Metals and pH TMDLs for the Monongahela River Watershed, West Virginia

U.S. Environmental Protection Agency
Region 3
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1.0 Problem Understanding

The Clean Water Act at Section 303(d) and its implementing regulations (Water Quality and Planning and Management Regulations at 40 CFR 130) require a Total Maximum Daily Load (TMDL) to be developed for those waterbodies identified as impaired by the state where technology-based and other required controls did not provide for the attainment of water quality standards. As part of the consent decree requirements relating to *Ohio Valley Environmental Coalition, Inc., et al.* v. *Carol Browner, et al., No. 2:95-0529 (S.D. W.VA.)* entered on July 9, 1997, TMDLs will be completed by the U.S. Environmental Protection Agency for the waters included on West Virginia's 1996 and 1998 Section 303(d) lists of impaired waterbodies. The consent decree resulting from this lawsuit also sets out a 10-year schedule for establishing TMDLs for certain portions of the Ohio River, including a TMDL for dioxin; 44 other "priority" water quality limited segments (WQLSs); and about 500 WQLSs impaired by abandoned mine drainage. The objective of this study was to develop TMDLs for waterbodies impaired by abandoned mine drainage in the West Fork watershed, West Virginia.

1.1 Watershed Description

The Monongahela River is located in north central West Virginia and the mainstem of the Monongahela River is formed by the confluence of the Tygart Valley and West Fork rivers at Fairmont, West Virginia (Figure 1-1). The mainstem flows north for 37 miles in West Virginia before it enters Pennsylvania and eventually joins the Allegheny River at Pittsburgh, Pennsylvania. The river drains approximately 465 square miles (297,599 acres) and drains the Monongahela River watershed as shown in Figure 1-2. The watershed covers most of Monongalia and Marion counties and smaller portions of Preston and Taylor counties. Major tributaries that enter the mainstem in West Virginia are Buffalo Creek and Deckers Creek. The flow of the Monongahela mainstem is regulated by four lock and dam structures at Opekiska, Hildebrande, Point Marion, and Morgantown. These structures were constructed primarily for navigation, however in recent years, navigation activities are very limited (WVDEP, 2001).

The watershed is dominated by forest and agricultural lands. Common industrial practices include coal mining, natural gas production, glass, brick and tile manufacturing, recreational development, and agricultural activities (WVDEP, 1985). Counties in the watershed contain active surface and deep mining operations and many of the coal fields in the watershed contain abandoned coal mines. The population of the watershed is distributed throughout small towns and rural unincorporated communities. The largest communities in the watershed are Morgantown and Fairmont. Population estimates, based on 2000 census data, for Morgantown, Fairmont and the counties located in and near the basin are given in Table 1-1. Note that only portions of these counties lie within the Monongahela watershed. Since 1990, the entire region has seen an increase in population (Table 1-1).

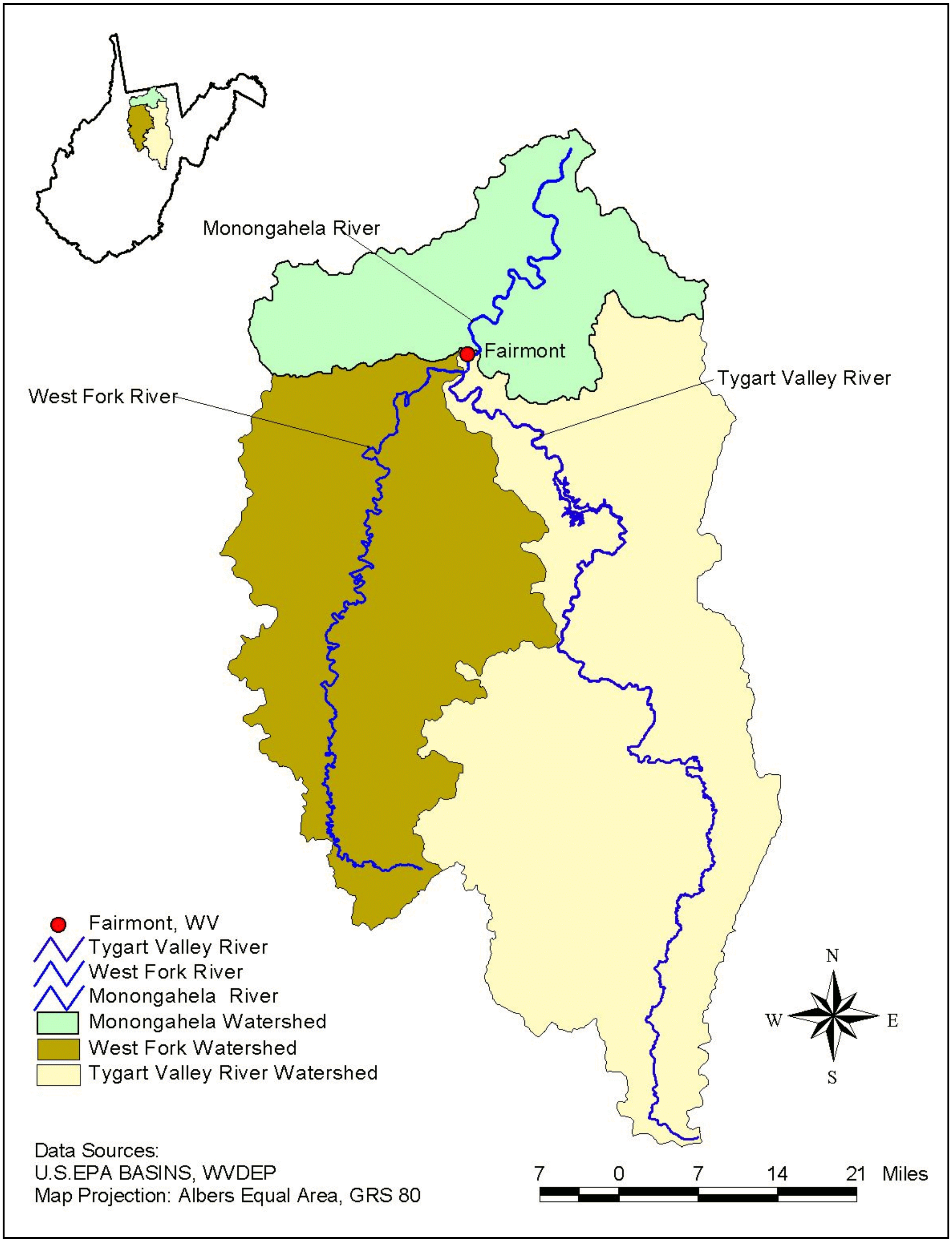


Figure 1-1. Monongahela River, West Fork River, Tygart Valley River and their respective watersheds

Figure 2 Location of the Monongahela River Watershed

Table 1-1. Population Estimates in the Monongahela watershed

County	1990 Population Estimate	2000 Population Estimate	1990-2000 Numeric Population Change	1990-2000 Percent Population Change
West Virginia	1,793,477	1,808,344	14,867	0.8
Marion	57,249	56,598	-651	-1.1
Monongalia	77,006	81,866	4,860	5.9
Taylor	15,144	16,089	945	6.2
Total	**149,399**	**154,553**	**5,154**	**3.3**
Morgantown	28,272	26,809	-1,463	-5.5
Fairmont	21,667	19,097	2,570	-13.5

Source: Population Estimates Program, Population Division, U.S. Census Bureau, Washington, DC.

1.2 Economy

Mining

Historically, coal mining has represented the most economically valuable mineral resource in the Monongahela watershed. The basin lies in the northern coalfields of West Virginia, where coal has been mined extensively since the1800s. The Pittsburgh coal seam lies in the central portion of the watershed, while the Upper Kittanning and Upper Freeport coal seams are found in the eastern areas. The coal deposits in this region contain large amounts of pyrite which, coupled with the large extent of historical mining, has caused widespread acid mine drainage throughout the Monongahela watershed. Other raw materials produced in the area include oil and gas production, sandstone, shale, limestone, and gravel.

Coal production in this region began after the Civil War, when the industry spread into new localities, and by 1880 there were extensive operations in Monongalia and Marion counties (WVGES, 1999). Extensive mining continued in this region through World War II until 1970's. when coal production declined (WVDEP, 2002). Recent mining has been limited to the Upper Freeport coal seam and constitutes only a small portion (approximately 7%) of the total production for the entire state. Table 1-2 presents the total amount of coal produced in 2000.

Table 1-2. Total coal production in West Virginia for 2000

County	Total Employees	Underground Production (tons)	Surface Production (tons)	Total Production (tons)
West Virginia	14,254	109,395,146	59,975,456	169,371,450
Marion	87	6,000	6,717	12,717
Monongalia	1,130	10,804,385	1,040,218	11,844,603
Total	**1,217**	**10,810,385**	**1,046,935**	**11,857,320**

West Virginia Office of Miners' Health Safety and Training, 2002

Forestry

Forestry is another major industry in the Monongahela watershed. According to the U.S. Forest Service Forest Inventory and Analysis Database Retrieval System, more than 400 square miles of forest land (approximately 256, 000 acres) in the three counties in and around the Monongahela watershed. Nearly all of those acres are held under corporate (timber industry) ownership. Table 1-3 shows the estimated area of forested land (in square miles) for each of the counties in or adjacent to the Monongahela watershed.

Table 1-3. Forested area in and near the Monongahela

County	All_land (sq. Mi.)	Total Forest (sq. Mi.)	Timberland (sq. Mi.)	Nonforest_land (sq. Mi.)
Marion	310	212	212	97
Monongalia	148	97	97	52
Taylor	187	115	109	72
Total	**645**	**425**	**419**	**221**

Source: U.S. Forest Service, 1996

Agriculture

Agriculture is also very important part of the economy in the Monongahela watershed. Farming activities have increased slightly (approximately 2.7%) from 1987 to 1997 with the total number of farms in the counties in and around the Monongahala watershed increasing from 997 to 1,025 (Table 1-4). Farms in this region are generally 120 to 160 acres in size and comprise approximately 20% of the landuse area in the Monongahela watershed.

Table 1-4. Agricultural activities in and near the Monongahela watershed

	1997			1987		
County	Farms (number)	Land in Farms (acres)	Land in Farms-average size of farm (acres)	Farms (number)	Land in Farms (acres)	Land in Farms-average size of farm (acres)
Marion	317	39,350	124	362	41,548	115
Monongalia	430	58,074	135	390	52,964	136
Taylor	278	43,697	157	245	41,826	171
Total	**1,025**	**141,121**	**(Average 139)**	**997**	**136,338**	**141**

Census of Agriculture, 1997. U.S. Department of Agriculture

1.3 Section 303(d) Listed Waterbodies

Thirty-nine waterbodies in the Monongahela watershed have been included on West Virginia's 1996 and 1998 Section 303(d) list due to metals and/or pH impairments (Table 1-5). These listed waterbodies include the main stem of the Monongahela River and 38 additional stream segments in the watershed. The pH and metals impairments, which have been defined by WVDEP to include total iron, aluminum, and manganese, have been attributed to acid mine drainage (AMD), and other point and nonpoint sources.

AMD occurs when surface and subsurface water percolates through coal bearing minerals containing high concentrations of pyrite and marcasite, which are crystalline forms of iron sulfide (FeS_2). It is these chemical reactions of the pyrite which generate acidity in water. A synopsis of these reaction are as follows: Exposure of pyrite to air and water causes the oxidation of pyrite. The sulfur component of pyrite is oxidized releasing dissolved ferrous (Fe^{2+}) ions and also hydrogen (H^+) ions. It is these H^+ ions which cause the acidity. The intermediate reaction with the dissolved Fe^{2+} ions generates a precipitate, ferric hydroxide [$Fe(OH)_3$], and also releases more H^+ ions, thereby causing more acidity. Another reaction is one between the pyrite and generated ferric (Fe^{3+}) ions, in which more acidity (H^+) is released as well as Fe^{2+} ions, which then can enter the reaction cycle (Stumm and Morgan, 1996).

This report presents TMDLs for each of the 39 impaired waterbodies in the Monongahela watershed. In order to develop the TMDLs the watershed was divided into 12 regions (Figure 1-3). These regions represent hydrologic units. Each region was further divided into subwatersheds, 210 total for the entire Monongahela River watershed, for modeling purposes. The 12 regions and their respective subwatersheds provide a good basis for georeferencing pertinent source information, monitoring data, and presenting TMDLs. This information is presented in Appendices A-1 through A-12 of this report. Numeric designation for each Appendix A section corresponds to the same numerically-identified region of the Monongahela watershed (e.g., A-3 corresponds to region 3 of the Monongahela watershed).

Table 1-5. Section 303(d) listed waterbodies and corresponding impairments

Listed Segment ID	Stream Name	Length (mi)	Trout Waters	Al	Fe	Mn	Metals[A]	pH	Year[B] Listed
M	Monongahela River	37.5		x					1998
M-20.2	UT @ Montana/Mon. River	1.00					x	x	1998 & 1996
M-25.9	UT @ Millersville/Mon.River	1.00					x	x	1998 & 1996
M-2.1	Camp Run	3.20					x	x	1998 & 1996
M-2.6	UT @ Bakers Ridge/Mon. River	1.00					x	x	1998 & 1996
M-2.7	Laurel Run/Mon. River	1.90					x	x	1998 & 1996
M-3	West Run	6.40					x	x	1998
M-4	Robinson Run	4.40					x	x	1998 & 1996
M-4-A	Crafts Run	0.00					x	x	1998
M-4-B	UT#1/Robinson Run	0.00					x	x	1998
M-6	Scott Run	6.00		x	x	x			1998 & 1996
M-7	Dents Run	5.69		x	x	x			1998 & 1996
M-7-C	UT#2/Dents Run	0.00					x	x	1998 & 1996
M-8	Deckers Creek	24.7					x	x	1998 & 1996
M-8-0.5A	Hartman Run/Deckers Creek	1.60					x	x	1998
M-8-A.7	UT#2/Deckers CK (Deep Hollow)	1.30					x	x	1998 & 1996
M-8-D	Glady Run/Deckers Creek	1.40					x	x	1998 & 1996
M-8-F	Slabcamp Run	1.40					x	x	1998 & 1996
M-8-G	Dillan Creek	5.40					x		1998 & 1996
M-8-H	Laurel Run/Deckers Creek	3.40					x	x	1998 & 1996
M-8-I	Kanes Creek	4.80					x	x	1998 & 1996
M-9	Cobun Creek	9.60						x	1998
M-10	Booths Creek	9.60					x	x	1998 & 1996
M-10-F	UT#2/Booths Run	0.00					x	x	1998 & 1996
M-10-D	Owl Creek	4.05					x	x	1998 & 1996
M-10-E	Mays Run	2.10					x	x	1998 & 1996
M-11	Brand Run	2.40					x	x	1998 & 1996
M-14	Flaggy Meadow Run	3.00					x	x	1998 & 1996
M-15	Birchfield Creek	2.30					x	x	1998 & 1996
M-17	Indian Creek	2.08		x					1998 & 1996
M-20	Parker Run	2.60					x	x	1998 & 1996
M-21	Pharaoh Run	3.30					x	x	1998 & 1996
M-22-C	Robinson Run/Pawpaw Creek	4.40					x	x	1998 & 1996
M-22-K	Sugar Run/Pawpaw Creek	2.20					x	x	1998 & 1996
M-23	Buffalo Creek	30.2		X					1998 & 1996

Listed Segment ID	Stream Name	Length (mi)	Trout Waters	Al	Fe	Mn	Metals[A]	pH	Year[B] Listed
M-23-K	Mod Run	4.00					x		1998 & 1996
M-23-N-1	Fleming Fork	1.50					x	x	1998 & 1996
M-23-Q	Whetstone Run	2.60					x	x	1998 & 1996
M-23-R	Joes Run/Buffalo Creek	1.80					x	x	1998 & 1996

Note: Impaired streams in this table reflects information provide in West Virginia's 1998 Section 303 (d) list, 0.00 is used when the length is unknown.
A - Metals includes Al, Fe and Mn as designated by WVDEP
B - Date of initial listing on West Virginia's Section 303 (d) list

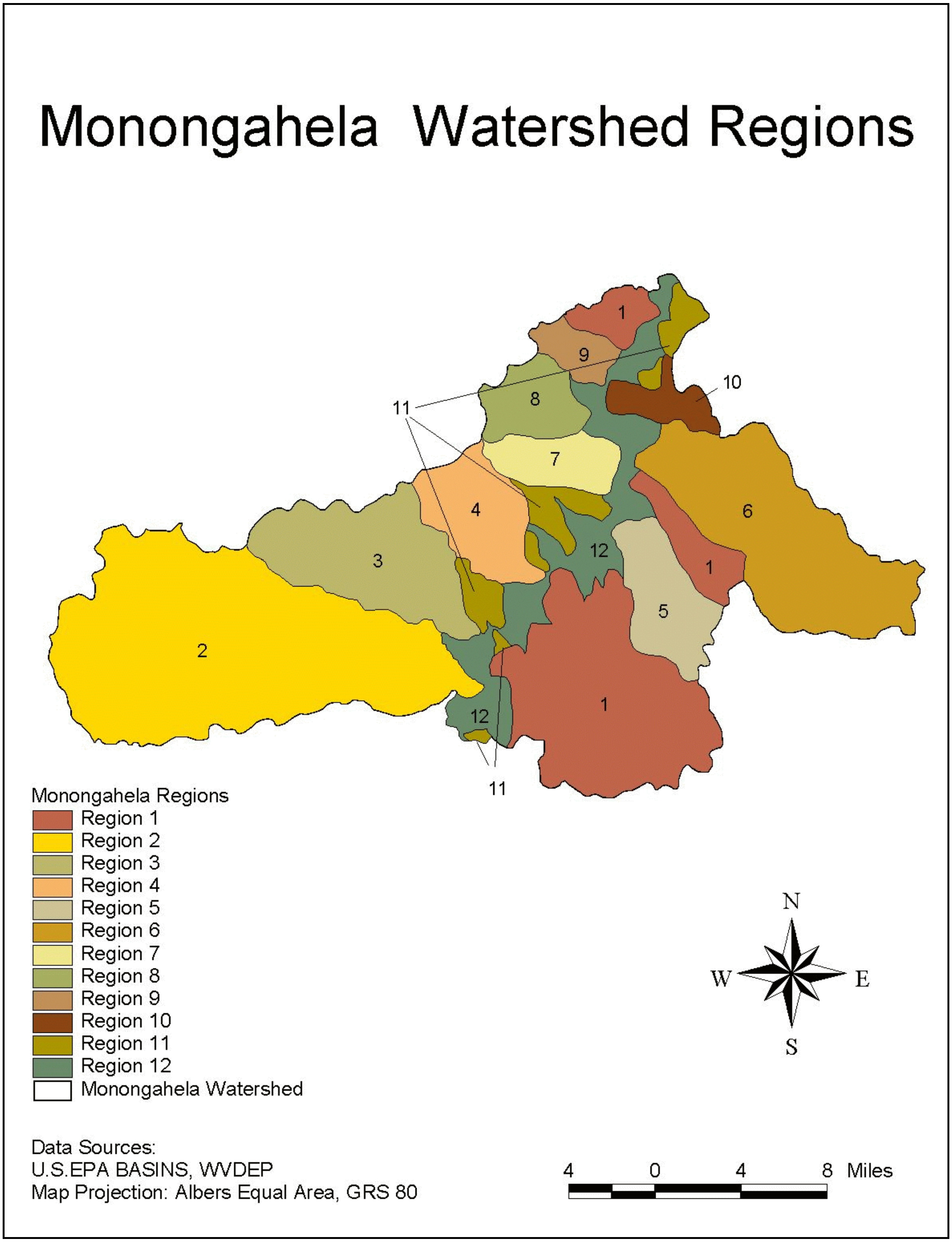


Figure 1-3. Monongahela River watershed and its 12 regions

2.0 Water Quality Standards

Water Quality Standards consist of three components: designated and existing uses; narrative and/or numerical water quality criteria necessary to support those uses; and an anti-degradation statement. Furthermore, water quality standards serve two purposes. The first is establishing the water quality goals for a specific waterbody. And the second is establishing water quality-based treatment controls and strategies beyond the technology-based levels of treatment required by Sections 301(b) and 306 of the Act (U.S. EPA, 1991). In Title 46, Legislative Rule, Environmental Quality Board, Series 1, *Requirements Governing Water Quality Standards, West Virginia*, sets forth designated and existing uses as well as numeric and narrative water quality criteria for waters in the state. Appendix E of the Requirements Governing Water Quality Standards displays numeric water quality criteria, while narrative water quality criteria are contained in Section §46-1-3 of the same document. Total aluminum, iron, manganese, and pH have numeric criteria under the Aquatic Life and the Human Health use designation categories (Table 2-1). The listed waterbodies in the Monongahela watershed have been designated as having an Aquatic Life and a Human Health use (WVDEP, 1998a). The Monongahela River and its tributaries are identified as warm water fishery streams by West Virginia DEP.

Table 2-1. Applicable West Virginia water quality criteria

Parameter	Use Designation				
	Aquatic Life				Human Health
	B1, B4		B2		A
	Acute	Chronic	Acute	Chronic	
Aluminum, Total (µg/L)	750[a]	-	750[a]	-	-
Iron, Total (mg/L)	-	1.5[b]	-	0.5[b]	1.5[c]
Manganese, Total (mg/L)	-	-	-	-	1.0[c]
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

Source: WVWQS, 2000; B1 = Warm water fishery streams, B4 = Wetlands, B2 = Trout waters, A = Water supply, public;
[a] One-hour average concentration not be exceeded more than once every three years on the average,
[b] Four-day average concentration not to be exceeded more than once every three years on the average, Warm water criteria was applied throughout Monongahela watershed.
c Not to exceed

There are approximately 170 existing water quality stations in the Monongahela River watershed. Tables 3a, 3b, and 3c in each of Appendices A-1 through A-12 summarize applicable water quality data for monitoring stations throughout the watershed.

3.0 Source Assessment

This section examines and identifies the potential sources of aluminum, iron, and manganese in the Monongahela watershed. Multiple sources of data were used to identify potential sources and to characterize the relationship between point and nonpoint source discharges and in-stream response at monitoring stations.

3.1 Data Inventory

Data collection was a cooperative effort among various governmental groups and agencies in West Virginia, while U.S. EPA Region 3 provided support and guidance for TMDL analysis and development. The categories of data used in the development of these TMDLs include physiographic data that describe the physical conditions of the watershed, environmental monitoring data that identify potential pollutant sources and their contribution, and in-stream water quality monitoring data. Additional water quality monitoring data gathered by non-governmental groups were obtained through the WVDEP. Table 3-1 shows the various data types and data sources used in these TMDLs.

Table 3-1. Inventory of data and information used to develop the Monongahela watershed TMDLs

Data Category	Description	Data Source(s)
Watershed Physiographic Data	Land Use (GAP 2000)	U.S. Geological Survey (USGS)
	Abandoned Mining Coverage	WVDEP Division of Mining & Reclamation (DMR)
	Active and historical mining information	WVDEP DMR
	Soil data (STATSGO)	U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS)
	Stream Reach Coverage	USGS, WVDEP Division of Water Resources (DWR)
	Weather Information	National Climatic Data Center
Environmental Monitoring Data	NPDES Data	WVDEP DMR, WVDEP DWR
	Discharge Monitoring Report Data	WVDEP DMR
	Abandoned Mine Land Data	WVDEP DMR, WVDEP DWR
	Section 303(d) Listed Waters	WVDEP DWR
	Water Quality Monitoring Data for 685 Sampling Stations	EPA STORET, WVDEP DWR, Special Reclamation Group, Stream Restoration Group

3.2 Stream Flow Data

There are ten U.S. Geological Survey (USGS) flow gages in the Monongahela watershed. Flow data from these USGS gages were used to support flow analysis for the watershed. Table 3-2 shows the ten flow gaging stations with available records of flow data and the corresponding period of record for each. These ten stations were used to characterize the stream flow in the watershed.

Table 3-2. Flow analysis for the Monongahela watershed

Station	Stream Name	Start Date	End Date	Min (cfs)	Mean (cfs)	Max (cfs)
3061410	Laurel Run at Curtisville, WV	10/2/77	9/30/80	0	2.1	41
3061435	Hibbs Run near Mannington, WV	10/2/77	9/30/79	0	2.9	45
3061495	Davy Run at Katy, WV	10/2/77	9/30/79	0	2.3	11
3061500	Buffalo Creek at Barrackville, WV	8/7/32	9/30/98	0	170.2	5,710
3062000	Monongahela R at Lock 15, at Hoult, WV	10/2/38	9/30/65	229	4,089	63,100
		10/2/66	9/30/67	320	4,328	54,000
3062213	Stewart Run at Crown, WV	10/2/77	9/30/79	0	4.2	96
3062215	Indian Creek at Crown, WV	10/2/77	9/30/80	1	23.7	1,700
3062400	Cobun Creek at Morgantown, WV	10/2/97	9/30/98	0	19.9	178
3062500	Deckers Creek at Morgantown, WV	3/2/46	10/2/69	0	98.3	2,740
3114650	Buffalo Run near Little, WV	1/25/69	10/5/77	0	5.6	219

3.3 Water Quality

Water quality monitoring data for the Monongahela watershed were obtained from a variety of sources, including the EPA STORET database, WVDEP DWR, Stream Restoration Group, and Special Reclamation Group. Observations used to configure, calibrate, and test the model were taken from throughout the watershed. As stated in Section 2, there are 170 water quality monitoring stations in the Monongahela watershed. The water quality monitoring data and pertinent source information are summarized for each of the 12 regions in Appendices A-1 through A-12 of this report.

3.4 Point Sources

Point sources, according to 40 CFR 122.3, are defined as 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 National Pollutant Discharge Elimination System (NPDES) Program, under Clean Water Act Sections 318, 402, and 405, requires permits for the discharge of pollutants from point sources. Permitted point sources can be classified into two major categories: non-mining point sources and mining point sources.

3.4.1 Permitted Non-mining Point Sources

Data regarding non-mining point sources were retrieved from EPA's Permit Compliance System (PCS) and WVDEP. Only one outfall for the Monongahela Power Company has a permit limit for iron. The other seven outfalls and the other four non-mining point sources located in the Monongahela watershed that are "report only" for discharges and the parameter shown in Table 3-3. The non-mining point sources typically do not discharge significant amounts of aluminum, iron, or manganese, e.g., wastewater treatment plants, non-metal producing industries, etc., and are required to discharge within the pH criteria range of 6 to 9 (inclusive).

Table 3-3. Non-mining point sources in the Monongahela watershed

NPDES ID	Facility Name	Facility Type	Receiving Water	Permitted pollutant discharged	Number of permitted outlets	Number of "Report Only" outlets	Status	Major ID	Issue Date	Expire Date
WV0004731	Monongahela Power Co.	Electrical Services	Monongahela River	Fe, Al	8	7	Active	Major	8/24/98	8/23/03
WV0113697	Mt State Bit Service Inc.	Chemicals and Allied Products	Bloody Run, Booths Creek, Monongahela River	Fe	2	2	Active	Minor	3/17/99	3/16/04
WV0115461	Morton International, Inc.	Chemicals and Allied Products	Monongahela River	Fe	1	1	Active	Minor	8/8/99	8/7/03
WV0005240	Philips Lighting Co.	Electric Lamps	UT of Monongahela River	Al	2	2	Active	Major	8/10/95	8/9/00
WV0022047	GE Specialty Chemicals Inc	Cyclic Crudes Interm., Dyes	UT of Monongahela River	Al	6	6	Active	Major	6/30/00	6/29/04

3.4.2 Permitted Mining Point Sources

Untreated mining related point source discharges, from deep, surface, and other mines, typically contain low pH values and high concentrations of metals, iron, aluminum, and manganese. Consequently, mining related activities are issued discharge permits, which require treatment and monitoring for these parameters. A spatial coverage of the mining permit data was provided by West Virginia Division of Mining and Reclamation (DMR). The coverage includes both active and inactive mining facilities, classified by type of mine and facility status. The mines are classified into eight different categories: coal surface mine, coal underground mine, haulroad, coal preparation plant, coal reprocessing, prospective mine, quarry, and other. The haulroad and prospective mine categories represent mining access roads and potential coal mining areas, respectively. The permits were also classified by mining status (seven categories) describing the status of each permitted discharge. DMR provided a brief description regarding classification and associated potential impact on water quality. Mining types and status descriptions are shown in Table 3-4.

Table 3-4. Classification of mining permit type and status

Type of Mining	Status Code	Description
- Coal Surface Mine - Coal Underground Mine - Haulroad - Coal Preparation Plant - Coal Reprocessing - Prospective Mine - Quarry - Other	Completely Released	Completely reclaimed, revegetated; should not be any associated water quality problems
	Phase II Released	Sediment and ponding are gone, partially revegetated, very little water quality impact
	Phase I Released	Regraded and reseeded: initial phase of the reclamation process; could potentially impact water quality
	Renewed	Active mining facility, assumed to be discharging according to the permit limits
	New	Newly issued permit; could be currently active or inactive; assumed to be discharging according to permit limits
	Inactive	Currently inactive; could become active anytime; assumed to be discharging according to discharge limits
	Revoked	Bond forfeited; forfeiture may be caused by poor water quality; highest impact to water quality

Coal mining operations and sandstone quarries typically have permits for concentrations of total iron, total manganese, total nonfilterable residue, and pH. They are also required to monitor and report total aluminum discharges. Limestone quarry permits have report only-discharge limits for flow, pH, total nonfilterable residue and aluminum, but not for total iron and manganese. There are a total of 129 active mining discharge permits in the Monongahela watershed. A complete listing of mining permits in the Monongahela watershed is located in Appendix B.

Surface Mining Control and Reclamation Act

The Surface Mining Control and Reclamation Act of 1977 (SMCRA, Public Law 95-87) and its subsequent revisions were enacted to established a nationwide program to, among other things, protect the beneficial uses of land or water resources, and pubic health and safety from the adverse effects of current surface coal mining operations, as well as promote the reclamation of mined areas left without adequate reclamation prior to August 3, 1977. SMCRA requires a permit for the 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 the regulatory authority in the event that the applicant forfeits. Mines that ceased operating by the effective date of SMCRA, (often called “pre-law” mines) are not subject to the requirements of SMCRA.

Title IV of the Act is designed to provide assistance for reclamation and restoration of abandoned mines, while Title V states that any surface coal mining operations shall be required to meet all applicable performance standards. Some general performance standards include:

- Restoring the land affected to a condition capable of supporting the uses which it was capable of supporting prior to any mining,

- Backfilling and compacting (to insure stability or to prevent leaching of toxic materials) in order to restore the approximate original contour of the land with all highwalls, and

- Minimizing the disturbances to the hydrologic balance and to the quality and quantity of water in surface and ground water systems both during and after surface coal mining operations and during reclamation by avoiding acid or other toxic mine drainage.

For purposes of these TMDLs only, point sources are identified as NPDES-permitted discharge points, and nonpoint sources include discharges from abandoned mine lands, including but not limited to, tunnel discharges, seeps, and surface runoff. Abandoned and reclaimed mine lands were treated in the allocations as nonpoint sources because there are no NPDES permits associated with these areas. In the absence of an NPDES permit, the discharges associated with these land uses were assigned load allocations, as opposed to wasteload allocations. The decision to assign load allocations to abandoned and reclaimed mine lands does not reflect any determination by EPA as to whether there are, in fact, unpermitted point source discharges within these land uses. In addition, by establishing these TMDLs with mine drainage discharges treated as load allocations, EPA is not determining that these discharges are exempt from NPDES permitting requirements.

Abandoned Mine Treatment Facilities

The western side of the Monongahela watershed contains hundreds of thousands of acres of abandoned underground mine workings, many of which are inter-connected. When these mines were active during the 1970s, the groundwater was pumped and treated in order to keep the mines operational. Many of the mines closed in the mid to late 1990s and the water treatment facilities were shut down. As a result, the water levels continue to rise in the mines. Connections between mines, both horizontally and vertically, become important factors in determining how large a mine pool will become and whether it will discharge to the surface (EPA, 1999).

A group of abandoned underground coal mines located just north of Fairmont, WV, became connected to form the Fairmont Pool covering approximately 27,000 acres (EPA, 1999). As the water in the Fairmont Pool rises, it will begin to discharge to the surface waters throughout the Monongahela watershed. The Fairmont Pool was blamed for discoloration of Buffalo Creek in October 1996 and a siphon was installed to drain the mine water to an adjacent mine pool so that it could be pumped and treated by one of the large mine drainage treatment facilities (EPA, 1999). This siphon is located near the mouth of Paw Paw Creek and the water flows through other mines for several miles before it is pumped to the surface and treated at the Dogwood Lakes treatment facility (EPA, 1999).

In addition to the above treatment facility, there are three additional AMD treatment facilities located in the Monongahela watershed (Figure 3-1). Two of the facilities operate under a single mining permit (u007083) and a single NPDES permit (WV0038288). The Dogwood Lakes treatment facility discharges continuously at a rate of 2,000 gallons per minute (gpm) into Indian Creek. The Sears facility discharges into Little Indian Creek at 2,500 gpm one day per week. The Flaggy Meadows treatment facility discharged into Flaggy Meadows Run until 1995 when it was taken off-line for modifications to increase flow capacity and is currently not operational.

The design flow is projected to be 10,000 gpm. The Bowlby Mills treatment facility discharges to Robinson Run and operates under the mining permit (u011983) and the NPDES permit (WV0046612). The design flow of Bowlby Mills facility is 3,500 gpm.

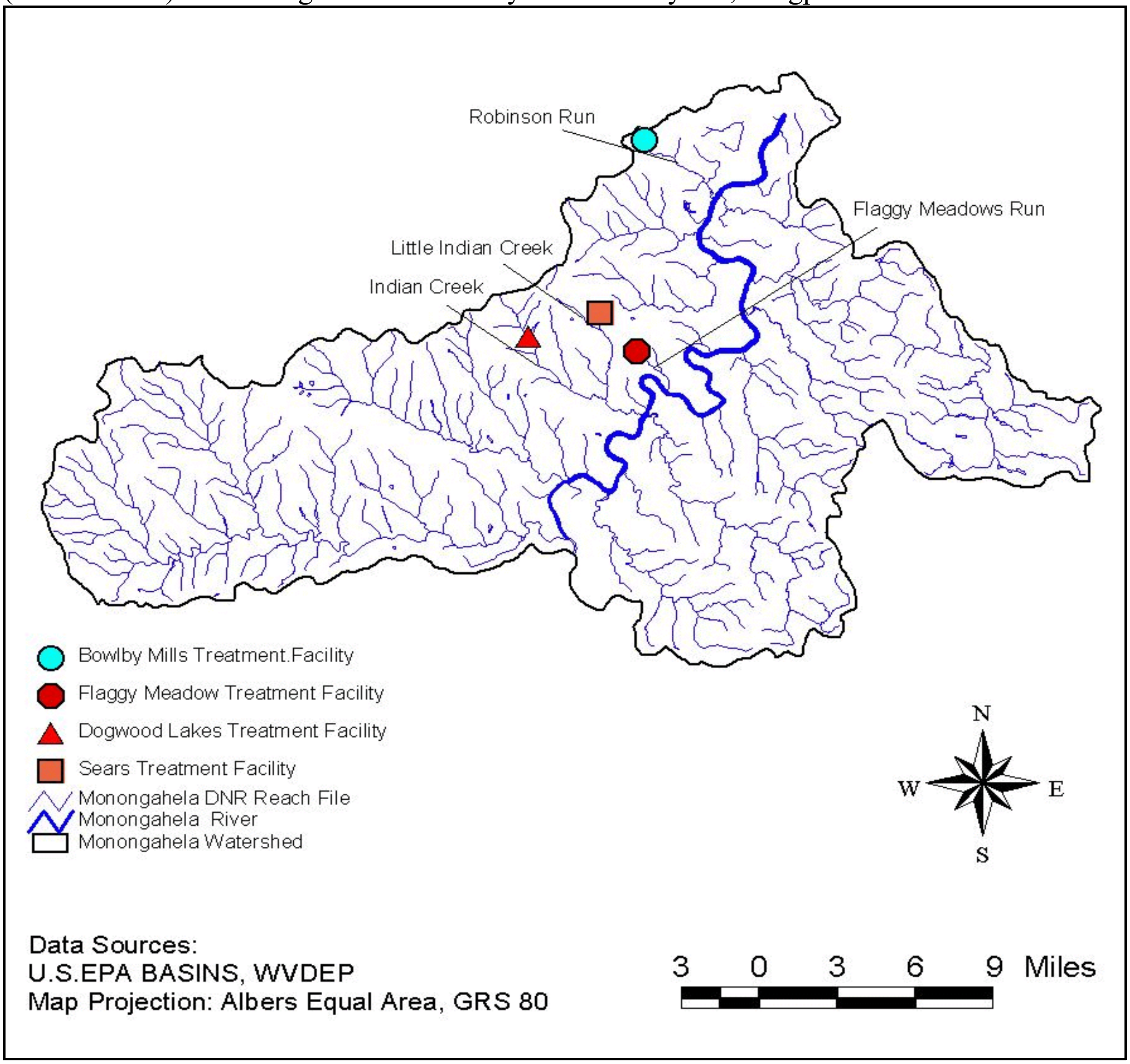


Figure 3-1. Abandoned Mine Treatment facilities

3.5 Nonpoint Sources

In addition to point sources, nonpoint sources also contribute to water quality impairments in the Monongahela watershed. Nonpoint sources represent contributions from diffuse sources, including rainfall runoff, rather than from a defined outlet. Based on the identification of a number of abandoned (AML) and revoked mining activities in the Monongahela watershed, these two sources represent a significant nonpoint source within the watershed. Abandoned and revoked mines can contribute significant amounts of acid mine drainage, which produces low pH and high metals concentrations, to surface and subsurface water. Because they are present in the Monongahela watershed, nonpoint source contributions were grouped for assessment into three separate categories: AML, revoked mines and other nonpoint sources, which include forest and agricultural land as well as barren and urban lands. Figure 3-2 presents a schematic of potential sources in the Monongahela watershed.

3.5.1 Abandoned Mine Lands (AML) and *Revoked mines*

Generally, the abandoned surface and/or deep mines (AML) are responsible for the numerous AML sites which produce AMD flows (WVDEP, 1985). Data regarding AML sites in the Monongahela watershed were compiled from spatial coverages provided by WVDEP Division of Mining and Reclamation (DMR) and the *Monongahela River Subbasin Abandoned Mine Drainage Assessment* (WVDEP, 1985). The AML sites were classified into three categories:

- High walls: near vertical face of exposed overburden and coal from surface and underground mining activities,
- Disturbed land: disturbed land from both surface and underground mining activities, and
- Abandoned mines: abandoned surface and underground mines.

Additional qualitative data were retrieved from DMR Problem Area Data Sheets (PADS). Information regarding the locations of the most significant sources, namely abandoned mines, are presented in Table 2 in each of Appendices A-1 through A-12.

Mines with revoked permits lack the presence of a permittee and discharge from these mines is typically untreated. Consequently, mines with revoked permits are treated as nonpoint sources.

3.5.2 Other Nonpoint Sources

The predominant land uses in the Monongahela watershed were identified based on the USGS's GAP2000 land use data representative of the mid-1990s. According to the GAP2000 data, the major land uses in the watershed are forest land, which constitutes approximately 68% of the watershed area, and agricultural land, which makes up 20% of the watershed area. In addition to forest land and agricultural land uses, other landuses which may contribute nonpoint source metals loads to the receiving streams include barren and urban land. The land use distribution for the Monongahela watershed is presented in Figure 3-3 and Table 3-5.

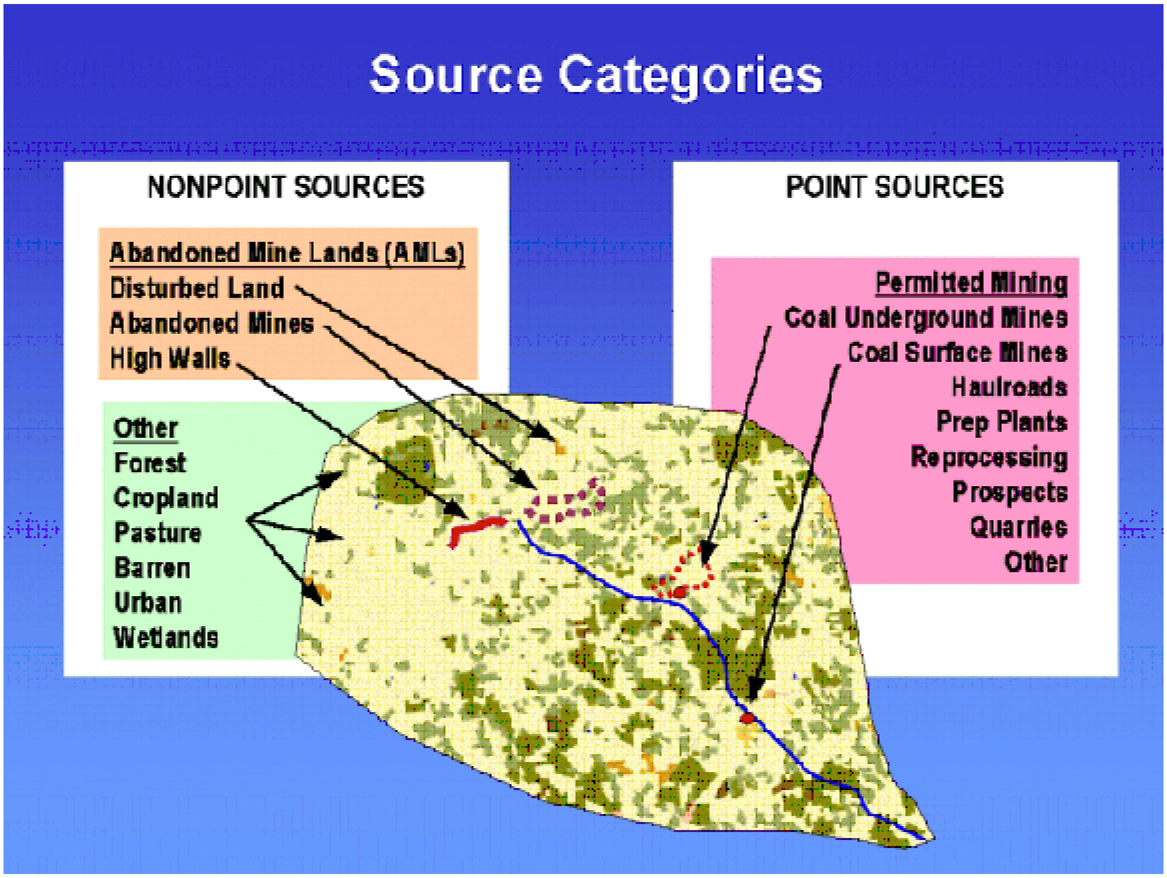


Figure 3-2. Potential sources contributing to impairments in the Monongahela River watershed

Table 3-5. GAP2000 Landuse distribution in the Monongahela watershed

GAP2000 Landuse Category	Area (Acres)	Area (Percent)
Shrubland	7,821	2.7%
Woodland	3,221	1.1%
Surface water	740	0.3%
Roads	518	0.2%
Power lines	1,652	0.6%
Populated areas	4,863	1.7%
Light intensity urban	10,352	3.5%
Moderate intensity urban	3,070	1.1%
Intensive urban	1,657	0.6%
Pasture/grassland	58,285	19.9%
Barren land - mining, construction	1,691	0.6%
Conifer plantation	244	0.1%
Floodplain forest	1,072	0.4%
Herbaceous wetland	188	0.1%
Surface water	3,155	1.1%
Cove hardwood forest	1,707	0.6%
Diverse/mesophytic hardwood forest	77,216	26.4%
Hardwood/conifer forest	826	0.3%
Oak dominant forest	112,641	38.5%
Mountain hardwood forest	1,321	0.5%

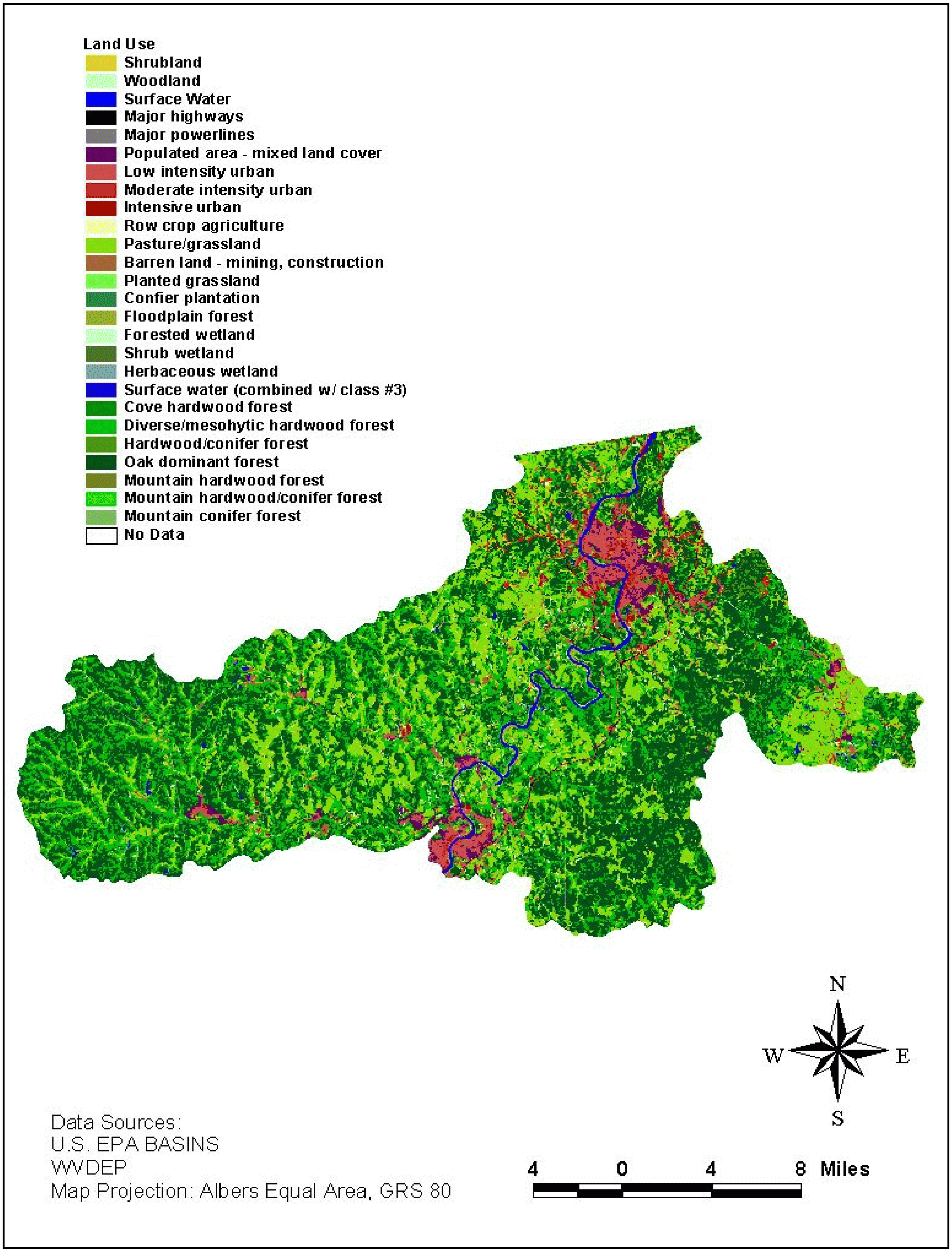


Figure 3-3. Land use distribution in the Monongahela River watershed

4.0 Technical Approach

Establishing the relationship between the in-stream water quality targets and source loadings is a critical component of TMDL development. It allows for 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 to flow and loading conditions. The objective of this section is to present the approach taken to develop the linkage between sources and in-stream response for TMDL development in the Monongahela watershed.

4.1 Model Framework Selection

Selection of the appropriate approach or modeling technique required consideration of the following:

- Expression of water quality criteria
- Dominant processes
- Scale of analysis

Numeric water quality criteria for aluminum, manganese, and iron for aquatic life, such as those applicable here, require evaluation of magnitude, frequency, and duration. Magnitude refers to the criterion maximum concentration (CMC) to protect against short-term (acute) effects or the criterion continuous concentration (CCC) to protect against long-term (chronic) effects. Frequency indicates the number of water quality criteria violations over a specified time period. In this case, for aquatic life criterion, the water quality standards allow one excursion every three years, on average. Duration measures the time period of exposure to increased pollutant concentrations. For CMC criteria, excursions are measured over a one-hour period while excursions for CCC criteria are measured over a four-day period. In addition, any technical approach must consider how numeric aquatic life criteria are expressed. West Virginia aquatic life criteria for metals are expressed as total recoverable metals concentrations. The methodology must predict the total metals concentration in the water column of the receiving waterbody. The approach or modeling technique must permit representation of in-stream concentrations under a variety of flow conditions, in order to evaluate critical periods for comparison to chronic and acute criteria.

Furthermore, according to 40 CFR Section 130, TMDLs must be designed to implement applicable water quality standards. The applicable water quality standards for metals and pH in West Virginia were presented in Section 2.

The TMDL development approach must also consider the dominant processes regarding pollutant loadings and in-stream fate. For the Monongahela watershed, primary sources contributing to metals and pH impairments include an array of nonpoint or diffuse sources as well as discrete point sources/permitted discharges. Loading processes for nonpoint sources or land-based activities are typically rainfall-driven and thus relate to surface runoff and subsurface discharge to a stream. Permitted discharges may or may not be dependent on rainfall.

Key in-stream factors that are considered include routing of flow, dilution, transport of total metals, sediment adsorption/desorption, and precipitation of metals. In the stream systems of the Monongahela watershed, the primary physical driving process is the transport of total metals (including sediment bound and dissolved metals) by diffusion and advection in the flow.

Scale of analysis and waterbody type must also be considered in the selection of the overall approach. The approach should have the capability to evaluate watersheds at multiple scales, particularly those of a few hundred acres in size. The listed waters in the Monongahela watershed range from small headwater streams to larger tributaries of the Monongahela River. Selection of scale should be sensitive to locations of key features, such as abandoned mines and point source discharges. At the larger watershed scale, land areas are lumped into subwatersheds for practical representation of the system, commensurate with the available data. Occasionally, there are site specific and localized acute problems which may require more detailed segmentation or definition of detailed modeling grids.

Based on the considerations described above, analysis of the monitoring data, review of the literature, and past pH and metals modeling experience, the Mining Data Analysis System (MDAS) was used to represent the source-response linkage in the Monongahela watershed. The MDAS is a comprehensive data management and modeling system that is capable of representing loading from nonpoint and point sources found in the Monongahela watershed and simulating in-stream processes.

4.2 Mining Data Analysis System (MDAS) Overview

The MDAS is a system designed to support TMDL development for areas impacted by AMD. The system integrates the following:

- Graphical interface
- Data storage and management system
- Dynamic watershed model
- Data analysis/post-processing system

The graphical interface supports basic geographic information systems (GIS) functions, including electronic geographic data importation and manipulation. Key data sets include stream networks, landuse, flow and water quality monitoring station locations, weather station locations, and permitted facility locations. The data storage and management system functions as a database and supports storage of all data pertinent to TMDL development, including water quality observations, flow observations, permitted facility Discharge Monitoring Reports (DMRs), as well as stream and watershed characteristics used for modeling. The system also includes functions for inventorying the data sets. The Dynamic Watershed Model, also referred to as the Hydrological Simulation Program - C++ (HSPC), simulates nonpoint source flow and pollutant loading as well as in-stream flow and pollutant transport, and it is capable of representing time-variable point source contributions. The data analysis/post-processing system conducts correlation and statistical analyses and enables the user to plot model results and observation data.

The most critical component of the MDAS to TMDL development is the HSPC model, because it provides the linkage between source contributions and in-stream response. The HSPC is a comprehensive watershed model used to simulate watershed hydrology and pollutant transport as well as stream hydraulics and in-stream water quality. It is capable of simulating flow, sediment, metals, nutrients, pesticides, and other conventional pollutants, as well as temperature and pH for pervious and impervious lands and waterbodies. The HSPC is essentially a re-coded C++ version of selected Hydrologic Simulation Program-FORTRAN (HSPF) modules. HSPC's algorithms are identical to those in HSPF. Table 4-1 presents the modules from HSPF used in HSPC. Refer to the *Hydrologic Simulation Program FORTRAN User's Manual for Release 11* for a more detailed discussion of simulated processes and model parameters (Bicknell et al., 1996).

Table 4-1. Modules from HSPF[a] converted to HSPC

RCHRES Modules	HYDR	Simulates hydraulic behavior
	CONS	Simulates conservative constituents
	HTRCH	Simulates heat exchange and water
	SEDTRN	Simulates behavior of inorganic sediment
	GQUAL	Simulates behavior of a generalized quality constituent
	PHCARB	Simulates pH, carbon dioxide, total inorganic carbon, and alkalinity
PQUAL and IQUAL Modules	PWATER	Simulates water budget for a pervious land segment
	SEDMNT	Simulates production and removal of sediment
	PWTGAS	Estimates water temperature and dissolved gas concentrations
	IQUAL	Uses simple relationships with solids and water yield
	PQUAL	Simple relationships with sediment and water yield

[a] Source: Bicknell et al., 1996

4.3 Model Configuration

The MDAS was configured for the Monongahela watershed, and the HSPC model was used to simulate the watershed as a series of hydrologically connected subwatersheds. Configuration of the model involved subdivision of the Monongahela watershed into modeling units and continuous simulation of flow and water quality for these units using meteorological, landuse, point source loading, and stream data. Specific pollutants that were simulated include total aluminum, total iron, total manganese, and pH. This section describes the configuration process and key components of the model in greater detail.

4.3.1 Watershed Subdivision

To represent watershed loadings and resulting concentrations of metals in the Monongahela River watershed, the watershed was divided into 210 subwatersheds. These subwatersheds are presented in Figure 1 in each of Appendices A-1 through A-12, and they represent hydrologic boundaries. The division was based on elevation data (7.5 minute Digital Elevation Model [DEM] from USGS), stream connectivity (from EPA's Reach File, Version 3 [RF3] stream coverage), and locations of monitoring stations.

4.3.2 Meteorological Data

Meteorological data are a critical component of the watershed model. Appropriate representation of precipitation, wind speed, potential evapotranspiration, cloud cover, temperature, and dewpoint are required to develop a valid model. Meteorological data were accessed from a number of sources in an effort to develop the most representative dataset for the Monongahela watershed.

In general, hourly precipitation data are recommended for nonpoint source modeling. Therefore, only weather stations with hourly-recorded data were considered in development of a representative dataset. Long-term hourly precipitation data available from four National Climatic Data Center (NCDC) weather stations located near the watershed were used (Figure 4-1):

- Terra Alta No 1
- Tygart Dam
- Elkins WSO Airport
- Lake Lynn

Meteorological data for the remaining required parameters were available from the Elkins WSO Airport station. These data were applied based on subwatershed location relative to the weather stations. Consistent with the technical and regulatory requirements of 40 CFR Section 130, a subset of the period of record is used. These regulations require TMDLs to consider critical environmental conditions and seasonal environmental variations. The requirements are designed to simultaneously ensure that water quality is protected during times when it is most vulnerable and take into account changes in streamflow and loading characteristics as a result of hydrological or climatological variations. These conditions are important because they describe the factors that combine to cause violations of water quality standards and can help identify necessary remedial actions.

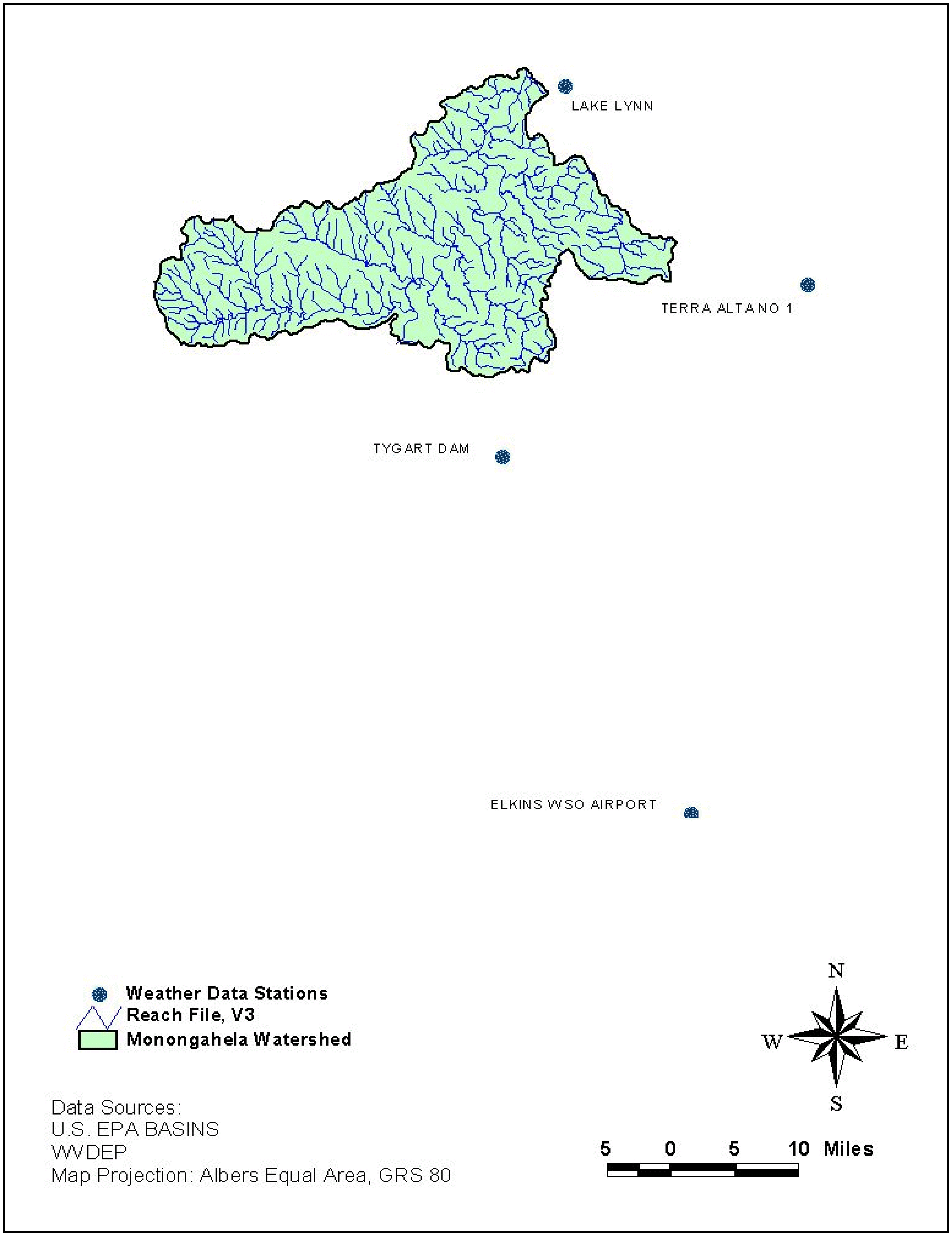


Figure 4-1. Weather stations used in modeling

4.3.3 Nonpoint Source Representation

To explicitly model nonpoint sources in the Monongahela watershed, several additional land use categories were created and added to the land use grouping (GAP 2000) shown in Table 4-2. The additional land use categories are explained in the following sections. The updated land use coverage provided the basis for estimating and distributing total aluminum, iron, and manganese loadings associated with conventional land uses. This land use coverage provided the basis for estimating and distributing total aluminum, iron, and manganese loadings associated with conventional land uses. The assumed pervious and impervious percentage for each land use affects representation of the hydrology and water quality of the Monongahlea watershed MDAS model.

In addition, contributions of relevant parameters from groundwater sources are also considered. In the case of naturally-occurring parameters, such as aluminum, iron, and manganese, it is important to consider and incorporate groundwater contributions for a more accurate representation of actual conditions.

Table 4-2. Model land use grouping

Model Category	GAP2000 Category
Barren	Barren Land, Mining and Construction
Crop land	Row Crops Agriculture
	Small Grains
Forest	Shrubland
	Woodland
	Conifer Plantation
	Floodplain Forest
	Cove Hardwood Forest
	Diverse/Mesophytic Hardwood Forest
	Hardwood/Conifer Forest
	Oak Dominant Forest
	Mountain Hardwood Forest
	Mountain Hardwood/Conifer Forest
	Mountain Conifer Forest
Pasture	Power Lines
	Pasture/Grassland
	Planted Grassland
Strip Mining	Quarries/Strip Mines/Gravel Pits
Urban Impervious	Roads
	Populated Areas
	Light Intensity Urban
	Moderate Intensity Urban
	Intensive Urban
Urban Pervious	Roads
	Populated Areas
	Light Intensity Urban
	Moderate Intensity Urban
	Intensive Urban
Water	Surface Water
Wetlands	Forested Wetland
	Shrub Wetland
	Herbaceous Wetland

Abandoned Mine Lands (AML)

In order to represent AMLs as nonpoint sources, the AML categories were broken down into three land use categories: high walls, disturbed land, and abandoned mines. The abandoned mines represent either discharge from abandoned deep mines or seeps and leachate from other abandoned mine sites. Specific data regarding the three AML land uses were not available from the GAP 2000 land use coverage. WVDEP provided AML land use coverage data which had to be incorporated into the GAP 2000 land use coverage. In order to incorporate these land uses to appropriately account for flow and loading characteristics, the existing GAP 2000 land use coverage was modified on a subwatershed basis. For instance, assume that data from WVDEP indicated 60 acres of abandoned mines, 40 acres of disturbed land, and 20 acres of high walls in a particular subwatershed. Additionally, available GAP 2000 data indicated 900 acres of forested land and 100 acres of "active mining land" in the same watershed. The GAP 2000 data would be modified such that the 100 acres of "active mining land" would become 120 acres of AML land use distributed according to the WVDEP data, i.e., 60 acres of abandoned mines, 40 acres of disturbed land, and 20 acres of high walls. However, because the size of the new AML land use coverage exceeds the original "active mining land" coverage by 20 acres, the forested land use coverage is reduced by 20 acres such that the total size of the watershed remains constant. In no case, was the total size of any subwatershed modified as a result of including more accurate data regarding AML land uses, described below in the Other Nonpoint Sources section.

Other Nonpoint Sources

Impervious urban lands contribute nonpoint source metals loads to the receiving streams through the washoff of metals that build up in industrial areas, on paved roads, and in other urban areas because of human activities. Percent impervious estimates for urban land use categories were used to calculate the total area of impervious urban land in each subwatershed.

4.3.4 Point Sources Representation

Permitted Non-mining Point Sources

The non-mining permits that are permitted to discharge Aluminum, Iron, and/or Manganese were not considered as significant contributors to the metal loading in Monongahela Watershed. These loadings were included in background conditions during the model calibration process. It is assumed that these dischargers will continue to operate under current permit limits/ requirements under this TMDL.

Permitted Mining Point Sources

The permitted mining point sources from West Virginia were introduced as nine land use categories based on the type of mine and the current status of the mine. Phase II and Completely Released permitted facilities were modeled as pasture since reclamation of these mines is either completed or nearly complete, and they are assumed to have little potential water quality impact (WVDEP, 2000a). Table 4-3 shows the land uses representing current active mines that were modeled. The permitted mining point sources were introduced as nine land use categories based on the type of mine and the current status of the mine.

Table 4-3. Model nonpoint source representation of different permitted mines

Type and status of active mine	Land use representation
Active deep mines	ADM
New/inactive deep mines	IADM
Phase I released deep mines	PIDM
Revoked deep mines	RDM
Active/inactive/revoked surface mines	ASM
Other mines (other, haulroad, prospect, quarry)	Other
Phase 1 released surface mines	PIRS
Revoked surface mines	RSM
Revoked other mines	ROM

To account for the additional deep mine land use categories that were not categorized in the MRLC landuse coverage (ADM, IADM, RDM and PIDM), the area of each permitted deep mine was subtracted from the existing GAP 2000 landuse area as described in Section 4.3.3. The remaining additional land use categories (ASM, PIRS, RSM, ROM and Other) were subtracted from the strip mine land use areas. The size of each mine was assumed to be equivalent to the surface disturbed area, which were provided by WVDEP DMR mining permit database. These areas are shown in Appendix B. A summary of the land use distribution is shown in Table 4-4.

Table 4-4. Modeled land use distribution in acres for Regions 1 through 12

Land Use Name	1	2	3	4	5	6	7	8	9	10	11	12
ADM	0	520	372	0	0	259	0	0	62	0	0	0
AML	176	657	34	114	271	1,100	113	208	211	357	602	722
ASM	47	58	0	100	164	2	670	829	86	0	16	29
Cropland	0	0	0	0	0	34	7	14	22	0	4	0
Disturb	65	1,084	84	161	0	211	7	76	12	16	4	140
Forest	40,302	61,914	19,030	9,343	9,999	24,102	3,164	4,371	2,269	2,029	6,287	11,333
Highwall	22	61	5	39	102	90	60	78	44	36	127	164
IADM	0	367	0	0	0	14	0	0	0	0	0	57
IASM	0	0	0	75	0	0	0	2	0	0	0	6
Other	2	263	241	0	1	105	304	1	259	0	5	25
Pasture	12,283	12,704	5,854	3,937	2,509	10,331	2,710	2,453	976	1,015	3,221	3,338
PIDM	0	0	30	0	20	0	0	0	18	0	3	0
PIRS	30	0	0	111	22	0	145	286	53	0	90	242
RDM	0	0	49	147	5	5	98	11	11	0	208	98
ROM	0	12	0	0	0	6	0	0	0	0	0	26
RSM	86	0	0	143	0	143	115	0	30	0	15	0
StripMining	145	134	176	5	86	275	4	0	37	8	88	190
UrbanImpervious	1,699	2,277	748	121	464	3,953	1,206	740	330	2,029	600	6,534

Land Use Name	1	2	3	4	5	6	7	8	9	10	11	12
UrbanPervious	1,699	2,277	748	121	464	3,953	1,206	740	330	2,029	600	6,534
Water	119	272	144	105	18	304	22	20	13	11	69	2,969
Wetlands	68	81	26	26	0	179	9	1	0	4	2	2
Total	56,743	82,683	27,540	14,547	14,125	45,067	9,839	9,831	4,764	7,533	11,941	32,409

Point sources were represented differently, depending on the stage of modeling for TMDL development. The two major stages, which are described in more detail later in this section and in Section 5, are included in both the calibration and the allocation scenarios.

Calibration Condition

For matching model results to historical data, which is described in more detail in the Model Calibration section, it was necessary to represent the existing point sources using available historical data. Discharges that were issued permits after the calibration period were not considered during the calibration process. If time series Discharge Monitoring Report data (DMRs) were available, continuous flow permitted mines were represented in the model using average flows and pollutant loads. The DMR data includes monthly averages and maximums for flow, pH, total aluminum, total iron, and manganese. The monthly average metals concentrations were multiplied by the discharge flows to estimate average loadings for these point sources.

In most cases, time series DMRs were insufficient to support representation in the model, indicating that the permitted mines were precipitation driven. For these situations, discharges from permitted mines were represented in the model by adjusting parameters affecting pollutant concentrations in the PQUAL (simulation of quality constituents for pervious land segments) and IQUAL (simulation of quality constituents for impervious land segments) modules of HSPC. These parameters were assigned using representative DMR concentrations of similar mining activities within the entire Monongahela watershed. Concentrations from these mines were adjusted to be consistent with typical discharge characteristics from similar mining activities or to match site-specific in-stream monitoring data.

Allocation Conditions

Modeling for allocation conditions required running multiple scenarios, including a baseline scenario and multiple allocation scenarios. This process is further explained in Section 5. For the allocation conditions, all permitted mining facilities, except the three AMD treatment facilities described in section 3.3.2, were represented using precipitation-driven nonpoint source processes in the model. Under this nonpoint source representation, flow was estimated in a manner similar to other nonpoint sources in the watershed, i.e., based on precipitation and hydrologic properties. This is consistent with DMR's estimation that discharges from most surface mines and some deep mines are precipitation-driven (WVDEP, 2000b). Flow was typically present at all times, and it increased during storm events. Under baseline conditions, the concentration of metals of discharges from point sources, including NPDES mining permits, was consistent with permit limits. During the allocation scenario, reductions were applied to abandoned mine lands, sediment producing lands, and active mines in that order to achieve in-stream TMDL endpoints.

Actual discharge from the AMD treatment facilities are estimated to be approximately 70 percent of the maximum discharge capacity (Leavitt, 2001). Based on this estimation, the AMD treatment facilities were represented as continuous flow point sources operating at 70 percent of their maximum discharge capacity. The treatment facilities were assigned water-quality based permit limits based on information provided by WVDEP.

Mining discharge permits have either technology-based or water quality-based limits. Monthly average permit concentrations for technology-based limits are 3.0 mg/L and 2.0 mg/L for total iron and manganese, respectively, with a “report only” limit for total aluminum. Permitted discharges with water quality-based limits must meet in-stream water quality criteria at end-of-pipe. Point sources were assigned concentrations based on the appropriate limits. For discharges that are technology-based, the aluminum waste load concentration for was assumed to be 4.3 mg/L.

Allocations were developed to fulfill the technical and regulatory requirements of 40 CFR Section 130. For instance, following the data analysis and model calibration, it was determined that violations of applicable water quality criteria occur at both low-flow and high-flow conditions. Accordingly, the TMDL, model calibration, and allocation process were designed to consider both low-flow and high-flow critical conditions.

4.3.5 Stream Representation

Modeling subwatersheds and calibrating hydrologic and water quality model components required routing flow and pollutants through streams and the resulting in-stream water quality was compared to the water quality criteria. The watershed streams were represented in two ways:

> Watershed tributary streams - Each subwatershed was represented with a single stream. Stream segments were identified using EPA's RF3 stream coverage.
> Monongahela mainstem - A two dimensional grid representing the river’s locks and dams.

In order to route flow and pollutants through the tributaries, development of rating curves was required. Rating curves were developed for each stream using Manning's equation and representative stream data. Required stream data includes slope, Manning's roughness coefficient, and stream dimensions including mean and channel widths and depths. Manning's roughness was assumed to be 0.05 for all streams (representative of mountain streams). Slopes were calculated based on digital elevation model (DEM) data and stream lengths measured from the RF3 stream coverage. Stream dimensions were estimated using regression curves that relate upstream drainage area to stream dimensions (Rosgen, 1996).
The Monongahela mainstem model representation is discussed in Section 4.4.

4.3.6 Hydrologic Representation

Hydrologic processes were represented in the HSPC using algorithms from the PWATER, water budget simulation for pervious land segments, and IWATER, water budget simulation for impervious land segments, modules of HSPF (Bicknell et al., 1996). Parameters associated with infiltration, groundwater flow, and overland flow were designated during model calibration.

4.3.7 Pollutant Representation

In addition to flow, three pollutants were modeled with the HSPC:

- Total aluminum
- Total iron
- Total manganese

The loading contributions of these pollutants from different nonpoint sources were represented in the HSPC using the PQUAL, simulation of quality constituents for pervious land segments, and IQUAL, simulation of quality constituents for impervious land segments, modules in HSPF (Bicknell et al., 1996). Pollutant transport was represented in the streams using the GQUAL, simulation of behavior of a generalized quality constituent, module. Values for the pollutant representation were refined through the water quality calibration process.

4.4 Environmental Fluid Dynamics Computer Code

Because of the lock and dam structures, Point Marion, Morgantown, Hildebrand, and Opekiska, along the Monongahela River mainstem (Figure 4-2), the mainstem was simulated using the Environmental Fluid Dynamics Computer Code (EFDC) (Hamrick, 1992). EFDC is a general 3-Dimensional receiving water model capable of simulating flow, suspended solids, and metals. The model simulates metal transport processes and the associated sorption and desorption processes based on the equilibrium assumption between particulate and dissolved phases of the pollutants. The model can be configured in 1D, 2D, or 3D to simulate different various waterbody types and has built-in capabilities to simulate physical structures such as dams, locks, and spillways.

The Monongahela River from the junction of Tygart Valley and West Fork Rivers to Point Marion lock and dam structure was simulated using the EFDC model. The lock and dam structures were represented using a horizontal two-dimensional modeling grid. The river was divided into 36 segments with three model cells representing the river cross-section. Only one vertical layer was applied since a vertical flow structure is not essential for metals transport processes in this study. A diagram of the model grid is shown in Figure 4-3.

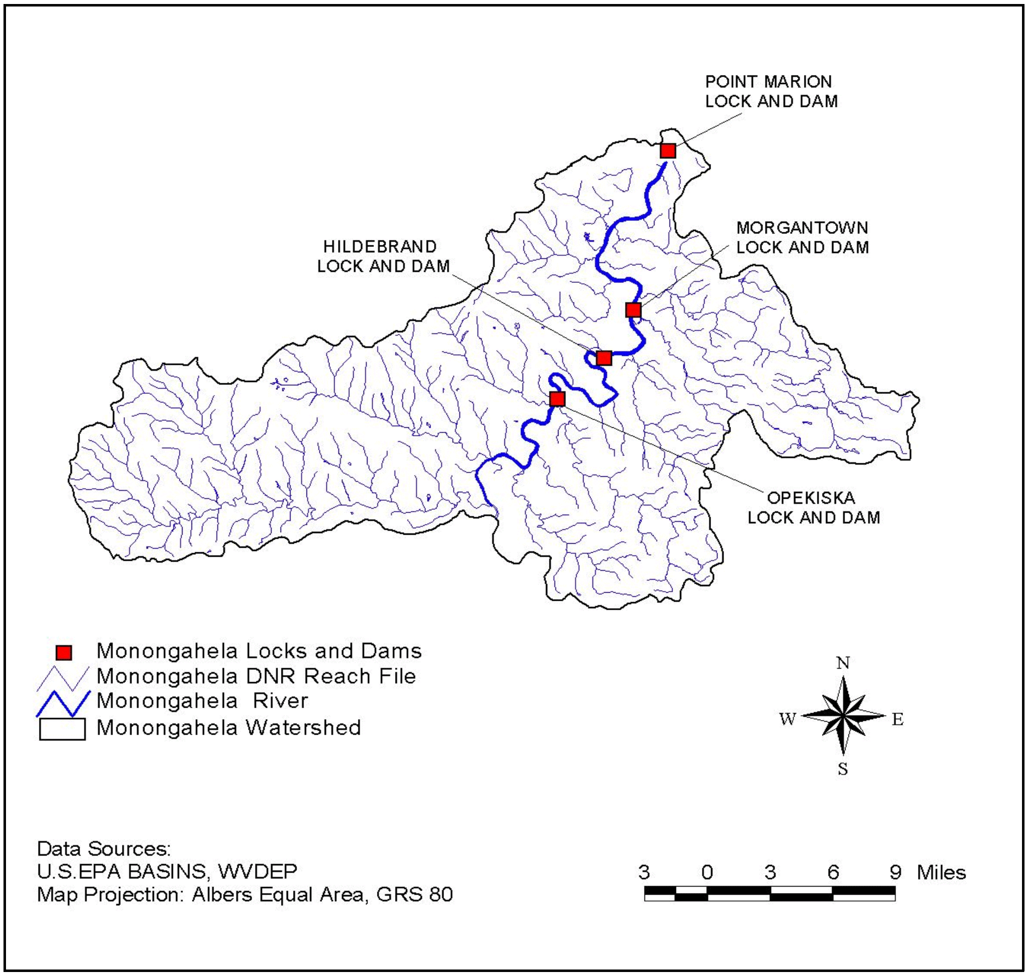


Figure 4-2. Locks and dams on the Monongahela River

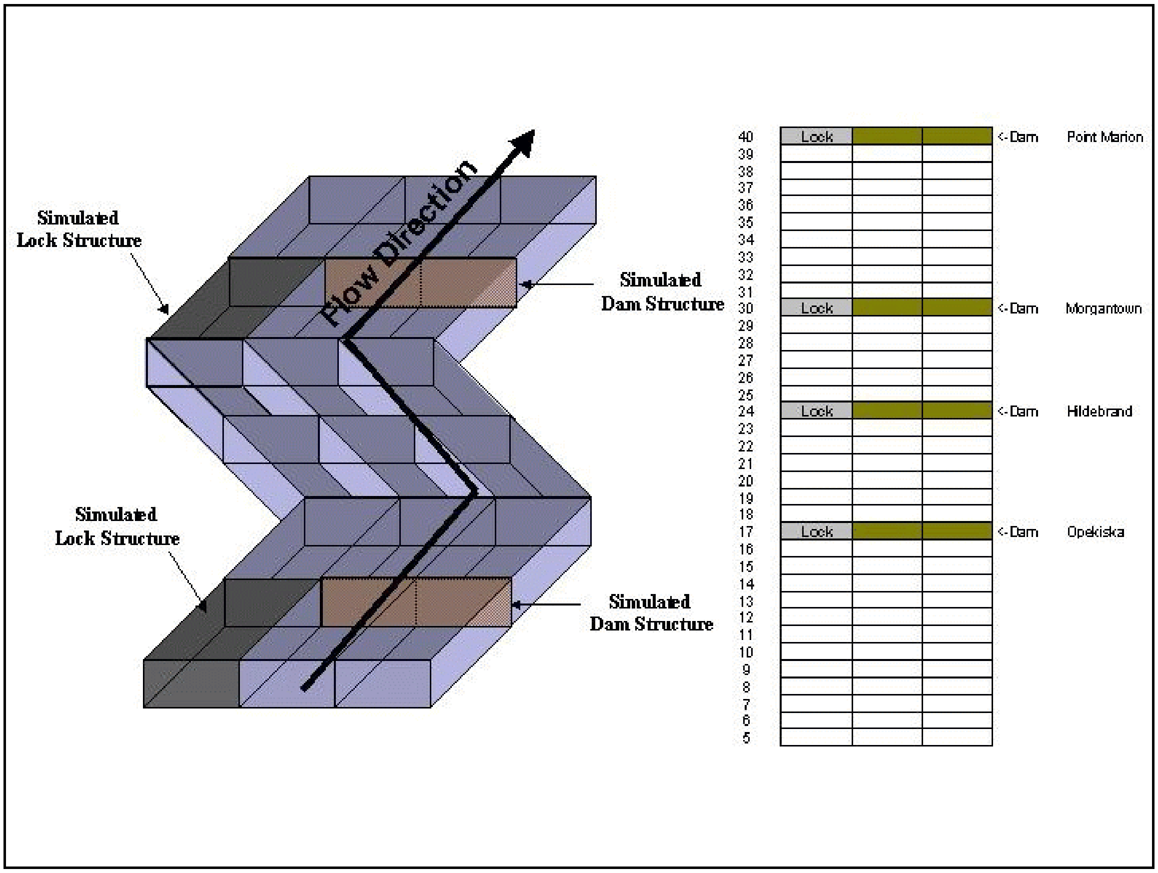


Figure 4-3. EFDC modeling grid for the Monongahela River

Both the left and right model cells were used to represent lock structures, while the middle cell represents the main channel. The four locks were simulated using dam structure functions and the length of the cells range from 300 to 2,700 meters. Smaller cells were used to represent lock structures while the larger cells were used for river segments without structures. The height and width of each dam were specified based on the U.S. Army Corps of Engineers navigation charts and flow within the model was controlled by the spillway function within EFDC. The dimensions of each lock and dam structure is shown in Table 4-5. Since current navigation activities are limited (WVDEP, 2001), the lock structures were configured to be closed and scheduled opening was not simulated.

Table 4-5. Dimesions of the lock and dam structures on the Monongahela River.

Lock and Dam Structure	Length of Dam (ft)	Length of Pool (mi)	Size of Lock (ft)	Lift (ft)	Elevation of pool (above mean sea level)
Point Marion	560	11.2	84 W x 720 L	19.0	797
Morgantown	410	6.0	84 W x 600 L	17.0	814
Hildebrand	530	7.4	84 W x 600 L	21.0	835
Opekiska	366	13.3	84 W x 600 L	22.2	857

Source: U.S. Army Corps of Engineers

EFDC uses rectangular geometry to represent the stream channel. Cross-sectional information for the Point Marion, Morgantown, Hildebrand, and Opekiska pools was obtained from Flood Insurance Study HEC2[1] data files provided by the U.S. Army Corps of Engineers. The HEC2 data was used to derive the cross-sectional area for each model cell and the mean depth of each cell was then computed based on channel width and cross-sectional area.

The MDAS/HSPC watershed model was applied for TMDL development for the upstream watersheds (Tygart Valley and West Fork Rivers). In-stream flow from these modeling efforts, as well as lateral flow from Monongahela watershed model, were used as inputs for the model hydrology. For the watersheds that discharge to more than one model cell, the flows were evenly distributed to discharge into the multiple cells. In cases where multiple watersheds and streams discharged into a single cell, the flows were aggregated to discharge into the cell. The model was calibrated to maintain the mean pool elevation for the Point Marion, Morgantown, Hildebrand, and Opekiska pools. A minimum depth of nine feet was maintained throughout the length of the lock and dam structures.

Pollutant loadings, total aluminum, total iron, and total manganese, from the upstream watersheds were also simulated using MDAS/HSPC. The output from the the watershed model was used as input to the EFDC model. As with flow, if one subwatershed covered more than one EFDC model cell, the loads were evenly distributed among the cells. Permitted mines that discharge directly to the Monongahela mainstem were simulated using MDAS/HSPC to produce precipitation driven discharges. The resulting discharges were included as inputs to the EFDC model.

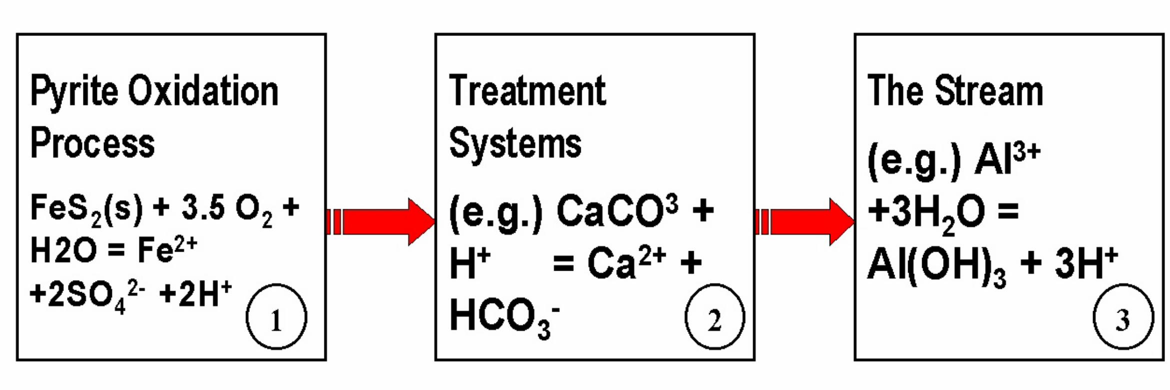
Pollutant transport and the associated sorption and desorption processes were simulated using EFDC. In order to model the sorption and desorption process, suspended solids were also simulated. Since the watershed models did not model suspended solids directly, a constant sediment boundary condition of 50 mg/l, representing the total suspended solids concentration at water quality station 550447, was used to specify sediment input. The settling and resuspension process was fully activated to simulate sediment transport process using a constant partition coefficient of 0.025 in the water.

4.5 pH TMDL Methodology Overview

4.5.1 Overview

Streams affected by acid mine drainage often exhibit high metals concentrations, specifically for iron (Fe), aluminum (Al), and manganese (Mn), along with low pH. The relationship between these metals and pH provides justification for using metals TMDLs as a surrogate for a separate pH TMDL calculation. The following figure shows three representative physical components that are critical to establishing this relationship.

[1]HEC2 is a computer program developed by the Corps of Engineers Hydraulic Engineering Center to calculated water surface profiles.



Note: Several major ions compose the water chemistry of a stream. The cations are usually Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, and H^{+}, and the anions consist of HCO_3^-, CO_3^{2-}, NO_3^-, Cl^-, SO_4^{2-}, and OH^- (Stumm and Morgan, 1996).

Component 1 describes the beginning oxidation process of pyrite (FeS_2) resulting from its exposure to H_2O and O_2. This process is common in mining areas. The kinetics of pyrite oxidation processes are also affected by bacteria, Thiobacillus ferrooxidans, pH, pyrite surface area, crystallinity, and temperature (PADEP, 2000). The overall stoichiometric reaction of the pyrite oxidation process is as follows:

$$FeS_2(s) + 3.75\ O_2 + 3.5\ H_2O \longrightarrow Fe(OH)_3\ (s) + 2SO_4^{2-} + 4H+$$

Component 2 presents an example chemical reaction occurring within a mining treatment system. Examples of treatment systems include wetlands, successive alkalinity-producing systems, and open limestone channels. Carbonate and other bases, e.g., hydroxide, created in treatment systems consume hydrogen ions produced by pyrite oxidation and hydrolysis of metals, thereby increasing pH. The increased pH of the solution will precipitate metals as metal hydroxides. Treatment systems may not necessarily work properly, however, because the removal rate of metals, and, therefore, the attenuation of pH depends on chemical constituents of the inflow, the age of the systems, and physical characteristics of the systems such as flow rate and detention rate (West Virginia University Extension Service, 2000).

After treatment, the focus shifts to Component 3 and the relationship between metals concentrations and pH in the stream. The chemical process that needs to be considered is the hydrolysis reaction of metals in the stream. Component 3 presents an example of this reaction. To estimate pH resulting from chemical reactions occurring in the stream, MINTEQA2, a geochemical equilibrium speciation model for dilute aqueous systems, was used.

4.5.2 MINTEQA2 Application

MINTEQA2 is an EPA geochemical equilibrium speciation model capable of computing equilibrium aqueous speciation, adsorption, gas phase partitioning, solid phase saturation states, and precipitation-dissolution of metals in an environmental or lab setting. The model includes an extensive database of reliable thermodynamic data. The MINTEQA2 model was run using the inputs shown in Table 4-5.

Table 4-5. Input values for MINTEQA2

Species	Input Values (mg/L)
Ca	43.2
Mg	14.5
Na [(a)]	6.3
K [(a)]	2.3
Cl [(a)]	7.8
SO_4	86.6
Fe [(b)]	1.5 and 0.5
Al [(b)]	0.75
Mn [(b)]	1.0
Alkalinity	29.0 (as $CaCO_3$)

[a] source: Livingstone (1963)
[b] allowable maximum concentrations (TMDL endpoints)

Input values for Fe, Al, and Mn were based on TMDL endpoints, maximum allowable limits. The alkalinity value was based on average in-stream concentrations for rivers relatively unimpacted by mining activities in the Monongahela River watershed. Mean observation values were used for the remaining ions requiring input for MINTEQA2. Where observation data were not available, literature values were used for the chemical species. Additionally, the model was set to equilibrium with atmospheric CO_2. Based on the inputs presented, the resultant equilibrium pH was estimated to be 7.98 using the aquatic life standard, 1.5 mg/L total Fe.

The model was also run using typical in-stream metals concentrations found in the vicinity of mining activities, 10 mg/L for total Fe, 10 mg/L for Al, 5 mg/L for Mn, and 3 mg/L as $CaCO_3$ for alkalinity. These inputs resulted in an equilibrium pH of 4.38. Observed data at each water quality station shows various combination of metals and alkalinity values. However, observed pHs are generally low, similar to the model result when the concentration of iron and aluminum are high.

Results from MINTEQA2 imply that pH will be within the West Virginia criterion of equal to or above 6 and equal to or below 9, provided that in-stream metals concentrations simultaneously meet applicable water quality criteria.

4.5.3 Assumptions

The chemical processes generating AMD and the processes to treat AMD are subject to many variables which may or may not be addressed in the chemical equations. Some of the variables are discussed below:

Iron (Fe)

Ferric iron was selected as total iron based on the assumption that the stream will be in equilibrium with the atmospheric oxygen. Because iron exhibits oxidized and reduced states, the redox part of the iron reactions might need to be considered. The reduced state of iron, ferrous iron, can be oxidized to ferric iron through abiotic and biotic oxidation processes in the stream. The first process refers to oxidation by increasing the dissolved oxygen because of the mixing of flow. The other process is oxidation by microbial activity in acidic conditions on bedrock (Mcknight and Bencala, 1990). Photoreduction of hydrous oxides also can increase the dissolved ferrous form. This reaction could increase pH of the stream followed by oxidation and hydrolysis reactions of ferrous iron (Mcknight, Kimball and Bencala, 1988). Since water quality data are limited, the concentration of total Fe was assumed to be constant at 1.5 mg/L, and it was assumed that total Fe increase by photoreduction would be negligent. This assumption could ignore pH changes during daytime.

Sodium (Na), Potassium (K), and Chloride (Cl)

The concentration of Na, K, and Cl can be higher in streams affected by acid mine drainage. These ions are conservative and are not reactive in natural water, however, so it is likely that the pH of the stream would not be affected.

Calcium (Ca), Magnesium (Mg)

These ions may have higher concentrations than the values used for the modeling in this study due to the dissolution of minerals under acidic conditions and the reactions within treatment systems. Increasing the concentrations of these ions in the stream, however, could result in more complex forms with sulfate in the treatment system and in the river. This should not affect pH.

Manganese (Mn)

Manganese oxide (MnO_2) can have a redox reaction with ferrous iron and produce ferric iron (Evangelou, 1998). This ferric iron can go through a hydrolysis reaction and produce hydrogen ions, thereby decreasing pH.

Biological Activities

Biological activities such as photosynthesis, respiration, and aerobic decay can influence the pH of localized areas in the stream. Biological reactions such as the following:

$$CO_2 + H_2O \longleftrightarrow 1/6\ C_6H_{12}O_6 + O_2$$

will assimilate CO_2 during photosynthesis and produce CO_2 during respiration or aerobic decay. Reducing CO_2 levels will increase the pH and increasing CO_2 levels will lower the pH of the water (Langmuir, 1997). It is possible that as a result of these biological activities, the pH standards might be violated even though metals concentrations are below in-stream water quality standards.

Kinetic Considerations

The kinetic aspect of metal reactions in the stream is an important factor that also needs to be considered. For example, Fe and Mn can be oxidized very rapidly if the pH of the solution is 7.5 to 8.5; otherwise, the oxidization process is much slower (Evangelou, 1995). Having a violation of metals concentrations but no pH violation might be a result of the kinetic aspect of the reactions.

4.6 Model Calibration

After the model was configured, calibration was performed at multiple locations throughout the Monongahela watershed. Calibration refers to the adjustment or fine-tuning of modeling parameters to reproduce observations. Model calibration focused on two main areas: hydrology and water quality. Upon completion of the calibration at selected locations, the calibrated dataset containing parameter values for modeled sources and pollutants was complete. This dataset was applied to areas where calibration data were not available.

A significant amount of time-varying monitoring data were necessary to calibrate the model. Available monitoring data in the watershed were identified and assessed for application to calibration, Tables 3a, 3b, and 3c in each of Appendices A-1 through A-12. Only monitoring stations with data representing a range of hydrologic conditions, source types, and pollutants were selected. The locations selected for calibration are presented in Figure 4-2.

4.6.1 Hydrology Calibration

Hydrology was the first model component calibrated. The hydrology calibration involved a comparison of model results to in-stream flow observations at selected locations and the subsequent adjustment of hydrologic parameters. Key considerations included the overall water balance, the high-flow low-flow distribution, storm flows, and seasonal variation.

As shown in Table 3.2, stations with recent historical flow data with extended periods of record are limited to USGS #03061500 on Buffalo Creek at Barrackville, WV, and USGS # 03062215 on Indian Creek at Crown, WV. In order to represent hydrologic variability throughout the watershed, these two USGS stations with daily flow monitoring data were selected for calibration. To represent a range of hydrologic conditions, the model was calibrated for the individual years 1979 and 1989. Flow-frequency curves, temporal comparisons (daily and monthly), and comparisons of high flows and low flows were developed to support calibration. The calibration involved adjustment of infiltration, subsurface storage, evapotranspiration, surface runoff, and interception storage parameters.

After adjusting the appropriate parameters within acceptable ranges, good correlations were found between model results and observed data for the comparisons made. Flow-frequency curves and temporal analyses are presented in Appendix C.

Parameter values were validated for an independent, extended time period (between 1988 and 1998) after calibrating parameters at the stations. Validation involved comparison of model results and flow observations without further adjustment of parameters. The validation comparisons also showed a good correlation between modeled and observed data. Refer to Appendix C for validation results.

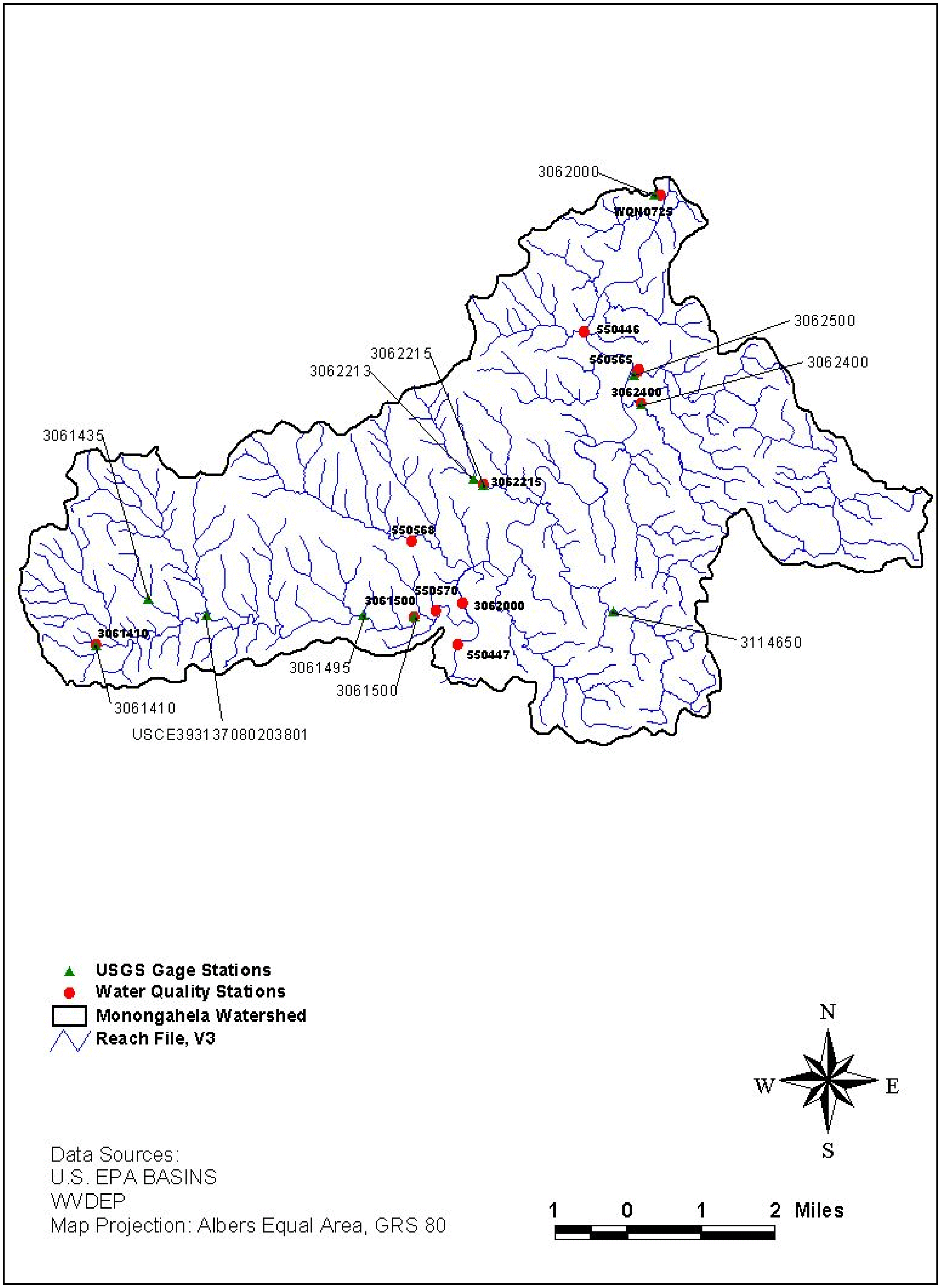


Figure 4-2. Calibration locations used in modeling

4.6.2 Water Quality Calibration

After calibration for hydrology is complete, water quality calibration is performed. In the broadest sense, calibration consists of executing the watershed model, comparing water quality time series output to available water quality observation data, and adjusting water quality parameters within a reasonable range. In order to establish reasonable ranges for use in water quality calibration, DMR and high flow data was analyzed to develop appropriate water quality parameters for active mines, surface, deep, and other mines, but not AML or revoked mines, and barren lands, respectively. Reasonable water quality parameters for AML lands were based on previous watershed modeling experience in areas with AML lands (see *pH and Metals TMDLs for the Tygart Valley River Watershed, 2001*). Parameters for background conditions were based on observed water quality data.

The approach taken to calibrate water quality focused on matching trends identified during the water quality analysis. Daily average in-stream concentration from the model was compared directly to observed data. Observed data were obtained from EPA's STORET database as well as from WV DEP Division of Water Resources, Special Reclamation Group, and Stream Restoration Group. Each group's data were obtained through WVDEP. The objective was to best simulate low flow, mean flow, and storm peaks at representative water quality monitoring stations. Representative stations were selected based on both location (distributed throughout the Monongahela watershed) and loading source type. Results of the water quality calibration are presented in Appendix C.

5.0 Allocation Analysis

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

$$TMDL = \sum WLAs + \sum LAs + MOS$$

In order to develop aluminum, iron, manganese, and pH TMDLs for each of the waterbodies in the Monogahela watershed listed on the West Virginia 303(d) list, the following approach was taken:

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

5.1 TMDL Endpoints

TMDL endpoints represent the in-stream water quality targets used in quantifying TMDLs and their individual components. Different TMDL endpoints are necessary for aluminum, iron, manganese, and pH. West Virginia's numeric water quality criteria for aluminum, iron, manganese, and pH (identified in Section 2) and an explicit margin of safety (MOS) were used to identify endpoints for TMDL development.

5.1.1 Aluminum, Iron, and Manganese

The TMDL endpoint for aluminum was selected as 712.5 ug/L (based on the 750 ug/L criteria for aquatic life minus a 5 percent MOS). The endpoint for iron was selected as 1.425 mg/L (based on the 1.5 mg/L criteria for aquatic life minus a 5 percent MOS). The endpoint for manganese was selected as 0.95 mg/L (based on the 1.0 mg/L criteria for human health minus a 5 percent MOS).

Components of the TMDLs for aluminum, iron, and manganese are presented in terms of mass per time for nonpoint sources and mass per volume for point sources in this report.

5.1.2 pH

The water quality criteria for pH requires it to be above 6 and below 9 (inclusive). In the case of acid mine drainage, pH, is not a good indicator of the acidity in a waterbody and can be a misleading characteristic. Water with near neutral pH (~7) but containing elevated concentrations of dissolved ferrous (Fe^{2+}) ions can become acidic after oxidation and precipitation of the iron (PADEP, 2000). Therefore, a more practical approach to meeting the water standards of pH is to use the concentration of metal ions as a surrogate for pH. Through reducing in-stream metals, namely aluminum and iron, to meet water quality criteria (or TMDL endpoints), it is assumed that the pH will result in meeting the WQS. This assumption is based on the application of MINTEQA2, a geochemical equilibrium speciation model, to aqueous systems representative of waterbodies in the Monongahela watershed. By inputting into the model the dissolved concentrations of metals, a pH value can be predicted. Refer to Section 4.4 for a detailed description of the modeling.

5.1.3 Margin of Safety

A five percent explicit MOS was used to account for uncertainties during the TMDL development process. For example, pollutant loading from unidentified nonpoint sources could not be characterized and therefore were not assigned LAs. In addition to the five percent explicit MOS, an implicit MOS was included in TMDL development through application of a dynamic model for simulating daily loading over a wide range of hydrologic and environmental conditions, and through the use of conservative assumptions in model calibration and scenario development. For example, long-term water quality monitoring data were used for model calibration. While these data represented actual conditions, they were not continuous time series and may not have captured the full range of in-stream conditions that occurred during the simulation period. Furthermore, TMDL conditions were evaluated using continuous time series model output, which allowed for an additional MOS.

5.2 Baseline Conditions

The calibrated model provided the basis for performing the allocation analysis. The first step in this analysis involved simulation of baseline conditions. Baseline conditions represent existing nonpoint source loading conditions and permitted point source discharge conditions. The baseline conditions allow for an evaluation of in-stream water quality under the "worst currently allowable" scenario.

The model was run for baseline conditions using hourly precipitation data from January 1, 1987 through December 31, 1992. Predicted in-stream concentrations of aluminum, iron, and manganese for the impaired waterbodies in the Monongahela watershed were compared directly to the TMDL endpoints. This comparison allowed evaluation of the expected magnitude and frequency of exceedances under a range of hydrologic and environmental conditions, including dry periods, wet periods, and average periods. Figure 5-1 presents the annual rainfall totals for the years 1970 through 2000 at the Terra Alta weather station. Precipitation data from 1987 through 1992 was selected to generate baseline conditions for Monongahela watershed. Although Figure 5.1 shows higher total annual rainfall for 1996 compared to 1989, higher intensify rainfall events occurred in 1989. In order to address the potential critical flow conditions for the targeted pollutants, the period of 1987 to 1992 was selected.

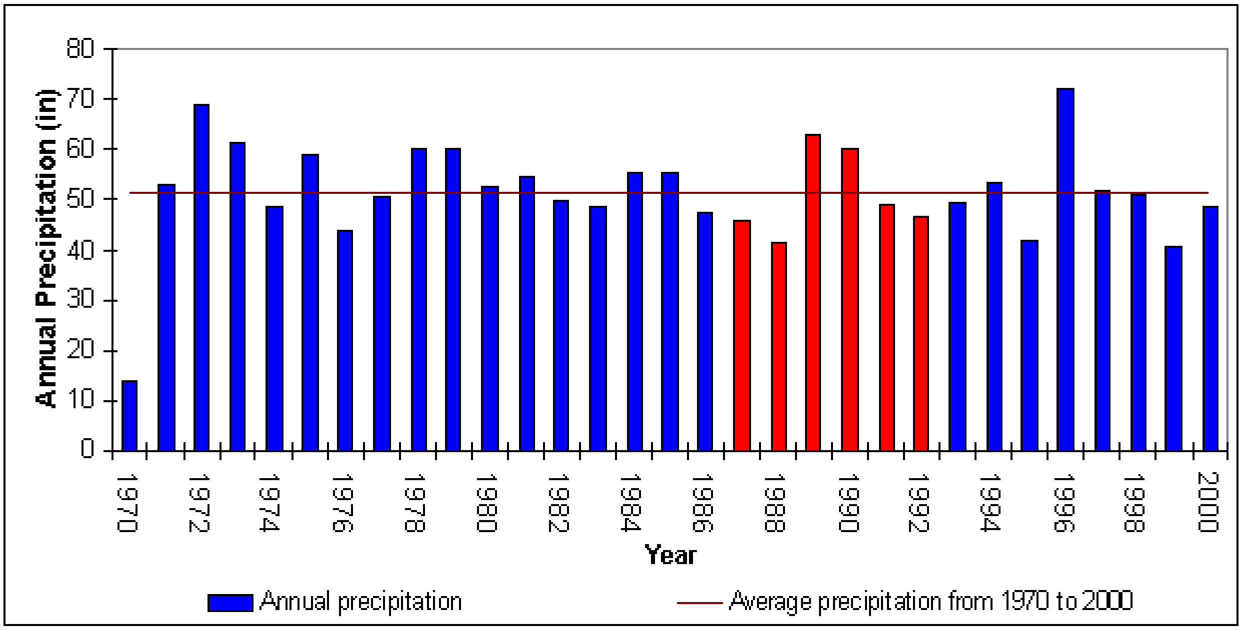


Figure 5-1. Annual precipitation for Terra Alta, WV (the red shows the modeling periods)

Permitted conditions for mines were represented using precipitation-driven flow estimations and the metals concentrations presented in Table 5-1.

Table 5-1. Metals concentrations used in representing permitted conditions for mines

Pollutant	Technology-based Permits	Water Quality-based Permits
Aluminum, total	4.3 mg/L (assumed for "report only")	0.75 mg/L
Iron, total	3.2 mg/L	1.5 mg/L
Manganese, total	2.0 mg/L	1.0 mg/L

5.3 Source Loading Alternatives

Simulation of baseline conditions provided the basis for evaluating each stream's response to variations in source contributions under virtually all conditions. This sensitivity analysis gave insight into the dominant sources and how potential decreases in loads would affect in-stream metals concentrations. For example, loading contributions from abandoned mines, permitted facilities, and other nonpoint sources were individually adjusted and in-stream concentrations were observed.

Multiple scenarios were run for the impaired waterbodies. Successful scenarios were those that achieved the TMDL endpoints under all conditions for aluminum, iron, and manganese through comparison of model results for the modeling period. Exceedances for aluminum and iron were allowed once every three years. The averaging period was taken into consideration during these assessments, e.g., a four-day average was used for iron, daily average for aluminum. In general, loads contributed by abandoned mines and revoked mines were reduced first, because they generally had the greatest impact on in-stream concentrations. If additional load reductions were required to meet the TMDL endpoints, then subsequent reductions were made in point source (permitted) contributions.

5.4 TMDLs and Source Allocations

A top-down methodology was followed to develop the TMDLs and allocate loads to sources. Headwaters were analyzed first, because their impact frequently had a profound effect on down-stream water quality. In impaired subwatersheds, loading contributions were reduced to the extent necessary to ensure compliance with instream criteria, and the loading associated with that condition was transferred to downstream subwatersheds. Conversely, where MDAS indicated that the baseline condition was compliant with water quality criteria, the loading associated with the baseline condition was transferred to downstream subwatersheds. The required headwater reductions often led to downstream water quality improvements, effectively decreasing necessary loading reductions from downstream sources.

In some situations, reductions in sources contributing to unlisted stream segments have been determined necessary to ensure universal compliance with water quality criteria in the watershed. Recent water quality data is not available for all streams in the watershed and MDAS is the best technical tool available to determine if a particular permit is protective of water quality criteria. Other situations have been encountered where recent water quality data indicates that a particular stream segment is not impaired, yet the TMDL imposes point source wasteload allocations that represent a reduction of existing permit limitations. For example, Camp run, which flows through SWS 2 and SWS 4, is listed on West Virginia's 1998 Section 303(d) list for pH and metals. A headwater tributary (SWS3) that flows into Camp run is not listed on the Section 303(d) list. Under baseline conditions, a load reduction for total manganese was required in order to achieve compliance with instream water quality criteria in Camp Run. Certain permittees that are currently achieving discharge quality that is better than required by their permit may need to maintain such improved performance in order for the receiving water to consistently meet standards.

The general allocation philosophy used in this TMDL is further described as follows:

- Pollutant reductions were not required of non-mining point or nonpoint sources. Non-mining point sources in this watershed do not discharge significant amounts of aluminum, iron and manganese. The model predicts that, in the absence of other sources, the pollutants contributed by non-mining nonpoint sources (forest, agriculture, urban) do not cause water quality criteria violation.

- Pollutant reductions of mining nonpoint sources (AML and revoked permits) were required first, to the extent necessary to achieve instream compliance or to the extent expected to be reasonably achievable. Table 5-2 shows that AML and revoked permit loads were reduced to a value that is considered achievable.

- Pollutant reductions from mining point sources were required only if mining nonpoint sources are not present in the subwatershed, or if the reduction of existing mining nonpoint sources was inadequate to achieve instream compliance.

Table 5-2. Source Reduction (AML) for SWS 201

Parameter	Landuse	Total Area (acres)	Base Load (lb/yr)	Base Unit Area Loading (lb/ac/yr)	Allocated Load (lb/yr)	Allocated Unit Area Loading (lb/ac/yr)
Aluminum	Forest	1887.7	1,170	0.62	1,170	0.62
Aluminum	AML	121.3	251,790	2,075.8	252	2.08
Iron	Forest	1887.7	3,001	1.59	3,001	1.59
Iron	AML	121.3	153,265	1,263.5	153	1.26
Manganese	Forest	1887.7	529	0.28	529	0.28
Manganese	AML	121.3	14,564	120.1	291	2.40

This methodology ensures water quality criteria compliance in all streams in the watershed, targets pollutant reductions from the primary causative sources of impairment, and minimizes the impact to existing point sources in the watershed.

The TMDLs for the Monongahela watershed were determined on a subwatershed basis for each of the 12 defined regions.

Once source allocations were made to the upstream watersheds, the EFDC model was run for baseline conditions for the period of January 1, 1987 through December 31, 1992. The EFDC model was run using the outputs from the watershed models under TMDL conditions (see Section 4.5). As in the watershed modeling process, discharges from permitted mine were represented in the model at permit limits. In-stream pollutant concentrations in the Monongahela mainstem were then evaluated against the appliciable water quality criteria. Figures 2-2 through 2-4 of Appendix A-12 show the results of the EFDC simulations at three locations along the Monongahela River mainstem. Under the TMDL scenarios of Tygert River , West Fork River, and tributaries of Monongahela, the concentration of each metals along the mainstem are consistently under the West Virginia's water quality standard as shown in the figures.

5.4.1 Wasteload Allocations (WLAs)

Waste load allocations (WLAs) were made for all permitted facilities except for limestone quarries (quarries are not permitted to discharge metals) and those with a completely released or Phase 2 released classification which were modeled as pasture. For TMDL purposes these point sources are assumed to be compliant with water quality criteria, since they were assumed to have little potential water quality impact . Loading from revoked permitted facilities was assumed to be a nonpoint source contribution based on the absence of a permittee. [1]

[1] The decision to assign load allocations to abandoned and reclaimed mine lands does not reflect any determination by EPA as to whether there are unpermitted point source discharges within these land uses. In addition, in establishing these TMDLs with mine drainage discharges treated as load allocations, EPA is not determining that these discharges are exempt from NPDES permitting requirements.

The WLA for the Monongahela Power Company for iron is shown in Table 4b, Appendix 12. The "report only" outfalls are recognized as discharging *de minims* waste loads which are accounted for in the TMDL development as part of the background loads. Each of the "report only" outfalls are located in subwatershed where no reductions are required. Although lack of sufficient data prevents quantifying pollutant loads, no reductions in waste loads are required.

The WLAs for aluminum, iron, and manganese are presented in Tables 4a, 4b, and 4c in Appendices A-1 through A-12. The WLAs are presented as annual loads, in terms of pounds per year and as constant concentrations. They are presented on an annual basis, as an average annual load, because they were developed to meet TMDL endpoints under a range of conditions observed throughout the year. Using the WLAs presented, permit limits can be derived using EPA's *Technical Support Document for Water Quality-based Toxics Control* (USEPA, 1991) to find the monthly average discharge concentration. The WLA concentration ranges are as follows: Al: 0.75-4.3 mg/L, Fe:1.5 -3.2 mg/L, Mn: 1.0-2.0 mg/L.

5.4.2 Load Allocations (LAs)

Load allocations (LAs) were made for the dominant source categories, as follows:

- Abandoned mine lands - including abandoned mines, surface and deep, and high walls
- Revoked permits - loading from revoked permitted facilities
- Other nonpoint sources - urban, agricultural, and forested land contributions, loadings from other nonpoint sources were not reduced

The LAs for aluminum, iron, and manganese are presented in Tables 5a, 5b, and 5c for each of Appendices A-1 through A-12. The LAs are presented as annual loads, in terms of pounds per year. They are presented on an annual basis, as an average annual load, because they were developed to meet TMDL endpoints under a range of conditions observed throughout the year. Tables 5-3, 5-4, and 5-5 present the summation of LAs and summation of WLAs for aluminum, iron, and manganese, respectively, for each of the Section 303(d) listed segments.

5.4.3 pH Modeling Results

As described in section 5.1.2, aluminum, iron, and manganese concentrations were input into MINTEQA2 to simulate various scenarios including conditions with metals concentrations meeting water quality standards and conditions in proximity to mining activities. MINTEQA2 was run using the water quality criteria for aquatic life. Based on the inputs, described in more detail in Appendix D, pH was estimated to be 7.98. For the scenario representative of mining areas, typical in-stream metals concentrations were used, and pH was estimated to be 4.38. Results from MINTEQA2 imply that pH will meet the West Virginia pH criteria of above 6 and below 9 if metals concentrations meet water quality criteria.

5.4.4 Seasonal Variation

A TMDL must consider seasonal variation in the derivation of the allocation. For the Monongahela River watershed metals TMDLs, seasonal variation was considered a daily simulation. By using continuous simulation by modeling over a period of several years, seasonal hydrologic and source loading variability was inherently considered. The metals concentrations simulated on a daily time step by the model were compared to TMDL endpoints. An allocation which meets these endpoints throughout the year was developed.

Table 5-3. Load and waste load allocations for aluminum

Region	Stream Name	List ID	LAs (lbs/yr)	WLAs (lbs/yr)	TMDL (lbs/yr)	MOS (lbs/yr)
1	Cobun Creek	M-9	4409	0	4641	232
2	Joes Run	M-23-R	396	49	468	23
2	Mod Run	M-23-K	1327	308	1722	86
2	Whetstone Run	M-23-Q	1327	308	1722	86
2	Llewellyn Run	M-23-O-3-	776	561	1408	70
2	Fleming Fork	M-23-N-1	722	722	1520	76
2	Plum Run	M-23-I	4180	1031	5485	274
2	Pyles Fork	M-23-O	14811	5749	21643	1082
2	Buffalo Creek	M-23	65490	18750	88673	4434
2	Dunkard Mill Run	M-23-E	8396	0	8838	442
2	Finchs Run	M-23-B	2216	0	2333	117
3	SUGAR RUN	M-22-K	751	692	1519	76
3	ROBINSON RUN	M-22-C	4637	0	4881	244
4	Indian Creek	M-17	67,066	44,540	117,480	5,874
5	Mays Run	M-10-E	1593	301	1993	100
5	Owl Creek	M-10-D	4136	332	4703	235
5	Booths Creek	M-10	13277	2808	16931	847
5	UT#2/Booths Run	M-10-F	339	0	356	18
6	Deckers Creek	M-8	86413	11224	102776	5139
6	Kanes Creek	M-8-I	2603	105	2850	143
6	Laurel Run	M-8-H	4059	180	4462	223
6	Dillan Creek	M-8-G	2767	998	3963	198
6	UT#2/Deckers CK	M-8-A.7	1618	0	1703	85
6	Hartman Run	M-8-O.5	1764	0	1857	93
6	Slabcamp Run	M-8-F	41877	0	44081	2204
6	Glady Run	M-8-D	631	0	664	33
7	Dents Run	M-7	6468	14308	21869	1093
7	UT#2 Dents Run	M-7-C	670	0	705	35
8	Scotts Run	M-6	6517	7037	14268	713
9	UT#1/Robinson Run	M-4-B	385	58	466	23
9	Crafts Run	M-4-A	753	58	854	43
9	Robinson Run	M-4	3366	12204	16389	819
10	West Run	M-3	11165	0	11752	588
11	Brand Run	M-11	2847	62	3062	153
11	Parker Run	M-20	1206	115	1391	70
11	Birchfield Run	M-15	861	356	1282	64
11	Flaggy Meadow Run	M-14	1849	21085	24141	1207
11	Camp Run	M-2.1	2066	0	2175	109
11	UT@Montana/Mon Rv	M-20.2	581	0	612	31
11	UT@Millersville/Mon	M-25.9	732	0	771	39
11	Laurel Run/Mon Rv	M-2.7	1219	0	1283	64
11	UT@Bakers Ridge/Mon	M-2.6	674	0	709	35
11	Pharaoh Run	M-21	3484	0	3668	183
12	Monongahela River	M	306555	170050	501690	25084

Table 5-4. Load and waste load allocations for iron

Region	Stream Name	List ID	LAs (lbs/yr)	WLAs (lbs/yr)	TMDL (lbs/yr)	MOS (lbs/yr)
1	Cobun Creek	M-9	17325	0	18237	912
2	Joes Run	M-23-R	2372	43	2542	127
2	Fleming Fork	M-23-N-1	2839	45	3036	152
2	Mod Run	M-23-K	7875	459	8773	439
2	Whetstone Run	M-23-Q	7875	459	8773	439
2	Llewellyn Run	M-23-O-3-	4712	772	5773	289
2	Plum Run	M-23-I	24456	772	26556	1328
2	Pyles Fork	M-23-O	50411	4635	57943	2897
2	Buffalo Creek	M-23	226849	19424	259235	12962
2	Dunkard Mill Run	M-23-E	19475	0	20500	1025
2	Finchs Run	M-23-B	6506	0	6849	342
3	SUGAR RUN	M-22-K	2713	1348	4275	214
3	ROBINSON RUN	M-22-C	17889	0	18831	942
4	Indian Creek	M-17	284,781	50,258	352,673	17,634
5	Mays Run	M-10-E	4183	224	4639	232
5	Owl Creek	M-10-D	8350	247	9049	452
5	Booths Creek	M-10	29655	2464	33810	1690
5	UT#2/Booths Run	M-10-F	731	0	770	38
6	Deckers Creek	M-8	162079	6604	177561	8878
6	Kanes Creek	M-8-I	7844	78	8339	417
6	Laurel Run	M-8-H	16829	166	17889	894
6	Dillan Creek	M-8-G	14211	767	15766	788
6	UT#2/Deckers CK	M-8-A.7	6386	0	6722	336
6	Hartman Run	M-8-O.5	5811	0	6117	306
6	Slabcamp Run	M-8-F	7053	0	7424	371
6	Glady Run	M-8-D	2661	0	2801	140
7	Dents Run	M-7	28278	18442	49179	2459
7	UT#2 Dents Run	M-7-C	1198	0	1261	63
8	Scotts Run	M-6	36514	11693	50744	2537
9	UT#1/Robinson Run	M-4-B	2095	82	2292	115
9	Crafts Run	M-4-A	4812	82	5151	258
9	Robinson Run	M-4	19871	24868	47094	2355
10	West Run	M-3	21165	0	22279	1114
11	Parker Run	M-20	2446	150	2732	137
11	Brand Run	M-11	5956	154	6432	322
11	Birchfield Run	M-15	2065	755	2968	148
11	Flaggy Meadow Run	M-14	8423	42189	53276	2664
11	Camp Run	M-2.1	5597	0	5891	295
11	UT@Montana/Mon Rv	M-20.2	2240	0	2358	118
11	UT@Millersville/Mon	M-25.9	1513	0	1592	80
11	Laurel Run/Mon Rv	M-2.7	2485	0	2615	131
11	UT@Bakers Ridge/Mon	M-2.6	1351	0	1422	71
11	Pharaoh Run	M-21	11704	0	12320	616
12	Monongahela River	M	939826	207043	1207230	60362

Table 5-5. Load and waste load allocations for manganese

Region	Stream Name	List ID	LAs (lbs/yr)	WLAs (lbs/yr)	TMDL (lbs/yr)	MOS (lbs/yr)
1	cobun Creek	M-9	1700	0	1790	89
2	Joes Run	M-23-R	149	27	27	27
2	Mod Run	M-23-K	501	287	830	41
2	Whetstone Run	M-23-Q	501	287	830	41
2	Llewellyn Run	M-23-O-3-	375	483	903	45
2	Plum Run	M-23-I	2408	483	3044	152
2	Fleming Fork	M-23-N-1	180	600	821	41
2	Pyles Fork	M-23-O	5789	2899	9145	457
2	Buffalo Creek	M-23	28415	14421	45091	2255
2	Dunkard Mill Run	M-23-E	2938	0	3093	155
2	Finchs Run	M-23-B	1586	0	1669	83
3	SUGAR RUN	M-22-K	457	808	1332	67
3	ROBINSON RUN	M-22-C	5150	0	5421	271
4	Indian Creek	M-17	48,255	21,290	73,205	3,660
4	Little Indian Cree	M-17-A	16,135	10,937	28,497	1,425
5	Mays Run	M-10-E	1115	140	1321	66
5	Owl Creek	M-10-D	1404	154	1640	82
5	Booths Creek	M-10	8168	1320	9987	499
5	UT#2/Booths Run	M-10-F	198	0	209	10
6	Deckers Creek	M-8	43640	7212	53528	2676
6	Kanes Creek	M-8-I	2775	49	2973	149
6	Laurel Run	M-8-H	4621	151	5023	251
6	Dillan Creek	M-8-G	4169	516	4931	247
6	UT#2/Deckers CK	M-8-A.7	2293	0	2414	121
6	Hartman Run	M-8-O.5	1933	0	2035	102
6	Slabcamp Run	M-8-F	2164	0	2278	114
6	Glady Run	M-8-D	706	0	744	37
7	Dents Run	M-7	7969	14577	23732	1187
7	UT#2 Dents Run	M-7-C	496	0	522	26
8	Scotts Run	M-6	7715	7246	15748	787
9	UT#1/Robinson Run	M-4-B	386	51	460	23
9	Crafts Run	M-4-A	424	51	500	25
9	Robinson Run	M-4	2828	8311	11725	586
10	West Run	M-3	7525	0	7921	396
11	Parker Run	M-20	196	52	261	13
11	Brand Run	M-11	1774	82	1954	98
11	Birchfield Run	M-15	310	471	822	41
11	Flaggy Meadow Run	M-14	3284	28112	33048	1652
11	Camp Run	M-2.1	1200	0	1263	63
11	UT@Montana/Mon Rv	M-20.2	724	0	763	38
11	UT@Millersville/Mon	M25.9	758	0	798	40
11	Laurel Run/Mon Rv	M-2.7	857	0	903	45
11	UT@Bakers Ridge/Mon	M-2.6	167	0	176	9
12	Monongahela River	M	172889	127780	316494	15825

5.4.5 Future Growth

These Monongahela River watershed TMDLs do not include specific future growth allocations to each subwatershed. Because of the general allocation philosophy used in this TMDL, such allocations would be made at the expense of active mining point sources in the watershed. However, the absence of specific future growth allocations does not prohibit new mining in the subwatersheds where the in-stream water quality is at the water quality criteria for the allocation scenario. Future growth could occur in the subwatershed under the following scenarios:

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

2. Remining could occur without a specific allocation to the new permittee, provided that the requirements of existing State remining regulations are achieved. Remining activities are viewed as a partial nonpoint source load reduction from Abandoned Mine Lands.

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

5.4.6 Remining and Water Quality Trading

It is also possible that the TMDL may be refined in the future through remodeling. Such refinement may incorporate new information and/or to the redistribute pollutant loads. Trading may provide an additional opportunity for future growth, contingent upon the State's development of a statewide or watershed-based trading program.

6.0 Reasonable Assurance

Two primary programs that provide reasonable assurance for maintenance and improvement of water quality in the watershed are in effect. The WVDEP's efforts to reclaim abandoned mine lands, coupled with its duties and responsibilities for issuing NPDES permits, will be the focal points in water quality improvement.

Additional opportunities for water quality improvement are both ongoing and anticipated. Historically, a great deal of research into mine drainage has been conducted by scientists at West Virginia University, the West Virginia Division of Natural Resources, the United States Office of Surface Mining, the National Mine Land Reclamation Center, the National Environmental Training Laboratory and many other agencies and individuals. Funding from EPA's 319 Grant program has been used extensively to remedy mine drainage impacts. These many activities are expected to continue and result in water quality improvement.

6.1 Reclamation

Two distinct units of WVDEP reclaim land and water resources impacted by abandoned mines. The Office of Abandoned Mine Lands and Reclamation remedies eligible sites under Title IV of the Surface Mining Control and Reclamation Act of 1977. The Division of Mining and Reclamation's Special Reclamation Program remedies sites where operating permits have been revoked and/or performance bonds have been forfeited. Funding of the Office of Abandoned Mine Lands and Reclamation is derived from a federal tax on coal producers. The Special Reclamation Program is funded by the Special Reclamation Fund, which has primary sources of income from civil penalties, forfeited bonds, and a tax on all coal produced.

A description of the operating procedures and accomplishments of each program follows.

6.1.1 Office of Abandoned Mine Lands and Reclamation

Title IV of the Surface Mining Control and Reclamation Act (Public Law 30 U.S.C. " 1231-1243) is designed to help reclaim and restore coal mine areas abandoned prior to August 3, 1977, throughout the country. The AML Program supplements existing state programs and allows the state of West Virginia to correct many abandoned mine-related problems that would otherwise not be addressed.

The major purpose of the AML Program is to reclaim and restore abandoned mine areas so as to protect the health, safety, and general welfare of the public and the environment. The AML Program corrects abandoned mine-related problems in accordance with the prioritization process specified in Public Law 30 U.S.C. ' 1233.

Priorities:

- <u>Priority One</u> : The protection of public health, safety, general welfare, and property from extreme danger of adverse effects related to coal mining practices.

- <u>Priority Two</u>: The protection of public health, safety, and general welfare from adverse effects related to coal mining practices.

- Priority Three: The restoration of the environment, including the land and water resources that were degraded by adverse effects related to coal mining practices. This restoration involves the conservation and development of soil, water (not channelization), woodland, fish and wildlife, recreational resources, and agricultural productivity.

Priority One and Two problem areas include unsafe refuse piles, treacherous highwalls, pollution of domestic water supplies from mine drainage, mine fires, subsidence, and other abandoned mine-related problems.

The AML Program is now also focused on Priority Three problem areas and on treating and abating water quality problems associated with abandoned mine lands. By recognizing the need to protect and, in many cases, improve the quality of the state's water resources from the impacts of mine drainage pollution from abandoned coal mines, coordinated efforts are now being employed to deal with this nonpoint source pollution problem.

Although OAML&R has been actively involved in the successful remediation of mine drainage pollution, inadequate funding and the lack of cost-effective mine drainage pollution treatment and abatement technologies have limited water quality improvement efforts. In 1990 the Surface Mining Control and Reclamation Act was amended to include a provision allowing states and tribes to establish an Acid Mine Drainage Treatment and Abatement Program and Fund. States and tribes may set aside up to 10 percent of their annual grant to begin to address abandoned polluted coal mine drainage problems. Money from the Acid Mine Drainage Treatment and Abatement Fund can be used to clean up mine drainage pollution at sites where mining ceased before August 3, 1977, and where no continuing reclamation responsibility can be determined. To qualify and be eligible, qualified hydrologic units or watersheds must be identified and water quality must adversely affect biological resources. A plan must be prepared and presented to the Natural Resources Conservation Service for review and the Office of Surface Mining for approval. Plans that include the most cost-effective treatment and abatement alternatives, the greatest down-stream benefits to the ecosystem, and diverse cooperators and stakeholders, will be the highest priority for approval.

AML&R has created an Acid Mine Drainage Abatement Policy to guide efforts in treating and abating mine drainage pollution. The Policy acts to guide the expenditure of funds to achieve the maximum amount of mine drainage pollution treatment within the boundaries imposed by budgetary and statutory constraints. The goal is to utilize existing technologies and practical economic considerations to maximize the amount of treatment for dollars expended.

The policy includes a holistic watershed characterization and remediation procedure known as the Holistic Watershed Approach Protocol. The Protocol involves diverse stakeholders in the establishing various sampling networks and subsequently generating water quality data that focus remediation efforts. The Protocol is first used to subdivide the watershed into focus areas. More specific data are then generated to allow identification of the most feasible pollution sources to address and the best available pollution abatement technology to apply. The Protocol also includes the establishment of post-construction sampling networks to assess the impacts of remediation efforts. The Protocol is iteratively implemented until all focus areas have been addressed and all feasible pollution abatement technologies have been applied.

Table 6-1 displays the status and costs of abandoned mine land projects occurring within the

Monongahela River watershed.

Table 6-1. Abandoned Mine Land Projects in the Monongahela watershed.

Project	County	Cost	Status
Dillan Creek	Preston	$284,874	Under Construction
Elkins Coal & Cole	Preston	$374,260	Under Construction
National Mine Complex	Monongalia	$818,000	Under Construction
Slab Camp Run #2	Preston	$362,945	In-Design

6.1.2 Special Reclamation Group

When notice of permit revocation is received from the Director, a liability estimate is completed within 60 days of the revocation. The liability estimate notes any special health and safety characteristics of the site and calculates the cost to complete reclamation according to the permit reclamation plan. At sites where acid mine drainage is present, the permit is flagged for water quality characterization and a priority index assigned.

The reclamation plan at all sites includes the application of the best professional judgment to address the site specific problems including acid mine drainage. Any change or modification to the permit reclamation plan is done by or under the supervision of a Registered Professional Engineer. All construction requires application of best management practices to insure quality work and protect the environment.

Prioritization of bond forfeiture sites is consistent with the criteria used in the Abandoned Mine Land and Reclamation (AML&R) program. The criteria, as described below, have been used successfully for many years on abandoned mine areas with similar characteristics to bond forfeiture sites.

<u>**Priority**</u>	**Description**
1.	The highest priority sites are those that entail protection of public health, safety, general welfare, and property from extreme danger. There are relatively few of these types of bond forfeiture sites; however, they are unquestionably first order priorities and receive a ranking of 1.
2.	Second order priority sites are those where public health, safety, welfare, and property values are judged to be threatened. Examples include sites with a high potential for landslides or flooding or the presence of dangerous highwalls, derelict buildings, or other structures.
3a.	Third order priorities comprise the bulk of bond forfeiture sites. Therefore, this ranking level is sub-divided into smaller groupings. The first sub-group is sites that are causing or have a high potential for causing off-site environmental damage to the land and water resources. Such off-site damage would most likely be from heavy erosion, or high loadings of acid mine drainage.
3b.	The second sub-group would include sites that are of a lower priority, but are in close geographic proximity to first or second priority sites. It is more efficient and cost effective to “cluster” projects where possible.

3c. The third sub-group includes sites near high-use public recreation areas and major thoroughfares.

3d. The fourth sub-group includes sites that are nearly fully reclaimed by the operator and only require monitoring of vegetative growth or other parameters. Sites which have a real potential for re-permitting by another operator or reclamation by a third party, will also be placed in this sub-group.

Reclamation construction contracts occur by submittal of a detailed Project Requisition to the State Purchasing Division. All state purchasing policies and procedures are applicable and the contract is awarded to the lowest qualified bidder. Special Reclamation personnel perform inspection and contract management activities through the life of the contract. When all reclamation work is satisfactorily completed, a one-year contract warranty period begins to insure adequate vegetative growth and drainage system operation. Upon completion of the contract warranty period and recommendation of the Regional Supervisor, the permit status is classified as "completed." A completed status removes the liability of the forfeited site and terminates WVDEP jurisdiction and responsibility as a Phase III bond release.

At the sites with AMD, treatment operations are conducted pursuant to the authority granted in the West Virginia Surface Coal Mining and Reclamation Act. Due to funding deficits and regulatory restrictions on the amount of funding that could be applied to water treatment, the Special Reclamation Group historically conducted active treatment operations only at the highest priority bond forfeiture sites (i.e those with the highest potential for significant water quality impact). Recent legislation increased funding for the Special Reclamation Fund and removed restrictions relative to water treatment expenditures. The Special Reclamation plans to abate all impacting AMD from existing Bond Forfeiture sites over the next five years.

6.2 Permitting

NPDES permits in the watershed will be issued, reissued, or modified by the Office of Water Resources in close cooperation with the Office of Mining and Reclamation. Because offices have adjusted permitting schedules to accommodate the state's Watershed Management Framework, implementation of TMDL requirements at existing facilities will generally occur at the time of scheduled permit reissuance. Permits for existing facilities in the Monongahela River watershed are scheduled to be reissued in 2004.

7.0 Monitoring Plan

Follow-up monitoring of the Monongahela River watershed is recommended. Future monitoring can be used to evaluate water quality conditions, changes or trends in water quality conditions, and contribute to an improved understanding of the source loading behavior. The following monitoring activities are recommended for this TMDL.

West Virginia DEP should continue monitoring the impaired segments of the Monongahela River (tributaries) via its established Watershed Management monitoring approach in 2002, 2007 and beyond.

West Virginia DEP should continue monitoring in advance of, during, and after installation of reclamation activities affecting water quality at abandoned mine sites.

West Virginia DEP should consider additional stations and more frequent sampling of water quality in the impaired reaches, and continue to encourage participation by active watershed organizations.

West Virginia DEP should emphasize the use of proper Quality Assurance Quality Control (QA/QC) protocols to avoid potential sample contamination during water sample collection and transfer.

8.0 Public Participation

EPA policy is that there must be full and meaningful public participation in the TMDL development process. Each state must, therefore, provide for public participation consistent with its own continuing planning process and public participation requirements. As a result, it is the intent of the West Virginia DEP to solicit public input by providing opportunities for public comment and review of the draft TMDLs. The public meetings pertaining to the Monongahela River watershed occurred as follows:

The original public informational meeting for the tributaries for the Monongahela River was held April 10, 2001, in Fairmont. The date for establishing the TMDLs was changed to September 30, 2002, to allow new information regarding treatment facilities to be incorporated into the TMDLs and to allow establishment of the West Fork and Monongalela mainstem TMDLs in conjunction with the Monongahela tributary TMDLs.

A 35-day public comment period began on July 22, 2002, and ended on August 26, 2002. WVDEP published notice of the public comment period in the *Times West Virginian*, Fairmont; *Clarksburg Exponent/Telegram*, Clarksburg; and *Dominion Post*, Morgantown, newspapers.

A final public informational meeting was held August 14, 2002, in Bridgeport for the Monongahela and West Fork Rivers TMDLs.

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