Metals and pH TMDLs for the Tygart Valley River Watershed West Virginia

U.S. Environmental Protection Agency
Region 3
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Date

Decision Rationale

Total Maximum Daily Loads for Metals and pH for the Tygart Valley River Watershed West Virginia

I. Introduction

This document sets forth the Environmental Protection Agency's (EPA) rationale for establishing the Total Maximum Daily Loads (TMDLs) for metals (aluminum, iron, and manganese) and pH for the Tygart Valley River watershed. The public comment period for the proposed TMDLs began on December 15, 2000, and ended January 31, 2001. EPA's rationale is based on the determination that the TMDLs meet the following eight regulatory conditions pursuant to 40 CFR Part 130.

1. The TMDLs are designed to implement applicable water quality standards.
2. The TMDLs include a total allowable load as well as individual waste load allocations and load allocations.
3. The TMDLs consider the impacts of background pollutant contributions.
4. The TMDLs consider critical environmental conditions.
5. The TMDLs consider seasonal environmental variations.
6. The TMDLs include a margin of safety.
7. There is reasonable assurance that the TMDLs can be met.
8. The TMDLs have been subject to public participation.

II. Summary

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and instream conditions. By following the TMDL process, states can establish water quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (EPA, 1991b).

The West Virginia Division of Environmental Protection (WVDEP) has identified the Tygart Valley River mainstem and 53 tributaries as being impaired by acid mine drainage, as reported on the 1996 Section 303(d) list of water quality limited waters (WVDEP, 1996). The 1997 consent decree, established in conjunction with the West Virginia TMDL lawsuit, requires that a minimum of 100 TMDLs for mine drainage impacted waters, including the Tygart Valley

River mainstem, be established by September 30, 1999. WVDEP and EPA selected the Tygart Valley River watershed as 54 of the required 100 mine impacted waters for TMDLs. However, EPA requested, and the plaintiffs agreed to, an 18-month extension to the due date, or until March 30, 2001.

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

Listed Segment ID	Stream Name	Length (mi)	Trout Waters	Al	Fe	Mn	Metals*	pH
WV_M-27(a)_1998	TYGART RIVER	36					x	x
WV_M-27(b)_1998	TYGART RIVER	23	x	x				
WV_MT-11-A_1998	SHELBY RN	3.6	x				x	x
WV_MT-11-B-1_1998	BERRY RN	1.5	x				x	x
WV_MT-11-B_1998	LONG RN / BERKELEY RN	3.6	x				x	x
WV_MT-11_1998	BERKELY RN	7.2	x				x	x
WV_MT-12-C-2_1998	LITTLE RACOON RN	2.6					x	
WV_MT-12-C_1998	RACCOON CK/THREEFORK CK	8.8					x	x
WV_MT-12-H_1998	BIRDS CK	5.5					x	x
WV_MT-12-I_1998	SQUIRES CK	4.5					x	x
WV_MT-12-G2_1998	BRAINS CK/FIELDS CK	4.9					x	x
WV_MT-12_1998	THREEFORK CK	19					x	x
WV_MT-18-C_1998	GLADE RN / SANDY CK	2.9					x	x
WV_MT-18-E-1_1998	MAPLE RN	4.8					x	x
WV_MT-18-E-3_1998	LEFT FK / LL SANDY CK	5.4					x	x
WV_MT-18-E_1998	LITTLE SANDY CK	10.6					x	x
WV_MT-18-G_1998	LEFT FORK / SANDY CK	8					x	
WV_MT-18_1998	SANDY CK	16.4					x	x
WV_MT-24-A_1998	FROST RN	2.2					x	x
WV_MT-26-B_1998	FOXGRAPE RN	3.4		x				
WV_MT-26-C_1998	LITTLE HACKERS CK	1.6		x				
WV_MT-27_1998	FORD RN	2.7					x	x
WV_MT-29_1998	ANGLINS RN	2.6					x	x
WV_MT-31_1998	BUCKHANNON RIVER	5.55			x			
WV_MT-33(a)_1998	MIDDLE FORK RIVER	4.7	x					x
WV_MT-33(b)_1998	MIDDLE FORK RIVER	4.7	x	x				
WV_MT-36_1998	ISLAND RN	1.2					x	x
WV_MT-37_1998	BEAVER CK	4.6	x				x	x
WV_MT-39_1998	LAUREL RN	3.4	x				x	x
WV_MT-4_1998	GOOSE CK	2.6	x				x	x
WV_MT-40.?_1998[a]	U.T /TYGART RIVER (HARDING)	0					x	x
WV_MT-41_1998	GRASSY RN	2.8					x	x
WV_MT-42_1998	ROARING CK	15	x				x	x
WV_MT-5_1998	LOST RN	8.6	x				x	x
wv_MTB-5-.8A	UT / PECKS RUN	.69					x	x
WV_MTB-10-A_1998	SUGAR RN	1.73					x	
WV_MTB-10_1998	TURKEY RN	7.04					x	x
WV_MTB-11-B_1998	MUD LICK OF FINK RN	1.9			x	x		
WV-MTB-11-B.7	BRIDGE RN / FINK RN	2.47					x	x
WV_MTB-11_1998	FINK RN	8.17					x	x
WV_MTB-18	FRENCH CREEK	18.47					x	
WV_MTB-18-A	CROOKED RUN	1.38					x	

Listed Segment ID	Stream Name	Length (mi)	Trout Waters	Al	Fe	Mn	Metals*	pH
WV_MTB-18-B-3	MUDLICK RN	1.14			x			
WV_MTB-18-B-2_1998	BLACKLICK RN	2.09			x			
WV_MTB-18-B_1998	BULL RN	3.9			x			
WV_MTB-25_1998	TEN MILE CREEK	3.2	x	x	x			
WV_MTB-27_1998	PANTHER FK	6.4	x					x
WV_MTB-29_1998	SWAMP RN	1.68	x				x	x
WV_MTB-30_1998	HERODS RN	2.62	x					x
WV_MTB-32(a)_1998	LEFT FK / BUCKHANNON RV	17.9			x			x
WV_MTB-8	BIG RUN	1.89					x	x
WV_MTB-5-B_1998	LITTLE PECKS RN	2.49			x	x		
WV_MTB-5-C_1998	MUD RN/PECKS RN	1.18					x	
WV_MTB-5_1998	PECKS RN	8.2					x	x
WV_MTB-3	BIG RUN	6.01					x	x
WV_MTM-16 (TBL_B)_1998	CASSITY CK	6.4	x				x	x
WV_MTM-16-A_1998	PANTHER RN	5.8	x				x	x
WV_MTM-4_1998	DEVIL RN	2.33	x				x	x
WV_MTM-6_1998	HELL RN	3.23	x				x	x
WV_MTM-8_1998	WHITEOAK RN	1.92	x				x	x

[a]Official WV stream code, exact location unknown
* Metals includes aluminum, iron, and managese

Table 2 includes three streams that were subsequently removed from the section 303(d) list, streams for which TMDLs were previously developed, and one stream not on the 1996 section 303(d) list but that is on the 1998 section 303(d) list.

The *Metals and pH TMDLs for the Tygart Valley River Watershed, West Virginia*, March 2001 (TMDL Report), presents the TMDLs for each of the listed segments in the Tygart Valley River watershed. In order to develop the TMDLs and other pertinent watershed and waterbody information, the watershed was divided into 21 regions (Figure 1). These regions represent hydrologic units. Each region was further divided into subwatersheds (1,007 total for the entire Tygart Valley River watershed) for modeling purposes. The 21 regions and their respective subwatersheds provide a basis for georeferencing pertinent source information, monitoring data, and presenting TMDLs. This information is presented in Appendices A-1 through A-21 of the TMDL Report. Numeric designation for each Appendix A section corresponds to the same numerically-identified region of the Tygart watershed (*e.g.*, A-3 corresponds to region 3 of the Tygart watershed).

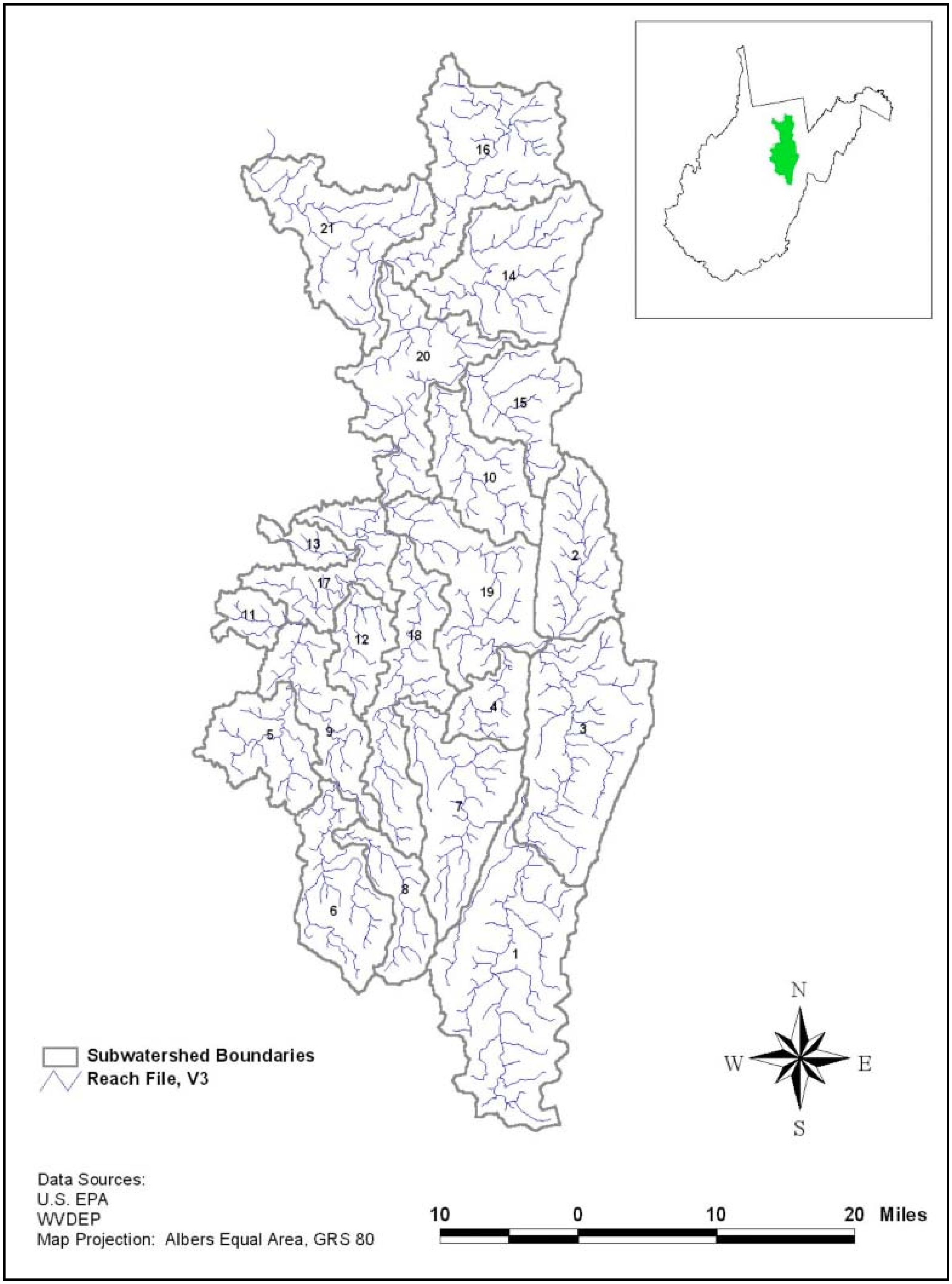

Figure 1. Tygart Valley River watershed and its 21 regions

Table 2 presents the TMDLs developed for this report. The WLAs and 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. The values may be converted to daily loads by dividing by 365 days/year, *e.g.,* 2,539 lbs/yr ÷ 365 day/yr = 6.9 lbs/day.

Table 2. TMDLs, load, and waste load allocations for aluminum

Region	Stream Name	List ID [A]	TMDL (lbs/yr)	∑ LAs (lbs/yr)	∑ WLAs (lbs/yr)	MOS (lbs/)
10	Frost RN	MT-24-A	2,412	2,412	0	Implicit
11	Bridge RN	MTB-11-B.7	3,247	3,247	0	Implicit
11	Fink RN	MTB-11-B	20,886	20,862	24	Implicit
11	Mud lick	MTB-11-B	3,759	3,759	0	Implicit
13	Little Pecks R	MTB-5-B	1,922	1,922	0	Implicit
13	Mud RN/Pecks R	MTB-5-C	4,836	4,836	0	Implicit
13	Pecks RN	MTB-5	16,337	14,605	1,732	Implicit
13	U.T./Pecks RN	MTB-5-.8A	1,523	1,523	0	Implicit
14	Glade RN/Sandy	MT-18-C	3,644	1,342	2,302	Implicit
14	Left Fork/ LL	MT-18-E-3	6,910	5,698	1,212	Implicit
14	Left Fork/ San	MT-18-G	10,713	10,713	0	Implicit
14	Little Sandy C	MT-18-E	32,870	29,969	2,901	Implicit
14	Maple RN	MT-18-E-1	4,828	3,166	1,662	Implicit
14	Sandy CK	MT-18	68,251	65,350	2,901	Implicit
16	Birds CK	MT-12-H	12,419	9,341	3,078	Implicit
16	Brains CK	MT-12-G-2	4,996	3,056	1,940	Implicit
16	Little Racoon	MT-12-C-2	2,560	1,720	840	Implicit
16	Racoon CR	MT-12-C	16,971	12,977	3,994	Implicit
16	Squires CK	MT-12-I	6,798	3,484	3,314	Implicit
16	Threefork CK	MT-12	83,892	70,432	13,460	Implicit
17	Big RN1	MTB-8	2,463	2,463	0	Implicit
17	Big RN2	MTB-3	7,449	6,505	944	Implicit
17	Buckhanno	MT-31	315,933	310,371	5,562	Implicit
17	Sugar RN	MTB-10-A	2,369	2,369	0	Implicit
17	Turkey RN	MTB-11	6,010	4,579	1,431	Implicit
18	Devil RN	MTM-4	2,760	2,760	0	Implicit
18	Hell RN	MTM-6	2,624	2,624	0	Implicit
18	Whiteoak RN	MTM-8	1,342	1,342	0	Implicit
19	Beaver CK	MT-37	9,374	7,833	1,541	Implicit
19	Grassy RN	MT-41	4,386	4,386	0	Implicit
19	Island RN	MT-36	2,531	2,531	0	Implicit
19	Laurel RN	MT-39	4,343	4,343	0	Implicit
20	Anglins RN	MT-29	5,084	5,084	0	Implicit
20	Ford RN	MT-27	3,465	3,450	15	Implicit
20	Foxgrape RN	MT-26-B	4,404	3,316	1,088	Implicit
20	Little Hackers	MT-26-C	1,658	686	972	Implicit
21	Berkely RN	MT-11	10,682	10,682	0	Implicit
21	Berry RN	MT-11B-1	1,081	1,081	0	Implicit
21	Goose CK	MT-4	3,644	1,342	2,302	Implicit
21	Long RN	MT-11-B	3,040	3,040	0	Implicit
21	Lost RN	MT-5	10,175	10,175	0	Implicit
21	Shelby RN	MT-11-A	3,225	3,225	0	Implicit
21	Tygart River	M-27	1,504,474	1,458,849	45,625	Implicit
4	Roaring CK	MT-42	45,488	41,360	4,128	Implicit
5	Blacklick RN	MTB-18-B-2	1,216	1,216	0	Implicit
5	Bull RN	MTB-18-B	6,605	6,605	0	Implicit

Region	Stream Name	List ID [A]	TMDL (lbs/yr)	∑ LAs (lbs/yr)	∑ WLAs (lbs/yr)	MOS (lbs/)
5	Crooked	MTB-18-A	1,309	1,309	0	Implicit
5	Franch CK	MTB-18	42,218	42,218	0	Implicit
6	Herods RN	MTB-30	1,980	1,980	0	Implicit
6	Swamp RN	MTB-29	1,043	1,043	0	Implicit
7	Cassity CK	MTM-16	266,159	252,851	0	Implicit
7	Middle Fork Ri	MT-33	301,225	286,163	0	Implicit
7	Panther RN	MTM-16-A	152,734	145,097	0	Implicit
9	Panther FK	MTB-27	6,374	6,055	0	Implicit

[A] These IDs are the same as Table 1 except for WV_MTB_11-B.7

Table 3. TMDLs, load, and waste load allocations for iron

Region	Stream Name	List ID	TMDL (lbs/yr)	∑ LAs (lbs/yr)	∑ WLAs (lbs/yr)	MOS (lbs/yr)
10	Frost RN	MT-24-A	3,405	3,405	0	Implicit
11	Bridge RN	MTB-11-B.7	4,015	4,015	0	Implicit
11	Fink RN	MTB-11-B	24,484	24,466	18	Implicit
11	Mud lick	MTB-11-B	5,193	5,193	0	Implicit
13	Little Pecks R	MTB-5-B	2,404	2,404	0	Implicit
13	Mud RN/Pecks R	MTB-5-C	6,269	6,269	0	Implicit
13	Pecks RN	MTB-5	20,854	19,520	1,334	Implicit
13	U.T./Pecks RN	MTB-5-.8A	2,450	2,450	0	Implicit
14	Glade RN/Sandy	MT-18-C	2,897	1,237	1,660	Implicit
14	Left Fork/ LL	MT-18-E-3	11,529	8,711	2,818	Implicit
14	Left Fork/ San	MT-18-G	11,238	11,238	0	Implicit
14	Little Sandy C	MT-18-E	36,274	31,794	4,480	Implicit
14	Maple RN	MT-18-E-1	4,883	3,241	1,642	Implicit
14	Sandy CK	MT-18	70,508	66,028	4,480	Implicit
16	Birds CK	MT-12-H	19,659	13,344	6,315	Implicit
16	Brains CK	MT-12-G-2	6,453	3,081	3,372	Implicit
16	Little Racoon	MT-12-C-2	2,270	1,645	625	Implicit
16	Racoon CR	MT-12-C	22,214	15,847	6,367	Implicit
16	Squires CK	MT-12-I	10,961	3,997	6,964	Implicit
16	Threefork CK	MT-12	100,836	75,785	25,051	Implicit
17	Big RN1	MTB-8	2,402	2,402	0	Implicit
17	Big RN2	MTB-3	8,885	6,069	2,816	Implicit
17	Buckhanno	MT-31	321,319	306,052	15,267	Implicit
17	Sugar RN	MTB-10-A	1,947	1,947	0	Implicit
17	Turkey RN	MTB-11	6,579	3,948	2,631	Implicit
18	Devil RN	MTM-4	2,122	2,122	0	Implicit
18	Hell RN	MTM-6	2,003	2,003	0	Implicit
18	Whiteoak RN	MTM-8	1,860	1,860	0	Implicit
19	Beaver CK	MT-37	8,854	7,707	1,147	Implicit
19	Grassy RN	MT-41	4,093	4,093	0	Implicit
19	Island RN	MT-36	3,550	3,550	0	Implicit
19	Laurel RN	MT-39	4,552	4,552	0	Implicit
20	Anglins RN	MT-29	4,269	4,269	0	Implicit
20	Ford RN	MT-27	3,379	3,365	14	Implicit
20	Foxgrape RN	MT-26-B	2,994	2,994	0	Implicit
20	Little Hackers	MT-26-C	548	548	0	Implicit
21	Berkely RN	MT-11	10,802	10,802	0	Implicit
21	Berry RN	MT-11B-1	946	946	0	Implicit
21	Goose CK	MT-4	2,897	1,237	1,660	Implicit
21	Long RN	MT-11-B	3,495	3,495	0	Implicit
21	Lost RN	MT-5	9,435	9,435	0	Implicit

Region	Stream Name	List ID	TMDL (lbs/yr)	∑ LAs (lbs/yr)	∑ WLAs (lbs/yr)	MOS (lbs/yr)
21	Shelby RN	MT-11-A	3,171	3,171	0	Implicit
21	Tygart River	M-27	1,683,897	1,623,376	60,521	Implicit
4	Roaring CK	MT-42	42,118	39,202	2,916	Implicit
5	Blacklick RN	MTB-18-B-2	2,590	1,106	1,484	Implicit
5	Bull RN	MTB-18-B	6,996	5,512	1,484	Implicit
5	Crooked	MTB-18-A	1,379	1,379	0	Implicitt
5	Franch CK	MTB-18	37,162	35,678	1,484	Implicit
6	Herods RN	MTB-30	2,059	2,059	0	Implicit
6	Swamp RN	MTB-29	1,062	1,062	0	Implicit
7	Cassity CK	MTM-16	97,282	92,418	0	Implicit
7	Middle Fork Ri	MT-33	130,743	124,206	0	Implicit
7	Panther RN	MTM-16-A	55,865	53,072	0	Implicit
9	Panther FK	MTB-27	7,265	6,902	0	Implicit

Table 4. TMDLs, load, and waste load allocations for manganese

Region	Stream Name	List ID	TMDL (lbs/yr)	∑ LAs (lbs/yr)	∑ WLAs (lbs/yr)	MOS (lbs/yr)
10	Frost RN	MT-24-A	2,375	2,375	0	Implicit
11	Bridge RN	MTB-11-B.7	2,442	2,442	0	Implicit
11	Fink RN	MTB-11-B	14,700	14,689	11	Implicit
11	Mud lick	MTB-11-B	2,689	2,689	0	Implicit
13	Little Pecks R	MTB-5-B	1,887	1,887	0	Implicit
13	Mud RN/Pecks R	MTB-5-C	4,400	4,400	0	Implicit
13	Pecks RN	MTB-5	13,453	12,599	854	Implicit
13	U.T./Pecks RN	MTB-5-.8A	1,274	1,274	0	Implicit
14	Glade RN/Sandy	MT-18-C	4,466	842	3,624	Implicit
14	Left Fork/ LL	MT-18-E-3	5,477	3,857	1,620	Implicit
14	Left Fork/ San	MT-18-G	7,136	7,136	0	Implicit
14	Little Sandy C	MT-18-E	20,609	18,097	2,512	Implicit
14	Maple RN	MT-18-E-1	2,737	1,856	881	Implicit
14	Sandy CK	MT-18	42,224	39,712	2,512	Implicit
16	Birds CK	MT-12-H	11,891	8,693	3,198	Implicit
16	Brains CK	MT-12-G-2	3,902	2,175	1,727	Implicit
16	Little Racoon	MT-12-C-2	1,297	961	336	Implicit
16	Racoon CR	MT-12-C	11,751	8,489	3,262	Implicit
16	Squires CK	MT-12-I	6,500	2,374	4,126	Implicit
16	Threefork CK	MT-12	58,936	45,495	13,441	Implicit
17	Big RN1	MTB-8	1,160	1,160	0	Implicit
17	Big RN2	MTB-3	6,109	4,042	2,067	Implicit
17	Buckhanno	MT-31	164,078	150,890	13,188	Implicit
17	Sugar RN	MTB-10-A	1,236	1,236	0	Implicit
17	Turkey RN	MTB-11	4,207	2,550	1,657	Implicit
18	Devil RN	MTM-4	2,399	2,399	0	Implicit
18	Hell RN	MTM-6	2,321	2,321	0	Implicit
18	Whiteoak RN	MTM-8	1,152	1,152	0	Implicit
19	Beaver CK	MT-37	8,435	7,716	719	Implicit
19	Grassy RN	MT-41	2,375	2,375	0	Implicit
19	Island RN	MT-36	1,985	1,985	0	Implicit
19	Laurel RN	MT-39	1,870	1,870	0	Implicit
20	Anglins RN	MT-29	3,064	3,064	0	Implicit
20	Ford RN	MT-27	2,106	2,103	3	Implicit
20	Foxgrape RN	MT-26-B	1,968	1,968	0	Implicit
20	Little Hackers	MT-26-C	363	363	0	Implicit
21	Berkely RN	MT-11	7,369	7,369	0	Implicit

Region	Stream Name	List ID	TMDL (lbs/yr)	∑ LAs (lbs/yr)	∑ WLAs (lbs/yr)	MOS (lbs/yr)
21	Berry RN	MT-11B-1	1,003	1,003	0	Implicit
21	Goose CK	MT-4	4,466	842	3,624	Implicit
21	Long RN	MT-11-B	2,554	2,554	0	Implicit
21	Lost RN	MT-5	5,926	5,926	0	Implicit
21	Shelby RN	MT-11-A	2,251	2,251	0	Implicit
21	Tygart River	M-27	769,408	724,286	45,122	Implicit
4	Roaring CK	MT-42	33,276	27,604	5,672	Implicit
5	Blacklick RN	MTB-18-B-2	717	717	0	Implicit
5	Bull RN	MTB-18-B	3,399	3,399	0	Implicit
5	Crooked	MTB-18-A	781	781	0	Implicit
5	Franch CK	MTB-18	18,729	18,729	0	Implicit
6	Herods RN	MTB-30	1,238	1,238	0	Implicit
6	Swamp RN	MTB-29	641	641	0	Implicit
7	Cassity CK	MTM-16	93,174	93,174	0	Implicit
7	Middle Fork Ri	MT-33	106,238	106,238	0	Implicit
7	Panther RN	MTM-16-A	53,464	53,464	0	Implicit
9	Panther FK	MTB-27	3,494	3,494	0	Implicit

The pH, a measurement of hydrogen ion acidity presented as a negative logarithm, is not conducive to modeling as pH. While stream flow and the metals may be modeled, including instream processes, compliance with the pH is assumed when the metals are at or below their water quality standard. This was demonstrated by the used of MINTEQA2, a geochemical speciation model.

While EPA developed these TMDLs, the WVDEP played an integral role in their development. A majority of permit-specific information was provided from State files. The Office of Water Resources and Office of Mining and Reclamation developed policies regarding waste load allocations, including future growth.

The TMDL is a written plan and analysis established to ensure that a waterbody will attain and maintain water quality standards. The TMDL is a scientifically-based strategy which considers current and foreseeable conditions, the best available data, and uncertainty in the margin of safety. It is possible that, in the future, conditions and/or available data may change, or the understanding of the natural processes may change, sometimes in ways not accounted for by the margin of safety. The option is always available to modify or refine the TMDL based on new information. EPA is aware of WVDEP's plan for achieving a comprehensive, statewide watershed assessment which was developed and implemented in 1996. After completion of the initial assessments, WVDEP's long-range goal is to reassess all waters on a five-year cycle. The TMDL should not be modified at the expense of achieving water quality standards expeditiously. Nevertheless, the TMDL may be modified when modification is warranted by new information, subject to an appropriate public participation process and EPA's approval.

III. Background

The Tygart Valley River is located in northeastern West Virginia. The drainage area is approximately 1,362 square miles and the main stem is approximately 207 miles long. The mainstem source is on Cheat Mountain near Spruce in Pocahontas County; the two major tributaries to the main stem are the Middle Fork River and the Buckhannon River.

The mainstem Tygart Valley River, Buckhannon River, Ten Mile Creek, and Middle Fork River, together with 54 waterbodies within the watershed, were placed on the State of West Virginia's 1996 Section 303(d) list of water quality impaired waterbodies resulting from aluminum, iron, manganese, and/or pH from abandoned mine discharges. TMDLs for the Buckhannon and Ten Mile Creek were developed by EPA in 1998. Of the 54, two waterbodies were subsequently delisted from the Section 303(d) list. The table of Section 303(d) listed waterbodies includes these adjustments and a waterbody listed in 1998. Water quality data and visual observations show that the metal concentrations exceed the State's standards and that pH is below the State's standards.

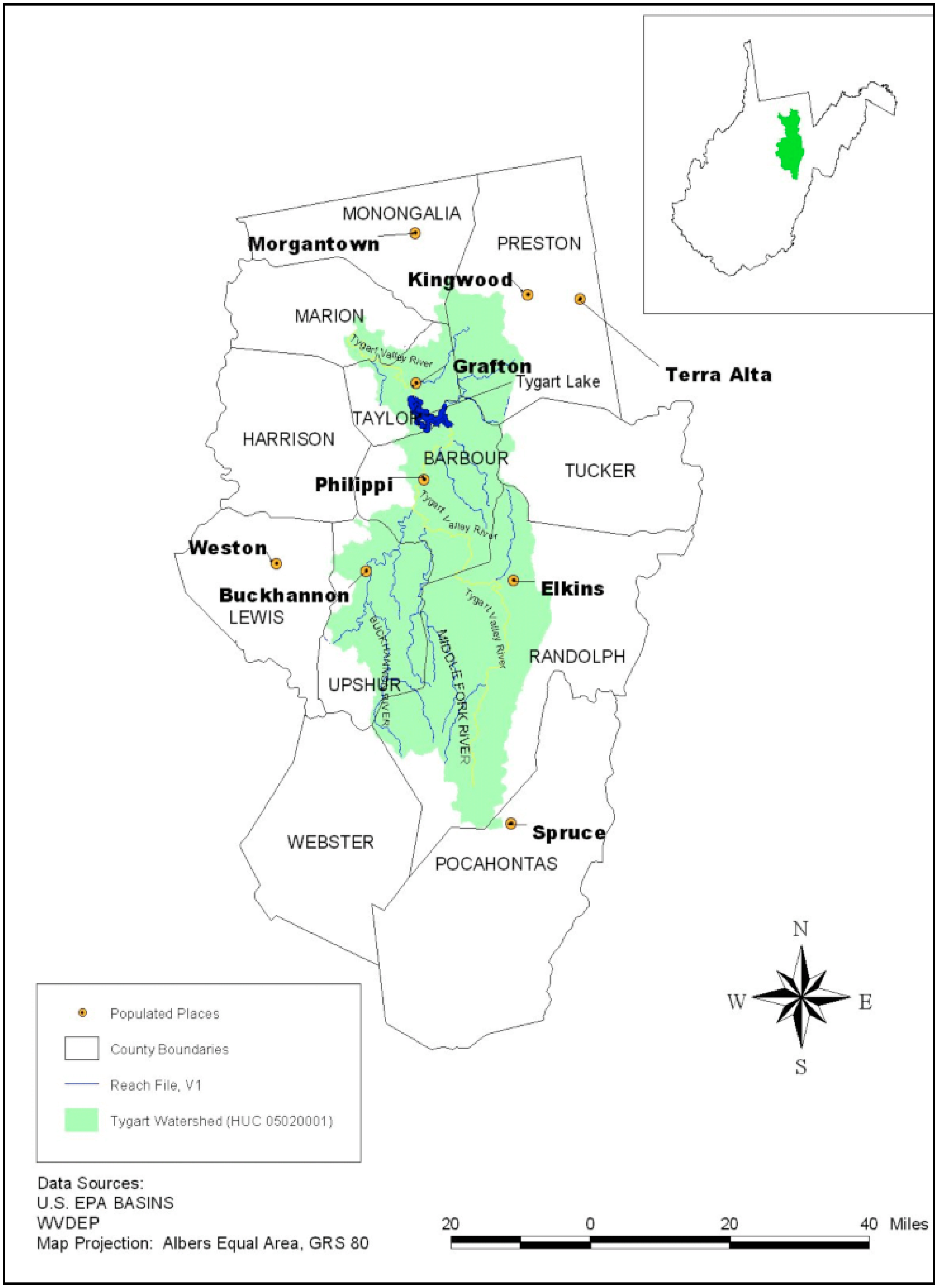

Figure 2. Location of the Tygart Valley River watershed

The watershed is dominated by forest and agricultural lands with coal mining, timber harvesting, and recreational development occurring (WVDEP, 1982). Many of the 12 counties in the watershed contain active surface and deep mining operations. Virtually all of the coal fields in the watershed contain abandoned coal mines. The watershed's population is widely distributed throughout small towns and rural unincorporated communities. The largest towns in the watershed include Elkins, Philippi, Grafton, and Fairmont (where Tygart Valley River joins the West Fork River to form the Monogahela River).

On December 15, 2000, a public notice was published in the following newspapers; *Preston Co. News, Parsons Advocate, Dominion Post, Inter-Mountain, Mountain Statesman, Barbour Democrat*, and *Record Delta* newspapers and EPA posted the notice, together with the draft TMDLs, on the EPA Region III TMDL web page. The draft TMDLs were revised in *Metals and pH TMDLs for the Tygart Valley River Watershed, West Virginia,* March 2001 (TMDL Report). While the complete allocation tables are presented in this document, only representative samples of other figures and tables are included.

Technical Approach

Deep coal mining may result in extensive underground tunnel systems in which, after the mine workings have been abandoned, the tunnels often collapse, fill up with water, and some discharge to the surface. Discharges from abandoned mine lands includes tunnel discharges, seeps, and surface runoff. Acid mine drainage (AMD) occurs when surface and subsurface water percolates through coal bearing minerals containing high concentrations of pyrite and, less commonly, marcasite, which are crystalline forms of iron sulfide (FeS_2). It is these chemical reactions of the pyrite which generate[1] 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 which cause the acidity. The intermediate reaction with the dissolved Fe^{2+} ions generates a precipitate, ferric hydroxide [$Fe(OH)_3$], and also releases more H^+ ions, thereby causing more acidity. Another reaction is one between the pyrite and generated ferric (Fe^{3+}) ions, in which more acidity (H^+) is released as well as Fe^{2+} ions, which then can enter the reaction cycle (Stumm and Morgan, 1996).

Establishing the relationship between the instream 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. Currently, there is no widely used model for AMD TMDLs.

[1]If carbonate rock overlies the coal, alkaline mine discharge can be generated.

For metals, the West Virginia criteria are expressed as total metals. This dictates that the methodology predict the total metals concentration in the water column of the receiving water. Thresholds of a numeric measure are evaluated for frequency of exceedance (*e.g*., not to exceed more than once every three years on average). Acute standards require evaluation over short time periods and violations may occur under variable flow conditions. Chronic criteria require the evaluation of the response over a four-day averaging period. The approach or modeling technique must permit representation of instream concentrations under a variety of flow conditions, in order to evaluate critical periods for comparison to chronic and acute criteria.

The selected approach must also consider the dominant processes regarding pollutant loadings and instream fate. For the Tygart watershed, primary sources contributing to metals and pH impairments include an array of unpermitted, 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 instream factors to be considered include routing of flow, dilution, and transport of total metals. In the Tygart watershed, the primary physical driving process is the transport of total metals by diffusion and advection in the flow. Significant chemical processes are speciation and precipitation of metals followed by sediment adsorption/desorption and redox reactions related to the precipitation reactions.

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 Tygart watershed range from small streams to the main stem of the 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 aggregated 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, EPA tasked its support contractor, Tetra Tech, Inc., with developing the Mining Data Analysis System (MDAS) to represent the source-response linkage in the Tygart watershed. The MDAS is a comprehensive data management and modeling system that is capable of representing loading from nonpoint and point sources found in the Tygart watershed and simulating instream processes. A major objective of MDAS is to allow West Virginia WVDEP and/or OMR (Office of Mining and Reclamation) to re-run the model to evaluate the effects of changing permit, watershed, or water quality conditions, or to evaluate alternate remedial options.

In order to develop the TMDLs and other pertinent watershed and waterbody information, the Tygart Valley River watershed was divided into 21 regions. These regions represent hydrologic units. Each region was further divided into subwatersheds (1,007 total for the entire Tygart Valley River watershed) for modeling purposes. Source information, monitoring data, and TMDLs are presented in Appendices A-1 through A-21 of the TMDL Report dated March 2001.

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

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

The graphical interface supports basic geographic information systems (GIS) functions, including electronic geographic data importation and manipulation. Key data sets include stream networks, landuse, flow and water quality monitoring station locations, weather station locations, and permitted facility locations. The data storage and management system functions as a database and supports storage of all data pertinent to TMDL development, including water quality observations, flow observations, permitted facility Discharge Monitoring Reports (DMRs), as well as stream and watershed characteristics used for modeling. The system also includes functions for inventorying the data sets. The Dynamic Watershed Model, also referred to as the Hydrological Simulation Program - C++ (HSPC), simulates nonpoint source flow and pollutant loading as well as instream 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 engineering component of MDAS is the HSPC model which provides the linkage between source contributions and instream response. The HSPC is a comprehensive watershed model used to simulate watershed hydrology and pollutant transport as well as stream hydraulics and instream 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 5. 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

The MDAS is configured for the Tygart 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 Tygart 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, and total manganese, and pH.

The watershed was divided into 1,007 subwatersheds. These subwatersheds represent hydrologic boundaries based on based on elevation data (7.5 minute Digital Elevation Model [DEM] from USGS), stream connectivity (from EPA's Reach File, Version 3 [RF3] stream coverage), and locations of monitoring stations.

Meteorological data included precipitation, wind speed, potential evapotranspiration, cloud cover, temperature, and dewpoint obtained from a number of sources in an effort to develop the most representative dataset for the Tygart watershed. In general, hourly precipitation data are recommended for nonpoint source modeling. Therefore, only weather stations with hourly-recorded data were considered in development of a representative dataset. Long-term hourly precipitation data available from four National Climatic Data Center (NCDC) weather stations located near the watershed were used from Terra Alta No 1, Tygart Dam, Elkins WSO

Airport, and Valley Head. Meteorological data for the remaining required parameters were available from the Elkins WSO Airport station. These data were applied to all subwatersheds in the Tygart watershed.

Nonpoint Sources

In order to represent abandoned mine lands (AMLs) as nonpoint sources, the AML categories are represented as three land use categories: high walls, disturbed land, and abandoned mines. The abandoned mines represent either discharge from abandoned deep mines or seepage from other abandoned mine sites. The forested area land use was reduced to account for the three additional land uses.

Other nonpoint sources are represented by the MRLC land use categories reclassified into eight land use categories that best describe the watershed conditions and dominant source categories. The eight land uses represent nonpoint sources, which include barren land, crop land, forest, pasture, strip mining/quarries/gravel pits, urban impervious, urban pervious, and wetlands.

Table 6. Modeled land use distribution in acres for regions 1 through 11 (in acres)

Land Use Name	1	2	3	4	5	6	7	8	9	10	11
ADM	0	0	0	0	33	0	0	27	173	0	0
AML	0	0	0	30	20	50	308	0	40	0	21
ASM	3	0	0	361	0	109	0	160	818	37	0
Barren	427	22	126	144	45	161	218	140	158	47	297
Cropland	2652	1527	1994	2	2320	510	399	80	1377	2769	1081
Disturbed land	0	0	0	16	42	5	170	0	24	23	84
Forest	89878	30895	57829	16372	18336	37984	49447	21623	26766	24315	5848
Highwall	0	0	11	98	37	8	28	83	15	68	29
IADM	0	0	0	0	0	0	10	33	0	0	0
Other mines	71	0	130	0	106	6	0	219	146	0	1
Pasture	8163	5717	9696	385	4465	1256	367	189	4350	7136	2188
PIDM	0	0	0	0	0	0	37	32	0	0	0
RDM	22	0	0	35	0	8	2	18	0	9	5
Strip mining	59	0	52	896	3	324	117	307	938	44	1
Urban Impervious	91	485	17	41	12	18	12	121	5	383	0
Urban Pervious	262	824	19	62	30	8	14	460	20	352	0
Water	201	73	507	11	38	43	9	15	326	31	31
Wetlands	308	223	761	29	38	24	22	10	40	20	15
Total	**101902**	**38811**	**72415**	**18415**	**25586**	**40530**	**51159**	**22962**	**35752**	**34524**	**10335**

Table 7. Modeled land use distribution in acres for regions 12 through 21 (in acres)

Land Use Name	12	13	14	15	16	17	18	19	20	21
ADM	0	0	235	0	131	37	0	0	136	0
AML	0	10	72	0	52	75	102	370	34	25
ASM	88	55	381	0	1309	220	874	364	87	48
Barren	109	11	101	80	350	133	265	268	854	316
Cropland	755	842	2423	1743	1897	2518	883	1780	2203	2535
Disturbed land	67	10	16	0	142	132	57	239	107	60
Forest	15833	4538	42959	27242	52665	20827	41292	41099	38481	40357
Highwall	1	47	10	3	151	102	15	184	72	72
IADM	0	0	0	0	7	0	0	85	35	133
Other mines	0	17	28	139	348	187	8	605	300	368
Pasture	2102	2195	9711	4879	6498	6694	2070	6378	8020	9406
PIDM	0	0	0	0	0	0	0	0	36	0
RDM	0	0	144	0	4	14	20	0	0	0
Strip mining	112	30	147	58	493	207	231	914	367	106
Urban	8	4	3	62	109	7	96	266	664	0
Urban Pervious	20	26	16	269	106	21	288	197	1527	0
Water	34	16	50	60	96	489	276	648	2288	953
Wetlands	17	5	67	56	55	109	22	103	408	62
Total	**19179**	**7803**	**56375**	**34280**	**64528**	**31959**	**46143**	**53422**	**53890**	**56633**

The land use coverage was used to estimate total aluminum, iron, and manganese loadings associated with conventional land uses. The assumed pervious and impervious percentage for each land use, which affects the hydrology and water quality of the Tygart watershed, is listed in Table 8.

Table 8. Average percent perviousness and imperviousness for different land use types

Landuse	Pervious (%)	Impervious (%)
Pasture	100	0
Crop	100	0
Forest	100	0
Barren	100	0
Strip mine	100	0
High density commercial/industrial/transportation (urban impervious)	15	85
Lower density residential (urban pervious)	88	12
Wetlands	100	0

Point Sources

There are no non-mining point sources in the Tygart watershed permitted for iron, aluminum, or manganese discharges. Therefore, the non-mining facilities were not considered in the modeling effort.

The permitted mining point sources were classified into six land use categories based on the type of mine and the current status of the mine. Mining NPDES permits are point sources as far as regulation is concerned but may be modeled as nonpoint sources. 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 9. Model nonpoint source representation of different permitted mines

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

To account for the additional deep mine land use categories (ADM, IADM, RDM and PIDM), the area of each permitted deep mine was subtracted from the forested land use area. The remaining additional land use categories (ASM 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. A summary of the land use distribution is shown in Tables 6 and 7.

Other Data

Modeling subwatersheds and calibrating hydrologic and water quality model components required routing flow and pollutants through streams. Each subwatershed was represented with a single stream. Stream segments were identified using EPA's RF3 stream coverage. In order to route flow and pollutants, rating curves were developed for each stream using Manning's equation which requires the stream slope, Manning's roughness coefficient, and channel widths and depths. Manning's roughness 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 RF3 stream coverage. Stream dimensions were estimated using regression curves that relate upstream drainage area to stream dimensions (Rosgen, 1996).

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.

Model Calibration/Validation

After the model was configured, calibration was performed at multiple locations throughout the Tygart 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, a calibrated dataset containing parameter values for modeled sources and pollutants was developed. This dataset was applied to areas where calibration data were not available.

A significant amount of time-varying monitoring data was necessary to calibrate the model. Available monitoring data in the watershed were identified and assessed for application to calibration (Tables 3a, 3b, and 3c in each of Appendices A-1 through A-21). 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 the following figure.

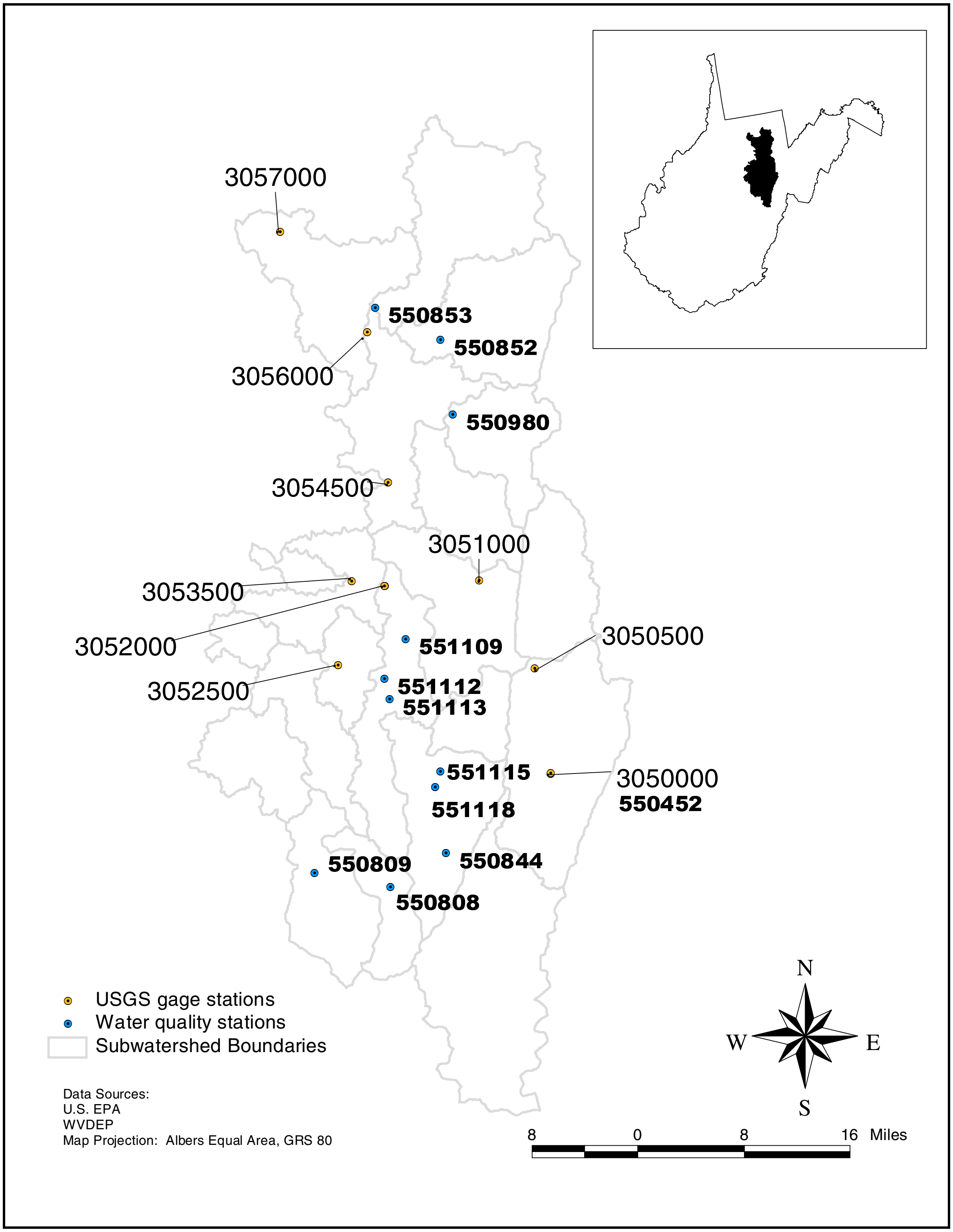

Figure 3. Calibration locations used in modeling

The model is first calibrated for hydrology which involves 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.

To best represent hydrologic variability throughout the watershed, three locations with daily flow monitoring data were selected for calibration. The stations were USGS #03053500 on the Buckhannon River, USGS #03050500 on the Tygart Valley River, and USGS # 03052500 on Sand Run. The model was calibrated for the year 1986, because it represented a range of hydrologic conditions. 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 the TMDL Report*,* Appendix C.

Parameter values were validated for an independent, extended time period (usually between 1980 and 1992) 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.

In addition to flow, three pollutants were modeled with the HSPC: total aluminum, total iron, and total manganese. The parameters affecting these pollutants were also calibrated and validated.

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) and SEDMNT (simulation of sediment and its associated quality constituents) modules. Values for the pollutant representation were refined through the water quality calibration process.

After hydrology had been sufficiently calibrated, water quality calibration was performed. Modeled versus observed in-stream concentrations were directly compared during model calibration. The water quality calibration consisted 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.

For matching model water quality results to historical data the existing point sources were represented using available historical data. Permitted discharges that were issued after the calibration period were not considered during the calibration process. If Discharge Monitoring Reports (DMRs) were available, permitted mines were represented in the model using average flows and pollutant loads. The DMR data include 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, DMRs were insufficient to support representation in the model, therefore, permitted point sources were represented by the following approach. When DMR data were available for point sources within a region, the average flow and monthly average concentrations were distributed throughout that particular region. In cases where there were no available DMR data within a region, the average point source flow from the entire Tygart watershed and the permitted average concentrations were used to estimate the loadings for the point sources. Parameters affecting pollutant concentrations from these mines were adjusted to be consistent with typical discharge characteristics from similar mining activities or to match site-specific instream monitoring data.

Daily average instream concentration from the model was compared directly to observed data. Observed data were obtained from EPA's STORET database as well as from three additional groups collecting water quality data in the Tygart watershed. - the Stream Restoration Group, the Special Reclamation Group, and Bond Forfeiture. Each group's data were obtained through WVDEP. The objective was to best simulate low flow, mean flow, and storm peaks at representative water quality monitoring stations. Representative stations were selected based on both location (distributed throughout the Tygart watershed) and source type. These stations were typically WVDEP monitoring stations. Results of the water quality calibration are presented in the TMDL Report, Appendix C.

Allocation

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are 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 waterbody. Conceptually, this definition is denoted by the equation:

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

TMDL endpoints represent the instream water quality targets used in quantifying TMDLs and their individual components. Different TMDL endpoints are necessary for each impairment type (*i.e.*, aluminum, iron, manganese, and pH). West Virginia's numeric water quality criteria for aluminum, iron, manganese, and pH and an implicit MOS were used to identify endpoints for TMDL development.

The TMDL endpoint for aluminum was selected as 712.5 ug/L (based on the 750 ug/L criterion for aquatic life minus a 5% MOS). The endpoint for iron was selected either as 0.475 mg/L (based on the 0.5 mg/L criterion for aquatic life-trout waters minus a 5% MOS) or 1.425 mg/L (based on the 1.5 mg/L criterion for aquatic life minus a 5% 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% MOS). Components of the TMDLs for aluminum, iron, and manganese are presented in terms of mass per time in this report.

The water quality criterion for pH requires it to be equal to or above 6 and equal to or below 9. In the case of acid mine drainage, pH, is not a good indicator of the acidity in a waterbody and can be a misleading characteristic. Water with near neutral pH (~7) but containing elevated concentrations of dissolved ferrous (Fe^{2+}) ions can become acidic after oxidation and precipitation of the iron (PADEP, 2000). Therefore, a more practical approach to meeting the water standards of pH is to use the concentration of metal ions as a surrogate for pH. Through reducing instream 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 Tygart watershed. By inputting into the model the dissolved concentrations of metals, a pH value can be predicted. Refer to the TMDL Report, Appendix D, for a more detailed description of the modeling.

Multiple scenarios were run for the impaired waterbodies. Successful scenarios were those that achieved the TMDL endpoints under all conditions for aluminum, iron, and manganese (through comparison of model results for the 1987-1992 modeling period). Exceedances for aluminum and iron were allowed once every three years, consistent with West Virginia's water quality standards. 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 instream concentrations. If additional load reductions were required to meet the TMDL endpoints, then reductions were made in point source (permitted) contributions.

A top-down methodology was followed to develop the TMDLs and allocate loads to sources. Impaired headwaters were first analyzed, because their impact frequently had a profound effect on downstream water quality. Loading contributions were reduced from applicable sources for these waterbodies and TMDLs were developed. Model results from the selected successful scenarios were then routed through downstream waterbodies. Therefore, when TMDLs were developed for downstream impaired waterbodies, up stream contributions were representing conditions meeting water quality criteria. Using this method, contributions from all sources were weighted equitably. In some situations, reductions in sources impacting unimpaired headwaters were required in order to meet downstream water quality criteria. In other situations, reductions in sources impacting impaired headwaters ultimately led to improvements far downstream. This decreased required loading reductions from many potential downstream sources.

The TMDLs for the Tygart watershed were determined on a subwatershed basis (for each of the 21 defined regions with the exception of Region 8). The TMDLs for Region 8 were completed in 1998 as a part of *Metals TMDL for Buckhannon River, West Virginia,* dated 1998.

Waste load allocations (WLAs) were made for all permitted facilities except for limestone quarries and those with a "Completely Released" or "Phase 2 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.

The WLAs for aluminum, iron, and manganese (for each permit) are presented in Tables 4a, 4b, and 4c for each of Appendices A-1 through A-21. The WLAs are presented as annual loads, in terms of pounds per year and as permit discharge 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. The permitted concentrations represent a range of concentrations that achieve instream water quality criteria (under the same range of conditions). Each parameter was assigned a WLA (as a concentration) within a range of discharge concentrations, the minimum reflecting the instream water quality criteria, the maximum having been derived from the EPA's *Technical Support Document for Water Quality-based Toxics Control*, (USEPA, 1991) as the water quality based equivalent to the technology based limits . The WLA ranges are as follows: aluminum: 0.75-4.3mg/L, iron: 0.5 or 1.5 -3.2mg/L, manganese: 1.0-2.0 mg/L.

The allocated WLAs must be converted to permit average monthly limits and maximum daily limits according to the technical support document which considers the type of water quality criteria (acute, chronic, human health, maximum allowable, four-day average, etc.), effluent variability, and monitoring requirements. For an iron WLA of 3.2 mg/l, the average monthly value is 3.0 mg/l, the maximum daily limit is 5.2 mg/l, the assumed effluent variability is 0.6, and two samples per month are required. A manganese WLA equal to 2.0 mg/L translates into an average monthly limit of 2.0 mg/L and a maximum daily limit of 3.5 mg/L. Presently aluminum is not limited in permits but will be required in any new or reissued permits. An aluminum WLA equal to 4.3 mg/L translates into an average monthly limit of 2.5 mg/L and a maximum daily limit of 4.3 mg/L.

The following are sample tables:

Table 4a. Aluminum baseline conditions and allocations (WLAs) for permitted mining point sources

SWS	Permit ID	Baseline (lbs/yr)	Allocation(lbs/yr)	Allocation (mg/L)
103	u100798	5729	1135	0.9
132	s006183	2206	1662	3.2

Table 4b. Iron baseline conditions and allocations (WLAs) for permitted mining point sources

SWS	Permit ID	Baseline (lbs/yr)	Allocation(lbs/yr)	Allocation (mg/L)
103	u100798	4264	2638	2.0
132	s006183	2206	1662	3.2

Table 4c. Manganese baseline conditions and allocations (WLAs) for permitted mining point sources

SWS	Permit ID	Baseline (lbs/yr)	Allocation(lbs/yr)	Allocation (mg/L)
103	u100798	2285	1517	2.0
132	s006183	881	881	2.0

The LAs for aluminum, iron, and manganese are presented in Tables 5a, 5b, and 5c for each of Appendices A-1 through A-21. 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. The following are sample tables:

Table 5a. Aluminum baseline conditions and allocations (LAs) for nonpoint sources

SWS	AML		Nonpoint		Revoked Mine		Requires Reduction
	Baseline (lbs/yr)	Allocation (lbs/yr)	Baseline (lbs/yr)	Allocation (lbs/yr)	Baseline (lbs/yr)	Allocation (lbs/yr)	
95	0	0	485	485	0	0	
96	0	0	375	375	0	0	
97	7	7	488	488	0	0	
Total	20236	1607	61660	61660	16972	8558	

Table 5b. Iron baseline conditions and allocations (LAs) for nonpoint sources

SWS	AML		Nonpoint		Revoked Mine		Requires Reduction
	Baseline (lbs/yr)	Allocation (lbs/yr)	Baseline (lbs/yr)	Allocation (lbs/yr)	Baseline (lbs/yr)	Allocation (lbs/yr)	
95	0	0	475	475	0	0	
96	0	0	346	346	0	0	
97	10	10	470	470	0	0	
Total	156597	5628	57254	57254	17338	14004	

Table 5c. Manganese baseline conditions and allocations (LAs) for nonpoint sources

SWS	AML		Nonpoint		Revoked Mine		Requires Reduction
	Baseline (lbs/yr)	Allocation (lbs/yr)	Baseline (lbs/yr)	Allocation (lbs/yr)	Baseline (lbs/yr)	Allocation (lbs/yr)	
95	0	0	246	246	0	0	
96	0	0	202	202	0	0	
97	6	6	263	263	0	0	
Total	17583	1958	35362	35362	11232	8987	

Tables 5-2, 5-3, and 5-4 present the $\sum$ LAs and $\sum$ WLAs for aluminum, iron, and manganese, respectively, for each of the Section 303(d) listed segments.

As described previously, 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 twice using the two different iron standards for aquatic life and trout waters. Based on the inputs (described in more detail in the TMDL Report, Appendix D), pH was estimated to be 7.74 for the aquatic life iron standard of 1.5 mg/L and 7.76 for the trout waters standard of 0.5 mg/L. For the scenario representative of mining areas, typical instream 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 equal to or above 6 and equal to or below 9 if metals concentrations meet water quality criteria.

Future Growth

WVDEP has chosen not to include specific future growth allocations for 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 watershed. Future growth could occur in the watershed under the following scenarios:

- 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.

- 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.

- 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.

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

Trading

These TMDLs neither prohibit nor authorize trading in the Tygart Valley River watershed. Both the WVDEP and EPA generally endorse the concept of trading, and recognize that it may 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 the West Virginia Division of Environmental Protection in their development of a statewide or watershed-based trading program. Further, EPA supports program development assisted by a consensus-based stakeholder process.

Prior to the development of a formal trading program, it is conceivable that the regulation of specific point source to point source trades may 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.

III. Discussion of Regulatory Conditions

As noted earlier, the TMDL is a scientifically-based plan and analysis established to ensure that a waterbody will attain and maintain water quality standards. It considers current and foreseeable conditions, the best available data, and uncertainty in the margin of safety (MOS). Conditions and/or available data change, or the understanding of the natural processes change, sometimes more than anticipated by the MOS. The option is always available to refine the TMDL for re-submittal to EPA for approval. WVDEP's plan for achieving a comprehensive, statewide watershed approach was developed and implemented in 1996. After completion of the initial assessments, the long-range goal is to reassess all waters on a five-year cycle. Therefore, while the TMDL should not be modified at the expense of achieving water quality standards expeditiously, the TMDL may be modified when warranted.

EPA finds that sufficient information has been provided to meet all of the eight basic regulatory requirements for establishing pH and metal TMDLs in the Tygart Valley River Watershed.

1. The TMDL is designed to meet the applicable water quality standards.

The applicable water quality standards for the Tygart Valley River are:

Table 10. Applicable West Virginia water quality criteria

Parameter	Use Designation				
	Aquatic Life				Human Health
	B1, B4		B2		A
	Acute	Chronic	Acute	Chronic	
Aluminum, Total (µg/L)	750[a]	-	750[a]	-	-
Iron, Total (mg/L)	-	1.5[b]	-	0.5[b]	1.5[c]
Manganese, Total (mg/L)	-	-	-	-	1.0[c]
pH	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0

Source: WVSOS, 2000; B1 = Warm water fishery streams, B4 = Wetlands, B2 = Trout waters, A = Water supply, public;
[a] One hour average concentration not be exceeded more than once every three years on the average,
[b] Four-day average concentration not to be exceeded more than once every three years on the average,
[c] Not to exceed, designed to protect human health from toxic effects through drinking water and fish consumption.

All waters of West Virginia are designated for the propagation and maintenance of fish and other aquatic life and for water contact recreation as part of State water quality standards (WV 46-1-6.1). In addition, the tributaries to the Tygart Valley River has been designated as Water Use Category A – public water supply (WV 46-1-7.2.a) and must be protected for this use.

These TMDLs have been developed based on WVDEP's designation of each impacted waterbody as a warm water fishery or trout stream and the above water quality criteria.

The water quality criteria for pH requires it to be equal to or above 6 and equal to or below 9. In the case of acid mine drainage, pH, is not a good indicator of the acidity in a waterbody and can be a misleading characteristic. Water with near neutral pH (~7) but containing elevated concentrations of dissolved ferrous (Fe^{2+}) ions can become acidic after oxidation and precipitation of the iron (PADEP, 2000). Therefore, a more practical approach to meeting the water standards of pH is to use the concentration of metal ions as a surrogate for pH. Through reducing instream 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 Tygart watershed. By inputting into the model the dissolved concentrations of metals, a pH value can be predicted.

MINTEQA2 was run using typical instream 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), resulting in a predicted equilibrium pH of 4.38. MINTEQA2 was run with 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 (or literature values if necessary) for rivers relatively unimpacted by mining activities in the Tygart Valley River watershed, and set to equilibrium with atmospheric CO_2. The resultant equilibrium pH was estimated to be 7.74 using the aquatic life standard (1.5 mg/L total Fe) and 7.76 using the trout waters standard (0.5 mg/L total Fe).

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

2. *The TMDL includes a total allowable load as well as individual waste load allocations and load allocations.*

TMDLs are comprised of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for non-point sources, and natural background levels. In addition, the TMDL must include a MOS, either implicitly or explicitly, that accounts for uncertainty in the relation between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

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

The TMDLs represent the maximum load that a receiving water can assimilate while still achieving water quality standards. The TMDL is allocated into waste load allocations (WLAs) for point sources, load allocations (LAs) for non-point sources, and the Margin of Safety (MOS) components. The TMDL divides allowable loading into separate categories corresponding to point sources (which enter the river from a well-defined source location) and nonpoint (diffuse) sources. The TMDL defines allowable point source loads (called wasteload allocations) and the non-point and background sources that will achieve instream water quality standards (called load allocations). These sources must be characterized so that the waste load and load allocations can be assigned to ensure compliance with the TMDL.

For purposes of this set of TMDLs only, point sources are identified as permitted discharge points and nonpoint sources are other discharges from abandoned mine lands which includes 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. As such, 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 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. The TMDLs consider the impacts of background pollutant contributions.

The impact of background contributions is an integral part of the watershed modeling. The model is calibrated to observed instream water quality observations at multiple locations throughout the watershed. The calibration dataset was applied to areas where calibration data were not available.

4 & 5. The TMDLs consider critical and seasonal environmental conditions.

A TMDL must consider critical and seasonal variation in the derivation of the allocation. For the Tygart Valley River watershed metals TMDLs , critical and seasonal variation was considered in the formulation of the modeling analysis. By using continuous simulation (modeling over a period from January 1, 1987 to December 31, 1992), seasonal hydrologic and source loading variability was inherently considered. The metals concentrations simulated on a daily time step by the model were compared to TMDL endpoints. An allocation which meets these endpoints throughout the year was developed.

6. The TMDLs include a margin of safety.

The Clean Water Act and federal regulations require TMDLs to include a MOS to take into account any lack of knowledge concerning the relationship between effluent limitations and water quality. EPA guidance suggest two approaches to satisfy the MOS requirement. First, it can be met implicitly by using conservative model assumptions to develop the allocations. Alternately, it can be met explicitly by allocating a portion of the allowable load to the MOS.

A 5% explicit MOS was selected in identifying endpoints to account for potential inaccuracies in the modeling process. A relatively small MOS is acceptable in that the TMDL development used a dynamic model for simulating daily loading over a wide range of hydrologic and environmental conditions, and long-term flow and water quality data were used in the model calibration and validation.

TMDL endpoints represent the instream water quality targets used in quantifying TMDLs and their individual components. Different TMDL endpoints are necessary for each impairment type, *i.e.*, aluminum, iron, manganese, and pH. West Virginia's numeric water quality criteria for aluminum, iron, manganese, and pH and an explicit MOS were used to identify endpoints for TMDL development.

The TMDL endpoint for aluminum is 712.5 ug/L (based on the 750 ug/L criterion for aquatic life minus a 5% MOS). The endpoint for iron is either as 0.475 mg/L (based on the 0.5 mg/L criterion for aquatic life-trout waters minus a 5% MOS) or 1.425 mg/L (based on the 1.5

mg/L criterion or aquatic life minus a 5% MOS). And the endpoint for manganese is 0.95 mg/L (based on the 1.0 mg/L criterion for human health minus a 5% MOS).

7. There is reasonable assurance that the proposed TMDLs can be met.

Federal regulations at 40 CFR § 130.7(a) require that WLAs, LAs, and TMDLs be incorporated into the states' water quality management plans and NPDES permits. WLAs were developed for all known permittees in the Tygart Valley River watershed. Any new or reissued NPDES permit must convert the WLAs into permit limits. EPA's *Technical Support Document for Water Quality-based Toxics Control*, March 1991, provides guidance for developing permit limits. Permitting, together with WVDEP's efforts to reclaim abandoned mines, will be the focal points in water quality improvement.

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 Office of Mining and Reclamation's Special Reclamation Program remedies sites where operating permits and bonds have been revoked. 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 three-cent per ton fee on all coal produced.

The Office of Abandoned Mine Lands and Reclamation is responsible for implementation of Title IV of the Surface Mining Control and Reclamation Act (Public Law 95-87) is designed to help reclaim and restore coal mine areas abandoned prior to August 3, 1977. 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 first priority is the protection of pubic health, safety, general welfare, and property from extreme danger resulting from past coal mining conditions. These conditions include unsafe refuse piles, treacherous highwalls, pollution of domestic water supplies from mine drainage, mine fires, subsidence and other problems.

The AML Program is now also focused on treating and abating water quality problems associated with abandoned mine lands but is not required by law or any statutory authority to do so. 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% 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 utilized to clean up mine drainage pollution at sites where mining ceased prior to August 3, 1977, and where no continuing reclamation responsibility can be determined. In order to qualify and be eligible, qualified hydrologic units or watersheds must be identified and water quality must adversely impact 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 downstream 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 in order 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.

A special reclamation group deals with revoked mines. 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.

8. The TMDLs have been subject to public participation.

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

January 26, 1999	Public meeting presenting an introduction to the TMDL process, together with the requirements of the consent decree.
July 28, 1999	Public meeting presented by WVDEP, EPA and Tetra Tech.
May 9, 2000	Public meeting presented by WVDEP, EPA and Tetra Tech.
October 11, 2000	Public meeting presented by WVDEP, EPA and Tetra Tech.
January 15, 2001	Public hearing presented by WVDEP, EPA and Tetra Tech.

On December 15, 2000, a public notice was published in the following newspapers; *Preston Co. News, Parsons Advocate, Dominion Post, Inter-Mountain, Mountain Statesman, Barbour Democrat*, and *Record Delta* newspapers and posted the notice, together with the draft TMDLs, on the EPA Region III TMDL web page. The draft TMDLs were revised in *Metals and pH TMDLs for the Tygart Valley River Watershed, West Virginia,* March 2001 (TMDL Report).