


May 2012

USEPA Approved Report

Total Maximum Daily Loads for Selected Streams in the Lower Kanawha River Watershed, West Virginia

Prepared for
West Virginia Department of Environmental Protection
Division of Water and Waste Management
Watershed Protection Branch, TMDL Section

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CONTENTS

TABLES

FIGURES

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

µg/L	micrograms per liter
7Q10	7-day, 10-year low flow
AMD	acid mine drainage
AML	abandoned mine land
AML&R	[WVDEP] Office of Abandoned Mine Lands & Reclamation
BMP	best management practice
BOD	biochemical oxygen demand
CFR	Code of Federal Regulations
CSO	combined sewer overflow
CSR	Code of State Rules
DEM	Digital Elevation Model
DMR	[WVDEP] Division of Mining and Reclamation
DO	dissolved oxygen
DWWM	[WVDEP] Division of Water and Waste Management
ERIS	Environmental Resources Information System
GIS	geographic information system
gpd	gallons per day
GPS	global positioning system
HAU	home aeration unit
LA	load allocation
MDAS	Mining Data Analysis System
MF	membrane filter counts per test
mg/L	milligrams per liter
mL	milliliter
MOS	margin of safety
MPN	most probable number
MRLC	Multi-Resolution Land Characteristics Consortium
MS4	Municipal Separate Storm Sewer System
NLCD	National Land Cover Dataset
NOAA-NCDC	National Oceanic and Atmospheric Administration, National Climatic Data Center
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OOG	[WVDEP] Office of Oil and Gas
POTW	publicly owned treatment works
SI	stressor identification
SMCRA	Surface Mining Control and Reclamation Act
SRF	State Revolving Fund
SSO	sanitary sewer overflow
STATSGO	State Soil Geographic database
TMDL	Total Maximum Daily Load
TSS	total suspended solids
UNT	unnamed tributary

USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WLA	wasteload allocation
WVDEP	West Virginia Department of Environmental Protection
WVDNR	West Virginia Division of Natural Resources
WVDOH	West Virginia Division of Highways
WVSCI	West Virginia Stream Condition Index
WVU	West Virginia University

Watershed

A general term used to describe a drainage area within the boundary of a United States Geologic Survey's 8-digit hydrologic unit code. In this report, the Lower Kanawha River and drainage area from its confluence with the Elk River at Charleston, WV downstream to its confluence with the Ohio River at Henderson, WV is referred to as the Lower Kanawha River watershed. Throughout this report, the Lower Kanawha River watershed refers to the tributary streams that eventually drain to the Lower Kanawha River (**Figure I-1**). The term "watershed" is also used more generally to refer to the land area that contributes precipitation runoff that eventually drains to the Lower Kanawha River.

TMDL Watershed

This term is used to describe the total land area draining to an impaired stream for which a TMDL is being developed. This term also takes into account the land area drained by un-impaired tributaries of the impaired stream, and may include impaired tributaries for which additional TMDLs are presented. This report addresses 221 impaired streams contained within 22 TMDL watersheds in the Lower Kanawha River watershed.

Subwatershed

The subwatershed delineation is the most detailed scale of the delineation that breaks each TMDL watershed into numerous catchments for modeling purposes. The 22 TMDL watersheds have been subdivided into 515 modeled subwatersheds. Pollutant sources, allocations and reductions are presented at the subwatershed scale to facilitate future permitting actions and TMDL implementation.

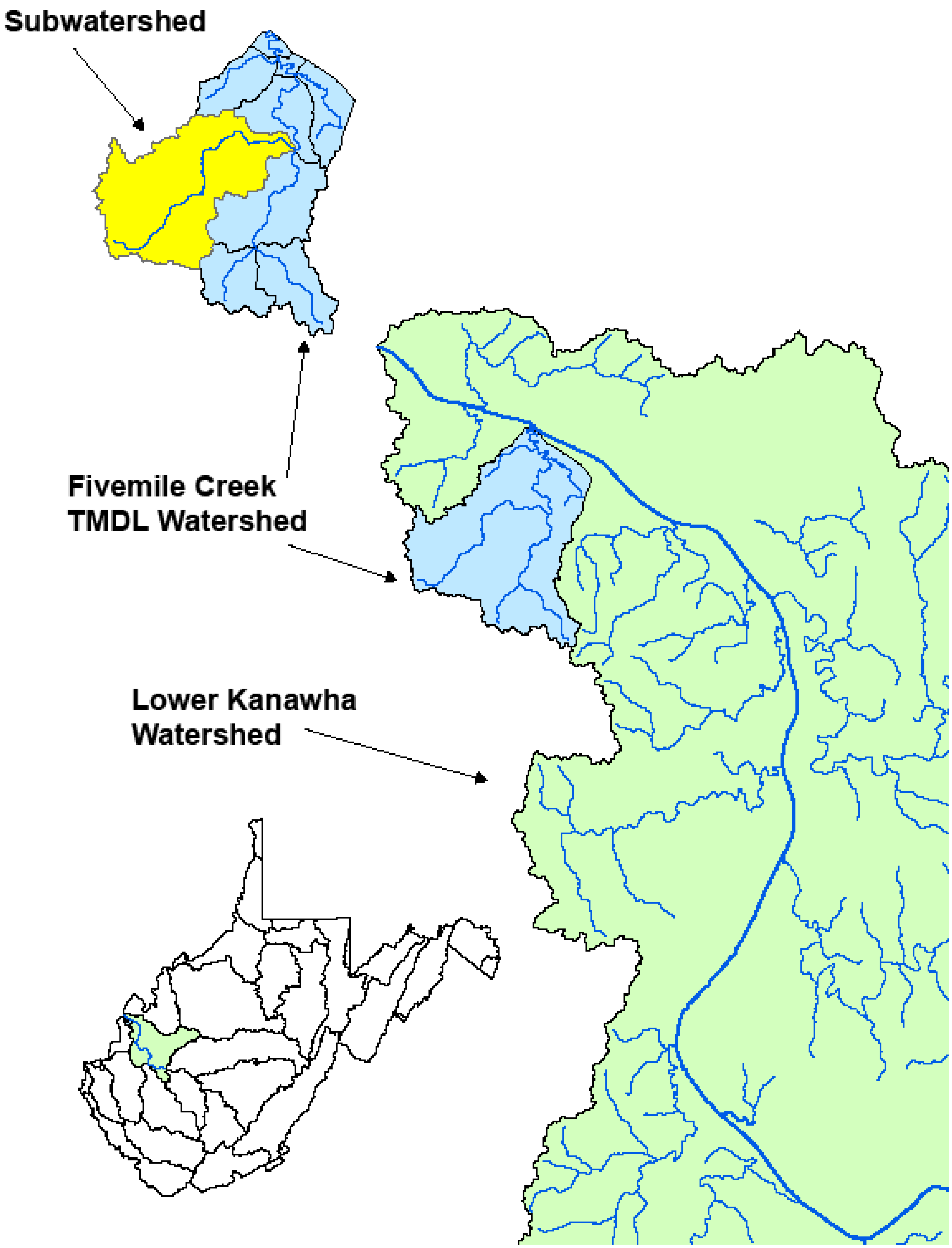


Figure I-1. Examples of a watershed, TMDL watershed, and subwatersheds

EXECUTIVE SUMMARY

This report includes Total Maximum Daily Loads (TMDLs) for 221 impaired streams in the Lower Kanawha River watershed located in western West Virginia.

A TMDL establishes the maximum allowable pollutant loading for a waterbody to comply with water quality standards, distributes the load among pollutant sources, and provides a basis for actions needed to restore water quality. West Virginia's water quality standards are codified at Title 47 of the *Code of State Rules* (CSR), Series 2, and titled *Legislative Rules, Department of Environmental Protection: Requirements Governing Water Quality Standards*. The standards include designated uses of West Virginia waters and numeric and narrative criteria to protect those uses. The West Virginia Department of Environmental Protection routinely assesses use support by comparing observed water quality data with criteria and reports impaired waters every two years as required by Section 303(d) of the Clean Water Act ("303(d) list"). The Act requires that TMDLs be developed for listed impaired waters.

The subject impaired streams are included on West Virginia's 2010 Section 303(d) List. Documented impairments are related to numeric water quality criteria for total iron, dissolved aluminum, pH, dissolved oxygen, and fecal coliform bacteria. Certain waters are also biologically impaired based on the narrative water quality criterion of 47 CSR 2–3.2.i, which prohibits the presence of wastes in state waters that cause or contribute to significant adverse impacts on the chemical, physical, hydrologic, and biological components of aquatic ecosystems.

Impaired waters were organized into 22 TMDL watersheds. For hydrologic modeling purposes, impaired and unimpaired streams in these 22 TMDL watersheds were further divided into 515 smaller subwatershed units for modeling. The subwatershed delineation provided a basis for georeferencing pertinent source information, monitoring data, and presentation of the TMDLs.

The Mining Data Analysis System (MDAS) was used to represent linkage between pollutant sources and instream responses for fecal coliform bacteria, iron, and aluminum. The MDAS is a comprehensive data management and modeling system that is capable of representing loads from nonpoint and point sources in the watershed and simulating instream processes.

Point and nonpoint sources contribute to the fecal coliform bacteria impairments in the watershed. Failing on-site systems, direct discharges of untreated sewage, and precipitation runoff from agricultural and residential areas are significant nonpoint sources of fecal coliform bacteria. Point sources of fecal coliform bacteria include the effluents of sewage treatment facilities, collection system overflows (CSO) from publicly owned treatment works (POTWs), and stormwater discharges from Municipal Separate Storm Sewer Systems (MS4s).

Iron impairments are also attributable to both point and nonpoint sources. Nonpoint sources of iron include abandoned mine lands (AML), roads, oil and gas operations, timbering, agriculture, urban/residential land disturbance and streambank erosion. Iron point sources include the permitted discharges from mining activities, and stormwater contributions from Municipal Separate Storm Sewer Systems (MS4), construction sites and non-mining industrial facilities. The presence of individual source categories and their relative significance varies by subwatershed. Because iron is a naturally-occurring element that is present in soils, the iron loading from many of the identified sources is associated with sediment contributions.

There are five pH impaired streams in the Lower Kanawha watershed. Four are primarily associated with historic mining sources. The pH impairment of Hoffman Hollow is caused by atmospheric deposition and low buffering capacity.

Biological integrity/impairment is based on a rating of the stream’s benthic macroinvertebrate community using the multimetric West Virginia Stream Condition Index (WVSCI). The first step in TMDL development for biologically impaired waters is stressor identification (SI). **Section 4** discusses the SI process. SI was followed by stream-specific determinations of the pollutants for which TMDLs must be developed. Organic enrichment and sedimentation were identified as causative stressors for the biologically impaired streams addressed in this effort.

Organic enrichment was identified as a significant biological stressor in many waters. All such waters also demonstrated violations of the numeric criteria for fecal coliform bacteria. It was determined that implementation of fecal coliform TMDLs would remove untreated sewage and significantly reduce animal wastes, thereby reducing the organic and nutrient loading causing the biological impairment.

Where sedimentation was identified as a significant stressor, sediment TMDLs were initially developed within the MDAS using a reference watershed approach. The MDAS was configured to examine upland sediment loading and streambank erosion and depositional processes. Load reductions for sediment-impaired waters were projected based upon the sediment loading present in an unimpaired reference watershed. For all of those waters, a strong, positive correlation between iron and total suspended solids (TSS) was identified and iron TMDLs are presented. It was universally determined that the sediment reductions necessary for the attainment of iron water quality criteria exceed those necessary to address biological stress from sedimentation. As such, the iron TMDLs serve as surrogates for the biological impairments caused by sedimentation.

Uncertainty remains regarding the causative pollutants and impairment thresholds associated with ionic toxicity. A strong presence of sulfates and other dissolved solids exists in all streams where ionic toxicity has been determined to be a significant biological stressor. TMDLs have not been presented for their biological impairments and those impairments will be retained on the Section 303(d) List. WVDEP and USEPA Region III have agreed upon a plan to develop these biological impairment TMDLs by 2014.

This report describes the TMDL development and modeling processes, identifies impaired streams and existing pollutant sources, discusses future growth and TMDL achievability, and documents the public participation associated with the process. It also contains a detailed discussion of the allocation methodologies applied for various impairments. Various provisions attempt to ensure the attainment of criteria throughout the watershed, achieve equity among categories of sources, and target pollutant reductions from the most problematic sources. Nonpoint source reductions were not specified beyond natural (background) levels. Similarly, point source wasteload allocations (WLAs) were no more stringent than numeric water quality criteria.Applicable TMDLs are displayed in **Section 11** of this report. Accompanying spreadsheets provide TMDLs and allocations of loads to categories of point and nonpoint sources that achieve the total TMDL. Also provided is an interactive ArcGIS geographic information system (GIS) project that allows for the exploration of spatial relationships among the source assessment data. A Technical Report is also available that describes the detailed technical approaches used in the process and displays the data upon which the TMDLs are based.

In 2006, WVDEP developed total iron TMDLs for Heizer Creek, Manila Creek and Tupper Creek tributaries of the Pocatalico River. A fecal coliform TMDL was also developed for Tupper Creek. In this effort, WVDEP did not reevaluate the impairments of those tributaries. Instead, the TMDL time series outputs from the previous effort were used to establish boundary conditions for the pollutants contributed by the tributaries. The loadings associated with the 2006 TMDLs are included in the Pocatalico River TMDLs and are displayed on the LA tabs of the corresponding allocation spreadsheets.

1.0 REPORT FORMAT

This report describes the overall total maximum daily load (TMDL) development process for selected tributaries of the Lower Kanawha River watershed, identifies impaired streams, and outlines the source assessment for all pollutants for which TMDLs are presented. It also describes the modeling and allocation processes and lists measures that will be taken to ensure that the TMDLs are met. The applicable TMDLs are displayed in **Section 11** of this report. The report is supported by a compact disc containing spreadsheets (in Microsoft Excel format) that provide detailed source allocations associated with successful TMDL scenarios. A Technical Report is also included that describes the detailed technical approaches used in the process and displays the data upon which the TMDLs are based. The CD also contains an ArcView GIS project (and shapefiles) that allows the user to explore spatial relationships among pollutant sources.

2.0 INTRODUCTION

The West Virginia Department of Environmental Protection (WVDEP), Division of Water and Waste Management (DWWM), is responsible for the protection, restoration, and enhancement of the state's waters. Along with this duty comes the responsibility for TMDL development in West Virginia.

2.1 Total Maximum Daily Loads

Section 303(d) of the federal Clean Water Act and the U.S. Environmental Protection Agency's (USEPA) Water Quality Planning and Management Regulations (at Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to identify waterbodies that do not meet water quality standards and to develop appropriate TMDLs. A TMDL establishes the maximum allowable pollutant loading for a waterbody to achieve compliance with applicable standards. It also distributes the load among pollutant sources and provides a basis for the actions needed to restore water quality.

A TMDL is composed of the sum of individual wasteload allocations (WLAs) for point sources, and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. TMDLs can be expressed in terms of mass per time or other appropriate units. Conceptually, this definition is denoted by the following equation:

$$\text{TMDL} = \text{sum of WLAs} + \text{sum of LAs} + \text{MOS}$$

WVDEP is developing TMDLs in concert with a geographically-based approach to water resource management in West Virginia—the Watershed Management Framework. Adherence to the Framework ensures efficient and systematic TMDL development. Each year, TMDLs are developed in specific geographic areas. The Framework dictates that 2010 TMDLs should be pursued in Hydrologic Group B, which includes the Lower Kanawha River watershed. **Figure 2-1** depicts the hydrologic groupings of West Virginia's watersheds; the legend includes the target year for finalization of each TMDL.

WVDEP is committed to implementing a TMDL process that reflects the requirements of the TMDL regulations, provides for the achievement of water quality standards, and ensures that ample stakeholder participation is achieved in the development and implementation of TMDLs. A 48-month development process enables the agency to carry out an extensive data generating and gathering effort to produce scientifically defensible TMDLs. It also allows ample time for modeling, report finalization, and frequent public participation opportunities.

The TMDL development process begins with pre-TMDL water quality monitoring and source identification and characterization. Informational public meetings are held in the affected watersheds. Data obtained from pre-TMDL efforts are compiled, and the impaired waters are modeled to determine baseline conditions and the gross pollutant reductions needed to achieve water quality standards. WVDEP then presents a status update meeting in which allocation strategies and the progress of TMDL development is presented. After the second public meeting, draft TMDL reports are developed. The draft TMDL is advertised for public review and comment, and a third informational meeting is held during the public comment period. Public comments are addressed, and the draft TMDL is submitted to USEPA for approval.

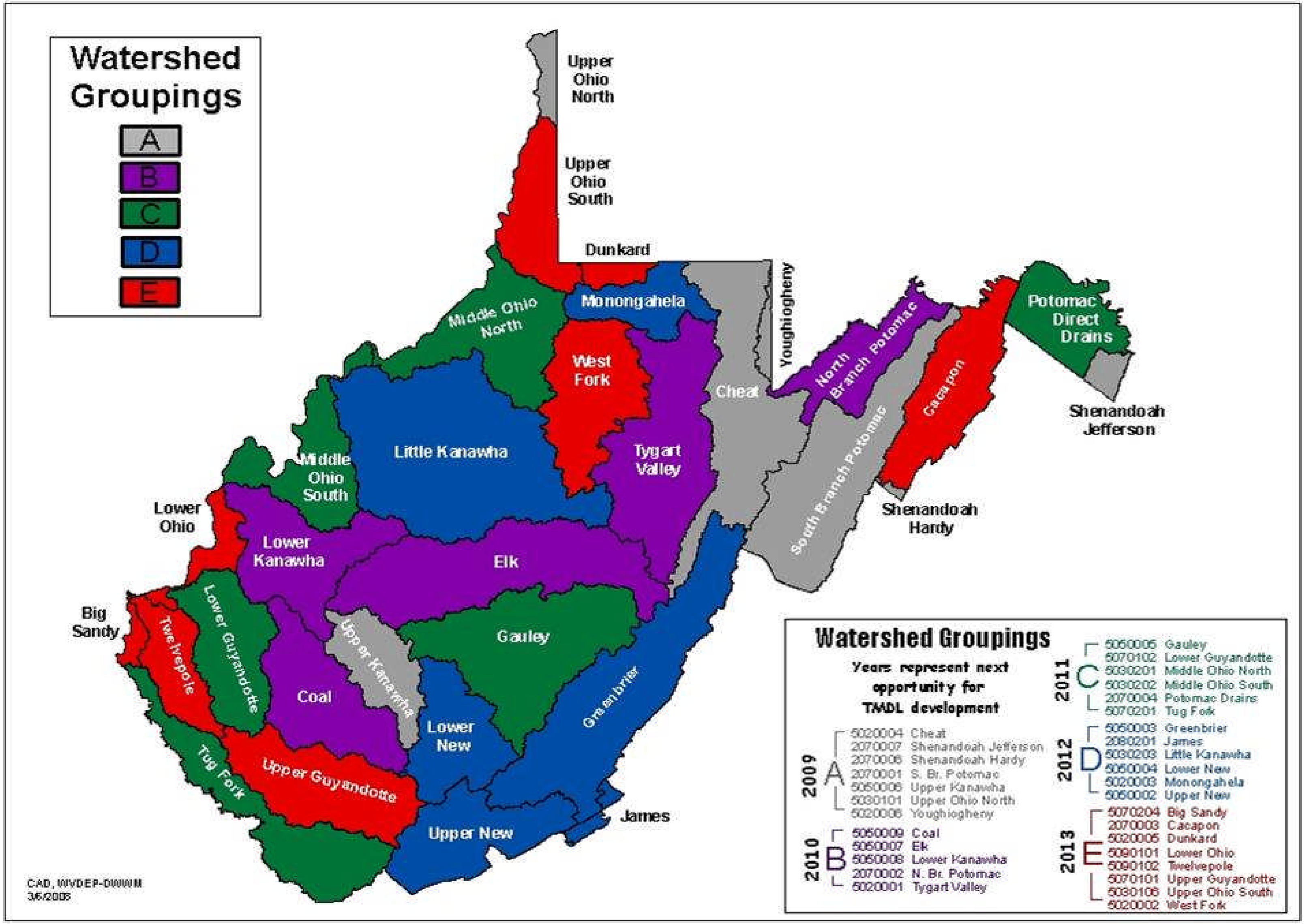


Figure 2-1. Hydrologic groupings of West Virginia's watersheds

2.2 Water Quality Standards

The determination of impaired waters involves comparing instream conditions to applicable water quality standards. West Virginia's water quality standards are codified at Title 47 of the *Code of State Rules* (CSR), Series 2, titled *Legislative Rules*, *Department of Environmental Protection: Requirements Governing Water Quality Standards*. These standards can be obtained online from the West Virginia Secretary of State Internet site (http://www.wvsos.com/).

Water quality standards consist of three components: designated uses; narrative and/or numeric water quality criteria necessary to support those uses; and an antidegradation policy. Appendix E of the Standards contains the numeric water quality criteria for a wide range of parameters, while Section 3 of the Standards contains the narrative water quality criteria.

Designated uses include: propagation and maintenance of aquatic life in warmwater fisheries and troutwaters, water contact recreation, and public water supply. In various streams in the Lower Kanawha River watershed, warmwater fishery aquatic life use impairments have been determined pursuant to exceedances of iron, dissolved aluminum, dissolved oxygen, and/or pH numeric water quality criteria. Water contact recreation and/or public water supply use impairments have also been determined in various waters pursuant to exceedances of numeric water quality criteria for fecal coliform bacteria, dissolved oxygen and total iron.

All West Virginia waters are subject to the narrative criteria in Section 3 of the Standards. That section, titled "Conditions Not Allowable in State Waters," contains various general provisions related to water quality. The narrative water quality criterion at Title 47 *CSR* Series 2 – 3.2.i prohibits the presence of wastes in state waters that cause or contribute to significant adverse impacts to the chemical, physical, hydrologic, and biological components of aquatic ecosystems. This provision is the basis for "biological impairment" determinations. Biological impairment signifies a stressed aquatic community, and is discussed in detail in **Section 4**.

The numeric water quality criteria applicable to the impaired streams addressed by this report are summarized in **Table 2-1**. The stream-specific impairments related to both numeric and narrative water quality criteria are displayed in **Table 3-3**.

TMDLs presented herein are based upon the water quality criteria that are currently effective. If the West Virginia Legislature adopts Water Quality Standard revisions that alter the basis upon which the TMDLs are developed, then the TMDLs and allocations may be modified as warranted. Any future Water Quality Standard revision and/or TMDL modification must receive USEPA approval prior to implementation.

Table 2-1. Applicable West Virginia water quality criteria

POLLUTANT	USE DESIGNATION				
	Aquatic Life				Human Health
	Warmwater Fisheries		Troutwaters		Contact Recreation/Public Water Supply
	Acute[a]	Chronic[b]	Acute[a]	Chronic[b]	
Aluminum, dissolved (µg/L)	750	750	750	87	--
Iron, total (mg/L)	--	1.5	--	1.0	1.5
pH	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0
Dissolved Oxygen	Not less than 5 mg/L at any time	Not less than 5 mg/L at any time	Not less than 6 mg/L at any time	Not less than 6 mg/L at any time	Not less than 5 mg/L at any time
Fecal coliform bacteria	**Human Health Criteria** Maximum allowable level of fecal coliform content for Primary Contact Recreation (either MPN [most probable number] or MF [membrane filter counts/test]) shall not exceed 200/100 mL as a monthly geometric mean based on not less than 5 samples per month; nor to exceed 400/100 mL in more than 10 percent of all samples taken during the month.				

[a] One-hour average concentration not to be exceeded more than once every 3 years on the average.
[b] Four-day average concentration not to be exceeded more than once every 3 years on the average.
Source: 47 CSR, Series 2, Legislative Rules, Department of Environmental Protection: Requirements Governing Water Quality Standards.

3.0 WATERSHED DESCRIPTION AND DATA INVENTORY

3.1 Watershed Description

The Lower Kanawha River watershed (U.S. Geological Survey [USGS] 8-digit hydrologic unit code 05050008) encompasses nearly 925 square miles in western West Virginia (**Figure 3-1**). It extends northwest from the City of Charleston to the Ohio River and lies in portions of Cabell, Kanawha, Jackson, Mason, Putnam and Roane Counties. The Lower Kanawha River mainstem runs northwest along the southwestern portion of the watershed. The major tributaries within the watershed are the Pocatalico River, Hurricane Creek, and Eighteenmile Creek. Cities and towns in the vicinity of the area of study are Charleston, Point Pleasant, Sissonville, and Winfield.

The average elevation in the watershed is 807 feet. The highest point is 1,587 feet on a ridge top above Hoffman Hollow in the headwaters of the Davis Creek watershed. The minimum elevation is 550 feet, located at the confluence of the Kanawha River and the Ohio River near Henderson, WV. The total population living in the subject watersheds of this report is estimated to be 96,000 people.

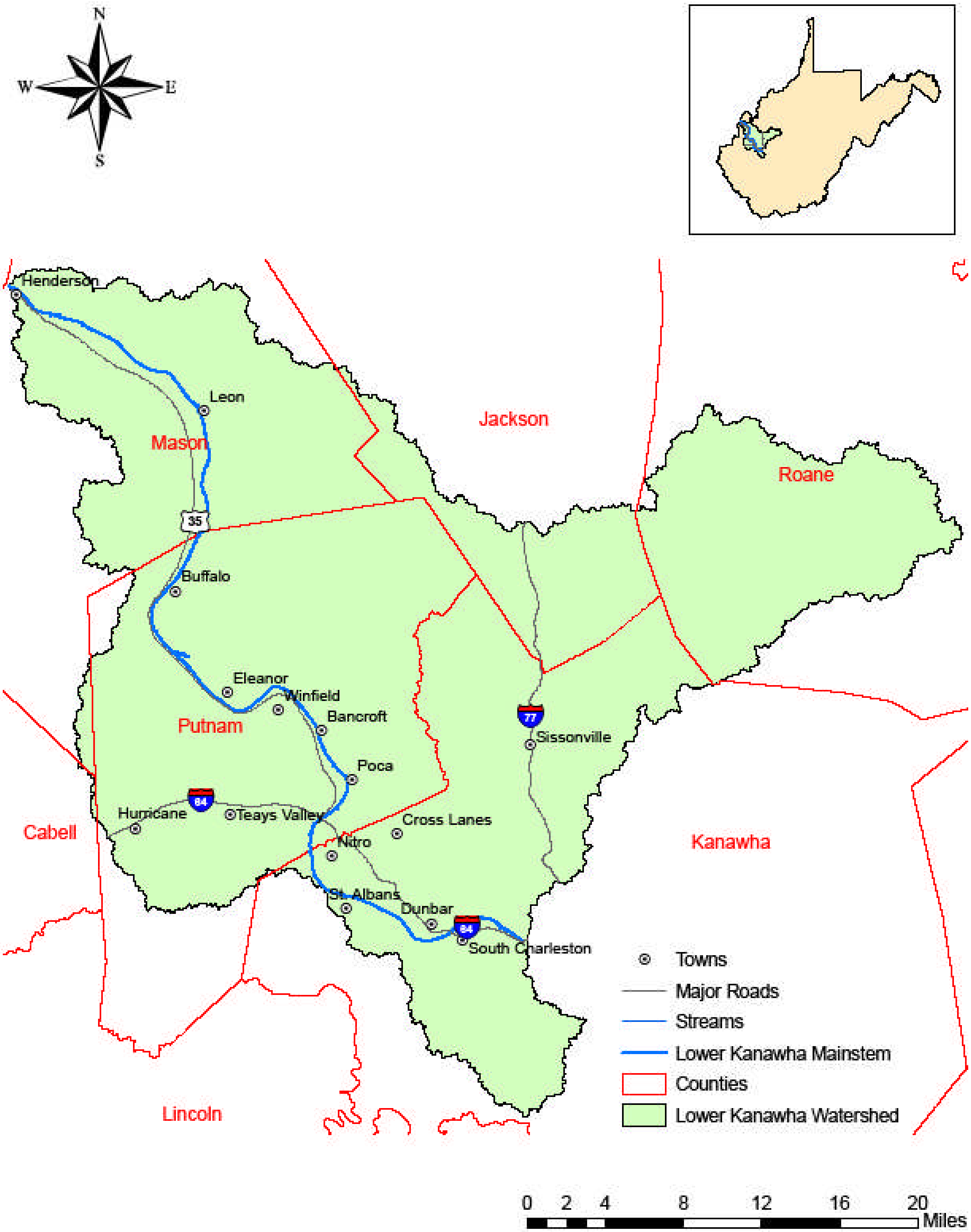


Figure 3-1. Location of the Lower Kanawha River watershed in West Virginia

Landuse and land cover estimates were originally obtained from vegetation data gathered from the National Land Cover Dataset (NLCD) 2001. The Multi-Resolution Land Characteristics Consortium (MRLC) produced the NLCD coverage. The NLCD database for West Virginia was derived from satellite imagery taken during the early 2000s, and it includes detailed vegetative spatial data. Enhancements and updates to the NLCD coverage were made to create a modeled landuse by custom edits derived primarily from WVDEP source tracking information and 2003 aerial photography with 1-meter resolution. Additional information regarding the NLCD spatial database is provided in Appendix D of the Technical Report.

Table 3-1 displays the landuse distribution for the 515 modeled subwatersheds in the Lower Kanawha River watershed, derived from NLCD as described above. The dominant landuse is forest, which constitutes 75.8 percent of the total landuse area. Other important modeled landuse types are grassland (6.1 percent), urban/residential (9.5 percent), barren (3.8 percent), and agriculture (4.1 percent). Individually, all other land cover types compose less than one percent of the total watershed area.

Table 3-1. Modified landuse for the Lower Kanawha TMDL watershed

Landuse Type	Area of Watershed		
	Acres	Square Miles	Percentage
Water	833.0	1.3	0.2%
Wetland	165.6	0.3	<0.1%
Barren	18,605.7	29.1	3.8%
Forest	371,367.9	580.3	75.8%
Grassland	30,101.0	47.0	6.1%
Agriculture	19,860.4	31.0	4.1%
Urban/Residential	46,463.8	72.6	9.5%
Mining	135.3	0.2	<0.1%
AML	2,401.5	3.8	0.5%
Total Area	489,934.4	765.5	100%

Note: < symbol represents less than

3.2 Data Inventory

Various sources of data were used in the TMDL development process. The data were used to identify and characterize sources of pollution and to establish the water quality response to those sources. Review of the data included a preliminary assessment of the watershed's physical and socioeconomic characteristics and current monitoring data. **Table 3-2** identifies the data used to support the TMDL assessment and modeling effort. These data describe the physical conditions of the TMDL watersheds, the potential pollutant sources and their contributions, and the impaired waterbodies for which TMDLs need to be developed. Prior to TMDL development, WVDEP collected comprehensive water quality data throughout the watershed. This pre-TMDL monitoring effort contributed the largest amount of water quality data to the process and is summarized in the Technical Report, Appendix J. The geographic information is provided in the GIS viewer tool.

Table 3-2. Datasets used in TMDL development

Type of Information		Data Sources
Watershed physiographic data	Stream network	USGS National Hydrography Dataset (NHD)
	Landuse	National Land Cover Dataset 2001 (NLCD)
	2003 Aerial Photography (1-meter resolution)	WVDEP
	Counties	U.S. Census Bureau
	Cities/populated places	U.S. Census Bureau
	Soils	State Soil Geographic Database (STATSGO) U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) soil surveys
	Hydrologic Unit Code boundaries	U.S. Geological Survey (USGS)
	Topographic and digital elevation models (DEMs)	National Elevation Dataset (NED)
	Dam locations	USGS
	Roads	U.S. Census Bureau TIGER, WVU WV Roads
	Water quality monitoring station locations	WVDEP, USEPA STORET
	Meteorological station locations	National Oceanic and Atmospheric Administration, National Climatic Data Center (NOAA-NCDC)
	Permitted facility information	WVDEP Division of Water and Waste Management (DWWM), WVDEP Division of Mining and Reclamation (DMR)
	Timber harvest data	WV Division of Forestry
	Oil and gas operations coverage	WVDEP Office of Oil and Gas (OOG)
	Abandoned mining coverage	WVDEP DMR
Monitoring data	Historical Flow Record (daily averages)	USGS
	Rainfall	NOAA-NCDC
	Temperature	NOAA-NCDC
	Wind speed	NOAA-NCDC
	Dew point	NOAA-NCDC
	Humidity	NOAA-NCDC
	Cloud cover	NOAA-NCDC
	Water quality monitoring data	USEPA STORET, WVDEP
	National Pollutant Discharge Elimination System (NPDES) data	WVDEP DMR, WVDEP DWWM
	Discharge Monitoring Report data	WVDEP DMR, Mining Companies
	Abandoned mine land data	WVDEP DMR, WVDEP DWWM
Regulatory or policy information	Applicable water quality standards	WVDEP
	Section 303(d) list of impaired waterbodies	WVDEP, USEPA
	Nonpoint Source Management Plans	WVDEP

3.3 Impaired Waterbodies

WVDEP conducted extensive water quality monitoring throughout the Lower Kanawha River watershed from July 2007 through June 2008. The results of that effort were used to confirm the impairments of waterbodies identified on previous 303(d) lists and to identify other impaired waterbodies that were not previously listed.

In this TMDL development effort, modeling at baseline conditions demonstrated additional pollutant impairments to those identified via monitoring. The prediction of impairment through modeling is validated by applicable federal guidance for 303(d) listing. WVDEP could not perform water quality monitoring and source characterization at frequencies or sample location resolution sufficient to comprehensively assess water quality under the terms of applicable water quality standards, and modeling was needed to complete the assessment. Where existing pollutant sources were predicted to cause noncompliance with a particular criterion, the subject water was characterized as impaired for that pollutant.

TMDLs were developed for impaired waters in 22 TMDL watersheds (**Figure 3-2**). The impaired waters for which TMDLs have been developed are presented in **Table 3-3**. The table includes the TMDL watershed, stream code, stream name, and impairments for each stream.

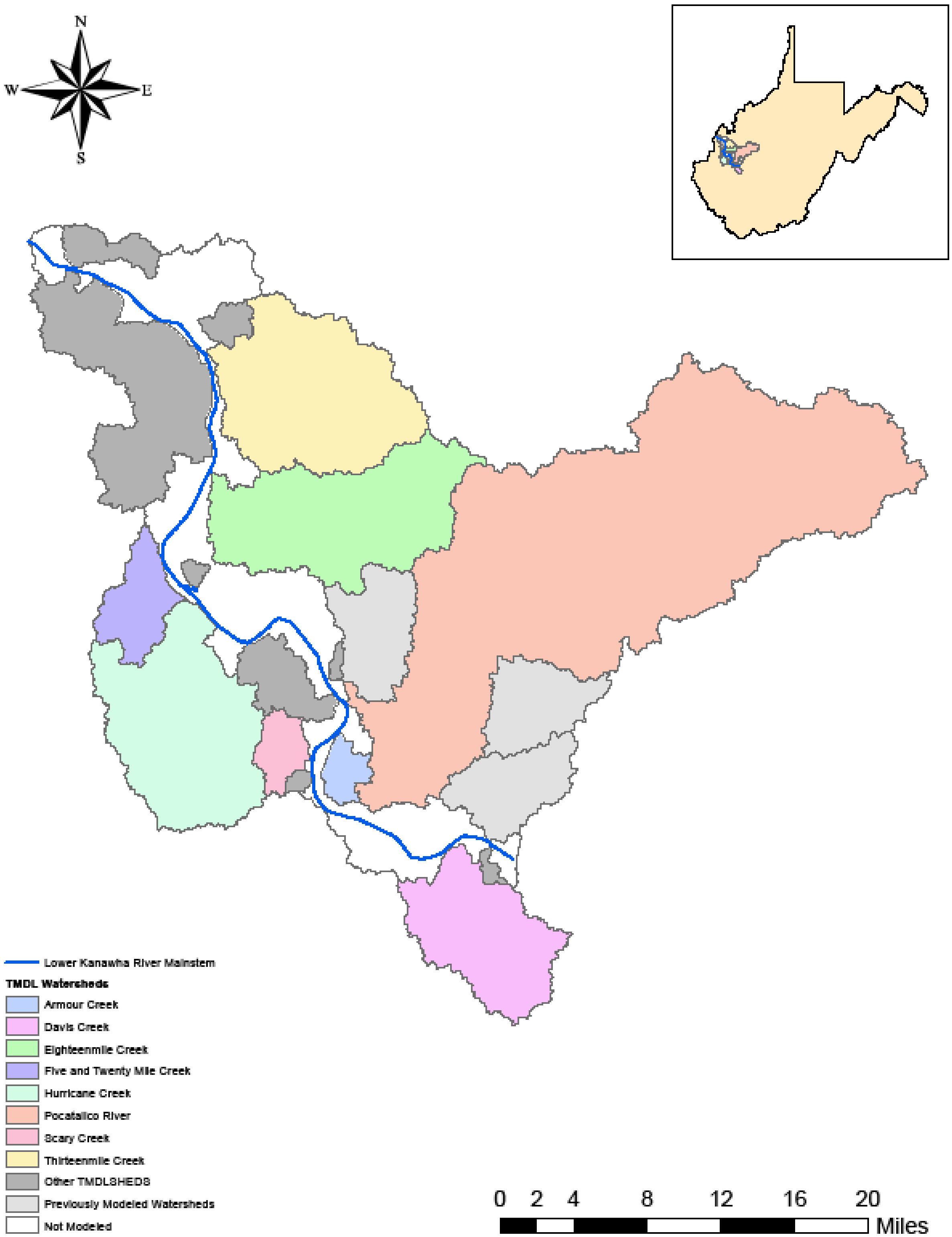


Figure 3-2. 22 Lower Kanawha TMDL watersheds

Table 3-3. Waterbodies and impairments for which TMDLs have been developed

TMDL Watershed	Stream Name	WV_NHD_Code	Trout	pH	Fe	Al	DO	Se	FC	BIO
Ninemile Creek	Ninemile Creek	WV-KL-12							x	
Ninemile Creek	Upper Ninemile Creek	WV-KL-12-B							x	x
Cooper Fork	Cooper Fork	WV-KL-15-C			x				x	
Cooper Fork	UNT/Cooper Fork RM 1.41	WV-KL-15-C-1			x					
Pond Branch	Pond Branch	WV-KL-17							x	x
Pond Branch	UNT/Pond Branch RM 1.4	WV-KL-17-A			x				x	
Thirteenmile Creek	Thirteenmile Creek	WV-KL-19			x				x	
Thirteenmile Creek	Rocky Fork	WV-KL-19-D			x				x	
Thirteenmile Creek	Buzzard Creek	WV-KL-19-H							x	
Thirteenmile Creek	Mudlick Fork	WV-KL-19-M			x				x	
Thirteenmile Creek	Poplar Fork	WV-KL-19-N			x				x	x
Little Sixteenmile Creek	Little Sixteenmile Creek	WV-KL-20							x	
Sixteenmile Creek	Sixteenmile Creek	WV-KL-22							x	
Eighteenmile Creek	Eighteenmile Creek	WV-KL-27			x				x	
Eighteenmile Creek	Cherry Fork	WV-KL-27-AB							x	
Eighteenmile Creek	Buckelew Hollow	WV-KL-27-AK			x				x	x
Eighteenmile Creek	Cottrell Run	WV-KL-27-AL			x				x	
Eighteenmile Creek	Jakes Run	WV-KL-27-H							x	x
Eighteenmile Creek	Right Fork/Eighteenmile Creek	WV-KL-27-X							x	
Eighteenmile Creek	Saltlick Creek	WV-KL-27-X-8							x	x
Five and Twenty Mile Creek	Five And Twenty Mile Creek	WV-KL-35							x	
Five and Twenty Mile Creek	Evans Creek	WV-KL-35-E							x	
Five and Twenty Mile Creek	UNT/Five And Twenty Mile Creek RM 7.41	WV-KL-35-H							x	x
UNT/Little Buffalo Creek RM 1.17	UNT/Little Buffalo Creek RM 1.17	WV-KL-40-A							x	x
Hurricane Creek	Hurricane Creek	WV-KL-42			x				x	x

TMDL Watershed	Stream Name	WV_NHD_Code	Trout	pH	Fe	Al	DO	Se	FC	BIO
Hurricane Creek	Rider Creek	WV-KL-42-AO							x	x
Hurricane Creek	Sams Fork	WV-KL-42-AQ							x	
Hurricane Creek	Poplar Fork	WV-KL-42-I			x				x	x
Hurricane Creek	Long Branch	WV-KL-42-I-10			x				x	x
Hurricane Creek	Crooked Creek	WV-KL-42-I-16			x				x	
Hurricane Creek	UNT/Crooked Creek RM 0.72	WV-KL-42-I-16-B			x				x	x
Hurricane Creek	Cow Creek	WV-KL-42-I-4			x				x	x
Hurricane Creek	Sleepy Creek	WV-KL-42-N			x				x	x
Hurricane Creek	Trace Creek	WV-KL-42-N-2			x				x	
Hurricane Creek	Mill Creek	WV-KL-42-U			x				x	x
Little Hurricane Creek	Little Hurricane Creek	WV-KL-46			x				x	
Threemile Creek (South)	Threemile Creek (South)	WV-KL-5							x	x
Farley Creek	Farley Creek	WV-KL-54							x	
Bills Creek	Bills Creek	WV-KL-56							x	x
Pocatalico River	Pocatalico River	WV-KL-57			x				x	x
Pocatalico River	Grapevine Creek	WV-KL-57-AA							x	x
Pocatalico River	Right Fork	WV-KL-57-AA-2							x	
Pocatalico River	Boardtree Run	WV-KL-57-AA-4							x	x
Pocatalico River	Pocatalico Creek	WV-KL-57-AD			x				x	x
Pocatalico River	Middle Fork/Pocatalico Creek	WV-KL-57-AD-2			x				x	x
Pocatalico River	Allen Fork	WV-KL-57-AD-3							x	
Pocatalico River	Raccoon Creek	WV-KL-57-AL							x	x
Pocatalico River	Leatherwood Creek	WV-KL-57-AO							x	x
Pocatalico River	Camp Creek	WV-KL-57-AT								x
Pocatalico River	Coleman Fork	WV-KL-57-AV-3							x	
Pocatalico River	Straight Creek	WV-KL-57-AX								x
Pocatalico River	Flat Fork	WV-KL-57-BH							x	
Pocatalico River	Cabbage Fork	WV-KL-57-BH-13							x	
Pocatalico River	Higby Run	WV-KL-57-BH-3							x	
Pocatalico River	Cox Fork	WV-KL-57-BH-8							x	
Pocatalico River	McKown Creek	WV-KL-57-BQ							x	x
Pocatalico River	Johnson Creek	WV-KL-57-BT							x	
Pocatalico River	Greathouse Hollow	WV-KL-57-BT-4							x	
Pocatalico River	Big Lick Run	WV-KL-57-BU							x	
Pocatalico River	Silcott Fork	WV-KL-57-BU-2			x				x	
Pocatalico River	Rush Creek	WV-KL-57-BX							x	
Pocatalico River	Laurel Fork	WV-KL-57-CD							x	

TMDL Watershed	Stream Name	WV_NHD_Code	Trout	pH	Fe	Al	DO	Se	FC	BIO
Pocatalico River	UNT/Pocatalico River RM 8.52	WV-KL-57-I		x		x				
Pocatalico River	Kelly Creek	WV-KL-57-J		x						
Pocatalico River	Harmond Creek	WV-KL-57-K							x	x
Pocatalico River	UNT/Harmond Creek RM 1.00	WV-KL-57-K-2		x		x				
Pocatalico River	Rocky Fork	WV-KL-57-L			x				x	x
Pocatalico River	UNT/Rocky Fork RM 4.32	WV-KL-57-L-10			x				x	
Pocatalico River	Howard Fork	WV-KL-57-L-14			x				x	
Pocatalico River	Fisher Branch	WV-KL-57-L-3							x	
Pocatalico River	Wolfpen Run	WV-KL-57-L-4			x				x	
Pocatalico River	Martin Branch	WV-KL-57-N			x				x	
Pocatalico River	Schoolhouse Branch	WV-KL-57-O			x				x	
Pocatalico River	Campbells Branch	WV-KL-57-P							x	
Pocatalico River	Kelly Creek	WV-KL-57-Q			x				x	x
Pocatalico River	UNT/Kelly Creek RM 0.51	WV-KL-57-Q-1		x	x					
Pocatalico River	Spring Branch	WV-KL-57-Q-2			x				x	
Pocatalico River	Frog Creek	WV-KL-57-R			x				x	
Pocatalico River	Derrick Creek	WV-KL-57-U							x	
Threemile Creek (North)	Threemile Creek (North)	WV-KL-6							x	
Armour Creek	Armour Creek	WV-KL-60			x				x	x
Armour Creek	Blakes Creek	WV-KL-60-C							x	x
Scary Creek	Scary Creek	WV-KL-63			x				x	x
Scary Creek	UNT/Scary Creek RM 0.14	WV-KL-63-A			x				x	x
Scary Creek	Rockstep Run	WV-KL-63-C			x				x	x
Scary Creek	UNT/UNT RM 0.33/Scary Creek RM 2.13	WV-KL-63-E-1			x				x	x
Gallatin Branch	Gallatin Branch	WV-KL-64							x	x
Fivemile Creek	Fivemile Creek	WV-KL-7			x				x	
Davis Creek	Davis Creek	WV-KL-74			x				x	x
Davis Creek	Ward Hollow	WV-KL-74-B							x	
Davis Creek	Trace Fork	WV-KL-74-C			x				x	x
Davis Creek	Middle Fork/Davis Creek	WV-KL-74-F							x	
Davis Creek	Rays Branch	WV-KL-74-G							x	x
Davis Creek	Coal Hollow	WV-KL-74-L							x	x
Davis Creek	Cane Fork	WV-KL-74-N							x	x
Davis Creek	Kanawha Fork	WV-KL-74-O							x	
Davis Creek	Hoffman Hollow	WV-KL-74-O-1-A		x						

TMDL Watershed	Stream Name	WV_NHD_Code	Trout	pH	Fe	Al	DO	Se	FC	BIO
Joplin Branch	Joplin Branch	WV-KL-77							x	x
Fivemile Creek	Little Fivemile Creek	WV-KL-7-A			x		x		x	

Modeled Impairments				
TMDL Watershed	**Stream Name**	**WV_NHD_Code**	**Fe**	**Al**
Ninemile Creek	Ninemile Creek	WV-KL-12	x	
Ninemile Creek	UNT/ Ninemile Creek RM 0.27	WV-KL-12-A	x	
Ninemile Creek	Upper Ninemile Creek	WV-KL-12-B	x	
Ninemile Creek	Middle Ninemile Creek	WV-KL-12-D	x	
Ninemile Creek	UNT/Ninemile Creek RM 3.25	WV-KL-12-E	x	
Cooper Fork	UNT/UNT RM 0.39/Cooper Fork RM 1.41	WV-KL-15-C-1-A	x	
Cooper Fork	UNT/Cooper Fork RM 3.40	WV-KL-15-C-6	x	
Pond Branch	Pond Branch	WV-KL-17	x	
Pond Branch	UNT/Pond Branch RM 1.88	WV-KL-17-B	x	
Thirteenmile Creek	Long Hollow	WV-KL-19-AC	x	
Thirteenmile Creek	Little Spruce Run	WV-KL-19-AF	x	
Thirteenmile Creek	Peppermint Creek	WV-KL-19-AM	x	
Thirteenmile Creek	UNT/Rocky Fork RM 0.69	WV-KL-19-D-1	x	
Thirteenmile Creek	Tom Allen Creek	WV-KL-19-F	x	
Thirteenmile Creek	Buzzard Creek	WV-KL-19-H	x	
Thirteenmile Creek	Bailey Branch	WV-KL-19-M-15	x	
Thirteenmile Creek	Sapsucker Run	WV-KL-19-M-8	x	
Thirteenmile Creek	Beech Fork	WV-KL-19-M-9	x	
Thirteenmile Creek	UNT/Poplar Fork RM 4.81	WV-KL-19-N-6	x	
Thirteenmile Creek	UNT/Thirteenmile Creek RM 15.64	WV-KL-19-O	x	
Thirteenmile Creek	UNT/Thirteenmile Creek RM 15.82	WV-KL-19-P	x	
Thirteenmile Creek	Yeager Fork	WV-KL-19-R	x	
Thirteenmile Creek	Baker Branch	WV-KL-19-X	x	
Thirteenmile Creek	Spruce Run	WV-KL-19-Z	x	
Little Sixteenmile Creek	Little Sixteenmile Creek	WV-KL-20	x	
Little Sixteenmile Creek	Shady Fork	WV-KL-20-D	x	
Sixteenmile Creek	Sixteenmile Creek	WV-KL-22	x	
Sixteenmile Creek	Slaty Hollow	WV-KL-22-A	x	
Sixteenmile Creek	UNT/Sixteenmile Creek RM 8.16	WV-KL-22-L	x	
Eighteenmile Creek	Sulug Branch	WV-KL-27-AA	x	
Eighteenmile Creek	Cherry Fork	WV-KL-27-AB	x	
Eighteenmile Creek	Stumpy Run	WV-KL-27-AB-3	x	
Eighteenmile Creek	Painters Branch	WV-KL-27-AB-4	x	
Eighteenmile Creek	Sigman Fork	WV-KL-27-AB-6	x	
Eighteenmile Creek	Clendenin Creek	WV-KL-27-AF	x	

Modeled Impairments				
TMDL Watershed	Stream Name	WV_NHD_Code	Fe	Al
Eighteenmile Creek	Harris Branch	WV-KL-27-AH	x	
Eighteenmile Creek	UNT/Eighteenmile Creek RM 2.84	WV-KL-27-D	x	
Eighteenmile Creek	Otter Branch	WV-KL-27-E	x	
Eighteenmile Creek	Jakes Run	WV-KL-27-H	x	
Eighteenmile Creek	Isaacs Branch	WV-KL-27-K	x	
Eighteenmile Creek	Lukes Branch	WV-KL-27-L	x	
Eighteenmile Creek	Dads Branch	WV-KL-27-M	x	
Eighteenmile Creek	Bear Branch	WV-KL-27-N	x	
Eighteenmile Creek	Turkey Branch	WV-KL-27-P	x	
Eighteenmile Creek	Left Fork/Turkey Branch	WV-KL-27-P-3	x	
Eighteenmile Creek	Buffalo Branch	WV-KL-27-S	x	
Eighteenmile Creek	Right Fork/Eighteenmile Creek	WV-KL-27-X	x	
Eighteenmile Creek	Slab Hollow	WV-KL-27-X-3	x	
Eighteenmile Creek	Bucklick Creek	WV-KL-27-X-7	x	
Eighteenmile Creek	Saltlick Creek	WV-KL-27-X-8	x	
Eighteenmile Creek	Spring Valley Branch	WV-KL-27-Y	x	
Five and Twenty Mile Creek	Five And Twenty Mile Creek	WV-KL-35	x	
Five and Twenty Mile Creek	Honeycutt Run	WV-KL-35-A	x	
Five and Twenty Mile Creek	Stave Branch	WV-KL-35-B	x	
Five and Twenty Mile Creek	Evans Creek	WV-KL-35-E	x	
Five and Twenty Mile Creek	Barnett Branch	WV-KL-35-E-1	x	
Five and Twenty Mile Creek	UNT/Evans Creek RM 1.92	WV-KL-35-E-4	x	
Five and Twenty Mile Creek	UNT/Evans Creek RM 2.30	WV-KL-35-E-5	x	
Five and Twenty Mile Creek	UNT/Five And Twenty Mile Creek RM 7.41	WV-KL-35-H	x	
UNT/Little Buffalo Creek RM 1.17	UNT/Little Buffalo Creek RM 1.17	WV-KL-40-A	x	
UNT/Little Buffalo Creek RM 1.17	UNT/UNT RM 0.44/Little Buffalo Creek RM 1.17	WV-KL-40-A-1	x	
Hurricane Creek	Trace Fork	WV-KL-42-AC	x	
Hurricane Creek	Buffs Branch	WV-KL-42-AF	x	
Hurricane Creek	Joes Branch	WV-KL-42-AL	x	
Hurricane Creek	Rider Creek	WV-KL-42-AO	x	
Hurricane Creek	Sams Fork	WV-KL-42-AQ	x	
Hurricane Creek	UNT/Hurricane Creek RM 1.64	WV-KL-42-D	x	
Hurricane Creek	Rockstep Run	WV-KL-42-I-10-C	x	
Hurricane Creek	UNT/Long Branch RM 1.25	WV-KL-42-I-10-D	x	
Hurricane Creek	UNT/Poplar Fork RM 9.86	WV-KL-42-I-17	x	
Hurricane Creek	Sugar Branch	WV-KL-42-I-3	x	
Hurricane Creek	UNT/Cow Creek RM 2.33	WV-KL-42-I-4-F	x	
Hurricane Creek	UNT/Poplar Fork RM 3.78	WV-KL-42-I-5	x	
Hurricane Creek	Lick Branch	WV-KL-42-I-9	x	

Modeled Impairments				
TMDL Watershed	**Stream Name**	**WV_NHD_Code**	**Fe**	**Al**
Hurricane Creek	Tackett Branch	WV-KL-42-U-1	x	
Hurricane Creek	UNT/Mill Creek RM 1.02	WV-KL-42-U-2	x	
Little Hurricane Creek	Long Branch	WV-KL-46-A	x	
Little Hurricane Creek	UNT/Little Hurricane Creek RM 1.35	WV-KL-46-B	x	
Little Hurricane Creek	Harmon Branch	WV-KL-46-D	x	
Little Hurricane Creek	Morrison Fork	WV-KL-46-E	x	
Little Hurricane Creek	Lick Run	WV-KL-46-I	x	
Threemile Creek (South)	Threemile Creek (South)	WV-KL-5	x	
Farley Creek	Farley Creek	WV-KL-54	x	
Bills Creek	Bills Creek	WV-KL-56	x	
Bills Creek	UNT/Bills Creek RM 0.81	WV-KL-56-A	x	
Pocatalico River	Grapevine Creek	WV-KL-57-AA	x	
Pocatalico River	Right Fork	WV-KL-57-AA-2	x	
Pocatalico River	Boardtree Run	WV-KL-57-AA-4	x	
Pocatalico River	Dog Fork	WV-KL-57-AD-10	x	
Pocatalico River	Gays Branch	WV-KL-57-AD-14	x	
Pocatalico River	Sugar Creek	WV-KL-57-AD-2-H	x	
Pocatalico River	First Creek	WV-KL-57-AD-2-K	x	
Pocatalico River	Laurel Fork	WV-KL-57-AD-2-P	x	
Pocatalico River	Allen Fork	WV-KL-57-AD-3	x	
Pocatalico River	Trace Fork	WV-KL-57-AD-3-B	x	
Pocatalico River	Dudden Fork	WV-KL-57-AD-9	x	
Pocatalico River	Raccoon Creek	WV-KL-57-AL	x	
Pocatalico River	Leatherwood Creek	WV-KL-57-AO	x	
Pocatalico River	Hicumbottom Run	WV-KL-57-AP	x	
Pocatalico River	Goose Creek	WV-KL-57-AR	x	
Pocatalico River	Camp Creek	WV-KL-57-AT	x	
Pocatalico River	Allen Creek	WV-KL-57-AU	x	
Pocatalico River	Green Creek	WV-KL-57-AV	x	
Pocatalico River	Coleman Fork	WV-KL-57-AV-3	x	
Pocatalico River	Left Fork/Green Creek	WV-KL-57-AV-4	x	
Pocatalico River	Rush Fork	WV-KL-57-AV-6	x	
Pocatalico River	Straight Creek	WV-KL-57-AX	x	
Pocatalico River	White Oak Run	WV-KL-57-AZ	x	
Pocatalico River	Red Oak Run	WV-KL-57-BB	x	
Pocatalico River	Wolf Creek	WV-KL-57-BE	x	
Pocatalico River	Flat Fork	WV-KL-57-BH	x	
Pocatalico River	Trace Fork	WV-KL-57-BH-1	x	
Pocatalico River	Cabbage Fork	WV-KL-57-BH-13	x	
Pocatalico River	Wolfpen Run	WV-KL-57-BH-13-A	x	

Modeled Impairments				
TMDL Watershed	Stream Name	WV_NHD_Code	Fe	Al
Pocatalico River	Higby Run	WV-KL-57-BH-3	x	
Pocatalico River	Payne Hollow	WV-KL-57-BH-3-A	x	
Pocatalico River	Cox Fork	WV-KL-57-BH-8	x	
Pocatalico River	Wolfcamp Run	WV-KL-57-BH-8-B	x	
Pocatalico River	Coon Creek	WV-KL-57-BH-8-D	x	
Pocatalico River	Rock Creek	WV-KL-57-BK	x	
Pocatalico River	Big Creek	WV-KL-57-BN	x	
Pocatalico River	McKown Creek	WV-KL-57-BQ	x	
Pocatalico River	Left Hand Run	WV-KL-57-BQ-3	x	
Pocatalico River	Johnson Creek	WV-KL-57-BT	x	
Pocatalico River	Jackson Fork	WV-KL-57-BT-10	x	
Pocatalico River	Pad Fork	WV-KL-57-BT-6	x	
Pocatalico River	Big Lick Run	WV-KL-57-BU	x	
Pocatalico River	UNT/Silcott Fork RM 1.96	WV-KL-57-BU-2-B	x	
Pocatalico River	Bear Fork	WV-KL-57-BU-4	x	
Pocatalico River	Round Knob Run	WV-KL-57-BV	x	
Pocatalico River	Rush Creek	WV-KL-57-BX	x	
Pocatalico River	Slab Fork	WV-KL-57-BX-1	x	
Pocatalico River	Laurel Fork	WV-KL-57-CD	x	
Pocatalico River	Flat Fork	WV-KL-57-CF	x	
Pocatalico River	Claybank Branch	WV-KL-57-F	x	
Pocatalico River	Kelly Creek	WV-KL-57-J	x	x
Pocatalico River	Harmond Creek	WV-KL-57-K	x	
Pocatalico River	Lick Branch	WV-KL-57-L-1	x	
Pocatalico River	Fisher Branch	WV-KL-57-L-3	x	
Pocatalico River	Campbells Branch	WV-KL-57-P	x	
Pocatalico River	Grasslick Run	WV-KL-57-R-8	x	
Pocatalico River	Tanner Fork	WV-KL-57-R-9	x	
Pocatalico River	Derrick Creek	WV-KL-57-U	x	
Pocatalico River	UNT/Pocatalico River RM 23.03	WV-KL-57-X	x	
Threemile Creek (North)	Threemile Creek (North)	WV-KL-6	x	
Armour Creek	Blakes Creek	WV-KL-60-C	x	
Armour Creek	UNT/Armour Creek RM 3.25	WV-KL-60-D	x	
Armour Creek	UNT/Armour Creek RM 3.54	WV-KL-60-E	x	
Scary Creek	UNT/Rockstep Run RM 0.82	WV-KL-63-C-2	x	
Scary Creek	UNT/Scary Creek RM 2.13	WV-KL-63-E	x	
Scary Creek	UNT/Scary Creek RM 3.84	WV-KL-63-H	x	
Gallatin Branch	Gallatin Branch	WV-KL-64	x	
Gallatin Branch	UNT/Gallatin Branch RM 0.47	WV-KL-64-A	x	
Threemile Creek (North)	UNT/Threemile Creek RM 2.61	WV-KL-6-B	x	
Threemile Creek (North)	UNT/Threemile Creek RM 7.11	WV-KL-6-F	x	

Modeled Impairments				
TMDL Watershed	Stream Name	WV_NHD_Code	Fe	Al
Threemile Creek (North)	UNT/Threemile Creek RM 8.65	WV-KL-6-H	x	
Davis Creek	Ward Hollow	WV-KL-74-B	x	
Davis Creek	Mudsuck Branch	WV-KL-74-C-2	x	
Davis Creek	Pot Branch	WV-KL-74-C-4	x	
Davis Creek	Sugarcamp Creek	WV-KL-74-D	x	
Davis Creek	Dry Branch	WV-KL-74-E	x	
Davis Creek	Middle Fork/Davis Creek	WV-KL-74-F	x	
Davis Creek	Long Branch	WV-KL-74-F-2	x	
Davis Creek	Rays Branch	WV-KL-74-G	x	
Davis Creek	Kirby Hollow	WV-KL-74-K	x	
Davis Creek	Coal Hollow	WV-KL-74-L	x	
Davis Creek	Cane Fork	WV-KL-74-N	x	
Davis Creek	UNT/Cane Fork RM 0.83	WV-KL-74-N-1	x	
Davis Creek	Kanawha Fork	WV-KL-74-O	x	
Davis Creek	Middlelick Branch	WV-KL-74-O-1	x	
Joplin Branch	Joplin Branch	WV-KL-77	x	
Fivemile Creek	UNT/Fivemile Creek RM 2.40	WV-KL-7-B	x	
Fivemile Creek	Lower Fivemile Creek	WV-KL-7-C	x	
Fivemile Creek	Upper Fivemile Creek	WV-KL-7-D	x	

Notes:
RM is River Mile
UNT is Unnamed tributary
FC indicates fecal coliform bacteria impairment
BIO indicates a biological impairment

4.0 BIOLOGICAL IMPAIRMENT AND STRESSOR IDENTIFICATION

Initially, TMDL development in biologically impaired waters requires identification of the pollutants that cause the stress to the biological community. Sources of those pollutants are often analogous to those already described: mine drainage, untreated sewage, and sediment. **Section 2** of the Technical Report discusses biological impairment and the stressor identification (SI) process in detail.

4.1 Introduction

Assessment of the biological integrity of a stream is based on a survey of the stream's benthic macroinvertebrate community. Benthic macroinvertebrate communities are rated using a multimetric index developed for use in wadeable streams of West Virginia. The West Virginia Stream Condition Index (WVSCI; Gerritsen et al., 2000) is composed of six metrics that were selected to maximize discrimination between streams with known impairments and reference streams. In general, streams with WVSCI scores of fewer than 60.6 points, on a normalized 0–100 scale, are considered biologically impaired.

Biological assessments are useful in detecting impairment, but they may not clearly identify the causes of impairment, which must be determined before TMDL development can proceed. USEPA developed *Stressor Identification: Technical Guidance Document* (Cormier et al., 2000) to assist water resource managers in identifying stressors and stressor combinations that cause biological impairment. Elements of the SI process were used to evaluate and identify the significant stressors to the impaired benthic communities. In addition, custom analyses of biological data were performed to supplement the framework recommended by the guidance document.

The general SI process entailed reviewing available information, forming and analyzing possible stressor scenarios, and implicating causative stressors. The SI method provides a consistent process for evaluating available information. TMDLs were established for the responsible pollutants at the conclusion of the SI process. As a result, the TMDL process established a link between the impairment and benthic community stressors.

4.2 Data Review

WVDEP generated the primary data used in SI through its pre-TMDL monitoring program. The program included water quality monitoring, benthic sampling, and habitat assessment. In addition, the biologists' comments regarding stream condition, potential stressors and sources were captured and considered. Other data sources were: source tracking data, WVDEP mining activities data, NLCD 2001 landuse information, Natural Resources Conservation Service (NRCS) State Soil Geographic database (STATSGO) soils data, National Pollutant Discharge Elimination System (NPDES) point source data, and literature sources.

4.3 Candidate Causes/Pathways

The first step in the SI process was to develop a list of candidate causes, or stressors. The candidate causes responsible for biological impairments are listed below:

1. Metals contamination (including metals contributed through soil erosion) causes toxicity
2. Acidity (low pH) causes toxicity
3. Basic (high pH >9) causes toxicity
4. Increased ionic strength causes toxicity
5. Organic enrichment (e.g. sewage discharges and agricultural runoff cause habitat alterations
6. Increased metals flocculation and deposition causes habitat alterations (e.g., embeddedness)
7. Increased total suspended solids (TSS)/erosion and altered hydrology cause sedimentation and other habitat alterations
8. Altered hydrology causes higher water temperature, resulting in direct impacts
9. Altered hydrology, nutrient enrichment, and increased biochemical oxygen demand (BOD) cause reduced dissolved oxygen (DO)
10. Algal growth causes food supply shift
11. High levels of ammonia cause toxicity (including increased toxicity due to algal growth)
12. Chemical spills cause toxicity

A conceptual model was developed to examine the relationship between candidate causes and potential biological effects. The conceptual model (**Figure 4-1**) depicts the sources, stressors, and pathways that affect the biological community.

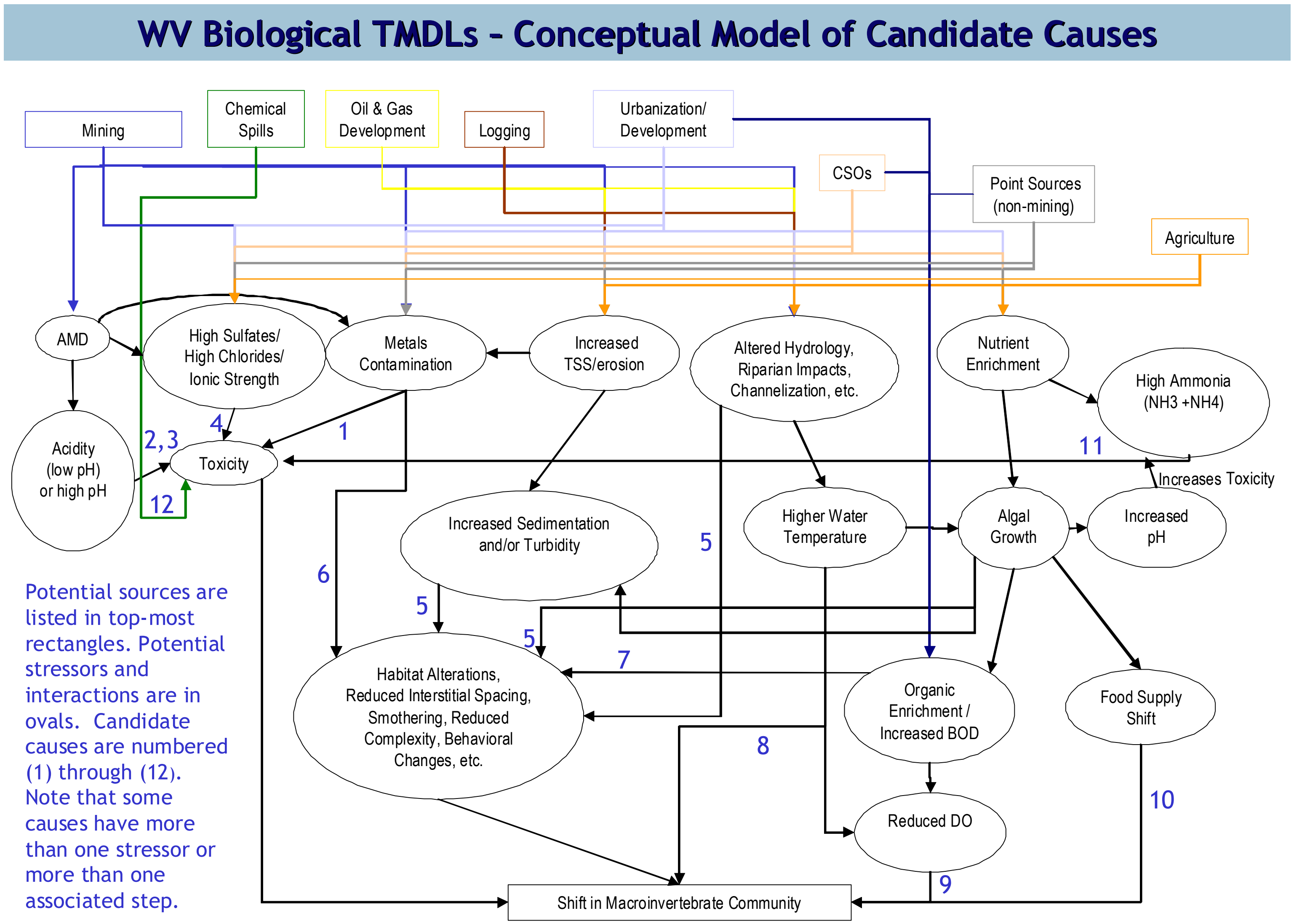


Figure 4-1. Conceptual model of candidate causes and potential biological effects

4.4 Stressor Identification Results

The SI process determined the significant causes of biological impairment. Biological impairment was linked to a single stressor in some cases and multiple stressors in others. The SI process identified the following stressors for the biologically impaired waters in the Lower Kanawha River watershed:

- Organic enrichment (the combined effects of oxygen-demanding pollutants, nutrients, and the resultant algal and habitat alteration)
- Sedimentation
- Ionic toxicity

After stressors were identified, WVDEP determined the pollutants for which TMDLs were required to address the impairment.

Where the SI process identified organic enrichment as the cause of biological impairment, data also indicated violations of the fecal coliform water quality criteria. The predominant sources of both organic enrichment and fecal coliform bacteria in the watershed are inadequately treated sewage and runoff from agricultural landuses. WVDEP determined that implementation of fecal coliform TMDLs would remove untreated sewage and significantly reduce loadings in agricultural runoff and resolve the biological impairment in these streams. Therefore, fecal coliform TMDLs will serve as a surrogate where organic enrichment was identified as a stressor.

WVDEP initially pursued the development of TMDLs directly for sediment to address the sedimentation biological stressor. The intended approach involved selection of a reference stream with an unimpaired biological condition, prediction of the sediment loading present in the reference stream, and use of the area-normalized sediment loading of the reference stream as the TMDL endpoint for sediment impaired waters.

Higby Run (KL-57-BH-3) was selected as the achievable reference stream as it shares similar landuse, ecoregion and geomorphologic characteristics with the sediment impaired streams. The location of Higby Run is shown in **Figure 4-2**.

All of the biologically impaired waters for which sedimentation was identified as a significant stressor are also impaired pursuant to total iron water quality criteria and the TMDL assessment for iron included representation and allocation of iron loadings associated with sediment. In each stream, the sediment loading reduction necessary for attainment of water quality criteria for iron exceeds that which was determined to be necessary using the reference approach. As such, the iron TMDLs are acceptable surrogates for biological impairments from sedimentation.

In certain waters (Joplin Branch WV-KL-77), the SI process determined ionic toxicity to be a significant stressor. A strong presence of sulfates and other dissolved solids exists in that stream where ionic toxicity has been determined to be a significant biological stressor. During the TMDL development period, there was insufficient information available regarding the causative pollutants and their associated impairment thresholds for biological TMDL development for ionic toxicity. WVDEP is deferring biological TMDL development for ionic toxicity stressed streams and retaining those waters on the Section 303(d) list. WVDEP and USEPA Region III have agreed upon a plan to develop these biological impairment TMDLs by 2014. **Table 4-1** summarizes the stressors identified for each biologically impaired stream and the appropriate TMDLs to address the biological impairment.

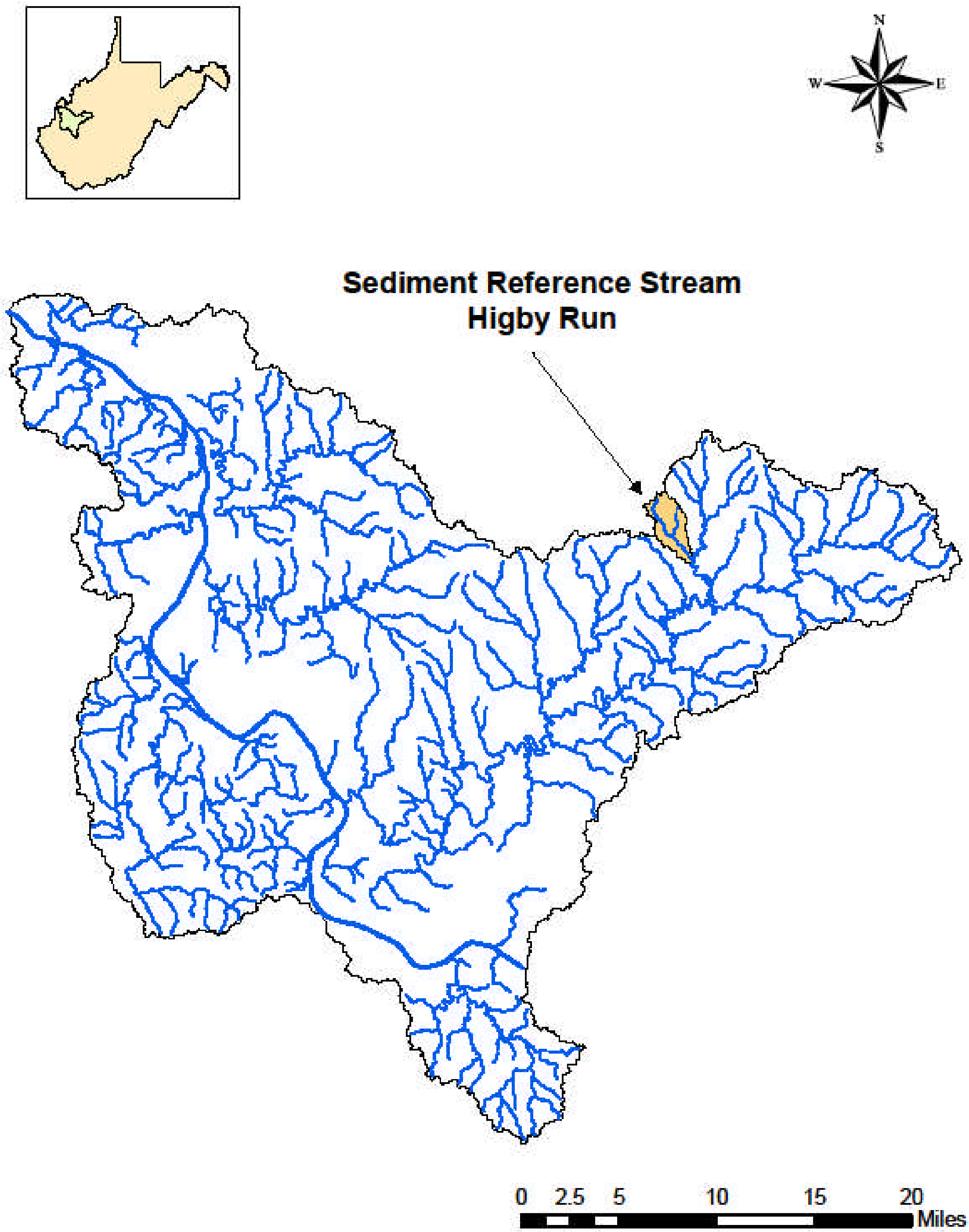


Figure 4-2. Location of the sediment reference stream, Higby Run (WV-KL-57-BH-3)

Table 4-1. Significant stressors of biologically impaired streams in the Lower Kanawha River watershed

Stream Name	NHD_Code	SI Stressor(s)	TMDLs Developed
Threemile Creek (South)	WV-KL-5	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Upper Ninemile Creek	WV-KL-12-B	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Pond Branch	WV-KL-17	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Poplar Fork	WV-KL-19-N	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Jakes Run	WV-KL-27-H	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Saltlick Creek	WV-KL-27-X-8	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Buckelew Hollow	WV-KL-27-AK	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
UNT/Five and Twenty Mile Creek RM 7.41	WV-KL-35-H	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
UNT/Little Buffalo Creek RM 1.17	WV-KL-40-A	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Hurricane Creek	WV-KL-42	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Poplar Fork	WV-KL-42-I	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Cow Creek	WV-KL-42-I-4	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Long Branch	WV-KL-42-I-10	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
UNT/Crooked Creek RM 0.72	WV-KL-42-I-16-B	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Sleepy Creek	WV-KL-42-N	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Mill Creek	WV-KL-42-U	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Rider Creek	WV-KL-42-AO	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Bills Creek	WV-KL-56	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Pocatalico River	WV-KL-57	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Harmond Creek	WV-KL-57-K	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Rocky Fork	WV-KL-57-L	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Kelly Creek	WV-KL-57-Q	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Grapevine Creek	WV-KL-57-AA	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Boardtree Run	WV-KL-57-AA-4	Organic Enrichment Sedimentation	Fecal Coliform Total Iron

Stream Name	NHD_Code	SI Stressor(s)	TMDLs Developed
Pocatalico Creek	WV-KL-57-AD	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Middle Fork/Pocatalico Creek	WV-KL-57-AD-2	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Raccoon Creek	WV-KL-57-AL	Sedimentation	Total Iron
Leatherwood Creek	WV-KL-57-AO	Sedimentation	Total Iron
Camp Creek	WV-KL-57-AT	Sedimentation	Total Iron
Straight Creek	WV-KL-57-AX	Sedimentation	Total Iron
Mckown Creek	WV-KL-57-BQ	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Armour Creek	WV-KL-60	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Blakes Creek	WV-KL-60-C	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Scary Creek	WV-KL-63	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
UNT/Scary Creek RM 0.14	WV-KL-63-A	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Rockstep Run	WV-KL-63-C	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
UNT/UNT RM 0.33/Scary Creek RM 2.13	WV-KL-63-E-1	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Gallatin Branch	WV-KL-64	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Davis Creek	WV-KL-74	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Trace Fork	WV-KL-74-C	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Rays Branch	WV-KL-74-G	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Coal Hollow	WV-KL-74-L	Organic Enrichment Sedimentation	Fecal Coliform Total Iron
Cane Fork	WV-KL-74-N	Organic Enrichment	Fecal Coliform
Joplin Branch	WV-KL-77	Organic Enrichment Sedimentation Ionic Stress	Fecal Coliform Total Iron Ionic Strength to be retained on the 303(d) list

5.0 METALS SOURCE ASSESSMENT

This section identifies and examines the potential sources of iron and aluminum impairments in the Lower Kanawha River watershed. Sources can be classified as point (permitted) or nonpoint (non-permitted) sources.

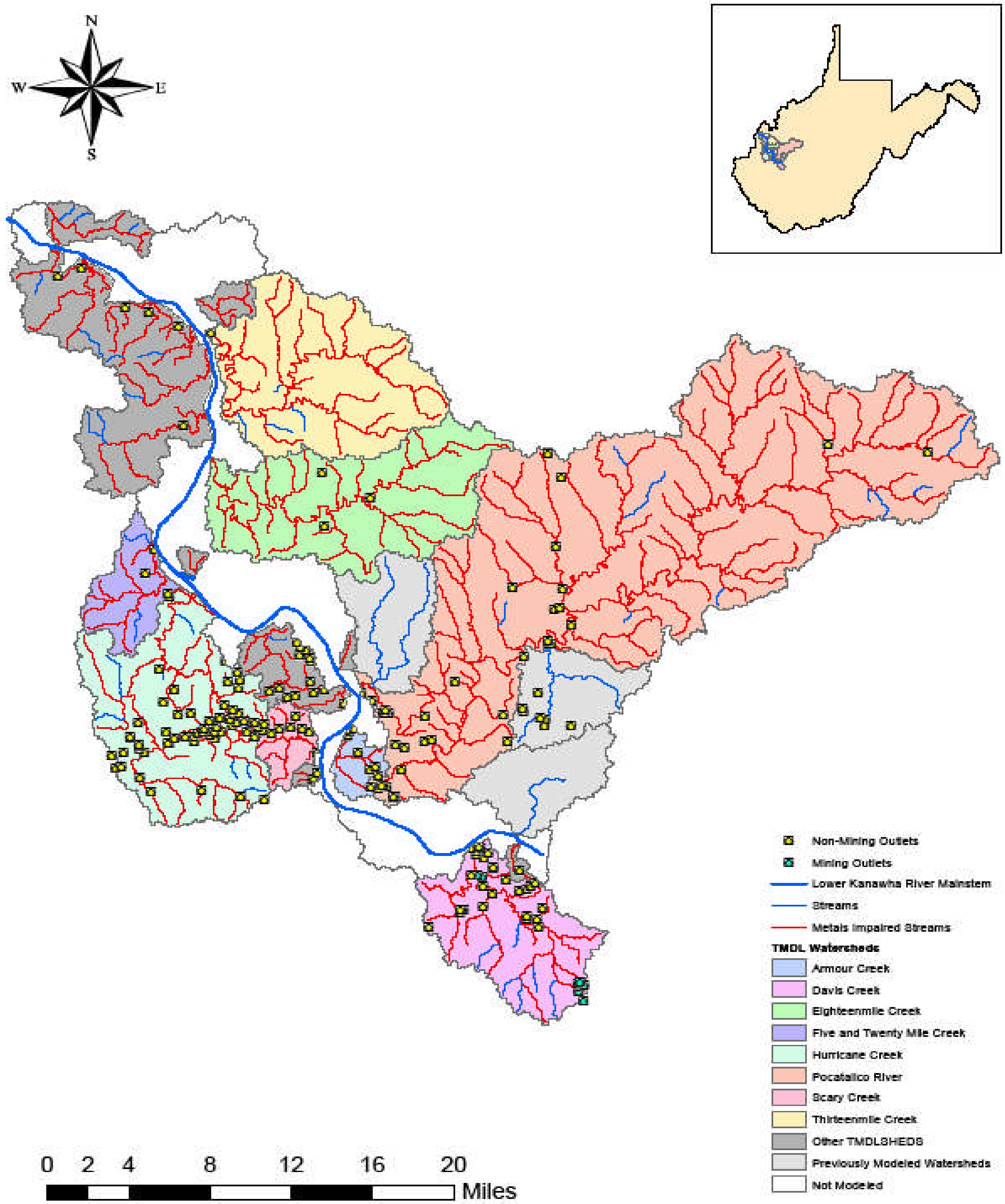
A point source, according to 40 CFR 122.3, is any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, and vessel or other floating craft from which pollutants are or may be discharged. The NPDES program, established under Clean Water Act Sections 318, 402, and 405, requires permits for the discharge of pollutants from point sources. For purposes of this TMDL, NPDES-permitted discharge points are considered point sources.

Nonpoint sources of pollutants are diffuse, non-permitted sources. They most often result from precipitation-driven runoff. For the purposes of these TMDLs only, WLAs are given to NPDES-permitted discharge points, and LAs are given to discharges from activities that do not have an associated NPDES permit, such as bond forfeiture sites and AML. The assignment of LAs to AML and bond forfeiture sites does not reflect any determination by WVDEP or USEPA as to whether there are, in fact, unpermitted point source discharges within these landuses. Likewise, by establishing these TMDLs with mine drainage discharges treated as LAs, WVDEP and USEPA are not determining that these discharges are exempt from NPDES permitting requirements.

The physiographic data discussed in **Section 3.2** enabled the characterization of pollutant sources. As part of the TMDL development process, WVDEP performed additional field-based source tracking activities to supplement the available source characterization data. WVDEP staff recorded physical descriptions of pollutant sources and the general stream condition in the vicinity of the sources. WVDEP collected global positioning system (GPS) data and water quality samples for laboratory analysis as necessary to characterize the sources and their impacts. Source tracking information was compiled and electronically plotted on maps using GIS software. Detailed information, including the locations of pollutant sources, is provided in the following sections, the Technical Report, and the GIS-based TMDL Viewer tool.

5.1 Metals Point Sources

Metals point sources are classified by the mining- and non-mining-related permits issued by WVDEP. The following sections discuss the potential impacts and the characterization of these source types, the locations of which are displayed in **Figure 5-1**.



(Note: permits in close proximity appear to overlap in the figure)

Figure 5-1. Metals point sources in the Lower Kanawha River watershed

5.1.1 Mining Point Sources

The Surface Mining Control and Reclamation Act of 1977 (SMCRA, Public Law 95-87) and its subsequent revisions were enacted to establish a nationwide program to protect the beneficial uses of land or water resources, protect public health and safety from the adverse effects of current surface coal mining operations, and promote the reclamation of mined areas left without adequate reclamation prior to August 3, 1977. SMCRA requires a permit for development of new, previously mined, or abandoned sites for the purpose of surface mining. Permittees are required to post a performance bond that will be sufficient to ensure the completion of reclamation requirements by a regulatory authority in the event that the applicant forfeits its permit. Mines that ceased operations before the effective date of SMCRA (often called “pre-law” mines) are not subject to the requirements of the SMCRA.

SMCRA Title IV is designed to provide assistance for the reclamation and restoration of abandoned mines; whereas Title V states that any surface coal mining operations must be required to meet all applicable performance standards. Some general performance standards include the following:

- Restoring the affected land to a condition capable of supporting the uses that it was capable of supporting prior to any mining
- Backfilling and compacting (to ensure stability or to prevent leaching of toxic materials) to restore the approximate original contour of the land, including all highwalls
- Minimizing disturbances to the hydrologic balance and to the quality and quantity of water in surface water and groundwater systems both during and after surface coal mining operations and during reclamation by avoiding acid or other toxic mine drainage

Untreated mining-related point source discharges from deep, surface, and other mines may have low pH values (i.e. acidic) and contain high concentrations of metals (iron and aluminum). Mining-related activities are commonly issued NPDES discharge permits that contain effluent limits for total iron, total manganese, total suspended solids, and pH. Many permits also include effluent monitoring requirements for total aluminum and some, more recently issued permits include aluminum water quality based effluent limits. WVDEP’s Division of Mining and Reclamation (DMR) provided a spatial coverage of the mining-related NPDES permit outlets. The discharge characteristics, related permit limits, and discharge data for these NPDES outlets were acquired from West Virginia’s ERIS database system. The spatial coverage was used to determine the location of the permit outlets. Additional information was needed, however, to determine the areas of the mining activities. WVDEP DMR also provided spatial coverage of the mining permit areas and related SMCRA Article 3 and NPDES permit information. WVDEP DWWM personnel used the information contained in the SMCRA Article 3 and NPDES permits to further characterize the mining point sources. Information gathered included type of discharge, pump capacities, and drainage areas (including total and disturbed areas). Using this information, the mining point sources were then represented in the model and assigned individual WLAs for metals.

There are 3 mining-related NPDES permits, with 8 associated outlets in the metals impaired watersheds of the Lower Kanawha River watershed. Some permits include multiple outlets with discharges to more than one TMDL watershed. A complete list of the permits and outlets is provided in Appendix H of the Technical Report. **Figure 5-1** illustrates the extent of the mining NPDES outlets in the watershed.

5.1.2 Non-mining Point Sources

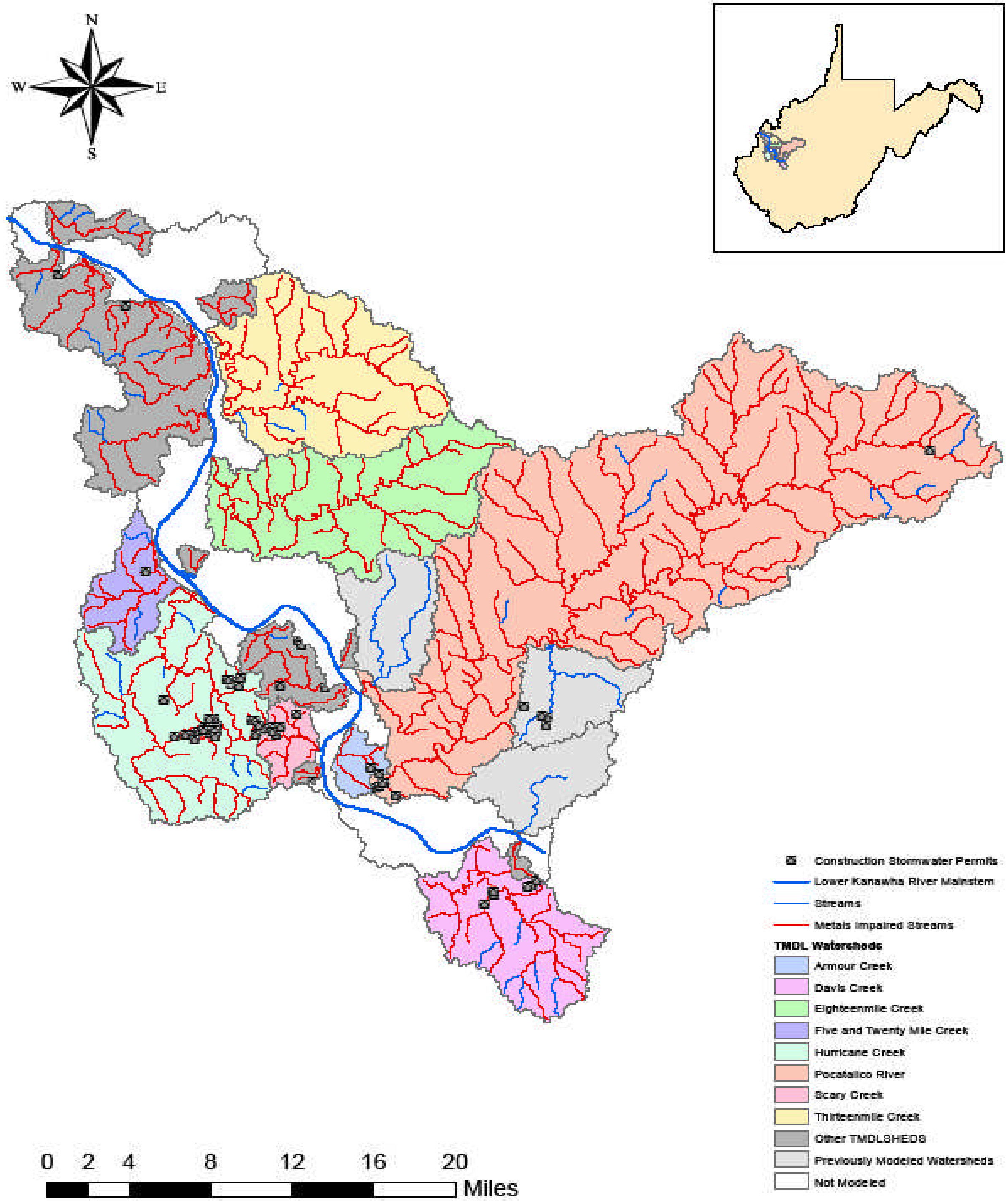
WVDEP DWWM controls water quality impacts from non-mining activities with point source discharges through the issuance of NPDES permits. WVDEP's OWRNPDES GIS coverage was used to determine the locations of these sources, and detailed permit information was obtained from WVDEP's ERIS database. Sources may include the process wastewater discharges from water treatment plants and industrial manufacturing operations, and stormwater discharges associated with industrial activity.

There are 57 modeled non-mining NPDES permitted outlets in the watersheds of metals impaired streams, which are displayed in **Figure 5-1**. 31 of the non-mining permitted outlets regulate stormwater associated with industrial activity and implement stormwater benchmark values of 100 mg/L TSS and/or 1.0 mg/L total iron. 2 additional outlets are associated with a groundwater remediation project registered under the Ground Water Remediation General NPDES Permit and is subject to an existing 1.2 mg/L monthly average total iron limitation. There are 5 individual industrial outlets and three water treatment plants and 16 solid waste landfills. The assigned WLAs for all non-mining NPDES outlets allow for continued discharge under existing permit requirements. A complete list of the permits and outlets is provided in Appendix H of the Technical Report.

5.1.3 Construction Stormwater Permits

The discharges from construction activities that disturb more than one acre of land are legally defined as point sources and the sediment introduced from such discharges can contribute iron and aluminum. WVDEP issues a General NPDES Permit (permit WV0115924) to regulate stormwater discharges associated with construction activities with a land disturbance greater than one acre. These permits require that the site have properly installed best management practices (BMPs), such as silt fences, sediment traps, seeding/mulching, and riprap, to prevent or reduce erosion and sediment runoff. The BMPs will remain intact until the construction is complete and the site has been stabilized. Individual registration under the General Permit is usually limited to less than one year.

There are 55 active construction sites with a total disturbed acreage of 1706.6 acres registered under the Construction Stormwater General Permit in the watersheds of metals impaired waters (**Figure 5-2).** Although specific wasteload allocations are not prescribed for these sites, the associated disturbed areas conform to the subwatershed-based allocations for registrations under the permit, as described in **Section 12.0**.



(Note: permits in close proximity appear to overlap in the figure)

Figure 5-2. Construction stormwater permits in the Lower Kanawha River watershed

5.1.4 Municipal Separate Storm Sewer Systems (MS4)

Runoff from residential and urbanized areas during storm events can be a significant sediment source. USEPA's stormwater permitting regulations require public entities to obtain NPDES permit coverage for stormwater discharges from MS4s in specified urbanized areas. As such, their stormwater discharges are considered point sources and are prescribed wasteload allocations.

The Charleston urbanized area overlaps Lower Kanawha TMDL watersheds. Four municipalities and the West Virginia Division of Highways (WVDOH) own and operate MS4s. The City of Charleston's MS4 is contained within the Davis Creek and Joplin Branch watersheds. The City of South Charleston's MS4 is also mostly within the Davis Creek and Joplin Branch watersheds. The City of Nitro's MS4 area is mostly within the Armour Creek watershed. The City of Hurricane's MS4 area falls mostly within the Hurricane Creek watershed. WVDOH MS4 area occurs inside and on the periphery of the four cities listed above.

MS4 source representation was based upon precipitation and runoff from landuses determined from the modified NLCD 2001 landuse data, the jurisdictional boundary of the cities, and the transportation-related drainage areas for which WVDOH has MS4 responsibility. In certain areas, urban/residential stormwater runoff may drain to both CSO and MS4 systems. WVDEP consulted with local governments and obtained information to determine drainage areas to the respective systems and best represent MS4 pollutant loadings. The location and extent of the four MS4 jurisdictions are shown in **Figure 5-3**.

The MS4 entities are registered under the MS4 General Permit (WV0116025). Individual registration numbers for the MS4 entities are as follows:

- City of Charleston WVR030006
- City of Hurricane/Storm Water Board WVR030010
- City of Nitro WVR030027
- City of South Charleston WVR030001
- WV Department of Transportation WVR030004

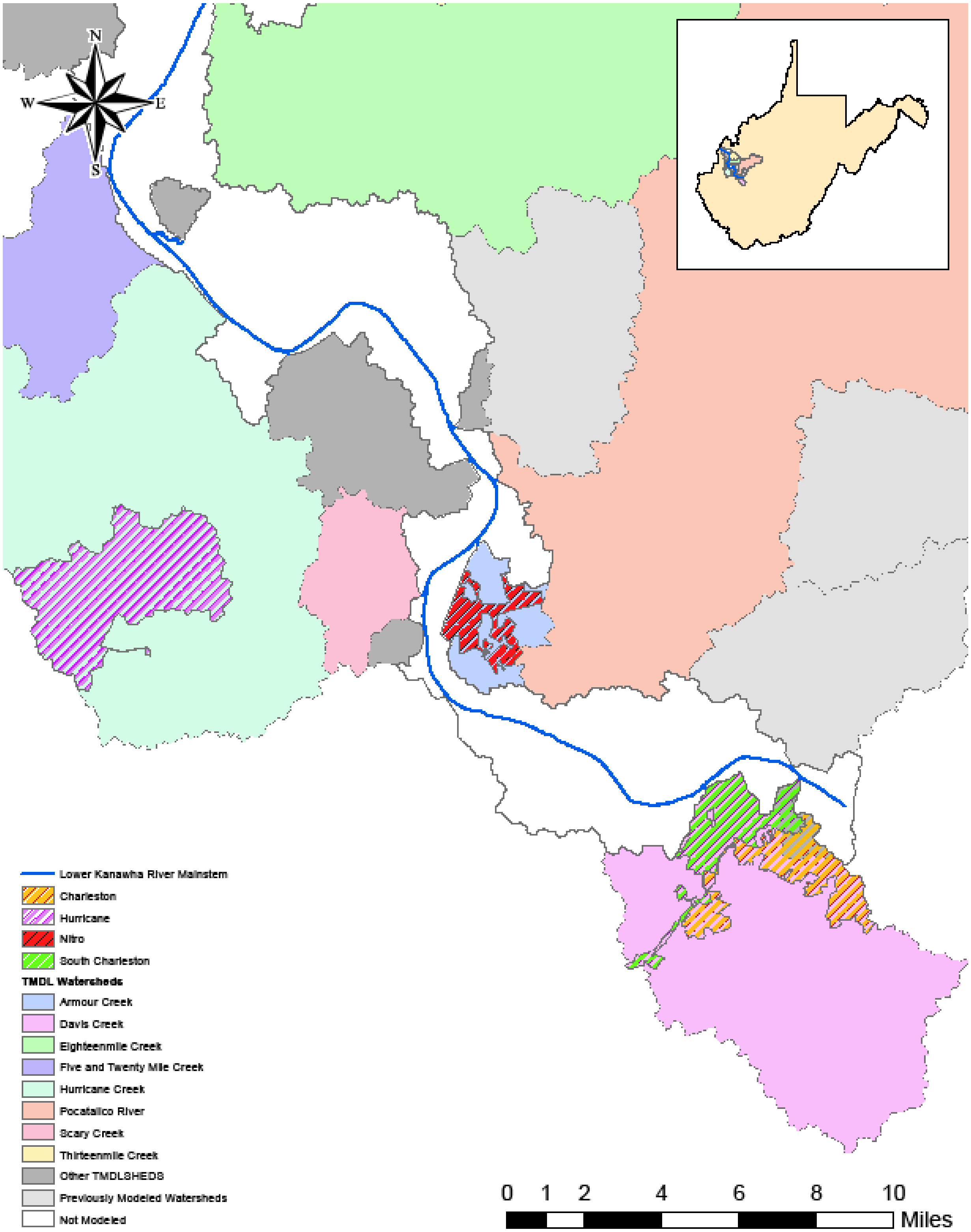


Figure 5-3. MS4 jurisdictions in the Lower Kanawha River watershed

5.2 Metals Nonpoint Sources

In addition to point sources, nonpoint sources can contribute to water quality impairments related to metals. AML may contribute acid mine drainage (AMD), which produces low pH and high metals concentrations in surface and subsurface water. Similarly, facilities that were subject to the Surface Mining Control and Reclamation Act of 1977 (SMCRA, Public Law 95-87) during active operations and subsequently forfeited their bonds and abandoned operations can be a significant source of metals. Also, land disturbing activities that introduce excess sediment are considered nonpoint sources of metals.

5.2.1 Abandoned Mine Lands

WVDEP's Office of Abandoned Mine Lands & Reclamation (AML&R) was created in 1981 to manage the reclamation of lands and waters affected by mining prior to passage of SMCRA in 1977. AML&R's mission is to protect public health, safety, and property from past coal mining and to enhance the environment through the reclamation and restoration of land and water resources. The AML program is funded by a fee placed on coal mining. Allocations from the AML fund are made to state and tribal agencies through the congressional budgetary process.

The Office of AML&R identified locations of AML in the Lower Kanawha River watershed from their records. In addition, source tracking efforts by WVDEP DWWM and AML&R identified additional AML sources (discharges, seeps, portals, and refuse piles). Field data, such as GPS locations, water samples, and flow measurements, were collected to represent these sources and characterize their impact on water quality. Based on this work, AML represent a significant source of metals in certain metals impaired streams for which TMDLs are presented. In TMDL watersheds with metals impairments, a total of 2,364 acres of AML area, 5 AML seeps, and 37 acres of highwall were incorporated into the TMDL model (**Figure 5-4**).

5.2.2 SMCRA Bond Forfeiture Sites

Mining permittees are required to post a performance bond to ensure the completion of reclamation requirements. When a bond is forfeited, WVDEP assumes the responsibility for the reclamation requirements. The Office of Special Reclamation in WVDEP's Division of Land Restoration provided bond forfeiture site locations and information regarding the status of land reclamation and water treatment activities. Sites with unreclaimed land disturbance and unresolved water quality impacts were represented, as were sites with ongoing water treatment activities. There are no unreclaimed bond forfeiture sites located in the metals impaired TMDL watersheds.

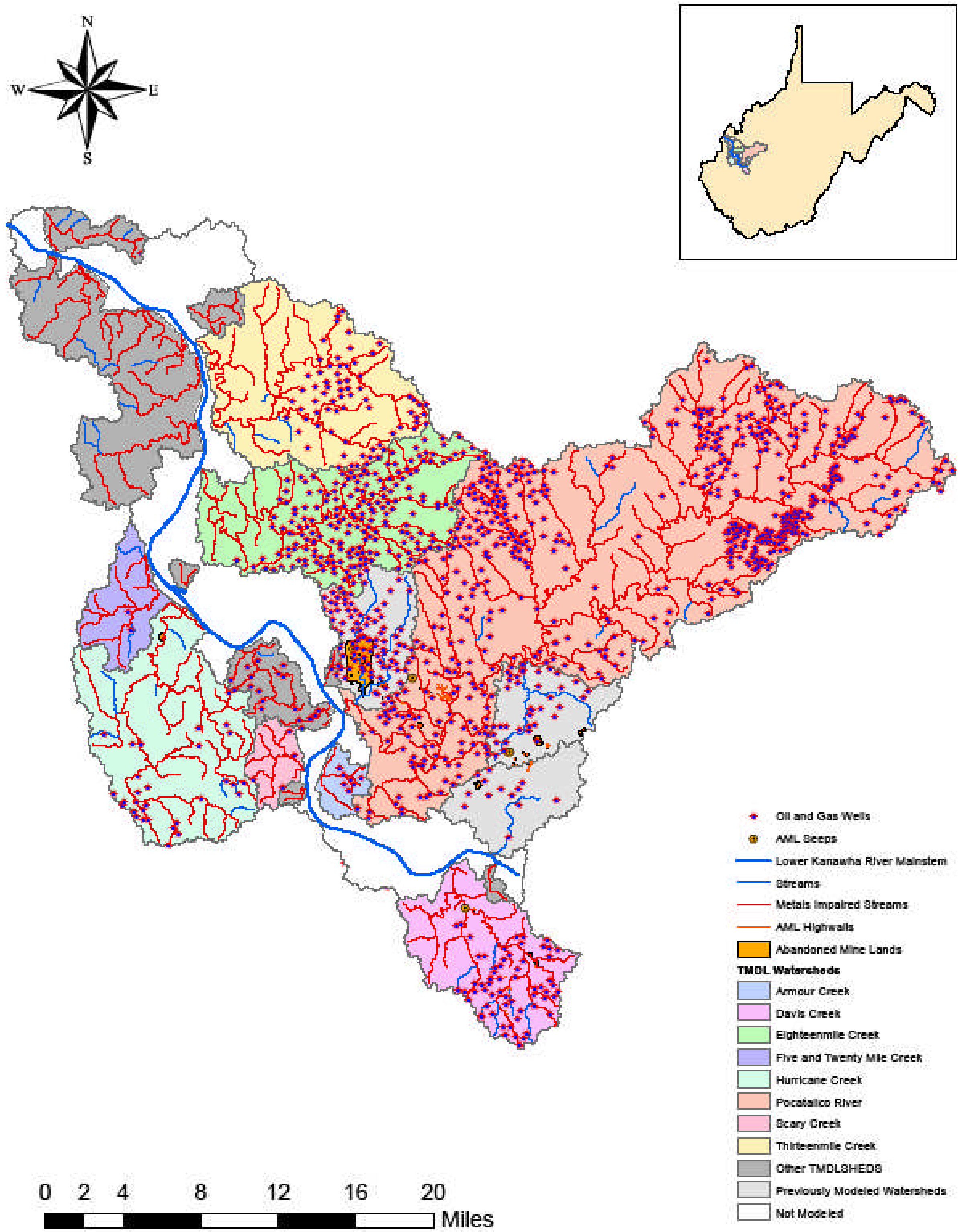


Figure 5-4. Metals non-point sources in the Lower Kanawha River watershed

5.2.3 Sediment Sources

Land disturbance can increase sediment loading to impaired waters. The control of sediment-producing sources has been determined to be necessary to meet water quality criteria for total iron during high-flow conditions. Nonpoint sources of sediment include forestry operations, oil and gas operations, roads, agriculture, stormwater from construction sites less than one acre, and stormwater from urban and residential land in non-MS4 areas. Additionally, streambank erosion represents a significant sediment source throughout the watershed. Upland sediment nonpoint sources are summarized below.

Forestry

The West Virginia Bureau of Commerce's Division of Forestry provided information on forest industry sites (registered logging sites) in the metals impaired TMDL watersheds. This information included the harvested area (14,248 acres) and the subset of land disturbed by roads and landings (1,015 acres) for registered logging sties, as well as 326 acres of burned forest, in the metals impaired TMDL watersheds.

West Virginia recognizes the water quality issues posed by sediment from logging sites. In 1992, the West Virginia Legislature passed the Logging Sediment Control Act. The act requires the use of best management practices (BMPs) to reduce sediment loads to nearby waterbodies. Without properly installed BMPs, logging and associated access roads can increase sediment loading to streams. According to the Division of Forestry, illicit logging operations represent approximately 2.5 percent of the total harvested forest area (registered logging sites) throughout West Virginia. These illicit operations do not have properly installed BMPs and can contribute sediment to streams. This rate of illicit activity has been represented in the model.

Oil and Gas

The WVDEP Office of Oil and Gas (OOG) is responsible for monitoring and regulating all actions related to the exploration, drilling, storage, and production of oil and natural gas in West Virginia. It maintains records on more than 40,000 active and 25,000 inactive oil and gas wells, and manages the Abandoned Well Plugging and Reclamation Program. The OOG also ensures that surface water and groundwater are protected from oil and gas activities.

Oil and gas data incorporated into the TMDL model were obtained from the WVDEP OOG GIS coverage. There are 1,150 active (1,587 acres) oil and gas wells in the metals impaired TMDL watersheds addressed in this report. Runoff from unpaved access roads to these wells and the disturbed areas around the wells contribute sediment to adjacent streams (**Figure 5-4**).

Roads

Heightened stormwater runoff from paved roads (impervious surface) can increase erosion potential. Unpaved roads can contribute sediment through precipitation-driven runoff. Roads that traverse stream paths elevate the potential for direct deposition of sediment. Road construction and repair can further increase sediment loads if BMPs are not properly employed.

Information on roads was obtained from various sources, including the 2000 TIGER/Line shapefiles from the U.S. Census Bureau and the WV Roads GIS coverage prepared by WVU. Unpaved roads that were not included in either GIS coverage were digitized from topographic maps.

Agriculture

Agricultural activities can contribute sediment loads to nearby streams through typical tillage practices and unrestricted livestock access. Agricultural landuses are significant sediment sources in a number of areas in the metals impaired TMDL watersheds. In addition to upland sediment loading, agricultural activities can negatively impact streambank conditions and increase bank erosion loading.

Streambank Erosion

Streambank erosion has been determined to be a significant sediment source. The sediment loading from bank erosion is associated with bank condition and upland imperviousness. The streambank erosion modeling process is discussed in **Section 10.2.2**.

Other Land-Disturbance Activities

Stormwater runoff from residential and urban landuses in non-MS4 areas is a significant source of sediment in parts of the watershed. Outside urbanized area boundaries, these landuses are considered to be nonpoint sources and load allocations are prescribed. The modified NLCD2001 landuse data were used to determine the extent of residential and urban areas not subject to MS4 permitting requirements and source representation was based upon precipitation and runoff.

The NLCD 2001 landuse data also classifies certain areas as “barren” land. In the model configuration process, portions of the barren landuse were reclassified to account for other known sources (abandoned mine lands, mining permits, etc.). The remainder is represented as a specific nonpoint source category in the model.

Construction activities disturbing less than one acre are not subject to construction stormwater permitting. While not specifically represented in the model, their impact is indirectly accounted for in the loading rates established for the urban/residential landuse category.

6.0 pH SOURCES

The pH impairments in the Lower Kanawha River watershed have been attributed to two source categories. In areas where historical, unregulated mining occurred, discharges from AML continue to introduce drainage of low pH and high dissolved metals. In contrast, the low pH impairments of waters in relatively pristine areas are the result of acid precipitation and the low buffering capacity of the watershed. WVDEP source tracking and pre-TMDL water quality monitoring were used to determine the causative sources.

Discharges from historical mining activities can cause low pH impairments, iron and/or aluminum impairments. Because of the complex chemical interactions that occur between dissolved metals and acidity, the TMDL approach focused on reducing metals concentrations to meet metals water quality criteria while accounting for watershed dynamics associated with acidic atmospheric deposition and low watershed buffering capacity. Where appropriate, the approach prescribes the necessary reductions associated with the metals TMDL condition and presents the net alkalinity additions necessary to achieve the pH water quality criteria.

Table 6-1. Causative sources of pH impaired streams

TMDL Watershed	Stream Name	NHD_Code	Causative Sources
Pocatalico River	UNT/Pocatalico River RM 8.52	WV-KL-57-I	Historic Mining
Pocatalico River	Kelly Creek	WV-KL-57-J	Historic Mining
Pocatalico River	UNT/Harmond Creek RM 1.00	WV-KL-57-K-2	Historic Mining
Pocatalico River	UNT/Kelly Creek RM 0.51	WV-KL-57-Q-1	Historic Mining
Davis Creek	Hoffman Hollow	WV-KL-74-O-1-A	Acid deposition

Acid rain is produced when atmospheric moisture reacts with gases to form sulfuric acid, nitric acid, and carbonic acid. These gases are primarily formed from nitrogen dioxides and sulfur dioxide, which enter the atmosphere through exhaust and smoke from burning fossil fuels such as gas, oil, and coal. Two-thirds of sulfur dioxides and one-forth of nitrogen oxides present in the atmosphere are attributed to fossil fuel burning electric power generating plants (USEPA, 2005a). Acid rain crosses watershed boundaries and may originate in the Ohio valley or the midwest.

Decreased pH levels in streams can be aided by natural conditions such as wetlands, more specifically, bogs; and the lack of stream buffering capacity. Bogs receive most of their water from precipitation, which is naturally acidic, and pH may be decreased from the natural decomposition of organic materials (MDE 2003). The other natural condition that may result in lowered pH levels is the lack of buffering capacity in soils and certain geologic formations. Acidic soils (e.g., Atkins, Brinkerton, Delkalb, Ernest, Gilpin, and Latham types) and the Pottsville Sandstone formation (very low buffering capacity) are known to significantly influence the pH conditions.

The majority of the acid deposition occurs in the eastern United States. In March 2005, the USEPA issued the Clean Air Interstate Rule (CAIR), which places caps on emissions for sulfur dioxide and nitrogen dioxides for the eastern United States. It is expected that CAIR will reduce sulfur dioxide emissions by over 70 percent and nitrogen oxides emissions by over 60 percent from the 2003 emission levels (USEPA, 2005b). Since the pollution is highly mobile in the atmosphere, reductions based on CAIR in West Virginia, Ohio, and Pennsylvania will likely improve the quality of precipitation in the watershed.

Atmospheric deposition occurs by two main methods: wet and dry. Wet deposition occurs through rain, fog, and snow. Dry deposition occurs from gases and particles. Dry deposition accounts for approximately half of the atmospheric deposition of acidity (USEPA, 2005a).

Particles and gases from dry deposition can be washed from trees, roofs, and other surfaces by precipitation after it is deposited and washed into streams. Winds blow the particles and gases contributing to acid deposition over large distances, including political boundaries, such as state boundaries.

Atmospheric deposition data were obtained from the USEPA Office of Air Quality Planning and Standards at Research Triangle Park, North Carolina. The data are a result of air quality modeling in support of the CAIR. The data include concentrations of sulfate and nitrogen oxides in wet and dry deposition. For the technical information on these data, please see the Technical Support Document for the Final Clean Air Intestate Rule – Air Quality Modeling (USEPA, 2005c). National Atmospheric Deposition Program (NADP) monitoring data collected at the USDA Forest Service Northeastern Research Station, Tucker County, WV was also used to characterize the extent of atmospheric deposition in the watershed.

7.0 FECAL COLIFORM SOURCE ASSESSMENT

7.1 Fecal Coliform Point Sources

Publicly and privately owned sewage treatment facilities and home aeration units are point sources of fecal coliform bacteria. Combined sewer overflows (CSOs) and discharges from MS4s are additional point sources that may contribute loadings of fecal coliform bacteria to receiving streams. The following sections discuss the specific types of fecal coliform point sources that were identified in the Lower Kanawha River watershed.

7.1.1 Individual NPDES Permits

WVDEP issues individual NPDES permits to both publicly owned and privately owned wastewater treatment facilities. Publicly owned treatment works (POTWs) are relatively large facilities with extensive wastewater collection systems, whereas private facilities are usually used in smaller applications such as subdivisions and shopping centers.

In the subject watersheds of this report, two individually permitted POTWs discharge treated effluent at two outlets. In addition, the City of Hurricane has 2 stormwater outlets associated with the POTW. No additional privately owned sewage treatment plants operating under an individual NPDES permit discharge treated effluent in subject watersheds. No mining bathhouse facilities discharge to TMDL streams in the Lower Kanawha TMDL watersheds.

These sources are regulated by NPDES permits that require effluent disinfection and compliance with strict fecal coliform effluent limitations (200 counts/100 mL [geometric mean monthly] and 400 counts/100 mL [maximum daily]). Compliant facilities do not cause fecal coliform bacteria impairments because effluent limitations are more stringent than water quality criteria.

7.1.2 Overflows

CSOs are outfalls from POTW sewer systems that carry untreated domestic waste and surface runoff. CSOs are permitted to discharge only during precipitation events. Sanitary sewer overflows (SSOs) are unpermitted overflows that occur as a result of excess inflow and/or infiltration to POTW separate sanitary collection systems. Both types of overflows contain fecal coliform bacteria. Eight CSO outlets in the subject watersheds are associated with the POTWs operated by the Charleston Sanitary Board (7) and the City of Nitro (1). No significant SSOs were represented in the model.

7.1.3 Municipal Separate Storm Sewer Systems (MS4)

Runoff from residential and urbanized areas during storm events can be a significant fecal coliform source. USEPA's stormwater permitting regulations require public entities to obtain NPDES permit coverage for stormwater discharges from MS4s in specified urbanized areas. As such, MS4 stormwater discharges are considered point sources and are prescribed wasteload allocations.

MS4 entities and their areas of responsibility are described in **Section 5.1.4** and displayed in **Figure 5-3**. MS4 source representation is based upon precipitation and runoff from landuses determined from the modified NLCD 2001 landuse data, the jurisdictional boundary of the cities, and the transportation-related drainage areas for which WVDOH has MS4 responsibility. In certain areas, urban/residential stormwater runoff may drain to both CSO and MS4 systems. WVDEP consulted with local governments and obtained information to determine drainage areas to the respective systems and best represent MS4 pollutant loadings.

7.1.4 General Sewage Permits

General sewage permits are designed to cover like discharges from numerous individual owners and facilities throughout the state. General Permit WV0103110 regulates small, privately owned sewage treatment plants ("package plants") that have a design flow of 50,000 gallons per day (gpd) or less. General Permit WV0107000 regulates home aeration units (HAUs). HAUs are small sewage treatment plants primarily used by individual residences where site considerations preclude typical septic tank and leach field installation. Both general permits contain fecal coliform effluent limitations identical to those in individual NPDES permits for sewage treatment facilities. In the areas draining to streams for which fecal coliform TMDLs have been developed, 18 facilities are registered under the "package plant" general permit and 213 are registered under the "HAU" general permit.

7.2 Fecal Coliform Nonpoint Sources

7.2.1 On-site Treatment Systems

Failing septic systems and straight pipes are significant nonpoint sources of fecal coliform bacteria. Information collected during source tracking efforts by WVDEP yielded an estimate of

16,700 homes that are not served by centralized sewage collection and treatment systems. Estimated septic system failure rates across the watershed range from three percent to 28 percent.

Due to a wide range of available literature values relating to the bacteria loading associated with failing septic systems, a customized Microsoft Excel spreadsheet tool was created to represent the fecal coliform bacteria contribution from failing on-site septic systems. WVDEP's pre-TMDL monitoring and source tracking data were used in the calculations. To calculate loads, values for both wastewater flow and fecal coliform concentration are needed.

To calculate failing septic wastewater flows, the TMDL watersheds were divided into four septic failure zones. During the WVDEP source tracking process, septic failure zones were delineated by soil characteristics (soil permeability, depth to bedrock, depth to groundwater and drainage capacity) as shown in United States Department of Agriculture (USDA) county soil survey maps. Two types of failure were considered, complete failure and periodic failure. For the purposes of this analysis, complete failure was defined as 50 gallons per house per day of untreated sewage escaping a septic system as overland flow to receiving waters and periodic failure was defined as 25 gallons per house per day. **Figure 7-1** shows the failing septic flows represented in the model by subwatershed.

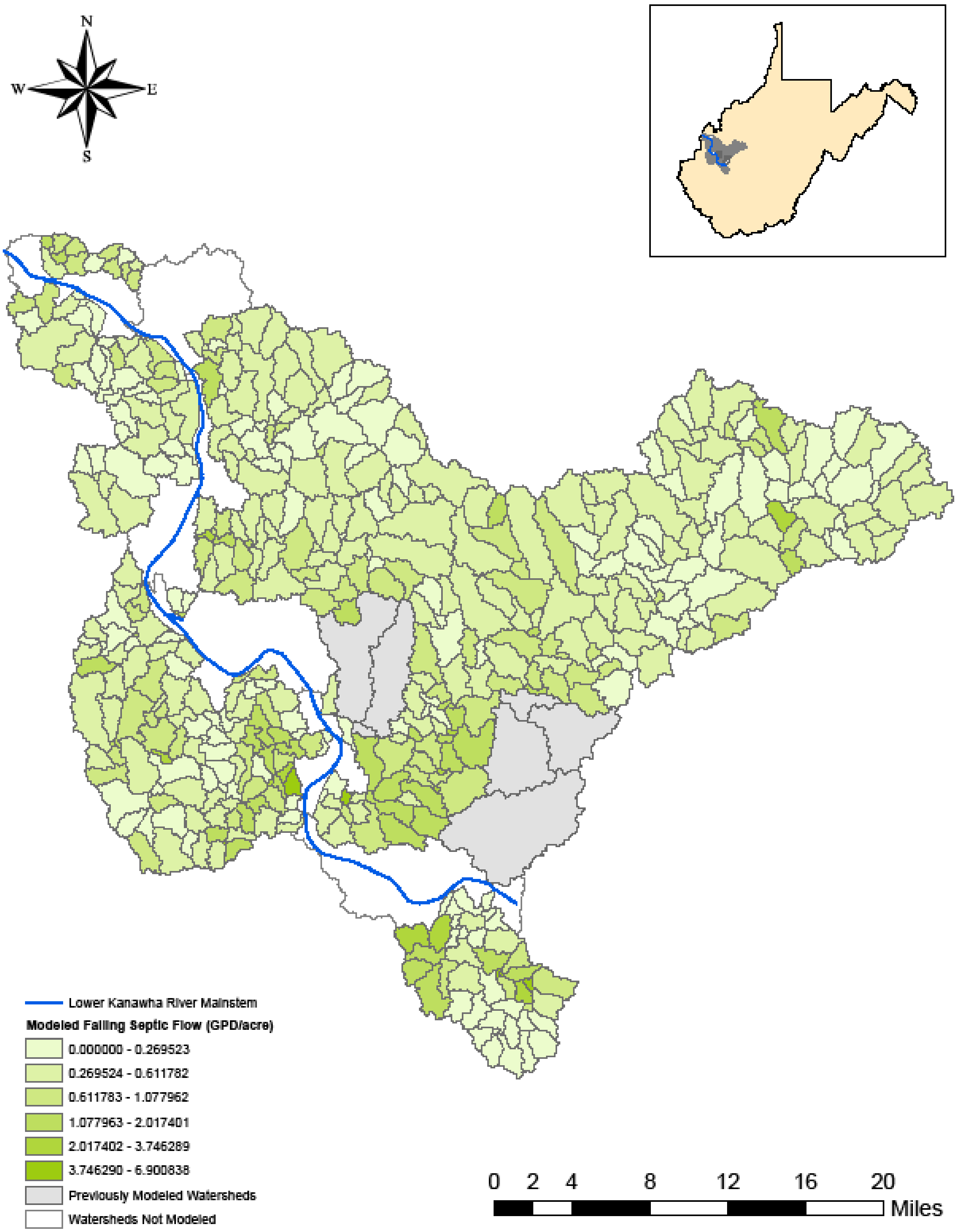


Figure 7-1. Failing septic flows in the Lower Kanawha River watershed

Once failing septic flows were modeled, a fecal coliform concentration was determined at the TMDL watershed scale. Based on past experience with other West Virginia TMDLs, a base concentration of 10,000 counts per 100 ml was used as a beginning concentration for failing septic systems. This concentration was further refined during model calibration. A sensitivity analysis was performed by varying the modeled failing septic concentrations in multiple model runs, and then comparing model output to pre-TMDL monitoring data. Additional details of the failing septic analyses are elucidated in the Technical Report.

For the purposes of this TMDL, discharges from activities that do not have an associated NPDES permit, such as failing septic systems and straight pipes, are considered nonpoint sources. The decision to assign LAs to those sources does not reflect a determination by WVDEP or USEPA as to whether they are, in fact, non-permitted point source discharges. Likewise, by establishing these TMDLs with failing septic systems and straight pipes treated as nonpoint sources, WVDEP and USEPA are not determining that such discharges are exempt from NPDES permitting requirements.

7.2.2 Urban/Residential Runoff

Stormwater runoff from residential and urbanized areas that are not subject to MS4 permitting requirements can be a significant source of fecal coliform bacteria. These landuses are considered to be nonpoint sources and load allocations are prescribed. The modified NLCD 2001 landuse data were used to determine the extent of residential and urban areas not subject to MS4 permitting requirements and source representation was based upon precipitation and runoff.

7.2.3 Agriculture

Agricultural activities can contribute fecal coliform bacteria to receiving streams through surface runoff or direct deposition. Grazing livestock and land application of manure result in the deposition and accumulation of bacteria on land surfaces. These bacteria are then available for wash-off and transport during rain events. In addition, livestock with unrestricted access can deposit feces directly into streams.

Agricultural activity is a ubiquitous fecal coliform bacteria nonpoint source in the watershed. Pasture/cropland landuses were determined to be present in approximately 75% of the modeled subwatersheds. Source tracking efforts identified pastures and feedlots near impaired segments that have localized impacts on instream bacteria levels. Source representation was based upon precipitation and runoff, and source tracking information regarding number of livestock, proximity and access to stream, and overall runoff potential were used to develop accumulation rates.

7.2.4 Natural Background (Wildlife)

A certain “natural background” contribution of fecal coliform bacteria can be attributed to deposition by wildlife in forested areas. Accumulation rates for fecal coliform bacteria in forested areas were developed using reference numbers from past TMDLs, incorporating wildlife estimates obtained from West Virginia’s Division of Natural Resources (WVDNR). In addition, WVDEP conducted storm-sampling on a 100 percent forested subwatershed (Shrewsbury

Hollow) within the Kanawha State Forest, Kanawha County, West Virginia to determine wildlife contributions of fecal coliform. These results were used during the model calibration process. On the basis of the low fecal accumulation rates for forested areas, the storm water sampling results, and model simulations, wildlife is not considered to be a significant nonpoint source of fecal coliform bacteria in the watershed.

8.0 DISSOLVED OXYGEN SOURCE ASSESSMENT

The dissolved oxygen impairment of Little Five Mile Creek (WV-KL-7-A) is directly related to an animal confinement/feeding operation located within 50 meters of stream monitoring location (KL-00083-0.8). Significant accumulations of animal wastes were routinely observed on the stream banks and substrate in the vicinity of the monitoring station. Pre-TMDL monitoring also documented extreme nonattainment with fecal coliform water quality criteria at this location and source tracking activities clearly identify the causative source of both impairments (**Figures 8-1** thru **8-3**).

A fecal coliform TMDL is presented for Little Five Mile Creek. Successful implementation of the 98.5% fecal coliform reduction prescribed for agriculture in the watershed (model subwatershed 30139) would necessitate installation of BMPs to cease releases of animal wastes to the stream, which, in turn, would result in attainment of the dissolved oxygen criterion. As such, the Little Five Mile Creek fecal coliform TMDL is an appropriate surrogate for the dissolved oxygen impairment.

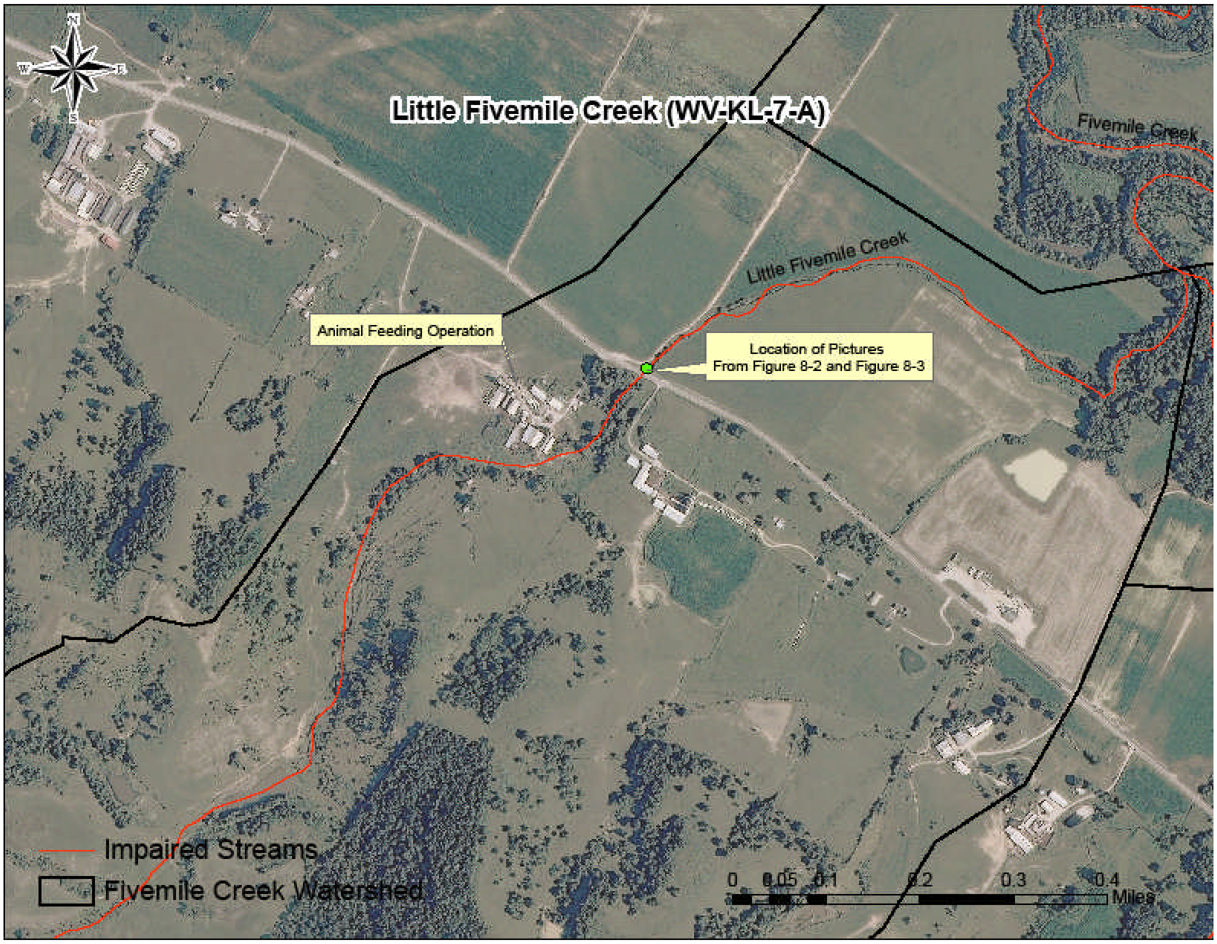


Figure 8-1. Little Five Mile Creek location

Figure 8-2. Photo of Little Five Mile Creek

Figure 8-3. Photo Little Five Mile substrate

9.0 SEDIMENT SOURCE ASSESSMENT

Excess sediment has been identified as a significant stressor in relation to the biological impairments of a number of streams in the Lower Kanawha River watershed. In all of the subject waters, it was determined that the sediment reductions necessary to ensure attainment of the iron water quality criteria exceed those that would be needed to address biological impairment through a reasonably achievable sediment reference approach. Therefore, the iron TMDLs are an appropriate surrogate in place of sediment TMDLs. Sediment sources considered in the TMDL model are described in detail in **Section 5.2.3**.

10.0 MODELING PROCESS

Establishing the relationship between the instream water quality targets and source loadings is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses with flow and loading conditions. This section presents the approach taken to develop the linkage between sources and instream response for TMDL development in the Lower Kanawha River watershed.

10.1 Model Selection

Selection of the appropriate analytical technique for TMDL development was based on an evaluation of technical and regulatory criteria. The following key technical factors were considered in the selection process:

- Scale of analysis
- Point and nonpoint sources
- Metals and fecal coliform bacteria impairments are temporally variable and occur at low, average, and high flow conditions
- Dissolved aluminum impairments are related to pH water quality
- Total iron and total aluminum loadings and instream concentrations are related to sediment
- Time-variable aspects of land practices have a large effect on instream metals and bacteria concentrations
- Metals and bacteria transport mechanisms are highly variable and often weather-dependent

The primary regulatory factor that influenced the selection process was West Virginia’s water quality criteria. According to 40 CFR Part 130, TMDLs must be designed to implement applicable water quality standards. The applicable water quality criteria for iron, aluminum, pH, dissolved oxygen, and fecal coliform bacteria in West Virginia are presented in **Section 2**, **Table 2-1**. West Virginia numeric water quality criteria are applicable at all stream flows greater than the 7-day, 10-year low flow (7Q10). The approach or modeling technique must permit representation of instream concentrations under a variety of flow conditions to evaluate critical flow periods for comparison with criteria.

The TMDL development approach must also consider the dominant processes affecting pollutant loadings and instream fate. In the Lower Kanawha River watershed, an array of point and nonpoint sources contributes to the various impairments. Most nonpoint sources are rainfall-driven with pollutant loadings primarily related to surface runoff, but some, such as AML seeps and inadequate onsite residential sewage treatment systems, function as continuous discharges. Similarly, certain point sources are precipitation-induced while others are continuous discharges. While loading function variations must be recognized in the representation of the various sources, the TMDL allocation process must prescribe WLAs for all contributing point sources and LAs for all contributing nonpoint sources.

The Mining Data Analysis System (MDAS) was developed specifically for TMDL application in West Virginia to facilitate large scale, data intensive watershed modeling applications. The MDAS is a system designed to support TMDL development for areas affected by nonpoint and point sources. The MDAS component most critical to TMDL development is the dynamic watershed model because it provides the linkage between source contributions and instream response. The MDAS is used to simulate watershed hydrology and pollutant transport as well as stream hydraulics and instream water quality. It is capable of simulating different flow regimes and pollutant loading variations. A key advantage of the MDAS' development framework is that it has no inherent limitations in terms of modeling size or upper limit of model operations. In addition, the MDAS model allows for seamless integration with modern-day, widely available software such as Microsoft Access and Excel. Sediment, total iron, dissolved aluminum, pH, and fecal coliform bacteria were modeled using the MDAS.

10.2 Model Setup

Model setup consisted of configuring the following three separate MDAS models: iron/sediment, aluminum/pH, and fecal coliform bacteria.

10.2.1 General MDAS Configuration

Configuration of the MDAS model involved subdividing the TMDL watersheds into subwatershed modeling units connected by stream reaches. Physical characteristics of the subwatersheds, weather data, landuse information, continuous discharges, and stream data were used as input. Flow and water quality were continuously simulated on an hourly time-step.

The 22 TMDL watersheds were broken into 515 separate subwatershed units, based on the groupings of impaired streams shown in **Figure 10-1**. The TMDL watersheds were divided to allow evaluation of water quality and flow at pre-TMDL monitoring stations.

In 2006, WVDEP developed total iron TMDLs for Heizer Creek, Manila Creek and Tupper Creek tributaries of the Pocatalico River. A fecal coliform TMDL was also developed for Tupper Creek. In this effort, WVDEP did not reevaluate the impairments of those tributaries. Instead, the TMDL time series outputs from the previous effort were used to establish boundary conditions for the pollutants contributed by the tributaries. The loadings associated with the 2006 TMDLs are included in the Pocatalico River TMDLs and are displayed on the LA tabs of the corresponding allocation spreadsheets.

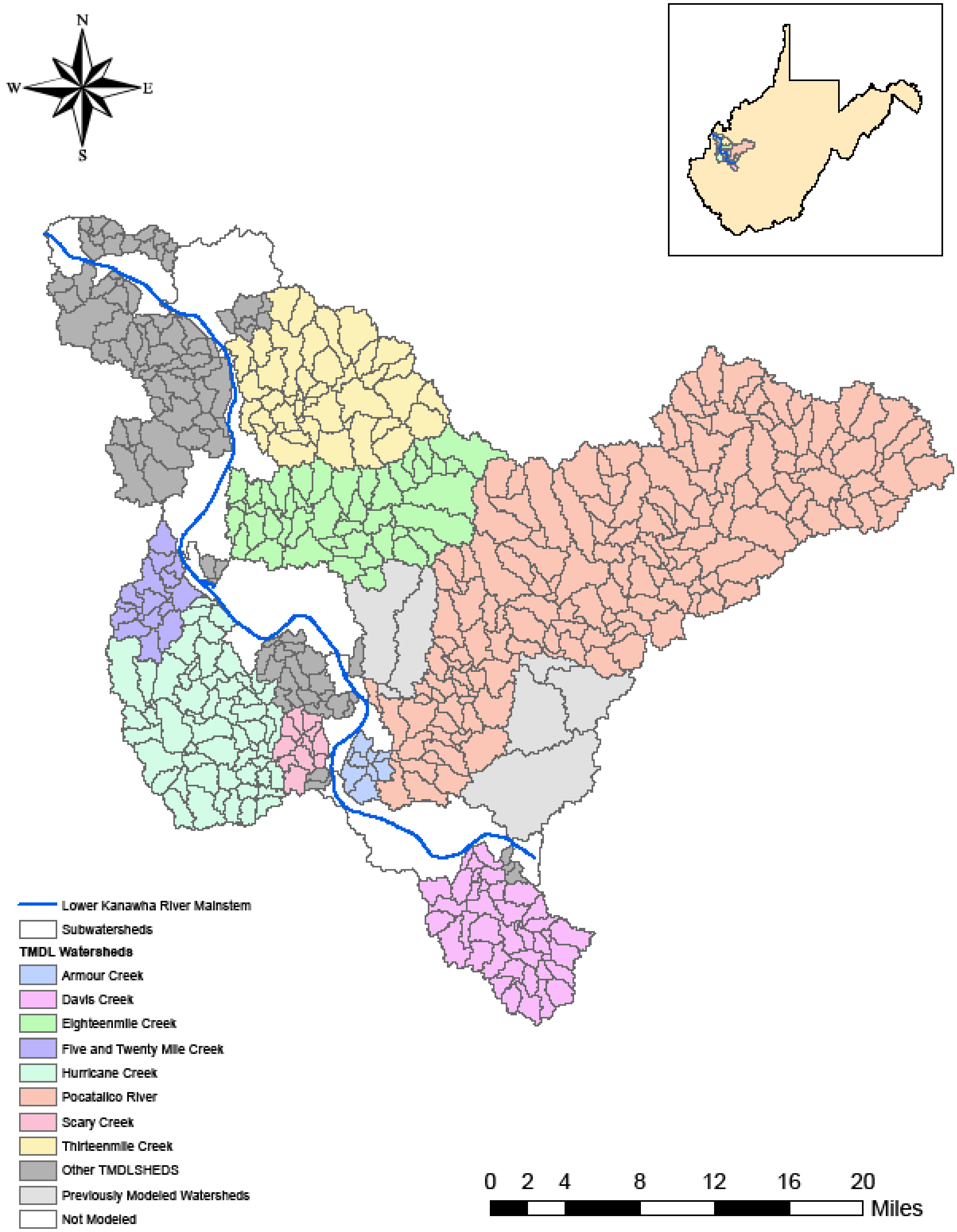


Figure 10-1. TMDL watersheds and subwatershed delineation

10.2.2 Iron and Sediment Configuration

The modeled landuse categories contributing metals via precipitation and runoff include forest, pasture, cropland, wetlands, barren, residential/urban impervious, and residential/urban pervious. These sources were represented explicitly by consolidating existing NLCD 2001 landuse categories to create modeled landuse groupings. Several additional landuse categories were created to account for landuses either not included in the NLCD 2001 and/or representing recent land disturbance activities (i.e. abandoned mine lands, harvested forest and skid roads, oil and gas operations, paved and unpaved roads, and active mining). The process of consolidating and updating the modeled landuses is explained in further detail in the Technical Report. In addition, non-sediment related iron land-based sources were modeled using representative average concentrations for the surface, interflow and groundwater portions of the water budget. Other sources, such as AML seeps identified by WVDEP's source tracking efforts, and water treatment plants were modeled as direct, continuous-flow sources in the model.

Sediment-producing landuses and bank erosion are sources of iron because the relatively high iron content of the soils in the watershed. Statistical analyses using pre-TMDL monitoring data collected in the TMDL watersheds were performed to establish the correlation between in-stream sediment and iron metals concentrations. The results of the correlation analysis are shown in Appendix J. Spatial variability of this correlation were analyzed in GIS to develop sediment iron relationship throughout the watershed. Sediment iron slope of individual subwatersheds are displayed on the GIS project. The results were then applied to the sediment from sediment-producing landuses and bank erosion to calculate the iron loads delivered to the streams. Generation of sediment depends on the intensity of surface runoff. It also varies by landuse and the characteristics of the land. Sediment delivery paths modeled were surface runoff erosion, and streambank erosion. Surface sediment sources were modeled as soil detachment and sediment transport by landuse. Soil erodibility and sediment washoff coefficients varied between soil types and landuses were used to simulate sediment erosion by surface runoff. Bank erosion was modeled as a rate per unit area of submerged erodible area. Bank erosion will only happen after a critical flow is reached, and as the flow increases, so does the bank erosion yield. Sediment produced during bank erosion episodes is also dependent on the stability of the banks, as defined by the total bank stability score.

The relevant parameters in the bank-erosion algorithms are the threshold flow at which bank erosion starts to occur, and a coefficient for scour of the bank matrix soil for the reach. The threshold flow at which bank erosion starts to occur was estimated as the flow that occurs at bank-full depth. The coefficient for scour of the bank matrix soil was a direct function of the reach's stability factor (S-value).

The MDAS bank erosion model takes into account stream flow and bank stability. The bank erosion rate per unit area was defined as a function of: bank flow volume above a specified threshold and the bank erodible area. Each stream segment had a flow threshold above which streambank erosion occurred. The bank scouring process is a power function dependent on high-flow events, defined as exceeding the flow threshold. The coefficient of scour for the bank soil was related to the Bank Stability Index. Streambank erosion was modeled as a unique sediment source independent of other upland-associated erosion sources.

The wetted perimeter and reach length represent ground area covered by water (**Figure 10-2**). The erodible wetted perimeter is equal to the difference between the actual wetted perimeter and wetted perimeter during threshold flow conditions. The bank erosion rate per unit area was multiplied by the erodible perimeter and the reach length to obtain an estimate of sediment mass eroded corresponding to the stream segment. The Technical Report provides more detailed discussions on the technical approaches used for sediment modeling.

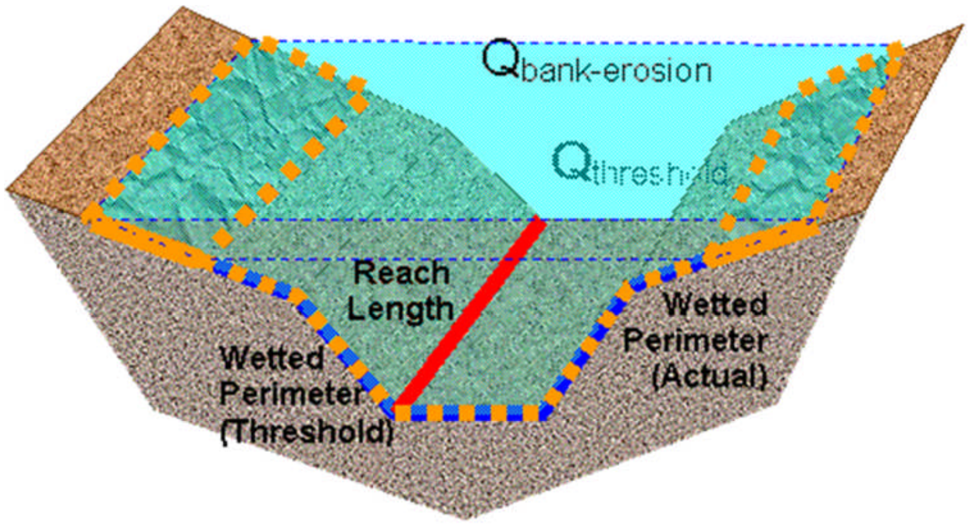


Figure 10-2. Stream channel conceptual diagram components used in bank erosion model

10.2.3 Aluminum and pH Configuration

To derive the dissolved aluminum and pH TMDLs, it was necessary to include additional MDAS modules capable of representing instream chemical reactions of several water quality components. MDAS includes a dynamic chemical species fate and transport module that simulates soil subsurface and in-stream water quality taking into account chemical species interaction and transformation. The total chemical concentration and flows time series generated by MDAS are used as inputs for the modules' pollutant transformation and transport routines. The modules simulate soil subsurface and in-stream chemical reactions, assuming instant mixing and concentrations equally distributed throughout soil and stream segments. The model supports major chemical reactions, including acid/base, complexation, precipitation, and dissolution reactions and some kinetic reactions, if selected by the user. The model selection process, modeling methodologies, and technical approaches are discussed further in the Technical Report.

AML seeps were modeled as direct, continuous-flow sources in the model. AML and other land-based sources were modeled using representative average concentrations for the surface, interflow and groundwater portions of the water budget.

With the atmospheric deposition module, MDAS is able to model acidity loading from dry and wet deposition. Both dry and wet deposition were represented similarly for landuses and included contributions for nitrate, ammonium, and sulfate. Fluxes (mass per area per time) for dry deposition and concentrations for wet deposition were modeled using data obtained from the USEPA Office of Air Quality Planning and Standards at Research Triangle Park, North Carolina. The data are a result of air quality modeling in support of the CAIR.

Because of the complex chemical interactions that occur between dissolved metals and acidity, the TMDL approach focused on reducing metals concentrations, using the MDAS model previously described, to meet metals water quality criteria and then verifying that the resultant pH associated with the metals TMDL condition would be in compliance with pH criteria.

10.2.4 Fecal Coliform Configuration

Modeled landuse categories contributing bacteria via precipitation and runoff include pasture, cropland, urban/residential pervious lands, urban/residential impervious lands, grassland, forest, barren land, and wetlands. Other sources, such as failing septic systems, straight pipes, and discharges from sewage treatment facilities, were modeled as direct, continuous-flow sources in the model.

The basis for the initial bacteria loading rates for landuses and direct sources is described in the Technical Report. The initial estimates were further refined during the model calibration. A variety of modeling tools were used to develop the fecal coliform bacteria TMDLs, including the MDAS, and a customized spreadsheet to determine the fecal loading from failing residential septic systems identified during source tracking efforts by the WVDEP. **Section 7.2.1** describes the process of assigning flow and fecal coliform concentrations to failing septic systems.

As noted in **Table 3-3**, Little Fivemile Creek is impaired for dissolved oxygen and fecal coliform bacteria, both impairments are commonly associated with organic enrichment. Excessive amounts of organic matter increase fecal coliform bacteria counts and reduce dissolved oxygen levels. The actions typically used to reduce instream fecal coliform levels such as restrict stream access, adding streambank buffer zones, developing nutrient management plans and eliminating failing septic systems will reduce fecal coliform levels and increase dissolved oxygen levels. As such, the fecal coliform TMDL presented for Little Fivemile Creek is an appropriate surrogate for the necessary dissolved oxygen TMDL.

10.3 Hydrology Calibration

Hydrology and water quality calibration were performed in sequence because water quality modeling is dependent on an accurate hydrology simulation. Typically, hydrology calibration involves a comparison of model results with instream flow observations from USGS flow gauging stations throughout the watershed. There were no USGS flow gauging stations with adequate data records for hydrology calibration on tributaries to the Lower Kanawha River. USGS gages on the Lower Kanawha mainstem were not appropriate for this effort because the mainstem was not modeled. Instead, a reference approach was used to define hydrologic parameters used in the model. Model parameters developed concurrently for the nearby and hydrologically similar Elk River were transferred to the Lower Kanawha model.

Final adjustments to model hydrology were based on flow measurements obtained during WVDEP's pre-TMDL monitoring in the Lower Kanawha River watershed. A detailed description of the hydrology calibration and a summary of the results and validation are presented in the Technical Report.

10.4 Water Quality Calibration

After the model was configured and calibrated for hydrology, the next step was to perform water quality calibration for the subject pollutants. The goal of water quality calibration was to refine model parameter values to reflect the unique characteristics of the watershed so that model output would predict field conditions as closely as possible. Both spatial and temporal aspects were evaluated through the calibration process.

The water quality was calibrated by comparing modeled versus observed pollutant concentrations. The water quality calibration consisted of executing the MDAS model, comparing the model results to available observations, and adjusting water quality parameters within reasonable ranges. Initial model parameters for the various pollutant parameters were derived from previous West Virginia TMDL studies, storm sampling efforts, and literature values. Available monitoring data in the watershed were identified and assessed for application to calibration. Monitoring stations with observations that represented a range of hydrologic conditions, source types, and pollutants were selected. The time-period for water quality calibration was selected based on the availability of the observed data and their relevance to the current conditions in the watershed.

WVDEP also conducted storm monitoring on Shrewsbury Hollow in Kanawha State Forest, Kanawha County, West Virginia. The data gathered during this sampling episode was used in the calibration of fecal coliform and to enhance the representation of background conditions from undisturbed areas. The results of the storm sampling fecal coliform calibration are shown in **Figure 10-3**.

Sediment calibration consisted of adjusting the soil erodibility and sediment washoff parameters by soil types and by landuse, and the coefficient of scour for bank-erosion. The water quality parameters that were adjusted to obtain a calibrated model for sediment were the sediment concentrations by landuse, and the magnitude of the coefficient of scour for bank-erosion. Calibration parameters that were relevant for the land-based sediment calibration were the sediment concentrations (in mg/L) for runoff, interflow, and groundwater. These concentrations were defined for each modeled landuse. Initial values for these parameters were based on available landuse-specific storm-sampling monitoring data. Initial values were adjusted so that the model's suspended solids output closely matched observed instream data in watersheds with predominately one type of source.

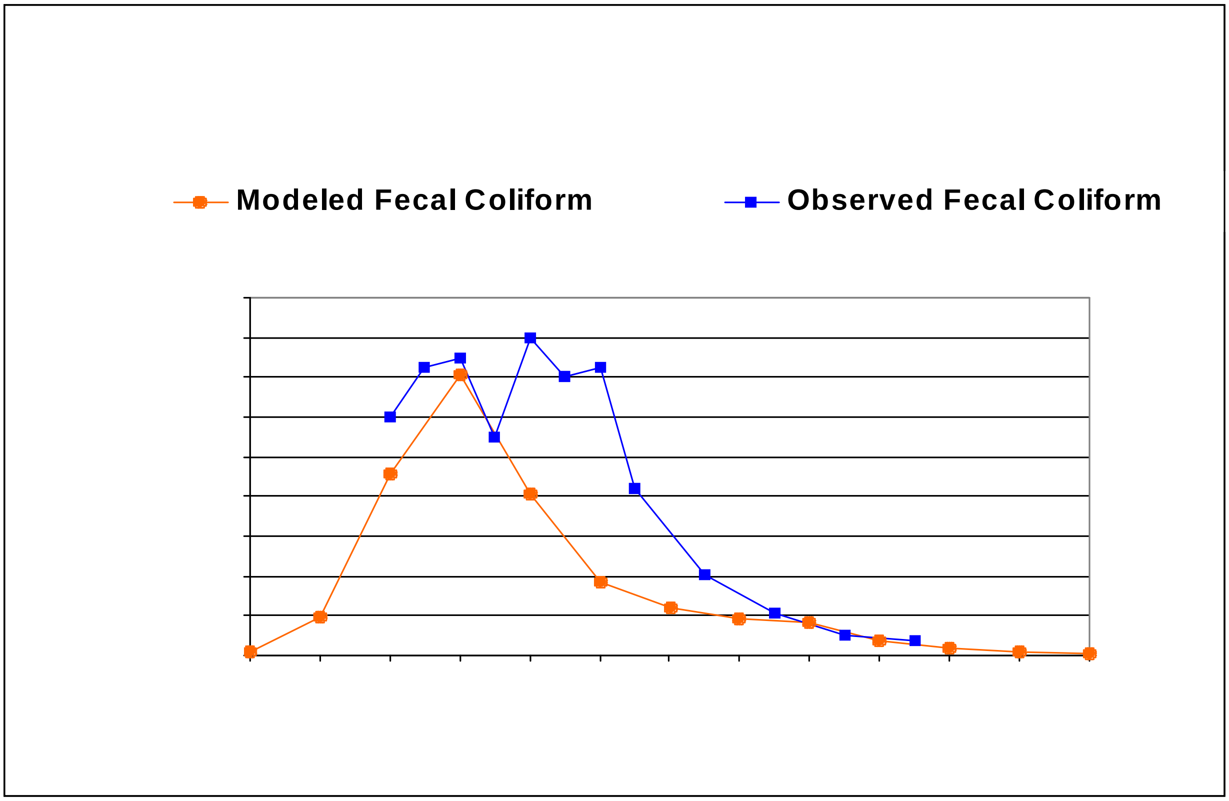


Figure 10-3. Shrewsbury Hollow fecal coliform observed data

10.5 Modeling Technique for Biological Impairments with Sedimentation Stressors

The SI process discussed in **Section 4** indicated a need to reduce the contribution of excess sediment to some of the biologically impaired streams. Initially, a “reference watershed” TMDL development approach was pursued. The approach was based on selecting a non-impaired watershed that shares similar landuse, ecoregion, and geomorphologic characteristics with the impaired watershed. Stream conditions in the reference watershed are assumed to be representative of the conditions needed for the impaired streams to attain their designated uses, and the normalized loading associated with the reference stream is used as the TMDL endpoint for the impaired streams. Given these parameters and a non-impaired WVSCI score, Higby Run (WV-KL-57-BH-3) was selected as the reference watershed. The location of the reference watershed is shown in **Figure 4-2**.

All of the sediment-impaired streams exhibited impairments pursuant to total iron water quality criteria. Upon finalization of modeling based on the reference watershed approach, it was determined that sediment reductions necessary to ensure compliance with iron criteria are greater than those necessary to correct the biological impairments associated with sediment. In fact, significant sediment reductions are needed in the biological reference stream to attain compliance with the iron criterion. As such, the iron TMDLs presented for the subject waters are appropriate surrogates for necessary sediment TMDLs. For affected streams, **Table 10-1** contrasts the sediment reductions necessary to attain iron criteria with those needed to resolve biological impairment under the reference watershed approach. Please refer to the Technical Report for details regarding the reference watershed approach.

Table 10-1. Sediment loadings using different modeling approaches

Stream Name	Stream Code	Allocated Sediment Load Iron TMDL (tons/yr)	Allocated Sediment Load Reference Approach (tons/yr)
Armour Creek	WV-KL-60	265	603
Blakes Creek	WV-KL-60-C	104	266
Bills Creek	WV-KL-56	64	229
Davis Creek	WV-KL-74	1439	4223
Trace Fork	WV-KL-74-C	285	809
Rays Branch	WV-KL-74-G	78	174
Coal Hollow	WV-KL-74-L	46	105
Buckelew Hollow	WV-KL-27-AK	23	92
Jakes Run	WV-KL-27-H	28	117
Saltlick Creek	WV-KL-27-X-8	68	229
UNT/Five and Twenty Mile Creek RM 7.41	WV-KL-35-H	32	127
Gallatin Branch	WV-KL-64	42	121
Hurricane Creek	WV-KL-42	1810	6868
Rider Creek	WV-KL-42-AO	25	118
Poplar Fork	WV-KL-42-I	562	2269
Long Branch	WV-KL-42-I-10	58	253
UNT/Crooked Creek RM 0.72	WV-KL-42-I-16-B	16	62
Cow Creek	WV-KL-42-I-4	65	337
Sleepy Creek	WV-KL-42-N	210	1005
Mill Creek	WV-KL-42-U	210	581
Joplin Branch	WV-KL-77	61	138
UNT/Little Buffalo Creek RM 1.17	WV-KL-40-A	32	130
Upper Ninemile Creek	WV-KL-12-B	81	369
Pocatalico River	WV-KL-57	7679	31910
Grapevine Creek	WV-KL-57-AA	162	804
Boardtree Run	WV-KL-57-AA-4	10	69
Pocatalico Creek	WV-KL-57-AD	1497	5814
Middle Fork/Pocatalico Creek	WV-KL-57-AD-2	677	2640
Raccoon Creek	WV-KL-57-AL	48	204
Leatherwood Creek	WV-KL-57-AO	132	452
Camp Creek	WV-KL-57-AT	29	122

Stream Name	Stream Code	Allocated Sediment Load Iron TMDL (tons/yr)	Allocated Sediment Load Reference Approach (tons/yr)
Straight Creek	WV-KL-57-AX	29	181
Mckown Creek	WV-KL-57-BQ	117	441
Harmond Creek	WV-KL-57-K	51	263
Rocky Fork	WV-KL-57-L	524	1702
Kelly Creek	WV-KL-57-Q	102	482
Pond Branch	WV-KL-17	156	397
Scary Creek	WV-KL-63	252	841
UNT/Scary Creek RM 0.14	WV-KL-63-A	8	41
Rockstep Run	WV-KL-63-C	55	182
UNT/UNT RM 0.33/Scary Creek RM 2.13	WV-KL-63-E-1	24	104
Poplar Fork	WV-KL-19-N	202	822
Threemile Creek (South)	WV-KL-5	110	366

10.6 Allocation Strategy

As explained in **Section 2**, a TMDL is composed of the sum of individual WLAs for point sources, LAs for nonpoint sources, and natural background levels. In addition, the TMDL must include a MOS, implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. TMDLs can be expressed in terms of mass per time or other appropriate units. Conceptually, this definition is denoted by the equation:

$$\text{TMDL} = \text{sum of WLAs} + \text{sum of LAs} + \text{MOS}$$

To develop the TMDLs for each of the impairments listed in **Table 3-3** of this report, the following approach was taken:

- Define TMDL endpoints
- Simulate baseline conditions
- Assess source loading alternatives
- Determine the TMDL and source allocations

10.6.1 TMDL Endpoints

TMDL endpoints represent the water quality targets used to quantify TMDLs and their individual components. In general, West Virginia's numeric water quality criteria for the subject pollutants and an explicit five percent MOS were used to identify endpoints for TMDL development.

The five percent explicit MOS was used to counter uncertainty in the modeling process. Long-term water quality monitoring data were used for model calibration. Although these data represented actual conditions, they were not of a continuous time series and might not have captured the full range of instream conditions that occurred during the simulation period. The explicit five percent MOS also accounts for those cases where monitoring might not have captured the full range of instream conditions. The TMDL endpoints for the various criteria are displayed in **Table 10-2**.

Table 10-2. TMDL endpoints

Water Quality Criterion	Designated Use	Criterion Value	TMDL Endpoint
Total Iron	Aquatic Life, warmwater fisheries	1.5 mg/L (4-day average)	1.425 mg/L (4-day average)
Dissolved Aluminum	Aquatic Life, warmwater fisheries	0.75 mg/L (1-hour average)	0.7125 mg/L (1-hour average)
pH	Aquatic Life	6.00 Standard Units (Minimum)	6.02 Standard Units (Minimum)
Fecal Coliform	Water Contact Recreation and Public Water Supply	200 counts / 100 mL (Monthly Geometric Mean)	190 counts / 100 mL (Monthly Geometric Mean)
Fecal Coliform	Water Contact Recreation and Public Water Supply	400 counts / 100 mL (Daily, 10% exceedance)	380 counts / 100 mL (Daily, 10% exceedance)

TMDLs are presented as average daily loads that were developed to meet TMDL endpoints under a range of conditions observed throughout the year. For most pollutants, analysis of available data indicated that critical conditions occur during both high- and low-flow events. To appropriately address the low- and high-flow critical conditions, the TMDLs were developed using continuous simulation (modeling over a period of several years that captured precipitation extremes), which inherently considers seasonal hydrologic and source loading variability.

10.6.2 Baseline Conditions and Source Loading Alternatives

The calibrated model provides the basis for performing the allocation analysis. The first step is to simulate baseline conditions, which represent existing nonpoint source loadings and point sources loadings at permit limits. Baseline conditions allow for an evaluation of instream water quality under the highest expected loading conditions.

Baseline Conditions for MDAS

The MDAS model was run for baseline conditions using hourly precipitation data for a representative six year simulation period (January 1, 1998 through December 31, 2003). The precipitation experienced over this period was applied to the landuses and pollutant sources as they existed at the time of TMDL development. Predicted instream concentrations were compared directly with the TMDL endpoints. This comparison allowed for the evaluation of the magnitude and frequency of exceedances under a range of hydrologic and environmental conditions, including dry periods, wet periods, and average periods. **Figure 10-4** presents the annual rainfall totals for the years 1990 through 2008 at the Charleston (WV1570) weather station in West Virginia. The years 1998 to 2003 are highlighted to indicate the range of precipitation conditions used for TMDL development in the Lower Kanawha River watershed.

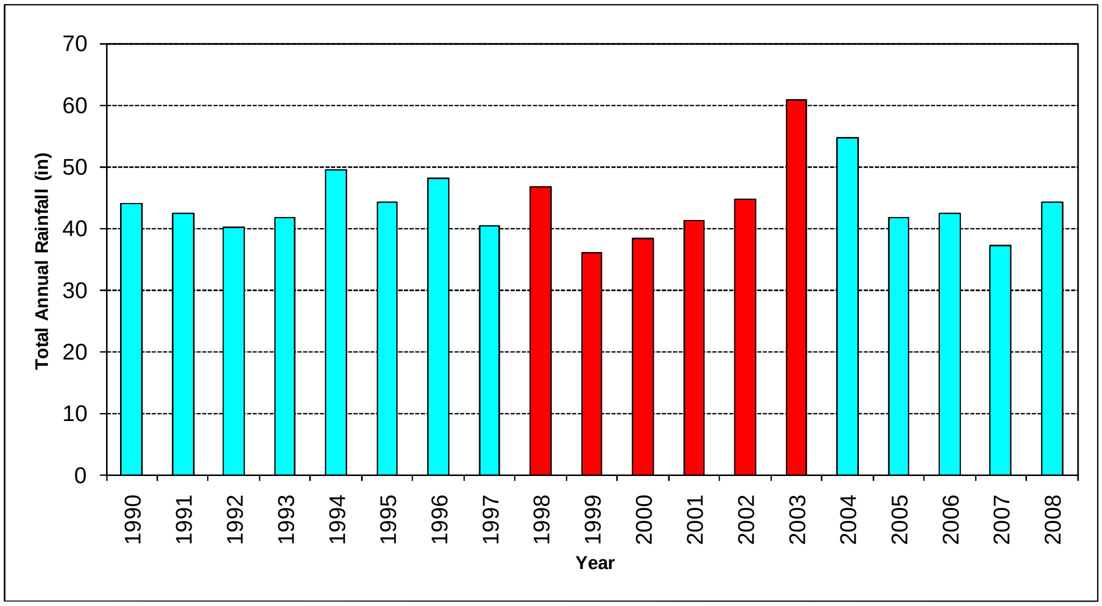


Figure 10-4. Annual precipitation totals for the Charleston (WV1570) weather station

Mining discharges that are influenced by precipitation were represented during baseline conditions using precipitation, drainage area and applicable effluent limitations. For non-precipitation-induced mining discharges, available flow and/or pump capacity information was used in conjunction with applicable effluent limitations. The metals concentrations associated with common effluent limitations are presented in **Table 10-3**. The concentrations displayed in **Table 10-3** accurately represent existing wasteload allocations for the majority of mining discharges. In the limited instances where existing effluent limitations vary from the displayed values, the outlets were represented at next higher condition. For example, existing iron effluent limits between 1.5 and 3.2 mg/L were represented at 3.2 mg/L.

Table 10-3. Concentrations used in representing permitted conditions for active mining

Pollutant	Technology-Based Permits	Water Quality-Based Permits
Iron, total	3.2 mg/L	1.5 mg/L

Certain non-mining discharges (stormwater associated with non-construction, industrial activity) were represented using precipitation, drainage area, and the stormwater benchmark iron value of 1.0 mg/L.

Based upon guidance from WVDEP's permitting program, a range of 1.5 to 2.5 percent of the total subwatershed area was allotted for concurrent construction activity under the Construction Stormwater General Permit. Baseline loadings were based upon precipitation and runoff and an assumption that proper installation and maintenance of required BMPs will achieve a TSS benchmark value of 100 mg/L.

Sediment producing nonpoint source and background loadings were represented using precipitation, drainage area, and the iron loading associated with their predicted sediment contributions.

Effluents from sewage treatment plants were represented under baseline conditions as continuous discharges, using the design flow for each facility and the monthly geometric mean fecal coliform effluent limitation of 200 counts/100 mL.

CSO outlets were represented as discreet point sources in the model. CSO flow and discharge frequency was derived from overflow data generated by the POTWs. This information was augmented with precipitation analysis and watershed modeling to develop model inputs needed to build fecal coliform loading values for a ten-year time series from which annual average fecal coliform loading values could be calculated. Under baseline conditions, Charleston and Nitro CSO quality was represented as a concentration of 100,000 counts/100 mL to reflect baseline conditions for untreated CSO discharges.

MS4, nonpoint source and background loadings for fecal coliform were represented using drainage area, precipitation, and pollutant accumulation and wash off rates, as appropriate for each landuse.

Source Loading Alternatives

Simulating baseline conditions allowed for the evaluation of each stream's response to variations in source contributions under a variety of hydrologic conditions. This sensitivity analysis gave insight into the dominant sources and the mechanisms by which potential decreases in loads would affect instream pollutant concentrations. The loading contributions from the various existing sources were individually adjusted; the modeled instream concentrations were then evaluated.

Multiple allocation scenarios were run for the impaired waterbodies. Successful scenarios achieved the TMDL endpoints under all flow conditions throughout the modeling period. The averaging period and allowable exceedance frequency associated with West Virginia water quality criteria were considered in these assessments. The subsequent sections of this report describe detailed allocation strategies for the various TMDLs. **Figure 10-5** shows an example of model output for a baseline condition and a successful TMDL scenario.

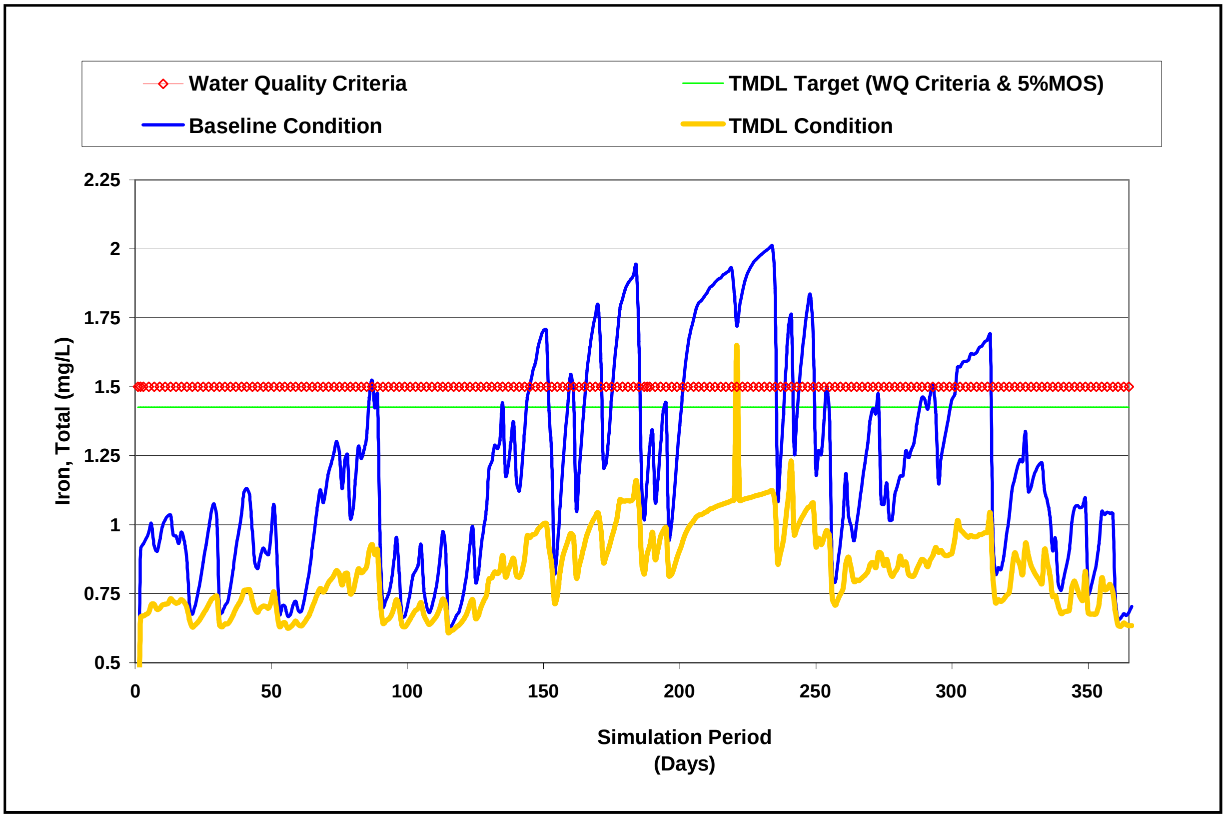


Figure 10-5. Example of baseline and TMDL conditions for total iron

10.7 TMDLs and Source Allocations

10.7.1 Total Iron TMDLs

Source allocations were developed for all modeled subwatersheds contributing to the iron impaired streams. Nonpoint source reductions did not result in allocated loadings less than natural conditions. Allocations to continuous flow sources were no more stringent than water quality criteria.

Due to the highly erodible soils that are present in the watershed, land disturbing activities and stream bank erosion cause widespread nonattainment of the total iron criterion. In some subwatersheds, multiple source categories contribute problematic loadings during precipitation events and in others existing sources are limited to a particular category. The magnitude of predicted nonattainment is generally correlated to the amount of disturbed land within the subwatershed.

Although extremely limited in this watershed, abandoned mine land (AML) influences were also shown to impact water quality where present. Active mining discharges and non-mining stormwater discharges in compliance with existing permit limitations were not determined to be problematic.

The following methodology was used when allocating to iron sources.

- In watersheds influenced by AML, iron loadings were reduced until the water quality criterion was attained or until practical limits were reached.

- The loading from streambank erosion was reduced to the loading characteristics associated with the upper 5th percentile of observed bank conditions.

- For equity with permitted construction activities and among the various categories of sediment sources of iron, baseline loadings from harvested forest, oil and gas, barren, unpaved roads, agriculture and pervious urban/residential landuses were reduced to the iron loadings associated with a 100 mg/l Total Suspended Solids discharge level. The model predicted attainment of the iron criterion for the majority of subwatersheds after this allocation step.

- If further reduction was necessary, an analysis of the relative existing areas of all land disturbing source categories was performed. If an individual source category comprised 75% or greater of the total disturbed area of a subwatershed, then additional reductions were prescribed only for that source category until the model predicted criterion attainment. If an individual source category was not prevalent (less than 75% of subwatershed disturbed area), then additional reductions were prescribed for all land disturbing sources until model predicted criterion attainment.

The flow chart presented in **Figure 10-6** displays the total iron allocation methodology.

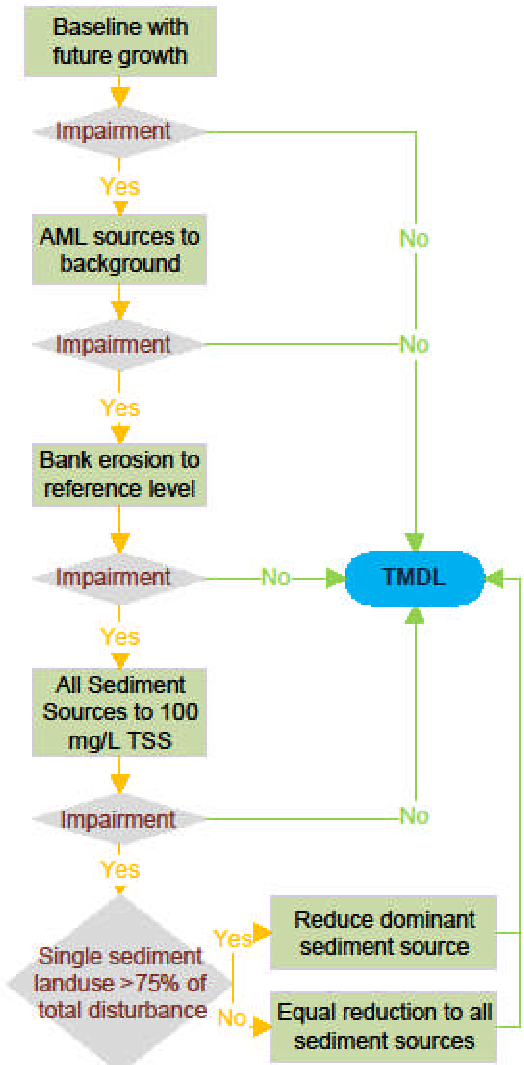


Figure 10-6. Flow chart of allocation methodology

Wasteload Allocations (WLAs)
WLAs were developed for all point sources permitted to discharge iron under a NPDES permit. Because of the established relationship between iron and TSS, iron WLAs are also provided for facilities with stormwater discharges that are regulated under NPDES permits that contain TSS and/or iron effluent limitations or benchmarks values, MS4 facilities, and facilities registered under the General NPDES permit for construction stormwater.

Active Mining Operations

WLAs are provided for all existing outlets of NPDES permits for mining activities, except those where reclamation has progressed to the point where existing limitations are based upon the Post-Mining Area provisions of Subpart E of 40 CFR 434. The WLAs for active mining operations consider the functional characteristics of the permitted outlets (i.e. precipitation driven, pumped continuous flow, gravity continuous flow, commingled) and their respective impacts at high and low flow conditions.

The federal effluent guidelines for the coal mining point source category (40 CFR 434) provide various alternative limitations for discharges caused by precipitation. Under those technology-based guidelines, effluent limitations for total iron and TSS may be replaced with an alternative limitation for “settleable solids” during certain magnitude precipitation events that vary by mining subcategory. The water quality-based WLAs and future growth provisions of the iron TMDLs preclude the applicability of the “alternative precipitation” iron provisions of 40 CFR 434. Also, the established relationship between iron and TSS requires continuous control of TSS concentration in permitted discharges to achieve iron WLAs. As such, the “alternative precipitation” TSS provisions of 40 CFR 434 should not be applied to point source discharges associated with the iron TMDLs.

In certain instances, prescribed WLAs may be less stringent than existing effluent limitations. However, the TMDLs are not intended to relax effluent limitations that were developed under the alternative basis of WVDEP’s implementation of the antidegradation provisions of the Water Quality Standards, which may result in more stringent allocations than those resulting from the TMDL process. Whereas TMDLs prescribe allocations that minimally achieve water quality criteria (i.e. 100 percent use of a stream’s assimilative capacity), the antidegradation provisions of the standards are designed to maintain the existing quality of high-quality waters. Antidegradation provisions may result in more stringent allocations that limit the use of remaining assimilative capacity. Also, water quality-based effluent limitations developed in the NPDES permitting process may dictate more stringent effluent limitations for discharge locations that are upstream of those considered in the TMDLs. TMDL allocations reflect pollutant loadings that are necessary to achieve water quality criteria at distinct locations (i.e., the pour points of delineated subwatersheds). In contrast, effluent limitation development in the permitting process is based on the achievement/maintenance of water quality criteria at the point of discharge.

Specific WLAs are not provided for “post-mining” outlets because programmatic reclamation was assumed to have returned disturbed areas to conditions that approach background. Barring unforeseen circumstances that alter their current status, such outlets are authorized to continue to discharge under the existing terms and conditions of their NPDES permit.

Discharges regulated by the Multi Sector Stormwater Permit

Certain registrations under the general permit for stormwater associated with industrial activity implement TSS and/or iron benchmark values. Facilities that are compliant with such limitations are not considered to be significant sources of sediment or iron. Facilities that are present in the watersheds of iron-impaired streams are assigned WLAs that allow for continued discharge under existing permit conditions.

Municipal Separate Storm Sewer System (MS4)

USEPA's stormwater permitting regulations require municipalities to obtain permit coverage for stormwater discharges from MS4s. In the TMDL watersheds of the Lower Kanawha there are five designated MS4 entities: the City of Charleston, the City of South Charleston, the City of Nitro, the City of Hurricane, and the WVDOH. Each entity will be registered under, and subject to, the requirements of General Permit Number WV0110625. The stormwater discharges from MS4s are point sources for which the TMDLs prescribe wasteload allocations.

In the majority of the subwatersheds where MS4 entities have areas of responsibility, the urban, residential and road landuses strongly influence bank erosion. As such, portions of the baseline and allocated loads associated with bank erosion are included in the MS4 wasteload allocations.

The subdivision of the bank erosion component between point and nonpoint sources, and where applicable, between multiple MS4 entities, is proportional to their respective drainage areas within each subwatershed. Model representation of bank erosion is accomplished through consideration of a number of inputs including slope, soils, imperviousness, and the stability of existing streambanks. Bank erosion loadings are most strongly influenced by upland impervious area and bank stability. The decision to include bank erosion in the MS4 wasteload allocations results from the predominance of urban/residential/road landuses and impacts in MS4 areas. WVDEP's assumption is that management practices will be implemented under the MS4 permit to directly address impacts from bank erosion. However, even if the implementation of stormwater controls on uplands is maximized, and the volume and intensity of stormwater runoff are minimized, the existing degraded stability of streambanks may continue to accelerate erosion. The erosion of unstable streambanks is a nonpoint source of sediment that is included in the MS4 allocations. Natural attenuation of legacy impacts cannot be expected in the short term, but may be accelerated by bank stabilization projects. The inclusion of the bank erosion load component in the wasteload allocations of MS4 entities is not intended to prohibit or discourage cooperative bank stabilization projects between MS4 entities and WVDEP's Nonpoint Source Program, or to prohibit the use of Section 319 funding as a component of those projects.

Construction Stormwater

Specific WLAs for future activity under the Construction Stormwater General Permit are provided at the subwatershed scale and are described in **Section 12.0**. An allocation of 1.5 to 2.5 percent of subwatershed area was generally provided with loadings based upon precipitation and runoff and an assumption that proper installation and maintenance of required BMPs will achieve a TSS benchmark value of 100 mg/L. The existing level of activity under the Construction Stormwater General Permit conforms to the subwatershed allocations. As such, specific WLAs for existing registrations under the General Permit are not presented.

Load Allocations (LAs)
LAs are made for the dominant nonpoint source categories as follows:

- AML: loading from abandoned mine lands, including loads from disturbed land, highwalls, deep mine discharges and seeps

- Sediment sources: loading associated with sediment contributions from barren land, harvested forest, oil and gas well operations, agricultural landuses, residential/urban/road landuses and streambank erosion in non-MS4 areas

- Background and other nonpoint sources: loading from undisturbed forest and grasslands (loadings associated with this category were represented but not reduced)

10.7.2 Dissolved Aluminum and pH TMDLs

Source allocations were developed for all modeled subwatersheds contributing to the dissolved aluminum and/or pH impaired streams of the Lower Kanawha River watershed. Sources of total iron were reduced prior to total aluminum reduction because existing instream iron concentrations can significantly reduce pH and consequently increase dissolved aluminum concentrations. In four subwatersheds, the dissolved aluminum and/or pH TMDL endpoints were not attained after source reductions to iron, therefore the total aluminum loading from AMLs was reduced in combination with acidity reduction (via alkalinity addition) to the extent necessary to attain the water quality criteria for both pH and dissolved aluminum. The following methodology was used when allocating aluminum loadings and/or prescribing acidity reductions:

- In Hoffman Hollow (subwatershed 30936), low watershed buffering capacity and acidic atmospheric deposition results in nonattainment of the pH criterion. Acidity load reductions were prescribed (via alkalinity addition) to the extent necessary to attain pH criteria at the subwatershed outlet.

- Historical mining sources are present in subwatersheds 30608, 30610, and 30614. The predicted acid loads from atmospheric deposition were first offset by alkalinity addition then the total aluminum loading from AMLs were reduced to the extent necessary to attain dissolved aluminum water quality criteria.

All sources were represented and provided allocations in terms of the total aluminum loadings that are necessary to attain the dissolved aluminum water quality criteria. The reductions of total aluminum loading from land-based sources, coupled with the mitigation of acid precipitation impacts by alkalinity addition, are predicted to result in attainment of both dissolved aluminum and pH water quality criteria at all evaluated locations in the pH and dissolved aluminum impaired streams.

Wasteload Allocations (WLAs)

There are no point sources in dissolved aluminum and pH impaired watersheds.

Load Allocations (LAs)

LAs of total aluminum are made for contributing nonpoint source categories as follows:

- AML: loading from abandoned mine lands, including loads from disturbed land, highwalls, deep mine discharges and seeps

- Other nonpoint sources: loading associated with sediment contributions from barren land, harvested forest, oil and gas well operations, agriculture, undisturbed forest and grasslands, and residential/urban/road landuses were represented but not reduced

Baseline and TMDL load allocations (LAs) include the natural background sources of alkalinity from carbonate geologic formations. The additional acidity reduction (alkalinity addition) required to meet pH water quality criterion are presented in the TMDL load allocations for the pH impaired streams.

10.7.3 Fecal Coliform Bacteria TMDLs

TMDLs and source allocations were developed for impaired streams and their tributaries on a subwatershed basis throughout the watershed. The following general methodology was used when allocating loads to fecal coliform bacteria sources:

- The effluents from all NPDES permitted sewage treatment plants were set at the permit limit (200 counts/100 mL monthly geometric mean).

- Because West Virginia Bureau for Public Health regulations prohibit the discharge of raw sewage into surface waters, all illicit discharges of human waste (from failing septic systems and straight pipes) were reduced by 100 percent in the model.

- All CSO discharges were set at 200 cts/100 ml to reflect USEPA's position on bacteria water quality criteria and mixing zones as prescribed in an EPA memo dated November 12, 2008 from Ephram S. King, Director of the Office of Science Technology.

- If further reduction was necessary, MS4 and non-point source loadings from agricultural lands and residential areas were subsequently reduced until in-stream water quality criteria were met in each subwatershed.

Wasteload Allocations (WLAs)

WLAs were developed for all facilities permitted to discharge fecal coliform bacteria, including MS4s, as described below.

Sewage Treatment Plant Effluents

The fecal coliform effluent limitations for NPDES permitted sewage treatment plants are more stringent than water quality criteria; therefore, all effluent discharges from sewage treatment facilities were given wasteload allocations equal to existing monthly fecal coliform effluent limitations of 200 counts/100 mL.

Combined Sewer Overflows

In TMDL watersheds there are a total of eight CSO outlets associated with POTWs operated by the cities of Charleston and Nitro. (**Table 10-4**). These systems have Long Term Control Plans, but currently experience frequent stormwater-related CSO discharges, and do not have systems in place to store or treat CSO discharges.

Table 10-4. Combined sewer overflows in the Lower Kanawha River watershed

City	SWS	Receiving Stream	Receiving Stream Code	Permit ID	Outlet
Nitro	30802	Armour Creek	WV-KL-60	WV0023299	C007
Charleston	30910	Sugarcamp Creek	WV-KL-74-D	WV0023205	C045
Charleston	30919	Davis Creek	WV-KL-74	WV0023205	C040
Charleston	30920	Rays Branch	WV-KL-74-G	WV0023205	C048
Charleston	30920	Rays Branch	WV-KL-74-G	WV0023205	C049
Charleston	30926	Coal Hollow	WV-KL-74-L	WV0023205	C050
Charleston	30953	Joplin Branch	WV-KL-77	WV0023205	C038
Charleston	30953	Joplin Branch	WV-KL-77	WV0023205	C039

All fecal coliform bacteria wasteload allocations for CSO discharges have been established at 200 counts/100 mL. Implementation can be accomplished by CSO elimination or by disinfection treatment and discharge in compliance with the operable, concentration-based allocations.

Municipal Separate Storm Sewer System (MS4)
USEPA's stormwater permitting regulations require municipalities to obtain permit coverage for stormwater discharges from MS4s. The cities of Charleston, South Charleston, Nitro, Hurricane, as well as the WVDOH are designated MS4 entities in the subject watersheds. Each entity will be registered under, and subject to, the requirements of General Permit Number WV0110625. The stormwater discharges from MS4s are point sources for which the TMDLs prescribe wasteload allocations.

Load Allocations (LAs)
Fecal coliform LAs are assigned to the following source categories:

- Pasture/Cropland
- On-site Sewage Systems — loading from all illicit discharges of human waste (including failing septic systems and straight pipes)
- Residential — loading associated with urban/residential runoff from non-MS4 areas
- Background and Other Nonpoint Sources — loading associated with wildlife sources from all other landuses (contributions/loadings from wildlife sources were not reduced)

10.7.4 Seasonal Variation

Seasonal variation was considered in the formulation of the modeling analysis. Continuous simulation (modeling over a period of several years that captured precipitation extremes) inherently considers seasonal hydrologic and source loading variability**.** The metals and fecal coliform concentrations simulated on a daily time step by the model were compared with TMDL endpoints. Allocations that met these endpoints throughout the modeling period were developed.

10.7.5 Critical Conditions

A critical condition represents a scenario where water quality criteria are most susceptible to violation. Analysis of water quality data for the impaired streams addressed in this effort shows high pollutant concentrations during both high- and low-flow thereby precluding selection of a single critical condition. Both high-flow and low-flow periods were taken into account during TMDL development by using a long period of weather data that represented wet, dry, and average flow periods.

Nonpoint source loading is typically precipitation-driven and impacts tend to occur during wet weather and high surface runoff. During dry periods little or no land-based runoff occurs, and elevated instream pollutant levels may be due to point sources (Novotny and Olem, 1994). Also, failing on-site sewage systems and AML seeps (both categorized as nonpoint sources but represented as continuous flow discharges) often have an associated low-flow critical condition, particularly where such sources are located on small receiving waters.

10.7.6 TMDL Presentation

The TMDLs for all impairments are shown in **Section 11** of this report. The TMDLs for iron, and aluminum are presented as average daily loads, in pounds per day. The dissolved aluminum TMDLs are based on a dissolved aluminum TMDL endpoint; however, components and allocations are provided in the form of total metal. The pH TMDLs are presented as average daily loads of net acidity, in pounds per day. The TMDLs for fecal coliform bacteria are presented in average number of colonies per day. The biological TMDLs are handled using surrogate approach where iron or fecal loads are presented. All TMDLs were developed to meet TMDL endpoints under a range of conditions observed over the modeling period. TMDLs and their components are also presented in the allocation spreadsheets associated with this report. The filterable spreadsheets also display detailed source allocations and include multiple display formats that allow comparison of pollutant loadings among categories and facilitate implementation.

The iron WLAs for active mining operations are presented both as annual average loads, for comparison with other pollutant sources, and equivalent allocation concentrations. The prescribed concentrations are the operable allocations and are to be implemented by conversion to monthly average and daily maximum effluent limitations using USEPA's Technical Support Document for Water Quality-based Toxics Control (USEPA, 1991). The iron WLAs for Construction Stormwater General Permit registrations are presented as both annual average loads, for comparison with other sources, and equivalent area registered under the permit. The registered area is the operable allocation. The iron WLAs for non construction sectors registered under the Multi Sector Stormwater Permit are presented both as annual average loads, for comparison with other pollutant sources, and equivalent allocation concentrations. The prescribed concentrations are operable, and because they are equivalent to existing effluent limitations/benchmark values, they are to be directly implemented.

The fecal coliform bacteria WLAs for sewage treatment plant effluents and CSOs for are presented both as annual average loads, for comparison with other pollutant sources, and equivalent allocation concentrations. The prescribed concentrations are the operable allocations for NPDES permit implementation.

The WLAs for precipitation induced MS4 discharges are presented in terms of average annual loads (Fe) or average number of colonies per day (FC) and the percent pollutant reduction from baseline conditions. The “MS4 WLA Summary” tabs of the allocation spreadsheets contain the operable allocations. The “MS4 WLA Detailed” tabs on the allocation spreadsheets provide drainage areas of various landuse types represented in the baseline condition (without BMPs) for each MS4 entity at the subwatershed scale. That information is intended to assist registrants under the MS4 General Permit in describing the management practices to be employed to achieve prescribed allocations.

11.0 TMDL RESULTS

Table 11-1. Dissolved Aluminum TMDLs

Major Watershed	Stream Code	Stream Name	Metal	Load Allocation (lbs/day)	Wasteload Allocation (lbs/day)	Margin of Safety (lbs/day)	TMDL (lbs/day)
Pocatalico River	WV-KL-57-I	UNT/Pocatalico River RM 8.52	Aluminum	0.27	NA	0.01	0.29
Pocatalico River	WV-KL-57-J	Kelly Creek	Aluminum	0.54	NA	0.03	0.57
Pocatalico River	WV-KL-57-K-2	UNT/Harmond Creek RM 1.00	Aluminum	0.45	NA	0.02	0.47

NA = not applicable; UNT = unnamed tributary; RM = river mile.

Table 11-2. Iron TMDLs

Major Watershed	Stream Code	Stream Name	Metal	LA (lbs/day)	WLA (lbs/day)	MOS lbs/day)	TMDL (lbs/day)
Threemile Creek (North)	WV-KL-6	Threemile Creek (North)	Iron	30.98	4.63	37.48	37.48
Threemile Creek (North)	WV-KL-6-B	UNT/Threemile Creek RM 2.61	Iron	1.90	0.27	2.28	2.28
Threemile Creek (North)	WV-KL-6-F	UNT/Threemile Creek RM 7.11	Iron	1.95	0.27	2.34	2.34
Threemile Creek (North)	WV-KL-6-H	UNT/Threemile Creek RM 8.65	Iron	2.01	0.26	2.39	2.39
Threemile Creek (South)	WV-KL-5	Threemile Creek (South)	Iron	16.38	2.89	20.28	20.28
Fivemile Creek	WV-KL-7	Fivemile Creek	Iron	54.01	6.21	63.39	63.39
Fivemile Creek	WV-KL-7-B	UNT/Fivemile Creek RM 2.40	Iron	2.73	0.48	3.38	3.38
Fivemile Creek	WV-KL-7-D	Upper Fivemile Creek	Iron	19.41	1.82	22.34	22.34

Major Watershed	Stream Code	Stream Name	Metal	LA (lbs/day)	WLA (lbs/day)	MOS lbs/day)	TMDL (lbs/day)
Fivemile Creek	WV-KL-7-C	Lower Fivemile Creek	Iron	18.16	2.67	21.92	21.92
Fivemile Creek	WV-KL-7-A	Little Fivemile Creek	Iron	3.38	0.49	4.08	4.08
Ninemile Creek	WV-KL-12	Ninemile Creek	Iron	37.68	6.70	46.72	46.72
Ninemile Creek	WV-KL-12-A	UNT/ Ninemile Creek RM 0.27	Iron	4.45	0.85	5.58	5.58
Ninemile Creek	WV-KL-12-B	Upper Ninemile Creek	Iron	14.99	2.85	18.79	18.79
Ninemile Creek	WV-KL-12-D	Middle Ninemile Creek	Iron	3.66	0.58	4.46	4.46
Ninemile Creek	WV-KL-12-E	UNT/Ninemile Creek RM 3.25	Iron	3.36	0.83	4.42	4.42
Tenmile Creek	WV-KL-15-C	Cooper Fork	Iron	15.63	3.02	19.63	19.63
Tenmile Creek	WV-KL-15-C-6	UNT/Cooper Fork RM 3.40	Iron	2.69	0.27	3.12	3.12
Tenmile Creek	WV-KL-15-C-1	UNT/Cooper Fork RM 1.41	Iron	3.79	0.80	4.83	4.83
Tenmile Creek	WV-KL-15-C-1-A	UNT/UNT RM 0.39/Cooper Fork RM 1.41	Iron	1.53	0.32	1.94	1.94
Pond Branch	WV-KL-17	Pond Branch	Iron	20.66	2.52	24.41	24.41
Pond Branch	WV-KL-17-B	UNT/Pond Branch RM 1.88	Iron	3.94	0.46	4.62	4.62
Pond Branch	WV-KL-17-A	UNT/Pond Branch RM 1.4	Iron	3.75	0.80	4.79	4.79
Thirteenmile Creek	WV-KL-19	Thirteenmile Creek	Iron	289.09	28.83	334.66	334.66
Thirteenmile Creek	WV-KL-19-D	Rocky Fork	Iron	18.40	3.24	22.77	22.77
Thirteenmile Creek	WV-KL-19-D-1	UNT/Rocky Fork RM 0.69	Iron	5.59	1.27	7.22	7.22
Thirteenmile Creek	WV-KL-19-F	Tom Allen Creek	Iron	3.46	0.71	4.39	4.39
Thirteenmile Creek	WV-KL-19-H	Buzzard Creek	Iron	12.42	1.34	14.49	14.49
Thirteenmile Creek	WV-KL-19-M	Mudlick Fork	Iron	61.52	5.89	70.96	70.96
Thirteenmile Creek	WV-KL-19-M-8	Sapsucker Run	Iron	10.09	1.24	11.92	11.92
Thirteenmile Creek	WV-KL-19-M-15	Bailey Branch	Iron	3.98	0.35	4.56	4.56
Thirteenmile Creek	WV-KL-19-M-9	Beech Fork	Iron	13.69	1.01	15.48	15.48
Thirteenmile Creek	WV-KL-19-N	Poplar Fork	Iron	35.62	4.00	41.71	41.71

Major Watershed	Stream Code	Stream Name	Metal	LA (lbs/day)	WLA (lbs/day)	MOS lbs/day)	TMDL (lbs/day)
Thirteenmile Creek	WV-KL-19-N-6	UNT/Poplar Fork RM 4.81	Iron	10.99	1.13	12.76	12.76
Thirteenmile Creek	WV-KL-19-O	UNT/Thirteenmile Creek RM 15.64	Iron	1.46	0.17	1.71	1.71
Thirteenmile Creek	WV-KL-19-P	UNT/Thirteenmile Creek RM 15.82	Iron	1.92	0.19	2.22	2.22
Thirteenmile Creek	WV-KL-19-R	Yeager Fork	Iron	8.46	0.72	9.66	9.66
Thirteenmile Creek	WV-KL-19-X	Baker Branch	Iron	8.36	0.74	9.58	9.58
Thirteenmile Creek	WV-KL-19-Z	Spruce Run	Iron	16.90	1.25	19.11	19.11
Thirteenmile Creek	WV-KL-19-AC	Long Hollow	Iron	5.93	0.67	6.95	6.95
Thirteenmile Creek	WV-KL-19-AF	Little Spruce Run	Iron	5.64	0.39	6.35	6.35
Thirteenmile Creek	WV-KL-19-AM	Peppermint Creek	Iron	8.36	0.87	9.72	9.72
Little Sixteenmile Creek	WV-KL-20	Little Sixteenmile Creek	Iron	42.46	7.14	52.22	52.22
Little Sixteenmile Creek	WV-KL-20-D	Shady Fork	Iron	6.45	1.42	8.29	8.29
Sixteenmile Creek	WV-KL-22	Sixteenmile Creek	Iron	94.60	12.21	112.43	112.43
Sixteenmile Creek	WV-KL-22-L	UNT/Sixteenmile Creek RM 8.16	Iron	16.80	2.55	20.37	20.37
Sixteenmile Creek	WV-KL-22-A	Slaty Hollow	Iron	2.77	0.65	3.60	3.60
Eighteenmile Creek	WV-KL-27	Eighteenmile Creek	Iron	357.22	33.62	411.40	411.40
Eighteenmile Creek	WV-KL-27-D	UNT/Eighteenmile Creek RM 2.84	Iron	3.81	0.42	4.45	4.45
Eighteenmile Creek	WV-KL-27-E	Otter Branch	Iron	2.56	0.25	2.95	2.95
Eighteenmile Creek	WV-KL-27-H	Jakes Run	Iron	5.27	0.55	6.13	6.13
Eighteenmile Creek	WV-KL-27-K	Isaacs Branch	Iron	7.36	0.90	8.70	8.70
Eighteenmile Creek	WV-KL-27-L	Lukes Branch	Iron	4.39	0.39	5.03	5.03
Eighteenmile Creek	WV-KL-27-M	Dads Branch	Iron	2.61	0.33	3.10	3.10
Eighteenmile Creek	WV-KL-27-N	Bear Branch	Iron	6.54	0.78	7.70	7.70
Eighteenmile Creek	WV-KL-27-P	Turkey Branch	Iron	19.73	1.95	22.82	22.82
Eighteenmile Creek	WV-KL-27-P-3	Left Fork/Turkey Branch	Iron	7.21	0.74	8.37	8.37

Major Watershed	Stream Code	Stream Name	Metal	LA (lbs/day)	WLA (lbs/day)	MOS lbs/day)	TMDL (lbs/day)
Eighteenmile Creek	WV-KL-27-S	Buffalo Branch	Iron	10.41	1.42	12.45	12.45
Eighteenmile Creek	WV-KL-27-X	Right Fork/Eighteenmile Creek	Iron	35.52	3.47	41.04	41.04
Eighteenmile Creek	WV-KL-27-X-8	Saltlick Creek	Iron	13.29	1.09	15.13	15.13
Eighteenmile Creek	WV-KL-27-X-7	Bucklick Creek	Iron	6.51	0.78	7.67	7.67
Eighteenmile Creek	WV-KL-27-X-3	Slab Hollow	Iron	2.65	0.34	3.15	3.15
Eighteenmile Creek	WV-KL-27-Y	Spring Valley Branch	Iron	9.77	1.12	11.46	11.46
Eighteenmile Creek	WV-KL-27-AA	Sulug Branch	Iron	4.84	0.68	5.82	5.82
Eighteenmile Creek	WV-KL-27-AB	Cherry Fork	Iron	49.60	6.04	58.57	58.57
Eighteenmile Creek	WV-KL-27-AB-4	Painters Branch	Iron	17.49	2.55	21.10	21.10
Eighteenmile Creek	WV-KL-27-AB-6	Sigman Fork	Iron	6.11	0.85	7.32	7.32
Eighteenmile Creek	WV-KL-27-AB-3	Stumpy Run	Iron	7.63	0.71	8.77	8.77
Eighteenmile Creek	WV-KL-27-AH	Harris Branch	Iron	3.12	0.35	3.66	3.66
Eighteenmile Creek	WV-KL-27-AK	Buckelew Hollow	Iron	3.23	0.44	3.86	3.86
Eighteenmile Creek	WV-KL-27-AL	Cottrell Run	Iron	1.59	0.20	1.89	1.89
Eighteenmile Creek	WV-KL-27-AF	Clendenin Creek	Iron	29.33	2.88	33.91	33.91
Five and Twenty Mile Creek	WV-KL-35	Five And Twenty Mile Creek	Iron	71.00	12.48	87.88	87.88
Five and Twenty Mile Creek	WV-KL-35-A	Honeycutt Run	Iron	10.86	2.00	13.53	13.53
Five and Twenty Mile Creek	WV-KL-35-B	Stave Branch	Iron	2.91	0.49	3.58	3.58
Five and Twenty Mile Creek	WV-KL-35-H	UNT/Five And Twenty Mile Creek RM 7.41	Iron	5.27	1.00	6.60	6.60
Five and Twenty Mile Creek	WV-KL-35-E	Evans Creek	Iron	20.39	3.58	25.23	25.23
Five and Twenty Mile Creek	WV-KL-35-E-5	UNT/Evans Creek RM 2.30	Iron	1.12	0.25	1.45	1.45
Five and Twenty Mile Creek	WV-KL-35-E-4	UNT/Evans Creek RM 1.92	Iron	3.34	0.41	3.95	3.95
Five and Twenty Mile Creek	WV-KL-35-E-1	Barnett Branch	Iron	6.34	1.42	8.17	8.17
Little Buffalo Creek	WV-KL-40-A	UNT/Little Buffalo Creek RM 1.17	Iron	5.31	1.02	6.67	6.67

Major Watershed	Stream Code	Stream Name	Metal	LA (lbs/day)	WLA (lbs/day)	MOS lbs/day)	TMDL (lbs/day)
Little Buffalo Creek	WV-KL-40-A-1	UNT/UNT RM 0.44/Little Buffalo Creek RM 1.17	Iron	1.78	0.34	2.24	2.24
Hurricane Creek	WV-KL-42	Hurricane Creek	Iron	251.55	106.73	377.13	377.13
Hurricane Creek	WV-KL-42-D	UNT/Hurricane Creek RM 1.64	Iron	1.71	0.41	2.23	2.23
Hurricane Creek	WV-KL-42-I	Poplar Fork	Iron	99.18	17.39	122.70	122.70
Hurricane Creek	WV-KL-42-I-3	Sugar Branch	Iron	6.30	1.54	8.25	8.25
Hurricane Creek	WV-KL-42-I-4	Cow Creek	Iron	11.57	2.65	14.98	14.98
Hurricane Creek	WV-KL-42-I-4-F	UNT/Cow Creek RM 2.33	Iron	1.89	0.26	2.26	2.26
Hurricane Creek	WV-KL-42-I-5	UNT/Poplar Fork RM 3.78	Iron	5.67	1.26	7.29	7.29
Hurricane Creek	WV-KL-42-I-9	Lick Branch	Iron	3.93	0.74	4.92	4.92
Hurricane Creek	WV-KL-42-I-10	Long Branch	Iron	10.30	2.00	12.95	12.95
Hurricane Creek	WV-KL-42-I-10-D	UNT/Long Branch RM 1.25	Iron	2.53	0.37	3.06	3.06
Hurricane Creek	WV-KL-42-I-10-C	Rockstep Run	Iron	2.81	0.59	3.58	3.58
Hurricane Creek	WV-KL-42-I-16	Crooked Creek	Iron	10.47	1.81	12.93	12.93
Hurricane Creek	WV-KL-42-I-16-B	UNT/Crooked Creek RM 0.72	Iron	2.64	0.49	3.30	3.30
Hurricane Creek	WV-KL-42-I-17	UNT/Poplar Fork RM 9.86	Iron	3.48	0.47	4.16	4.16
Hurricane Creek	WV-KL-42-N	Sleepy Creek	Iron	39.63	6.61	48.68	48.68
Hurricane Creek	WV-KL-42-N-2	Trace Creek	Iron	16.13	2.36	19.47	19.47
Hurricane Creek	WV-KL-42-U	Mill Creek	Iron	3.97	21.67	26.99	26.99
Hurricane Creek	WV-KL-42-U-2	UNT/Mill Creek RM 1.02	Iron	0.11	10.10	10.74	10.74
Hurricane Creek	WV-KL-42-U-1	Tackett Branch	Iron	0.95	2.46	3.59	3.59
Hurricane Creek	WV-KL-42-AC	Trace Fork	Iron	6.19	2.27	8.90	8.90
Hurricane Creek	WV-KL-42-AF	Buffs Branch	Iron	9.75	2.24	12.62	12.62
Hurricane Creek	WV-KL-42-AL	Joes Branch	Iron	2.44	0.58	3.18	3.18

Major Watershed	Stream Code	Stream Name	Metal	LA (lbs/day)	WLA (lbs/day)	MOS lbs/day)	TMDL (lbs/day)
Hurricane Creek	WV-KL-42-AO	Rider Creek	Iron	4.30	0.93	5.50	5.50
Hurricane Creek	WV-KL-42-AQ	Sams Fork	Iron	3.30	0.57	4.08	4.08
Little Hurricane Creek	WV-KL-46	Little Hurricane Creek	Iron	43.73	15.87	62.74	62.74
Little Hurricane Creek	WV-KL-46-A	Long Branch	Iron	2.97	0.70	3.86	3.86
Little Hurricane Creek	WV-KL-46-B	UNT/Little Hurricane Creek RM 1.35	Iron	2.36	0.52	3.03	3.03
Little Hurricane Creek	WV-KL-46-D	Harmon Branch	Iron	4.95	0.86	6.11	6.11
Little Hurricane Creek	WV-KL-46-E	Morrison Fork	Iron	8.37	1.63	10.53	10.53
Little Hurricane Creek	WV-KL-46-I	Lick Run	Iron	7.56	7.60	15.96	15.96
Farley Creek	WV-KL-54	Farley Creek	Iron	3.65	1.07	4.97	4.97
Bills Creek	WV-KL-56	Bills Creek	Iron	10.57	1.80	13.02	13.02
Bills Creek	WV-KL-56-A	UNT/Bills Creek RM 0.81	Iron	1.49	0.20	1.78	1.78
Pocatalico River	WV-KL-57	Pocatalico River	Iron	2164.63	135.97	2421.68	2421.68
Pocatalico River	WV-KL-57-F	Claybank Branch	Iron	6.20	1.29	7.89	7.89
Pocatalico River	WV-KL-57-J	Kelly Creek	Iron	1.84	0.27	2.23	2.23
Pocatalico River	WV-KL-57-K	Harmond Creek	Iron	9.89	1.31	11.79	11.79
Pocatalico River	WV-KL-57-L	Rocky Fork	Iron	75.37	11.14	91.06	91.06
Pocatalico River	WV-KL-57-L-1	Lick Branch	Iron	3.24	0.46	3.90	3.90
Pocatalico River	WV-KL-57-L-3	Fisher Branch	Iron	19.29	3.02	23.49	23.49
Pocatalico River	WV-KL-57-L-4	Wolfpen Run	Iron	2.40	0.39	2.93	2.93
Pocatalico River	WV-KL-57-L-10	UNT/Rocky Fork RM 4.32	Iron	5.26	1.03	6.62	6.62
Pocatalico River	WV-KL-57-L-14	Howard Fork	Iron	6.03	1.24	7.65	7.65
Pocatalico River	WV-KL-57-N	Martin Branch	Iron	17.61	2.67	21.35	21.35
Pocatalico River	WV-KL-57-O	Schoolhouse Branch	Iron	0.95	0.20	1.21	1.21
Pocatalico River	WV-KL-57-P	Campbells Branch	Iron	1.87	0.28	2.26	2.26

Major Watershed	Stream Code	Stream Name	Metal	LA (lbs/day)	WLA (lbs/day)	MOS lbs/day)	TMDL (lbs/day)
Pocatalico River	WV-KL-57-Q	Kelly Creek	Iron	19.96	2.57	23.72	23.72
Pocatalico River	WV-KL-57-Q-1	UNT/Kelly Creek RM 0.51	Iron	1.65	0.34	2.09	2.09
Pocatalico River	WV-KL-57-Q-2	Spring Branch	Iron	2.23	0.36	2.72	2.72
Pocatalico River	WV-KL-57-R	Frog Creek	Iron	38.33	4.65	45.24	45.24
Pocatalico River	WV-KL-57-R-8	Grasslick Run	Iron	6.43	0.66	7.45	7.45
Pocatalico River	WV-KL-57-R-9	Tanner Fork	Iron	6.42	0.71	7.51	7.51
Pocatalico River	WV-KL-57-U	Derrick Creek	Iron	15.49	2.15	18.56	18.56
Pocatalico River	WV-KL-57-X	UNT/Pocatalico River RM 23.03	Iron	1.35	0.17	1.60	1.60
Pocatalico River	WV-KL-57-AA	Grapevine Creek	Iron	32.53	4.71	39.20	39.20
Pocatalico River	WV-KL-57-AA-4	Boardtree Run	Iron	2.45	0.42	3.02	3.02
Pocatalico River	WV-KL-57-AA-2	Right Fork	Iron	7.05	0.95	8.41	8.41
Pocatalico River	WV-KL-57-AD	Pocatalico Creek	Iron	235.78	29.36	279.09	279.09
Pocatalico River	WV-KL-57-AD-3	Allen Fork	Iron	37.70	6.49	46.52	46.52
Pocatalico River	WV-KL-57-AD-3-B	Trace Fork	Iron	8.25	1.58	10.35	10.35
Pocatalico River	WV-KL-57-AD-10	Dog Fork	Iron	20.21	2.17	23.55	23.55
Pocatalico River	WV-KL-57-AD-14	Gays Branch	Iron	8.72	1.15	10.39	10.39
Pocatalico River	WV-KL-57-AD-9	Dudden Fork	Iron	20.53	2.85	24.61	24.61
Pocatalico River	WV-KL-57-AD-2	Middle Fork/Pocatalico Creek	Iron	98.19	10.31	114.21	114.21
Pocatalico River	WV-KL-57-AD-2-H	Sugar Creek	Iron	16.46	1.58	18.98	18.98
Pocatalico River	WV-KL-57-AD-2-P	Laurel Fork	Iron	12.46	1.40	14.59	14.59
Pocatalico River	WV-KL-57-AD-2-K	First Creek	Iron	4.09	0.47	4.79	4.79
Pocatalico River	WV-KL-57-AL	Raccoon Creek	Iron	7.50	0.75	8.68	8.68
Pocatalico River	WV-KL-57-AO	Leatherwood Creek	Iron	18.41	1.48	20.93	20.93
Pocatalico River	WV-KL-57-AP	Hicumbottom Run	Iron	5.01	0.58	5.88	5.88

Major Watershed	Stream Code	Stream Name	Metal	LA (lbs/day)	WLA (lbs/day)	MOS lbs/day)	TMDL (lbs/day)
Pocatalico River	WV-KL-57-AR	Goose Creek	Iron	4.44	0.58	5.28	5.28
Pocatalico River	WV-KL-57-AT	Camp Creek	Iron	2.67	0.40	3.23	3.23
Pocatalico River	WV-KL-57-AU	Allen Creek	Iron	2.41	0.30	2.86	2.86
Pocatalico River	WV-KL-57-AV	Green Creek	Iron	51.62	6.31	60.98	60.98
Pocatalico River	WV-KL-57-AV-4	Left Fork/Green Creek	Iron	11.06	1.61	13.34	13.34
Pocatalico River	WV-KL-57-AV-6	Rush Fork	Iron	6.01	0.87	7.24	7.24
Pocatalico River	WV-KL-57-AV-3	Coleman Fork	Iron	9.30	1.13	10.98	10.98
Pocatalico River	WV-KL-57-AX	Straight Creek	Iron	5.54	0.86	6.73	6.73
Pocatalico River	WV-KL-57-AZ	White Oak Run	Iron	6.28	0.91	7.56	7.56
Pocatalico River	WV-KL-57-BB	Red Oak Run	Iron	7.09	0.71	8.22	8.22
Pocatalico River	WV-KL-57-BE	Wolf Creek	Iron	20.58	2.47	24.26	24.26
Pocatalico River	WV-KL-57-BH	Flat Fork	Iron	90.91	9.11	105.29	105.29
Pocatalico River	WV-KL-57-BH-3	Higby Run	Iron	13.64	1.36	15.79	15.79
Pocatalico River	WV-KL-57-BH-3-A	Payne Hollow	Iron	3.88	0.45	4.55	4.55
Pocatalico River	WV-KL-57-BH-8	Cox Fork	Iron	21.55	2.30	25.10	25.10
Pocatalico River	WV-KL-57-BH-8-B	Wolfcamp Run	Iron	6.33	0.64	7.34	7.34
Pocatalico River	WV-KL-57-BH-8-D	Coon Creek	Iron	3.06	0.34	3.58	3.58
Pocatalico River	WV-KL-57-BH-13	Cabbage Fork	Iron	6.52	0.81	7.72	7.72
Pocatalico River	WV-KL-57-BH-13-A	Wolfpen Run	Iron	3.61	0.37	4.19	4.19
Pocatalico River	WV-KL-57-BH-1	Trace Fork	Iron	13.46	1.20	15.43	15.43
Pocatalico River	WV-KL-57-BK	Rock Creek	Iron	18.78	2.68	22.59	22.59
Pocatalico River	WV-KL-57-BN	Big Creek	Iron	16.12	1.89	18.96	18.96
Pocatalico River	WV-KL-57-BQ	McKown Creek	Iron	21.74	2.09	25.09	25.09
Pocatalico River	WV-KL-57-BQ-3	Left Hand Run	Iron	3.85	0.46	4.54	4.54

Major Watershed	Stream Code	Stream Name	Metal	LA (lbs/day)	WLA (lbs/day)	MOS lbs/day)	TMDL (lbs/day)
Pocatalico River	WV-KL-57-BT	Johnson Creek	Iron	44.32	5.15	52.07	52.07
Pocatalico River	WV-KL-57-BT-6	Pad Fork	Iron	6.78	0.71	7.89	7.89
Pocatalico River	WV-KL-57-BT-10	Jackson Fork	Iron	5.59	0.72	6.64	6.64
Pocatalico River	WV-KL-57-BU	Big Lick Run	Iron	38.35	4.24	44.83	44.83
Pocatalico River	WV-KL-57-BU-2	Silcott Fork	Iron	10.74	1.42	12.80	12.80
Pocatalico River	WV-KL-57-BU-2-B	UNT/Silcott Fork RM 1.96	Iron	2.57	0.32	3.04	3.04
Pocatalico River	WV-KL-57-BU-4	Bear Fork	Iron	4.71	0.57	5.56	5.56
Pocatalico River	WV-KL-57-BV	Round Knob Run	Iron	11.07	1.46	13.19	13.19
Pocatalico River	WV-KL-57-BX	Rush Creek	Iron	22.87	2.92	27.14	27.14
Pocatalico River	WV-KL-57-BX-1	Slab Fork	Iron	7.83	1.23	9.54	9.54
Pocatalico River	WV-KL-57-CD	Laurel Fork	Iron	11.42	1.62	13.72	13.72
Pocatalico River	WV-KL-57-CF	Flat Fork	Iron	7.14	0.87	8.43	8.43
Armour Creek	WV-KL-60	Armour Creek	Iron	17.74	17.30	36.88	36.88
Armour Creek	WV-KL-60-E	UNT/Armour Creek RM 3.54	Iron	0.18	1.24	1.49	1.49
Armour Creek	WV-KL-60-D	UNT/Armour Creek RM 3.25	Iron	0.71	1.21	2.02	2.02
Armour Creek	WV-KL-60-C	Blakes Creek	Iron	6.77	7.15	14.65	14.65
Scary Creek	WV-KL-63	Scary Creek	Iron	39.09	6.36	47.84	47.84
Scary Creek	WV-KL-63-A	UNT/Scary Creek RM 0.14	Iron	0.97	0.23	1.25	1.25
Scary Creek	WV-KL-63-H	UNT/Scary Creek RM 3.84	Iron	2.03	0.47	2.63	2.63
Scary Creek	WV-KL-63-E	UNT/Scary Creek RM 2.13	Iron	9.26	1.55	11.38	11.38
Scary Creek	WV-KL-63-E-1	UNT/UNT RM 0.33/Scary Creek RM 2.13	Iron	4.18	0.82	5.26	5.26
Scary Creek	WV-KL-63-C	Rockstep Run	Iron	9.72	1.45	11.76	11.76
Scary Creek	WV-KL-63-C-2	UNT/Rockstep Run RM 0.82	Iron	3.68	0.56	4.46	4.46
Gallatin Branch	WV-KL-64	Gallatin Branch	Iron	4.10	0.71	5.06	5.06

Major Watershed	Stream Code	Stream Name	Metal	LA (lbs/day)	WLA (lbs/day)	MOS lbs/day)	TMDL (lbs/day)
Gallatin Branch	WV-KL-64-A	UNT/Gallatin Branch RM 0.47	Iron	2.06	0.34	2.53	2.53
Davis Creek	WV-KL-74	Davis Creek	Iron	142.63	79.32	233.63	233.63
Davis Creek	WV-KL-74-B	Ward Hollow	Iron	0.21	9.04	9.74	9.74
Davis Creek	WV-KL-74-C	Trace Fork	Iron	28.24	13.02	43.43	43.43
Davis Creek	WV-KL-74-C-4	Pot Branch	Iron	4.12	2.47	6.94	6.94
Davis Creek	WV-KL-74-C-2	Mudsuck Branch	Iron	9.53	0.90	10.97	10.97
Davis Creek	WV-KL-74-D	Sugarcamp Creek	Iron	0.33	5.81	6.46	6.46
Davis Creek	WV-KL-74-E	Dry Branch	Iron	2.07	1.02	3.25	3.25
Davis Creek	WV-KL-74-F	Middle Fork/Davis Creek	Iron	23.28	5.42	30.22	30.22
Davis Creek	WV-KL-74-F-2	Long Branch	Iron	2.09	1.16	3.42	3.42
Davis Creek	WV-KL-74-G	Rays Branch	Iron	2.00	10.12	12.76	12.76
Davis Creek	WV-KL-74-K	Kirby Hollow	Iron	1.55	0.21	1.85	1.85
Davis Creek	WV-KL-74-L	Coal Hollow	Iron	0.77	3.32	4.31	4.31
Davis Creek	WV-KL-74-N	Cane Fork	Iron	11.19	1.32	13.17	13.17
Davis Creek	WV-KL-74-N-1	UNT/Cane Fork RM 0.83	Iron	4.26	0.50	5.01	5.01
Davis Creek	WV-KL-74-O	Kanawha Fork	Iron	12.80	5.09	18.83	18.83
Davis Creek	WV-KL-74-O-1	Middlelick Branch	Iron	9.86	3.34	13.90	13.90
Joplin Branch	WV-KL-77	Joplin Branch	Iron	0.09	7.72	8.21	8.21

NA = not applicable; UNT = unnamed tributary; RM = river mile.

Table 11-3. pH TMDLs

Major Watershed	Stream Code	Stream Name	LA Average Daily Net Acidity Load (lbs/day)	WLA Average Daily Net Acidity Load (lbs/day)	MOS Average Daily Net Acidity Load (lbs/day)	TMDL Average Daily Net Acidity Load (lbs/day)
Pocatalico River	WV-KL-57-I	UNT/Pocatalico River RM 8.52	-7.42	NA	0.29	-7.81
Pocatalico River	WV-KL-57-J	Kelly Creek	-13.09	NA	1.34	-13.78
Pocatalico River	WV-KL-57-K-2	UNT/Harmond Creek RM 1.00	-5.68	NA	1.45	-5.98
Pocatalico River	WV-KL-57-Q-1	UNT/Kelly Creek RM 0.51	-8.39	NA	2.24	-8.84
Davis Creek	WV-KL-74-O-1-A	Hoffman Hollow	-24.24	NA	0.32	-25.52

NA = not applicable; UNT = unnamed tributary; RM = river mile.

Table 11-4. Fecal coliform bacteria TMDLs

NHD Stream Code	Stream Name	LA (counts/day)	WLA (counts/day)	MOS (counts/day)	TMDL (counts/day)
WV-KL-5	Threemile Creek (South)	2.31E+10	NA	1.22E+09	2.43E+10
WV-KL-6	Threemile Creek (North)	3.16E+10	3.03E+08	1.68E+09	3.36E+10
WV-KL-7	Fivemile Creek	5.65E+10	2.45E+06	2.97E+09	5.94E+10
WV-KL-7-A	Little Fivemile Creek	3.67E+09	NA	1.93E+08	3.86E+09
WV-KL-12	Ninemile Creek	4.23E+10	5.88E+06	2.22E+09	4.45E+10
WV-KL-12-B	Upper Ninemile Creek	1.77E+10	2.94E+06	9.33E+08	1.87E+10
WV-KL-15-C	Cooper Fork	1.90E+10	NA	1.00E+09	2.00E+10

NHD Stream Code	Stream Name	LA (counts/day)	WLA (counts/day)	MOS (counts/day)	TMDL (counts/day)
WV-KL-17	Pond Branch	1.87E+10	NA	9.84E+08	1.97E+10
WV-KL-17-A	UNT/Pond Branch RM 1.4	4.37E+09	NA	2.30E+08	4.60E+09
WV-KL-19	Thirteenmile Creek	2.91E+11	2.12E+07	1.53E+10	3.07E+11
WV-KL-19-D	Rocky Fork	1.71E+10	NA	8.98E+08	1.80E+10
WV-KL-19-H	Buzzard Creek	1.70E+10	NA	8.94E+08	1.79E+10
WV-KL-19-M	Mudlick Fork	7.34E+10	NA	3.86E+09	7.72E+10
WV-KL-19-N	Poplar Fork	4.01E+10	NA	2.11E+09	4.22E+10
WV-KL-20	Little Sixteenmile Creek	4.14E+10	2.94E+06	2.18E+09	4.35E+10
WV-KL-22	Sixteenmile Creek	7.61E+10	NA	4.00E+09	8.01E+10
WV-KL-27	Eighteenmile Creek	2.94E+11	2.45E+06	1.55E+10	3.09E+11
WV-KL-27-H	Jakes Run	5.83E+09	NA	3.07E+08	6.13E+09
WV-KL-27-X	Right Fork/Eighteenmile Creek	3.16E+10	NA	1.66E+09	3.33E+10
WV-KL-27-X-8	Saltlick Creek	1.01E+10	NA	5.31E+08	1.06E+10
WV-KL-27-AB	Cherry Fork	5.52E+10	NA	2.91E+09	5.81E+10
WV-KL-27-AK	Buckelew Hollow	2.71E+09	NA	1.42E+08	2.85E+09
WV-KL-27-AL	Cottrell Run	2.51E+09	NA	1.32E+08	2.64E+09
WV-KL-35	Five and Twenty Mile Creek	7.02E+10	1.03E+07	3.70E+09	7.39E+10
WV-KL-35-H	UNT/Five and Twenty Mile Creek RM 7.41	6.11E+09	2.45E+06	3.22E+08	6.44E+09
WV-KL-35-E	Evans Creek	2.24E+10	NA	1.18E+09	2.36E+10
WV-KL-40-A	UNT/Little Buffalo Creek RM 1.17	5.55E+09	NA	2.92E+08	5.85E+09
WV-KL-42	Hurricane Creek	2.50E+11	1.06E+11	1.87E+10	3.75E+11
WV-KL-42-I	Poplar Fork	1.06E+11	3.41E+07	5.58E+09	1.12E+11
WV-KL-42-I-4	Cow Creek	1.38E+10	2.45E+06	7.25E+08	1.45E+10
WV-KL-42-I-10	Long Branch	1.02E+10	NA	5.34E+08	1.07E+10

NHD Stream Code	Stream Name	LA (counts/day)	WLA (counts/day)	MOS (counts/day)	TMDL (counts/day)
WV-KL-42-I-16	Crooked Creek	1.28E+10	6.78E+06	6.76E+08	1.35E+10
WV-KL-42-I-16-B	UNT/Crooked Creek RM 0.72	3.85E+09	6.00E+06	2.03E+08	4.06E+09
WV-KL-42-N	Sleepy Creek	4.08E+10	2.56E+08	2.16E+09	4.32E+10
WV-KL-42-N-2	Trace Creek	1.99E+10	5.39E+06	1.05E+09	2.09E+10
WV-KL-42-U	Mill Creek	5.53E+06	3.47E+10	1.83E+09	3.65E+10
WV-KL-42-AO	Rider Creek	5.14E+09	NA	2.71E+08	5.41E+09
WV-KL-42-AQ	Sams Fork	4.91E+09	NA	2.58E+08	5.17E+09
WV-KL-46	Little Hurricane Creek	4.64E+10	2.35E+07	2.44E+09	4.89E+10
WV-KL-54	Farley Creek	4.31E+09	2.65E+06	2.27E+08	4.54E+09
WV-KL-56	Bills Creek	1.35E+10	1.89E+08	7.23E+08	1.45E+10
WV-KL-57	Pocatalico River	1.30E+12	5.50E+09	6.86E+10	1.37E+12
WV-KL-57-K	Harmond Creek	1.06E+10	2.45E+06	5.56E+08	1.11E+10
WV-KL-57-L	Rocky Fork	6.27E+10	4.84E+08	3.33E+09	6.65E+10
WV-KL-57-L-3	Fisher Branch	1.32E+10	1.46E+08	7.02E+08	1.40E+10
WV-KL-57-L-4	Wolfpen Run	3.28E+09	NA	1.73E+08	3.46E+09
WV-KL-57-L-10	UNT/Rocky Fork RM 4.32	6.53E+09	1.67E+07	3.45E+08	6.89E+09
WV-KL-57-L-14	Howard Fork	7.85E+09	6.98E+06	4.13E+08	8.27E+09
WV-KL-57-N	Martin Branch	1.14E+10	7.20E+07	6.06E+08	1.21E+10
WV-KL-57-O	Schoolhouse Branch	1.46E+09	NA	7.67E+07	1.53E+09
WV-KL-57-P	Campbells Branch	2.34E+09	NA	1.23E+08	2.47E+09
WV-KL-57-Q	Kelly Creek	1.97E+10	2.45E+06	1.04E+09	2.07E+10
WV-KL-57-Q-2	Spring Branch	3.00E+09	2.45E+06	1.58E+08	3.16E+09
WV-KL-57-R	Frog Creek	4.04E+10	4.90E+06	2.13E+09	4.26E+10
WV-KL-57-U	Derrick Creek	1.60E+10	2.45E+06	8.42E+08	1.68E+10

NHD Stream Code	Stream Name	LA (counts/day)	WLA (counts/day)	MOS (counts/day)	TMDL (counts/day)
WV-KL-57-AA	Grapevine Creek	3.12E+10	1.03E+07	1.64E+09	3.28E+10
WV-KL-57-AA-4	Boardtree Run	2.56E+09	NA	1.35E+08	2.70E+09
WV-KL-57-AA-2	Right Fork	8.77E+09	2.45E+06	4.62E+08	9.23E+09
WV-KL-57-AD	Pocatalico Creek	2.58E+11	1.24E+08	1.36E+10	2.72E+11
WV-KL-57-AD-3	Allen Fork	3.61E+10	4.90E+06	1.90E+09	3.80E+10
WV-KL-57-AD-2	Middle Fork/Pocatalico Creek	1.14E+11	7.58E+07	6.02E+09	1.20E+11
WV-KL-57-AL	Raccoon Creek	7.30E+09	NA	3.84E+08	7.69E+09
WV-KL-57-AO	Leatherwood Creek	1.94E+10	NA	1.02E+09	2.04E+10
WV-KL-57-AV-3	Coleman Fork	9.01E+09	NA	4.74E+08	9.48E+09
WV-KL-57-BH	Flat Fork	1.13E+11	2.45E+06	5.96E+09	1.19E+11
WV-KL-57-BH-3	Higby Run	1.74E+10	NA	9.17E+08	1.83E+10
WV-KL-57-BH-8	Cox Fork	2.80E+10	NA	1.47E+09	2.94E+10
WV-KL-57-BH-13	Cabbage Fork	9.11E+09	NA	4.80E+08	9.59E+09
WV-KL-57-BQ	Mckown Creek	2.43E+10	2.94E+06	1.28E+09	2.56E+10
WV-KL-57-BT	Johnson Creek	4.51E+10	2.94E+06	2.37E+09	4.75E+10
WV-KL-57-BT-4	Greathouse Hollow	1.14E+09	NA	5.99E+07	1.20E+09
WV-KL-57-BU	Big Lick Run	4.09E+10	3.81E+07	2.16E+09	4.31E+10
WV-KL-57-BU-2	Silcott Fork	1.14E+10	NA	6.01E+08	1.20E+10
WV-KL-57-BX	Rush Creek	2.51E+10	NA	1.32E+09	2.64E+10
WV-KL-57-CD	Laurel Fork	1.39E+10	NA	7.34E+08	1.47E+10
WV-KL-60	Armour Creek	2.46E+10	1.73E+10	2.20E+09	4.41E+10
WV-KL-60-C	Blakes Creek	6.02E+09	7.07E+09	6.89E+08	1.38E+10
WV-KL-63	Scary Creek	4.18E+10	1.72E+08	2.21E+09	4.42E+10
WV-KL-63-A	UNT/Scary Creek RM 0.14	1.66E+09	7.34E+06	8.79E+07	1.76E+09

NHD Stream Code	Stream Name	LA (counts/day)	WLA (counts/day)	MOS (counts/day)	TMDL (counts/day)
WV-KL-63-E-1	UNT/UNT RM 0.33/Scary Creek RM 2.13	4.88E+09	1.19E+05	2.57E+08	5.14E+09
WV-KL-63-C	Rockstep Run	1.05E+10	1.49E+08	5.63E+08	1.13E+10
WV-KL-64	Gallatin Branch	6.91E+09	NA	3.64E+08	7.27E+09
WV-KL-74	Davis Creek	1.71E+11	7.03E+10	1.27E+10	2.54E+11
WV-KL-74-B	Ward Hollow	5.86E+07	1.15E+10	6.10E+08	1.22E+10
WV-KL-74-C	Trace Fork	3.62E+10	1.32E+10	2.60E+09	5.20E+10
WV-KL-74-F	Middle Fork/Davis Creek	2.90E+10	4.35E+09	1.76E+09	3.52E+10
WV-KL-74-G	Rays Branch	3.14E+09	1.13E+10	7.59E+08	1.52E+10
WV-KL-74-L	Coal Hollow	2.04E+09	6.65E+09	4.57E+08	9.15E+09
WV-KL-74-N	Cane Fork	1.73E+10	1.81E+07	9.13E+08	1.83E+10
WV-KL-74-O	Kanawha Fork	1.83E+10	NA	9.63E+08	1.93E+10
WV-KL-77	Joplin Branch	3.42E+06	1.79E+10	9.40E+08	1.88E+10

NA = not applicable; UNT = unnamed tributary; RM = river mile.

"Scientific notation" is a method of writing or displaying numbers in terms of a decimal number between 1 and 10 multiplied by a power of 10. The scientific notation of 10,492, for example, is 1.0492×10^4 or 1.0492E+4.

Table 11-5. Biological TMDLs

Stream (NHD_Code)	Biological Stressor	TMDL Parameter	LA	WLA	MOS	TMDL	Units
Threemile Creek (South) (WV-KL-5)	Organic Enrichment	Fecal Coliform	2.31E+10	NA	1.22E+09	2.43E+10	counts/ day
	Sediment	Total Iron	16.38	2.89	20.28	20.28	lbs/day
Upper Ninemile Creek (WV-KL-12-B)	Organic Enrichment	Fecal Coliform	1.77E+10	2.94E+06	9.33E+08	1.87E+10	counts/ day
	Sediment	Total Iron	14.99	2.85	18.79	18.79	lbs/day
Pond Branch (WV-KL-17)	Organic Enrichment	Fecal Coliform	1.87E+10	NA	9.84E+08	1.97E+10	counts/ day
	Sediment	Total Iron	20.66	2.52	24.41	24.41	lbs/day
Poplar Fork (WV-KL-19-N)	Organic Enrichment	Fecal Coliform	4.01E+10	NA	2.11E+09	4.22E+10	counts/ day
	Sediment	Total Iron	35.62	4.00	41.71	41.71	lbs/day
Jakes Run (WV-KL-27-H)	Organic Enrichment	Fecal Coliform	5.83E+09	NA	3.07E+08	6.13E+09	counts/ day
	Sediment	Total Iron	5.27	0.55	6.13	6.13	lbs/day
Saltlick Creek (WV-KL-27-X-8)	Organic Enrichment	Fecal Coliform	1.01E+10	NA	5.31E+08	1.06E+10	counts/ day
	Sediment	Total Iron	13.29	1.09	15.13	15.13	lbs/day
Buckelew Hollow (WV-KL-27-AK)	Organic Enrichment	Fecal Coliform	2.71E+09	NA	1.42E+08	2.85E+09	counts/ day
	Sediment	Total Iron	3.23	0.44	3.86	3.86	lbs/day
UNT/Five And Twenty Mile Creek RM 7.41 (WV-KL-35-H)	Organic Enrichment	Fecal Coliform	6.11E+09	2.45E+06	3.22E+08	6.44E+09	counts/ day
	Sediment	Total Iron	5.27	1.00	6.60	6.60	lbs/day
UNT/Little Buffalo Creek RM 1.17 (WV-KL-40-A)	Organic Enrichment	Fecal Coliform	5.55E+09	NA	2.92E+08	5.85E+09	counts/ day
	Sediment	Total Iron	5.31	1.02	6.67	6.67	lbs/day
Hurricane Creek (WV-KL-42)	Organic Enrichment	Fecal Coliform	2.50E+11	1.06E+11	1.87E+10	3.75E+11	counts/ day
	Sediment	Total Iron	251.55	106.73	377.13	377.13	lbs/day
Poplar Fork (WV-KL-42-I)	Organic Enrichment	Fecal Coliform	1.06E+11	3.41E+07	5.58E+09	1.12E+11	counts/ day
	Sediment	Total Iron	99.18	17.39	122.70	122.70	lbs/day

Stream (NHD_Code)	Biological Stressor	TMDL Parameter	LA	WLA	MOS	TMDL	Units
Cow Creek (WV-KL-42-I-4)	Organic Enrichment	Fecal Coliform	1.38E+10	2.45E+06	7.25E+08	1.45E+10	counts/ day
	Sediment	Total Iron	11.57	2.65	14.98	14.98	lbs/day
Long Branch (WV-KL-42-I-10)	Organic Enrichment	Fecal Coliform	1.02E+10	NA	5.34E+08	1.07E+10	counts/ day
	Sediment	Total Iron	10.30	2.00	12.95	12.95	lbs/day
UNT/Crooked Creek RM 0.72 (WV-KL-42-I-16-B)	Organic Enrichment	Fecal Coliform	3.85E+09	6.00E+06	2.03E+08	4.06E+09	counts/ day
	Sediment	Total Iron	2.64	0.49	3.30	3.30	lbs/day
Sleepy Creek (WV-KL-42-N)	Organic Enrichment	Fecal Coliform	4.08E+10	2.56E+08	2.16E+09	4.32E+10	counts/ day
	Sediment	Total Iron	39.63	6.61	48.68	48.68	lbs/day
Mill Creek (WV-KL-42-U)	Organic Enrichment	Fecal Coliform	5.53E+06	3.47E+10	1.83E+09	3.65E+10	counts/ day
	Sediment	Total Iron	3.97	21.67	26.99	26.99	lbs/day
Rider Creek (WV-KL-42-AO)	Organic Enrichment	Fecal Coliform	5.14E+09	NA	2.71E+08	5.41E+09	counts/ day
	Sediment	Total Iron	4.30	0.93	5.50	5.50	lbs/day
Bills Creek (WV-KL-56)	Organic Enrichment	Fecal Coliform	4.64E+10	2.35E+07	2.44E+09	4.89E+10	counts/ day
	Sediment	Total Iron	10.57	1.80	13.02	13.02	lbs/day
Pocatalico River (WV-KL-57)	Organic Enrichment	Fecal Coliform	1.30E+12	5.50E+09	6.86E+10	1.37E+12	counts/ day
	Sediment	Total Iron	2164.63	135.97	2421.68	2421.68	lbs/day
Harmond Creek (WV-KL-57-K)	Organic Enrichment	Fecal Coliform	1.06E+10	2.45E+06	5.56E+08	1.11E+10	counts/ day
	Sediment	Total Iron	9.89	1.31	11.79	11.79	lbs/day
Rocky Fork (WV-KL-57-L)	Organic Enrichment	Fecal Coliform	6.27E+10	4.84E+08	3.33E+09	6.65E+10	counts/ day
	Sediment	Total Iron	75.37	11.14	91.06	91.06	lbs/day
Kelly Creek (WV-KL-57-Q)	Organic Enrichment	Fecal Coliform	1.97E+10	2.45E+06	1.04E+09	2.07E+10	counts/ day
	Sediment	Total Iron	19.96	2.57	23.72	23.72	lbs/day
Grapevine Creek (WV-KL-57-AA)	Organic Enrichment	Fecal Coliform	3.12E+10	1.03E+07	1.64E+09	3.28E+10	counts/ day
	Sediment	Total Iron	32.53	4.71	39.20	39.20	lbs/day

Stream (NHD_Code)	Biological Stressor	TMDL Parameter	LA	WLA	MOS	TMDL	Units
Boardtree Run (WV-KL-57-AA-4)	Organic Enrichment	Fecal Coliform	2.56E+09	NA	1.35E+08	2.70E+09	counts/ day
	Sediment	Total Iron	2.45	0.42	3.02	3.02	lbs/day
Pocatalico Creek (WV-KL-57-AD)	Organic Enrichment	Fecal Coliform	2.58E+11	1.24E+08	1.36E+10	2.72E+11	counts/ day
	Sediment	Total Iron	235.78	29.36	279.09	279.09	lbs/day
Middle Fork/Pocatalico Creek (WV-KL-57-AD-2)	Organic Enrichment	Fecal Coliform	1.14E+11	7.58E+07	6.02E+09	1.20E+11	counts/ day
	Sediment	Total Iron	98.19	10.31	114.21	114.21	lbs/day
Raccoon Creek (WV-KL-57-AL)	Sediment	Total Iron	7.50	0.75	8.68	8.68	lbs/day
Leatherwood Creek (WV-KL-57-AO)	Sediment	Total Iron	18.41	1.48	20.93	20.93	lbs/day
Camp Creek (WV-KL-57-AT)	Sediment	Total Iron	2.67	0.40	3.23	3.23	lbs/day
Straight Creek (WV-KL-57-AX)	Sediment	Total Iron	5.54	0.86	6.73	6.73	lbs/day
McKown Creek (WV-KL-57-BQ)	Organic Enrichment	Fecal Coliform	2.43E+10	2.94E+06	1.28E+09	2.56E+10	counts/ day
	Sediment	Total Iron	21.74	2.09	25.09	25.09	lbs/day
Armour Creek (WV-KL-60)	Organic Enrichment	Fecal Coliform	2.46E+10	1.73E+10	2.20E+09	4.41E+10	counts/ day
	Sediment	Total Iron	17.74	17.30	36.88	36.88	lbs/day
Blakes Creek (WV-KL-60-C)	Organic Enrichment	Fecal Coliform	6.02E+09	7.07E+09	6.89E+08	1.38E+10	counts/ day
	Sediment	Total Iron	6.77	7.15	14.65	14.65	lbs/day
Scary Creek (WV-KL-63)	Organic Enrichment	Fecal Coliform	4.18E+10	1.72E+08	2.21E+09	4.42E+10	counts/ day
	Sediment	Total Iron	39.09	6.36	47.84	47.84	lbs/day
UNT/Scary Creek RM 0.14 (WV-KL-63-A)	Organic Enrichment	Fecal Coliform	1.66E+09	7.34E+06	8.79E+07	1.76E+09	counts/ day
	Sediment	Total Iron	0.97	0.23	1.25	1.25	lbs/day
Rockstep Run (WV-KL-63-C)	Organic Enrichment	Fecal Coliform	1.05E+10	1.49E+08	5.63E+08	1.13E+10	counts/ day
	Sediment	Total Iron	9.72	1.45	11.76	11.76	lbs/day
UNT/UNT RM 0.33/Scary Creek RM 2.13	Organic Enrichment	Fecal Coliform	4.88E+09	1.19E+05	2.57E+08	5.14E+09	counts/ day

Stream (NHD_Code)	Biological Stressor	TMDL Parameter	LA	WLA	MOS	TMDL	Units
(WV-KL-63-E-1)	Sediment	Total Iron	4.18	0.82	5.26	5.26	lbs/day
Gallatin Branch (WV-KL-64)	Organic Enrichment	Fecal Coliform	6.91E+09	NA	3.64E+08	7.27E+09	counts/ day
	Sediment	Total Iron	4.10	0.71	5.06	5.06	lbs/day
Davis Creek (WV-KL-74)	Organic Enrichment	Fecal Coliform	1.71E+11	7.03E+10	1.27E+10	2.54E+11	counts/ day
	Sediment	Total Iron	142.63	79.32	233.63	233.63	lbs/day
Trace Fork (WV-KL-74-C)	Organic Enrichment	Fecal Coliform	3.62E+10	1.32E+10	2.60E+09	5.20E+10	counts/ day
	Sediment	Total Iron	28.24	13.02	43.43	43.43	lbs/day
Rays Branch (WV-KL-74-G)	Organic Enrichment	Fecal Coliform	3.14E+09	1.13E+10	7.59E+08	1.52E+10	counts/ day
	Sediment	Total Iron	2.00	10.12	12.76	12.76	lbs/day
Coal Hollow (WV-KL-74-L)	Organic Enrichment	Fecal Coliform	2.04E+09	6.65E+09	4.57E+08	9.15E+09	counts/ day
	Sediment	Total Iron	0.77	3.32	4.31	4.31	lbs/day
Cane Fork (WV-KL-74-N)	Organic Enrichment	Fecal Coliform	1.73E+10	1.81E+07	9.13E+08	1.83E+10	counts/ day
Joplin Branch (WV-KL-77)	Organic Enrichment	Fecal Coliform	3.42E+06	1.79E+10	9.40E+08	1.88E+10	counts/ day
	Sediment	Total Iron	0.09	7.72	8.21	8.21	lbs/day
	Ionic Stress	Ionic Strength to remain on the 303(d) list					

NA = not applicable; UNT = unnamed tributary; RM = river mile

“Scientific notation” is a method of writing or displaying numbers in terms of a decimal number between 1 and 10 multiplied by a power of 10. The scientific notation of 10,492, for example, is 1.0492 × 104.

12.0 FUTURE GROWTH

12.1 Iron and Aluminum

With the exception of allowances provided for Construction Stormwater General Permit registrations discussed below, this TMDL does not include specific future growth allocations for iron or aluminum. However, the absence of specific future growth allocations does not prohibit the permitting of new or expanded activities in the watersheds of streams for which metals TMDLs have been developed. Pursuant to 40 CFR 122.44(d)(1)(vii)(B), effluent limits must be "consistent with the assumptions and requirements of any available wasteload allocation for the discharge...." In addition, the federal regulations generally prohibit issuance of a permit to a new discharger "if the discharge from its construction or operation will cause or contribute to the violation of water quality standards." A discharge permit for a new discharger could be issued under the following scenarios:

- A new facility could be permitted anywhere in the watershed, provided that effluent limitations are based on the achievement of water quality standards at end-of-pipe for the pollutants of concern in the TMDL.

- NPDES permitting rules mandate effluent limitations for metals to be prescribed in the total recoverable form. West Virginia water quality criteria for iron are in total recoverable form and may be directly implemented. Because aluminum water quality criteria are in dissolved form, a dissolved/total pollutant translator is needed to determine effluent limitations. A new facility could be permitted in the watersheds of dissolved aluminum impaired streams, provided that total aluminum effluent limitations are based on the dissolved aluminum, acute, aquatic life protection criterion and a dissolved/total aluminum translator equal to 1.0. As described previously, the alternative precipitation provisions of 40 CFR 434 that suspend applicability of TSS limitations cannot be applied to new discharges in iron TMDL watersheds.

- Remining (under an NPDES permit) could occur without a specific allocation to the new permittee, provided that the requirements of existing State remining regulations are met. Remining activities will not worsen water quality and in some instances may result in improved water quality in abandoned mining areas.

- Reclamation and release of existing permits could provide an opportunity for future growth provided that permit release is conditioned on achieving discharge quality better than the WLA prescribed by the TMDL.

- Most traditional, non-mining point source discharges are assigned technology-based TSS effluent limitations that would not cause biological impairment. For example, NPDES permits for sewage treatment and industrial manufacturing facilities contain monthly average TSS effluent limitations between 30 and 100 mg/L. New point sources may be permitted in the watersheds of biologically impaired streams for which sedimentation has been identified as a significant stressor with the implementation of applicable technology based TSS requirements. If iron or aluminum is identified as a pollutant of concern in a process wastewater discharge from a new, non-mining activity, then the discharge can be permitted if effluent limitations are based on the achievement of water quality standards at end-of-pipe for the pollutants of concern.

- Subwatershed-specific future growth allowances have been provided for site registrations under the Construction Stormwater General Permit. In general, the successful TMDL allocation provides 1.5 or 2.5 percent of modeled subwatershed area to be registered under the general permit at any point in time. Furthermore, the iron allocation spreadsheet provides a cumulative area allowance for the immediate subwatershed and all upstream contributing subwatersheds. Projects in excess of the acreage provided for the immediate subwatershed may also be registered under the general permit, provided that the total registered disturbed area in the immediate subwatershed and all upstream subwatersheds is less than the cumulative area provided. Furthermore, larger projects may be permitted in phases that adhere to the area allowances or by implementing controls beyond those afforded by the general permit. Larger areas may be permitted if it can be demonstrated that more stringent controls will result in a loading condition commensurate with that afforded by the management practices associated with the general permit.

WVDEP does not have regulatory authority to control of nonpoint sediment sources of iron, but new activities with potential water quality impacts are likely to occur. The detailed assessments performed in this project provide insight into the maximum percentage of watershed area that may be disturbed while maintaining compliance with the warmwater fishery total iron criterion. This additional information is provided to guide implementing entities with an ability to control new sources/concurrent disturbance and water quality standard attainment goals.

As described in **Section 10.2.2** three iron/sediment relationships were developed and applied across the Lower Kanawha watershed. The water quality impact associated with land disturbance will vary with the iron content of soils. **Table 12-1** displays disturbance information for each iron/sediment relationship. The relationship category applied to all modeled subwatershed is provided in Technical Report Appendix C and this information is also displayed graphically in the GIS project.

Table 12-1. Iron sediment relationships and maximum land disturbance targets

Slope Group	Fe/TSS Slope	Allowed percent landuse disturbance (100mg/L TSS)
1	0.024	32
2	0.035	19
3	0.045	13

This assessment is a simplistic evaluation of upland disturbance in the absence of non-sediment sources of iron and degraded stream bank influences. The Table 12-1 results reflect the water quality impact if all land disturbances were managed with practices achieving a 100 mg/l TSS benchmark. Water quality may be negatively affected with upland disturbance less than the displayed values if additional iron sources (upland or instream) are present, or if less than 100% nonpoint source control is attained. As such, the results should be considered to be the upper limits of managed disturbance above which criterion nonattainment is likely.

12.2 Fecal Coliform Bacteria

Specific fecal coliform bacteria future growth allocations are not prescribed. The absence of specific future growth allocations does not prohibit new development in the watersheds of streams for which fecal coliform bacteria TMDLs have been developed, or preclude the permitting of new sewage treatment facilities.

In many cases, the implementation of the TMDLs will consist of providing public sewer service to unsewered areas. The NPDES permitting procedures for sewage treatment facilities include technology-based fecal coliform effluent limitations that are more stringent than applicable water quality criteria. Therefore, a new sewage treatment facility may be permitted anywhere in the watershed, provided that the permit includes monthly geometric mean and maximum daily fecal coliform limitations of 200 counts/100 mL and 400 counts/100 mL, respectively. Furthermore, WVDEP will not authorize construction of combined collection systems nor permit overflows from newly constructed collection systems.

13.0 PUBLIC PARTICIPATION

13.1 Public Meetings

Informational public meetings were held on May 29, 2007 and October 26, 2010 at the Winfield High School. The May 29, 2007 meeting occurred prior to pre-TMDL stream monitoring and pollutant source tracking and included a general TMDL overview and a presentation of planned monitoring and data gathering activities. The October 26, 2010 meeting occurred prior to allocation of pollutant loads and provided a description of the status of TMDL development. A public meeting will be held to present the draft TMDLs on September 28, 2011at the Winfield High School. The meeting will begin at 6:00 PM. and will provide information to stakeholders intended to facilitate comments on the draft TMDLs.

13.2 Public Notice and Public Comment Period

The availability of draft TMDLs was advertised in various local newspapers between September 12, 2011 and September 15, 2011. Interested parties were invited to submit comments during the public comment period, which began on September 12, 2011 and ended on October 14, 2011. The electronic documents were also posted on the WVDEP’s internet site at www.dep.wv.gov/tmdl

13.3 Response Summary

The West Virginia Department of Environmental Protection received written comments on the draft TMDLs from the Charleston Sanitary Board. Comments have been compiled and responded to in this response summary. Comments and comment summaries are in boldface and italic. Agency responses appear in plain text.

The commenter contended that the TMDL wasteload allocations for CSOs and MS4s have the potential to have devastating financial ramifications for the City of Charleston and that the TMDLs may undermine unprecedented investments and years of planning relative to CSO control.

CSO and MS4 controls require significant financial expenditures, but the TMDLs do not increase costs or undermine past investments. CSO wasteload allocations accurately reflect discharge requirements necessary to attain currently effective water quality standards. The TMDLs also include a description of implementation expectations that recognize the National CSO Control Policy. The TMDLs do not drive higher prioritization of controls on the subject CSOs, nor do they disallow extended compliance schedules or the pursuit of warranted water quality standard modifications.

The MS4 wasteload allocations provide appropriate targets for BMP implementation under the MS4 general NPDES permit. The pollutant reductions necessary to achieve MS4 wasteload allocations are not so large as to indicate that BMP implementation would not be successful.

The commenter contended that the TMDL is inconsistent with the National CSO Policy and that WVDEP did not fully consider the policy when developing the TMDLs. Specifically, the commenter indicated that wasteload allocations that require CSO elimination or the attainment of water quality criteria "end-of-pipe" are inconsistent with the National CSO Policy.

In simple terms, the TMDLs allow progressive CSO control to occur in accordance with the principles of the National CSO Policy and the wasteload allocations define the endpoints at which discharges will not cause or contribute to violations of currently effective water quality standards.

In order to be approvable, TMDLs must prescribe allocations that result in the attainment of currently effective water quality standards. The currently effective fecal coliform water quality criteria are applicable to water contact recreation (both primary and secondary contact) and public water supply designated uses. Those designated uses are applicable to the streams affected by CSO wasteload allocations. The criteria are applicable year round and no wet weather exemptions are afforded.

47CSR 2-5.2.c. states:

> Concentrations of pollutants which exceed the criteria for the protection of human health set forth in Appendix E, Table 1 shall not be allowed at any point unless a mixing zone

has been assigned by the Secretary after consultation with the Commissioner of the West Virginia Bureau for Public Health.

USEPA guidance clearly indicates that mixing zones are not appropriate for bacteria. Given those constraints, the wasteload allocations prescribed for CSOs are precisely what is necessary to attain currently effective West Virginia Water Quality Standards.

It is true that the National CSO Policy identifies a "presumptive approach" for Long Term Control Plan development. But supporting guidance for the policy indicates that the presumptive approach is only appropriate when the level of control needed to achieve water quality standards is unclear and when no information suggests that the approach will not allow achievement of water quality standards. Information used to develop the wasteload allocations suggests that the "85% reduction" endpoint proposed by the commenter will not achieve currently effective standards. It is also important to note that final long-term control plan resolution requires confirmation of water quality standard compliance.

The commenter contended that, with regard to fecal coliform bacteria, designated uses cannot be attained and that a Use Attainability Analysis needs to be undertaken "to determine the appropriate designated uses and relevant water quality standards for these waters". Additional comments suggest that the National CSO Policy creates a federal obligation for the State of West Virginia to pursue such water quality standard modifications.

The WVDEP does not possess the necessary information to support water quality standard modifications for the streams affected by CSO discharges, nor does it have a duty or obligation to pursue them on behalf of the City of Charleston. West Virginia examples exist where POTWs have eliminated CSOs and where they have provided treatment to achieve bacteria limits commensurate with the wasteload allocations. Charleston is best suited to document its ability or inability to implement controls necessary to achieve standards. To the extent that it can document conditions that warrant standard modifications, it may pursue them through established processes. Execution of water quality standard modifications can only be obtained through cooperative efforts of the permittee, the WVDEP and the Environmental Protection Agency. WVDEP will fully cooperate and fairly evaluate requests for water quality standard modifications received from affected entities and propose warranted modifications to the West Virginia Legislature and USEPA for approval.

The commenter suggested that the TMDL reports be revised to expressly state that the TMDLs may be revised based upon a UAA at any time in the future, and recognize that TMDLs may need to be revised if West Virginia changes its bacteria indicator from fecal coliform to e.coli.

The requested statement was already included in the Draft TMDL report (**Section 2.2, page 4**) and has been retained.

The commenter stated that the TMDL report should state: "…the final TMDLs and associated wasteload allocations shall not trump, contradict or supersede the approval of a CSO Long Term Control Plan (LTCPs) or the National CSO Policy"

The requested statement has not been added because it is ambiguous. The implementation language of Section 14.1 clarifies agency expectations regarding implementation of the CSO wasteload allocations. Although the wasteload allocations prescribed for CSOs are necessary to achieve currently effective water quality standards, the TMDLs are not to be construed to supersede the prioritization and scheduling of CSO controls pursuant to the national CSO program. Nor are the TMDLs intended to prohibit the pursuit of the water quality standard revisions envisioned in the national policy.

The commenter stated that the TMDL report should state "the TMDL does not preclude the approval of a CSO LTCP that does not call for loadings consistent with the proposed CSO allocations in the TMDLs as long as the approved LTCP calls for a Use Attainability ("UAA") within the LTCP implementation period.

The requested statement has not been added because an alternative LTCP endpoint would not be appropriate until approval of water quality standard modification is secured. Both TMDL reports state that the TMDLs do not prohibit the pursuit of water quality standard modifications envisioned by the national policy, and that approved revisions may be cause for TMDL modification.

The commenter contended that the TMDL targets the majority of fecal coliform reduction to CSO and MS4 wet weather sources and that the dry weather impacts from absent or inadequate on-site sewage treatment facilities were ignored.

The contention is inaccurate. The fecal coliform loadings from failing or nonexistent onsite sewage treatment systems were accounted for in the baseline condition and reduced (100%) in the TMDL scenario, throughout the watershed. No reductions were specified for home aeration units because those facilities operate under an NPDES permit with effluent limitations that are protective of criteria. Allocation methodology is described in **Section 10.7.3** above and **Section 5.3.1** of the Technical Report. Reductions to on-site systems are evidenced in the load allocation tab of the fecal coliform spreadsheet. Fecal coliform modeling indicates that baseline loadings result in criteria exceedances during both low and high flow conditions and the prescribed wasteload and load allocations appropriately target the problematic sources for both conditions.

The commenter incorrectly presumed that illegal discharges from failing septic systems and straight pipes were not represented in the fecal coliform model and therefore questioned the validity of the TMDLs.

In the baseline scenario model run, failing septic flow is incorporated into the model as a constant, low-flow point source. In the allocated scenario model run, loadings from failing septic systems are reduced 100%. This allocation scenario assumes that during TMDL implementation, failing septic systems will either be repaired or replaced so they function properly, or that future centralized system extensions will assimilate failing on-site systems. The baseline scenario recognizes the bacteria loading associated with failing septic systems.

The commenter suggested prescription of CSO wasteload allocations in annual average loading terms.

This suggestion was not implemented because such an approach would not ensure attainment of currently effective water quality standards.

The commenter stated that the baseline representation of CSO fecal coliform quality (100,000 counts / 100ml) grossly over-represents their loading and that an "event mean concentration" should have been used.

During model set-up, WVDEP and its contractors consulted the commenter to seek available information and guidance for representation of CSOs. Local information concerning the drainage area contributing to each outlet and the approximate frequency of overflows per year was provided and used. The commenter did not provide CSO fecal coliform discharge quality information. The use of literature values was therefore mandated.

TMDL modeling for CSB CSOs used 100,000 counts per 100ml fecal coliform as an average concentration applied to all modeled CSO overflows. This concentration was conservatively selected from the low end of a range of literature values for fecal coliform concentrations in raw CSO effluent. Examples from CSO literature are cited below:

- The USEPA's 2004 Report To Congress concerning CSOs reported that out of 603 CSO samples reported in literature, fecal coliform concentrations ranged from 3 to 40,000,000 counts per 100 ml, with a median value of 215,000 counts per 100 ml.[1]
- In a study published by the U.S. Geological Survey, mean concentrations of fecal coliforms sampled from Cuyahoga River combined-sewer-overflow effluent at Independence, Ohio in May and June 1995 were distributed across a range of 2,000 to 4,000,000 counts per 100 ml, with many observations falling between 50,000 and 150,000 counts per 100 ml (Francy, et al. 1996).[2]
- The book, Management of Combined Sewer Overflows, edited by Richard Field, Daniel Sullivan, and Anthony N. Tafuri, describes typical CSO effluents as having fecal coliform concentrations between 100,000 and 10,000,000 counts per 100ml.[3]
- A study to compare treatment options at a CSO storage facility in New York City reported untreated CSO effluent fecal coliform concentrations between 1,000,000 and 10,000,000 counts per 100 ml.[4]

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[1] United States Environmental Protection Agency (USEPA). 2004. Office of Water. *Report to Congress—Impacts and Control of CSOs and SSOs*. EPA 833-R-04-00

[2] Francy, Donna S., Teresa L. Hart, and Cathy M. Virosteck. 1996. *Effects of Receiving-Water Quality and Wastewater Treatment on Injury, Survival, and Regrowth of Fecal-Indicator Bacteria and Implications for Assessment of Recreational Water Quality*. U.S. Geological Survey Water-Resources Investigations Report 96-4199.

[3] Field, Richard, Daniel Sullivan, and Anthony N. Tafuri. 2004. *Management of Combined Sewer Overflows*. CRC Press, LLC, Boca Raton, Florida.

[4] Wojtenko, Izabela, and Mary Stinson. 2003. *CSO Disinfection Pilot Study: Spring Creek CSO Storage Facility Upgrade*. U.S. Environmental Protection Agency, Urban Watershed Management Branch, Edison, NJ. EPA/600/R-02/077.

The commenter stated that WVDEP should have prescribed a 400 counts/100ml wasteload allocation for CSOs instead of the 200 counts/100ml.

The establishment of wasteload allocations equal to the value of the monthly geometric mean component of the applicable criteria was selected as the most reasonable means to implement 47CSR 2-5.2.c.

The commenter questioned the adequacy of model hydrology calibration because a suitable USGS flow gauging station is not present in the Lower Kanawha watershed.

Although an appropriate USGS gage station was not available for hydrology calibration in the Lower Kanawha watershed, a reference watershed approach using hydrologic model parameters from the nearby and hydrologically similar Elk River. This reference approach has been used to calibrate hydrology in MDAS models used to develop past USEPA-approved TMDLs in West Virginia, including Camp Creek of East Fork Twelvepole Creek, and Copen Run of Little Kanawha River. In addition, model output for Lower Kanawha tributaries was compared to flow measurements collected during pre-TMDL stream monitoring to verify model performance.

The commenter questioned the adequacy of fecal coliform water quality calibration, stating that the only data available for calibration was a storm event monitoring of Shrewsbury Hollow.

Storm sampling in Shrewsbury Hollow was performed to better understand fecal coliform loading rates from undisturbed forest landuse. This sampling event is presented as one example of a field investigation, and was not the only model calibration effort undertaken by WVDEP. WVDEP’s pre-TMDL monitoring dataset provided a comprehensive dataset available for MDAS model calibration. It included monthly monitoring at hundreds of sites over a range of weather and stream flow conditions. The monitoring plan included stations in both impaired and unimpaired streams/stream segments and segments draining various landuses. Used in conjunction, WVDEP’s source tracking and characterization work and pre-TMDL stream monitoring provide a sound basis for calibration and source representation.

The commenter also questioned the sufficiency of the fecal coliform dataset water quality calibration in light of the 30-day exposure duration component of the water quality criteria.

The goal of the modeling calibration was to determine a set of parameters to best describe the hydrologic and water quality processes in the Lower Kanawha and Elk River watersheds. The calibration process objective is to adequately replicate the hydrologic processes occurring in the watershed and streams. The modeling process utilized hourly precipitation data from Charleston Yeager Airport to simulate these processes on an hourly time step. Daily average model output was directly compared with the pre-TMDL monitoring data to assess that the model is simulating low flow, mean flow, and storm peaks within observed ranges. The daily outputs of the calibrated model can then be compared to both the daily and monthly components of the criteria.

Analysis of the available in-stream water quality data from all monitoring stations was performed to establish low-flow, high-flow and seasonal trends. Background values were established by using data from the Shrewsbury Hollow study mentioned above. Graphical results of model performance were evaluated at many different locations throughout the watersheds following each water quality simulation. Model parameters were further adjusted following iterations to improve model performance.

Looking at a time series plot of modeled versus observed data provides insight into the nature of the system. Trends in the observed data and cause-effect relationships between various parameters can be replicated with a model, although precise values at each and every point in time may not be. As long as the trends, relationships, and magnitudes are well-represented, and thus the underlying physics and kinetics are also being represented, a model is successful and can be used for simulating management alternatives.

The commenter stated that MS4 wasteload allocations should be qualified with the "maximum extent practical" standard in Clean Water Act Section 402(p).

This statement was not included in the final report because technology-based requirements for point sources do not necessarily constrain TMDL wasteload allocations.

14.0 REASONABLE ASSURANCE

Reasonable assurance for maintenance and improvement of water quality in the affected watershed rests primarily with two programs. The NPDES permitting program is implemented by WVDEP to control point source discharges. The West Virginia Watershed Network is a cooperative nonpoint source control effort involving many state and federal agencies, whose task is protection and/or restoration of water quality.

14.1 NPDES Permitting

WVDEP's Division of Water and Waste Management (DWWM) is responsible for issuing non-mining NPDES permits within the State. WVDEP's Division of Mining and Reclamation (DMR) develops NPDES permits for mining activities. As part of the permit review process, permit writers have the responsibility to incorporate the required TMDL WLAs into new or reissued permits. New facilities will be permitted in accordance with future growth provisions described in **Section 12**.

Both the permitting and TMDL development processes have been synchronized with the Watershed Management Framework cycle, such that TMDLs are completed just before the permit expiration/reissuance time frames. Permits for existing nonmining facilities in the Lower Kanawha River watershed will be reissued beginning in July 2011 and the reissuance of mining permits will begin January 1, 2012.

The MS4 permitting program is being implemented to address stormwater impacts from urbanized areas. West Virginia has developed a General NPDES Permit for MS4 discharges (WV0110625). The cities of Charleston, South Charleston, Nitro, Hurricane, as well as the WVDOH are registered under the permit. The permit is based upon national guidance and is non-traditional in that it does not contain numeric effluent limitations, but instead proposes Best Management Practices that must be implemented. The MS4 permit is being reissued and in their application for registration under the reissued permit, MS4 entities must specifically describe management practices intended for implementation that will achieve the wasteload allocations prescribed in applicable TMDLs. A mechanism to assess the effectiveness of the BMPs in achieving the wasteload allocations must also be provided. The TMDLs are not intended to mandate imposition of numerical effluent limitations and/or discharge monitoring requirements for MS4s. Reasonable alternative methodologies may be employed for targeting and assessing BMP effectiveness in relation to prescribed wasteload allocations. The "MS4 WLA Detailed" tabs on the allocation spreadsheets wasteload allocations provide drainage areas of various landuse types represented in the baseline condition (without BMPs) for each MS4 entity at the subwatershed scale. Through consideration of anticipated removal efficiencies of selected BMPs and their areas of application, it is anticipated that this information will allow MS4 permittees to make meaningful predictions of performance under the permit.

DWWM also implements a program to control discharges from CSOs. Specified fecal coliform wasteload allocations for CSOs will be implemented in accordance with the provisions of the national Combined Sewer Overflow Control Policy and the state Combined Sewer Overflow Strategy. Those programs recognize that comprehensive CSO control may require significant resources and an extended period of time to accomplish. The wasteload allocations prescribed for CSOs are necessary to achieve current fecal coliform water quality criteria. However, the TMDL should not be construed to supersede the prioritization and scheduling of CSO controls and actions pursuant to the national CSO program. Nor are the TMDLs intended to prohibit the pursuit of the water quality standard revisions envisioned in the national policy. TMDLs may be modified to properly implement future water quality standard revisions (designated use and/or criteria), if enacted and approved by the USEPA.

14.2 Watershed Management Framework Process

The Watershed Management Framework is a tool used to identify priority watersheds and coordinate efforts of state and federal agencies with the goal of developing and implementing watershed management strategies through a cooperative, long-range planning effort.

The West Virginia Watershed Network is an informal association of state and federal agencies, and nonprofit organizations interested in the watershed movement in West Virginia. Membership is voluntary and everyone is invited to participate. The Network uses the Framework to coordinate existing programs, local watershed associations, and limited resources. This coordination leads to the development of Watershed Based Plans to implement TMDLs and document environmental results.

The principal area of focus of watershed management through the Framework process is correcting problems related to nonpoint source pollution. Network partners have placed a greater emphasis on identification and correction of nonpoint source pollution. The combined resources of the partners are used to address all different types of nonpoint source pollution through both public education and on-the-ground projects.

Among other things, the Framework includes a management schedule for integration and implementation of TMDLs. In 2000, the schedule for TMDL development under Section 303(d) was merged with the Framework process. The Framework identifies a six-step process for developing integrated management strategies and action plans for achieving the state's water quality goals. Step 3 of that process includes “identifying point source and/or nonpoint source management strategies - or Total Maximum Daily Loads - predicted to best meet the needed [pollutant] reduction.” Following development of the TMDL, Steps 5 and 6 provide for preparation, finalization, and implementation of a Watershed Based Plan to improve water quality.

Each year, the Framework is included on the agenda of the Network to evaluate the restoration potential of watersheds within a certain Hydrologic Group. This evaluation includes a review of TMDL recommendations for the watersheds under consideration. Development of Watershed Based Plans is based on the efforts of local project teams. These teams are composed of Network members and stakeholders having interest in or residing in the watershed. Team formation is based on the type of impairment(s) occurring or protection(s) needed within the watershed. In addition, teams have the ability to use the TMDL recommendations to help plan future activities. Additional information regarding upcoming Network activities can be obtained from the Western Nonpoint Source Program Basin Coordinator, Dustin Johnson (Dustin.c.Johnson@wv.gov).

The Davis Creek Watershed Association, Inc. and the Tyler Mountain Community Association are the only active watershed associations in the Lower Kanawha River watershed. For additional information concerning the associations, contact the above mentioned Basin Coordinator.

14.3 Public Sewer Projects

Within WVDEP DWWM, the Engineering and Permitting Branch’s Engineering Section is charged with the responsibility of evaluating sewer projects and providing funding, where available, for those projects. All municipal wastewater loans issued through the State Revolving Fund (SRF) program are subject to a detailed engineering review of the engineering report, design report, construction plans, specifications, and bidding documents. The staff performs periodic on-site inspections during construction to ascertain the progress of the project and compliance with the plans and specifications. Where the community does not use SRF funds to undertake a project, the staff still performs engineering reviews for the agency on all POTWs prior to permit issuance or modification. For further information on upcoming projects, a list of funded and pending water and wastewater projects in West Virginia can be found at http://www.wvinfrastructure.com/projects/index.php.

14.4 AML Projects

Within WVDEP, the Office of Abandoned Mine Lands and Reclamation (AML&R) manages the reclamation of lands and waters affected by mining prior to the passage of the Surface Mining Control and Reclamation Act (SMCRA) in 1977. Title IV of the act addresses adverse impacts associated with abandoned mine lands. Funding for reclamation activities is derived from fees placed on coal mined which are placed in a fund and annually distributed to state and tribal agencies.

Various abandoned mine land reclamation activities are addressed by the program as necessary to protect public health, safety, and property from past coal mining and to enhance the environment through the reclamation and restoration of land and water resources. Portions of the annual grant are also used to repair or replace drinking water supplies that were substantially damaged by pre-SMCRA coal mining and to administer the program.

In December 2006, Congress passed legislation amending SMCRA and the Title IV program and in November 2008, the Office of Surface Mining finalized rules to implement the amendments. After an initial ramp-up period, AML&R will realize significant increases in its annual reclamation funding and the flexibility to direct a larger portion of those funds to address water resource impacts from abandoned mine drainage (AMD).

Title IV now contains a “30% AMD set-aside” provision that allows a state to use up to 30% of its annual grant to address AMD problems. In determining the amount of money to set-aside, AML&R must balance its multiple areas of responsibility under the program and ensure that funding is available for perpetual operation and maintenance of treatment facilities. In regard to water resource impacts, project prioritization will consider treatment practicability and sustainability and will be accomplished under a methodology that provides for the efficient application of funds to maximize restoration of fisheries across AML impacted areas of the State.

15.0 MONITORING PLAN

The following monitoring activities are recommended:

15.1 NPDES Compliance

WVDEP’s DWWM and DMR have the responsibility to ensure that NPDES permits contain effluent limitations as prescribed by the TMDL WLAs and to assess and compel compliance. Permits will contain self-monitoring and reporting requirements that are periodically reviewed by WVDEP. WVDEP also inspects treatment facilities and independently monitors NPDES discharges. The combination of these efforts will ensure implementation of the TMDL WLAs.

15.2 Nonpoint Source Project Monitoring

All nonpoint source restoration projects should include a monitoring component specifically designed to document resultant local improvements in water quality. These data may also be used to predict expected pollutant reductions from similar future projects.

15.3 TMDL Effectiveness Monitoring

TMDL effectiveness monitoring should be performed to document water quality improvements after significant implementation activity has occurred where little change in water quality would otherwise be expected. Full TMDL implementation will take significant time and resources, particularly with respect to the abatement of nonpoint source impacts. WVDEP will continue monitoring on the rotating basin cycle and will include a specific TMDL effectiveness component in waters where significant TMDL implementation has occurred.

16.0 REFERENCES

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