions DBA All Seasons MHP	3PV00047	0.0353	0.0550	126	0.26
Sebring WTP	3IV00182	0.0487	0.0500	0	0.00
Marlington Local Schools	3PT00045	0.0213	0.0450	126	0.21
US Corp of Engineers Mill Creek R	3PN00000	0.0205	0.0300	126	0.14
Timashamie Family Campground	3PR00305	0.0039	0.0250	161	0.15
Western Reserve High School	3PT00143	0.0019	0.0240	161	0.15
Stark County Village Green Allot STP	3PG00087	0.0275	0.0200	126	0.10
Paradise Lake Park Campground STU	3PR00325	0.0200	0.0200	161	0.12
Waterloo K-12 Campus	3PT00079	0.0058	0.0200	161	0.12
Stark County Village Green Allot STP	3PG00087	0.0275	0.0200	126	0.10
North East Ohio Church of God Campground	3PR00437	0.0140	0.0140	126	0.07
Tecumseh Village MHP	3PV00023	0.0019	0.0125	126	0.06
West Branch Nursing Home LLC	3PR00458	0.0118	0.0118	126	0.06
Country Squire Estates Ltd	3PV00130	0.0300	0.0100	126	0.05
Washington Elementary School	3PT00101	0.0050	0.0080	161	0.05

Regulated point source	NPDES OEPA ID	Exist Flow Avg MGD	Design Flow Avg MGD	Conc Limit	WLA
Damascus WWTP	3PA00037	0.0547	0.0080	126	0.04
Washington Elementary School	3PT00101	0.0050	0.0080	161	0.05
Knox Elementary School - West Branch	3PT00123	0.0019	0.0070	126	0.03
Green Acres Campground	3PR00221	0.0027	0.0050	126	0.02
Grace Community Church of Alliance	3PR00451	0.0050	0.0050	126	0.02
Circle Restaurant Inc	3PR00120	0.0014	0.0044	126	0.02
Ben's Restaurant and Bar	3PR00491	0.0037	0.0037	126	0.02
RC Sports Lounge	3PR00323	0.0005	0.0035	126	0.02
Buckeye Packaging Co Inc	3PR00259	0.0013	0.0035	161	0.02
Nemenz Little Village Shoppe Inc	3PR00190	0.0007	0.0025	126	0.01
Nemenz Food Mart	3PR00210	0.0008	0.0015	126	0.01
Custom Poly Bag Inc	3PR00389	0.0016	0.0015	161	0.01
Pelican Grove Campground	3PR00348	0.0006	0.0008	126	0.00
Pelican Grove Campground	3PR00373	0.0006	0.0008	126	0.00
Evrol LLC Atwater Terminal	3IG00025	0.0001	0.0001	0	0.00
Industrial Mining - City Stone	3IJ00067	0.3500	0.0000	0	0.00
Trilogy Alliance	3IN00347	0.0180	0.0000	0	0.00
Sebring Landfill Facility	3IN00351	0.0180	0.0000	0	0.00
BP Amoco Oil Corp Bulk Plant Alliance	3IN00287	0.0009	0.0000	0	0.00
Central Waste Inc	3IN00313	0.0045	0.0000	0	0.00
Trilogy Alliance	3IN00347	0.0180	0.0000	0	0.00
Alliance WWTP	3PD00000	5.2550	7.5000	126	35.77
Newton Falls STP	3PD00015	1.1084	1.5000	126	7.15
Sebring WWTP	3PC00011	0.7469	1.5000	126	7.15

5.3.2 Sediment and Habitat (HUCs 03-01, 03-02, 03-03, 03-05, 03-06)

Poor habitat quality is impairing aquatic life at one site and sediment at six sites. The deficit is 34 percent for the overall QHEI scores for sites impaired by habitat only and the riffle and cover metrics were generally the most problematic. For sediment, deficits range from zero to 59 percent for the substrate metric, zero to 46 percent for the riparian metric, and zero to 37 percent for the channel metric. Table 5-32 shows the results of TMDLs developed to address aquatic life impairments caused by fine sediment and poor habitat quality using the QHEI.

Table 5-32. Sediment and Habitat TMDLs for the 05030103-03 10-digit HUC based on QHEI metrics (total score and substrate, riparian, and channel scores).

Stream/River (Use)	River Mile[1]	Aquatic Life Use Attainment	Applicable TMDLs - Listed Cause[2] (B = bedload; H = habiteat)	Bedload TMDL: Allocations ≥13 – QHEI Categories: Substrate	Bedload TMDL: Allocations ≥14 – QHEI Categories: Channel	Bedload TMDL: Allocations ≥5 – QHEI Categories: Riparian	Bedload TMDL: TMDL ≥32 – Total Bedload Score	% Deviation fromTarget[3]	Metrics with Substantial Deviation[4] (S = substrate; C = channel; R = riparian)	Habitat TMDL: Allocations ≥60 = 1pt – QHEI Score	Habitat TMDL: Allocations <2 = 1pt – # High Influence Atributes	Habitat TMDL: Allocations <5 = 1pt – Total # of Modified Attributes	Habitat TMDL: Subscore – QHEI	Habitat TMDL: Subscore – High Influence	Habitat TMDL: Subscore – # Modified Attributes	Habitat TMDL: TMDL 3 – Total Habitat Score
Mahoning River EOLP Ecoregion (WWH)	**70.70[B]**	Partial	H	17	13	7	37	-16%	Channel	78.5	0	4	1	1	0	**2**
	62.68[B]	Partial	H	20	14	5.5	39.5	-23%	---	80.5	0	2	1	1	1	**3**
	58.13[B]	Non	H	1	6	6.5	13.5	**58%**	S / C	41.5	2	6	0	0	0	0
	56.53[B]	Partial	H	12	9	4.5	25.5	**20%**	C	60.5	2	5	1	0	0	**1**
Kale Creek (WWH)	**13.08[H]**	Non	B / H	4.5	12	7.5	24	**25%**	S	51	1	7	0	0	0	0
	11.27[H]	Non	B	8.5	11.5	5	25	**22%**	S	54	0	6	0	1	0	**1**
	6.05[H]	Partial		1	12	6	19	**41%**	S	51	2	5	0	0	0	0
	3.70[W]	Partial		17	10	7.5	34.5	-8%	C	65	0	4	1	1	0	**2**
West Branch Mahoning River (WWH)	27.92[H]	Full		15	15	8.5	38.5	-20%	---	64.5	2	2	1	0	1	**2**
	24.35[H]	Full		14.5	17	6	37.5	-17%	---	72	0	2	1	1	1	**3**
	20.94[W]	Full		19	15.5	6	40.5	-27%	---	82	0	2	1	1	1	**3**
	11.39[W]	Partial	H	12	14	10	36	-13%	---	76	0	2	1	1	1	**3**
	3.15[B]	Non	H	0	6	5.5	11.5	**64%**	S / C	34.5	2	6	0	0	0	0
	0.40[B]	Full		14	14.5	10	38.5	-20%	---	78.5	0	1	1	1	1	**3**
Silver Creek (trib. to W. Branch)	3.46[H]	Full		12	14	4	30	**6%**	---	67	0	4	1	1	0	**2**
	1.83[H]	Full		16	16	7	39	-22%	---	68	0	1	1	1	1	**3**

Stream/River (Use)	River Mile[1]	Aquatic Life Use Attainment	Applicable TMDLs - Listed Cause[2] (B = bedload; H = habiteat)	Bedload TMDL						Habitat TMDL						
				Allocations			TMDL	% Deviation fromTarget[3]	Metrics with Substantial Deviation[4] (S = substrate; C = channel; R = riparian)	Allocations			Subscore			TMDL
				≥13	≥14	≥5	≥32			≥60 = 1pt	<2 = 1pt	<5 = 1pt				3
				QHEI Categories												
				Substrate	Channel	Riparian	Total Bedload Score			QHEI Score	# High Influence Atributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
(WWH)																
Hinkley Creek (WWH)	0.7[H]	Full		15	11	7.5	33.5	-5%	---	60.5	3	3	1	0	1	**2**
Barrel Run (WWH)	**5.31[H]**	Partial	H	14	12	7.5	33.5	-5%		67.5	1	5	1	0	0	**1**
	3.65[H]	Full		11	14	5.5	30.5	**5%**	---	61.5	0	6	1	1	0	**2**
Harmon Brook (WWH)	**0.49[H]**	Partial	B	14	15.5	6.5	36	-13%	---	77	0	3	1	1	1	**3**
Trib to West Branch Mahoning River at RM 0.01 (WWH)	**2.10[H]**	Non	B	9	14	7.5	30.5	**5%**	S	67.5	0	4	1	1	0	**2**
Trib to West Branch Mahoning River at RM 9.63 (WWH)	**0.6[H]**	Partial	H	8	8.5	3	19.5	**39%**	S / C	40.5	4	4	0	0	0	0

Stream/River (Use)	River Mile[1]	Aquatic Life Use Attainment	Applicable TMDLs - Listed Cause[2] (B = bedload; H = habiteat)	Bedload TMDL						Habitat TMDL						
				Allocations			TMDL	% Deviation fromTarget[3]	Metrics with Substantial Deviation[4] (S = substrate; C = channel; R = riparian)	Allocations			Subscore			TMDL
				≥13	≥14	≥5	≥32			≥60 = 1pt	<2 = 1pt	<5 = 1pt	QHEI	High Influence	# Modified Attributes	3
				QHEI Categories												
				Substrate	Channel	Riparian	Total Bedload Score			QHEI Score	# High Influence Atributes	Total # of Modified Attributes				Total Habitat Score
Trib to West Branch Mahoning River at RM 8.28 (WWH)	**0.27**[H]	Non	B / H	7	8	5.5	20.5	**36%**	S / C	42.5	2	7	0	0	0	0
Trib to Kale Creek at RM 5.29 (WWH)	**1.08**[H]	Partial	B	10	14	6.5	30.5	**5%**	S	56.5	1	5	0	0	0	0

1 H – Headwater site, W – Wading site, B – Boat site
2 Habitat TMDLs applicable to sites (i.e., indicated by river mile) with orange highlight and bold font; sediment TMDLs applicable to sites (i.e., indicated by river mile) that are have bold, underline font and are left aligned in the cell.
3 Causes for which habitat TMDLs are developed include: habitat alteration; flow alteration; alteration in streamside vegetation.
4 Negative values shown in light grey indicate where the minimum target is exceeded.
5 Deviations more than 20 to 25 percent of the target value are considered substantial. Deviations are not considered for sites that are not listed as impaired for sediment and/or habitat.

5.4 Eagle Creek - Mahoning River (05030103-04)

TMDLs were developed in these six 12-digt HUCs for bacteria (*E. coli*), sediment and habitat (QHEI), and nutrients (total phosphorus). The results are presented for the applicable assessment units (i.e., 12-digit HUCs) in the following sub-sections.

5.4.1 *E. coli* Bacteria (HUCs 04-01, 04-02, 04-03, 04-04, 04-05, 04-06)

Tables 5-33, 5-35, 5-37, 5-39, 5-40, and 5-42 provide the *E. coli* allocations for each flow interval in the load duration curves for sampling sites located in the 01, 02, 03, 04, 05, and 06 twelve-digit HUCs, respectively. Tables 5-34, 5-36, 5-38, 5-41, and 5-43 show the wasteload allocations for NPDES permitted facilities within the 01, 02, 03, 05, and 06 twelve digit HUCs, respectively. In this case the other 12-digit HUCs within this 10-digit HUC do not have NPDES facilities that are sources of *E. coli* bacteria.

Water samples were collected at least once during conditions reflective of three highest flow regimes, but none were collected during dry and low flows. A total of 38 samples were collected and seven of the eight sites each had four samples collected while one site had ten samples collected. Sample collection was not as evenly distributed across the flow regimes as it was in the other ten-digit HUCs since the wet flow condition (fifth to fortieth exceedance percentiles) only had samples collected at one of the eight sites. Eleven of the 38 samples are estimated to have had more than 50 percent of the flow as storm water.

E. coli loading was the lowest in this ten-digit HUC as compared to the others in the TMDL project area (from about three to six times greater than the target). Again the high flows showed the higher exceedance of target loading but differences across the flow regimes cannot be well determined due to the fairly uneven sampling distribution. The site at the USGS gage on Eagle Creek (NO2PO8) stands out as the one with the highest exceedance of the target loads. The drainage area is nearly 100 square miles and this point received effluent from several upstream wastewater dischargers; however the outfalls to these facilities are at least six river miles upstream of this sample point. A series of wetlands are located immediately upstream of this sample (based on Ohio's Wetland Inventory) location making wildlife wastes perhaps a more significant sources in this area.

Table 5-33. *E. coli* TMDLs for the 05030103-04-01 12-digit HUC.

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N02S02 - South Fork Eagle Cr. (RM 2.3; Drainage area = 5.20 square miles)					
Samples Collected	1		3		
Sample Median Load	213		7		
NPDES Point Source Existing Load	0.06	0.06	0.06	0.06	0.06
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	34.8	2.4	0.8	0.4	0.3
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	18.2%	No Data	40.5%	No Data	No Data
LA (Non-Point Allocation)	173.94	11.91	4.16	1.95	1.45
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	8.70	0.60	0.21	0.10	0.08
WLA (NPDES Point/MS4 permits)	0.06	0.06	0.06	0.06	0.06
TMDL minus (MOS + Future Growth)	174.01	11.97	4.22	2.02	1.51
N02S03 - Silver Cr. (RM 0.79; Drainage area = 11.20 square miles)					
Samples Collected	1		3		
Sample Median Load	849		20		
NPDES Point Source Existing Load	1.22	1.22	1.22	1.22	1.22
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	74.9	5.2	1.8	0.9	0.7
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	55.9%	No Data	54.2%	No Data	No Data
LA (Non-Point Allocation)	373.52	24.56	7.83	3.13	2.06
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	18.74	1.29	0.45	0.22	0.16
WLA (NPDES Point/MS4 permits)	1.22	1.22	1.22	1.22	1.22
TMDL minus (MOS + Future Growth)	374.74	25.78	9.04	4.35	3.28

Table 5-34. *E. coli* wasteload allocations for the 05030103-04-01 12-digit HUC.

Regulated point source	**NPDES OEPA ID**	**Exist Flow Avg MGD**	**Design Flow Avg MGD**	**Conc Limit**	**WLA**
Camp Asbury Central	3PR00220	0.0013	0.009	161	0.055
Custom Poly Bag Inc	3PR00389	0.0016	0	161	0.009
Hiram WWTP	3PB00020	0.1160	0	161	1.219

Table 5-35. *E. coli* TMDLs for the 05030103-04-02 12-digit HUC.

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N02K06 - South Fork Eagle Cr. (RM 2.3; Drainage area = 23.50 square miles)					
Samples Collected	1		3		
Sample Median Load	1,470		69		
NPDES Point Source Existing Load	2.74	2.74	2.74	2.74	2.74
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	157.3	10.8	3.8	1.8	1.4
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	46.5%	No Data	72.4%	No Data	No Data
LA (Non-Point Allocation)	783.54	51.30	16.23	6.36	4.10
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	39.31	2.70	0.95	0.46	0.34
WLA (NPDES Point/MS4 permits)	2.74	2.74	2.74	2.74	2.74
TMDL minus (MOS + Future Growth)	786.28	54.04	18.97	9.11	6.84

Table 5-36. *E. coli* wasteload allocations for the 05030103-04-02 12-digit HUC.

Regulated point source requirements	**NPDES OEPA ID**	**Exist Flow Avg MGD**	**Dgn Flow Avg MGD**	**Conc Limit**	**WLA**
Windham WWTP	3PC00019	0.349	0	161	2.74
Harbison Walker Refractories Windham Works	3IE00043	0	0	0	0

Table 5-37. *E. coli* TMDLs for the 05030103-04-03 12-digit HUC.

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N02K09 - Mahoning Cr. (RM 0.7; Drainage area = 3.70 square miles)					
Samples Collected	1		3		
Sample Median Load	490		14		
NPDES Point Source Existing Load	0.00	0.00	0.00	0.00	0.00
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	24.8	1.7	0.6	0.3	0.2
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	74.7%	No Data	78.7%	No Data	No Data
LA (Non-Point Allocation)	123.81	8.54	2.99	1.45	1.10
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	6.19	0.43	0.15	0.07	0.06
WLA (NPDES Point/MS4 permits)	-	-	-	-	-
TMDL minus (MOS + Future Growth)	123.81	8.54	2.99	1.45	1.10
N02K10 - Eagle Cr. (RM 15.04; Drainage area = 36.00 square miles)					
Samples Collected	1		3		
Sample Median Load	3,682		80		
NPDES Point Source Existing Load	4.84	4.84	4.84	4.84	4.84
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	240.9	16.6	5.8	2.8	2.1
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	67.3%	No Data	63.5%	No Data	No Data
LA (Non-Point Allocation)	1,199.70	77.97	24.25	9.12	5.62
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	60.23	4.14	1.45	0.70	0.52
WLA (NPDES Point/MS4 permits)	4.84	4.84	4.84	4.84	4.84
TMDL minus (MOS + Future Growth)	1204.54	82.81	29.09	13.96	10.46

Table 5-38. *E. coli* wasteload allocations for the 05030103-04-03 12-digit HUC.

Regulated point source	**NPDES OEPA ID**	**Exist Flow Avg MGD**	**Design Flow Avg MGD**	**Conc Limit**	**WLA**
Hiram WWTP	3PB00020	0.116	0.200	161.00	1.219
Blackbrook Valley Estates	3PG00093	0.064	0.030	161	0.183
Therm-O-Link Inc	3IQ00059	0	0	0.000	0
Western Reserve WWTP	3PG00121	0.022	0	161.000	0.134
Northern Ohio Multipurpose	3IH00073	0.350	0.350	0.000	0
Garrettsville WWTP	3PB00016	0.281	0.500	161	3.047
Homestead Manor MHP	3PV00103	0.030	0.030	161	0.183
Camp Asbury Central	3PR00220	0.001	0.009	161	0.055
Johnson Farm Recreational Camp	3PR00387	0.003	0.003	161	0.018

Table 5-39. *E. coli* TMDLs for the 05030103-04-04 12-digit HUC.

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N02K02 - Tinker Cr. (RM 2.5; Drainage area = 11.20 square miles)					
Samples Collected	1		3		
Sample Median Load	485		210		
NPDES Point Source Existing Load	0.00	0.00	0.00	0.00	0.00
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	74.9	5.2	1.8	0.9	0.7
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	22.8%	No Data	95.7%	No Data	No Data
LA (Non-Point Allocation)	374.74	25.78	9.04	4.35	3.28
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	18.74	1.29	0.45	0.22	0.16
WLA (NPDES Point/MS4 permits)	-	-	-	-	-
TMDL minus (MOS + Future Growth)	374.74	25.78	9.04	4.35	3.28

Table 5-40. *E. coli* TMDLs for the 05030103-04-05 12-digit HUC.

***E. coli* TMDL Allocation (billion/day)**	**Higher Flows**	**Wet Weather**	**Mid-Range Summer**	**Dry Weather**	**Low**
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
N02P08 - Eagle Cr. (RM 5.6; Drainage area = 97.80 square miles)					
Samples Collected	2	1	7		
Sample Median Load	89,391	4,644	137		
NPDES Point Source Existing Load	7.58	7.58	7.58	7.58	7.58
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	511.1	35.1	12.3	5.9	4.4
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	97.1%	96.2%	54.8%	No Data	No Data
LA (Non-Point Allocation)	2,548.09	168.08	54.07	22.01	14.61
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	127.78	8.78	3.08	1.48	1.11
WLA (NPDES Point/MS4 permits)	7.58	7.58	7.58	7.58	7.58
TMDL minus (MOS + Future Growth)	2555.67	175.66	61.65	29.59	22.20

Table 5-41. *E. coli* wasteload allocations for the 05030103-04-05 12-digit HUC.

Regulated point source	NPDES OEPA ID	Exist Flow Avg MGD	Design Flow Avg MGD	Conc Limit	WLA 0.5
Hiram WWTP	3PB00020	0	0.200	161	1.219
Blackbrook Valley Estates	3PG00093	0	0.030	161	0.183
Therm-O-Link Inc	3IQ00059	0	0.000	0	0
Western Reserve WWTP	3PG00121	0	0.022	161	0.134
Northern Ohio Multipurpose	3IH00073	0.350	0.350	0	0
Garrettsville WWTP	3PB00016	0.281	0.500	161	3.047
Homestead Manor MHP	3PV00103	0.030	0.030	161	0.183
Camp Asbury Central	3PR00220	0.001	0.009	161	0.055
Johnson Farm Recreational Camp	3PR00387	0.003	0.003	161	0.018

Table 5-42. *E. coli* TMDLs for the 05030103-04-06 12-digit HUC.

***E. coli* TMDL Allocation (billion/day)**	Higher Flows	Wet Weather	Mid-Range Summer	Dry Weather	Low
Recreation Season Interval	0-5%	5-40%	40-80%	80-95%	95-100%
602280 - Mahoning River (RM 5.6; Drainage area = 575.00 square miles)					
Samples Collected					
Sample Median Load					
NPDES Point Source Existing Load	67.86	67.86	67.86	67.86	67.86
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	3011.3	207.0	72.6	34.9	26.2
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	No Data	No Data	No Data	No Data	No Data
LA (Non-Point Allocation)	14,989	967	295	106	63
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	752.82	51.74	18.16	8.72	6.54
WLA (NPDES Point/MS4 permits)	67.86	67.86	67.86	67.86	67.86
TMDL minus (MOS + Future Growth)	15056.48	1034.85	363.24	174.36	130.78
N03S64 - Mahoning River (RM 45.73; Drainage area = 542.00 square miles)					
Samples Collected	1		3		
Sample Median Load	41,086		4,239		
NPDES Point Source Existing Load	67.86	67.86	67.86	67.86	67.86
Margin of Safety (%)	20%	20%	20%	20%	20%
Margin of Safety (Load)	2838.5	195.1	68.5	32.9	24.7
Included Upstream TMDL Allocation	0	0	0	0	0
Subwatershed % Reduction Required	65.5%	No Data	91.9%	No Data	No Data
LA (Non-Point Allocation)	14,125	908	275	96	55
Allowance for Future Growth (%)	4%	4%	4%	4%	4%
Allowance for Future Growth	709.62	48.77	17.12	8.22	6.16
WLA (NPDES Point/MS4 permits)	67.86	67.86	67.86	67.86	67.86
TMDL minus (MOS + Future Growth)	14192.36	975.46	342.40	164.34	123.26

Table 5-43. *E. coli* wasteload allocations for the 05030103-04-06 12-digit HUC.

Regulated Point Sources	NPDES OEPA ID	Exist Flow Avg MGD	Design Flow Avg MGD	Conc Limit	WLA
ODOT Rest Area 04-35 WWTP	3PP00033	0.004	0.020	126	0.0954
Southeast High School	3PT00016	0.015	0.050	126	0.2385
The Diamond Lodge	3PR00505	0.010	0.010	126	0.0477
Gionino's Pizza	3PR00390	0.000	0.002	126	0.0072
Maple Del Manor MHP	3PV00034	0.027	0.040	126	0.1908
Crest Rubber Co	3IR00015	0.108	0.001	0	0.0000
Countryside Estates	3PG00120	0.026	0.035	126	0.1669
Country Acres Campground 1	3PR00234	0.003	0.010	126	0.0477
Leisure Lake Park	3PR00265	0.817	0.038	126	0.1789
ODNR Beach Area W Branch SP	3PP00010	0.004	0.100	126	0.4770
Arnies West Branch Steak House	3PR00174	0.001	0.003	126	0.0159
Jolly Time MHP	3PV00085	0.001	0.002	126	0.0110
KMV III Ltd DBA Hamlet MHP	3PV00041	0.016	0.020	126	0.0954
Newton Falls STP	3PD00015	1.108	1.500	126	7.1544
RC Sports Lounge	3PR00323	0.000	0.004	126	0.0167
Craig Beach WWTP	3PH00030	0.527	1.000	126	4.7696
Industrial Mining - City Stone	3IJ00067	0.350	0.000	0	0.0000
Green Acres Campground	3PR00221	0.003	0.005	126	0.0238
Washington Elementary School	3PT00101	0.005	0.008	161	0.0488
North East Ohio Church of God Campground	3PR00437	0.014	0.014	126	0.0668
Ben's Restaurant and Bar	3PR00491	0.004	0.004	126	0.0174
US Corp of Engineers Mill Creek R	3PN00000	0.020	0.030	126	0.1431
Pelican Grove Campground	3PR00348	0.001	0.001	126	0.0038
Circle Restaurant Inc	3PR00120	0.001	0.004	126	0.0209
Nemenz Food Mart	3PR00210	0.001	0.002	126	0.0072
Modern Management Solutions DBA All Seasons MHP	3PV00047	0.035	0.055	126	0.2623
Alliance WWTP	3PD00000	5.255	7.500	126	35.7722
Grace Community Church of Alliance	3PR00451	0.005	0.005	126	0.0238
Stark County Village Green Allot STP	3PG00087	0.028	0.020	126	0.0954
Trilogy Alliance	3IN00347	0.018	0.000	0	0.0000
Paradise Lake Park Campground STU 1	3PR00325	0.020	0.020	161	0.1219
Timashamie Family Campground	3PR00305	0.004	0.025	161	0.1524
Knox Elementary School - West Branch	3PT00123	0.002	0.007	126	0.0334
Sebring WTP	3IV00182	0.049	0.050	0	0.0000
West Branch Nursing Home LLC	3PR00458	0.012	0.012	126	0.0560
Damascus WWTP	3PA00037	0.055	0.008	126	0.0382
Country Squire Estates Ltd	3PV00130	0.030	0.010	126	0.0477
Beloit WWTP	3PB00005	0.069	0.190	126	0.9062
Tecumseh Village MHP	3PV00023	0.002	0.013	126	0.0596
Sebring Landfill Facility	3IN00351	0.018	0.000	0	0.0000
BP Amoco Oil Corp Bulk Plant Alliance	3IN00287	0.001	0.000	0	0.0000
Sebring WWTP	3PC00011	0.747	1.500	126	7.1544
Central Waste Inc	3IN00313	0.005	0.000	0	0.0000
Alliance Tubular Products Co	3ID00043	1.700	0.069	0	0.0000
Pelican Grove Campground	3PR00373	0.001	0.001	126	0.0038
Buckeye Packaging Co Inc	3PR00259	0.001	0.004	161	0.0213
Custom Poly Bag Inc	3PR00389	0.002	0.002	161	0.0091
Atwater WWTP	3PH00033	0.107	0.200	126	0.9539
Waterloo K-12 Campus	3PT00079	0.006	0.020	161	0.1219

Regulated Point Sources	NPDES OEPA ID	Exist Flow Avg MGD	Design Flow Avg MGD	Conc Limit	WLA
Evrol LLC Atwater Terminal	3IG00025	0.000	0.000	0	0.0000
Nemenz Little Village Shoppe Inc	3PR00190	0.001	0.003	126	0.0121
Stark County Village Green Allot STP	3PG00087	0.028	0.020	126	0.0954
Trilogy Alliance	3IN00347	0.018	0.000	0	0.0000
Washington Elementary School	3PT00101	0.005	0.008	161	0.0488
Marlington Local Schools	3PT00045	0.021	0.045	126	0.2146
Western Reserve High School	3PT00143	0.002	0.024	126	0.1145
Hiram WWTP	3PB00020	0.116	0.200	161	1.2189
Blackbrook Valley Estates	3PG00093	0.064	0.030	161	0.1828
Therm-O-Link Inc	3IQ00059	0.033	0.000	0	0.0000
Western Reserve WWTP	3PG00121	0.022	0.022	161	0.1341
Northern Ohio Multipurpose	3IH00073	0.350	0.350	0	0.0000
Garrettsville WWTP	3PB00016	0.281	0.500	161	3.0473
Homestead Manor MHP	3PV00103	0.030	0.030	161	0.1828
Camp Asbury Central	3PR00220	0.001	0.009	161	0.0549
Johnson Farm Recreational Camp	3PR00387	0.003	0.003	161	0.0183
Windham WWTP	3PC00019	0.349	0.450	161	2.7425
Harbison Walker Refractories Windham Works	3IE00043	0.099	0.065	0	0.0000
Southington Local School Dist	3PT00134	0.002	0.024	126	0.1145
Arhaven Estates MHP	3PV00064	0.013	0.018	126	0.0835
PK Rentals	3GV00030	0.010	0.010	126	0.0477
William C Wilson	3GV00027	0.010	0.010	126	0.0477
Short Stop Truck Plaza	3PR00162	0.007	0.010	126	0.0477
Denman Tire Corp	3IR00002	0.057	0.130	0	0.0000
Warren No 3 WWTP	3PG00106	0.016	0.013	126	0.0596
Full Convenant Tabernacle Church	3GV00035	0.010	0.010	126	0.0477
Top of the Hill Store	3GV00019	0.010	0.010	126	0.0477
Ridge Ranch Campgrounds Sh	3PR00310	0.002	0.003	126	0.0143
Pleasant Park Mobile Court	3PV00067	0.021	0.023	126	0.1073
Delightful Auto Center	3GV00021	0.010	0.010	126	0.0477

5.4.2 Sediment and Habitat (HUCs 04-01, 04-02)

Poor habitat quality and sediment is impairing aquatic life at one each. The deficit is 24 percent for the overall QHEI scores for the site impaired by habitat only and the riffle metric was the most problematic. For sediment, the deficits was 100 percent for the substrate metric, zero percent for the riparian metric, and zero percent for the channel metric. Table 5-44 shows the results of TMDLs developed to address aquatic life impairments caused by fine sediment and poor habitat quality using the QHEI.

Table 5-44. Sediment and Habitat TMDLs for the 05030103-04 10-digit HUC based on QHEI metrics (total score and substrate, riparian, and channel scores).

Stream/River (Use)	River Mile[1]	Aquatic Life Use Attainment	Applicable TMDLs - Listed Cause[2] (B = bedload; H = habiteat)	Bedload TMDL						Habitat TMDL						
				Allocations			TMDL	% Deviation fromTarget[3]	Metrics with Substantial Deviation[4] (S = substrate; C = channel; R = riparian)	Allocations			Subscore			TMDL
				≥13	≥14	≥5	≥32			≥60 = 1pt	<2 = 1pt	<5 = 1pt				3
				QHEI Categories												
				Substrate	Channel	Riparian	Total Bed-load Score			QHEI Score	# High Influence Atributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Mahoning River EOLP Ecoregion (WWH)	**54.73[B]**	Partial		8	12	7.5	27.5	**14%**	S	58.5	1	5	0	0	0	0
	45.70[B]	Non		9	7	7.5	23.5	**27%**	S / C	48.5	2	6	0	0	0	0
Chocolate Run (WWH)	**0.11[H]**	Non	B / H	9	9.5	5	23.5	**27%**	S / C	46.5	2	4	0	0	0	0
Eagle Creek (WWH)	22.44[H]	Non		4.5	12	7.5	24	**25%**	S	54	1	5	0	0	0	0
	17.61[W]	Full		15	16	7.5	38.5	-20%	---	81.5	0	4	1	1	0	**2**
	15.04[W]	Full		13	12.5	8	33.5	-5%	---	61.5	0	4	1	1	0	**2**
	10.10[W]	Full		10	10.5	6.5	27	**16%**	S / C	53	0	6	0	1	0	**1**
	5.60[B]	Non		11	14.5	5.5	31	**3%**		65	0	4	1	1	0	**2**
Tinker Creek (WWH)	5.45[H]	Partial		10.5	17	5.5	33	-3%	S	68	0	2	1	1	1	**3**
	2.50[H]	Partial		14	11.5	5	30.5	**5%**		68.5	2	2	1	0	1	**2**
Nelson Ditch (WWH)	**0.4[H]**	Non	B / H	5.5	6	5.5	17	**47%**	S / C	44	3	5	0	0	0	0
South Fork Eagle Creek (WWH)	3.86[H]	Full		9	13	8.5	30.5	**5%**	S	66.5	0	5	1	1	0	**2**
	2.30[W]	Full		10	14	8	32	0%	S	61	1	6	1	0	0	**1**

Stream/River (Use)	River Mile[1]	Aquatic Life Use Attainment	Applicable TMDLs - Listed Cause[2] (B = bedload; H = habiteat)	Bedload TMDL						Habitat TMDL						
				Allocations			TMDL	% Deviation fromTarget[3]	Metrics with Substantial Deviation[4] (S = substrate; C = channel; R = riparian)	Allocations			Subscore			TMDL
				≥13	≥14	≥5	≥32			≥60 = 1pt	<2 = 1pt	<5 = 1pt				3
				QHEI Categories												
				Substrate	Channel	Riparian	Total Bed-load Score			QHEI Score	# High Influence Atributes	Total # of Modified Attributes	QHEI	High Influence	# Modified Attributes	Total Habitat Score
Camp Creek (CWH)	3.16[H]	Full		16	14	6.5	36.5	-14%	---	74	1	4	1	0	0	**1**
Silver Creek (trib. to Eagle Creek) (CWH)	2.26[H]	Full		11	12	6	29	**9%**	---	66	0	4	1	1	0	**2**
	0.79[H]	Full		12.5	7.5	6.5	26.5	**17%**	---	64	2	4	1	0	0	**1**
Mahoning Creek (WWH)	**0.7**[H]	Non	B	0	14	9	23	**28%**	S	54	1	5	0	0	0	0

1 H – Headwater site, W – Wading site, B – Boat site
2 Habitat TMDLs applicable to sites (i.e., indicated by river mile) with orange highlight and bold font; sediment TMDLs applicable to sites (i.e., indicated by river mile) that are have bold, underline font and are left aligned in the cell.
3 Causes for which habitat TMDLs are developed include: habitat alteration; flow alteration; alteration in streamside vegetation.
4 Negative values shown in light grey indicate where the minimum target is exceeded.
5 Deviations more than 20 to 25 percent of the target value are considered substantial. Deviations are not considered for sites that are not listed as impaired for sediment and/or habitat.

5.4.3 Total Phosphorus (HUCs 04-01, 04-03, 04-04)

Three sites were impaired for nutrients in this 10-digit HUC that were addressed with the GWLF watershed loading model. The area covered by this modeling includes four entire 12-digit HUCs (01 through 04) and part of another one (05). Other nutrient impaired sites were not addressed.

Based on the watershed model, cropland is the largest source of total phosphorus to the producing 91.66% of the total load for the drainage. All other sources are minimal in comparison and point sources comprise only 2.81% of the total phosphorus load (all combined waste water design volume is about five percent of the average stream flow in the Mahoning River at the Alliance stream gage – see Table 5-47 for design discharge).

For Eagle Creek at Phalanx Station gage, the summer and autumn seasons required reductions of total phosphorus as 80% and 62%, respectively. Spring and winter values for total phosphorus existing load medians fell within the TMDL 95% confidence interval of the median which required no reductions in existing load.

Figure 5-3 presents the seasonally grouped data (see Section 5.1.3 for months included in each of the seasons) for the Eagle Creek at Phalanx Station gage. The box and whisker plots in this figure are also explained in Section 5.1.3. Table 5-45 provides the median loads and the corresponding median TMDLs for the seasons within this drainage. Again, decisions about needed reductions were made by visual median hypothesis test. Reductions are calculated as stated previously by equating medians of the existing load and TMDL groups.

The summer and autumn seasons require reductions in total phosphorus of non-point sources of 83.1% and 65.7%, respectively. The median values for the existing total phosphorus load in spring and winter fell within the 95% confidence interval of the median TMDL therefore no load reductions are required. Total load reductions and associated allocations were proposed for these seasons in Table 5-46. Table 5-47 provides individual source loads and TMDL allocations with corresponding percent reductions.

For point source loads, 17% is proposed for both spring and summer within this watershed. To assure point source discharges are allocated appropriate load reductions, effluent limits were set to 1 mg/L total phosphorus for facilities with a design discharge of more than 150,000 gallons per day. Table 5-47 indicates this proposed concentration limit and associated discharge load allocated to the respective point source. These limits are proposed only during seasons in which loads reductions are needed to meet TMDL goals (i.e., summer and autumn). For septic systems, 100% reduction is needed.

Again, an explicit 5% margin of safety for each reduced source, except failing septics, was added to the TMDL value prior to determination of gross reductions needed. Pollutant yields for all sources can be viewed in Table 5-48 for Eagle Creek at Phalanx Station gage.

Table 5-45. Total phosphorus TMDLs for Eagle Creek and tributaries.

Season	Median Existing Daily Load (kg/d)	Median Daily TMDL (kg/day)	TMDL MOS (%)	Total Reduction	
				(kg/d)	Percent
Spring	26,360	27,402	0%	-	0%
Summer	27,325	5,872	5%	21,747	80%
Autumn	17,342	6,850	5%	10,834	62%
Winter	21,498	22,509	0%	-	0%

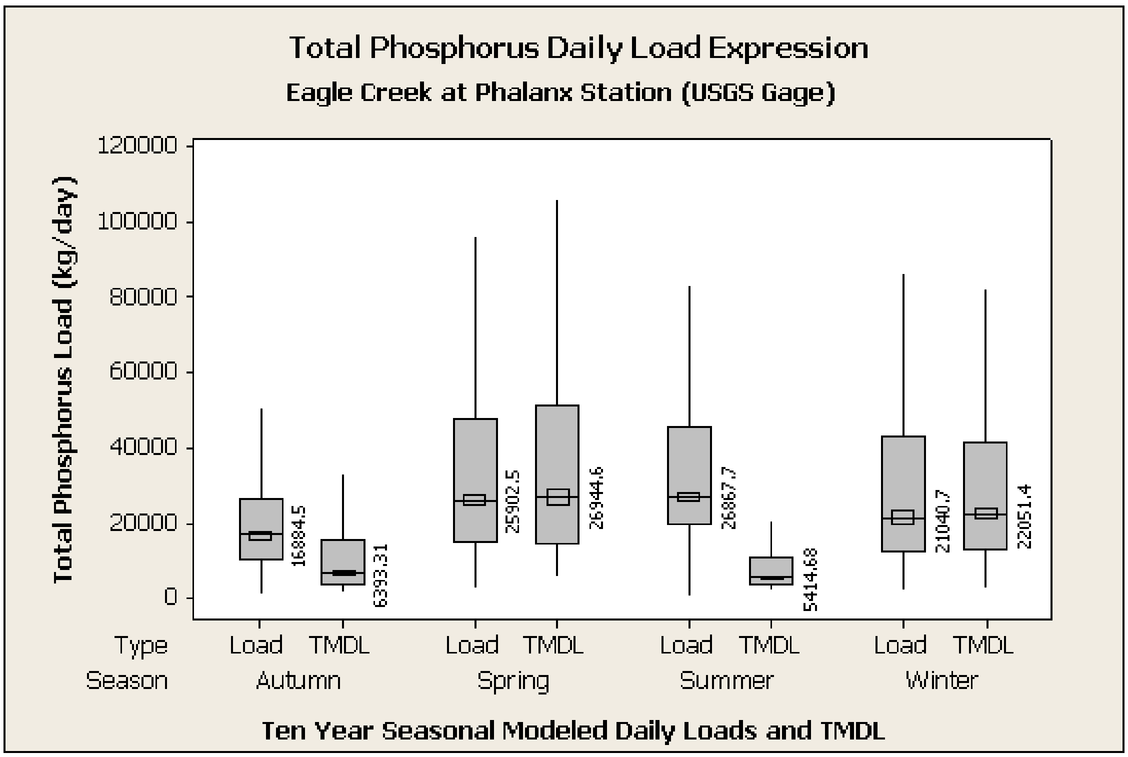

Figure 5-3. Eagle Creek at Phalanx Station Gage Daily Load and TMDL Modeled over 10 years for Total Phosphorus (median 95% confidence interval range and values are presented).

Table 5-46. Allocations and percent reductions for total phosphorus by source within the GWLF modeled area that employs the Phalanx Station gage on Eagle Creek (12-digit HUCs 01 through 05).

SOURCE	Spring Load					Summer Load				
	Total P (kg/d)	TMDL (kg/d)	MOS (%)	Reduction (%)	Total Reduction (kg/d)	Total P (kg/d)	TMDL (kg/d)	MOS (%)	Reduction (%)	Total Reduction (kg/d)
Water	74.3	74.3	0%	0%	-	46.6	46.6	0%	0%	-
Urban	272.7	48.4	5%	83%	226.7	171	61.8	5%	66%	112.3
Other_Urban	187.7	33.3	5%	83%	156.1	117.7	42.6	5%	66%	77.3
Forest	312	312	0%	0%	-	195.6	195.6	0%	0%	-
Pasture	98.4	17.5	5%	83%	81.8	61.7	22.3	5%	66%	40.5
Cropland	25,406.1	4,507.2	5%	83%	21,124.3	15929.9	5,755.87	5%	66%	10,461.82
Wetland	413.2	413.2	0%	0%	-	259.1	259.1	0%	0%	-
Groundwater	-	-	0%	0%	-	0	-	0%	0%	-
Point Source	10.5	9.1	5%	17%	1.7	10.5	9.1	5%	17%	5.1
Septic Systems	103.3	-	5%	100%	103.3	103.3	-	5%	100%	103.3
TOTAL	**26,878.10**	**5,414.70**		**79.90%**	**21694**	**16895**	**6,393.30**		**62.20%**	**10,800.32**

Table 5-47. Existing and proposed loading information, including wasteload allocations for NPDES dischargers within the GWLF modeled area that employs the Phalanx Station gage on Eagle Creek (HUCs 01 through 05).

Permit Number	Facility	Design Flow (mgd)	Existing Total Phosphorus Effluent Concentration (mg/l)	Existing Total Phosphorus Load (kg/day)	Proposed Total Phosphorus Effluent Concentration (mg/l)	Proposed Total Phosphorus Load - WLA (kg/day)
3PB00020	Hiram WWTP	0.20	3.26	2.468	1	0.757
3PV00103	Homestead Manor MHP	0.03	0.794	0.090	1	0.114
3PR00387	Johnson Farm Recreational Camp	0.0030	3*	0.034	3	0.034
3IH00073	Northern Ohio Multi Purpose	0.35	1**	1.325	1	1.325
3PX00004	Modern Management Solutions DBA PM Estates	0.05	3*	0.568	3	0.568
3PG00093	Blackbrook Estates MHP	0.030	3.51	0.399	3.51	0.399
3PR00220	Camp Asbury WWTP	0.0090	3*	0.102	3	0.102
3PG00121	Western Reserve WWTP	0.0132	3*	0.150	3	0.150
3PC00019	Windham WWTP	0.45	0.745	1.269	1	1.703
3PB00016	Garrettsville WWTP	0.3560	3*	4.043	3	4.043
TOTAL		**1.491**	**na**	**10.448**	**na**	**10.519**

* Indicates estimate utilized for TMDL purposes for those facilities in which no data exists.
** Total P concentration is limited by NPDES permit.

Table 5-48. Total annual loads and pollutant yields per the significant sources within the GWLF modeled area that employs the Phalanx Station gage on Eagle Creek (HUCs 01 through 05).

Source	Area (ha)	Total P (kg/d)	kg/ha/day	lb/ac/day	% of Total
Cropland	5,301	15,159	2.860	2.551	97%
Urban	2,188	214	0.098	0.087	1%
Septic Systems	na	103	na	na	1%
Pasture	2,806	73	0.026	0.023	0.5%
Forest	12,689	54	0.004	0.004	0.3%
Water	152	35	0.231	0.206	0.2%
Other_Urban	2,116	28	0.013	0.012	0.2%
Wetland	26	20	0.758	0.676	0.1%
Point Source	na	10	na	na	0.1%
Groundwater	na	-	na	na	0.0%
TOTAL	**25,278**	**15,697**	**0.621**	**0.549**	**100%**

5.5 Summary of TMDL Results

This sub-section examines the results of the respective TMDLs in terms of the entire project area.

5.5.1 Nutrient TMDLs (Total Phosphorus)

As discussed earlier in the report, nutrient enrichment constitutes one of the more widespread problems adversely impacting 18 of the 74 sites surveyed. The reductions calculated for meeting the target concentrations of total phosphorus (a limiting nutrient) ranged from about 44 to 96 percent in the headwaters of the Mahoning River and 62 to 80 percent in the Eagle Creek watershed. Table 5-49 shows these and other sites where total phosphorus is elevated. The relative magnitude of the exceedance of the target as well as the type of stream (i.e., headwater or wadeable) is indicated.

Table 5-49. Sites exceeding phosphorus target.

			One to Two times Target Value		
			Over Two times Target Value		
HUC_10	**RIVER**	**River Mile**	**Drainage Area (sq. mi.)**	**Headwater**	**Wadeable**
0503010301	Mahoning River at Winona Rd	102.24	3.2		
	Sulphur Ditch at Allied Rd. dwst Sebring WWTP,	0.47	0.8		
	Fish Creek at Lexington Rd	0.36	9.0		
	Fish Creek at Courtney Rd, second dwst crossing	2.00	4.5		
	Fish Creek at Johnson Rd	3.56	3.0		
	Naylor Ditch at Heritage Dr	3.63	4.5		
	Beech Creek at Vine St	3.54	17.4		
	Little Beech Creek at SR 619 at McCallum Rd	1.83	9.0		
0503010302	Deer Creek at Waterloo Rd	10.87	3.5		
	Willow Creek at Porter Rd	8.13	3.5		
	Island Creek at 12th St	2.65	19.1		
	Mill Creek at West Calla Rd	6.28	9.9		
	Mill Creek at Leffingwell Rd	3.64	19.1		
	Turkey Broth Creek at SR 534	3.36	4.9		
	Garfield Ditch at SR 165	0.66	4.0		
0503010303	Harmon Brook at Peck Rd	0.49	4.1		
	West Branch Mahoning River at Cooley Rd	27.92	5.0		
0503010304	Silver Creek at SR 82, dwst Hiram WWTP	0.79	11.2		
	Camp Creek at SR 305	3.16	4.2		
	Eagle Creek at Hopkins Rd	15.04	36.0		
	Eagle Creek at Brosius Rd	17.61	32.0		

Table 5-49. Sites exceeding phosphorus target.

			One to Two times Target Value		
			Over Two times Target Value		
HUC_10	**RIVER**	**River Mile**	**Drainage Area (sq. mi.)**	**Headwater**	**Wadeable**
	Mahoning Creek dwst PM Estates MHP discharge	0.70	3.7		
	Tinker Creek at Nicholson Rd	2.50	11.2		
	Chocolate Run	0.11	4.4		

5.5.2 Habitat and Sediment TMDLs (QHEI Analyses)

QHEI values less than 61.5 are below habitat goals for WWH streams (see Section 4.3.2). Figure 5-4 shows the upper Mahoning River basin QHEI scores for each site survey for habitat and aquatic life and the overall QHEI target score. Breakdown of the scores into three groups based on drainage area reveals a pattern of impact which is greater at the smaller watershed sizes (Table 5-50). When data is analyzed for the watershed sizes: headwaters (<20 mi^2), wadable streams (20 – 200 mi^2), and small rivers >200 mi^2, it is apparent that headwater streams and small rivers are seeing a disproportionate level of habitat impact. The headwater streams show 56% of the sites below the QHEI target, the smaller rivers show 71% of the sites below the target.

Although the QHEI scores indicate a disproportionate attainment status for different sized streams, statistical analysis shows no differences (Figure 5-5). The watershed is characterized by a large number of dams and reservoirs. Watershed segmentation contributes to habitat impacts and strongly influences biological health in the watershed.

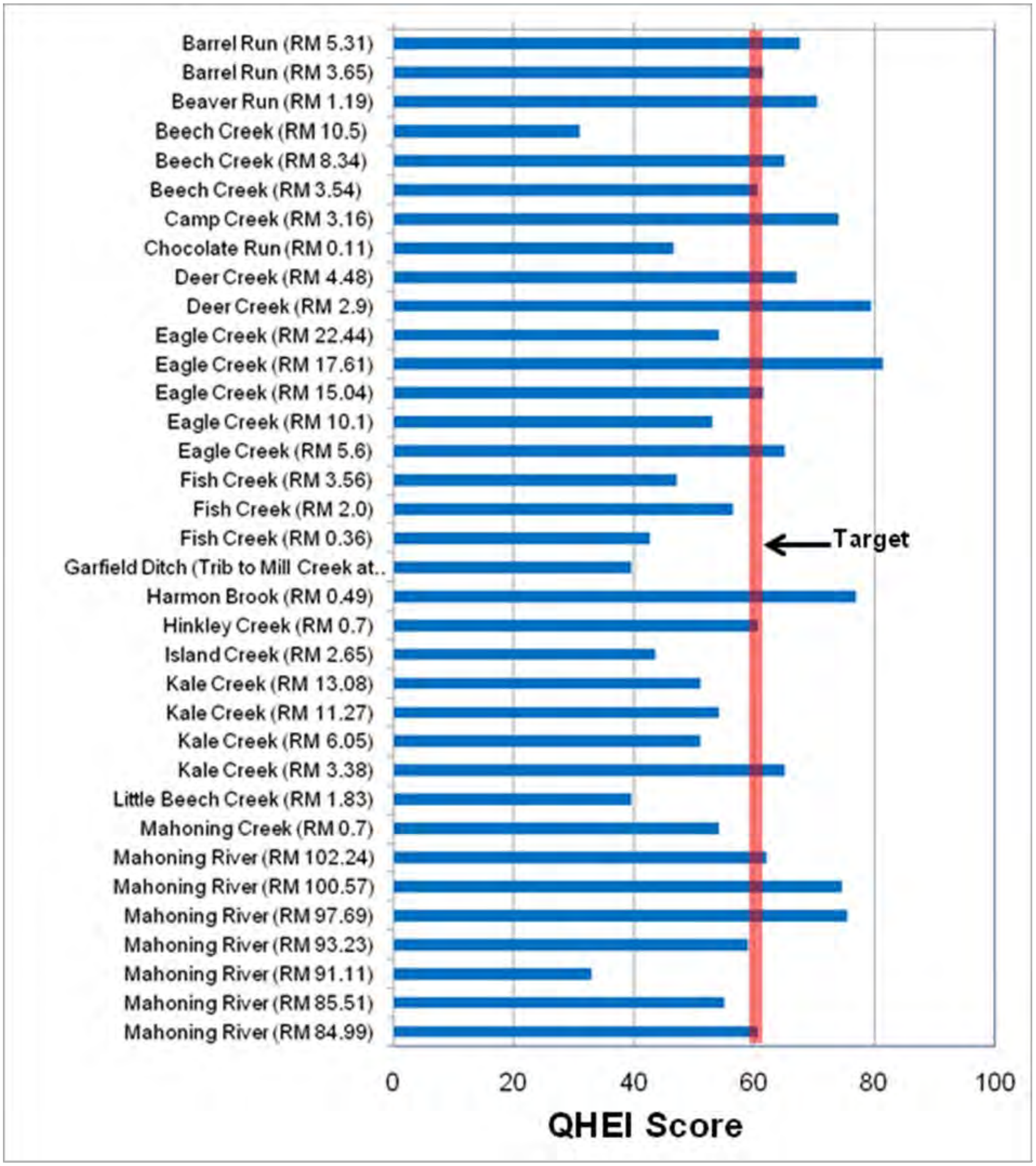

Figure 5-4. QHEI scores for upper Mahoning River watershed.

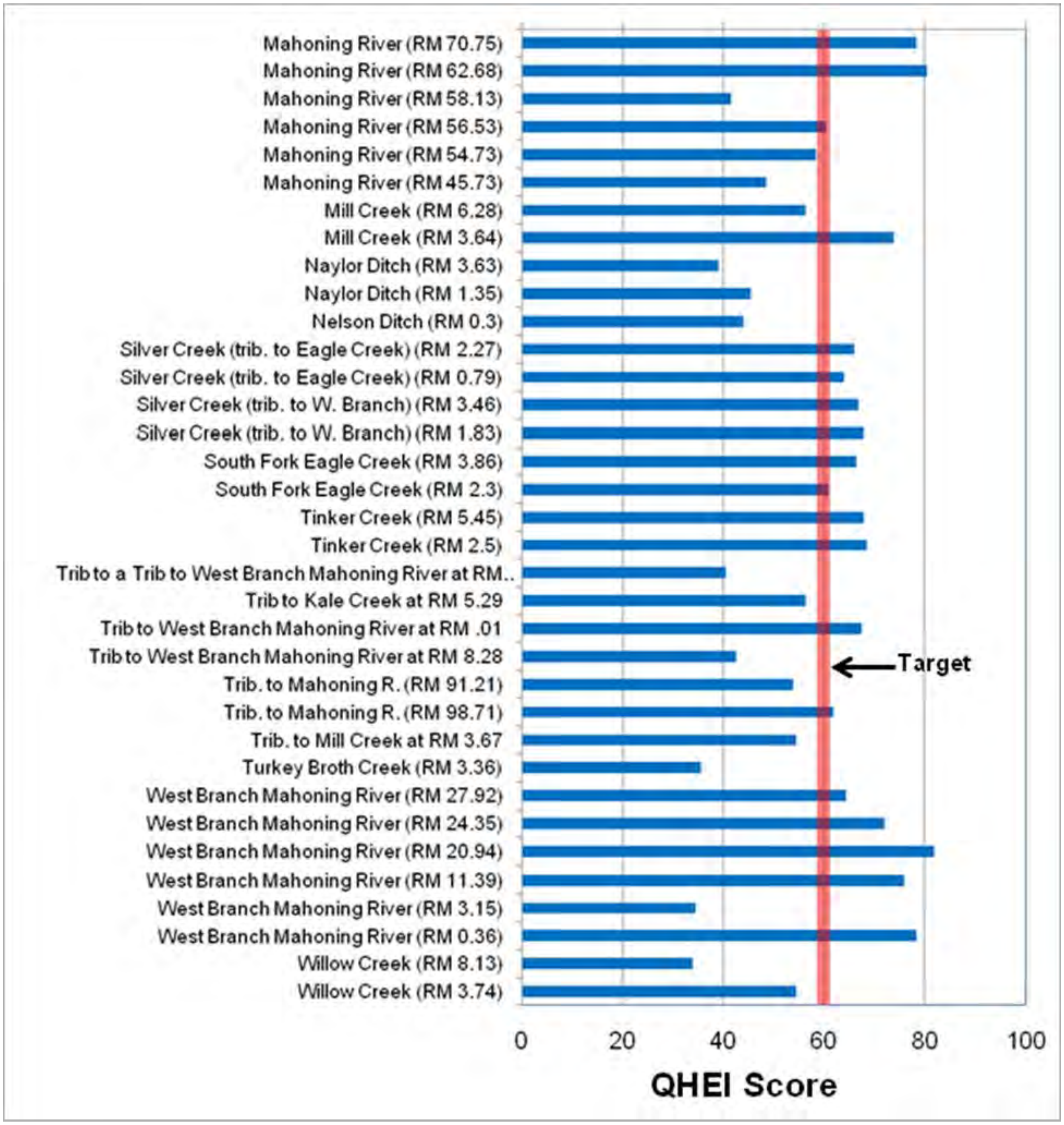

Figure 5-4 (continued). QHEI scores for upper Mahoning River watershed.

Table 5-50. Habitat target attainment by stream size (bolded values for >50%)

		QHEI	Substrate Score	Cover Score	Channel Score	Riparian Score	Pool Score	Riffle Score	Gradient Score
	Target	**61.5**	**11.1**	**13**	**12.6**	**5.6**	**8**	**3**	**8**
Headwater	Meets	44%	38%	**63%**	42%	**52%**	46%	42%	**69%**
	Does Not Meet	**56%**	**63%**	38%	**58%**	48%	**54%**	**58%**	31%
Wadable	Meets	**59%**	**59%**	**76%**	47%	**65%**	**88%**	**71%**	35%
	Does Not Meet	41%	41%	24%	**53%**	35%	12%	29%	**65%**
Small River	Meets	29%	**57%**	**71%**	29%	**71%**	**100%**	29%	**57%**
	Does Not Meet	**71%**	43%	29%	**71%**	29%	0%	**71%**	43%

6 WATER QUALITY IMPROVEMENT STRATEGY

A series of tables list actions appropriate for abating the water quality stressors at specific locations in the basin. The recommended actions are well established practices with proven effectiveness. Details regarding these practices are included in Appendix E of this report. Additionally, Appendix E compiles various programs and organizations that can be sources for assistance in carrying out the recommended actions.

The actions recommended are not the only means for making the water quality improvements but rather highlight the some common approaches. Additionally, there is redundancy in these recommendations because certain stressors can be addressed by a variety of approaches (e.g., both naturalizing watershed hydrology and stream restoration improve habitat quality). The abatement options were selected considering effectiveness coupled with efficiency. In other words more costly actions may produce similar or greater levels of improvement but this may go beyond the minimum level of abatement needed in addressing the stressors causing impairments. Additionally, good land management practices are applicable everywhere so not specifically recommending a management practice does not necessarily suggest that a given management practice is inappropriate in that location. The recommendations are made to prioritize watershed restoration activities and not merely list what is beneficial. A primary objective of these recommendations is to assist watershed planning and/or provide guidance regarding investments that are made to improve water quality.

Table 6-1 lists the actions that are to be taken through regulatory authority. These are relegated to the Ohio EPA and deal with NPDES permitting and compliance. This table is used separately and placed first in this section because these actions have the highest assurances of being implemented. The subsequent tables provide more detail about the recommendations for each assessment area.

Following discussion about actions to be taken that fall under the regulatory process, the remainder of the chapter discusses all recommendations to address water quality stressors organized by ten digit hydrologic units (HUC 10s). Within each of these sub-sections the individual sub-watersheds (HUC 12s) are discussed individually.

6.1 Regulatory Measures for Abatement

This section summarizes recommendations from this TMDL that can be implemented using Ohio EPA's regulatory authority. This differs from other recommendations found in this plan regarding land management or other measures that currently have no associated regulations. The National Pollution Discharge Elimination System (NPDES) is the primary regulatory means for making improvements to restore water quality. Table 6-1 shows the recommendations for NPDES permit holders.

Table 6-1. NPDES permit limits for facilities in the lower Little Miami River watershed.

Area of Assessment (last four HUC 12 digits)	Facility name / design flow / Ohio EPA permit number	Permit expiration date	Recommendation
01 - 03	Beloit WWTP / 3PB00005[1]	2/29/2016	Total phosphorus limit = 1.0 mg/l and monitoring required
01 - 03	Sebring WWTP / 3PC00011[2]	8/31/2015	Total phosphorus limit = 1.0 mg/l and monitoring required
02 - 01	Atwater WWTP / 3PH00033	5/31/2012	Total phosphorus limit = 1.0 mg/l and monitoring required
04 – 01	Hiram WWTP / 3PB00020	5/31/2013	Total phosphorus limit = 1.0 mg/l and monitoring required
04 - 02	Windham WWTP / 3PC00019	12/31/2012	Total phosphorus limit = 1.0 mg/l and monitoring required
04 - 03	Garrettsville WWTP / 3PB00016	10/31/2015	Total phosphorus limit = 1.0 mg/l and monitoring required
04 - 03	Modern Management Solutions DBA PM Estates / 3PX00004	9/30/2010	Total phosphorus limit = 1.0 mg/l and monitoring required
04 - 03	Northern Ohio Multipurpose / 3IH00073	9/30/2010	Total phosphorus limit = 1.0 mg/l and monitoring required

[1] A monthly average effluent limit of 1.0 mg/l of total phosphorus will be in effect starting 01/01/2015.
[2] A maximum effluent limit of 1.0 mg/l of total phosphorus will be in effect starting 09/01/2013.

Table 6.2 in this section lists impairments to aquatic life and recreation uses for each impaired assessment unit including major cause/source associations (sources are listed with causes in parentheses) and an associated suite of potential abatement actions are marked. The abatement actions are grouped in general categories which are described in more detail in subsections for each assessment unit. Each of the following sections represents a 10-digit HUC unit of the project area and the subsections represent the constituent 12-digit HUC units.

6.2 Mahoning River – headwaters to below Beech Cr. (05030103-01)

Seven out of 20 sites (35 percent) surveyed fully meet aquatic life use criteria; however 50 percent meet none of the criteria and 15 percent met some but not all of the criteria. Water quality problems were associated mostly with siltation and nutrient enrichment from cropland sources while poor habitat and disturbed flow conditions contributed a relatively small portion of the problems in this HUC. Recreation uses were impaired at all 21 sites (100 percent) surveyed in this ten digit HUC with failed septic systems being the source of bacteria for the majority of the sites. However, inadequate waste water treatment may be causing problems on the mainstem of the Mahoning River and livestock wastes are a likely source in some discrete areas. Figure 6-1 shows the assessment sites that are impaired for aquatic life and recreation uses. The following subsections examine issues on a smaller scale for increased resolution of the water quality improvement strategy. Table 6-2 summarizes all of the recommended actions for abating water quality issues in this ten-digit HUC, separated by the respective 12-digit HUCs.

6.2.1 Beaver Run-Mahoning River 01-01

The majority of water quality improvement will be derived from abatement of nonpoint sources. Cropland sources of sediment and nutrients can be reduced with grassed waterways, cover cropping and conservation tillage, creation or restoration of vegetated buffers or wetlands and general nutrient management. Identification and subsequent correction of failed home septic systems, livestock fencing, and inspection and compliance of small wastewater dischargers would abate bacteria pollution. More detail regarding the appropriate locations of these actions follows.

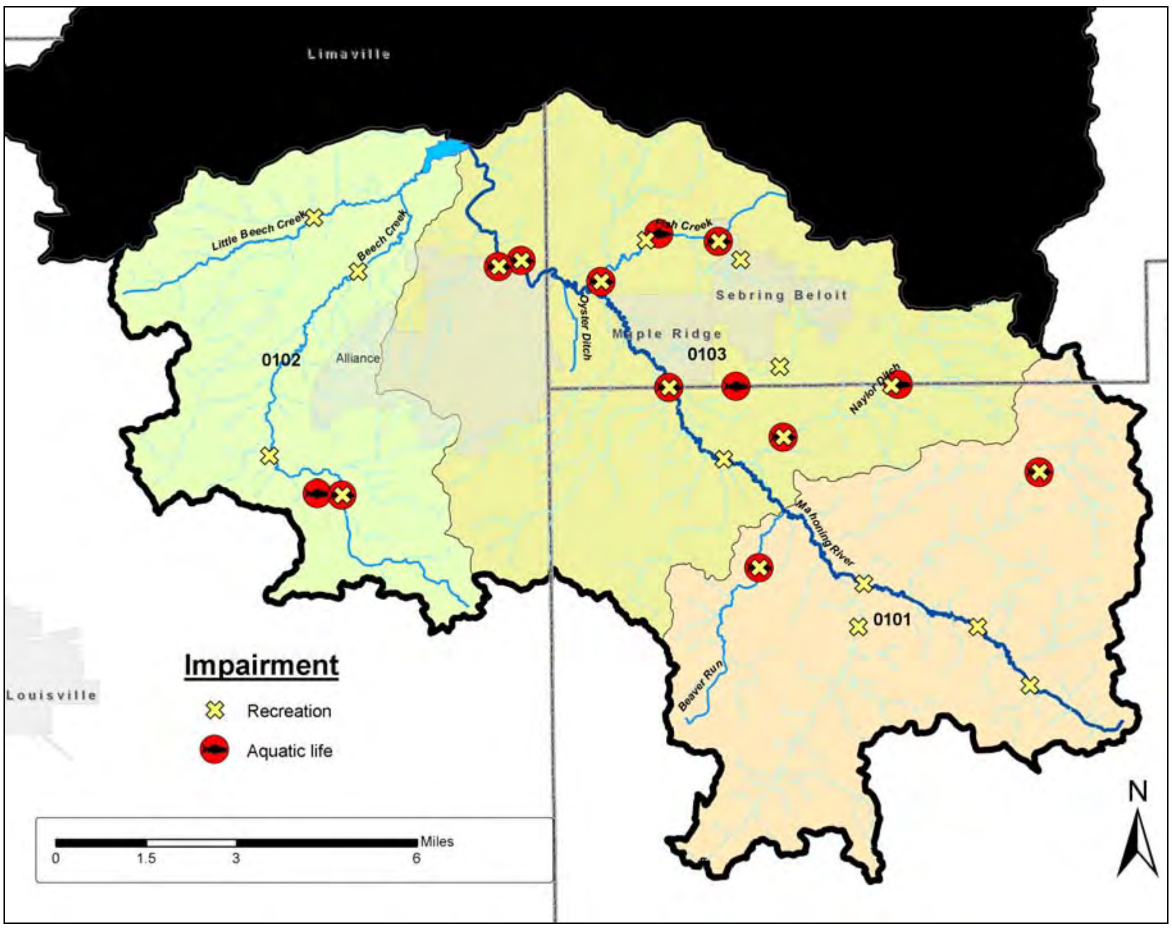

Figure 6-1. Twelve digit HUCs in the 01 watershed and sites impaired for aquatic life and recreation uses.

Between river miles 4.7 and 5.7 on unnamed tributary to the Mahoning River at river mile 98.71 (around Whitacre Rd) there are significant gullies leading to the river from the south. Aquatic life use is impaired for both sediment and nutrient at river mile 4.59. Grassed waterways are good to abate these sources of sediment (and nutrients by association). Other problem areas appear to be in the Hartley / Georgetown / Cider Mill Road areas (west of Cider Mill)

Additionally, grassed waterways as well as protective covers are appropriate to address sediment issues on Beaver Run. Gullies appear just upstream (Beaver Run and Center Road – river mile 1.19) and directly discharging to stream. Other areas upstream and further away from the stream network also look problematic. The first tributary south of Bowman Road (entering from east) and the first tributary north of Bowman (entering from west) have little in the way of stream-side buffers. Buffers (grass or trees) are needed on several small tributaries to this tributary stream. Also livestock management that includes exclusion from the stream (fencing and alternative watering) and prescribed grazing might be considered for pastures just south of Hartley Road and west of Slater Road. On the mainstem of the Mahoning River near river mile 97.7 (Georgetown-Damascus Road) livestock exclusion is also needed.

Wetland creation (or restoration if applicable) is generally recommended in this part of the watershed because it is good for sediment trapping. Most of the soils within 200 to 1600 feet surrounding streams are partially hydric (hydric soil indicates former wetland hydrology) and much of this occurs on cropland. There are two small areas of fully hydric soils (north of Hartley and west of Slater) and another location near watershed divide which indicates former permanent wetland conditions therefore, giving wetland restoration a much greater chance of success.

There are several small housing developments in the 5.3 square mile drainage area leading to the sampling site at river mile 4.71 of the unnamed tributary to the Mahoning River at river mile 98.71. The geometric mean was 1,433 cfu per 100 ml of sample which is substantially above the water quality standards. It would seem that both home septic systems and possibly a much smaller impact from livestock are contributing to the bacteria problems at this site. At unnamed tributary at river mile 97.11 there are less obvious sources as the homes are near site but seem to be draining to downstream locations. Upstream there is no substantial animal agriculture or housing. The geometric mean was 1,002 cfu/100ml. It seems that the site on the Mahoning River at Georgetown – Damascus Road is impacted by the Timashamie Campground's wastewater outfall (permit renewed on 4/1/07 and expires on 3/31/12). It appears to be the most significant source between that site and the next one upstream and there was a doubling on the geometric mean despite a near doubling in drainage area (which provides dilution). The distance between sites is just over three river miles and the point source is about 1.25 river miles up from the Georgetown-Damascus site.

6.2.2 Beech Creek 01- 02

Dam pool is listed as cause of aquatic life use impairment (Mahoning River at river mile 85.51) but removing this structure is unlikely because Alliance WTP withdraws at the dam and used the pool to secure pumping reliability.

The Beech Creek site at river mile 10.5 may be a good candidate for stream restoration because it is channelized (i.e., poor habitat due to channelization is listed as the cause and source) and the immediate upstream area has low gradient and less energy to lead to natural recovery of channel morphology and quality habitat. Likewise, there is a wooded riparian corridor that may be slowing any channel evolution and floodplain development (i.e., Simon and Hupp's channel evolution model (Simon and Hupp, 1986)). In such cases, channel restoration is more urgent if water quality goals are ever to be met in that part of the stream network.

Bacteria sources on Beech Creek (river miles 10.5 and 8.34) are most likely failing home septic systems from the surrounding homes. The more than doubling of the *E. coli* concentration from the upstream to downstream site in about two river miles suggests that the substantially more homes surrounding the stream (there are relatively few around the river mile 10.5 site) is related to the bacteria problems. The Washington Elementary School and Dairy Kool are both waste water dischargers located about two and three miles upstream from the RM 10.5 site.

Small tributaries entering Beech Creek around river miles 2.0 and 2.6 have little in the way of buffers. It is likely that cover cropping and conservation tillage would help abate sediment loading to Beech Creek and the aquatic life use impairments in that stream. Likewise, Beech Creek itself can afford additional buffering and adjacent cropland sediment controls especially beginning around river mile 1.8 and proceeding to it's the top of its headwaters. Increased floodplain connection would benefit water quality in terms of sediment processing in those areas as well and strategically placed wetlands would likewise capture excess sediment and keep it out of the stream system.

Buffers needed on Little Beech Creek especially from river mile 4.5 and upstream including tributary streams. In-field gulley erosion appears to be problematic surrounding the tributaries entering Little Beech Creek especially with regard to the tributary entering around river mile 4.48 where soil slopes are in the range of 15-20 percent. Grassed waterways will abate sediment problems here. Livestock with stream access are having a substantial negative impact on Little Beech Creek around river mile 1.83 (in the vicinity of State Route 619 and Freshley Road). Exclusion practices are strongly recommended for this cattle operation.

6.2.3 Fish Creek-Mahoning River 01-03

The recommended point source control in this 12-digit subwatershed is that several point source dischargers get a 1 mg/l – total phosphorus limit. These dischargers include:

- Beloit WWTP
- Sebring WWTP

Otherwise the majority of water quality improvement should be derived from abatement of nonpoint sources including storm water management in Alliance and Maple Ridge.

Three sites on the mainstem of the Mahoning River are impaired for aquatic life uses. The site located at river mile 91.11 would benefit from additional stream-side buffering particularly between river miles 91.5 and 91.0 (stream crossing with Knox School and Hartley Roads). The other two impaired sites are further downstream in Alliance and are impacted by urban land uses where unnatural hydrology and increased pollutant loadings associated with impervious covers are the problems. Maximizing infiltration of precipitation and general decentralized management of storm water will help abate this impairment. Such practices include disconnection of existing drains (e.g., downspouts) from centralized storm sewers and creating outlets that store storm water on smaller, more localized scales. These include rain gardens or bio-retention areas where groundwater recharge and evapo-transpiration provide alternative pathways rather than being routed to streams or other surface waters.

Buffering around Fish Creek generally looks good with large tracts of forest adjacent to streams at several locations. This seems to co-occur with some fully hydric soils suggesting that wet-woodlands that are difficult to farm and/or develop (also topographic maps and digital elevation models are showing this area to be atypically flat relative to the surrounding landscape). Also, generally speaking, soil drainage is poor throughout the Fish Creek watershed. Cropland nonpoint sources are not particularly obvious but there are some locations where buffers are non-existent (east of Bandy and north of Courtney Roads) and should be installed.

Abatement options may be limited in the immediate vicinity of Fish Creek at river mile 0.36 (Lexington Road) where it is listed as impaired because it is a swamp stream. The silt is either a natural phenomena or the loading should be abated from sources much further up in the watershed. Also, it is possible that the high bacteria near this site would be a wildlife issue since it is swampy and good for ducks and other wildlife as well as the limited flushing potential due to its low gradient. The abundance of silts is a good medium for bacteria growth and is possibly facilitating longer survival in stream bed sediments. This may result in internal loading of bacteria when the sediment is disturbed such as under higher flow events or animal movements. Another possible source is the Sebring WWTP which has one of its two discharges to Fish Creek located just less than four miles upstream of this sample location. The geometric mean for *E. coli* concentrations at this site is 334 cfu/100ml.

Downstream site on Naylor Ditch is down from a small reservoir. Lawns nearby may be a source of nutrients and agriculture may not be a significant source. Buffers are ample except for in the immediate vicinity of the sampling site. Homes nearby might also be a source of bacteria. Also there are two fields upstream that are listed to be used by the Alliance WWTP for sludge application.

Table 6-2. Restoration and abatement actions recommended for the 01 ten-digit HUC.

Restoration Categories		Specific Restoration Actions	05030103-01		
			01	02	03
Bank & Riparian Restoration		Plant grasses in riparian areas	x	x	x
		Plant prairie grasses in riparian areas	x	x	x
		Plant trees or shrubs in riparian areas	x	x	x
Stream Restoration		Restore flood plain		x	x
		Restore stream channel		x	x
		Install in-stream habitat structures			
		Install grade structures			
		Construct 2-stage channel		x	x
		Restore natural flow			
Wetland Restoration		Reconnect wetland to stream			
		Reconstruct & restore wetlands	x	x	
Home Sewage Planning and Improvement		Develop HSTS plan	x		
		Inspect HSTS	x		
		Repair or replace traditional HSTS	x		
		Repair or replace alternative HSTS	x		
Storm Water Best Mgt Practices	quantity controls	Post-construction BMPs: innovative BMPs			x
		Post-construction BMPs: infiltration			x
		Post-construction BMPs: retention/detention			x
	quality controls	Post-construction BMPs: filtration			x
		Construction BMPs: erosion control			
		Construction BMPs: runoff control			
		Construction BMPs: sediment control			
Point Source Controls (Regulatory Programs)	collection and new treatment	Install sewer systems in communities			
		Develop and/or implement long-term control plan (CSOs)			
		Eliminate SSOs/CSOs/by-passes			
	storm water	Implement an MS4 permit			
		Implement an industrial permit			
		Implement a construction permit			
	enhanced treatment	Issue permit(s) and/or modify permit limit(s)			x
		Improve quality of effluent			x
	monitoring	Establish ambient monitoring program			
		Increase effluent monitoring			

Restoration Categories		Specific Restoration Actions	05030103-01		
			01	02	03
	alternatives	Establish water quality trading			
Agricultural Best Mgt Practices	farmland	Plant cover/manure crops	x	x	
		Implement conservation tillage practices	x	x	
		Implement grass/legume rotations		x	
		Convert to permanent hayland	x	x	
		Install grassed waterways	x		
		Install vegetated buffer strips	x	x	
		Install / restore wetlands	x	x	
	nutrients / agro-chemicals	Conduct soil testing	x	x	
		Install nitrogen reduction practices	x	x	
		Develop nutrient management plans	x	x	
	drainage	Install sinkhole stabilization structures			
		Install controlled drainage system	x	x	
		Implement drainage water management	x	x	
		Construct overwide ditch		x	
		Construct 2-stage channel		x	
	livestock	Implement prescribed & conservation grazing practices	x		
		Install livestock exclusion fencing	x		
		Install livestock crossings	x		
		Install alternative water supplies	x		
		Install livestock access lanes			
	manure	Implement manure management practices	x		
		Construct animal waste storage structures	x		
		Implement manure transfer practices			
		Install grass manure spreading strips	x		

6.3 Deer Creek - Mahoning River (05030103-02)

Two out of 10 sites (20 percent) surveyed fully met aquatic life use criteria; while 60 percent meet none of the criteria and 20 percent met some but not all of the criteria (Figure 6-2). Non attainment was found in each of the large tributaries to the east of the reservoir (12-digit HUCs 02-03 and 02-04) including Garfield Ditch, Mill Creek, Turkey Broth Creek and Island Creek. Willow Creek was also in non attainment and Deer Creek was in partial attainment downstream of the dam for the Walborn Reservoir.

Recreation uses were impaired at 10 sites (91 percent) of the 11 sites surveyed in this ten digit HUC where the one attaining site was immediately downstream from the Dale Walborn Reservoir. Figure 6-2 shows the assessment sites that are impaired for aquatic life and recreation uses. Table 6-3 summarizes all of the recommended actions for abating water quality issues in this ten-digit HUC, separated by the respective 12-digit HUCs.

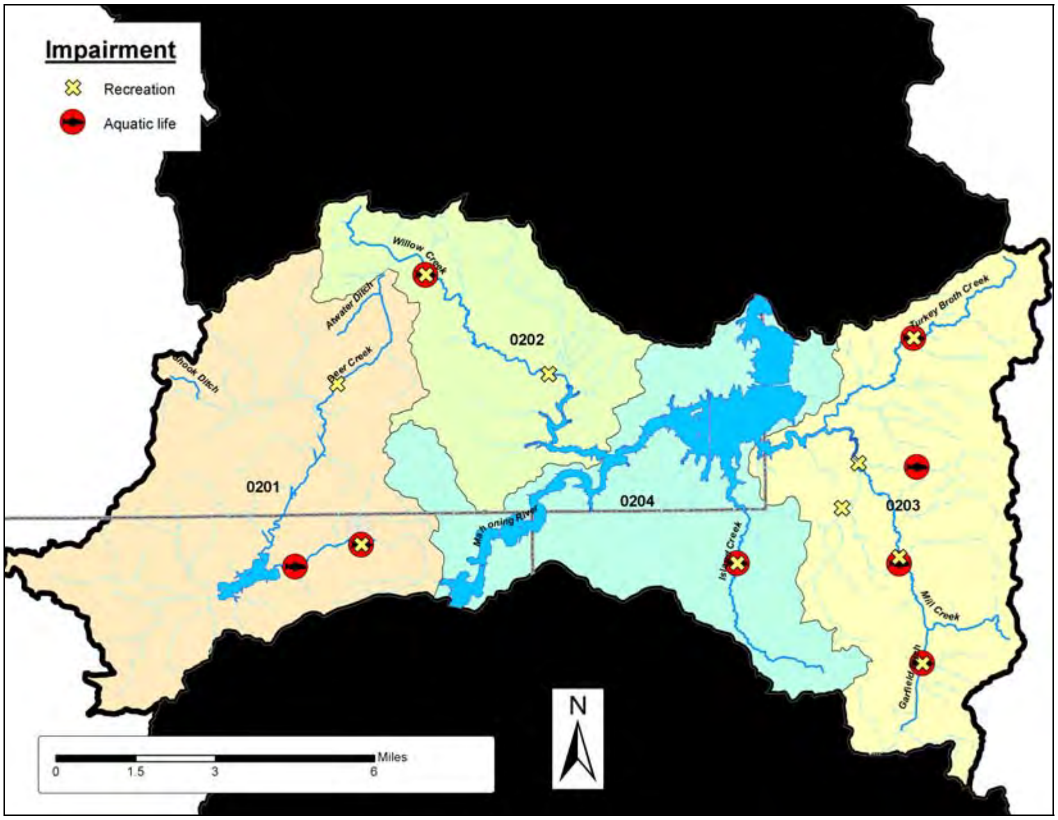

Figure 6-2. Twelve digit HUCs in the 02 watershed and sites impaired for aquatic life and recreation uses.

6.3.1 Deer Creek 02-01

Aquatic life is impacted by the reservoir systems on Deer Creek, namely the Dale Walborn and Deer Creek reservoirs. Partial and non attainment of aquatic life use was found at river mile 4.48 due to changes in hydrology and the nutrient enriched conditions being exported from Dale Walborn reservoir (high nutrient and algae loading) and non attainment due primarily to the impacts of the system on hydrology. TMDLs were developed for nutrients (total phosphorus) entering Dale Walborn to shift the trophic conditions from a high state of algae/plant production (eutrophic to hyper-eutrophic) to a mid range level of productivity (meso-trophic). Controlling nutrients to the lake will reduce their export and subsequent detrimental effects to the downstream as well as limit the amount of dead and/or living algae which likewise impairs habitat and other aspect of the aquatic community.

The recommended point source control in this 12-digit subwatershed is that one point source discharger gets a 1 mg/l – total phosphorus limit. This discharger is:

- Atwater WWTP

There are approximately 30 square miles of watershed leading to Dale Walborn and nutrient management on cropland is the most import means for addressing the water quality problems identified based on the fact that it is the dominant land use and by far the one with the highest nutrient yield (most of the other land use is forest). Good nutrient management is predicated on effective planning (often done in conjunction with local conservation professional such as Natural Resource Conservation Service (NRCS) or soil and water conservation district employees).

Additionally, in this area the soils are relatively flat and poorly drained with a significant proportion of hydric to partially hydric soils (indicating existing or former wetlands). Based on a visual assessment of the Ohio Department of Natural Resource’s wetland inventory it is among two areas with the highest density of wetlands. Nutrient controls therefore, involving the creation or restoration of wetlands may prove a more effective and efficient (e.g., cost effective) means for abating nutrient rich runoff. Controlled drainage is also likely to have greater relevance as a means for nutrient control due to the flatter soils, and the likely predominance of subsurface drainage on farmland in this area.

There is a substantial streamside buffering already in this area, probably because farming is difficult where the riparian intersects wetlands and other very poorly drained soils. This highlights the need to rely more on nutrient management, the use of controlled drainage, and wetland restoration and creation. Tillage and sediment loss is unlikely to be a significant problem due to the flat soil slopes.

Recreation uses are impaired at two locations in this HUC12 watershed. One site is significantly upstream of the Dale Walborn reservoir and the other between Dale Walborn and Deer Creek reservoirs. Limaville is immediately adjacent to the site between the reservoirs as well as a relatively small number of homes (dozens) near Deer Creek and upstream of Limaville. The geometric mean at this site was a little more than three times the standard indicating, in relative terms, only a modest degree of pollutant loading. It is likely that the reservoir has abated loading from further upstream and the majority of the bacteria in that stretch of Deer Creek are from failed septic systems and/or illicit connections to storm water infrastructure. This relatively discrete area may lend itself to effective abatement through inspection and compliance enforcement with local and state ordinances regarding septic systems.

The other site impaired for recreation use is in the area of Waterloo Road and State Route 183. Several homes along both of these roads are likely a source of bacteria due to ineffective treatment of household sewage. The only other potentially significant source of bacteria in the area appears to be several fields that may have waste water sludge applied. The geometric mean of the bacteria concentration is similar to what was found at the site between the Dale Walborn and Deer Creek.

6.3.2 Willow Creek 02-02

Only one site is impaired regarding aquatic life with sediment, nutrients, and habitat related issue as the problems. Like Deer Creek, this area is also flat, poorly drained, and has a high presence of wetlands. For this reason, wetlands and drainage based conservation practices on cropland (the dominant land use accompanied by forest cover) are probably the most practical and effective ways to abate the problems (see Section 6.2.1). Streamside buffers are mostly needed on a set of tributaries that enter Willow Creek at river mile 8.96.

Two sites are impaired for recreation uses. The downstream site is at river mile 3.74 near Notman Road and has a high geometric mean concentration of bacteria. There are several homes along Notman Road which, aside from some crop fields, pose the only obvious sources of bacteria. It is a similar situation for the site upstream on Willow Creek at river mile 8.13 although the geometric mean is much lower and only a relatively small proportion above the water quality standards. Increased inspection and compliance with local and state septic system ordinances is recommended for both of these discrete areas.

6.3.3 Mill Creek 02-03

The site impaired for aquatic life use on Garfield Ditch is showing sediment issues most likely due to channelization. Although the upland sources of sediment are probably modest due to the treatment from a small pond constructed within the stream and the significant amount of forested stream-side buffering the fact that the stream is channelized makes effectively processing even a modest sediment load difficult. Creation of floodplain access is likely the best form of abatement for this stretch of stream (i.e., down from the pond). Siltation is also a problem on Mills Creek where livestock damaging the stream banks and riparian areas is listed as the source. Livestock exclusion and bank protections through bio-engineering (e.g., willow posts, roots wads, deflectors, etc.) are recommended in this area. Likewise, natural channel design may be appropriate to abate sediment issues and improve habitat quality. On an unnamed tributary to Mill Creek (at river mile 3.67) channelization is responsible for the bank erosion and again, bio-engineering or bank protection though tree planting along banks and in the riparian is recommended. Likewise, a two-stage channel approach may be appropriate to stabilize the banks through the reduced peak flow depths, better side slope angles, and robust vegetative cover that provides stability and also can assimilate some of the in-stream sediment load. On Turkey Broth Run, a small lowhead dam should be considered for removal since it is exacerbating the problems associated with sedimentation and elevated nutrient concentrations.

Overall, wetland restoration and creation may prove valuable throughout this HUC 12 since there are a high proportion of hydric or partially hydric soils and the drainage is mostly poor. Increases in wetland coverage will stabilize watershed hydrology and may abate some of the peak flows that could be exacerbating channel degradation and floodplain disconnection.

The primary sources for bacteria pollution are likely agriculture related, including cropland runoff and livestock manures. On Turkey Broth Creek cows were observed in the stream, and such access is perhaps the most intense source for bacteria loading, since fecal matter is directly deposited in the stream. The obvious way to abate this is to drastically limit or eliminate stream access for cattle. Barriers like livestock fencing are effective ways of doing this and often are conservation practices eligible for cost sharing through Farm Bill programs (namely the Environmental Quality Improvement Program – EQIP). However, excluding livestock from stream requires that alternative sources of watering and cooling be provided for the herd. These alternatives are also often eligible for cost share. Failing septic systems are likely a source of bacteria at each of the sites impaired for recreation uses, therefore a focus on inspections in these areas is warranted.

6.3.4 Island Creek-Mahoning River 02-04

Only one site was evaluated for each aquatic life and recreation uses. The site river mile 2.65 on Island Creek was in non attainment for aquatic life and recreation. Nutrients and sediment are listed as causing the impairment with cropland as the source. Bacteria concentrations were above the water quality standard but low compared to the majority of sites in the TMDL project area. Soils slopes are modest; however, drainage is generally poor and there are a significant proportion of partially hydric soils.

Abatement options should center on controlling nutrient and sediment losses from cropland. Based on aerial photography, there are substantial existing wooded buffers which, suggests that a significant proportion of the sediment loading is coming from within the channel itself, perhaps due to altered hydrology. Controlled drainage would help abate stream loading of the dissolved fraction of the nutrients (i.e., that which is not transported with sediment) while wetland restoration and creation would abate both dissolved and particulate forms of nutrients. Nutrient management will also control the build-up of nutrients in the soil which impacts the availability for transport to stream systems.

Table 6-3. Restoration and abatement actions recommended for the 02 ten-digit HUC.

Restoration Categories		Specific Restoration Actions	05030103-02			
			01	02	03	04
Bank & Riparian Restoration	constructed	Restore streambank using bio-engineering			X	
		Restore streambank by recontouring or regrading			X	
	planted	Plant grasses in riparian areas	X	X		
		Plant prairie grasses in riparian areas	X	X		
		Plant trees or shrubs in riparian areas	X	X	X	
Stream Restoration		Restore flood plain			X	
		Restore stream channel			X	
		Install in-stream habitat structures				
		Install grade structures				
		Construct 2-stage channel			X	
		Restore natural flow				
Wetland Restoration		Reconnect wetland to stream	X	X	X	X
		Reconstruct & restore wetlands	X	X	X	X
Home Sewage Planning and Improvement		Develop HSTS plan	X	X	X	X
		Inspect HSTS	X	X	X	X
		Repair or replace traditional HSTS	X	X	X	X
		Repair or replace alternative HSTS	X	X	X	X
Agricultural Best Mgt Practices	farmland	Plant cover/manure crops	X		X	X
		Implement conservation tillage practices	X			X
		Implement grass/legume rotations	X			
		Convert to permanent hayland	X	X		
		Install grassed waterways				
		Install vegetated buffer strips	X	X		

Restoration Categories		Specific Restoration Actions	05030103-02			
			01	02	03	04
		Install / restore wetlands	x	x	x	x
	nutrients / agro-chemicals	Conduct soil testing	x	x	x	x
		Install nitrogen reduction practices	x	x	x	x
		Develop nutrient management plans	x	x	x	x
	drainage	Install sinkhole stabilization structures				
		Install controlled drainage system	x	x	x	x
		Implement drainage water management	x	x	x	x
		Construct overwide ditch	x	x	x	
		Construct 2-stage channel	x	x	x	
	livestock	Implement prescribed & conservation grazing practices				
		Install livestock exclusion fencing			x	
		Install livestock crossings				
		Install alternative water supplies			x	
		Install livestock access lanes				

6.4 West Branch Mahoning River - Mahoning River (05030103-03)

Eight out of 24 sites (33 percent) surveyed fully meet aquatic life use criteria; however 25 percent meet none of the criteria and 42 percent met some but not all of the criteria (Figure 6-3). The majority of the impairment was found on Kale Creek where two sites were in non attainment and three in partial. The mainstem of the Mahoning River is impaired downstream of the Berlin and Lake Milton dams with respective partial and non attainment statuses. Partial attainment was also found on the mainstem in Newton Falls. Three tributaries to the West Branch were in partial attainment, Barrel Run and Harmon Brook above the reservoir and an unnamed tributary downstream of the reservoir. The West Branch was in partial attainment just down from the dam and in non attainment where it is pooled from the influence of the dam on the mainstem of the Mahoning River in Newton Falls.

Recreation uses were impaired at 22 sites (88 percent) of the 25 sites surveyed in this ten digit HUC. The three sites that were not impaired are each located just downstream from the spillway of the three reservoirs that are fully or partially found in this ten-digit HUC. The sites found with the highest bacteria concentrations were on small tributaries (with drainage areas of about five square miles or less) and one site on Barrel Run which, at that point, has a drainage area of about ten square miles. Each of these sites had *E. coli* concentrations above 1,000 cfu per 100 ml of sample and the highest was 3,322 cfu per 100 ml of sample on a tributary to a tributary of the West Branch Mahoning River (somewhat near its spillway). Figure 6-3 shows the assessment sites that are impaired for aquatic life and recreation uses.

Table 6-4 summarizes all of the recommended actions for abating water quality issues in this ten-digit HUC, separated by the respective 12-digit HUCs.

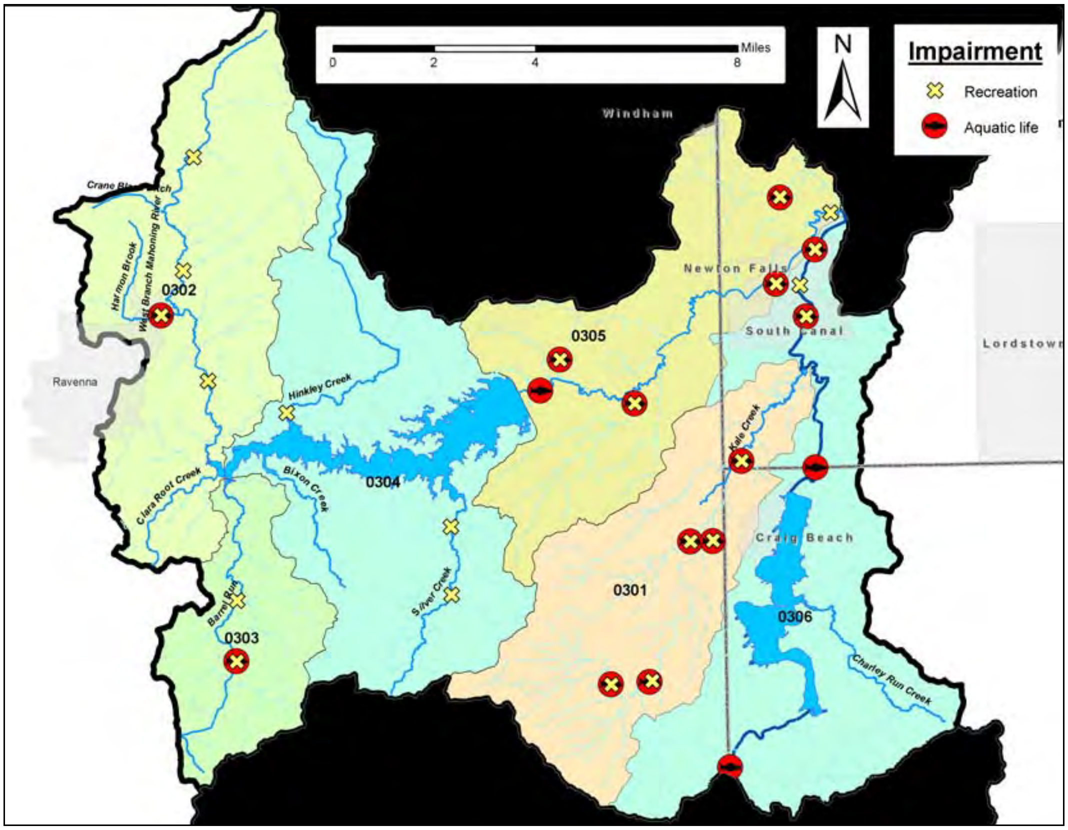

Figure 6-3. Twelve digit HUCs in the 03 watershed and sites impaired for aquatic life and recreation uses.

6.4.1 Kale Creek 03-01

Kale Creek is the most impaired in terms of aquatic life in this ten-digit HUC. Siltation is the biggest problem for these sites as well as loss of riparian vegetation in some discrete areas. The soils in this area are generally susceptible to surface erosion and have a high rate of runoff. There is also a high shrink-swell capacity among these soils which lends itself to cracking and bank failures upon wetting and drying cycles. It is therefore very likely that the characteristics of these soils have had a big part in sediment problems that are seen in the streams of this area. Consequently, protections against surface erosion such as cover cropping, and conservation tillage is especially important in these areas. Likewise, minimizing shrink-swell cycles may be beneficial where again protective land covers will minimize drying of the soils surface and practices such as mulches and residues as well as controlled drainage and wetland restoration and creation may have localized impacts on retaining soil moisture (and curbing the extremes in the drying cycles). Generally buffers cover the majority of the stream length however, a stretch of Kale Creek near its intersection with State Route 225 (just upstream from site located at river mile 13.08), has little riparian cover and appears to be in an area with unprotected soils. The soil slopes in this area are fairly steep and the soils have a relatively high sand content (being silt loams).

From river mile 11 to 11.8 the banks look somewhat unstable and wooded vegetation is not growing robustly along the banks. Likewise, from river mile 2.1 to 1.8 there are steep slopes adjacent to the riparian zones and wooded vegetation does not appear to be robust along the banks. This area may be a source of soils erosion and sedimentation in the stream. Additional tree planting and/or bio-engineering practices done to protect the banks are recommended to address sediment issues in this area of the watershed.

Recreation uses are impaired at four sites along Kale Creek and one site along one of its tributaries. Of the five impaired sites only one drastically exceeds the water quality standard (i.e., geometric mean of sample values = 2,005 cfu per 100 ml sample). This site is located at river mile 13.08 near intersection of Williams Road and State Route 225. Such a high geometric mean suggests a steady loading, and based on the possible sources surrounding this sampling site, it is most likely an illicitly discharging home septic system. There are several homes in the area without central sewer service, so it is recommended that the Portage County Health Department carry out inspections of home septic systems in this area. There is a similar situation at river mile 1.08 which is near the intersection of Whippoorwill and Jones Roads and a focus on inspections in this area is also recommended.

6.4.2 Headwaters West Branch Mahoning River 03-02

There is only one site impaired for aquatic life uses in this 12-digit HUC watershed, located on Harmon Brook. This site is also impaired for recreation uses; however, the water quality standard is exceeded by a modest amount (geometric mean = 325 cfu per 100 ml sample). Causes for aquatic life impairment are nutrients, organic enrichment and sediment and sources are listed as home septic systems, crop production and the upstream impoundments. This site is located immediately downstream of a small pond formed by impounding the stream. It is possible that the pond has abated upstream sources of bacteria and consequently the concentrations are as low as they are. Conversely the pond may also be acting as a source of bacteria if waterfowl and other wildlife are using it as a resource.

This impoundment is also facilitating algae production which is exported downstream (the dam is a top release) causing the problems associated with organic and nutrient enrichment. If this dam (located approximately at river mile 0.5) and those that are upstream (two on a tributary joining Harmon Brook at river mile 1.38 about 0.3 and 0.9 miles upstream from this confluence) are no longer serving their intended purpose, removal is recommended to abate the nutrient and organic enrichment issues. Based on aerial photography, wooded streamside buffering looks excellent upstream of this site with the exception of the area of the survey site to the confluence with the tributary just mentioned (i.e., at river mile 1.38). Streamside buffers and nutrient management for the adjacent cropland and turf grass areas are recommended, especially for the Windmill Lakes Golf Course.

Recreation uses are impaired at three other sites in this 12-digit HUC on the West Branch Mahoning River. Each of these sites exceed the water quality standard by a relatively modest amount except for the site at river mile 24.35 which had a geometric mean of 866 cfu per 100 ml of sample. Wooded stream-side buffering along the West Branch in the area of each of the sites is substantial so bacteria transported in runoff is likely to currently be getting some level of abatement. Based on interpretation of satellite imagery, there is a significant amount of wetlands in the area, most likely wet woodlands. Wastes from wildlife in these areas may also be contributing to bacteria problems. However, homes in the area of the sites at river mile 24.35 and 27.92 are a possible source if home septic systems are not functioning properly. Inspections are recommended for these areas of the watershed.

6.4.3 Barrel Run 03-03

One site is impaired for aquatic life uses and two for recreation uses. The aquatic life impairment is due exclusively to a lowhead dam that is an impediment to fish movements and a marginal degrader of stream habitat (QHEI score was still 67.5). Dam removal is recommended to bring this site in to attainment of the water quality standards. Homes in the vicinity of Giddings and Industry Roads as well as Tallmadge and Industry Roads should be inspected to ensure proper functioning of the septic systems.

6.4.4 Kirwan Reservoir-West Branch Mahoning River 03-04

No sites were impaired for aquatic life uses; however, three were impaired for recreation uses. A site on Silver Creek at river mile 3.6 is surrounded by several homes. Inspections in this area are especially important due to the rather high geometric mean for the bacteria concentration in this location (1,713 cfu per 100 ml of sample). There are fewer homes in the area of the other site impaired on Silver Creek and the geometric mean is less than one half of the upstream site. Hinckley Creek at river mile 5.5 is impaired for recreation and the multiple homes near this location just off of Knapp Road are the most probable source. Inspections in this area are recommended to address this fairly intense impairment (geometric mean = 1,050 cfu per 100 ml of sample).

6.4.5 Town of Newton Falls-West Branch Mahoning River 03-05

One site is attaining and two sites are impaired for aquatic life uses on the West Branch Mahoning River. The site immediately downstream from the William Kirwan Reservoir dam is impacted by the flow alteration associated with the dam release. The other site (river mile 3.15) is impacted by the backwater of a lowhead dam in Newton Falls. As with the dams for the Lake Milton and Berlin Reservoir, the release protocols for the William Kirwan Reservoir can be adjusted to better mimic a natural hydrologic regime. The Sustainable Rivers Project has taken the lead on developing computer programs (Indicators of Hydrologic Alteration) that identify approximate naturalized flow conditions which are predicated on existing watershed and flow data that predates the building of the dam. It is recommended that the Army Corps of Engineers and other partners discuss possible modifications to flow release protocols to improve the quality of the stream system. The lowhead dam in Newton Falls would be recommended for removal if there are currently no important public uses of the structure.

One site on a tributary to West Branch at river mile 0.01 is impacted by sediment. The upstream watershed is almost exclusively the Ravenna Arsenal and there is exposed soil in many locations. The road system itself may also be a source of sediment under intense rain events. Sediment and erosion controls that address these exposed areas are recommended and may included passive (vegetation plantings) or structural (sediment detention, silt fencing) measures. The site on a tributary to West Branch at river mile 9.63 is impaired due to poor habitat in a channelized but fairly well buffered stream. In this case it is possible that the stream side tree growth is impeding a natural recovery of the channel form (i.e., lateral erosion that eventually leads to development of a small floodplain bench and greater sinuosity and riffle and pool development). It is clear that the channel is very trapezoidal and lacks much of the in-stream structure and flow variation necessary for good habitat. For these reasons it is possible that the best means for achieving water quality standards here is through channel restoration or an over-wide or two-stage construction. The site on the tributary to the West Branch at river mile 8.28 is impaired due to sediment and a poor flow regime that may be impacted by the unnatural hydrology in the West Branch (due to flow control). However, this site is also located in an area that appears to be swamp wetland and soils slopes are low. This may also be exacerbating a slow flowing regime and hindering the stream's capacity to transport fine sediment. As such, the primary recommendation is an improved flow regime in the West Branch as discussed above.

Bacteria are a severe problem on the tributary to West Branch at river mile 9.63 and livestock may by the source. Livestock exclusion practices are likely to be the most effective means to abate these problems. Likewise inspection of home in this area is warranted to determine if failed septic systems are also contributing. On the tributary to the West Branch at river mile 8.28 bacteria is also a problem but to a much lesser degree and potential sources include wildlife in this swampy area. Land applied manure is also a possibility since there is cropland in the area. Controlled drainage is a protective measure to stop manure spills if they should happen following land application.

Within the City of Newton Falls on the West Branch Mahoning River (at river miles 3.15 and 0.36) bacteria is somewhat elevated. The City is in the process of implementing a long term control plan which includes diverting storm water away from the combined sewer system and increased storage and treatment capacity to handle greater volumes of combined flow before allowing a direct discharge. These abatement actions are expected to reduce pollutant loading associated with CSO including bacteria.

6.4.6 Charley Run Creek-Mahoning River 03-06

Only sites on the Mahoning River mainstem were surveyed in this assessment unit. Also, Lake Milton constitutes a large proportion of the mainstem in this area. Two sites, each immediately downstream from the spillways of Berlin Reservoir and Lake Milton are in partial attainment because the fish community lacked sensitive species and had a relative high proportion of tolerant species. This is related to a very artificial flow regime due to the controls of the spillway. The Nature Conservancy and the Army Corp of Engineers have been working together on the Sustainable Rivers Project which primary goals if to mimic natural flow regimes downstream from flow controls structures such as large dams. More naturalized release protocols are likely to help the aquatic community in this area of the Mahoning River.

The other aquatic life use impairments are related to the lowhead dam in Newton Falls, where habitat quality is degraded and flow natural flow characteristics disrupted. Removal of this dam would improve water quality and help achieve the standards for aquatic life uses.

Table 6-4. Restoration and abatement actions recommended for the 03 ten-digit HUC.

Restoration Categories		Specific Restoration Actions	05030103-03					
			01	02	03	04	05	06
Bank & Riparian Restoration	planted	Plant grasses in riparian areas		x				
		Plant prairie grasses in riparian areas		x				
		Plant trees or shrubs in riparian areas		x				
Stream Restoration		Restore flood plain					x	
		Restore stream channel					x	
		Install in-stream habitat structures						
		Install grade structures						
		Construct 2-stage channel					x	
		Restore natural flow						
Dam Modification or Removal		Remove Dams		x	x		x	x
		Modify Dams						
		Install Fish Passage and/or Habitat Structures						
		Restore Natural Flow					x	x
Home Sewage Planning and Improvement		Develop HSTS plan	x	x	x	x	x	
		Inspect HSTS	x	x	x	x	x	
		Repair or replace traditional HSTS	x	x	x	x	x	
		Repair or replace alternative HSTS	x	x	x	x	x	
Storm Water Best Mgt Practices	quantity controls	Post-construction BMPs: innovative BMPs						
		Post-construction BMPs: infiltration						
		Post-construction BMPs: retention/detention						
	quality controls	Post-construction BMPs: filtration						

Restoration Categories		Specific Restoration Actions	05030103-03 01	02	03	04	05	06
		Construction BMPs: erosion control					x	
		Construction BMPs: runoff control						
		Construction BMPs: sediment control					x	
Point Source Controls (Regulatory Programs)	collection and new treatment	Install sewer systems in communities						
		Develop and/or implement long-term control plan (CSOs)					x	x
		Eliminate SSOs/CSOs/by-passes					x	x
	storm water	Implement an MS4 permit					x	x
		Implement an industrial permit						
		Implement a construction permit						
	nutrients / agro-chemicals	Conduct soil testing		x				
		Install nitrogen reduction practices		x				
		Develop nutrient management plans		x				
	drainage	Install sinkhole stabilization structures						
		Install controlled drainage system					x	
		Implement drainage water management					x	
		Construct overwide ditch					x	
		Construct 2-stage channel					x	
	livestock	Implement prescribed & conservation grazing practices						
		Install livestock exclusion fencing					x	
		Install livestock crossings						
		Install alternative water supplies					x	

Restoration Categories		Specific Restoration Actions	05030103-03					
			01	02	03	04	05	06
		Install livestock access lanes						
	manure	Implement manure management practices					x	
		Construct animal waste storage structures						
		Implement manure transfer practices						
		Install grass manure spreading strips						

6.5 Eagle Creek - Mahoning River (05030103-04)

Nine out of 16 sites (56 percent) surveyed fully meet aquatic life use criteria; however 31 percent meet none of the criteria and 13 percent met some but not all of the criteria (Figure 6-4). The majority of the impairment was found on the mainstem of the Mahoning River where two sites in the Leavittsburg area were in non attainment while one site downstream from Newton Falls is in partial attainment. Tinker Creek was also impaired with one site in non attainment and one in partial attainment. One site on Mahoning Creek was also in non attainment.

Recreation uses were impaired at 18 sites (100 percent) of the 18 sites surveyed in this ten digit HUC and distributed fairly evenly across this area. Figure 6-4 shows the assessment sites that are impaired for aquatic life and recreation uses.

Table 6-5 summarizes all of the recommended actions for abating water quality issues in this ten-digit HUC, separated by the respective 12-digit HUCs.

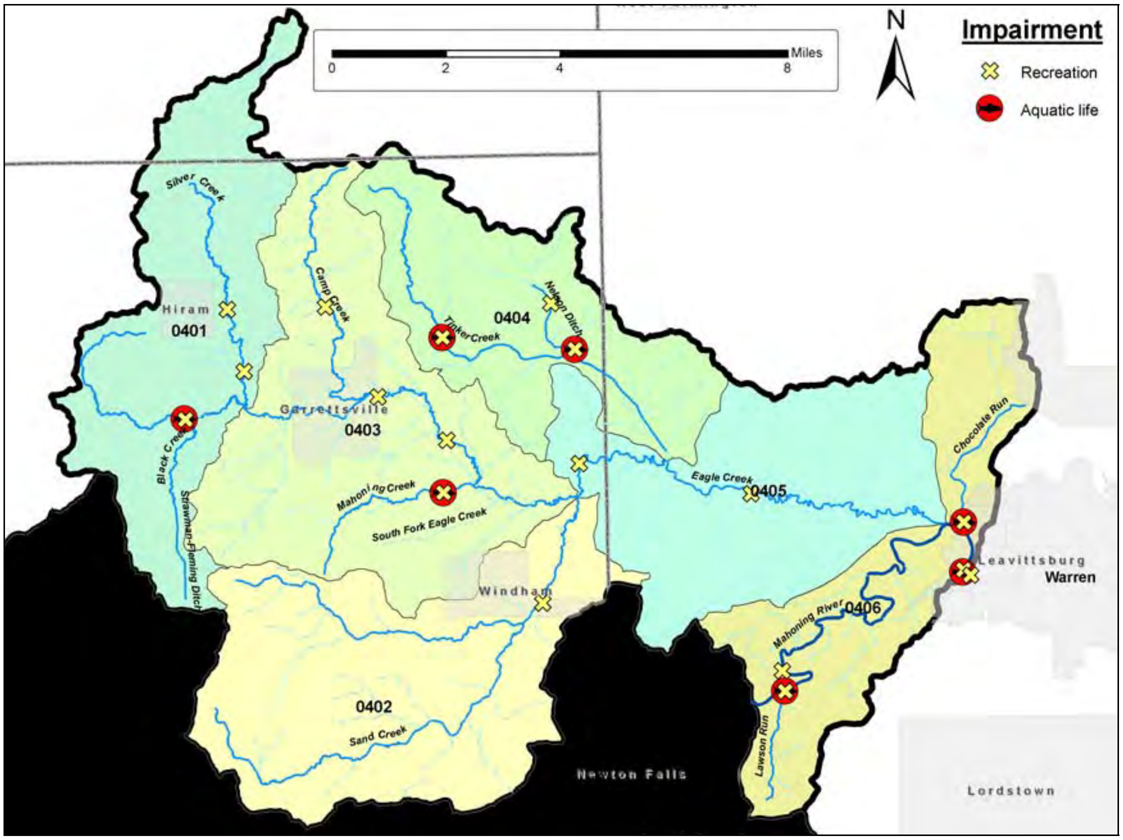

Figure 6-4. Twelve digit HUCs in the 04 watershed and sites impaired for aquatic life and recreation uses.

6.5.1 Headwaters Eagle Creek 04-01

Only one site is impaired for aquatic life uses in this 12-digit HUC and three are impaired for recreation uses. Natural flow alterations from beaver dams are responsible for the aquatic life impairment; however, this part of the watershed contributes nutrients to downstream areas on Eagle Creek and therefore has nutrient reductions assigned.

The recommended point source control in this 12-digit subwatershed is that one discharger gets a 1 mg/l - total phosphorus limit:

- Hiram WWTP

Otherwise the majority of water quality improvement should be derived from abatement of nonpoint sources. Streams in this 12-digit HUC are well buffered. Likely the most significant source of nutrients is from crop production. The flat soils and relatively high proportion of hydric or poorly drained soils suggest that wetland restoration or controlled drainage are well suited in this area. Nutrient management, as a general rule is an important practice to reduce nutrient loading to surface waters from cropland and highly managed turf areas.

Source of bacteria are most likely from failed home septic systems. There are several homes in the immediate vicinity of the site on Silver Creek where it crosses State Route 305. Inspections of septic systems are warranted for homes in this area. The same can be said for the site located at the intersection of Silver Creek and State Route 82. Both of these sites have not substantially exceeded the water quality standards relative to many other sites in this TMDL project area as well as in other basins across Ohio. The impaired site on Eagle Creek near State Route 700 likewise has only modestly exceeded the water quality standards; however sources in this case are more likely to be wildlife (only one home at some distance from the stream).

6.5.2 South Fork Eagle Creek 04-02

The only impairment in this watershed was a site on the South Fork of Eagle Creek which failed to meet the recreation use criteria. This is a relatively low magnitude impairment with wildlife a probable source.

The recommended point source control in this 12-digit subwatershed is that one discharger gets a 1 mg/l - total phosphorus limit:

- Windham WWTP

Nutrients are also to be addressed in this 12-digit HUC to improve downstream water quality. The recommended point source control is that Windham WWTP gets a 1 mg/l –total phosphorus limit. Otherwise the majority of water quality improvement should be derived from abatement of nonpoint sources which includes nutrient management on cropland and highly managed turf grass areas.

6.5.3 Camp Creek-Eagle Creek 04-03

Only one site is impaired for aquatic life uses in this 12-digit HUC and four are impaired for recreation uses. Nutrients and sediment are responsible for the aquatic life impairment with part of the problem associated with the wetland character of the stream and the natural lack in capacity to transport fine sediment (and improve stream substrate habitats). Nutrients are also impacting the stream from treated wastewater come from the Modern Management Solutions DBA PM Estates waste water treatment plant. A one mg/l – total phosphorus effluent limit is recommended (see also below). Nutrients are also to be addressed in this 12-digit HUC to improve downstream water quality.

The recommended point source control in this 12-digit subwatershed is that several point source dischargers get a 1 mg/l – total phosphorus limit. These include:

- Garrettsville WWTP
- Modern Management Solutions DBA PM Estates
- Northern Ohio Multipurpose

Otherwise the majority of water quality improvement should be derived from abatement of nonpoint sources which includes nutrient management on cropland and highly managed turf grass areas, particularly the Sugar Bush Golf Club and lawns in Garrettsville.

Bacteria issues are likely largely related to wildlife contributions based on the substantial forest and wetland covers in and around streams as well as the fact that the water quality standards are exceeded by a relatively small amount which suggests that illicit or other chronic sources are minimal.

6.5.4 Tinkers Creek 04-04

Three sites are impaired for aquatic life uses in this 12-digit HUC and three are impaired for recreation uses. Nutrients and sediments and poor habitat due to channelization are responsible for the aquatic life impairments. The site on Nelson Ditch (river mile 0.3) is highly channelized; however, there is a substantial amount of tree growth in the riparian and the channel gradient is low. This stream is therefore a good candidate for stream restoration or a two-stage approach since natural recovery is unlike due to these circumstances. The flat slopes and relatively high proportion of hydric or partially hydric soils make controlled drainage and wetland restoration or creation good option s for abating nutrient in the watershed. Nutrient management on cropland and highly managed turf grass areas is also recommended. In general stream in this watershed are well buffered.

Addressing bacteria may be more difficult for the site on Nelson Ditch since sources are more difficult to identify. However, cluster of homes may be the sources of bacteria on Tinker Creek near Nicholson Road and the site near Center Road. Inspections of home septic systems are warranted in these areas.

6.5.5 Mouth Eagle Creek 04-05

None of the sites are impaired for aquatic life uses but two sites are impaired for recreation uses. Part of this watershed should be managed for nutrient reductions to improve downstream water quality. The flat slopes and relatively high proportion of hydric or partially hydric soils make controlled drainage and wetland restoration or creation good option s for abating nutrient in the watershed. Nutrient management on cropland and highly managed turf grass areas is also recommended. In general stream in this watershed are well buffered.

In addressing bacteria problems, a cluster of homes may be the sources of bacteria on Eagle Creek near County Road 114 (river mile 5.6). Inspections of home septic systems are warranted in this area.

6.5.6 Chocolate Run-Mahoning River 04-06

Three sites are impaired for aquatic life uses, two are on the Mahoning River and impacted by habitat degradation from the backwaters behind the Leavittsburg lowhead dam and one is on Chocolate Run and impacted by channelization and high nutrient concentrations. Removal of the Leavittsburg lowhead dam is recommended.

Due to the channelization on Chocolate Run it is a good candidate for stream restoration or a two-stage approach since natural recovery is unlike due to the substantial amount of tree growth in the riparian and the low channel gradient. The flat slopes and relatively high proportion of hydric or partially hydric soils make controlled drainage and wetland restoration or creation good option s for abating nutrient for this site as well as the rest of the watershed. Nutrient management on cropland and highly managed turf grass areas is also recommended. In general stream in this watershed are well buffered.

In terms of bacteria issues, small wastewater treatment plants are located upstream from two of the impaired sites. The Pleasant Park Mobile Court is upstream of the impaired site on Chocolate Run and may be having compliance issues. Likewise, there is a significant increase in the bacteria concentrations from the Mahoning River site at river mile 54.73 (geometric mean

= 191 cfu per 100 ml of sample) to 53.63 (geometric mean = 696 cfu per 100 ml of sample) between which the Arhaven Estates Mobile Home Park discharges. This discharger should be checked for compliance.

Table 6-5. Restoration and abatement actions recommended for the 04 ten-digit HUC.

Restoration Categories		Specific Restoration Actions	05030103-04					
			01	02	03	04	05	06
Stream Restoration		Restore flood plain				x		x
		Restore stream channel				x		x
		Install in-stream habitat structures						
		Install grade structures						
		Construct 2-stage channel				x		x
		Restore natural flow				x		x
Dam Modification or Removal		Remove Dams						x
		Modify Dams						
		Install Fish Passage and/or Habitat Structures						
		Restore Natural Flow						
Wetland Restoration		Reconnect wetland to stream						
		Reconstruct & restore wetlands	x	x	x	x	x	
		Plant wetland species						
Home Sewage Planning and Improvement		Develop HSTS plan	x	x	x	x	x	
		Inspect HSTS	x	x	x	x	x	
		Repair or replace traditional HSTS	x	x	x	x	x	
		Repair or replace alternative HSTS	x	x	x	x	x	
Storm Water Best Mgt Practices	quantity controls	Post-construction BMPs: innovative BMPs						
		Post-construction BMPs: infiltration						

Restoration Categories		Specific Restoration Actions	05030103-04					
			01	02	03	04	05	06
		Post-construction BMPs: retention/detention						
	quality controls	Post-construction BMPs: filtration						
		Construction BMPs: erosion control						
		Construction BMPs: runoff control						
		Construction BMPs: sediment control						
Point Source Controls (Regulatory Programs)	collection and new treatment	Install sewer systems in communities						
		Develop and/or implement long-term control plan (CSOs)						
		Eliminate SSOs/CSOs/by-passes						
	storm water	Implement an MS4 permit						
		Implement an industrial permit						
		Implement a construction permit						
	enhanced treatment	Issue permit(s) and/or modify permit limit(s)	x	x	x			
		Improve quality of effluent	x	x	x			
	monitoring	Establish ambient monitoring program						
		Increase effluent monitoring						
	alternatives	Establish water quality trading						
Agricultural Best Mgt Practices	farmland	Plant cover/manure crops	x	x		x		x
		Implement conservation tillage practices						
		Implement grass/legume rotations						
		Convert to permanent hayland	x	x		x		x
		Install grassed waterways						

Restoration Categories		Specific Restoration Actions	05030103-04 01	02	03	04	05	06
		Install vegetated buffer strips						
		Install / restore wetlands	x	x	x	x	x	x
	nutrients / agro-chemicals	Conduct soil testing	x	x	x	x	x	x
		Install nitrogen reduction practices	x	x	x	x	x	x
		Develop nutrient management plans	x	x	x	x	x	x
	drainage	Install sinkhole stabilization structures						
		Install controlled drainage system	x	x	x	x	x	
		Implement drainage water management	x	x	x	x	x	
		Construct overwide ditch						
		Construct 2-stage channel						
	manure	Implement manure management practices	x	x	x	x	x	x
		Construct animal waste storage structures						
		Implement manure transfer practices						
		Install grass manure spreading strips						

6.6 Future Evaluations of the Project Area and Corrective Actions

6.6.1 Current and Ongoing Monitoring

The effectiveness of actions implemented based on the TMDL recommendations should be validated through ongoing monitoring and evaluation. Information derived from water quality analyses can guide changes to the implementation strategy to more effectively reach the TMDL goals. Additionally, monitoring is required to determine if and when formerly impaired segments meet applicable water quality standards (WQS).

This section highlights past efforts and those planned to be carried out in the future by the Ohio EPA and others. It also briefly outlines a process by which changes to the implementation strategy can be made if needed.

Evaluation and Analyses
Aquatic life habitat and recreational uses are impaired in the watershed, so monitoring that evaluates the stream system with respect to these uses is a priority to the Ohio EPA. The degree of impairment of aquatic life habitat is exclusively determined through the analysis of biological monitoring data. Recreational use impairment is determined through bacteria counts from water quality samples. Ambient conditions causing impairment include ***point sources (home septic treatment systems, sanitary sewer overflows, storm sewers, wastewater treatment plants), and non point sources (agricultural activity, dam impoundments, and urban/suburban land uses)***. This report sets targets values for these parameters (Chapters 4 and 5), which should also be measured through ongoing monitoring.

A serious effort should be made to determine if and to what degree the recommended implementation actions have been carried out. This should occur within an appropriate timeframe following the completion of this TMDL report and occur prior to measuring the biological community, water quality or habitat.

Past and Ongoing Water Resource Evaluation
The Ohio EPA has surveyed various sections of the Mahoning River basin in the past. Table 6-6 is a brief overview of this activity.

Table 6-6. Ohio EPA reports on water quality in the upper Mahoning River watershed.

Survey year	Area covered	Publication year
2006	Upper Mahoning River watershed (HUC 10s - 01, 02, 03, and 04).	2008 TSD
2003	Facility-Wide Biological and Water Quality Study 2003 Ravenna Army Ammunition Plant	2005 (Army Corps)
1994	Entire Mahoning River watershed including mainstem and major tributary streams	1996 TSD

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. Through this, 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.

6.6.2 Schedule for Ohio EPA Monitoring

In accordance with the Ohio 2010 Integrated Water Quality Monitoring and Assessment Report (Ohio EPA, 2010), the next scheduled Ohio EPA evaluation of this watershed is in 2022.

6.6.3 Approach Toward Revisions

An adaptive management approach will be taken in the upper Mahoning River watershed. Adaptive management is recognized as a viable strategy for managing natural resources (Baydack et al., 1999) and this approach is applied on federally-owned lands. An adaptive management approach allows for changes in the management strategy if environmental indicators suggest that the current strategy is inadequate or ineffective.

The recommendations put forth for the upper Mahoning River watershed largely center on point source controls, reducing pathogen, nutrient and sediment loading into streams and preventing further habitat loss.

If chemical water quality does not show improvement and/or water bodies are still not attaining water quality standards after the implementation plan 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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