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

U.S. Environmental Protection Agency
Region 3
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Executive Summary

The West Fork watershed is located in northern West Virginia and forms part of the Monongahela River watershed. It extends over 880 square miles (569,000 acres) of relatively small valleys and narrow winding ridges ranging from 1,200 to 1,500 feet in elevation, with higher elevations occurring in the southern region of the watershed. The watershed encompasses Harrison county, extends into portions of Marion, Taylor, Barbour, Upshur, and Lewis counties, and borders Doddridge and Wetzel counties. The West Fork river flows north approximately 103 miles from its headwaters in Upshur and Lewis counties, through the City of Weston and the City of Clarksburg, to its confluence with the Tygart River near the City of Fairmont to form the Monongahela River. The West Fork River watershed is dominated by forest and pasture land.

The West Fork watershed is located in the north central coalfields of West Virginia. Historically, coal deposits represented the most economically valuable mineral resource in the West Fork watershed. Coal mining played a significant role in the regional economy from the 1800's until a decline in coal production in the 1970's. As the production of coal mining declined, forestry, agriculture, oil and gas production, as well as sandstone, shale, and limestone extraction have become increasingly important economic factors.

The West Fork river mainstem and 98 additional stream segments in the West Fork watershed are listed on West Virginia’s 1996 and 1998 Section 303(d) lists due to metals and/or pH impairments. The segments were listed based on water quality samples collected by West Virginia Department of Environmental Protections (WVDEP). In addition, the WVDEP identified extensive areas of abandoned mine land (AML) created as coal production declined in this region. The metals and/or pH impairments are attributed to acid mine drainage (AMD) generated by abandoned mine lands. Total Maximum Daily Loads (TMDL) were developed for each of the listed waterbodies in the region of the West Fork watershed.

West Virginia Code of State Rules, Title 46, Series 1 defines total aluminum, iron, manganese, and pH criteria under the Aquatic Life and Human Health use designation categories. The criteria for dissolved zinc is a numeric formula dependent of hardness. The West Fork mainstem is listed as having human health and aquatic life designated uses, while the 98 additional stream segments are listed as having aquatic life designated use.

The West Fork watershed was divided into 17 regions representing hydrologic units, shown in Figure 1-1. Each region was further divided into subwatersheds for modeling purposes. A total of 645 subwatersheds were created for the entire West Fork Watershed. The 17 regions and their respective subwatersheds provided a basis for georeferencing pertinent source information and monitoring data, and for presenting TMDLs. The Mining Data Analysis System (MDAS) was used to represent the source-response linkage in the West Fork watershed for aluminum, manganese, and iron. The MDAS is a comprehensive data management and modeling system that is capable of representing loads from nonpoint and point sources found in the watershed and simulating in-stream processes. The MINTEQ modeling system was used to represent the source-response linkage in the West Fork watershed for pH.

The TMDLs are allocated to Abandoned Mine Land (AML) and Revoked Mines. TMDL endpoints are based on West Virginia's numeric water quality criteria for aluminum, iron, manganese, and pH in conjunction with a five percent explicit margin of safety (MOS). TMDL development for zinc was not necessary, as it was shown that all monitoring samples were meeting the hardness-based zinc criteria. The baseline load, allocated load and percent reduction for aluminum, iron and aluminum for each region are shown in Tables 1-1 to 1-3.

Table 1-1. Aluminum Baseline and Allocated Loads by Region

Region	Baseline Load		Allocated Load		Margin of Safety	Percent Reduction
	LA	WLA	LA	WLA		
1	13,050	3,173	7,436	1,586	451	44%
2	20,784	6,571	14,833	5,188	1,001	27%
3	53,161	1,675	21,760	1,595	1,168	57%
4	101,825	2,137	33,375	534	1,695	67%
5	97,948	2,460	54,160	2,460	2,831	44%
6	62,476	1,584	24,962	1,584	1,327	59%
7	114,340	6,246	55,695	5,199	3,045	50%
8	44,258	2,336	15,282	2,336	881	62%
9	38,186	3,008	21,879	2,838	1,236	40%
10	18,862	-	12,395	-	620	34%
11	15,077	-	9,645	-	482	36%
12	30,524	1,120	17,776	1,120	945	40%
13	3,465	-	3,465	-	173	0%
14	15,959	76	10,301	76	519	35%
15	9,048	-	4,811	-	241	47%
16	9,445	-	9,369	-	468	1%
17	82,205	1,565	54,111	1,565	2,784	34%

Table 1-2. Iron Baseline and Allocated Loads by Region

Region	Baseline Load		Allocated Load		Margin of Safety	Percent Reduction
	LA	WLA	LA	WLA		
1	37,013	2,180	16,518	2,180	935	52%
2	57,107	4,515	33,060	4,515	1,879	39%
3	160,507	1,155	47,739	1,155	2,445	70%
4	324,417	1,469	65,717	1,396	3,356	79%
5	281,063	1,694	117,645	1,694	5,967	58%
6	193,640	1,093	54,151	1,093	2,762	72%
7	337,404	4,305	113,059	4,305	5,868	66%
8	144,242	1,613	38,482	1,613	2,005	73%
9	115,096	2,076	44,793	2,076	2,343	60%
10	56,078	-	25,014	-	1,251	55%
11	41,808	-	19,421	-	971	54%
12	90,681	772	36,133	772	1,845	60%
13	6,800	-	6,800	-	340	0%
14	44,686	52	22,448	52	1,125	50%
15	27,957	-	10,149	-	507	64%
16	19,584	-	19,137	-	957	2%
17	261,276	1,080	103,363	1,080	5,222	60%

Table 1-3. Manganese Baseline and Allocated Loads by Region

Region	Baseline Load		Allocated Load		Margin of Safety	Percent Reduction
	LA	WLA	LA	WLA		
1	8,989	1,421	6,827	1,421	412	21%
2	14,549	2,944	13,591	2,944	827	5%
3	35,024	743	23,094	743	1,192	33%
4	65,849	955	40,286	955	2,062	38%
5	65,117	1,095	53,912	1,095	2,750	17%
6	41,691	703	30,840	703	1,577	26%
7	75,241	2,777	58,252	2,777	3,051	22%
8	28,835	1,034	16,576	1,034	881	41%
9	27,474	1,334	25,702	1,334	1,352	6%
10	13,709	-	13,129	-	656	4%
11	10,973	-	10,808	-	540	2%
12	21,622	498	17,492	498	900	19%
13	3,053	-	3,053	-	153	0%
14	11,996	34	10,467	34	525	13%
15	6,413	-	5,369	-	268	16%
16	8,083	-	8,083	-	404	0%
17	53,764	694	51,275	694	2,598	5%

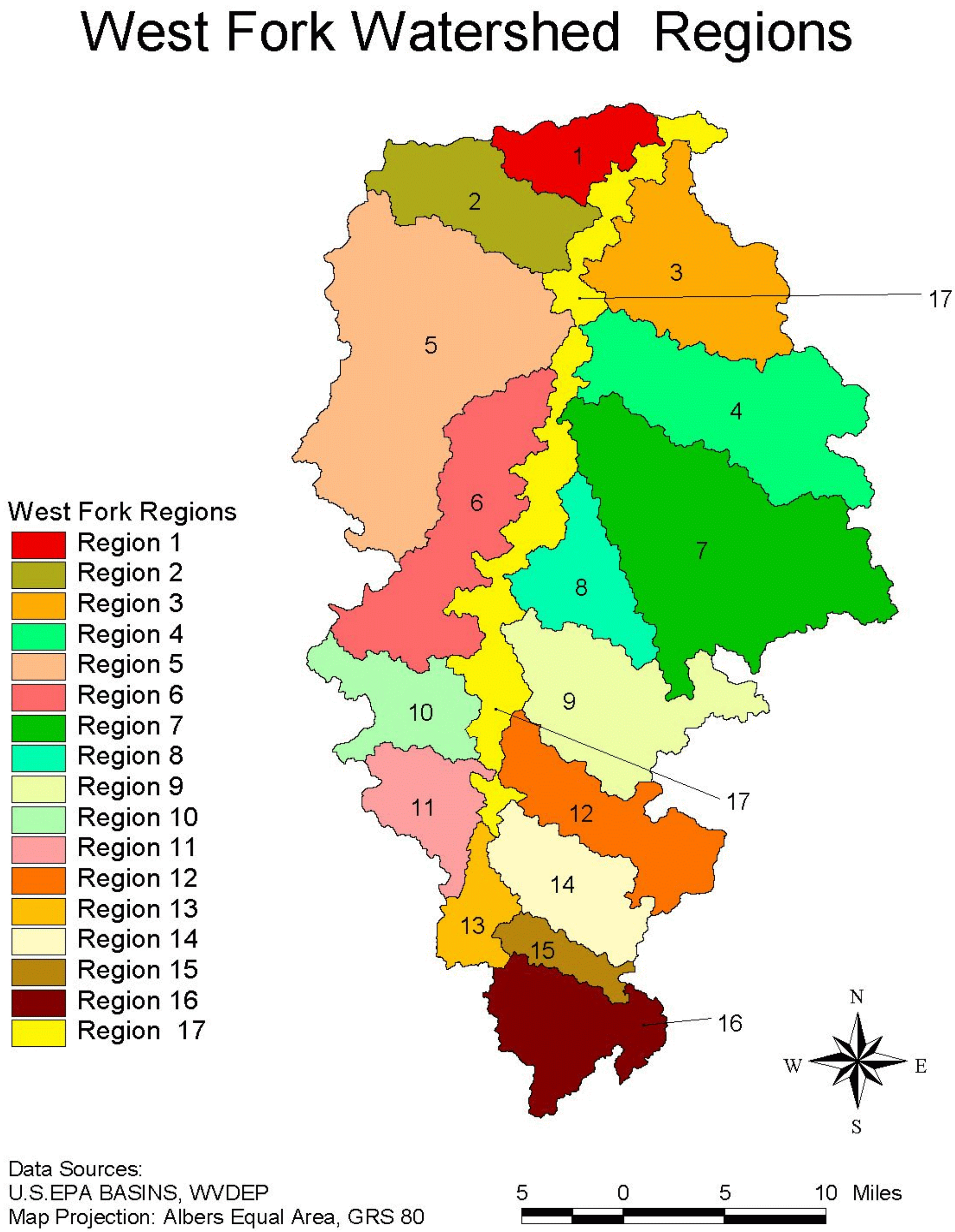


Figure 1-1. West Fork Watershed Regions

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 do not provide for the attainment of water quality standards. To fulfil the consent decree requirements relating to Ohio Valley Environmental Coalition Inc., 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 operative Section 303(d) lists of impaired waterbodies to the extent such TMDLs are not established by the State consistent with the schedule in the consent decreee. 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 almost 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 West Fork River is located in northeastern West Virginia. Its approximately 888 square mile (568,847 acre) drainage area is represented by the West Fork River Watershed (Figure 1-2). The West Fork River basin lies entirely in the Appalachian Plateau Physiographic Providence. From its headwaters in Upshur County, the West Fork River flows in a northern direction through Lewis, Harrison and Marion counties to its confluence with the Tygart Valley River at Fairmont to form the Monongahela River (Figure 1-3) (WVDNR, 1983). The river flows north for approximately 103 miles. The largest tributaries of the West Fork are Tenmile Creek and Elk Creek with drainage areas of 132 and 121 square miles, respectively. Hackers Creek and Simpson Creek are other significant tributaries that enter the West Fork River. The West Fork watershed is comprised of relatively small valleys and narrow winding ridges ranging from 1,200 to 1,500 feet in elevation, with higher elevations occurring in the southern region of the watershed, which drain to an outlet elevation of approximately 850 feet at Fairmont, West Virginia.

The West Fork watershed lies in Marion, Harrison, Taylor, Barbour, Lewis and Upshur counties and is adjacent to Doddridge and Wetzel counties, as illustrated in Figure 1-3. The majority of the population resides in the lower two-thirds of the basin with Weston and Clarksburg as the largest cities. Population estimates (based on 2000 census data) for Weston, Clarksburg and the counties located in and near the basin are given in Table 1-4. Note that only portions of some of these counties lie within the West Fork watershed. Since 1990, the entire region has seen a very slight decline in population (Table 1-4).

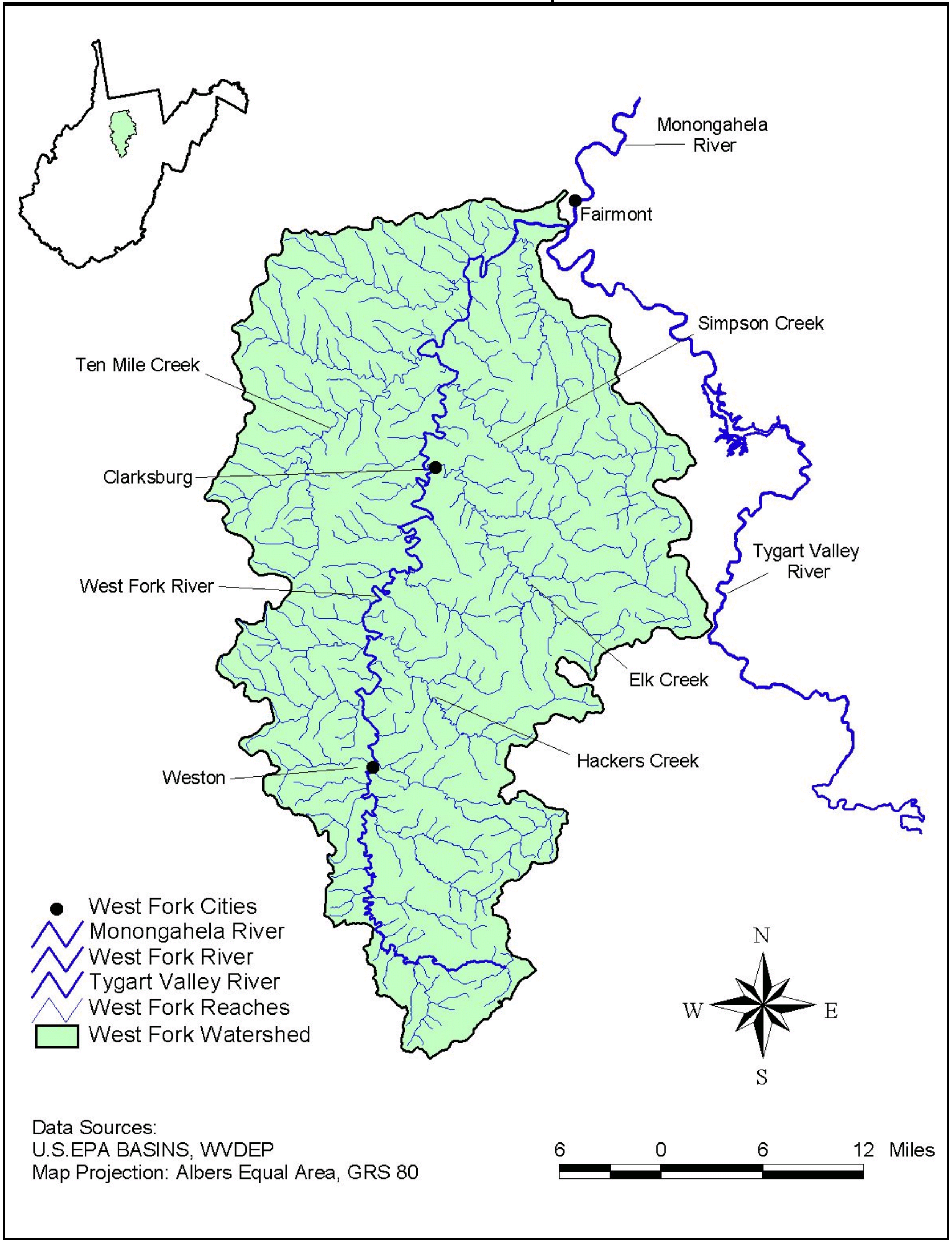


Figure 1-2. Location of the West Fork watershed

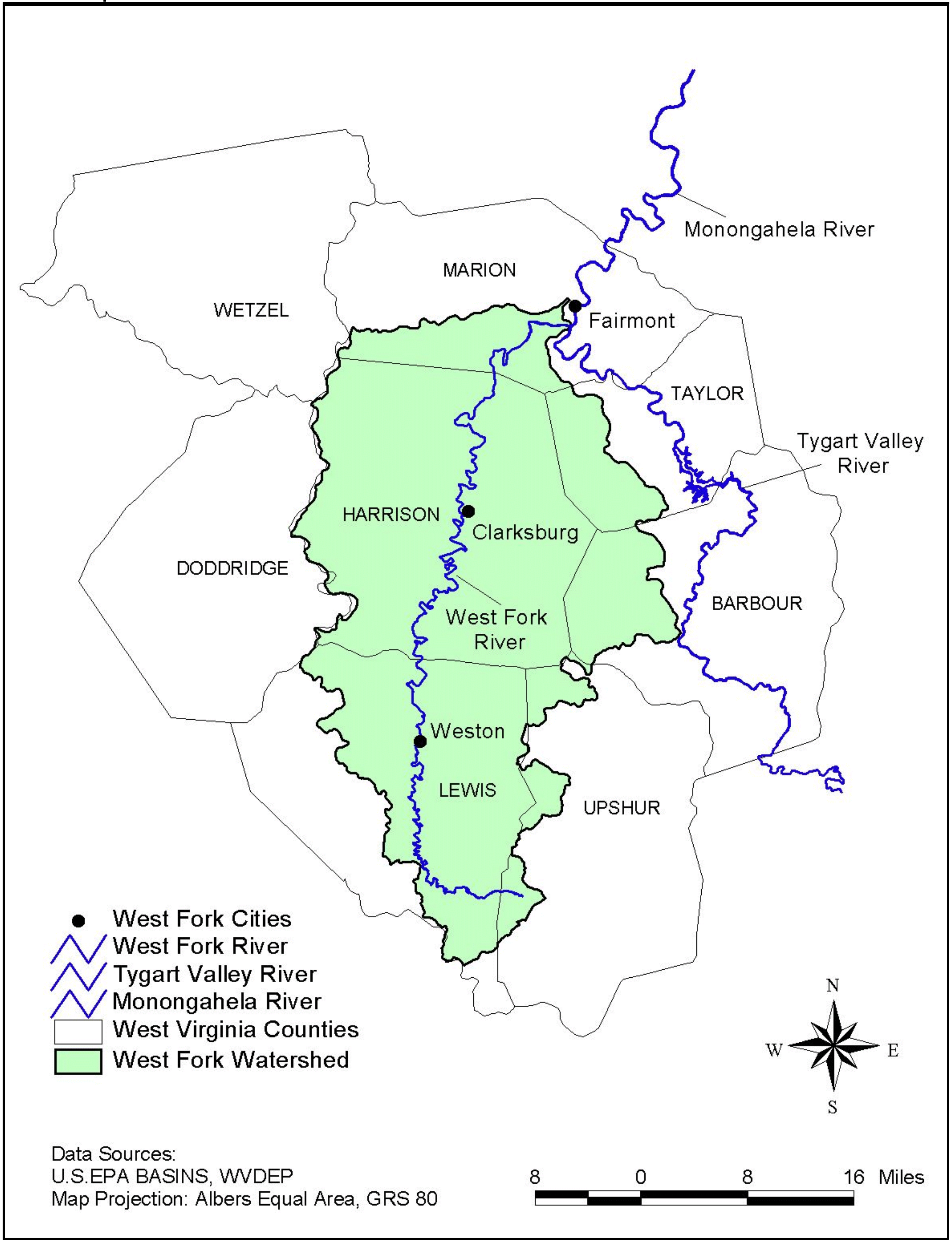


Figure 1-3. Counties in and around the West Fork basin

Table 1-4. Population Estimates in West Fork basin

Location	1990 Population Estimate	2000 Population Estimate	1990-2000 Numeric Population Change	1990-2000 Percent Population Change
State of West Virginia	1,793,477	1,808,344	14867	0.8
Barbour County	15,699	15,557	-142	-0.9
Harrison County	69,371	68,652	-719	-1.0
Lewis County	17,223	16,919	-304	-1.8
Marion County	57,249	56,598	-651	-1.1
Taylor County	15,144	16,089	945	6.2
Upshur County	22,867	23,404	537	2.3
Total of all Counties	**197,553**	**197,219**	**-334**	**-0.02**
City of Clarksburg	18,035	16,743	-1292	-7.2
City of Weston	4,994	4,317	-677	-13.6

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

1.2 Economy

Mining

Historically, coal mining has represented the most economically valuable mineral resource in the West Fork watershed. The basin lies in the north-central coalfields of West Virginia, where coal deposits have 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 (AMD) throughout the West Fork 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 Marion and Harrison counties (WVOMHST, 2002). Extensive mining continued in this region through the 1970s, when coal production declined (WVDEP, 2002). Recent mining has been limited to the Upper Freeport coal seam and constitutes only a small portion (approximately 10 percent) of the total production for the entire state. Table 1-5 presents the total amount of coal produced in 2000.

Table 1-5. Total coal production in West Virginia for 2000

Location	Total Employees	Underground Production (tons)	Surface Production (tons)	Total Production (tons)
State of West Virginia	14,254	109,395,146	59,975,456	169,371,450
Barbour County	151	706,083	37,674	743,757
Harrison County	631	7,030,199	239,269	7,269,468
Lewis County *	NA	NA	NA	NA
Marion County	87	6,000	6,717	12,717
Upshur County	314	2,789,733	138,153	2,927,886
Total of all Counties	1,183	10,532,015	421,813	10,953,828

Source: West Virginia Office of Miners' Health, Safety and Training , 2002
* 2000 data was not available for Lewis County

Forestry

Forestry is another major industry in the West Fork watershed. According to the U.S. Forest Service Forest Inventory and Analysis Database Retrieval System, there are more than 1,050 square miles of forest land (approximately 670,000 acres) in the five counties in and around the West Fork Basin. Nearly all of these acres are held under corporate (timber industry) ownership. Table 1-6 shows the estimated area of forested land (in square miles) for each of the counties in or adjacent to the West Fork basin.

Table 1-6. Forested area in and near the West Fork Basin

County	All_land (sq. Mi.)	Total Forest (sq. Mi.)	Timberland (sq. Mi.)	Nonforest_land (sq. Mi.)
Barbour	333	227	227	105
Harrison	414	240	240	174
Lewis	308	295	295	93
Marion	310	212	212	97
Taylor	187	115	109	72
Upshur	354	260	260	95
Total	**1,598**	**1,055**	**1,049**	**543**

Source: U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis Retrieval System 1996
Forest Inventory and Analysis Retrieval System. Retrieved January, 2002. U.S. Department of Agriculture Forest Service.

Agriculture

Agriculture is also a very important part of the economy in the West Fork watershed. Total number of farms have increased from 2,309 to 2,396 (approximately 8.5 percent) in recent years (Table 1-7). Farms in this region are generally 150 to 200 acres in size and comprise approximately 25 percent of the land use area in the West Fork watershed.

Table 1-7. Agricultural activities in and near the West Fork watershed

County	1997			1987		
	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)
Barbour	437	86,546	198	459	83,174	181
Harrison	601	103,181	172	554	89,467	161
Lewis	364	79,427	215	335	75,434	225
Marion	317	39,350	124	362	41,548	115
Taylor	278	43,697	157	245	41,826	171
Upshur	399	64,282	161	354	60,106	170
Total	**2,396**	**416,483**	**1,027**	**2,309**	**391,555**	**1,023**

Source: US Department of Agriculture National Agricultural Statistics Service, 1997

1.3 Section 303(d) Listed Waterbodies

West Virginia's 1996 and 1998 Section 303(d) lists includes 99 waterbodies in the West Fork watershed because of metals and/or pH impairments. The impaired waterbodies include the mainstem of the West Fork as well as 98 additional stream segments in the watershed, shown in Table 1-8. The pH and metals impairments, which include total iron, aluminum, manganese, and zinc, have been attributed to acid mine drainage (AMD).

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). The chemical reactions of the pyrite generate acidity in water. A synopsis of these reactions is as follows: Exposure of pyrite to air and water causes the pyrite to oxidize. The sulfur component of pyrite is oxidized, releasing dissolved ferrous (Fe^{2+}) ions and also hydrogen (H^+) ions. It is these H^+ ions that 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. A third reaction occurs between the pyrite and the generated ferric (Fe^{3+}) ions, in which more acidity (H^+) is released as well as Fe^{2+} ions, which can then enter the reaction cycle (Stumm and Morgan, 1996).

A separate water quality analysis was performed to further evaluate the zinc impairments in the West Fork River mainstem. Dissolved zinc concentrations in the main stem of the West Fork River were shown not to exceed the hardness-based water quality criteria in Table 1 and Figures 1 and 2 in Appendix B. These findings suggest that the main stem of the West Fork River is not impaired for dissolved zinc and therefore TMDL development for this pollutant is not necessary.

This report presents pH and metals TMDLs for 98 impaired waterbodies in the West Virginia regions of the West Fork watershed. Unnamed Tributary of Simpson Creek (MW-15?) no longer exists as a "water of the State" and therefore TMDL development is not applicable (WVDEP, 2002).

To develop the TMDLs and other pertinent watershed and waterbody information, the West Fork watershed was divided into 17 regions (Figure 1-4), representing hydrologic units. The 17 watershed regions provide a good basis for georeferencing pertinent source information, monitoring data, and for presenting TMDLs. To facilitate hydrologic modeling, the 17 regions were further divided into 645 subbasins. This information is presented in Appendices A-1 through A-17 of this report. The numeric designation for each Appendix A section corresponds to the same numerically identified region of the West Fork watershed, e.g., A-3 corresponds to region 3 of the West Fork watershed.

Table 1-8. West Virginia Section 303(d) Listed Waterbodies in the West Fork Basin

DNR Name	DNR Code	Miles Affected	Human Health	Aquatic Life	Pollutant	Source	Year Listed[A]
West Fork River	M-26	73.00	X	X	Aluminum; Zinc; Iron	Mine Drainage; Metals Tailings	1996 & 1998
U.t.#4@Hutchinson	MW?	0.00		X	pH, Metals	Mine Drainage	1996 & 1998
Browns Run	MW-10	1.00		X	Metals	Mine Drainage	1996 & 1998
Shinns Run	MW-11	6.60		X	pH; Metals	Mine Drainage	1996 & 1998
Robinson Run	MW-12	5.40		X	Metals	Mine Drainage	1996 & 1998
U.t./Robinson Run	MW-12?	0.00		X	Metals	Mine Drainage	1996 & 1998
Pigeon Run	MW-12-A	1.20		X	Metals	Mine Drainage	1996 & 1998
Tenmile Creek	MW-13	26.40		X	Metals	Mine Drainage	1996 & 1998
Jack Run/Tenmile Creek	MW-13.5-A	1.00		X	Metals	Mine Drainage	1996 & 1998
U.t./Tenmile Creek	MW-13?	0.00		X	Metals	Mine Drainage	1996 & 1998
Jones Run	MW-13-A	8.80		X	Metals	Mine Drainage	1996 & 1998
Little Tenmile Creek	MW-13-B	13.00		X	Metals	Mine Drainage	1996 & 1998
Ut#1little Tenmile ck	MW-13-B?	0.00		X	Metals	Mine Drainage	1996 & 1998
Peters Run	MW-13-B-1	1.20		X	Metals	Mine Drainage	1996 & 1998
Bennett Run	MW-13-B-2	2.40		X	pH; Metals	Mine Drainage	1996 & 1998
Laurel Run/ Little Tenmile Creek	MW-13-B-4	2.00		X	Metals	Mine Drainage	1996 & 1998
Elk Creek/Little Tenmile Creek	MW-13-B-6	3.00		X	Metals	Mine Drainage	1996 & 1998
Mudlick Run/Little Tenmile Creek	MW-13-B-9	2.40		X	pH; Metals	Mine Drainage	1996 & 1998
Isaacs Creek	MW-13-C	2.80		X	Metals	Mine Drainage	1996 & 1998
Little Isaac Creek	MW-13-C-1	0.60		X	Metals	Mine Drainage	1996 & 1998
Gregory Run	MW-13-D	2.40		X	Metals	Mine Drainage	1996 & 1998
Katy Lick Run	MW-13-E	2.80		X	Metals	Mine Drainage	1996 & 1998
Rockcamp Run	MW-13-F	6.80		X	Metals	Mine Drainage	1996 & 1998
Little Rockcamp Run	MW-13-F-1	4.20		X	Metals	Mine Drainage	1996 & 1998
Cherrycamp Run	MW-13-I-2	3.20		X	Metals	Mine Drainage	1996 & 1998
Patterson Fork	MW-13-I-3	2.40		X	Metals	Mine Drainage	1996 & 1998
Coburn Fork	MW-13-N	4.20		X	pH; Metals	Mine Drainage	1996 & 1998
Shaw Run	MW-13-N-1	1.00		X	pH; Metals	Mine Drainage	1996 & 1998
U.t.#1@gypsy	MW-14.2	1.45		X	pH, Metals	Mine Drainage	1996 & 1998
Simpson Creek	MW-15	28.00		X	pH; Metals	Mine Drainage	1996 & 1998
U.t.#1/simpson ck	MW-15?	0.00		X	pH, Metals	Mine Drainage	1996 & 1998
U.t.#2 Simpson ck[B]	MW-15?	0.00		X	pH, Metals	Mine Drainage	1996 & 1998
U.t.#3/simpson ck	MW-15?	0.00		X	pH, Metals	Mine Drainage	1996 & 1998
U.t.#5 Simpson ck	MW-15?	0.00		X	pH, Metals	Mine Drainage	1996 & 1998
U.t.#6/simpson ck	MW-15?	0.00		X	pH, Metals	Mine Drainage	1996 & 1998
U.t.#4/Simpson ck	MW-15?	0.00		X	pH, Metals	Mine Drainage	1996 & 1998
Rt Br/west Br/simpson ck	MW-15-L?	0.00		X	pH, Metals	Mine Drainage	1996 & 1998
Ut#1/West Br/Simpson ck	MW-15-L?	0.00		X	pH, Metals	Mine Drainage	1996 & 1998
Jack Run/Simpson Creek	MW-15-A	1.60		X	pH; Metals	Mine Drainage	1996 & 1998
Smith Run/Simpson Creek	MW-15-B	2.00		X	pH; Metals	Mine Drainage	1996 & 1998
Jerry Run	MW-15-H	2.60		X	pH; Metals	Mine Drainage	1996 & 1998
Berry Run	MW-15-I	3.30		X	pH; Metals	Mine Drainage	1996 & 1998
Right Fork/Simpson Creek	MW-15-J	3.60		X	pH; Metals	Mine Drainage	1996 & 1998
Buck Run	MW-15-J-1	2.70		X	pH; Metals	Mine Drainage	1996 & 1998
Sand Lick Run	MW-15-J-2	3.20		X	pH; Metals	Mine Drainage	1996 & 1998
Gabe Fork	MW-15-J-3	5.50		X	pH; Metals	Mine Drainage	1996 & 1998

DNR Name	DNR Code	Miles Affected	Human Health	Aquatic Life	Pollutant	Source	Year Listed[A]
Bartlett Run	MW-15-K	1.80		X	pH; Metals	Mine Drainage	1996 & 1998
West Branch/Simpson Creek	MW-15-L	3.40		X	pH; Metals	Mine Drainage	1996 & 1998
Stillhouse rn	MW-15-L-1	1.00		X	pH, Metals	Mine Drainage	1996 & 1998
Camp Branch /Simpson Creek	MW-15-M	1.80		X	pH; Metals	Mine Drainage	1996 & 1998
Lambert Run	MW-16	4.40		X	pH; Metals	Mine Drainage	1996 & 1998
Jack Run	MW-17	2.40		X	Metals	Mine Drainage	1996 & 1998
Fall Run	MW-18	1.20		X	pH; Metals	Mine Drainage	1996 & 1998
Crooked Run	MW-19	2.50		X	pH; Metals	Mine Drainage	1996 & 1998
Booth Creek	MW-2	8.60		X	Metals	Mine Drainage	1996 & 1998
U.t.#1@booths ck	MW-2?	0.00		X	pH, Metals	Mine Drainage	1996 & 1998
U.t.#2@booths ck	MW-2?	0.00		X	pH, Metals	Mine Drainage	1996 & 1998
U.t.#3@booths ck	MW-2?	0.00		X	Metals	Mine Drainage	1996 & 1998
Limestone Run	MW-20-A	1.40		X	Metals	Mine Drainage	1996 & 1998
Elk Creek	MW-21	29.00		X	Metals	Mine Drainage	1996 & 1998
Murphy Run	MW-21-A	2.00		X	pH; Metals	Mine Drainage	1996 & 1998
Nutter Run	MW-21-D	1.36		X	Metals	Mine Drainage	1996 & 1998
Turkey Run /Elk Creek	MW-21-E	1.70		X	Metals	Mine Drainage	1996 & 1998
Hoop pole Run	MW-21-F	1.40		X	Metals	Mine Drainage	1996 & 1998
Brushy Fork	MW-21-G	14.00		X	Metals	Mine Drainage	1996 & 1998
Coplin Run	MW-21-G-1	1.80		X	Metals	Mine Drainage	1996 & 1998
Gnatty Creek	MW-21-M	8.88		X	Metals	Mine Drainage	1996 & 1998
Right Branch/Gnatty Creek	MW-21-M-5	2.70		X	Metals	Mine Drainage	1996 & 1998
Charity Fork	MW-21-M-5-A	1.90		X	Metals	Mine Drainage	1996 & 1998
Birds Run	MW-21-O	1.80		X	Metals	Mine Drainage	1996 & 1998
Arnold Run	MW-21-P	2.80		X	Metals	Mine Drainage	1996 & 1998
Isaacs Run/Elk Creek	MW-21-Q	2.00		X	Metals	Mine Drainage	1996 & 1998
Stewart Run	MW-21-S	3.40		X	Metals	Mine Drainage	1996 & 1998
Washburncamp Run/Davisson Run	MW-22-A	1.40		X	Metals	Mine Drainage	1996 & 1998
Browns Creek	MW-23	5.00		X	pH; Metals	Mine Drainage	1996 & 1998
Coburns Creek	MW-24	3.20		X	Metals	Mine Drainage	1996 & 1998
Sycamore Creek	MW-25	5.70		X	Metals	Mine Drainage	1996 & 1998
Lost Cree3+k	MW-26	11.40		X	Metals	Mine Drainage	1996 & 1998
U.t./lost ck	MW-26?	0.00		X	Metals	Mine Drainage	1996 & 1998
Bonds Run	MW-26-A	1.40		X	Metals	Mine Drainage	1996 & 1998
Buffalo Creek	MW-27	4.70		X	Metals	Mine Drainage	1996 & 1998
Hoglick Run	MW-2-A	1.40		X	Metals	Mine Drainage	1996 & 1998
Sweep Run	MW-2-C	1.10		X	Metals	Mine Drainage	1996 & 1998
Horners Run	MW-2-D	2.60		X	pH; Metals	Mine Drainage	1996 & 1998
Purdys rn/Horner’s Run	MW-2-D-1	1.40		X	pH, Metals	Mine Drainage	1996 & 1998

DNR Name	DNR Code	Miles Affected	Human Health	Aquatic Life	Pollutant	Source	Year Listed[A]
Coons Run	MW-3	0.00		X	pH; Metals	Mine Drainage	1996 & 1998
Hackers Creek	MW-31	25.40		X	pH; Metals	Mine Drainage	1996 & 1998
Mare rn/Freeman's Creek	MW-36-C.5	2.20		X	Metals	Mine Drainage	1996 & 1998
Grass Run/Stonecoal Creek	MW-38-E	1.40		X	Metals	Mine Drainage	1996 & 1998
Stone Lick	MW-44	1.00		X	Metals	Mine Drainage	1996 & 1998
Fitz Run	MW-50-C	1.20		X	pH; Metals	Mine Drainage	1996 & 1998
Ward Run	MW-50-D	1.00		X	Metals	Mine Drainage	1996 & 1998
Bingamon Creek	MW-7	14.80		X	Al; Fe	Mine Drainage	1996 & 1998
Elklick Run	MW-7-C	1.20		X	Metals	Mine Drainage	1996 & 1998
Cunningham Run	MW-7-D	2.40		X	Al; Fe	Mine Drainage	1996 & 1998
Laurel Run	MW-8	1.20		X	Metals	Mine Drainage	1996 & 1998
U.t.#2@viropa	MW-8.5	0.00		X	pH, Metals	Mine Drainage	1996 & 1998
U.t.#3@viropa	MW-8.7	0.70		X	pH, Metals	Mine Drainage	1996 & 1998
Mudlick Run	MW-9	2.90		X	pH; Metals	Mine Drainage	1996 & 1998

Note: Impaired streams in this table reflects information provide in West Virginia's 1998 Section 303 (d) list
A - As designated in Appendix A of 1999West Virginia's Water Quality Standards
B - Unnamed Tributary of Simpson Creek no longer exists

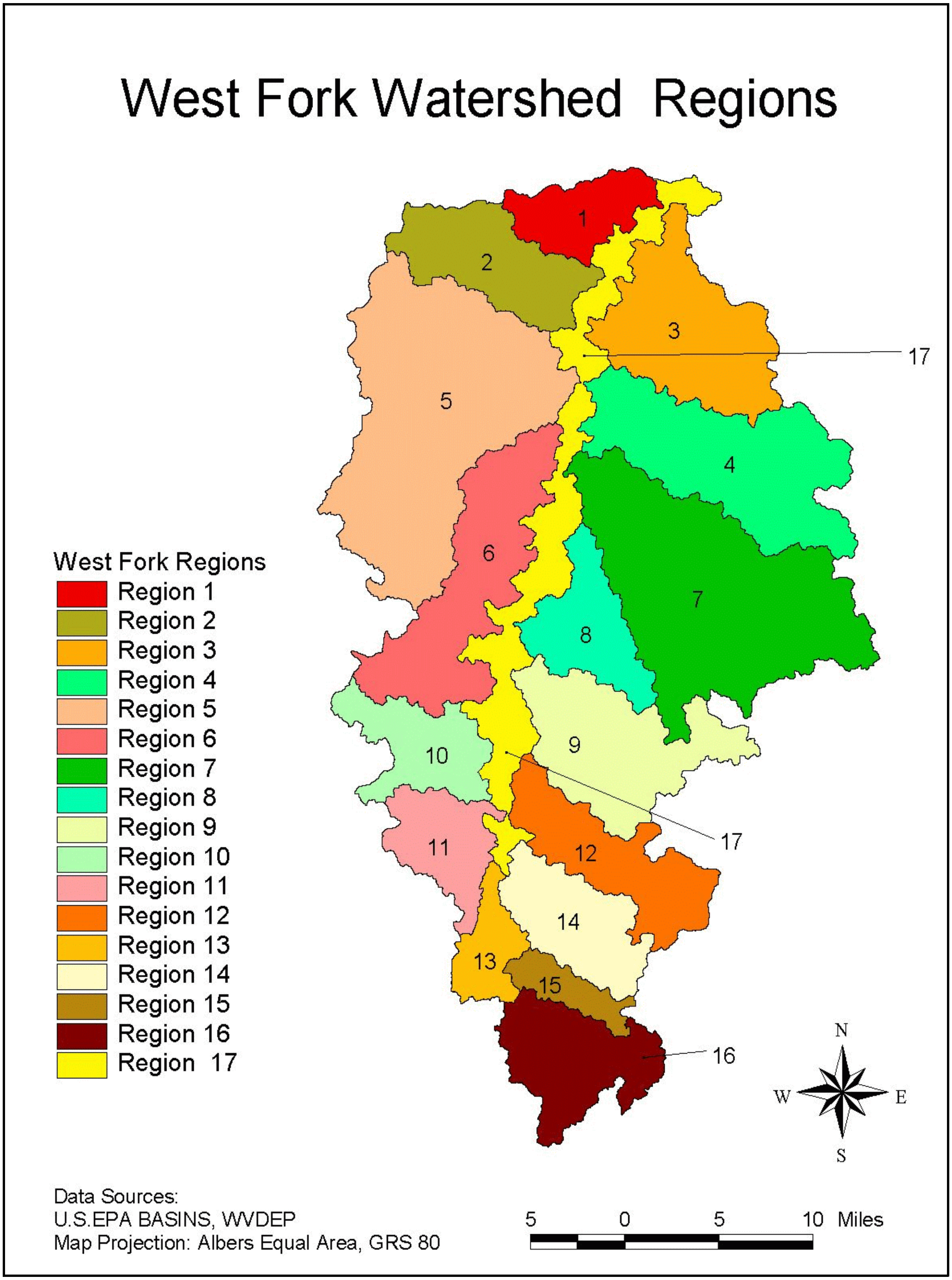


Figure 1-4. West Fork River watershed and its 17 regions

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 section 301(b) and 306 of the Act (USEPA, 1991). *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 the numeric water quality criteria, while narrative water quality criteria are largely contained in Section §46-1-3 of the same document. Total aluminum, total iron, total manganese, dissolved zinc, and pH have numeric criteria under the Aquatic Life and the Human Health use designation categories (Table 2-1). The listed waterbodies in the West Fork watershed have been designated as having an Aquatic Life and a Human Health use (WVDEP, 1998a).

Table 2-1. Applicable West Virginia water quality criteria

POLLUTANT	USE DESIGNATION				
	Aquatic Life				Human Health
	B1, B4		B2		A[c], C[c]
	Acute [a]	Chronic [b]	Acute [a]	Chronic [b]	
Aluminum, Total (ug/L)	750	-	750	-	-
Iron, Total (mg/L)	-	1.5	-	0.5	1.5
Manganese, Total (mg/L)	-	-	-	-	1.0
Zinc, dissolved (mg/L)	$(0.978)(e^{[(0.8473)(\ln[\text{hardness}\dagger]) + 0.8604]})$	$(0.986)(e^{[(0.8473)(\ln[\text{hardness}\dagger]) + 0.7614]})$	$(0.978)(e^{[(0.8473)(\ln[\text{hardness}\dagger]) + 0.8604]})$	$(0.986)(e^{[(0.8473)(\ln[\text{hardness}\dagger]) + 0.7614]})$	-
pH	No values below 6.0 or above 9.0 (inclusive)	No values below 6.0 or above 9.0 (inclusive)	No values below 6.0 or above 9.0 (inclusive)	No values below 6.0 or above 9.0 (inclusive)	No values below 6.0 or above 9.0 (inclusive)

Source: WVWQS, 1999.
Note: B1 = warm water fishery streams, B4 = wetlands, B2 = trout waters, A = public water supply, C = Water Contact Recreation.
[a] One-hour average concentration not to 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
[c] Not to exceed.
† Hardness as calcium carbonate (mg/L). The minimum hardness allowed for use in this equation shall not be less than 25 mg/l, even if the actual ambient hardness is less than 25 mg/l. The maximum hardness value for use in this equation shall not exceed 400 mg/l even if the actual hardness is greater than 400 mg/l.

There are 786 existing water quality stations in the West Fork River watershed. Tables 3a, 3b, 3c, 3d, 3e and 3f in each of Appendices A-1 through A- 17 summarize applicable water quality data for monitoring stations throughout the watershed. These results support the impairment listings for iron, aluminum, manganese, and pH in specified stream segments; however, zinc concentrations in the main stem of the West Fork River did not exceed the hardness-based water quality criteria (Appendix B). These findings suggest that the main stem of the West Fork River is not impaired for dissolved zinc and therefore TMDL development for this pollutant is not necessary.

3.0 Source Assessment

This section examines and identifies the potential sources of aluminum, iron, manganese, and pH in the West Fork watershed. A wide range 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 and Review

Data collection was a cooperative effort among various governmental groups and agencies in West Virginia, while U.S. EPA Region Three 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 West Fork Watershed TMDLs

Data Category	Description	Data Source(s)
Watershed Physiographic Data	Land Use (MRLC)	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
	Oil and Gas Operations Coverage	WVDEP Office of Oil and Gas (OOG)
	Paved and Unpaved Roads	WV Department of Transportation (DOT), USDOT
	Timber Harvest Data	USDA, U.S. Forest Service (USFS)
Environmental Monitoring Data	NPDES Data	WVDEP DMR, WVDEP DWR
	Discharge Monitoring Report Data	WVDEP DMR
	Abandoned Mine Land Data	WVDEP DMR, WVDEP DWR
	303(d) Listed Waters	WVDEP DWR
	Water Quality Monitoring Data for 685 Sampling Stations	EPA STORET, WVDEP DWR, U.S. Army Corps of Engineers

3.2 Stream Flow Data

There are 10 U.S. Geological Survey (USGS) flow gauges in the West Fork watershed. Flow data from these USGS gauges were used to support flow analysis for the watershed. Table 3-2 shows the 10 flow gauging stations with available records of flow data and the corresponding period of record for each. Note that two stations have two periods of record which have been listed as separate datasets, increasing the number of datasets to 12. These stations were used to characterize the stream flow in the watershed. Additional stream flow data was provided by the U.S. Army Corps of Engineers (USACE) for station 03058000 after 1985. Figure 3-1 shows the location of USGS gauges in the West Fork watershed.

Table 3-2. Flow analysis for the West Fork watershed

Station	Stream Name	Start Date	End Date	Minimum (cfs)	Average (cfs)	Maximum (cfs)
3057300	West Fork River at Walkersville	1997/10/02	1998/9/30	8.0	65.0	506.0
3057500	Skin Creek near Borwnsville	1945/10/02	1960/09/30	0.0	41.0	1,160.0
3058000	West Fork River below Stonewall Jackson Dam	1946/8/01	1985/3/28	25.0	190.0	1,450.0
3058000_a	West Fork River	1970/1/01	1973/07/24	0.0	187.0	3,530.0
3058006	West Fork River at Bendale	1984/10/02	1989/12/30	0.0	166.0	9,040.0
3058500	West Fork River at Butcherville	1925/10/02	1953/12/13	0.0	301.0	14,200.0
3058975	West Fork River near Mount Clare	1987/04/17	1998/9/30	7.0	587.0	9,780.0
3059000	West Fork River at Clarksburg	1923/03/04	1933/05/26	0.0	599.0	10,700.0
3059500	Elk Creek at Quiet Dell	1943/10/02	1960/1/05	0.2	124.0	4,860.0
3060500	Salem Fork at Salem	1951/01/02	1958/07/05	0.0	12.0	570.0
3061000	West Fork River at Enterprise	1984/10/02	1998/09/30	14.0	1,237.0	37,900.0
3061000_a	West Fork River at Enterprise	1932/10/24	1983/09/30	4.0	1,160.0	33,300.0

Note: "_a" implies the same station but has a different period of record.
Source: USGS Water Resources Division.

Additional stream flow data was provided by the U.S. Army Corps of Engineers (USACE) at the Stonewall Jackson Dam. USACE manages Stonewall Jackson Lake Project, which is part of the flood control system operated by the Army Corps of Engineers for the Monongahela and Upper Ohio River basins. The Stonewall Jackson Dam became fully operational in 1990 and is located at Brownsville, West Virginia, approximately 74 miles upstream above its confluence with the Tygart River at Fairmont, WV. The dam controls 102 square miles of the upper West Fork watershed, approximately three miles above the confluence of Stonecoal Creek with the West Fork mainstem. The location of the Stonewall Jackson Dam is shown in Figure 3-1.

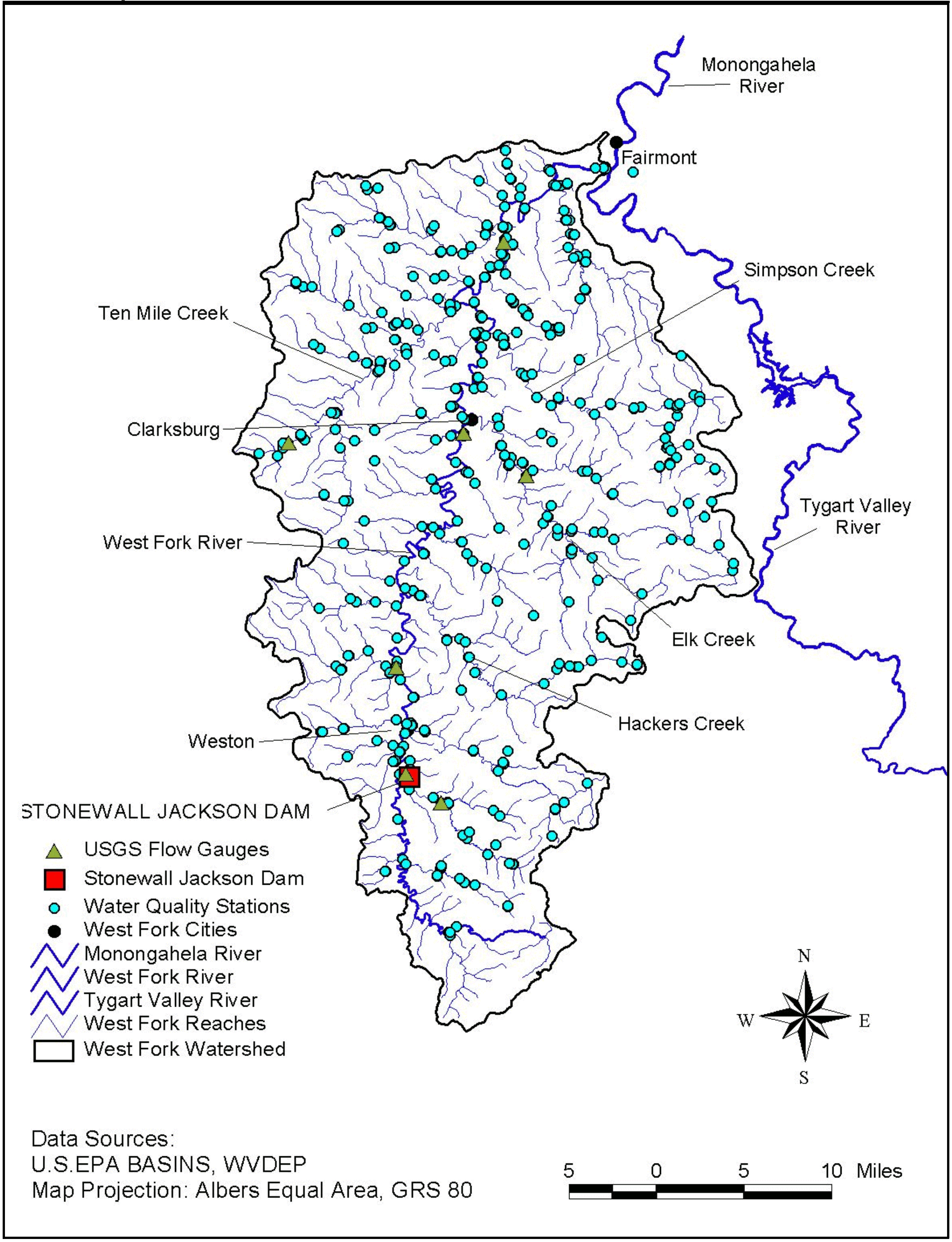


Figure 3-1 Water Quality Stations, USGS Stream Gages, and Stonewall Jackson Dam Location

3.3 Water Quality

Water quality monitoring data for the West Fork watershed were obtained from a variety of sources, including the EPA STORET database, WVDEP DWR, U.S. Army Corps of Engineers and mining companies. Observations used to configure, calibrate, and test the model were taken from throughout the watershed. Additionally, as part of the NPDES program, mining companies are required to monitor in-stream water quality upstream and downstream of all discharging outlets. WVDEP requested that mining companies submit these monitoring data in electronic format from areas affected by TMDL development throughout the state. Monitoring data were received from five mining operations in the West Fork watershed and these data were used to characterize the in-stream water quality conditions. As stated in Section 2, there are 786 water quality monitoring stations in the West Fork watershed. While the large number of stations provided extensive spatial coverage, few stations provided good temporal distribution of water quality data. The water quality monitoring data along with pertinent source information are summarized for each of the 17 regions in Appendices A-1 through A-17 of this report. Figure 3-1 shows the location of water quality stations in the West Fork watershed.

The mainstem of the West Fork River was included on West Virginia’s Section 303(d) list for high total zinc concentrations. In 1999, however, West Virginia’s water quality criteria for zinc changed from total zinc to a hardness-based dissolved zinc criteria. In-stream water quality observations from the West Fork River mainstem were analyzed to determine violations of the dissolved zinc criteria. The results of this analysis are shown in Appendix B. Dissolved zinc concentrations in the main stem of the West Fork River were shown not to exceed the hardness-based water quality criteria. These findings suggest that the main stem of the West Fork River is not impaired for dissolved zinc and therefore TMDL development for this pollutant is not necessary.

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. Point sources can be classified into two major categories: permitted non-mining point sources and permitted 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. Sixteen non-mining point sources located in the West Fork watershed are permitted to discharge metals (iron, aluminum, manganese, and/or zinc). These sources are shown in Table 3-3. All discharges are required to discharge within a pH criterion range of six to nine (inclusive). Ten of the sixteen non-mining point sources are not permitted to discharge aluminum, iron, or manganese and were not included in the model. Four of the sixteen non-mining discharges are permitted to either discharge iron, aluminum, or manganese, however, these four are classified as minor discharges. Two of the sixteen non-mining discharges, UCAR Carbon, Inc. (WV0004707) and Monongahela Power Station (WV0005339), are classified as major discharges that are permitted to discharge iron and aluminum.

Table 3-3. Non-mining point sources in the West Fork watershed

NPDES ID	Facility Name	Facility Type	Receiving Water	Permitted pollutant discharged	Status	Major ID	Issue Date	Expire Date
WV0004707	Ucar Carbon, Inc.	Carbon and Graphite Products	Ann Moore Run	Fe	Active	Major	4/24/00	4/23/04
WV0005339	Monongahela Power Station	Electrical Services	West Fork River	Al, Fe	Active	Major	3/9/01	3/8/05
WV0005363	Eagle Glass Specialties, Inc	Glass Products	Elk Creek	Al	Active	Minor	3/9/00	3/8/04
WV0020257	City of Salem	Sewerage Systems	Salem Fork	Zn	Active	Minor	4/14/01	4/13/05
WV0023302	Clarksburg Sanitary Board	Sewerage Systems	West Fork River	Zn	Active	Major	9/30/96	9/29/01
WV0025461	City of Bridgeport	Sewerage Systems	West Fork River	Zn	Active	Major	6/5/00	6/4/05
WV0027324	Town of Monongah	Sewerage Systems	West Fork River	Zn	Active	Minor	7/6/98	7/5/03
WV0040894	Jane Lew Water Comm	Sewerage Systems	Hackers Creek	Zn	Active	Minor	4/28/00	4/27/05
WV0044903	Reiss Viking	Sewerage Systems	Coons Run	Fe, Mn	Active	Minor	8/3/99	8/2/03
WV0054500	City of Shinnston	Sewerage Systems	West Fork River	Zn	Active	Minor	5/12/00	5/11/05
WV0077097	AFG Industries	Closed Landfill	Jerry Run	Fe, Mn	Active	Minor	6/15/01	6/14/05
WV0077283	F&t Enterprises	Refuse Systems	Ut of West Fork River	Fe, Mn	Active	Minor	8/8/99	8/7/04
WV008001	Hepzibah Psd	Sewerage Systems	West Fork River	Zn	Active	Minor	2/17/00	2/16/05
WV0084301	Greater Harrison Cnty Psd	Sewerage Systems	West Milford River	Zn	Active	Minor	4/21/98	4/20/03
WV0084352	Lake Floyd Psd	Sewerage Systems	Halls Run	Zn	Active	Minor	10/11/00	10/10/05
WV0100285	Town of Worthington	Sewerage Systems	West Fork River	Zn	Active	Minor	2/15/99	2/14/04

Source: U.S. EPA PCS, WVDEP

3.4.2 Permitted Mining Point Sources

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.

Mining related activities are issued discharge permits for iron, aluminum, manganese, and pH. 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, which are 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 West Virginia 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

Source: WVDEP DMR

Coal mining operations and sandstone quarries in West Virginia typically have discharge permits limiting total iron, total manganese, total nonfilterable residue, and pH. They are also required to monitor and report total aluminum concentrations. However, limestone quarries do not have discharge limits for total iron, total manganese, total nonfilterable residue and aluminum discharges. There are a total of 205 mining permits from in the West Fork watershed. A complete listing of mining permits in the West Fork watershed is located in Appendix E and Figure 3-2 illustrates the extent of the mining operations in the West Fork watershed.

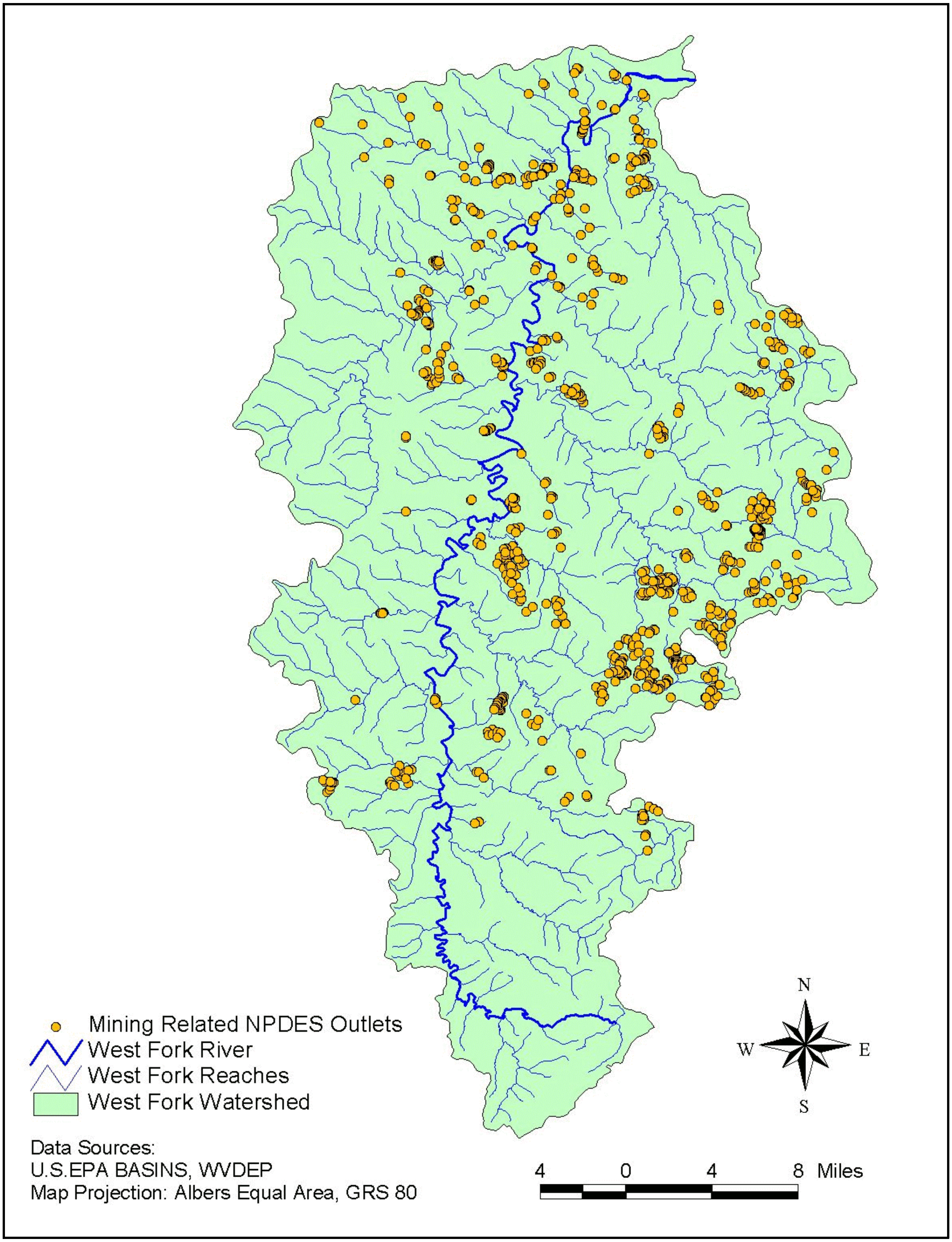


Figure 3-2. Mining permits in the West Fork River watershed

3.5 Nonpoint Sources

In addition to point sources, nonpoint sources also contribute to water quality impairments in the West Fork River watershed. Nonpoint sources represent contributions from diffuse, nonpermitted sources. Based on the identification of a number of abandoned mining activities in the West Fork River watershed, abandoned mine lands (AML) represent a significant nonpoint source. Abandoned mines contribute acid mine drainage (AMD), which produces low pH and high metals concentrations in surface and subsurface water.

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 that generate acidity in water. A synopsis of these reactions is 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 that 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. A third reaction occurs 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).

Sediment produced from land-based activities is another potential source of high metal contamination in the West Fork River watershed. It lies in the Appalachian Plateau province east of the Allegheny Front. The West Fork basin is composed of two basic geologic areas: the western two-thirds has relatively flat-lying rocks and the eastern one-third has folded and faulted rocks. The oldest formation, the Catoctin Formation (late Precambrian), is found in the eastern part of the state, with younger formations (Paleozoic) in the west. Quaternary alluvium overlays much of the formations.

The Appalachian Plateau, composed mostly of Pennsylvanian and Permian strata, is where much of the minable coal is located. The rocks of the Pennsylvanian System are widely exposed at the surface, having been extensively mined for coal and drilled extensively for oil and gas. Lower and Middle Pennsylvanian rocks that are exposed in the east-central part of the state (Kanawha, Clay, and western Roan counties) consist primarily of sandstone with clayey sediments and coal found in the subsurface. From east to west, shale and coal are commonly exposed in the younger Pennsylvanian formations (Watts et al., 1994).

The Lower Pocahontas basin is in the southern part of the state and is the older of two sedimentary basins in West Virginia. Alternating units of sandstone, shale, limestone, and coal of the Kanawha, New River, and Pocahontas Formations are found in the sediments in the Pocahontas basin. The Dunkard basin, the northern sedimentary basin, overlaps the Pocahontas basin in central West Virginia (Calhoun, Gilmer, Kanawha, and Roane counties). Sediments of the Dunkard basin consist largely of surface rocks of the Dunkard group.

Watts et al. (1994) identified clays derived from shale units within the drainage basins as the primary source of high aluminum concentrations in stream sediments. In addition, correlation coefficients indicate that iron and manganese are associated with aluminum as a result of precipitated iron oxides and oxyhydroxides in the streambeds (Watts et al., 1994).

Nonpoint source contributions were grouped for assessment into three separate categories: AML, sediment sources, and other nonpoint sources. Figure 3-3 presents a schematic of potential sources in the West Fork River watershed. The land use distribution for the West Fork watershed is presented in Figure 3-4.

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 (WVDNR, 1985). Data regarding AML sites in the West Fork watershed were compiled from spatial coverages provided by WVDEP DMR and the *West Fork River Basin Abandoned Mine Drainage Assessment* (WVDNR, 1983). The AML sites were classified into three categories:

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

Additional qualitative data were retrieved from WVDEP DMR Problem Area Data Sheets (PADS). Information regarding the locations of the largest sources, namely abandoned mines, are presented in Table 2 in each of Appendices A-1 through A-17.

Mines with revoked permits no longer have a permittee responsible for treating discharges from these mines which are typically untreated. Consequently, for purposes of this TMDL, mines with revoked permits are treated as nonpoint sources. 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 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.

3.5.2 Sediment Sources

Based on the data analysis and source characterization AML's were identified as a critical and controllable source (especially in the upper watershed). Potential sediment sources were assessed and major contributing land uses either were not present or did not have significant areas. High-sediment-yield areas include disturbed lands such as unpaved roads, forest harvest areas and access roads, oil and gas operations, crop land, barren land, and active mine areas. These land uses represent less than three percent of the watershed area.

Additional data analysis was conducted to support source characterization. Appendix C displays the data used to evaluate the linkage between loading sources and in-stream water quality targets for aluminum, iron, and manganese. The analysis is primarily conducted at three stations on the mainstem West Fork near Laurel Creek and Weston during a period from 1979 to 1995. Two sampling stations, 4wfs10201 and 4wfs13064, are both located near Weston while the other location, 550487, is located near Laurel Creek.

The relationship between flow and total suspended solids (TSS) is examined at three locations (4wfs10201, 4wfs13064, and 550487) on the West Fork mainstem. Appendix C Figures 1, 2, and 3, at stations 4wfs13064 and 4wfs10201 near Weston and 550487 near Laurel Creek, respectively, show elevated TSS occurring only at extremely high (90^{th} percentile) flows. There are 181 observations at station 550487, 36 observations at station 4wfs10201, and 29 observations at 4wfs13064. This does not necessarily mean that this is high-metals-laden TSS since AML site contributions are also precipitation driven and expected to increase at higher flows.

Appendix C Figures 4 through 6 show the analysis of flow and total iron in the West Fork watershed performed at the same three locations. Similar to the results from the flow/TSS analysis, the relationship between flow and total iron demonstrate a general positive relationship. Data for TSS and iron concentration are grouped together and analyzed in Appendix C Figure 13 to determine the strength of the relationship. The correlation coefficient between increasing TSS and increasing iron concentrations is only 0.271, indicating a weak relationship between TSS and iron concentration.

There is no relationship between flow and total manganese, shown in Appendix C Figures 7 through 9. The data for TSS/manganese concentration for the West Fork River watershed are grouped together and analyzed in Appendix C Figure 14 to determine the strength of the relationship between TSS and manganese concentration. The correlation coefficient between increasing TSS and increasing manganese concentrations is only 0.007, also indicating no relationship between TSS and manganese concentration.

The relationship between flow and total aluminum, shown in Appendix C Figures 10 through 12, demonstrate very similar trends to flow/TSS and flow/total iron at all three stations. The relationship between increasing TSS and increasing total aluminum is also weak as indicated by a correlation coefficient of 0.298 in Appendix C Figure 15.

At extremely high flows, 90th percentile, the data shows elevated TSS. However, these analyses regarding the relationship between TSS and iron, manganese, and aluminum in the West Fork watershed indicate that metals-laden sediment and sediment producing sources are not necessarily the most significant contributors to impaired water quality. Alternatively, this analysis confirms that discharges from AML lands are primarily responsible for water quality impairments due to metals and pH in the West Fork watershed. Based on available data, critical conditions in terms of stream flow could not be characterized as either low or high flow. It is reasonable to conclude that critical conditions in the West Fork watershed occur during both low and high flows. The data analysis indicates that sediment producing sources are not of primary significance in terms of critical conditions for the West Fork watershed. During critical conditions, water quality in the West Fork is vulnerable and violations of water quality criteria for total aluminum, total iron, and total manganese are likely to occur. In order to meet water quality criteria for total aluminum, total iron, and total manganese during critical conditions, control of AML sources is crucial.

In the West Fork River watershed, nonpoint sources of sediment include abandoned and active mine areas, forestry operations, oil and gas operations, unpaved roads, agricultural land uses, barren land, and mature forestland. High-sediment-yield areas include disturbed lands such as unpaved roads, forest harvest areas and access roads, oil and gas operations, agricultural land, barren land, and active mine areas and represent approximately three percent of the watershed area. Mature forestland and other undisturbed areas have the lowest sediment yield and therefore have the lowest impact on receiving waters. A conceptual representation of sediment loading from nonpoint sources relative to the natural or undisturbed forest condition is presented in Table 3-5. To spatially represent land-based nonpoint sources in the West Fork River watershed, the GAP2000 land use coverage for each subwatershed was updated to include paved and unpaved road areas, forest harvest areas, oil and gas operations, and mining areas.

Table 3-5. Sediment source characterization

	Sediment Contribution			Time Scale of impact on receiving water body	
Sources	**High**	**Medium**	**Low**	**Long**	**Short**
Forest (undisturbed)[A]			X	NA	NA
Forest operations	X				X
Access roads in forest	X			X	
Agriculture		X		X	
Oil and gas drilling		X			X
Oil and gas access road	X			X	
Mining (abandoned)		X		X	
Mining (active)			X	X	
Construction	X				X
Roadway construction	X				X
Paved roads and highways			X	X	
Unpaved roads	X			X	
Point sources (permitted)			X	X	

A - Undisturbed forest condition is the reference level condition.

3.5.3 Other Nonpoint Sources

The predominant land uses in the West Fork watershed were identified based on the USGS's GAP 2000 land use data (representative of the mid-1990s). According to the GAP 2000 data, the major land uses in the watershed are forest land, which constitutes approximately 65 percent of the watershed area, and pasture/grassland, which makes up 27 percent of the watershed area. In addition to forest land and pasture/grass 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 West Fork watershed is presented in Figure 3-4 and Table 3-6.

Table 3-6. GAP2000 Land Use Distribution in the West Fork Watershed

GAP2000 Landuse Category	Area (Acres)	Area (Percent)
Shrubland	16,341	2.93%
Woodland	5,768	1.04%
Surface Water	982	0.18%
Major Highways	673	0.12%
Major Powerlines	1,683	0.30%
Populated Area - mixed land Cover	5,094	0.91%
Low intensity Urban	14,345	2.57%
Moderate intensity Urban	937	0.17%
Intensive Urban	2,392	0.43%

GAP2000 Landuse Category	Area (Acres)	Area (Percent)
Pasture / Grassland	151,311	27.16%
Barren land - Mining / Construction	7,020	1.26%
Floodplain Forest	2,604	0.47%
Forested Wetland	64	0.01%
Shrub Wetland	54	0.01%
Herbaceous Wetland	363	0.07%
Surface Water	8,029	1.44%
Cove Hardwood Forest	4,153	0.75%
Diverse / Mesophytic hardwood Forest	179,341	32.19%
Oak dominant forest	154,393	27.71%
Mountain Hardwood Forest	1,644	0.30%

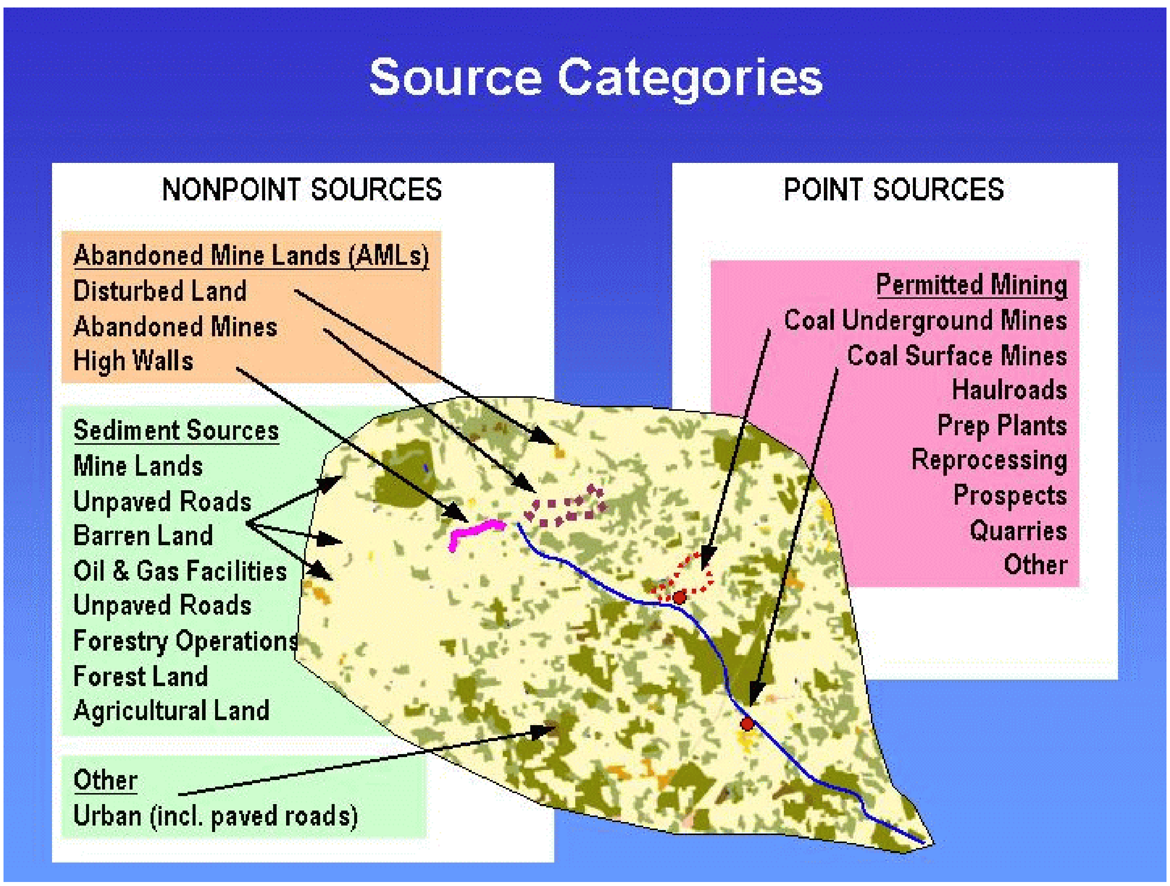
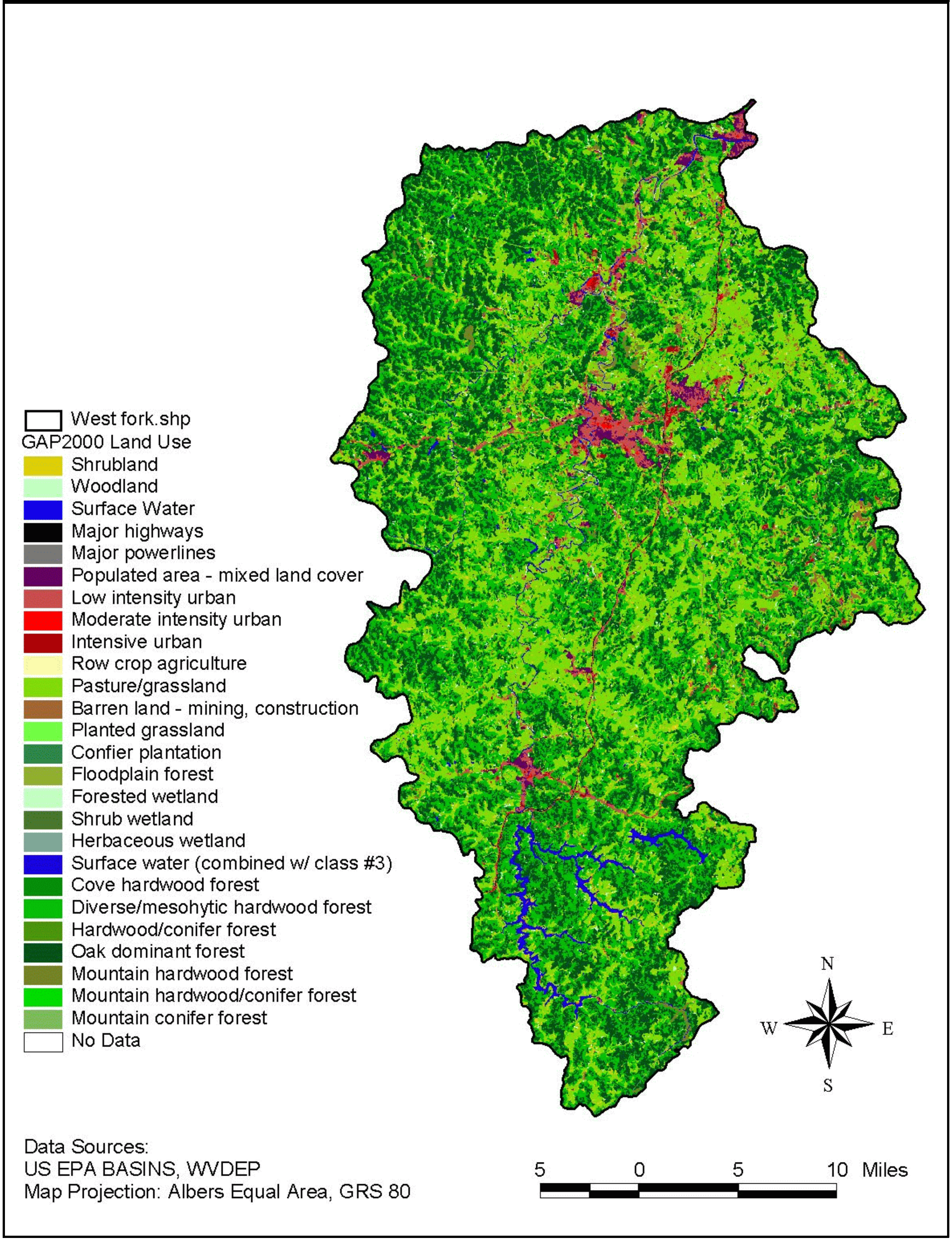


Figure 3-3. Potential sources contributing to impairments in the West Fork River watershed



3-4. Land use coverage for the West Fork 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 West Fork 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, WV regulations allow one exceedance every three years on average, which is equivalent to the 7Q10 design flow condition. 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 to these considerations, 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 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 are presented in Section 2, Table 2-1.

The TMDL development approach must also consider the dominant processes regarding pollutant loadings and in-stream fate. For the West Fork 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, however, they are controlled by permit limits.

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 West Fork watershed, the primary physical driving process is the transport of total 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 West Fork watershed range from small headwater streams to larger tributaries of the West Fork 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 West Fork watershed for aluminum, manganese, and iron. The MDAS is a comprehensive data management and modeling system that is capable of representing loading from nonpoint and point sources found in the West Fork watershed and simulating in-stream processes. The MINTEQ modeling system is used to represent the source-response linkage in the West Fork watershed for pH. The methodology and technical approach for pH using MINTEQ is discussed in section 4.4.

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 (DMR), 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 West Fork 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 West Fork 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 West Fork River watershed, the watershed was divided into 645 subwatersheds. These subwatersheds are presented in Figure 1 in each of Appendices A-1 through A-17, and they represent hydrologic boundaries. The division was based on elevation data (7.5 minute Digital Elevation Model [DEM] from USGS), stream connectivity (from USGS's National Hydrography Dataset [NHD] 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 West Fork 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 three National Climatic Data Center (NCDC) weather stations located near the watershed were used (Figure 4-1):

- Clarksburg 1
- Tygart Dam
- Freemansburg 5 NE

Meteorological data for the remaining required parameters were available from the Morgantown Hart Field and Elkins-Randolph stations. These data were applied based on subwatershed location relative to the weather stations.

The use of meteorological data over a period from 1985 to 1992 further ensures that the TMDL methodology is consistent with the technical and regulatory requirements of 40 CFR Section 130. 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.

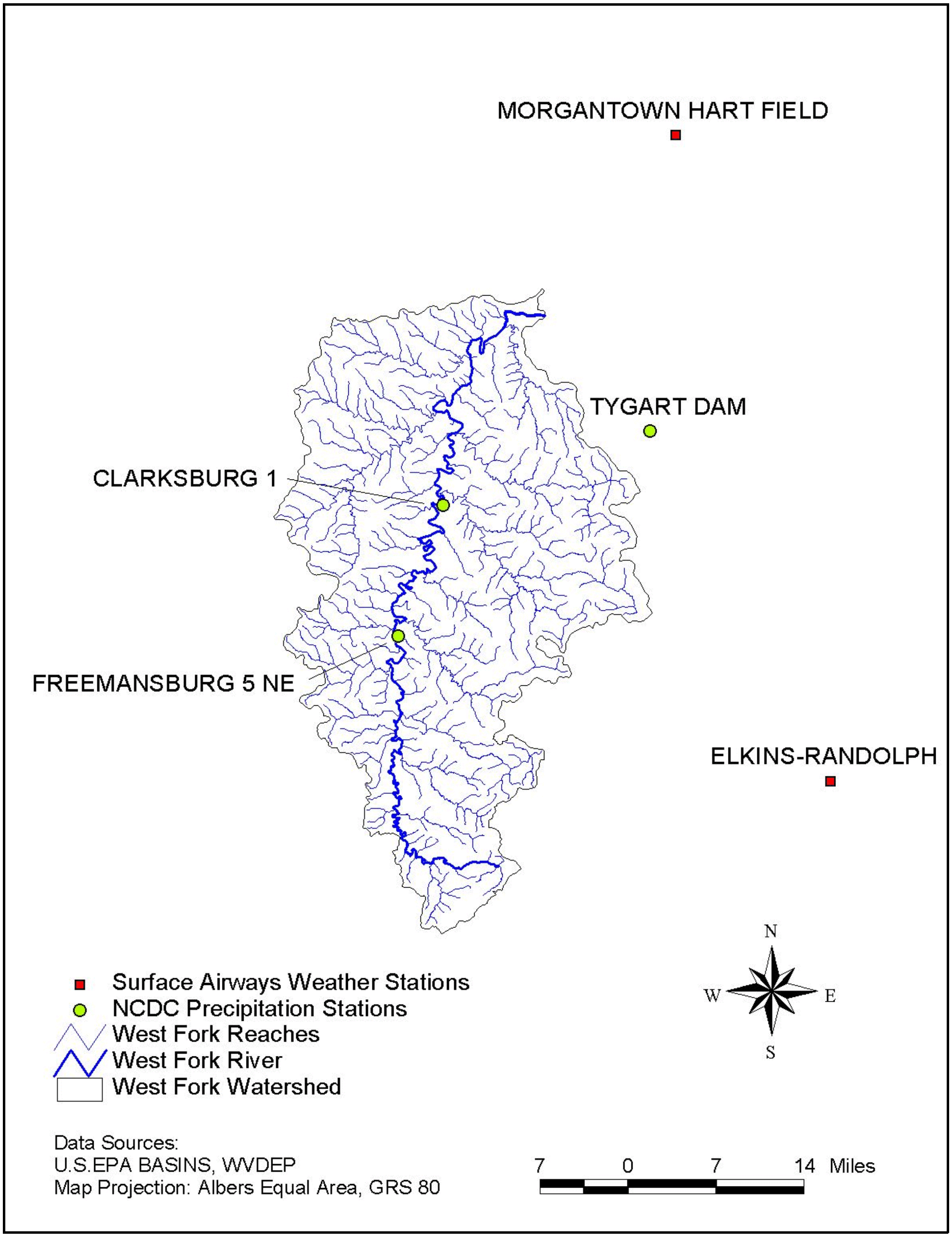


Figure 4-1. Weather stations used in modeling of the West Fork Watershed

4.3.3 Nonpoint Source Representation

To explicitly model nonpoint sources in the West Fork River watershed, several additional land use categories were created and added to the model 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.

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. Land Use Grouping

Model Category	GAP2000 Category
Barren	Barren land - mining / construction
Cropland	Row Crop Agriculture
Mature Forest	Shrubland
	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
Intermediate Forest	Woodland
Pasture	Planted Grassland
Urban Impervious	Major Highways
	Populated Area - mixed land Cover
	Low intensity urban
	Moderate intensity urban
	Intensive Urban
Urban Pervious	Major Highways
	Populated Area - mixed land Cover
	Low intensity urban
	Moderate intensity urban
	Intensive Urban
Water	Surface Water 1
	Surface Water 2
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 was not available from the GAP 2000 land use coverage. WVDEP provided AML land use coverage data which were incorporated into the GAP 2000 land use coverage. In order to incorporate these land uses to appropriately account for runoff and loading characteristics, the existing GAP 2000 land use coverage was modified on a subwatershed basis. For instance, assume that data from WVDEP indicated, no active mining, 60 acres of abandoned mines, 40 acres of disturbed land, and 20 acres of high walls in a particular subwatershed while 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). 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.

Sediment Sources

Additional land use categories were required to represent differences in the sediment loading and transport characteristics from various land use activities. Separate land use categories were designated for forest harvest areas (recent timber removal), oil and gas operations, paved roads, and unpaved roads.

The USDA Forest Service FIA Database Retrieval System provided information on annual timber removal for softwood and hardwood species by county. Forest harvest areas were calculated by area-weighting the softwood and hardwood timber removal estimates for counties located within each subwatershed. Harvested areas then were subtracted from the corresponding softwood and hardwood land use categories in the coverage before land use consolidation. The annual forest harvest land use category represents the total annual timber harvest in each subwatershed. Remaining forestlands were then aggregated and reclassified as mature forest.

WVDEP Office of Oil and Gas (WVDEP OOG) provided information regarding oil and gas operations in the West Fork River watershed. Active oil and gas operations were assumed to have a well site and access road area of approximately 6,400 square feet. Results from a random well survey conducted by WVDEP OOG in the Elk River watershed during the summer of 2001 showed similar average well site and access road areas. The cumulative area for oil and gas operations in each subwatershed was subtracted from the mature forest categories as stated above.

Information on paved and unpaved roads in the watershed was obtained from the inventory surveys provided by West Virginia Department of Transportation (WVDOT) and the United States Department of Transportation (USDOT). These inventories provide the approximate length (in miles) of paved and unpaved roads in several subcategories for counties in West

Virginia. Paved and unpaved roads were assumed to have an average width of 20 feet and 12 feet, respectively. The area of paved and unpaved roads was calculated by area-weighting the total paved and unpaved road area given for counties located within each subwatershed. Unpaved road areas were subtracted from mature forest lands. Paved road areas were subtracted from the urban impervious land use category and then from forest lands if necessary. Paved roads contribute little sediment.

Pervious urban land areas were estimated using typical percent pervious/impervious assumptions for urban land categories.

Other 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

Ten non-mining point source permits in the West Fork watershed were not permitted for iron, aluminum, or manganese discharges and, therefore, not considered in the modeling effort. The loading from the four minor discharges that are permitted to either discharge iron, aluminum, or manganese were included in the background conditions during water quality calibration. Under this TMDL, these minor discharges are assumed to operate under their current permit limits. If permit limits are revised in the future, the resulting waste load allocations will be assumed within the margin of safety.

The two remaining discharges were represented as follows:

The Monongahela Power Station (WV0005339) discharges to West Fork mainstem through nine outlets. Eight of these outlets are permitted to discharge iron and aluminum. The average combined flow (0.12 MGD) from these eight outlets was calculated from recent DMR data. The average daily flow from 1990 to 2000 at USGS 03061000, located approximately four miles downstream, is approximately 800 MGD. Since the total flow from the eight outlets is significantly smaller than the average daily mainstem flow, the loading from the Monongahela Power Station (WV0005339) was included as background conditions during water quality calibration.

UCAR Carbon, Inc. (WV0004707) discharges to Ann Moore Run (SWS 2407) through nine outlets. Each of the outlets are permitted to discharge iron at water quality criteria (1.5 mg/L). WV0004707 was represented in the model using the average flow from DMR data and the permit limits.

Permitted Mining Point Sources

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. Phase II and Completely Released permitted facilities were not modeled 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.

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 4-4a. Modeled land use distribution in acres for Regions 1 through 9

Modeled Land Use	1	2	3	4	5	6	7	8	9
Barren	7	59	413	553	165	11	954	43	84
Mature Forest	10,344	19,879	18,078	24,196	57,432	23,638	41,473	10,863	20,376
Cropland	0	0	0	0	0	0	0	0	0
Inter Forest	152	266	527	692	821	397	787	185	361
Pasture	2,667	3,697	15,723	15,579	18,082	13,069	24,015	6,573	12,887
Strip Mining	0	0	0	0	0	0	0	0	0
Urban Imper	115	211	591	1,482	626	381	1,733	229	425
Urban Per	193	213	840	1,901	1,098	837	2,752	400	499
Wetlands	0	1	44	36	15	13	219	67	15
Water	15	110	66	159	898	211	156	87	73
Annual Forest Harvest	35	38	13	40	23	38	117	4	239
Paved Roads	101	176	271	315	539	260	437	129	176
Unpaved Roads	41	66	88	110	184	91	186	44	89
Oil & Gas Ops	63	239	284	548	1,109	779	733	112	433
ADM	0	932	0	117	133	29	161	0	18
IADM	458	0	0	0	8	0	52	0	9
RDM	0	10	53	0	9	0	0	0	0
PIDM	0	0	3	0	0	0	0	0	39
ASM	0	0	84	0	109	75	167	172	0
RSM	0	0	14	97	391	0	449	0	6
PIRS	0	0	18	0	0	68	219	54	194
OTHER	0	14	82	196	51	0	138	0	42
ROM	0	0	42	0	0	46	134	38	0
AML	123	168	582	1,358	857	371	867	449	31
Disturbed	0	0	0	0	0	0	0	0	0
Highwall	39	78	328	830	572	739	1,055	450	606
Total	**14,354**	**26,159**	**38,147**	**48,213**	**83,127**	**41,059**	**76,811**	**19,907**	**36,611**

Table 4-4b. Modeled land use distribution in acres for Regions 10 through 17

Modeled Land Use	10	11	12	13	14	15	16	17
Barren	13	15	51	31	33	10	17	133
Mature Forest	11,724	10,431	17,947	7,128	15,700	5,955	18,997	17,884
Cropland	0	0	0	0	0	0	0	0
InterForest	183	194	148	93	214	64	175	502
Pasture	6,041	4,675	5,544	1,259	3,928	1,067	4,409	13,428
Strip Mining	0	0	0	0	0	0	0	0
Urban Imper	34	372	399	65	63	10	22	2,529
Urban Per	97	523	686	80	126	25	64	3,817
Wetlands	1	4	8	0	36	1	8	15
Water	20	84	826	1,499	1,596	292	899	2,019
Annual Forest Harvest	135	118	244	79	174	69	250	65
Paved Roads	85	76	123	47	101	35	114	262
Unpaved Roads	42	38	68	23	50	17	61	100
Oil & Gas Ops	363	200	358	150	260	98	160	439
ADM	0	0	0	0	10	0	0	7
IADM	0	0	0	0	0	0	0	0
RDM	0	0	6	0	0	0	0	0
PIDM	0	0	0	0	0	0	0	3
ASM	0	0	17	0	0	0	0	26
RSM	0	67	70	0	0	0	0	5
PIRS	0	0	0	0	0	0	0	97
OTHER	0	0	105	0	0	0	0	36
ROM	0	0	17	0	0	0	0	0
AML	19	16	113	0	1	0	0	1,099
Disturbed	0	0	0	0	0	0	0	0
Highwall	283	192	396	0	208	160	8	530
Total	**19,050**	**17,016**	**27,138**	**10,467**	**22,514**	**7,818**	**25,200**	**43,013**

Point sources were represented differently, depending on the modeling scenario for TMDL development. The two major scenarios, which are described in more detail later in this section and in Section 5, are the model calibration scenario 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 75^{th} percentile DMR concentrations of similar mining activities within the entire West Fork 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 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 WV 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, i.e., the waste load allocation (WLA) based on 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.

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 technology-based permits, the waste load concentration for aluminum was assumed to be the 99th percentile value from the DMR data (4.6 mg/L).

Allocations were made to provide consistency with 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 conditions.

4.3.5 Stream Representation

Modeling subwatersheds and calibrating hydrologic and water quality model components required routing flow and pollutants through streams, which were compared to the water quality criteria. Each subwatershed was represented with a single stream. Stream segments were identified using the USGS NHD stream coverage.

To route flow and pollutants, development of rating curves was required. Rating curves were developed for each stream using Manning's equation and representative stream data. Required stream data include slope, Manning's roughness coefficient, and stream dimensions, including mean depths and channel widths. Manning's roughness coefficient was assumed to be 0.05 for all streams (representative of natural streams). Slopes were calculated based on digital elevation model (DEM) data and stream lengths measured from the NHD stream coverage. Stream dimensions were estimated using regression curves that relate upstream drainage area to stream dimensions (Rosgen, 1996). The Stonewall Jackson Dam was represented as a time series input to the mainstem (subwatershed 51) derived from the flow data provided by USGS (#0305800) and USACE.

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

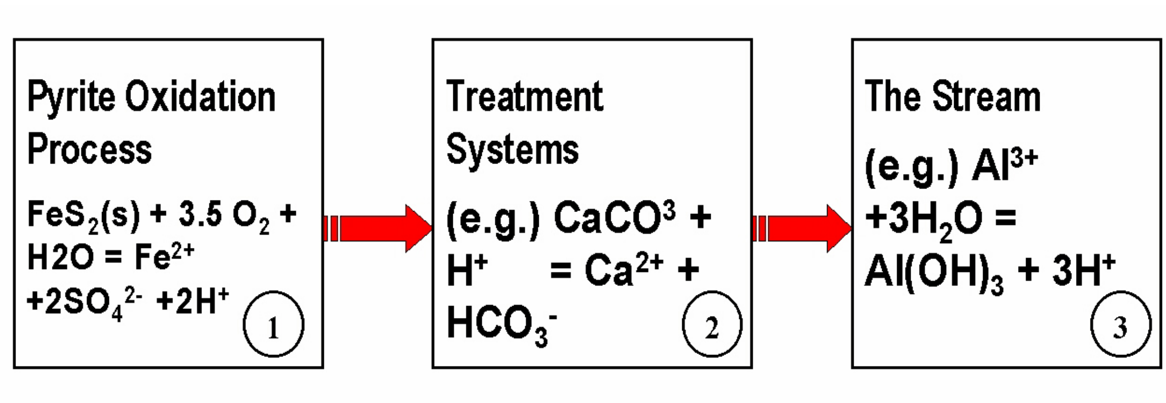
The loading contributions of these pollutants from different nonpoint sources were represented in the HSPC using the PQUAL (simulation of quality constituents for pervious land segments) and IQUAL (simulation of quality constituents for impervious land segments) modules in HSPF (Bicknell et al., 1996). 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.

Pollutant concentrations from the Stonewall Jackson Dam input were derived from the data provided by USACE. Aluminum, iron, and manganese were represented as a constant concentration of 100 ug/L.

4.4 pH TMDL Methodology Overview

4.4.1 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.



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).

It is assumed that implementing TMDLs in the West Fork watershed for aluminum, iron, and manganese will result in in-stream metals concentrations meeting the water quality criteria. This assumes that treatment systems are implemented properly and effectively increase pH in order to precipitate and thus lower metals concentrations.

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.

4.4.2 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	25.2
Mg	4.3
Na [(a)]	6.3
K [(a)]	2.3
Cl [(a)]	7.8
SO_4	66.0
Fe [(b)]	1.5 and 0.5
Al [(b)]	0.75
Mn [(b)]	1.0
Alkalinity	37.3 (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 West Fork 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 8.12 using the aquatic life standard (1.5 mg/L total Fe) and 8.12 using the trout waters standard (0.5 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.

Results from MINTEQA2 imply that pH will be within the West Virginia criterion of above six and below nine (inclusive), provided that in-stream metals concentrations simultaneously meet applicable water quality criteria.

4.4.3 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 these 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.

4.5 Model Calibration

After the model was configured, calibration was performed at multiple locations throughout the West Fork 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, 3c. 3d, 3e, and 3f in each of Appendices A-1 through A-17). 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.

4.5.1 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.

In order to best represent hydrologic variability throughout the watershed, three locations with daily flow monitoring data were selected for calibration. The stations were USGS 03061000 West Fork at Enterprise, USGS 03059000 West Fork at Mount Clare, USGS 03058500 West Fork at Butcherville. The model was calibrated at these three locations for the year 1990. 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 D. Hydrology calibration statistics are shown in Table 4-6.

Parameter values were validated for an independent, extended time period (10/1/1987 through 9/30/1997) 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 D for validation results.

Table 4-6. Comparison of Simulated and Observed Flow for 1990 (USGS#03061000)

Simulated versus Observed Flow	Percent Error	Recommended Criterion[1]
Error in total volume	**-2.15**	+/- 10%
Error in 50% lowest flows	**-1.66**	+/- 10%
Error in 10% highest flows	**5.10**	+/- 15%
Seasonal volume error - Summer	**-15.31**	+/- 30%
Seasonal volume error - Fall	**15.56**	+/- 30%
Seasonal volume error - Winter	**1.09**	+/- 30%
Seasonal volume error - Spring	**-27.25**	+/- 30%
Error in storm volumes	**0.14**	+/- 20%
Error in summer storm volumes	**-15.49**	+/- 50%

[1] Recommended Criterion: HSPExp

4.5.2 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 (*pH and Metals TMDLs for the Tygart Valley River Watershed, 2001* and *pH and Metals TMDL for the Elk 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 WVDEP Division of Water Resources, USACE, and data submitted by various mining companies throughout the watershed. Each group's data, except for USACE, 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 West Fork watershed) and loading source type. Results of the water quality calibration are presented in Appendix D.

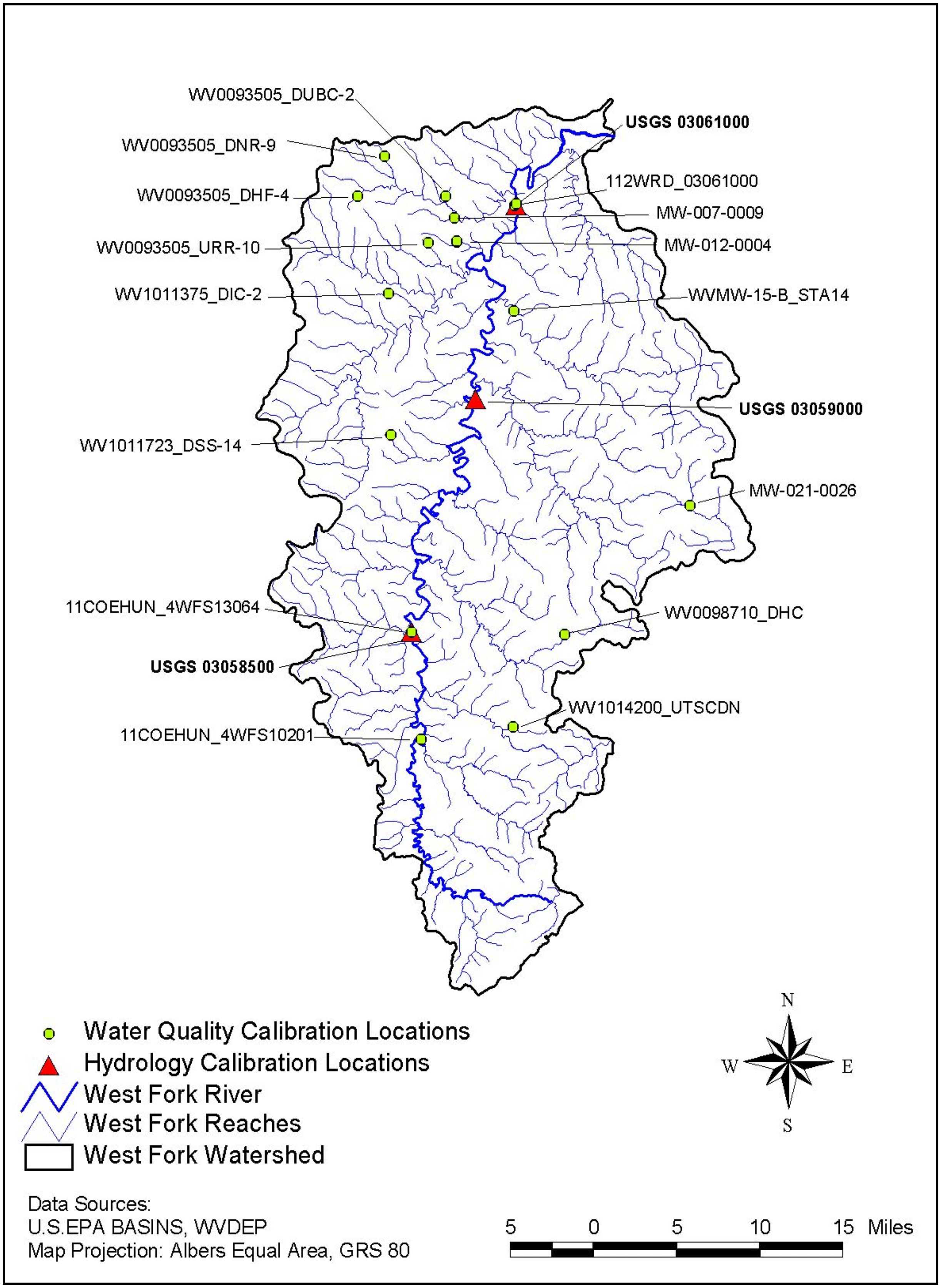


Figure 4-2. Calibration locations used in modeling

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= Summation of WLAs + Summation of LAs + MOS

In order to develop aluminum, iron, manganese, and pH TMDLs for each of the waterbodies in the West Fork watershed listed on the West Virginia Section 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 six and below nine (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 (~seven) 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

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. In addition to this implicit margin of safety, a 5 percent explicit MOS was used to account for the differences between modeled and monitored data. 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. The explicit 5percent MOS also accounts for those cases where monitoring data may not have captured the full range of in-stream conditions.

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 for the period January 1, 1987 through December 31, 1992. Predicted in-stream concentrations of aluminum, iron, and manganese for the impaired waterbodies in the West Fork 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 Clarksburg weather station. The years from 1987-1992 are marked to indicate that a range of precipitation conditions was used for TMDL development in the West Fork watershed.

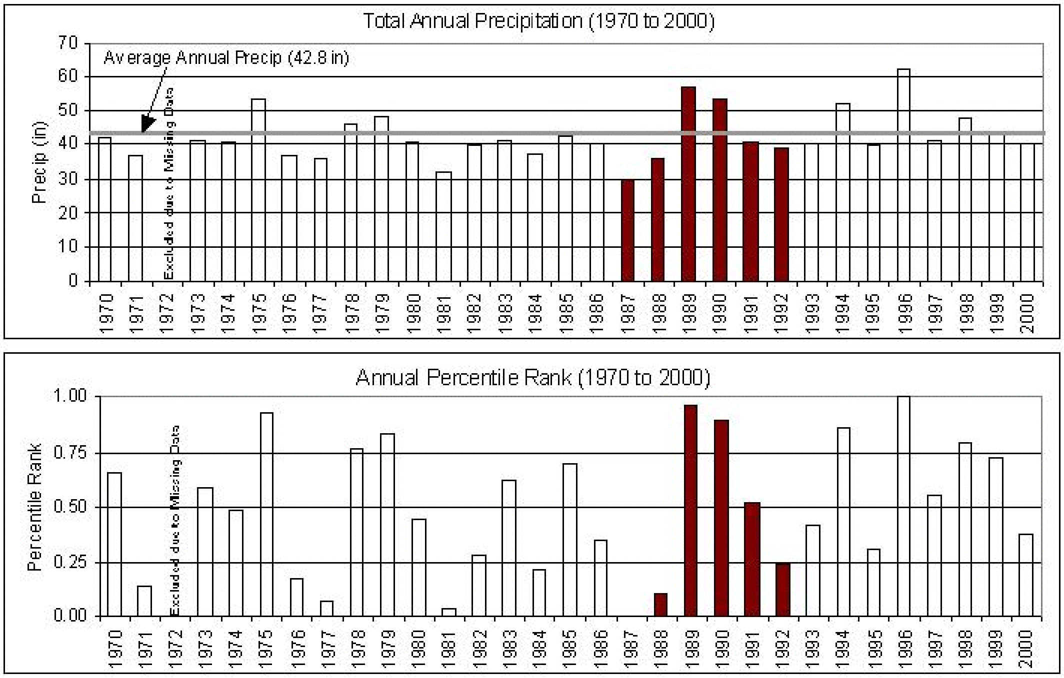


Figure 5-1. Annual Precipitation totals and Percentile Ranks for the Clarksburg weather station

Permitted conditions for the West Virginia mining facilities 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	4.6 mg/L (99th percentile DMR values)	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 out the 1987-1992 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). 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. Examples of the concentrations for iron, manganese, and aluminum baseline and TMDL conditions are presented in Figures 5-2, 5-3, and 5-4.

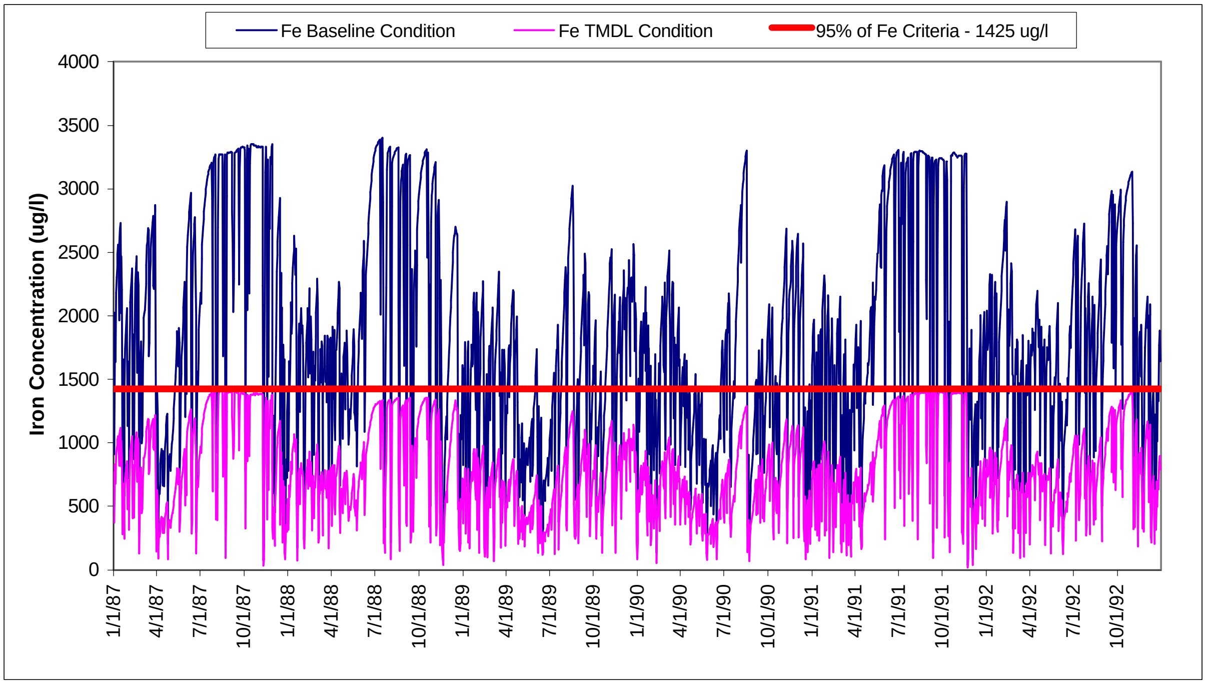


Figure 5-2 Iron Baseline and TMDL conditions Example

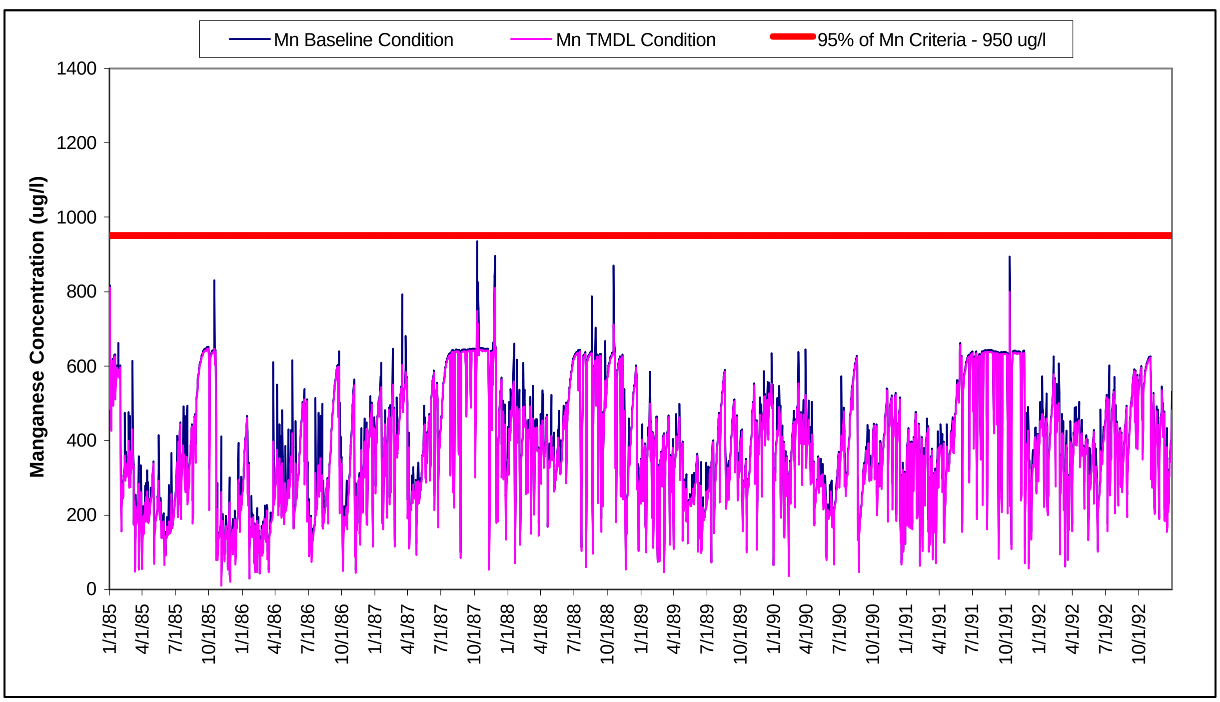


Figure 5-3 Manganese Baseline and TMDL conditions Example

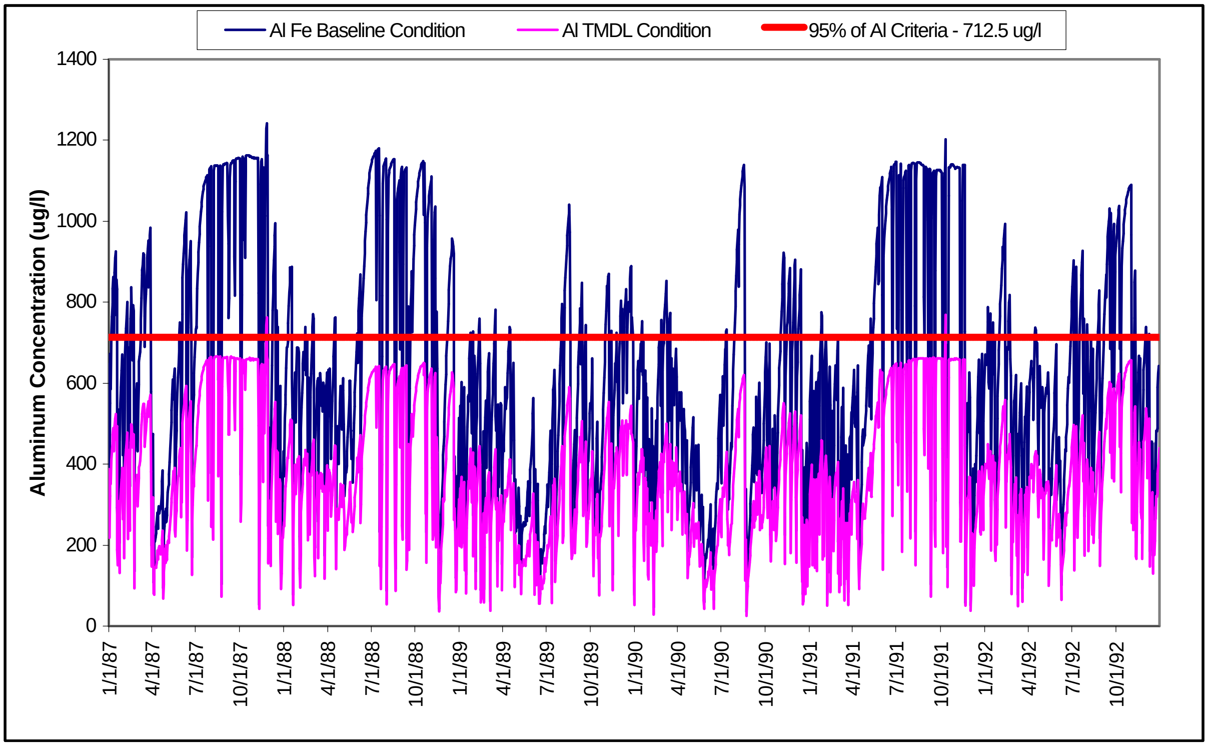


Figure 5-4 Aluminum Baseline and TMDL conditions Example

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, reductions were required in the unlisted headwaters of Booth Creek (subbasins 224 and 230), which contributed to down stream impairments. 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 following general methodology was used when allocating to sources for the West Fork watershed TMDLs.

- For watersheds with AMLs but no point sources, AMLs were reduced until in-stream water quality criteria were met.

- For watersheds with AMLs and point sources, point sources were set at the precipitation induced load defined by the permit limits and AMLs were subsequently reduced. AMLs and revoked mining permits were reduced (point sources were not reduced) until in-stream water quality criteria were met, if possible. Table 5-2 shows that AML and revoked permit loads were reduced to a value that is considered achievable. If further reduction was required once AMLs and revoked mines were reduced, the point source discharge limits were then reduced.

Table 5-2. Source Reduction (AML) for SWS 209

Parameter	Landuse	Total Area (acres)	Base Load (lb/yr)	Base Unit Area (lb/ac/yr)	Allocated Load (lb/yr)	Allocated Unit Area Loading (lb/ac/yr)
Aluminum	Mature Forest	327.90	130	0.40	130	0.40
Aluminum	AML	57.15	2,479	43.37	50	0.87
Iron	Mature Forest	327.90	274	0.84	274	0.84
Iron	AML	57.15	8,570	149.94	171	3.00
Manganese	Mature Forest	327.90	101	0.31	101	0.31
Manganese	AML	57.15	1,486	26.01	45	0.78

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 West Fork watershed were determined on a subwatershed basis for each of the 17 defined regions.

5.4.1 Wasteload Allocations (WLAs)

Waste load allocations (WLAs) were made for all permitted facilities except for limestone quarries and those with a Completely released or Phase two released classification. 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]

The WLA for the UCAR Carbon, Inc. for iron is shown in Table 4b, Appendix 7. The Monongahela Power Station and four minor dischargers are recognized as discharging *de minims* waste loads which are accounted for in the TMDL development as part of the background loads. 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-17. 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: 0.75-4.6 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-17. 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 the 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 Section 4.4), equilibrium pH was estimated to be 8.12 using the aquatic life standard (1.5

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[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.

mg/L total Fe) and 8.12 using the trout waters standard (0.5 mg/L total Fe). 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 (inclusive) 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 West Fork River watershed metals TMDLs, seasonal variation was considered in the formulation of the modeling analysis. By using continuous simulation (modeling over a period of several years), seasonal hydrologic and critical conditions were 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	SWS Outlet	DNR Code	DNR Name	LAs (lb/yr)	WLAs (lb/yr)	MOS (lb/yr)	TMDL (lb/yr)
1	501	MW-5	Tevebaugh Creek	1,437	0	72	1,509
2	710	MW-7-C	Elk Lick Run	318	0	16	334
2	713	MW-7-D	Cunningham Run	1,157	615	89	1,861
2	1501	MW-12	Robinson Run	211	0	11	222
2	1501	MW-15	Simpson Creek	723	1,383	105	2,212
2	1501	MW-13	Ten Mile Creek	296	0	15	311
2	1501	MW-16	Lambert Run	179	0	9	188
2	1502	MW-12-A	Pigotts Run	296	0	15	311
2	1505	MW-12?	Robinson Run: UT#1	179	0	9	188
3	201	MW-2	Booth Creek	13,946	840	739	15,526
3	202	MW-2?a	Booth Creek: UT#1	74	0	4	78
3	205	MW-2?b	Booth Creek: UT#2	92	0	5	97
3	207	MW-2?c	Booth Creek: UT#3	140	0	7	147
3	209	MW-2-A	Hog Lick Run	276	319	30	625
3	211	MW-2-C	Sweep Run	262	234	25	521
3	213	MW-2-D	Horners Run	701	0	35	736
3	231	MW-2-D-1	Purdys Run	312	78	19	409
3	301	MW-3	Coons Run	2,713	0	136	2,849
3	901	MW-8	Laurel Run	302	145	22	470
3	1101	MW-9	Mudlick Run	1,007	396	70	1,473
3	1401	MW-11	Shinns Run	3,790	214	200	4,205
4	1801	MW-15	Simpson Creek	32,332	534	1,643	34,509
4	1802	MW-15-A	Jack Run	373	0	19	392
4	1804	MW-15-B	Smith Run	1,197	0	60	1,257
4	1818	MW-15-H	Jerry Run	719	0	36	755
4	1820	MW-15-I	Berry Run	1,213	0	61	1,274
4	1824	MW-15-J	Right Fork	3,874	0	194	4,068
4	1826	MW-15?c	Simpson Creek: UT#3	78	0	4	82

Region	SWS Outlet	DNR Code	DNR Name	LAs (lb/yr)	WLAs (lb/yr)	MOS (lb/yr)	TMDL (lb/yr)
4	1828	MW-15-J-1	Buck Fork	987	0	49	1,036
4	1830	MW-15-J-2	Sand Lick Run	701	0	35	736
4	1833	MW-15-J-3	Gabe Fork	593	0	30	622
4	1837	MW-15?d	Simpson Creek: UT#4	464	0	23	487
4	1839	MW-15-K	Bartlett Run	497	0	25	521
4	1841	MW-15?e	Simpson Creek: UT#5	140	0	7	147
4	1843	MW-15-L	West Branch	1,964	0	98	2,062
4	1845	MW-15-M	Camp Branch	508	0	25	534
4	1847	MW-15?f	Simpson Creek: UT#6	369	0	18	387
4	1848	MW-15?a	Simpson Creek: UT#1	240	0	12	252
4	1850	MW-15-L-1	Stillhouse Run	296	0	15	311
4	1852	MW-15-L?	Right Branch-West Branch-Simpson Creek	470	0	24	494
4	2001	MW-17	Jack Run	610	0	30	640
4	2101	MW-18	Fall Run	433	0	22	455
5	1601	MW-13	Ten Mile Creek	50,620	2,460	2,654	55,734
5	1602	MW-13.5-A	Jack Run	165	0	8	173
5	1604	MW-13-A	Jones Run	4,738	922	283	5,943
5	1610	MW-13-B	Little Ten Mile Creek	12,488	0	624	13,112
5	1612	MW-13-B-1	Peters Run	171	0	9	179
5	1614	MW-13-B?	Little Ten Mile Creek: UT#1	266	0	13	279
5	1616	MW-13-B-2	Bennett Run	915	0	46	960
5	1620	MW-13-B-4	Laurel Run	364	0	18	382
5	1624	MW-13-B-6	Elk Creek	1,176	0	59	1,235
5	1630	MW-13-B-9	Mudlick Run	476	0	24	500
5	1632	MW-13-C	Isaacs Creek	792	423	61	1,275
5	1634	MW-13-C-1	Little Isaacs Creek	138	0	7	144
5	1636	MW-13-D	Gregorey Run	908	0	45	953
5	1638	MW-13-E	Katy Lick Run	1,026	0	51	1,077
5	1642	MW-13?	Tenmile Creek: UT#3	381	0	19	400
5	1643	MW-13-F	Rockcamp Run	4,144	0	207	4,351
5	1645	MW-13-F-1	Little Rockcamp Run	1,929	0	96	2,026
5	1661	MW-13-I-2	Cherry Camp Run	593	0	30	623
5	1664	MW-13-I-3	Patterson Fork	794	0	40	834
5	1678	MW-13-N	Coburn Fork	1,076	0	54	1,130
5	1680	MW-13-N-1	Shaw Run	220	0	11	231
5	1901	MW-16	Lambert Run	3,540	0	177	3,717
6	2201	MW-19	Crooked Run	972	0	49	1,020
6	2301	MW-20-A	Limestone Run	5,622	1,380	350	7,352
6	2502	MW-22-A	Washburn Camp Run	244	0	12	256
6	2701	MW-24	Coburns Creek	1,099	0	55	1,154
6	2801	MW-25	Sycamore Creek	3,903	204	205	4,312
6	3001	MW-27	Buffalo Creek	2,226	0	111	2,337
7	2401	MW-21	Elk Creek	55,695	5,199	3,045	63,939
7	2402	MW-21-A	Murphy Run	562	0	28	590
7	2409	MW-21-D	Nutter Run	354	0	18	372

Region	SWS Outlet	DNR Code	DNR Name	LAs (lb/yr)	WLAs (lb/yr)	MOS (lb/yr)	TMDL (lb/yr)
7	2411	MW-21-E	Turkey Run	260	0	13	273
7	2413	MW-21-F	Hoopole Run	321	0	16	337
7	2414	MW-21-G	Brushy Fork	8,956	203	458	9,617
7	2420	MW-21-G-1	Coplin run	971	0	49	1,020
7	2440	MW-21-M	Gnatty Creek	13,685	1,929	781	16,395
7	2443	MW-21-O	Birds Run	778	0	39	816
7	2446	MW-21-P	Arnold Run	968	371	67	1,405
7	2448	MW-21-Q	Isaacs Run	335	477	41	852
7	2449	MW-21-S	Stewart Run	1,574	95	83	1,753
7	2468	MW-21-M-5	Right Branch	935	861	90	1,886
7	2472	MW-21-M-5-A	Charity Fork	337	454	40	831
8	2601	MW-23	Browns Creek	3,113	0	156	3,269
8	2901	MW-26	Lost Creek	10,487	1,358	592	12,437
8	2902	MW-26?a	Lost Creek: UT#1	597	700	65	1,361
8	2907	MW-26-A	Bonds Run	555	0	28	583
9	3501	MW-31	HACKERS CREEK	21,879	2,838	1,236	25,953
10	4008	MW-36-C.5	Mare Run	903	0	45	948
12	4410	MW-38-E	GRASS RUN	695	0	35	729
14	4901	MW-44	Stone Lick	208	0	10	219
15	5403	MW-50-C	FITZ RUN	272	0	14	285
15	5404	MW-50-D	WARD RUN	382	0	19	401
17	1	MW	West Fork	353,611	26,080	18,985	398,676
17	701	MW-7	Bingamon Creek	16,393	3,804	1,010	21,207
17	801	MW?	West Fork: UT#4@Hutchinson	125	0	6	131
17	1001	MW-8.5	West Fork: UT#3@Viropa	80	31	6	117
17	1201	MW-8.7	West Fork: UT#2@Viropa	109	100	10	219
17	1301	MW-10	Browns Run	194	0	10	203
17	1701	MW-14.2	West Fork: UT#1@Gypsy	75	0	4	78

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

Region	SWS Outlet	DNR Code	DNR Name	LAs (lb/yr)	WLAs (lb/yr)	MOS (lb/yr)	TMDL (lb/yr)
1	501	MW-5	Tevebaugh Creek	3,298	0	165	3,463
2	710	MW-7-C	Elk Lick Run	640	0	32	672
2	713	MW-7-D	Cunningham Run	2,798	422	161	3,381
2	1501	MW-12	Robinson Run	177	0	9	186
2	1501	MW-16	Lambert Run	350	0	17	367
2	1501	MW-13	Ten Mile Creek	638	0	32	670
2	1501	MW-15	Simpson Creek	1,862	1,901	188	3,952
2	1502	MW-12-A	Pigotts Run	638	0	32	670
2	1505	MW-12?	Robinson Run: UT#1	350	0	17	367
3	201	MW-2	Booth Creek	32,303	607	1,646	34,556
3	202	MW-2?a	Booth Creek: UT#1	149	0	7	156
3	205	MW-2?b	Booth Creek: UT#2	185	0	9	195

Region	SWS Outlet	DNR Code	DNR Name	LAs (lb/yr)	WLAs (lb/yr)	MOS (lb/yr)	TMDL (lb/yr)
3	207	MW-2?c	Booth Creek: UT#3	281	0	14	295
3	209	MW-2-A	Hog Lick Run	646	248	45	938
3	211	MW-2-C	Sweep Run	605	161	38	805
3	213	MW-2-D	Horners Run	1,499	0	75	1,574
3	231	MW-2-D-1	Purdys Run	706	54	38	798
3	301	MW-3	Coons Run	5,335	0	267	5,602
3	901	MW-8	Laurel Run	731	100	42	873
3	1101	MW-9	Mudlick Run	2,475	273	137	2,885
3	1401	MW-11	Shinns Run	6,894	148	352	7,394
4	1801	MW-15	Simpson Creek	63,354	1,176	3,226	67,756
4	1802	MW-15-A	Jack Run	771	0	39	810
4	1804	MW-15-B	Smith Run	2,090	0	104	2,194
4	1818	MW-15-H	Jerry Run	1,525	0	76	1,601
4	1820	MW-15-I	Berry Run	2,347	0	117	2,464
4	1824	MW-15-J	Right Fork	8,064	0	403	8,468
4	1826	MW-15?c	Simpson Creek: UT#3	197	0	10	207
4	1828	MW-15-J-1	Buck Fork	1,983	0	99	2,083
4	1830	MW-15-J-2	Sand Lick Run	1,190	0	60	1,250
4	1833	MW-15-J-3	Gabe Fork	1,275	0	64	1,338
4	1837	MW-15?d	Simpson Creek: UT#4	846	0	42	889
4	1839	MW-15-K	Bartlett Run	1,003	0	50	1,053
4	1841	MW-15?e	Simpson Creek: UT#5	262	0	13	275
4	1843	MW-15-L	West Branch	3,803	0	190	3,994
4	1845	MW-15-M	Camp Branch	1,117	0	56	1,173
4	1847	MW-15?f	Simpson Creek: UT#6	623	0	31	654
4	1848	MW-15?a	Simpson Creek: UT#1	477	0	24	501
4	1850	MW-15-L-1	Stillhouse Run	550	0	28	578
4	1852	MW-15-L?	Right Branch-West Branch-Simpson Creek	801	0	40	841
4	2001	MW-17	Jack Run	1,558	0	78	1,636
4	2101	MW-18	Fall Run	805	0	40	845
5	1601	MW-13	Ten Mile Creek	111,564	1,694	5,663	118,921
5	1602	MW-13.5-A	Jack Run	433	0	22	455
5	1604	MW-13-A	Jones Run	9,497	634	507	10,637
5	1610	MW-13-B	Little Ten Mile Creek	25,757	0	1,288	27,045
5	1612	MW-13-B-1	Peters Run	311	0	16	327
5	1614	MW-13-B?	Little Ten Mile Creek: UT#1	613	0	31	644
5	1616	MW-13-B-2	Bennett Run	1,692	0	85	1,776
5	1620	MW-13-B-4	Laurel Run	751	0	38	789
5	1624	MW-13-B-6	Elk Creek	2,444	0	122	2,567
5	1630	MW-13-B-9	Mudlick Run	994	0	50	1,044
5	1632	MW-13-C	Isaacs Creek	1,807	291	105	2,204
5	1634	MW-13-C-1	Little Isaacs Creek	279	0	14	293
5	1636	MW-13-D	Gregorey Run	1,907	0	95	2,002
5	1638	MW-13-E	Katy Lick Run	2,093	0	105	2,197
5	1642	MW-13?	Tenmile Creek: UT#3	815	0	41	855

Region	SWS Outlet	DNR Code	DNR Name	LAs (lb/yr)	WLAs (lb/yr)	MOS (lb/yr)	TMDL (lb/yr)
5	1643	MW-13-F	Rockcamp Run	9,184	0	459	9,643
5	1645	MW-13-F-1	Little Rockcamp Run	4,305	0	215	4,520
5	1661	MW-13-I-2	Cherry Camp Run	1,212	0	61	1,273
5	1664	MW-13-I-3	Patterson Fork	1,592	0	80	1,672
5	1678	MW-13-N	Coburn Fork	2,178	0	109	2,287
5	1680	MW-13-N-1	Shaw Run	445	0	22	467
5	1901	MW-16	Lambert Run	6,082	0	304	6,386
6	2201	MW-19	Crooked Run	2,080	0	104	2,184
6	2301	MW-20-A	Limestone Run	10,918	953	594	12,464
6	2502	MW-22-A	Washburn Camp Run	689	0	34	723
6	2701	MW-24	Coburns Creek	2,245	0	112	2,357
6	2801	MW-25	Sycamore Creek	8,232	140	419	8,791
6	3001	MW-27	Buffalo Creek	4,549	0	227	4,777
7	2401	MW-21	Elk Creek	113,059	4,305	5,868	123,232
7	2402	MW-21-A	Murphy Run	1,411	0	71	1,482
7	2409	MW-21-D	Nutter Run	899	0	45	944
7	2411	MW-21-E	Turkey Run	547	0	27	574
7	2413	MW-21-F	Hoopole Run	657	0	33	689
7	2414	MW-21-G	Brushy Fork	17,008	140	857	18,006
7	2420	MW-21-G-1	Coplin run	1,892	0	95	1,987
7	2440	MW-21-M	Gnatty Creek	27,664	1,531	1,460	30,654
7	2443	MW-21-O	Birds Run	1,656	0	83	1,738
7	2446	MW-21-P	Arnold Run	2,091	256	117	2,464
7	2448	MW-21-Q	Isaacs Run	915	657	79	1,651
7	2449	MW-21-S	Stewart Run	3,097	66	158	3,321
7	2468	MW-21-M-5	Right Branch	2,273	593	143	3,009
7	2472	MW-21-M-5-A	Charity Fork	821	313	57	1,191
8	2601	MW-23	Browns Creek	7,399	0	370	7,769
8	2901	MW-26	Lost Creek	27,481	937	1,421	29,840
8	2902	MW-26?a	Lost Creek: UT#1	1,715	483	110	2,308
8	2907	MW-26-A	Bonds Run	1,586	0	79	1,666
9	3501	MW-31	HACKERS CREEK	44,793	2,076	2,343	49,212
10	4008	MW-36-C.5	Mare Run	1,812	0	91	1,902
12	4410	MW-38-E	GRASS RUN	1,412	0	71	1,483
14	4901	MW-44	Stone Lick	396	0	20	416
15	5403	MW-50-C	FITZ RUN	519	0	26	545
15	5404	MW-50-D	WARD RUN	798	0	40	838
17	1	MW	West Fork	737,540	21,682	37,961	797,183
17	701	MW-7	Bingamon Creek	36,856	2,614	1,973	41,443
17	801	MW?	West Fork: UT#4@Hutchinson	292	0	15	306
17	1001	MW-8.5	West Fork: UT#3@Viropa	213	21	12	246
17	1201	MW-8.7	West Fork: UT#2@Viropa	360	69	21	450
17	1301	MW-10	Browns Run	392	0	20	411
17	1701	MW-14.2	West Fork: UT#1@Gypsy	137	0	7	144

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

Region	SWS Outlet	DNR Code	DNR Name	LAs (lb/yr)	WLAs (lb/yr)	MOS (lb/yr)	TMDL (lb/yr)
1	501	MW-5	Tevebaugh Creek	1,653	0	83	1,735
2	710	MW-7-C	Elk Lick Run	471	0	24	494
2	713	MW-7-D	Cunningham Run	2,122	275	120	2,517
2	1501	MW-12	Robinson Run	457	0	23	479
2	1501	MW-13	Ten Mile Creek	354	0	18	372
2	1501	MW-15	Simpson Creek	1,232	1,240	124	2,595
2	1501	MW-16	Lambert Run	151	0	8	159
2	1502	MW-12-A	Pigotts Run	354	0	18	372
2	1505	MW-12?	Robinson Run: UT#1	151	0	8	159
3	201	MW-2	Booth Creek	12,197	409	630	13,236
3	202	MW-2?a	Booth Creek: UT#1	61	0	3	64
3	205	MW-2?b	Booth Creek: UT#2	108	0	5	114
3	207	MW-2?c	Booth Creek: UT#3	231	0	12	243
3	209	MW-2-A	Hog Lick Run	228	178	20	426
3	211	MW-2-C	Sweep Run	381	104	24	509
3	213	MW-2-D	Horners Run	859	0	43	902
3	231	MW-2-D-1	Purdys Run	489	35	26	550
3	301	MW-3	Coons Run	4,315	0	216	4,531
3	901	MW-8	Laurel Run	346	64	21	431
3	1101	MW-9	Mudlick Run	1,926	175	105	2,207
3	1401	MW-11	Shinns Run	4,310	95	220	4,625
4	1801	MW-15	Simpson Creek	38,769	955	1,986	41,710
4	1802	MW-15-A	Jack Run	639	0	32	671
4	1804	MW-15-B	Smith Run	1,660	0	83	1,743
4	1818	MW-15-H	Jerry Run	681	0	34	715
4	1820	MW-15-I	Berry Run	1,381	0	69	1,450
4	1824	MW-15-J	Right Fork	4,381	0	219	4,600
4	1826	MW-15?c	Simpson Creek: UT#3	145	0	7	153
4	1828	MW-15-J-1	Buck Fork	978	0	49	1,026
4	1830	MW-15-J-2	Sand Lick Run	1,078	0	54	1,132
4	1833	MW-15-J-3	Gabe Fork	917	0	46	963
4	1837	MW-15?d	Simpson Creek: UT#4	711	0	36	747
4	1839	MW-15-K	Bartlett Run	759	0	38	797
4	1841	MW-15?e	Simpson Creek: UT#5	225	0	11	236
4	1843	MW-15-L	West Branch	2,812	0	141	2,952
4	1845	MW-15-M	Camp Branch	772	0	39	810
4	1847	MW-15?f	Simpson Creek: UT#6	497	0	25	522
4	1848	MW-15?a	Simpson Creek: UT#1	314	0	16	329
4	1850	MW-15-L-1	Stillhouse Run	390	0	20	410
4	1852	MW-15-L?	Right Branch-West Branch-Simpson Creek	620	0	31	651
4	2001	MW-17	Jack Run	1,022	0	51	1,073
4	2101	MW-18	Fall Run	494	0	25	519
5	1601	MW-13	Ten Mile Creek	48,557	1,095	2,483	52,135
5	1602	MW-13.5-A	Jack Run	203	0	10	213

Region	SWS Outlet	DNR Code	DNR Name	LAs (lb/yr)	WLAs (lb/yr)	MOS (lb/yr)	TMDL (lb/yr)
5	1604	MW-13-A	Jones Run	5,953	413	318	6,685
5	1610	MW-13-B	Little Ten Mile Creek	11,461	0	573	12,034
5	1612	MW-13-B-1	Peters Run	225	0	11	236
5	1614	MW-13-B?	Little Ten Mile Creek: UT#1	204	0	10	214
5	1616	MW-13-B-2	Bennett Run	1,474	0	74	1,547
5	1620	MW-13-B-4	Laurel Run	289	0	14	303
5	1624	MW-13-B-6	Elk Creek	927	0	46	973
5	1630	MW-13-B-9	Mudlick Run	374	0	19	393
5	1632	MW-13-C	Isaacs Creek	1,274	188	73	1,536
5	1634	MW-13-C-1	Little Isaacs Creek	130	0	7	137
5	1636	MW-13-D	Gregorey Run	930	0	46	976
5	1638	MW-13-E	Katy Lick Run	1,442	0	72	1,514
5	1642	MW-13?	Tenmile Creek: UT#3	645	0	32	677
5	1643	MW-13-F	Rockcamp Run	4,985	0	249	5,234
5	1645	MW-13-F-1	Little Rockcamp Run	3,273	0	164	3,437
5	1661	MW-13-I-2	Cherry Camp Run	473	0	24	496
5	1664	MW-13-I-3	Patterson Fork	686	0	34	721
5	1678	MW-13-N	Coburn Fork	916	0	46	962
5	1680	MW-13-N-1	Shaw Run	177	0	9	185
5	1901	MW-16	Lambert Run	5,355	0	268	5,623
6	2201	MW-19	Crooked Run	1,494	0	75	1,569
6	2301	MW-20-A	Limestone Run	7,830	612	422	8,864
6	2502	MW-22-A	Washburn Camp Run	325	0	16	342
6	2701	MW-24	Coburns Creek	1,737	0	87	1,824
6	2801	MW-25	Sycamore Creek	5,685	91	289	6,065
6	3001	MW-27	Buffalo Creek	3,224	0	161	3,386
7	2401	MW-21	Elk Creek	58,252	2,777	3,051	64,081
7	2402	MW-21-A	Murphy Run	832	0	42	874
7	2409	MW-21-D	Nutter Run	587	0	29	616
7	2411	MW-21-E	Turkey Run	205	0	10	215
7	2413	MW-21-F	Hoopole Run	429	0	21	450
7	2414	MW-21-G	Brushy Fork	12,066	90	608	12,764
7	2420	MW-21-G-1	Coplin run	1,150	0	57	1,207
7	2440	MW-21-M	Gnatty Creek	14,709	986	785	16,480
7	2443	MW-21-O	Birds Run	1,013	0	51	1,064
7	2446	MW-21-P	Arnold Run	1,287	165	73	1,524
7	2448	MW-21-Q	Isaacs Run	364	424	39	827
7	2449	MW-21-S	Stewart Run	2,313	43	118	2,473
7	2468	MW-21-M-5	Right Branch	1,553	382	97	2,033
7	2472	MW-21-M-5-A	Charity Fork	592	201	40	833
8	2601	MW-23	Browns Creek	4,401	0	220	4,621
8	2901	MW-26	Lost Creek	10,182	601	539	11,323
8	2902	MW-26?a	Lost Creek: UT#1	1,660	310	98	2,068
8	2907	MW-26-A	Bonds Run	413	0	21	434
9	3501	MW-31	HACKERS CREEK	25,702	1,334	1,352	28,388
10	4008	MW-36-C.5	Mare Run	1,500	0	75	1,575

Region	SWS Outlet	DNR Code	DNR Name	LAs (lb/yr)	WLAs (lb/yr)	MOS (lb/yr)	TMDL (lb/yr)
12	4410	MW-38-E	GRASS RUN	1,147	0	57	1,205
14	4901	MW-44	Stone Lick	187	0	9	197
15	5403	MW-50-C	FITZ RUN	450	0	22	472
15	5404	MW-50-D	WARD RUN	624	0	31	656
17	1	MW	West Fork	372,249	14,233	19,324	405,807
17	701	MW-7	Bingamon Creek	13,601	1,704	765	16,070
17	801	MW?	West Fork: UT#4@Hutchinson	89	0	4	94
17	1001	MW-8.5	West Fork: UT#3@Viropa	60	14	4	78
17	1201	MW-8.7	West Fork: UT#2@Viropa	87	44	7	138
17	1301	MW-10	Browns Run	156	0	8	164
17	1701	MW-14.2	West Fork: UT#1@Gypsy	51	0	3	54

5.4.5 Future Growth

This West Fork TMDL does 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 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.

This TMDL neither prohibits nor authorizes trading in the West Fork watershed. Both the WVDEP and EPA generally endorse the concept of trading and recognize that it might become an effective tool for TMDL implementation. However, significant regulatory framework development is necessary before large-scale trading in West Virginia may be realized. EPA will cooperate with WVDEP in its development of a statewide or watershed-based trading program. Further, EPA supports program development assisted by a consensus-based stakeholder process.

Before the development of a formal trading program, it is conceivable that the regulation of specific point source-to-point source trades might be feasible under the framework of the NPDES program. EPA commits to cooperate with the WVDEP to facilitate such trades if opportunities arise and are proven to be environmentally beneficial.

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 West Fork River watershed.

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

Project	County	Cost	Status
Flemming Protals & Drainage	Barbour	$244,190	In-Design
Stillhouse Run Refuse	Barbour	$344,685	In-Design
Robey Mine Highwall & Portals	Harrison	$185,680	Mapped
Clarksburg (Bailey) Mine Drainage	Harrison	$37,290	In-Design
Rosemont Highwall & Portals	Taylor	$307,450	In-Design
Sauls Run Strip & Landslide	Lewis	$137,900	In-Design
Viropa Mine Drainage	Harrison	$35,530	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.

Priority	**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 West Fork River watershed are scheduled to be reissued in 2005.

7.0 Monitoring Plan

Follow-up monitoring of the West Fork 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.

WVDEP should continue monitoring the impaired segments of the West Fork River (tributaries) via its established Watershed Management monitoring approach in 2005, 2009 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 WVDEP to solicit public input by providing opportunities for public comment and review of the draft TMDLs. The public comment period began on July 22, 2002 and ended August 26, 2002. Public notices were published in two newspapers, *The Times West Virginian* in Fairmont, West Virginia and *The Clarksburg Exponent/Telegram* in Clarksburg, West Virginia. The public meetings pertaining to the West Fork River watershed occurred as follows:

- An informational TMDL 101 public meeting was held on May 29, 2002.
- An informational public meeting to present the Draft TMDL was held on August 14, 2002.

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