Western Maryland pH TMDLs for the Casselman River, Georges Creek, Savage River, Upper North Branch of the Potomac River, and Wills Creek Watersheds

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FINAL

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ACRONYMS

Al	aluminum
AMD	acid mine drainage or acidic mine discharge
ANC	acid neutralizing capacity
BASINS	Better Assessment Science Integrating Point and Nonpoint Sources
BOM	Bureau of Mines
$CaCO_3$	calcium carbonate
CAIR	Clean Air Interstate Rule
CFR	*Code of Federal Regulations*
cfs	cubic feet per second
Cl	chloride
CO_2	carbon dioxide
COMAR	Code of Maryland Regulations
COOP	Cooperative Observer Network
CWA	Clean Water Act
DEM	Digital Elevation Model
DMR	discharge monitoring report
DOC	dissolved organic carbon
EPA	U.S. Environmental Protection Agency
Fe	iron
$Fe(OH)_3$	ferric hydroxide
Fe^{+2}	ferrous iron
Fe^{+3}	ferric iron
FeS_2	iron sulfide
FA	future allocation
GIS	Geographical Information System
H^+	hydrogen ion
HSPF	Hydrologic Simulation Program FORTRAN
LA	load allocation
lb/yr	pound per year
MDAS	Mining Data Analysis System
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
MGD	million gallons per day
mg/L	milligrams per liter
MOS	margin of safety
MSTLAY	Moisture Storage and Transport in Soil Layers
N	nitrogen
NCDC	NOAA’s National Climatic Data Center
NH_3	ammonia
NH_4^+	ionized ammonia
NHD	National Hydrography Data
NOAA	National Oceanic and Atmospheric Administration
NO_3	nitrate
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PCS	Permit Compliance System
PSU	Pennsylvania State University
SIC	Standard Industrial Classification

SMCRA	Surface Mining Control and Reclamation Act
SO_2	sulfur dioxide
SO_4	sulfate
STATSGO	State Soil Geographic Database
STORET	EPA’s STOrage and RETrieval water quality database
TMDL	Total Maximum Daily Load
UNB	Upper North Branch
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WBAN	Weather Bureau Army-Navy
WLA	wasteload allocation

EXECUTIVE SUMMARY

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's Water Quality Planning and Management Regulations (codified at Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for impaired waterbodies. A TMDL establishes the amount of a pollutant that a waterbody can assimilate without exceeding its water quality standard for that pollutant. TMDLs provide the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

The areas of interest for these TMDLs are the watersheds of the Casselman River, Georges Creek, the Savage River, the Upper North Branch of the Potomac River, and Wills Creek. All five watersheds are in western Maryland; however, the headwaters of Wills Creek are in Pennsylvania and portions of the Casselman River flow through both Maryland and Pennsylvania. The Casselman River eventually flows into the Youghiogheny River. Georges Creek, the Savage River, and Wills Creek are all tributaries to the North Branch of the Potomac River. The Upper North Branch of the Potomac flows along the southern edge of Maryland and into the South Branch of the Potomac River, which eventually flows to the Potomac River and the Chesapeake Bay. The watershed area is dominated by forest (72 percent) and agriculture (19 percent). Urban land use accounts for less than 5 percent of the total watershed area and is mostly concentrated near rivers and other waterbodies.

The Casselman River 8-digit Basin (basin code - 05020204) is impaired by impacts on biological communities (2002/2004 listing) and low pH (1996 listing). The Georges Creek 8-digit Basin (basin code - 02141004) is impaired by impacts on biological communities (2002 listing) and low pH (1998 listing). The Savage River 8-digit Basin (basin code - 02141006) is impaired by impacts on biological communities (2004/2006 listing). The Upper North Branch of the Potomac River 8-digit Basin (basin code - 02141005) is impaired by impacts on biological communities (2004 listing) and low pH (1996 listing). The Wills Creek 8-digit Basin (basin code - 02141003) was identified on Maryland's section 303(d) list of impaired surface waters as impaired by impacts on biological communities (2002 listing) and nutrients (1996 listing). In addition to the 8-digit basin listings for low pH there are several 12-digit basin listings for low pH in Georges Creek, the Upper North Branch Potomac River, and Wills Creek. All low pH listings are displayed in Table ES-1. The Maryland Department of the Environment (MDE) conducted a survey in all basins with pH listings in 2005 to monitor stream segments with the potential to be impaired and identified 52 as being impaired (Table ES-2) due to atmospheric deposition, acid mine drainage (AMD), or if a source was not determined through the assessment process, as having episodic or chronic acidification. Upon approval, this document establishes TMDLs of low pH in the 52 impaired stream segmentsthat will address the low pH listings found in Table ES-1.

Maryland's water quality standards require the water quality in the five impaired watersheds to support their designated uses. The mainstem of the Casselman River is designated as use IV—Recreational Trout Waters (COMAR 26.08.02.08S(5)). The mainstem of Georges Creek and the Upper North Branch of the Potomac River is designated as Use I-P—Water Contact Recreation, and Protection of Nontidal Warm Water Aquatic Life, and Public Water Supply (Code of Maryland Regulations [COMAR] 26.08.02.08R(1)(a) and (b)). The mainstem of Savage River is designated Use III-P – Natural Trout Waters and Public Water Supply (COMAR 26.08.02.08R(4)). The mainstem of Wills Creek is designated as use IV-P—Recreational Trout Waters and Public Water Supply (COMAR 26.08.02.08R(6)(a)). All remaining tributaries not listed are designated as Use I – Water Contact Recreation, and Protection of Nontidal Warm Water Aquatic Life (COMAR 26.08.02.07A). The numeric criteria for pH for all the above designated uses requires that pH values not be less than 6.5 or greater than 8.5 (COMAR 26.08.02.03-3(B)(1), (E)(2)(a), (F)(4) and (G)(1)).

Table ES-1. pH 303(d) listed waterbodies in the TMDL area

8-digit basin name	8-digit basin code	12-digit basin name	12-digit basin code	Impairment	Impairment category	303(d) List
Casselman River	05020204	-	-	pH	pH	1996
Georges Creek	02141004	-	-	pH	pH	1998
		Tributary of Sand Spring Run	021410040094	pH (AMD)	Biological	2002
		Tributary of Georges Creek	021410040088	pH (AMD)	Biological	2002
		Staub Run	021410040092	pH (AMD)	Biological	2002
Savage River	2141006	Aarons Run	021410060075	pH (AMD)	pH	2004
Upper North Branch Potomac River	02141005	-	-	pH (AMD)	pH	1996
		Three Forks Run	021410050048	pH (AMD)	Biological	2002
Wills Creek	2141003	Tributary of Jennings Run - Mt Savage	021410030098	pH	pH	2006
		Jennings Run	021410030099	pH	pH	2006
		Tributary of Jennings Run	021410030099	pH	pH	2006
		Tributary of Jennings Run	021410030099	pH (AMD)	Biological	2002

Table ES-2. Impaired stream segments in the western Maryland watersheds

Basin	Station	Station code	Stream segment	pH source assessment
Casselman River	WM-135	MDW0008	Meadow Run	AMD and acidic deposition
Casselman River	WM-137	LLR0024	Little Laurel Run	Chronic acidification
Casselman River	WM-138	SPI0018	Spiker Run	Episodic acidification
Casselman River	WM-141	LLR0009	Little Laurel Run	Episodic acidification
Casselman River	WM-142	NBC0072	North Branch Casselman	AMD and acidic deposition
Casselman River	WM-143	SCA0067	South Branch Casselman	AMD
Casselman River	WM-144	ALE0011	Alexander Run	Chronic acidification
Casselman River	WM-145	NBC0090	North Branch Casselman	AMD and acidic deposition
Casselman River	WM-146	TAR0003	Tarkiln Run	AMD and acidic deposition
Casselman River	WM-147	PLE0008	Pleasant Valley Run	AMD and acidic deposition
Casselman River	WM-148	NBC0106	North Branch Casselman	AMD and acidic deposition
Casselman River	WM-149	ZWN0003	Unnamed tributary to North Branch Casselman	Chronic acidification
Casselman River	WM-151	UNA0015	Unnamed tributary to North Branch Casselman	Chronic acidification
Casselman River	WM-155	LSR0015	Little Shade Run	Chronic acidification
Georges Creek	WM-110	UGQ0000	Unnamed tributary to Georges Creek	AMD
Georges Creek	WM-111	MIL0001	Mill Run	AMD

Table ES-2. (continued)

Basin	Station	Station code	Stream segment	pH source assessment
Georges Creek	WM-113	JAC0001	Jackson Run	AMD
Georges Creek	WM-116	MTH0000	Matthew Run	AMD
Georges Creek	WM-117	STA0024	Staub Run	Episodic acidification
Georges Creek	WM-118	UJB0000	Unnamed tributary to Jackson Run	AMD
Georges Creek	WM-119	WBN0002	Winebrenner Run	AMD
Georges Creek	WM-120	WBN0010	Winebrenner Run	AMD
Georges Creek	WM-122	UMD0000	Unnamed tributary to Moores Run	AMD
Georges Creek	WM-125	JAC0006	Jackson Run	AMD
Savage River	WM-72	ZWV0001	Unnamed tributary (to Savage R.) above Aaron Run	AMD and acidic deposition
Savage River	WM-73	AAR0000	Aaron Run	AMD
Savage River	WM-77	PYS0024	Pine Swamp Run	AMD and acidic deposition
Savage River	WM-78	ZWA0000	Unnamed tributary to Aaron Run	AMD
Savage River	WM-80	MRR0000	Miller Run	Episodic acidification
Savage River	WM-81	BRU0048	Big Run	Episodic acidification
Savage River	WM-86	LSA0028	Little Savage River	Chronic acidification
Savage River	WM-96	POP0065	Poplar Lick Run	Episodic acidification
Savage River	WM-97	POP0071	Poplar Lick Run	Episodic acidification
UNB Potomac	WM-43	WOL0004	Wolfden Run	AMD and acidic deposition
UNB Potomac	WM-45	EKL0003	Elklick Run	AMD
UNB Potomac	WM-48	RTF0005	Right Prong Three Forks Run	AMD
UNB Potomac	WM-50	NPL0001	North Prong Lostland Run	AMD and acidic deposition
UNB Potomac	WM-51	SPL0016	South Prong Lostland Run	AMD and acidic deposition
UNB Potomac	WM-54	TFR0016	Three Forks Run	AMD
UNB Potomac	WM-55	ZWT0000	Unnamed tributary to Three Forks Run	AMD
UNB Potomac	WM-60	SHO0016	Short Run	Episodic acidification
UNB Potomac	WM-61	LNB0014	Laurel Run	AMD
UNB Potomac	WM-62	ULF0003	Unnamed tributary to Laurel Run (LNB)	AMD
UNB Potomac	WM-64	NPL0018	North Prong Lostland Run	AMD and acidic deposition
UNB Potomac	WM-67	LRE0029	Laurel Run	AMD and acidic deposition
UNB Potomac	WM-69	GLR0031	Glade Run	AMD and acidic deposition
Upper North Branch (UNB) Potomac	WM-42	TFR0021	Three Forks Run	AMD and acidic deposition
Wills Creek	WM-33	UJN0005	Unnamed tributary to Jennings Run	AMD
Wills Creek	WM-34	UJH0015	Unnamed tributary to Jennings Run	AMD
Wills Creek	WM-37	UJF0002	Unnamed tributary to Jennings Run	AMD
Wills Creek	WM-39	JEN0092	Jennings Run	AMD
Wills Creek	WM-41	UJH0011	Unnamed tributary to Jennings Run	AMD

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody and may include a future allocation (FA) component. The TMDL components are illustrated using the following equation:

$$\text{TMDL} = \Sigma\, WLAs + \Sigma\, LAs + MOS + FA$$

In TMDL development, allowable loadings from pollutant sources are determined, the sum of which amounts to a cumulative TMDL threshold, thus providing a quantitative basis for establishing water quality-based controls. To address pH impairments, chemical species that affect pH (such as sulfate, iron, aluminum, nitrate, and ammonium) were reduced in the model simulation to raise the pH above 6.5.

For this TMDL, the Mining Data Analysis System (MDAS) was used to represent the source-response linkage for pH. MDAS is a comprehensive data management and modeling system capable of representing loads from nonpoint and point sources in the watershed and simulating in-stream processes.

MDAS model simulation for a multiyear period inherently accounts for seasonal variation—a required component of TMDLs. Continuous simulation represents both hydrologic and source loading variability seasonally. In addition, the model takes critical conditions into account through dynamic model simulation (i.e., using the model to predict conditions over a long period of time that represents wet, dry, and average flow periods).

A total allowable TMDL loading was determined from these reductions. WLAs were assigned to eight permitted facilities that discharge to waters above impaired monitoring stations. An explicit MOS of five percent of the total TMDL was subtracted from the total TMDL to obtain the LAs. The LAs include nonpoint sources such as atmospheric deposition and AMD. A summary of annual LAs for the subwatersheds addressed in this report is presented in Table ES-3. Table ES-4 presents the percent reduction of each parameter betweent the baseline and TMDL loadings. Daily maximum loads are presented in full in Section 5 (Table 5-2) of this report. The state reserves the right to revise these allocations provided that the allocations are consistent with the achievement of water quality standards.

Table ES-3. TMDL summary for iron, aluminum, sulfate, nitrate, and ammonium yearly loads

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
CR	WM-135	MDW0008	Meadow Run	LA	1,447	1,064	31,932	3,480	1,037
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	85	63	1,878	205	61
				FA	170	125	3,757	409	122
				Total	1,703	1,251	37,567	4,094	1,220
CR	WM-137	LLR0024	Little Laurel Run	LA	14	26	840	83	18
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	1	2	49	5	1
				FA	2	3	99	10	2
				Total	16	30	989	97	21
CR	WM-138	SPI0018	Spiker Run	LA	150	217	7,252	1,205	286
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	9	13	427	71	17
				FA	18	26	853	142	34
				Total	177	255	8,532	1,417	337

Table ES-3. (continued)

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
CR	WM-141[a]	LLR0009	Little Laurel Run	LA	278	519	18,962	1,329	291
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	16	31	1,115	78	17
				FA	33	61	2,231	156	34
				Total	327	610	22,308	1,564	342
CR	WM-142[b]	NBC0072	North Branch Casselman River	LA	16,981	12,882	234,888	8,859	2,190
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	999	758	13,817	521	129
				FA	1,998	1,516	27,634	1,042	258
				Total	19,977	15,156	276,339	10,423	2,577
CR	WM-143	SCA0067	South Branch Casselman River	LA	703	1,310	46,958	1,775	389
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	41	77	2,762	104	23
				FA	83	154	5,524	209	46
				Total	827	1,541	55,244	2,088	457
CR	WM-144	ALE0011	Alexander Run	LA	57	100	4,394	479	96
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	3	6	258	28	6
				FA	7	12	517	56	11
				Total	67	118	5,169	563	112
CR	WM-145[c]	NBC0090	North Branch Casselman River	LA	13,131	7,907	55,999	5,232	1,347
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	772	465	3,294	308	79
				FA	1,545	930	6,588	616	159
				Total	15,448	9,302	65,881	6,156	1,585
CR	WM-146	TAR0003	Tarkiln Run	LA	57	103	4,129	376	78
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	3	6	243	22	5
				FA	7	12	486	44	9
				Total	67	122	4,857	443	92
CR	WM-147	PLE0008	Pleasant Valley Run	LA	543	561	19,108	3,089	803
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	32	33	1,124	182	47
				FA	64	66	2,248	363	94
				Total	639	660	22,480	3,634	944
CR	WM-148[d]	NBC0106	North Branch Casselman River	LA	2,543	1,900	31,737	4,036	1,049
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	150	112	1,867	237	62
				FA	299	224	3,734	475	123
				Total	2,992	2,236	37,338	4,748	1,234
CR	WM-149	ZWN0003	UT to North Branch Casselman River	LA	381	364	11,991	824	217
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	22	21	705	48	13
				FA	45	43	1,411	97	26
				Total	449	428	14,107	969	255

Table ES-3. (continued)

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
CR	WM-151	UNA0015	UT to North Branch Casselman River	LA	261	346	14,022	1,685	394
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	15	20	825	99	23
				FA	31	41	1,650	198	46
				Total	307	407	16,496	1,982	464
CR	WM-155	LSR0015	Little Shade Run	LA	239	409	19,996	1,824	383
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	14	24	1,176	107	23
				FA	28	48	2,352	215	45
				Total	282	481	23,525	2,145	451
GC	WM-110	UGQ0000	UT to Georges Creek	LA	1,100	501	3,242	3,891	1,514
				WLA	3.20	0.00	0.00	0.00	0.00
				MOS	65	29	191	229	89
				FA	130	59	381	458	178
				Total	1,298	590	3,814	4,578	1,781
GC	WM-111	MIL0001	Mill Run	LA	8,368	3,229	18,852	2,181	899
				WLA	15.63	0.00	0.00	0.00	0.00
				MOS	493	190	1,109	128	53
				FA	986	380	2,218	257	106
				Total	9,863	3,799	22,179	2,566	1,057
GC	WM-113[e]	JAC0001	Jackson Run	LA	11,446	5,122	40,857	8,231	4,101
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	673	301	2,403	484	241
				FA	1,347	603	4,807	968	482
				Total	13,466	6,026	48,067	9,683	4,824
GC	WM-116	MTH0000	Matthew Run	LA	2,038	1,049	9,593	3,084	1,778
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	120	62	564	181	105
				FA	240	123	1,129	363	209
				Total	2,397	1,234	11,286	3,628	2,091
GC	WM-117	STA0024	Staub Run	LA	314	728	3,533	210	81
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	18	43	208	12	5
				FA	37	86	416	25	9
				Total	369	856	4,156	247	95
GC	WM-118	UJB0000	UT to Jackson Run	LA	1,282	667	6,427	2,081	1,177
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	75	39	378	122	69
				FA	151	78	756	245	138
				Total	1,509	785	7,561	2,448	1,384
GC	WM-119[f]	WBN0002	Winebrenner Run	LA	14,197	6,581	43,974	9,759	6,363
				WLA	6.09	0.00	0.00	0.00	0.00
				MOS	835	387	2,587	574	374
				FA	1,671	774	5,173	1,148	749
				Total	16,709	7,742	51,734	11,482	7,486

Table ES-3. (continued)

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
GC	WM-120	WBN0010	Winebrenner Run	LA	3,392	1,716	15,183	4,189	2,437
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	200	101	893	246	143
				FA	399	202	1,786	493	287
				Total	3,990	2,019	17,862	4,929	2,867
GC	WM-122	UMD0000	UT to Moores Run	LA	5,221	2,295	17,304	3,573	1,316
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	307	135	1,018	210	77
				FA	614	270	2,036	420	155
				Total	6,142	2,700	20,358	4,203	1,548
GC	WM-125	JAC0006	Jackson Run	LA	8,980	3,903	31,370	3,937	1,455
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	528	230	1,845	232	86
				FA	1,056	459	3,691	463	171
				Total	10,564	4,592	36,906	4,632	1,712
PR	WM-42	TFR0021	Three Forks Run	LA	1,724	3,031	98,993	5,414	964
				WLA	0.23	0.00	0.00	0.00	0.00
				MOS	101	178	5,823	318	57
				FA	203	357	11,646	637	113
				Total	2,028	3,566	116,463	6,370	1,134
PR	WM-43	WOL0004	Wolfden Run	LA	18,911	35,795	1,042,429	12,179	2,257
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	1,112	2,106	61,319	716	133
				FA	2,225	4,211	122,639	1,433	266
				Total	22,248	42,112	1,226,387	14,328	2,655
PR	WM-45	EKL0003	Elklick Run	LA	1,246	2,031	59,693	3,440	637
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	73	119	3,511	202	37
				FA	147	239	7,023	405	75
				Total	1,466	2,389	70,228	4,047	749
PR	WM-48	RTF0005	Right Prong Three Forks Run	LA	1,372	3,625	1,244,350	6,618	1,302
				WLA	0.46	0.00	0.00	0.00	0.00
				MOS	81	213	73,197	389	77
				FA	162	426	146,394	779	153
				Total	1,615	4,264	1,463,941	7,786	1,531
PR	WM-50[g]	NPL0001	North Prong Lostland Run	LA	9,054	17,448	517,583	13,196	2,443
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	533	1,026	30,446	776	144
				FA	1,065	2,053	60,892	1,552	287
				Total	10,651	20,528	608,921	15,524	2,874
PR	WM-51	SPL0016	South Prong Lostland Run	LA	2,890	5,586	161,641	6,438	1,201
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	170	329	9,508	379	71
				FA	340	657	19,017	757	141
				Total	3,400	6,572	190,166	7,574	1,412

Table ES-3. (continued)

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
PR	WM-54	TFR0016	Three Forks Run	LA	3,893	7,348	1,345,541	12,055	2,270
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	229	432	79,149	709	134
				FA	458	864	158,299	1,418	267
				Total	4,580	8,644	1,582,989	14,182	2,670
PR	WM-55	ZWT0000	UT to Three Forks Run	LA	434	1,435	470,712	650	118
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	26	84	27,689	38	7
				FA	51	169	55,378	76	14
				Total	510	1,688	553,779	765	139
PR	WM-60	SHO0016	Short Run	LA	3,616	8,451	247,332	2,727	474
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	213	497	14,549	160	28
				FA	425	994	29,098	321	56
				Total	4,254	9,942	290,979	3,208	558
PR	WM-61	LNB0014	Laurel Run	LA	7,765	7,296	91,327	4,205	790
				WLA	9.14	0.00	0.00	0.00	0.00
				MOS	457	429	5,372	247	46
				FA	915	858	10,744	495	93
				Total	9,147	8,583	107,443	4,946	929
PR	WM-62	ULF0003	UT to Laurel Run	LA	7,700	7,060	21,740	3,777	706
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	453	415	1,279	222	42
				FA	906	831	2,558	444	83
				Total	9,059	8,306	25,576	4,444	830
PR	WM-64	NPL0018	North Prong Lostland Run	LA	5,782	11,265	326,461	8,792	1,644
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	340	663	19,204	517	97
				FA	680	1,325	38,407	1,034	193
				Total	6,803	13,253	384,072	10,344	1,934
PR	WM-67	LRE0029	Laurel Run	LA	1,685	2,728	76,171	1,672	317
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	99	160	4,481	98	19
				FA	198	321	8,961	197	37
				Total	1,982	3,209	89,612	1,967	373
PR	WM-69	GLR0031	Glade Run	LA	3,312	6,264	177,803	4,271	808
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	195	368	10,459	251	48
				FA	390	737	20,918	502	95
				Total	3,896	7,369	209,180	5,024	950
SR	WM-72	ZWV0001	UT to Savage River above Aaron Run	LA	910	1,615	74,432	2,248	364
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	54	95	4,378	132	21
				FA	107	190	8,757	265	43
				Total	1,071	1,899	87,567	2,645	428

Table ES-3. (continued)

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
SR	WM-73[h]	AAR0000	Aaron Run	LA	747	2,048	953,471	2,392	415
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	44	120	56,087	141	24
				FA	88	241	112,173	281	49
				Total	878	2,409	1,121,730	2,814	488
SR	WM-77	PYS0024	Pine Swamp Run	LA	32,714	25,425	106,854	2,625	490
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	1,924	1,496	6,286	154	29
				FA	3,849	2,991	12,571	309	58
				Total	38,487	29,912	125,710	3,088	576
SR	WM-78	ZWA0000	UT to Aaron Run	LA	41	122	52,643	231	42
				WLA	18.28	0.00	0.00	0.00	0.00
				MOS	3	7	3,097	14	2
				FA	7	14	6,193	27	5
				Total	70	143	61,932	271	50
SR	WM-80	MRR0000	Miller Run	LA	73	106	23,511	765	117
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	4	6	1,383	45	7
				FA	9	12	2,766	90	14
				Total	86	125	27,660	901	138
SR	WM-81	BRU0048	Big Run	LA	20	35	2,392	163	28
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	1	2	141	10	2
				FA	2	4	281	19	3
				Total	23	41	2,814	192	33
SR	WM-86	LSA0028	Little Savage River	LA	109,634	100,322	42,278	4,169	839
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	6,449	5,901	2,487	245	49
				FA	12,898	11,803	4,974	490	99
				Total	128,981	118,026	49,738	4,905	987
SR	WM-96[i]	POP0065	Poplar Lick Run	LA	24,065	7,368	54,720	3,148	637
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	1,416	433	3,219	185	37
				FA	2,831	867	6,438	370	75
				Total	28,312	8,668	64,377	3,703	749
SR	WM-97	POP0071	Poplar Lick Run	LA	23,514	7,091	24,521	2,400	496
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	1,383	417	1,442	141	29
				FA	2,766	834	2,885	282	58
				Total	27,664	8,342	28,848	2,823	583
WC	WM-33	UJN0005	UT to Jennings Run	LA	113	269	1,285	859	568
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	7	16	76	51	33
				FA	13	32	151	101	67
				Total	133	317	1,511	1,011	668

Table ES-3. (continued)

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
WC	WM-34	UJH0015	UT to Jennings Run	LA	184	438	785	5,081	2,823
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	11	26	46	299	166
				FA	22	52	92	598	332
				Total	217	516	923	5,978	3,321
WC	WM-37	UJF0002	UT to Jennings Run	LA	251	616	3,366	2,012	1,145
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	15	36	198	118	67
				FA	30	72	396	237	135
				Total	295	725	3,960	2,367	1,347
WC	WM-39	JEN0092	Jennings Run	LA	1,449	21,705	15,338	7,499	4,691
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	85	1,277	902	441	276
				FA	170	2,554	1,804	882	552
				Total	1,704	25,535	18,044	8,823	5,519
WC	WM-41[j]	UJH0011	UT to Jennings Run	LA	304	735	2,198	6,896	4,027
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	18	43	129	406	237
				FA	36	86	259	811	474
				Total	358	865	2,585	8,113	4,738

Notes:
CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek
[a] WM-141 includes upstream loads from WM-137.
[b] WM-142 includes upstream loads from WM-145 and WM-151.
[c] WM-145 includes upstream loads from WM-148.
[d] WM-148 includes upstream loads from WM-147 and WM-149.
[e] WM-113 includes upstream loads from WM-118 and WM-125.
[f] WM-119 includes upstream loads from WM-120.
[g] WM-50 includes upstream loads from WM-64.
[h] WM-73 includes upstream loads from WM-78.
[i] WM-96 includes upstream loads from WM-97.
[j] WM-41 includes upstream loads from WM-34.

Table ES-4. Comparison between baseline loads and TMDLs (lb/yr)

Basin	Station	Station code	Station name	Load	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
CR	WM-135	MDW0008	Meadow Run	Baseline	18,918	13,749	446,478	7,006	1,116
				TMDL	1,703	1,251	37,567	4,094	1,220
				% reduction	91.0	90.9	91.6	41.6	-9.3
CR	WM-137	LLR0024	Little Laurel Run	Baseline	407	741	25,450	169	22
				TMDL	16	30	989	97	21
				% reduction	96.0	95.9	96.1	42.4	3.4
CR	WM-138	SPI0018	Spiker Run	Baseline	4,413	6,206	222,637	2,431	335
				TMDL	177	255	8,532	1,417	337
				% reduction	96.0	95.9	96.2	41.7	-0.6
CR	WM-141[a]	LLR0009	Little Laurel Run	Baseline	4,843	8,912	339,676	2,698	350
				TMDL	327	610	22,308	1,564	342
				% reduction	93.3	93.2	93.4	42.1	2.4
CR	WM-142[b]	NBC0072	North Branch Casselman River	Baseline	153,336	103,684	1,534,917	17,972	2,530
				TMDL	19,977	15,156	276,339	10,423	2,577
				% reduction	87.0	85.4	82.0	42.0	-1.9

Table ES-4. (continued)

Basin	Station	Station code	Station name	Load	Iron (lb/yr)	Alum-inum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammon-ium (lb/yr)
CR	WM-143	SCA0067	South Branch Casselman River	Baseline	6,360	11,769	438,472	3,608	467
				TMDL	827	1,541	55,244	2,088	457
				% reduction	87.0	86.9	87.4	42.1	2.1
CR	WM-144	ALE0011	Alexander Run	Baseline	1,664	2,874	133,586	976	118
				TMDL	67	118	5,169	563	112
				% reduction	96.0	95.9	96.1	42.3	4.5
CR	WM-145[c]	NBC0090	North Branch Casselman River	Baseline	140,678	87,295	883,295	10,639	1,535
				TMDL	15,448	9,302	65,881	6,156	1,585
				% reduction	89.0	89.3	92.5	42.1	-3.3
CR	WM-146	TAR0003	Tarkiln Run	Baseline	1,337	2,383	100,347	767	95
				TMDL	67	122	4,857	443	92
				% reduction	95.0	94.9	95.2	42.3	3.4
CR	WM-147	PLE0008	Pleasant Valley Run	Baseline	12,783	12,904	473,756	6,278	921
				TMDL	639	660	22,480	3,634	944
				% reduction	95.0	94.9	95.3	42.1	-2.5
CR	WM-148[d]	NBC0106	North Branch Casselman River	Baseline	27,440	23,128	614,050	8,201	1,198
				TMDL	2,992	2,236	37,338	4,748	1,234
				% reduction	89.1	90.3	93.9	42.1	-3.0
CR	WM-149	ZWN0003	UT to North Branch Casselman River	Baseline	4,078	3,854	135,434	1,667	243
				TMDL	449	428	14,107	969	255
				% reduction	89.0	88.9	89.6	41.9	-4.9
CR	WM-151	UNA0015	UT to North Branch Casselman River	Baseline	5,118	6,665	290,909	3,385	463
				TMDL	307	407	16,496	1,982	464
				% reduction	94.0	93.9	94.3	41.4	-0.1
CR	WM-155	LSR0015	Little Shade Run	Baseline	4,023	6,765	350,629	3,703	474
				TMDL	282	481	23,525	2,145	451
				% reduction	93.0	92.9	93.3	42.1	5.0
GC	WM-110	UGQ0000	UT to Georges Creek	Baseline	129,493	55,271	390,267	8,422	1,875
				TMDL	1,298	590	3,814	4,578	1,781
				% reduction	99.0	98.9	99.0	45.6	5.0
GC	WM-111	MIL0001	Mill Run	Baseline	164,139	62,592	376,323	4,901	1,094
				TMDL	9,863	3,799	22,179	2,566	1,057
				% reduction	94.0	93.9	94.1	47.7	3.4
GC	WM-113[e]	JAC0001	Jackson Run	Baseline	162,017	71,420	601,487	19,636	4,856
				TMDL	13,466	6,026	48,067	9,683	4,824
				% reduction	91.7	91.6	92.0	50.7	0.6
GC	WM-116	MTH0000	Matthew Run	Baseline	34,248	16,648	177,755	7,842	2,074
				TMDL	2,397	1,234	11,286	3,628	2,091
				% reduction	93.0	92.6	93.7	53.7	-0.8
GC	WM-117	STA0024	Staub Run	Baseline	947	2,194	11,067	447	98
				TMDL	369	856	4,156	247	95
				% reduction	61.0	61.0	62.4	44.8	3.5

Table ES-4. (continued)

Basin	Station	Station code	Station name	Load	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
GC	WM-118	UJB0000	UT to Jackson Run	Baseline	21,552	10,589	118,776	5,245	1,380
				TMDL	1,509	785	7,561	2,448	1,384
				% reduction	93.0	92.6	93.6	53.3	-0.4
GC	WM-119[f]	WBN0002	Winebrenner Run	Baseline	147,676	67,600	551,187	26,146	7,197
				TMDL	16,709	7,742	51,734	11,482	7,486
				% reduction	88.7	88.5	90.6	56.1	-4.0
GC	WM-120	WBN0010	Winebrenner Run	Baseline	49,875	24,016	246,232	10,634	2,831
				TMDL	3,990	2,019	17,862	4,929	2,867
				% reduction	92.0	91.6	92.7	53.7	-1.3
GC	WM-122	UMD0000	UT to Moores Run	Baseline	102,371	44,034	345,645	7,616	1,663
				TMDL	6,142	2,700	20,358	4,203	1,548
				% reduction	94.0	93.9	94.1	44.8	6.9
GC	WM-125	JAC0006	Jackson Run	Baseline	105,641	45,276	376,171	8,361	1,840
				TMDL	10,564	4,592	36,906	4,632	1,712
				% reduction	90.0	89.9	90.2	44.6	7.0
PR	WM-42	TFR0021	Three Forks Run	Baseline	15,601	27,332	934,941	10,959	1,160
				TMDL	2,028	3,566	116,463	6,370	1,134
				% reduction	87.0	87.0	87.5	41.9	2.3
PR	WM-43	WOL0004	Wolfden Run	Baseline	34,228	64,855	1,966,367	24,607	2,675
				TMDL	22,248	42,112	1,226,387	14,328	2,655
				% reduction	35.0	35.1	37.6	41.8	0.7
PR	WM-45	EKL0003	Elklick Run	Baseline	11,278	18,314	563,696	6,981	756
				TMDL	1,466	2,389	70,228	4,047	749
				% reduction	87.0	87.0	87.5	42.0	0.9
PR	WM-48	RTF0005	Right Prong Three Forks Run	Baseline	17,942	46,735	16,299,485	13,598	1,493
				TMDL	1,615	4,264	1,463,941	7,786	1,531
				% reduction	91.0	90.9	91.0	42.7	-2.6
PR	WM-50[g]	NPL0001	North Prong Lostland Run	Baseline	36,322	70,015	2,161,796	26,678	2,899
				TMDL	10,651	20,528	608,921	15,524	2,874
				% reduction	70.7	70.7	71.8	41.8	0.9
PR	WM-51	SPL0016	South Prong Lostland Run	Baseline	17,893	34,529	1,043,066	13,032	1,421
				TMDL	3,400	6,572	190,166	7,574	1,412
				% reduction	81.0	81.0	81.8	41.9	0.6
PR	WM-54	TFR0016	Three Forks Run	Baseline	36,076	76,266	17,241,555	24,603	2,658
				TMDL	4,580	8,644	1,582,989	14,182	2,670
				% reduction	87.3	88.7	90.8	42.4	-0.5
PR	WM-55	ZWT0000	UT to Three Forks Run	Baseline	1,759	5,812	1,913,004	1,328	137
				TMDL	510	1,688	553,779	765	139
				% reduction	71.0	70.9	71.1	42.4	-1.6
PR	WM-60	SHO0016	Short Run	Baseline	7,878	18,423	557,151	5,508	567
				TMDL	4,254	9,942	290,979	3,208	558
				% reduction	46.0	46.0	47.8	41.8	1.6
PR	WM-61	LNB0014	Laurel Run	Baseline	303,540	281,473	2,511,018	8,608	907
				TMDL	9,147	8,583	107,443	4,946	929
				% reduction	97.0	97.0	95.7	42.5	-2.5

Table ES-4. (continued)

Basin	Station	Station code	Station name	Load	Iron (lb/yr)	Alum-inum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammon-ium (lb/yr)
PR	WM-62	ULF0003	UT to Laurel Run	Baseline	301,955	276,000	871,252	7,731	810
				TMDL	9,059	8,306	25,576	4,444	830
				% reduction	97.0	97.0	97.1	42.5	-2.5
PR	WM-64	NPL0018	North Prong Lostland Run	Baseline	24,296	47,302	1,429,071	17,778	1,944
				TMDL	6,803	13,253	384,072	10,344	1,934
				% reduction	72.0	72.0	73.1	41.8	0.5
PR	WM-67	LRE0029	Laurel Run	Baseline	5,663	9,167	266,851	3,387	374
				TMDL	1,982	3,209	89,612	1,967	373
				% reduction	65.0	65.0	66.4	41.9	0.1
PR	WM-69	GLR0031	Glade Run	Baseline	12,175	23,024	681,250	8,640	952
				TMDL	3,896	7,369	209,180	5,024	950
				% reduction	68.0	68.0	69.3	41.9	0.1
SR	WM-72	ZWV0001	UT to Savage River above Aaron Run	Baseline	8,238	14,590	694,782	4,390	457
				TMDL	1,071	1,899	87,567	2,645	428
				% reduction	87.0	87.0	87.4	39.7	6.4
SR	WM-73[h]	AAR0000	Aaron Run	Baseline	7,920	21,686	10,089,103	4,758	496
				TMDL	878	2,409	1,121,730	2,814	488
				% reduction	88.9	88.9	88.9	40.8	1.6
SR	WM-77	PYS0024	Pine Swamp Run	Baseline	202,565	157,404	678,333	5,174	578
				TMDL	38,487	29,912	125,710	3,088	576
				% reduction	81.0	81.0	81.5	40.3	0.3
SR	WM-78	ZWA0000	UT to Aaron Run	Baseline	1,048	2,853	1,240,601	462	50
				TMDL	70	143	61,932	271	50
				% reduction	93.3	95.0	95.0	41.2	1.7
SR	WM-80	MRR0000	Miller Run	Baseline	308	442	105,161	1,497	148
				TMDL	86	125	27,660	901	138
				% reduction	72.0	71.8	73.7	39.8	6.4
SR	WM-81	BRU0048	Big Run	Baseline	63	109	8,827	319	34
				TMDL	23	41	2,814	192	33
				% reduction	63.0	62.9	68.1	39.8	4.1
SR	WM-86	LSA0028	Little Savage River	Baseline	339,425	310,533	149,294	8,241	946
				TMDL	128,981	118,026	49,738	4,905	987
				% reduction	62.0	62.0	66.7	40.5	-4.3
SR	WM-96[i]	POP0065	Poplar Lick Run	Baseline	75,813	23,027	151,535	6,217	726
				TMDL	28,312	8,668	64,377	3,703	749
				% reduction	62.7	62.4	57.5	40.4	-3.2
SR	WM-97	POP0071	Poplar Lick Run	Baseline	74,767	22,501	88,919	4,750	557
				TMDL	27,664	8,342	28,848	2,823	583
				% reduction	63.0	62.9	67.6	40.6	-4.8
WC	WM-33	UJN0005	UT to Jennings Run	Baseline	6,626	15,345	81,770	2,308	635
				TMDL	133	317	1,511	1,011	668
				% reduction	98.0	97.9	98.2	56.2	-5.2
WC	WM-34	UJH0015	UT to Jennings Run	Baseline	21,650	47,307	119,484	13,171	3,310
				TMDL	217	516	923	5,978	3,321
				% reduction	99.0	98.9	99.2	54.6	-0.3

Table ES-4. (continued)

Basin	Station	Station code	Station name	Load	Iron (lb/yr)	Alum-inum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammon-ium (lb/yr)
WC	WM-37	UJF0002	UT to Jennings Run	Baseline	14,763	33,199	209,447	4,989	1,317
				TMDL	295	725	3,960	2,367	1,347
				% reduction	98.0	97.8	98.1	52.6	-2.2
WC	WM-39	JEN0092	Jennings Run	Baseline	56,814	131,112	649,571	19,522	5,311
				TMDL	1,704	25,535	18,044	8,823	5,519
				% reduction	97.0	80.5	97.2	54.8	-3.9
WC	WM-41[j]	UJH0011	UT to Jennings Run	Baseline	35,810	80,138	298,812	18,008	4,656
				TMDL	358	865	2,585	8,113	4,738
				% reduction	99.0	98.9	99.1	54.9	-1.7

Notes:

CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek

[a] WM-141 includes upstream loads from WM-137.

[b] WM-142 includes upstream loads from WM-145 and WM-151.

[c] WM-145 includes upstream loads from WM-148.

[d] WM-148 includes upstream loads from WM-147 and WM-149.

[e] WM-113 includes upstream loads from WM-118 and WM-125.

[f] WM-119 includes upstream loads from WM-120.

[g] WM-50 includes upstream loads from WM-64.

[h] WM-73 includes upstream loads from WM-78.

[i] WM-96 includes upstream loads from WM-97.

[j] WM-41 includes upstream loads from WM-34.

1 INTRODUCTION AND BACKGROUND

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (codified at Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not supporting their designated uses even if pollutant sources have implemented technology-based controls. A TMDL establishes the maximum allowable load (mass per unit of time) of a pollutant that a waterbody is able to assimilate and still support its designated use(s). The maximum allowable load is determined based on the relationship between pollutant sources and in-stream water quality. A TMDL provides the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991). The development of TMDLs requires an assessment of streams' assimilative capacity, critical conditions, and other considerations.

The Casselman River 8-digit Basin (basin code - 05020204) is impaired by impacts on biological communities (2002/2004 listing) and low pH (1996 listing). The Georges Creek 8-digit Basin (basin code - 02141004) is impaired by impacts on biological communities (2002 listing) and low pH (1998 listing). The Savage River 8-digit Basin (basin code - 02141006) is impaired by impacts on biological communities (2004/2006 listing). The Upper North Branch of the Potomac River 8-digit Basin (basin code - 02141005) is impaired by impacts on biological communities (2004 listing) and low pH (1996 listing). The Wills Creek 8-digit Basin (basin code - 02141003) was identified on Maryland's section 303(d) list of impaired surface waters as impaired by impacts on biological communities (2002 listing) and nutrients (1996 listing). In addition to the 8-digit basin listings for low pH there are several 12-digit basin listings for low pH in George Creek, the Upper North Branch Potomac River, and Wills Creek. All low pH listings are displayed in Table 1-1. Water quality monitoring data collected in all basins with pH listings in 2005 by the Maryland Department of the Environment (MDE) indicate that observed pH levels sometimes exceed water quality standards for 52 segments in the five watersheds included in this report (Table 1-2 and Figure 1-1). The pollutant loadings were classified by source, including acid mine drainage (AMD) and atmospheric deposition, and organic sources. In addition, a segment could be classified as having chronic or episodic acidification, with no identified source.

While the headwaters of Wills Creek and portions of the Casselman River flow though Pennsylvania, only the portions of these waterbodies that flow through Maryland are included in this TMDL and addressed in this document.

This TMDL report addresses the low pH impairment in the five western Maryland watersheds. Low pH in a waterbody leads to acidic conditions. A pH of less than 5 is considered to be harmful to most stream biota (USEPA 1999). Healthy freshwater ecosystems have a diverse number of species (e.g., zooplankton, fish, and waterfowl) that depend on the freshwater environment for life. As pH becomes more acidic, the number of aquatic species and their populations tend to decline, with some species being more tolerant of low pH than others (USEPA 2007). Low pH in a waterbody affects gill function, egg development, and larval survival (USEPA 1999). Species that do not tolerate acidic environments will begin to lose the ability to reproduce, and even if a species is able to spawn, the offspring often do not survive the harsh acidic environment and might be more susceptible to disease or deformity (Environment Canada 2005).

When pH falls below 5, most fish cannot survive, and terrestrial animals, such as waterfowl, that are dependent on the aquatic species for survival are affected as their aquatic food sources are diminished (Environment Canada 2005). Metals concentrations in streams (e.g., aluminum) can also become toxic to fish when stream water and runoff entering the stream is acidic (USEPA 1999).

Table 1-1. pH 303(d) listed waterbodies in the TMDL area

8-digit Basin Name	8-digit Basin Code	12-digit Basin Name	12-digit Basin Code	Impairment	Impairment Category	303(d) List
Casselman River	05020204	-	-	pH	pH	1996
Georges Creek	02141004	-	-	pH	pH	1998
		Tributary of Sand Spring Run	021410040094	pH (AMD)	Biological	2002
		Tributary of Georges Creek	021410040088	pH (AMD)	Biological	2002
		Staub Run	021410040092	pH (AMD)	Biological	2002
Savage River	2141006	Aarons Run	021410060075	pH (AMD)	pH	2004
Upper North Branch Potomac River	02141005	-	-	pH (AMD)	pH	1996
		Three Forks Run	021410050048	pH (AMD)	Biological	2002
Wills Creek	2141003	Tributary of Jennings Run - Mt Savage	021410030098	pH	pH	2006
		Jennings Run	021410030099	pH	pH	2006
		Tributary of Jennings Run	021410030099	pH	pH	2006
		Tributary of Jennings Run	021410030099	pH (AMD)	Biological	2002

Table 1-2. Impaired stream segments in the western Maryland watersheds

Basin	Station	Station code	Stream segment	pH source assessment
Casselman River	WM-135	MDW0008	Meadow Run	AMD and acidic deposition
Casselman River	WM-137	LLR0024	Little Laurel Run	Chronic acidification
Casselman River	WM-138	SPI0018	Spiker Run	Episodic acidification
Casselman River	WM-141	LLR0009	Little Laurel Run	Episodic acidification
Casselman River	WM-142	NBC0072	North Branch Casselman	AMD and acidic deposition
Casselman River	WM-143	SCA0067	South Branch Casselman	AMD
Casselman River	WM-144	ALE0011	Alexander Run	Chronic acidification
Casselman River	WM-145	NBC0090	North Branch Casselman	AMD and acidic deposition
Casselman River	WM-146	TAR0003	Tarkiln Run	AMD and acidic deposition
Casselman River	WM-147	PLE0008	Pleasant Valley Run	AMD and acidic deposition
Casselman River	WM-148	NBC0106	North Branch Casselman	AMD and acidic deposition
Casselman River	WM-149	ZWN0003	Unnamed tributary to North Branch Casselman	Chronic acidification
Casselman River	WM-151	UNA0015	Unnamed tributary to North Branch Casselman	Chronic acidification
Casselman River	WM-155	LSR0015	Little Shade Run	Chronic acidification
Georges Creek	WM-110	UGQ0000	Unnamed tributary to Georges Creek	AMD
Georges Creek	WM-111	MIL0001	Mill Run	AMD
Georges Creek	WM-113	JAC0001	Jackson Run	AMD
Georges Creek	WM-116	MTH0000	Matthew Run	AMD
Georges Creek	WM-117	STA0024	Staub Run	Episodic acidification

Table 1-2. (continued)

Basin	Station	Station code	Stream segment	pH source assessment
Georges Creek	WM-118	UJB0000	Unnamed tributary to Jackson Run	AMD
Georges Creek	WM-119	WBN0002	Winebrenner Run	AMD
Georges Creek	WM-120	WBN0010	Winebrenner Run	AMD
Georges Creek	WM-122	UMD0000	Unnamed tributary to Moores Run	AMD
Georges Creek	WM-125	JAC0006	Jackson Run	AMD
Savage River	WM-72	ZWV0001	Unnamed tributary (to Savage R.) above Aaron Run	AMD and acidic deposition
Savage River	WM-73	AAR0000	Aaron Run	AMD
Savage River	WM-77	PYS0024	Pine Swamp Run	AMD and acidic deposition
Savage River	WM-78	ZWA0000	Unnamed tributary to Aaron Run	AMD
Savage River	WM-80	MRR0000	Miller Run	Episodic acidification
Savage River	WM-81	BRU0048	Big Run	Episodic acidification
Savage River	WM-86	LSA0028	Little Savage River	Chronic acidification
Savage River	WM-96	POP0065	Poplar Lick Run	Episodic acidification
Savage River	WM-97	POP0071	Poplar Lick Run	Episodic acidification
Upper North Branch (UNB) Potomac	WM-42	TFR0021	Three Forks Run	AMD and acidic deposition
UNB Potomac	WM-43	WOL0004	Wolfden Run	AMD and acidic deposition
UNB Potomac	WM-45	EKL0003	Elklick Run	AMD
UNB Potomac	WM-48	RTF0005	Right Prong Three Forks Run	AMD
UNB Potomac	WM-50	NPL0001	North Prong Lostland Run	AMD and acidic deposition
UNB Potomac	WM-51	SPL0016	South Prong Lostland Run	AMD and acidic deposition
UNB Potomac	WM-54	TFR0016	Three Forks Run	AMD
UNB Potomac	WM-55	ZWT0000	Unnamed tributary to Three Forks Run	AMD
UNB Potomac	WM-60	SHO0016	Short Run	Episodic acidification
UNB Potomac	WM-61	LNB0014	Laurel Run	AMD
UNB Potomac	WM-62	ULF0003	Unnamed tributary to Laurel Run (LNB)	AMD
UNB Potomac	WM-64	NPL0018	North Prong Lostland Run	AMD and acidic deposition
UNB Potomac	WM-67	LRE0029	Laurel Run	AMD and acidic deposition
UNB Potomac	WM-69	GLR0031	Glade Run	AMD and acidic deposition
Wills Creek	WM-33	UJN0005	Unnamed tributary to Jennings Run	AMD
Wills Creek	WM-34	UJH0015	Unnamed tributary to Jennings Run	AMD
Wills Creek	WM-37	UJF0002	Unnamed tributary to Jennings Run	AMD
Wills Creek	WM-39	JEN0092	Jennings Run	AMD
Wills Creek	WM-41	UJH0011	Unnamed tributary to Jennings Run	AMD

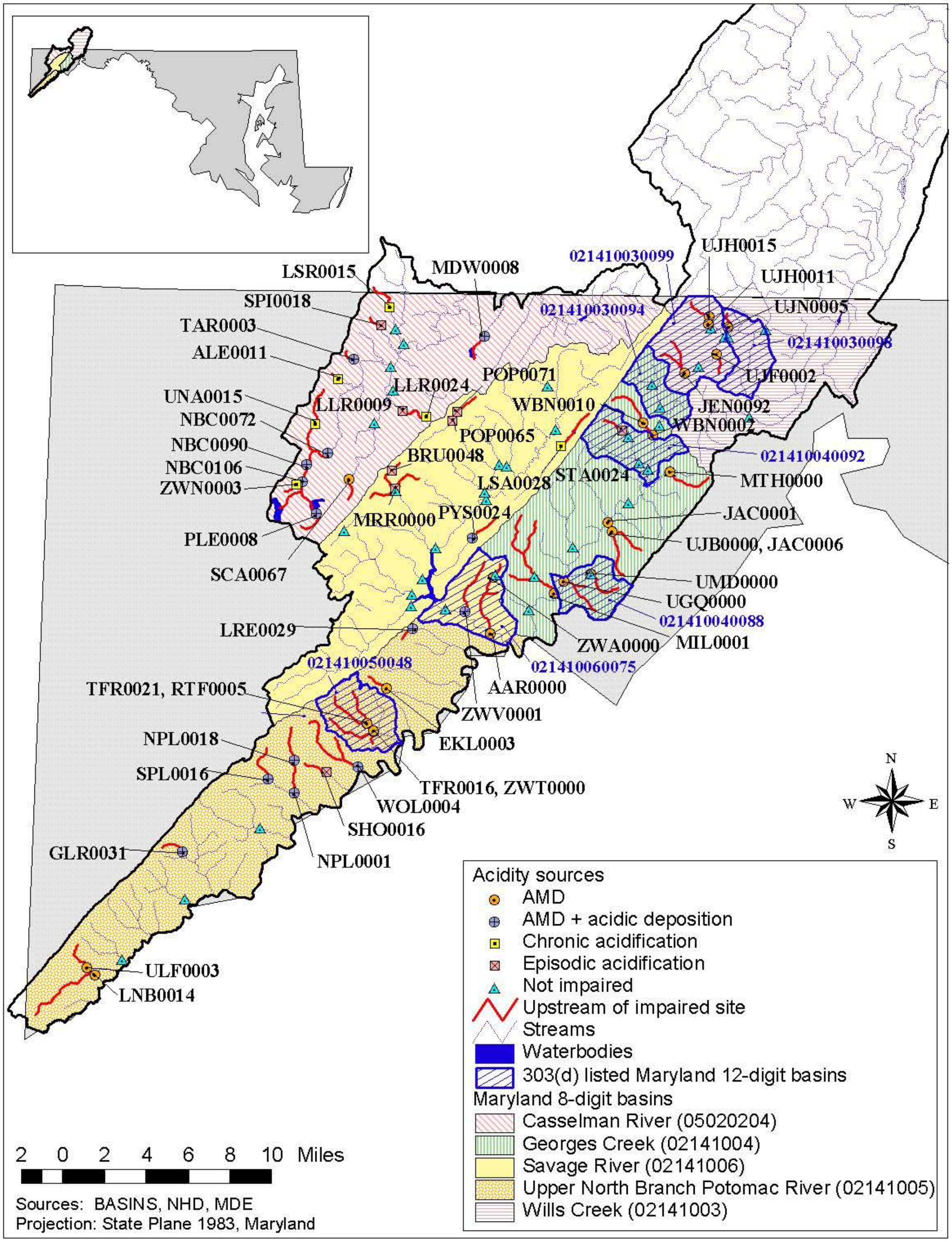


Figure 1-1. Impaired monitoring locations in the western Maryland watersheds.

1.1 Watershed Description

The study area includes five watersheds: the Casselman River, Georges Creek, the Savage River, the Upper North Branch of the Potomac River, and Wills Creek. All five watersheds are in western Maryland; however, portions of Wills Creek and the Casselman River also flow through Pennsylvania. The headwaters of Wills Creek begin in Pennsylvania. The Casselman River flows through portions of Maryland and Pennsylvania and eventually flows into the Youghiogheny River. The Savage River, Georges Creek, and Wills Creek all flow into the Upper North Branch of the Potomac River. The North Branch of the Potomac flows along the southern edge of Maryland until the river reaches the Chesapeake Bay.

The watersheds are in portions of Garrett and Allegany County in Maryland and Somerset County in Pennsylvania. The area of interest for this TMDL study is the portions of the watersheds in Maryland only. Figure 1-2 shows the location of the watersheds.

1.2 Water Quality Problem Statement

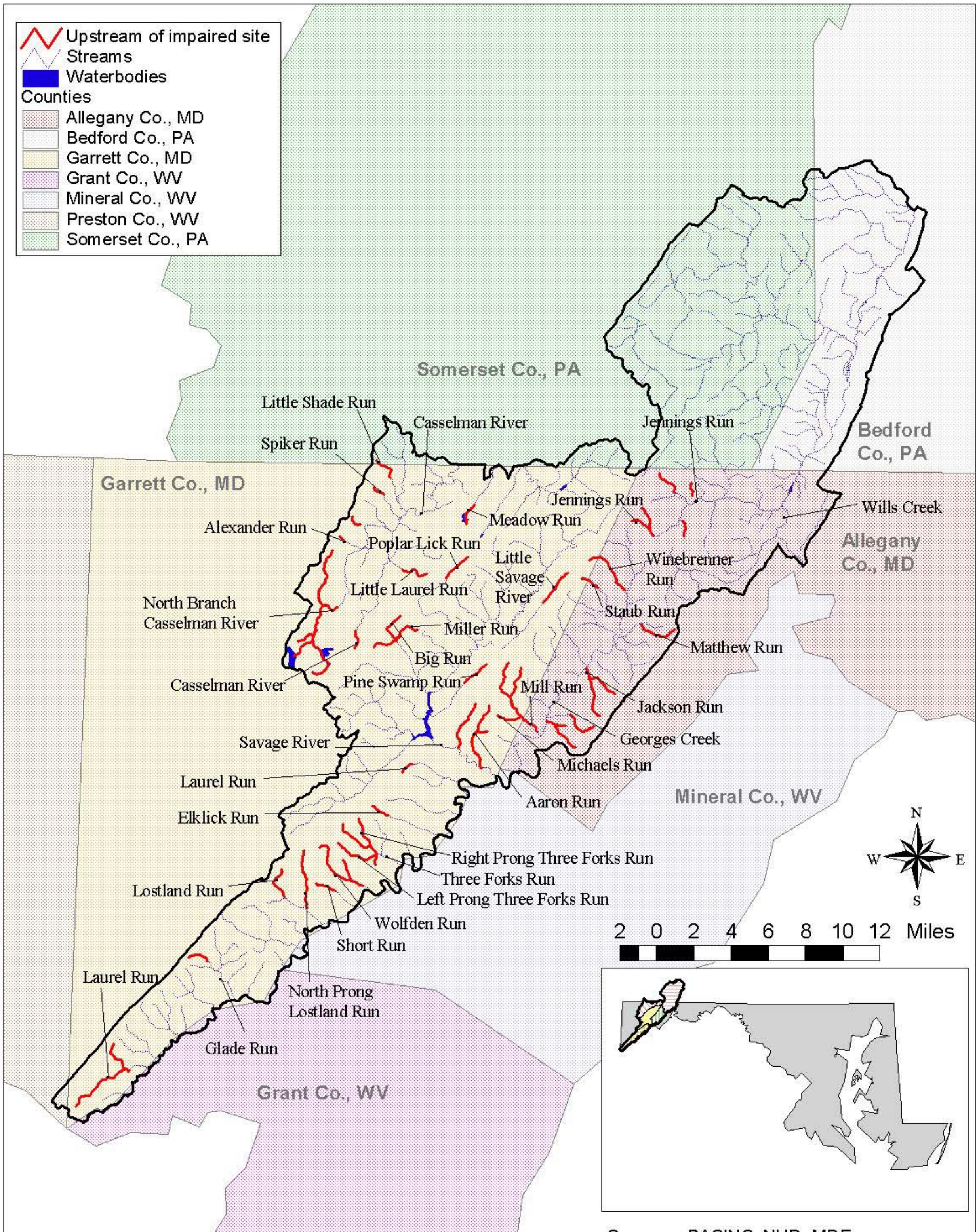
There are several potential sources affecting pH levels in the Casselman River, Georges Creek, the Savage River, the Upper North Branch of the Potomac River, and Wills Creek watersheds: atmospheric deposition (acid rain), AMD, and naturally occurring conditions.

Acid rain is produced when atmospheric moisture reacts with gases to form sulfuric acid and nitric acids. These gases are primarily formed from nitrogen dioxides and sulfur dioxide, which enter the atmosphere through exhaust and smoke from burning fossil fuels such as gas, oil, and coal. Acid rain crosses political and watershed boundaries and can originate out of state.

AMD occurs when surface and subsurface water percolates through coal-bearing minerals containing large amounts 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 (Stumm and Morgan 1996):

- Exposure of pyrite to air and water causes the oxidation of pyrite.
- The sulfur component of pyrite is oxidized, releasing dissolved ferrous (Fe^{+2}) and hydrogen (H^{+}) ions. These hydrogen ions cause the acidity.
- The intermediate reaction with the dissolved Fe^{+2} ions generates a precipitate, ferric hydroxide [$Fe(OH)_3$], and releases hydrogen ions, thereby causing more acidity.
- A third reaction occurs between the pyrite and the generated ferric (Fe^{+3}) ions contained in the ferric hydroxide precipitate, where more hydrogen ions (increasing acidity) are released as well as Fe^{+2} ions, which enter the reaction cycle.

pH levels can further be lowered by natural conditions such as wetlands, more specifically bogs, and the lack of stream buffering capacity. In bogs, pH might be decreased from the natural decomposition of organic material. The other natural condition that could result in lowered pH levels is the lack of buffering-capacity in streams. The bedrock in the study watersheds are mainly sandstone, shale, and siltstone, which contain little calcium carbonate. There are only small areas containing limestone and calcareous shale that include calcium carbonate, which buffers excess hydrogen ions to raise pH levels in streams.



Sources: BASINS, NHD, MDE
Projection: State Plane 1983, Maryland

Figure 1-2. Location of the western Maryland watersheds.

1.3 Water Quality Standards

Maryland water quality standards consist of two components that are relevant here: (1) designated and existing uses; and (2) narrative or numeric water quality criteria necessary to support those uses. Furthermore, water quality standards serve the purpose of protecting public health, enhancing the quality of water, and protecting aquatic resources.

Maryland's water quality standards require the water quality in the five impaired watersheds to support their designated uses. The mainstem of the Casselman River is designated as use IV—Recreational Trout Waters (COMAR 26.08.02.08S(5)). The mainstem of Georges Creek and the Upper North Branch of the Potomac River is designated as Use I-P—Water Contact Recreation, and Protection of Nontidal Warm Water Aquatic Life, and Public Water Supply (Code of Maryland Regulations [COMAR] 26.08.02.08R(1)(a) and (b)). The mainstem of Savage River is designated Use III-P – Natural Trout Waters and Public Water Supply (COMAR 26.08.02.08R(4)). The mainstem of Wills Creek is designated as use IV-P—Recreational Trout Waters and Public Water Supply (COMAR 26.08.02.08R(6)(a)). All remaining tributaries not listed are designated as Use I – Water Contact Recreation, and Protection of Nontidal Warm Water Aquatic Life (COMAR 26.08.02.07A). The numeric criteria for pH for all the above designated uses requires that pH values not be less than 6.5 or greater than 8.5 (COMAR 26.08.02.03-3(B)(1), (E)(2)(a), (F)(4) and (G)(1)).

Portions of Wills Creek and the Casselman River are in Pennsylvania. Maryland's and Pennsylvania's water quality standards are presented in Table 1-3, as are EPA's national recommended water quality criteria.

Table 1-3. Water quality standards

Parameter	Maryland[a]		Pennsylvania[b]		EPA[c]	
	Value	Comment	Value	Comment	Value	Comment
Acidity	--		--		--	
Alkalinity	--		20 mg/L as $CaCO_3$		20 mg/L	
Aluminum	--		750 µg/L		750 µg/L 87 µg/L	Freshwater maximum concentration at pH 6.5–9.0 Freshwater continuous concentration at pH 6.5–9.0
Ammonia Nitrogen	--		--	Varies based on pH	--	Varies based on pH and temperature
Iron	--		1.5 mg/L 0.3 mg/L	30-day average total recoverable Dissolved	1.0 mg/L 0.3 mg/L	Freshwater continuous concentration Human health for consumption of water and organism
Nitrate	--		10 mg/L as N	Nitrate + Nitrite	10 mg/L	Human health for consumption of water and organism
pH	6.5–8.5		6.0–9.0		6.5–9.0 5.0–9.0	Freshwater continuous range Human health for consumption of water and organism
Sulfate	--		250 mg/L		--	

Notes:
[a] COMAR 2005
[b] PADEP 2006
[c] USEPA 2006

1.4 Impaired Waterbodies

MDE monitored 92 stream segments in the the Casselman River, Georges Creek, the Savage River, the Upper North Branch of the Potomac River, and Wills Creek watersheds in 2005 in order to identify pH-impaired streams. Of these, MDE identified 52 as being impaired (14 in the Casselman River watershed, ten in the Georges Creek watershed, nine in the Savage River watershed, 14 in the Upper North Branch of the Potomac River watershed, and five in the Wills Creek watershed). For a full description of the assessment process, see Section 2.2.1. These streams were identified as impaired due to atmospheric deposition and AMD, or as having episodic or chronic acidification if a source was not determined through the assessment process.

Portions of the Casselman River and Wills Creek are in Somerset County, Pennsylvania. Pennsylvania includes the Casselman River on its 2006 Section 303(d) for impairments to the Aquatic Life designated use caused by metals and pH from AMD. Wills Creek and the North Branch of Jennings Run, a tributary to Wills Creek, are attaining Pennsylvania's water quality criteria where they enter Maryland.

1.5 History of Mining in Western Maryland

Coal mining has occurred in western Maryland since the early 1700s. Coal was discovered in the North Branch of the Potomac River watershed in 1736, with commercial development beginning in 1738 in the Georges Creek coal field (Salstrom 1994). Deep mine production peaked in the early 1900s. Coal mining in Maryland peaked at 5.5 million tons in 1907 but usually averaged 4 to 5 million tons annually (USDOI 2006). Deep mines in the area produced AMD when water was pumped from the mines and discharged to the streams. AMD was also an issue after the closure of deep mines because they filled with water, which also caused AMD. Underground mining declined in Maryland after 1945, with 91 percent of the mines being surface mines in 1977 (USDOI 2006). In the 1980s, production fluctuated between 3 and 4.5 million tons annually (USDOI 2006).

In the western Maryland watersheds, mining is now confined to the southeast and northwest portions of the watersheds. The mining is mostly in the Cassleman River, Wills Creek, Georges Creek, and North Branch watersheds with a small area of mining also in the Savage River watershed.

Beginning in the 1960s, several studies showed the effects that coal mining and the resulting AMD had on the North Branch of the Potomac watershed. These publications and reports document the biological status of the North Branch of the Potomac River watershed up to 1990. Studies documented the severe effect AMD has had on the water quality in the watershed by causing chronically low pH (Clark 1969; Lauby 1966–1968; Mason et al. 1976; Skelly and Loy, Inc. 1976).

Other studies documented the effect AMD has had on fish and benthic communities in the North Branch of the Potomac watershed. Davis (1973) sampled several stations with no fish as well as no measurable alkalinity, low pH, and high iron; acidity; sulfates; and conductivity. Staubitz (1981) and Staubitz and Sobashinski (1983) sampled the North Branch watershed's streamflow, water quality, and biological data. All stations affected by AMD had very poor benthic populations and many stations in the Upper North Branch watershed had low pH as a result of AMD. Hendricks et al. (1984), Lebo (1983), and the Morgan Mining and Environmental Consultants (Morgan Mining) report (1994) all found few to no fish at many of their sampling stations and poor benthic macroinvertebrate populations. At the stations that did have fish or benthic populations, the diversity of species was low.

2 DATA INVENTORY AND ANALYSIS

2.1 Data Inventory

Table 2-1 outlines key data sets compiled for this project. The data sets include geographical and political information, such as county boundaries and land uses, and in-stream monitoring data, such as water quality and flow. Descriptions of the data sets that were used in model development are provided in Sections 2.1.1 through 2.1.8.

Table 2-1. Data sets compiled for the Western Maryland watersheds

Data type	Information sources
Reservoir boundaries and stream network	BASINS[a], USGS[b] 7.5 minute Quads, MDE
Land use	MDE; Pennsylvania Spatial Data Access
Soils	STATSGO[c]
Watershed boundaries	USGS Hydrologic Unit Boundaries (8-digit), MDE
Topographic relief and elevation data	USGS 7.5 minute Quads, Digital Elevation Models from BASINS
Surface geology	Maryland Geological Survey
Active and abandoned mine locations	MDE
Flow data and locations	USGS
Meteorological data and locations[d]	National Oceanic and Atmospheric Administration – National Climatic Data Center (NOAA–NCDC)
Water quality data and locations	MDE, STORET
NPDES permitted facilities and locations[e]	Permit Compliance System (PCS), MDE

Notes:

[a] BASINS (Better Assessment Science Integrating Point and Nonpoint Sources)

[b] U.S. Geological Survey

[c] STATSGO (State Soil Geographic database)

[d] Precipitation, dry-bulb [air] temperature, dew point temperature, wind speed, cloud cover.

[e] NPDES permit limits, design flow, DMR data

2.1.1 Hydrology and Topography

The U.S. Geological Survey (USGS) online database (NWISWeb) contains eight stations that have daily flow data for the modeling period in the five TMDL watersheds (USGS 2005). These stations are shown in Figure 2-1 and listed in Table 2-2.

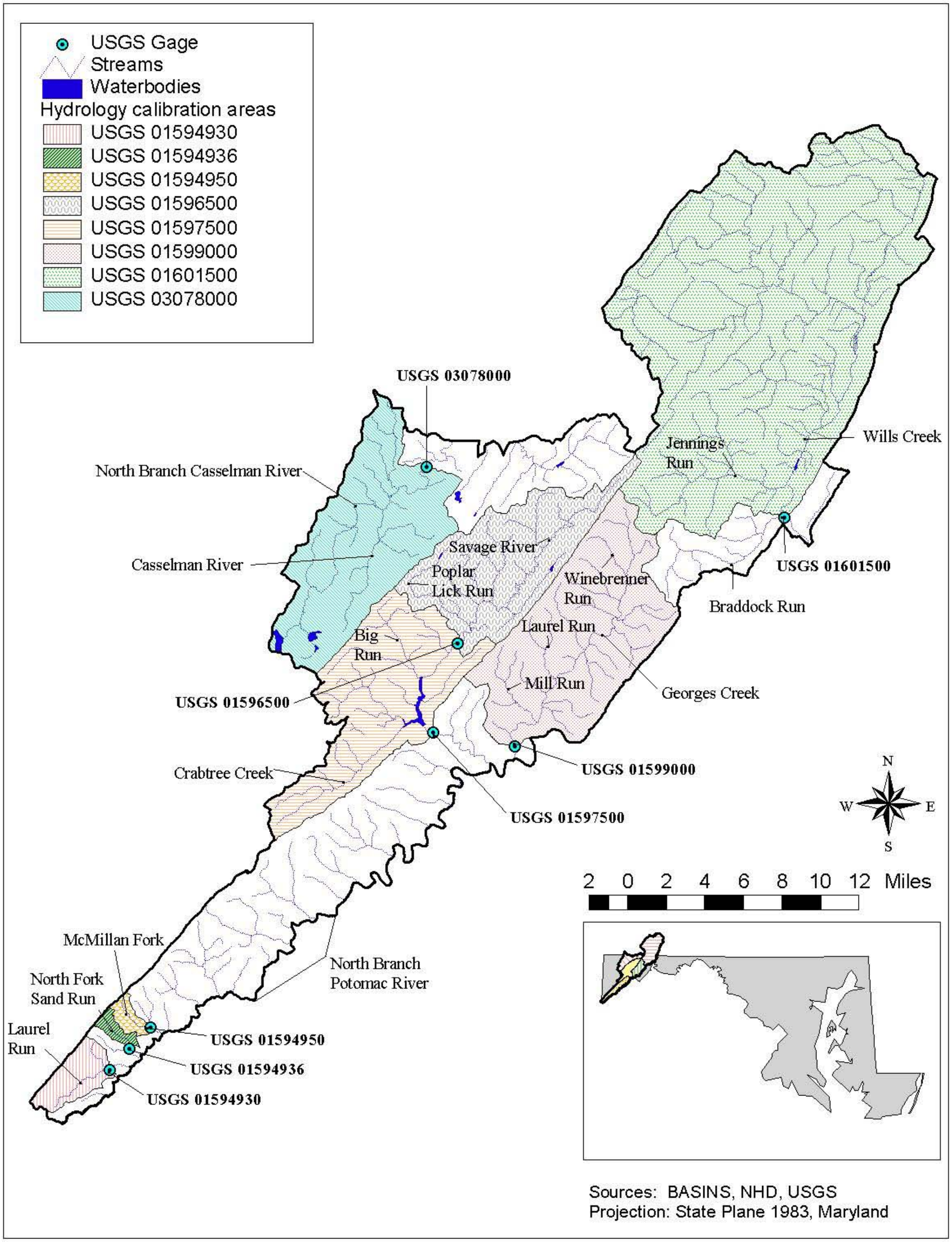


Figure 2-1. USGS gages in the western Maryland watersheds.

Table 2-2. Eight USGS gaging stations with daily flow data

Station	Station name	Drainage area (square miles)	Start date	End date	Percent complete*
01594930	Laurel Run at Dobbin Road near Wilson, Maryland	8.23	5/1/1980	9/30/2004	100
01594936	North Fork Sand Run near Wilson, Maryland	1.91	5/1/1980	9/30/2005	100
01594950	McMillan F near Fort Pendleton, Maryland	2.3		6/8/2006	100
01596500	Savage River near Barton, Maryland	49	9/18/1948	present	100
01597500	Savage River below Savage River Dam near Bloomington, Maryland	106	10/1/1948	present	100
01599000	George's Creek at Franklin, Maryland	72.5	5/1/1905	present	100
01601500	Will's Creek near Cumberland, Maryland	247	5/1/1905	present	100
03078000	Casselman River at Grantsville, Maryland	62.5	7/25/1947	present	100

*Note that the percent complete was calculated for the period of record used in the watershed model, not the entire period of record for each USGS gage.

The elevation of the western Maryland watersheds ranges from approximately 587 feet to over 3,000 feet, with an average elevation of 2,178 feet. Topographic information was obtained from Digital Elevation Models (DEMs) from EPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) (USEPA 2004) and USGS topographic maps.

2.1.2 Climate

The National Oceanic and Atmospheric Administration (NOAA) collects weather data from numerous regional climate stations. NOAA's National Climatic Data Center (NCDC) stores and distributes weather data gathered by the Cooperative Observer Network (COOP) throughout the United States and from Weather Bureau Army-Navy (WBAN) airways stations. The COOP stations record hourly or daily rainfall data, while the WBAN stations record hourly rainfall plus additional hourly data.

The identification of the best weather data for this modeling effort was based on several factors including geographic coverage, data record, and data completeness. There were nine stations used for this TMDL study, based mainly on geographic location. There were other nearby weather stations with more complete data sets; however, they were not considered representative of the watershed because they were on opposite sides of the surrounding mountains and most likely had different rainfall patterns. Information on the selected hourly and daily COOP and WBAN stations is presented in Table 2-3 and Figure 2-2. Table 2-3 also provides statistics regarding the period of record and the completeness of records expressed as percentages of reported data corresponding to the respective station's period of record.

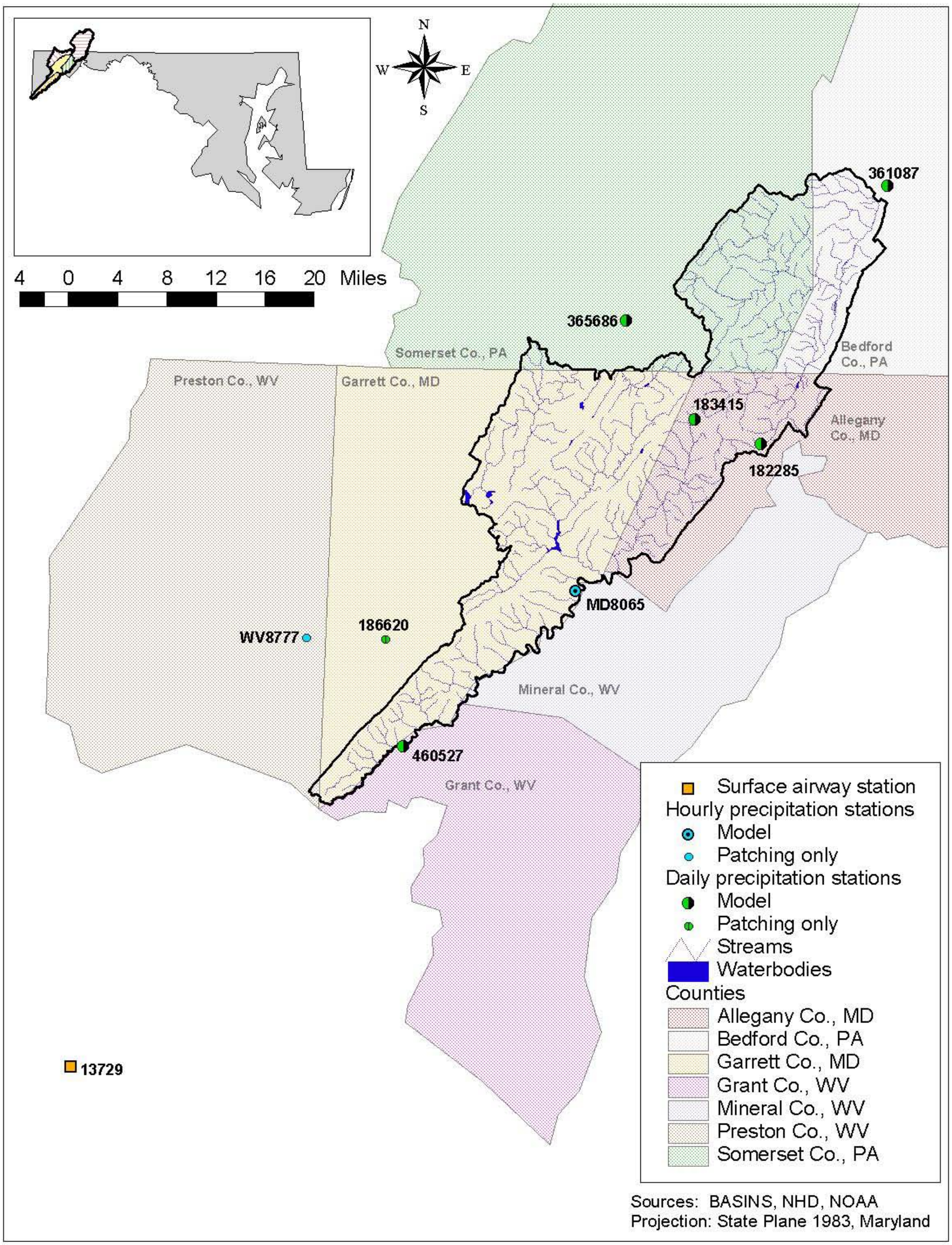
Data for dry bulb air temperature, wind speed, solar radiation, cloud cover, and dewpoint temperature data were required in addition to hourly precipitation and evapotranspiration. Precipitation, wind speed, temperature, and cloud cover data were taken directly from the NOAA stations. Solar radiation was calculated using the Hamon equation (Hamon 1961) using latitude (to determine the hours of sunshine) and cloud cover. Potential evapotranspiration was calculated using the Penman method (Penman 1948). The Penman equation uses air temperature, wind speed, solar radiation, and dewpoint temperature to compute pan evaporation. An additional conversion factor of 0.8 for winter and 1.0 for summer was applied to estimate potential evapotranspiration. This conversion factor is used to represent the influence of vegetative cover on the land surface.

Table 2-3. Available meteorological data

Station ID	Station name	Start date	End date[a]	Percent complete	Data type
361087	Buffalo Mills	1/1/1990	12/31/2004	98	Precipitation
183415	Frostburg 2	1/1/1990	12/31/2004	98	Precipitation
MD8065	Savage River Dam	1/1/1990	12/31/2004	98	Precipitation
460527	Bayard	1/1/1990	12/31/2003	99	Precipitation
186620	Oakland 1 SE	1/1/1990	12/31/2004	85	Precipitation
365686	Meyersdale 2 SSW	1/1/1990	12/31/2004	95	Precipitation
182285	Cumberland Police Brk	1/1/1997	12/31/2004	85	Precipitation
WV8777	Terra Alta No 1	1/1/1978	12/20/2004	90	Precipitation
13729	Elkins - Randolph Co Airport	7/1/1996	12/31/2002	100	Altimeter pressure
		1/1/1980	12/31/2002	100	Ceiling height
		7/1/1996	12/31/2002	100	Dewpoint temperature (Celsius)
		1/1/1980	12/31/2002	96	Dewpoint temperature (Fahrenheit)
		1/1/1980	12/31/2002	96	Haze/visibility
		1/1/1980	6/30/1996	100	Station pressure
		1/1/1980	12/31/2002	96	Relative humidity
		1/1/1980	12/31/2002	96	Sea-level pressure
		7/1/1996	12/31/2002	100	Dry-bulb temperature (Celsius)
		1/1/1980	12/31/2002	100	Dry-bulb temperature (Fahrenheit)
		1/1/1980	12/31/2002	96	Wet-bulb temperature (Fahrenheit)
		1/1/1980	4/30/1996	95	Cloud cover
		1/1/1980	12/31/2002	96	Windspeed and direction

2.1.3 Water Quality Data

Water quality data for the western Maryland watersheds were provided by the MDE. Additional data were obtained from EPA’s STORET database (USEPA 2005a). Table 2-4 presents the available water quality data sets and the availability of the corresponding location data, flow data, data range, and parameters. Figure 2-3 shows the locations of the water quality stations. The data sets contained many parameters including pH, nitrate, sulfate, total iron, and total aluminum. Water quality data are summarized in Appendix A.



Sources: BASINS, NHD, NOAA
Projection: State Plane 1983, Maryland

Figure 2-2. Climate stations used in the western Maryland watershed model.

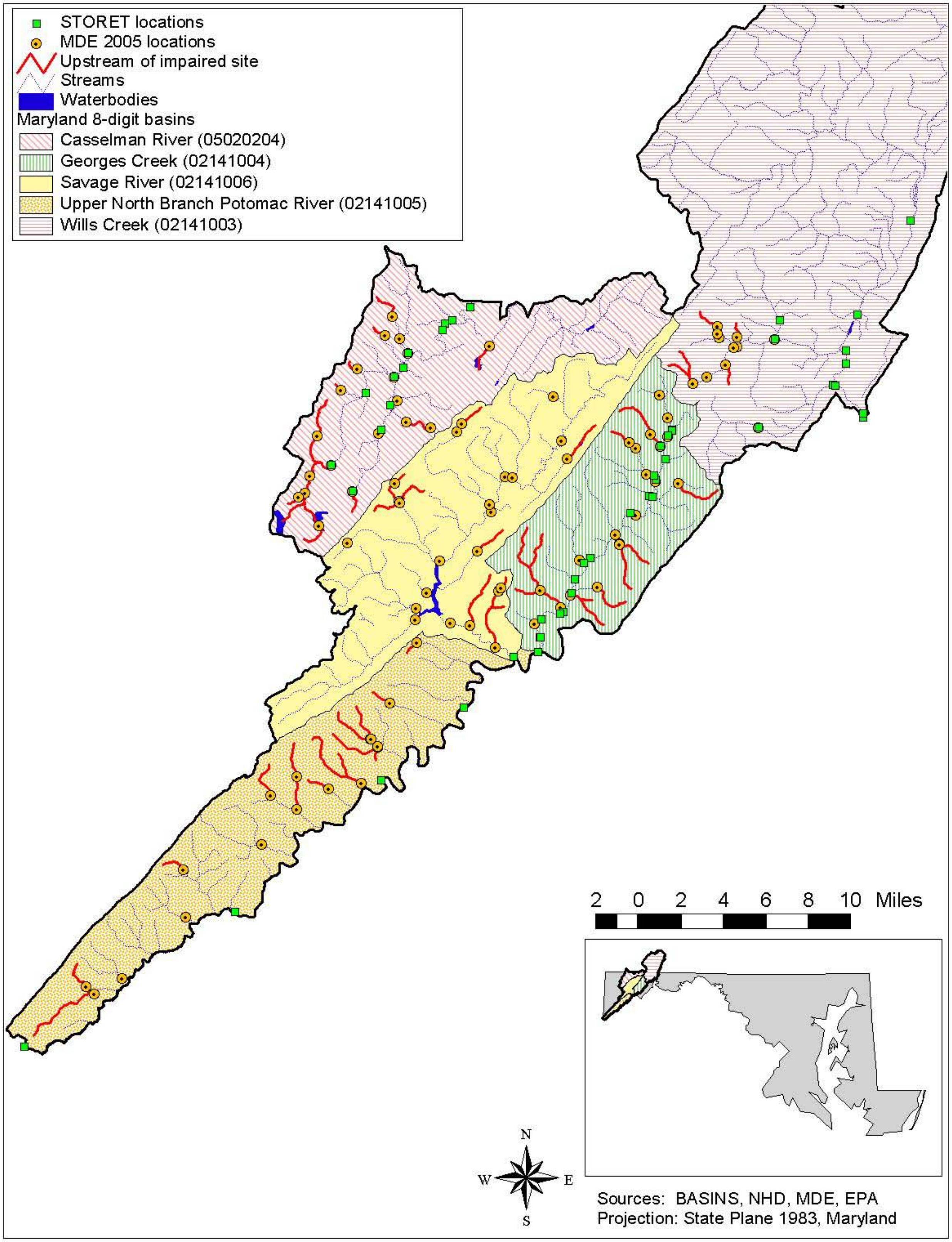


Figure 2-3. Water quality stations in the western Maryland watersheds.

Table 2-4. Water quality monitoring data sets

Watershed	Source file	No. of stations	Percent of stations with flow	Period of record	Parameters
Casselman River	MDE 2005	19	0	3/31/2005–4/21/2005	acidity, alkalinity, acid neutralizing capacity, chloride, dissolved iron, dissolved organic carbon, hardness, total aluminum, total iron, nitrate, pH, sulfate
	MDE 2005f	18	0	9/22/2005–11/3/2005	
Georges Creek	MDE 2005	21	0	3/28/2005–4/18/2005	
	MDE 2005f	20	0	9/19/2005–10/31/2005	
Savage River	MDE 2005	22	0	3/30/2005–4/21/2005	
	MDE 2005f	22	0	9/21/2005–11/3/2005	
Upper North Branch of the Potomac River	MDE 2005	17	0	3/30/2005–4/20/2005	
	MDE 2005f	17	0	9/21/2005–11/2/2005	
Wills Creek	MDE 2005	11	0	3/28/2005–4/18/2005	
	MDE 2005f	11	0	9/19/2005–10/31/2005	
	STORET	1	0	3/8/2001–10/21/2003	ammonium

2.1.4 Land Use Data

Because the portion of the watersheds included in this study encompass parts of two states, land use data were obtained from two different sources. Land use data for Maryland were obtained from the Maryland Department of Planning (MDP). The land use data for Pennsylvania were obtained from the Pennsylvania Spatial Data Access Website, which is housed at Pennsylvania State University (PSU 2003).

Each land use data set had its own classification system, therefore, it was necessary to reclassify the land uses to be consistent between data sets. The MDE classifications were used as the basis for the reclassification. The detailed MDE classifications were grouped into seven categories (Table 2-5). The land use classifications from Pennsylvania were compared to the MDE categories and reclassified into the appropriate land use categories (Table 2-6).

Table 2-7 presents the final land use classifications and the area of each land use in the watershed. The dominant land use in the watersheds is forest (72 percent) followed by agriculture (19 percent). Urban land uses account for less than 5 percent of the total watershed area and are mostly concentrated around rivers and other waterbodies. Figure 2-4 presents the land use coverage for the watersheds.

2.1.5 Soils and Geology

The Natural Resources Conservation Service (NRCS) has defined four hydrologic soil groups providing a means for grouping soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils (Group D) that are poorly drained have the lowest infiltration rates with the highest amount of runoff, while sandy soils (Group A) that are well drained have high infiltration rates, with little runoff. Data for the watershed were obtained from BASINS, which contains information from the State Soil Geographic Database (STATSGO) and are presented in Figure 2-5. The majority of the watersheds are made up of soil groups B and C. The Wills Creek watershed contains mostly B soils, while the Casselman River, Savage River, Georges Creek, and North Branch of the Potomac watersheds mostly consist of C soils. There are small portions of A soils in the Wills Creek and North Branch of the Potomac watersheds and a very small portion of D soils in the North Branch of the Potomac.

The TMDL watersheds are in the Appalachian Plateaus and Ridge and Valley Physiologic Province. The Appalachian Plateau is characterized by gently folded sedimentary rocks, such as sandstone, shale, and siltstone. The Ridge and Valley is characterized by stronger folding and faulting than the Appalachian Plateau. The rocks range in age from Silurian to Permian and contain several coal beds.

Table 2-5. Land use reclassifications from the MDP data set

Detailed land use description	Land use group
Agricultural breeding building	Agriculture
Agriculture	Agriculture
Bare exposed rock	Barren land
Bare ground	Barren land
Barren land	Barren land
Beaches	Barren land
Brush	Forest
Commercial—retail and wholesale services	Urban built-up
Cropland	Agriculture
Deciduous forest	Forest
Evergreen forest	Forest
Extractive-surface mines/quarries/pits	Mining
Feeding operations	Agriculture
Forest	Forest

Detailed land use description	Land use group
High-density residential	Urban built-up
Industrial	Urban built-up
Institutional	Urban built-up
Low-density residential	Urban built-up
Medium-density residential	Urban built-up
Mixed forest	Forest
Open urban land	Urban built-up
Orchards/vineyards/ horticulture	Agriculture
Pasture	Agriculture
Row and garden crops	Agriculture
Transportation	Urban built-up
Urban built-up	Urban built-up
Water	Water
Wetlands	Wetlands

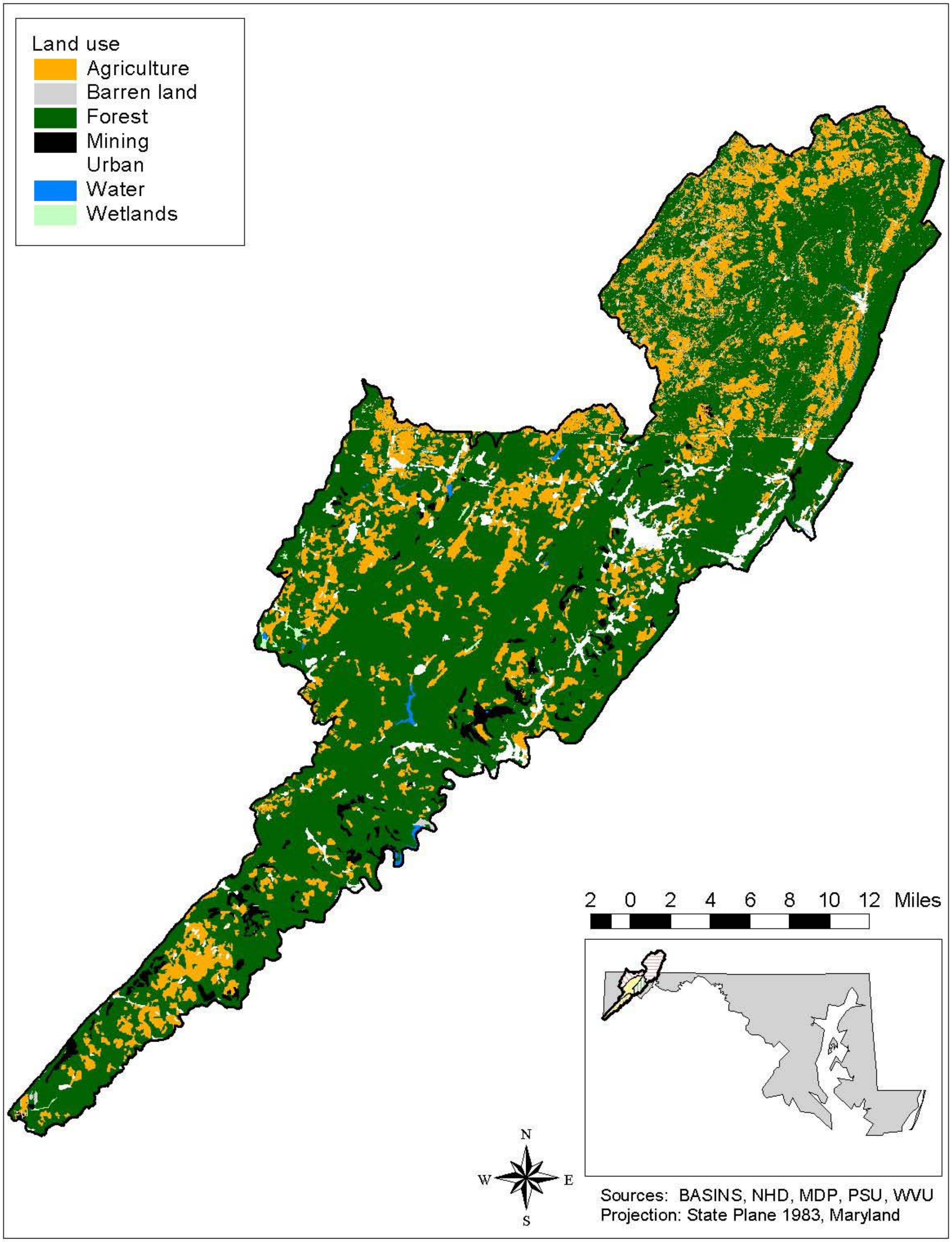
Table 2-6. Land use classification conversion between Pennsylvania and Maryland data sets

Pennsylvania detailed land use description	Maryland detailed land use description	Reclassified land use group
Coal mines	Extractive-surface mines/quarries/pits	Mining
Coniferous forest	Evergreen forest	Forest
Deciduous forest	Deciduous forest	Forest
Emergent wetland	Wetlands	Wetlands
Hay Pasture	Pasture	Agriculture
High-density urban	High-density residential	Urban built-up
Low-density urban	Low-density residential	Urban built-up
Mixed forest	Mixed forest	Forest
Probably row crops	Agriculture	Agriculture
Quarries	Extractive-surface mines/quarries/pits	Mining
Row crops	Row and garden crops	Agriculture
Transitional	Barren land	Barren land
Water	Water	Water
Woody wetland	Wetlands	Wetlands

Surface geology of the area consists of the Dunkard Group, Chemung Formation, Hampshire Formation, Pocono Group, Greenbrier Formation, Rockwell Formation, Mauch Chunk Formation, Monongahela Formation, Pottsville Formation, Allegheny Formation, Conemaugh Formation, Parkhead Sandstone, Brallier Formation, Harrell Shale, Pursland Sandstone, and the Oriskany Group. Four of these formations contain significant coal-bearing layers: the Monongahela Formation (Waynesburg and Pittsburgh coals), the Conemaugh Formation (Upper Freeport and Barton coals) and the Pottsville and Allegheny Formations (Upper Freeport and Brookville coals). The Greenbrier Formation and Harrell Shale are the only formations that contain significant limestone and calcareous shale. These rock types act as a natural acidity buffer. The Georges Creek and Wills Creek watersheds are underlain by carbonate rock. Figure 2-6 presents the surface geology of the watersheds.

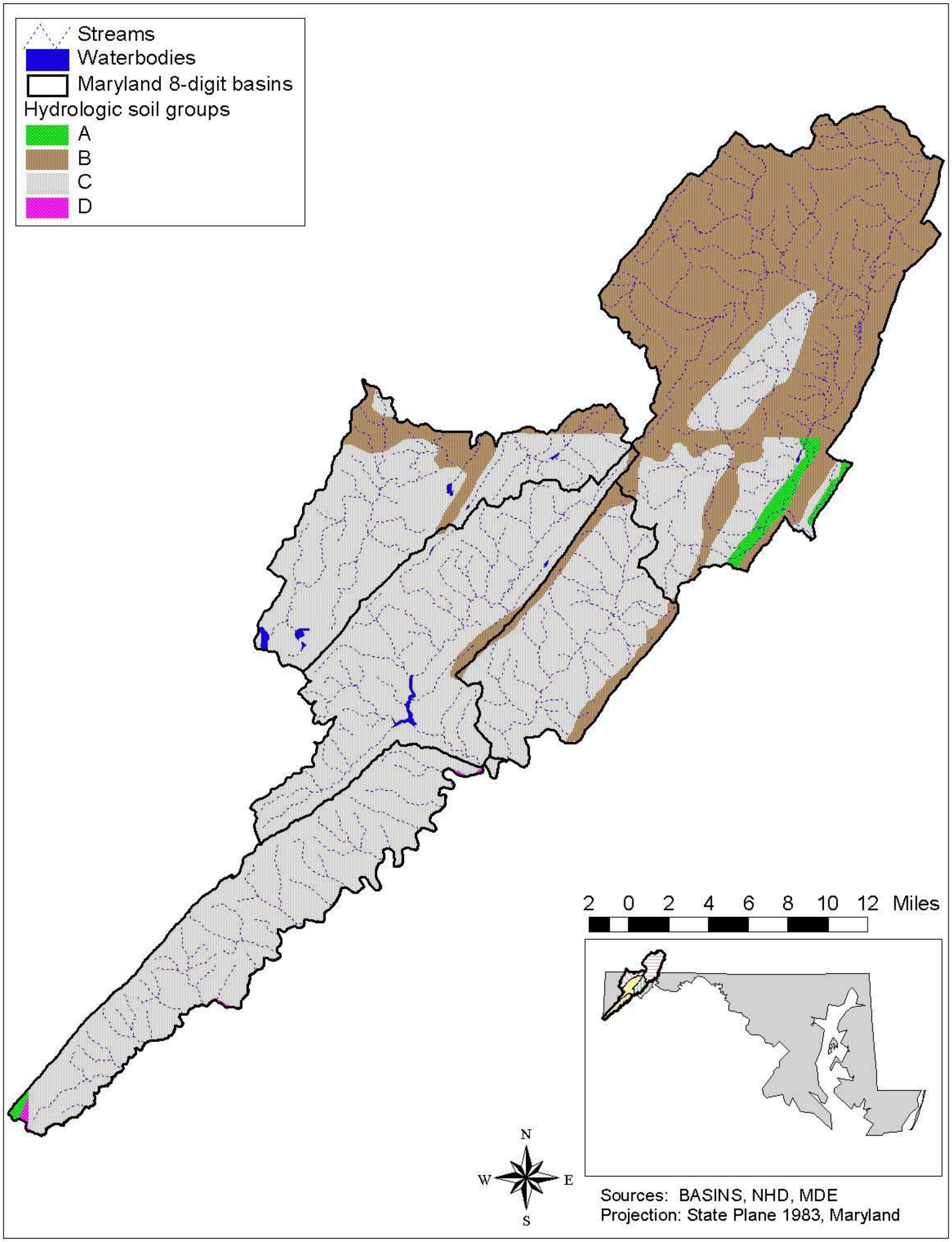
Table 2-7. Land use areas used for the western Maryland watersheds

Detailed land use description	Model land use group	Area (acres)	Area (square miles)	Percent land use
Agricultural breeding building	Agriculture	141	0.22	0.03
Agriculture	Agriculture	0	0.00	0.00
Cropland	Agriculture	25,880	40.44	6.25
Feeding operations	Agriculture	0	0.00	0.00
Orchards/vineyards/ horticulture	Agriculture	0	0.00	0.00
Pasture	Agriculture	32,793	51.24	7.92
Row and garden crops	Agriculture	21,901	34.22	5.29
	Agriculture subtotal	**80,715**	**126.12**	**19.49**
Bare exposed rock	Barren land	0	0.00	0.00
Bare ground	Barren land	387	0.61	0.09
Barren land	Barren land	5,519	8.62	1.33
Beaches	Barren land	0	0.00	0.00
	Barren land subtotal	**5,906**	**9.23**	**1.42**
Brush	Forest	8,737	13.65	2.11
Deciduous forest	Forest	259,652	405.71	62.69
Evergreen forest	Forest	7,711	12.05	1.86
Forest	Forest	0	0.00	0.00
Mixed forest	Forest	21,625	33.79	5.22
	Forest subtotal	**297,725**	**465.20**	**71.88**
Extractive-surface mines/quarries/pits	Mining	9,036	14.12	2.18
	Mining subtotal	**9,036**	**14.12**	**2.18**
Commercial—retail and wholesale services	Urban built-up	1,316	2.06	0.32
High-density residential	Urban built-up	200	0.31	0.05
Industrial	Urban built-up	250	0.39	0.06
Institutional	Urban built-up	702	1.10	0.17
Low-density residential	Urban built-up	10,377	16.21	2.51
Medium-density residential	Urban built-up	5,101	7.97	1.23
Open urban land	Urban built-up	531	0.83	0.13
Transportation	Urban built-up	0	0.00	0.00
Urban built-up	Urban built-up	16	0.03	0.00
	Urban built-up subtotal	**18,493**	**28.90**	**4.46**
Water	Water	1,314	2.05	0.32
	Water subtotal	**1,314**	**2.05**	**0.32**
Wetlands	Wetlands	1,005	1.57	0.24
	Wetlands subtotal	**1,005**	**1.57**	**0.24**
Total		**414,194**	**647.19**	**100**



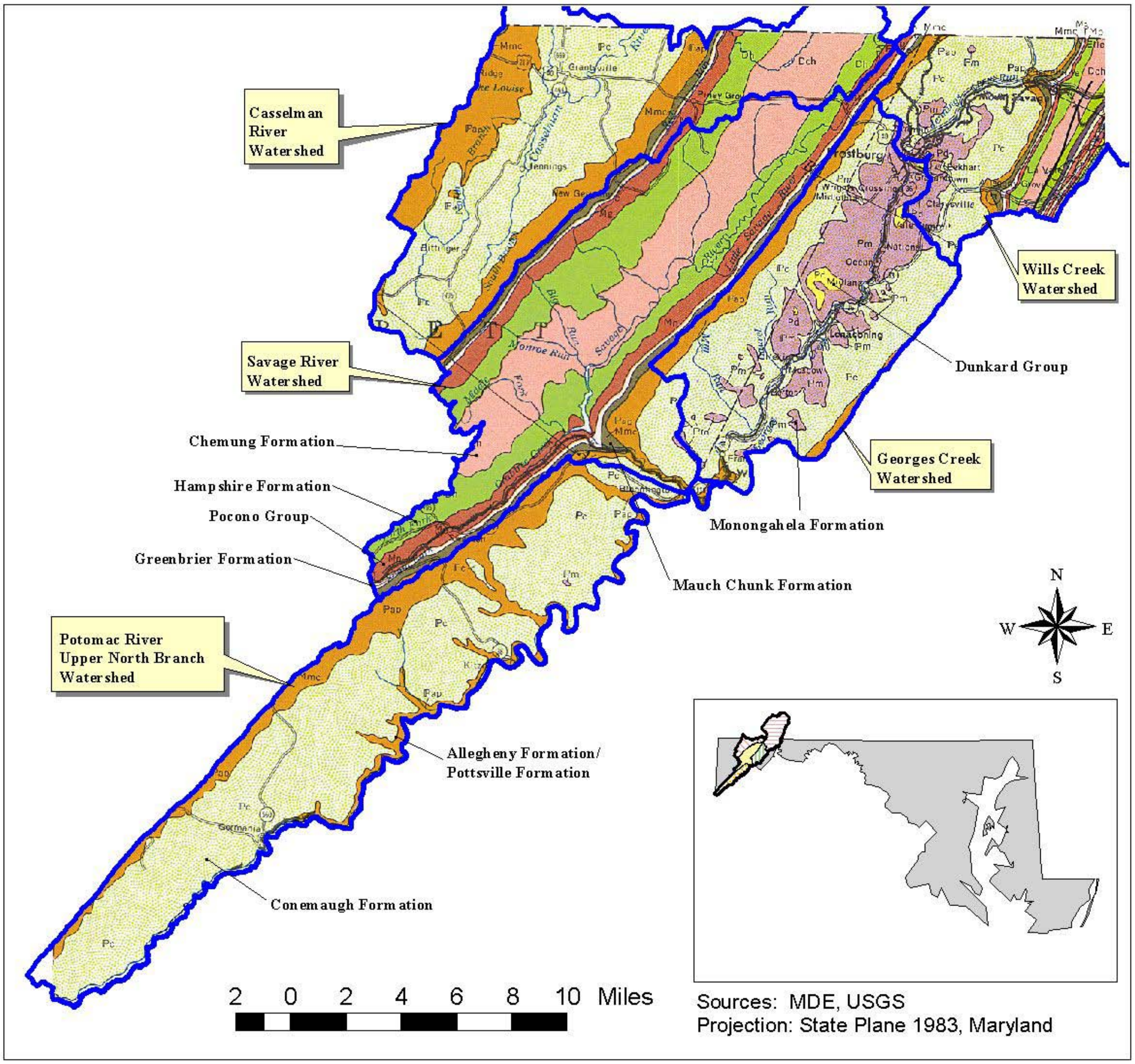
Sources: BASINS, NHD, MDP, PSU, WVU
Projection: State Plane 1983, Maryland

Figure 2-4. Land use in the western Maryland watersheds.



Sources: BASINS, NHD, MDE
Projection: State Plane 1983, Maryland

Figure 2-5. Hydrologic soil groups in the western Maryland watersheds.



Sources: MDE, USGS
Projection: State Plane 1983, Maryland

Figure 2-6. Geology in the western Maryland watersheds.

2.1.6 Historical Mining Data

Historical mining activities are an important consideration when developing pH TMDLs. The study area contains numerous mining activities, but information on past activities is difficult to obtain because many operations did not keep thorough records. MDE provided information on mine drainage sources such as portals, sediment ponds, and pits (Figure 2-7). This information was plotted, and each location was assigned to its corresponding subwatershed in the model area. In all, 313 mine sources were included as model inputs. Few of the locations had concentration or flow data associated with them. In addition, Figure 2-7 shows areas of historical mining activities.

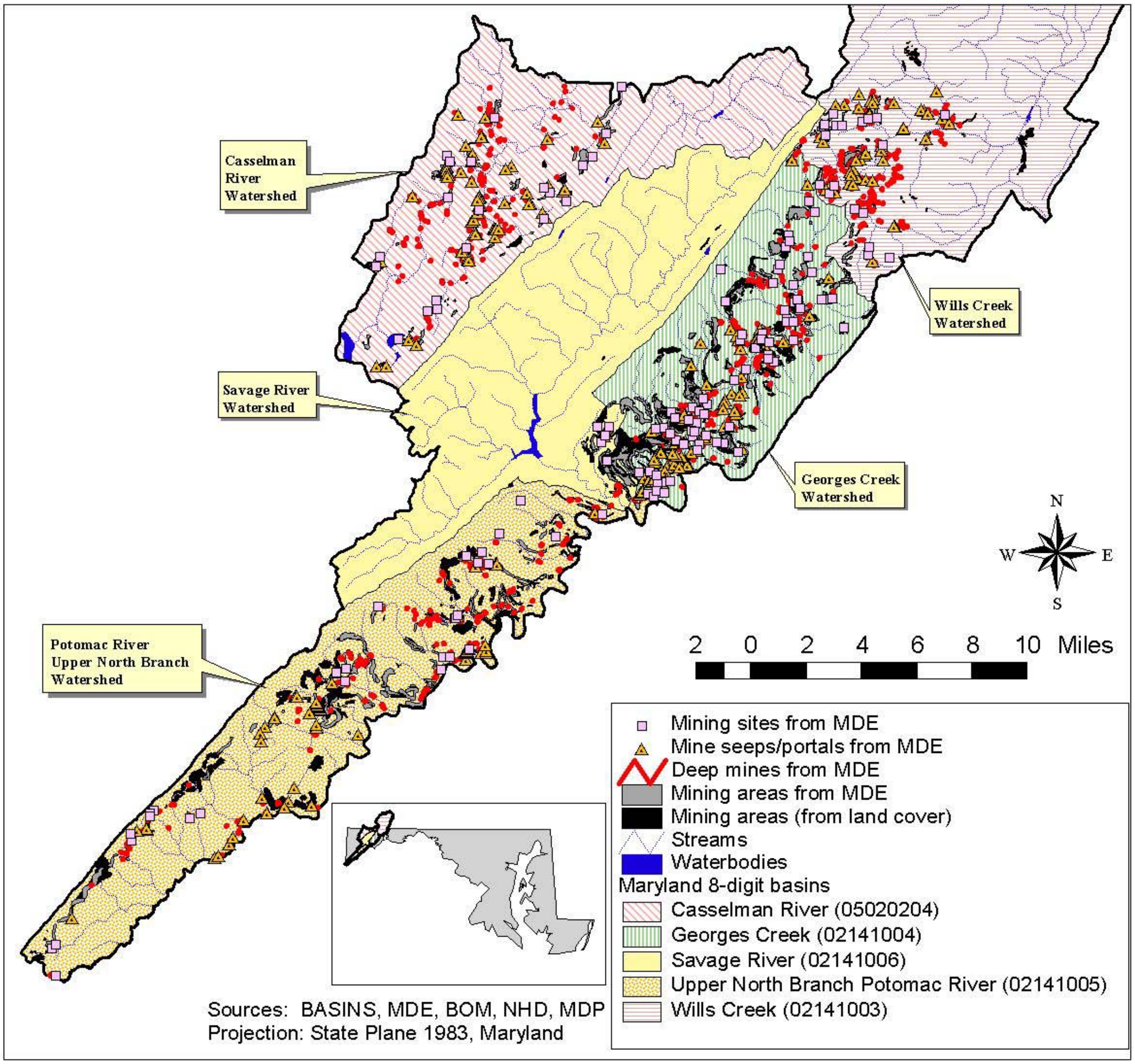


Figure 2-7. Mining activities in the western Maryland watersheds.

2.1.7 Point Source Data

A point source, according to 40 CFR 122.3, is any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, and vessel or other floating craft from which pollutants are or could be discharged. The National Pollutant Discharge Elimination System (NPDES) program, established under Clean Water Act sections 318, 402, and 405, requires permits for the discharge of pollutants from point sources.

2.1.7.1 Non-Mining NPDES Permits

NPDES permit information was obtained from EPA's Permit Compliance System (PCS) (USEPA 2005b) and MDE. Table 2-8 identifies the one non-mining NPDES permit in the model area that was included in this TMDL development as well as its permitted flow and permit limits for iron and pH. Figure 2-8 shows the location of the NPDES facility.

Table 2-8. Permitted non-mining facilities included in the western Maryland watershed model

NPDES permit number	Facility name	Outfall	Permitted flow (mgd)	Total iron (mg/L)		pH	
				Daily avg.	Daily max	Daily min	Daily max
MD0066958	Midlothian Water Treatment Plant	001	--	2	3	6.5	8.5

2.1.7.2 Mining NPDES Permits

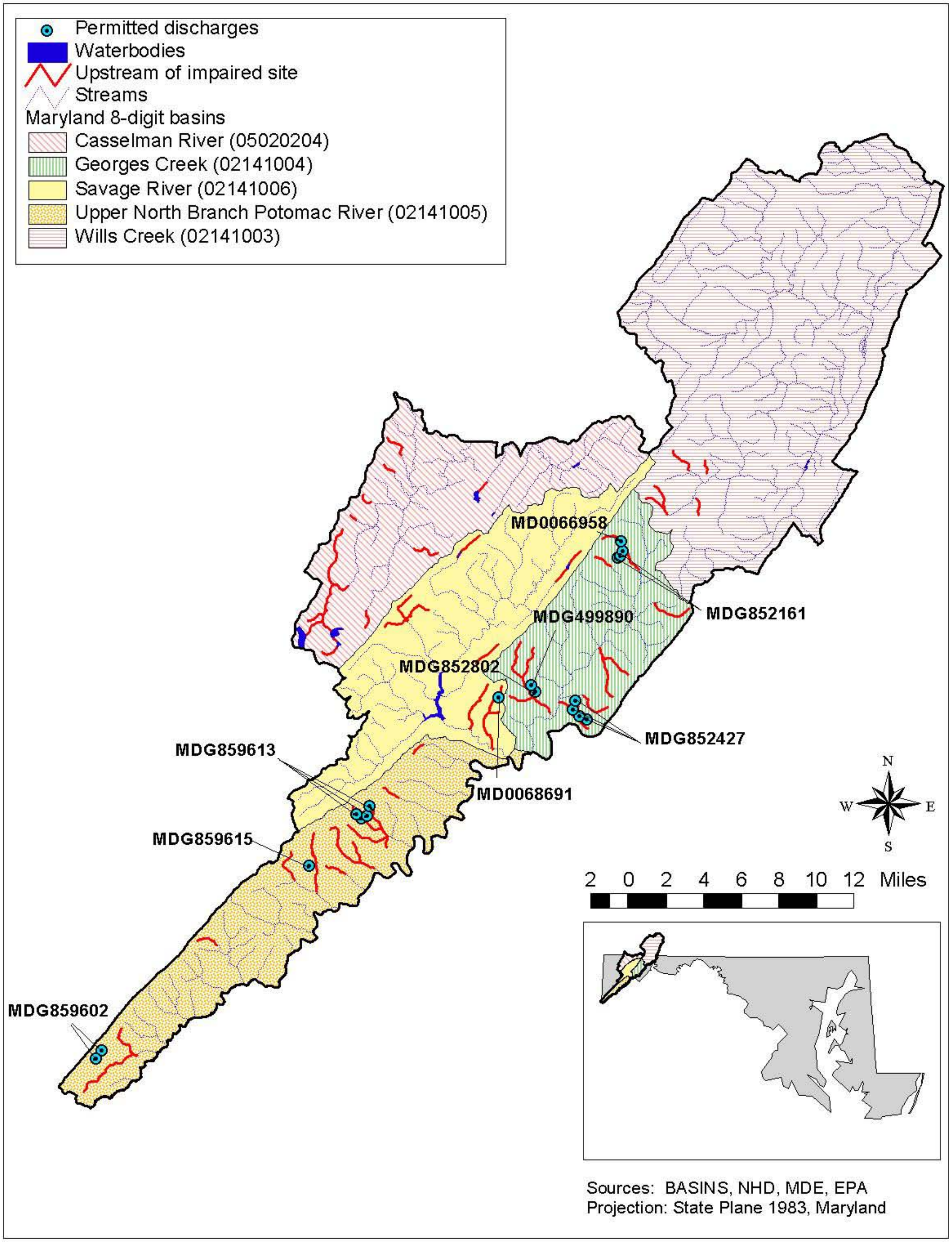
The Surface Mining Control and Reclamation Act of 1977 (SMCRA, Public Law 95-87) and its subsequent revisions were enacted to establish a nationwide program to protect the beneficial uses of land or water resources, protect public health and safety from the adverse effects of current surface coal mining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

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

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

Untreated coal mining-related point source discharges from deep, surface, and other mines typically have low pH values (that is, they are acidic) and contain high concentrations of metals (e.g., iron, aluminum, and manganese). Coal mining-related activities are commonly issued NPDES discharge permits that contain effluent limits for total iron, total manganese, nonfilterable residue, and pH. Many permits also include effluent monitoring requirements for total aluminum.

There are a total of 8 mining-related NPDES permits, with 29 associated outlets, included in the TMDL development for the western Maryland watersheds. A complete list of the mining permits and outlets is provided in Table 2-9. Figure 2-8 illustrates the extent of the mining NPDES outlets in the watershed.



Sources: BASINS, NHD, MDE, EPA
Projection: State Plane 1983, Maryland

Figure 2-8. NPDES permitted facilities discharging to waters upstream of impaired monitoring sites in the western Maryland watersheds.

Table 2-9. Permitted mining facilities included in the western Maryland watershed model

Permit number	Facility name	Outfall	Permit flow (mgd)	Total iron (mg/L)		pH	
				Monthly avg.	Daily max	Min	Max
MD0068691	Georges Creek, Inc./ ARJ Construction Company	001	0.0020	3	45	6.0	9.0
MDG499890	Tri-Star Mining Quarry Operation	001	0	--	--	6.0	9.0
MDG499890	Tri-Star Mining Quarry Operation	002	0	--	--	6.0	9.0
MDG499890	Tri-Star Mining Quarry Operation	003	0.000735	--	--	6.0	9.0
MDG852161	Fairview Coal Company, Inc.	001	0	--	--	NA	NA
MDG852161	Fairview Coal Company, Inc.	002	0	--	--	NA	NA
MDG852161	Fairview Coal Company, Inc.	003	0	--	--	NA	NA
MDG852427	Barton Mining Company (Mine #1)	001	0.000050	3	6	6.0	9.0
MDG852427	Barton Mining Company (Mine #1)	002	0.000150	3	6	6.0	9.0
MDG852427	Barton Mining Company (Mine #1)	003	0.000150	3	6	6.0	9.0
MDG852427	Barton Mining Company (Mine #1)	004	0	3	6	6.0	9.0
MDG852802	Caledonia Hill Mine	001	0.000110	3	6	6.0	9.0
MDG852802	Caledonia Hill Mine	003	0.000967	3	6	6.0	9.0
MDG852802	Caledonia Hill Mine	006	0.000081	3	6	6.0	9.0
MDG852802	Caledonia Hill Mine	007	0.000072	3	6	6.0	9.0
MDG852802	Caledonia Hill Mine	008	0.000120	3	6	6.0	9.0
MDG852802	Caledonia Hill Mine	009	0.000180	3	6	6.0	9.0
MDG852802	Caledonia Hill Mine	010	0.000165	3	6	6.0	9.0
MDG852802	Caledonia Hill Mine	013	0.000015	3	6	6.0	9.0
MDG852802	Caledonia Hill Mine	014	0	3	6	6.0	9.0
MDG859602	Mettiki Coal, Inc./C Mine Surface Mine	001	0	3	6	6.0	9.0
MDG859602	Mettiki Coal, Inc./C Mine Surface Mine	002	0	3	6	6.0	9.0
MDG859602	Mettiki Coal, Inc./C Mine Surface Mine	003	0	3	6	6.0	9.0
MDG859602	Mettiki Coal, Inc./C Mine Surface Mine	004	0	3	6	6.0	9.0
MDG859613	Island Tract Surface Mine—Vindex Energy Corporation	001	0.000050	3	6	6.0	9.0
MDG859613	Island Tract Surface Mine—Vindex Energy Corporation	002	0.000025	3	6	6.0	9.0
MDG859613	Island Tract Surface Mine—Vindex Energy Corporation	003	0	3	6	6.0	9.0
MDG859613	Island Tract Surface Mine—Vindex Energy Corporation	004	0	3	6	6.0	9.0
MDG859615	LAOC Corporation—Paugh Tract Mine	001	0	3	6	6.0	9.0

2.1.8 Nonpoint Source Data

Nonpoint sources of pollutants are diffuse, nonpermitted sources. They most often result from precipitation-driven runoff. The two main sources of nonpoint source pollution that contribute to the low pH levels in the Casselman River, Georges Creek, Savage River, Upper North Branch of the Potomac River, and Wills Creek are mining (i.e., historical mining without NPDES permits) and atmospheric deposition. Mining was described in Section 2.1.7 and atmospheric deposition is described below.

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

Atmospheric deposition occurs by two main methods: wet and dry. Wet deposition occurs through rain, fog, and snow. Dry deposition occurs from gases and particles. Dry deposition accounts for approximately half of the atmospheric deposition of acidity (USEPA 2005d). Particles and gases from dry deposition can be washed from trees, roofs, and other surfaces by precipitation after it is deposited and washed into streams. Winds blow the particles and gases contributing to acid deposition over long distances, including political boundaries, such as state boundaries. The primary pollutants from atmospheric deposition are sulfur dioxide (SO_2) and nitrogen oxides (NO_x). The majority of sulfur dioxides (two-thirds) and one-fourth of nitrogen oxides are from fossil fuel burning electric power generating plants (USEPA 2005d).

Atmospheric deposition data were obtained from EPA’s Office of Air Quality Planning and Standards at Research Triangle Park, North Carolina. The data are a result of air quality modeling in support of the CAIR. The data include concentrations of sulfate and nitrogen oxides in wet and dry deposition. For the technical information on these data, see the *Technical Support Document for the Final Clean Air Intestate Rule—Air Quality Modeling* (USEPA 2005e).

2.2 Data Analysis

2.2.1 Source Assessment

Streams in the designated watersheds were monitored in the spring and fall of 2005. MDE analyzed the monitoring results following the method summarized below and in Table 2-10 for identifying the source(s) of acid impairments in streams.

- Assuming baseflow conditions, there is most likely no major source of acidification if the acid neutralizing capacity (ANC) of the stream is greater than 200 µeq/L.
- If agriculture represents greater than 50 percent of the drainage area for the monitoring location and the nitrogen nitrate (NO_3-N) level is greater than 100 µeq/L (≈ 14 mg/L), there is a strong probability that agriculture is the major influence in stream acidification.
- If sulfate levels are greater than 500 µeq/L (≈ 24 mg/L), the primary acidification source is most likely AMD.
- If sulfate is greater than 300 µeq/L (≈ 14 mg/L), there is the potential that the stream can be affected by both AMD and atmospheric deposition.
- If conductivity is greater than 80–100 µS/cm, the stream is considered AMD-influenced.

- If the levels of organic ions are greater than the levels of nitrate and sulfate, there is the potential that the stream is acidified by organic acids.
- If the concentration of dissolved organic carbon (DOC) is greater than 8 mg/L, the stream could be influenced by organic sources and atmospheric deposition.
- Finally, stream water quality can be broken into three levels of acidification depending on the levels of ANC:
  - Low (ANC > 50 and ≤ 200 µeq/L): This level has episodic acidification, especially during high intensity storm events, and occasionally long-duration storms.
  - Very Low (ANC > 0 and ≤ 50 µeq/L): This level has chronic acidification where small acid inputs would drive the stream below 0 µeq/L.
  - Acidic (ANC ≤ 0 µeq/L): These streams have a baseflow ANC that remains below 0 µeq/L.

Results of the data assessment are presented in Table 1-1 and Figure 1-1. Of the 92 segments that MDE monitored, 52 segments were found to be impaired by low pH. There were 15 stations assessed for AMD and atmospheric deposition, 23 for only AMD, six for chronic acidification, and eight for episodic acidification.

2.2.1 Data Trends

Data trends were not able to be determined because of the limited amount of available data.

Table 2-10. Methodology for assessment of stream acidification in Maryland

Water chemistry measurement		Source of acidification
Baseflow ANC < 200 µeq/L	No ⟶	None
Yes ↓		
Agriculture > 50% of drainage area and NO_3-N > 100 µeq/L (≈ 1.4 mg/L)	Yes ⟶	Possible agricultural influence
No ↓		
$SO_4 \geq 500$ µeq/L (≈ 24 mg/L)	Yes ⟶	Primarily AMD
No ↓		
$SO_4 \geq 300$ µeq/L (≈ 14 mg/L)	Yes ⟶	Possibly affected by both AMD and atmospheric deposition—look at conductivity (> 80–100 µS/cm consider AMD influenced)
No ↓		
Organic Ions > NO_3 + SO_4	Yes ⟶	Primarily organic sources
No ↓		
DOC > 8 mg/L	Yes ⟶	Affected by both organic sources and atmospheric deposition
No ↓		
Baseflow ANC 50–200 µeq/L	Yes ⟶	Stream vulnerable to episodic acidification
No ↓		
Baseflow ANC < 50 µeq/L	Yes ⟶	Chronic acidification (Baseflow ANC may be less than 0 µeq/L.)

3 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. This section presents the approach taken to develop the linkage between sources and in-stream response for TMDL development in the Casselman River, Georges Creek, Savage River, Upper North Branch of the Potomac River, and Wills Creek.

A watershed model is a useful tool for providing a quantitative linkage between sources and in-stream response. It is essentially a series of algorithms applied to watershed characteristics and meteorological data to simulate naturally occurring, land-based processes over an extended period, including hydrology and pollutant transport. Many watershed models are also capable of simulating in-stream processes using the land-based and subsurface calculations as input. Once a model has been adequately set up and calibrated for a watershed, it can be used to quantify the existing loading of pollutants from subwatersheds or from land use categories and also can be used to assess the impacts of a variety of hypothetical scenarios.

The following technical factors were critical to selecting an appropriate watershed model:

- The model should be able to address the pollutants of concern (e.g., pH).
- The model should be able to simulate processes and constituents that influence pH levels, such as sulfate, iron, and aluminum.
- The model should be able to simulate chemical processes and interactions in the surface and subsurface environments because the cumulative effect of these two environments and chemical/biological reactions will affect in-stream pH levels.
- The model should be able to address a watershed with primarily rural land uses.
- The model should provide adequate time-step estimation of flow and not oversimplify storm events to provide accurate representation of rainfall events/snowmelt and resulting peak runoff.
- The model should be capable of simulating various pollutant transport mechanisms (e.g., groundwater contributions, sheet flow).
- The model should be able to simulate wet and dry atmospheric deposition.
- The model should include an acceptable snowmelt routine.

Using the above considerations, the Mining Data Analysis System (MDAS) was selected for modeling the Casselman River, Georges Creek, Savage River, Upper North Branch of the Potomac River, and Wills Creek. MDAS is a re-coded C++ version of the Hydrologic Simulation Program FORTRAN (HSPF) model. MDAS integrates a geographical information system (GIS), comprehensive data storage and management capabilities, the original HSPF algorithms, and a data analysis/post-processing system. MDAS's algorithms are identical to a subset of those in the HSPF model. A brief overview of the HSPF model is provided below, and a detailed discussion of HSPF-simulated processes and model parameters is available in the HSPF User's Manual (Bicknell et al. 1996).

HSPF is a comprehensive watershed and receiving water quality modeling framework that was originally developed in the mid-1970s. During the past several years, it has been used to develop hundreds of EPA-approved TMDLs, and it is generally considered the most advanced hydrologic and watershed loading model available. The hydrologic portion of HSPF is based on the Stanford Watershed Model (Crawford and Linsley 1966), which was one of the pioneering watershed models developed in the 1960s. The HSPF framework is developed in a modular fashion with many different components that can be assembled in different ways, depending on the objectives of the individual project. The model includes three major modules:

- PERLND for simulating watershed processes on pervious land areas
- IMPLND for simulating processes on impervious land areas
- RCHRES for simulating processes in streams and vertically mixed lakes

All three modules include many subroutines that calculate the various hydrologic and water quality processes in the watershed. Many options are available for both simplified and complex process formulations. Spatially, the watershed is divided into a series of subwatersheds representing the drainage areas that contribute to each of the stream reaches. These subwatersheds are then further subdivided into segments representing different land uses. For the developed areas, the land use segments are further divided into the pervious (PERLND) and impervious (IMPLND) fractions. The stream network (RCHRES) links the surface runoff and groundwater flow contributions from each of the land segments and subbasins and routes them through the waterbodies using storage routing techniques. The stream model includes precipitation and evaporation from the water surfaces, as well as flow contributions from the watershed, tributaries, and upstream stream reaches. Flow withdrawals can also be accommodated. The stream network is constructed to represent all the major tributary streams, as well as different portions of stream reaches where significant changes in water quality occur.

Like the watershed components, several options are available for simulating water quality in the receiving waters. The simpler options consider transport through the waterways and represent all transformations and removal processes using simple, first-order decay approaches. The framework is flexible and allows different combinations of constituents to be modeled depending on data availability and the objectives of the study.

The current version of MDAS includes algorithms for simulation of pollutant accumulation and washoff from land surfaces. MDAS integrates comprehensive data storage and management capabilities, a dynamic watershed model, and a data analysis/post-processing system into a convenient PC-based Windows interface that dictates no software requirements.

For the Western Maryland pH TMDLs, MDAS was updated to include additional modules from HSPF plus new modules designed specifically for these TMDLs. Each of the additional modules is briefly described below and is more thoroughly explained in Appendix B.

The first module that was added to MDAS from HSPF was atmospheric deposition. With this addition, the model is able to model dry and wet deposition. Users have the option to enter fluxes (mass per area per time) for dry deposition and concentrations for wet deposition, which the program automatically combines with the input rainfall time series to compute the resulting flux. Either type of deposition data can be input as a constant value or alternatively, as a set of monthly values that is used for each year of the simulation.

The Moisture Storage and Transport in Soil Layers (MSTLAY) module from HSPF uses the fluxes that are computed from surface water, converts them into soil moisture, and inter-layer fluxes makes them usable for adsorption/desorption in solute transport calculations. MSTLAY estimates moisture storages in the four soil layers in addition to the fluxes of moisture between the storages.

Six modules were created to better simulate pH in the subsurface and in-stream reaches by modeling sulfate and nitrogen species. These modules, which are further described in Appendix B, include routines to calculate the transfer and transformation of the different constituents in surface water and subsurface soils.

All these modules were added to MDAS to better predict pH levels in the streams because of the following factors:

- Sulfate and nitrate from atmospheric deposition carry hydrogen, which is the source of acidity, and play a role in water quality in the eastern United States.
- Acidity from atmospheric deposition might intensify or buffer pH levels in the subsurface environment.
- Minerals in the subsurface buffer pH.
- Seasonal biological activity generates carbon dioxide, which can influence pH. Carbon dioxide saturated interflow/groundwater can increase pH when the transport water is subjected to air and the carbon dioxide is released from the water.
- Biological nitrogen transformation, which changes concentrations of nitrate and ammonium, influences pH.
- Increased pH levels could again decrease pH because of dissolved aluminum entering surface water from interflow/groundwater flow.

All these processes are important to consider in the pH modeling process and were added to the MDAS model to better predict pH in the Casselman River, Georges Creek, Savage River, Upper North Branch of the Potomac River, and Wills Creek. Generalized diagrams of how the pollutant flows and how MDAS and the modules interact are shown in Figure 3-1.

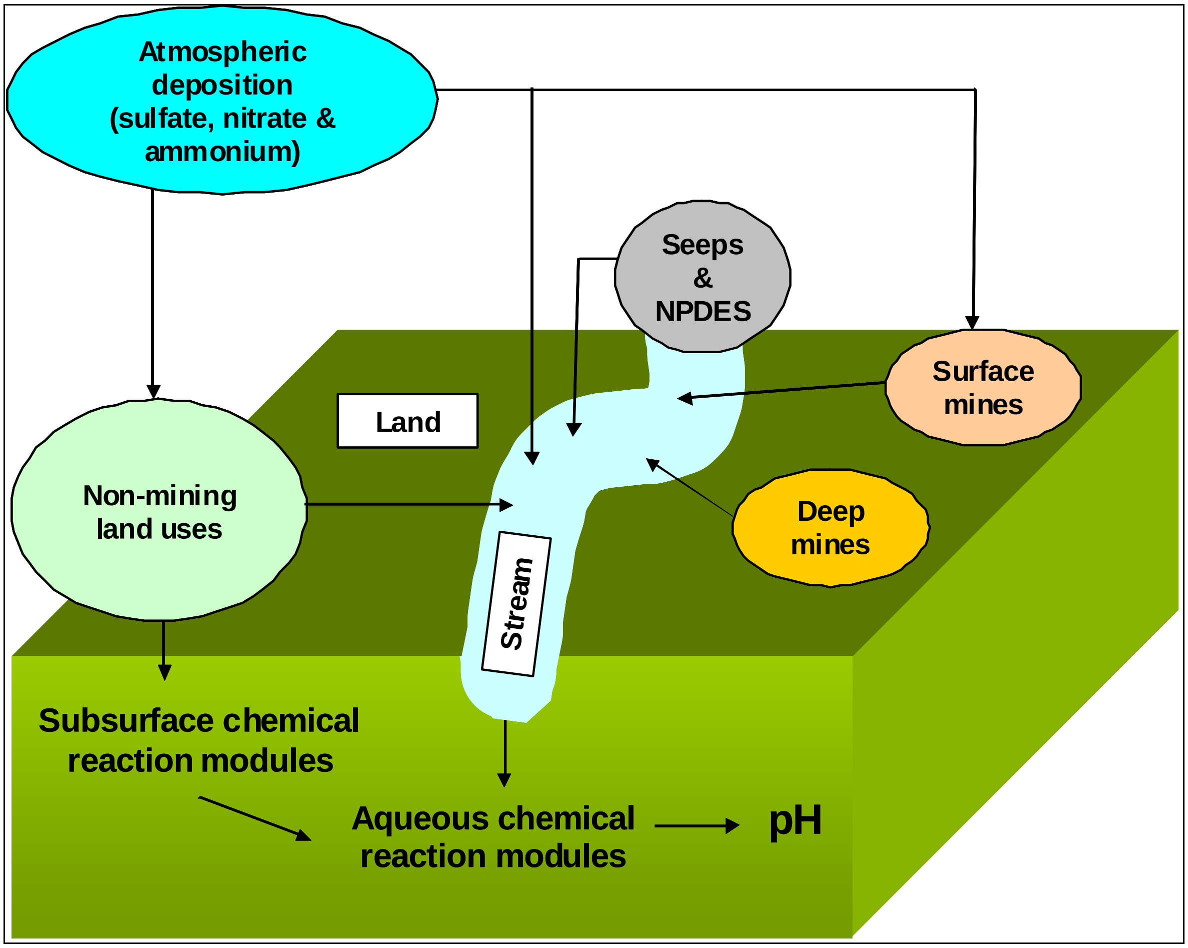


Figure 3-1. Generalized diagram of pollutant flow in the modeling process.

4 MDAS MODEL DEVELOPMENT

4.1 Model Configuration

Configuration of the model involved consideration of the following five major components, all of which provide the basis for the model's ability to estimate flow and pollutant loadings:

- Watershed subdivision, which provides the basis for how the model is set up (e.g., land uses are input into the model by watershed subdivisions)
- Stream representation, which represent the actual stream channels in the model
- Land use representation, which provides the basis for distributing runoff and pollutant loading characteristics throughout the basin
- Meteorological data, which drive the watershed model
- Hydrologic and pollutant representation, which refers to the MDAS modules or algorithms used to simulate hydrologic processes (e.g., surface runoff, infiltration) and flow and pollutant transport through streams and rivers

4.1.1 Watershed Subdivision

Watershed subdivision refers to the subdivision of the entire watershed into smaller, discrete subwatersheds for modeling and analysis. MDAS calculates watershed processes with user-defined, hydrologically connected subwatersheds. These subdivisions were based on stream networks and topographic variability and secondarily on the locations of flow and water quality monitoring stations to facilitate model calibration. Using this method, 323 subwatersheds were defined for the five watersheds (Figure 4-1).

4.1.2 Stream Representation

Each delineated subwatershed in the MDAS model was conceptually represented with a single stream assumed to be a completely mixed, one-dimensional segment with a constant cross-section. The National Hydrography Dataset (NHD) stream reach network was used to determine the representative stream length for each subwatershed. The stream lengths were used along with the 30-meter National Elevation Dataset to calculate reach slope.

Channel dimensions for a number of segments were available from field surveys. Assuming representative trapezoidal geometry for all streams, mean stream depth and channel width were estimated using regression curves that relate upstream drainage area to stream dimensions (Rosgen 1996). Rating curves consisted of a representative depth-outflow-volume-surface area relationship. Estimated Manning's roughness coefficients of 0.035 were applied to each representative stream reach using typical literature values for natural streams (Chapra 1997).

4.1.3 Land Use Representation

MDAS requires a basis for distributing hydrologic and pollutant loading parameters. This is necessary to appropriately represent hydrologic variability throughout the watershed, which is influenced by land surface and subsurface characteristics. It is also necessary to represent variability in pollutant loading, which is highly related to land practices. Land use typically represents the primary unit for computing both water quantity and quality. In addition to the need for land use data in computing water quantity and quality, nonpoint source management decisions are also frequently based on land use related activity at the subwatershed level. Therefore, it is important to have a detailed land use representation with

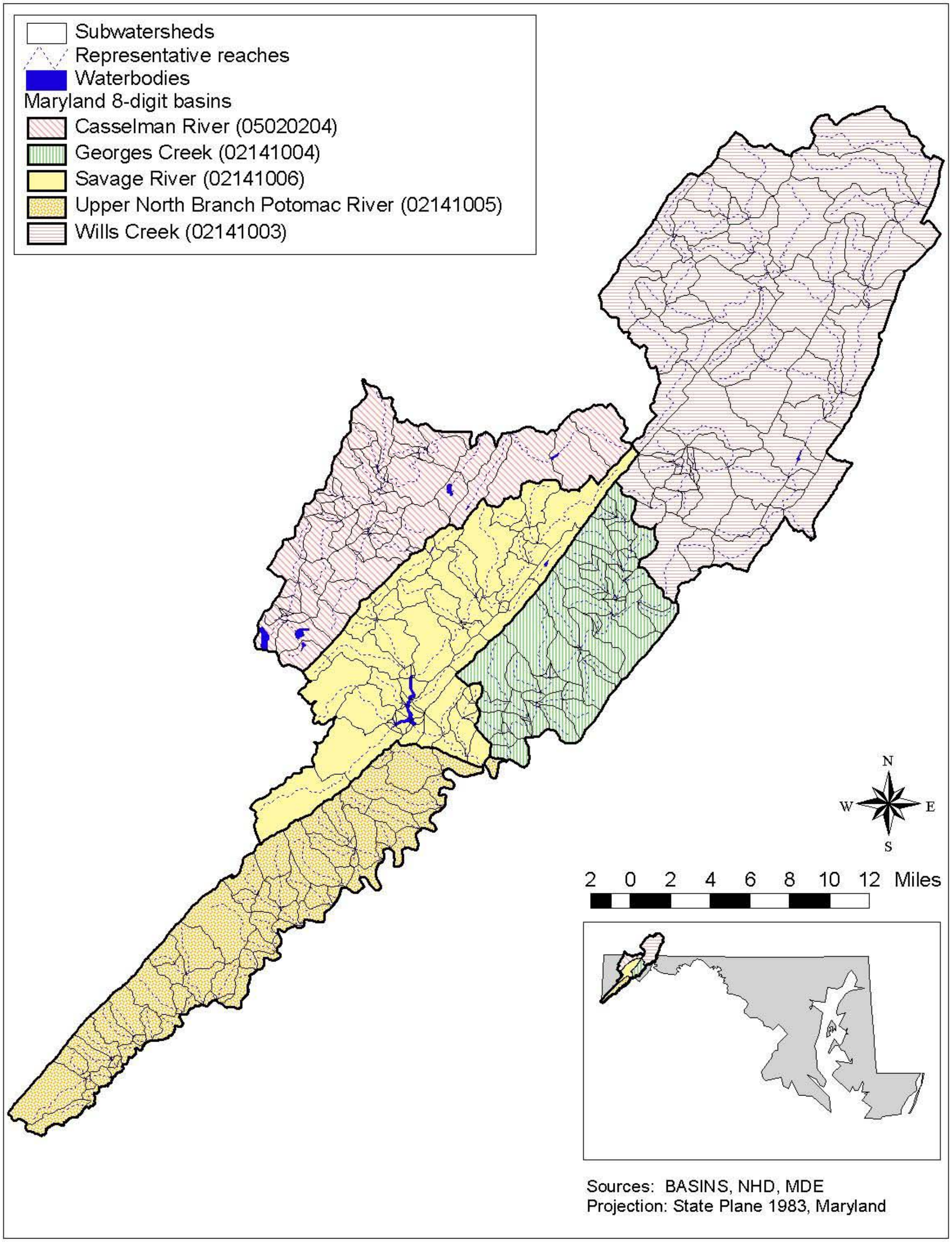


Figure 4-1. Watershed delineation for the western Maryland watersheds MDAS model.

classifications that are meaningful for load allocation and load reduction. The following sections describe the source and rationale for the land use data used in the modeling effort.

Existing land use and land cover in the watershed were determined from information provided by MDP. The land use data for the portion of the watershed in Pennsylvania were obtained from the Pennsylvania Spatial Data Access Website, which is housed at Pennsylvania State University (PSU 2003). Each land use data set has its own classification system, therefore, it was necessary to reclassify the land uses to be consistent between data sets. The MDE classifications were used as the basis for the reclassification. The detailed MDE classifications were grouped into seven general categories (Table 2-5). Forest areas include deciduous forest, evergreen forest, and brush. Agriculture includes row crops, orchards, pasture, and non-specific cropland. Urban built-up areas include residential, commercial, industrial, institutional (e.g., schools, hospitals), and major highways.

4.1.4 Meteorological Representation

Hydrologic processes are time varying and depend on changes in environmental conditions such as precipitation, temperature, and wind speed. As a result, meteorological data are a critical component of watershed models.

Meteorological conditions are the driving force for nonpoint source transport processes in watershed modeling. Generally, the finer the spatial and temporal resolution available for meteorology, the more representative the simulation of associated watershed processes will be. At a minimum, precipitation and potential evapotranspiration are required as forcing functions for most watershed models. For the Casselman River, Georges Creek, Savage River, Upper North Branch of the Potomac River, and Wills Creek, where the snowfall and snowmelt processes are a significant factor in watershed-wide hydrology, additional data were required for snow simulation. These data included temperature, dew point temperature, wind speed, and solar radiation.

The available precipitation data for a given station are not always 100 percent complete. An effort was made to select weather stations with a high level of completeness, above 90 percent. However, precipitation stations might contain various intervals of accumulated, missing, or deleted data.[1] In these circumstances, rainfall patching must be performed. Patching involves using the *normal-ratio method*, which estimates a missing rainfall record with a weighted average from surrounding stations with similar rainfall patterns. Accumulated, missing, and deleted data records were repaired on the basis of hourly rainfall patterns at nearby stations with unimpaired data.

After reviewing the available weather data, it was concluded that there were six adequate precipitation gages for the western Maryland watersheds: Buffalo Mills (361087), Meyersdale 2 SSW (365686), Frostburg 2 (183415), Cumberland Police Brk (182285), Savage River Dam (MD8065), and Bayard (460527). The additional weather data were obtained from Oakland 1 SE (186620), Terra Alta No 1 (WV8777), and Elkins-Randolph Co Airport (13729).

Data from these gages were used to develop an input file with hourly time-series data from January 1987 through May 2005. An hourly time step for weather data was required to properly reflect diurnal temperature changes (and the resulting influence on whether precipitation was modeled as rainfall or snow) and provide adequate resolution for rainfall/runoff intensity to drive erosion and water quality processes during storms or snowmelt events.

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[1] Accumulated data represent cumulative precipitation over several hours, but the exact hourly distribution of the data is unknown.

4.1.5 Hydrologic and Pollutant Representation

4.1.5.1 Soils

To account for the variability of hydrology characteristics throughout the watershed associated with different soil types or topography, three groups of hydrology parameters were configured in the model. The hydrologic soil group classification is a means for grouping soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils that are poorly drained have the worst infiltration rates (D soils), while sandy soils that are well drained have the best infiltration rates (A soils).

Hydrologic group data for the TMDL watersheds were obtained from the STATSGO database. The data were summarized using the major hydrologic group in the surface layers of the map unit. Soils in the Casselman River, Georges Creek, Savage River, and North Branch of the Potomac watersheds are primarily classified as C, having moderate to slow infiltration rates when saturated. Soils in the Wills Creek watershed are primarily classified as B, having moderate infiltration rates. These hydrologic groups served as a starting point for the designation of infiltration and groundwater flow parameters during the MDAS setup.

4.1.5.2 Point Sources

Point source contributions of flow and total iron were incorporated into the model. Data were obtained from EPA's PCS database (Section 2.1.7). Monthly flow and pollutant concentrations obtained from discharge monitoring reports (DMR) were used when available (Table 4-1).

Table 4-1. Modeled permitted flow and total iron concentrations

Basin	Permit	Outfall	Min flow (cfs)	Avg flow (cfs)	Max flow (cfs)	Min conc. (mg/L)	Avg conc. (mg/L)	Max conc. (mg/L)	Data Source
GC	MD0066958	001	0.0001	0.001	0.001	0.02	0.201	0.357	DMR
GC	MDG499890	001	0.000	0.010	0.048	0.000	0.000	0.000	DMR
GC	MDG499890	002	0.000	0.000	0.000	0.000	0.000	0.000	DMR
GC	MDG499890	003	0.000	0.003	0.007	0.000	0.000	0.000	DMR
GC	MDG852161	001	0.000	0.000	0.000	0.000	0.000	0.000	DMR
GC	MDG852161	002	0.000	0.000	0.000	0.000	0.000	0.000	DMR
GC	MDG852161	003	0.000	0.000	0.000	0.000	0.000	0.000	DMR
GC	MDG852427	001	0.000	0.000	0.000	0.000	0.000	0.000	DMR
GC	MDG852427	002	0.000	0.000	0.000	0.000	0.000	0.000	DMR
GC	MDG852427	003	0.000	0.000	0.000	0.000	0.000	0.000	DMR
GC	MDG852802	001	0.000	8.439E-05	0.003	0.000	0.041	2.460	DMR
GC	MDG852802	003	0.000	0.0008	0.016	0.000	0.158	2.580	DMR
GC	MDG852802	014	0.000	0.000	0.000	0.000	0.000	0.000	DMR
PR	MDG859602	001	0.000	0.000	0.000	0.000	0.000	0.000	DMR
PR	MDG859602	002	0.000	0.000	0.000	0.000	0.000	0.000	DMR
PR	MDG859602	003	0.000	0.000	0.000	0.000	0.000	0.000	DMR
PR	MDG859602	004	0.000	0.000	0.000	0.000	0.000	0.000	DMR
PR	MDG859613	001	0.000	3.696E-05	9.670E-05	0.000	0.612	6.066	DMR
PR	MDG859613	002	0.000	0.000	0.000	0.000	0.000	0.000	DMR
PR	MDG859613	003	0.000	0.000	0.000	0.000	0.000	0.000	DMR
PR	MDG859613	004	0.000	0.000	0.000	0.000	0.000	0.000	DMR
PR	MDG859615	001	0.000	0.000	0.000	0.000	0.000	0.000	DMR
SR	MD0068691	001	3.868E-05	0.057	0.275	0.03	1.560	15.500	DMR

Notes:
GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River

4.1.5.3 Nonpoint Source Representation

Nonpoint source contributions of nitrate, ammonium, sulfate, iron, and aluminum were represented in the model through a number of mechanisms. Contributions were land use dependent and represented through surface, interflow, and groundwater outflows. Concentrations were initially based on literature values and then calibrated to correspond to observed concentrations (Section 4.2.2). In addition to the land use-based contributions, specific contributions were also included in the model for atmospheric deposition and mine seepage.

Atmospheric deposition was represented by two different pathways in the model: dry deposition and wet deposition. Both pathways were represented similarly for land uses and included contributions for nitrate, ammonium, and sulfate. Dry-weather deposition was represented using a constant load over time (weight/area/time). Wet deposition was represented by associating a specified concentration with precipitation data in the model. Data for both types of deposition were obtained from EPA’s Office of Air Quality Planning and Standards at Research Triangle Park, North Carolina. The data are a result of air quality modeling in support of the CAIR. The data include concentrations of sulfate and nitrogen oxides in wet and dry deposition. For additional information on these data, please see the *Technical Support Document for the Final Clean Air Interstate Rule—Air Quality Modeling* (USEPA 2005e).

Dry and wet deposition was represented for two different time periods in the model. The year 2001 was used to represent current conditions for calibration. Predicted levels for 2020 were used in the model to represent TMDL conditions. These levels are reflective of the CAIR reducing emissions to the 2020 estimated levels. Table 4-2 presents both 2001 levels and predicted 2020 levels.

Table 4-2. Modeled atmospheric deposition concentrations and fluxes

2001												
	Jan.	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Dry deposition (gram/acre-day)												
NH_4	0.29	0.28	0.51	0.80	0.88	1.00	0.86	0.56	0.69	0.64	0.47	0.45
NO_3	0.18	0.18	0.27	0.17	0.05	0.03	0.02	0.04	0.02	0.06	0.12	0.11
SO_4	30.40	26.39	29.08	20.63	35.82	43.54	34.36	43.11	38.91	35.30	27.59	39.89
Wet deposition (mg/L)												
NH_4	0.15	0.10	0.21	0.28	0.35	0.28	0.11	0.11	0.09	0.08	0.12	0.17
NO_3	1.11	0.96	1.32	1.16	1.34	1.22	0.69	0.54	0.47	0.43	0.95	1.85
SO_4	1.14	1.44	1.58	2.47	4.18	4.17	2.16	1.93	1.31	0.85	1.39	2.43
2020												
	Jan.	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Dry deposition (gram/acre-day)												
NH_4	0.40	0.42	0.62	1.08	1.22	1.55	1.22	0.63	1.05	0.96	0.71	0.59
NO_3	0.17	0.18	0.23	0.17	0.04	0.02	0.01	0.01	0.01	0.05	0.10	0.10
SO_4	10.51	8.83	9.38	5.82	9.13	8.92	7.96	7.27	9.41	9.74	8.25	12.43
Wet deposition (mg/L)												
NH_4	0.16	0.10	0.22	0.28	0.35	0.27	0.11	0.11	0.08	0.08	0.12	0.17
NO_3	0.72	0.57	0.79	0.61	0.57	0.49	0.26	0.21	0.21	0.19	0.44	1.85
SO_4	0.63	0.73	0.97	1.34	1.90	1.58	0.86	0.81	0.59	0.47	0.79	1.26

Mine seepage was modeled as a constant input (flow and concentration) at specific, known, abandoned mine locations. Pollutants in the mine seepage included iron, aluminum, and sulfate. Mine seepage locations were available through MDE and are shown in Figure 2-7, labeled as “Mine seeps/portals from MDE.” Flow and chemical data were not provided for most sites, so median values of the available data were used. Table 4-3 presents the flow and chemical data that were used for these seeps and portals.

Table 4-3. Flow and chemical data for mine seeps and portals used in the model

Basin	Mine seep or portal	Associated Station	Associated station code	Associated station name	Flow (cfs)	Iron (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)
CR	GR-15-P2	WM-138	SPI0018	Spiker Run	**0.04653**	**15**	**12**	**761**
CR	C-24-S1	WM-141	LLR0009	Little Laurel Run	0.00891	2	0	84
CR	C-48-S1	WM-142	NBC0072	North Branch Casselman River	0.03342	11	0	214
CR	C-49-P1	WM-142	NBC0072	North Branch Casselman River	0.03342	**15**	**12**	**761**
CR	C-49-S1	WM-142	NBC0072	North Branch Casselman River	0.00780	**24**	**5**	**636**
CR	C-50-S1	WM-142	NBC0072	North Branch Casselman River	0.03342	**24**	**5**	**636**
CR	C-50-S2	WM-142	NBC0072	North Branch Casselman River	0.01782	20	1	12
CR	C-51-S1	WM-142	NBC0072	North Branch Casselman River	0.01114	51	0	247
CR	C-51-S2	WM-142	NBC0072	North Branch Casselman River	0.05570	69	0	556
CR	C-48-S1	WM-145	NBC0090	North Branch Casselman River	0.03342	11	0	214
CR	C-49-P1	WM-145	NBC0090	North Branch Casselman River	0.03342	**15**	**12**	**761**
CR	C-49-S1	WM-145	NBC0090	North Branch Casselman River	0.00780	**24**	**5**	**636**
CR	C-50-S1	WM-145	NBC0090	North Branch Casselman River	0.03342	**24**	**5**	**636**
CR	C-50-S2	WM-145	NBC0090	North Branch Casselman River	0.01782	20	1	12
CR	C-50-S1	WM-147	PLE0008	Pleasant Valley Run	0.03342	**24**	**5**	**636**
CR	C-50-S2	WM-147	PLE0008	Pleasant Valley Run	0.01782	20	1	12
CR	C-48-S1	WM-148	NBC0106	North Branch Casselman River	0.03342	11	0	214
CR	C-49-P1	WM-148	NBC0106	North Branch Casselman River	0.03342	**15**	**12**	**761**

Table 4-3. (continued)

Basin	Mine seep or portal	Associated Station	Associated station code	Associated station name	Flow (cfs)	Iron (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)
CR	C-49-S1	WM-148	NBC0106	North Branch Casselman River	0.00780	**24**	**5**	**636**
CR	C-50-S1	WM-148	NBC0106	North Branch Casselman River	0.03342	**24**	**5**	**636**
CR	C-50-S2	WM-148	NBC0106	North Branch Casselman River	0.01782	20	1	12
GC	BA-05-P1	WM-110	UGQ0000	UT to Georges Creek	0.02228	**15**	**12**	**761**
GC	BA-05-P2	WM-110	UGQ0000	UT to Georges Creek	0.00223	**15**	**12**	**761**
GC	BA-05-P4	WM-110	UGQ0000	UT to Georges Creek	0.01114	**15**	**12**	**761**
GC	BA-05-P6	WM-110	UGQ0000	UT to Georges Creek	0.01114	**15**	**12**	**761**
GC	BA-05-P7	WM-110	UGQ0000	UT to Georges Creek	0.02228	**15**	**12**	**761**
GC	G-70-P5	WM-111	MIL0001	Mill Run	**0.04653**	**15**	**12**	**761**
GC	R-48-P5	WM-111	MIL0001	Mill Run	**0.04653**	12	16	1,033
GC	BA-10-P1	WM-111	MIL0001	Mill Run	**0.04653**	**15**	**12**	**761**
GC	BA-10-P2	WM-111	MIL0001	Mill Run	**0.04653**	**15**	**12**	**761**
GC	BA-10-P3	WM-111	MIL0001	Mill Run	**0.04653**	**15**	**12**	**761**
GC	BA-10-P4	WM-111	MIL0001	Mill Run	**0.04653**	**15**	**12**	**761**
GC	BA-10-P5	WM-111	MIL0001	Mill Run	**0.04653**	**15**	**12**	**761**
GC	G-03-P1	WM-119	WBN0002	Winebrenner Run	**0.04653**	**15**	**12**	**761**
GC	G-03-P1	WM-120	WBN0010	Winebrenner Run	**0.04653**	**15**	**12**	**761**
GC	G-52-P1	WM-122	UMD0000	UT to Moores Run	**0.04653**	0	2	195
GC	R-43-P1	WM-122	UMD0000	UT to Moores Run	0.00668	**15**	**12**	**761**
PR	Cogley Subsid-P9	WM-45	EKL0003	Elklick Run	**0.04653**	**15**	**12**	**761**
PR	P-88-P1	WM-51	SPL0016	South Prong Lostland Run	0.03342	**15**	**12**	**761**
PR	P-88-P2	WM-51	SPL0016	South Prong Lostland Run	**0.04653**	**15**	**12**	**761**
PR	P-54-P1	WM-54	TFR0016	Three Forks Run	**0.04653**	**15**	**12**	**761**

Table 4-3. (continued)

Basin	Mine seep or portal	Associated Station	Associated station code	Associated station name	Flow (cfs)	Iron (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)
PR	P-03-S1	WM-61	LNB0014	Laurel Run	**0.02902**	**24**	**5**	**636**
SR	R-52-P1	WM-73	AAR0000	Aaron Run	0.00223	15	12	761
SR	R-52-P10	WM-73	AAR0000	Aaron Run	0.00223	15	12	761
SR	R-52-P11	WM-73	AAR0000	Aaron Run	0.05570	30	12	2,073
SR	R-52-P7	WM-73	AAR0000	Aaron Run	0.00223	**15**	**12**	**761**
SR	R-52-P8	WM-73	AAR0000	Aaron Run	0.00446	4	6	1,150
SR	R-52-P9	WM-73	AAR0000	Aaron Run	0.00223	**15**	**12**	**761**
SR	R-52-S1	WM-73	AAR0000	Aaron Run	**0.02902**	**24**	**5**	**636**
SR	R-52-S2	WM-73	AAR0000	Aaron Run	0.05347	14	7	1,562
WC	FB-08-P1	WM-34	UJH0015	UT to Jennings Run	0.00223	2	2	11
WC	NG-03-P1	WM-34	UJH0015	UT to Jennings Run	0.00111	0	0	930
WC	NG-03-P3	WM-34	UJH0015	UT to Jennings Run	0.04653	0	0	799
WC	NG-03-S1	WM-34	UJH0015	UT to Jennings Run	0.02902	24	5	636
WC	R-01-P1	WM-34	UJH0015	UT to Jennings Run	0.00557	15	12	761
WC	R-02-P1	WM-34	UJH0015	UT to Jennings Run	0.07798	5	31	316
WC	R-03-P1	WM-34	UJH0015	UT to Jennings Run	0.03342	2	1	38
WC	FB-29-P4	WM-37	UJF0002	UT to Jennings Run	0.04653	15	12	761
WC	FB-01-P1	WM-39	JEN0092	Jennings Run	0.00446	3	48	482
WC	R-05-P1	WM-39	JEN0092	Jennings Run	0.13368	2	9	106
WC	FB-06-P1	WM-41	UJH0011	UT to Jennings Run	0.22280	10	0	20
WC	FB-06-P2	WM-41	UJH0011	UT to Jennings Run	0.22280	5	4	647
WC	FB-08-P1	WM-41	UJH0011	UT to Jennings Run	0.00223	2	2	11
WC	NG-03-P1	WM-41	UJH0011	UT to Jennings Run	0.00111	0	0	930
WC	NG-03-P3	WM-41	UJH0011	UT to Jennings Run	0.04653	0	0	799
WC	NG-03-S1	WM-41	UJH0011	UT to Jennings Run	0.02902	24	5	636
WC	R-01-P1	WM-41	UJH0011	UT to Jennings Run	0.00557	15	12	761
WC	R-02-P1	WM-41	UJH0011	UT to Jennings Run	0.07798	5	31	316

Table 4-3. (continued)

Basin	Mine seep or portal	Associated Station	Associated station code	Associated station name	Flow (cfs)	Iron (mg/L)	Aluminum (mg/L)	Sulfate (mg/L)
WC	R-03-P1	WM-41	UJH0011	UT to Jennings Run	0.03342	2	1	38

Notes:
CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek
Highlighted and bolded values are averages for either seeps or portals.

4.2 Calibration and Validation

After initially configuring the watershed model, model calibration and validation for hydrology and water quality were performed. Calibration refers to the adjustment or fine-tuning of modeling parameters to reproduce observations. Validation is performed for different monitoring stations without further adjustments to ensure that the model represents other locations as well as it represents the original calibration periods. If the model exhibited a poor validation, the calibration process was revisited. After completing the calibration and validation at selected locations, a calibrated data set containing parameter values for each modeled land use and soil type was obtained.

4.2.1 Hydrology Calibration

Hydrologic calibration was performed after the initial model setup. For MDAS, calibration is an iterative procedure of parameter evaluation and refinement as a result of comparing simulated and observed values of interest. It is required for parameters that cannot be deterministically and uniquely evaluated from topographic, climatic, physical, and chemical characteristics of the watershed and compounds of interest. Calibration is based on several years of simulation to evaluate parameters under a variety of climatic conditions. The calibration procedure results in parameter values that produce the best overall agreement between simulated and observed flows throughout the calibration period.

Eight USGS flow-gaging stations were used for MDAS hydrology calibration and validation (Figure 2-1). These stations are listed in Table 2-2, with periods of record and measures of completeness. The calibration years were selected after examining annual precipitation variability and the availability of observation data. The periods were determined to represent a range of hydrologic conditions including low-, mean-, and high-flow conditions. Calibration for these conditions is necessary to ensure that the model accurately predicts a range of conditions over the entire simulation period.

During calibration, parameters influencing the simulation of runoff, infiltration, and evapotranspiration were adjusted on the basis of land use and soil type. Modeling parameters were varied to keep with observed temporal trends and soil and land cover characteristics. An attempt was made to keep the modeling parameters within the guidelines included in the BASINS Technical Note 6 (USEPA 2000).

Key considerations in the hydrology calibration included the overall water balance, the high-flow and low-flow distribution, storm-flow volumes and timing, and seasonal variation. At least three criteria for goodness of fit were used for calibration: volumetric comparison, graphical comparison, and the relative error method. The calculation of runoff volumes at various time scales (e.g., daily, monthly) provides an assessment of the model’s ability to accurately simulate the water budget.

For this model, five stations (USGS 01594936, USGS 01596500, USGS 01599000, USGS 01601500, and USGS 03078000) were used in the hydrology calibration, and five stations (USGS 01594930, USGS 01594950, USGS 01597500, USGS 01599000, and USGS 01601500) were used for validation. Each station used the period from January 1, 2000, through November 30, 2005, as the model period. Result plots and tables are included in Appendix C.

Stations USGS 016015000 and USGS 01596500 showed the best correlation between predictions and monitoring data. Discrepancies can largely be explained by differences in measured precipitation data (used in the model) and the actual precipitation that fell within the watershed. The weather stations that were used in the model often contained localized storm events that did not occur over the entire watershed, thus creating peaks in the modeled results that were not present in the observed data. Likewise, the model did not predict storms at other times because the precipitation data did not include events that might have occurred in the watershed. These types of discrepancies are common and acceptable in watershed modeling applications. In these watersheds, total flow for March 2003 was under-predicted across the stations, while total flow for September 2004 was over-predicted across the stations, because of weather data that was not representative to the station’s drainage areas.

Overall, the calibration and validation results demonstrated that the model predicts hydrology. Generally, the model under-predicted winter flows and over-predicted summer flows.

4.2.2 Water Quality Calibration

After hydrology was sufficiently calibrated, water quality calibration was performed. The water quality calibration consisted of running the watershed model, comparing water quality output to available water quality observation data, and adjusting pollutant loading and in-stream water quality parameters within a reasonable range. Recent data (2005) were used for the calibration process to insure that current conditions were simulated.

The 52 stations classified as impaired by MDE were used for MDAS water quality calibration and validation (Table 1-1 and Figure 1-1). Twenty-six stations were used for calibration and 26 were used for validation. The stations were selected on the basis of the amount of data and how recent the data are. The calibration year(s) were selected on the basis of available data.

During calibration, parameters influencing the simulation of water quality were adjusted using land use and soil type. Modeling parameters were adjusted so that model concentrations corresponded with observed concentrations. Calibration and validation were conducted for nitrate, ammonium, sulfate, iron, aluminum, and pH.

For nitrate and ammonium calibration, calibration parameters included the nitrogen transformation rates in the different model layers (surface layer, upper subsurface layer, lower subsurface layer, and streams) and precipitation of organic nitrogen in streams. In addition, a temperature correction for nitrogen transformation rates was calibrated.

The calibration of sulfate was conducted by adjusting stream and subsurface variables. Calibration parameters included desorption ratio (DESORP), sulfate transformation rate (kk_1), and background concentrations, which were land use specific.

After nitrogen and sulfate calibrations were completed, metals and pH calibrations were conducted, mainly with the subsurface chemical reaction parameters and background concentrations. Specific parameters included precipitation rates, metal dissolution constants, base saturation percentage, aluminum solubility constant, carbon dioxide (CO_2) pressure, and the aluminum selectivity constant.

During water quality calibration, it became clear that some calibration and validation locations contain unknown sources of metals, sulfate, or pH. These locations often exhibited higher concentrations than locations where mine seeps were known to exist. To account for these sources, which were assumed to be unidentified abandoned mines, mining land use was adjusted by removing acres from the forest land use and adding them to the mining land use. The additional acreage was retained during the allocation process. This shift in land use did not adversely affect the hydrology calibration.

Examples of pH calibration and validation are presented in Figures 4-2 and 4-3. Model calibration and validation results, for all parameters, are presented in Appendices D through I. Most of the modeled pH levels were within the pH observed range.

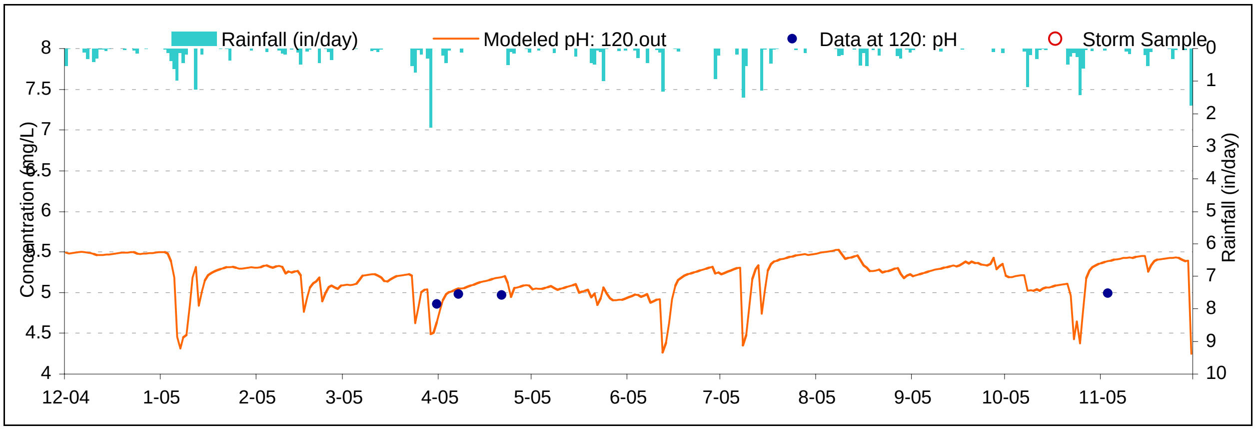

Figure 4-2. pH Calibration plot for Little Shade Run (WM-155/LSR0015).

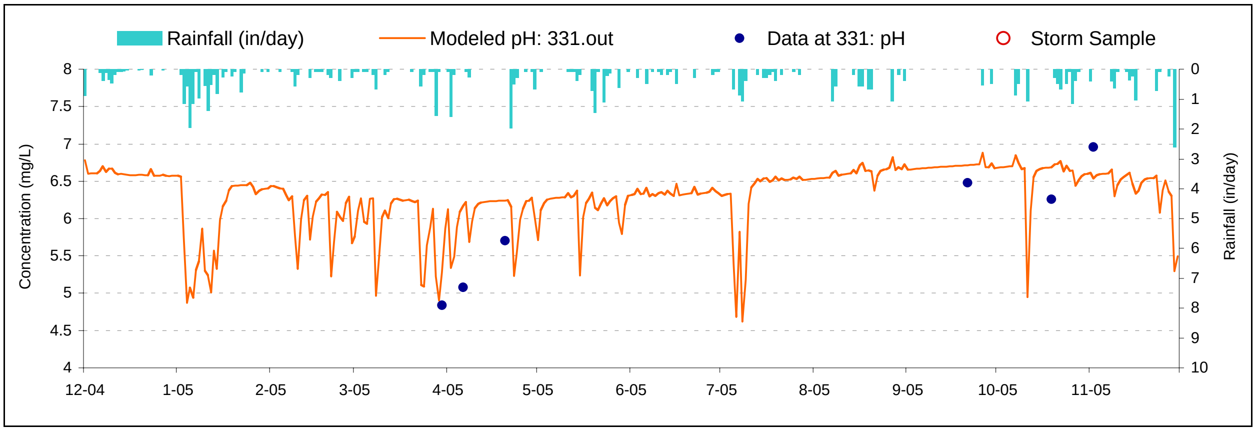

Figure 4-3. pH Validation plot for North Prong Lostland Run (WM-64/NPL0018).

There were several watersheds where the iron, aluminum, or sulfate concentrations were either lower than observed data or higher than observed data, although the pH simulation was reasonable. Further investigation is needed in these watersheds. For instance, if the modeled iron concentrations were too low but the pH and the other parameters were fairly well represented, it could mean there is a local source of iron that had not been identified (and thus generally not represented in the model). Similarly, if modeled iron, aluminum, and sulfate (the hallmarks of AMD) are below observed levels and modeled pH is reasonable, the watershed might have a greater acid-neutralizing capability than calibrated for, or there could be an acid-neutralizing source. Additionally, in watersheds where pH predictions reasonably match observations and iron, aluminum, and sulfate are modeled above observed levels, there might be an additional source of acidity not represented in the model. For instance, in the Three Forks Run watershed

(WM-54/THR0016), the Vindex Abandoned Mine Land Reclamation Project is occurring. Iron, sulfate, and aluminum concentrations vary widely along with pH levels. The project uses a lime doser to increase pH. During two monitoring periods the pH was about 10, and the metal concentrations spiked with the pH. These periods are not able to be simulated during modeling.

4.3 Assumptions and Limitations

The goal of the modeling calibration was to determine a set of parameters that best describe hydrologic and water quality processes in the Georges Creek, Casselman River, Savage River, Wills Creek, and North Branch of the Potomac River watersheds. Using the best available data, model output was evaluated at representative calibration gages. The MDAS model is considered to be calibrated to the currently available data. Imprecision in the model output is present, expected and is primarily governed by uncertainty with the model inputs. Some uncertainties with the inputs are corrected during the calibration process (i.e., infiltration rates, interception capacity). Others simply appear as unexplained variance between the modeled and observed data. Model uncertainty is difficult to quantify because it changes as temporal and spatial conditions vary. The remainder of this section outlines the model inputs and limitations most likely to cause uncertainty with the model output.

Weather gages are a likely source of model uncertainty. Only eight precipitation gages were available for the modeling analysis, and they were responsible for generating precipitation data for 647 square miles. In addition, the climate station used for climate data (e.g., temperature, cloud cover) was outside the watershed. The lack of weather gages significantly increases model uncertainty in terms of amount and timing of water flowing through the system. Lack of weather gages particularly increases model uncertainty during storm events (timing and volume of water)

Because of the large watershed size and model limitations, large areas of land were lumped together as modeling subwatersheds. This process inherently simplifies watershed representation and reduces some level of detail. However, this process most likely introduces little modeling uncertainty when compared to the other potential sources of uncertainty.

Point source discharges have the potential to affect flow and water quality in a stream. The MDAS model can account for these sources by using time-series inputs of flow and concentrations. However, most point sources only report data on a monthly basis (or less), and data were extrapolated to provide daily model input. In other cases, very little information was available about the point sources, and best professional judgment was used to estimate flow, timing, or outfall location. Point source uncertainties have the greatest potential to affect model output during low-flow events, when point sources make up a larger percentage of the pollutant load.

Mining information for the model is limited. Few mine seep data were available. The flow information for these seeps were labeled as estimated. The values used for the model are considered assumptions. If more data are obtained and contributions are found to be more significant than current estimates, mine seeps might have an effect on modeled pH. In addition, land area was subtracted from forest land use and added to the mining land use on the basis of observed concentrations. This assumed that on the basis of monitoring data, additional mine lands/seeps were present in the watersheds, though they have not yet been identified.

Each MDAS/HSPF model is driven by the basic physiographic characteristics that make up a watershed—land use, soils, slopes, and geology (Section 2.1). Therefore, physiographic data must be accurate and complete for each subwatershed. Potential uncertainties were introduced into the model because several of these physiographic characteristics were simplified to facilitate modeling. In addition, physiographic characteristics change over time and are not necessarily represented by the available data and the chosen calibration period. However, this process most likely does not introduce much modeling uncertainty when compared to the other potential sources of uncertainty.

The model was built to simulate only iron, aluminum, sulfate, nitrate, and ammonium. These constituents were assumed to have the greatest impact on pH levels in the watershed, after a review of available data. There are other metals and ions that could affect pH, but these were not included in the model.

Atmospheric deposition was based on a regional model and predicted values. It was assumed to contribute at a constant rate (in terms of dry deposition) and a constant concentration (for wet deposition) over multiple years and the entire watershed.
For LAs, the CO_2 pressure was adjusted at a number of locations because CO_2 is created by respiration and the decay of organic matter. For acidic streams with pH levels as low as 4.4, these processes do not occur. With improved pH levels, these processes are likely to occur, thus changing the CO_2 pressure to values reflective of less impaired watersheds.

The following is a list of the major limitations and assumptions in the MDAS model for predicting pH:

- No explicit AMD chemical reactions are incorporated.
- Chemical reactions are based on an equilibrium concept, with no kinetic considerations.
- Nitrogen transformations are assumed to be a first-order reaction.
- Sulfate adsorption to soil particles is assumed to be linear.
- Generated soil CO_2 follows a seasonal sine curve.

4.4 Baseline Model Results

The calibrated and validated model was run for a *baseline* condition. This condition was essentially the starting point for TMDL analysis. For the baseline condition, permit flows and permit limits were included in the model instead of observed DMR flows and concentrations. (Permit information is provided in Table 2-9.) By using these permit values, the total loading from a point source is included in the model.

To give a sense of the extent of impairment at each location, the existing modeled pH minimum, mean, and maximum are presented in Table 4-4. Streams that exhibited lower pH minimum values generally required the greatest load reductions to achieve pH criteria. The model was run for the period of December 1, 2004, through November 30, 2005. This produced daily loads that were then summed over the year to create the annual loads, which are presented in Table 4-5 and subsequent tables.

Tables 4-5 through 4-7 present existing (before TMDL reductions) total daily loads per watershed, annual loads per watershed, loads from atmospheric deposition, and loads from mine seeps. Table 4-5 presents the total existing modeled loads for the model year for iron, aluminum, sulfate, and ammonium at each station. Table 4-6 presents the existing yearly atmospheric loads for sulfate, nitrate, and ammonium, on the basis of information presented in Table 4-2 over each impaired watershed. Table 4-7 presents the existing yearly loads of iron, aluminum, and sulfate from mine seeps and portals in the impaired watersheds on the basis of information presented in Table 4-3.

Table 4-4. Modeled baseline pH minimum, mean, and maximum

Basin	Station	Station code	Station name	pH minimum	pH average	pH maximum
CR	WM-135	MDW0008	Meadow Run	5.54	6.52	6.86
CR	WM-137	LLR0024	Little Laurel Run	4.22	5.26	5.61
CR	WM-138	SPI0018	Spiker Run	5.57	6.95	7.78
CR	WM-141	LLR0009	Little Laurel Run	4.67	6.37	6.61
CR	WM-142	NBC0072	North Branch Casselman River	4.41	6.69	7.50
CR	WM-143	SCA0067	South Branch Casselman River	5.21	6.47	6.82
CR	WM-144	ALE0011	Alexander Run	4.20	5.17	5.55
CR	WM-145	NBC0090	North Branch Casselman River	4.23	6.60	7.67
CR	WM-146	TAR0003	Tarkiln Run	4.25	5.31	5.63
CR	WM-147	PLE0008	Pleasant Valley Run	4.75	6.84	7.88
CR	WM-148	NBC0106	North Branch Casselman River	4.26	6.87	7.73
CR	WM-149	ZWN0003	UT to North Branch Casselman River	4.85	6.92	8.07
CR	WM-151	UNA0015	UT to North Branch Casselman River	4.36	5.32	6.16
CR	WM-155	LSR0015	Little Shade Run	4.25	5.20	5.53
GC	WM-110	UGQ0000	UT to Georges Creek	4.06	6.67	7.12
GC	WM-111	MIL0001	Mill Run	3.93	6.62	7.13
GC	WM-113	JAC0001	Jackson Run	4.04	7.24	7.69
GC	WM-116	MTH0000	Matthew Run	4.42	6.94	7.19
GC	WM-117	STA0024	Staub Run	5.16	7.06	7.25
GC	WM-118	UJB0000	UT to Jackson Run	4.52	6.96	7.21
GC	WM-119	WBN0002	Winebrenner Run	4.34	6.88	7.16
GC	WM-120	WBN0010	Winebrenner Run	4.44	6.09	6.28
GC	WM-122	UMD0000	UT to Moores Run	4.03	5.95	6.27
GC	WM-125	JAC0006	Jackson Run	4.15	7.33	7.71
PR	WM-42	TFR0021	Three Forks Run	4.46	6.02	6.85
PR	WM-43	WOL0004	Wolfden Run	6.28	6.98	7.48
PR	WM-45	EKL0003	Elklick Run	4.45	6.31	7.60

Table 4-4. (continued)

Basin	Station	Station code	Station name	pH minimum	pH average	pH maximum
PR	WM-48	RTF0005	Right Prong Three Forks Run	4.77	6.25	7.31
PR	WM-50	NPL0001	North Prong Lostland Run	4.66	6.79	7.41
PR	WM-51	SPL0016	South Prong Lostland Run	4.51	6.60	7.32
PR	WM-54	TFR0016	Three Forks Run	4.73	6.37	7.51
PR	WM-55	ZWT0000	UT to Three Forks Run	4.88	6.90	7.34
PR	WM-60	SHO0016	Short Run	5.80	6.47	6.78
PR	WM-61	LNB0014	Laurel Run	3.49	4.43	5.54
PR	WM-62	ULF0003	UT to Laurel Run	3.36	4.31	5.13
PR	WM-64	NPL0018	North Prong Lostland Run	4.62	6.31	6.89
PR	WM-67	LRE0029	Laurel Run	4.55	5.53	6.26
PR	WM-69	GLR0031	Glade Run	4.69	6.36	6.91
SR	WM-72	ZWV0001	UT to Savage River above Aaron Run	4.62	6.17	6.56
SR	WM-73	AAR0000	Aaron Run	4.68	5.50	6.91
SR	WM-77	PYS0024	Pine Swamp Run	4.29	5.67	6.56
SR	WM-78	ZWA0000	UT to Aaron Run	3.92	4.47	5.00
SR	WM-80	MRR0000	Miller Run	6.07	6.89	7.28
SR	WM-81	BRU0048	Big Run	5.73	6.42	6.84
SR	WM-86	LSA0028	Little Savage River	4.25	5.61	6.19
SR	WM-96	POP0065	Poplar Lick Run	4.45	6.80	7.87
SR	WM-97	POP0071	Poplar Lick Run	4.38	6.80	7.82
WC	WM-33	UJN0005	UT to Jennings Run	4.20	6.72	7.48
WC	WM-34	UJH0015	UT to Jennings Run	3.72	5.85	6.22
WC	WM-37	UJF0002	UT to Jennings Run	4.42	5.85	6.13
WC	WM-39	JEN0092	Jennings Run	4.83	6.70	7.17
WC	WM-41	UJH0011	UT to Jennings Run	3.99	5.76	6.17

Note: CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek

Table 4-5. Modeled baseline iron, aluminum, sulfate, nitrate, and ammonium yearly loads

Basin	Station	Station code	Station name	Iron (lb/yr)	Alum-inum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammon-ium (lb/yr)
CR	WM-135	MDW0008	Meadow Run	18,918	13,749	446,478	7,006	1,116
CR	WM-137	LLR0024	Little Laurel Run	407	741	25,450	169	22
CR	WM-138	SPI0018	Spiker Run	4,413	6,206	222,637	2,431	335
CR	WM-141[a]	LLR0009	Little Laurel Run	4,843	8,912	339,676	2,698	350
CR	WM-142[b]	NBC0072	North Branch Casselman River	153,336	103,684	1,534,917	17,972	2,530
CR	WM-143	SCA0067	South Branch Casselman River	6,360	11,769	438,472	3,608	467
CR	WM-144	ALE0011	Alexander Run	1,664	2,874	133,586	976	118
CR	WM-145[c]	NBC0090	North Branch Casselman River	140,678	87,295	883,295	10,639	1,535
CR	WM-146	TAR0003	Tarkiln Run	1,337	2,383	100,347	767	95
CR	WM-147	PLE0008	Pleasant Valley Run	12,783	12,904	473,756	6,278	921
CR	WM-148[d]	NBC0106	North Branch Casselman River	27,440	23,128	614,050	8,201	1,198
CR	WM-149	ZWN0003	UT to North Branch Casselman River	4,078	3,854	135,434	1,667	243
CR	WM-151	UNA0015	UT to North Branch Casselman River	5,118	6,665	290,909	3,385	463
CR	WM-155	LSR0015	Little Shade Run	4,023	6,765	350,629	3,703	474
GC	WM-110	UGQ0000	UT to Georges Creek	129,493	55,271	390,267	8,422	1,875
GC	WM-111	MIL0001	Mill Run	164,139	62,592	376,323	4,901	1,094
GC	WM-113[e]	JAC0001	Jackson Run	162,017	71,420	601,487	19,636	4,856
GC	WM-116	MTH0000	Matthew Run	34,248	16,648	177,755	7,842	2,074
GC	WM-117	STA0024	Staub Run	947	2,194	11,067	447	98
GC	WM-118	UJB0000	UT to Jackson Run	21,552	10,589	118,776	5,245	1,380
GC	WM-119[f]	WBN0002	Winebrenner Run	147,676	67,600	551,187	26,146	7,197
GC	WM-120	WBN0010	Winebrenner Run	49,875	24,016	246,232	10,634	2,831
GC	WM-122	UMD0000	UT to Moores Run	102,371	44,034	345,645	7,616	1,663
GC	WM-125	JAC0006	Jackson Run	105,641	45,276	376,171	8,361	1,840
PR	WM-42	TFR0021	Three Forks Run	15,601	27,332	934,941	10,959	1,160
PR	WM-43	WOL0004	Wolfden Run	34,228	64,855	1,966,367	24,607	2,675
PR	WM-45	EKL0003	Elklick Run	11,278	18,314	563,696	6,981	756
PR	WM-48	RTF0005	Right Prong Three Forks Run	17,942	46,735	16,299,485	13,598	1,493
PR	WM-50[g]	NPL0001	North Prong Lostland Run	36,322	70,015	2,161,796	26,678	2,899
PR	WM-51	SPL0016	South Prong Lostland Run	17,893	34,529	1,043,066	13,032	1,421
PR	WM-54	TFR0016	Three Forks Run	36,076	76,266	17,241,555	24,603	2,658
PR	WM-55	ZWT0000	UT to Three Forks Run	1,759	5,812	1,913,004	1,328	137
PR	WM-60	SHO0016	Short Run	7,878	18,423	557,151	5,508	567
PR	WM-61	LNB0014	Laurel Run	303,540	281,473	2,511,018	8,608	907
PR	WM-62	ULF0003	UT to Laurel Run	301,955	276,000	871,252	7,731	810
PR	WM-64	NPL0018	North Prong Lostland Run	24,296	47,302	1,429,071	17,778	1,944
PR	WM-67	LRE0029	Laurel Run	5,663	9,167	266,851	3,387	374
PR	WM-69	GLR0031	Glade Run	12,175	23,024	681,250	8,640	952
SR	WM-72	ZWV0001	UT to Savage River above Aaron Run	8,238	14,590	694,782	4,390	457
SR	WM-73[h]	AAR0000	Aaron Run	7,920	21,686	10,089,103	4,758	496

Table 4-5. (continued)

Basin	Station	Station code	Station name	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
SR	WM-77	PYS0024	Pine Swamp Run	202,565	157,404	678,333	5,174	578
SR	WM-78	ZWA0000	UT to Aaron Run	1,048	2,853	1,240,601	462	50
SR	WM-80	MRR0000	Miller Run	308	442	105,161	1,497	148
SR	WM-81	BRU0048	Big Run	63	109	8,827	319	34
SR	WM-86	LSA0028	Little Savage River	339,425	310,533	149,294	8,241	946
SR	WM-96[i]	POP0065	Poplar Lick Run	75,813	23,027	151,535	6,217	726
SR	WM-97	POP0071	Poplar Lick Run	74,767	22,501	88,919	4,750	557
WC	WM-33	UJN0005	UT to Jennings Run	6,626	15,345	81,770	2,308	635
WC	WM-34	UJH0015	UT to Jennings Run	21,650	47,307	119,484	13,171	3,310
WC	WM-37	UJF0002	UT to Jennings Run	14,763	33,199	209,447	4,989	1,317
WC	WM-39	JEN0092	Jennings Run	56,814	131,112	649,571	19,522	5,311
WC	WM-41[j]	UJH0011	UT to Jennings Run	35,810	80,138	298,812	18,008	4,656

Notes:

CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek

[a] WM-141 includes upstream loads from WM-137.
[b] WM-142 includes upstream loads from WM-145 and WM-151.
[c] WM-145 includes upstream loads from WM-148.
[d] WM-148 includes upstream loads from WM-147 and WM-149.
[e] WM-113 includes upstream loads from WM-118 and WM-125.
[f] WM-119 includes upstream loads from WM-120.
[g] WM-50 includes upstream loads from WM-64.
[h] WM-73 includes upstream loads from WM-78.
[i] WM-96 includes upstream loads from WM-97.
[j] WM-41 includes upstream loads from WM-34.

Table 4-6. Baseline (2001) yearly loads from atmospheric deposition

Basin	Station	Station code	Station name	Dry (lb/yr)			Wet (lb/yr)		
				Sulfate	Nitrate	Ammonium	Sulfate	Nitrate	Ammonium
CR	WM-135	MDW0008	Meadow Run	33,051	118	871	26,328	11,667	2,470
CR	WM-137	LLR0024	Little Laurel Run	2,371	8	62	1,889	837	177
CR	WM-138	SPI0018	Spiker Run	16,246	58	428	12,941	5,735	1,214
CR	WM-141[a]	LLR0009	Little Laurel Run	26,855	96	707	21,392	9,480	2,007
CR	WM-142[b]	NBC0072	North Branch Casselman River	229,953	819	6,058	183,173	81,174	17,183
CR	WM-143	SCA0067	South Branch Casselman River	33,558	120	884	26,732	11,846	2,508
CR	WM-144	ALE0011	Alexander Run	9,597	34	253	7,644	3,388	717
CR	WM-145[c]	NBC0090	North Branch Casselman River	138,202	492	3,641	110,088	48,786	10,327
CR	WM-146	TAR0003	Tarkiln Run	7,335	26	193	5,843	2,589	548
CR	WM-147	PLE0008	Pleasant Valley Run	32,506	116	856	25,893	11,475	2,429
CR	WM-148[d]	NBC0106	North Branch Casselman River	124,372	443	3,276	99,070	43,903	9,293
CR	WM-149	ZWN0003	UT to North Branch Casselman River	9,551	34	252	7,608	3,372	714

Table 4-6. (continued)

Basin	Station	Station code	Station name	Dry (lb/yr)			Wet (lb/yr)		
				Sulfate	Nitrate	Ammon-ium	Sulfate	Nitrate	Ammon-ium
CR	WM-151	UNA0015	UT to North Branch Casselman River	18,783	67	495	14,962	6,630	1,403
CR	WM-155	LSR0015	Little Shade Run	23,019	82	606	18,336	8,126	1,720
GC	WM-110	UGQ0000	UT to Georges Creek	31,035	111	818	24,721	10,955	2,319
GC	WM-111	MIL0001	Mill Run	117,915	420	3,106	93,927	41,624	8,811
GC	WM-113[e]	JAC0001	Jackson Run	60,747	216	1,600	48,389	21,444	4,539
GC	WM-116	MTH0000	Matthew Run	24,932	89	657	19,860	8,801	1,863
GC	WM-117	STA0024	Staub Run	20,027	71	528	15,953	7,070	1,496
GC	WM-118	UJB0000	UT to Jackson Run	18,009	64	474	14,346	6,357	1,346
GC	WM-119[f]	WBN0002	Winebrenner Run	45,871	163	1,208	36,540	16,193	3,428
GC	WM-120	WBN0010	Winebrenner Run	33,756	120	889	26,889	11,916	2,522
GC	WM-122	UMD0000	UT to Moores Run	33,845	121	892	26,960	11,947	2,529
GC	WM-125	JAC0006	Jackson Run	39,522	141	1,041	31,482	13,951	2,953
PR	WM-42	TFR0021	Three Forks Run	33,408	119	880	26,612	11,793	2,496
PR	WM-43	WOL0004	Wolfden Run	71,255	254	1,877	56,759	25,153	5,324
PR	WM-45	EKL0003	Elklick Run	19,657	70	518	15,658	6,939	1,469
PR	WM-48	RTF0005	Right Prong Three Forks Run	28,756	102	758	22,906	10,151	2,149
PR	WM-50[g]	NPL0001	North Prong Lostland Run	77,183	275	2,033	61,482	27,246	5,767
PR	WM-51	SPL0016	South Prong Lostland Run	36,515	130	962	29,087	12,890	2,729
PR	WM-54	TFR0016	Three Forks Run	97,799	348	2,576	77,904	34,523	7,308
PR	WM-55	ZWT0000	UT to Three Forks Run	4,080	15	107	3,250	1,440	305
PR	WM-60	SHO0016	Short Run	21,264	76	560	16,939	7,506	1,589
PR	WM-61	LNB0014	Laurel Run	131,134	467	3,455	104,457	46,291	9,799
PR	WM-62	ULF0003	UT to Laurel Run	22,321	79	588	17,780	7,879	1,668
PR	WM-64	NPL0018	North Prong Lostland Run	50,544	180	1,332	40,262	17,842	3,777
PR	WM-67	LRE0029	Laurel Run	9,573	34	252	7,626	3,379	715
PR	WM-69	GLR0031	Glade Run	24,118	86	635	19,212	8,514	1,802
SR	WM-72	ZWV0001	UT to Savage River above Aaron Run	41,436	148	1,092	33,006	14,627	3,096
SR	WM-73[h]	AAR0000	Aaron Run	54,925	196	1,447	43,751	19,389	4,104
SR	WM-77	PYS0024	Pine Swamp Run	24,770	88	653	19,731	8,744	1,851
SR	WM-78	ZWA0000	UT to Aaron Run	11,276	40	297	8,982	3,980	843
SR	WM-80	MRR0000	Miller Run	22,442	80	591	17,877	7,922	1,677
SR	WM-81	BRU0048	Big Run	9,057	32	239	7,214	3,197	677

Table 4-6. (continued)

Basin	Station	Station code	Station name	Dry (lb/yr)			Wet (lb/yr)		
				Sulfate	Nitrate	Ammon-ium	Sulfate	Nitrate	Ammon-ium
SR	WM-86	LSA0028	Little Savage River	33,806	120	891	26,929	11,934	2,526
SR	WM-96[i]	POP0065	Poplar Lick Run	28,767	102	758	22,915	10,155	2,150
SR	WM-97	POP0071	Poplar Lick Run	19,964	71	526	15,902	7,047	1,492
WC	WM-33	UJN0005	UT to Jennings Run	3,375	12	89	2,688	1,191	252
WC	WM-34	UJH0015	UT to Jennings Run	30,705	109	809	24,458	10,839	2,294
WC	WM-37	UJF0002	UT to Jennings Run	16,664	59	439	13,274	5,883	1,245
WC	WM-39	JEN0092	Jennings Run	38,251	136	1,008	30,470	13,503	2,858
WC	WM-41[j]	UJH0011	UT to Jennings Run	38,725	138	1,020	30,847	13,670	2,894

Notes:

CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek

[a] WM-141 includes upstream loads from WM-137.

[b] WM-142 includes upstream loads from WM-145 and WM-151.

[c] WM-145 includes upstream loads from WM-148.

[d] WM-148 includes upstream loads from WM-147 and WM-149.

[e] WM-113 includes upstream loads from WM-118 and WM-125.

[f] WM-119 includes upstream loads from WM-120.

[g] WM-50 includes upstream loads from WM-64.

[h] WM-73 includes upstream loads from WM-78.

[i] WM-96 includes upstream loads from WM-97.

[j] WM-41 includes upstream loads from WM-34.

Table 4-7. Baseline yearly loads from mine seeps and portals

Basin	Mine seep or portal	Associated station	Associated station code	Associated station name	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)
CR	GR-15-P2	WM-138	SPI0018	Spiker Run	1374.1	1099.3	69,753
CR	C-24-S1	WM-141	LLR0009	Little Laurel Run	35.1	0.0	1,474
CR	C-48-S1	WM-142	NBC0072	North Branch Casselman River	723.7	0.0	14,080
CR	C-49-P1	WM-142	NBC0072	North Branch Casselman River	986.9	789.5	50,100
CR	C-49-S1	WM-142	NBC0072	North Branch Casselman River	368.5	75.2	9,762
CR	C-50-S1	WM-142	NBC0072	North Branch Casselman River	1579.1	322.4	41,836
CR	C-50-S2	WM-142	NBC0072	North Branch Casselman River	701.8	35.1	421
CR	C-51-S1	WM-142	NBC0072	North Branch Casselman River	1118.5	0.0	5,417
CR	C-51-S2	WM-142	NBC0072	North Branch Casselman River	7566.4	0.0	60,970
CR	C-48-S1	WM-145	NBC0090	North Branch Casselman River	723.7	0.0	14,080
CR	C-49-P1	WM-145	NBC0090	North Branch Casselman River	986.9	789.5	50,100
CR	C-49-S1	WM-145	NBC0090	North Branch Casselman River	368.5	75.2	9,762

Table 4-7. (continued)

Basin	Mine seep or portal	Associated station	Associated station code	Associated station name	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)
CR	C-50-S1	WM-145	NBC0090	North Branch Casselman River	1579.1	322.4	41,836
CR	C-50-S2	WM-145	NBC0090	North Branch Casselman River	701.8	35.1	421
CR	C-50-S1	WM-147	PLE0008	Pleasant Valley Run	1579.1	322.4	41,836
CR	C-50-S2	WM-147	PLE0008	Pleasant Valley Run	701.8	35.1	421
CR	C-48-S1	WM-148	NBC0106	North Branch Casselman River	723.7	0.0	14,080
CR	C-49-P1	WM-148	NBC0106	North Branch Casselman River	986.9	789.5	50,100
CR	C-49-S1	WM-148	NBC0106	North Branch Casselman River	368.5	75.2	9,762
CR	C-50-S1	WM-148	NBC0106	North Branch Casselman River	1579.1	322.4	41,836
CR	C-50-S2	WM-148	NBC0106	North Branch Casselman River	701.8	35.1	421
GC	BA-05-P1	WM-110	UGQ0000	UT to Georges Creek	657.9	526.4	33,400
GC	BA-05-P2	WM-110	UGQ0000	UT to Georges Creek	65.9	52.7	3,343
GC	BA-05-P4	WM-110	UGQ0000	UT to Georges Creek	329.0	263.2	16,700
GC	BA-05-P6	WM-110	UGQ0000	UT to Georges Creek	329.0	263.2	16,700
GC	BA-05-P7	WM-110	UGQ0000	UT to Georges Creek	657.9	526.4	33,400
GC	G-70-P5	WM-111	MIL0001	Mill Run	1374.1	1099.3	69,753
GC	R-48-P5	WM-111	MIL0001	Mill Run	1099.3	1465.7	94,628
GC	BA-10-P1	WM-111	MIL0001	Mill Run	1374.1	1099.3	69,753
GC	BA-10-P2	WM-111	MIL0001	Mill Run	1374.1	1099.3	69,753
GC	BA-10-P3	WM-111	MIL0001	Mill Run	1374.1	1099.3	69,753
GC	BA-10-P4	WM-111	MIL0001	Mill Run	1374.1	1099.3	69,753
GC	BA-10-P5	WM-111	MIL0001	Mill Run	1374.1	1099.3	69,753
GC	G-03-P1	WM-119	WBN0002	Winebrenner Run	1374.1	1099.3	69,753
GC	G-03-P1	WM-120	WBN0010	Winebrenner Run	1374.1	1099.3	69,753
GC	G-52-P1	WM-122	UMD0000	UT to Moores Run	0.0	183.2	17,863
GC	R-43-P1	WM-122	UMD0000	UT to Moores Run	197.3	157.8	10,014
PR	Cogley Subsid-P9	WM-45	EKL0003	Elklick Run	1374.1	1099.3	69,753
PR	P-88-P1	WM-51	SPL0016	South Prong Lostland Run	986.9	789.5	50,100
PR	P-88-P2	WM-51	SPL0016	South Prong Lostland Run	1374.1	1099.3	69,753
PR	P-54-P1	WM-54	TFR0016	Three Forks Run	1374.1	1099.3	69,753
PR	P-03-S1	WM-61	LNB0014	Laurel Run	1371.3	280.0	36,331
SR	R-52-P1	WM-73	AAR0000	Aaron Run	65.9	52.7	3,343
SR	R-52-P10	WM-73	AAR0000	Aaron Run	65.9	52.7	3,343
SR	R-52-P11	WM-73	AAR0000	Aaron Run	3289.7	1315.9	227,321
SR	R-52-P7	WM-73	AAR0000	Aaron Run	65.9	52.7	3,343
SR	R-52-P8	WM-73	AAR0000	Aaron Run	35.1	52.7	10,098
SR	R-52-P9	WM-73	AAR0000	Aaron Run	65.9	52.7	3,343
SR	R-52-S1	WM-73	AAR0000	Aaron Run	1371.3	280.0	36,331
SR	R-52-S2	WM-73	AAR0000	Aaron Run	1473.8	736.9	164,435
WC	FB-08-P1	WM-34	UJH0015	UT to Jennings Run	8.8	8.8	48

Table 4-7. (Contunued)

Basin	Mine seep or portal	Associated station	Associated station code	Associated station name	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)
WC	NG-03-P1	WM-34	UJH0015	UT to Jennings Run	0.0	0.0	2,032
WC	NG-03-P3	WM-34	UJH0015	UT to Jennings Run	0.0	0.0	73,192
WC	NG-03-S1	WM-34	UJH0015	UT to Jennings Run	1371.3	280.0	36,331
WC	R-01-P1	WM-34	UJH0015	UT to Jennings Run	164.5	131.6	8,350
WC	R-02-P1	WM-34	UJH0015	UT to Jennings Run	767.6	4759.2	48,513
WC	R-03-P1	WM-34	UJH0015	UT to Jennings Run	131.6	65.8	2,500
WC	FB-29-P4	WM-37	UJF0002	UT to Jennings Run	1374.1	1099.3	69,753
WC	FB-01-P1	WM-39	JEN0092	Jennings Run	26.3	421.5	4,232
WC	R-05-P1	WM-39	JEN0092	Jennings Run	526.4	2368.6	27,897
WC	FB-06-P1	WM-41	UJH0011	UT to Jennings Run	4386.3	0.0	8,773
WC	FB-06-P2	WM-41	UJH0011	UT to Jennings Run	2193.2	1754.5	283,795
WC	FB-08-P1	WM-41	UJH0011	UT to Jennings Run	8.8	8.8	48
WC	NG-03-P1	WM-41	UJH0011	UT to Jennings Run	0.0	0.0	2,032
WC	NG-03-P3	WM-41	UJH0011	UT to Jennings Run	0.0	0.0	73,192
WC	NG-03-S1	WM-41	UJH0011	UT to Jennings Run	1371.3	280.0	36,331
WC	R-01-P1	WM-41	UJH0011	UT to Jennings Run	164.5	131.6	8,350
WC	R-02-P1	WM-41	UJH0011	UT to Jennings Run	767.6	4759.2	48,513
WC	R-03-P1	WM-41	UJH0011	UT to Jennings Run	131.6	65.8	2,500

Notes:
CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek

5 ALLOCATION ANALYSIS

A TMDL is the total amount of pollutant that can be assimilated by the receiving waterbody while still achieving water quality standards or goals. It is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody and may include a future allocation (FA) component. Conceptually, this definition is represented by the following equation:

$$\text{TMDL} = \Sigma WLAs + \Sigma LAs + MOS + FA$$

In TMDL development, allowable loadings from each pollutant source are summed to a cumulative TMDL threshold, thus providing a quantitative basis for establishing water quality-based controls. TMDLs can be expressed as a mass loading (e.g., grams of pollutant per year) or as a concentration in accordance with 40 CFR 130.2(l). The state reserves the right to revise these allocations, provided that the allocations are consistent with the achievement of water quality standards.

5.1 TMDL Endpoints

TMDL endpoints represent the water quality targets used to quantify TMDLs and their individual components. The water quality criteria for pH allow no values below 6.5 or above 8.5. For pH to meet these criteria, chemical species that affect pH (such as sulfate, iron, aluminum, nitrate, and ammonium) were reduced to raise pH above 6.5. Appendix J (Model Development and Configuration) contains a detailed description of the pH modeling approach.

There are several possible causes for low pH in waterbodies. Atmospheric acid deposition (acid rain) and AMD are being considered as sources in the Western Maryland watersheds. Using these source considerations, sulfate, nitrate, ammonium, aluminum, and iron were selected to predict pH and were assigned allocations to the TMDL endpoint. Sulfate and nitrate are common species in acid deposition.

Acid rain can affect pH of streams over large areas. Sulfate and nitrate were selected as TMDL endpoints because hydrogen ions associate with atmospheric sulfate and nitrate, which, during and after precipitation events, have the potential to add acidity to soils and streams, thus reducing pH.

Ammonia is present in aqueous systems in two forms: ammonia (NH_3) and ionized ammonia (NH_4^+), also known as ammonium. When ammonia enters stream with low pH, the ammonia becomes ammonium, which might increase pH. When ammonium enters a stream with high pH, it releases hydrogen ions which, in turn, lower stream pH. Ammonium was selected because it is also a result of atmospheric deposition and is a critical chemical species for bacterial-facilitated nitrogen transformation in soils. This nitrogen transformation changes nitrate and other nitrogen species in addition to changing chemical conditions within the soils. This process affects hydrogen concentrations, and thus, affects pH.

Increased acidity from mining activities is also a concern in western Maryland. Aluminum, iron, and sulfate were selected as inputs from the mining areas because these ions and their associated acid loadings can be large enough to influence in-stream pH, depending on local geology and condition of the mines. Decreasing these ions from abandoned mine areas will increase pH. In addition, hydrogen, which is generated from the previously mentioned nitrate and sulfate reactions, dissolves aluminosilicate to form free aluminum ions in soils. The newly generated free aluminum ions can further increase acidity.

These interconnected biogeochemical and physical reactions are simulated in the model to estimate daily stream pH conditions. Although the derived TMDLs are based on best professional judgment using current data in the calibrated model, meeting these TMDLs might not be necessary if alternative remediation and future monitoring prove that pH is being corrected without reducing these parameters.

5.2 Critical Conditions and Seasonal Variations

Federal regulations (40 CFR 130.7(c)(1)) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of the waterbody is protected during times when it is vulnerable. Critical conditions are the set of environmental conditions, which, if met, will ensure the attainment of objectives for all other conditions. Nonpoint source loading is typically precipitation-driven. In-stream impacts tend to occur during wet-weather and storm events that cause surface runoff to carry pollutants to waterbodies. During dry periods, little or no land-based runoff occurs, and elevated in-stream pollutant levels could be due to point sources. Because of the presence of both point and nonpoint sources in the watershed, both high-flow and low-flow periods were taken into account during TMDL development. This was accomplished through dynamic model simulation (i.e., using the model to predict conditions over a long period of time that represents wet-, dry-, and average-flow periods).

The TMDL must also consider seasonal variation. MDAS model simulation for a multiyear period inherently accounts for seasonal variation. Continuous simulation represents both hydrologic and source loading variability seasonally**.** The constituent concentrations simulated on a daily time step by the model were compared to the TMDL endpoints. Allocations that met these endpoints throughout the modeling period were developed and are presented in Section 5.3.

5.3 TMDLs and Allocations

For the load reduction simulation (TMDL simulation), the model was run similar to the baseline condition. For the baseline condition, permit flows and permit limits were included in the model instead of observed DMR flows and concentrations. (Permit information is provided in Table 2-9.) By using these permit values, the total loading from a point source is included in the model.

TMDLs and source allocations were developed on a subwatershed basis for each of the impaired watersheds in Table 1-1. TMDL allocations include the LAs for nonpoint sources and the WLAs for point sources. A top-down methodology was followed to develop these TMDLs and allocate loads to sources. Headwaters were analyzed first because their loadings affect downstream water quality. Loading contributions (of aluminum, iron, sulfate, nitrate, and ammonium) were reduced from applicable sources to these waterbodies until pH criteria were met. The loading contributions of unimpaired headwaters and the reduced loadings for impaired headwaters were then routed through downstream waterbodies. Using this method, contributions from all sources were weighted equitably, and pH criteria were achieved throughout the system. Reductions in sources affecting impaired headwaters ultimately led to improvements downstream and effectively decreased necessary loading reductions from downstream sources. Source allocations were developed for aluminum, iron, sulfate, nitrate, and ammonium.

Allocations were assigned so that pH did not fall below 6.5. Table 5-1 presents the pH ranges in the impaired watersheds after allocations were applied. Subsections 5.3.1, 5.3.2, and 5.3.3 describe WLAs, LAs, and the MOS and FA components, respectively. Table 5-2 summarizes the annual TMDL allocations. Table 5-3 presents the percent reduction of each parameter betweent eh baseline and TMDL loadings.The model was run to for the period of December 1, 2004, through November 30, 2005. This produced daily loads that were then summed over the year to create the annual loads, which are presented in Table 5-2 and subsequent tables. Note that the atmospheric deposition contribution of some parameters is expected to increase in the model area on the basis of the CAIR model; thus, some TMDL conditions are greater than baseline conditions.

One way to express loads is through load duration curves. Figure 5-1 is an example of a curve for sulfate for Laurel Run (WM-67/LRE0029). Points at the lower end of the curve plot (0 through 10 percent) represent high-flow conditions where only 0 through 10 percent of the flow exceeds the plotted point. Conversely, points on the high end of the plot (90 to 100 percent) represent low-flow conditions. The load duration curve shows the calculation of the TMDL at any flow rather than at a single, critical flow. The official TMDL number is reported as a single number, but the curve is provided to demonstrate the value of the acceptable load at any flow. Tables 5-4 through 5-8 present the maximum daily load by flow percentile range for iron, aluminum, sulfate, nitrate, and ammonium, respectively. Appendix J presents additional daily statistics and load duration curves by flow percentile range for each segment.

Table 5-1. TMDL pH minimum, mean, and maximum

Basin	Station	Station code	Station name	pH minimum	pH average	pH maximum
CR	WM-135	MDW0008	Meadow Run	6.50	7.06	7.39
CR	WM-137	LLR0024	Little Laurel Run	6.51	7.02	7.28
CR	WM-138	SPI0018	Spiker Run	6.50	7.10	7.84
CR	WM-141	LLR0009	Little Laurel Run	6.50	7.04	7.33
CR	WM-142	NBC0072	North Branch Casselman River	6.53	7.04	7.80
CR	WM-143	SCA0067	South Branch Casselman River	6.50	7.06	7.36
CR	WM-144	ALE0011	Alexander Run	6.51	6.99	7.26
CR	WM-145	NBC0090	North Branch Casselman River	6.59	7.06	7.85
CR	WM-146	TAR0003	Tarkiln Run	6.51	7.02	7.29
CR	WM-147	PLE0008	Pleasant Valley Run	6.51	7.09	7.93
CR	WM-148	NBC0106	North Branch Casselman River	6.57	7.06	7.82
CR	WM-149	ZWN0003	UT to North Branch Casselman River	6.50	7.09	8.11
CR	WM-151	UNA0015	UT to North Branch Casselman River	6.51	7.04	7.72
CR	WM-155	LSR0015	Little Shade Run	6.50	6.96	7.23
GC	WM-110	UGQ0000	UT to Georges Creek	6.62	7.54	7.70
GC	WM-111	MIL0001	Mill Run	6.76	7.53	7.66
GC	WM-113	JAC0001	Jackson Run	7.19	7.61	7.81
GC	WM-116	MTH0000	Matthew Run	6.98	7.64	7.77
GC	WM-117	STA0024	Staub Run	6.60	7.64	7.77
GC	WM-118	UJB0000	UT to Jackson Run	6.95	7.65	7.77
GC	WM-119	WBN0002	Winebrenner Run	6.99	7.60	7.70
GC	WM-120	WBN0010	Winebrenner Run	6.95	7.61	7.71
GC	WM-122	UMD0000	UT to Moores Run	7.08	7.58	7.70
GC	WM-125	JAC0006	Jackson Run	7.06	7.61	7.81
PR	WM-42	TFR0021	Three Forks Run	6.50	6.99	7.42
PR	WM-43	WOL0004	Wolfden Run	6.50	7.00	7.48
PR	WM-45	EKL0003	Elklick Run	6.51	7.00	7.65
PR	WM-48	RTF0005	Right Prong Three Forks Run	6.53	7.14	7.44
PR	WM-50	NPL0001	North Prong Lostland Run	6.50	6.99	7.43
PR	WM-51	SPL0016	South Prong Lostland Run	6.51	7.00	7.38
PR	WM-54	TFR0016	Three Forks Run	6.52	7.03	7.55
PR	WM-55	ZWT0000	UT to Three Forks Run	6.51	7.09	7.34

Table 5-1. (continued)

Basin	Station	Station code	Station name	pH minimum	pH average	pH maximum
PR	WM-60	SHO0016	Short Run	6.50	6.99	7.28
PR	WM-61	LNB0014	Laurel Run	6.80	7.11	7.61
PR	WM-62	ULF0003	UT to Laurel Run	6.92	7.13	7.43
PR	WM-64	NPL0018	North Prong Lostland Run	6.50	7.01	7.41
PR	WM-67	LRE0029	Laurel Run	6.50	7.02	7.67
PR	WM-69	GLR0031	Glade Run	6.50	7.01	7.42
SR	WM-72	ZWV0001	UT to Savage River above Aaron Run	6.50	6.91	7.20
SR	WM-73	AAR0000	Aaron Run	6.55	7.04	7.30
SR	WM-77	PYS0024	Pine Swamp Run	6.50	7.01	7.30
SR	WM-78	ZWA0000	UT to Aaron Run	6.64	7.06	7.29
SR	WM-80	MRR0000	Miller Run	6.50	6.92	7.29
SR	WM-81	BRU0048	Big Run	6.50	6.95	7.35
SR	WM-86	LSA0028	Little Savage River	6.51	7.31	7.67
SR	WM-96	POP0065	Poplar Lick Run	6.58	7.25	7.93
SR	WM-97	POP0071	Poplar Lick Run	6.51	7.36	7.89
WC	WM-33	UJN0005	UT to Jennings Run	6.87	7.44	7.54
WC	WM-34	UJH0015	UT to Jennings Run	7.01	7.54	7.66
WC	WM-37	UJF0002	UT to Jennings Run	6.87	7.46	7.57
WC	WM-39	JEN0092	Jennings Run	6.96	7.58	7.70
WC	WM-41	UJH0011	UT to Jennings Run	7.00	7.44	7.62

Notes:
CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek

Table 5-2. Summary of yearly LA, WLA, MOS, and total TMDLs

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
CR	WM-135	MDW0008	Meadow Run	LA	1,447	1,064	31,932	3,480	1,037
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	85	63	1,878	205	61
				FA	170	125	3,757	409	122
				Total	1,703	1,251	37,567	4,094	1,220
CR	WM-137	LLR0024	Little Laurel Run	LA	14	26	840	83	18
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	1	2	49	5	1
				FA	2	3	99	10	2
				Total	16	30	989	97	21
CR	WM-138	SPI0018	Spiker Run	LA	150	217	7,252	1,205	286
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	9	13	427	71	17
				FA	18	26	853	142	34
				Total	177	255	8,532	1,417	337
CR	WM-141[a]	LLR0009	Little Laurel Run	LA	278	519	18,962	1,329	291
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	16	31	1,115	78	17
				FA	33	61	2,231	156	34
				Total	327	610	22,308	1,564	342

Table 5-2. (continued)

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
CR	WM-142[b]	NBC0072	North Branch Casselman River	LA	16,981	12,882	234,888	8,859	2,190
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	999	758	13,817	521	129
				FA	1,998	1,516	27,634	1,042	258
				Total	19,977	15,156	276,339	10,423	2,577
CR	WM-143	SCA0067	South Branch Casselman River	LA	703	1,310	46,958	1,775	389
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	41	77	2,762	104	23
				FA	83	154	5,524	209	46
				Total	827	1,541	55,244	2,088	457
CR	WM-144	ALE0011	Alexander Run	LA	57	100	4,394	479	96
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	3	6	258	28	6
				FA	7	12	517	56	11
				Total	67	118	5,169	563	112
CR	WM-145[c]	NBC0090	North Branch Casselman River	LA	13,131	7,907	55,999	5,232	1,347
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	772	465	3,294	308	79
				FA	1,545	930	6,588	616	159
				Total	15,448	9,302	65,881	6,156	1,585
CR	WM-146	TAR0003	Tarkiln Run	LA	57	103	4,129	376	78
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	3	6	243	22	5
				FA	7	12	486	44	9
				Total	67	122	4,857	443	92
CR	WM-147	PLE0008	Pleasant Valley Run	LA	543	561	19,108	3,089	803
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	32	33	1,124	182	47
				FA	64	66	2,248	363	94
				Total	639	660	22,480	3,634	944
CR	WM-148[d]	NBC0106	North Branch Casselman River	LA	2,543	1,900	31,737	4,036	1,049
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	150	112	1,867	237	62
				FA	299	224	3,734	475	123
				Total	2,992	2,236	37,338	4,748	1,234
CR	WM-149	ZWN0003	UT to North Branch Casselman River	LA	381	364	11,991	824	217
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	22	21	705	48	13
				FA	45	43	1,411	97	26
				Total	449	428	14,107	969	255
CR	WM-151	UNA0015	UT to North Branch Casselman River	LA	261	346	14,022	1,685	394
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	15	20	825	99	23
				FA	31	41	1,650	198	46
				Total	307	407	16,496	1,982	464

Table 5-2. (continued)

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
CR	WM-155	LSR0015	Little Shade Run	LA	239	409	19,996	1,824	383
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	14	24	1,176	107	23
				FA	28	48	2,352	215	45
				Total	282	481	23,525	2,145	451
GC	WM-110	UGQ0000	UT to Georges Creek	LA	1,100	501	3,242	3,891	1,514
				WLA	3.20	0.00	0.00	0.00	0.00
				MOS	65	29	191	229	89
				FA	130	59	381	458	178
				Total	1,298	590	3,814	4,578	1,781
GC	WM-111	MIL0001	Mill Run	LA	8,368	3,229	18,852	2,181	899
				WLA	15.63	0.00	0.00	0.00	0.00
				MOS	493	190	1,109	128	53
				FA	986	380	2,218	257	106
				Total	9,863	3,799	22,179	2,566	1,057
GC	WM-113[e]	JAC0001	Jackson Run	LA	11,446	5,122	40,857	8,231	4,101
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	673	301	2,403	484	241
				FA	1,347	603	4,807	968	482
				Total	13,466	6,026	48,067	9,683	4,824
GC	WM-116	MTH0000	Matthew Run	LA	2,038	1,049	9,593	3,084	1,778
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	120	62	564	181	105
				FA	240	123	1,129	363	209
				Total	2,397	1,234	11,286	3,628	2,091
GC	WM-117	STA0024	Staub Run	LA	314	728	3,533	210	81
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	18	43	208	12	5
				FA	37	86	416	25	9
				Total	369	856	4,156	247	95
GC	WM-118	UJB0000	UT to Jackson Run	LA	1,282	667	6,427	2,081	1,177
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	75	39	378	122	69
				FA	151	78	756	245	138
				Total	1,509	785	7,561	2,448	1,384
GC	WM-119[f]	WBN0002	Winebrenner Run	LA	14,197	6,581	43,974	9,759	6,363
				WLA	6.09	0.00	0.00	0.00	0.00
				MOS	835	387	2,587	574	374
				FA	1,671	774	5,173	1,148	749
				Total	16,709	7,742	51,734	11,482	7,486
GC	WM-120	WBN0010	Winebrenner Run	LA	3,392	1,716	15,183	4,189	2,437
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	200	101	893	246	143
				FA	399	202	1,786	493	287
				Total	3,990	2,019	17,862	4,929	2,867

Table 5-2. (continued)

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
GC	WM-122	UMD0000	UT to Moores Run	LA	5,221	2,295	17,304	3,573	1,316
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	307	135	1,018	210	77
				FA	614	270	2,036	420	155
				Total	6,142	2,700	20,358	4,203	1,548
GC	WM-125	JAC0006	Jackson Run	LA	8,980	3,903	31,370	3,937	1,455
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	528	230	1,845	232	86
				FA	1,056	459	3,691	463	171
				Total	10,564	4,592	36,906	4,632	1,712
PR	WM-42	TFR0021	Three Forks Run	LA	1,724	3,031	98,993	5,414	964
				WLA	0.23	0.00	0.00	0.00	0.00
				MOS	101	178	5,823	318	57
				FA	203	357	11,646	637	113
				Total	2,028	3,566	116,463	6,370	1,134
PR	WM-43	WOL0004	Wolfden Run	LA	18,911	35,795	1,042,429	12,179	2,257
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	1,112	2,106	61,319	716	133
				FA	2,225	4,211	122,639	1,433	266
				Total	22,248	42,112	1,226,387	14,328	2,655
PR	WM-45	EKL0003	Elklick Run	LA	1,246	2,031	59,693	3,440	637
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	73	119	3,511	202	37
				FA	147	239	7,023	405	75
				Total	1,466	2,389	70,228	4,047	749
PR	WM-48	RTF0005	Right Prong Three Forks Run	LA	1,372	3,625	1,244,350	6,618	1,302
				WLA	0.46	0.00	0.00	0.00	0.00
				MOS	81	213	73,197	389	77
				FA	162	426	146,394	779	153
				Total	1,615	4,264	1,463,941	7,786	1,531
PR	WM-50b	NPL0001	North Prong Lostland Run	LA	9,054	17,448	517,583	13,196	2,443
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	533	1,026	30,446	776	144
				FA	1,065	2,053	60,892	1,552	287
				Total	10,651	20,528	608,921	15,524	2,874
PR	WM-51	SPL0016	South Prong Lostland Run	LA	2,890	5,586	161,641	6,438	1,201
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	170	329	9,508	379	71
				FA	340	657	19,017	757	141
				Total	3,400	6,572	190,166	7,574	1,412
PR	WM-54	TFR0016	Three Forks Run	LA	3,893	7,348	1,345,541	12,055	2,270
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	229	432	79,149	709	134
				FA	458	864	158,299	1,418	267
				Total	4,580	8,644	1,582,989	14,182	2,670

Table 5-2. (continued)

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
PR	WM-55	ZWT0000	UT to Three Forks Run	LA	434	1,435	470,712	650	118
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	26	84	27,689	38	7
				FA	51	169	55,378	76	14
				Total	510	1,688	553,779	765	139
PR	WM-60	SHO0016	Short Run	LA	3,616	8,451	247,332	2,727	474
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	213	497	14,549	160	28
				FA	425	994	29,098	321	56
				Total	4,254	9,942	290,979	3,208	558
PR	WM-61	LNB0014	Laurel Run	LA	7,765	7,296	91,327	4,205	790
				WLA	9.14	0.00	0.00	0.00	0.00
				MOS	457	429	5,372	247	46
				FA	915	858	10,744	495	93
				Total	9,147	8,583	107,443	4,946	929
PR	WM-62	ULF0003	UT to Laurel Run	LA	7,700	7,060	21,740	3,777	706
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	453	415	1,279	222	42
				FA	906	831	2,558	444	83
				Total	9,059	8,306	25,576	4,444	830
PR	WM-64	NPL0018	North Prong Lostland Run	LA	5,782	11,265	326,461	8,792	1,644
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	340	663	19,204	517	97
				FA	680	1,325	38,407	1,034	193
				Total	6,803	13,253	384,072	10,344	1,934
PR	WM-67	LRE0029	Laurel Run	LA	1,685	2,728	76,171	1,672	317
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	99	160	4,481	98	19
				FA	198	321	8,961	197	37
				Total	1,982	3,209	89,612	1,967	373
PR	WM-69	GLR0031	Glade Run	LA	3,312	6,264	177,803	4,271	808
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	195	368	10,459	251	48
				FA	390	737	20,918	502	95
				Total	3,896	7,369	209,180	5,024	950
SR	WM-72	ZWV0001	UT to Savage River above Aaron Run	LA	910	1,615	74,432	2,248	364
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	54	95	4,378	132	21
				FA	107	190	8,757	265	43
				Total	1,071	1,899	87,567	2,645	428
SR	WM-73[h]	AAR0000	Aaron Run	LA	747	2,048	953,471	2,392	415
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	44	120	56,087	141	24
				FA	88	241	112,173	281	49
				Total	878	2,409	1,121,730	2,814	488

Table 5-2. (continued)

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
SR	WM-77	PYS0024	Pine Swamp Run	LA	32,714	25,425	106,854	2,625	490
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	1,924	1,496	6,286	154	29
				FA	3,849	2,991	12,571	309	58
				Total	38,487	29,912	125,710	3,088	576
SR	WM-78	ZWA0000	UT to Aaron Run	LA	41	122	52,643	231	42
				WLA	18.28	0.00	0.00	0.00	0.00
				MOS	3	7	3,097	14	2
				FA	7	14	6,193	27	5
				Total	70	143	61,932	271	50
SR	WM-80	MRR0000	Miller Run	LA	73	106	23,511	765	117
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	4	6	1,383	45	7
				FA	9	12	2,766	90	14
				Total	86	125	27,660	901	138
SR	WM-81	BRU0048	Big Run	LA	20	35	2,392	163	28
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	1	2	141	10	2
				FA	2	4	281	19	3
				Total	23	41	2,814	192	33
SR	WM-86	LSA0028	Little Savage River	LA	109,634	100,322	42,278	4,169	839
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	6,449	5,901	2,487	245	49
				FA	12,898	11,803	4,974	490	99
				Total	128,981	118,026	49,738	4,905	987
SR	WM-96[i]	POP0065	Poplar Lick Run	LA	24,065	7,368	54,720	3,148	637
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	1,416	433	3,219	185	37
				FA	2,831	867	6,438	370	75
				Total	28,312	8,668	64,377	3,703	749
SR	WM-97	POP0071	Poplar Lick Run	LA	23,514	7,091	24,521	2,400	496
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	1,383	417	1,442	141	29
				FA	2,766	834	2,885	282	58
				Total	27,664	8,342	28,848	2,823	583
WC	WM-33	UJN0005	UT to Jennings Run	LA	113	269	1,285	859	568
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	7	16	76	51	33
				FA	13	32	151	101	67
				Total	133	317	1,511	1,011	668
WC	WM-34	UJH0015	UT to Jennings Run	LA	184	438	785	5,081	2,823
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	11	26	46	299	166
				FA	22	52	92	598	332
				Total	217	516	923	5,978	3,321

Table 5-2. (continued)

Basin	Station	Station code	Station name	TMDL fraction	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
WC	WM-37	UJF0002	UT to Jennings Run	LA	251	616	3,366	2,012	1,145
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	15	36	198	118	67
				FA	30	72	396	237	135
				Total	295	725	3,960	2,367	1,347
WC	WM-39	JEN0092	Jennings Run	LA	1,449	21,705	15,338	7,499	4,691
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	85	1,277	902	441	276
				FA	170	2,554	1,804	882	552
				Total	1,704	25,535	18,044	8,823	5,519
WC	WM-41[j]	UJH0011	UT to Jennings Run	LA	304	735	2,198	6,896	4,027
				WLA	0.00	0.00	0.00	0.00	0.00
				MOS	18	43	129	406	237
				FA	36	86	259	811	474
				Total	358	865	2,585	8,113	4,738

Notes:
CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek
[a] WM-141 includes upstream loads from WM-137.
[b] WM-142 includes upstream loads from WM-145 and WM-151.
[c] WM-145 includes upstream loads from WM-148.
[d] WM-148 includes upstream loads from WM-147 and WM-149.
[e] WM-113 includes upstream loads from WM-118 and WM-125.
[f] WM-119 includes upstream loads from WM-120.
[g] WM-50 includes upstream loads from WM-64.
[h] WM-73 includes upstream loads from WM-78.
[i] WM-96 includes upstream loads from WM-97.
[j] WM-41 includes upstream loads from WM-34.

Table 5-3. Comparison between baseline loads and TMDLs (lb/yr)

Basin	Station	Station code	Station name	Load	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
CR	WM-135	MDW0008	Meadow Run	Baseline	18,918	13,749	446,478	7,006	1,116
				TMDL	1,703	1,251	37,567	4,094	1,220
				% reduction	91.0	90.9	91.6	41.6	-9.3
CR	WM-137	LLR0024	Little Laurel Run	Baseline	407	741	25,450	169	22
				TMDL	16	30	989	97	21
				% reduction	96.0	95.9	96.1	42.4	3.4
CR	WM-138	SPI0018	Spiker Run	Baseline	4,413	6,206	222,637	2,431	335
				TMDL	177	255	8,532	1,417	337
				% reduction	96.0	95.9	96.2	41.7	-0.6
CR	WM-141[a]	LLR0009	Little Laurel Run	Baseline	4,843	8,912	339,676	2,698	350
				TMDL	327	610	22,308	1,564	342
				% reduction	93.3	93.2	93.4	42.1	2.4
CR	WM-142[b]	NBC0072	North Branch Casselman River	Baseline	153,336	103,684	1,534,917	17,972	2,530
				TMDL	19,977	15,156	276,339	10,423	2,577
				% reduction	87.0	85.4	82.0	42.0	-1.9
CR	WM-143	SCA0067	South Branch Casselman River	Baseline	6,360	11,769	438,472	3,608	467
				TMDL	827	1,541	55,244	2,088	457
				% reduction	87.0	86.9	87.4	42.1	2.1

Table 5-3. (continued)

Basin	Station	Station code	Station name	Load	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
CR	WM-144	ALE0011	Alexander Run	Baseline	1,664	2,874	133,586	976	118
				TMDL	67	118	5,169	563	112
				% reduction	96.0	95.9	96.1	42.3	4.5
CR	WM-145[c]	NBC0090	North Branch Casselman River	Baseline	140,678	87,295	883,295	10,639	1,535
				TMDL	15,448	9,302	65,881	6,156	1,585
				% reduction	89.0	89.3	92.5	42.1	-3.3
CR	WM-146	TAR0003	Tarkiln Run	Baseline	1,337	2,383	100,347	767	95
				TMDL	67	122	4,857	443	92
				% reduction	95.0	94.9	95.2	42.3	3.4
CR	WM-147	PLE0008	Pleasant Valley Run	Baseline	12,783	12,904	473,756	6,278	921
				TMDL	639	660	22,480	3,634	944
				% reduction	95.0	94.9	95.3	42.1	-2.5
CR	WM-148[d]	NBC0106	North Branch Casselman River	Baseline	27,440	23,128	614,050	8,201	1,198
				TMDL	2,992	2,236	37,338	4,748	1,234
				% reduction	89.1	90.3	93.9	42.1	-3.0
CR	WM-149	ZWN0003	UT to North Branch Casselman River	Baseline	4,078	3,854	135,434	1,667	243
				TMDL	449	428	14,107	969	255
				% reduction	89.0	88.9	89.6	41.9	-4.9
CR	WM-151	UNA0015	UT to North Branch Casselman River	Baseline	5,118	6,665	290,909	3,385	463
				TMDL	307	407	16,496	1,982	464
				% reduction	94.0	93.9	94.3	41.4	-0.1
CR	WM-155	LSR0015	Little Shade Run	Baseline	4,023	6,765	350,629	3,703	474
				TMDL	282	481	23,525	2,145	451
				% reduction	93.0	92.9	93.3	42.1	5.0
GC	WM-110	UGQ0000	UT to Georges Creek	Baseline	129,493	55,271	390,267	8,422	1,875
				TMDL	1,298	590	3,814	4,578	1,781
				% reduction	99.0	98.9	99.0	45.6	5.0
GC	WM-111	MIL0001	Mill Run	Baseline	164,139	62,592	376,323	4,901	1,094
				TMDL	9,863	3,799	22,179	2,566	1,057
				% reduction	94.0	93.9	94.1	47.7	3.4
GC	WM-113[e]	JAC0001	Jackson Run	Baseline	162,017	71,420	601,487	19,636	4,856
				TMDL	13,466	6,026	48,067	9,683	4,824
				% reduction	91.7	91.6	92.0	50.7	0.6
GC	WM-116	MTH0000	Matthew Run	Baseline	34,248	16,648	177,755	7,842	2,074
				TMDL	2,397	1,234	11,286	3,628	2,091
				% reduction	93.0	92.6	93.7	53.7	-0.8
GC	WM-117	STA0024	Staub Run	Baseline	947	2,194	11,067	447	98
				TMDL	369	856	4,156	247	95
				% reduction	61.0	61.0	62.4	44.8	3.5
GC	WM-118	UJB0000	UT to Jackson Run	Baseline	21,552	10,589	118,776	5,245	1,380
				TMDL	1,509	785	7,561	2,448	1,384
				% reduction	93.0	92.6	93.6	53.3	-0.4

Table 5-3. (continued)

Basin	Station	Station code	Station name	Load	Iron (lb/yr)	Alum-inum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammon-ium (lb/yr)
GC	WM-119[f]	WBN0002	Winebrenner Run	Baseline	147,676	67,600	551,187	26,146	7,197
				TMDL	16,709	7,742	51,734	11,482	7,486
				% reduction	88.7	88.5	90.6	56.1	-4.0
GC	WM-120	WBN0010	Winebrenner Run	Baseline	49,875	24,016	246,232	10,634	2,831
				TMDL	3,990	2,019	17,862	4,929	2,867
				% reduction	92.0	91.6	92.7	53.7	-1.3
GC	WM-122	UMD0000	UT to Moores Run	Baseline	102,371	44,034	345,645	7,616	1,663
				TMDL	6,142	2,700	20,358	4,203	1,548
				% reduction	94.0	93.9	94.1	44.8	6.9
GC	WM-125	JAC0006	Jackson Run	Baseline	105,641	45,276	376,171	8,361	1,840
				TMDL	10,564	4,592	36,906	4,632	1,712
				% reduction	90.0	89.9	90.2	44.6	7.0
PR	WM-42	TFR0021	Three Forks Run	Baseline	15,601	27,332	934,941	10,959	1,160
				TMDL	2,028	3,566	116,463	6,370	1,134
				% reduction	87.0	87.0	87.5	41.9	2.3
PR	WM-43	WOL0004	Wolfden Run	Baseline	34,228	64,855	1,966,367	24,607	2,675
				TMDL	22,248	42,112	1,226,387	14,328	2,655
				% reduction	35.0	35.1	37.6	41.8	0.7
PR	WM-45	EKL0003	Elklick Run	Baseline	11,278	18,314	563,696	6,981	756
				TMDL	1,466	2,389	70,228	4,047	749
				% reduction	87.0	87.0	87.5	42.0	0.9
PR	WM-48	RTF0005	Right Prong Three Forks Run	Baseline	17,942	46,735	16,299,485	13,598	1,493
				TMDL	1,615	4,264	1,463,941	7,786	1,531
				% reduction	91.0	90.9	91.0	42.7	-2.6
PR	WM-50[g]	NPL0001	North Prong Lostland Run	Baseline	36,322	70,015	2,161,796	26,678	2,899
				TMDL	10,651	20,528	608,921	15,524	2,874
				% reduction	70.7	70.7	71.8	41.8	0.9
PR	WM-51	SPL0016	South Prong Lostland Run	Baseline	17,893	34,529	1,043,066	13,032	1,421
				TMDL	3,400	6,572	190,166	7,574	1,412
				% reduction	81.0	81.0	81.8	41.9	0.6
PR	WM-54	TFR0016	Three Forks Run	Baseline	36,076	76,266	17,241,555	24,603	2,658
				TMDL	4,580	8,644	1,582,989	14,182	2,670
				% reduction	87.3	88.7	90.8	42.4	-0.5
PR	WM-55	ZWT0000	UT to Three Forks Run	Baseline	1,759	5,812	1,913,004	1,328	137
				TMDL	510	1,688	553,779	765	139
				% reduction	71.0	70.9	71.1	42.4	-1.6
PR	WM-60	SHO0016	Short Run	Baseline	7,878	18,423	557,151	5,508	567
				TMDL	4,254	9,942	290,979	3,208	558
				% reduction	46.0	46.0	47.8	41.8	1.6
PR	WM-61	LNB0014	Laurel Run	Baseline	303,540	281,473	2,511,018	8,608	907
				TMDL	9,147	8,583	107,443	4,946	929
				% reduction	97.0	97.0	95.7	42.5	-2.5
PR	WM-62	ULF0003	UT to Laurel Run	Baseline	301,955	276,000	871,252	7,731	810
				TMDL	9,059	8,306	25,576	4,444	830
				% reduction	97.0	97.0	97.1	42.5	-2.5

Table 5-3. (continued)

Basin	Station	Station code	Station name	Load	Iron (lb/yr)	Alum-inum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammon-ium (lb/yr)
PR	WM-64	NPL0018	North Prong Lostland Run	Baseline	24,296	47,302	1,429,071	17,778	1,944
				TMDL	6,803	13,253	384,072	10,344	1,934
				% reduction	72.0	72.0	73.1	41.8	0.5
PR	WM-67	LRE0029	Laurel Run	Baseline	5,663	9,167	266,851	3,387	374
				TMDL	1,982	3,209	89,612	1,967	373
				% reduction	65.0	65.0	66.4	41.9	0.1
PR	WM-69	GLR0031	Glade Run	Baseline	12,175	23,024	681,250	8,640	952
				TMDL	3,896	7,369	209,180	5,024	950
				% reduction	68.0	68.0	69.3	41.9	0.1
SR	WM-72	ZWV0001	UT to Savage River above Aaron Run	Baseline	8,238	14,590	694,782	4,390	457
				TMDL	1,071	1,899	87,567	2,645	428
				% reduction	87.0	87.0	87.4	39.7	6.4
SR	WM-73[h]	AAR0000	Aaron Run	Baseline	7,920	21,686	10,089,103	4,758	496
				TMDL	878	2,409	1,121,730	2,814	488
				% reduction	88.9	88.9	88.9	40.8	1.6
SR	WM-77	PYS0024	Pine Swamp Run	Baseline	202,565	157,404	678,333	5,174	578
				TMDL	38,487	29,912	125,710	3,088	576
				% reduction	81.0	81.0	81.5	40.3	0.3
SR	WM-78	ZWA0000	UT to Aaron Run	Baseline	1,048	2,853	1,240,601	462	50
				TMDL	70	143	61,932	271	50
				% reduction	93.3	95.0	95.0	41.2	1.7
SR	WM-80	MRR0000	Miller Run	Baseline	308	442	105,161	1,497	148
				TMDL	86	125	27,660	901	138
				% reduction	72.0	71.8	73.7	39.8	6.4
SR	WM-81	BRU0048	Big Run	Baseline	63	109	8,827	319	34
				TMDL	23	41	2,814	192	33
				% reduction	63.0	62.9	68.1	39.8	4.1
SR	WM-86	LSA0028	Little Savage River	Baseline	339,425	310,533	149,294	8,241	946
				TMDL	128,981	118,026	49,738	4,905	987
				% reduction	62.0	62.0	66.7	40.5	-4.3
SR	WM-96[i]	POP0065	Poplar Lick Run	Baseline	75,813	23,027	151,535	6,217	726
				TMDL	28,312	8,668	64,377	3,703	749
				% reduction	62.7	62.4	57.5	40.4	-3.2
SR	WM-97	POP0071	Poplar Lick Run	Baseline	74,767	22,501	88,919	4,750	557
				TMDL	27,664	8,342	28,848	2,823	583
				% reduction	63.0	62.9	67.6	40.6	-4.8
WC	WM-33	UJN0005	UT to Jennings Run	Baseline	6,626	15,345	81,770	2,308	635
				TMDL	133	317	1,511	1,011	668
				% reduction	98.0	97.9	98.2	56.2	-5.2
WC	WM-34	UJH0015	UT to Jennings Run	Baseline	21,650	47,307	119,484	13,171	3,310
				TMDL	217	516	923	5,978	3,321
				% reduction	99.0	98.9	99.2	54.6	-0.3
WC	WM-37	UJF0002	UT to Jennings Run	Baseline	14,763	33,199	209,447	4,989	1,317
				TMDL	295	725	3,960	2,367	1,347
				% reduction	98.0	97.8	98.1	52.6	-2.2

Table 5-3. (continued)

Basin	Station	Station code	Station name	Load	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
WC	WM-39	JEN0092	Jennings Run	Baseline	56,814	131,112	649,571	19,522	5,311
				TMDL	1,704	25,535	18,044	8,823	5,519
				% reduction	97.0	80.5	97.2	54.8	-3.9
WC	WM-41[j]	UJH0011	UT to Jennings Run	Baseline	35,810	80,138	298,812	18,008	4,656
				TMDL	358	865	2,585	8,113	4,738
				% reduction	99.0	98.9	99.1	54.9	-1.7

Notes:

CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek

[a] WM-141 includes upstream loads from WM-137.

[b] WM-142 includes upstream loads from WM-145 and WM-151.

[c] WM-145 includes upstream loads from WM-148.

[d] WM-148 includes upstream loads from WM-147 and WM-149.

[e] WM-113 includes upstream loads from WM-118 and WM-125.

[f] WM-119 includes upstream loads from WM-120.

[g] WM-50 includes upstream loads from WM-64.

[h] WM-73 includes upstream loads from WM-78.

[i] WM-96 includes upstream loads from WM-97.

[j] WM-41 includes upstream loads from WM-34.

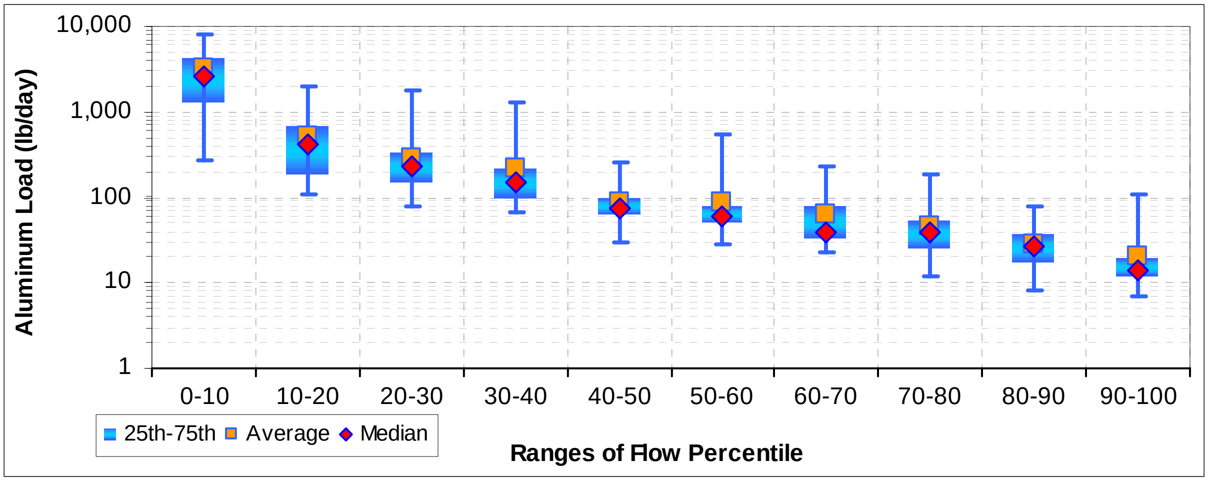

Figure 5-1. Aluminum loads by flow percentile for Laurel Run (WM-67/LRE0029).

Table 5-4. TMDL maximum daily iron loads by flow percentile range (lb/d)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-33	UJN0005	UT to Jennings Run	510	701	275	136	286	241	63	41	1	9
WM-34	UJH0015	UT to Jennings Run	2,960	348	129	90	648	361	64	4	3	2
WM-37	UJF0002	UT to Jennings Run	1,985	1,102	438	246	543	317	86	58	3	13
WM-39	JEN0092	Jennings Run	14,625	9,053	4,203	1,325	1,685	2,416	784	532	16	207
WM-41a	UJH0011	UT to Jennings Run	3,318	1,039	438	230	852	600	99	48	3	11
WM-42	TFR0021	Three Forks Run	4,448	913	1,054	449	213	458	213	245	92	129
WM-43	WOL0004	Wolfden Run	46,683	11,189	12,178	6,410	2,246	3,498	2,032	2,109	800	1,176

Table 5-4. (continued)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-45	EKL0003	Elklick Run	4,004	802	1,529	535	134	553	260	363	132	188
WM-48	RTF0005	Right Prong Three Forks Run	12,111	1,334	3,165	410	154	897	182	178	83	70
WM-50b	NPL0001	North Prong Lostland Run	21,017	5,153	4,629	2,900	1,116	1,545	825	756	409	427
WM-51	SPL0016	South Prong Lostland Run	6,765	1,602	1,613	1,060	351	621	295	295	135	162
WM-54	TFR0016	Three Forks Run	19,111	2,870	4,684	1,095	493	1,708	481	506	252	248
WM-55	ZWT0000	UT to Three Forks Run	3,718	241	928	115	43	177	54	28	16	11
WM-60	SHO0016	Short Run	8,104	2,127	1,081	1,141	459	305	257	212	163	108
WM-61	LNB0014	Laurel Run	26,751	4,849	5,549	2,799	1,018	3,186	1,338	679	373	255
WM-62	ULF0003	UT to Laurel Run	26,252	4,811	5,424	2,782	1,010	3,156	1,329	674	370	253
WM-64	NPL0018	North Prong Lostland Run	13,167	3,321	2,986	2,098	708	1,018	549	511	264	288
WM-67	LRE0029	Laurel Run	5,581	1,009	2,284	813	168	708	372	523	191	275
WM-69	GLR0031	Glade Run	8,556	1,910	2,343	1,288	388	788	394	434	162	239
WM-72	ZWV0001	UT to Savage River above Aaron Run	1,586	968	468	273	153	94	73	64	36	15
WM-73[c]	AAR0000	Aaron Run	5,371	951	408	210	142	144	49	82	39	17
WM-77	PYS0024	Pine Swamp Run	79,541	26,824	11,863	8,779	7,222	4,060	2,450	1,859	1,054	748
WM-78	ZWA0000	UT to Aaron Run	288	37	16	24	9	11	3	6	3	1
WM-80	MRR0000	Miller Run	90	62	35	24	16	10	7	6	3	1
WM-81	BRU0048	Big Run	19	11	9	6	5	3	2	2	1	0
WM-86	LSA0028	Little Savage River	474,558	146,427	43,603	43,125	26,842	30,817	11,605	7,133	3,120	2,833
WM-96[d]	POP0065	Poplar Lick Run	141,648	21,768	9,305	14,879	4,677	5,144	1,966	1,592	769	848
WM-97	POP0071	Poplar Lick Run	139,795	21,112	8,844	14,639	4,627	5,117	1,943	1,419	714	718
WM-110	UGQ0000	UT to Georges Creek	8,363	2,523	2,149	1,486	257	1,462	583	823	120	186
WM-111	MIL0001	Mill Run	50,901	30,300	18,389	14,180	957	11,846	4,633	7,584	944	1,449
WM-113[e]	JAC0001	Jackson Run	79,527	43,940	14,137	11,738	5,121	11,266	5,143	5,188	837	1,307
WM-116	MTH0000	Matthew Run	10,679	14,674	6,222	2,095	5,198	4,917	1,142	740	15	139
WM-117	STA0024	Staub Run	4,094	658	161	113	85	16	11	9	6	3
WM-118	UJB0000	UT to Jackson Run	6,629	9,497	4,046	1,384	3,137	3,019	713	469	10	88
WM-119[f]	WBN0002	Winebrenner Run	28,510	118,787	47,847	20,508	22,934	31,515	9,980	7,087	130	1,348
WM-120	WBN0010	Winebrenner Run	17,323	25,490	10,666	3,542	6,860	7,404	1,926	1,331	26	250
WM-122	UMD0000	UT to Moores Run	49,773	10,945	6,904	9,365	725	4,327	1,628	2,699	336	513
WM-125	JAC0006	Jackson Run	78,326	24,263	14,116	11,655	1,563	9,873	4,034	5,185	834	1,305

Table 5-4. (continued)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-135	MDW0008	Meadow Run	8,174	1,842	4,921	453	1,735	840	329	694	1,296	54
WM-137	LLR0024	Little Laurel Run	51	14	7	5	8	5	3	1	2	1
WM-138	SPI0018	Spiker Run	1,579	122	77	50	65	27	18	21	16	5
WM-141[g]	LLR0009	Little Laurel Run	1,624	282	127	105	96	64	43	25	26	11
WM-142[h]	NBC0072	North Branch Casselman River	92,747	11,100	11,221	5,359	16,406	5,800	2,608	2,517	1,961	494
WM-143	SCA0067	South Branch Casselman River	4,144	684	302	246	288	176	106	60	63	27
WM-144	ALE0011	Alexander Run	219	57	28	19	35	21	12	6	6	2
WM-145[i]	NBC0090	North Branch Casselman River	58,372	8,194	7,832	4,277	14,127	5,034	2,135	1,815	1,308	377
WM-146	TAR0003	Tarkiln Run	293	56	27	20	31	18	11	6	6	2
WM-147	PLE0008	Pleasant Valley Run	4,029	538	1,229	121	544	240	80	197	289	14
WM-148[j]	NBC0106	North Branch Casselman River	12,473	1,875	2,953	600	2,937	915	387	597	498	68
WM-149	ZWN0003	UT to North Branch Casselman River	2,826	382	892	97	409	184	55	139	172	10
WM-151	UNA0015	UT to North Branch Casselman River	2,565	207	145	76	154	67	41	39	28	9
WM-155	LSR0015	Little Shade Run	974	249	124	70	127	79	51	26	26	11

Notes:
[a] WM-41 includes upstream loads from WM-34.
[b] WM-50 includes upstream loads from WM-64.
[c] WM-73 includes upstream loads from WM-78.
[d] WM-96 includes upstream loads from WM-97.
[e] WM-113 includes upstream loads from WM-118 and WM-125.
[f] WM-119 includes upstream loads from WM-120.
[g] WM-141 includes upstream loads from WM-137.
[h] WM-142 includes upstream loads from WM-145 and WM-151.
[i] WM-145 includes upstream loads from WM-148.
[j] WM-148 includes upstream loads from WM-147 and WM-149.

Table 5-5. TMDL maximum daily aluminum loads by flow percentile range (lb/d)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-33	UJN0005	UT to Jennings Run	1,184	1,802	633	329	696	616	151	99	3	24
WM-34	UJH0015	UT to Jennings Run	6,986	926	294	239	1,568	987	171	3	2	1
WM-37	UJF0002	UT to Jennings Run	4,607	2,616	1,005	597	1,323	811	207	138	5	35
WM-39	JEN0092	Jennings Run	34,626	24,140	9,638	3,209	1,121,243	6,088	1,890	1,284	36	502

Table 5-5. (continued)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-41[a]	UJH0011	UT to Jennings Run	7,849	2,719	1,007	580	2,067	1,626	262	113	5	28
WM-42	TFR0021	Three Forks Run	9,450	2,022	1,369	791	269	630	244	136	104	57
WM-43	WOL0004	Wolfden Run	110,506	27,040	16,416	14,242	3,321	3,509	2,386	876	558	522
WM-45	EKL0003	Elklick Run	6,207	1,376	1,268	815	207	592	192	160	90	77
WM-48	RTF0005	Right Prong Three Forks Run	15,890	3,805	2,737	1,614	553	1,921	658	294	345	166
WM-50[b]	NPL0001	North Prong Lostland Run	53,400	12,768	7,506	6,981	1,631	2,086	1,131	476	326	198
WM-51	SPL0016	South Prong Lostland Run	17,068	3,920	2,454	2,567	534	913	394	189	165	72
WM-54	TFR0016	Three Forks Run	28,025	6,261	4,551	2,655	940	2,922	1,033	510	563	253
WM-55	ZWT0000	UT to Three Forks Run	5,912	1,109	1,137	537	168	618	229	81	27	18
WM-60	SHO0016	Short Run	26,368	6,491	3,236	3,626	795	575	521	188	133	88
WM-61	LNB0014	Laurel Run	28,098	5,601	5,370	3,473	970	3,629	1,317	463	188	136
WM-62	ULF0003	UT to Laurel Run	27,192	5,416	5,200	3,380	938	3,517	1,277	449	176	129
WM-64	NPL0018	North Prong Lostland Run	34,606	8,320	4,834	5,186	1,075	1,340	761	305	235	131
WM-67	LRE0029	Laurel Run	8,188	1,972	1,782	1,258	254	547	236	183	80	111
WM-69	GLR0031	Glade Run	19,192	4,526	2,938	2,903	598	957	462	201	114	102
WM-72	ZWV0001	UT to Savage River above Aaron Run	5,033	2,711	1,024	432	137	77	60	52	29	12
WM-73[c]	AAR0000	Aaron Run	7,443	4,947	1,822	776	555	783	136	382	127	17
WM-77	PYS0024	Pine Swamp Run	78,897	28,763	9,865	7,389	6,157	3,271	1,250	620	230	163
WM-78	ZWA0000	UT to Aaron Run	416	189	66	34	36	64	10	31	10	1
WM-80	MRR0000	Miller Run	323	178	67	28	10	5	4	3	2	1
WM-81	BRU0048	Big Run	99	52	15	10	2	1	1	1	0	0
WM-86	LSA0028	Little Savage River	429,268	175,663	47,206	45,304	28,023	36,561	11,591	5,099	2,004	1,695
WM-96[d]	POP0065	Poplar Lick Run	37,938	8,450	2,977	3,316	1,843	2,284	729	294	104	120
WM-97	POP0071	Poplar Lick Run	37,222	8,276	2,885	3,260	1,810	2,271	721	270	96	104
WM-110	UGQ0000	UT to Georges Creek	3,441	1,161	1,576	603	106	500	204	280	45	63
WM-111	MIL0001	Mill Run	19,395	11,332	6,632	5,290	408	4,043	1,609	2,522	351	482
WM-113[e]	JAC0001	Jackson Run	34,664	19,202	5,736	5,000	3,154	4,398	1,833	1,764	314	437
WM-116	MTH0000	Matthew Run	5,476	6,511	2,713	969	3,217	1,928	430	298	23	108
WM-117	STA0024	Staub Run	10,822	1,773	402	272	202	13	9	7	5	3
WM-118	UJB0000	UT to Jackson Run	3,426	4,222	1,704	655	1,942	1,184	259	189	15	68
WM-119[f]	WBN0002	Winebrenner Run	14,691	50,451	20,153	8,682	14,161	12,133	3,608	2,842	193	1,085

Table 5-5. (continued)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-120	WBN0010	Winebrenner Run	8,876	11,155	4,653	1,638	4,243	2,886	697	535	40	194
WM-122	UMD0000	UT to Moores Run	22,020	4,917	2,725	3,957	406	1,482	567	918	126	172
WM-125	JAC0006	Jackson Run	34,063	10,880	5,562	4,955	851	3,372	1,401	1,761	311	435
WM-135	MDW0008	Meadow Run	4,197	1,324	650	403	668	213	143	161	166	15
WM-137	LLR0024	Little Laurel Run	116	37	13	11	22	10	4	1	1	0
WM-138	SPI0018	Spiker Run	984	311	106	102	96	45	20	9	8	4
WM-141[g]	LLR0009	Little Laurel Run	2,535	804	277	228	238	121	56	21	22	9
WM-142[h]	NBC0072	North Branch Casselman River	51,296	15,028	5,140	5,486	16,087	6,324	2,208	872	520	162
WM-143	SCA0067	South Branch Casselman River	6,269	1,979	675	535	792	389	160	49	51	22
WM-144	ALE0011	Alexander Run	461	149	54	36	95	44	18	5	5	2
WM-145[i]	NBC0090	North Branch Casselman River	37,687	7,700	2,645	3,443	12,999	4,896	1,608	627	322	80
WM-146	TAR0003	Tarkiln Run	473	152	54	42	85	39	16	5	5	2
WM-147	PLE0008	Pleasant Valley Run	2,258	718	250	242	406	157	65	45	39	8
WM-148[j]	NBC0106	North Branch Casselman River	8,167	1,799	1,201	682	2,733	1,053	360	283	130	23
WM-149	ZWN0003	UT to North Branch Casselman River	1,409	449	169	142	349	139	52	32	24	5
WM-151	UNA0015	UT to North Branch Casselman River	1,536	492	174	139	283	126	52	18	16	6
WM-155	LSR0015	Little Shade Run	2,023	655	237	107	337	156	69	23	22	9

Notes:
[a] WM-41 includes upstream loads from WM-34.
[b] WM-50 includes upstream loads from WM-64.
[c] WM-73 includes upstream loads from WM-78.
[d] WM-96 includes upstream loads from WM-97.
[e] WM-113 includes upstream loads from WM-118 and WM-125.
[f] WM-119 includes upstream loads from WM-120.
[g] WM-141 includes upstream loads from WM-137.
[h] WM-142 includes upstream loads from WM-145 and WM-151.
[i] WM-145 includes upstream loads from WM-148.
[j] WM-148 includes upstream loads from WM-147 and WM-149.

Table 5-6. TMDL maximum daily sulfate loads by flow percentile range (1,000 lb/d)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-33	UJN0005	UT to Jennings Run	10.45	4.57	2.09	1.39	5.03	4.82	0.75	0.22	0.20	0.09
WM-34	UJH0015	UT to Jennings Run	1.97	0.46	1.08	0.19	1.87	4.45	0.82	0.07	0.05	0.04
WM-37	UJF0002	UT to Jennings Run	38.23	6.86	3.45	2.30	9.59	6.36	0.96	0.35	0.32	0.14
WM-39	JEN0092	Jennings Run	99.09	59.56	34.49	18.73	32.78	48.47	7.39	2.84	2.62	1.19
WM-41[a]	UJH0011	UT to Jennings Run	13.42	5.39	2.52	1.75	5.76	9.25	1.53	0.28	0.26	0.11
WM-42	TFR0021	Three Forks Run	134.31	39.42	27.91	22.33	17.39	14.41	11.90	9.92	7.54	4.77
WM-43	WOL0004	Wolfden Run	1,534.00	446.22	281.28	236.51	181.29	138.24	117.62	96.86	74.28	49.25
WM-45	EKL0003	Elklick Run	83.74	23.06	17.72	13.56	10.25	10.68	7.91	6.54	4.87	3.09
WM-48	RTF0005	Right Prong Three Forks Run	2,283.42	720.56	476.87	426.19	198.88	425.92	228.59	143.47	95.54	69.97
WM-50[b]	NPL0001	North Prong Lostland Run	748.76	217.04	142.36	117.74	90.02	70.29	59.99	49.65	37.97	25.05
WM-51	SPL0016	South Prong Lostland Run	234.79	66.29	46.09	37.99	28.16	23.02	19.89	16.43	12.49	8.21
WM-54	TFR0016	Three Forks Run	2,410.69	750.64	499.73	447.43	216.14	441.06	240.03	152.57	102.59	73.53
WM-55	ZWT0000	UT to Three Forks Run	883.94	257.28	161.86	146.05	75.96	134.11	74.29	47.11	32.30	23.17
WM-60	SHO0016	Short Run	366.84	106.78	66.34	56.16	43.13	32.39	27.79	23.07	17.71	11.78
WM-61	LNB0014	Laurel Run	158.23	50.05	33.04	29.63	14.94	28.64	15.78	9.87	6.63	4.65
WM-62	ULF0003	UT to Laurel Run	36.28	12.07	8.26	7.28	3.64	7.13	3.89	2.39	1.59	1.12
WM-64	NPL0018	North Prong Lostland Run	476.98	137.92	90.42	76.90	56.95	45.05	39.06	32.24	24.54	16.12
WM-67	LRE0029	Laurel Run	111.51	31.84	21.31	18.12	13.11	10.88	9.36	7.51	5.69	3.73
WM-69	GLR0031	Glade Run	261.70	74.13	50.05	42.59	31.06	24.85	21.19	17.38	13.29	8.89
WM-72	ZWV0001	UT to Savage River above Aaron Run	75.70	54.64	33.54	24.13	16.21	9.95	7.82	6.79	3.81	1.63
WM-73[c]	AAR0000	Aaron Run	1,074.31	1,081.69	548.01	326.37	206.45	161.69	97.21	105.30	60.54	34.97
WM-77	PYS0024	Pine Swamp Run	128.81	76.63	39.58	28.59	23.68	14.96	9.73	8.07	4.89	3.46
WM-78	ZWA0000	UT to Aaron Run	55.67	41.64	21.84	15.39	12.51	11.78	5.90	7.48	4.03	2.13
WM-80	MRR0000	Miller Run	24.35	17.59	10.75	7.73	5.48	3.43	2.41	2.05	1.19	0.50
WM-81	BRU0048	Big Run	2.63	1.42	1.03	0.68	0.52	0.33	0.24	0.20	0.11	0.06
WM-86	LSA0028	Little Savage River	63.05	48.87	16.87	16.45	11.75	12.10	5.16	3.11	1.73	0.91
WM-96[d]	POP0065	Poplar Lick Run	64.07	37.87	19.95	13.95	12.36	10.05	5.74	4.21	2.16	1.24

Table 5-6. (continued)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-97	POP0071	Poplar Lick Run	37.26	21.79	9.30	9.27	6.88	6.85	2.95	1.79	0.91	0.52
WM-110	UGQ0000	UT to Georges Creek	13.88	4.89	3.94	2.25	0.54	1.87	1.41	1.12	0.34	0.50
WM-111	MIL0001	Mill Run	94.37	60.28	31.11	20.88	2.38	19.12	11.11	10.16	2.51	3.88
WM-113[e]	JAC0001	Jackson Run	132.64	73.00	28.01	22.12	22.65	47.57	16.04	7.40	2.62	3.55
WM-116	MTH0000	Matthew Run	31.58	24.93	12.79	7.78	22.67	31.42	4.56	1.07	0.92	0.39
WM-117	STA0024	Staub Run	6.03	3.83	2.49	1.33	0.78	0.63	0.45	0.35	0.23	0.13
WM-118	UJB0000	UT to Jackson Run	20.04	16.30	7.44	5.10	13.70	19.33	3.25	0.70	0.60	0.25
WM-119[f]	WBN0002	Winebrenner Run	84.72	190.29	86.03	61.46	99.09	201.72	31.75	8.62	7.06	3.60
WM-120	WBN0010	Winebrenner Run	51.06	42.91	21.77	13.55	29.90	47.35	7.17	1.86	1.57	0.69
WM-122	UMD0000	UT to Moores Run	84.81	18.47	12.90	16.65	2.93	7.50	3.99	3.78	1.02	1.40
WM-125	JAC0006	Jackson Run	129.50	40.55	25.99	21.46	5.97	12.69	9.73	7.21	2.43	3.53
WM-135	MDW0008	Meadow Run	57.85	24.87	14.15	12.33	10.79	8.56	6.07	4.49	5.76	1.92
WM-137	LLR0024	Little Laurel Run	1.42	0.67	0.42	0.31	0.39	0.28	0.21	0.13	0.13	0.05
WM-138	SPI0018	Spiker Run	13.63	5.89	3.37	3.00	2.44	2.09	1.45	1.02	1.07	0.46
WM-141[g]	LLR0009	Little Laurel Run	35.46	15.60	9.08	7.51	6.23	5.37	4.03	2.69	2.81	1.18
WM-142[h]	NBC0072	North Branch Casselman River	421.76	185.77	108.21	90.26	97.06	67.84	48.50	31.91	32.81	13.74
WM-143	SCA0067	South Branch Casselman River	86.95	37.52	21.42	17.81	16.89	12.86	9.44	6.41	6.72	2.87
WM-144	ALE0011	Alexander Run	7.29	3.56	2.26	1.55	2.10	1.53	1.14	0.68	0.70	0.26
WM-145[i]	NBC0090	North Branch Casselman River	94.44	41.53	24.18	21.82	31.65	18.57	11.33	7.11	7.07	2.99
WM-146	TAR0003	Tarkiln Run	7.11	3.32	2.03	1.53	1.83	1.33	0.99	0.62	0.64	0.24
WM-147	PLE0008	Pleasant Valley Run	33.93	15.23	9.02	7.58	7.59	5.46	4.04	2.76	2.80	1.14
WM-148[j]	NBC0106	North Branch Casselman River	55.23	24.88	14.80	12.22	13.75	9.33	6.64	4.52	4.53	1.84
WM-149	ZWN0003	UT to North Branch Casselman River	20.50	9.31	5.57	4.44	5.49	3.60	2.46	1.62	1.64	0.66

Table 5-6. (continued)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-151	UNA0015	UT to North Branch Casselman River	23.96	11.11	6.77	5.14	6.12	4.45	3.30	2.08	2.15	0.80
WM-155	LSR0015	Little Shade Run	34.15	16.57	10.49	6.67	8.71	6.63	5.09	2.96	3.04	1.22

Notes:
[a] WM-41 includes upstream loads from WM-34.
[b] WM-50 includes upstream loads from WM-64.
[c] WM-73 includes upstream loads from WM-78.
[d] WM-96 includes upstream loads from WM-97.
[e] WM-113 includes upstream loads from WM-118 and WM-125.
[f] WM-119 includes upstream loads from WM-120.
[g] WM-141 includes upstream loads from WM-137.
[h] WM-142 includes upstream loads from WM-145 and WM-151.
[i] WM-145 includes upstream loads from WM-148.
[j] WM-148 includes upstream loads from WM-147 and WM-149.

Table 5-7. TMDL maximum daily nitrate loads flow percentile range (lb/d)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-33	UJN0005	UT to Jennings Run	3,513	935	4,234	385	4,836	15,286	2,628	265	186	6
WM-34	UJH0015	UT to Jennings Run	18,355	1,916	43,162	809	40,723	66,637	15,084	162	186	34
WM-37	UJF0002	UT to Jennings Run	8,463	1,293	8,135	526	9,007	20,065	3,162	381	271	15
WM-39	JEN0092	Jennings Run	25,924	11,965	37,024	3,663	31,807	101,577	18,363	3,758	1,621	52
WM-41[a]	UJH0011	UT to Jennings Run	21,448	2,414	53,022	1,085	49,715	96,961	19,843	708	469	41
WM-42	TFR0021	Three Forks Run	15,060	4,264	2,022	2,090	571	1,435	680	703	372	234
WM-43	WOL0004	Wolfden Run	33,200	9,451	4,799	4,198	1,187	1,767	1,345	1,128	419	424
WM-45	EKL0003	Elklick Run	9,252	2,738	1,398	1,510	375	1,117	527	496	243	205
WM-48	RTF0005	Right Prong Three Forks Run	17,768	7,791	4,970	5,476	1,012	3,725	1,530	895	919	536
WM-50[b]	NPL0001	North Prong Lostland Run	35,724	10,242	5,055	4,737	1,321	2,377	1,478	1,366	597	475
WM-51	SPL0016	South Prong Lostland Run	17,397	4,982	2,452	2,463	659	1,476	769	745	354	264
WM-54	TFR0016	Three Forks Run	32,888	12,081	6,678	7,586	1,587	5,173	2,208	1,480	1,297	773
WM-55	ZWT0000	UT to Three Forks Run	1,775	757	395	459	93	312	132	55	26	24
WM-60	SHO0016	Short Run	7,432	2,092	1,010	937	275	376	286	258	99	86
WM-61	LNB0014	Laurel Run	10,972	4,947	3,025	3,205	632	2,279	950	397	211	191
WM-62	ULF0003	UT to Laurel Run	9,850	4,442	2,729	2,880	568	2,055	856	353	173	167

Table 5-7. (continued)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-64	NPL0018	North Prong Lostland Run	23,974	6,757	3,380	3,230	869	1,585	1,001	936	404	330
WM-67	LRE0029	Laurel Run	4,493	1,349	709	672	173	350	247	188	70	92
WM-69	GLR0031	Glade Run	11,576	3,340	1,658	1,630	435	883	509	444	184	173
WM-72	ZWV0001	UT to Savage River above Aaron Run	7,406	2,969	1,121	664	455	315	133	152	117	17
WM-73[c]	AAR0000	Aaron Run	6,490	4,805	1,856	677	1,116	2,250	274	1,142	192	34
WM-77	PYS0024	Pine Swamp Run	7,326	3,100	944	763	1,229	349	140	178	64	22
WM-78	ZWA0000	UT to Aaron Run	593	269	131	88	118	317	32	179	18	4
WM-80	MRR0000	Miller Run	2,682	1,035	382	245	162	102	40	42	41	5
WM-81	BRU0048	Big Run	609	216	53	30	26	18	7	12	9	1
WM-86	LSA0028	Little Savage River	13,226	5,007	2,211	1,867	2,322	1,344	428	142	42	28
WM-96[d]	POP0065	Poplar Lick Run	9,705	3,712	1,190	1,233	1,541	817	266	246	107	244
WM-97	POP0071	Poplar Lick Run	7,795	2,891	1,002	1,092	1,335	742	235	167	71	92
WM-110	UGQ0000	UT to Georges Creek	16,803	7,364	4,717	2,488	557	1,834	1,762	621	237	521
WM-111	MIL0001	Mill Run	10,959	2,898	2,221	2,610	376	2,943	2,332	794	201	672
WM-113[e]	JAC0001	Jackson Run	21,743	8,016	4,430	3,397	14,810	88,919	13,466	2,624	1,257	377
WM-116	MTH0000	Matthew Run	10,048	3,306	1,347	1,177	11,665	53,855	5,825	1,014	566	18
WM-117	STA0024	Staub Run	719	433	260	106	38	17	8	6	9	1
WM-118	UJB0000	UT to Jackson Run	6,634	2,141	1,010	752	7,059	33,270	5,175	653	362	12
WM-119[f]	WBN0002	Winebrenner Run	35,518	19,204	3,642	7,134	32,646	214,782	25,237	5,862	3,166	73
WM-120	WBN0010	Winebrenner Run	14,152	5,213	1,863	1,841	13,466	71,145	8,038	1,588	884	22
WM-122	UMD0000	UT to Moores Run	9,933	4,632	2,744	2,227	623	2,392	843	299	187	247
WM-125	JAC0006	Jackson Run	9,624	4,927	3,051	1,833	731	1,968	1,203	429	116	369
WM-135	MDW0008	Meadow Run	14,864	4,567	9,520	12,040	13,644	566	597	601	3,389	31
WM-137	LLR0024	Little Laurel Run	500	155	50	33	70	31	12	20	12	0
WM-138	SPI0018	Spiker Run	7,836	2,408	757	595	589	283	114	246	146	3
WM-141[g]	LLR0009	Little Laurel Run	8,623	2,660	842	608	773	377	155	301	183	4

Table 5-7. (continued)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-142[h]	NBC0072	North Branch Casselman River	49,200	15,153	4,790	3,781	13,108	2,947	1,092	1,914	1,061	25
WM-143	SCA0067	South Branch Casselman River	11,331	3,489	1,101	764	1,147	543	213	378	231	5
WM-144	ALE0011	Alexander Run	2,729	851	276	176	480	215	85	132	79	3
WM-145[i]	NBC0090	North Branch Casselman River	27,143	8,352	3,135	2,333	10,636	1,781	642	1,090	866	14
WM-146	TAR0003	Tarkiln Run	2,231	692	221	156	326	148	58	97	58	2
WM-147	PLE0008	Pleasant Valley Run	17,168	5,291	1,674	1,325	6,336	890	342	706	810	11
WM-148[j]	NBC0106	North Branch Casselman River	21,641	6,671	2,381	1,680	9,271	1,216	458	913	846	13
WM-149	ZWN0003	UT to North Branch Casselman River	4,093	1,262	834	1,270	2,376	250	91	153	84	4
WM-151	UNA0015	UT to North Branch Casselman River	9,775	3,021	962	644	1,390	623	239	421	243	6
WM-155	LSR0015	Little Shade Run	11,155	3,472	1,121	489	1,745	796	311	468	278	9

Notes:
[a] WM-41 includes upstream loads from WM-34.
[b] WM-50 includes upstream loads from WM-64.
[c] WM-73 includes upstream loads from WM-78.
[d] WM-96 includes upstream loads from WM-97.
[e] WM-113 includes upstream loads from WM-118 and WM-125.
[f] WM-119 includes upstream loads from WM-120.
[g] WM-141 includes upstream loads from WM-137.
[h] WM-142 includes upstream loads from WM-145 and WM-151.
[i] WM-145 includes upstream loads from WM-148.
[j] WM-148 includes upstream loads from WM-147 and WM-149.

Table 5-8. TMDL maximum daily ammonium loads flow percentile range (lb/d)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-33	UJN0005	UT to Jennings Run	2,469	732	1,678	182	2,498	13,314	1,888	207	273.4	33.7
WM-34	UJH0015	UT to Jennings Run	13,134	899	17,002	339	20,354	64,507	11,289	83	76.2	13.8

Table 5-8. (continued)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-37	UJF0002	UT to Jennings Run	8,870	1,009	3,219	248	4,681	17,519	2,311	295	386.2	52.7
WM-39	JEN0092	Jennings Run	26,186	9,237	14,662	1,788	15,219	89,187	13,188	2,130	2,385.7	301.1
WM-41[a]	UJH0011	UT to Jennings Run	18,652	1,766	20,915	426	24,814	90,965	14,786	499	635.9	80.9
WM-42	TFR0021	Three Forks Run	4,127	1,185	845	308	91	312	120	53	45.7	40.9
WM-43	WOL0004	Wolfden Run	9,829	3,009	2,038	888	235	335	191	93	41.2	75.1
WM-45	EKL0003	Elklick Run	2,627	757	616	251	65	261	94	47	34.4	49.7
WM-48	RTF0005	Right Prong Three Forks Run	4,495	1,438	1,314	886	167	952	345	181	180.5	137.9
WM-50[b]	NPL0001	North Prong Lostland Run	10,699	3,200	2,154	996	257	474	208	104	56.0	72.3
WM-51	SPL0016	South Prong Lostland Run	5,186	1,534	1,052	525	131	315	125	58	45.3	41.7
WM-54	TFR0016	Three Forks Run	8,637	2,627	2,163	1,144	258	1,267	466	226	227.2	179.6
WM-55	ZWT0000	UT to Three Forks Run	431	127	124	68	15	74	28	10	2.9	4.0
WM-60	SHO0016	Short Run	2,094	630	404	194	51	62	41	17	8.0	8.6
WM-61	LNB0014	Laurel Run	2,825	893	799	495	106	560	209	72	31.0	38.8
WM-62	ULF0003	UT to Laurel Run	2,521	803	718	442	95	503	187	64	24.4	32.9
WM-64	NPL0018	North Prong Lostland Run	7,183	2,176	1,449	721	179	315	150	72	42.2	50.9
WM-67	LRE0029	Laurel Run	1,331	408	321	139	34	79	33	21	9.8	25.6
WM-69	GLR0031	Glade Run	3,444	1,037	720	352	87	188	78	38	17.7	31.4
WM-72	ZWV0001	UT to Savage River above Aaron Run	2,124	523	192	77	44	21	12	10	4.9	3.3
WM-73[c]	AAR0000	Aaron Run	2,053	904	340	116	159	344	50	168	31.8	3.5
WM-77	PYS0024	Pine Swamp Run	2,265	995	178	243	181	113	39	16	8.1	2.8
WM-78	ZWA0000	UT to Aaron Run	200	57	21	15	17	51	6	27	3.5	0.4
WM-80	MRR0000	Miller Run	721	178	65	29	16	5	3	3	1.1	0.7
WM-81	BRU0048	Big Run	172	69	12	5	3	1	1	1	0.3	0.2

Table 5-8. (continued)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-86	LSA0028	Little Savage River	4,856	1,575	298	627	363	551	170	55	25.5	19.7
WM-96[d]	POP0065	Poplar Lick Run	3,435	1,330	219	411	243	351	110	52	22.8	108.8
WM-97	POP0071	Poplar Lick Run	2,851	1,044	169	377	216	339	105	33	14.8	54.1
WM-110	UGQ0000	UT to Georges Creek	10,489	2,060	2,553	971	304	964	804	508	128.5	814.8
WM-111	MIL0001	Mill Run	6,924	814	1,020	1,015	210	1,534	1,063	653	99.4	1,060.1
WM-113[e]	JAC0001	Jackson Run	18,791	6,148	2,228	1,554	7,602	67,214	8,790	2,074	1,769.2	573.5
WM-116	MTH0000	Matthew Run	9,083	2,609	628	566	6,039	41,330	4,065	795	816.0	79.6
WM-117	STA0024	Staub Run	299	180	108	51	23	9	4	3	3.9	0.5
WM-118	UJB0000	UT to Jackson Run	6,394	1,686	493	361	3,648	25,450	3,342	512	518.4	51.1
WM-119[f]	WBN0002	Winebrenner Run	34,085	15,185	1,934	3,389	16,899	164,129	17,597	4,610	4,675.7	488.7
WM-120	WBN0010	Winebrenner Run	13,038	4,118	881	885	6,969	54,536	5,610	1,248	1,282.8	124.6
WM-122	UMD0000	UT to Moores Run	5,904	1,385	1,448	839	343	1,287	385	239	92.9	375.1
WM-125	JAC0006	Jackson Run	5,681	1,637	1,657	688	404	1,058	550	351	93.4	569.3
WM-135	MDW0008	Meadow Run	4,131	1,266	2,221	2,041	5,250	759	565	458	1,215.8	118.0
WM-137	LLR0024	Little Laurel Run	142	44	14	11	13	5	2	2	0.7	0.1
WM-138	SPI0018	Spiker Run	2,183	669	210	202	185	35	17	22	15.7	1.6
WM-141[g]	LLR0009	Little Laurel Run	2,426	744	234	192	114	45	22	23	10.3	1.2
WM-142[h]	NBC0072	North Branch Casselman River	13,687	4,207	1,333	1,252	4,841	613	276	363	406.0	35.9
WM-143	SCA0067	South Branch Casselman River	3,192	978	307	240	186	73	32	29	12.9	1.5
WM-144	ALE0011	Alexander Run	753	233	75	50	76	28	12	10	4.5	0.7
WM-145[i]	NBC0090	North Branch Casselman River	7,563	2,323	735	781	3,943	495	240	296	344.6	33.8

Table 5-8. (continued)

Station	Station code	Station name	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
WM-146	TAR0003	Tarkiln Run	621	191	61	48	53	19	9	8	3.2	0.5
WM-147	PLE0008	Pleasant Valley Run	4,830	1,486	472	443	2,403	314	187	205	299.4	30.8
WM-148[j]	NBC0106	North Branch Casselman River	6,062	1,866	592	561	3,443	429	222	266	314.0	32.8
WM-149	ZWN0003	UT to North Branch Casselman River	1,129	347	187	214	902	108	35	60	58.5	3.1
WM-151	UNA0015	UT to North Branch Casselman River	2,723	840	269	207	259	92	40	39	18.7	2.2
WM-155	LSR0015	Little Shade Run	3,110	965	313	126	329	122	54	42	18.6	2.7

Notes:
[a] WM-41 includes upstream loads from WM-34.
[b] WM-50 includes upstream loads from WM-64.
[c] WM-73 includes upstream loads from WM-78.
[d] WM-96 includes upstream loads from WM-97.
[e] WM-113 includes upstream loads from WM-118 and WM-125.
[f] WM-119 includes upstream loads from WM-120.
[g] WM-141 includes upstream loads from WM-137.
[h] WM-142 includes upstream loads from WM-145 and WM-151.
[i] WM-145 includes upstream loads from WM-148.
[j] WM-148 includes upstream loads from WM-147 and WM-149.

5.3.1 Wasteload Allocations

Federal regulations (40 CFR 130.7) require TMDLs to include individual WLAs for each point source. On the basis of the types of activities and the minimal flow of the discharges, these permitted non-mining sources are believed to be negligible. Under these TMDLs, these minor discharges are assumed to operate under their current permit limits and are assigned WLAs that allow them to discharge at their current permit limits. Table 5-9 presents the WLAs for each point source. It was assumed that if a parameter limit was not in the permit, the present discharge levels were not adversely affecting the stream.

Table 5-9. WLAs for permitted facilities upstream of impaired segments

Basin	NPDES permit number	Outlet	Permittee	Station	Station code	Station name	Flow (mgd)	Iron (lb/yr)	Alum-inum (lb/yr)	Sulfate (lb/yr)
GC	MDG852802	001	Caledonia Hill Mine - Star Mining, Inc.	WM-111	MIL0001	Mill Run	0.00011	1.01	--	--
GC	MDG852802	003	Caledonia Hill Mine - Star Mining, Inc.	WM-111	MIL0001	Mill Run	0.000967	8.84	--	--
GC	MDG852802	006	Caledonia Hill Mine - Star Mining, Inc.	WM-111	MIL0002	Mill Run	0.000081	0.74	--	--

Table 5-9. (continued)

Basin	NPDES permit number	Outlet	Permittee	Station	Station code	Station name	Flow (mgd)	Iron (lb/yr)	Alum-inum (lb/yr)	Sulfate (lb/yr)
GC	MDG852802	007	Caledonia Hill Mine - Star Mining, Inc.	WM-111	MIL0003	Mill Run	0.000072	0.66	--	--
GC	MDG852802	008	Caledonia Hill Mine - Star Mining, Inc.	WM-111	MIL0004	Mill Run	0.00012	1.10	--	--
GC	MDG852802	009	Caledonia Hill Mine - Star Mining, Inc.	WM-111	MIL0005	Mill Run	0.00018	1.64	--	--
GC	MDG852802	010	Caledonia Hill Mine - Star Mining, Inc.	WM-111	MIL0006	Mill Run	0.000165	1.51	--	--
GC	MDG852802	013	Caledonia Hill Mine - Star Mining, Inc.	WM-111	MIL0007	Mill Run	0.000015	0.14	--	--
GC	MDG852802	014	Caledonia Hill Mine - Star Mining, Inc.	WM-111	MIL0001	Mill Run	0	--	--	--
GC	MDG852427	001	Barton Mining Company (Mine #1)	WM-110	UGQ0000	UT to Georges Creek	0.00005	0.46	--	--
GC	MDG852427	002	Barton Mining Company (Mine #1)	WM-110	UGQ0000	UT to Georges Creek	0.00015	1.37	--	--
GC	MDG852427	003	Barton Mining Company (Mine #1)	WM-110	UGQ0000	UT to Georges Creek	0.00015	1.37	--	--
GC	MDG852427	004	Barton Mining Company (Mine #1)	WM-110	UGQ0000	Moores Run	0	--	--	--
GC	MD0066958	001	Midlothian Water Treatment Plant	WM-119	WBN0002	Winebrenner Run	0.001	6.09	--	--
GC	MDG852161	001	Fairview Coal Company Inc	WM-119	WBN0002	Winebrenner Run	0	--	--	--
GC	MDG852161	002	Fairview Coal Company Inc	WM-119	WBN0002	Winebrenner Run	0	--	--	--
GC	MDG852161	003	Fairview Coal Company Inc	WM-120	WBN0010	Winebrenner Run	0	--	--	--
GC	MDG499890	001	Tri-Star Mining Quarry Operation	WM-111	MIL0001	Mill Run	0	--	--	--
GC	MDG499890	002	Tri-Star Mining Quarry Operation	WM-111	MIL0001	Mill Run	0	--	--	--
GC	MDG499890	003	Tri-Star Mining Quarry Operation	WM-111	MIL0001	Mill Run	0.000735	--	--	--
PR	MDG859602	001	C Mine Surface Mine - Mettiki Coal, Inc	WM-61	LNB0014	Laurel Run	0	--	--	--
PR	MDG859602	002	C Mine Surface Mine - Mettiki Coal, Inc	WM-61	LNB0014	Laurel Run	0.001	9.14	--	--

Table 5-9. (continued)

Basin	NPDES permit number	Outlet	Permittee	Station	Station code	Station name	Flow (mgd)	Iron (lb/yr)	Alum-inum (lb/yr)	Sulfate (lb/yr)
PR	MDG859602	003	C Mine Surface Mine - Mettiki Coal, Inc	WM-61	LNB0014	Laurel Run	0	--	--	--
PR	MDG859602	004	C Mine Surface Mine - Mettiki Coal, Inc	WM-61	LNB0014	Laurel Run	0	--	--	--
PR	MDG859615	001	LAOC Corporation - Paugh Tract Mine	WM-50	NPL0001	North Prong Lostland Run	0	--	--	--
PR	MDG859613	002	Island Tract Surface Mine - Vindex Energy Corporation	WM-42	TFR0021	Three Forks Run	0.000025	0.23	--	--
PR	MDG859613	003	Island Tract Surface Mine - Vindex Energy Corporation	WM-42	TFR0021	Three Forks Run	0	--	--	--
PR	MDG859613	001	Island Tract Surface Mine - Vindex Energy Corporation	WM-48	RTF0005	Right Prong Three Forks Run	0.00005	0.46	--	--
PR	MDG859613	004	Island Tract Surface Mine - Vindex Energy Corporation	WM-48	RTF0005	Right Prong Three Forks Run	0	--	--	--
SR	MD0068691	001	Georges Creek Inc.	WM-78	ZWA0000	UT to Aaron Run	0.0020	18.28	--	--

Notes:
CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River;

Because the permits do not have limits for all parameters, during model development an analysis was performed on other data in PCS to see if these data had an affect on pH. The PCS database was searched for permits with the same Standard Industrial Classification (SIC) codes as the permits in the model. Average flow and loads from these facilities were used to calculate average effluent concentrations by SIC code. Additional information was obtained from EPA's national recommended water quality criteria (USEPA 2006). No effect was observed; therefore, these concentrations were not used in the final model.

5.3.2 Load Allocations

The LA is that portion of the TMDL that is assigned to nonpoint sources. LAs were first applied to atmospheric deposition. These TMDL loads are based on the 2020 predictions under the CAIR regulation from EPA's Office of Air Quality Planning and Standards at Research Triangle Park, North Carolina. After these future loads were applied to the model, the loads from known mining seeps and portals were reduced. If further reductions were required, the loads from other nonpoint sources were reduced. These loads were applied to the whole watershed and not a specific nonpoint source or land use.

Table 5-10 presents total annual load allocations at the monitoring locations, as the stream leaves the watershed. Note that the loads in these tables include atmospheric deposition loads, which are also presented separately in Table 5-11 (but as direct inputs to the land surface rather than as the stream leaves the watershed). Atmospheric deposition reductions were not found to have a significant impact on predicted pH in the watershed. The loads in Table 5-10 include background concentration and atmospheric loads that have gone through chemical reactions. These loads also include loads from mine seeps, which are presented in Table 5-12. These loads represent a 99 percent reduction in flow and pollutant concentration levels for the mine seeps.

Table 5-10. LAs for iron, aluminum, sulfate, nitrate, and ammonium yearly loads

Basin	Station	Station code	Station name	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammonium (lb/yr)
CR	WM-135	MDW0008	Meadow Run	1,447	1,064	31,932	3,480	1,037
CR	WM-137	LLR0024	Little Laurel Run	14	26	840	83	18
CR	WM-138	SPI0018	Spiker Run	150	217	7,252	1,205	286
CR	WM-141[a]	LLR0009	Little Laurel Run	278	519	18,962	1,329	291
CR	WM-142[b]	NBC0072	North Branch Casselman River	16,981	12,882	234,888	8,859	2,190
CR	WM-143	SCA0067	South Branch Casselman River	703	1,310	46,958	1,775	389
CR	WM-144	ALE0011	Alexander Run	57	100	4,394	479	96
CR	WM-145[c]	NBC0090	North Branch Casselman River	13,131	7,907	55,999	5,232	1,347
CR	WM-146	TAR0003	Tarkiln Run	57	103	4,129	376	78
CR	WM-147	PLE0008	Pleasant Valley Run	543	561	19,108	3,089	803
CR	WM-148[d]	NBC0106	North Branch Casselman River	2,543	1,900	31,737	4,036	1,049
CR	WM-149	ZWN0003	UT to North Branch Casselman River	381	364	11,991	824	217
CR	WM-151	UNA0015	UT to North Branch Casselman River	261	346	14,022	1,685	394
CR	WM-155	LSR0015	Little Shade Run	239	409	19,996	1,824	383
GC	WM-110	UGQ0000	UT to Georges Creek	1,100	501	3,242	3,891	1,514
GC	WM-111	MIL0001	Mill Run	8,368	3,229	18,852	2,181	899
GC	WM-113[e]	JAC0001	Jackson Run	11,446	5,122	40,857	8,231	4,101
GC	WM-116	MTH0000	Matthew Run	2,038	1,049	9,593	3,084	1,778
GC	WM-117	STA0024	Staub Run	314	728	3,533	210	81
GC	WM-118	UJB0000	UT to Jackson Run	1,282	667	6,427	2,081	1,177
GC	WM-119[f]	WBN0002	Winebrenner Run	14,197	6,581	43,974	9,759	6,363
GC	WM-120	WBN0010	Winebrenner Run	3,392	1,716	15,183	4,189	2,437
GC	WM-122	UMD0000	UT to Moores Run	5,221	2,295	17,304	3,573	1,316
GC	WM-125	JAC0006	Jackson Run	8,980	3,903	31,370	3,937	1,455
PR	WM-42	TFR0021	Three Forks Run	1,724	3,031	98,993	5,414	964
PR	WM-43	WOL0004	Wolfden Run	18,911	35,795	1,042,429	12,179	2,257
PR	WM-45	EKL0003	Elklick Run	1,246	2,031	59,693	3,440	637
PR	WM-48	RTF0005	Right Prong Three Forks Run	1,372	3,625	1,244,350	6,618	1,302
PR	WM-50[g]	NPL0001	North Prong Lostland Run	9,054	17,448	517,583	13,196	2,443
PR	WM-51	SPL0016	South Prong Lostland Run	2,890	5,586	161,641	6,438	1,201
PR	WM-54	TFR0016	Three Forks Run	3,893	7,348	1,345,541	12,055	2,270
PR	WM-55	ZWT0000	UT to Three Forks Run	434	1,435	470,712	650	118
PR	WM-60	SHO0016	Short Run	3,616	8,451	247,332	2,727	474

Table 5-10. (continued)

Basin	Station	Station code	Station name	Iron (lb/yr)	Alum-inum (lb/yr)	Sulfate (lb/yr)	Nitrate (lb/yr)	Ammon-ium (lb/yr)
PR	WM-61	LNB0014	Laurel Run	7,765	7,296	91,327	4,205	790
PR	WM-62	ULF0003	UT to Laurel Run	7,700	7,060	21,740	3,777	706
PR	WM-64	NPL0018	North Prong Lostland Run	5,782	11,265	326,461	8,792	1,644
PR	WM-67	LRE0029	Laurel Run	1,685	2,728	76,171	1,672	317
PR	WM-69	GLR0031	Glade Run	3,312	6,264	177,803	4,271	808
SR	WM-72	ZWV0001	UT to Savage River above Aaron Run	910	1,615	74,432	2,248	364
SR	WM-73[h]	AAR0000	Aaron Run	747	2,048	953,471	2,392	415
SR	WM-77	PYS0024	Pine Swamp Run	32,714	25,425	106,854	2,625	490
SR	WM-78	ZWA0000	UT to Aaron Run	41	122	52,643	231	42
SR	WM-80	MRR0000	Miller Run	73	106	23,511	765	117
SR	WM-81	BRU0048	Big Run	20	35	2,392	163	28
SR	WM-86	LSA0028	Little Savage River	109,634	100,322	42,278	4,169	839
SR	WM-96[i]	POP0065	Poplar Lick Run	24,065	7,368	54,720	3,148	637
SR	WM-97	POP0071	Poplar Lick Run	23,514	7,091	24,521	2,400	496
WC	WM-33	UJN0005	UT to Jennings Run	113	269	1,285	859	568
WC	WM-34	UJH0015	UT to Jennings Run	184	438	785	5,081	2,823
WC	WM-37	UJF0002	UT to Jennings Run	251	616	3,366	2,012	1,145
WC	WM-39	JEN0092	Jennings Run	1,449	21,705	15,338	7,499	4,691
WC	WM-41[j]	UJH0011	UT to Jennings Run	304	735	2,198	6,896	4,027

Notes:
CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek

[a] WM-41 includes upstream loads from WM-34.
[b] WM-50 includes upstream loads from WM-64.
[c] WM-73 includes upstream loads from WM-78.
[d] WM-96 includes upstream loads from WM-97.
[e] WM-113 includes upstream loads from WM-118 and WM-125.
[f] WM-119 includes upstream loads from WM-120.
[g] WM-141 includes upstream loads from WM-137.
[h] WM-142 includes upstream loads from WM-145 and WM-151.
[i] WM-145 includes upstream loads from WM-148.
[j] WM-148 includes upstream loads from WM-147 and WM-149.

Table 5-11. Projected (2020) yearly loads from atmospheric deposition for TMDL scenario

Basin	Station	Station code	Station name	Dry (lb/yr)			Wet (lb/yr)		
				Sulfate	Nitrate	Ammon-ium	Sulfate	Nitrate	Ammon-ium
CR	WM-135	MDW0008	Meadow Run	11,318	108	1,314	13,214	6,045	2,518
CR	WM-137	LLR0024	Little Laurel Run	812	8	94	948	434	181
CR	WM-138	SPI0018	Spiker Run	5,563	53	646	6,495	2,972	1,238
CR	WM-141[a]	LLR0009	Little Laurel Run	9,196	88	1,068	10,736	4,912	2,046
CR	WM-142[b]	NBC0072	North Branch Casselman River	78,744	754	9,145	91,933	42,061	17,518
CR	WM-143	SCA0067	South Branch Casselman River	11,492	110	1,335	13,416	6,138	2,556
CR	WM-144	ALE0011	Alexander Run	3,286	31	382	3,837	1,755	731

Table 5-11. (continued)

Basin	Station	Station code	Station name	Dry (lb/yr)			Wet (lb/yr)		
				Sulfate	Nitrate	Ammonium	Sulfate	Nitrate	Ammonium
CR	WM-145[c]	NBC0090	North Branch Casselman River	47,326	453	5,496	55,252	25,279	10,528
CR	WM-146	TAR0003	Tarkiln Run	2,512	24	292	2,933	1,342	559
CR	WM-147	PLE0008	Pleasant Valley Run	11,131	107	1,293	12,996	5,946	2,476
CR	WM-148[d]	NBC0106	North Branch Casselman River	42,589	408	4,946	49,723	22,749	9,474
CR	WM-149	ZWN0003	UT to North Branch Casselman River	3,271	31	380	3,819	1,747	728
CR	WM-151	UNA0015	UT to North Branch Casselman River	6,432	62	747	7,509	3,436	1,431
CR	WM-155	LSR0015	Little Shade Run	7,882	75	915	9,203	4,210	1,754
GC	WM-110	UGQ0000	UT to Georges Creek	10,627	102	1,234	12,407	5,677	2,364
GC	WM-111	MIL0001	Mill Run	40,378	386	4,689	47,141	21,568	8,983
GC	WM-113[e]	JAC0001	Jackson Run	20,802	199	2,416	24,286	11,111	4,628
GC	WM-116	MTH0000	Matthew Run	8,538	82	992	9,967	4,560	1,899
GC	WM-117	STA0024	Staub Run	6,858	66	796	8,007	3,663	1,526
GC	WM-118	UJB0000	UT to Jackson Run	6,167	59	716	7,200	3,294	1,372
GC	WM-119[f]	WBN0002	Winebrenner Run	15,708	150	1,824	18,339	8,390	3,494
GC	WM-120	WBN0010	Winebrenner Run	11,559	111	1,342	13,495	6,174	2,572
GC	WM-122	UMD0000	UT to Moores Run	11,590	111	1,346	13,531	6,191	2,578
GC	WM-125	JAC0006	Jackson Run	13,534	130	1,572	15,801	7,229	3,011
PR	WM-42	TFR0021	Three Forks Run	11,440	109	1,329	13,356	6,111	2,545
PR	WM-43	WOL0004	Wolfden Run	24,400	234	2,834	28,487	13,033	5,428
PR	WM-45	EKL0003	Elklick Run	6,731	64	782	7,858	3,595	1,497
PR	WM-48	RTF0005	Right Prong Three Forks Run	9,847	94	1,144	11,496	5,260	2,191
PR	WM-50[g]	NPL0001	North Prong Lostland Run	26,430	253	3,069	30,857	14,118	5,880
PR	WM-51	SPL0016	South Prong Lostland Run	12,504	120	1,452	14,598	6,679	2,782
PR	WM-54	TFR0016	Three Forks Run	33,490	321	3,889	39,099	17,889	7,450
PR	WM-55	ZWT0000	UT to Three Forks Run	1,397	13	162	1,631	746	311
PR	WM-60	SHO0016	Short Run	7,282	70	846	8,501	3,890	1,620
PR	WM-61	LNB0014	Laurel Run	44,905	430	5,215	52,426	23,986	9,990
PR	WM-62	ULF0003	UT to Laurel Run	7,644	73	888	8,924	4,083	1,700
PR	WM-64	NPL0018	North Prong Lostland Run	17,308	166	2,010	20,207	9,245	3,850

Table 5-11. (continued)

Basin	Station	Station code	Station name	Dry (lb/yr)			Wet (lb/yr)		
				Sulfate	Nitrate	Ammonium	Sulfate	Nitrate	Ammonium
PR	WM-67	LRE0029	Laurel Run	3,278	31	381	3,827	1,751	729
PR	WM-69	GLR0031	Glade Run	8,259	79	959	9,642	4,412	1,837
SR	WM-72	ZWV0001	UT to Savage River above Aaron Run	14,189	136	1,648	16,566	7,579	3,157
SR	WM-73[h]	AAR0000	Aaron Run	18,808	180	2,184	21,958	10,046	4,184
SR	WM-77	PYS0024	Pine Swamp Run	8,482	81	985	9,903	4,531	1,887
SR	WM-78	ZWA0000	UT to Aaron Run	3,861	37	448	4,508	2,062	859
SR	WM-80	MRR0000	Miller Run	7,685	74	892	8,972	4,105	1,710
SR	WM-81	BRU0048	Big Run	3,101	30	360	3,621	1,657	690
SR	WM-86	LSA0028	Little Savage River	11,576	111	1,344	13,515	6,184	2,575
SR	WM-96[i]	POP0065	Poplar Lick Run	9,851	94	1,144	11,501	5,262	2,191
SR	WM-97	POP0071	Poplar Lick Run	6,836	65	794	7,981	3,652	1,521
WC	WM-33	UJN0005	UT to Jennings Run	1,156	11	134	1,349	617	257
WC	WM-34	UJH0015	UT to Jennings Run	10,514	101	1,221	12,275	5,616	2,339
WC	WM-37	UJF0002	UT to Jennings Run	5,706	55	663	6,662	3,048	1,269
WC	WM-39	JEN0092	Jennings Run	13,099	125	1,521	15,293	6,997	2,914
WC	WM-41[j]	UJH0011	UT to Jennings Run	13,261	127	1,540	15,482	7,083	2,950

Notes:
CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek
[a] WM-41 includes upstream loads from WM-34.
[b] WM-50 includes upstream loads from WM-64.
[c] WM-73 includes upstream loads from WM-78.
[d] WM-96 includes upstream loads from WM-97.
[e] WM-113 includes upstream loads from WM-118 and WM-125.
[f] WM-119 includes upstream loads from WM-120.
[g] WM-141 includes upstream loads from WM-137.
[h] WM-142 includes upstream loads from WM-145 and WM-151.
[i] WM-145 includes upstream loads from WM-148.
[j] WM-148 includes upstream loads from WM-147 and WM-149.

Table 5-12. Yearly loads from mine seeps and portals

Basin	Mine seep or portal	Associated Station	Associated station code	Associated station name	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)
CR	GR-15-P2	WM-138	SPI0018	Spiker Run	13.74	10.99	697.53
CR	C-24-S1	WM-141	LLR0009	Little Laurel Run	0.35	0.00	14.74
CR	C-48-S1	WM-142	NBC0072	North Branch Casselman River	7.24	0.00	140.80
CR	C-49-P1	WM-142	NBC0072	North Branch Casselman River	9.87	7.90	501.00
CR	C-49-S1	WM-142	NBC0072	North Branch Casselman River	3.68	0.75	97.62
CR	C-50-S1	WM-142	NBC0072	North Branch Casselman River	15.79	3.22	418.36

Table 5-12. (continued)

Basin	Mine seep or portal	Associated Station	Associated station code	Associated station name	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)
CR	C-50-S2	WM-142	NBC0072	North Branch Casselman River	7.02	0.35	4.21
CR	C-51-S1	WM-142	NBC0072	North Branch Casselman River	11.19	0.00	54.17
CR	C-51-S2	WM-142	NBC0072	North Branch Casselman River	75.66	0.00	609.70
CR	C-48-S1	WM-145	NBC0090	North Branch Casselman River	7.24	0.00	140.80
CR	C-49-P1	WM-145	NBC0090	North Branch Casselman River	9.87	7.90	501.00
CR	C-49-S1	WM-145	NBC0090	North Branch Casselman River	3.68	0.75	97.62
CR	C-50-S1	WM-145	NBC0090	North Branch Casselman River	15.79	3.22	418.36
CR	C-50-S2	WM-145	NBC0090	North Branch Casselman River	7.02	0.35	4.21
CR	C-50-S1	WM-147	PLE0008	Pleasant Valley Run	15.79	3.22	418.36
CR	C-50-S2	WM-147	PLE0008	Pleasant Valley Run	7.02	0.35	4.21
CR	C-48-S1	WM-148	NBC0106	North Branch Casselman River	7.24	0.00	140.80
CR	C-49-P1	WM-148	NBC0106	North Branch Casselman River	9.87	7.90	501.00
CR	C-49-S1	WM-148	NBC0106	North Branch Casselman River	3.68	0.75	97.62
CR	C-50-S1	WM-148	NBC0106	North Branch Casselman River	15.79	3.22	418.36
CR	C-50-S2	WM-148	NBC0106	North Branch Casselman River	7.02	0.35	4.21
GC	BA-05-P1	WM-110	UGQ0000	UT to Georges Creek	6.58	5.26	334.00
GC	BA-05-P2	WM-110	UGQ0000	UT to Georges Creek	0.66	0.53	33.43
GC	BA-05-P4	WM-110	UGQ0000	UT to Georges Creek	3.29	2.63	167.00
GC	BA-05-P6	WM-110	UGQ0000	UT to Georges Creek	3.29	2.63	167.00
GC	BA-05-P7	WM-110	UGQ0000	UT to Georges Creek	6.58	5.26	334.00
GC	G-70-P5	WM-111	MIL0001	Mill Run	13.74	10.99	697.53
GC	R-48-P5	WM-111	MIL0001	Mill Run	10.99	14.66	946.28
GC	BA-10-P1	WM-111	MIL0001	Mill Run	13.74	10.99	697.53
GC	BA-10-P2	WM-111	MIL0001	Mill Run	13.74	10.99	697.53
GC	BA-10-P3	WM-111	MIL0001	Mill Run	13.74	10.99	697.53
GC	BA-10-P4	WM-111	MIL0001	Mill Run	13.74	10.99	697.53
GC	BA-10-P5	WM-111	MIL0001	Mill Run	13.74	10.99	697.53
GC	G-03-P1	WM-119	WBN0002	Winebrenner Run	13.74	10.99	697.53
GC	G-03-P1	WM-120	WBN0010	Winebrenner Run	13.74	10.99	697.53
GC	G-52-P1	WM-122	UMD0000	UT to Moores Run	0.00	1.83	178.63
GC	R-43-P1	WM-122	UMD0000	UT to Moores Run	1.97	1.58	100.14
PR	Cogley Subsid-P9	WM-45	EKL0003	Elklick Run	13.74	10.99	697.53
PR	P-88-P1	WM-51	SPL0016	South Prong Lostland Run	9.87	7.90	501.00
PR	P-88-P2	WM-51	SPL0016	South Prong Lostland Run	13.74	10.99	697.53
PR	P-54-P1	WM-54	TFR0016	Three Forks Run	13.74	10.99	697.53
PR	P-03-S1	WM-61	LNB0014	Laurel Run	13.71	2.80	363.31
SR	R-52-P1	WM-73	AAR0000	Aaron Run	0.66	0.53	33.43

Table 5-12. (continued)

Basin	Mine seep or portal	Associated Station	Associated station code	Associated station name	Iron (lb/yr)	Aluminum (lb/yr)	Sulfate (lb/yr)
SR	R-52-P10	WM-73	AAR0000	Aaron Run	0.66	0.53	33.43
SR	R-52-P11	WM-73	AAR0000	Aaron Run	32.90	13.16	2,273.21
SR	R-52-P7	WM-73	AAR0000	Aaron Run	0.66	0.53	33.43
SR	R-52-P8	WM-73	AAR0000	Aaron Run	0.35	0.53	100.98
SR	R-52-P9	WM-73	AAR0000	Aaron Run	0.66	0.53	33.43
SR	R-52-S1	WM-73	AAR0000	Aaron Run	13.71	2.80	363.31
SR	R-52-S2	WM-73	AAR0000	Aaron Run	14.74	7.37	1,644.35
WC	FB-08-P1	WM-34	UJH0015	UT to Jennings Run	0.09	0.09	0.48
WC	NG-03-P1	WM-34	UJH0015	UT to Jennings Run	0.00	0.00	20.32
WC	NG-03-P3	WM-34	UJH0015	UT to Jennings Run	0.00	0.00	731.92
WC	NG-03-S1	WM-34	UJH0015	UT to Jennings Run	13.71	2.80	363.31
WC	R-01-P1	WM-34	UJH0015	UT to Jennings Run	1.64	1.32	83.50
WC	R-02-P1	WM-34	UJH0015	UT to Jennings Run	7.68	47.59	485.13
WC	R-03-P1	WM-34	UJH0015	UT to Jennings Run	1.32	0.66	25.00
WC	FB-29-P4	WM-37	UJF0002	UT to Jennings Run	13.74	10.99	697.53
WC	FB-01-P1	WM-39	JEN0092	Jennings Run	0.26	4.21	42.32
WC	R-05-P1	WM-39	JEN0092	Jennings Run	5.26	23.69	278.97
WC	FB-06-P1	WM-41	UJH0011	UT to Jennings Run	43.86	0.00	87.73
WC	FB-06-P2	WM-41	UJH0011	UT to Jennings Run	21.93	17.55	2,837.95
WC	FB-08-P1	WM-41	UJH0011	UT to Jennings Run	0.09	0.09	0.48
WC	NG-03-P1	WM-41	UJH0011	UT to Jennings Run	0.00	0.00	20.32
WC	NG-03-P3	WM-41	UJH0011	UT to Jennings Run	0.00	0.00	731.92
WC	NG-03-S1	WM-41	UJH0011	UT to Jennings Run	13.71	2.80	363.31
WC	R-01-P1	WM-41	UJH0011	UT to Jennings Run	1.64	1.32	83.50
WC	R-02-P1	WM-41	UJH0011	UT to Jennings Run	7.68	47.59	485.13
WC	R-03-P1	WM-41	UJH0011	UT to Jennings Run	1.32	0.66	25.00

Note:
CR = Casselman River; GC = Georges Creek; PR = Upper North Branch of the Potomac River; SR = Savage River; WC = Wills Creek

5.3.3 Margin of Safety and Future Allocation

The MOS is the portion of the pollutant loading reserved to account for uncertainty in the TMDL development process. There are two ways to incorporate the MOS (USEPA 1991): (1) implicitly by using conservative model assumptions to develop allocations, or (2) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For this TMDL, a 5 percent explicit MOS was used to account for uncertainty in the modeling process. The MOS loadings are presented in Table 5-2.

While the MOS is an allocation for scientific uncertainly, the FA is an allocation for growth. Ten percent of the load was allocated for FA in the area covered by the TMDL. This growth includes future urban developments, including point sources, coal mining areas, agriculture, and other nonpoint sources. The FA could also be used for sources not accounted for or unknown and, therefore, not otherwise included in the TMDL. The FA loadings are presented in Table 5-2.

6 REASONABLE ASSURANCE

Section 303(d) of the Clean Water Act (CWA) and EPA regulations require reasonable assurance that TMDLs will be implemented. TMDLs represent an attempt to quantify the pollutant load that may be present in a waterbody and still ensure attainment and maintenance of water quality standards. The Western Maryland TMDLs identify the necessary overall load reductions for those pollutants causing use impairments and distributes those reduction goals to the appropriate sources. Reaching the reduction goals established by these TMDLs will occur only through changes in current land use practices, including the remediation of AMD and the implementation of the CAIR. Although the derived TMDLs are based on best professional judgment using current data in the calibrated model, meeting these TMDLs might not be necessary if alternative remediation and future monitoring prove that pH is being corrected without reducing these parameters.

The Maryland Bureau of Mines (BOM) is responsible for protecting the environment from potential impacts from active mining and promoting the restoration of abandoned mine lands and water resources. In issuing new or updated permits in the TMDL area, BOM will ensure that permit limits will not adversely affect the pH in impaired waters. BOM also reclaims abandoned mine lands. These lands are prioritized on the basis of health, safety, and environmental impacts. Within the BOM, the Acid Mine Drainage Abatement Section’s mission is to improve the state’s waters that are impaired by AMD from abandoned coal mines. This is an ongoing process that is limited by the amount of funding available and can be aided by partnerships with industries, watershed groups, other government agencies, and other interested parties.

On March 10, 2005, EPA issued the CAIR, which places caps on emissions for sulfur dioxide and nitrogen dioxides in the eastern United States. It is expected that CAIR will reduce sulfur dioxide emissions by more than 70 percent and reduce nitrogen oxides emissions by more than 60 percent from the 2003 emission levels (USEPA 2005d). Because these pollutants are highly mobile in the atmosphere, emission reductions in West Virginia, Ohio, Pennsylvania, and possibly Michigan are expected to improve the quality of precipitation in the five TMDL watersheds.

Individuals or local watershed groups interested in improving conditions in the watersheds are strongly encouraged to review funding sources available through MDE and other state and federal agencies. Numerous state programs, including section 319 programs, are available. Other Maryland programs include the Small Creeks and Estuaries Restoration Program and the State Revolving Loan Fund. For more information, visit http://www.mde.state.md.us/AboutMDE/grants/index.asp (MDE 2006). Watershed groups in the area include the Braddock Run Watershed Association in the Wills Creek watershed, the Georges Creek Watershed Association, and the Savage River Watershed Association.

There are several installed and operating AMD treatment systems in the western Maryland watersheds as well as pending systems that are being designed and planned for construction in the next few years (Table 6-1).

Table 6-1. AMD treatment systems installed or pending installation in western Maryland watersheds

Basin	Treatment type	System designation	Design	Year operational
North Branch Casselman River	Passive	Amish Road I	Aluminator / pond	2005
North Branch Casselman River	Passive	Amish Road II	Alds / ponds / wetlands	2006
Georges Creek	Active	Mill Run PLB	Pulse limestone bed	2001
Georges Creek	Passive	Coney Cleaners	Saps	2002
Georges Creek	Active	McDonald Mine	Boxholm bucket doser	2003
Georges Creek	Passive	Fazenbaker	Saps / wetland	2003
Georges Creek	Passive	Potomac Hill	Steel slag ditch / saps	2003
Georges Creek	Passive	Oak Hill I	Saps / wetlands	2005
Georges Creek	Passive	Midlothian School	Pyrolucite	2006
Georges Creek	Passive	Neff Run I	Limestone leach bed	2006
Georges Creek	Passive	Neff Run II	Steel slag leach bed	2006
Georges Creek	Passive	Neff Run III	Limestone leach bed	2006
Georges Creek	Passive	Railroad Street	Saps	2007
Georges Creek	Passive	Getson	Leach beds	10/2007
Georges Creek	Passive	Hampshire Hill	Steel slag leach bed	07/2008
Savage River	Passive	Aarons Run Owens North	Pyrolusite	10/2007
Savage River	Passive	Aarons Run Owens South	Pyrolusite	10/2007
Savage River	Active	Aarons Run	Boxholm bucket doser	04/2008
Savage River	Passive	Aarons Run Headwater Rest.	Leach beds	10/2008
Savage River	Passive	Aarons Run Stream Rest.	Saps / leach bed	10/2008
Upper North Branch Potomac	Active	Kitzmiller	Aquafix waterwheel doser	1993
Upper North Branch Potomac	Active	Gorman	Pumpkonsult slurry doser	1994
Upper North Branch Potomac	Active	Laurel Run	Pumpkonsult slurry doser	1994
Upper North Branch Potomac	Active	Lost Land Run	Boxholm bucket doser	1994
Upper North Branch Potomac	Passive	Elk Kick I	Ald / wetland	1995
Upper North Branch Potomac	Active	Vindex	Aquafix waterwheel doser	1996
Upper North Branch Potomac	Passive	Elk Lick II	Saps / steel slag / wetlands	1999
Upper North Branch Potomac	Active	Kempton Air Shaft	Aquafix waterwheel doser	2000
Upper North Branch Potomac	Passive	Elk Lick III	Saps / wetlands	2001
Upper North Branch Potomac	Active	Shallmar	Aquafix waterwheel doser	2006

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