State of Ohio
Environmental Protection Agency

Division of Surface Water

Total Maximum Daily Loads for the Black River Watershed

Black River, Days Dam Metropark, Lorain County

Final Report
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Ted Strickland, Governor
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List of Acronyms and Abbreviations

AOC	Area of Concern
AU	Assessment Unit
AWS	Agricultural Water Supply
BMP	best management practice
BR	Black River
cfs	cubic feet per second
cfu	colony forming unit
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CRWP	Chagrin River Watershed Partners
CWA	Clean Water Act
CWH	Cold Water Habitat
DEFA	Division of Environmental and Financial Assistance
DO	Dissolved Oxygen
DSW	Division of Surface Water
EB	East Branch
EFEB	East Fork of the East Branch
EOLP	Erie Ontario Lake Plain
EQIP	Environmental Quality Incentives Program
ESP	Environmental Strategic Plan
EWH	Exceptional Warmwater Habitat
FC	Fecal Coliform
FCr	French Creek
ft^3/sec	cubic feet per second
gpd	gallons per day
HSTS	household sewage treatment system
HUC	hydrologic unit code
HRU	Hydrologic Response Unit
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
IWS	Industrial Water Supply
kg/day	Kilogram per day
LA	load allocations
lb/yr	pounds per year
LCCDD	Lorain County Community Development Dept.
LDC	Load Duration Curve
LTI	LimnoTech, Inc.
mg/L	milligrams per liter
MGD	million gallons per day
MIWB	Modified Index of Well-Being
mi^2	square mile
ml	milliliter
MOS	margin of safety
MS4	municipal separate storm sewer system
MUSLE	Modified Universal Soil Loss Equation
MWH	Modified Warmwater Habitat
NO3	Nitrate
NOACA	Northeast Ohio Areawide Coordinating Agency
NPDES	National Pollutant Discharge Elimination System

NPS	nonpoint source
NRCS	Natural Resource Conservation Service
OAC	Ohio Administrative Code
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
ORC	Ohio Revised Code
PC	Plum Creek
PCB	Polychlorinated Biphenyls
PCR	Primary Contact Recreation
PET	Potential Envirotranspiration
QHEI	Qualitative Habitat Evaluative Index
RAP	Remedial Action Plan
RM	river mile
SOD	Sediment Oxygen Demand
SSH	Seasonal Salmonid Habitat
SWAT	Soil and Water Assessment Tool
SWCD	Soil and Water Conservation District
SWP3	Storm Water Pollution Prevention Plan
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
USACE	U.S. Army Corps of Engineers
U.S. EPA	U.S. Environmental Protection Agency
USGS	U.S. Geologic Survey
WAP	Watershed Action Plan
WLA	wasteload allocations
WPCLF	Water Pollution Control Loan Fund
WQS	water quality standards
WRRSP	Water Resource Restoration Sponsor Program
WWH	Warmwater Habitat
WWTP	wastewater treatment plant

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1.0 INTRODUCTION

The Black River watershed is located in north-central Ohio and drains approximately 470 square miles of both agricultural and highly urbanized land uses (Figure 2-1). Four 11-digit Assessment Units (AUs) are included within the Black River watershed (Table 1-1) and all four AUs appear on Ohio's 2006 Section 303(d) list because the Warmwater Habitat and Primary Contact Recreation designated uses are not supported in one or more streams. The causes of impairment include nutrients, siltation, organic enrichment/dissolved oxygen, unknown toxicity, other habitat alterations, and bacteria. Additional physical habitat impairments exist based on Quality Habitat Evaluation Index (QHEI) scores (Rankin, 1989), which measure the overall habitat and ecosystem health. Table 1-1 summarizes the impairment causes and sources reported on Ohio's most recent Section 303(d) *Integrated Water Quality Monitoring and Assessment Report* (Ohio EPA, 2006).

The Clean Water Act and U.S. Environmental Protection Agency (U.S. EPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters on the Section 303(d) lists. The TMDL and water quality restoration planning process involves several steps including watershed characterization, target identification, source assessment, and allocation of loads. The pollutant load is allocated among all sources within the watershed and voluntary (for nonpoint sources) and regulatory (for point sources) control measures are identified for attaining the source allocations. An implementation plan is also typically established to ensure that the control measures are effective at restoring water quality and all designated water uses.

The overall goals and objectives in developing the Black River TMDLs were to:

- Assess the existing water quality within the watershed and identify key issues associated with the impairments and potential pollutant sources.

- Use the best available science and available data to determine water quality conditions that will result in all streams fully supporting their designated uses.

- Prepare a final TMDL report that meets the requirements of the Clean Water Act and provides information to the key stakeholders that can be used to facilitate implementation activities to improve water quality.

This report documents the results of the TMDL analysis. Section 2 briefly describes the watershed and applicable water quality standards, Section 3 describes the methodology used to estimate the current and allowable pollutant loads, Section 4 presents the resulting TMDLs and Section 5 presents the watershed implementation plan. Appendix A presents the load duration curve analysis reports, Appendix B describes the SWAT modeling assumptions and calibration, Appendix C summarizes the allocation approach for the sediment and nutrient TMDLs, Appendix D describes the CE-QUAL-W2 modeling of the Lower Black River, and Appendix E displays the CE-QUAL-W2 scenario results.

Computer modeling was conducted on seven single implementation scenarios (Appendix B) and although increased use of riparian buffer strips and vegetative corridors were predicted to provide the greatest reduction of all pollutant impacts, each single implementation scenario alone, could predict full compliance with OHIO EPA target concentrations. Of the allocation scenarios, a combination (Combo2) of increased riparian buffers, elimination of failing septic tanks, point source controls and a reduction in streambank erosion predicts the achievement of water quality standards at compliance points in the watershed.

The implementation of the suite of scenarios in Combo2 coupled with an educational outreach effort, designed by the Black River RAP Coordinating Committee to increase acceptance of the implementation scenarios by the residents and other watershed stakeholders, will lead to the ultimate success of this TMDL and help restore the Black River Area of Concern.

Table 1-1. Summary of Section 303(d) listings in the Black River watershed, Ohio.

Assessment Unit	Designated Uses	Causes	Sources
04110001 020 West Branch Black River (headwaters to mouth) Priority Points = 6	WWH, AWS, IWS, PCR	Nutrients, Siltation, Organic Enrichment – Dissolved Oxygen, Bacteria	Urban Runoff/Storm Sewers, Non-irrigated Crop Production/ Pasture Land Runoff, Onsite Septic Systems
04110001 030 East Branch Black River (headwaters to downstream Coon Creek) Priority Points = 9	WWH, AWS, IWS, PCR	Siltation, Bacteria	Non-irrigated Crop Production
04110001 040 East Branch Black River (downstream Coon Creek to mouth) Priority Points = 8	WWH, AWS, IWS, PCR	Nutrients, Siltation, Organic Enrichment – Dissolved Oxygen, Direct Habitat Alterations, Bacteria	Minor Municipal Point Sources, Combined Sewer Overflows, Non-irrigated Crop Production, Channelization/Agriculture
04110001 050 Black River (confluence of East and West branches to mouth)[1] Priority Points = 7	WWH, AWS, IWS, PCR	Unknown Toxicity, Priority Organics, Nutrients, Organic Enrichment – Dissolved Oxygen, Bacteria	Industrial Point Sources, Major Municipal Point Sources, Combined Sewer Overflows

WWH = Warmwater Habitat; AWS = Agricultural Water Supply; IWS = Industrial Water Supply; PCR = Primary Contact Recreation

[1]Subwatershed as defined includes minor Lake Erie tributaries East of Black River to West of Porter Creek. This project would include only the Black River portion of the subwatershed

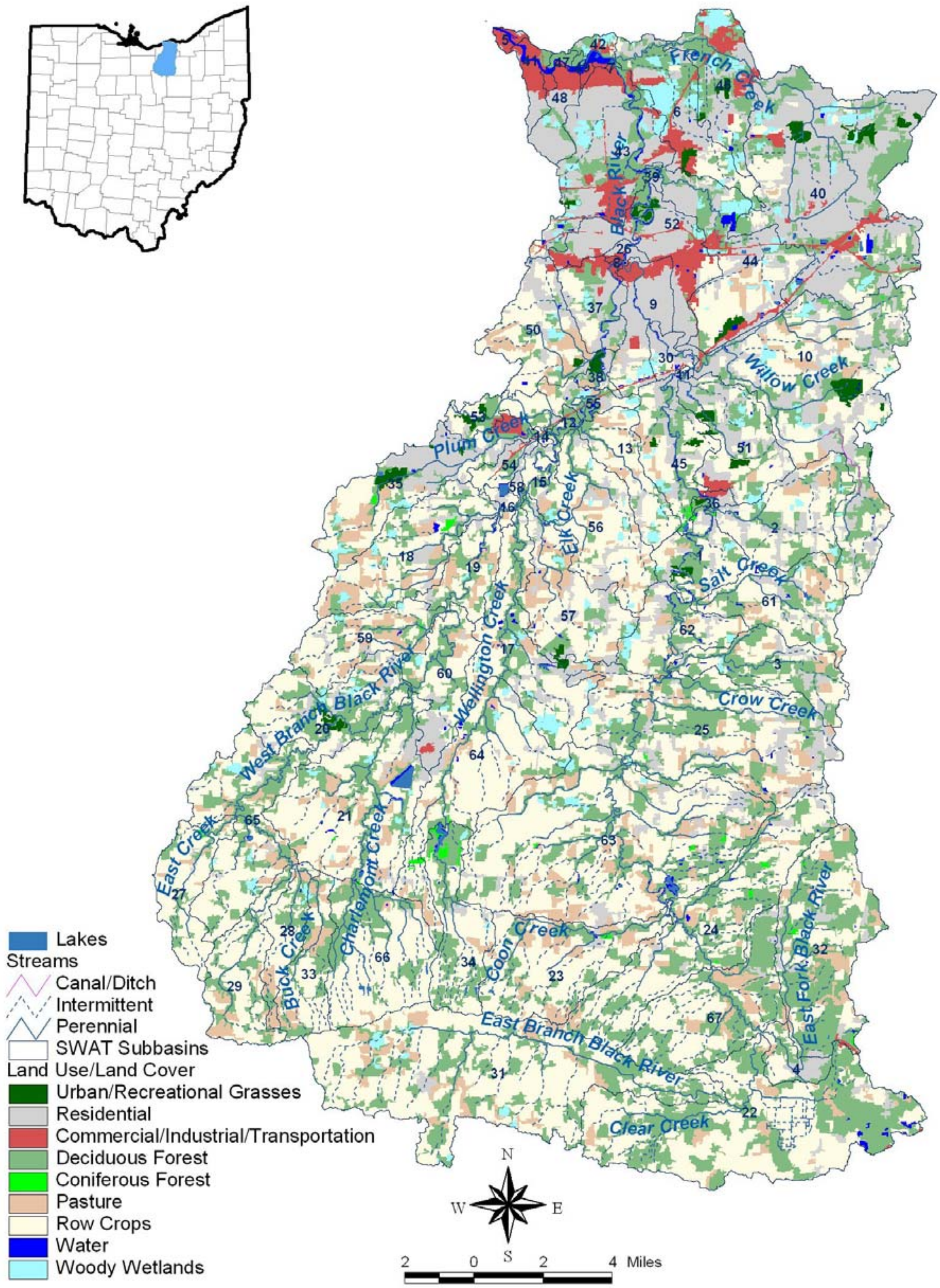

Figure 2-1. Land use/land cover and SWAT modeling subbasins within the Black River watershed.

2.0 DESCRIPTION OF WATERBODIES, IMPAIRMENT STATUS AND WATER QUALITY STANDARDS

The purpose of this section of the report is to provide a brief background of the Black River and its corresponding watershed. Extensive descriptions of the watershed are also available from the Black River Area of Concern website (**http://www.epa.gov/glnpo/aoc/blackriver.html**), the Black River Watershed Project website (**http://www.blackriverwatershed.org/**), and in the Black River Remedial Action Plan Update (**http://www.noaca.org/05BRRAPrep.pdf**).

2.1 Description of the Black River Watershed

The Black River drains a 470 square mile watershed in north-central Ohio (Figure 2-2). The watershed lies within the Erie/Ontario Lake Plain (EOLP) ecoregion. The EOLP ecoregion is characterized by gently rolling plains from previous glaciations, unconsolidated glacial deposits, sandstone and shale bedrock, and glacial end moraines.

Past geological events that shaped the landscape, bedrock and soils, left the study area highly susceptible to erosion and the various anthropogenic water quality impacts noted in the Section 303(d) list. Approximately 360 million years ago, a vast inland sea covered much of northeastern Ohio, including the Black River study area, and left sedimentary formations of sandstone and shale in the northern sections of the watershed. Because of the confining layers of shale and sandstone, ground water resources in the study area are very limited and the absorption of runoff waters is restricted.

Ground water typically yields an average of only 5-25 gallons per minute, except for an extreme southeastern section of the watershed where a buried aquifer yields up to 500 gallons per minute. Since stream flow in the study area is primarily dependent upon precipitation, of which about 35 inches is received annually, there are wide fluctuations in volume. The average annual stream flow for the USGS gage on the Black River mainstem is 333 ft^3/second. River flows during the summer months are routinely less than 50 ft^3/second, but the river has witnessed, after major storm events, peak flows as high as 50,000 ft^3/second.

During glacial advances, huge amounts of till material were pushed ahead of the glacier's leading edges. With the recession of glaciers, piles of the till material were left as end moraines. These end moraines are especially prominent in the southern reaches of the study area as rolling hills. These expansive elevations result in increased stream gradients and add velocity of stream flow. The increased stream velocities can add to erosion and sediment loadings. The Spencer and Defiance Moraines at the southern edge of the watershed are part of the continental divide between the Ohio River and Great Lakes watersheds.

The Wisconsian glacial advance (between 70,000 and 25,000 years ago) left a thick layer of glacial till upon the land. Glacial till, a surface deposit of up to 50 feet deep, is a mixture of clay and sand, ground up by the glacial advance. The glacial till material comprises the predominant soil types of the study area, which are medium to fine textured silt loams or silty-clay loams and are characterized as poorly drained to moderately well drained, but are highly erodible, especially in the southern sub-basins where the increases in slope add velocity to the runoff waters. Another concern for erosion and siltation in the southern basins is the predominant agricultural land use, which leaves significant expanses of land uncovered for a large portion of the year. During storm events, increased volumes and velocities of surface runoff wash sediments and nutrients off the land and into the tributary stream network. The sub-basins in the southern areas experience more than 20% of the land area eroding at more than 5 tons/acre/year.

After the retreat of the glaciers, several ancestral variants of present Lake Erie formed prominent beach ridges in the northern areas of the study area. The beach areas were formed when an earlier lake stabilized in size long enough for an accumulation of sands and sediments to occur along the shorelines. Most of these inland beach ridges run west to east, roughly paralleling, but inland of the present Lake Erie shoreline. The stream network system of the study area winds around and through these beach ridges. Higher in elevation than the surrounding lands, the beach ridges drain surface waters more rapidly and were extensively used as transit routes and settlement sites by Native Americans and early settlers. Many of these traditional transit routes remain, named after the beach ridges (i.e., Butternut Ridge Road, Center Ridge Road, etc.).

The land areas between the beach ridges were, historically, large wetland expanses. These wetland areas were the eastern reaches of the Great Black Swamp, which extended as far west as Detroit. The soils in these areas are characterized as poorly drained with shallow bedrock layers. The wetland areas were extensively drained in the late 1800s to facilitate human developments and agricultural activities.

The Black River watershed is divided among five counties: Lorain, Medina, Ashland, Huron, and Cuyahoga. A majority of the watershed lies within Lorain County with portions of the East Branch headwaters draining Medina and Ashland Counties. The West Branch headwaters drain small portions of northern Ashland County and Eastern Huron County. The northeastern portion of the watershed drains a small section of Cuyahoga County. Cities located partially or entirely within the watershed include Avon, Avon Lake, Eaton Estates, Elyria, Grafton, Lagrange, Lorain, North Ridgeville, Oberlin, Rochester, Sheffield, Wellington, North Olmstead, Westlake, Lodi, and Spencer. As development of the watershed increases, much of the land is being covered by impervious surfaces, such as rooftops, driveways and parking lots. Increases to watershed imperviousness can cause an increase in stream flow, stream velocities and erosion of stream banks.

The watershed is divided into the following four 11-digit AUs:

- West Branch Black River – 04110001 020
- East Branch Black River (headwaters to downstream Coon Creek) – 04110001 030
- East Branch Black River (downstream Coon Creek to mouth) – 04110001 040
- Black River mainstem; Lake Erie tributaries (East of Black River to West of Porter Creek) – 04110001 050

Each of the 11-digit AUs is further subdivided into 14-digit hydrologic unit code (HUC) sub-watersheds as presented in Table 2-1.

Table 2-1. Assessment Unit (AU) and 14-Digit Hydrologic Unit Code (HUC) Designations for the Black River Watershed.

11-Digit AU	14-Digit HUC	Description	Drainage Area (mi^2)
04110001-020		**West Branch Black River**	**174.0**
	010	West Branch Black River headwaters to below Buck Cr.	14.6
	020	West Branch Black River below Buck Cr. to above Charlemont Cr.	25.5
	030	Charlemont Creek	26.0
	040	West Branch Black River below Charlemont Cr. to above Wellington Cr.	25.6
	050	Wellington Creek	29.7
	060	West Branch Black River below Wellington Cr. to above Plum Cr.	10.3
	070	Plum Creek	13.6
	080	West Branch Black River below Plum Cr. to above East Branch	28.7
04110001-030		**East Branch Black River (headwaters to downstream Coon Creek)**	**95.8**
	010	West Fork of East Branch Black River headwaters to near Lodi	28.0
	020	West Fork of East Branch Black River from near Lodi to above E. Fork Black R.	14.5
	030	East Fork of East Branch Black River	15.1
	040	East Branch Black River below E. Fork of E. Branch to below Coon Cr.	38.2
04110001-040		**East Branch Black River (downstream Coon Creek to mouth)**	**125.8**
	010	East Branch Black River below Coon Cr. to Grafton	74.0
	020	East Branch Black River from Grafton to above West Branch [except Willow Creek]	28.9
	030	Willow Creek	22.9
04110001-050		**Black River (excluding Lake Erie tributaries)**	**74.4**
	010	Black River below confluence of E. Br. & W. Br. to Lake Erie [except French Cr.]	35.5
	020	French Creek	38.9

Area of Concern

The Black River watershed has been identified as an Area of Concern and a remedial action plan (RAP) has been developed. The Great Lakes Water Quality Agreement of 1978, and its 1987 Protocol Amendments, required identification of Areas of Concern and identified a list of 14 beneficial use impairments to be addressed in the Remedial Action Plan. In 1990 the Ohio EPA appointed the Black River RAP Coordinating Committee and charged them to identify the existing use impairments, their sources and causes, and to develop and implement remedial measures or actions to eliminate the impairments.

Originally the AOC designation was only applied to the lower portions of the mainstem, but was expanded to the entire watershed area during RAP development. The RAP process was initiated to fully evaluate and address pollutant sources to improve water and habitat quality of the AOC and reduce its subsequent influence on Lake Erie. Annex 2 of the Great Lakes Water Quality Agreement contains the following beneficial use impairments:

- restrictions on fish and wildlife consumption;
- tainting of fish and wildlife flavor;
- degradation of fish and wildlife populations;
- fish tumors or other deformities;
- bird or animal deformities or reproduction problems;
- degradation of benthos;
- restrictions on dredging activities;
- eutrophication or undesirable algae;
- restrictions on drinking water consumption, or taste and odor problems;
- beach closings;
- degradation of aesthetics;
- added costs to agriculture or industry;
- degradation of phytoplankton and zooplankton populations; and
- loss of fish and wildlife habitat.

A specific impairments list for the Black River Area of Concern is contained in Table 2.2. Beneficial use delisting criteria for Ohio Areas of Concern can be found at:
http://www.epa.state.oh.us/dsw/rap/DelistingTargetsOhioAOC_Final_June20-2005.pdf

The 1994 *Black River Remedial Action Plan Stage One Report – Impairments of Beneficial Uses and Sources of Pollution in the Black River Area of Concern* identified loss of habitat and riparian vegetation due to agricultural and developmental activities; point sources; agricultural, urban and developing suburban non-point sources of pollution; stream bank erosion; home sewage treatment systems; stream channelization and modifications; and combined and sanitary sewer overflows as the principle causes of the use impairments in the Black River watershed. Since that time, the RAP and its partner organizations have implemented stream and wetland restoration and protection projects, educated local citizens about non-point source pollution and controls, supported combined sewer overflow control measures, and worked with local officials to protect and restore riparian and wetland areas.

Table 2-2. Black River Beneficial Use Impairment Status

Use Impairment	Current Status	Notes
Restrictions on fish and wildlife consumption	Fish consumption - Impaired	Fish – Consumption advisories for mercury, PCBs.
	Wildlife consumption – Not Impaired	Snapping turtle advisory for mercury.
Tainting of fish and wildlife flavor	Not Impaired	No reports of tainting from wildlife officials and no WQS exceedences of compounds associated with tainting (phenol, 2-chlorophenol and 2,4 dichlorophenol).
Degradation of fish and wildlife populations	Fish populations – Impaired	Fish biocriteria scores (IBI and MIwb) below attainment levels in many areas.
	Wildlife populations – Impaired	Although no data are available, wildlife populations are suspected to be impaired.
Loss of fish and wildlife habitat	Fish habitat - Impaired	Fish habitat biocriteria scores (QHEI) below attainment level in many areas of the basin.
	Wildlife Habitat – Impaired	Although no data are available, wildlife habitat is suspected to be impaired.
Fish tumors or other deformities	In recovery phase	Remedial dredging of 1989-1990 removed contaminated sediments in the main stem. Fish populations have been recovering.
Bird or animal deformities or reproduction problems	Unknown	Little data available, but no reports of bird or animal deformities from wildlife officials.

Use Impairment	Current Status	Notes
Degradation of benthos	Impaired	Restored in the East Branch in 2006. Biocriteria scores (ICI) below attainment levels in other areas of the basin.
Restrictions on dredging activities	Impaired	Not all areas of navigation channel have sediments suitable for open lake disposal.
Eutrophication or undesirable algae	Impaired	Low dissolved oxygen levels in navigation channel in the summer months. Although improving, there remain occasional blooms of nuisance algae.
Restrictions on drinking water consumption, or taste and odor problems	Not Impaired	Occasionally high sediment loads cause temporary operational problems. No chronic taste or odor problems reported by municipal drinking water plants.
Beach closings	Impaired	A state contact advisory to restrict contact with water and sediments of the mainstem was lifted in 2004. High bacteria levels remain in many areas of the basin. Two Lake Erie beaches near the mouth of the Black River experience occasional high bacteria levels.
Degradation of aesthetics	Impaired	Eroding stream banks and nonpoint sources of pollution cause high sediment loads. Occasional nuisance blooms of algae caused by high nutrient loads. Periodic overflows from Elyria’s and Lorain’s waste water collection systems. Debris entering river system throughout much of the basin.
Added costs to agriculture or industry	Not Impaired	No reports of added costs.
Degradation of phytoplankton and zooplankton populations	Not Impaired	Generally not applicable to lotic waters.

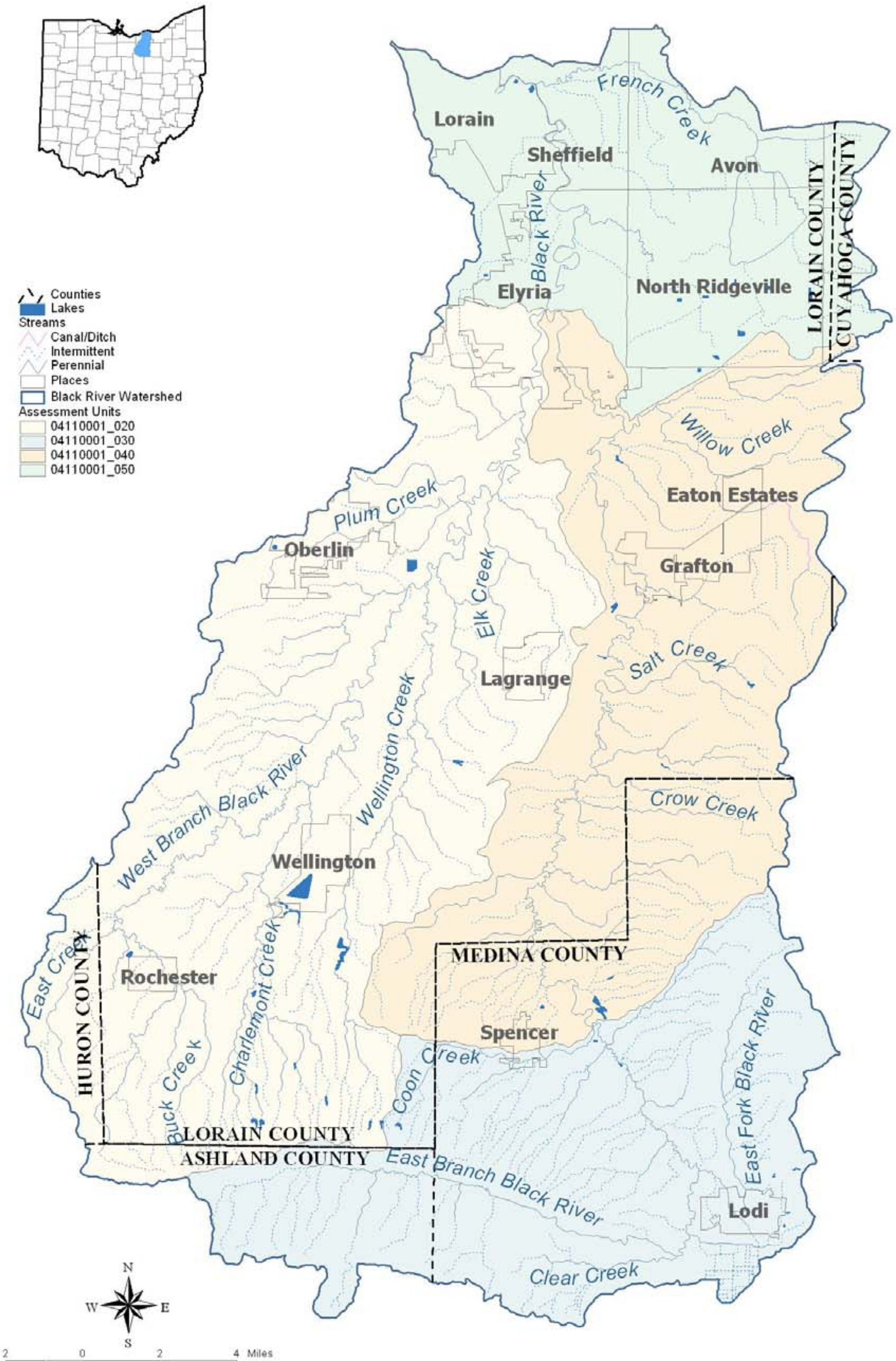

Figure 2-2. The Black River watershed.

2.2 Land Use and Land Cover within the Black River Watershed

The land use/land cover for the Black River watershed was extracted from the Ohio Statewide Land Cover Classification. This spatial database was derived from satellite imagery collected from 1999 to 2003 and is the most current detailed land use/land cover data known to be available for the watershed. Each 98-foot by 98-foot pixel contained within the satellite image was classified according to its reflective characteristics and the resulting land use and land cover characteristics of the Black River watershed are presented in Figure 2-1 and summarized in Table 2-3. The figure and the table show that row crop agriculture is the dominant land use/land cover in the watershed as it accounts for approximately 44 percent of the total area. Deciduous forest is the second most common and it accounts for 25 percent of the watershed area. Residential land cover and pasture lands make up approximately 16 and 8 percent of the Black River watershed, respectively.

Table 2-3. Land Use and Land Cover Characteristics of the Black River Watershed.

Land Use/Land Cover Description	Area (acres)	Area (mi^2)	Percent of Watershed
Row Crops	135,745.9	212.1	44.2
Deciduous Forest	76,702.3	119.8	25.0
Residential	48,680.0	76.1	15.8
Pasture	24,850.7	38.8	8.1
Commercial/Industrial/Transportation	7,883.4	12.3	2.6
Woody Wetlands	7,554.9	11.8	2.5
Water	2,810.8	4.4	0.9
Urban/Recreational Grasses	2,472.6	3.9	0.8
Coniferous Forest	535.5	0.8	0.2
	307,236.4	**480.1**	**100.0**

2.3 Pollutant Sources

Sediment is one of the most dominant stressors in the Black River due to its impact on the physical habitat of aquatic communities (Ohio EPA, 1999b). A major source of the excessive sediment loads is the storm water that runs off over the various land uses in the watershed. Agricultural practices are thought to contribute substantially to the sediment deposition in the Black River watershed as past and some current agricultural and construction practices leave bare fields exposed to erosion. In some cases, this may occur over extended periods of time and have extensive effects on the Black River drainage network (Ohio EPA, 1999b). Stream bank erosion is also a significant source of sediment (USAED Buffalo, 1977). Eroding stream banks can be worsened or further destabilized when fields are plowed to the edges of streams, livestock are given direct access to streams, and also when riparian vegetation is disturbed or removed.

Closely associated with sediments in runoff, nutrient concentrations are also elevated within the Black River and its major tributaries. Excessive nutrient loads (total phosphorus and nitrates) are delivered to the Black River through agricultural runoff from the surrounding watershed (nonpoint), numerous point source discharges throughout the watershed, and home sewage treatment systems. Algal blooms, increased oxygen demand, and depressed aquatic communities have all been noted in the Black River and its tributaries as a result of nutrient enrichment (Ohio EPA, 1999b).

Increased bacteria levels (fecal coliform) can come from failing home sewage treatment systems and illegal septage dumping (Boddy, 2002), combined sewage overflows, manure application in agricultural fields, and runoff from both feedlots and urban areas (Ohio EPA, 1999b). Due to the nature of these impairments, elevated bacteria levels are typically accompanied by organic/nutrient enrichment and the associated water quality issues. Human health is also of great concern in areas where bacteria concentrations exceed water quality standards.

2.4 Water Quality Standards

The purpose of developing a TMDL is to identify the pollutant loading that a waterbody can receive and still achieve water quality standards. 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 Clean Water Act's goal of "swimmable/fishable" waters. Water quality standards consist of three components: designated uses, numeric or narrative criteria, and an antidegradation policy. Ohio's water quality standards are summarized in Table 2-4 and explained in greater detail below.

Table 2-4. Ohio water quality standards.

Component	Description
Designated Use	Designated use reflects how the water can potentially be 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 (i.e., they are waterbody specific).*
Numeric Criteria	Chemical criteria represent the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody. Biological criteria indicate the health of the instream biological community by using one of three indices: • Index of Biotic Integrity (IBI) (measures fish health). • Modified Index of well being (MIwb) (measures fish health). • Invertebrate Community Index (ICI) (measures benthic macroinvertebrate health).
Narrative Criteria	These are the general water quality criteria that apply to all surface waters. These criteria state that all waters must be free from sludge; floating debris; oil and scum; color- and odor-producing materials; substances that are harmful to human, animal or aquatic life; and nutrients in concentrations that may cause algal blooms.
Antidegradation Policy	This policy establishes situations under which Ohio EPA 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.

* According to OAC 3745-1-07(A)(1) each waterbody is assigned a designated use. Any streams in Ohio that are undesignated still must attain the chemical criteria associated with the Warm Water Habitat designation. There is no similar protection for recreational use.

2.4.1 Designated Uses

The Black River and its tributaries are designated by Ohio EPA as warmwater habitat (WWH). A portion of the West Branch Black River (from Parsons Road to US Route 20) and Wellington Creek (within the Findley State Forest) are designated as State Resource Waters. The Black River mainstem and French Creek from Gulf Road to the mouth are also designated Seasonal Salmonid Habitat (SSH). All of the streams in the Black River watershed are designated for Primary Contact Recreation (OAC 3745-1-22) as well as Agricultural Water Supply (AWS) and Industrial Water Supply (IWS).

2.4.2 Numeric Criteria

Numeric criteria exist in Ohio to protect contact recreation designated uses. However, interpreting Ohio's water quality standards for fecal coliform and *E. coli* is somewhat complex and the state is currently considering changing the standard. Standards have been established to protect three different designated uses:

> Bathing waters: these are waters that, during the recreation season, are suitable for swimming where a lifeguard and/or bathhouse facilities are present, and include any additional such areas where the water quality is approved by the director.
>
> Primary contact: these are waters that, during the recreation season, are suitable for full-body contact recreation such as, but not limited to, swimming, canoeing, and scuba diving with minimal threat to public health as a result of water quality.
>
> Secondary contact: these are waters that, during the recreation season, are suitable for partial body contact recreation such as, but not limited to, wading with minimal threat to public health as a result of water quality.

Table 2-5 shows that the primary contact *E. coli* criterion of 126 cfu/100 mL is identical to the bathing water *E. coli* criterion as a geometric mean. However, this is not the case for fecal coliforms. While the primary contact fecal coliform criterion is 1,000 cfu/100 mL, the bathing water fecal coliform criterion is 200/100 mL. For this reason, *E. coli* is not used by itself to determine if there is a violation of the primary contact recreation criteria because Ohio EPA's regulations state that:

> *"For each designation at least one of the two bacteriological standards (fecal coliform or* E. coli*) must be met (OAC 3745-1-07, Table 7-13)."*

Therefore, when both fecal coliform and *E. coli* data are available from the same sample, if at least one of the two standards is met, there is not a human health violation. If only one of the two bacteria groups are available to determine violations of recreational standards, then fecal coliform should be used, not *E. coli,* because it is very rare that a fecal coliform count of 1,000/100 mL would violate the criteria and *E. coli* would not violate the 126/100 mL criteria. For this reason, the Black River TMDLs are based on meeting the primary contact fecal coliform standard. Note that the standard only applies during the recreation season (May 1 to October 15).

Table 2-5. Fecal coliform and *E. coli* standards for Ohio. Standards only apply for the period May 1 through October 15.

Parameter	Bathing Waters		Primary Contact		Secondary Contact
	Geometric Mean[1]	Instantaneous[2]	Geometric Mean[1]	Instantaneous[2]	Instantaneous[2]
Fecal Coliform	200/100 mL	400/100 mL	1,000/100 mL	2,000/100 mL	5,000/100 mL
E. coli	126/100 mL	235/100 mL	126/100 mL	298/100 mL	576/100 mL

[1] Geometric mean fecal coliform content should not exceed this standard based on not less than five samples within a thirty-day period.
[2] Fecal coliform content should not exceed this standard in more than ten percent of the samples taken in any thirty-day period.

Numeric criteria for dissolved oxygen have also been developed for the state of Ohio to protect aquatic life uses. Targets have been set for both instantaneous minimum (4 mg/L) and 24-hour average (5 mg/L) dissolved oxygen concentrations. The dissolved oxygen water quality standards are further discussed in Section 4.3.

2.4.3 Narrative Criteria

Only narrative criteria are available for nutrient and total suspended solids (TSS) in Ohio. TMDL numeric targets are therefore needed to compare existing water quality conditions to desired water quality conditions and to derive "maximum daily loads." Ohio EPA (Ohio EPA, 1999) has established water quality targets for nutrients and these were applied for TMDL development purposes in the Black River watershed (Table 2-5). The total phosphorus and nitrate targets are Ohio EPA suggested concentrations that are protective of aquatic life. These proposed values have been derived from a state-wide dataset and are categorized by drainage area. TSS targets were identified using a reference-based 25th percentile approach consistent with other TMDL studies completed by Ohio EPA.

Table 2-6. Nutrient TMDL Target Values for the Black River Watershed.

Water Quality Parameter	Source of TMDL Target	Target Value	Duration
Phosphorus	OHIO EPA Guidelines	0.17 mg/L	Monthly Average
Nitrate Nitrogen	OHIO EPA Guidelines	1.5 mg/L	Monthly Average
Siltation (Total Suspended Solids)	Reference Reach Approach	41 mg/L	Monthly Average

The Index of Biotic Integrity (IBI) and the Invertebrate Community Index (ICI) scores are measures of fish and macroinvertebrate community health, respectively. These indices have been found to display an inverse relationship with nutrient and TSS concentrations in Ohio streams and rivers (Ohio EPA, 1999). Ohio EPA therefore believes that maintaining nutrient concentrations at these target levels will result in improved aquatic communities and meeting the WWH designated use.

2.4.4 Biocriteria and Habitat Targets

Biocriteria are the final measure by which aquatic life use attainment decisions are made in Ohio. Once control strategies have been implemented, biological measures including the Index of Biotic Integrity (IBI), Invertebrate Community Index (ICI), Qualitative Habitat Evaluation Index (QHEI) and the Modified Index of Well-Being (MIwb) will be used to validate biological improvement and biocriteria attainment. Applicable biocriteria for the Black River basin are included in Table 2-6.

Table 2-7. Black River basin applicable biocriteria.

Ecoregion Biocriteria: Erie Ontario Lake Plain (EOLP)	
INDEX - Type	**WWH Biocriteria**
IBI	38-40
MIwb	7.9 – 8.7
ICI	34

Habitat loss has been identified as a cause of impairment in the Black River watershed. OAC 3745-1-04(A) states that all waters of the state shall be free from suspended solids and other substances that enter the waters as a result of human activity and that will settle to form objectionable sludge deposits, or that will adversely affect aquatic life. However, no statewide numeric criteria have been developed specifically for sediment or total suspended solids (TSS). Instead, target QHEI scores, based on reference data sites for some of the aquatic life use designations, can be used as surrogates.

The Warmwater Habitat (WWH) use designation QHEI target is 60. In addition, since habitat is strongly correlated with the IBI biocriteria, the QHEI provides a target and format to evaluate how habitat issues and impairments affect attainment of the aquatic use designations. Degraded habitat has been identified as a contributing cause of nonattainment in several stream segments within the TMDL area and has resulted in the Black River RAP listing the Area of Concern as impaired for fish habitat. Additional discussion of the Ohio EPA's QHEI methodology can be found in *The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Ohio EPA, 1989) web link:* **http://www.epa.state.oh.us/dsw/documents/BioCrit88_QHEIIntro.pdf***)*, and the 2006 updated manual found at the web link: **http://www.epa.state.oh.us/dsw/documents/QHEIManualJune2006.pdf**.

For additional information on the targets for the Black River watershed, refer to the technical report entitled *Association between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA, 1999).

2.4.4.1 Habitat Alteration: Nutrients and Sediment/Siltation

Habitat loss and nonpoint source impacts have been identified as causes of impairment in the upper watershed areas and contribute to impairments in the mainstem. Degradation of fish and wildlife populations, degradation of aesthetics and loss of fish and wildlife habitat are three of the impairments to beneficial uses that have been identified by the Black River Remedial Action Plan Coordinating Committee. OAC 3745-1-04(A) states that all waters of the state shall be free from suspended solids and other substances that enter the waters as a result of human activity and that will settle to form objectionable sludge deposits, or that will adversely affect aquatic life.

No statewide numeric criteria have been developed specifically for sediment or total suspended solids (TSS). Instead, target Qualitative Habitat Evaluation Index (QHEI) scores, based on reference data sites for some of the aquatic life use designations, can be used as surrogates.

Table 2-8. QHEI attribute (target) that can serve as management goals for efforts to restore, enhance, or protect aquatic life in streams

	Target	
Attribute	**WWH**	**EWH**
Number of any Modified Attributes	$\leq$4	$\leq$2
No. of High Influence Modified Attributes	$\leq$1	0
Substrate Metric Score	$\geq$13	$\geq$15
Substrate Embeddedness Score	$\geq$3	$\geq$4
Channel Metric Score	$\geq$14	$\geq$15
Overall QHEI Score	$\geq$60	$\geq$75

The QHEI is a quantitative composite of six physical habitat variables used to 'score' a stream's habitat. The variables are: substrate, instream cover, riparian characteristics, channel characteristics, pool/riffle quality, and gradient and drainage area. QHEI can be used to assess and evaluate a stream's aquatic habitat, and determine which of the six habitat components need to be improved to reach the QHEI target score. The 'substrate' parameter accounts for the source and texture of the sediment and its proportional distribution in the substrate. It also accounts for the overall quality of the substrate in the embeddedness metric. These measurements can provide a numeric target for sedimentation.

The use designation target for Warmwater Habitat streams is a QHEI score of 60. In addition, since habitat is strongly correlated with IBI criteria, the QHEI provides a target and format to evaluate how habitat issues and impairments affect attainment of aquatic use designations. Degraded habitat, as witnessed in QHEI scores, is a major cause of non-attainment in the greater Black River basin, particularly the East Branch (downstream Coon Creek to mouth) watershed assessment unit (04110001 040), where increases in suburban development activities and subsequent hydromodifications to stream channels have led to habitat impacts. As development of the Black River watershed continues, habitat alterations resulting in lower QHEI scores could increase adding to the areas in non-attainment.

The effects of nutrient enrichment can be exacerbated by poor physical habitat; conversely, high quality habitat can mitigate those effects. High quality riverine habitats with intact riparian zones and natural channel morphology may decrease the potentially adverse effects of nutrients by assimilating excess nutrients directly into plant biomass (*e.g.*, trees and macrophytes), by sequestering nutrients into invertebrate and vertebrate biomass, by “deflecting” nutrients into the immediate riparian zone during runoff events (see reviews by Malanson, 1993; Barling and Moore, 1994), and by reducing sunlight through shading which is a principal limiting factor in algal production. Also, high quality habitats minimize nutrient retention time in the water column during low flows because they tend to have high flow velocities in narrow low flow channels (e.g., unbraided vs. braided riffles), and coarse substrates with little potential for adsorption. Additionally, a healthy community of aquatic organisms typical of high quality habitats process and utilize nutrients very efficiently.

Poor quality habitat with reduced or debilitated riparian zones (either no riparian zone is present or runoff bypasses the zone via field tiles) and simplified channel morphology generally exacerbate the deleterious effects of nutrients. Under these circumstances, several conditions are likely to influence the severity of the nutrient impact, including:

- a reduction of the riparian uptake and conversion of nutrients
- an increased retention time for nutrients through increased sediment-water column interface via a wide channel and subsequent loss of low flow energy (*e.g.*, increased intermittency)
  a retention of nutrients within the channel due to diminished filtering time during overland flow events
- allowing full sunlight to stimulate nuisance growths of algae.

These factors also interact to increase the retention of nutrients attached to fine sediments, and in planktonic and attached algae (Ohio EPA, 1999). Because phosphorus is delivered to streams attached to fine particles, low gradient streams with a high bedload of fine sediment also provide more time for the available phosphorus to be utilized in undesirable ways such as the production of excess algal biomass, thus promoting tolerant and omnivorous organisms and circumventing assimilation among multiple species and trophic levels (Ohio EPA, 1999). As expected, low gradient streams, are more susceptible to the effects of nutrients because of longer nutrient and sediment retention times. An example in the Black River watershed is the sluggish, lake affected section of the lower mainstem.

Habitat alteration through channelization can exacerbate the effects of sedimentation. Channelization is the removal of trees from stream banks coupled with deepening and often straightening the stream course, and is a direct cause of sedimentation. Channelization increases both the amount of sediment trapped by downstream impoundments and the amount of sedimentation resulting from bank erosion. In addition, channelization and tiling to expedite drainage also result in the loss or reduction of sustained stream flow, and less flow for a given drainage area means less assimilative capacity from a pollutant loadings standpoint.

Portions of channels in the Black River network of streams have been modified and some continue to be maintained in a modified state to facilitate rapid drainage for agricultural and residential land uses. Row crop agriculture accounts for 44.2 percent of the land use in the watershed and pastureland accounts for 8.1 percent. Agricultural activities remain a major source of habitat degradation responsible for non-attainment of aquatic life uses in many of the tributaries. Residential development in the Black River watershed is expected to increase which can lead to increases in imperviousness and additional infringement upon riparian corridors.

Sediment flux in and out of an ecosystem is a natural process, but when deposition exceeds export, degradation of habitat may result. Sediment deposited on the streambed fills interstitial spaces within the substrate, eliminating the niche in which bottom-dwelling organisms reside.

To improve degraded stream habitats and protect areas with adequate habitat characteristics, targets for habitat characteristics for the Black River TMDL study area are presented in Table 2.7 and have been taken from the technical report entitled *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA, 1999). Additional discussion of the Ohio EPA's QHEI methodology can be found in *The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Ohio EPA, 1989)*, web link: **http://www.epa.state.oh.us/dsw/documents/BioCrit88_QHEIIntro.pdf** and the updated manual found at web link: **http://www.epa.state.oh.us/dsw/documents/QHEIManualJune2006.pdf**.

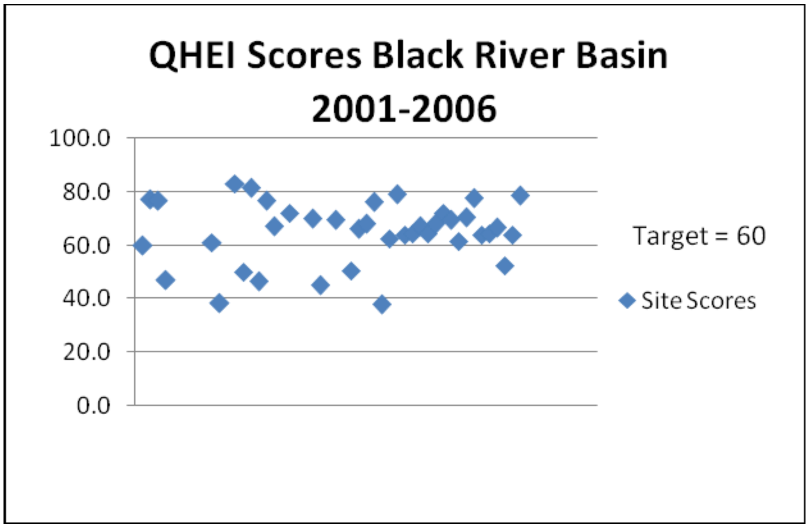

Figure 2-3. Black River watershed QHEI Scores (2001-2006).

3.0 TECHNICAL APPROACH

This section of the report presents the technical approach used to estimate current and allowable loading to the Black River and its tributary streams. As discussed below, three methods were used for TMDL development:

- A load duration approach was used for fecal coliform bacteria TMDL development
- The Soil Water Assessment Tool (SWAT) model was utilized for total suspended solids (TSS), nitrate (NO_3), and total phosphorus (TP) TMDL development
- The CE-QUAL-W2 model was used to further evaluate water quality issues in the most downstream segments of the Black River for dissolved oxygen (DO), nutrients, temperature, sediment oxygen demand and their interrelationships

Load duration analyses were applied to several sampling stations in the watershed that had a sufficient amount of samples (greater than 10) taken after the year 2000. The SWAT model was applied to the upstream portions of the Black River watershed and was linked to the CE-QUAL-W2 analysis in the downstream reaches of the Black River to further study water quality issues throughout the watershed. Each of the various methods is more fully described in the following sections.

3.1 Load Duration Curves

Fecal coliform load reductions were determined through the use of load duration curves because fecal coliform is not well modeled by SWAT. The load duration curve 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. A flow duration curve for the stream is developed by generating 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.

2. The flow curve is translated 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. Each water quality sample is converted to a load by multiplying the water quality 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 represent individual samples that exceed the TMDL target of 1,000 counts/100 mL. Those plotting below the curve represent compliance with the target and the daily allowable load. Further, it can be determined which locations contribute loads above or below the target.

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, such as septic systems and illicit sewer connections; exceedences on the left side of the graph occur during higher flow events, such as runoff. The example shown in Figure 3-1 shows that the exceedences occur at the left side of the graph, or high

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

An example load duration curve is presented in Figure 3-1 and illustrates that all observed fecal coliform loads exceed allowable loads during high flows. Additional exceedences occur at moist and mid-range flows, and all other observed loads are below allowable loads across dry and low flow zones. The figure also indicates that excessive loads primarily occur during high surface runoff events. The proportion of surface versus subsurface flows was determined using the sliding-interval method for streamflow hydrograph separation contained in the USGS HYSEP program (Sloto and Crouse, 1996). Algorithms from HYSEP were incorporated into the load duration analysis to determine the proportion of daily mean discharge that was overland runoff (surface) or ground water discharge (subsurface) components. A surface flow threshold value of 50 percent was used to identify water quality samples that were collected during primarily surface runoff events.

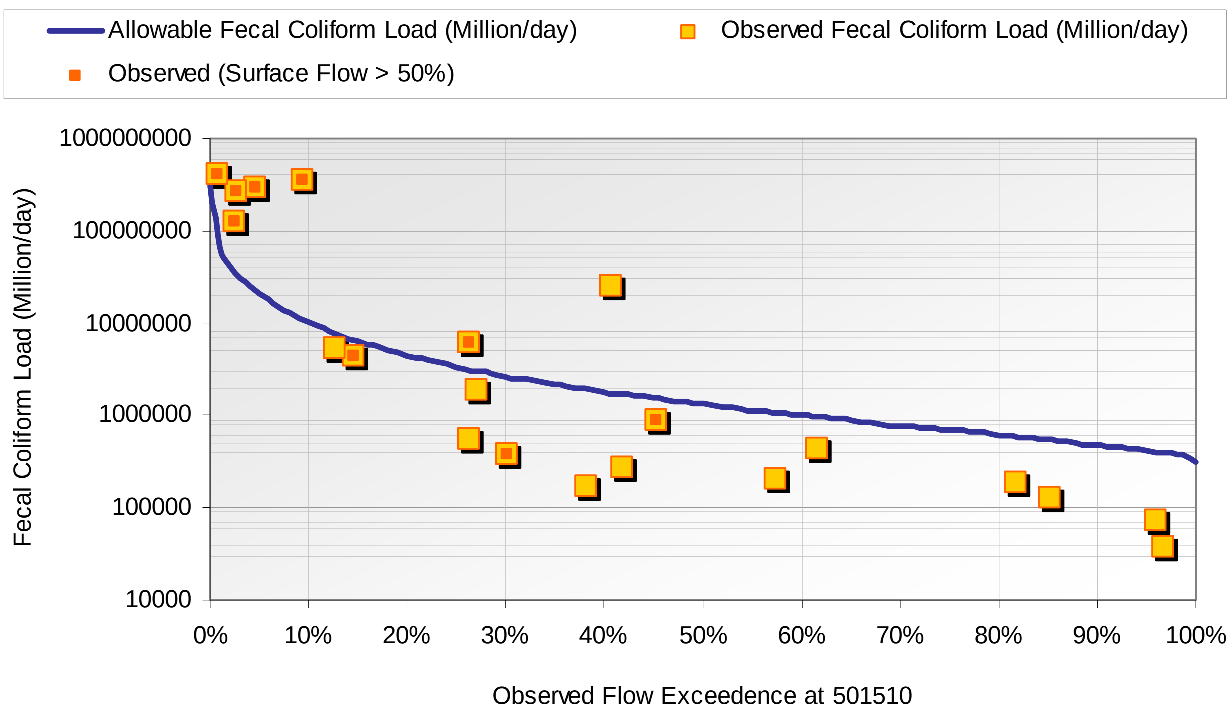

Figure 3-1. Fecal Coliform load duration curve example for monitoring station 501510 located on the Black River mainstem at Ford Road.

The stream flows displayed on a load duration curve may be grouped into various flow regimes to aid with interpretation of the load duration curves. The flow regimes are typically divided into 10 groups which can be further categorized into the following five "hydrologic zones" (Cleland, 2005):

- High flow zone: stream flows that plot in the 0 to 10 percentile range, related to flood flows.
- Moist zone: flows in the 10 to 40 percentile range, related to wet weather conditions.
- Mid-range zone: flows in the 40 to 60 percentile range, median stream flow conditions.
- Dry zone: flows in the 60 to 90 percentile range, related to dry weather flows.
- Low flow zone: flows in the 90 to 100 percentile range, related to drought conditions.

The load duration curve approach is based upon the premise that loads vary depending upon the flow, and different sources may contribute loads under different flow conditions. Using the load duration curve approach assists with determining which implementation practices are most effective for reducing loads based on flow magnitude. For example, if existing loads exceed allowable loads primarily during storm and winter snow melt events, implementation efforts can target those best management practices (BMPs) that will most effectively reduce loads associated with runoff.

The load duration curve is a cost-effective TMDL approach that addresses the reductions necessary to meet target loads. This TMDL ties directly into Ohio's numeric water quality standard for pathogens and numeric targets for nutrients and sediments, therefore meeting these loading capacities should result in attainment of water quality standards.

3.1.1 Stream Flow Estimates

Daily stream flows for each monitoring site of interest are needed to apply the load duration curve. Continuous stream flow data are available for several USGS gage station sites on the Black River. Since the load duration approach requires a stream flow time series for each site where the method is applied, stream flows were extrapolated from the closest gage station to the load duration site. For all stations, the Black River USGS gage near Elyria, Ohio (USGS gage # 04200500) was used for flow estimation. Daily average flows for the Black River gage station were downloaded from **http://waterdata.usgs.gov/nwis**.

Flow time series for the load duration sites were estimated using a multiplier based upon the ratio of the upstream drainage area for the water quality sampling site to the upstream drainage area of the USGS gage station (396 square miles). The USGS gage station flows were then multiplied by the ratio to estimate continuous flows at the water quality sampling sites. Point source design flows were added to the flow estimates of any downstream load duration assessment locations when the flow estimates would otherwise result in minimum flows less than the design flow.

3.2 SWAT Modeling

To support TMDL development for total phosphorus (TP), nitrate (NO_3), and total suspended solids (TSS), the SWAT model was applied to the Black River watershed. SWAT was developed by the U.S. Department of Agriculture to estimate how changes in land management practices in large, complex watersheds influence water, sediment, nutrient, and chemical yields. SWAT requires data inputs for weather, soils, topography, vegetation, and land use to model water and sediment movement, nutrient cycling, and numerous other watershed processes. SWAT is capable of simulating long-term watershed changes and the resulting fluctuations in pollutant concentrations downstream.

Sediment yield and erosion are calculated by SWAT using the Modified Universal Soil Loss Equation (MUSLE). The MUSLE is based on several factors including surface runoff volume, peak runoff rate, area of hydrologic response unit (HRU), soil erodibility, land cover and management, support practice, topography, and a coarse fragment factor. Nutrient movement is simulated using overland runoff and subsurface flow. The transformation of various nitrogen and phosphorus species are simulated using the nitrogen and phosphorus cycles. The modeling process and results are summarized below and more fully described in Appendix B.

3.2.1 Model Setup

This section provides a brief outline of the SWAT model setup and calibration. A detailed report can be found in Appendix B.

The water balance equation drives the SWAT model and selection of an appropriate method for calculating the water balance is critical. The Green & Ampt/Mein-Larson infiltration method was chosen to simulate surface runoff in the Black River SWAT model. An important consideration in modeling the hydrology of the Black River watershed is that much of the agricultural land in the basin is tiled, altering the hydrology of the area. To address this factor, SWAT's tile drainage option was used for subwatersheds that were estimated to have a significant amount of tile drains as determined from information provided by the Medina County and Lorain County Soil and Water Conservation Districts. In addition, several model parameters were adjusted to simulate the effects of tiling on watershed hydrology.

Because significant streambank erosion has been noted in the Black River watershed, SWAT's streambank erosion module was activated. The two parameters used to simulate streambank erosion were the Channel Erodibility Factor (CH_EROD) and the Channel Cover Factor (CH_COV). CH_EROD was set by taking the USLE K factor assigned to each subbasin and reducing this value by one order of magnitude, reflecting the general relationship that is observed between soil and channel erodibility. CH_COV was set by using the percent of eroding bank estimated by USAED Buffalo (1977). Bank erosion for the headwater reaches was not estimated by USAED Buffalo (1977); for these subbasins, the CH_COV of the downstream receiving subbasin was applied.

An ArcView interface for SWAT (DiLuzio et al., 2001) was employed to efficiently derive and build the input files for the SWAT modeling of the Black River watershed. The interface requires digital elevation data (DEM), land use/land cover, soils, and meteorological data. Ten-meter DEM data representing 7.5-minute U.S. Geological Survey (USGS) quadrangles were downloaded from the USGS seamless data distribution system < http://seamless.usgs.gov>. General soils data and map unit delineations for the United States are provided as part of the State Soil Geographic (STATSGO) database (USDA, 1995). From the STATSGO data, USLE K factors as well as hydrologic soil groups were derived. The land use/land cover for the Black River watershed was extracted from the Ohio Statewide Land Cover Classification as described in Section 2.2.

Hourly precipitation and daily temperature data were obtained from the National Climatic Data Center (NCDC) for the Cleveland WSFO Airport (331657), Chippewa Lake (331541), Elyria 3 E (332599), and the Oberlin (336156) climate stations. Relative humidity, solar radiation and wind speed were simulated using a climate simulator available in SWAT. Measured potential evapotranspiration (PET) values are not available for the watershed; however SWAT provides three options for calculating PET values from other meteorological data and the Priestley-Taylor method was chosen to estimate PET in the Black River watershed.

For the Black River watershed, the USGS 14-digit Hydrologic Unit Code (HUC) served as the basis for subbasin definition. Additional subbasins were delineated to obtain model input and output at key locations (e.g., point sources and sampling stations). This resulted in a total of 67 subbasins as shown in Figure 2-1.

Sediment, nutrient, and flow contributions from a number of point sources in the Black River watershed were incorporated in the SWAT model. Data for all of the significant facilities in the watershed were provided by Ohio EPA from the Surface Water Information System (SWIMS) database. To account for the potential loads of household sewage treatment systems (HSTS), artificial "point sources" were input to each modeling subwatershed based on the estimated population served by HSTSs and a representative failure rate of 20 percent.

Several assumptions had to be made regarding agricultural practices in the watershed to provide appropriate input to the model. These assumptions (provided in Appendix B) were based on information obtained during a previous project in the neighboring Huron River watershed and information provided by the Lorain and Medina County Soil and Water Conservation Districts. A majority of the land in the basin is used in row-crop agriculture. The existing model simulates this as a single land cover class (AGRR), subdivided by soil hydrologic group, representing an alternating-year corn-soy rotation. The AGRR management file for each hydrologic soil group was subdivided into two files, one starting with corn and one starting with soybeans. The representation of AGRR management was refined with input from the Medina County SWCD on typical two year crop rotations, conservation tillage practices, fertilizer application, and time between planting and harvest.

3.2.2 Model Calibration

The Black River SWAT model was calibrated for both hydrology and water quality. Calibration was completed by comparing time-series model results to monitoring data. Key considerations in the hydrology calibration were the overall water balance, the high-flow to low-flow distribution, storm flows, and seasonal variation. Two criteria for goodness of fit were used for calibration: graphical comparison and the relative error method. The model's accuracy was primarily assessed through interpretation of the time-variable plots. The relative error method was used to support the goodness of fit evaluation through a quantitative comparison.

Hydrologic calibration initially focused on the period 1990 to 1997. Subsequent application to the period 1998 to 2004 revealed the need for modifications, due to the fact that 1999 to 2002 was generally much drier than 1990 to 1997. Final hydrologic calibration adjustments were performed on the entire 1990 to 2004 period. As a result, there is not a truly independent model validation period. However, the final model performs equally well on both the 1990 to 1997 and 1998 to 2004 periods, as demonstrated below.

Hydrology was the first model component calibrated, and it involved a comparison of observed data from an in-stream USGS flow gauging station to modeled in-stream flow and an adjustment of key hydrologic parameters. With the exception of the very lowest flows, the model adequately describes flow variability within the Black River watershed. The model was found to under predict several large storms, but otherwise captures the timing and volume of most storm event and baseflow conditions. The simulated total flow volume is within 3 percent of the observed total flow volume and all seasonal volumes are within 20 percent. In general, the hydrologic calibration appears adequate in that it reflects the total water yield, seasonal variability, and magnitude of individual storm events in the basin.

After hydrology was sufficiently calibrated, water quality calibration was performed for suspended solids, nitrogen species, and total phosphorus at seven calibration sites. Modeled versus observed in-stream concentrations were directly compared during model calibration. The water quality calibration consisted of running the watershed model, comparing water quality time series output to available water quality observation data, and adjusting pollutant loading and in-stream water quality parameters within a reasonable range. The objective was to best simulate the observed data for individual samples, as well as to obtain modeling output with ranges (i.e., minimums and maximums) similar to the observed data.

The general water quality calibration approach includes graphical comparison of time-series plots, concentration-duration plots and statistical comparison. A visual inspection of the calibration graphs together with the statistics (Appendix B) indicates that the model provides a reasonable description of the significant water quality processes occurring throughout the watershed. Both baseflow and high flow conditions appear to be reasonably simulated by the model. Though there were a few small discrepancies between modeled and observed loads, model performance in general is good across the whole suite of monitored sites. Overall, the model calibration and validation appear acceptable for use in nutrient and suspended sediment TMDLs.

3.3 CE-QUAL-W2 Modeling

The U.S. Army Corps of Engineers CE-QUAL-W2 (W2) model was selected as the receiving water model for simulating dissolved oxygen in the lowermost reaches of the Black River. W2 is a two-dimensional, longitudinal/vertical (laterally averaged), hydrodynamic water quality model (Cole and Wells, 2005) that is applicable to lakes, rivers, and estuaries that do not exhibit significant lateral variability in water quality conditions. W2 can be applied to geometrically complex waterbodies because it allows for variable grid spacing, time variable boundary conditions, and multiple inflows and outflows from point/nonpoint sources and precipitation.

Advantages to choosing W2 for the Black River modeling application include the following:

- W2 is able to address the pollutants of concern (e.g., phosphorus, nitrogen, dissolved oxygen, and chlorophyll *a*).
- W2 is appropriate for a long and narrow river with spatially varying depths.
- W2 is able to provide output from upstream to downstream in the river and at depth.
- W2 could be appropriately linked to the SWAT watershed model.
- W2 is capable of simulating cause-and-effect relationship between loading and river response.

The two major components of the W2 model include hydrodynamics and water quality kinetics. Both of these components are coupled (i.e. the hydrodynamic output is used to drive the water quality at every timestep). This makes it very efficient to execute model runs. The hydrodynamic portion of the model predicts water surface elevations, velocities, and temperature. The water quality portion of W2 can simulate the constituents required for the Black River, including dissolved oxygen (DO), nutrients, and phytoplankton interactions.

3.3.1 Model Setup

Configuration of the W2 model involved setting up the model computational grid, setting initial conditions, boundary conditions, and hydrodynamic parameters for the hydrodynamic simulations.

Bathymetry for the Black River was generated using an existing flood model available from the Federal Emergency Management Agency (FEMA) that provided detailed channel cross sectional information of the navigation channel up to approximately river mile 5. Bathymetry upstream of river mile 5 was based on data from U.S. Geological Survey quadrangle maps.

Initial conditions for the W2 model were estimated based on observed in-stream monitoring data at the start of the calibration period (2001). Boundary conditions were established based on predicted inflows from the watershed model, reported data for the point sources and withdrawals, and hourly surface airways meteorological data. Point sources in the Black River W2 model include five outfalls from the Republic Engineered Products, Inc. (REP) steel plant as well as the Lorain WWTP that is currently located near the confluence of the river and Lake Erie. Two REP cooling water withdrawals, located at river miles 2.9 and 3.9, were also included in the model.

Meteorological data are an important component of the W2 model because the surface boundary conditions are determined by prevailing meteorological conditions. The meteorological data required by the W2 model are air temperature, dew point temperature, wind speed, wind direction, and cloud cover and these data were available hourly from the Lorain County Regional Airport (WBAN-04849).

3.3.2 Model Calibration

The W2 model was calibrated to conditions observed in 2001 because this year had the best set of available water quality data due to a previous modeling effort (LTI, 2003a; Kaur et al., 2007). The year 2001 included both wet and dry periods that provided an opportunity to evaluate the model's performance for a variety of conditions.

The hydrodynamic calibration involved calibration of the temperatures to observed data to ensure that the model represented heat dynamics, mixing, and thermal structure within the water-column profile. The model calibration for temperature involved an iterative process of adjusting model parameters to achieve a reasonable match between the simulated vertical temperature profiles and the observed data. In most cases default values were determined to be sufficient for the model to reasonably predict the observed temperature data (refer to Appendix D for details).

Water quality calibration was done for the same period as the hydrodynamic calibration and similarly involved an iterative process of adjusting key model kinetic parameters to achieve a reasonable match between the model prediction and the observed concentrations. Ammonia, nitrate/nitrite, total phosphorus, and dissolved oxygen were calibrated for vertical profiles at the eight monitoring stations where data were available. All kinetic coefficients were set either in the range of the values observed in literature or based on default values prescribed in the W2 manual. Sediment oxygen demand (SOD) values were assigned based on values reported from a previous study (LTI, 2003b).

The water quality calibration started with nutrients followed by algae and, finally, dissolved oxygen. The nutrient and algae interaction was particularly challenging in the Black River because there were such large differences in observed chlorophyll *a* samples from upstream (higher) to downstream (lower). During the growing season nutrients (especially phosphorus) can be a significant limiting factor that controls algal growth and, therefore, the simulation of chlorophyll a is very dependent on the simulation of nutrients. Algal growth, in turn, impacts the nutrient simulation and the intertwined relationship between nutrient and algae in the Black River required that the algal temperature multipliers be adjusted to simulate timing and magnitude of the algae in the system.

The model simulates a clear seasonal pattern in phytoplankton biomass in that algae are generally more abundant during the warm period. There is also a spatial trend, with higher algal concentrations observed in the upstream shallower part of the river and lower concentrations in the dredged portion of the river. The model is able to capture the temporal and spatial trends fairly well, although it underpredicts a peak concentration that occurs at the end of July. The highly dynamic, short-term variations of chlorophyll *a* are extremely difficult to model since eutrophication models are better suited to simulating the long-term (daily to monthly time scale) chlorophyll *a* levels rather than the short-term (hourly) concentrations."

The simulated profiles of dissolved oxygen match the observed profiles well in terms of magnitude and vertical variation at most locations. The model adequately captures the general trend of high dissolved oxygen occurring throughout the water column during periods when the river is not stratified, and very low dissolved oxygen in the lower portions of the river during the summer and early fall when the lower portion of the river is stratified. Model performance, however, is suboptimal at several of the shallow monitoring locations and where the dissolved oxygen profile stratifies twice. This may be due to a variety of reasons including:

- W2 might also not be well simulating the algal settling and therefore is underestimating the (unknown) algal density at intermediate depths of the river. This, in turn, would lead to a corresponding underprediction of the oxygen demand.
- W2 might also be overestimating the down-mixing of oxygen from the surface. However, this is not as likely since the temperatures are calibrated quite well which suggests that mixing is well simulated by the model. Furthermore, the observed EC and TDS do not exhibit the same type of strong stratification as evidenced by the dissolved oxygen. Overall, the model has mimicked the dynamics of DO in the lake in both spatial and seasonal pattern.

Despite these sporadic discrepancies between the modeled and observed concentrations, the model provides a reasonable description of the significant water quality processes that occurs in the lower Black River. Overall, the model calibration appears acceptable for use in evaluating the potential benefits of a variety of management alternatives to improve dissolved oxygen conditions.

4.0 TMDL RESULTS

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. TMDLs can also optionally be developed with a Future Growth Reserve for watersheds that are experiencing significant population growth. Conceptually, this is defined by the equation:

$$TMDL = WLA + LA + MOS + (Future\ Growth\ Reserve)$$

A summary of the load reductions needed for all parameters in the Black River watershed is presented in this section of the report. The allocations by each of the various sources and parameters are shown in the following tables. WLAs were established for facilities with individual National Pollutant Discharge Elimination System (NPDES) permits and for the Municipal Separate Storm Sewer Systems (MS4's), throughout the Black River watershed, regulated under Phase II of EPA's storm water program. The MS4 WLAs were calculated as the allowable daily load times the fraction of upstream watershed area occupied by the MS4 times the ratio of the per-acre loading rate for the pollutant from urban areas to the averaging loading rate from all the dispersed sources in the watershed (see Appendix C for details). A five percent allowance for Future Growth within the watershed is also factored into TMDL calculation due to portions of the watershed that are developing rapidly.

The WLAs for individual facilities are summarized in the subsections below and were established based on each plant's design flow and permit limits. Additional details are provided below and in Appendix C.

Load duration analyses were used to develop the fecal coliform TMDLs and the SWAT model was used to develop the nitrate, total phosphorus, and total suspended solids TMDLs. Because of the different approaches, the remainder of this section is organized by TMDL pollutant.

4.1 Fecal Coliform

Load duration curves were developed for nine sampling stations throughout the Black River watershed (Figure 4-1):

- Two sites on the mainstem of the Black River, downstream of the East and West Branch confluence:
    - At RM 9.8, downstream of the Elyria WWTP (501510)
    - At RM 10.6, upstream of the Elyria WWTP (BR10.6)
- One site on French Creek
    - At RM 2.8 upstream of the French Creek WWTP (FCr)
- One site on Plum Creek
    - At RM 2.9, upstream of the Oberlin WWTP (PC2.9)
- One site on the East Branch Black River
    - At RM 11.2, upstream of the Grafton WWTP (EB11.2)
- One site on the East Fork of the East Branch Black River
    - At RM 41.5, upstream of the Lodi WWTP (EFEB)

For each load duration site, all appropriate and available water quality and flow data were used. The load duration analyses for fecal coliform were based on flows and samples collected during the recreation season (May 1 to October 15) to be consistent with Ohio's water quality standards. Table 4-1 summarizes the data used for the load duration analyses in the Black River watershed. Due to a lack of recent data, load duration analysis for fecal coliform could not be performed on the mainstem of the West Branch Black River.

Table 4-1. Summary of Data Used for Load Duration Analysis.

Stream (Station ID)	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
Black River (501510)	At RM 9.8, downstream of the Elyria WWTP	Fecal Coliform (#/100ml)	21	3,903	88	33,000	5/18/2000-8/4/2004
Black River (BR10.6)	At RM 10.6, upstream of the Elyria WWTP	Fecal Coliform (#/100ml)	40	469	27	3,300	5/11/2000-9/7/2006
French Creek (FCr)	At RM 2.8 upstream of the French Creek WWTP	Fecal Coliform (#/100ml)	39	1,229	208	8,000	6/8/2000-10/3/2006
Schroeder Ditch (CARL99-02)	At intersection of Oberlin-Elyria Road and Murray Ridge Road	Fecal Coliform (#/100ml)	12	728	40	2,700	6/17/1999-9/7/2000
Elk Creek (CARL99-14)	At Nickel Plate Diagonal Road	Fecal Coliform (#/100ml)	14	947	60	6,800	9/21/1999-8/29/2000
Plum Creek (PC2.9)	At RM 2.9, upstream of the Oberlin WWTP	Fecal Coliform (#/100ml)	37	860	33	13,000	6/5/2000-9/26/2006
Brentwood Lake Tributary (CARL99-07)	At Robson Road	Fecal Coliform (#/100ml)	14	707	100	3,000	6/15/1999-9/21/2000
East Branch Black River (EB11.2)	At RM 11.2, upstream of the Grafton WWTP	Fecal Coliform (#/100ml)	36	341	4	1,750	6/6/2000-10/4/2006
East Fork of the East Branch Black River (EFEB)	At RM 41.5, upstream of the Lodi WWTP	Fecal Coliform (#/100ml)	14	1,646	100	11,400	6/5/2000-8/10/2006

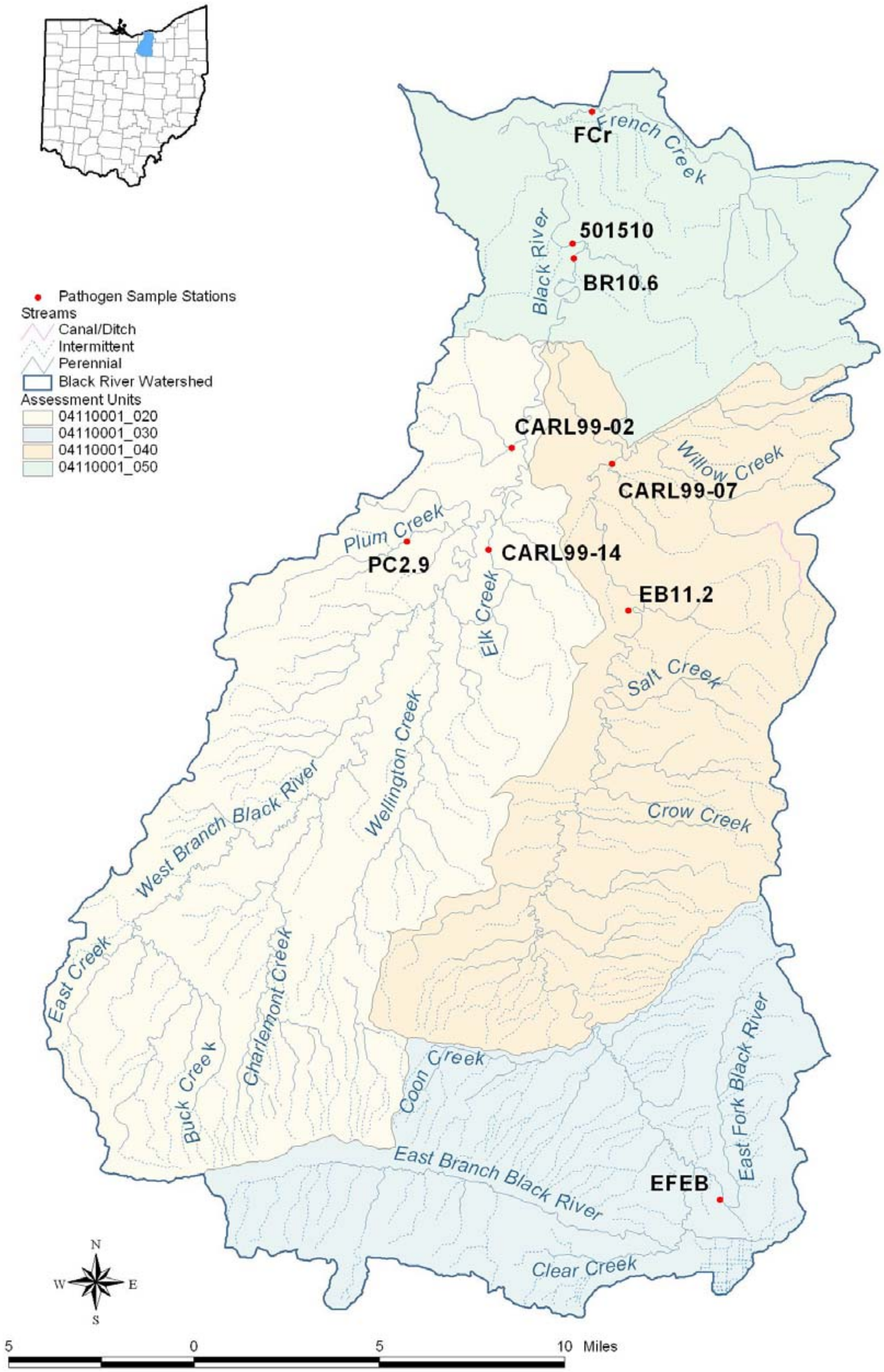

Figure 4-1. Load duration site locations for fecal coliform analysis.

4.1.1 Black River (501510)

Existing and allowable fecal coliform loads were calculated for the Black River at River Mile (RM) 9.8, downstream of the Elyria WWTP (501510). This sampling station drains 412 square miles and land use/land cover upstream of this station consists primarily of row crops (49%), deciduous forest (25%), residential (12%), and pasture/hay (9%) land uses. A total of 21 fecal coliform samples collected by Ohio EPA were available for the load duration analysis at site 501510 (Table 4-1) and samples have been collected across all flow conditions. Ten permitted WWTP facilities (Table 4-2) and five designated MS4's (Table 4-3) discharge upstream of site 501510.

Table 4-2. Fecal coliform WLA calculation for WWTPs upstream of site 501510.

Facility	NPDES ID	Permit #	Design Flow (MGD)	Fecal Coliform Limit (#/100ml)	Fecal Coliform WLA (million/day)
Lagrange WWTP	OH0046221	3PB00061	0.363	1,000	13,741
Oberlin WWTP	OH0020427	3PD00025	1.5	1,000	56,781
Wellington WWTP	OH0026158	3PC00014	0.75	1,000	28,391
Findlay State Park Campground	OH00370044	3PP00004	0.025	1,000	946
Spencer WWTP	OH0022071	3PA00018	0.09	1,000	3,407
Lodi WWTP	OH0020991	3PB00027	0.8	1,000	30,283
Grafton WWTP	OH0025372	3PB00024	1.5	1,000	56,781
Eaton Estates WWTP	OH0026140	3PH00023	0.20	1,000	7,571
Brentwood Lake WWTP	OH0026158	3PH00024	0.12	1,000	4,542
Elyria WWTP	OH0025003	3PD00034	13	1,000	492,103
Total Fecal Coliform WLA					**694,546**

Table 4-3. Fecal coliform WLA calculation for MS4s upstream of site 501510.

Designated MS4	Percent of Upstream Drainage Area	WLA at High Flows (million/day)	WLA at Moist Conditions (million/day)	WLA at Mid-Range Flows (million/day)
City of Elyria	3.64%	783,374	134,811	60,610
City of Grafton	1.10%	235,529	40,532	18,223
City of North Ridgeville	2.29%	493,086	84,855	38,150
City of Oberlin	0.88%	189,338	32,583	14,649
Village of Sheffield	0.01%	1,466	252	113
Total Fecal Coliform WLA		**1,702,793**	**293,033**	**131,745**

Table 4-4 presents the TMDL summary for site 501510. The analysis indicates that significant load reductions are needed during high flow conditions but that current loads are less than allowable loads during all other flows. Sources of fecal coliform during high flows likely includes runoff from both urban and rural areas, sewer overflows and re-suspension of fecal coliform from the bottom of the river channel.

Table 4-4 indicates that the cumulative WLAs for the WWTPs (694,546 Million/day total) are a significant portion of the low flow TMDL load. However, this is misleading for several reasons. First, the cumulative WLA assumes that each and every plant is discharging at its maximum capacity (or design flow) and fecal coliform permit limit (1000 cfu/100 mL). This would almost never occur, as demonstrated by the fact that the current instream loads shown in Table 4-4 are often less than the cumulative WLAs. Furthermore, the load duration analysis does not account for the die-off of fecal coliform that occurs between the facilities and the assessment location.

Table 4-4. Loading Statistics for the Black River (501510).

501510 TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Fecal Coliform (Million/day)	Current Load	293,762,159	2,071,431	705,359	277,679	99,582
	TMDL= LA+WLA+MOS	**21,508,419**	**3,701,380**	**1,664,107**	**1,001,993**	**737,147**
	LA	16,960,238	2,343,662	671,405	207,248	5,744
	Future Growth Reserve (5%)	1,075,421	185,069	83,205	50,100	36,857
	Total WLA: WWTPs	694,546	694,546	694,546	694,546	694,546
	Total WLA: MS4s	1,702,793	293,033	131,745	0	0
	MOS (5%)	1,075,421	185,069	83,205	50,100	0
	TMDL Reduction (%)	93%	0%	0%	0%	0%

4.1.2 Black River (BR10.6)

Existing and allowable fecal coliform loads were calculated for the Black River at RM 10.6, upstream of the Elyria WWTP (BR10.6). This sampling station drains 401.01 square miles and land use/land cover upstream of this station consists primarily of row crops (50%), deciduous forest (25%), residential (11%), and pasture/hay (9%) land uses. A total of 40 fecal coliform samples were available for the load duration analysis at site BR10.6 (Table 4-1). Water quality data for this station consists of samples collected by the Elyria WWTP and reported to Ohio EPA as part of its NPDES permit requirements. Fecal data have been collected across all flow conditions and there are nine permitted WWTP facilities (Table 4-5) and five designated MS4's (Table 4-6) that discharge upstream of the BR10.6 sampling station.

Table 4-5. Fecal coliform WLA calculation for WWTPs upstream of site BR10.6.

Facility	NPDES ID	Permit #	Design Flow (MGD)	Fecal Coliform Limit (#/100ml)	Fecal Coliform WLA (million/day)
Lagrange WWTP	OH0046221	3PB00061	0.363	1,000	13,741
Oberlin WWTP	OH0020427	3PD00025	1.5	1,000	56,781
Wellington WWTP	OH0026158	3PC00014	0.75	1,000	28,391
Findlay State Park Campground	OH00370044	3PP00004	0.025	1,000	946
Spencer WWTP	OH0022071	3PA00018	0.09	1,000	3,407
Lodi WWTP	OH0020991	3PB00027	0.8	1,000	30,283
Grafton WWTP	OH0025372	3PB00024	1.5	1,000	56,781
Eaton Estates WWTP	OH0026140	3PH00023	0.20	1,000	7,571
Brentwood Lake WWTP	OH0026158	3PH00024	0.12	1,000	4,542
Total Fecal Coliform WLA					**202,443**

Table 4-6. Fecal coliform WLA calculation for MS4s upstream of site BR10.6.

Designated MS4	Percent of Upstream Drainage Area	WLA at High Flows (million/day)	WLA at Moist Conditions (million/day)	WLA at Mid-Range Flows (million/day)
City of Elyria	3.74%	765,506	116,940	42,739
City of Grafton	1.13%	230,157	35,159	12,850
City of North Ridgeville	2.36%	481,839	73,607	26,901
City of Oberlin	0.90%	185,020	28,264	10,330
Village of Sheffield	0.01%	1,432	219	80
Total Fecal Coliform WLA		**1,663,954**	**254,189**	**92,900**

Table 4-7 presents the TMDL summary for the BR10.6 sampling station. Although there have been occasional exceedences of the fecal coliform water quality standard, the load duration analysis suggests that the median observed loads are less than the allowable loads and thus no reductions are necessary.

Table 4-7. Loading Statistics for the Black River (BR10.6).

BR10.6 TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Fecal Coliform (Million/day)	Current Load	7,161,861	2,040,895	302,166	97,392	15,668
	TMDL= LA+WLA+MOS	**20,447,754**	**3,123,638**	**1,141,615**	**497,458**	**239,795**
	LA	16,536,582	2,354,643	732,111	245,269	13,373
	Future Growth Reserve (5%)	1,022,388	156,182	57,081	24,873	11,990
	Total WLA: WWTPs	202,443	202,443	202,443	202,443	202,443
	Total WLA: MS4s	1,663,954	254,189	92,900	0	0
	MOS (5%)	1,022,388	156,182	57,081	24,873	11,990
	TMDL Reduction (%)	0%	0%	0%	0%	0%

4.1.3 French Creek (FCr)

Existing and allowable loads were calculated for French Creek upstream of the French Creek WWTP at RM 2.8 (FCr). This sampling station drains 32 square miles and land use/land cover upstream of this station consists primarily of residential (50%), deciduous forest (25%), row crops (8%), and commercial/industrial/transportation (6%). A total of 39 fecal coliform samples were available for the load duration analysis at site FCr (Table 4-1). Water quality data for this station consists of samples collected upstream of the French Creek WWTP discharge as part of NPDES permit requirements. Fecal coliform samples at this site were collected across all flow conditions. Portions of five designated MS4's lie within the watershed upstream of the FCr sampling station (Table 4-8). There are no permitted WWTPs that discharge upstream of FCr.

Table 4-8. Fecal coliform WLA calculation for MS4s upstream of site FCr.

Designated MS4	Percent of Upstream Drainage Area	WLA at High Flows (million/day)	WLA at Moist Conditions (million/day)	WLA at Mid-Range Flows (million/day)
City of Avon	37.11%	607,781	92,617	33,678
City of Avon Lake	0.004%	67	10	4
City of North Ridgeville	40.41%	661,726	100,838	36,668
Village of Sheffield	1.74%	28,569	4,353	1,583
City of North Olmsted	2.66%	43,537	6,634	2,412
City of Westlake	7.66%	125,404	19,110	6,949
Total Fecal Coliform WLA		**1,467,083**	**223,563**	**81,294**

Table 4-9 presents the TMDL summary for the FCr sampling station. Load reductions are needed for both high and mid-range flow conditions. Sources of fecal coliform during these periods likely include runoff from urban areas as well as re-suspension of fecal coliform from the bottom of the river channel. The cumulative MS4 fecal coliform loads appear to contribute a large portion of the allowable loads at mid-range, moist and high flow conditions, likely a result of the MS4 areas covering a large percentage of the French Creek watershed (nearly 90 percent).

Table 4-9. Loading Statistics for French Creek (FCr).

FC TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Fecal Coliform (Million/day)	Current Load	22,955,813	201,237	111,274	14,581	7,322
	TMDL= LA+WLA+MOS	**1,637,603**	**249,548**	**90,743**	**39,131**	**18,487**
	LA	6,759	1,030	375	35,218	16,638
	Future Growth Reserve (5%)	81,880	12,477	4,537	1,957	924
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	Total WLA: MS4s	1,467,083	223,563	81,294	0	0
	MOS (5%)	81,880	12,477	4,537	1,957	924
	TMDL Reduction (%)	94%	0%	27%	0%	0%

4.1.4 Schroeder Ditch

Existing and allowable loads were calculated for Schroeder Ditch, at the intersection of Oberlin-Elyria Road and Murray Ridge Road (CARL99-02). This sampling station drains 7.56 square miles and land use/land cover upstream of this station consists primarily of row crop agriculture (48%), residential (19%), pasture (16%), and deciduous forest (11%). A total of 12 fecal coliform samples were available for the load duration analysis at this site (Table 4-1). Water quality data for this station were collected by the Lorain County General Health District as part of a study to evaluate the effects of residential sewage treatment/disposal in the Black River watershed. Fecal coliform samples at this site were collected across moist to dry flow conditions. Portions of the Elyria designated MS4 lie within the watershed upstream of this sampling station (Table 4-10) and there are no permitted WWTPs that discharge upstream of the monitoring site.

Table 4-10. Fecal coliform WLA calculation for the Elyria MS4 upstream of Schroeder Ditch.

Designated MS4	Percent of Upstream Drainage Area	WLA at High Flows (million/day)	WLA at Moist Conditions (million/day)	WLA at Mid-Range Flows (million/day)
City of Elyria	19.88%	76,431	11,512	4,085

Table 4-11 presents the TMDL summary for the sampling station on Schroeder Ditch. Current loads exceed the allowable loads during moist conditions and no data are available for high and low flow periods. Sources of fecal coliform during moist condition flows likely include runoff from both urban and rural areas.

Table 4-11. Loading Statistics for Schroeder Ditch.

Schroeder Ditch TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Fecal Coliform (Million/day)	Current Load	No Data	96,894	2,382	1,308	No Data
	TMDL= LA+WLA+MOS	**384,518**	**57,917**	**20,551**	**8,407**	**3,550**
	LA	269,635	40,613	14,410	7,567	3,196
	Future Growth Reserve (5%)	19,226	2,896	1,028	420	177
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: Elyria MS4	76,431	11,512	4,085	0	0
	MOS (5%)	19,226	2,896	1,028	420	177
	TMDL Reduction (%)	No Data	46%	0%	0%	No Data

4.1.5 Elk Creek

Existing and allowable loads were calculated for Elk Creek (a tributary to the West Branch Black River), at Nickel Plate Diagonal Road (CARL99-14). This sampling station drains 8.84 square miles and land use/land cover upstream of this station consists primarily of row crop agriculture (64%), residential (13%), pasture (11%), and deciduous forest (9%). A total of 14 fecal coliform samples were available for the load duration analysis in Elk Creek (Table 4-1). Water quality data for this station consists of samples collected by the Lorain County General Health District as part of a study to evaluate the effects of residential sewage treatment/disposal in the Black River watershed. Fecal coliform samples at this site were collected across moist to low flow conditions. There are no designated MS4s or permitted WWTPs discharging upstream of this sampling site.

Table 4-12 presents the TMDL summary for the Elk Creek sampling station and indicates that load reductions are needed during dry conditions (no data are available during high flow conditions). Sources of fecal coliform during dry conditions could include livestock and wildlife with direct access to the stream as well as failing home sewage treatment systems.

Table 4-12. Loading Statistics for Elk Creek.

Elk Creek TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Fecal Coliform (Million/day)	Current Load	No Data	30,585	2,130	10,049	879
	TMDL= LA+WLA+MOS	**449,622**	**67,723**	**24,031**	**9,831**	**4,151**
	LA	404,660	60,951	21,627	8,847	3,735
	Future Growth Reserve (5%)	22,481	3,386	1,202	492	208
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (5%)	22,481	3,386	1,202	492	208
	TMDL Reduction (%)	No Data	0%	0%	12%	0%

4.1.6 Plum Creek (PC2.9)

Existing and allowable loads were calculated for Plum Creek upstream of the Oberlin WWTP at RM 2.9 (PC2.9). This sampling station drains 8.65 square miles and land use/land cover upstream of this station consists primarily of row crops (35%), residential (32%), pasture (13%), and deciduous forest (11%) land uses. A total of 37 fecal coliform samples were available for the load duration analysis at site PC2.9 (Table 4-1). Water quality data for this station consists of samples collected upstream of the Oberlin WWTP discharge following NPDES permit requirements. Data for this station were collected across all flow regimes. One designated MS4, the City of Oberlin (37.89% of the total upstream watershed area), is within the Plum Creek watershed, upstream of the PC2.9 station. There are no permitted WWTP facilities located upstream of the sampling station.

Table 4-13 presents the TMDL summary for site PC2.9. Though there are several observed samples that exceed the water quality standard; however, the median loads for each flow category indicate that no fecal coliform reductions are needed. The City of Oberlin designated MS4 appears to contribute a large portion of the current load across high, moist, and mid-range flow conditions, likely due to the municipal area contributing to a large percentage of the upstream watershed (nearly 40 percent).

Table 4-13. Loading Statistics for Plum Creek (PC2.9).

PC2.9 TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Fecal Coliform (Million/day)	Current Load	350,577	23,728	8,818	3,078	406
	TMDL= LA+WLA+MOS	**439,958**	**66,268**	**23,514**	**9,619**	**4,062**
	LA	229,282	34,535	12,254	8,658	3,655
	Future Growth Reserve (5%)	21,998	3,313	1,176	481	203
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: City of Oberlin MS4	166,680	25,106	8,909	0	0
	MOS (5%)	21,998	3,313	1,176	481	203
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	**0%**

4.1.7 Brentwood Lake Tributary (CARL99-07)

Existing and allowable loads were calculated for the Brentwood Lake tributary (CARL99-07). This sampling station drains 5.21 square miles and land use/land cover upstream of this station consists primarily of row crop agriculture (35%), residential (31%), deciduous forest (25%), and urban/recreational grasses (5%). A total of 14 fecal coliform samples were available for the load duration analysis at site CARL99-07 (Table 4-1). Water quality data for this station consists of samples collected by the Lorain County General Health District. Fecal coliform samples at this site were collected across all flow conditions. Portions of the Grafton designated MS4 lies within the watershed upstream of this sampling station (Table 4-14). The Brentwood Lake WWTP discharges upstream of the monitoring station on the Brentwood Lake Tributary.

Table 4-14. Fecal coliform WLA calculation for the Grafton MS4 upstream of site the Brentwood Lake Tributary site.

Designated MS4	Percent of Upstream Drainage Area	WLA at High Flows (million/day)	WLA at Moist Conditions (million/day)	WLA at Mid-Range Flows (million/day)
City of Grafton	10.23%	27,109	4,083	1,449

Table 4-15 presents the TMDL summary for the Brentwood Lake tributary sampling station and indicates that load reductions are needed for mid-range flows. Sources of fecal coliform during these periods could include runoff from urban and rural areas, livestock and wildlife with direct access to the stream, and failing onsite wastewater treatment systems.

Table 4-15. Loading Statistics for the Brentwood Lake tributary (CARL99-07).

Brentwood Lake Tributary TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Fecal Coliform (Million/day)	Current Load	144,242	39,929	28,610	3,133	686
	TMDL= LA+WLA+MOS	**269,535**	**44,457**	**18,706**	**10,337**	**6,990**
	LA	211,384	31,840	11,299	5,215	2,204
	Future Growth Reserve (5%)	13,250	1,996	708	290	122
	WLA: Brentwood Lake WWTP	4,542	4,542	4,542	4,542	4,542
	WLA: MS4	27,109	4,083	1,449	0	0
	MOS (5%)	13,250	1,996	708	290	122
	TMDL Reduction (%)	0%	0%	34%	0%	0%

4.1.8 East Branch Black River (EB11.2)

Existing and allowable loads were calculated for the East Branch Black River, upstream of the Grafton WWTP at RM 11.2 (EB11.2). This sampling station drains 169.88 square miles and land use/land cover upstream of this station consists primarily of row crops (52%), deciduous forest (31%), pasture /hay (10%) and residential (6%) land uses. A total of 36 fecal coliform samples were available for the load duration analysis at site EB11.2 (Table 4-1). Data for this station have been collected across all flow regimes upstream of the Grafton WWTP discharge following NPDES permit requirements. The Lodi WWTP discharges upstream of the EB11.2 sample station. There are no designated MS4s upstream of site EB11.2.

Table 4-16 presents the TMDL summary for the EB11.2 sample station. Although three of the 36 fecal coliform observations exceed water quality standards, median loads are less than allowable loads for all flow conditions.

Table 4-16. Loading Statistics for the East Branch Black River (EB11.2).

EB11.2 TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Fecal Coliform (Million/day)	Current Load	6,767,538	513,107	132,244	10,076	8,276
	TMDL= LA+WLA+MOS	**8,640,471**	**1,301,450**	**461,805**	**188,920**	**79,766**
	LA	7,746,141	1,141,022	385,341	139,745	41,507
	Future Growth Reserve (5%)	432,024	65,072	23,090	9,446	3,988
	WLA: Lodi WWTP	30,283	30,283	30,283	30,283	30,283
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (5%)	432,024	65,072	23,090	9,446	3,988
	TMDL Reduction (%)	0%	0%	0%	0%	0%

4.1.9 East Fork of the East Branch Black River (EFEB)

Existing and allowable loads were calculated for the East Fork of the East Branch Black River, upstream of the Lodi WWTP at RM 41.5. This sampling station drains 13.82 square miles and land use/land cover upstream of this station consists primarily of deciduous forest (50%), row crops (31%), pasture/hay (9%) and residential (9%) land uses. A total of 14 fecal coliform samples were available for load duration analysis at site EFEB (Table 4-1). Water quality data for this station consists of samples collected upstream of the Lodi WWTP discharge following NPDES permit requirements. Fecal coliform samples were obtained across moist, mid-range, and dry flow conditions at this site. There are no WWTPs or designated MS4s located upstream of the EFEB sampling.

Table 4-17 presents the TMDL summary for site EFEB. Although two of the 14 fecal coliform observations exceed water quality standards, median loads are less than allowable loads for all flow conditions.

Table 4-17. Loading Statistics for the East Fork of the East Branch Black River (EFEB).

EFEB TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Fecal Coliform (Million/day)	Current Load	No Data	39,550	20,109	4,911	No Data
	TMDL= LA+WLA+MOS	**702,916**	**105,875**	**37,569**	**15,369**	**6,489**
	LA	632,624	95,287	33,812	13,832	5,840
	Future Growth Reserve (5%)	35,146	5,294	1,878	768	324
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (5%)	35,146	5,294	1,878	768	324
	TMDL Reduction (%)	No Data	0%	0%	0%	No Data

4.2 TSS and Nutrients

Allowable and existing loads of total suspended solids, nitrate, and total phosphorus were calculated using the calibrated SWAT model instead of load duration curves. The allocation approach and results are described in the following sections.

4.2.1 Allocation Approach

For sediment and nutrients, the targets for the watershed TMDL are expressed as monthly average concentrations (Table 2-6) at the following assessment locations:

- West Branch Black River near the mouth (SWAT Subbasin 8- corresponds to the furthest downstream point on the West Branch in AU 04110001-020)
- East Branch Black River near the mouth (SWAT Subbasin 9- corresponds to the furthest downstream point on the East Branch in AU 04110001-030)
- East Branch Black River, east of Spencer (SWAT Subbasin 24- corresponds to the furthest downstream point on the East Branch in AU 04110001-040)

The monthly average concentration targets can be met by many different combinations of daily concentrations and loads, and indeed do not constrain loads on individual days. The concentrations at the assessment locations are also determined after losses in transit from the upstream source areas; thus, the loads entering the stream are equal to or greater than the loads present in the river at the assessment locations.

The TMDL scenario simulated by the SWAT model is predicted to meet the compliance targets, and thus contains a time series of source loads that are consistent with the Black River's loading capacity. The key to achieving water quality standards is the set of management practices proposed in the TMDL scenario and their impact is best summarized in terms of monthly and annual loading rates by source. However, the TMDL must include daily load allocations. To specify a daily maximum load that achieves the loading capacity, an appropriate strategy is to start with the predicted series of source loads in the TMDL modeling scenario, then choose an upper confidence limit as the maximum load that is allowable on a daily basis. That is, the maximum daily loads that are consistent with the loading capacity are the set of loads that are consistent with the statistical distribution of daily loads in the allocation scenario. The daily load expression, while required by law, is thus a supplementary expression to the longer term loading capacity and allocations that form the essential part of achieving use support in the watershed.

The TMDL regulations at 140 CFR 130.2 define the TMDL as "the sum of the individual WLAs for point sources and LAs for nonpoint sources and natural background." WLAs (wasteload allocations) and LAs (load allocations) are defined as "portions of a receiving water's loading capacity," while loading capacity is defined as "the greatest amount of load that a water can receive without violating water quality standards." TMDLs for the Black River are defined as the sum of two general components: (1) a static or constant component consisting of the WLAs for wastewater treatment plants, and (2) a dynamic, flow-dependent component that contains the LAs for nonpoint sources, along with any WLAs for permitted MS4s. The resulting TMDLs thus consist of constant terms plus an equation relating additional allowable loads to flow. Appendix C provides a detailed description of the approach that was used to estimate the static and dynamic loads.

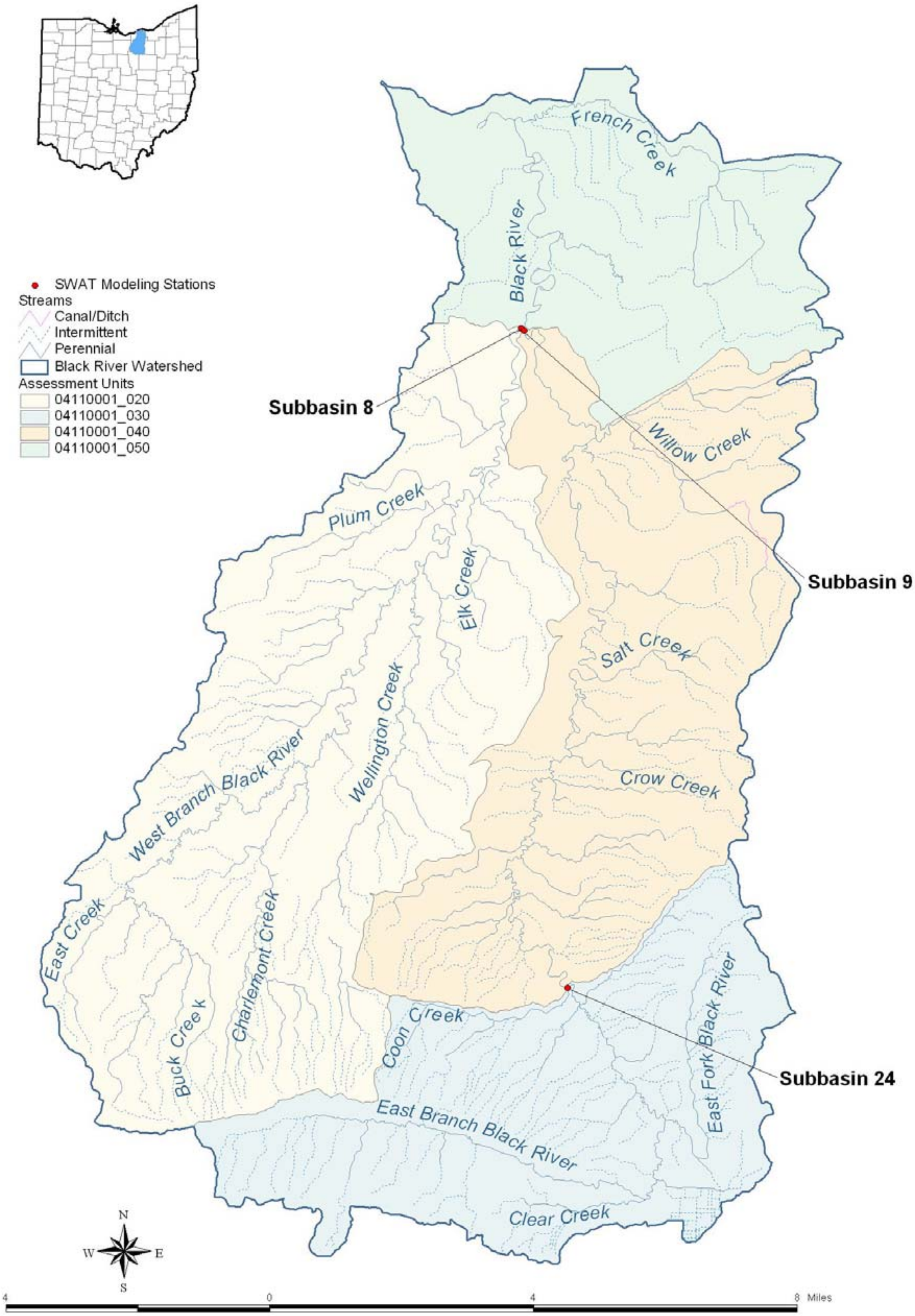

Figure 4-2. TSS and nutrient TMDL assessment locations.

4.2.2 Subbasin 8

Existing and allowable loads were calculated for the West Branch Black River near the mouth (Subbasin 8). This sampling station drains 174.1 square miles and land use/land cover upstream of this station consists primarily of row crops (53%), deciduous forest (22%), pasture/hay (10%), and residential (9%) land uses. Four WWTPs discharge upstream of Subbasin 8 and two designated MS4s are within the upstream watershed (Table 4-18).

Table 4-21 presents the TMDL summary for Subbasin 8. As presented in Appendix B, annual average load reductions of approximately 54 percent total phosphorus, 43 percent nitrate, and 48 percent total suspended solids are needed to meet the TMDL targets. The SWAT modeling suggests that these reductions can be achieved through a combination of increased riparian buffers, the elimination of failing home sewage treatment plants, point source controls, and reduced streambank erosion (see Appendix B for details).

Table 4-18. TMDL Allocation Summary for Subbasin 8.

Pollutant	Allocation Component	High Flows (780 cfs)	Moist Conditions (112 cfs)	Mid-Range Flows (23 cfs)	Dry Conditions (6 cfs)	Low Flows (4 cfs)
Total Phosphorus (kg/day)	**TMDL= LA+WLA+MOS**	**1607.78**	**145.43**	**23.91**	**11.47**	**11.42**
	LA	1477.76	129.87	17.87	6.50	6.50
	City of Oberlin MS4 (part) WLA	19.55	1.72	0.24	0.04	0.02
	City of Elyria MS4 (part) WLA	29.60	2.60	0.36	0.07	0.04
	Lagrange WWTP WLA	0.39	0.39	0.39	0.39	0.39
	Oberlin WWTP WLA	2.39	2.39	2.39	2.39	2.39
	Wellington WWTP WLA	1.28	1.28	1.28	1.28	1.28
	Findlay State Park Campground WLA	0.25	0.25	0.25	0.25	0.25
	MOS (5%)	76.56	6.93	1.14	0.55	0.54
Nitrate (kg/day)	**TMDL= LA+WLA+MOS**	**15007.11**	**1168.34**	**189.86**	**103.01**	**103.00**
	LA	14230.89	1058.92	127.21	44.51	44.51
	City of Oberlin MS4 (part) WLA	2.68	0.20	0.02	0.00	0.00
	City of Elyria MS4 (part) WLA	5.34	0.40	0.05	0.01	0.00
	Lagrange WWTP WLA	2.62	2.62	2.62	2.62	2.62
	Oberlin WWTP WLA	40.49	40.49	40.49	40.49	40.49
	Wellington WWTP WLA	8.44	8.44	8.44	8.44	8.44
	Findlay State Park Campground WLA	2.03	2.03	2.03	2.03	2.03
	MOS (5%)	714.62	55.66	9.04	4.91	4.90
Total Suspended Solids (1000kg/day)	**TMDL= LA+WLA+MOS**	**1248.282**	**156.882**	**29.029**	**12.375**	**12.238**
	LA	1127.551	141.560	26.055	11.270	11.270
	City of Oberlin MS4 (part) WLA	30.542	3.834	0.706	0.168	0.103
	City of Elyria MS4 (part) WLA	30.567	3.838	0.706	0.168	0.103
	Lagrange WWTP WLA	0.025	0.025	0.025	0.025	0.025
	Oberlin WWTP WLA	0.102	0.102	0.102	0.102	0.102
	Wellington WWTP WLA	0.051	0.051	0.051	0.051	0.051

Pollutant	Allocation Component	High Flows (780 cfs)	Moist Conditions (112 cfs)	Mid-Range Flows (23 cfs)	Dry Conditions (6 cfs)	Low Flows (4 cfs)
	Findlay State Park Campground WLA	0.002	0.002	0.002	0.002	0.002
	MOS (5%)	59.442	7.471	1.382	0.589	0.583

4.2.3 Subbasin 9

Existing and allowable loads were calculated for the East Branch Black River, near the mouth (Subbasin 9). This sampling station drains 125.89 square miles and land use/land cover upstream of this station consists primarily of row crops (48%), deciduous forest (28%), residential (12%), and pasture/hay (9%) land uses. Eight WWTPs discharge upstream of Subbasin 8 and three designated MS4s are within the upstream watershed (Table 4-18).

Table 4-19 presents the TMDL summary for Subbasin 9. As presented in Appendix B, annual average load reductions of approximately 54 percent total phosphorus, 41 percent nitrate, and 52 percent total suspended solids are needed to meet the TMDL targets. The SWAT modeling suggests that these reductions can be achieved through a combination of increased riparian buffers, the elimination of failing septic tanks, point source controls, and reduced streambank erosion (see Appendix B for details).

Table 4-19. TMDL Allocation Summary for Subbasin 9.

Pollutant	Allocation Component	High Flows (929 cfs)	Moist Conditions (185 cfs)	Mid-Range Flows (54 cfs)	Dry Conditions (12 cfs)	Low Flows (4 cfs)
Total Phosphorus (kg/day)	**TMDL= LA+WLA+MOS**	**966.07**	**204.18**	**65.03**	**18.88**	**16.94**
	LA	892.02	185.08	55.74	12.87	11.29
	City of North Ridgeville MS4 (part) WLA	0.12	0.09	0.07	0.04	0.02
	City of Grafton MS4 (part) WLA	0.53	0.41	0.31	0.19	0.11
	City of Elyria MS4 (part) WLA	22.77	4.25	1.18	0.25	0.08
	Spencer WWTP WLA	0.39	0.39	0.39	0.39	0.39
	Lodi WWTP WLA	1.58	1.58	1.58	1.58	1.58
	Grafton WWTP WLA	2.18	2.18	2.18	2.18	2.18
	Eaton Estates WWTP WLA	0.29	0.29	0.29	0.29	0.29
	Brentwood Lake WWTP WLA	0.19	0.19	0.19	0.19	0.19
	MOS (5%)	46.00	9.72	3.10	0.90	0.81
Nitrate (kg/day)	**TMDL= LA+WLA+MOS**	**7554.70**	**1442.43**	**429.12**	**120.14**	**109.66**
	LA	6707.67	1251.53	347.60	72.69	66.76
	City of North Ridgeville (part) WLA	127.62	23.81	6.61	1.38	0.44
	City of Grafton (part) WLA	4.61	3.52	2.69	1.68	0.94
	City of Elyria MS4 (part) WLA	319.85	59.68	16.57	3.47	1.11
	Spencer WWTP WLA	2.64	2.64	2.64	2.64	2.64
	Lodi WWTP WLA	14.92	14.92	14.92	14.92	14.92
	Grafton WWTP WLA	13.81	13.81	13.81	13.81	13.81
	Eaton Estates WWTP WLA	2.33	2.33	2.33	2.33	2.33
	Brentwood Lake WWTP WLA	1.50	1.50	1.50	1.50	1.50
	MOS (5%)	359.75	68.69	20.43	5.72	5.22
Total Suspended Solids (1000kg/day)	**TMDL= LA+WLA+MOS**	**718.694**	**187.732**	**67.529**	**19.485**	**17.382**
	LA	636.226	165.955	59.520	17.010	15.810
	City of North Ridgeville (part) WLA	0.232	0.177	0.135	0.084	0.047
	City of Grafton (part) WLA	33.130	8.642	3.099	0.886	0.355
	City of Elyria MS4 (part) WLA	14.697	3.834	1.375	0.393	0.157
	Spencer WWTP WLA	0.006	0.006	0.006	0.006	0.006
	Lodi WWTP WLA	0.055	0.055	0.055	0.055	0.055
	Grafton WWTP WLA	0.102	0.102	0.102	0.102	0.102
	Eaton Estates WWTP WLA	0.014	0.014	0.014	0.014	0.014
	Brentwood Lake WWTP WLA	0.008	0.008	0.008	0.008	0.008
	MOS (5%)	34.224	8.940	3.216	0.928	0.828

4.2.4 Subbasin 24

Existing and allowable loads were calculated for the East Branch Black River, east of Spencer (Subbasin 24). This sampling station drains 95.85 square miles and land use/land cover upstream of this station consists primarily of row crops (53%), deciduous forest (34%), pasture/hay (9%), and residential (3%) land uses. The Lodi WWTP is the only point source discharge upstream of this sampling station.
As presented in Appendix B, annual average load reductions of approximately 59 percent total phosphorus, 35 percent nitrate, and 13 percent total suspended solids are needed to meet the TMDL targets. The SWAT modeling suggests that these reductions can be achieved through a combination of increased riparian buffers, the elimination of failing septic tanks, point source controls, and reduced streambank erosion (see Appendix B for details).

Table 4-20. TMDL Allocation Summary for Subbasin 24.

Pollutant	Allocation Component	High Flows (372 cfs)	Moist Conditions (69 cfs)	Mid-Range Flows (20 cfs)	Dry Conditions (3 cfs)	Low Flows (1 cfs)
Total Phosphorus (kg/day)	**TMDL= LA+WLA+MOS**	**458.37**	**75.03**	**20.75**	**10.62**	**10.62**
	LA	435.04	69.95	18.25	8.61	8.61
	Lodi WWTP WLA	1.58	1.58	1.58	1.58	1.58
	MOS (5%)	21.75	3.50	0.91	0.43	0.43
Nitrate (kg/day)	**TMDL= LA+WLA+MOS**	**4264.41**	**546.85**	**130.40**	**64.04**	**64.04**
	LA	4047.13	506.60	109.98	46.78	46.78
	Lodi WWTP WLA	14.92	14.92	14.92	14.92	14.92
	MOS (5%)	202.36	25.33	5.50	2.34	2.34
Total Suspended Solids (1000kg/day)	**TMDL= LA+WLA+MOS**	**309.670**	**60.415**	**18.202**	**9.316**	**9.316**
	LA	294.872	57.486	17.284	8.820	8.820
	Lodi WWTP WLA	0.055	0.055	0.055	0.055	0.055
	MOS (5%)	14.744	2.874	0.864	0.441	0.441

4.3 Dissolved Oxygen

Ohio's dissolved oxygen criteria specify that waterbodies such as the Black River that are designated as Warmwater Habitat should maintain oxygen levels above 5 mg/L as a twenty-four-hour average and above 4 mg/L at all times. The available sampling data indicate that these criteria are frequently not met in the Black River, especially at deeper depths in the most downstream section of the river during the late summer. Potential reasons for not meeting these criteria include the following:

- **River Morphology.** The Black River from approximately river mile 2.8 to Lake Erie is periodically dredged to support its use as a navigation channel. The deepening of the channel, when coupled with large swings in the surface elevation of the lake, results in frequent and significant flow reversals and rapid changes in water levels. The temperature and density differences between the river and lake waters in the warmer summer months also lead to vertical stratification and potential short-circuiting of upstream flow, where the warmer upstream river flow remains at the surface. Stratification also reduces vertical mixing, which reduces the downward transfer of surface oxygen.
- **Sediment Oxygen Demand.** Sediment oxygen demand (SOD) is the rate at which oxygen is consumed by river sediments from the overlying water column. SOD is a combination of all of

the oxygen-consuming processes that occur at or just below the sediment/water interface. SOD is partly due to biological processes and partly due to chemical processes. Most of the SOD at the surface of the sediment is due to the biological decomposition of organic material and the bacterially facilitated nitrification of ammonia, while the SOD several centimeters into the sediment is often dominated by the chemical oxidation of species such as iron, manganese, and sulfide (Wang, 1980; Walker and Snodgrass, 1986). SOD rates in the Black River have been measured to be as high as 4.5 grams of oxygen per square meter per day (LTI, 2003b).

- **Wastewater Treatment Plant Loadings.** There are several large wastewater treatment plants in the Black River watershed, including Lorain, Elyria, and North Ridgeville. These facilities have the potential to directly contribute to low dissolved oxygen through the discharge of oxygen-consuming materials such as organic material and ammonia, as well as indirectly through the discharge of nitrogen and phosphorus which can stimulate excessive algal growth (which in turn consumes oxygen).
- **Upstream Nonpoint Source Loadings.** Pollutant loading of organic material, ammonia, and nutrients from nonpoint sources upstream in the Black River watershed can also contribute to low dissolved oxygen conditions downstream.

The calibrated W2 model was used to evaluate the potential significance of each of these issues for the observed low dissolved oxygen conditions in the Black River. The model was used to run a variety of hypothetical scenarios, shown in Table 4-21, that differed in how certain key model inputs were simulated. For example, for Scenario 2 upstream loads were reduced consistent with the sediment and nutrient TMDLs presented in Section 4.2 and the sediment oxygen demand was reduced by thirty percent. The modeling period was for the year 2001 (same as the calibration).

Table 4-21. Black River W2 modeling scenarios.

Number	Scenario	Description
0	Baseline	This is the baseline condition to which all other model runs are compared. It is the same as the model calibration run.
1	Upstream TMDL Reductions	This condition is the same as the Baseline condition but with reduced loadings from the Black River SWAT model that correspond to meeting the TSS, nitrogen, and phosphorus TMDL targets.
2	Upstream TMDL Reductions + 30% SOD Reduction	This condition is the same as the Baseline condition but with reduced loadings from the Black River SWAT model that correspond to meeting the TSS, nitrogen, and phosphorus TMDL targets plus reducing the SOD rate in the CE-QUAL-W2 model by 30%.
3	Upstream TMDL Reductions + 40% SOD Reduction	This condition is the same as the Baseline condition but with reduced loadings from the Black River SWAT model that correspond to meeting the TSS, nitrogen, and phosphorus TMDL targets plus reducing the SOD rate in the CE-QUAL-W2 model by 40%.
4	Upstream TMDL Reductions + 50% SOD Reduction	This condition is the same as the Baseline condition but with reduced loadings from the Black River SWAT model that correspond to meeting the TSS, nitrogen, and phosphorus TMDL targets plus reducing the SOD rate in the CE-QUAL-W2 model by 50%.
5	100% SOD Reduction	This condition is the same as the Baseline condition with 100% reduction of SOD.
6	No Point Sources	This condition is the same as the Baseline condition with all point sources removed from the model.

Detailed results of the W2 modeling scenario runs are presented in Appendix E. Table 4-22 summarizes the results for one of the most critical locations (river mile 1.75) and indicates that both the 5 mg/L average dissolved oxygen criterion and the 4 mg/L minimum dissolved oxygen criterion are met in all scenarios for the surface waters (top two meters). In contrast, none of the scenarios result in always meeting the criteria in the bottom waters. Furthermore, Scenario 5 results in the most number of days meeting the 5 mg/L component of the water quality standard which suggests that SOD is a key reason for the dissolved oxygen deficit. This finding matches the findings of a similar modeling study of the Black River (Kaur et al., 2007) and indicates that a site-specific water quality standard, similar to the one derived for the Cuyahoga River[1], might be warranted. One potential option would be to require that the dissolved oxygen standard only apply above a certain depth of the river, or to set a less stringent criterion for the lower depths. Before this happens, it is suggested that a diurnal dissolved oxygen sonde study be performed on the Black River mainstem.

Table 4-22. W2 model scenario results for Black River Mile 1.75.

Scenario	Surface		Bottom	
	# Days/Year Average DO < 5 mg/L	Minimum DO (mg/L)	# Days/Year Average DO < 5 mg/L	Minimum DO (mg/L)
0	0	5.02	104	0
1	0	5.42	101	0.56
2	0	5.56	93	1.02
3	0	5.62	87	1.15
4	0	5.70	80	1.31
5	0	5.64	47	0.47
6	0	5.70	68	0

4.4 Margin of Safety

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). An explicit MOS has been applied as part of all of the Black River TMDLs by reserving five percent of the allowable load (see allocation tables in Sections 4.1 and 4.2). A relatively low MOS was selected based on the use of load duration curves, which minimize potential uncertainties associated with calculating the allowable loads (i.e., the allowable loads are based on observed data rather than modeling simulations) as well as the good calibration of the SWAT model which generally predicted average total suspended solids, nitrate, and total phosphorus concentrations within ± 20 percent of the observed data[1].

An additional implicit MOS has been applied as part of the fecal coliform TMDLs by comparing individual samples to the geometric mean component of the standard to determine the needed load reductions. This is considered conservative because the geometric mean component of the standard is intended to be used when five samples in a 30 day period are available (i.e., taking the geometric mean of five samples will "dampen" the effect of high values).

4.5 Critical Conditions and Seasonality

The Clean Water Act requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. Through the load duration curve and SWAT modeling approach it has been determined that load reductions are needed for specific flow conditions; however, the critical conditions (the periods when the greatest reductions are required) vary by location and are inherently addressed by specifying different levels of reduction according to flow.

[1] Modeling errors of less than 15 percent are considered very good and errors between 15 and 25 percent are considered good for the simulation of water quality (Donigian, 2000).

The allocation of point source loads (i.e., the WLA) also takes into account critical conditions by assuming the facilities will always discharge at their maximum design flows. In reality, many facilities discharge at below their design flows.

The Clean Water Act also requires that TMDLs be established with consideration of seasonal variations. Seasonal variations are addressed in the fecal coliform TMDLs by only assessing conditions during the season when the water quality standard applies (May through October). The load duration approach and SWAT modeling also account for seasonality by evaluating allowable loads on a daily basis over the entire range of observed flows and presenting daily allowable loads that vary by flow.

5.0 IMPLEMENTATION PLAN

Restoration methods to bring an impaired waterbody into attainment with water quality standards generally involve an increase in the water body's capacity to assimilate pollutants, a reduction in pollutant loads to a waterbody, or some combination of both.

The Black River TMDL project team recognized four important strategies to focus efforts in developing an implementation plan for the watershed. The strategies will lower pollutant loadings and may help, but not completely ameliorate, the dissolved oxygen levels in the Black River main stem. The strategies are: 1) increased focus on the protection and restoration of riparian corridors; 2) elimination of failing home sewage treatment systems; 3) point source controls; and 4) reduced erosion of stream banks. These strategies are recognized by the Black River RAP Coordinating Committee as serving to restore many of the designated use impairments in the Black River Area of Concern.

Two of the strategies (the protection and restoration of riparian corridors and the reduced erosion of stream banks) are linked as effective means of controlling erosion and non-point sources of pollution. The degree of excessive sediment loading in the Black River basin can be seen in the figures below. In Figure 5-2, note the sediment plume entering Lake Erie.

Figure 5-1. Black River mouth during a dry period

Figure 5-2. Black River mouth after a storm event

Graphics courtesy of OhioLINK Landsat 7 Satellite Image Server

Generally, the base level of a stream is a critical component of a stream's behavior and equilibrium. The stream base level is controlled by the elevation of the receiving waters; lake, ocean, or larger stream segment. The base level for the Black River mainstem is Lake Erie, so the base level remains relatively constant. The base level for tributaries is the larger receiving stream and man-made or natural actions that lower or raise the elevation of the receiving stream can cause the tributary to react by attaining its earlier slope either by deposition or by down-cutting. The Black River watershed has many stream segments that have been channelized to facilitate drainage. This may have caused some stream bed erosion of the tributary systems and a disconnection to the natural floodplain. If stream flow increases, more force is experienced through the deeper stream channels.

A stream's power is often described as the stream's ability in discharging water and sediment. Any increases in flow will increase the streams energy or power. If, due to flow increases, a stream becomes capable of transporting more sediment, erosion will occur either in the stream bed or banks. Streams that have been disconnected to their natural floodplain keep the force of flow within their channels and that leads to stream bank erosion.

Portions of the Black River watershed are experiencing unprecedented development. Between 2000 and 2005, housing units in Lorain County has increased about eight percent. The City of Avon, in the French Creek watershed, saw an increase of housing units of almost 45 percent and North Ridgeville saw an increase of about 25 percent (Lorain County Community Development, 2006).

With development comes an increase in impervious surface, such as roads, parking lots, driveways and rooftops. Figure 5-3 shows a relationship between the number of housing units and the amount of impervious surface in the Black River watershed upstream of the USGS flow gage at Cascade Park in Elyria. Thomas Schueler of the Center for Watershed Protection has developed a classification scheme where stream quality if based on imperviousness (Schueler, 1994). The scheme divides streams into three categories:

- Stressed Streams 1 to 10% impervious surfaces
- Impacted streams 11 to 25% impervious surfaces
- Degraded streams 26 to 100% impervious surfaces

With the Black River mainstem at 20.39% impervious surfaces and French Creek at 11.47% impervious surfaces, both fall into the category of impacted streams. Most of the remainder of the watershed would be categorized as stressed, but the East Branch (below Grafton), the West Branch (below Plum Creek) and Plum Creek may soon achieve the category of impacted.

With increases to impervious surfaces in the Black River watershed, there is an increase in runoff, resulting in an increase in stream flow and thereby an increase in stream energy. The increased energy of the stream can erode and incise the stream channel and banks as channels widen and straighten to accommodate the higher flows. This is becoming more evident by the erosion of stream banks in the watershed. A stream is not considered to be in equilibrium if it experiences excessive erosion or deposition and restoration efforts can sometimes regain the equilibrium faster than the stream would on its own (Riley, 1998).

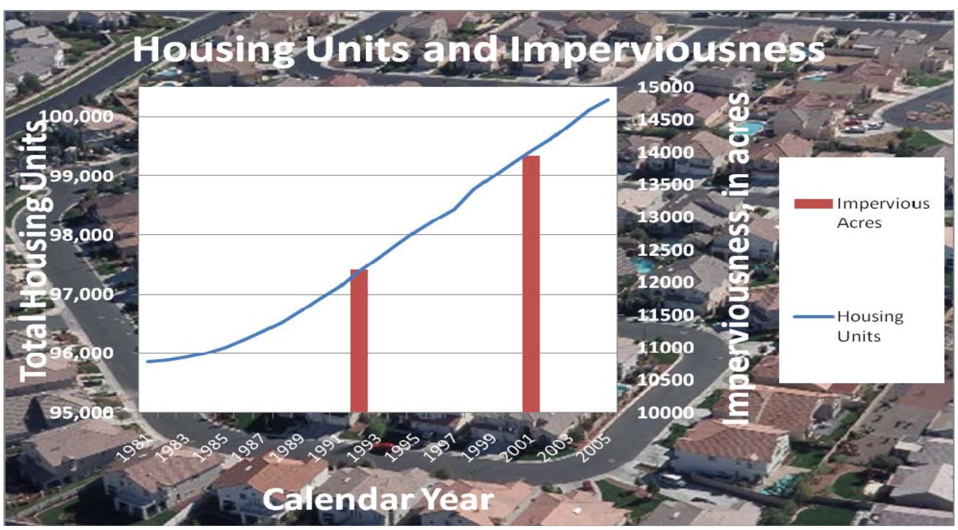

Figure 5-3. Impervious Surfaces and Housing

(Sources: Lorain County Community Development Department and USGS National Land Cover Dataset)

Restoration and protection of riparian corridors, including the establishment of watershed-wide stream set-back ordinances, and a program to identify channelized streams and reconnect these streams to their floodplain should help reduce stream bank erosion and nutrient loadings.

In March 2006, the Lorain County Board of Commissioners released an Environmental Strategic Plan (ESP) for the County of Lorain. The ESP focused on land use, storm water and wastewater management and urban redevelopment policies and strategies to address environmental issues in the county. Many of the strategies listed in this section were noted in the Lorain County ESP and as such, should be incorporated in WAPs currently under development and any future WAPs for other areas of the Black River watershed.

5.1 Increased Focus on the Protection and Restoration of Riparian Corridors

Sediment loading, from both stream bank erosion and nonpoint sources, as well as nutrient loading have been identified as major causes of impairment in the Black River watershed. Stream bank protection along with storm water controls will be needed to reduce sediment loading in the basin. Increased restoration and protection of riparian corridors will lead to stream bank stability and a lessening of impacts from nonpoint sources of pollution.

5.1.1 Agricultural Lands

The lands of the upper Black River watershed are predominately used mostly for row crop production. Increased use of riparian corridors will help lessen the nutrient and sediment loads from agricultural fields located along the tributary systems of the upper East and West Branches of the Black River basin.

Wooded or shrubby vegetation along riverbanks will reduce erosion and lower sediment loadings. For most of the agricultural areas in the Black River basin, the second allocation scenario, Combo2 (Appendix B) predicts water quality standard compliance with 15-foot filter strips adjacent to all crop land. For the southern East Branch (subbasin 24 compliance point), computer modeling determined the filter strip widths need to be increased from 15 to 20 feet for water quality compliance for nitrate and total phosphorus.

Many management practices abate sediment and nutrient loading to surface waters from crop fields. Examples include vegetated buffer strips, grassed waterways, nutrient management, conservation tillage, conservation crop rotations, wetland restoration, and water table management.

In the past few decades, conservation efforts by farmers, local partnerships and units of government have strived to reduce non-point sources of pollution, and efforts in this direction should be expanded as non-point contributions of nutrients and sediment from agricultural lands still exist. Landowners can take advantage of several incentive programs that will cover significant portions of the cost of adopting Best Management Practices on farmland, while educational initiatives exist to boost participation in these programs. These programs include:

- *Conservation Reserve Enhancement Program (CREP)*
  This is a voluntary land retirement program that helps the agricultural community protect environmentally sensitive land, decrease erosion, restore wildlife and protect ground and surface waters. The CREP, an off-shoot of the Conservation Reserve Program (CRP), partners landowners with state and federal governments in a cost-effective way to address environmental impacts, such as nonpoint source pollution and land erosion, and provide a viable option to supplement farm income. Eligible practices include filter strips and forested buffers. The CREP

program is administered by county Soil and Water Conservation Districts, the Natural Resource Conservation Service and the Farm Service Agency.

- *Environmental Quality Incentives Program (EQIP)*
  The objective of this U.S. Department of Agriculture (USDA) voluntary program is to increase the use of agriculture related best management and conservation practices. Contracts are five years in length and operators receive a cost share and/or incentive payments for employing conservation management practices. More information is available on the NRCS website at: **http://www.nrcs.usda.gov/programs/eqip/**.

- *Conservation Reserve Program (CRP)*
  The Conservation Reserve Program, by providing technical and financial assistance, helps reduce soil erosion and sedimentation in streams and lakes, improves water and habitat quality and enhances forest and wetland resources. Through financial incentives, the CRP encourages farmers to convert environmentally sensitive areas, such as highly erodible soils, from agricultural production to native grasses, wildlife plantings, trees and riparian buffers. More information can be found on the CRP website at: **http://www.nrcs.usda.gov/programs/crp/**.

- *Wildlife Habitat Incentives Program (WHIP)*
  This voluntary program is designed for people wanting to develop or improve wildlife habitat on private land. The USDA's Natural Resources Conservation Service will provide technical assistance and up to 75% cost-share assistance to enrollees wanting to improve fish and wildlife habitat on their lands. WHIP contracts typically last from 5 to 10 years from the date of the signed agreement.

- *Section 319 Nonpoint Source Grants*
  Section 319 of the 1987 Clean Water Act created a national program to control and prevent nonpoint source pollution of the Nation's surface and ground water resources. The Ohio EPA, Ohio's designated water quality agency, is responsible for administering the program in Ohio. A goal of 80% aquatic life use attainment for Ohio waters by 2010 is a state priority. In concert with this goal, the Section 319 Implementation Grant program is designed to provide financial assistance to projects that eliminate or reduce water quality impairments caused by nonpoint source pollution (NPS) and prevent future NPS related impairments.

  A clear, strong rationale for project work is required for each award along with a match of local resources. This rationale directs Ohio 319 awards to watersheds with state endorsed watershed plans, Acid Mine Drainage Abatement – Treatment Plans, and late stage TMDLs. In each case, demonstrable aquatic life use impairments due to NPS pollution must be addressed by the project.

  Project categories that will be funded include: 1) Stream Restoration and or Renaturalization Projects; 2) Acid Mine Drainage Abatement and AML Reclamation Projects; 3) Agricultural Best Management Practices and Projects *; 4) Riparian Restoration Projects; 5) Riparian Protection and Conservation Easement Projects; and 6) Source Water (public water supplies) Protection Implementation Grants. Other projects may be funded particularly if they are highly effective and innovative means to eliminate NPS pollutants and restore impaired waters.

  Applicants may apply for a maximum of $500,000 for a three year period. Each project funded must provide an additional 40% matching share. The total federally funded share of project costs may not exceed 60%.

Since inception, Ohio's program has funded over 225 local and state level NPS projects. The latest Ohio EPA 319 Grant program Request for Proposals and Application Package can be found on the Agency's website: **http://www.epa.state.oh.us/dsw/index.html**.

* Section 319 grant funds may not be used to cost share practices that duplicate or supplement traditional Farm Bill program funded practices and activities. Neither may Section 319 Grant funds be used to cost share for tillage and/or other agricultural equipment purchase.

Protection of stream riparian corridors plays an important role in stream integrity. Smaller streams, as typically seen flowing through farmlands in the upper watershed, are better able to maintain thermal regimes with riparian protection. Open streams lacking riparian protection are influenced by sunlight which in addition to water temperature and increased algae production can lead to lower dissolved oxygen levels.

BMP Challenge
A new NRCS program has recently become available to corn farmers (for grain or silage) in Ohio in 2007. While not affecting riparian corridors in farmlands, the *BMP Challenge* reduces economic risks to farmers when they adopt agricultural BMPs by providing financial assurance so that farmers can see how university-recommended BMPs perform on their own fields without financial risk. Although farmers in the counties of Champaign, Crawford, Medina, Stark, Tuscarawas and Wayne have been participating in this program, there is no current participation in the Black River watershed. NRCS and local soil and water conservation districts should implement this program to lessen impacts from nutrient loadings from agricultural lands.

The *BMP Challenge* is supported in part by grants from the USDA, NRCS, Altria Group, Iowa Department of Economic Development, McKnight Foundation and the Great Lakes Protection Fund. Programs are available for nutrient BMPs and reduced tillage BMPs. They have been used successfully in conjunction with grant funded projects, including Section 319 funds. To lessen impacts from agricultural lands, NRCS and county SWCDs should develop BMP Challenge enrollment in the Black River watershed. More information is available on the *BMP Challenge* web site at: **http://www.bmpchallenge.org**.

5.1.2 Increased Use of Riparian Borders – Developed and Developing Areas

The Black River watershed is undergoing a period of rapid development, especially in the lower East and West branches (and their tributary streams) and the French Creek subwatershed.

The relatively high volume of runoff generated in urban and high density residential areas increases the potential for pollution. Sediment and nutrient residues on surfaces that are impervious or poorly pervious (e.g., compacted lawns, gravel drives, etc.) are more easily transported in this higher volume of runoff and negligible attenuation of the loading occurs due to infiltration. Reducing imperviousness and improving on-site retention and infiltration can abate sediment and nutrient loading by reducing the runoff discharge.

The Black River TMDL recognizes stream setbacks as an important factor for improved water and habitat quality. The intent in identifying stream setbacks is to provide protection for future natural movement by the stream channel and to increase stream assimilative capacity for sediment and nutrients by providing for export of these materials from the channel. Stream setbacks should be considered to be an area of land/water interface, where weather patterns will dictate the degree to which the interface area will be used by the stream. In terms of human activity, it is important to understand that high water levels are to be expected at times, even though it may not happen annually. Additionally, protection and restoration of riparian zones along streams can help reduce sediment loading.

County-wide and municipal setback ordinances should be enacted to protect the vegetated buffers along streams and wetlands before these protective corridors are lost. Woody riparian vegetation reduces erosion of stream banks.

In many areas of the country, setback ordinances have been integrated as a nonstructural BMP component of Phase 2 Storm Water Pollution Prevention Plans for municipal separate storm sewer systems. Effective vegetative riparian border systems reduce nutrient and sediment runoff. Model ordinances for the protection of riparian zones have been developed by The Chagrin River Partners (**http://www.crwp.org**) and NOACA (**http://www.noaca.org**). Comprehensive land use planning and better site design that protects important natural resources such as riparian corridors and wetlands should be expanded in the Black River watershed.

As part of urban renewal and brownfield re-development in the Black River mainstem in the City of Lorain, the Black River RAP has formed a local stakeholder group to develop a master plan for re-development that accounts for local economic growth as well as the needs of the environment. The Black River RAP has secured funding for this master plan through the USEPA Great Lakes National Program Office. The master plan will include the location of sites for stream banks and near shore habitat remediation as well as conceptual plans for the remediation effort. Funding for the construction of remedial measures may begin with a supplemental environmental project (SEP). The Black River RAP and the local stakeholder group have been in discussions with Lorain County and the Ohio EPA about the possibility of securing supplemental environmental project (SEP) funding to form a mainstem conservation fund. Funding for remedial measures in the lower mainstem in the City of Lorain would come from this conservation fund. In the future, the Ohio EPA should look to supplement this fund with future SEPs and 401 mitigation monies.

5.1.3 Storm Water Management

Storm water runoff is a significant source of nonpoint source pollution throughout the entire Black River watershed. Although some storm water impacts will be regulated through the National Pollutant Discharge Elimination System (NPDES) Storm Water Program, other actions can be used to help lessen the impacts from storm water runoff.

5.1.3.1 Municipal Storm Sewer Systems

Permit coverage for the National Pollutant Discharge Elimination System (NPDES) Storm Water Program is required for medium and large municipal separate storm sewer systems (MS4s). Operators of MS4s are required to develop storm water management programs that implement minimum measures focusing on a Best Management Practice approach. The six minimum control measures are:

- A public education and outreach program on the impacts of storm water on surface water and possible steps to reduce storm water pollution. The program must target both the general public as well as commercial, industrial and institutional dischargers.
- Public involvement and participation in developing and implementing the Storm Water Management Plan.
- Elimination of illicit discharges to the MS4.
- Construction site storm water runoff regulations that require the use of appropriate BMPs, pre-construction review of Storm Water Pollution Prevention Plans (SWP3s), site inspections during construction for compliance with the SWP3, and penalties for non-compliance.

- Post-construction storm water management regulations that require the implementation of structural and non-structural BMPs within new development and redevelopment areas, including assurances of the long-term operation of these BMPs.
- Pollution prevention and good housekeeping for municipal operations such as efforts to reduce storm water pollution from the maintenance of open space, parks and vehicle fleets.

For larger communities, SWP3s should already be in place. For the smaller communities, the Phase 2 regulations require these plans to be in place by 2008. Human induced changes have altered the hydrology of the Black River system and with the current scale of development, implementation actions should include riparian protection and enhancement, drafting ordinances for storm water and sediment and erosion control, creating and publishing a list of acceptable storm water BMPs, and expanding existing programs. Municipal and county-wide set-back ordinances should be enacted as nonstructural BMP components of Phase 2 Storm Water Pollution Prevention Plans for municipal separate storm sewer systems. It is suggested that MS4s follow the set-back recommendations that have been developed by The Chagrin River Partners (**http://www.crwp.org/**) and NOACA (**http://www.noaca.org**).

These controls should help reduce the loading of sediments from nonpoint sources and reduce stream flows that can cause stream bank erosion. Public education, such as developing an adult education program about storm water pollution, would be an important and necessary part of the implementation plan. Ohio EPA will continue to assist local communities with implementation of Storm Water Phase 2 regulations.

Residential and commercial development has been occurring in the Black River watershed at an unprecedented rate. As reflected within the Ohio Lake Erie Commission's Balanced Growth Program (see **http://www.epa.state.oh.us/oleo/index.html**), all communities in the watershed are encouraged to review their existing zoning ordinances and educate their planning commissions to:

1. **Allow mixed-use, higher density development within the community.** This leads to the creation of more self-contained, walkable neighborhoods and greatly reduces the rate at which land within the watershed is consumed. Development should be directed away from important water resources and natural areas through the use of riparian setbacks, conservation easements and other such tools.

2. **Encourage redevelopment within existing urbanized areas.** Although many older communities give economic incentives for this type of redevelopment, it is largely centered on revitalizing old industrial areas with new industrial uses. Redevelopment should be encouraged to create new or revitalize residential and commercial areas where infrastructure already exists. Target neighborhoods around existing transportation hubs (like bus stations or train stops) and employment hubs so as to reduce the need for automobiles.

3. **Encourage practices which lead to greater infiltration of rainfall.** This can include codes/policies that preserve green spaces, encourage practices such as green roofs, rain gardens, rain barrels and permeable pavements.

4. **Discourage the unnecessary creation of impervious surfaces.** In addition to practices noted in Item 3, this could include a review of parking space codes to reduce the number created and/or encourage shared parking. Also included would be conservation development zoning and compact development zoning.

5. **Encourage more widespread use of lower impact structural BMPs** such as pocket wetlands, dry and wet enhanced swales, bioretention cells, infiltration trenches, sand filters,

and vegetated filter strips. Developments should not resort to the use of one centralized storm water management practice, like a pond. Rather, developments should be planned that incorporate many, smaller storm water management practices within the site design.

In 2004, the Ohio Lake Erie Commission finalized the Balanced Growth Program, defined as a *local planning framework to coordinate decisions about how growth and conservation should be promoted by State and local investments.* The Balanced Growth Program produced the following documents:

- **Planning Framework:** Recommends the formation of Watershed Planning Partnerships to draft Watershed Balanced Growth Plans through which communities designate Priority Conservation Areas and Priority Development Areas. These areas are defined as:
  - **Priority Conservation Areas** are locally designated areas for protection and restoration. They may be important ecological, recreational, heritage, agricultural, and public access areas that are significant for their contribution to Lake Erie water quality and general quality of life.
  - **Priority Development Areas** are locally designated areas where development and/or redevelopment is to be encouraged in order to maximize development potential, maximize the efficient use of infrastructure, promote the revitalization of cities and towns, and contribute to the restoration of Lake Erie.
- **Best Local Land Use Practices Document:** Recommends model regulations and programs for better land use and development.

For additional information on the Ohio Lake Erie Commission and the Balanced Growth Program, please see **http://www.epa.state.oh.us/oleo/**

5.1.3.2 Industrial facilities

Industrial facilities with NPDES permit coverage for storm water discharges associated with industrial activities must develop and implement a Storm Water Pollution Prevention Plan (SWP3), which identifies potential sources of pollution. The SWP3 must also describe and ensure the implementation of practices to reduce pollutants in storm water discharges. It is recommended that these facilities review their SWP3s during their annual comprehensive site evaluation to ensure that appropriate BMPs are implemented that address the causes of impairment for the Black River watershed, including habitat alteration, nutrient enrichment, siltation, flow alteration and bacteria.

5.2 Bacteria

5.2.1 Elimination of Failing Home Sewage Treatment Systems

Home sewage treatment systems (HSTSs) are used to treat sanitary sewage in areas where no municipal treatment facilities exist. HSTS systems can impact water quality in the Black River watershed through both point and nonpoint discharges from failed, faulty, or discharging systems and improper disposal of wastes from septic systems. Some older HSTS systems are located in the more-or-less developed areas of southern Elyria, but the majority of HSTS systems are located in the rural and agricultural areas of the upper East and West branches.

Implementation actions to address these sources of pollution would include oversight of septic tank waste haulers, identification and repair of faulty septic systems, elimination of onsite septic systems through extension of municipal sanitary sewers, and public education on home sewage treatment system maintenance.

A report titled *A Survey of Northeast Ohio Home Sewage Disposal Systems and Semi-public Sewage Disposal Systems* (NOACA, 2001) provides information on HSTS in the NOACA region, which includes the Black River basin. Some of the findings in the report were that there were approximately 2,112 on-lot HSTS and 2,762 off-lot HSTS constructed in Lorain County, and 675 on-lot and 6,440 off-lot systems constructed in Medina County between 1979 and 1998.

Recent inspections determined that between 12 and 20 percent of the on-lot systems and 20 and 33 percent of the off-lot systems were malfunctioning, depending on the type of system installed. One-third to two-thirds of the systems did not meet Ohio Department of Health effluent standards. The report concluded that improved management and inspections of these systems as well as greater homeowner attention to system operation and maintenance is needed. A regular local health department inspection program and better homeowner education has the potential for improving the performance rates for these home systems.

Often homeowners are unaware of the operation and required maintenance of their HSTS system. The Lorain County General Health District is in the process of implementing a program that will enable the health district to better regulate routine pumping of HSTS. A database will be used to keep track of pumping dates, and queries will be run to determine which systems are due to be pumped. A reminder notice, as well as a pumping fact sheet and list of registered pumpers, will be mailed directly to the homeowner. In order to prevent an overload on pumpers, homeowners in two or three townships would be notified at a time (on a rotating monthly basis).

With funding from the Ohio EPA, the Black River RAP and the Lorain County General Health District are developing a DVD-formatted HSTS educational video that 1) explains the operation of a household HSTS system; 2) outlines the need for routine inspection and maintenance of household treatment systems; and 3) describes how an HSTS owner can recognize when a system is not functioning properly. The video will be provided to each home system owner in Lorain County at the time of inspection. A version of the video, which is less specific as to county, will be produced and made available to all Ohio counties in the Lake Erie watershed, including the counties of Medina, Cuyahoga, Ashland and Huron, parts of which are in the Black River basin. County and local health departments are encouraged to use this educational tool when it becomes available and to improve and expand the routine inspection and maintenance programs for HSTS and semi-public WWTPs.

5.2.2 Livestock Access to Streams and Manure Management Practices

A program of identifying locations where livestock have free access to streams should be carried out by the local soil and water conservation districts and the Natural Resources Conservation Service. These efforts should focus on headwater streams where livestock densities are higher in order to prioritize stream reaches targeted for livestock exclusion. Once these locations have been identified, landowner education and a targeted use of incentives within existing state and federal programs should be used to provide alternative livestock water supplies, animal stream crossing structures, and fencing to exclude livestock from streams. This program will be most effective when it can be implemented in conjunction with habitat and flood plain restoration efforts and the establishment, restoration and protection of buffer strips and riparian corridors.

To minimize water and habitat quality impacts from any size animal feeding operation, a critical factor is the proper management of manure. All animal feeding operations should have updated manure management plans and make every effort to avoid land application of their manure during wet weather and during the winter when runoff is more likely to occur. An important aspect of manure application plans should be the provision of adequate isolation distances from streams, preferably within areas with adequate buffer strips or forested riparian buffers. Continued efforts by local soil and water conservation district and NRCS staff to work with producers on updating management plans will be critical.

5.3 Point Source Controls

Adequate point source control mechanisms shall be utilized for all direct discharges in the Black River TMDL area. NPDES permits for point sources shall be prepared and issued with limits (especially for limits for nitrate and total phosphorus noted in this report) and conditions necessary to protect and restore water quality in the Black River watershed. Ohio EPA will continue to work with permitted direct dischargers throughout the permitting process. When appropriate, Ohio EPA shall take enforcement actions necessary to maintain compliance with discharge permit limits.

5.4 Stream Restoration to Reduce Erosion of Stream Banks

It should be noted that some channel erosion and lateral migration occurs naturally in stable streams. Likely caused by rapidly changing land uses, the Black River watershed may be within a period of instability. While precipitation remains relatively constant, Figure 5-4 shows the trend for daily river flow in the Black River basin is increasing.

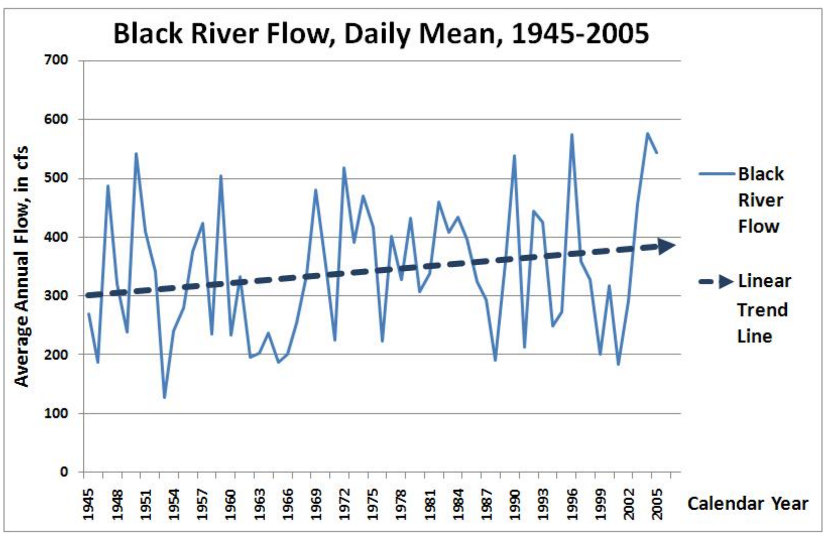

Figure 5-4. Black River Flow (from USGS Black River Flow Gage, available at http://waterdata.usgs.gov/oh/nwis/uv/?site_no=04200500&PARAmeter_cd=00065,00060,00010)

More water traveling through channelized streams that are disconnected to their flood plains leads to increased erosion of stream banks and, as evidence of this, eroding stream banks can be found throughout the basin. The recommended stream restoration scenario is to create or lead to the development of well-connected floodplain areas, channel sinuosity, and also riffle and pool habitats where appropriate. The detention and temporary storage of high flows in created floodplains will likely mitigate downstream impacts associated with flooding. Stream restoration provides greater capacity to accommodate sub-surface drainage and enhances that use of the stream.

Stream restoration that employs natural channel design is superior to a two-stage ditch approach when strictly considering environmental benefits, but since stream restoration entails more earth moving and is considerably more expensive, a two-stage approach may be practical for addressing channelization, and it is suggested by this TMDL, especially in agricultural areas. A two-stage ditch is similar to a typical ditch (one-stage) but differs in some key ways. Two-stage ditches are wider at the top of their banks, which increases the overall capacity of the ditch and out-of-bank flooding occurs less often. The bottom of a two-stage ditch has low elevation benches that are inundated during moderately high and higher flow events. The bottom, low-flow channel is narrower than a typical ditch bottom and often develops a low-amplitude, sinusoidal pattern within the larger ditch. Two-stage ditches yield modest improvements to stream habitat as compared to one-stage ditches. These benefits are realized because the benches function to some degree like flood plains, and the channels undergo more stable erosion and deposition processes. Bank erosion is less likely to occur because the toe (i.e., where the bank meets the channel bottom) is protected by vegetated bench deposits and flow depths are lower, which results in lower shear stress. Less bank erosion in these fairly unstable systems is beneficial to immediate and downstream reaches because in-stream sources of sediment are reduced.

The Ohio Department of Natural Resources is promoting over-wide ditch construction as a lower cost means for achieving two-stage form in ditches. The over-wide channel approach may avoid problems associated with errors in design and/or construction that result in inappropriate channel dimensions (i.e., does not facilitate desirable sediment transport processes). Over-wide channels rely on fluvial deposits to form the benches, which are likely to have large contributions from upland soils that are richer in organic matter and have a greater potential for de-nitrification and other biological processing of pollutants.

Two-stage and over-wide construction may be inappropriate for improving stream biota and/or water quality when it is necessary to remove riparian trees in the process. Such consideration is particularly important when the channel demonstrates that it is recovering from past channelization. Two-stage and over-wide designs are clearly inappropriate when it results in a reduction in the amount of flood plain connectivity. This includes natural to moderately modified streams that have an intact connection to a flood plain and riparian areas. Such action would degrade the resource and the ameliorative effects of the benches will be far inferior to those of an established flood plain.

Bank stabilization and channel erosion controls that use hard engineering techniques (e.g., placement of concrete and/or rock) have little to no value in terms of aquatic habitat. Bioengineering techniques promoted by the Ohio Department of Natural resources (see **http://www.dnr.state.oh.us/water/pubs/fs_st/streamsfs.htm**) use more natural materials and construction techniques that provide bank habitat structure. When bank erosion control is necessary, bioengineering approaches should be promoted by local conservation authorities (e.g., NRCS and SWCD) and used by private and public entities as a means of abatement.

For existing sites of eroding stream banks, the Black River RAP is currently evolving an initiative that will identify these sites, develop plans for remediation and seek to secure funding for construction. One of the main hurdles for the restoration of any surface water system is locating and securing sufficient funding. In partnership with the U.S. Army Corps of Engineers-Buffalo District (USACE), the Black River RAP is starting an eroding stream bank initiative. Several sites of eroding stream banks have been identified by RAP members and other local stakeholders. In the partnership, the USACE will develop conceptual plans, with tentative costing determinations, that can be utilized to seek appropriate funding sources to complete remedial measures. The Black River RAP is working to locate funding to complete the remedial measures, but funding of projects to reduce stream bank erosion is highly competitive. Often a series of smaller scale stream bank erosion projects, when taken collectively, can have a large positive impact on sediment loads but each individual site may be less able to compete with other proposals from around the state or country. For example, the Ohio EPA's Water Resource Restoration Sponsorship

Program (WRRSP) uses a proposal rating system that allows attaining river systems to score higher than non-attaining systems such as the Black River Watershed Area of Concern.

The protection and restoration of riparian corridors and projects to reduce erosion of steam banks should become a critical component of the watershed action plans being developed for the West Branch and French Creek as well as any future action plans for the Black River watershed. A watershed-specific restoration fund needs to be developed for non-attaining waterways such as the Black River basin. As no dedicated funding source is available for eroding stream banks in the Black River watershed, it is the recommendation of this TMDL that any future enforcement action in the watershed include a SEP where a portion of the penalty is deposited in a Black River Watershed Remediation Fund (similar to the fund being proposed for the Black River mainstem). Mitigation funds can also be directed to this fund. The fund would then be available to develop or implement projects in the Black River basin to reduce stream bank erosion such as those being developed by the USACE.

5.5 Reconnection to Floodplain in Channelized Stream Reaches

Agricultural land use and crop productivity throughout large portions of the upper Black River watershed depend upon adequate soil drainage. Many segments of the stream network within the East and West Branches have been significantly entrenched and channelized to alleviate flooding and enhance agricultural productivity. These activities are related to agricultural drainage improvements, but there is also channelization in urban areas where buildings and other infrastructure lie in close proximity to the streams. These altered streams are isolated from their flood plains except during extreme flood events. In agricultural areas, practices specifically designed to increase drainage efficiency (sub-surface drainage, channelization) as well as unintended impacts of farming (soil compaction, poor vegetative cover for much of the year) increase storm flows. In developing areas of the watershed, increases in the amount of impervious land covers result in greater runoff and increased storm flows.

On a watershed scale, practices involving agricultural drainage, stream channelization, and flood reduction degrade the ecological health of the Black River watershed. The cumulative impacts of high flow rates and the associated relative increase in stream power, as well as elevated sediment delivery, contribute to water quality degradation, declining biological integrity, and possibly higher counts of pathogen indicator bacteria. Additional stress to the system has been added by the activities of private landowners and public projects to control stream bank erosion and flooding in localized areas.

The challenge of meeting the TMDL goals will be to find acceptable methods for restoration that simultaneously accommodate agricultural drainage, erosion protection and flood reduction work and the ecological needs of the Black River system. Implementation strategies will need to provide for long-tem improvement in stream channel condition, flood plain connectivity, and habitat quality.

First, in some circumstances, the USACE issues permits for dredging and placement of fill in a stream below the ordinary high water mark. The determination of when a Section 404 permit is needed is made by the USACE and may involve the consideration of comments from Ohio EPA and others. When a 404 permit is needed, Ohio EPA is responsible for reviewing Section 401 water quality certifications and isolated wetland applications for this activity and certifying that the activity will meet water quality standards. Future 401 and isolated wetland certifications by Ohio EPA should include a review for attainment of water quality standards in light of the habitat and water quality targets, and where attainment is not possible, the certification should seek mitigation of the proposed activity. Mitigation within the same sub-watershed and downstream of the proposed disturbance activity is highly preferable because it can help the system absorb the increased amount of flood water and erosion energy created when projects fail to ensure attainment of on-site sediment loading and habitat impacts. Where appropriate, Ohio EPA should require, as part of the mitigation plan, natural channel design or flood plain excavation to allow the stream channel access to the flood plain.

Secondly, the action of local government entities is necessary. Local jurisdictions through zoning and through their authority to enact flood plain regulations have the ability to protect existing flood plains and to make wooded riparian corridors a preferred land use in those areas. There are a number of locally-driven benefits associated with reaching the sediment/nutrient loading and habitat quality targets. Meeting these targets will improve and preserve the water resources and will also keep or restore features that could add to local land values. In addition, zoning and flood plain regulations, including set-back ordinances that keep new development out of the stream floodplain, within which the stream channel itself is likely to move over the course of time, will reduce public and private costs associated with flood damage and loss of property.

The third and primary implementable mechanism is to maintain agricultural drainage through environmentally sound means. Petition ditch maintenance work and privately maintained drainage projects on waters designated as Warmwater Habitat should be performed with an eye towards installing BMPs that will reduce sediment loads and improve habitat and flood plain width characteristics within the tributary network. Conversion of traditional ditch design and maintenance practices to innovative two-stage channel and over-widened ditch design to create flood plain, flood plain excavation, or natural channel design features should also be encouraged. These measures should be incorporated within watershed actions plans for the West Branch and French Creek as well as any future actions plans developed for the remainder of the Black River watershed. Strategies should target cost sharing or other mechanisms of funding these efforts by local, state and federal agencies.

5.6 Develop a Watershed Action Plan for the Entire Black River Watershed

The Black River Watershed Project was initiated in January 2004 to address environmental concerns within the upstream areas of the Black River watershed in Lorain County. Ohio DNR awarded the Lorain County Community Development Department (LCCDD) a Watershed Coordinator Grant that will fund a position in the County to develop state-endorsable Watershed Action Plans (WAPs) for the West Branch of the Black River and the French Creek subwatershed. The Watershed Coordinator has convened two local advisory committees to aid in the development of the WAPs. In the past few years, turnover in this Watershed Coordinator position has occurred. Ohio DNR and LCCDD should prioritize the funding to complete the process of generating the endorsable WAPs. Completion of the WAP planning process is crucial for obtaining funding for pollution abatement and environmental restoration programs such as the 319 Non-Point Source program.

A critical component of any watershed action plan being developed or proposed in the future will be the control of nonpoint source (NPS) pollution from agricultural lands. The Soil and Water Conservation Districts of Lorain and Medina Counties and the local Natural Resource Conservation Service office recently developed an Agricultural NPS Management Plan. The plan can be found in Appendix F. Components of the plan include the following:

- The use of existing USDA programs to improve stream corridors, including the establishment of grass / tree filter strips on 50% of agricultural fields within 10 years and a focus on outreach efforts to agricultural producers in the watershed.
- In an effort to reduce streambank erosion and facilitate drain age, the development of a demonstration project to remove logjams and major stream obstructions. (It should be noted, however, that woody snags and logjams provide stream shading and habitat for fish and are an excellent environment for biota that supply food for fish. Removal of logjams and the clearing

of snags to facilitate flow and reduce erosion should be considered carefully, weighing the environmental needs of the stream.)

- The development of an educational/outreach program on the various and appropriate methods of streambank erosion control
- Provide technical assistance and financial resources to traditional and non-traditional livestock operations
- Encourage the use of permanent conservation practices and nutrient management to control erosion and lessen nutrient loadings to streams

Since locally driven planning efforts are more likely to be acceptable to watershed residents and may result in greater voluntary participation in the water resource improvement efforts, the development of watershed action plans should be generated for the remainder of the watershed and funding for this planning process needs to be identified and secured.

5.7 Education

NOACA, the 208 agency that covers Lorain, Medina and Cuyahoga Counties, has updated their water quality plan. It is available at **http://www.noaca.org**. The report details the wastewater management plans, home sewage disposal plans, NPS and storm water management plans, protection of critical water resources (model riparian protection ordinance), and watershed planning approaches for the NOACA area (NOACA, 2000).

In order to avoid duplication of educational efforts, one organization such as the Black River RAP, which serves the entire Black River watershed, should serve as a central educational entity. This would avoid duplication of outreach by Storm Water Phase 2 entities and some local agricultural initiatives. The Black River RAP has produced two videos detailing conditions in the Black River Area of Concern. Both videos have been broadcast on local and regional television stations and copies have been made available to local schools, libraries, and municipalities. A third RAP video, on home sewage treatment systems, is currently in production. In partnership with the U.S. Army Corps of Engineers-Buffalo District, the Black River RAP produced a French Creek subwatershed specific brochure titled *Living Along French Creek; A User's Guide* that has gone into its third printing and is also available on the web at: **http://www.epa.state.oh.us/dsw/rap/Living%20Along%20French%20Creek.pdf**. Because of the success of the French Creek brochure, funding for "user's guides" for other subwatersheds in the Black River basin will be sought out and secured.

Efforts will be made to educate the farming community about the types of problems associated with farming practices and the assistance that is available to correct and prevent further environmental degradation due to NPS pollution. Funding for this outreach in the Black River watershed agricultural communities will be sought out and secured.

Ohio EPA staff has presented numerous talks dealing with implementation of the storm water Phase 2 program and other issues. They also attend RAP and watershed stakeholder meetings. These activities will continue to be a part of the Ohio EPA work plan. Black River RAP members, Ohio EPA storm water, water quality, and NPS staff are frequent presenters at workshops and conferences.

5.8 Reasonable Assurances

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

The following discusses organizations and programs that have an important role or can provide assistance for meeting the goals and recommendations of this TMDL. This section establishes why it is reasonable to be assured of successful implementation.

5.8.1 Ohio EPA

The several programs that Ohio EPA Division of Surface Water administers are designed to control pollution from point sources and certain storm water discharges as well as provide assistance for abating nonpoint sources of pollution. Other divisions within the Ohio EPA provide assistance such as funding, technical assistance, and education for water resource related issues. Information regarding the specific programs within the Ohio EPA Division of Surface Water (DSW) can be found on the web at: **http://epa.state.oh.us/dsw/** and information about the agency's Division of Environmental and Financial Assistance at: **http://www.epa.state/oh.us/defa/**. What follows are programs within the agency especially important for the implementation of this TMDL.

NPDES Program

National Pollution Discharge Elimination System (NPDES) permits authorize the discharge of substances at levels that meet the more stringent of technology or water quality based effluent limits and establish requirements related to combined sewer overflows, pretreatment, and sludge disposal. All entities that wish to discharge to the waters of the state must first obtain a NPDES permit and both general and individual permits are available for coverage. Through the NPDES program (**http://www.epa.state.oh.us/dsw/permits/permits.html**), the Ohio EPA will use its authority to ensure that recommended effluent limits are applied to the appropriate permit holders within the Black River watershed. Ohio EPA staff in the NPDES program can provide technical assistance for permitted entities when needed. Permits issued under the NPDES program must be consistent with the point source recommendations in a TMDL that has been approved by the U.S. EPA.

Combined Sewer Overflow (CSO) Program

Ohio EPA implements CSO controls through provisions included in the NPDES permits and by using orders and consent agreements when appropriate. The NPDES permits for CSO communities require the implementation of nine minimum control measures (Ohio EPA, 1995; **http://www.epa.state.oh.us/cso/csostrem.pdf**). Requirements to develop and implement Long Term Control Plans are also included where appropriate. Through the CSO program, the Ohio EPA will use its authority to ensure that recommended activities are conducted by the permit holders within the Black River watershed.

Storm Water Program

Ohio EPA implements the federal regulations for storm water dischargers (**http://cfpub1.epa.gov/npdes/home.cfm?program_id=6**). Dischargers currently include Lorain, Medina, Cuyahoga, Richland and Erie counties; the cities of Avon, Elyria, Lorain and Oberlin; the villages of Carlisle, Grafton, and Sheffield; the townships of Brownhelm, Carlisle, Columbia, Eaton, Elyria, New Russia, and Sheffield; and those facilities that meet the definition of industrial activity, including construction, in the federal regulations. Through the Storm Water Program, the Ohio EPA will ensure that the storm water permit related recommendations of this TMDL are applied. Staff within the Storm Water Program provides technical assistance to permitted entities when needed. District Office staff within the Storm Water Program respond to and investigate complaints received by individuals and organizations.

401 Water Quality Certification Program

In Ohio, anyone wishing to discharge dredged or fill material into the waters of the United States, regardless of whether on private or public property, must obtain a Section 404 permit from the U.S. Army Corps of Engineers (Corps) and a Section 401 Water Quality Certification (WQC) from the state.

Stream and wetland mitigation is used as a condition for granting 401 certificates and is the means of ensuring what water resources do not experience a net decline in quality. When a wetland or stream segment is impacted, an appropriate mitigation is required such that there is a no net loss of wetlands or impacted stream length. Restoration, creation, or other forms of enhancement are required at a level that depends upon the original quality of the resource.

Currently there are proposed rule changes to the 401 Program that are designed to provide a more scientific basis for determining appropriate criteria for 401 permit decisions (i.e., acceptance or denial) as mitigation stipulations for respective projects (**http://www.epa.state.oh.us/dsw/401/401Section.html**). Ohio EPA staff will conduct reviews and issue permits to provide the most reasonable protections and improvements, where possible, of surface waters in the Black River watershed.

The Mitigation Clearing House, coordinated by the 401 Section, promotes the exchange of information between applicants that are seeking projects for mitigation of unavoidable environmental impacts to wetlands, streams and lakes that are part of a Section 401 Water Quality Certification or Isolated Wetland Permit, and individuals that may have property or projects that are available. The Clearinghouse may also be beneficial for parties seeking to locate potential supplemental environmental projects, Water Resource Restoration Sponsor Program projects, or actions to be taken consistent with needs identified in a Total Maximum Daily Load for a watershed.

Interested Parties with potential mitigation sites submit information on the Ohio EPA Data Sheet located at **http://www.epa.state.oh.us/dsw/MCH/index.html**. Ohio EPA enters that information into a database. Submitted projects may be viewed by anyone interested in finding potential mitigation areas by clicking on the map included on the web site. Inclusion of a potential mitigation site in the Mitigation Clearinghouse does not constitute Ohio EPA endorsement or approval of that site; it means only that Ohio EPA received sufficient information to post the information in the Mitigation Clearinghouse. When a potential mitigation site is submitted as part of a permit application, Ohio EPA will determine if that particular mitigation proposal is appropriate for the specific impact to surface waters on a case-by-case basis.

Wetland Protection Program

House Bill 231 established a permanent permitting process for isolated wetlands. Reviewers in the 401 Water Quality Certification Section are responsible for the isolated wetland permits required by this State law. Ohio EPA staff will conduct reviews and issue permits to provide the most reasonable protections and improvements of surface waters in the Black River watershed.

Enforcement Program

In cases that Ohio EPA is unable to resolve continuing water quality problems, DSW may recommend that enforcement action be taken. The enforcement and compliance staff work with Ohio EPA attorneys, as well as the Attorney General’s Office, to resolve these cases. Where possible, an added emphasis and priority is given to actions in sensitive watersheds. All completed enforcement actions are posted on the DSW web page.

208 Program (State Water Quality Management Plans)

Ohio EPA oversees the State Water Quality Management (WQM) Plan. The State WQM Plan is like an encyclopedia of information used to plan, direct and evaluate actions that abate pollution and preserve clean water. All types of water quality issues may be addressed and potential solutions framed within the context of both voluntary incentive-based programs and regulation of pollution sources through applicable laws and rules. Where existing laws and regulations fall short of being able to achieve the clean water standards in a particular water body, the state's 208 Plan provides a process to set forth procedures and methods that would control sources of pollution. This process might employ existing legal authorities in a different fashion, or the process might require new legal authorities granted by the appropriate state and local governmental bodies. Normally, the State Plan is reviewed and updated as needed on an annual basis.

The Black River TMDL will become a part of the State WQM Plan when it is approved by U.S. EPA and the recommendations found herein align with and support the state's overall plan for clean waters. More importantly, the requirement and intention to review and update the State Water Quality management plan on an annual basis creates an avenue to apply adaptive management and make adjustments in these recommendations as necessary. The State 208 planning process provides a mechanism for local stakeholders to seek additional authorities should it prove necessary for achieving the water quality standards.

Nonpoint Source Program

The Ohio Nonpoint Source (NPS) program focuses on identifying and supporting implementation of best management practices (BMPs) and measures that reduce pollutant loadings, control pollution from nonpoint sources and improve overall quality of surface waters in the state (**http://www.epa.state.oh.us/dsw/nps.index.html**). Ohio receives federal Section 319(h) funding to implement a statewide NPS program, including offering grants to address nonpoint sources of pollution. Staff from the NPS program work with state and local agencies, governments, watershed groups, and citizens.

In addressing sources of impairment related to agricultural activities, NPS staff will work with Ohio DNR to promote BMPs as well as cost-share and incentive based conservation programs. In particular, Ohio EPA will encourage the Ohio DNR to continue to work with Farm Service Agency personnel and staff from local SWCD and NRCS offices. NPS staff will also provide assistance to agencies and groups actively promoting conservation as well as direction to other appropriate resources within the Ohio EPA.

NPS staff will continue to work with the Black River RAP Coordinating Committee and with the watershed groups (see watershed groups below) that are active in the French Creek and West Branch subwatersheds of the Black River basin and are developing watershed management plans for these subwatersheds. In addition, NPS staff will encourage and assist in the formation of a watershed group for the East Branch subwatershed and their development of an East Branch watershed management plan. Local NPS implementation is a key to achieving state environmental targets. Additionally, there is a reliance on watershed management plans to identify and outline actions to correct water quality problems caused by NPS pollution.

Section 319(h) grants are expected to be directed to projects that eliminate or reduce water quality impairments caused by nonpoint sources of pollution. Applicants may apply for a maximum grant of $500,000 for a three-year period. Each funded project must provide an additional 40% matching share and the total federally funded share of the project costs may not exceed 60%. Upon acceptance by the U.S. EPA of this TMDL, grant proposals for work within the Black River watershed will receive special consideration for funding.

Source Water Protection

Two community public drinking water systems obtain their source waters from streams in the West Branch of the Black River watershed.

The City of Oberlin operates a community public water system (PWS) that serves a population of approximately 8,600 people through approximately 2,520 service connections. The raw water source for the Oberlin Community PWS is the West Branch of the Black River through the Parsons Road reservoir. The Village of Wellington operates a community public water system that serves a population of approximately 4,600 people through approximately 1,700 service connections. The raw water source for the Wellington Community PWS is Charlemont Creek.

Both community public water systems received a source water assessment and protection (SWAP) report completed by Ohio EPA for their respective source water areas. These reports included a delineation of each SWAP area (**http://www.epa.state.oh.us/ddagw/pdu/swap.html**), Corridor Management Zones, along with contributing streams and Emergency Management Zones around the intakes. The SWAP assessment includes an examination of the characteristics of a watershed contributing to the reservoirs and water quality. Finally the reports suggested actions that the public water supplier and local community may take to reduce the risk of contaminating their source of drinking water.

The staff from both public water systems have been collecting and analyzing raw water samples in the reservoirs and raw source streams to monitor surface water quality and adjust water treatment accordingly. In an effort to lower treatment costs, both water systems occasionally draw water from the source streams at times when raw water analysis shows lower levels of total suspended solids and/or nutrients. Since the West Branch watershed has been identified as being in non-attainment for water quality criteria, in part because of elevated loadings of nutrients and silt, source water protection plans developed for these two community public water systems should be updated with many of the recommendations offered in this TMDL. Updated source water protection plans present a reasonable assurance of continued watershed improvements.

Division of Environmental and Financial Assistance

The Division of Environmental and Financial Assistance (DEFA) provides incentive financing, supports the development of effective projects, and encourages environmentally proactive behaviors through the Ohio Water Pollution Control Loan Fund (WPCLF; **http://www.epa.state.oh.us/defa/wpclf.html**). Municipal wastewater treatment improvements—sewage treatment facilities, interceptor sewers, sewage collection systems and storm sewer separation projects—are eligible for financing. Nonpoint pollution control projects that are eligible for financing include:

- Improvement or replacement of on-lot wastewater treatment systems
- Agricultural runoff control and best management practices
- Urban storm water runoff
- Septage receiving facilities
- Forestry best management practices

The Water Resource Restoration Sponsor Program (WRRSP) is a part of the WPCLF and directs funding towards stream protection and restoration projects. The primary focus of this program is to improve and protect stream habitat. Like Section 319 (h) grants, proposals for stream improvements within the Black River watershed will receive special consideration. For a link to the WRRSP fact sheet go to **http://www.epa.state.oh.us/defa/current_program_links.html**.

5.8.2 Ohio Department of Natural Resources

The Ohio Department of Natural Resources (Ohio DNR) works to protect land and water resources throughout Ohio. A specific objective regarding water resources is to *"Lead in the development and* *implementation of stream and wetlands conservation initiatives, applying advanced science, technology and research to restore and protect stream and wetlands habitats"* (Ohio DNR web site). This commitment attests that the Ohio DNR will be a reliable partner in addressing causes and sources of impairment in the Black River watershed.

The following are programs within the Ohio DNR that are particularly instrumental in protecting and improving water resources within the Black River watershed.

Pollution Abatement Program

Under Ohio's Pollution Abatement Rules (OAC 1501), the Ohio DNR is required to respond to written and non-written complaints regarding agricultural pollution. As defined by OAC 1501, agricultural pollution is the "failure to use management or conservation practices in farming or silvicultural operations to abate wind or water erosion of the soil or to abate the degradation of waters of the state by animal waste or soil sediment including substances attached thereto." In cooperation with SWCDs, an investigation is begun within 5 days of receipt of the complaint and a Pollution Investigation Report (PIR) is generated within 10 days. Resource management specialists from Ohio DNR within the Division of Soil and Water Conservation (DSWC) typically become involved with pollution abatement cases in their respective areas of the state.

If it is determined necessary, an operation and management plan will generated to abate the pollution. This plan is to be approved by the SWCD or Ohio DNR and implemented by the landowner. Cost share funding may be available to assist producers in implementing the appropriate management practices to abate the pollution problems and such practices may be phased in if necessary. If a landowner fails to take corrective action within the required timeframe, the Chief of the Division of Soil and Water Conservation (Ohio DNR) may issue an order such that failure to comply is a first degree misdemeanor. This program will provide safeguards against chronic problems that lead to the degradation of water quality within the Black River watershed.

SWCD Program

Ohio DNR-DSWC has a cooperative working agreement with the Soil and Water Conservation Districts throughout Ohio and the NRCS. According to the agreement, Ohio DNR-DSWC is responsible to "provide leadership to Districts in strategic planning, technical assistance, fiscal management, staffing, and administering District programs." The Division also provides "training and technical assistance to District supervisors and personnel in their duties, responsibilities, and authorities." Program Specialists from Ohio DNR work with the SWCDs to identify program needs and training opportunities. Ohio DNR also ensures that program standards and technical specifications are available to SWCDs and NRCS personnel. State matching dollars from the Ohio DNR constitute roughly half of the annual operating budgets of SWCDs.

Through the partnership established by the working agreement and their history of collaboration, Ohio DNR can communicate the goals and recommendations highlighted in this TMDL to SWCDs and provide guidance to actively promote conservation efforts that are consistent with those goals.

5.8.3 Agricultural Services and Programs

Local SWCD, NRCS, and Farm Service Agency (FSA) offices often work to serve the county's agricultural community. Staff from these offices establishes working relationships with private landowners and operators within their county, which are often based on trust and cooperation.

SWCD and NRCS staff is trained to provide sound conservation advice and technical assistance (based on standard practices) to landowners and operators as they manage and work the land. Sediment and erosion control and water quality protections make up a large component of the mission of their work. SWCD and NRCS activities also include outreach and education in order to promote stewardship and conservation of natural resources. The close working relationships that SWCD and NRCS staffs typically have with local land owners and producers make them well suited for promoting both widely-used conservation practices as well as some that are more innovative.

Federal Farm Bill programs are administered by the local NRCS and FSA offices. NRCS is responsible for the Environmental Quality Incentives Program (EQIP), while FSA is responsible for set-aside programs such as the Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), and the Wetland Reserve Program (WRP).

Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is an incentive-based, voluntary program designed to increase the use of agriculturally-related best management and conservation practices. EQIP is available to operators throughout the entire Black River watershed, irrespective of whether they own or rent the land that they farm. Through this program, operators receive cost share and/or incentive payments for employing conservation management practices. Contracts are five years in length.

Eligible conservation practices cover broad categories such as nutrient and pesticide management, conservation tillage, conservation crop rotation, cover cropping, manure management and storage, pesticide and fertilizer handling facilities, livestock fencing, pastureland management, and drainage water management, among others. However, funding for these practices is competitive and limited to the allocations made to any respective county in Ohio. Each county in receives a minimum of $100,000 per year and may receive more depending on state priorities for that year. More information on this program is available on the NRCS website at **www.nrcs.usda.gov**.

Conservation Reserve Program and Wetland Reserve Program

The Conservation Reserve and Wetland Reserve Programs (CRP and WRP, respectively) are set aside programs much like the Conservation Reserve Enhancement Program (CREP, see below), which is the enhanced version of CRP. The goals of these programs are to protect environmentally sensitive lands (e.g., highly erodible soils) and improve water quality and wildlife habitat.

Set-aside programs are voluntary and incentive-based and provide compensation to farmers for establishing and maintaining buffers, wetlands, grasslands or woodlands on land that would otherwise be used for agricultural production. Compensation is restricted to the timeframe established in the contract agreement. Incentive payments for these two programs are lower than the enhanced versions (i.e., CREP and WREP), which are limited to areas that have been approved by the USDA for the additional funding. These programs can assist in creating land use changes that improve water resource quality in the Black River watershed.

Ohio Lake Erie Conservation Reserve Enhancement Program (CREP)

CREP is a voluntary program that helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water. These conservation practices will target environmentally sensitive areas in the Lake Erie Watershed to reduce sediments and nutrients, prevent water pollution and minimize the risk of flooding and enhance wildlife habitat. The Lake Erie CREP is available in 27 counties that includes; Allen, Ashland, Auglaize, Crawford, Defiance, Erie, Fulton, Hancock, Hardin, Henry, Huron, Lucas, Lorain, Marion, Medina, Mercer, Ottawa, Paulding, Putnam, Richland, Sandusky, Seneca, Shelby, Van Wert, Williams, Wood and Wyandot. The Black River watershed falls within the program.

The Ohio Lake Erie CREP officially began in May of 2001. There are no acreage limits per county, so it is hard to predict the extent at which the program's conservation practices will be installed in any given area. Within the Black River watershed there are currently approximately 216 acres enrolled in CP21, the filter strip CREP practice, and approximately fifteen acres are enrolled in CP22 (riparian buffers) CREP practice.

With continued federal funding, the program will run on a continuous basis, meaning eligible land may be enrolled at any time until 67,000 acres have been enrolled. Currently, 25,500 acres are enrolled in the program. With the changes in this amendment, farmers and landowners will have thirteen different Lake Erie CREP practices to choose from, including grass filter strips, wetlands, riparian buffers and develop wildlife habitats. The cleaner water filtered through the streamside buffers will directly benefit landowners, farmers, aquatic and upland wildlife, as well as help maintain the lucrative Great Lakes tourism and water sports economy. Information regarding this program is available on the web at: **http://www.dnr.state.oh.us/soilandwater/crephome.htm**.

5.8.4 Extension and Development Services

Each county in Ohio has an extension agent dedicated to agricultural and natural resource issues. The primary purpose of extension is to disseminate up-to-date science and technology so it can be applied for the betterment of the environment and society. Like SWCD and NRCS staff, extension agents provide technical advice to landowners and operators and often develop strong relationships with the local community. Local extension agents are particularly well suited for promoting innovative conservation measures that have not yet been established in the standard practices developed by NRCS.

5.8.5 Local Health Departments

Under OAC 3701-29, local health departments are responsible for code enforcement, operational inspections, and nuisance investigations of household sewage treatment systems serving 1, 2, or 3 family dwellings. The Ohio Department of Health works with local health departments and provides technical assistance and training.

5.8.6 Phase II Storm Water Communities

Phase II storm water communities, including Lorain, Medina, Cuyahoga, Richland and Erie counties; the cities of Avon, Elyria, Lorain and Oberlin; the villages of Carlisle, Grafton, and Sheffield; and the townships of Brownhelm, Carlisle, Columbia, Eaton, Elyria, New Russia, and Sheffield, must develop storm water management plans that include controls for the six minimum control measures outlined by the U.S. EPA (**www.epa.state.oh.us/dsw/storm/ms4.html**).

5.8.7 Local Watershed Groups

Through a blend of public and private agencies and organizations, the Black River RAP is a leader in remedial action. In 2004, the Black River RAP re-designated beneficial use impairment from Impaired to In Recovery Stage, becoming the first AOC in Ohio to demonstrate a significant improvement in the RAP process. In 2005, the improvement continued when the Black River became the first AOC on the U.S. side to completely delist an impairment in part of its AOC. The Black River RAP continues to be a catalyst to advance the watershed approach for ecosystem remediation and restoration, and it continues to make progress towards the restoration and protection of the Black River Watershed Area of Concern. The Black River AOC is the only AOC in Ohio that encompasses and entire watershed. With such a large area, several years ago, the RAP started the Sub-Watershed Initiative. This initiative is now being run by

RAP member, the Lorain County Community Development Department. They have received a watershed coordinator grant from Ohio DNR and the coordinator has developed local watershed groups in French Creek and the West Branch. Information about these local watershed groups can be found at : **http://www.blackriverwatershed.org/**. Watershed actions plans addressing agricultural and residential issues for these sub-watersheds are being developed for submission to the state.

5.9 Process for Evaluation and Revision

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.

This section of the report provides a general strategy for continued monitoring and evaluation and lists parties who can potentially carry out such work. It highlights past efforts and those planned to be carried out in the future by the Ohio EPA and entities external to the agency. It also outlines a process by which changes to the implementation strategy can be made if needed.

5.9.1 Evaluation and Analyses

Aquatic life and recreational uses are impaired in the watershed, so monitoring that evaluates the river system with respect to these uses is a priority to the Ohio EPA. The degree of impairment of aquatic life use 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 high phosphorus and sediment concentrations (or loads) and degraded habitat. This report sets targets values for these parameters such as in-stream concentrations and loads, 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.

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