State of Ohio
Environmental Protection Agency

Division of Surface Water

Total Maximum Daily Loads for the Leading Creek Watershed

Leading Creek

Final Report
November 2, 2007

Ted Strickland, Governor
Chris Korleski, Director

Contents

1.0 Introduction 1
1.1 The Clean Water Act Requirement to Address Impaired Waters 1
1.2 Public Involvement 1
1.3 Organization of the Report 2
2.0 Description of Waterbodies, Impairment Status and Water Quality Standards 3
2.1 Description of the Leading Creek Watershed 3
2.2 Land Use and Land Cover within the Leading Creek Watershed 6
2.3 Water Quality Standards 8
2.3.1 Designated Uses 8
2.3.2 Numeric Criteria 8
2.3.3 Narrative Criteria 10
2.3.4 Biocriteria and Habitat Targets 10
2.4 Sources of Data and Previous Studies 11
3.0 Technical Approach 13
3.1 Load Duration Curves 13
3.2 Stream Flow Estimates 15
3.3 Estimating Total Dissolved Solids Concentrations 19
4.0 TMDL Results 20
4.1 Assessment Unit 05030202090: The Leading Creek Watershed 21
4.1.1 Subwatershed 010: Leading Creek Headwaters to Below Fivemile Run 23
4.1.2 Subwatershed 020: Leading Creek Below Fivemile Run to Above Mud Fork 31
4.1.3 Subwatershed 030: Mud Fork 42
4.1.4 Subwatershed 040: Leading Creek Below Mud Fork to Above Little Leading Creek 44
4.1.5 Subwatershed 050: Little Leading Creek 58
4.1.6 Subwatershed 060: Leading Creek below Little Leading Creek to the Ohio River 62
4.1.7 Subwatershed 070: Thomas Fork 70
4.2 Margin of Safety 74
4.3 Critical Conditions and Seasonality 75
5.0 Additional Water Quality Impairments in the Leading Creek Watershed 76
5.1 Fecal Coliform 76
5.2 Nutrients 77
5.3 pH 78
6.0 Implementation and Monitoring Recommendations 80
6.1 Total Suspended Solids 80
6.1.1 Sisson Run – AU 05030202 090 020 (Leading Creek below Fivemile Run to above Mud Fork) 81
6.1.2 Ogden Run – AU 05030202 090 020 (Leading Creek below Fivemile Run to above Mud Fork) 84
6.1.3 Mud Fork- AU 05030202 090 030 87
6.1.4 Little Leading Creek- AU 05030202 090 050 90
6.1.5 Titus Run – AU 05030202 090 060 94
6.1.6 Thomas Fork – AU 05030202 090 070 97
6.2 Total Dissolved Solids and Chlorides 101
7.0 References 104
Appendix A: Load Duration Curves
Appendix B: Estimated vs. Actual Stream Flows
Appendix C: Public Comment Response Summary
Appendix D: 2007 Leading Creek Water Quality Data

Figures

Figure 2-1. The Leading Creek watershed. 5
Figure 2-2. Land use and land cover within the Leading Creek watershed. 7
Figure 3-1. Total dissolved solids load duration curve example for monitoring station LCMS01 located on the Leading Creek mainstem. 14
Figure 3-2. Location of load duration sites. 18
Figure 3-3. TDS vs. conductivity in the Leading Creek watershed at stations with both parameters sampled. 19
Figure 4-1. Subwatersheds within the Leading Creek Assessment Unit. 22
Figure 4-2. Load duration sites within subwatershed 010. 25
Figure 4-3. Load duration sites within subwatershed 020. 34
Figure 4-4. Load duration sites within subwatershed 030. 43
Figure 4-5. Load duration sites within subwatershed 040. 48
Figure 4-6. Average chlorides concentrations along the Leading Creek mainstem. 53
Figure 4-7. Average TDS concentrations along the Leading Creek mainstem. 57
Figure 4-8. Load duration sites within subwatershed 050. 60
Figure 4-9. Load duration sites within subwatershed 060. 65
Figure 4-10. Load duration sites within subwatershed 070. 72

Tables

Table 1-1. Summary of section 303(d) listings in the Leading Creek watershed, Ohio. 2
Table 2-1. Assessment Unit (AU) and 14-Digit Hydrologic Unit Code (HUC) designations for the Leading Creek watershed. 3
Table 2-2. Land use and land cover characteristics of the Leading Creek watershed. 6
Table 2-3. Ohio water quality standards. 8
Table 2-4. Fecal coliform and *E. coli* standards for Ohio. Standards only apply for the period May 1 through October 15. 9
Table 2-5. TMDL target values for the Leading Creek watershed. 9
Table 2-6. TMDL targets for the Leading Creek watershed derived from WAP reference site statistics. Targets listed are 90th percentile values. 10
Table 2-7. Leading Creek basin applicable biocriteria. 10
Table 3-1. Relationship Between Load Duration Curve Zones and Contributing Sources. 15
Table 3-2. Drainage area ratios used to estimate stream flow for load duration analyses in the Leading Creek watershed. 17
Table 4-1. Summary of available water quality data for subwatershed 010. 24
Table 4-2. Loading statistics for the East Fork headwaters of Leading Creek (TM17). 26
Table 4-3. Loading statistics for the West Fork headwaters of Leading Creek (TM16). 27
Table 4-4. Loading statistics for Leading Creek (LCMS08). 28
Table 4-5. Loading statistics for Fivemile Run (TM15). 29
Table 4-6. Loading statistics for Leading Creek (LCMS07). 30
Table 4-7. Summary of available water quality data for subwatershed 020. 32
Table 4-8. Loading statistics for Sharps Run (TM14). 35
Table 4-9. Loading statistics for Leading Creek (LCMS06). 36
Table 4-10. Loading statistics for Sisson Run (TM13). 37
Table 4-11. Loading statistics for Ogden Run (TM12). 39
Table 4-12. Loading statistics for Leading Creek (LCMS05). 40
Table 4-13. Loading statistics for Dyesville Run (TM11). 41

Table 4-14. Summary of available water quality data for subwatershed 030. 42
Table 4-15. Loading statistics for Mud Fork (TM10). 44
Table 4-16. Summary of available water quality data for subwatershed 040. 46
Table 4-17. Loading statistics for Dexter Run (TM09). 49
Table 4-18. Loading statistics for Grass Run (TM08). 50
Table 4-19. Loading statistics for Leading Creek (LCMS04). 51
Table 4-20. NPDES WLAs for the Meigs #31 Mine 52
Table 4-21. Loading statistics for Parker Run (TM07). 54
Table 4-22. Loading statistics for Malloons Run (TM06). 55
Table 4-23. Loading statistics for Leading Creek (LCMS03). 56
Table 4-24. Loading statistics for Lasher Run (TM05). 58
Table 4-25. Summary of available water quality data for subwatershed 050. 59
Table 4-26. NPDES WLAs for the Rutland WWTP. 61
Table 4-27. Loading statistics for Little Leading Creek (TM04). 62
Table 4-28. Summary of available water quality data for subwatershed 060. 64
Table 4-29. Loading statistics for Titus Run (TM03). 66
Table 4-30. Loading statistics for Paulins Hill Run (TM02). 67
Table 4-31. Loading statistics for Leading Creek (LCMS02). 68
Table 4-32. Loading statistics for Leading Creek (LCMS01). 70
Table 4-33. Summary of available water quality data for subwatershed 070. 71
Table 4-34. Loading statistics for Thomas Fork (TM01). 74
Table 5-1. Fecal coliform counts at areas of concern and suggested long-term monitoring sites. 76
Table 5-2. Subwatersheds and tributaries with possible nutrient issues. 78
Table 5-3. Initial tributary investigation – pH results. 78
Table 6-1. Needed TSS reductions derived from load duration analysis. 80
Table 6-2. Land Cover/Land Use within the Sisson Run subwatershed and associated estimates of sediment loading. 82
Table 6-3. Potential effectiveness of the recommended BMPs for Sisson Run. 83
Table 6-4. Estimated sediment load reductions for Sisson Run. 83
Table 6-5. Land Cover/Land Use within the Ogden Run subwatershed and associated estimates of sediment loading. 85
Table 6-6. Potential effectiveness of the recommended BMPs for Ogden Run. 86
Table 6-7. Estimated sediment load reductions for Ogden Run. 87
Table 6-8. Land Cover/Land Use within the Mud Fork subwatershed and associated estimates of sediment loading. 88
Table 6-9. Potential effectiveness of the recommended BMPs for Mud Fork. 89
Table 6-10. Estimated sediment load reductions for Mud Fork. 90
Table 6-11. Land Cover/Land Use within the Little Leading Creek subwatershed and associated estimates of sediment loading. 92
Table 6-12. Potential effectiveness of the recommended BMPs for Mud Fork. 93
Table 6-13. Estimated sediment load reductions for Little Leading Creek. 94
Table 6-14. Land Cover/Land Use within the Titus Run subwatershed and associated estimates of sediment loading. 95
Table 6-15. Effectiveness of the recommended BMPs for Titus Run. 96
Table 6-16. Estimated sediment load reductions for Titus Run. 97
Table 6-17. Land Cover/Land Use within the Bailey Run subwatershed and associated estimates of sediment loading. 98
Table 6-18. Land Cover/Land Use within the Hysell Run subwatershed and associated estimates of sediment loading. 99
Table 6-19. Land Cover/Land Use within the “Casto’s seep” subwatershed and associated estimates of sediment loading. 99

Table 6-20. Potential effectiveness of the recommended BMPs for the Thomas Fork target areas... 100
Table 6-21. Estimated sediment load reductions for the Thomas Fork target areas. 101
Table 6-22. Needed TDS reductions derived from load duration analysis. 102
Table 6-23. Needed chlorides reductions derived from load duration analysis. 102

Acknowledgements

The TMDL report was prepared by Tetra Tech, Inc. (1468 West 9th Street, Suite 620, Cleveland, Ohio 44113) in conjunction with Ohio EPA. Tetra Tech's services were provided under contract to the U.S. Environmental Protection Agency.

The following Ohio EPA staff provided technical services for this project:

Nonpoint Source Issues.....Dan Imhoff
Point Source Issues .....Randy Spencer, Eric Nygaard, Mike McCullough
Water Quality Issues .....Kelly Capuzzi, Joann Montgomery, Jeff DeShon
TMDL Coordination, Project Leader.....Beth Risley

This TMDL project made use of biological, chemical and physical stream data collected by the Midwest Biodiversity Institute (P.O. Box 21561, Columbus, OH 43221-0561). The report was prepared for the Division of Mineral Resources Management at the Ohio Department of Natural Resources. Several watershed studies, as noted in the report, provided valuable insight into the Leading Creek watershed.

Ohio EPA gratefully acknowledges the assistance provided by Raina Fulks, the Leading Creek Watershed Coordinator.

Executive Summary

The Leading Creek watershed has a drainage area of approximately 150 square miles and flows into the Ohio River near Middleport. The Ohio Environmental Protection Agency (Ohio EPA) has evaluated the biological health and water quality of the watershed and determined that several segments of Leading Creek do not support designated aquatic life uses for Warm Water Habitat (WWH) or the Primary Contact Recreational use. The aquatic life use impairments are believed to be a result of poor habitat, elevated sediment loads and total dissolved solids (TDS), and reduced pH.

The Leading Creek watershed faces several impairments from a variety of sources. In the headwaters and upper portions of the watershed, agricultural activities are the primary source of impairment. The lower portions of the watershed are mostly impaired from historic mining practices and acid mine drainage (AMD). Surface and underground coal mines have had significant impacts on the water quality of Leading Creek for decades and the effects of mining are still noticeable today. Many tributaries are inundated with sand as large slugs of residual sediment slowly move through the drainage network. Some areas of the watershed that were historically long wall mined have experienced land subsidence. In a few of these areas, the stream hydrology has been disrupted and water loss has occurred. In 1993, an emergency discharge of contaminated water from the Meigs #31 Mine destroyed habitat and caused a large fish kill in Parker Run and downstream into segments of Leading Creek. To this day, the impacts of historic mining are still felt as over 2,000 acres of surface mines have been abandoned and left unreclaimed within the Leading Creek watershed (Bauers et al., 2006). The resulting landscape is speckled with coal mine spoil, seeps, and underdrain pipes (previous reclamation attempts-now AMD point sources) discharging from coal seams, auger holes, and/or mine entries.

A total maximum daily load (TMDL) is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. Load reductions were calculated for TDS, total suspended solids, and chlorides in the Leading Creek watershed in this report. There are additional water quality impairments in the Leading Creek Watershed; however, data limitations prevented the development of TMDLs for fecal coliform, nutrients, and pH values that exceed water quality standards or are parameters of concern.

As part of the TMDL reporting process, recommendations are made to implement actions with the goal of improving water quality. Most of the recommendations made in the report involve improved agricultural practices such as grazing land protection, replacing riparian vegetation, and limiting access of cows to streams. The Meigs #31 Mine is the only major point source discharge located in the watershed, and is contributing large loads of TDS to the stream. The TMDL recommends reducing the TDS load from this facility.

1.0 INTRODUCTION

The Leading Creek watershed has a drainage area of approximately 150 square miles and flows into the Ohio River near Middleport. The watershed lies in the forested hills of the Western Allegheny Plateau (WAP) ecoregion in southeastern Ohio as shown in Figure 2-1.

The Ohio Environmental Protection Agency (Ohio EPA) has evaluated the biological health and water quality of the watershed and determined that several segments of Leading Creek do not support designated aquatic life uses for Warm Water Habitat (WWH) or the Primary Contact Recreational use. Additional physical habitat impairments were determined using the Quality Habitat Evaluation Index (QHEI) scores (Ohio EPA, 1989), which measure the overall habitat and ecosystem health. Table 1-1 summarizes the impairment causes and sources within the Assessment Unit. The aquatic life use impairments are believed to be a result of poor habitat, elevated sediment loads and total dissolved solids (TDS), and reduced pH.

1.1 The Clean Water Act Requirement to Address Impaired Waters

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 Leading Creek TMDLs were to:

- Assess the 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.

1.2 Public Involvement

Public involvement is key to the success of any TMDL project. From the beginning, Ohio EPA has invited participation in all aspects of the TMDL program. The Ohio EPA convened an external advisory group (EAG) in 1998 to assist the Agency with the development of the TMDL program in Ohio. The EAG issued a report in July 2000 to the Director of Ohio EPA on their findings and recommendations. The Leading Creek watershed TMDL project has been completed using the process endorsed by the advisory group.

Consistent with Ohio's current Continuous Planning Process (CPP), the draft TMDL report was available for public comment from July 12, 2007 to August 13, 2007. A copy of the draft report was posted on Ohio EPA's web page (**http://www.epa.state.oh.us/dsw/tmdl/index.html**) and made available upon request. A summary of the comments received and the associated responses is included as Appendix C.

Table 1-1. Summary of section 303(d) listings in the Leading Creek watershed, Ohio.

Assessment Unit	Designated Uses	Pollutant	Sources of Impairment
05030202 090 Leading Creek Priority Points = 5	Aquatic Life Uses (WWH) and Recreational Use (Primary Contact)	pH, Siltation, Salinity/ TDS/Chlorides, Habitat Alterations, and Pathogens (Fecal Bacteria)	Major Industrial Point Source, Non-irrigated Crop Production, Pasture Land, Channelization, Surface Mining, Subsurface Mining, Acid Mine Drainage

1.3 Organization of the Report

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, and Section 4 presents the resulting TMDLs. Section 5 presents additional water quality impairments in the Leading Creek watershed. Recommendations for implementation activities are presented in Section 6. Appendix A provides additional information on existing and allowable loads in the watershed and Appendix B presents the results of an actual vs. estimated flow comparison. Appendix C includes a summary of comments received during the public review process of the draft report, including responses, and Appendix D presents the results of field sampling in the Leading Creek watershed during 2007.

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 Leading Creek and its surrounding watershed. Extensive descriptions of the watershed are available from the Ohio EPA endorsed Watershed Management Plan (**http://web.epa.state.oh.us/dsw/nps/NPSMP/docs/EndorsedLeadingCreekWAP.pdf**).

2.1 Description of the Leading Creek Watershed

Leading Creek drains approximately 150 square miles and its watershed is located in southeastern Ohio (Figure 2-1). The watershed lies within the unglaciated Western Allegheny Plateau (WAP) ecoregion. The WAP ecoregion is characterized by extensively forested rolling hills with small pockets of dairy, livestock, farming, and residential development. Its underlying bedrock primarily consists of sandstones, shales, limestones, and coal. The Leading Creek watershed is divided among three counties. A majority lies within Meigs County, the northernmost headwaters cross into Athens County, and a small portion of the watershed lies in Gallia County to the south. Cities within the watershed include Middleport, Pomeroy, Rutland, Albany and Dexter.

The watershed consists of one 11-digit Assessment Unit (AU) - Leading Creek (05030202 090). This 11-digit AU is further subdivided into seven 14-digit hydrologic unit code (HUC) subwatersheds as presented in Table 2-1.

Table 2-1. Assessment Unit (AU) and 14-Digit Hydrologic Unit Code (HUC) designations for the Leading Creek watershed.

11-Digit AU	14-Digit HUC	Description	Drainage Area (mi^2)
05030202 090	010	Leading Creek headwaters to below Fivemile Run	13.5
	020	Leading Creek below Fivemile Run to above Mud Fork	23.8
	030	Mud Fork	13.2
	040	Leading Creek below Mud Fork to above Little Leading Creek	33.9
	050	Little Leading Creek	25.6
	060	Leading Creek below Little Leading Creek to the Ohio River	9.0
	070	Thomas Fork	31.2

The Leading Creek watershed faces several impairments from a variety of sources. In the headwaters and upper portions of the watershed, agricultural activities are the primary source of impairment. The lower portions of the watershed are mostly impaired from historic mining practices and acid mine drainage (AMD). Surface and underground coal mines have had significant impacts on the water quality of Leading Creek for decades and the effects of mining are still noticeable today. Many tributaries are inundated with sand as large slugs of residual sediment slowly move through the drainage network. Some areas of the watershed that were historically long wall mined have experienced land subsidence. In a few of these areas, the stream hydrology has been disrupted and water loss has occurred. In 1993, an emergency discharge of contaminated water from the Meigs #31 Mine destroyed habitat and caused a large fish kill in Parker Run and downstream into segments of Leading Creek.

To this day, the impacts of historic mining are still felt as over 2,000 acres of surface mines have been abandoned and left unreclaimed within the Leading Creek watershed (Bauers et al., 2006). The resulting landscape is speckled with coal mine spoil, seeps, and underdrain pipes (previous reclamation attempts-now AMD point sources) discharging from coal seams, auger holes, and/or mine entries.

Two point source dischargers with NPDES permits are located in the watershed:

- Meigs #31 Mine waste water treatment plant, Permit Number 0IL00027
- Rutland waste water treatment plant, Permit Number 0PA00052

There are no concentrated animal feeding operations, Phase II storm water communities or municipal separate storm sewer systems (MS4s) in the Leading Creek watershed.

Figure 2-1. The Leading Creek watershed.

2.2 Land Use and Land Cover within the Leading Creek Watershed

The land use/land cover for the Leading Creek 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. The resulting land use and land cover characteristics of the Leading Creek watershed are presented in Figure 2-2 and summarized in Table 2-2. The figure and the table display that deciduous forest is the dominant land cover in the watershed as it accounts for approximately 70 percent of the total area. Pasture/hay land cover makes up approximately 20 percent of the watershed and residential areas and row crops cover about one percent of the watershed area each.

Table 2-2. Land use and land cover characteristics of the Leading Creek watershed.

Land Cover / Land Use	Area (acres)	Area (Sq. Miles)	Percent of Watershed
Open Water	323.87	0.51	0.3%
Developed, Open Space	5,196.18	8.12	5.4%
Developed, Low Intensity	619.31	0.97	0.6%
Developed, Medium Intensity	59.94	0.09	0.1%
Developed, High Intensity	9.32	0.01	0.0%
Barren Land (Rock/Sand/Clay)	334.11	0.52	0.3%
Deciduous Forest	67,859.96	106.03	70.6%
Evergreen Forest	723.73	1.13	0.8%
Mixed Forest	25.38	0.04	0.0%
Shrub/Scrub	291.03	0.45	0.3%
Grasslands/Herbaceous	1,203.92	1.88	1.3%
Pasture/Hay	18,534.21	28.96	19.3%
Cultivated Crops	996.53	1.56	1.0%
Woody Wetlands	1.02	0.00	0.0%
Emergent Herbaceous Wetlands	3.18	0.00	0.0%
Total	**96,181.69**	**150.27**	**100.0%**

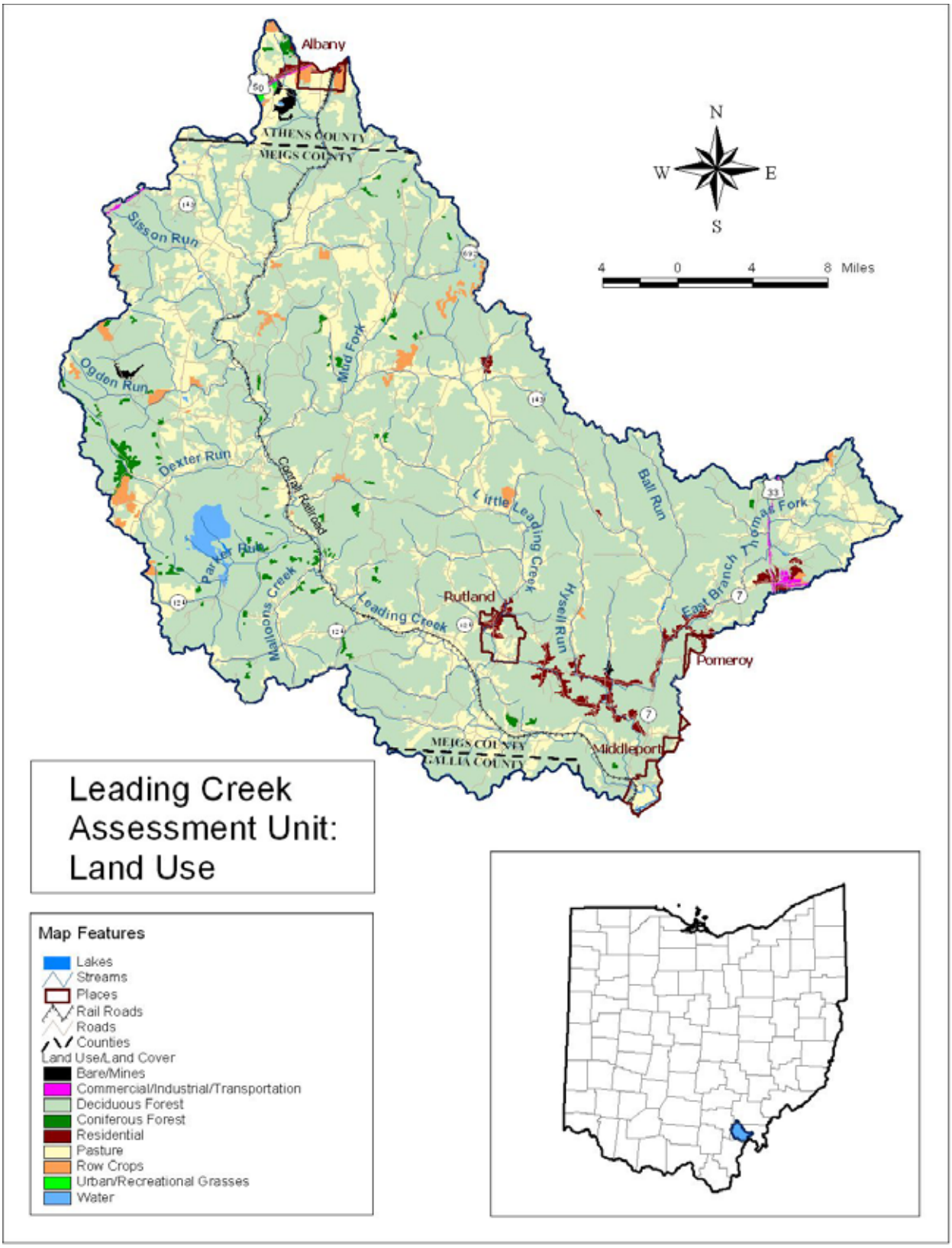


Figure 2-2. Land use and land cover within the Leading Creek watershed.

2.3 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 2-3 and explained in greater detail below.

Table 2-3. 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 in-stream 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. However, some streams in Ohio are undesignated and receive a default Warm Water Habitat designation for chemical loadings. There is no default protection for recreational use.

2.3.1 Designated Uses

Leading Creek and its tributaries are designated by Ohio EPA as warmwater habitat (WWH). All of the streams in the Leading Creek watershed are designated for Primary Contact Recreation (OAC 3745-1-22). Water Supply Uses for all waterbodies in the watershed are designated as Agricultural Water Supply (AWS) and Industrial Water Supply (IWS).

2.3.2 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 2-4 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 TMDLs for the Leading Creek watershed are based on meeting the primary contact fecal coliform standard.

Table 2-4. 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 30-day period.
[2] Fecal coliform content should not exceed this standard in more than 10 percent of the samples taken in any 30-day period.

TMDL targets are 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 numeric criteria for pH and TDS, as shown in Table 2-5.

Table 2-5. TMDL target values for the Leading Creek watershed.

Water Quality Parameter	Source of TMDL Target	Target Value
pH	Numeric Criteria	6.5 to 9 standard units (s.u.)
TDS	Numeric Criteria	Less than 1500 mg/L

2.3.3 Narrative Criteria

TMDL targets for water quality parameters not specifically addressed in Ohio EPA's water quality standards were derived from WAP ecoregion reference site statistics (Ohio EPA, 1999). The guideline values for total suspended solids (TSS) and chlorides are shown in Table 2-6.

Table 2-6. TMDL targets for the Leading Creek watershed derived from WAP reference site statistics. Targets listed are 90th percentile values.

Water Quality Parameter	Source of TMDL Target	Target Value
TSS	Ohio EPA Guidelines	Headwaters (< 20 square miles): 18.8 mg/L Wadeable (20 < 200 square miles): 36.8 mg/L Small Rivers (200 < 1000 square miles): 41.2 mg/L
Chlorides	Ohio EPA Guidelines	Headwaters (< 20 square miles): 86.2 mg/L Wadeable (20 < 200 square miles): 55.0 mg/L Small Rivers (200 < 1000 square miles): 60.0 mg/L

Using TSS as an indicator of sediment in streams is fairly common and has been used in numerous TMDL reports; however, TSS concentrations may be an underestimation of sediment loads as they only account for particles small enough to be suspended in the water column. Larger particles, such as sand and coarser particles that may have the most influence on aquatic life and stream substrates, are often not included in TSS concentrations as they usually settle out of the water column. Due to the lack of bed load and other sediment data throughout the Leading Creek watershed, TSS has been used as a surrogate for the sediment impairment. To supplement this analysis, QHEI, sediment depth, and watershed soil loss analyses are included in Section 6 for streams/subwatersheds known to be impaired by sediment.

2.3.4 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 Leading Creek basin are included in Table 2-7.

Table 2-7. Leading Creek basin applicable biocriteria.

Ecoregion Biocriteria: Western Allegheny Plateau (WAP)	
INDEX - Type	**WWH Biocriteria**
IBI	44-49
MIwb	8.4-9.3
ICI	36-44

Habitat loss has been identified as a cause of impairment in the Leading Creek 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 QHEI is a quantitative composite of six physical habitat variables used to 'score' a stream's habitat. The variables are: substrate, in-stream cover, riparian characteristics, channel characteristics, pool/riffle quality, and gradient and drainage area. It 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 provide a numeric target for sedimentation.

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. 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 Leading Creek watershed (Tables 2-5, 2-6 and 2-7), refer to the technical report entitled *Association between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA, 1999).

2.4 Sources of Data and Previous Studies

Several studies have been completed in the Leading Creek watershed and this report draws information from several of these sources. Data from select studies are also included in the analyses provided in this report. This section provides a description of each study/report as well as explains how each is used and referenced throughout the remainder of the report.

<u>Acid Mine Drainage Abatement and Treatment (AMDAT) Plan for the Leading Creek Watershed</u>

This report was completed in 2006 and is an inventory of all sources of acid mine drainage (AMD) within the Leading Creek watershed. The AMDAT Plan (also referred to as Bauers et al., 2006 in this report) also prioritizes the sources for future treatment, provides a cost benefit analysis for treatment, recommends future monitoring, and outlines possible funding strategies. Staff from the Meigs County Soil and Water Conservation District, Ohio University's Voinovich Center (ILGARD), and the Ohio Department of Natural Resources, Division of Mineral Resource Management completed the AMDAT Plan. Information from the AMDAT Plan is incorporated into sections the report to provide a brief review of the surrounding watershed, biological health, noted water quality issues, and physical habitat condition for each subwatershed. Where AMD issues are noted, the AMDAT Plan is referenced as a guidance document. As part of the AMDAT work, the Ohio Department of Natural Resources, Division of Mineral Resource Management sponsored the collection of watershed data and analysis by the Midwest Biodiversity Institute (Rankin, 2005). (Ohio EPA used the Rankin data to update the 303(d) listing for the Leading Creek watershed (Ohio EPA, 2006).)

<u>A Comprehensive Watershed Management Plan for the Leading Creek Watershed</u>

The Watershed Management Plan (also referred to as Bauers, 2005) is a comprehensive assessment of the Leading Creek watershed that includes information on watershed demographics, detailed descriptions of subwatersheds, discussions of aquatic biology and physical habitat, water quality issues, goals for restoring water quality, and an implementation schedule. Acting as the Leading Creek Watershed

Coordinator, Cynthia Bauers organized and wrote the report. The Watershed Management Plan was frequently used throughout this report for subwatershed descriptions, noting livestock access areas, streambank erosion estimates, failing home sewage treatment system estimates, and sediment sources. Additionally, the Watershed Management Plan assisted with noting fecal coliform areas of concern (Section 5) and severely sediment limited subwatersheds (Section 6).

Leading Creek Improvement Plan

This extensive report was generated in 1999 by Virginia Tech staff through a Federal Court Consent Decree with the following objectives:

- Characterize the historic and current watershed conditions
- Identify impairments and possible sources
- Determine attainment status of Aquatic Life Uses
- Present possible remediation/improvement actions and their associated costs
- Prioritize an approach to improving water quality in the Leading Creek watershed

The following information from the Leading Creek Improvement Plan (also referred to as Cherry et al., 1999) was used to supplement this report: water quality sampling data for TMDL development, noted sediment sources for discussion in Section 6, and watershed descriptions for discussion of each assessment unit. In the implementation section of this report, the Leading Creek Improvement Plan is also referenced for specific projects and pollution mitigation strategies.

3.0 TECHNICAL APPROACH

This section of the report presents the technical approach used to estimate current and allowable loading to Leading Creek and its tributary streams. As discussed below, a load duration approach was used to make these estimates.

3.1 Load Duration Curves

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

1. 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 deviations from the water quality standard/target and the daily allowable load. Those plotting below the curve represent compliance with standards and the daily allowable load. Further, it can be determined which locations contribute loads above or below the water quality standard/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 observed TDS loads exceed allowable loads during dry and low flow zones and are below allowable loads during moist and high flow zones. The figure also indicates that excessive loads mostly occur during the critical summer months of June to September. 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.

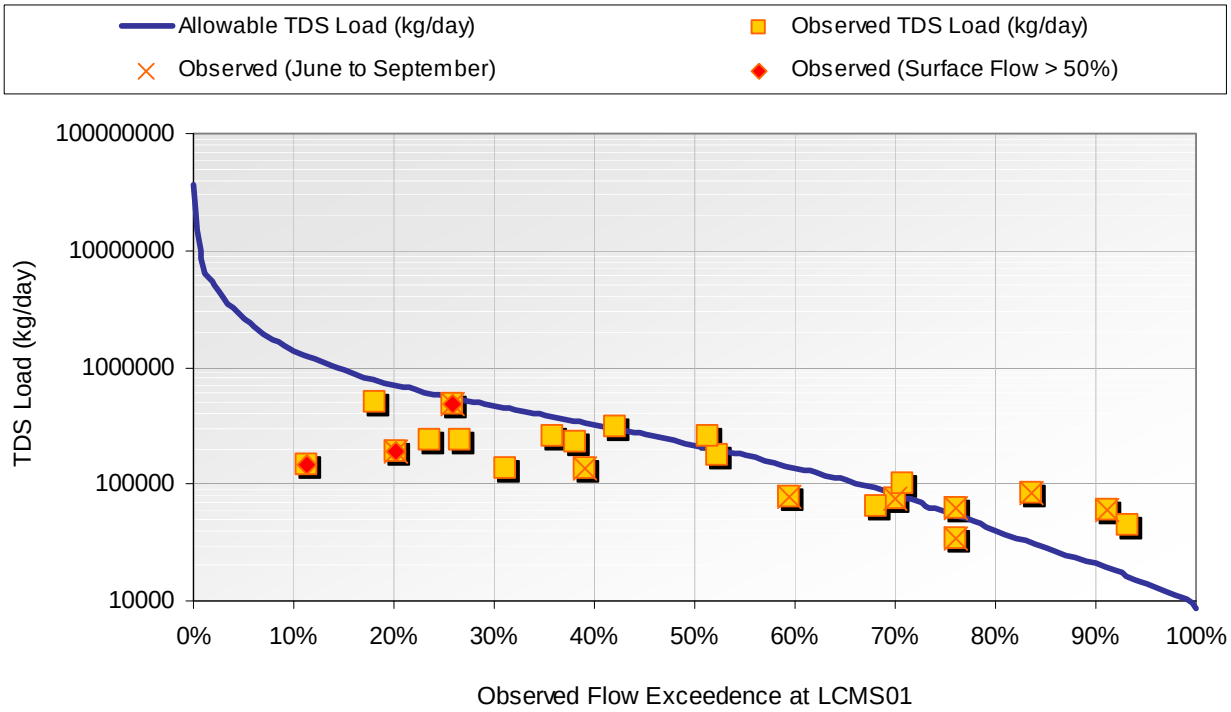


Figure 3-1. Total dissolved solids load duration curve example for monitoring station LCMS01 located on the Leading Creek mainstem.

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.

Because the load duration approach determines loads based on various flow regimes, it helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 3-1 summarizes the relationship between the five hydrologic zones and potentially contributing source areas.

The load reduction approach also considers critical conditions and seasonal variation in the TMDL development as required by the Clean Water Act and the U.S. EPA's implementing regulations. Because the approach establishes loads based on a representative flow regime, it inherently considers seasonal variations and critical conditions attributed to flow conditions.

Table 3-1. Relationship Between Load Duration Curve Zones and Contributing Sources.

Contributing Source Area	Duration Curve Zone				
	High	Moist	Mid-Range	Dry	Low
Point source				M	H
Livestock direct access to streams				M	H
Onsite wastewater systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Storm water: Impervious		H	H	H	
Combined sewer overflow (CSO)	H	H	H		
Storm water: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			

Note: Potential relative importance of source area to contribute loads under a given hydrologic condition (H: High; M: Medium; L: Low)

The LDC 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 loads are significant 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 approach also aids in sharing the responsibility for nutrient and pathogen reductions among various stakeholders in the TMDL watershed, which encourages efficient and collective implementation efforts.

Load duration curves were determined to be an appropriate TMDL approach due to the relatively small amount of data and time required. 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 criteria for nutrients, therefore meeting these loading capacities should result in attainment of water quality standards.

Weaknesses of this TMDL approach are that nonpoint source load allocations were not assigned to specific sources within the watershed and the identified sources of pathogens and nutrients were assumed based on the data collected in the watershed, rather than determined by detailed monitoring and sampling efforts. Moreover, specific source reductions were not quantified. Despite the limitations of the LDC, Ohio EPA believes the strengths of the approach outweigh the weaknesses and that this methodology is appropriate based upon the information available.

3.2 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 not available for the Leading Creek watershed. Since the load duration approach requires a stream flow time series for each site where the method is applied, stream flows were extrapolated from a surrogate gage station for each load duration site. The Shade River near Chester, Ohio (USGS gage 03159540) was selected as the surrogate station because it is located within the WAP ecoregion, has a comparable drainage area of 156 square miles, and is directly adjacent to the Leading

Creek watershed. Daily average flows for the Shade River gage station were downloaded from **http://waterdata.usgs.gov/nwis**.

Flow time series for each load duration site were estimated using a multiplier based upon the ratio of the upstream drainage area for a given site to the drainage area of the Shade River. For example, the ratio of the drainage area at the Thomas Fork monitoring site TM01 is 30.61 square miles which, if divided by the drainage area of Shade River (156 square miles), equals 0.196. Thus, the observed daily stream flows at the Chester, Ohio USGS gage were multiplied by 0.196 to estimate the daily stream flows at the Thomas Fork monitoring site. Table 3-2 presents the drainage area ratios used to estimate stream flow for all of the load duration sites included in this TMDL; the locations of the sites are shown in Figure 3-2.

Actual flow data collected by the Leading Creek Watershed Group were available for Thomas Fork (TM01), Titus Run (TM03), and one station on the Leading Creek mainstem (LCMS03). These actual measured flow values were compared to the estimated flow values used in the load duration analysis to determine if the flow estimation produced similar flows. The resulting graphics are presented in Appendix B. The estimated flows were found to be very similar in magnitude and timing to the actual flows across ten dates in Thomas Fork, five dates in Titus Run, and two dates on the Leading Creek Mainstem. R-squared values between the estimated and actual flow values are all above 0.90, indicating that the estimated flows explain a large proportion of the variability seen in the observed flows.

The Meigs #31 Mine is permitted by the Ohio EPA to discharge a maximum of 7.5 million gallons per day (MGD) of treated mine water into Parker Run. The WLA for the facility therefore had to account for this potential flow volume and, in turn, the estimates of downstream flows had to also reflect this discharge rate (or the WLA would have greatly exceeded the loading capacity of the stream). The maximum design flow of 7.5 MGD (or 11.6 cfs) was therefore added to all flows extrapolated for the TM07 station in Parker Run. The Meigs #31 Mine discharge was also added to the sampling stations downstream of the Parker Run confluence with Leading Creek (LCMS03, LCMS02, and LCMS01).

Table 3-2. Drainage area ratios used to estimate stream flow for load duration analyses in the Leading Creek watershed.

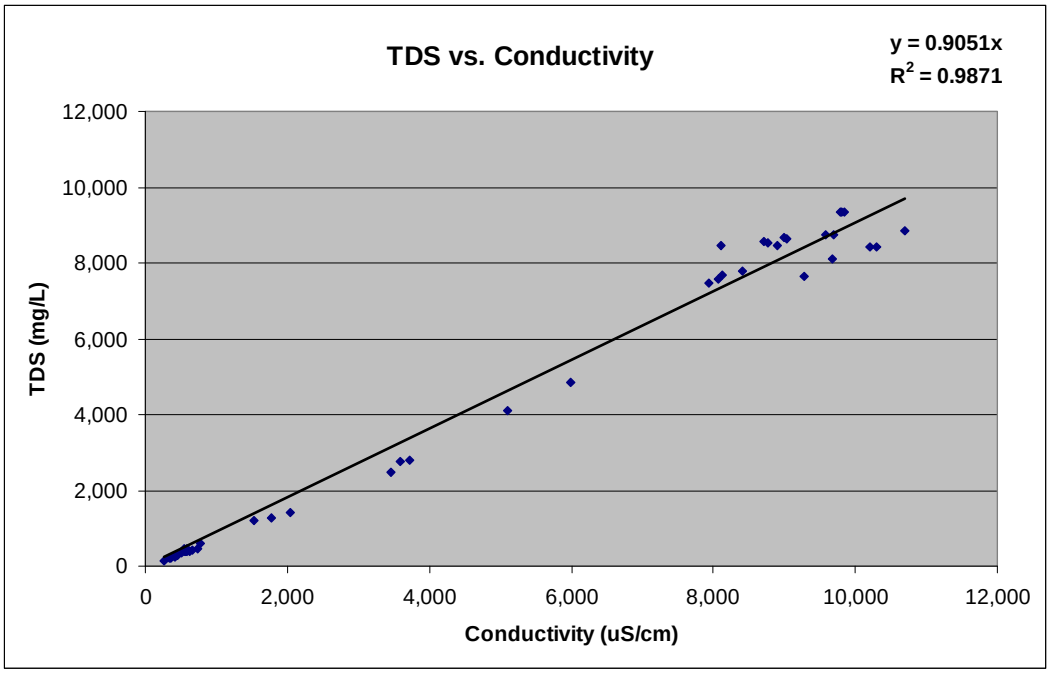
11-Digit AU	14-Digit HUC	Station ID	Stream Name	Location	River Mile	Upstream Drainage Area (sq. mi.)	Drainage Area Ratio
05030202090	010	TM17	East Fork-Headwaters	Headwaters - at US Route 50	0.3	0.61	0.004
	010	TM16	West Fork-Headwaters	Headwaters - Dst. Columbia Rd	0.1	0.46	0.003
	010	LCMS08	Leading Creek	At Carpenter Rd	30.0	3.85	0.025
	010	TM15	Fivemile Run	At SR-143	0.9	2.69	0.017
	010	LCMS07	Leading Creek	At Carpenter Hill Rd	26.5	13.49	0.086
	020	TM14	Sharps Run	At SR-143	0.7	3.69	0.024
	020	LCMS06	Leading Creek	At Staneart Rd	24.5	18.75	0.120
	020	TM13	Sisson Run	Adj. to Sisson Run Rd. Near Mouth	0.1	5.60	0.036
	020	TM12	Ogden Run	Adj. Ogden Rd, Near Mouth	0.3	7.36	0.047
	020	LCMS05	Leading Creek	At Folden Rd	21.1	33.44	0.214
	020	TM11	Dyesville Run	At Harmon Rd	0..5	2.46	0.016
	030	TM10	Mud Fork	At Bridge on CR-10	0.1	13.28	0.085
	040	TM09	Dexter Run	Dst. Bowles Rd	0.7	7.35	0.047
	040	TM08	Grass Run	At McCumber Hill Rd	0.8	1.84	0.012
	040	LCMS04	Leading Creek	At Parker Run Rd Bridge	16.0	62.89	0.403
	040	TM07	Parker Run	At Parker Run Rd	1.6	4.76	0.031
	040	TM06	Malloons Run	At Malloons Run Rd	0.1	4.17	0.027
	040	LCMS03	Leading Creek	At Parkinson Rd Bridge	10.5	81.09	0.520
	040	TM05	Lasher Run	Dst. Bridge on Lasher Rd	0.5	1.79	0.011
	050	TM04	Little Leading Creek	At Bridge on Higley Rd	0.4	25.61	0.164
	060	TM03	Titus Run	Dst. Titus Run Rd, Near Mouth	0.2	6.32	0.041
	060	TM02	Paulins Hill Run	Adj. to Wells Rd, Near Mouth	0.1	1.99	0.013
	060	LCMS02	Leading Creek	Ust. Thomas Fork	3.5	117.49	0.753
	070	TM01	Thomas Fork	At Leading Ck Rd	1.2	30.61	0.196
	060	LCMS01	Leading Creek	Near Middleport at Hobson Dr	1.5	149.78	0.960

Figure 3-2. Location of load duration sites.

3.3 Estimating Total Dissolved Solids Concentrations

During several sampling events, TDS concentrations were not analyzed. This lack of data did not allow for load duration analysis for TDS at certain sampling stations. However, TDS and conductivity are known to typically have a strong correlation to one another and at most of the stations without TDS data, conductivity was sampled. Using a simple regression equation, TDS values were estimated using the available conductivity values. Several sampling events (49 total) had data available for both parameters and were used to develop the regression equation (Figure 3-3). TDS was plotted against conductivity to confirm a strong correlation ($R^2 = 0.9871$), and the regression equation ($y = 0.9051x$) was then used to estimate TDS values when only conductivity data were available.

Figure 3-3. TDS vs. conductivity in the Leading Creek watershed at stations with both parameters sampled.



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, 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. Typically, an additional component of the MOS is dedicated to future growth in the watershed. However no significant future growth is anticipated in this primarily rural watershed, therefore no future growth reserve was included in TMDL calculation. Conceptually, TMDL calculation is defined by the equation:

$$TMDL = WLA + LA + MOS$$

A summary of the load reductions needed for TDS, TSS, and chlorides in the Leading Creek 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. There are no Phase II storm water communities or MS4s in the Leading Creek watershed, so only WLAs for NPDES permitted facilities were calculated.

The allowable pollutant loads established in this TMDL for total dissolved solids (TDS) do not preclude the possibility of developing and/or approving a site-specific water quality criterion for TDS. A site-specific water quality criterion for TDS may result in higher loadings of this pollutant than those calculated for the TMDL for Parker Run and Leading Creek. However, any site-specific water quality criterion must be approved by Ohio EPA, and must demonstrate that it will be protective of all designated uses and will not jeopardize attainment of designated uses for impaired streams.

Load duration analyses were conducted for all sites with a sufficient number of samples (in most cases more than 15) within the Leading Creek Assessment Unit. A variety of data have been used to assess water quality conditions in the Leading Creek watershed. A master database was initially generated to organize water chemistry data from Legacy STORET (**http://www.epa.gov/storet/dbtop.html**), the Leading Creek Watershed Group, and a watershed study performed for the Leading Creek Improvement Plan.

The Watershed Group samples (collected 2003 to 2006) and Leading Creek Improvement Plan samples (1996 to 1997) were determined to best reflect current watershed conditions and were extracted from the database for use in the load duration analyses. These records include data for water chemistry and fecal coliform parameters; however there are very few fecal coliform samples, so load duration analysis for this parameter was not able to be completed. A discussion of fecal, nutrient, and pH issues in the Leading Creek watershed is presented in Section 5.0.

Where possible, data from the two sampling events were combined based on coordinate locations and/or site descriptions. A new set of station IDs was then developed for each load duration sampling site using the following naming convention:

- Leading Creek mainstem site IDs are labeled with “LCMS…”
- Tributary monitoring site IDs are labeled with “TM…”

All load duration sampling site labels are followed by a number which descends as the sampling stations move from the headwaters of Leading Creek to the mouth.

4.1 Assessment Unit 05030202090: The Leading Creek Watershed

The load duration approach was applied to 25 sampling stations total within the Leading Creek Assessment Unit (Figure 4-1). For each load duration site, all appropriate and available water quality and flow data were used.

- Eight sites along the mainstem of Leading Creek:
  - At Carpenter Road (LCMS08).
  - At Carpenter Hill Road (LCMS07).
  - At Staneart Road (LCMS06).
  - At Folden Road (LCMS05).
  - At Parker Run Road Bridge (LCMS04).
  - At Parkinson Road Bridge (LCMS03).
  - Upstream of Thomas Fork (LCMS02).
  - Near Middleport at Hobson Drive (LCMS01).

- Seventeen sites near the mouth of each of the following tributaries to Leading Creek:
  - East Fork Headwaters at US Route 50 (TM17).
  - West Fork Headwaters Downstream of Columbia Road (TM16).
  - Fivemile Run at State Route 143 (TM15).
  - Sharps Run at State Route 143 (TM14).
  - Sisson Run Adjacent to Sisson Run Road, Near Mouth (TM13).
  - Ogden Run Adjacent to Ogden Run Road (TM12).
  - Dyesville Run at Harmon Road (TM11).
  - Mud Fork at Bridge on County Road 10 (TM10).
  - Dexter Run Downstream of Bowles Road (TM09).
  - Grass Run at McCumber Hill Road (TM08).
  - Parker Run at Parker Run Road (TM07).
  - Malloons Run at Malloons Run Road (TM06).
  - Lasher Run Downstream of Bridge on Lasher Road (TM05).
  - Little Leading Creek at Bridge on Higley Road (TM04).
  - Titus Run Downstream of Titus Run Road (TM03).
  - Paulins Hill Run Adjacent to Wells Road, Near Mouth (TM02).
  - Thomas Fork at Leading Creek Road (TM01).

Because the Leading Creek watershed only consists of one 11-digit HUC unit, the following subsections are organized by 14-digit HUC units, seven subwatersheds total, starting in the headwaters of Leading Creek and moving downstream. Those subwatersheds with more than one sampling station are organized based on sample location (from headwaters to mouth) along the Leading Creek mainstem. Information from both the state-endorsed Watershed Management Plan and AMDAT Plan are incorporated into the subsections to provide a brief review of the surrounding watershed, biological health, noted water quality issues, and physical habitat condition for each subwatershed. Tables are also presented in each subsection summarizing the available water quality data.

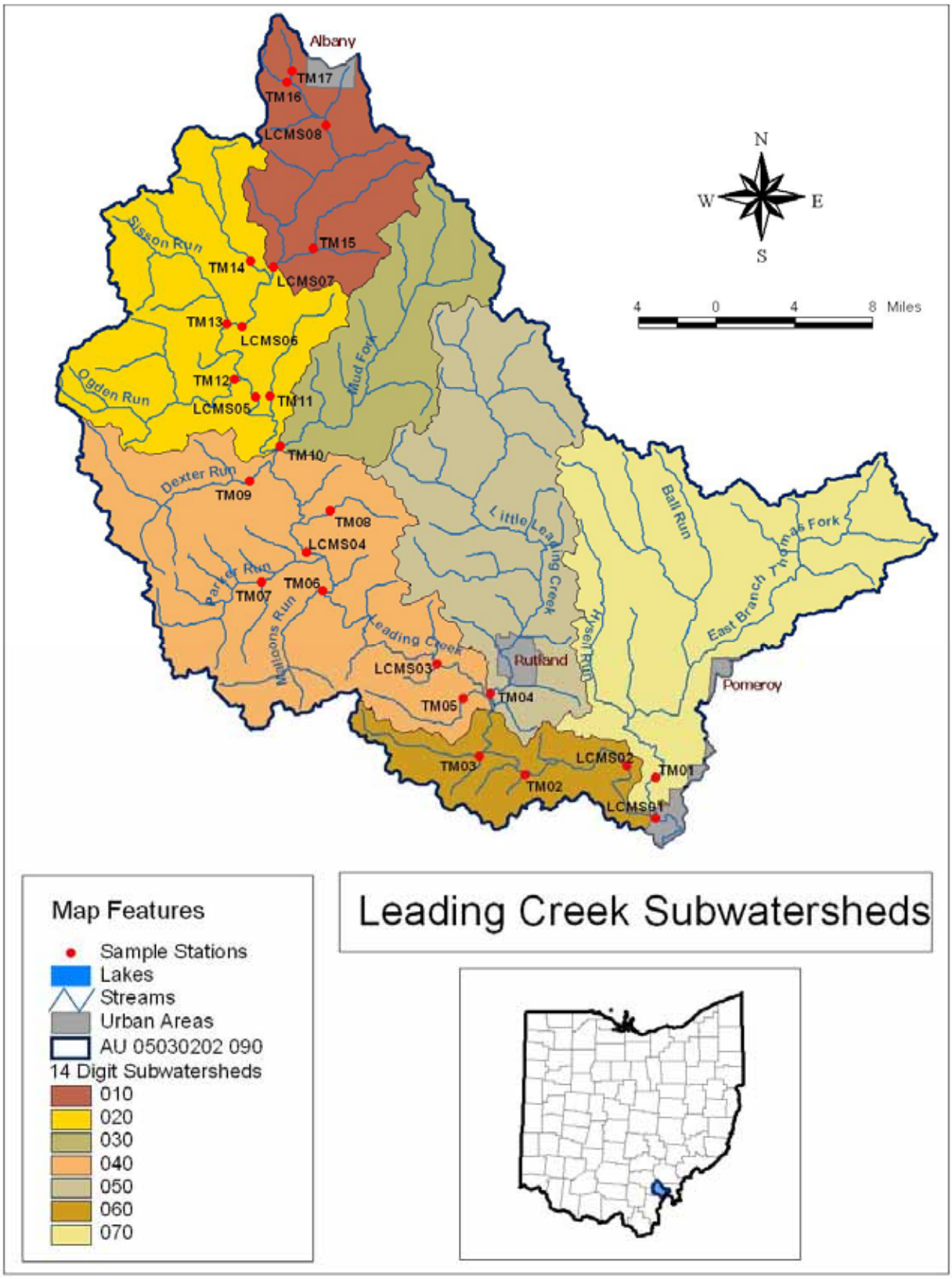


Figure 4-1. Subwatersheds within the Leading Creek Assessment Unit.

4.1.1 Subwatershed 010: Leading Creek Headwaters to Below Fivemile Run

This 13.5 square mile subwatershed is mostly forested (61 percent) with a higher proportion of pasture/hay (30 percent) than the other subwatersheds in the Leading Creek basin. Portions of Albany and the community of Carpenter are located within this subwatershed, as is a section of the Ohio University Airport. Along with a section of the Leading Creek mainstem, this subwatershed contains the East and West Headwater branches, Fivemile Run, and several other small tributaries.

Numerous fish and macroinvertebrate assessments have been performed in the Leading Creek headwaters that have found relatively diverse aquatic communities along the mainstem and in the tributaries. Fish communities met WWH criteria in two out of three samples, displaying fair to very good assemblages, and are noted as still intact in this subwatershed (Bauers, 2005 and Bauers et al., 2006). Macroinvertebrates were found to have more diverse communities in the mainstem of Leading Creek than in the tributaries in this subwatershed.

Water quality sampling has noted nitrate-nitrite and total phosphorus concentrations that exceed target values, making these two pollutants of concern in this subwatershed (see discussion in Section 5). Fivemile Run has noted cattle disturbances that may be a source of the high nitrate-nitrite, total phosphorus, and fecal coliform concentrations (Bauers, 2005). No historical mining occurred in the headwaters of Leading Creek, so there are no abandoned mine lands or related acidity/metals issues in this subwatershed (Bauers et al., 2006).

QHEI data display diverse and healthy habitat features along the Leading Creek mainstem; however, the aquatic life of the tributaries (East and West branches of the headwaters and Fivemile Run) may be limited by degraded substrates from excessive sediment and poor pool/riffle quality and depth (Bauers, 2005).

The load duration approach was applied to five sampling stations located within subwatershed 010 (Figure 4-2) for TDS, TSS, and chlorides:

- Two sites along the mainstem of Leading Creek:
  - At Carpenter Road (LCMS08).
  - At Carpenter Hill Road (LCMS07).

- Three sites near the mouth of each of the following tributaries to Leading Creek:
  - East Fork Headwaters at US Route 50 (TM17).
  - West Fork Headwaters Downstream of Columbia Road (TM16).
  - Fivemile Run at State Route 143 (TM15).

A summary of the available water quality data for the Leading Creek headwaters to below Fivemile Run is presented in Table 4-1.

Table 4-1. Summary of available water quality data for subwatershed 010.

Subwatershed/ Stream	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
East Fork - Headwaters	Headwaters - at US Route 50 (TM17)	pH	20	7.63	7.01	9.46	9/19/1996-7/27/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	20	306	117	963	4/30/1996-10/24/1997
		TSS (mg/L)	18	15	1	63	4/30/1996-7/30/2003
		Chlorides (mg/L)	15	9	2	28	4/30/1996-6/26/1997
West Fork - Headwaters	Headwaters - Downstream of Columbia Road (TM16)	pH	20	7.44	7.07	7.96	4/30/1996-10/24/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	20	320	113	863	4/30/1996-10/24/1997
		TSS (mg/L)	18	14	1	46	4/30/1996-7/30/2003
		Chlorides (mg/L)	15	11	4	20	4/30/1996-6/26/1997
Leading Creek	At Carpenter Road (LCMS08)	pH	22	7.88	7.28	8.52	4/30/1996-10/24/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	22	466	135	835	4/30/1996-10/24/1997
		TSS (mg/L)	17	15	1	112	4/30/1996-10/24/1997
		Chlorides (mg/L)	15	6	3	10	4/30/1996-6/26/1997
Fivemile Run	At State Route143 (TM15)	pH	21	7.57	6.10	8.29	4/30/1996-10/24/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	21	322	126	492	4/30/1996-10/24/1997
		TSS (mg/L)	18	42	3	229	4/30/1996-10/24/1997
		Chlorides (mg/L)	15	6	3	12	4/30/1996-6/26/1997
Leading Creek	At Carpenter Hill Road (LCMS07)	pH	25	7.68	7.07	8.27	4/30/1996-10/25/1997
		Fecal Coliform (#/100ml)	2	750	420	1,080	7/29/2003-9/30/2003
		TDS (mg/L)	25	362	17	679	4/30/1996-10/25/1997
		TSS (mg/L)	19	23	1	208	4/30/1996-10/25/1997
		Chlorides (mg/L)	18	6	3	9	4/30/1996-6/27/1997

*ND = No data available.

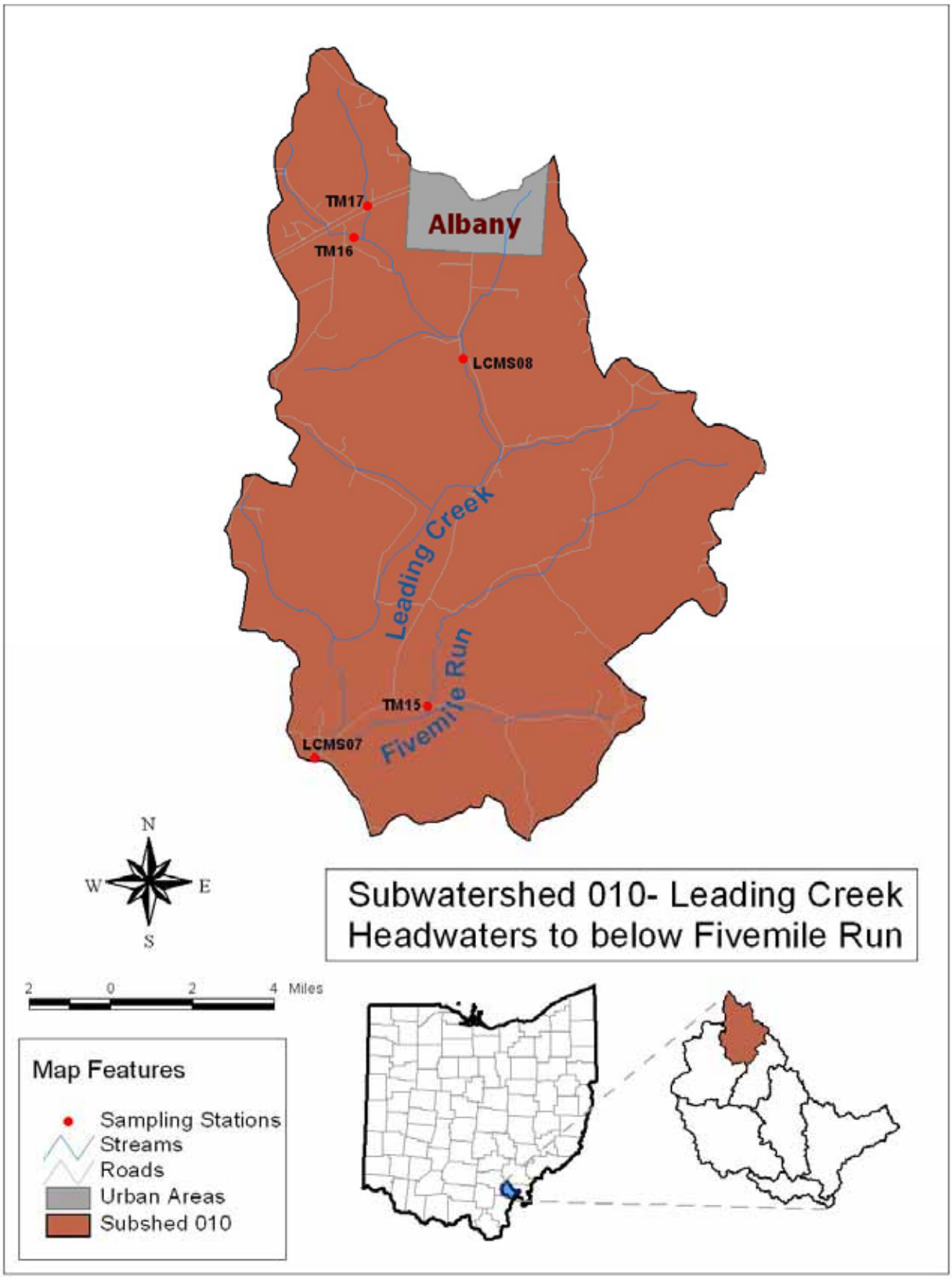


Figure 4-2. Load duration sites within subwatershed 010.

4.1.1.1 East Fork - Headwaters (TM17)

Existing and allowable loads were calculated for the East Fork Headwaters of Leading Creek at the bridge on US Route 50 west of Albany (TM17). This sampling station drains 0.61 square miles and land use/land cover upstream of this station consists primarily of pasture/hay (44%), forest (42%), and row crop (6%) land uses. A total of 20 TDS samples, 18 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM17 (Table 4-1). Water quality data for this station include samples collected by the Leading Creek Watershed Group and the Leading Creek Improvement Plan study. Most data have been collected across all flow conditions, with the exception of chlorides at low flows. There are no permitted facilities that discharge upstream of sampling station TM17.

Table 4-2 presents the TMDL summary for site TM17. None of the TDS or chlorides observations were found to exceed the loading limit. However, four of the eighteen TSS observations were found to exceed the loading limit for site TM17 (Appendix A). Two TSS observations exceeding the allowable load occurred during high flows, one during moist conditions, and one at low flows. The needed reductions for TSS range from 30 to 81 percent. There are no other reductions needed at Station TM17.

Table 4-2. Loading statistics for the East Fork headwaters of Leading Creek (TM17).

TM17 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**
TDS (kg/day)	Current Load	1,302	370	185	52	15
	TMDL= LA+WLA+MOS	**10,595**	**2,282**	**847**	**201**	**22**
	LA	10,065	2,168	805	191	21
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	530	114	42	10	1
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	226	39	5	1	1
	TMDL= LA+WLA+MOS	**133**	**29**	**11**	**3**	**0.3**
	LA	126	28	10.5	2.9	0.3
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	7	1	0.5	0.1	0.0
	TMDL Reduction (%)	**44%**	**30%**	**0%**	**0%**	**81%**
Chlorides (kg/day)	Current Load	26	11	5	3	No Data
	TMDL= LA+WLA+MOS	**609**	**131**	**49**	**12**	**1**
	LA	579	124	47	11	0.9
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	30	7	2	1	0.1
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.1.2 West Fork - Headwaters (TM16)

Existing and allowable loads were calculated for the West Fork of the Leading Creek headwaters downstream of Columbia Road (TM16). This sampling station drains 0.46 square miles and land use/land cover upstream of this station consists primarily of pasture/hay (69%), developed-open space (14%), and developed-low intensity (9%) land uses. A total of 20 TDS samples, 18 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM16 (Table 4-1). Water quality data for this station include samples collected by the Leading Creek Watershed Group and the Leading Creek Improvement Plan study. Most data have been collected across all flow conditions. There are no permitted facilities that discharge upstream of sampling station TM16.

Table 4-3 presents the TMDL summary for site TM16. No TDS or chlorides observations exceeded the loading limit at this sampling station (Appendix A) and there are no needed load reductions for these two parameters. However, four out of eighteen TSS observations (two at high flows, one at moist conditions, and one at low flows) were found to exceed loading limits at TM16, resulting in needed TSS reductions of 23 to 74 percent.

Table 4-3. Loading statistics for the West Fork headwaters of Leading Creek (TM16).

TM16 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**
TDS (kg/day)	Current Load	959	288	129	45	10
	TMDL= LA+WLA+MOS	**7,989**	**1,721**	**638**	**151**	**16**
	LA	7,590	1,635	606	143	15
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	399	86	32	8	1
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	151	27	4	1	1
	TMDL= LA+WLA+MOS	**100**	**22**	**8**	**2**	**0.2**
	LA	95	21	7.6	1.9	0.2
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	5	1	0.4	0.1	0.0
	TMDL Reduction (%)	**37%**	**23%**	**0%**	**0%**	**74%**
Chlorides (kg/day)	Current Load	26	13	5	2	No Data
	TMDL= LA+WLA+MOS	**459**	**99**	**37**	**9**	**1**
	LA	436	94	35	8.6	1
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	23	5	2	0.4	0.0
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.1.3 Leading Creek (LCMS08)

Existing and allowable loads were calculated for Leading Creek at Carpenter Road (LCMS08). This sampling station drains 3.85 square miles and land use/land cover upstream of this station consists primarily of pasture/hay (43%), forest (40%), and cultivated crops (7%). A total of 22 TDS, 17 TSS, and 15 chlorides samples were available for the load duration analysis at site LCMS08 (Table 4-1). Water quality data for this station include samples collected by the Leading Creek Improvement Plan study. Most data have been collected across all flow conditions. There are no permitted discharges upstream of this sampling station.

Table 4-4 presents the TMDL summary for site LCMS08. No TDS or chlorides observations were found to exceed loading limits at this site. A noted TSS reduction of 53 percent is needed during high flows, at which three observed loads were found to exceed loading limits.

Table 4-4. Loading statistics for Leading Creek (LCMS08).

LCMS08 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**
TDS (kg/day)	Current Load	8,110	2,940	1,780	602	117
	TMDL= LA+WLA+MOS	**66,868**	**14,401**	**5,344**	**1,268**	**136**
	LA	63,525	13,681	5,077	1,205	129
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	3,343	720	267	63	7
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	1,707	45	15	3	1
	TMDL= LA+WLA+MOS	**838**	**180**	**67**	**16**	**2**
	LA	796	171	64	15	1.9
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	42	9	3	1	0.1
	TMDL Reduction (%)	**53%**	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	165	63	28	9	No Data
	TMDL= LA+WLA+MOS	**3,843**	**828**	**307**	**73**	**8**
	LA	3,651	787	292	69	7.6
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	192	41	15	4	0.4
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.1.4 Fivemile Run (TM15)

Existing and allowable loads were calculated for Fivemile Run at State Route 143 (TM15). This sampling station drains 2.69 square miles and land use/land cover upstream of this station consists primarily of forest (67%), pasture/hay (28%) and developed-open space (4%). A total of 21 TDS samples, 18 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM15 (Table 4-1). Water quality data for this station include samples collected by the Leading Creek Improvement Plan study. All flow conditions are represented with the exception of chlorides during low flows. There are no permitted facilities that discharge upstream of sampling station TM15.

Table 4-5 presents the TMDL summary for site TM15. There are no TDS or chlorides exceedences displayed or reductions needed at this site. TSS samples displayed seven of eighteen observed loads (three at high flows, two at moist conditions, and one each at dry and low flow conditions) above loading limits resulting in needed reductions of 79 percent or greater across three flow conditions.

Table 4-5. Loading statistics for Fivemile Run (TM15).

TM15 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**
TDS (kg/day)	Current Load	5,286	1,779	919	261	53
	TMDL= LA+WLA+MOS	**46,721**	**10,062**	**3,734**	**886**	**95**
	LA	44,385	9,559	3,547	842	90
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	2,336	503	187	44	5
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	2,595	592	18	9	6
	TMDL= LA+WLA+MOS	**586**	**126**	**47**	**11**	**1**
	LA	557	120	45	10	0.9
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	29	6	2	1	0.1
	TMDL Reduction (%)	**79%**	**80%**	**0%**	**0%**	**82%**
Chlorides (kg/day)	Current Load	115	39	13	9	No Data
	TMDL= LA+WLA+MOS	**2,685**	**578**	**215**	**51**	**5**
	LA	2,551	549	204	48	4.7
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	134	29	11	3	0.3
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.1.5 Leading Creek (LCMS07)

Existing and allowable loads were calculated for Leading Creek at Carpenter Hill Road (LCMS07). This sampling station drains 13.49 square miles and land use/land cover upstream of this station consists primarily of forest (61%), pasture/hay (30%) and developed-open space (5%) land uses. A total of 25 TDS samples, 19 TSS samples, and 18 chlorides samples were available for the load duration analysis at site LCMS07 (Table 4-1). Most data have been collected across all flow conditions with the exception of chlorides sampling during low flows. There are no permitted facilities that discharge upstream of sampling station LCMS07.

Table 4-6 presents the TMDL summary for site LCMS07. Three of nineteen TSS observations were found to exceed loading limits for this station. These occurred during high flow conditions and resulted in a needed load reduction of 62 percent. All TDS and chlorides observations were within the loading limits and display no needed reductions at this site.

Table 4-6. Loading statistics for Leading Creek (LCMS07).

LCMS07 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**
TDS (kg/day)	Current Load	26,510	8,144	4,677	1,473	377
	TMDL= LA+WLA+MOS	**234,299**	**50,459**	**18,724**	**4,443**	**476**
	LA	222,584	47,936	17,788	4,221	452
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	11,715	2,523	936	222	24
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	7,375	219	69	25	2
	TMDL= LA+WLA+MOS	**2,937**	**632**	**235**	**56**	**6**
	LA	2,790	600	223	53	5.7
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	147	32	12	3	0.3
	TMDL Reduction (%)	**62%**	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	579	125	80	23	No Data
	TMDL= LA+WLA+MOS	**13,464**	**2,900**	**1,076**	**255**	**27**
	LA	12,791	2,755	1,022	242	26
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	673	145	54	13	1
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.2 Subwatershed 020: Leading Creek Below Fivemile Run to Above Mud Fork

Subwatershed 020 drains 23.8 square miles of sparsely populated land, containing only the small community of Dyesville. This section of Leading Creek has four major tributaries including Sharps Run, Sisson Run, Ogden Run, and Dyesville Run. Though mostly forested (72 percent), this subwatershed also contains over 18 percent agricultural land use (mostly pasture/hay, but also row crops).

The biological communities were found to be slightly impaired at sites within this subwatershed. Considerable variation was found between sites as fish assemblages displayed fair to very good community health. The Leading Creek mainstem displayed relatively good macroinvertebrate communities in three of seven surveys. Macroinvertebrate diversity was moderate with a fair percentage of sensitive taxa at all sites (Bauers, 2005).

Water quality sampling in this subwatershed has noted nitrate-nitrite and total phosphorus concentrations that exceed target values, but widespread impacts do not exist (see discussion in Section 5). Fecal coliform samples have also been found to exceed water quality standards in this subwatershed, and are noted as a possible problem. There are no abandoned mine lands in the subwatershed, so no related acidity/metals issues are noted (Bauers et al., 2006).

QHEI data display relatively healthy habitat features along the Leading Creek mainstem in this subwatershed. However, some sites displayed poor riparian vegetation width and quality, and riffle/run quality was noted as an area of concern for all sites in this subwatershed (Bauers, 2005).

The load duration approach was applied to six sampling stations located within subwatershed 020 (Figure 4-3) for TDS, TSS, and chlorides:

- Two sites along the mainstem of Leading Creek:
  - At Staneart Road (LCMS06).
  - At Folden Road (LCMS05).

- Four sites near the mouth of each of the following tributaries to Leading Creek:
  - Sharps Run at State Route 143 (TM14).
  - Sisson Run Adjacent to Sisson Run Road, Near Mouth (TM13).
  - Ogden Run Adjacent to Ogden Run Road (TM12).
  - Dyesville Run at Harmon Road (TM11).

A summary of the available water quality data for subwatershed 020 can be found in Table 4-7.

Table 4-7. Summary of available water quality data for subwatershed 020.

Subwatershed/ Stream	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
Sharps Run	At State Route143 (TM14)	pH	21	7.50	6.53	7.90	4/30/1996-10/24/1997
		Fecal Coliform (#/100ml)	1	150	150	150	9/30/2003
		TDS (mg/L)	21	223	111	289	4/30/1996-10/24/1997
		TSS (mg/L)	19	55	1	776	4/30/1996-7/30/2003
		Chlorides (mg/L)	15	7	4	11	4/30/1996-6/26/1997
Leading Creek	At Staneart Road (LCMS06)	pH	22	7.62	6.40	8.31	4/30/1996-10/24/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	22	316	133	496	4/30/1996-10/24/1997
		TSS (mg/L)	19	109	1	1,183	4/30/1996-10/24/1997
		Chlorides (mg/L)	15	6	2	11	4/30/1996-6/26/1997
Sisson Run	Adjacent to Sisson Run Road, Near Mouth (TM13)	pH	19	7.54	6.54	8.04	4/30/1996-10/24/1997
		Fecal Coliform (#/100ml)	2	1,305	510	2,100	7/29/2003-9/30/2003
		TDS (mg/L)	19	200	105	281	4/30/1996-10/24/1997
		TSS (mg/L)	19	75	1	1,128	4/30/1996-7/30/2003
		Chlorides (mg/L)	15	5	3	8	4/30/1996-6/26/1997
Ogden Run	Adjacent to Ogden Road, Near Mouth (TM12)	pH	21	7.61	7.28	8.02	4/30/1996-10/24/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	21	913	137	3,457	4/30/1996-10/24/1997
		TSS (mg/L)	18	28	1	162	4/30/1996-7/30/2003
		Chlorides (mg/L)	15	27	4	103	4/30/1996-6/26/1997
Leading Creek	At Folden Road (LCMS05)	pH	22	7.52	6.55	8.22	4/30/1996-10/25/1997
		Fecal Coliform (#/100ml)	2	1,025	350	1,700	7/29/2003-9/30/2003

Subwatershed/ Stream	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
		TDS (mg/L)	22	383	141	765	4/30/1996-10/25/1997
		TSS (mg/L)	18	40	1	206	4/30/1996-10/25/1997
		Chlorides (mg/L)	15	12	5	32	4/30/1996-6/26/1997
Dyesville Run	At Harmon Road (TM11)	pH	16	7.49	7.12	8.05	4/30/1996-6/26/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	16	228	84	321	4/30/1996-6/26/1997
		TSS (mg/L)	15	22	1	136	4/30/1996-6/26/1997
		Chlorides (mg/L)	15	3	1	9	4/30/1996-6/26/1997

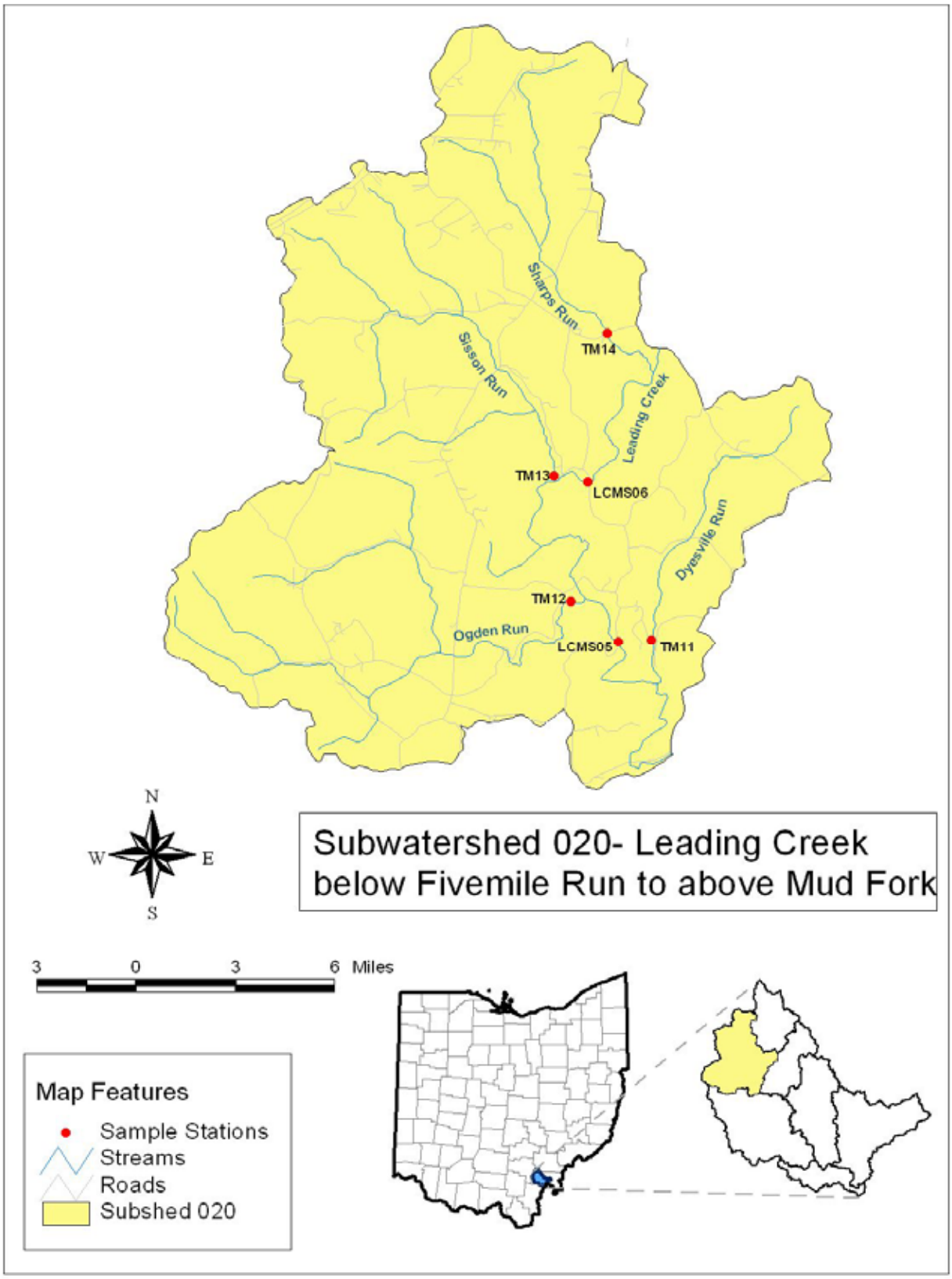


Figure 4-3. Load duration sites within subwatershed 020.

4.1.2.1 Sharps Run (TM14)

Existing and allowable loads were calculated for Sharps Run at State Route 143 (TM14). This sampling station drains 3.69 square miles and land use/land cover upstream of this station consists primarily of forest (49%), pasture/hay (43%), and developed-open space (6%). A total of 21 TDS samples, 19 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM14 (Table 4-7). Water quality data for this station include samples collected by the Leading Creek Watershed Group and the Leading Creek Improvement Plan study. Most data have been collected from high to low flow conditions. There are no permitted facilities that discharge upstream of sampling station TM14.

Table 4-8 presents the TMDL summary for site TM14. All observed loads for TDS and chlorides are below loading limits at this site (Appendix A) and no load reductions are needed for either parameter. TSS displayed needed reductions of 70 and 75 percent at high (two load exceedences) and moist flow conditions (one load exceedence), respectively.

Table 4-8. Loading statistics for Sharps Run (TM14).

TM14 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**
TDS (kg/day)	Current Load	6,417	2,050	948	257	42
	TMDL= LA+WLA+MOS	**64,089**	**13,802**	**5,122**	**1,215**	**130**
	LA	60,885	13,112	4,866	1,154	123
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	3,204	690	256	61	7
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	2,524	666	6	3	1
	TMDL= LA+WLA+MOS	**803**	**173**	**64**	**15**	**2**
	LA	763	164	61	14	1.9
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	40	9	3	1	0.1
	TMDL Reduction (%)	**70%**	**75%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	264	93	24	9	No Data
	TMDL= LA+WLA+MOS	**3,683**	**793**	**294**	**70**	**7**
	LA	3,499	753	279	67	6.6
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	184	40	15	3	0.4
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.2.2 Leading Creek (LCMS06)

Existing and allowable loads were calculated for Leading Creek at Staneart Road (LCMS06). This sampling station drains 18.75 square miles and land use/land cover upstream of this station consists primarily of forest (59%), pasture/hay (32%), and developed-open space (5%). A total of 22 TDS samples, 19 TSS samples, and 15 chlorides samples were available for the load duration analysis at site LCMS06 (Table 4-7). Water quality data for this station include samples collected by the Leading Creek Improvement Plan study. Most data have been collected during high to low flow conditions. There are no permitted facilities that discharge upstream of sampling station LCMS06.

Table 4-9 presents the TMDL summary for site LCMS06. No TDS or chlorides observations exceeded the loading limit at this sampling station (Appendix A) and there are no needed TMDL reductions for either parameter. However, seven of nineteen TSS observations (five at high flows and two at dry flow conditions) were found to exceed loading limits and a reduction of 91 percent is needed during high flows.

Table 4-9. Loading statistics for Leading Creek (LCMS06).

LCMS06 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**
TDS (kg/day)	Current Load	38,968	9,876	6,085	1,895	338
	TMDL= LA+WLA+MOS	**325,656**	**70,133**	**26,024**	**6,175**	**662**
	LA	309,373	66,626	24,723	5,866	629
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	16,283	3,507	1,301	309	33
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	41,604	348	115	39	4
	TMDL= LA+WLA+MOS	**4,082**	**879**	**326**	**77**	**8**
	LA	3,878	835	310	73	7.6
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	204	44	16	4	0.4
	TMDL Reduction (%)	**91%**	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	1,073	261	82	47	No Data
	TMDL= LA+WLA+MOS	**18,714**	**4,030**	**1,496**	**355**	**38**
	LA	17,778	3,828	1,421	337	36
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	936	202	75	18	2
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.2.3 Sisson Run (TM13)

Existing and allowable loads were calculated for Sisson Run adjacent to Sisson Run Road, near the mouth (TM13). This sampling station drains 5.60 square miles and land use/land cover upstream of this station consists primarily of forest (68%), pasture/hay (25%), and developed-open space (5%). A total of 19 TDS, 19 TSS, and 15 chlorides samples were available for the load duration analysis at site TM13 (Table 4-7). Water quality data for this station include samples collected by the Leading Creek Watershed Group and the Leading Creek Improvement Plan study. Data for this site have been collected during high to low flow conditions with the exception of chlorides at low flows. There are no permitted discharges upstream of this sampling station.

Table 4-10 presents the TMDL summary for site TM13. Five of nineteen TSS observed loads (two at high flows and one each at moist, mid and dry flow conditions) were above the allowable load at TM13. Load reductions of 63 percent are noted at high flows and 76 percent at moist flow conditions. No TDS or chlorides observations were found to exceed loading limits at this site resulting in no needed TMDL reductions.

Table 4-10. Loading statistics for Sisson Run (TM13).

TM13 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**
TDS (kg/day)	Current Load	9,184	2,954	1,270	366	44
	TMDL= LA+WLA+MOS	**97,263**	**20,946**	**7,773**	**1,844**	**198**
	LA	92,400	19,899	7,384	1,752	188
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	4,863	1,047	389	92	10
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	3,118	1,052	29	7	0
	TMDL= LA+WLA+MOS	**1,219**	**263**	**97**	**23**	**2**
	LA	1,158	250	92	22	1.9
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	61	13	5	1	0.1
	TMDL Reduction (%)	**63%**	**76%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	322	119	26	9	No Data
	TMDL= LA+WLA+MOS	**5,589**	**1,204**	**447**	**106**	**11**
	LA	5,310	1,144	425	101	10
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	279	60	22	5	1
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.2.4 Ogden Run (TM12)

Existing and allowable loads were calculated for Ogden Run adjacent to Ogden Road, near the mouth (TM12). This sampling station drains 7.36 square miles and land use/land cover upstream of this station consists primarily of forest (63%), pasture/hay (25%), developed-open space (5%), and cultivated crops (4%). The Ogden Run subwatershed also contains about 27 acres of barren land (rock/sand/clay). Long wall mining has caused land subsidence in this subwatershed that has resulted in increased sediment loads and water loss in portions of Ogden Run. A total of 21 TDS samples, 18 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM12 (Table 4-7). Water quality data for this station include samples collected by the Leading Creek Watershed Group and the Leading Creek Improvement Plan study. Most data have been collected during high to low flow conditions.

There is one permitted facility located in the headwaters of Ogden Run, the Southern Ohio Coal Company Meigs #2 Mine, which is upstream of TM12. This mine is closed and will likely have its NPDES permit revoked in the near future as only storm water is currently discharged. A new permit is still in draft for the Meigs #2 Mine bathhouse.

Table 4-11 presents the TMDL summary for site TM12. There are several observed loads that are exceeding the loading limits for this station (Appendix A). One of fifteen observed chlorides loads exceeded load limits at mid-range flows, but did not result in any needed reductions. Four of twenty-one observed TDS loads (two each at dry and low flow conditions) were above allowable loads and a needed TDS reduction of 74 percent during low flows was noted at TM12. Six of eighteen TSS loads were found to exceed loading limits and occurred across all flow conditions. Needed TSS load reductions were noted at high and moist flow conditions at 74 and 80 percent, respectively.

Table 4-11. Loading statistics for Ogden Run (TM12).

TM12 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**
TDS (kg/day)	Current Load	18,106	4,673	2,984	1,504	954
	TMDL= LA+WLA+MOS	**127,831**	**27,530**	**10,215**	**2,424**	**260**
	LA	121,439	26,154	9,704	2,303	247
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	6,392	1,376	511	121	13
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	**74%**
TSS (kg/day)	Current Load	5,863	1,631	35	17	2
	TMDL= LA+WLA+MOS	**1,602**	**345**	**128**	**30**	**3**
	LA	1,522	328	122	28	2.8
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	80	17	6	2	0.2
	TMDL Reduction (%)	**74%**	**80%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	805	136	133	63	No Data
	TMDL= LA+WLA+MOS	**7,346**	**1,582**	**587**	**139**	**15**
	LA	6,979	1,503	558	132	14
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	367	79	29	7	1
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.2.5 Leading Creek (LCMS05)

Existing and allowable loads were calculated for Leading Creek at Folden Road (LCMS05). This sampling station drains 33.44 square miles and land use/land cover upstream of this station consists primarily of forest (61%), pasture/hay (30%) and developed-open space (5%) land uses. A total of 22 TDS samples, 18 TSS samples, and 15 chlorides samples were available for the load duration analysis at site LCMS05 (Table 4-7). Most data have been collected across all flow conditions with the exception of chlorides sampling during low flows. There are no permitted facilities that discharge upstream of sampling station LCMS05.

Table 4-12 presents the TMDL summary for site LCMS05. There were no observed TDS or chlorides loads above the loading limits for this station. TSS displayed five of eighteen observed loads that were exceeding loading limits, four of which were during high flow conditions and one during dry conditions. The only needed TMDL load reduction for LCMS05 is a 64 percent reduction for TSS at high flows.

Table 4-12. Loading statistics for Leading Creek (LCMS05).

LCMS05 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**
TDS (kg/day)	Current Load	73,753	16,818	11,634	3,349	866
	TMDL= LA+WLA+MOS	**580,797**	**125,080**	**46,413**	**11,013**	**1,180**
	LA	551,757	118,826	44,092	10,462	1,121
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	29,040	6,254	2,321	551	59
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	37,656	776	85	123	12
	TMDL= LA+WLA+MOS	**14,249**	**3,069**	**1,139**	**270**	**29**
	LA	13,537	2,916	1,082	256	28
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	712	153	57	14	1
	TMDL Reduction (%)	**64%**	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	2,612	466	399	134	No Data
	TMDL= LA+WLA+MOS	**21,296**	**4,586**	**1,702**	**404**	**43**
	LA	20,231	4,357	1,617	384	41
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	1,065	229	85	20	2
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.2.6 Dyesville Run (TM11)

Existing and allowable loads were calculated for Dyesville Run at Carpenter Harmon Road (TM11). This sampling station drains 2.46 square miles and land use/land cover upstream of this station consists primarily of forest (79%), pasture/hay (11%) and developed-open space (6%) land uses. A total of 16 TDS samples, 15 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM11 (Table 4-7). Samples have been collected from high to dry flow conditions at this site. There are no permitted facilities that discharge upstream of sampling station TM11.

Table 4-13 presents the TMDL summary for site TM11. Five of fifteen TSS observations were found to exceed loading limits for this station across all conditions, with the exception of low flows. The only needed load reductions for this site include a 12 percent reduction for TSS at high flows and a 50 percent reduction of TSS during moist conditions. All TDS and chlorides observations were within the loading limits and have no needed reductions noted at this site.

Table 4-13. Loading statistics for Dyesville Run (TM11).

TM11 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**
TDS (kg/day)	Current Load	4,313	1,252	772	172	No Data
	TMDL= LA+WLA+MOS	**42,726**	**9,201**	**3,414**	**810**	**87**
	LA	40,590	8,741	3,243	769	83
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	2,136	460	171	41	4
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	No Data
TSS (kg/day)	Current Load	576	218	19	8	No Data
	TMDL= LA+WLA+MOS	**536**	**115**	**43**	**10**	**1**
	LA	509	109	41	9	0.9
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	27	6	2	1	0.1
	TMDL Reduction (%)	**12%**	**50%**	**0%**	**0%**	No Data
Chlorides (kg/day)	Current Load	70	27	6	2	No Data
	TMDL= LA+WLA+MOS	**2,455**	**529**	**196**	**47**	**5**
	LA	2,332	503	186	45	4.7
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	123	26	10	2	0.3
	TMDL Reduction (%)	**0%**	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.3 Subwatershed 030: Mud Fork

Subwatershed 030 drains 13.2 square miles of land and contains no communities or incorporated towns. This subwatershed consists of one main tributary, Mud Fork, which flows from the northeast to the southwest where it meets Leading Creek. Mud Fork is the first subwatershed, moving from the headwaters to the mouth of Leading Creek, that has noted mining impacts (Bauers et al., 2006). The headwaters of Mud Fork were strip mined in the 1950s and 1960s and despite reclamation efforts, severe erosion has resulted in significant sedimentation issues in this subwatershed. Compounding the excessive sediment issues and further limiting aquatic life are upland erosion from agricultural practices, stream channel erosion, and natural causes from exposed sandstone bedrock (Bauers, 2005).

Only macroinvertebrate sampling has been performed recently in Mud Fork and the results varied between two sampling sites. Generally, the macroinvertebrates display limited community diversity and low percentage of sensitive taxa in the subwatershed (Bauers, 2005). Historic fish sampling indicates that community health declined with increased mining activities in the mid-1900s, but there has been some recovery despite the residual sediment issues (Bauers et al., 2006).

There are no significant or widespread water quality issues noted in Mud Fork or its tributaries, but excessive sediment loads in this subwatershed (several feet of sand inundate stream substrates) are a noted high magnitude source of impairment. These habitat issues are reflected in the QHEI scores obtained in Mud Fork. Substrate, pool, and riffle metric scores display a severely homogenized habitat from excessive sediment inundating the stream beds (Bauers, 2005).

The load duration approach was applied to one sampling station located within subwatershed 030 (Figure 4-4) for TDS, TSS, and chlorides near the mouth of Mud Fork at the bridge on County Road 10 (TM10). A summary of the available water quality data for subwatershed 030 is presented in Table 4-14.

Table 4-14. Summary of available water quality data for subwatershed 030.

Subwatershed/ Stream	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
Mud Fork	At Bridge on County Road 10 (TM10)	pH	20	7.69	7.21	8.04	4/29/1996-10/24/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	21	377	159	1,063	4/29/1996-10/24/1997
		TSS (mg/L)	17	19	1	95	4/29/1996-10/24/1997
		Chlorides (mg/L)	15	4	2	7	4/29/1996-6/25/1997

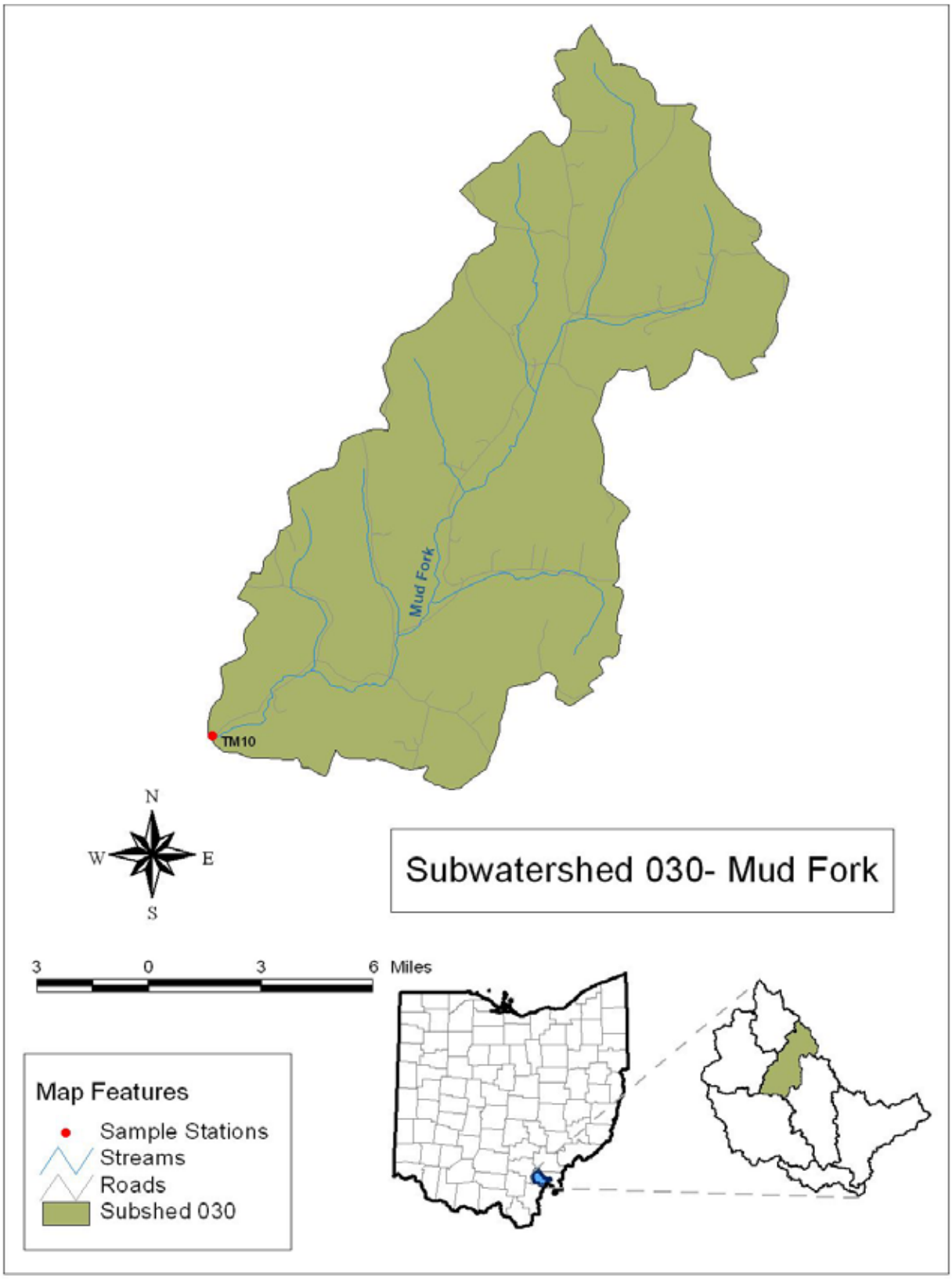


Figure 4-4. Load duration sites within subwatershed 030.

4.1.3.1 Mud Fork (TM10)

Existing and allowable loads were calculated for Mud Fork at the bridge on County Road 10 (TM10). This sampling station drains 13.28 square miles and land use/land cover upstream of this station consists primarily of forest (69%), pasture/hay (21%), developed-open space (4%), and cultivated crops (4%). A total of 21 TDS samples, 17 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM10 (Table 4-14). Water quality data for this station include samples collected during the Leading Creek Improvement Plan study. Most data have been collected from moist to low flow conditions. There are no permitted facilities that discharge upstream of sampling station TM10.

Table 4-15 presents the TMDL summary for site TM10. None of the TDS or chlorides observations were found to exceed the loading limit. However, seven of the seventeen TSS observations were found to exceed the loading limit for site TM10 (Appendix A). These TSS observations occurred during moist flow conditions (3), dry conditions (3), and low flows (1), resulting in a needed reduction of 23 percent during dry conditions and 59 percent during low flows. No other load reductions were identified as being needed at Station TM10.

Table 4-15. Loading statistics for Mud Fork (TM10).

TM10 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**
TDS (kg/day)	Current Load	No Data	9,239	4,645	1,673	210
	TMDL= LA+WLA+MOS	**230,651**	**49,673**	**18,432**	**4,374**	**469**
	LA	219,118	47,189	17,510	4,155	446
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	11,533	2,484	922	219	23
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	No Data	344	77	68	14
	TMDL= LA+WLA+MOS	**2,891**	**623**	**231**	**55**	**6**
	LA	2,746	592	219	52	5.7
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	145	31	12	3	0.3
	TMDL Reduction (%)	No Data	**0%**	**0%**	**23%**	**59%**
Chlorides (kg/day)	Current Load	No Data	125	54	22	No Data
	TMDL= LA+WLA+MOS	**13,255**	**2,855**	**1,059**	**251**	**27**
	LA	12,592	2,712	1,006	238	26
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	663	143	53	13	1
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.4 Subwatershed 040: Leading Creek Below Mud Fork to Above Little Leading Creek

Subwatershed 040 drains 33.9 square miles of mostly forested land (73 percent) and contains the small communities of Dexter and Langsville. This section of Leading Creek has five major tributaries including Dexter Run, Grass Run, Parker Run, Malloons Run, and Lasher Run. The Meigs #31 Mine discharges into an unnamed tributary to Parker Run (RM 2.1) increasing the flow in Parker Run by 10 times its natural level (Latimer, 1999). Additional mining has occurred (prior to reclamation laws) in Grass Run and Lasher Run, but initial screenings in these watersheds indicate little or no AMD impacts (Bauers, 2005).

After "recovering" from the catastrophic 1993 Meigs #31 Mine discharge, biological surveys showed that this subwatershed supports relatively healthy fish and macroinvertebrate communities. Sites in Grass Run, Malloons Run, and the Parker Run headwaters display high quality aquatic biology and may be considered for reference sites in the Leading Creek watershed. However, low fish biomass and ICI scores were often noted and assemblages in Parker Run (downstream of Meigs #31 Mine) only attained WWH in one of five surveys.

Water quality sampling in this subwatershed has noted nitrate-nitrite concentrations that exceed target values in Parker Run and also in some locations on the Leading Creek mainstem, but widespread impacts do not exist (see discussion in Section 5). Two ODNR underdrain projects were installed to drain water from strip mines in Grass Run in 1988, but they do not seem to be impairing water quality in this tributary. The Meigs #31 Mine discharge continues to treat and discharge water from the slurry impoundment; however, TDS concentrations are exceeding effluent limits in Parker Run (Bauers et al., 2006).

The QHEI data for this subwatershed display some of the highest quality habitat conditions in the entire Leading Creek watershed (Grass Run, Malloons Run, Parker Run, and sites on the Leading Creek mainstem) with coarse substrates and healthy, meandering pool-riffle sequences. Conversely, Lasher Run displays some of the poorest habitat conditions as it is impaired with excessive sediment loads causing a frequently shifting streambed (Bauers, 2005).

The load duration approach was applied to seven sampling stations located within subwatershed 040 (Figure 4-5) for TDS, TSS, and chlorides:

- Two sites along the mainstem of Leading Creek:
  - At Parker Run Road Bridge (LCMS04).
  - At Parkinson Road Bridge (LCMS03).

- Five sites near the mouth of each of the following tributaries to Leading Creek:
  - Dexter Run Downstream of Bowles Road (TM09).
  - Grass Run at McCumber Hill Road (TM08).
  - Parker Run at Parker Run Road (TM07).
  - Malloons Run at Malloons Run Road (TM06).
  - Lasher Run Downstream of Bridge on Lasher Road (TM05).

A summary of the available water quality data for subwatershed 040 is presented in Table 4-16.

Table 4-16. Summary of available water quality data for subwatershed 040.

Subwatershed/ Stream	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
Dexter Run	Downstream of Bowles Road (TM09)	pH	21	7.59	7.09	8.02	4/29/1996-10/24/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	21	255	114	661	4/29/1996-10/24/1997
		TSS (mg/L)	19	16	1	131	4/29/1996-7/30/2003
		Chlorides (mg/L)	15	5	2	7	4/29/1996-6/25/1997
Grass Run	At McCumber Hill Road (TM08)	pH	21	7.72	7.30	8.30	4/29/1996-10/24/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	21	389	181	601	4/29/1996-10/24/1997
		TSS (mg/L)	19	5	1	22	4/29/1996-7/30/2003
		Chlorides (mg/L)	15	4	2	7	4/29/1996-6/25/1997
Leading Creek	At Parker Run Road Bridge (LCMS04)	pH	22	7.62	7.05	8.12	4/29/1996-8/19/2003
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	21	372	158	665	4/29/1996-8/19/2003
		TSS (mg/L)	19	28	1	241	4/29/1996-10/25/1997
		Chlorides (mg/L)	16	9	4	13	4/29/1996-6/27/1997
Parker Run	At Parker Run Road (TM07)	pH	21	8.10	7.52	8.41	4/29/1996-10/24/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	21	4,361	787	5,612	4/29/1996-10/24/1997
		TSS (mg/L)	19	11	1	44	4/29/1996-10/24/1997
		Chlorides (mg/L)	15	349	74	456	4/29/1996-6/25/1997
Malloons Run	At Malloons Run Road (TM06)	pH	21	7.61	6.90	8.10	4/29/1996-10/24/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND

Subwatershed/ Stream	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
		TDS (mg/L)	21	285	155	394	4/29/1996-10/24/1997
		TSS (mg/L)	19	17	1	118	4/29/1996-7/30/2003
		Chlorides (mg/L)	15	9	4	16	4/29/1996-6/25/1997
Leading Creek	At Parkinson Road Bridge (LCMS03)	pH	24	7.61	7.13	8.06	4/29/1996-8/19/2003
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	24	1,848	180	5,204	4/29/1996-8/19/2003
		TSS (mg/L)	19	43	1	394	4/29/1996-10/24/1997
		Chlorides (mg/L)	15	127	6	504	4/29/1996-6/25/1997
Lasher Run	Downstream of Bridge on Lasher Road (TM05)	pH	22	7.36	6.88	7.61	4/29/1996-8/19/2003
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	22	462	201	733	4/29/1996-8/19/2003
		TSS (mg/L)	21	26	1	164	4/29/1996-8/19/2003
		Chlorides (mg/L)	15	31	6	100	4/29/1996-6/25/1997

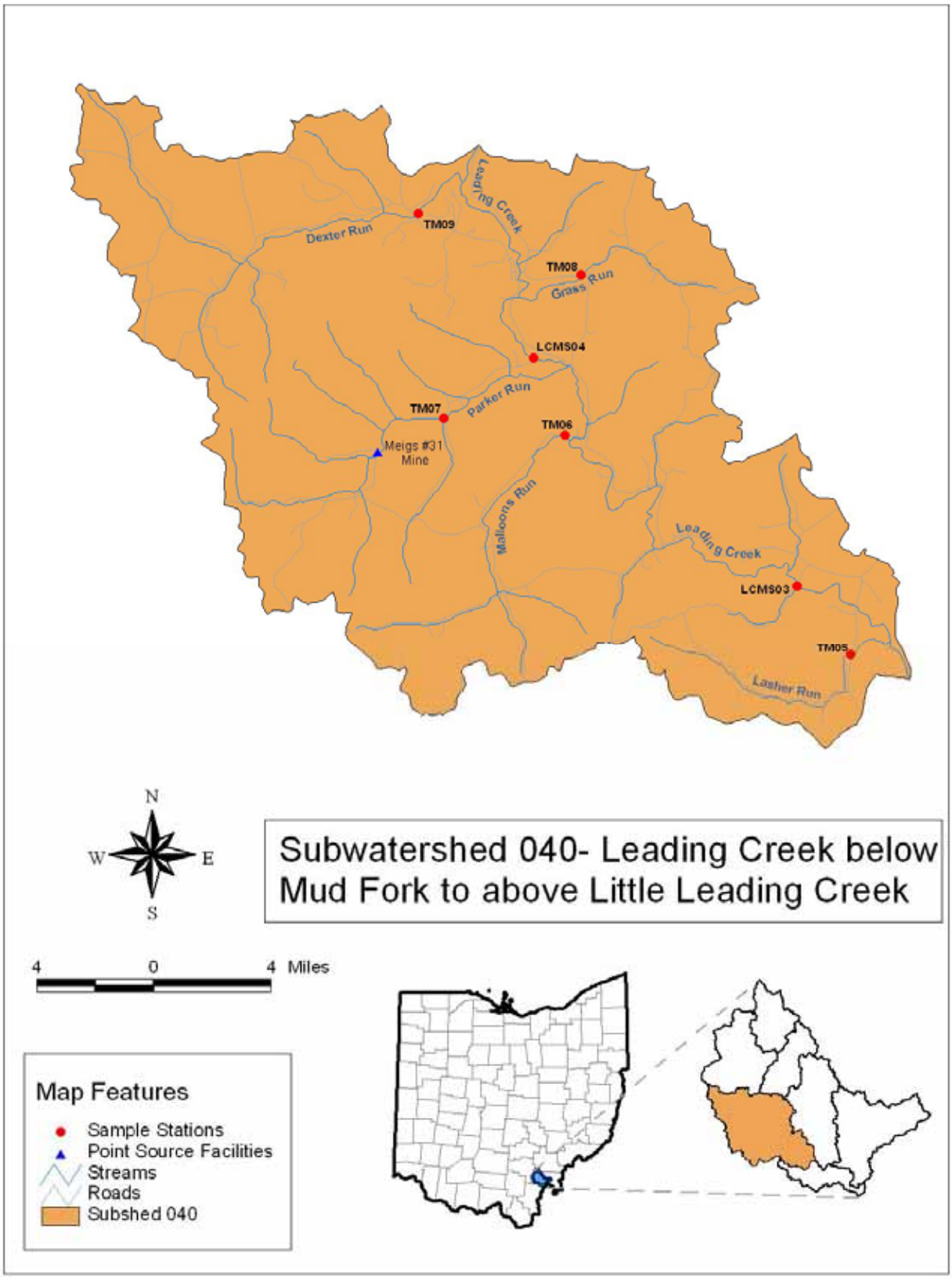


Figure 4-5. Load duration sites within subwatershed 040.

4.1.4.1 Dexter Run (TM09)

Existing and allowable loads were calculated for Dexter Run downstream of Bowles Road (TM09). This sampling station drains 7.35 square miles and land use/land cover upstream of this station consists primarily of forest (69%), pasture/hay (21%), developed-open space (4%), and cultivated crops (4%). A total of 21 TDS samples, 19 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM09 (Table 4-16). Water quality data for this station include samples collected by the Leading Creek Watershed Group and also during the Leading Creek Improvement Plan study. Most data have been collected from moist to low flow conditions. There are no permitted facilities that discharge upstream of sampling station TM09.

Table 4-17 presents the TMDL summary for site TM09. None of the TDS or chlorides observations were found to exceed the loading limit. Three of the nineteen TSS observations were found to exceed the loading limit for site TM09 (Appendix A), once during mid-range and twice during dry flow conditions. Despite these individual exceedences, median current loads remain below the allowable loading limit and no reductions were identified as being needed at station TM09.

Table 4-17. Loading statistics for Dexter Run (TM09).

TM09 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**
TDS (kg/day)	Current Load	No Data	3,376	1,402	526	142
	TMDL= LA+WLA+MOS	**127,657**	**27,492**	**10,202**	**2,421**	**259**
	LA	121,274	26,118	9,691	2,300	246
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	6,383	1,375	510	121	13
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	No Data	92	39	19	3
	TMDL= LA+WLA+MOS	**1,600**	**345**	**128**	**30**	**3**
	LA	1,520	327	121	29	2.8
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	80	17	6	2	0.2
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	No Data	74	31	15	No Data
	TMDL= LA+WLA+MOS	**7,336**	**1,580**	**586**	**139**	**15**
	LA	6,969	1,501	557	132	14
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	367	79	29	7	1
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.4.2 Grass Run (TM08)

Existing and allowable loads were calculated for Grass Run at McCumber Hill Road (TM08). This sampling station drains 1.84 square miles and land use/land cover upstream of this station consists primarily of forest (82%), pasture/hay (10%), developed-open space (5%), and cultivated crops (2%). A total of 21 TDS samples, 19 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM08 (Table 4-16). Water quality data for this station include samples collected during the Leading Creek Improvement Plan study and also by the Leading Creek Watershed Group. Most data have been collected from moist to low flow conditions. There are no permitted facilities that discharge upstream of sampling station TM08.

Table 4-18 presents the TMDL summary for site TM08. None of the TDS or chlorides observations were found to exceed the loading limit. However, one of the nineteen TSS observations was found to exceed the loading limit for site TM08 (Appendix A) during dry flow conditions. This exceeding TSS load did not result in a needed reduction, and there are no other reductions noted at Station TM08.

Table 4-18. Loading statistics for Grass Run (TM08).

TM08 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**
TDS (kg/day)	Current Load	No Data	1,351	582	179	32
	TMDL= LA+WLA+MOS	**31,958**	**6,882**	**2,554**	**606**	**65**
	LA	30,360	6,538	2,426	576	62
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	1,598	344	128	30	3
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	No Data	16	4	2	0
	TMDL= LA+WLA+MOS	**401**	**86**	**32**	**8**	**1**
	LA	381	82	30	7.6	1
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	20	4	2	0.4	0.0
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	No Data	13	8	4	No Data
	TMDL= LA+WLA+MOS	**1,837**	**396**	**147**	**35**	**4**
	LA	1,745	376	140	33	3.8
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	92	20	7	2	0.2
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.4.3 Leading Creek (LMCS04)

Existing and allowable loads were calculated for Leading Creek at the Parker Run Road bridge (LCMS04). This sampling station drains 62.89 square miles and land use/land cover upstream of this station consists primarily of forest (66%), pasture/hay (25%), developed-open space (5%), and cultivated crops (2%). A total of 21 TDS samples, 19 TSS samples, and 16 chlorides samples were available for the load duration analysis at site LCMS04 (Table 4-16). Water quality data for this station include samples collected by the Leading Creek Watershed Group and samples collected during the Leading Creek Improvement Plan study. Most data have been collected from moist to dry flow conditions. There are no permitted facilities that discharge upstream of sampling station LCMS04.

Table 4-19 presents the TMDL summary for site LCMS04. None of the chlorides or TDS observations were found to exceed the loading limit (Appendix A). TSS displayed loads above the loading limits with two out of nineteen TSS samples. Both occurred during high flows resulting in a needed load reduction of 74 percent. There are no other reductions noted at Station LCMS04.

Table 4-19. Loading statistics for Leading Creek (LCMS04).

LCMS04 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**
TDS (kg/day)*	Current Load	No Data	50,112	18,497	5,954	1,518
	TMDL= LA+WLA+MOS	**1,092,294**	**235,236**	**87,289**	**20,713**	**2,219**
	LA	1,037,679	223,474	82,925	19,677	2,108
	WLA: facility	n/a**	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	54,615	11,762	4,364	1,036	111
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	96,685	1,781	723	273	19
	TMDL= LA+WLA+MOS	**26,798**	**5,771**	**2,141**	**508**	**54**
	LA	25,458	5,482	2,034	483	51
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	1,340	289	107	25	3
	TMDL Reduction (%)	**74%**	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	No Data	1,038	565	213	No Data
	TMDL= LA+WLA+MOS	**40,051**	**8,625**	**3,201**	**759**	**81**
	LA	38,048	8,194	3,041	721	77
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	2,003	431	160	38	4
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	No Data

*A TDS value determined to be an extreme outlier was identified using statistical analysis at site LCMS04 and was removed from analysis. ** "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.4.4 Parker Run (TM07)

Existing and allowable loads were calculated for Parker Run at Parker Run Road (TM07). This sampling station drains 13.28 square miles and land use/land cover upstream of this station consists primarily of forest (57%), pasture/hay (18%), open water (9%), and barren land (rock/sand/clay) (4%). A total of 21 TDS samples, 19 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM07 (Table 4-16). Water quality data for this station include samples collected during the Leading Creek Improvement Plan study. Most data have been collected during moist to dry flow conditions.

The Southern Ohio Coal Company's Meigs #31 Mine discharges upstream of TM07 and contributes a large portion of the flow in Parker Run (Latimer, 1999). This discharge is continuous and rainfall has an influence on the volume of effluent discharged from the site. The Meigs #31 Mine is limited to discharging 7.5 million gallons per day (MGD), but the operation rarely discharges at that level. Monthly Operating Reports (MORs) from the past 12 years indicate that the Meigs #31 Mine has an average discharge of 2.22 MGD. Improvements will soon be made at the facility to better treat acidity; however, a significant TDS issue is likely to remain with this discharge. WLAs for TDS and TSS were calculated based on the 7.5 MGD design flow and median effluent concentration values derived from the facility MORs (Table 4-20). Chlorides are not sampled at this facility, so a WLA for this parameter was not able to be calculated. Future chlorides sampling at the Meigs #31 Mine is recommended to evaluate the discharge's impacts on water quality in Parker Run and Leading Creek.

Table 4-20. NPDES WLAs for the Meigs #31 Mine

Parameter	Design Flow (MGD)	Effluent Concentration (mg/L) Used to Develop WLA	Parameter Load (kg/day)
TDS	7.5	1,500*	42,581
TSS	7.5	5	142
Chlorides	7.5	Unknown	Unknown

*1,500 mg/L is the water quality standard for Ohio streams and is used for WLA calculation because the Meigs #31 Mine discharge contributes a large portion of the flow in Parker Run, especially during low flows, resulting in minimal dilution. Therefore, an effluent concentration limit of 1,500 mg/L is recommended for this discharge.

There are two additional discharges upstream of TM07, but these likely have minimal influence on downstream water quality. The Meigs #31 Mine waste water treatment plant (WWTP) has very little flow which is dependent upon the number of staff at the site at any given time. The Leading Creek Conservancy District Water Treatment Plant discharges to Little Parker Run and has a design flow of 0.025 MGD. This facility discharges daily, but likely does not significantly influence downstream water quality.

Table 4-21 presents the TMDL summary for TM07. The observed data show that fourteen of fifteen chlorides loads, four of nineteen TSS loads, and twenty of twenty-one TDS loads exceed the loading limit for TM07 (Appendix A). TSS loads are only exceeding loading limits during high flows where a 42 percent reduction is needed. Needed reductions (where data are available) are fairly consistent across all flow conditions for both TDS and chlorides. As flow conditions decrease, the needed reductions for TDS and chlorides increase, likely indicating the enhanced impacts of the Meigs #31 Mine as the discharge becomes less diluted during low flow events in Parker Run.

The TDS WLA for the Meigs #31 Mine discharge is very close to the total allowable load for Parker Run across mid-range, dry and low flow conditions. While the TSS WLA does contribute a significant portion of the observed load across mid-range, dry, and low flow conditions, it does not exceed the total

allowable TSS loads at this site. As mentioned above, this facility does not continuously discharge at 7.5 MGD, so it is difficult to make a direct comparison of the WLA to the current loads. However, even if WLAs were calculated using the average flow from the facility (2.22 MGD), the mine discharge would still contribute a majority of the TSS and TDS load, especially during mid-range, dry and low flow conditions. Furthermore, the Meigs #31 Mine discharge may be increasing its average discharge to 3 to 4 MGD in the near future.

Because a chlorides WLA was not calculated for the Meigs #31 Mine, the specific impacts of the discharge could not be evaluated for this parameter. The chlorides concentrations at site TM07 do suggest significant chlorides impairment with 76 percent or greater needed reductions across all flows sampled. The highest in-stream chlorides concentrations throughout the entire Leading Creek watershed (mainstem and tributaries) are found in Parker Run. Chlorides concentrations range from 74 to 456 mg/L and average 349 mg/L downstream of the Meigs #31 Mine discharge in Parker Run. The Leading Creek mainstem upstream of Parker Run displays low chlorides concentrations (Figure 4-6) with averages ranging from 6 to 12 mg/L and a maximum concentration of 32 mg/L (at LCMS05). Leading Creek sampling stations downstream of Parker Run have significantly higher average (68 to 127 mg/L) and maximum (229 to 504 mg/L) chlorides values suggesting that the Meigs #31 Mine discharge impacts water quality on the mainstem of Leading Creek. It is strongly recommended that the facility perform weekly effluent sampling for chlorides and include the results in future MORs so a comprehensive assessment can be made.

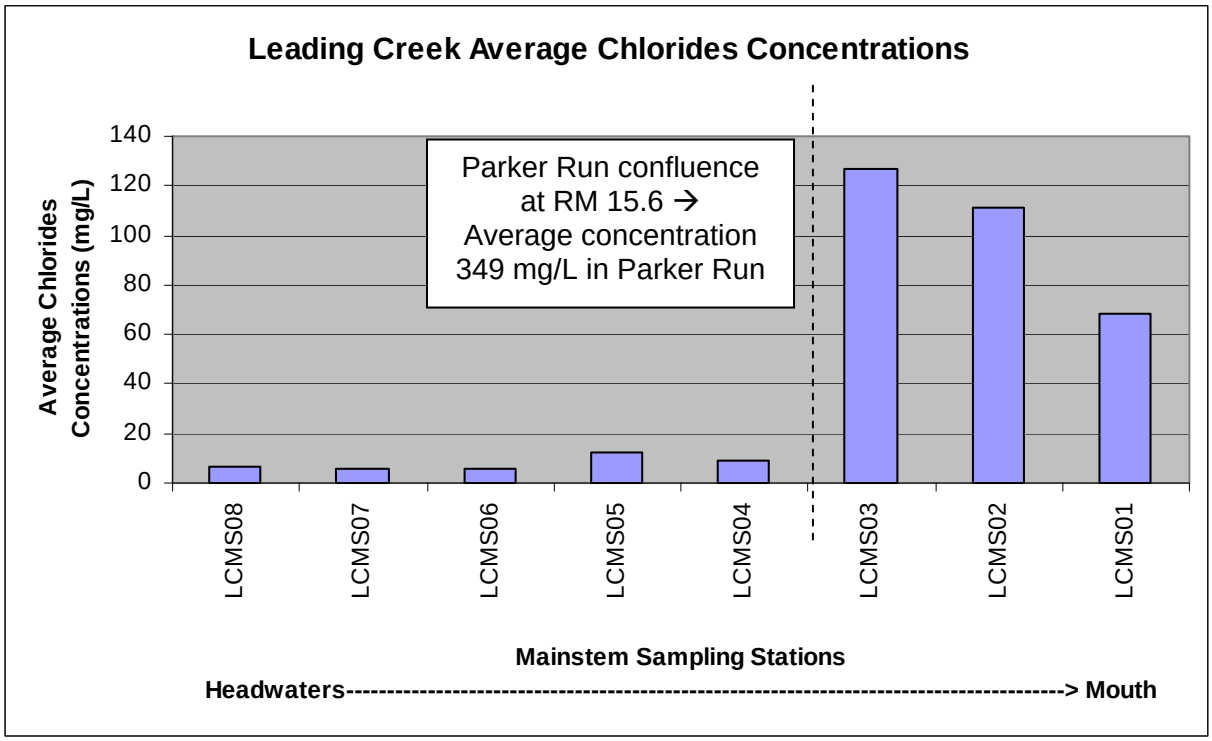


Figure 4-6. Average chlorides concentrations along the Leading Creek mainstem.

Table 4-21. Loading statistics for Parker Run (TM07).

TM07 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**
TDS (kg/day)	Current Load	No Data	156,976	152,250	150,333	150,722
	TMDL= LA+WLA+MOS	**125,259**	**60,390**	**49,193**	**44,154**	**42,754**
	LA	76,415	14,789	4,152	1,573	173
	WLA: Meigs #31 Mine	42,581	42,581	42,581	42,581	42,581
	WLA: MS4	n/a*	n/a	n/a	n/a	n/a
	Total WLA	42,581	42,581	42,581	42,581	42,581
	MOS (5%)	6,263	3,020	2,460	0**	0**
	TMDL Reduction (%)	No Data	**63%**	**69%**	**72%**	**73%**
TSS (kg/day)	Current Load	2,593	414	173	178	241
	TMDL= LA+WLA+MOS	**1,570**	**757**	**617**	**553**	**536**
	LA	1,350	577	444	383	367
	WLA: Meigs #31 Mine	142	142	142	142	142
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	142	142	142	142	142
	MOS (5%)	78	38	31	28	27
	TMDL Reduction (%)	**42%**	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	No Data	13,621	13,287	12,525	No Data
	TMDL= LA+WLA+MOS	**7,198**	**3,470**	**2,827**	**2,537**	**2,457**
	LA	6,838	3,296	2,686	2,410	2,334
	WLA: Meigs #31 Mine	Unknown	Unknown	Unknown	Unknown	Unknown
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	Unknown	Unknown	Unknown	Unknown	Unknown
	MOS (5%)	360	174	141	127	123
	TMDL Reduction (%)	No Data	**76%**	**80%**	**81%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.
**Margin of safety for dry and low flow conditions based upon assumption that WLAs are at design flows.

4.1.4.5 Malloons Run (TM06)

Existing and allowable loads were calculated for Malloons Run at Malloons Run Road (TM06). This sampling station drains 4.17 square miles and land use/land cover upstream of this station consists primarily of forest (81%), pasture/hay (11%), and developed-open space (7%). A total of 21 TDS samples, 19 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM06 (Table 4-16). Water quality data for this station include samples collected during the Leading Creek Improvement Plan study and samples collected by the Leading Creek Watershed Group. Most data have been collected from moist to low flow conditions. There are no permitted facilities that discharge upstream of sampling station TM06.

Table 4-22 presents the TMDL summary for site TM06. None of the TDS or chlorides observations were found to exceed the loading limit at this site. However, five of the nineteen TSS observations were found to exceed the loading limit for TM06 (Appendix A). These TSS observations occurred twice during

moist flow conditions, twice during dry flow conditions, and once during low flows. The only needed load reduction noted for this site is a 49 percent reduction in the TSS load during low flow conditions.

Table 4-22. Loading statistics for Malloons Run (TM06).

TM06 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**
TDS (kg/day)	Current Load	No Data	2,619	1,047	355	51
	TMDL= LA+WLA+MOS	**72,426**	**15,598**	**5,788**	**1,373**	**147**
	LA	68,805	14,818	5,499	1,304	140
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	3,621	780	289	69	7
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	No Data	39	5	8	3
	TMDL= LA+WLA+MOS	**908**	**195**	**73**	**17**	**2**
	LA	863	185	69	16	1.9
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	45	10	4	1	0.1
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**49%**
Chlorides (kg/day)	Current Load	No Data	81	42	10	No Data
	TMDL= LA+WLA+MOS	**4,162**	**896**	**333**	**79**	**8**
	LA	3,954	851	316	75	7.6
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	208	45	17	4	0.4
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.4.6 Leading Creek (LCMS03)

Existing and allowable loads were calculated for Leading Creek at the Parkinson Road Bridge (LCMS03). This sampling station drains 81.09 square miles and land use/land cover upstream of this station consists primarily of forest (70%), pasture/hay (22%), developed-open space (5%), and cultivated crops (2%). A total of 24 TDS samples, 19 TSS samples, and 15 chlorides samples were available for the load duration analysis at site LCMS03 (Table 4-16). Water quality data for this station include samples collected by the Leading Creek Watershed Group and also during the Leading Creek Improvement Plan study. Most data have been collected from moist to low flow conditions. The Meigs #31 Mine discharges upstream of this station (WLA calculations can be found in Table 4-20).

Table 4-23 presents the TMDL summary for site LCMS03. Of the observed loads at this site, nine of fifteen chlorides loads, two of nineteen TSS loads, and ten of twenty-four TDS loads were determined to exceed loading limits. This is the first site along the mainstem of Leading Creek with a needed TDS reduction (Figure 4-7). TDS load reductions are needed for dry and low flow conditions, but moist and mid-range flow loads are below the loading limits. TSS displays a needed reduction of 69 percent during high flows and chlorides have needed load reductions across all flow conditions with data available. As flow conditions decrease, both TDS and chlorides display increasing needed load reductions at site LCMS03. This is likely the result of the upstream Meigs #31 Mine discharge (see discussion of station TM07 and Figure 4-6 above).

Table 4-23. Loading statistics for Leading Creek (LCMS03).

LCMS03 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**
TDS (kg/day)	Current Load	No Data	123,644	126,087	162,626	158,270
	TMDL= LA+WLA+MOS	**1,450,984**	**345,898**	**155,136**	**69,293**	**45,447**
	LA	1,221,395	286,022	104,798	23,247	594
	WLA: Meigs #31 Mine	42,581	42,581	42,581	42,581	42,581
	WLA: MS4	n/a*	n/a	n/a	n/a	n/a
	Total WLA	42,581	42,581	42,581	42,581	42,581
	MOS (5%)	72,549	17,295	7,757	3,465	2,272
	TMDL Reduction (%)	No Data	**0%**	**0%**	**60%**	**73%**
TSS (kg/day)	Current Load	110,594	2,411	663	494	343
	TMDL= LA+WLA+MOS	**35,597**	**8,486**	**3,806**	**1,700**	**1,115**
	LA	33,675	7,920	3,474	1,473	917
	WLA: Meigs #31 Mine	142	142	142	142	142
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	142	142	142	142	142
	MOS (5%)	1,780	424	190	85	56
	TMDL Reduction (%)	**69%**	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	No Data	12,409	8,358	13,020	No Data
	TMDL= LA+WLA+MOS	**53,203**	**12,683**	**5,688**	**2,541**	**1,666**
	LA	50,543	12,049	5,404	2,414	1,583
	WLA: Meigs #31 Mine	Unknown	Unknown	Unknown	Unknown	Unknown
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	Unknown	Unknown	Unknown	Unknown	Unknown
	MOS (5%)	2,660	634	284	127	83
	TMDL Reduction (%)	No Data	**3%**	**35%**	**81%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

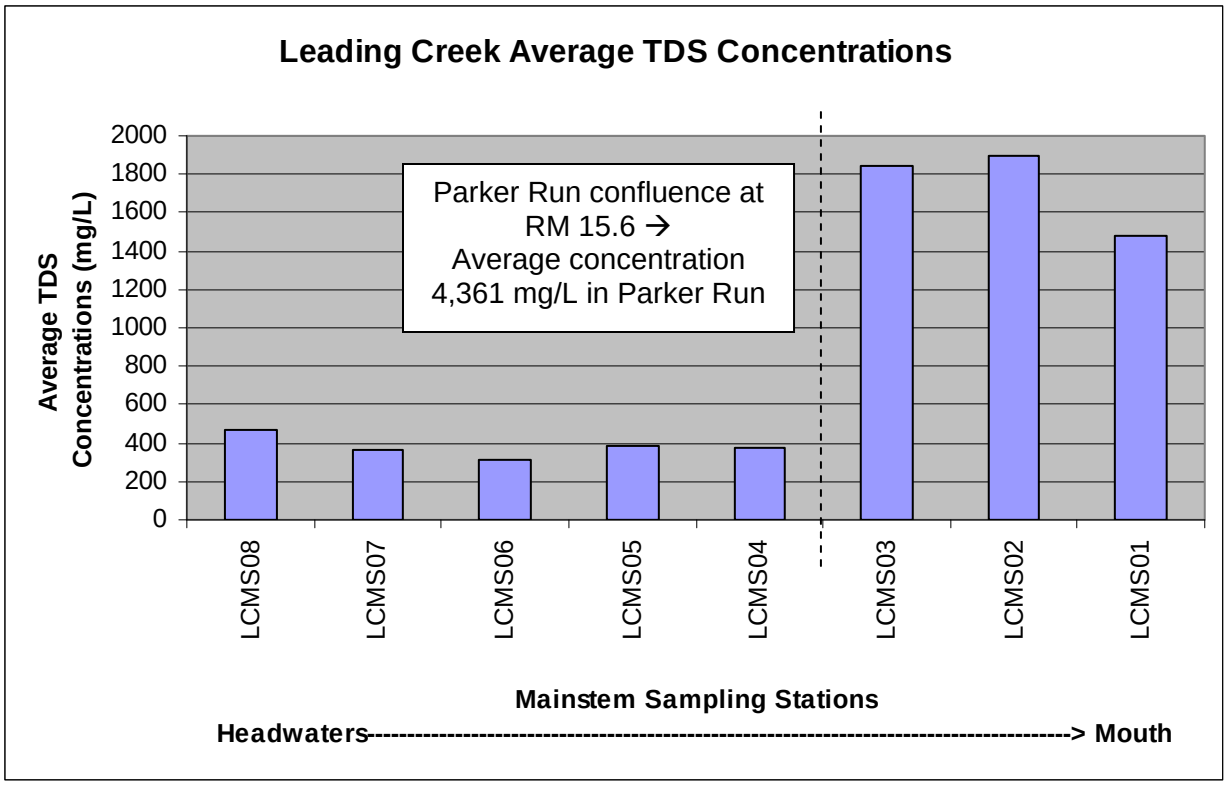


Figure 4-7. Average TDS concentrations along the Leading Creek mainstem.

4.1.4.7 Lasher Run (TM05)

Existing and allowable loads were calculated for Lasher Run downstream of the bridge on Lasher Road (TM05). This sampling station drains 1.79 square miles and land use/land cover upstream of this station consists primarily of forest (84%), pasture/hay (9%), and developed-open space (5%). A total of 22 TDS samples, 21 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM05 (Table 4-16). Water quality data for this station include samples collected during the Leading Creek Improvement Plan study and samples collected by the Leading Creek Watershed Group. Most data have been collected from moist to low flow conditions. There are no permitted facilities that discharge upstream of sampling station TM05.

Table 4-24 presents the TMDL summary for site TM05. None of the TDS observations were found to exceed the loading limit. One of fifteen chlorides samples exceeded the loading limit during dry flow conditions and six of twenty-one TSS loads were also exceeding load limits (three times during moist flow conditions, once at mid-range flows, and twice at dry flow conditions). The only needed load reduction at this site is a 9 percent reduction for TSS loads during moist flow conditions.

Table 4-24. Loading statistics for Lasher Run (TM05).

TM05 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**
TDS (kg/day)	Current Load	No Data	1,324	583	339	46
	TMDL= LA+WLA+MOS	**31,089**	**6,695**	**2,484**	**590**	**63**
	LA	29,535	6,360	2,360	561	60
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	1,554	335	124	29	3
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	No Data	88	4	1	1
	TMDL= LA+WLA+MOS	**390**	**84**	**31**	**7**	**1**
	LA	371	80	29	6.6	1
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	19	4	2	0.4	0.0
	TMDL Reduction (%)	No Data	**9%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	No Data	38	45	24	No Data
	TMDL= LA+WLA+MOS	**1,787**	**385**	**143**	**34**	**4**
	LA	1,698	366	136	32	3.8
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	89	19	7	2	0.2
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.5 Subwatershed 050: Little Leading Creek

Subwatershed 050 consists solely of the Little Leading Creek tributary and drains 25.6 square miles. Rutland and Harrisonville are the only communities within this primarily forest-covered watershed. Several hundred acres of abandoned mine lands contribute heavy sediment loads to Little Leading Creek and its tributaries (Bauers, 2005). Compounding the excessive sediment issues and further limiting aquatic life are upland erosion from agricultural practices, stream channel erosion, and natural geologic features (exposed sandstone bedrock). The Rutland WWTP discharges to Little Leading Creek at RM 1.7 and is the only public sewage treatment facility in the entire Leading Creek watershed.

The biological communities were found to be impaired at sites sampled within this subwatershed. Fish communities were found to be "fair," however very low biomass, numerous pioneering species, and few sensitive species indicate degraded fish assemblages. Relatively low macroinvertebrate diversity and percent sensitive taxa also indicate aquatic community impairment within the subwatershed (Bauers, 2005).

Water quality sampling in this subwatershed displays nitrate-nitrite concentrations (near the mouth) and fecal coliform counts (downstream Harrisonville and Rutland) that exceed target values (see discussion in Section 5), and both parameters are noted as pollutants of concern in Little Leading Creek (Bauers, 2005). The abandoned mine lands are also a source of isolated AMD impairments, though acidity and metals are not parameters of major concern in this subwatershed. Numerous ODNR underdrain projects have been completed for strip mines in Little Leading Creek, but because of limited underground and auger mining they are not thought to have significant impacts on water quality (Bauers et al., 2006).

Excessive sedimentation is severely limiting WWH attainment in Little Leading Creek, as displayed by the QHEI data collected throughout the subwatershed. Streambeds are inundated with several feet of sand along nearly the entire length of the Little Leading Creek mainstem. The excessive sediment loads impair stream substrate, riffle, and pool quality as well as riffle and pool depth (Bauers, 2005).

The load duration approach was applied to one sampling station located within subwatershed 050 (Figure 4-8) for TSS, TDS, and chlorides near the mouth of Little Leading Creek at the Bridge on Higley Road (TM04). A summary of available water quality data for Little Leading Creek is presented in Table 4-25.

Table 4-25. Summary of available water quality data for subwatershed 050.

Subwatershed/ Stream	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
Little Leading Creek	At Bridge on Higley Road (TM04)	pH	22	7.38	6.76	7.75	4/29/1996-8/19/2003
		Fecal Coliform (#/100ml)	1	1,800	1,800	1,800	7/29/2003
		TDS (mg/L)	22	535	188	3,978	4/29/1996-8/19/2003
		TSS (mg/L)	21	23	1	213	4/29/1996-8/19/2003
		Chlorides (mg/L)	15	9	4	16	4/29/1996-6/25/1997

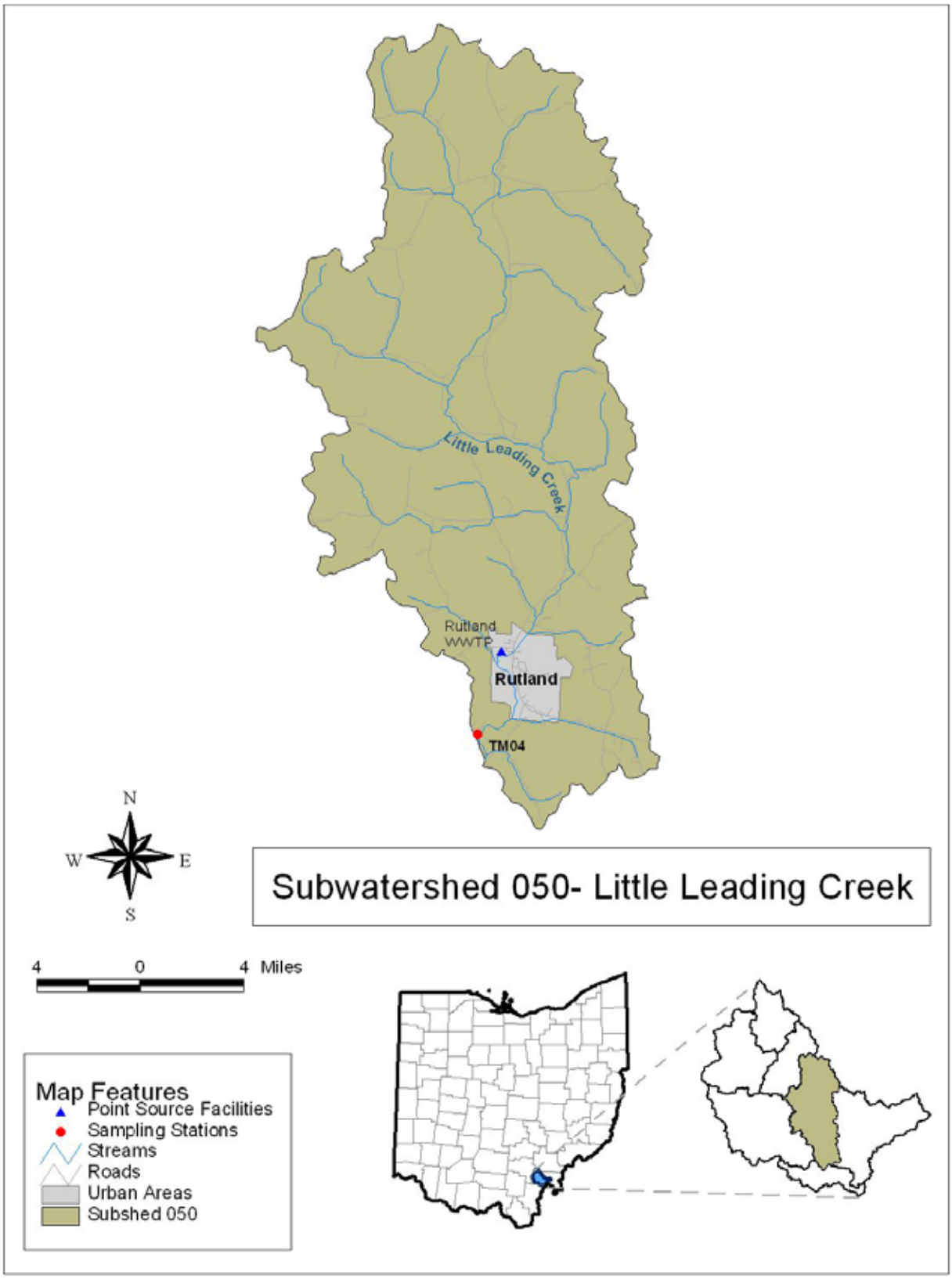


Figure 4-8. Load duration sites within subwatershed 050.

4.1.5.1 Little Leading Creek (TM04)

Existing and allowable loads were calculated for Little Leading Creek at the bridge on Higley Road (TM04). This sampling station drains 25.61 square miles and land use/land cover upstream of this station consists primarily of forest (75%), pasture/hay (17%), and developed-open space (5%). A total of 22 TDS samples, 21 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM04 (Table 4-25). Water quality data for this station include samples collected during the Leading Creek Improvement Plan study and samples obtained by the Leading Creek Watershed Group. Most data have been collected from moist to low flow conditions.

The Rutland WWTP discharges into Little Leading Creek upstream of sampling station TM04 and has a design flow of 0.052 MGD. This facility discharges continuously, but as load estimations using the design flow display, the Rutland WWTP has minimal impact on the TDS and TSS loads in Little Leading Creek (Table 4-26). Though a WLA was not calculated, it is not expected that this facility would be a significant source of chlorides or contribute to any related water quality impairments.

Table 4-26. NPDES WLAs for the Rutland WWTP.

Parameter	Design Flow (MGD)	Literature Value Effluent Concentration (mg/L)	Parameter Load (kg/day)
TDS	0.052	700	138
TSS	0.052	9	2
Chlorides	0.052	Unknown	Unknown

Table 4-27 presents the TMDL summary for site TM04. There are no observed chlorides loads that were found to exceed the loading limit at this station. Two of twenty-one TSS observed loads and one of twenty-two observed TDS loads were found to exceed loading limits. The TSS exceedences occurred at moist and high flows and the TDS exceedence was during moist flow conditions. The only needed load reduction at TM04 is noted as a 70 percent load reduction of TSS during high flows.

Table 4-27. Loading statistics for Little Leading Creek (TM04).

TM04 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**
TDS (kg/day)	Current Load	No Data	22,710	7,844	3,133	628
	TMDL= LA+WLA+MOS	**445,098**	**96,088**	**35,841**	**8,730**	**1,199**
	LA	422,705	91,146	33,911	8,156	1,001
	WLA: Rutland WWTP	138	138	138	138	138
	WLA: MS4	n/a*	n/a	n/a	n/a	n/a
	Total WLA	138	138	138	138	138
	MOS (5%)	22,255	4,804	1,792	436	60
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	34,834	992	119	101	7
	TMDL= LA+WLA+MOS	**10,920**	**2,357**	**879**	**214**	**29**
	LA	10,372	2,237	833	201	26
	WLA: Rutland WWTP	2	2	2	2	2
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	2	2	2	2	2
	MOS (5%)	546	118	44	11	1
	TMDL Reduction (%)	**70%**	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	No Data	423	241	104	No Data
	TMDL= LA+WLA+MOS	**16,320**	**3,523**	**1,314**	**320**	**44**
	LA	15,504	3,347	1,248	304	42
	WLA: Rutland WWTP	Unknown	Unknown	Unknown	Unknown	Unknown
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	Unknown	Unknown	Unknown	Unknown	Unknown
	MOS (5%)	816	176	66	16	2
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.6 Subwatershed 060: Leading Creek below Little Leading Creek to the Ohio River

Subwatershed 060 drains 9.0 square miles of sparsely populated land and contains no small communities or incorporated towns. This section of Leading Creek has two major tributaries including Titus Run and Paulins Hill Run. Though mostly forested (75%), this subwatershed also contains approximately 18% agricultural land use (mostly pasture/hay with some row crops).

The Leading Creek mainstem and both major tributaries have been sampled for biological community health. While there has been some recovery on the mainstem after the Meigs #31 Mine discharge, fish communities are still noted as impaired due to low biomass and only achieving the WWH designation once out of 7 sample events since 1995. Macroinvertebrate communities display variability in this subwatershed with communities ranging from "fair" to "marginally good" based on ICI scores, but overall diversity and the percent sensitive taxa were very low noting "poor" community conditions (Bauers, 2005).

This subwatershed has been intensively mined prior to reclamation laws resulting in numerous barren areas and one tributary impaired by AMD. The impacts in Titus Run are localized, but Paulins Hill Run and an unnamed tributary suffer widespread and severe AMD water quality impairments. The AMD from these tributaries has little or no effect on the mainstem of Leading Creek (Bauers et al., 2006). Additional water quality sampling in this subwatershed has noted nitrate-nitrite, a pollutant of concern as concentrations exceed target values on the mainstem of Leading Creek (see discussion in Section 5). However, nitrate-nitrite is not an issue in the two tributaries.

Low QHEI substrate, riffle/run, and in-stream cover scores indicate that the physical habitat of this subwatershed is very impaired. The Ohio River is thought to have a significant influence on habitat quality in the mainstem of Leading Creek as its backwater causes significant sediment issues near the mouth (Bauers, 2005).

The load duration approach was applied to four sampling stations located within subwatershed 060 (Figure 4-9) for TDS, TSS, and chlorides:

- Two sites along the mainstem of Leading Creek:
  - Upstream of Thomas Fork (LCMS02).
  - Near Middleport at Hobson Drive (LCMS01).

- Two sites near the mouth of each of the following tributaries to Leading Creek:
  - Titus Run Downstream of Titus Run Road (TM03).
  - Paulins Hill Run Adjacent to Wells Road, Near Mouth (TM02).

A summary of available water quality data for subwatershed 060 is presented in Table 4-28.

Table 4-28. Summary of available water quality data for subwatershed 060.

Subwatershed/ Stream	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
Titus Run	Downstream of Titus Run Road, Near Mouth (TM03)	pH	26	6.48	5.20	7.22	4/29/1996-4/26/2004
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	27	389	207	688	4/29/1996-4/26/2004
		TSS (mg/L)	27	31	1	128	4/29/1996-4/26/2004
		Chlorides (mg/L)	15	4	2	7	4/29/1996-6/25/1997
Paulins Hill Run	Adjacent to Wells Road, Near Mouth (TM02)	pH	5	4.63	4.34	4.95	5/13/2003-11/16/2004
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	5	492	380	538	5/13/2003-11/16/2004
		TSS (mg/L)	5	10	1	21	5/13/2003-11/16/2004
		Chlorides (mg/L)	0	ND	ND	ND	ND
Leading Creek	Upstream of Thomas Fork (LCMS02)	pH	23	7.49	7.01	8.10	4/29/1996-10/25/1997
		Fecal Coliform (#/100ml)	1	330	330	330	9/30/2003
		TDS (mg/L)	23	1,898	169	4,934	4/29/1996-10/25/1997
		TSS (mg/L)	21	63	1	720	4/29/1996-10/25/1997
		Chlorides (mg/L)	16	111	5	315	4/29/1996-6/27/1997
Leading Creek	Near Middleport at Hobson Drive (LCMS01)	pH	22	7.26	6.88	8.06	4/29/1996-10/24/1997
		Fecal Coliform (#/100ml)	0	ND	ND	ND	ND
		TDS (mg/L)	22	1,475	173	4,526	4/29/1996-10/24/1997
		TSS (mg/L)	21	138	2	804	4/29/1996-10/24/1997
		Chlorides (mg/L)	15	68	5	229	4/29/1996-6/25/1997

Figure 4-9. Load duration sites within subwatershed 060.

4.1.6.1 Titus Run (TM03)

Existing and allowable loads were calculated for Titus Run downstream of Titus Run Road, near the mouth (TM03). This sampling station drains 6.32 square miles and land use/land cover upstream of this station consists primarily of forest (90%), pasture/hay (7%), and developed-open space (2%). A total of 27 TDS samples, 27 TSS samples, and 15 chlorides samples were available for the load duration analysis at site TM03 (Table 4-28). Water quality data for this station include samples collected by the Leading Creek Watershed Group and samples collected during the Leading Creek Improvement Plan study. Most data have been collected from moist to low flow conditions. There are no permitted facilities that discharge upstream of sampling station TM03.

Table 4-29 presents the TMDL summary for site TM03. Only observed TSS loads were found to exceed the loading limits in Titus Run. Out of twenty-seven samples, eight TSS loads were above allowable limits. Four exceeding loads occurred during moist flow conditions and two occurred during both mid-range and dry flow conditions. Needed TSS load reductions at moist and dry conditions are noted at 41 and 15 percent, respectively. There are no other reductions noted at Station TM03.

Table 4-29. Loading statistics for Titus Run (TM03).

TM03 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**
TDS (kg/day)	Current Load	No Data	6,285	1,882	894	150
	TMDL= LA+WLA+MOS	**109,768**	**23,640**	**8,772**	**2,081**	**223**
	LA	104,280	22,458	8,333	1,977	212
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	5,488	1,182	439	104	11
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**0%**
TSS (kg/day)	Current Load	No Data	481	27	29	1
	TMDL= LA+WLA+MOS	**1,376**	**296**	**110**	**26**	**3**
	LA	1,307	281	105	25	2.9
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	69	15	5	1	0.1
	TMDL Reduction (%)	No Data	**41%**	**0%**	**15%**	**0%**
Chlorides (kg/day)	Current Load	No Data	50	16	5	No Data
	TMDL= LA+WLA+MOS	**6,308**	**1,358**	**504**	**120**	**13**
	LA	5,993	1,290	479	114	12
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	315	68	25	6	1
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.6.2 Paulins Hill Run (TM02)

Existing and allowable loads were calculated for Paulins Hill Run adjacent to Wells Road, near the mouth (TM02). This sampling station drains 1.99 square miles and land use/land cover upstream of this station consists primarily of forest (91%), pasture/hay (5%), and developed–open space (3%). A total of 5 TDS samples and 5 TSS samples were available for the load duration analysis at site TM02 (Table 4-28). No chlorides data were collected at this site, so load duration analysis was only completed for TDS and TSS. Water quality data for this station include samples collected by the Leading Creek Watershed Group. Data for this site were collected during moist and mid-range flow conditions. There are no permitted facilities that discharge upstream of sampling station TM02.

Table 4-30 presents the TMDL summary for site TM02. The only load limit exceedence at this site was one of the five TSS loads during moist flow conditions. There are no needed load reductions for site TM02.

Table 4-30. Loading statistics for Paulins Hill Run (TM02).

TM02 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**
TDS (kg/day)	Current Load	No Data	1,833	1,022	No Data	No Data
	TMDL= LA+WLA+MOS	**34,563**	**7,443**	**2,762**	**655**	**70**
	LA	32,835	7,071	2,624	622	66
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	1,728	372	138	33	4
	TMDL Reduction (%)	No Data	**0%**	**0%**	No Data	No Data
TSS (kg/day)	Current Load	No Data	60	12	No Data	No Data
	TMDL= LA+WLA+MOS	**433**	**93**	**35**	**8**	**1**
	LA	411	88	33	7.6	1
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	22	5	2	0.4	0.0
	TMDL Reduction (%)	No Data	**0%**	**0%**	No Data	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.6.3 Leading Creek (LCMS02)

Existing and allowable loads were calculated for Leading Creek upstream of Thomas Fork (LCMS02). This sampling station drains 117.49 square miles and land use/land cover upstream of this station consists primarily of forest (70%), pasture/hay (21%), and developed–open space (5%). A total of 23 TDS samples, 21 TSS samples, and 16 chlorides samples were available for the load duration analysis at site LCMS02 (Table 4-28). Water quality data for this station include samples collected by the Leading Creek Watershed Group and also samples collected by the Leading Creek Improvement Plan study. Most data have been collected from moist to low flow conditions. The Meigs #31 Mine and the Rutland

WWTP both discharge upstream of sampling station LCMS02 (WLA calculations can be found in Table 4-20 and Table 4-26).

Table 4-31 presents the TMDL summary for site LCMS02. Thirteen of twenty-three TDS loads (mostly during dry to low flows), five of twenty-one TSS loads (high and moist flows), and ten of sixteen chlorides loads (moist to dry flow conditions) exceeded the loading limits for LCMS02 (Appendix A). The load limit exceedences at this station mostly occurred at or below mid-range flow conditions (with the exception of five TSS loads during high and moist flow conditions) pointing to a relatively constant source of TDS and chlorides. As flows decrease, the ability of Leading Creek to assimilate these pollutants also decreases. This is displayed as the needed reductions increase from mid-range to low flow conditions for TDS (15 to 72%) and mid-range to dry flow conditions for chlorides (57 to 81%) at this site. As noted at the upstream Leading Creek site (LCMS03), these trends are likely the result of the upstream Meigs #31 Mine discharge (see discussion of station TM07 and Figure 4-6 above).

Table 4-31. Loading statistics for Leading Creek (LCMS02).

LCMS02 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**
TDS (kg/day)	Current Load	No Data	186,138	229,804	153,548	161,313
	TMDL= LA+WLA+MOS	**2,083,486**	**482,345**	**205,952**	**81,576**	**47,027**
	LA	1,936,593	415,509	152,935	34,778	1,957
	WLA: Meigs #31 Mine	42,581	42,581	42,581	42,581	42,581
	WLA: Rutland WWTP	138	138	138	138	138
	WLA: MS4	42,719	42,719	42,719	42,719	42,719
	Total WLA	138	138	138	138	138
	MOS (5%)	104,174	24,117	10,298	4,079	2,351
	TMDL Reduction (%)	No Data	**0%**	**15%**	**50%**	**72%**
TSS (kg/day)	Current Load	1,464,850	5,100	769	1,094	105
	TMDL= LA+WLA+MOS	**51,115**	**11,834**	**5,053**	**2,001**	**1,154**
	LA	48,415	11,098	4,656	1,757	952
	WLA: Meigs #31 Mine	142	142	142	142	142
	WLA: Rutland WWTP	2	2	2	2	2
	WLA: MS4	n/a*	n/a	n/a	n/a	n/a
	Total WLA	144	144	144	144	144
	MOS (5%)	2,556	592	253	100	58
	TMDL Reduction (%)	**97%**	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	No Data	13,724	16,652	14,906	No Data
	TMDL= LA+WLA+MOS	**76,394**	**17,686**	**7,552**	**2,991**	**1,724**
	LA	72,574	16,802	7,174	2,841	1,638
	WLA: Meigs #31 Mine	Unknown	Unknown	Unknown	Unknown	Unknown
	WLA: Rutland WWTP	Unknown	Unknown	Unknown	Unknown	Unknown
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	Unknown	Unknown	Unknown	Unknown	Unknown
	MOS (5%)	3,820	884	378	150	86
	TMDL Reduction (%)	No Data	**0%**	**57%**	**81%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.6.4 Leading Creek (LCMS01)

Existing and allowable loads were calculated for Leading Creek near Middleport at Hobson Drive (LCMS01). This sampling station drains 149.8 square miles and land use/land cover upstream of this station consists primarily of forest (72%), pasture/hay (19%), developed-open space (5%), and grasslands/herbaceous (1%). A total of 22 TDS samples, 21 TSS samples, and 15 chlorides samples were available for the load duration analysis at site LCMS01 (Table 4-28). Water quality data for this station include samples collected during the Leading Creek Improvement Plan study. Most data have been collected from moist to dry flow conditions. The Meigs #31 Mine and the Rutland WWTP both discharge upstream of sampling station LCMS01 (WLA calculations can be found in Table 4-20 and Table 4-26).

Table 4-32 presents the TMDL summary for site LCMS01. Seven of the twenty-two TDS, five of the twenty-one TSS, and eight of the fifteen chlorides observations were found to exceed the loading limit. TDS observations exceeding loading limits occurred from mid-range to low flow conditions and the needed reductions increase across these decreasing flow regimes from 6 to 69 percent. A similar trend is shown with needed chlorides reductions (occurring across moist to dry flow conditions), increasing from 46 percent at mid-range flows to 53 percent at dry flow conditions. TSS observations exceeded loading limits five times during high to moist flow conditions and twice during dry flow conditions (Appendix A). A 97 percent needed reduction in TSS loads is called for at this station during high flows. The TMDL results at this station are similar to those found upstream at site LCMS02.

Thomas Fork contributes almost 22 percent of the mean annual flow of Leading Creek (Leading Creek Management Plan), and this tributary enters Leading Creek in between LCMS02 and LSMC01. Despite the significant addition of flow, the various needed load reductions are only slightly lower than those noted at the upstream station LCMS02. As displayed at the previous Leading Creek mainstem sites downstream of Parker Run (LCMS03 an LCMS02), the increasing TDS and chlorides impairments with decreasing flows note a relatively constant source. The TDS and chlorides loads from the Meigs #31 Mine are the likely cause of impairment as previously noted (see discussion of site TM07 and Figure 4-6).

Table 4-32. Loading statistics for Leading Creek (LCMS01).

LCMS01 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**
TDS (kg/day)	Current Load	No Data	251,758	252,708	104,963	149,293
	TMDL= LA+WLA+MOS	**2,644,302**	**603,122**	**250,769**	**92,210**	**48,166**
	LA	2,469,368	530,247	195,512	44,880	3,039
	WLA: Meigs #31 Mine	42,581	42,581	42,581	42,581	42,581
	WLA: Rutland WWTP	138	138	138	138	138
	WLA: MS4	n/a*	n/a	n/a	n/a	n/a
	Total WLA	42,719	42,719	42,719	42,719	42,719
	MOS (5%)	132,215	30,156	12,538	4,611	2,408
	TMDL Reduction (%)	No Data	**0%**	**6%**	**17%**	**69%**
TSS (kg/day)	Current Load	2,173,022	6,294	3,318	1,403	405
	TMDL= LA+WLA+MOS	**64,874**	**14,797**	**6,152**	**2,262**	**1,182**
	LA	61,486	13,913	5,700	2,005	979
	WLA: Meigs #31 Mine	142	142	142	142	142
	WLA: Rutland WWTP	2	2	2	2	2
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	144	144	144	144	144
	MOS (5%)	3,244	740	308	113	59
	TMDL Reduction (%)	**97%**	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	No Data	15,962	16,165	6,882	No Data
	TMDL= LA+WLA+MOS	**96,958**	**22,114**	**9,195**	**3,381**	**1,766**
	LA	92,110	21,008	8,735	3,212	1,678
	WLA: Meigs #31 Mine	Unknown	Unknown	Unknown	Unknown	Unknown
	WLA: Rutland WWTP	Unknown	Unknown	Unknown	Unknown	Unknown
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	Unknown	Unknown	Unknown	Unknown	Unknown
	MOS (5%)	4,848	1,106	460	169	88
	TMDL Reduction (%)	No Data	**0%**	**46%**	**53%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.1.7 Subwatershed 070: Thomas Fork

Subwatershed 070 is the largest tributary to Leading Creek, draining 31.2 square miles. The subwatershed contains portions of Pomeroy and Middleport, two incorporated villages located in the southeast corner of the subwatershed. Consisting only of Thomas Fork, this tributary flows into Leading Creek between sampling stations LCMS02 and LCMS01. Though mostly forested (76 percent), this subwatershed also vividly displays the remnants of historical surface, auger, and underground mining. Surface mining occurred across 8 percent of the subwatershed and underground mining disturbed up to 15 percent of the Thomas Fork subwatershed. AMD impairs water quality and aquatic life in over 10 stream miles within this subwatershed making Thomas Fork the most severely impaired of the seven Leading Creek subwatersheds (Bauers et al., 2006).

Most biological communities were found to be extremely degraded at sampling sites within this subwatershed. Two recent fish surveys were completed, but not a single fish was collected during either sampling event. Additional historic sampling in 1953 and 1959 reported no aquatic life present and very low pH values. Some sites in the headwaters of Thomas Fork, the Upper East Branch, and Long Hollow Run display intact fish communities upstream of the AMD impairments. Macroinvertebrates displayed extremely degraded communities with a total of only 16 macroinvertebrates collected in two sampling events (Bauers et al., 2006).

Extensive water quality sampling in this subwatershed has noted average total phosphorus concentrations that exceed target values, but this parameter is a minor concern in the shadow of such severe AMD impacts (see discussion in Section 5). Several seeps, underdrains, and pipes in the subwatershed display average pH values of well below 4.0 (some as low as 2.79) and deliver heavy acid and metals loads to Thomas Fork. The AMD impacts are widespread throughout the subwatershed and several tributaries are listed as specific areas of concern. During low flow periods, the water quality in Thomas Fork worsens as AMD contributes a majority of the base flow (Bauers et al., 2006).

QHEI data indicate extreme variability in this subwatershed. There are many high quality reaches (some of the best in Leading Creek) as well as a few that are severely degraded by mine sediment and bank erosion. Habitat does not seem to be a limiting factor for aquatic life in Thomas Fork and its tributaries (Bauers, 2005).

The load duration approach was applied to one sampling station located within subwatershed 070 (Figure 4-10) for TDS, TSS, and chlorides at Thomas Fork near the mouth at Leading Creek Road (TM01). A summary of the available water quality data for the Thomas Fork subwatershed is presented in Table 4-33.

Table 4-33. Summary of available water quality data for subwatershed 070.

Subwatershed/ Stream	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
Thomas Fork	At Leading Creek Road (TM01)	pH	31	5.63	3.89	7.34	4/29/1996-8/22/2005
		Fecal Coliform (#/100ml)	1	10	10	10	7/29/2003
		TDS (mg/L)	31	755	190	3,620	4/29/1996-8/22/2005
		TSS (mg/L)	21	100	1	716	4/29/1996-10/25/1997
		Chlorides (mg/L)	16	25	8	42	4/29/1996-6/27/1997

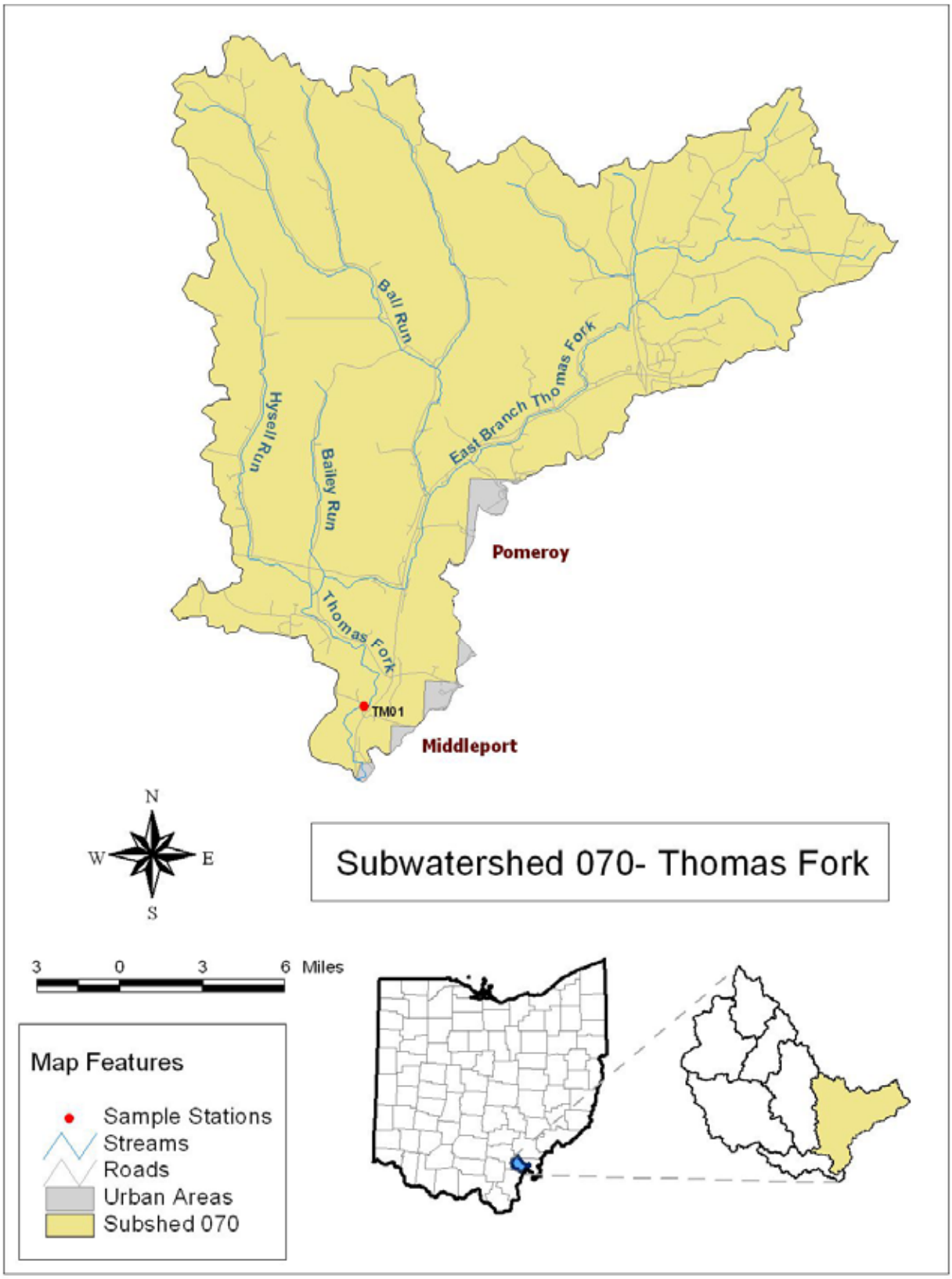


Figure 4-10. Load duration sites within subwatershed 070.

4.1.7.1 Thomas Fork (TM01)

Existing and allowable loads were calculated for Thomas Fork at Leading Creek Road (TM01). This sampling station drains 30.6 square miles and land use/land cover upstream of this station consists primarily of forest (76%), pasture/hay (14%), and developed-open space (1%). A total of 31 TDS samples, 21 TSS samples, and 16 chlorides samples were available for the load duration analysis at site TM01 (Table 4-33). Water quality data for this station include samples collected during the Leading Creek Improvement Plan study and samples collected by the Leading Creek Watershed Group. Most data have been collected from moist to dry flow conditions. There is one permitted facility that discharges sporadically upstream of sampling station TM01 (City Ice and Fuel - 0PR00151) but because its design flow is 0.0011 MGD, it likely has little or no impact on water quality.

Table 4-34 presents the TMDL summary for site TM01. None of the chlorides observations were found to exceed the loading limit. However, two of the thirty-one TDS observations and nine of the twenty-one TSS observations were found to exceed the loading limits for site TM01 (Appendix A). The TDS observations found to exceeding allowable loads occurred during moist and low flow conditions, and a needed reduction of 45 percent was noted during low flows. Most of the TSS observations above loading limits occurred during high to mid-range flows, but two were also noted during dry flow conditions. A TSS load reduction of 98 percent is needed during high flows. There are no other reductions noted at Station TM01.

Table 4-34. Loading statistics for Thomas Fork (TM01).

TM01 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**
TDS (kg/day)	Current Load	No Data	36,522	13,888	6,716	1,872
	TMDL= LA+WLA+MOS	**531,645**	**114,495**	**42,485**	**10,081**	**1,080**
	LA	505,063	108,770	40,361	9,577	1,026
	WLA: facility	n/a*	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	26,582	5,725	2,124	504	54
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	**45%**
TSS (kg/day)	Current Load	711,939	2,463	905	62	4
	TMDL= LA+WLA+MOS	**13,043**	**2,809**	**1,042**	**247**	**26**
	LA	12,391	2,669	990	235	25
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	652	140	52	12	1
	TMDL Reduction (%)	**98%**	**0%**	**0%**	**0%**	**0%**
Chlorides (kg/day)	Current Load	No Data	1,702	726	272	No Data
	TMDL= LA+WLA+MOS	**19,494**	**4,198**	**1,558**	**370**	**40**
	LA	18,519	3,988	1,480	352	38
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	975	210	78	18	2
	TMDL Reduction (%)	No Data	**0%**	**0%**	**0%**	No Data

* "n/a" is used to indicate that there are no point source dischargers in the subwatershed.

4.2 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 margin of safety has been included in all of the Leading Creek TMDLs by reserving 5 percent of the loading capacity. A relatively low margin of safety was selected because the load duration analysis is believed to accurately represent the allowable loads (i.e., the flow estimates are believed to be accurate (see Appendix B) and there are typically at least 15 to 20 samples available to estimate existing loads).

4.3 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 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.

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 this TMDL because the load duration approach accounts 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 ADDITIONAL WATER QUALITY IMPAIRMENTS IN THE LEADING CREEK WATERSHED

There are additional water quality impairments in the Leading Creek Watershed; however data limitations prevented the development of TMDLs for the following parameters. This section identifies tributaries and subwatersheds where fecal coliform, nutrients, and pH values exceed water quality standards or are a parameter of concern.

5.1 Fecal Coliform

There have only been two sampling events for fecal coliform bacteria in the Leading Creek Watershed and with such limited data, load duration analysis could not be performed for this parameter. As noted by the Watershed Management Plan, there are several sites with fecal coliform counts that exceed or nearly exceed the Ohio EPA primary contact water quality standard of 2,000/100mL (Table 5-1).

Table 5-1. Fecal coliform counts at areas of concern and suggested long-term monitoring sites.

Subwatershed	Stream Name	Sample Location (River Mile)	Fecal Coliform Count (#/100mL)		Suspected Source
			7/29/03	9/30/03	
010	Fivemile Run	1.8	21,000	7,000	Livestock Operations and Stream Access
010	Leading Creek	26.3	1,080	420	Unsewered Community (downstream of Carpenter)
020	Sisson Run	0.1	2,100	510	Livestock Operations and Stream Access
020	Leading Creek	20.8	1,700	350	Unsewered Community (downstream of Dyesville)
050	Little Leading Creek	9.4	2,400	540	Unsewered Community (downstream of Harrisonville)
050	Little Leading Creek	1.7	1,800	400	Sewered Community (downstream of Rutland)
Additional Suggested Long-term Monitoring Sites					
040	Dexter Run	0.8	n/a	n/a	HSTS, livestock access
040	Leading Creek	17.4	n/a	n/a	Dexter Run
040	Leading Creek	10.3	n/a	n/a	n/a – monitor water quality upstream of AMD impacts
070	Thomas Fork	1.2	n/a	n/a	HSTS in Thomas Fork, Bailey Run, and Hysell Run

Fecal coliform is a parameter of concern in three 14-digit HUC subwatersheds, as a result of limited sampling performed in 2003:

- 010: Leading Creek Headwaters to below Fivemile Run
- 020: Leading Creek below Fivemile Run to above Mud Fork
- 050: Little Leading Creek

Fecal loads in subwatershed 010 are thought to be from a combination of organic waste from livestock operations within Fivemile Run and failing onsite sewage treatment systems in several local residential areas. Pathogen loads in Fivemile Run should be reduced as the local livestock operation has implemented an Environmental Quality Incentive Program (EQIP) plan. However, there are an estimated 107 failing home sewage treatment systems (HSTS) contributing over 38,000 gallons of effluent per day to streams in this subwatershed (Bauers, 2005).

Within subwatershed 020, Sisson Run and Sharps Run tributaries contain livestock operations at which there are areas of unrestricted livestock access to streams. There are an estimated 180 failing HSTS with an effluent of nearly 65,000 gallons per day in this subwatershed (Bauers, 2005). An area of concern is the small community of Dyesville.

The Little Leading Creek subwatershed (050) has noted fecal coliform counts that exceed or nearly exceed water quality standards. Noted sources include livestock operations and failing HSTS in the Harrisonville area. An estimated 298 HSTS are failing in this subwatershed contributing over 107,000 gallons of effluent per day to Little Leading Creek (Bauers, 2005).

Though fecal coliform counts were below water quality standards, the potential for pathogen contamination also exists in subwatersheds 040 and 070 where numerous HSTS are failing and livestock have direct access to streams. Subwatershed 040 has an estimated 337 failing HSTS contributing over 121,000 gallons per day. Thomas Fork (subwatershed 070) also contains an estimated 471 HSTS, 60 percent of which are thought to be failing. These systems have the potential to contribute as much as 170,000 gallons of effluent per day (Bauers, 2005).

In addition to the noted fecal coliform areas of concern, four sites are recommended for long-term pathogen monitoring (Bauers, 2005) to determine project effectiveness and water quality trends. These sites are listed in the bottom of Table 5-1. These sites did not display elevated fecal coliform counts, however some suggest signs of possible organic enrichment (black sludge in streams, odors, livestock access). Others are recommended for long term monitoring because of their location downstream of other sources.

Further investigation is needed in these subwatersheds, as well as other subwatersheds and tributaries of Leading Creek, to confirm pathogen impairments and allow for load duration analysis. In some streams where fecal coliform contamination is probable, high metals/acidity might be masking the potential impairments.

5.2 Nutrients

Nutrients are not a listed impairment for the Leading Creek watershed, but extensive sampling has noted nitrate-nitrite (NN) and total phosphorus (TP) concentrations that exceed target levels. The nutrient targets used in Bauers (2005) report were derived from proposed benchmarks listed in an Ohio Bulletin (Ohio EPA, 1999). The suggested NN targets are 0.34 mg/L for headwater sites (< 20 square miles) and 0.47 mg/L for wadeable sites (> 20 square miles). TP targets are listed as 0.05 mg/L at headwater sites and 0.06 mg/L for wadeable sites. Subwatersheds and specific tributaries of concern are listed below in Table 5-2:

Table 5-2. Subwatersheds and tributaries with possible nutrient issues.

Subwatershed	Stream Name(s)	Parameters of Concern	Notes
010	FivemileRun, West Branch, East Branch	NN and TP	Nutrient concentrations are high in tributaries, but do not seem to be affecting the mainstem in this subwatershed.
020	Sharps Run, Leading Creek (RM 24.3)	NN	Impacts not widespread.
040	Parker Run (RM 1.5)	NN	Average concentrations above target value.
050	Little Leading Creek	NN	50% of samples exceed target value.
060	Leading Creek (RM 1.8, RM 3.5, and RM 7.2)	NN	Impacts seen on Leading Creek mainstem, particularly at RM 3.5, no impacts in Titus Run or Paulins Hill Run.
070	Thomas Fork (RM 1.2)	TP	TP of some concern in Thomas Fork with 13% of samples exceeding target.

The nutrient concerns in subwatersheds 010, 020, 050, and 070 are closely tied to the pathogen issues listed above, and are thought to be from failing HSTS and livestock operations. In Parker Run (subwatershed 040), there is some evidence of nutrient enrichment, but future monitoring may be needed to determine the specific sources. The potential sources of the NN issues seen on the Leading Creek mainstem in (subwatershed 060) have not been identified and will need additional investigation.

5.3 pH

Historic pre-law coal mining in the Leading Creek watershed has left several tributaries highly impaired by AMD and mine runoff. Though these effects are localized and do not directly affect the mainstem of Leading Creek, the impacts in the tributaries range from minor to severe. Because pH "loads" cannot be calculated, load duration analysis for this parameter was not completed. This subsection identifies the specific tributaries with pH values exceeding water quality standards. The numeric criterion for pH, as established by the Ohio EPA, is a range from 6.5 to 9.0 standard units (Ohio EPA, 1999). Specific details on the water quality impairments, AMD sources, and cost-benefit analyses of implementing various AMD treatment strategies can be found in the AMDAT Plan (Bauers et al., 2006).

Leading Creek tributaries with possible mine-related impairments were investigated by the Leading Creek Watershed Group and the range of pH values for each tributary is presented in Table 5-3.

Table 5-3. Initial tributary investigation - pH results.

Subwatershed	Stream Name	pH Range*
030	Mud Fork	6.08 to 6.75
040	Grass Run	6.23 to 6.81
040	Lasher Run	7.23 to 7.47
050	Little Leading Creek	6.43 to 7.65
060	Titus Run	5.83 to 7.00
060	Paulins Hill Run	3.18 to 5.36
070	Thomas Fork	2.58 to 7.60

*Ranges include measurements taken throughout the subwatershed.

From this investigation, three tributaries are noted as affected by mine runoff in the Leading Creek Watershed: Thomas Fork, Paulins Hill Run, and Titus Run. The AMDAT Plan focuses on Thomas Fork and Paulins Hill Run because the mine runoff impacts these two tributaries chemically, while Titus Run is primarily affected by mine sediments. Within Thomas Fork, several tributaries that are severely impaired with low pH values are of particular concern. These include an unnamed tributary on Bailey Run Road, two seeps (Kinzel's and Casto's), two underdrains (Venoy's and SR 124), Bailey Run, and Hysell Run (Bauers et al., 2006).

Fish and macroinvertebrate communities are limited, and in some locations completely absent, in Paulins Hill Run and Thomas Fork. These two tributaries are the most severely impaired by high acidity/low pH in the Leading Creek Watershed. The dewatering of the Meigs #31 Mine produces large volumes of mine water discharge in Parker Run, but the facility actively treats the discharge to decrease acidity and maintain an average pH near 8 standard units. While pH is not a problem with this discharge, there are still high TDS concentrations that remain a significant issue.

There are several projects listed in the AMDAT Plan (Bauers et al., 2006) that are recommended to address the most severe pH issues in the Leading Creek watershed. Both passive and active AMD treatment systems are recommended in several of the aforementioned tributaries. The Leading Creek Watershed Group is using the AMDAT Plan as a guidance document for prioritizing and addressing the AMD issues. The Watershed Group is currently working on funding for a preliminary design for a limestone doser that will address the number one acidity producing tributary in the Leading Creek watershed. The doser will be installed in an unnamed tributary that runs along Bailey Run Road in the Thomas Fork subwatershed to increase alkalinity and minimize the impacts on the receiving stream.

While no other AMD reclamation/remediation projects have been completed in the Leading Creek Watershed, the AMDAT Plan serves as an excellent guidance document for the future projects needed to address pH and other AMD associated issues.

6.0 IMPLEMENTATION AND MONITORING RECOMMENDATIONS

This section of the report provides implementation recommendations for the Leading Creek TMDL, focusing primarily on the widespread sediment/TSS impairments. Recommendations are also presented for addressing the needed TDS and chlorides reductions noted in Section 4.

6.1 Total Suspended Solids

With the exception of a few sampling stations, almost all of the load duration analyses identified some level of sediment reduction (using TSS as a surrogate for sediment). A majority of the reductions are needed during high and moist flow conditions, but there are additional needed reductions during dry and low flow conditions displayed at select sites. Table 6-1 summarizes all needed reductions in the Leading Creek watershed identified using load duration analysis.

Table 6-1. Needed TSS reductions derived from load duration analysis.

Sampling Site	Stream Name	High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
TM17	East Fork Headwaters	44%	30%	–	–	81%
TM16	West Fork Headwaters	37%	23%	–	–	74%
LCMS08	Leading Creek	53%	–	–	–	–
TM15	Fivemile Run	79%	80%	–	–	82%
LCMS07	Leading Creek	62%	–	–	–	–
TM14	Sharps Run	70%	75%	–	–	–
LCMS06	Leading Creek	91%	–	–	–	–
*TM13	Sisson Run	63%	76%	–	–	–
*TM12	Ogden Run	74%	80%	–	–	–
LCMS05	Leading Creek	64%	–	–	–	–
TM11	Dyesville Run	12%	50%	–	–	–
*TM10	Mud Fork	–	–	–	23%	59%
LCMS04	Leading Creek	74%	–	–	–	–
TM07	Parker Run	42%	–	–	–	–
TM06	Malloons Run	–	–	–	–	49%
LCMS03	Leading Creek	69%	–	–	–	–
TM05	Lasher Run	–	91%	–	–	–
*TM04	Little Leading Creek	70%	–	–	–	–
*TM03	Titus Run	–	41%	–	15%	–
LCMS02	Leading Creek	97%	–	–	–	–
*TM01	Thomas Fork	98%	–	–	–	–
LCMS01	Leading Creek	97%	–	–	–	–

Several of these streams (those marked with an *) are noted as significant sediment sources within the Leading Creek watershed and are severely degraded (Bauers, 2005). Detailed sediment analyses and recommended BMPs for each of these sites are provided in the subsections below. For all other sites, general discussion will be provided and several possible BMPs will be recommended.

The needed reductions at high and moist flow conditions correspond with wet weather events (rain and snow melt) and the associated erosional processes. Excessive TSS loads during higher flows may be reduced by minimizing the amount of bare or exposed land to erosion. Agricultural activities are most intensive in the upper portions of the Leading Creek watershed (Mud Fork and upstream) and minimal historic mining has occurred in the upper reaches. Areas of poorly managed pastureland, row crop agriculture, and missing riparian vegetation may all be contributing to TSS issues during wet weather events in the upper reaches of Leading Creek. The Leading Creek Management and Improvement Plans provide several recommendations for alleviating the sediment runoff associated with agricultural activities, pastureland management, and missing riparian vegetation.

The lower portion of the watershed also contains pockets of agriculture and pastureland, but has been intensively strip, auger, and deep mined in many areas. Historic mining practices in this watershed have left hundreds of acres of barren land exposed to erosion resulting in elevated TSS and sediment bed loads. Several reclamation strategies for these barren areas are provided in the Leading Creek Watershed Management Plan, AMDAT Plan, and the Leading Creek Improvement Plan.

Those sites with needed reductions at dry and low flow conditions may be influenced by one or more of the following: livestock access to streams, construction with poor sediment controls, off-road vehicle trails, agricultural drain tiles, or abandoned mine lands.

The remainder of the TSS section will focus on the targeted sediment source tributaries. Many of these streams have heavy sediment bed loads as a result of historic agricultural and/or mining land use practices. Excessive sediment in these streams is likely limiting aquatic biology where other, more severe impacts such as AMD are absent. The BMPs suggested below are meant to minimize additional watershed loading allowing the stream networks to flush out the existing sediment loads.

6.1.1 Sisson Run – AU 05030202 090 020 (Leading Creek below Fivemile Run to above Mud Fork)

6.1.1.1 Sediment Assessments and QHEI Data

The Meigs County Soil and Water Conservation District (SWCD) has performed extensive sediment monitoring in Sisson Run and the results indicate sediment may be a significant limiting factor for stream biota. Though sandy substrates are dominant, relatively stable bed and suspended sediment loads in Sisson Run indicate that sediment transport may be limited to high flow events. An average sediment depth of 1.9 feet smothers stream substrates and limits the stream's ability to transport excessive sediment loads.

Physical habitat in Sisson Run was assessed at river mile (RM) 0.1 and 2.6 using the Qualitative Habitat Evaluation Index (QHEI) and the results also suggest sediment impairments. Substrate metric scores range from 8.0 to 12.0 and riffle/run metrics scored 5.0 or lower. The entire substrate metric score range for all QHEIs obtained in Sisson Run falls below the 13.0 to 14.0 point benchmark score (Rankin, 2002). These scores indicate that stream substrates are dominated by sand and finer sized particles resulting in embeddedness and minimal habitat diversity.

6.1.1.2 Potential Sediment Sources

Agricultural practices (both historical and current), stream bank erosion, and natural geologic features are the probable significant sources of heavy sediment loads in Sisson Run (Bauers, 2005). Additional sediment may be derived from land subsidence resulting from historic long wall mining (Personal communication, Mary Ann Borch, Ohio Department of Natural Resources, 4/26/2007). Table 6-2 presents the land use/land cover statistics for the Sisson Run watershed. The dominant land cover is deciduous forest which comprises almost 70 percent of the watershed surface area. The second most common land cover is pasture/hay at just under 25 percent. Pastureland in Sisson Run is often poorly managed and livestock have open access to many stream segments (Bauers, 2005). Without restrictive barriers or fencing, significant erosion may result as livestock trample riparian vegetation and destabilize stream banks. Soil loss from pastureland produces an estimated 958 tons of sediment per year, of which 211 tons are delivered to Sisson Run (Table 6-2). In addition to watershed loading, there are nearly 4,000 feet of eroding stream banks between RM 0.5 and 1.3, contributing an estimated 190 tons of sediment per year to Sisson Run (Bauers, 2005). The total estimated sediment load in Sisson Run (watershed loading plus streambank erosion loading) is 566 tons/year.

Table 6-2. Land Cover/Land Use within the Sisson Run subwatershed and associated estimates of sediment loading.

Land Cover / Land Use	Area (acres)	Area (sq. mi.)	Percent of Watershed	Estimated Soil Loss[1] (tons/year)	Sediment Delivered to Stream[2] (tons/year)
Developed, Open Space[3]	182.97	0.29	5.0%	244	54
Developed, Low Intensity[3]	15.44	0.02	0.4%	5	1
Deciduous Forest	2,452.63	3.83	67.4%	272	60
Evergreen Forest	11.76	0.02	0.3%	1	0
Shrub/Scrub	11.14	0.02	0.3%	8	2
Grasslands/Herbaceous	59.98	0.09	1.7%	44	10
Pasture/Hay	893.17	1.40	24.5%	958	211
Cultivated Crops (Conventional Tillage)[4]	7.713	0.01	0.2%	123	27
Cultivated Crops (No Till)[4]	7.713	0.01	0.2%	51	11
Total	**3,642.52**	**5.69**	**100.0%**	**1,707**	**376**

[1] Soil loss estimated using the Universal Soil Loss Equation (USLE).
[2] Value derived using a delivery ratio of 0.22 (Vanoni, 1975).
[3] USLE not applied to impervious portions of land cover; soil loss and delivery values have been adjusted accordingly.
[4] Assuming 50% of cultivated crops land cover managed by conventional tillage and 50% by no till practices.

6.1.1.3 Recommended BMPs

Streambank erosion and pasture lands are the largest sources of sediment in Sisson Run. To reduce the excessive sediment loads associated with these sources the following BMPs are recommended:

- Cattle exclusion from streams (e.g., fencing)
- Grazing land protection

The estimated sediment load reductions for each recommended BMP are provided in Table 6-3.

Table 6-3. Potential effectiveness of the recommended BMPs for Sisson Run.

BMP	Description and Removal Mechanism	Estimated Sediment Reductions
Livestock exclusion from streams	Placement of fencing between the livestock grazing area and stream channel. Reduces riparian vegetation trampling and streambank destabilization.	50 percent decrease in annual sediment concentration and 40 percent decrease in annual soil loss [1]
Grazing land protection	Use of cover crop or rotational grazing patterns to maximize ground cover and reduce soil compaction.	88 percent reduction in sediment loading assuming increased ground cover from 60 percent to 95 percent [2]

[1] Owens, LB; Edwards, WM; Van Keuren, RW. 1996. Sediment losses from a pastured watershed before and after stream fencing. Journal of Soil and Water Conservation. Vol. 51, no. 1, pp. 90-94.
[2] Haith, D.A., R. Mandel, and R.S. Wu. 1992. GWLF, Generalized Watershed Loading Functions, Version 2.0, User's Manual. Dept. of Agricultural & Biological Engineering, Cornell University, Ithaca, NY.

If the recommended BMPs are implemented, a total soil loss reduction of 26 percent may be achieved in the Sisson Run watershed (Table 6-4). The soil loss reductions could prevent as much as 169 tons of sediment per year from entering Sisson Run, which is a significant portion of the load identified (30 percent) in the sediment analysis. Though TSS does not directly translate to a sediment load, this analysis will use TSS as a surrogate to allow for comparisons between the calculated TMDL in Section 4 and the estimated sediment load reductions listed below.

While the 30 percent reductions would prevent a significant amount of sediment from entering Sisson Run, TSS reductions of 63 and 76 percent are needed in Sisson Run during high and moist flow conditions, respectively (Table 4-10). The current analysis suggests that other efforts, not yet identified, are needed to achieve the TMDL load reductions. It is recommended that the most cost-effective controls be put in place first, with continued monitoring to confirm progress and refine the load reduction estimates as needed.

Table 6-4. Estimated sediment load reductions for Sisson Run.

Source	Existing Soil Loss (tons/year)	Proposed BMP	Percent of Watershed BMP Applied To	Effectiveness	Post-BMP Soil Loss (tons/year)	Sediment Delivered to Stream (tons/year)[1]
Forest	273	None	0%	0%	273	60
Pasture/Hay	958	Grazing Land Protection	50%	88%	536	118
Streambank Erosion	190	Livestock Exclusion-Fencing	100%	40%	114	114
Other Land Cover in Watershed	476	None	0%	0%	476	105
Total	**1,897**				**1,399**	**397**
Potential BMP Sediment Reductions:		498 Tons of Soil Loss per Year		26% Reduction in Soil Loss	30% Reduction in Sediment Delivered to Sisson Run	

[1] Value derived using a delivery ratio of 0.22 (Vanoni, 1975).

6.1.2 Ogden Run – AU 05030202 090 020 (Leading Creek below Fivemile Run to above Mud Fork)

6.1.2.1 Sediment Assessments and QHEI Data

Ogden Run is noted as a severely sediment impaired subwatershed and an average sediment depth of 1.9 feet smothers stream substrates limiting the stream's ability to transport excessive sediment loads (Bauers, 2005).

Physical habitat in Ogden Run was assessed near the mouth at river mile 0.2 using the QHEI. The two overall QHEI scores, as well as the metric scores, suggest severe sediment impairments. Substrate metric scores range from 9.0 to 10.5 and riffle/run metrics scored 4.0 or lower. All substrate metric scores in Ogden Run fall below the 13.0 to 14.0 point benchmark score (Rankin, 2002) and are indicative of stream substrates dominated by sand and finer-sized particles resulting in embeddedness and minimal habitat diversity.

6.1.2.2 Potential Sediment Sources

Historical agricultural practices, current pasture/grazing practices, stream bank erosion, and natural geologic features are the probable significant sources of heavy sediment loads in Ogden Run (Bauers, 2005). Additional sediment may be derived from land subsidence resulting from historic long wall mining (Personal communication, Mary Ann Borch, Ohio Department of Natural Resources, 4/26/2007). Table 6-5 presents the land use/land cover statistics for the Ogden Run watershed. The dominant land cover is deciduous forest which comprises nearly 62 percent of the watershed surface area. The second most common land cover is pasture/hay at just under 26 percent. About 167 acres of cultivated crops make up an additional 4 percent of the watershed.

Pastureland in Ogden Run is poorly managed in some areas and livestock have open access to many stream segments (Bauers, 2005). Unrestricted livestock access to Ogden Run occurs in areas of the headwaters to RM 3.87 and from RM 2.11 to 1.00. Additional livestock access occurs in a tributary that is confluent with Ogden Run at RM 1.21. Without restrictive barriers or fencing, significant erosion may result as livestock trample riparian vegetation and destabilize stream banks.

GIS analysis and USLE calculation show cultivated crops and pastureland as potentially being the largest source of watershed loading in Ogden Run (Table 6-5). Soil loss from cultivated crops (conventional tillage) is estimated at 1,116 tons/year resulting in 212 tons of sediment delivered to Ogden Run per year. Pastureland loses an estimated 1,076 tons of sediment per year of which 204 tons are delivered to Ogden Run. Compounding watershed loading issues are the nearly 21,000 feet of stream banks missing riparian buffers throughout the subwatershed (Bauers, 2005). The total estimated sediment load received by Ogden Run (watershed loading only) is 715 tons/year.

Table 6-5. Land Cover/Land Use within the Ogden Run subwatershed and associated estimates of sediment loading.

Land Cover / Land Use	Area (Acres)	Area (Sq. Miles)	Percent of Watershed	Estimated Soil Loss[1] (tons/year)	Sediment Delivered to Stream[2] (tons/year)
Open Water	5.81	0.01	0.1%	0	0
Developed, Open Space[3]	224.42	0.35	4.8%	251	48
Developed, Low Intensity[3]	2.22	0.00	0.0%	1	0
Developed, Medium Intensity[3]	1.56	0.00	0.0%	0	0
Developed, High Intensity[3]	3.93	0.01	0.1%	0	0
Barren Land (Rock/Sand/Clay)	26.57	0.04	0.6%	513	97
Deciduous Forest	2877.83	4.50	61.5%	269	51
Evergreen Forest	65.52	0.10	1.4%	6	1
Shrub/Scrub	35.56	0.06	0.7%	22	4
Grasslands/Herbaceous	80.15	0.13	1.7%	50	9
Pasture/Hay	1191.98	1.86	25.5%	1,076	204
Cultivated Crops (Conventional Tillage)[4]	83.37	0.13	1.8%	1,116	212
Cultivated Crops (No Till)[4]	83.37	0.13	1.8%	467	89
Total	**4682.29**	**7.32**	**100.0%**	**3,771**	**715**

[1] Soil loss estimated using the Universal Soil Loss Equation (USLE).
[2] Value derived using a delivery ratio of 0.19 (Vanoni, 1975).
[3] USLE not applied to impervious portions of land cover; soil loss and delivery values have been adjusted accordingly.
[4] Assuming 50% of cultivated crops land cover managed by conventional tillage and 50% by no till practices.

6.1.2.3 Recommended BMPs

Cultivated crops and pasture lands are the largest estimated sources of sediment in Ogden Run. Livestock access and missing riparian buffers in several areas may also be contributing to streambank erosion. To reduce the excessive sediment loads associated with these land use practices, the following BMPs are recommended:

- Conservation tillage
- Grazing land protection
- Cattle exclusion from streams (e.g., fencing)
- Restoration of riparian buffers

The estimated sediment load reductions for each recommended BMP are provided in Table 6-6.

Table 6-6. Potential effectiveness of the recommended BMPs for Ogden Run.

BMP	Description and Removal Mechanism	Estimated Sediment Reductions
Livestock Exclusion from Streams	Placement of fencing between the livestock grazing area and stream channel. Reduces riparian vegetation trampling and streambank destabilization.	50 percent decrease in annual sediment concentration and 40 percent decrease in annual soil loss [1]
Grazing Land Protection	Use of cover crop or rotational grazing patterns to maximize ground cover and reduce soil compaction.	88 percent reduction in sediment loading assuming increased ground cover from 60 percent to 95 percent [2]
Conservation Tillage	Reduced tillage practice with a minimum of 30 percent cover of crop residuals. Reduces erosion rates and phosphorus losses. Increases soil quality by providing organic material and nutrient supplementation.	75 to 88 percent reduction in soil loss rates [4; 5,] respectively
Restoration of Riparian Buffers	Conversion of land adjacent to stream channels to vegetated buffer zones. Removes pollutants by sedimentation and plant uptake. Provides stream bank stability, stream shading, and aesthetic enhancement.	97 percent removal of sediment from treated area, assuming a 90 ft buffer width [5]

[1] Owens, LB; Edwards, WM; Van Keuren, RW. 1996. Sediment losses from a pastured watershed before and after stream fencing. Journal of Soil and Water Conservation. Vol. 51, no. 1, pp. 90-94.
[2] Haith, D.A., R. Mandel, and R.S. Wu. 1992. GWLF, Generalized Watershed Loading Functions, Version 2.0, User's Manual. Dept. of Agricultural & Biological Engineering, Cornell University, Ithaca, NY.
[3] U.S. EPA. 2003. National Management Measures to Control Nonpoint Source Pollution from Agriculture. EPA 841-B-03-004, July 2003.
[4] USDA. 2004. Illinois Conservation Reserve Enhancement Program, Final, Programmatic Environmental Assessment June 3, 2004. Prepared by the U.S. Department of Agriculture, Farm Service Agency in partnership with the USDA Natural Resources Conservation Service, Illinois Department of Natural Resources, Illinois Department of Agriculture, Illinois Environmental Protection Agency, County Soil and Water Conservation Districts and Association of Illinois Soil and Water Conservation Districts.
[5] NCSU. 2002. Riparian Buffers and Controlled Drainage to Reduce Agricultural Nonpoint Source Pollution. Departments of Soil Science and Biological and Agricultural Engineering, North Carolina Agricultural Research Service, North Carolina State University Raleigh, North Carolina. Technical Bulletin 318, September 2002.

If the recommended BMPs are implemented, a total soil loss reduction of 30 percent may be achieved in the Ogden Run watershed (Table 6-7). These reductions could prevent as much as 212 tons of sediment per year from entering Ogden Run which is a significant portion of the watershed load identified (30 percent) in the sediment analysis. Though TSS does not directly translate to a sediment load, this analysis will use TSS as a surrogate to allow for comparisons between the calculated TMDL in Section 4 and the estimated sediment load reductions listed below.

While the 30 percent reductions would prevent a significant amount of sediment from entering Ogden Run, TSS reductions of 74 and 80 percent are needed during high and moist flow conditions, respectively (Table 4-11). The current analysis suggests that other efforts, not yet identified, are needed to achieve the TMDL load reductions for Ogden Run. It is recommended that the most cost-effective controls be put in place first, with continued monitoring to confirm progress and refine the load reduction estimates as needed.

Table 6-7. Estimated sediment load reductions for Ogden Run.

Source	Existing Soil Loss (tons/year)	Proposed BMP	Percent of Watershed BMP Applied To	Effectiveness	Post-BMP Soil Loss (tons/year)	Sediment Delivered to Stream (tons/year)[1]
Forest	275	None	0%	0%	275	52
Pasture/Hay	1,076	Grazing Land Protection	50%	88%	603	114
Streambank Erosion	Unknown	Livestock Exclusion-Fencing	Unknown	40%	Unknown	Unknown
Cultivated Crops (Conventional Tillage)	1,116	Conservation Tillage	50%	75%	698	133
Other Land Cover in Watershed	1,304	Riparian Buffer Restoration	18%[2]	97%	1,076	205
Total	**3,771**				**2,651**	**504**
Potential BMP Sediment Reductions:		1,120 Tons of Soil Loss per Year		30% Reduction in Soil Loss	30% Reduction in Sediment Delivered to Ogden Run	

[1] Value derived using a delivery ratio of 0.19 (Vanoni, 1975).
[2] Assumes buffers are effective for 300 feet adjacent to both stream banks, and that buffers are placed on all stream banks in Ogden Run.

6.1.3 Mud Fork- AU 05030202 090 030

6.1.3.1 Sediment Assessments and QHEI Data

Mud Fork streambed sediment depths average 2.6 feet and bed load transport is estimated to range from 7.38 to 30.19 lbs/day (Bauers, 2005). The excessive sediment bed loads severely impair the habitat of this subwatershed by smothering stream substrates and minimizing overall habitat quality (Bauers, 2005).

Physical habitat in Mud Fork was assessed near the mouth at river miles 0.2 and 0.8 using the QHEI. The three overall QHEI scores, as well as the individual metric scores, suggest severe habitat impairments. Substrate metric scores range from 6.0 to 9.0 and all three riffle/run metric scores were zero indicating shallow, unstable riffles with extensive embeddedness or poor/no riffle development at all. All substrate metric scores in Mud Fork fall below the 13.0 to 14.0 point benchmark score (Rankin, 2002) and are indicative of stream substrates dominated by sand and finer-sized particles resulting in minimal habitat diversity.

The Meigs County SWCD has performed extensive sediment monitoring in Mud Fork. Results indicate that the significant sediment bedloads and extreme streambed fluctuations may be limiting the aquatic communities of Mud Fork.

6.1.3.2 Potential Sediment Sources

Historical strip mining in the headwater reaches, current and historical agricultural practices, stream channel erosion, and natural geologic features are the likely significant sources of sediment loads in Mud Fork (Bauers, 2005; Cherry et al., 1999). Table 6-8 presents the land use/land cover statistics for the Mud

Fork watershed. The dominant land cover is deciduous forest which comprises nearly 70 percent of the watershed surface area. The second most common land cover is pasture/hay at just under 21 percent. About 180 acres of cultivated crops make up an additional 2 percent of the watershed.

As noted in the Watershed Management Plan, there are areas of unrestricted livestock access to Mud Fork that occur on the mainstem from RM 6.90 to 5.59 and also in areas from RM 4.74 to 2.58. Tributaries at RM 2.25 and RM 1.15 also have areas of livestock access to streams. Without restrictive barriers or fencing, significant erosion may result as livestock trample riparian vegetation and destabilize stream banks.

Historical strip mining in the headwaters of Mud Fork caused large areas of barren land to be exposed and even though reclamation efforts have addressed many of these issues, heavy residual sediment loads remain. It is important to note that a large portion of the sediment issue in Mud Fork is caused by sediment already in the stream channel that has persisted from mining and other historic land uses. Beaver dams and channelization/modification of Mud Fork near RM 0.3 to 0.7 may also be limiting the ability of the stream to transport sediment downstream (Bauers, 2005).

An analysis of current watershed loading shows pastureland and cultivated crops as the largest potential source of upland sediment loads in Mud Fork (Table 6-8). Pastureland loses an estimated 1,409 tons of sediment per year of which 225 tons are delivered to Mud Fork. Soil loss from cultivated crops (conventional tillage) is estimated at 1,061 tons/year resulting in 170 tons of sediment delivered to Mud Fork per year. Compounding watershed loading issues are more than 35,000 feet of stream banks missing riparian buffers throughout the subwatershed (Bauers, 2005). The total estimated sediment load received by Mud Fork from the surrounding watershed is 660 tons/year.

Table 6-8. Land Cover/Land Use within the Mud Fork subwatershed and associated estimates of sediment loading.

Land Cover / Land Use	Area (Acres)	Area (Sq. Miles)	Percent of Watershed	Estimated Soil Loss[1] (tons/year)	Sediment Delivered to Stream[2] (tons/year)
Open Water	12.60	0.02	0.1%	0	0
Developed, Open Space[3]	417.63	0.65	4.9%	414	66
Developed, Low Intensity[3]	9.31	0.01	0.1%	2	0
Barren Land (Rock/Sand/Clay)	14.31	0.02	0.2%	244	39
Deciduous Forest	5,902.64	9.22	69.4%	487	78
Evergreen Forest	82.04	0.13	1.0%	7	1
Shrub/Scrub	49.98	0.08	0.6%	27	4
Grasslands/Herbaceous	56.93	0.09	0.7%	31	5
Pasture/Hay	1,766.91	2.77	20.8%	1,409	225
Cultivated Crops (Conventional Tillage)[4]	89.68	0.14	1.1%	1,061	170
Cultivated Crops (No Till)[4]	89.68	0.14	1.1%	444	71
Emergent Herbaceous Wetlands	1.68	0.00	0.0%	1	0
Total	**8,493.39**	**13.27**	**100.0%**	**4,127**	**660**

[1] Soil loss estimated using the Universal Soil Loss Equation (USLE).
[2] Value derived using a delivery ratio of 0.16 (Vanoni, 1975).
[3] USLE not applied to impervious portions of land cover; soil loss and delivery values have been adjusted accordingly.
[4] Assuming 50% of cultivated crops land cover managed by conventional tillage and 50% by no till practices.

6.1.3.3 Recommended BMPs

Due to the large amounts of accumulated sediment in Mud Fork, the following BMPs are recommended to minimize additional sediment loading from upland watershed sources. Pasture lands and cultivated crops are the largest estimated watershed sources of sediment in Mud Fork. Livestock access and missing riparian buffers in several areas may also be contributing to streambank erosion and sediment loads. To reduce the excessive sediment loads associated with these land use practices, the following BMPs are recommended:

- Conservation tillage
- Grazing land protection
- Cattle exclusion from streams (e.g., fencing)
- Restoration of riparian buffers

Riparian buffer establishment/restoration and fencing are also mentioned as needed sediment mitigation projects in the Leading Creek Improvement Plan (Cherry et al., 1999). The estimated sediment load reductions for each recommended BMP are provided in Table 6-9.

Table 6-9. Potential effectiveness of the recommended BMPs for Mud Fork.

BMP	Description and Removal Mechanism	Estimated Sediment Reductions
Livestock Exclusion from Streams	Placement of fencing between the livestock grazing area and stream channel. Reduces riparian vegetation trampling and streambank destabilization.	50 percent decrease in annual sediment concentration and 40 percent decrease in annual soil loss [1]
Grazing Land Protection	Use of cover crop or rotational grazing patterns to maximize ground cover and reduce soil compaction.	88 percent reduction in sediment loading assuming increased ground cover from 60 percent to 95 percent [2]
Conservation Tillage	Reduced tillage practice with a minimum of 30 percent cover of crop residuals. Reduces erosion rates and phosphorus losses. Increases soil quality by providing organic material and nutrient supplementation.	75 to 88 percent reduction in soil loss rates [3; 4,] respectively
Restoration of Riparian Buffers	Conversion of land adjacent to stream channels to vegetated buffer zones. Removes pollutants by sedimentation and plant uptake. Provides stream bank stability, stream shading, and aesthetic enhancement.	97 percent removal of sediment from treated area, assuming a 90 ft buffer width [5]

[1] Owens, LB; Edwards, WM; Van Keuren, RW. 1996. Sediment losses from a pastured watershed before and after stream fencing. Journal of Soil and Water Conservation. Vol. 51, no. 1, pp. 90-94.
[2] Haith, D.A., R. Mandel, and R.S. Wu. 1992. GWLF, Generalized Watershed Loading Functions, Version 2.0, User's Manual. Dept. of Agricultural & Biological Engineering, Cornell University, Ithaca, NY.
[3] U.S. EPA. 2003. National Management Measures to Control Nonpoint Source Pollution from Agriculture. EPA 841-B-03-004, July 2003.
[4] USDA. 2004. Illinois Conservation Reserve Enhancement Program, Final, Programmatic Environmental Assessment June 3, 2004. Prepared by the U.S. Department of Agriculture, Farm Service Agency in partnership with the USDA Natural Resources Conservation Service, Illinois Department of Natural Resources, Illinois Department of Agriculture, Illinois Environmental Protection Agency, County Soil and Water Conservation Districts and Association of Illinois Soil and Water Conservation Districts.
[5] NCSU. 2002. Riparian Buffers and Controlled Drainage to Reduce Agricultural Nonpoint Source Pollution. Departments of Soil Science and Biological and Agricultural Engineering, North Carolina Agricultural Research Service, North Carolina State University Raleigh, North Carolina. Technical Bulletin 318, September 2002.

If the recommended BMPs are implemented, a total soil loss reduction of 29 percent may be achieved in the Mud Fork watershed (Table 6-10). These reductions could prevent as much as 191 tons of sediment per year from entering Mud Fork which is a significant portion of the watershed load identified (29 percent) in the sediment analysis. Though TSS does not directly translate to a sediment load, this analysis will use TSS as a surrogate to allow for comparisons between the calculated TMDL in Section 4 and the estimated sediment load reductions listed below.

While the 29 percent reductions would prevent a significant amount of sediment from entering Mud Fork, TSS reductions of 23 and 59 percent are needed during dry and low flow conditions, respectively (Table 4-15). The current analysis suggests that other efforts, not yet identified, are needed to achieve the TMDL load reductions for Mud Fork. It is recommended that the most cost-effective controls be put in place first, with continued monitoring to confirm progress and refine the load reduction estimates as needed.

Table 6-10. Estimated sediment load reductions for Mud Fork.

Source	Existing Soil Loss (tons/year)	Proposed BMP	Percent of Watershed BMP Applied To	Effectiveness	Post-BMP Soil Loss (tons/year)	Sediment Delivered to Stream (tons/year)[1]
Forest	494	None	0%	0%	494	79
Pasture/Hay	1,409	Grazing Land Protection	50%	88%	789	126
Streambank Erosion	Unknown	Livestock Exclusion-Fencing	Unknown	40%	Unknown	Unknown
Cultivated Crops (Conventional Tillage)	1,061	Conservation Tillage	50%	75%	663	106
Other Land Cover in Watershed	1,163	Riparian Buffer Restoration	16%[2]	97%	983	157
Total	**4,127**				**2,929**	**469**
Potential BMP Sediment Reductions:		1,198 Tons of Soil Loss per Year		29% Reduction in Soil Loss	29% Reduction in Sediment Delivered to Mud Fork	

[1] Value derived using a delivery ratio of 0.16 (Vanoni, 1975).
[2] Assumes buffers are effective for 300 feet adjacent to both stream banks, and that buffers are placed on all stream banks in Mud Fork.

6.1.4 Little Leading Creek- AU 05030202 090 050

6.1.4.1 Sediment Assessments and QHEI Data

Little Leading Creek is the top ranked restoration tributary in the Leading Creek Improvement Plan (Cherry et al., 1999) due to its streambed sediment depths of 1.0 to 1.9 feet, extensive abandoned strip mines, and its influence on the mainstem of Leading Creek. The sediment loads from Little Leading Creek are the largest source of sediment load on the Leading Creek mainstem (Cherry et al., 1999). While the mouth is the most affected with several feet of sand inundating stream substrates, excessive sedimentation is a significant concern along the entire mainstem of Little Leading Creek (Bauers, 2005).

The excessive sediment bed loads severely impair the habitat of this subwatershed by smothering stream substrates, minimizing overall habitat quality, and likely limiting the aquatic biota.

Physical habitat in Little Leading Creek was assessed near the mouth at river miles 0.2 and 0.4, as well as further upstream at RM 2.4 and RM 9.4 using the QHEI. The 5 overall QHEI scores, as well as the individual metric scores, suggest severe habitat impairments. Substrate metric scores averaged 8.0 points and riffle/run metric scores averaged 1.5, indicating shallow, unstable riffles with extensive embeddedness or poor/no riffle development at all. All substrate metric scores in Little Leading Creek fall below the 13.0 to 14.0 point benchmark score (Rankin, 2002) and are indicative of stream substrates dominated by sand and finer-sized particles resulting in minimal habitat diversity.

The Meigs County SWCD has performed extensive sediment monitoring in Little Leading Creek and numerous studies have been and are currently being performed by faculty and students of Ohio University and Virginia Tech.

6.1.4.2 Potential Sediment Sources

Several hundred acres of historical strip mining throughout the watershed, current agricultural practices (cultivated crops, overgrazing, and mismanaged pasturelands), severe stream bank erosion, and natural geologic features are the likely significant sources of sediment loads in Little Leading Creek (Bauers, 2005; Cherry et al., 1999). Table 6-11 presents the land use/land cover statistics for the Little Leading Creek watershed. The dominant land cover is deciduous forest which comprises nearly 75 percent of the watershed surface area. The second most common land cover is pasture/hay at just under 17 percent. About 65 acres of cultivated crops make up an additional 0.1 percent of the watershed.

As noted in the Watershed Management Plan, there are numerous areas of unrestricted livestock access to Little Leading Creek and its tributaries. Many of these areas occur along the mainstem from RM 5.25 to RM 10.81, as well as numerous tributaries along this section. Livestock also have access to Little Leading Creek near the mouth from RM 0.95 to the confluence with Leading Creek. Without restrictive barriers or fencing, significant erosion may result as livestock trample riparian vegetation and destabilize stream banks.

Another significant source of sediment in Little Leading Creek watershed is streambank and channel erosion. Compounding both watershed loading issues and sediment derived from stream banks are areas with missing riparian vegetation. Over 60,000 feet of riparian buffers are missing along the mainstem and tributaries of the watershed (Bauers, 2005).

Historical strip mining throughout Little Leading Creek caused large areas of barren land and mining waste to be exposed and even though reclamation efforts have successfully addressed many of these issues, residual sediment loads are still being flushed from the tributaries and mainstem. It is important to note that a large portion of the sediment issue in Little Leading Creek is caused by sediment already in the stream channel that has persisted from mining practices.

An analysis of current watershed loading shows that pastureland, deciduous forest, developed open space, barren land, and cultivated crops (conventional tillage) are the largest potential sources of upland sediment loads in Little Leading Creek (Table 6-11). Deciduous forest displays a large amount of soil loss due to its large proportion of the total area, but likely has minimal/no impact when compared to other land cover categories. Developed open space is likely found in small pockets throughout the watershed (e.g., small towns, villages, and farms) and soil loss values may be overestimated since this land cover category is not associated with highly intense disturbance in this watershed. Because deciduous forest

and developed open areas are not likely significant sources of sediment, the remainder of this analysis will focus on pastureland, barren land, and cultivated crops.

Pastureland loses an estimated 2,717 tons of sediment per year of which 380 tons per year are delivered to Little Leading Creek. Soil loss from barren land produces 864 tons of soil loss per year and 121 tons of sediment from these areas is delivered to Little Leading Creek. Cultivated crops (conventional tillage) lose an estimated 488 tons/year resulting in 68 tons of sediment delivered per year. The total estimated sediment load received by Little Leading Creek from the surrounding watershed is 960 tons/year.

Table 6-11. Land Cover/Land Use within the Little Leading Creek subwatershed and associated estimates of sediment loading.

Land Cover / Land Use	Area (Acres)	Area (Sq. Miles)	Percent of Watershed	Estimated Soil Loss[1] (tons/year)	Sediment Delivered to Stream[2] (tons/year)
Developed, Open Space[3]	881.57	1.38	5.4	1,094	153
Developed, Low Intensity[3]	107.95	0.17	0.7	32	4
Developed, Medium Intensity[3]	8.61	0.01	0.1	1	0
Barren Land (Rock/Sand/Clay)	40.40	0.06	0.2	864	121
Deciduous Forest	12,237.79	19.12	74.6	1,267	177
Evergreen Forest	37.21	0.06	0.2	4	1
Mixed Forest	9.76	0.02	0.1	1	0
Shrub/Scrub	46.61	0.07	0.3	32	4
Grasslands/Herbaceous	226.84	0.35	1.4	156	22
Pasture/Hay	2,717.27	4.25	16.6	2,717	380
Cultivated Crops (Conventional Tillage)[4]	32.92	0.05	0.2	488	68
Cultivated Crops (No Till)[4]	32.92	0.05	0.2	204	29
Total	**16,379.85**	**25.59**	**100.0**	**6,860**	**960**

[1] Soil loss estimated using the Universal Soil Loss Equation (USLE).
[2] Value derived using a delivery ratio of 0.14 (Vanoni, 1975).
[3] USLE not applied to impervious portions of land cover; soil loss and delivery values have been adjusted accordingly.
[4] Assuming 50% of cultivated crops land cover managed by conventional tillage and 50% by no till practices.

6.1.4.3 Recommended BMPs

Due to the large amounts of accumulated sediment within the Little Leading Creek stream channel, the following BMPs are recommended to minimize sediment loading from upland watershed sources. Pasture land, barren land, and cultivated crops are the largest estimated watershed sources of sediment in Little Leading Creek. Livestock access and missing riparian buffers in several areas may also be contributing to streambank erosion and further elevating sediment loads. To reduce the excessive sediment loads associated with these land use practices, the following BMPs are recommended:

- Conservation tillage
- Grazing land protection
- Cattle exclusion from streams (e.g., fencing)
- Restoration of riparian buffers
- Abandoned mine land/barren land/gob pile reclamation

Detailed projects and site descriptions are provided in the Watershed Management Plan and also in the Leading Creek Improvement Plan (Cherry et al., 1999). Several mine reclamation strategies are presented in the Leading Creek Improvement Plan, but specific project areas have yet to be identified (Bauers, 2005) so this analysis will only cover the first four recommended BMPs. The estimated sediment load reductions for each recommended BMP are provided in Table 6-12.

Table 6-12. Potential effectiveness of the recommended BMPs for Mud Fork.

BMP	Description and Removal Mechanism	Estimated Sediment Reductions
Livestock Exclusion from Streams	Placement of fencing between the livestock grazing area and stream channel. Reduces riparian vegetation trampling and streambank destabilization.	50 percent decrease in annual sediment concentration and 40 percent decrease in annual soil loss [1]
Grazing Land Protection	Use of cover crop or rotational grazing patterns to maximize ground cover and reduce soil compaction.	88 percent reduction in sediment loading assuming increased ground cover from 60 percent to 95 percent [2]
Conservation Tillage	Reduced tillage practice with a minimum of 30 percent cover of crop residuals. Reduces erosion rates and phosphorus losses. Increases soil quality by providing organic material and nutrient supplementation.	75 to 88 percent reduction in soil loss rates [3; 4,] respectively
Restoration of Riparian Buffers	Conversion of land adjacent to stream channels to vegetated buffer zones. Removes pollutants by sedimentation and plant uptake. Provides stream bank stability, stream shading, and aesthetic enhancement.	97 percent removal of sediment from treated area, assuming a 90 ft buffer width [5]

[1] Owens, LB; Edwards, WM; Van Keuren, RW. 1996. Sediment losses from a pastured watershed before and after stream fencing. Journal of Soil and Water Conservation. Vol. 51, no. 1, pp. 90-94.
[2] Haith, D.A., R. Mandel, and R.S. Wu. 1992. GWLF, Generalized Watershed Loading Functions, Version 2.0, User's Manual. Dept. of Agricultural & Biological Engineering, Cornell University, Ithaca, NY.
[3] U.S. EPA. 2003. National Management Measures to Control Nonpoint Source Pollution from Agriculture. EPA 841-B-03-004, July 2003.
[4] USDA. 2004. Illinois Conservation Reserve Enhancement Program, Final, Programmatic Environmental Assessment June 3, 2004. Prepared by the U.S. Department of Agriculture, Farm Service Agency in partnership with the USDA Natural Resources Conservation Service, Illinois Department of Natural Resources, Illinois Department of Agriculture, Illinois Environmental Protection Agency, County Soil and Water Conservation Districts and Association of Illinois Soil and Water Conservation Districts.
[5] NCSU. 2002. Riparian Buffers and Controlled Drainage to Reduce Agricultural Nonpoint Source Pollution. Departments of Soil Science and Biological and Agricultural Engineering, North Carolina Agricultural Research Service, North Carolina State University Raleigh, North Carolina. Technical Bulletin 318, September 2002.

If the recommended BMPs are implemented, a total soil loss reduction of 25 percent may be achieved in the Little Leading Creek watershed (Table 6-13). These reductions could prevent as much as 244 tons of sediment per year from entering Little Leading Creek which is a significant portion of the watershed load identified (25 percent) in the sediment analysis. Though TSS does not directly translate to a sediment load, this analysis will use TSS as a surrogate to allow for comparisons between the calculated TMDL in Section 4 and the estimated sediment load reductions listed below.

While the 25 percent reductions would prevent a significant amount of sediment from entering Little Leading Creek, TSS reductions of 70 percent are needed during high flow conditions (Table 4-27). The current analysis suggests that other efforts, not yet identified, are needed to achieve the TMDL load reductions for Little Leading Creek. It is recommended that the most cost-effective controls be put in

place first, with continued monitoring to confirm progress and refine the load reduction estimates as needed.

Table 6-13. Estimated sediment load reductions for Little Leading Creek.

Source	Existing Soil Loss (tons/year)	Proposed BMP	Percent of Watershed BMP Applied To	Effectiveness	Post-BMP Soil Loss (tons/year)	Sediment Delivered to Stream (tons/year)[1]
Forest	1,267	None	0%	0%	1,267	177
Pasture/Hay	2,717	Grazing Land Protection	50%	88%	1,522	213
Streambank Erosion	Unknown	Livestock Exclusion-Fencing	Unknown	40%	Unknown	Unknown
Cultivated Crops (Conventional Tillage)	488	Conservation Tillage	50%	75%	305	43
Barren Land	Unknown	Abandoned Mine Reclamation	Unknown	Unknown	Unknown	Unknown
Other Land Cover in Watershed	2,388	Riparian Buffer Restoration	16%[2]	97%	2,017	282
Total	**6,860**				**5,111**	**716**
Potential BMP Sediment Reductions:		1,749 Tons of Soil Loss per Year		25% Reduction in Soil Loss	25% Reduction in Sediment Delivered to Mud Fork	

[1] Value derived using a delivery ratio of 0.14 (Vanoni, 1975).
[2] Assumes buffers are effective for 300 feet adjacent to both stream banks, and that buffers are placed on all stream banks in Little Leading Creek.

6.1.5 Titus Run - AU 05030202 090 060

6.1.5.1 Sediment Assessments and QHEI Data

Titus Run stream substrates are smothered in sediment depths of 1.8 to > 4.0 feet. Extensive sediment studies performed by the Meigs SWCD showed that shifting stream substrates indicate sediment transport downstream (Bauers, 2005). The excessive sediment bed loads severely impair the habitat of this subwatershed by smothering stream substrates and minimizing overall habitat quality. Physical habitat in Titus Run was assessed near the mouth at river mile 0.2 using the QHEI. The two total QHEI scores suggest some degree of habitat degradation with an average of 53 points.

6.1.5.2 Potential Sediment Sources

An estimated 44 acres of unreclaimed strip mines, additional poorly reclaimed abandoned mine areas, agricultural practices, and stream bank erosion are the likely significant sources of sediment loads in the Titus Run subwatershed (Bauers, 2005 and Cherry et al., 1999). Table 6-14 presents the land use/land cover statistics for the Titus Run watershed. The dominant land cover is deciduous forest which comprises nearly 87 percent of the watershed surface area. The second most common land cover is pasture/hay at just under 7 percent. Forty-four acres of barren land makes up about 3 percent of the total watershed area.

Historical strip mining throughout Titus Run caused large areas of barren land and mining waste to be exposed to high erosion rates. Even though reclamation efforts have attempted to address many of these issues in the headwaters, many of the project areas were poorly reclaimed (Cherry et al., 1999). The largest sources of sediment in this subwatershed are still attributed to both the reclaimed and unreclaimed abandoned mines and additional sources may be derived from upstream agricultural practices and/or stream channel erosion related to livestock access (Bauers, 2005).

An analysis of current watershed loading shows that a majority of the upland soil loss is derived from barren lands associated with abandoned mines. Deciduous forest, pastureland, and developed open space are the largest potential sources of upland sediment loads in Titus Run (Table 6-14). Because deciduous forest and developed open areas are not likely significant sources of sediment, the remainder of this analysis will focus on barren land and pastureland.

As noted in the Watershed Management Plan, there are areas of unrestricted livestock access along Titus Run and its tributaries. Along the mainstem, direct access is noted from RM 1.15 to RM 1.00. An additional 2,271 foot long reach near RM 4.1 is noted as severely eroding due to cattle access and is estimated to contribute 6 tons of sediment per year to Titus Run. Two tributaries confluent with Titus Run at RM 1.00 and RM 0.20 also have areas of unrestricted livestock access. Without restrictive barriers or fencing, significant erosion may result as livestock trample riparian vegetation and destabilize stream banks.

Another significant source of sediment in the Titus Run watershed is streambank and channel erosion. Compounding both watershed loading issues and sediment derived from stream banks are areas with missing riparian vegetation. Nearly 3,000 feet of riparian buffers are missing along the mainstem and tributaries of the watershed (Bauers, 2005).

Soil loss from barren land produces 1,067 tons of soil loss per year and 267 tons of sediment from these areas are delivered to Titus Run. Pastureland loses an estimated 124 tons of sediment per year of which 31 tons per year are delivered to Titus Run. The total estimated sediment load received by Titus Run from the surrounding watershed is 358 tons/year, plus an additional 6 tons/year from streambank erosion (as noted by the Watershed Management Plan).

Table 6-14. Land Cover/Land Use within the Titus Run subwatershed and associated estimates of sediment loading.

Land Cover / Land Use	Area (Acres)	Area (Sq. Miles)	Percent of Watershed	Estimated Soil Loss[1] (tons/year)	Sediment Delivered to Stream[2] (tons/year)
Open Water	0.15	0.00	0.0	0	0
Developed, Open Space[3]	42.67	0.07	2.6	60	15
Barren Land (Rock/Sand/Clay)	44.00	0.07	2.6	1,067	267
Deciduous Forest	1,445.85	2.26	86.8	170	42
Evergreen Forest	5.78	0.01	0.3	1	0
Shrub/Scrub	4.13	0.01	0.2	3	1
Grasslands/Herbaceous	12.75	0.02	0.8	10	2
Pasture/Hay	109.55	0.17	6.6	124	31
Total	**1,664.89**	**2.60**	**100.0**	**1,435**	**358**

[1] Soil loss estimated using the Universal Soil Loss Equation (USLE).
[2] Value derived using a delivery ratio of 0.25 (Vanoni, 1975).
[3] USLE not applied to impervious portions of land cover; soil loss and delivery values have been adjusted accordingly.

6.1.5.3 Recommended BMPs

Due to the large amounts of accumulated sediment within the Titus Run stream channel, the following BMPs are recommended to minimize sediment loading from upland watershed sources. Barren land and pastureland are the largest estimated watershed sources of sediment in Titus Run. Livestock access and missing riparian buffers in several areas may also be contributing to streambank erosion and further elevating sediment loads. To reduce the excessive sediment loads associated with these land use practices, the following BMPs are recommended:

- Abandoned mine land reclamation
- Grazing land protection
- Cattle exclusion from streams (e.g., fencing)
- Restoration of riparian buffers

Detailed projects and site descriptions are provided in the Watershed Management Plan and also in the Leading Creek Improvement Plan (Cherry et al., 1999). The estimated sediment load reductions for each recommended BMP are provided in Table 6-15.

Table 6-15. Effectiveness of the recommended BMPs for Titus Run.

BMP	Description and Removal Mechanism	Estimated Sediment Reductions
Abandoned Mine Land Reclamation	Reclaim barren lands within the subwatershed to reduce upland soil loss and sediment delivery to streams.	Overall objective of a 50% reduction in soil loss listed in Watershed Management Plan applied to a 20-acre unreclaimed area (45% of total barren land)
Livestock Exclusion from Streams	Placement of fencing between the livestock grazing area and stream channel. Reduces riparian vegetation trampling and streambank destabilization.	50% decrease in annual sediment concentration and 40 percent decrease in annual soil loss [1]
Grazing Land Protection	Use of cover crop or rotational grazing patterns to maximize ground cover and reduce soil compaction.	88% reduction in sediment loading assuming increased ground cover from 60% to 95% [2]
Restoration of Riparian Buffers	Conversion of land adjacent to stream channels to vegetated buffer zones. Removes pollutants by sedimentation and plant uptake. Provides stream bank stability, stream shading, and aesthetic enhancement.	97% removal of sediment from treated area, assuming a 90 ft buffer width [3]

[1] Owens, LB; Edwards, WM; Van Keuren, RW. 1996. Sediment losses from a pastured watershed before and after stream fencing. Journal of Soil and Water Conservation. Vol. 51, no. 1, pp. 90-94.
[2] Haith, D.A., R. Mandel, and R.S. Wu. 1992. GWLF, Generalized Watershed Loading Functions, Version 2.0, User's Manual. Dept. of Agricultural & Biological Engineering, Cornell University, Ithaca, NY.
[3] NCSU. 2002. Riparian Buffers and Controlled Drainage to Reduce Agricultural Nonpoint Source Pollution. Departments of Soil Science and Biological and Agricultural Engineering, North Carolina Agricultural Research Service, North Carolina State University Raleigh, North Carolina. Technical Bulletin 318, September 2002.

If the recommended BMPs are implemented, a total soil loss reduction of 22 percent may be achieved in the Titus Run watershed preventing as much as 311 tons of soil loss per year (Table 6-16). These reductions could prevent as much as 75 tons of sediment per year from entering Titus Run which is a significant portion of the watershed load identified (21 percent) in the sediment analysis. Though TSS does not directly translate to a sediment load, this analysis will use TSS as a surrogate to allow for comparisons between the calculated TMDL in Section 4 and the estimated sediment load reductions listed below.

While the 21 percent reductions would prevent a significant amount of sediment from entering Titus Run, TSS reductions of 41 and 15 percent are needed during moist and dry flow conditions, respectively (Table 4-29). The current analysis suggests that other efforts, not yet identified, are needed to achieve the TMDL load reductions for Titus Run. It is recommended that the most cost-effective controls be put in place first, with continued monitoring to confirm progress and refine the load reduction estimates as needed.

Table 6-16. Estimated sediment load reductions for Titus Run.

Source	Existing Soil Loss (tons/year)	Proposed BMP	Percent of Watershed BMP Applied To	Effectiveness	Post-BMP Soil Loss (tons/year)	Sediment Delivered to Stream (tons/year)[1]
Forest	170	None	0%	0%	170	43
Pasture/Hay	124	Grazing Land Protection	50%	88%	69	17
Streambank Erosion	6	Livestock Exclusion-Fencing	100%	40%	4	1
Barren Land	1,067	Abandoned Mine Reclamation	45%	50%	827	207
Other Land Cover in Watershed	74	Riparian Buffer Restoration	19%[2]	97%	60	15
Total	**1,441**				**1,130**	**283**
Potential BMP Sediment Reductions:	311 Tons of Soil Loss per Year		22% Reduction in Soil Loss		21% Reduction in Sediment Delivered to Mud Fork	

[1] Value derived using a delivery ratio of 0.25 (Vanoni, 1975).
[2] Assumes buffers are effective for 300 feet adjacent to both stream banks, and that buffers are placed on all stream banks in Titus Run.

6.1.6 Thomas Fork - AU 05030202 090 070

6.1.6.1 Sediment Assessments and QHEI Data

Sediment and overall habitat conditions are highly variable within the Thomas Fork subwatershed. Streambed sediment depths at RM 1.2 average 3 feet and range from 2.1 to over 4 feet deep (Bauers, 2005). The excessive sediment bed loads severely impair Thomas Fork from RM 0.0 to 1.2. Due its location, the backwaters of the Ohio River significantly influence sediment transport near the mouth of Thomas Fork (Bauers, 2005). Other areas in the subwatershed have stream substrates with minimal sediment loads and some of the highest quality habitat found in the entire Leading Creek watershed (Bauers, 2005).

Physical habitat in Thomas Fork has been thoroughly assessed at various points throughout the subwatershed using the QHEI. The 14 total QHEI scores, as well as the individual metric scores, display the highly variable sediment and habitat impairments. Substrate metric scores ranged from 6.0 to 14.0, riffle/run metric scores ranged from 1.0 to 3.0, and pool/flow metrics were scored from 2.0 to 10.0. Though most of the substrate metric scores in Thomas Fork fall below the 13.0 to 14.0 point benchmark

score (Rankin, 2002), the overall habitat has the potential to support a healthy aquatic biota (Bauers, 2005). The main source of impairment in Thomas Fork is widespread acid mine drainage (AMD) that contributes to sediment toxicity as well as metals flocculent that may accumulate in the stream substrates (Bauers, 2005).

6.1.6.2 Potential Sediment Sources

As previously mentioned, sedimentation is not the main source of impairment in the Thomas Fork subwatershed. However, three target areas that are significant sediment (and AMD) sources have been identified within Thomas Fork: Bailey Run, Hysell Run, and "Casto's seep" (Bauers, 2005). These localized sediment impairments are likely the result of historic, unregulated mining practices. About 8 percent of the watershed area has been surface mined and 12.5 to 15 percent has been deep mined, leaving extensive disturbed areas across the landscape (Bauers, 2005). These abandoned mining areas contain several acres of barren land that are directly exposed to erosion potentially delivering large sediment loads to the adjacent streams. The remainder of this section will focus on the three sediment target areas.

An analysis of current watershed loading shows that for all three target subwatersheds, barren land is the largest potential source of upland sediment loads (Table 6-17 through Table 6-19). Excluding deciduous forest land cover, pastureland is the second largest source of watershed sediment loading in all three subwatersheds. The only cultivated crops noted in any of the three subwatersheds are 15 acres in Hysell Run that lose an estimated 145 tons of soil per year. While there are no listed areas where livestock have direct access to any of these subwatersheds, there are areas of missing riparian buffers in both Bailey Run and Hysell Run. Bailey Run needs 8,976 feet of riparian vegetation and Hysell Run needs 7,920 feet of riparian buffer restored (Bauers, 2005). The total combined area of Bailey Run, Hysell Run, and the Casto's seep is only 17.5 percent of the entire Thomas Fork subwatershed area; however these three areas contribute an estimated 330 tons of sediment per year to the Thomas Fork system (about 28 percent of the total estimated watershed load of 1,179 tons/year).

Table 6-17. Land Cover/Land Use within the Bailey Run subwatershed and associated estimates of sediment loading.

Land Cover / Land Use	Area (Acres)	Area (Sq. Miles)	Percent of Watershed	Estimated Soil Loss[1] (tons/year)	Sediment Delivered to Stream[2] (tons/year)
Developed, Open Space[3]	38.72	0.06	3.6	30	8
Developed, Low Intensity[3]	1.31	0.00	0.1	0	0
Barren Land (Rock/Sand/Clay)	8.00	0.01	0.7	107	30
Deciduous Forest	932.86	1.46	87.0	60	17
Grasslands/Herbaceous	14.03	0.02	1.3	6	2
Pasture/Hay	78.30	0.12	7.3	49	14
Total	**1073.22**	**1.67**	**100.0**	**252**	**71**

[1] Soil loss estimated using the Universal Soil Loss Equation (USLE).
[2] Value derived using a delivery ratio of 0.28 (Vanoni, 1975).
[3] USLE not applied to impervious portions of land cover; soil loss and delivery values have been adjusted accordingly.

Table 6-18. Land Cover/Land Use within the Hysell Run subwatershed and associated estimates of sediment loading.

Land Cover / Land Use	Area (Acres)	Area (Sq. Miles)	Percent of Watershed	Estimated Soil Loss[1] (tons/year)	Sediment Delivered to Stream[2] (tons/year)
Developed, Open Space[3]	28.98	0.05	1.3	33	8
Developed, Low Intensity[3]	7.24	0.01	0.3	2	0
Barren Land (Rock/Sand/Clay)	32.00	0.05	1.4	626	144
Deciduous Forest	1857.93	2.90	83.9	176	40
Evergreen Forest	7.99	0.01	0.4	1	0
Grasslands/Herbaceous	13.21	0.02	0.6	8	2
Pasture/Hay	254.43	0.40	11.5	233	54
Cultivated Crops (Conventional Tillage)[4]	7.51	0.01	0.3	102	23
Cultivated Crops (No Till)[4]	7.51	0.01	0.3	43	10
Total	**2216.80**	**3.46**	**100.0**	**1,224**	**281**

[1] Soil loss estimated using the Universal Soil Loss Equation (USLE).
[2] Value derived using a delivery ratio of 0.23 (Vanoni, 1975)
[3] USLE not applied to impervious portions of land cover; soil loss and delivery values have been adjusted accordingly
[4] Assuming 50% of cultivated crops land cover managed by conventional tillage and 50% by no till practices.

Table 6-19. Land Cover/Land Use within the "Casto's seep" subwatershed and associated estimates of sediment loading.

Land Cover / Land Use	Area (Acres)	Area (Sq. Miles)	Percent of Watershed	Estimated Soil Loss[1] (tons/year)	Sediment Delivered to Stream[2] (tons/year)
Developed, Open Space[3]	5.62	0.01	2.6	7	2
Developed, Low Intensity[3]	0.14	0.00	0.1	0	0
Barren Land (Rock/Sand/Clay)	2.00	0.00	0.9	43	15
Deciduous Forest	185.49	0.29	85.5	19	7
Grasslands/Herbaceous	8.28	0.01	3.8	6	2
Pasture/Hay	15.44	0.02	7.1	15	5
Total	**216.97**	**0.33**	**100.0**	**90**	**31**

[1] Soil loss estimated using the Universal Soil Loss Equation (USLE).
[2] Value derived using a delivery ratio of 0.35 (Vanoni, 1975).
[3] USLE not applied to impervious portions of land cover; soil loss and delivery values have been adjusted accordingly.

6.1.6.3 Recommended BMPs

Barren land and pasture/hay are the largest estimated watershed sources of sediment in the three target areas of Bailey Run, Hysell Run, and Casto's seep. Missing riparian buffers along several reaches of Bailey Run and Hysell Run may also be contributing to streambank erosion and sediment loads. To reduce the excessive sediment loads associated with these land cover categories, the following BMPs are recommended:

- Abandoned mine land reclamation
- Grazing land protection
- Restoration of riparian buffers

Abandoned mine land reclamation in the three target subwatersheds is also listed in the Watershed Management Plan as a sediment mitigation strategy. Additional reclamation projects are outlined in the AMDAT Plan that may benefit both acid mine drainage and sedimentation issues in some cases. The estimated sediment load reductions for each recommended BMP are provided in Table 6-20.

Table 6-20. Potential effectiveness of the recommended BMPs for the Thomas Fork target areas.

BMP	Description and Removal Mechanism	Estimated Sediment Reductions
Abandoned Mine Land Reclamation	Reclaim barren lands within the subwatershed to reduce upland soil loss and sediment delivery to streams.	Overall objective of a 50 percent reduction in soil loss listed in Watershed Management Plan for a project to reclaim all 42 acres of barren land in Bailey Run, Hysell Run, and Casto's seep
Grazing Land Protection	Use of cover crop or rotational grazing patterns to maximize ground cover and reduce soil compaction.	88 percent reduction in sediment loading assuming increased ground cover from 60 percent to 95 percent [1]
Restoration of Riparian Buffers	Conversion of land adjacent to stream channels to vegetated buffer zones. Removes pollutants by sedimentation and plant uptake. Provides stream bank stability, stream shading, and aesthetic enhancement.	97 percent removal of sediment from treated area, assuming a 90 ft buffer width [2]

[1] Haith, D.A., R. Mandel, and R.S. Wu. 1992. GWLF, Generalized Watershed Loading Functions, Version 2.0, User's Manual. Dept. of Agricultural & Biological Engineering, Cornell University, Ithaca, NY.
[2] NCSU. 2002. Riparian Buffers and Controlled Drainage to Reduce Agricultural Nonpoint Source Pollution. Departments of Soil Science and Biological and Agricultural Engineering, North Carolina Agricultural Research Service, North Carolina State University Raleigh, North Carolina. Technical Bulletin 318, September 2002.

If the recommended BMPs are implemented, a total soil loss reduction of up to 35 percent may be achieved in the three target areas of the Thomas Fork watershed (Table 6-21). These reductions could prevent as much as 126 tons of sediment per year from entering Thomas Fork which is a significant portion of the watershed load identified (27 percent) in the sediment analysis. Though TSS does not directly translate to a sediment load, this analysis will use TSS as a surrogate to allow for comparisons between the calculated TMDL in Section 4 and the estimated sediment load reductions listed below.

While the 35 percent reductions would prevent a significant amount of sediment from entering Thomas Fork, TSS reductions of 98 percent are needed during high flow conditions, respectively (Table 4-34). The current analysis suggests that other efforts, not yet identified, are needed to achieve the TMDL load reductions for Thomas Fork. It is recommended that the most cost-effective controls be put in place first, with continued monitoring to confirm progress and refine the load reduction estimates as needed.

Table 6-21. Estimated sediment load reductions for the Thomas Fork target areas.

Target Area	Source	Existing Soil Loss (tons/year)	Proposed BMP	Percent of Water-shed BMP Applied To	Effectiveness	Post-BMP Soil Loss (tons/year)	Sediment Delivered to Stream[1] (tons/year)
Bailey Run	Forest	60	None	0%	0%	60	17
	Pasture/Hay	49	Grazing Land Protection	50%	88%	27	8
	Barren Land	107	Abandoned Mine Land Reclamation	100%	50%	54	15
	Other Land Cover in Watershed	79	Riparian Buffer Restoration	16%[2]	97%	67	19
Hysell Run	Forest	177	None	0%	0%	177	41
	Pasture/Hay	233	Grazing Land Protection	50%	88%	130	30
	Barren Land	626	Abandoned Mine Land Reclamation	100%	50%	313	72
	Other Land Cover in Watershed	188	Riparian Buffer Restoration	17%[2]	97%	157	36
Casto's seep	Forest	19	None	0%	0%	19	7
	Pasture/Hay	15	Grazing Land Protection	50%	88%	8	3
	Barren Land	43	Abandoned Mine Land Reclamation	100%	50%	22	8
	Other Land Cover in Watershed	13	Riparian Buffer Restoration	23%[2]	97%	10	4
	Total	**1,609**				**1,044**	**258**
Potential BMP Sediment Reductions:		565 Tons of Soil Loss per Year		35% Reduction in Soil Loss		27% Reduction in Sediment Delivered to Streams	

[1] Value derived using delivery ratio of 0.23, 0.28, and 0.35 for Bailey Run, Hysell Run, and Casto's seep, respectively (Vanoni, 1975).
[2] Assumes buffers are effective for 300 feet adjacent to both stream banks, and that buffers are placed on all stream banks in each target tributary.

6.2 Total Dissolved Solids and Chlorides

Total dissolved solids and chlorides load reductions in the Leading Creek watershed are needed in streams with historic mining influences. There are three tributaries with needed TDS reductions: Ogden Run, Parker Run, and Thomas Fork. The three Leading Creek mainstem sites located downstream of Parker Run (LCMS03, LCMS02, and LCMS01) also display needed TDS and reductions (Table 6-22).

Table 6-22. Needed TDS reductions derived from load duration analysis.

Sampling Site	Stream Name	High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
TM12	Ogden Run	–	–	–	–	74%
TM07	Parker Run	–	63%	69%	72%	73%
LCMS03	Leading Creek	–	–	–	60%	73%
LCMS02	Leading Creek	–	–	15%	50%	72%
TM01	Thomas Fork	–	–	–	–	45%
LCMS01	Leading Creek	–	–	6%	17%	69%

The Parker Run tributary and the three downstream Leading Creek mainstem sampling stations are the only four sites with needed chlorides reductions within the entire Leading Creek watershed (Table 6-23).

Table 6-23. Needed chlorides reductions derived from load duration analysis.

Sampling Site	Stream Name	High Flows 0-10	Moist Conditions 10-40	Mid-Range Flows 40-60	Dry Conditions 60-90	Low Flows 90-100
TM07	Parker Run	–	76%	80%	81%	–
LCMS03	Leading Creek	–	3%	35%	81%	–
LCMS02	Leading Creek	–	–	57%	81%	–
LCMS01	Leading Creek	–	–	46%	53%	–

As mentioned in Bauers (2005), Ogden Run received TDS from the Meigs #2 Mine, which would explain the needed 74 percent reduction at low flows. However, this mine is now closed and only discharges storm water. Continued monitoring is recommended to confirm progress and refine the load reduction estimates as needed in Ogden Run.

The Meigs #31 Mine is the likely cause of elevated TDS and chlorides loads in Parker Run (see Figures 4-6 and 4-7), and also at the downstream Leading Creek mainstem sites. While the mine discharge is well treated for pH, its TDS concentrations (and likely its chlorides concentrations) are significantly influencing the water quality in Parker Run and further downstream on Leading Creek. The impacts of the mine increase at decreasing flows as dilution and assimilative capacity of the streams are reduced.

As previously mentioned, it is highly recommended that the facility perform weekly sampling for chlorides to confirm load concentrations and allow for the calculation of an appropriate WLA. Enhanced TDS treatment at this facility is also recommended, as its median effluent TDS concentration is 5,532 mg/L. During low flow periods, the mine discharge makes up a majority of the flow in Parker Run, and should be limited to an effluent concentration of 1,500 mg/L to correspond with the State of Ohio's numeric criteria for TDS.

The TDS issues in Thomas Fork are also related to historic mining practices and abandoned mine lands. Numerous sources of AMD exist in the Thomas Fork watershed, each outlined in the AMDAT Plan, and efforts are currently underway to address the largest source of AMD – an unnamed tributary to Thomas Fork on Bailey Run Road. Additional AMD projects and guidance for Thomas Fork are provided in detail in the AMDAT Plan.

7.0 REFERENCES

Bauers, C. January 2005. A Comprehensive Watershed Management Plan for the Leading Creek Watershed. Available online at:
http://web.epa.state.oh.us/dsw/nps/NPSMP/docs/EndorsedLeadingCreekWAP.pdf

Bauers, C., Gosnell, M., Ooten, R., Bowman, J., Flowers, B., Vosefski, D., and Borch, M.A. May 2006. Acid Mine Drainage Abatement and Treatment (AMDAT) Plan for the Leading Creek Watershed.

Cherry, D.S., Currie, R.J., Latimer, H.A., and Cairns, J. 1999. The Leading Creek Improvement Plan. Final Report to Southern Ohio Coal Company and American Electric Power.

Cleland, B. 2005. TMDL Development Using Duration Curves. Update & Habitat TMDL Applications. Presentation made at Region 5 TMDL Practitioners' Workshop
Hickory Corners, MI. November 15, 2005.

Latimer, H. A. II. May, 1999. *An Ecotoxicological Evaluation of Active Coal Mining, Sedimentation, and Acid Mine Drainage in Three Tributaries of the Leading Creek Watershed, Meigs County, Ohio*. Graduate Thesis- Virginia Polytechnic Institute.

Ohio Environmental Protection Agency (Ohio EPA). 1989. The Qualitative Habitat Evaluation Index (QHEI). Rationale, methods, and applications. Division of Water Quality Planning and Assessment, Ecological Analysis Section. Columbus, Ohio.

Ohio Environmental Protection Agency (Ohio EPA). 1999. Association between Nutrients, Habitat and the Aquatic Biota in Ohio Rivers and Streams. Ecological Assessment Unit, Division of Surface Water. Ohio Environmental Protection Agency, Columbus, Ohio. Available online at:
http://www.epa.state.oh.us/dsw/documents/assoc_load_apps.pdf

Ohio Environmental Protection Agency (Ohio EPA). 2006. Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI). Division of Surface Water. Ohio EPA Technical Bulletin EAS/2006-06-01.

Ohio Environmental Protection Agency (Ohio EPA). 2006. Ohio 2006 Integrated Water Quality and Assessment Report. Division of Surface Water. Ohio Environmental Protection Agency, Columbus, Ohio. Available online at:
(**http://www.epa.state.oh.us/dsw/tmdl/2006IntReport/2006OhioIntegratedReport.html**).

Rankin, E.T. 2002. Using the Qualitative Habitat Evaluation Index to Derive TMDL Targets for Sediment Impairment in Southeast Ohio.

Rankin, E.T. 2005. Fish and Macroinvertebrate Study of Leading Creek. 2004 Field Year. Midwest Biodiversity Institute. Columbus, Ohio.

Sloto, R. A. and Crouse, Michele Y. 1996. HYSEP: A Computer Program for Streamflow Hydrograph Separation and Analysis. U.S. Geological Survey. Water-Resources Investigations Report 96-4040.

Vanoni, V.A. (Ed.). 1975. Sedimentation Engineering. American Society of Civil Engineers, New York, NY.