

APPENDIX A

Land Use Distribution in the Wolf River Watershed

Table A-1. MRLC Land Use Distribution of Wolf River Subwatersheds

Land Use	HUC-12 Subwatershed (08010210____) or Drainage Area (DA)					
	0201		0302		0303	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	14	0.0*	0	0.0	0	0.0
Deciduous Forest	16,136	39.1	7212	31.5	7090	22.5
Evergreen Forest	1380	3.3	189	0.8	788	2.5
High Intensity Commercial/Industrial/Transportation	16	0.0*	18	0.1	11	0.0*
High Intensity Residential	8	0.0*	1	0.0*	0	0.0
Low Intensity Residential	64	0.2	27	0.1	14	0.0*
Mixed Forest	2560	6.2	649	2.8	3269	10.4
Open Water	270	0.7	280	1.2	277	0.9
Other Grasses	0	0.0	0	0.0	1	0.0*
Pasture/Hay	11,204	27.1	6275	27.4	9609	30.5
Row Crops	8440	20.5	8029	35.0	7756	24.6
Transitional	31	0.1	25	0.1	23	0.1
Woody Wetlands	1144	2.8	224	1.0	2677	8.5
Total	41,273	100	22,927	100	31,516	100

* <0.05

Table A-1. MRLC Land Use Distribution of Wolf River Subwatersheds (Cont.)

Land Use	HUC-12 Subwatershed (08010210____) or Drainage Area (DA)					
	0306		0307		0308	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	0	0.0	0	0.0	84	0.2
Deciduous Forest	1538	3.8	745	5.6	2463	9.5
Evergreen Forest	211	0.5	149	1.1	459	1.8
High Intensity Commercial/Industrial/Transportation	4088	10.1	567	4.3	955	4.5
High Intensity Residential	8185	20.2	1658	12.6	3803	16.2
Low Intensity Residential	17,521	43.2	4073	30.8	5254	27.6
Mixed Forest	1429	3.5	491	3.7	1694	8.2
Open Water	993	2.4	317	2.4	175	0.9
Other Grasses	1858	4.6	399	3.0	1235	6.0
Pasture/Hay	751	1.8	1831	13.9	1993	9.7
Quarries/Strip Mines/Gravel Pits	0	0.0	0	0.0	28	0.1
Row Crops	1197	2.9	1443	10.9	1948	9.5
Transitional	195	0.5	225	1.7	435	2.1
Woody Wetlands	2628	6.5	1312	9.9	32	0.2
Total	40,594	100	13,210	100	20,558	100

Table A-1. MRLC Land Use Distribution of Wolf River Subwatersheds (Cont.)

Land Use	HUC-12 Subwatershed (08010210____) or Drainage Area (DA)									
	Early Grove Creek DA		North Fork Wolf River DA		Hurricane Creek DA		Unnamed Tributary to Wolf River DA		Russell Creek DA	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	1753	27.4	1228	36.2	1577	35.7	1444	20.5	655	13.4
Evergreen Forest	42	0.7	841	24.8	22	0.5	48	0.7	52	1.1
High Intensity Commercial/Industrial/Transportation	0	0.0	0	0.0	0	0.0	8	0.1	15	0.3
High Intensity Residential	0	0.0	0	0.0	1	0.0*	0	0.0	0	0.0
Low Intensity Residential	2	0.0*	0	0.0	1	0.0*	14	0.2	26	0.5
Mixed Forest	179	2.8	245	7.2	333	7.5	224	3.2	142	2.9
Open Water	52	0.8	4	0.1	42	1.0	113	1.6	51	1.0
Pasture/Hay	1720	26.9	155	4.6	1490	33.7	2963	42.1	2525	51.5
Row Crops	2632	41.2	103	3.0	904	20.5	2128	30.2	1204	24.5
Transitional	5	0.1	4	0.1	4	0.1	5	0.1	1	0.0*
Woody Wetlands	4	0.1	813	24.0	37	0.8	105	1.5	225	4.6
Total	6390	100	3394	100	4411	100	7052	100	4898	100

* <0.05

Table A-1. MRLC Land Use Distribution of Wolf River Subwatersheds (Cont.)

Land Use	HUC-12 Subwatershed (08010210____) or Drainage Area (DA)									
	Wolf River DA		Johnson Creek DA		Unnamed Tributary to Grays Creek DA		Marys Creek DA		Marys Creek Headwaters DA	
	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]	[acres]	[%]
Deciduous Forest	3135	10.3	854	21.1	713	30.6	2845	28.0	622	26.1
Evergreen Forest	350	1.2	41	1.0	13	0.6	727	7.1	148	6.2
High Intensity Commercial/Industrial/Transportation	464	1.5	2	0.1	10	0.4	4	0.0*	0	0.0
High Intensity Residential	3261	10.7	0	0.0	252	10.8	0	0.0	0	0.0
Low Intensity Residential	3844	12.7	0	0.0	286	12.3	5	0.1	0	0.0
Mixed Forest	1709	5.6	389	9.6	223	9.6	1680	16.5	242	10.1
Open Water	562	1.9	56	1.4	19	0.8	408	4.0	254	10.7
Other Grasses	386	1.3	0	0.0	14	0.6	0	0.0	0	0.0
Pasture/Hay	5370	17.7	1544	38.1	321	13.8	2469	24.3	700	29.3
Quarries/Strip Mines/Gravel Pits	81	0.3	0	0.0	0	0.0	0	0.0	0	0.0
Row Crops	5330	17.6	778	19.2	416	17.9	2034	20.0	416	17.4
Transitional	593	2.0	0	0.0	46	2.0	0	0.0	0	0.0
Woody Wetlands	5275	17.4	395	9.8	17	0.7	3	0.0*	3	0.1
Total	30,359	100	4058	100	2330	100	10,175	100	2386	100

* <0.05

APPENDIX B
Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the Wolf River watershed. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded at these stations for E. coli are tabulated in Table B-1.

Table B-1. Water Quality Monitoring Data – Wolf River Watershed

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
EGROV001.6FA	3/28/00	15.6
	7/30/03	>2419.2
	10/27/03	>2419.2
	1/27/04	19.9
	2/23/04	7.4
	3/31/04	28.2
	4/28/04	116.9
	5/24/04	131.7
	6/23/04	>2419.2
MCKIN000.5FA	2/24/00	124.2
	10/18/99	23.5
	7/30/03	1732.9
	11/24/03	8664
	12/17/03	20
	1/27/04	231
	2/23/04	10.9
	3/31/04	111.2
	4/28/04	38.8
	5/24/04	198.9
MAY001.4FA	1/18/00	4.1
	7/30/03	770.1
	8/27/03	87.8
	9/24/03	224.7
	10/27/03	1299.7
	11/24/03	>2419.2
	12/17/03	41
	1/27/04	63
	2/23/04	18.7
	3/31/04	51.2
	4/28/04	53.8
	5/24/04	101.7
	6/23/04	>2419.2

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
NFORK004.4FA	7/30/03	2419.2
	11/24/03	>2419.2
	12/17/03	209
	1/27/04	213
	2/23/04	23.1
	3/31/04	66.9
	4/28/04	39.7
	5/24/04	184.2
	6/23/04	1299.7
NFWOL011.4FA	2/24/00	147
	10/18/99	59.2
	7/30/03	1413.6
	8/27/03	77.6
	9/24/03	127.4
	10/27/03	396.8
	11/24/03	1413.6
	12/17/03	52
	1/27/04	52.8
	2/23/04	21.3
	3/31/04	33.1
	4/28/04	105.4
	5/24/04	83.9
	6/23/04	1553.1
HURRI001.1FA	3/28/00	35.4
	5/23/00	9.8
	8/20/03	66.9
	11/19/03	>2419.2
	12/15/03	1198
	1/21/04	472
	2/18/04	218
	3/16/04	920.8
	4/27/04	108.6
	5/19/04	298.7
	6/16/04	>2419.2
WOLF1T1.1FA	10/8/03	>2419.2
	12/10/03	8164
	1/14/04	>2419.2

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
WOLF1T1.1FA	2/10/04	173
	3/9/04	248.9
	4/14/04	1732.9
	5/12/04	166.4
RUSSE001.5FA	3/28/00	325.5
	7/9/03	1553.1
	8/18/03	30.6
	9/10/03	>2419.2
	10/8/03	24192
	11/5/03	>2419.2
	12/10/03	5794
	1/14/04	350
	2/10/04	70.3
	3/9/04	86
	4/14/04	>2419.2
	5/12/04	1198
TEAGU001.4FA	8/20/03	298.7
	10/15/03	1732.9
	11/19/03	>2419.2
	12/15/03	1789
	1/21/04	691
	2/18/04	135
	3/16/04	201.4
	4/27/04	461.1
	5/19/04	866.4
	6/16/04	>2419.2
GRISS002.7FA	1/20/99	280.9
	2/17/99	109.5
	3/17/99	118.2
	4/15/99	>2419.2
	5/13/99	23.8
	6/16/99	5.2
	12/15/99	1119.9
	10/15/03	235.9
	11/19/03	>2419.2
	12/15/03	857
	2/18/04	24

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
GRISS002.7FA	3/16/04	39.3
	4/27/04	260.2
	6/16/04	>2419.2
ALEXA000.8FA	3/28/00	9.7
	7/16/03	2419.2
	8/20/03	613.1
	9/17/03	613.1
	10/15/03	>2419.2
	11/19/03	3255
	12/15/03	262
	1/21/04	34.5
	2/18/04	18.3
	3/16/04	727
	4/27/04	133.4
	5/19/04	344.8
	6/16/04	1986.3
SHAWS007.2FA	1/20/99	32.8
	2/17/99	8.5
	3/17/99	6.1
	4/15/99	>2419.2
	5/13/99	64
	6/16/99	127.4
	7/21/99	3
	8/18/99	172.6
	9/15/99	6.3
	10/13/99	11
	12/15/99	547.5
	8/20/03	12.1
	9/17/03	325.5
	10/15/03	>2419.2
	11/19/03	9804
	12/15/03	364
	1/21/04	62
	2/18/04	9.7
	3/16/04	41.1
	4/27/04	117.8
	5/19/04	93.2
	6/16/04	>2419.2

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
JOHNS002.9SH	7/9/03	272.3
	10/8/03	>2419.2
	1/14/04	579.4
	2/10/04	2419.2
	3/9/04	12.2
	4/14/04	>2419.2
	5/12/04	3873
	6/9/04	10
1W (Wolf River)	6/20/00	50
	7/19/00	10
	8/25/00	200
	9/18/00	10
	10/13/00	220
	10/23/00	20
	11/7/00	5400
	11/15/00	50
	12/5/00	40
	12/19/00	90
	1/19/01	10
	1/22/01	10
	2/5/01	10
	2/20/01	40
	3/7/01	20
	3/20/01	40
	4/2/01	10
	4/26/01	350
	5/8/01	130
	5/24/01	270
	6/5/01	50
	6/19/01	90
	7/18/01	90
	8/20/01	10
	9/20/01	10
	10/18/01	60000
	11/6/01	90
	12/3/01	110

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
1W (Wolf River)	1/10/02	10
	2/13/02	40
	3/7/02	10
	4/3/02	10
	5/13/02	110
	6/13/02	20
	7/25/02	1
	8/13/02	1
	9/17/02	6
	10/7/02	20
	11/7/02	360
	12/16/02	200
	1/7/03	10
	2/12/03	1500
	3/5/03	4200
	4/3/03	1100
	5/5/03	6000
	6/10/03	6000
	7/8/03	3400
	8/8/03	600
	9/10/03	10
	10/7/03	100
	11/3/03	10
	12/8/03	200
	1/21/04	200
	2/23/04	100
	3/16/04	2
	4/15/04	37
	5/13/04	5
	6/16/04	3400
	7/6/04	177
	8/12/04	2
	9/20/04	20
	10/18/04	300
	11/4/04	30
	12/2/04	540
	1/20/05	1600

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
1W (Wolf River)	2/1/05	3000
	3/1/05	1000
	4/19/05	2600
	4/21/05	1000
	5/16/05	600
	6/8/05	300
GRAYS1T2.1SH	9/7/99	33.6
	1/13/00	23.5
	7/9/03	110.6
	8/18/03	129.6
	9/10/03	36.4
	10/8/03	>2419.2
	11/5/03	22.8
	12/10/03	11199
	1/14/04	65
	2/10/04	686.7
	3/9/04	243
	4/14/04	>2419.2
	5/12/04	2481
	6/9/04	156
MARYS001.0SH	9/7/99	8.6
	1/13/00	38.4
	7/9/03	41.9
	8/18/03	57.1
	9/10/03	410
	10/8/03	2419.2
	11/5/03	33.6
	12/10/03	9804
	1/14/04	83.6
	2/10/04	228.2
	3/9/04	65
	4/14/04	2419.2
	5/12/04	259
MARYS005.8SH	10/8/03	>2419.2
	12/10/03	7270
	1/14/04	2419.2

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
MARYS005.8SH	2/10/04	213
	3/9/04	186
	4/14/04	686.7
	5/12/04	517.2
4W (Harrington Creek)	6/20/00	1900
	7/19/00	29000
	8/25/00	900
	9/18/00	520
	10/13/00	8000
	10/23/00	100
	11/7/00	4100
	11/15/00	10
	12/5/00	50
	12/19/00	10
	1/19/01	10
	1/22/01	20
	2/5/01	110
	2/20/01	90
	3/7/01	10
	3/20/01	60
	4/2/01	120
	4/26/01	1100
	5/8/01	190
	5/24/01	170
	6/5/01	150
	6/19/01	100
	7/18/01	120
	8/20/01	30
	9/20/01	10
	10/18/01	10
	11/6/01	40
	1/10/02	4200
	2/13/02	170
	3/7/02	90
	4/3/02	30
	5/13/02	50
	6/13/02	90

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
4W (Harrington Creek)	7/25/02	1
	8/13/02	1
	9/17/02	29
	10/7/02	80
	11/7/02	350
	12/16/02	160
	1/7/03	30
	2/12/03	300
	3/5/03	800
	4/3/03	90
	5/5/03	6000
	6/10/03	6000
	7/8/03	5500
	8/8/03	340
	9/10/03	220
	10/7/03	10
	11/3/03	200
	12/8/03	400
	1/21/04	250
	2/23/04	2
	3/16/04	180
	4/15/04	300
	5/13/04	211
	6/16/04	10300
	7/6/04	340
	8/12/04	209
	9/20/04	209
	10/18/04	29
	11/4/04	120
	12/2/04	1100
	1/20/05	1400
	2/1/05	3600
	3/1/05	4000
	4/19/05	1100
	4/21/05	1900
	5/16/05	400
	6/8/05	600

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
WORKH000.3SH	4/18/00	547.5
	3/3/99	>2419.2
	10/21/99	816.4
	6/30/03	344.8
	8/4/03	>2419.2
	9/3/03	301
	10/1/03	133.3
	11/3/03	38.8
	12/3/03	344.1
	1/7/04	238.2
	2/4/04	261.3
	3/2/04	1299.7
	4/7/04	139.6
	5/5/04	>2419.2
	6/2/04	1094
WOLF001.5SH	1/20/99	770.1
	2/17/99	46.4
	3/17/99	372.5
	4/15/99	>2419.2
	5/13/99	88.4
	6/16/99	>2419.2
	7/21/99	980.4
	8/18/99	257.2
	8/26/99	436
	9/15/99	579.4
	10/13/99	307.6
	11/17/99	137
	12/15/99	>2419.2
	3/14/01	125
	6/13/01	104.2
	8/14/01	1986.3
	11/20/01	>2419.2
	2/20/02	9804
	5/22/02	10
	8/20/02	798
	11/7/02	<2419.2
	2/11/03	238

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
WOLF001.5SH	5/27/03	63.8
	6/30/03	260.2
	8/4/03	>2419.2
	9/3/03	9804
	10/1/03	148
	11/3/03	131.3
	12/3/03	80.1
	1/7/04	185
	2/4/04	90.7
	3/2/04	>2419.2
	4/7/04	74
	5/5/04	203
	6/2/04	579.4
	10/25/04	1203.3
	2/8/05	19863
	6/29/05	1081
	9/21/05	106.7
CYPRE004.8SH	3/22/00	488.4
	10/7/99	1413.6
	6/30/03	1413.6
	8/4/03	>2419.2
	9/3/03	933
	10/1/03	426
	11/3/03	980.4
	12/3/03	>2419.2
	1/7/04	571
	3/2/04	24192
	4/7/04	697
	5/5/04	>24192
	6/2/04	1320
WOLF018.9SH	1/20/99	191.8
	2/17/99	133.4
	3/17/99	816.4
	4/15/99	1986.3
	5/13/99	104.3
	6/16/99	410.6
	7/21/99	57.3
	8/18/99	18.7

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
WOLF018.9SH	9/15/99	15.6
	10/13/99	104.3
	11/17/99	30.9
	12/15/99	613.1
	7/9/03	51.2
	8/18/03	62
	9/10/03	70.8
	10/8/03	>2419.2
	11/5/03	58.3
	12/10/03	2143
	1/14/04	20.1
	2/10/04	461.1
	3/9/04	29.5
	4/14/04	>2419.2
	5/12/04	86
	6/9/04	101.7
FLETC2T0.2SH	6/30/03	117.8
	8/4/03	>2419.2
	9/3/03	2489
	10/1/03	86
	11/3/03	517.2
	12/3/03	238.2
	1/7/04	727
	2/4/04	101
	3/2/04	1732.9
	4/7/04	43.5
	5/5/04	57.3
	6/2/04	290.9
FLETC1T0.4SH	6/30/03	1299.7
	8/4/03	>2419.2
	9/3/03	1935
	10/1/03	146
	11/3/03	48.8
	12/3/03	387.3
	1/7/04	1732.9
	2/4/04	488.4
	3/2/04	1413.6
	4/7/04	13.5

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
FLETC1T0.4SH	5/5/04	344.8
	6/2/04	920.8
6W (Fletcher Creek)	6/20/00	2600
	7/19/00	200
	8/25/00	73000
	9/18/00	37000
	10/13/00	250
	10/23/00	20
	11/7/00	41000
	11/15/00	290
	12/5/00	10
	12/19/00	30
	1/19/01	1400
	1/22/01	80
	2/5/01	60
	2/20/01	30
	3/7/01	130
	3/20/01	120
	4/2/01	180
	4/26/01	1400
	5/8/01	160
	5/24/01	290
	6/5/01	210
	6/19/01	40
	7/18/01	250
	8/20/01	30
	9/20/01	10
	10/18/01	60
	11/6/01	60
	12/3/01	400
	1/10/02	30
	2/13/02	60
	3/7/02	40
	4/3/02	10
	5/13/02	10
	6/13/02	20
	7/25/02	1
	8/13/02	1

Table B-1. Water Quality Monitoring Data – Wolf River Watershed (Cont.)

Monitoring Station	Date	E. Coli
		[CFU/100 mL]
6W (Fletcher Creek)	9/17/02	28
	10/7/02	30
	11/7/02	300
	12/16/02	320
	1/7/03	10
	2/12/03	900
	3/5/03	900
	4/3/03	50
	5/5/03	2800
	6/10/03	2500
	7/8/03	3400
	8/8/03	250
	9/10/03	100
	10/7/03	10
	11/3/03	1000
	12/8/03	100
	1/21/04	290
	2/23/04	2
	3/16/04	2
	4/15/04	10
	5/13/04	8
	6/16/04	5400
	7/6/04	320
	8/12/04	2
	9/20/04	1
	10/18/04	540
	11/4/04	1100
	11/17/04	40
	12/2/04	1200
	1/20/05	2200
	2/1/05	3700
	3/1/05	1
	4/19/05	1200
	4/21/05	2500
	5/16/05	700
	6/8/05	200

APPENDIX C

Load Duration Curve Development and Determination of Daily Loading

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

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

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) (<http://www.epa.gov/epacfr40/chapt-I.info/chi-toc.htm>) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.

C.1 Development of TMDLs and Load Reductions

E. coli TMDLs, WLAs, and LAs were developed for impaired subwatersheds in the Wolf River watershed using load duration curves (LDCs). Daily loads for TMDLs, WLAs, and LAs are expressed as a function of daily mean in-stream flow (daily loading function).

C.1.1 Development of Flow Duration Curves

A flow duration curve is a cumulative frequency graph, constructed from historic flow data at a particular location, that represents the percentage of time a particular flow rate is equaled or exceeded. Flow duration curves are developed for a waterbody from daily flows over an extended period of record. In general, there is a higher level of confidence that curves derived from data over a long period of record correctly represent the entire range of flow. The preferred method of flow duration curve computation uses daily mean data from U.S. Geological Survey (USGS) continuous-record stations (<http://waterdata.usgs.gov/tn/nwis/sw>) located on the waterbody of interest. For ungaged streams, alternative methods must be used to estimate daily mean flow. These include: 1) regression equations (using drainage area as the independent variable) developed from continuous record stations in the same ecoregion; 2) drainage area extrapolation of data from a nearby continuous-record station of similar size and topography; and 3) calculation of daily mean flow using a dynamic computer model, such as the Loading Simulation Program C++ (LSPC).

Flow duration curves for impaired waterbodies in the Wolf River watershed were derived from LSPC hydrologic simulations based on parameters derived from calibration at three USGS monitoring stations (07031692, Fletcher Creek at Sycamore View Road; 07031650, Wolf River at Germantown; and 07030392, Wolf River at LaGrange). See Appendix D for details of calibration. The data used included the period of record from 1/1/96 – 12/31/05. For example, a flow-duration curve for Wolf River at mile 1.5 was constructed using simulated daily mean flow for the period from 1/1/96 through 12/31/05 (mile 1.5 corresponds to the location of monitoring station WOLF001.5SH). This flow duration curve is shown in Figure C-1 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the highest daily mean flow during this period is exceeded 0% of the time and the lowest daily mean flow is equaled or exceeded 100% of the time). Flow duration curves for other impaired waterbodies were derived using a similar procedure.

C.1.2 Development of Load Duration Curves and TMDLs

When a water quality target concentration is applied to the flow duration curve, the resulting load duration curve (LDC) represents the allowable pollutant loading in a waterbody over the entire range of flow. Pollutant monitoring data, plotted on the LDC, provides a visual depiction of stream water quality as well as the frequency and magnitude of any exceedances. Load duration curve intervals can be grouped into several broad categories or zones, in order to provide additional insight about conditions and patterns associated with the impairment. For example, the duration curve could be divided into five zones: high flows (exceeded 0-10% of the time), moist conditions (10-40%), median or mid-range flows (40-60%), dry conditions (60-90%), and low flows (90-100%). Impairments observed in the low flow zone typically indicate the influence of point sources, while those further left on the LDC (representing zones of higher flow) generally reflect potential nonpoint source contributions (Stiles, 2003).

E. coli load duration curves for impaired waterbodies in the Wolf River watershed were developed from the flow duration curves developed in Section C.1.1, E. coli target concentrations, and available water quality monitoring data. LDCs and daily loading functions were developed using the following procedure (Fletcher Creek, station 6W is shown as an example):

1. A target LDC was generated for Fletcher Creek 6W by applying the E. coli target concentration of 941 CFU/100 mL to each of the ranked flows used to generate the flow duration curve (ref.: Section C.1.1) and plotting the results. The E. coli target maximum load corresponding to each ranked daily mean flow is:

$$(\text{Target Load})_{6W} = (941 \text{ CFU/100 mL}) \times (Q) \times (\text{UCF})$$

where: Target Load = TMDL (CFU/day)

Q = daily mean in-stream flow (cfs)

UCF = the required unit conversion factor

$$\text{TMDL} = 2.30 \times 10^{10} \times Q$$

2. Daily loads were calculated for each of the water quality samples collected at monitoring station 6W (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. Fletcher Creek 6W was selected for LDC analysis because it has numerous sampling points, well distributed across the full range of flow conditions, and multiple exceedances of the target concentration.

Note: In order to be consistent for all analyses, the derived daily mean flow was used to compute sampling data loads, even if measured ("instantaneous") flow data were available for some sampling dates.

Example (6/20/00 sampling event):

Modeled Flow = 1.33 cfs

Concentration = 2600 CFU/100 mL

Daily Load = 8.43×10^{10} CFU/day

3. Using the flow duration curves developed in Section C.1.1, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event. Each sample load was then plotted on the LDCs developed in Step 1 according to the PDFE. The resulting E. coli LDC for Fletcher Creek 6W is shown in Figure C-2.

LDCs of other impaired waterbodies were derived in a similar manner and are shown in Appendix E.

C.2 Development of WLAs, LAs, and MOS

As previously discussed, a TMDL can be expressed as the sum of all point source loads (WLAs), nonpoint source loads (LAs), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

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

Expanding the terms:

$$\text{TMDL} = [\Sigma \text{WLAs}]_{\text{WWTF}} + [\Sigma \text{WLAs}]_{\text{MS4}} + [\Sigma \text{WLAs}]_{\text{CAFO}} + [\Sigma \text{LAs}]_{\text{DS}} + [\Sigma \text{LAs}]_{\text{SW}} + \text{MOS}$$

For E. coli TMDLs in each impaired subwatershed, WLA terms include:

- $[\Sigma \text{WLAs}]_{\text{WWTF}}$ is the allowable load associated with discharges of NPDES permitted WWTFs located in impaired subwatersheds. Since NPDES permits for these facilities specify that treated wastewater must meet in-stream water quality standards at the point of discharge, no additional load reduction is required. WLAs for WWTFs are calculated from the facility design flow and the Monthly Average permit limit.
- $[\Sigma \text{WLAs}]_{\text{CAFO}}$ is the allowable E. coli load for all CAFOs in an impaired subwatershed. All wastewater discharges from a CAFO to waters of the state of Tennessee are prohibited, except when either chronic or catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain:
 - All process wastewater resulting from the operation of the CAFO (such as wash water, parlor water, watering system overflow, etc.); plus,
 - All runoff from a 25-year, 24-hour rainfall event for the existing CAFO or new dairy or cattle CAFOs; or all runoff from a 100-year, 24-hour rainfall event for a new swine or poultry CAFO.

Therefore, a WLA of zero has been assigned to this class of facilities.

- $[\Sigma \text{WLAs}]_{\text{MS4}}$ is the allowable E. coli load for discharges from MS4s. E. coli loading from MS4s is the result of buildup/wash-off processes associated with storm events.

LA terms include:

- $[\Sigma \text{LAs}]_{\text{DS}}$ is the allowable E. coli load from “other direct sources”. These sources include leaking septic systems, illicit discharges, and animals access to streams. The LA specified for all sources of this type is zero CFU/day (or to the maximum extent feasible).
- $[\Sigma \text{LAs}]_{\text{SW}}$ is the allowable E. coli load from nonpoint sources indirectly going to surface waters from all land use areas (except areas covered by a MS4 permit) as a result of the buildup/wash-off processes associated with storm events (i.e., precipitation induced).

Since $[\text{WLAs}]_{\text{CAFO}} = 0$ and $[\text{LAs}]_{\text{DS}} = 0$, the expression relating TMDLs to precipitation-based point and nonpoint sources may be simplified to:

$$\text{TMDL} - \text{MOS} = [\text{WLAs}]_{\text{WWTF}} + [\text{WLAs}]_{\text{MS4}} + [\Sigma \text{LAs}]_{\text{SW}}$$

As stated in Section 8.5, an explicit MOS, equal to 10% of the E. coli water quality targets (ref.: Section 5.0), was utilized for determination of the percent load reductions necessary to achieve the WLAs and LAs:

Instantaneous Maximum (lake, reservoir, State Scenic River, Tier II, and Tier III):

$$\text{Target} - \text{MOS} = (487 \text{ CFU/100 ml}) - 0.1(487 \text{ CFU/100 ml})$$

$$\text{Target} - \text{MOS} = 438 \text{ CFU/100 ml}$$

Instantaneous Maximum (other):

$$\text{Target} - \text{MOS} = (941 \text{ CFU/100 ml}) - 0.1(941 \text{ CFU/100 ml})$$

$$\text{Target} - \text{MOS} = 847 \text{ CFU/100 ml}$$

30-Day Geometric Mean:

$$\text{Target} - \text{MOS} = (126 \text{ CFU/100 ml}) - 0.1(126 \text{ CFU/100 ml})$$

$$\text{Target} - \text{MOS} = 113 \text{ CFU/100 ml}$$

C.2.1 Daily Load Calculation

Since WWTFs discharge must comply with instream water quality criteria (TMDL target) at the point of discharge, WLAs for WWTFs are expressed as a constant term. In addition, WLAs for MS4s and LAs for precipitation-based nonpoint sources are equal on a per unit area basis and may be expressed as the daily allowable load per unit area (acre) resulting from a decrease in in-stream E. coli concentrations to TMDL target values minus MOS:

$$[\text{WLAs}]_{\text{MS4}} = \text{LA} = (\text{TMDL} - \text{MOS} - [\text{WLAs}]_{\text{WWTF}}) / \text{DA}$$

where: DA = waterbody drainage area (acres)

Using Fletcher Creek 6W as an example:

$$\text{TMDL}_{6W} = (941 \text{ CFU/100 mL}) \times (Q) \times (\text{UCF})$$

$$= 2.30 \times 10^{10} \times Q$$

$$\text{MOS}_{6W} = \text{TMDL} \times 0.10$$

$$\text{MOS} = 2.30 \times 10^9 \times Q$$

$$\text{WLA}[\text{MS4}]_{6W} = \text{LA}_{6W}$$

$$= \{ \text{TMDL} - \text{MOS} - \text{WLA}[\text{WWTFs}] \} / \text{DA}$$

$$= \{ (2.30 \times 10^{10} \times Q) - (2.30 \times 10^9 \times Q) - (0) \} / (20,671)$$

$$\text{WLA}[\text{MS4}] = \text{LA} = 1.00 \times 10^6 \times Q$$

TMDLs, WLAs, LAs, and MOS for other impaired subwatersheds and drainage areas were derived in a similar manner and are summarized in Table C-1.

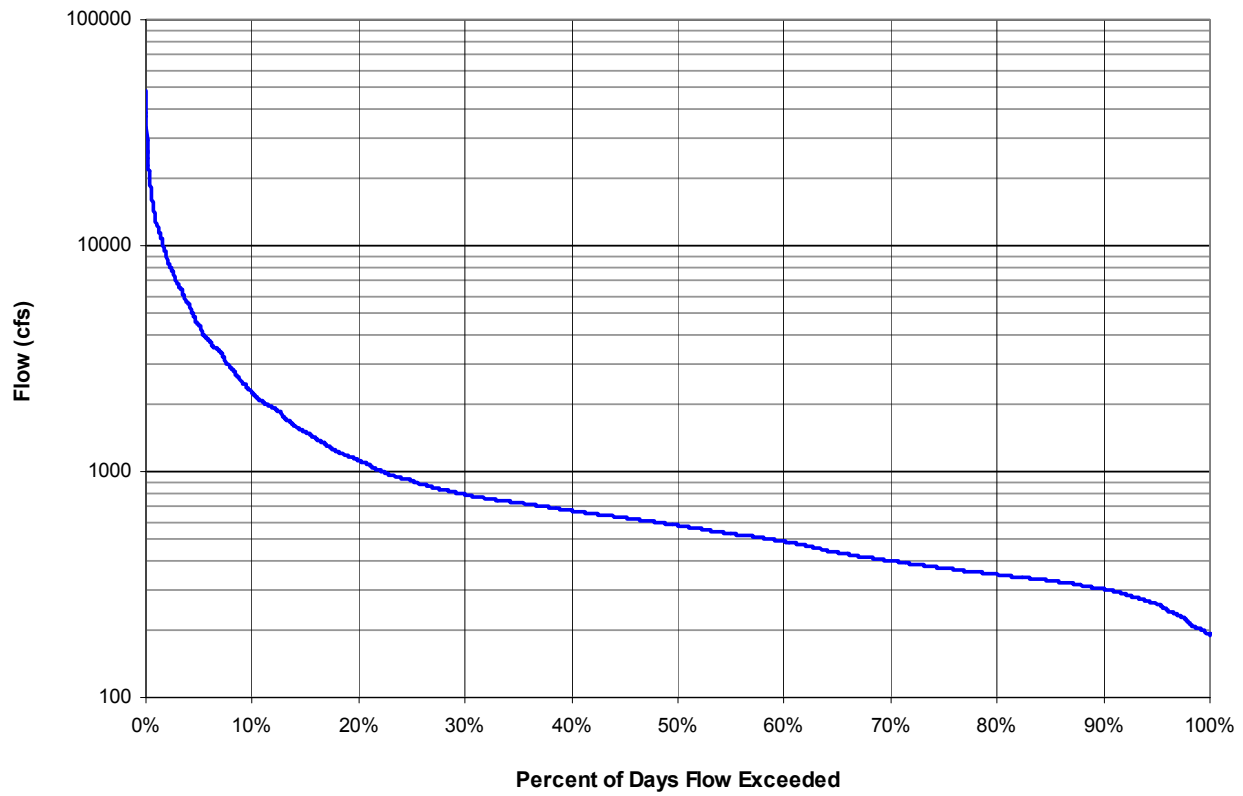


Figure C-1. Flow Duration Curve for Wolf River at Mile 1.5

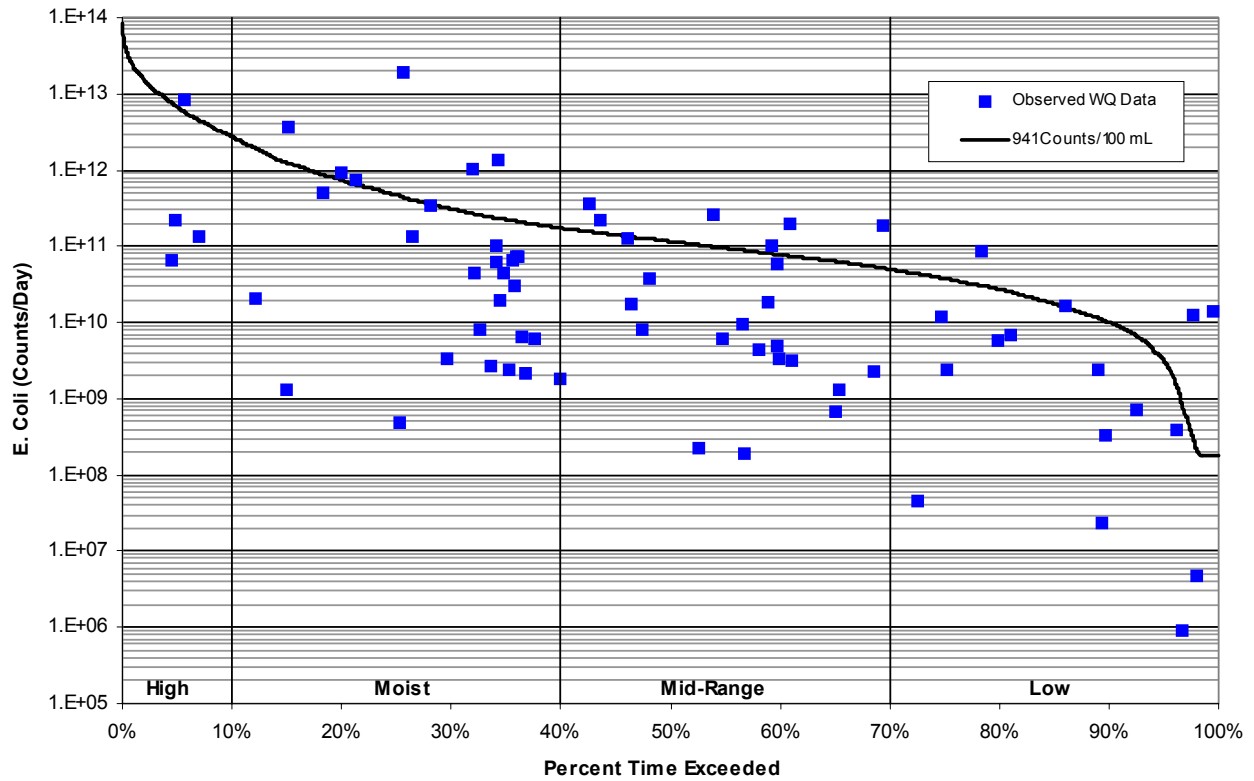


Figure C-2. E. Coli Load Duration Curve for Fletcher Creek at North Shelby Oaks (6W)

Table C-1. TMDLs, WLAs, & LAs for the Wolf River Watershed

HUC-12 Subwatershed (08010210__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs ^a			LAs
					WWTFs ^b	Leaking Collection Systems	MS4s	
			[CFU/day]	[CFU/day]	[CFU/day]	[CFU /day]	[CFU/day/acre]	[CFU/day/acre]
0105	Early Grove Creek	TN08010210009 – 0300	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	NA	NA	$3.24 \times 10^6 * Q$
0201	McKinnie Creek	TN08010210020 – 0300	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	NA	NA	$9.74 \times 10^5 * Q$
	May Creek	TN08010210020 – 0310	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	NA	NA	$2.29 \times 10^6 * Q$
	North Fork Creek	TN08010210020 – 0400	$1.19 \times 10^{10} * Q$	$1.19 \times 10^9 * Q$	NA	NA	NA	$8.28 \times 10^5 * Q$
0202	North Fork Wolf River	TN08010210020 – 2000	$1.19 \times 10^{10} * Q$	$1.19 \times 10^9 * Q$	NA	NA	NA	$2.46 \times 10^5 * Q$
0301	Hurricane Creek	TN08010210004 – 0100	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	NA	NA	$4.69 \times 10^6 * Q$
	Unnamed Tributary to Wolf River	TN08010210004 – 0400	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	0	NA	$2.94 \times 10^6 * Q$
	Russell Creek	TN08010210004 – 0500	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	NA	NA	$4.23 \times 10^6 * Q$
0302	Teague Branch	TN08010210005 – 0100	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	NA	NA	$3.17 \times 10^6 * Q$
	Grissum Creek	TN08010210005 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	NA	NA	$8.80 \times 10^5 * Q$
0303	Alexander Creek	TN08010210021 – 0100	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	NA	NA	$2.74 \times 10^6 * Q$
	Shaws Creek	TN08010210021 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	7.13×10^8	NA	NA	$6.79 \times 10^5 * Q - 2.34 \times 10^4$
0304	Wolf River	TN08010210002 – 2000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	4.31×10^{11}	0	$4.61 \times 10^4 * Q - 9.59 \times 10^5$	$4.61 \times 10^4 * Q - 9.59 \times 10^5$
	Johnson Creek	TN08010210003 – 0100	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	NA	$5.10 \times 10^6 * Q$	$5.10 \times 10^6 * Q$
0305	Unnamed Tributary to Grays Creek	TN08010210022 – 0100	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	0	$8.88 \times 10^6 * Q$	$8.88 \times 10^6 * Q$
	Marys Creek	TN08010210022 – 0300	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	NA	$2.03 \times 10^6 * Q$	$2.03 \times 10^6 * Q$
	Marys Creek Headwaters	TN08010210022 – 0350	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	NA	$8.68 \times 10^6 * Q$	$8.68 \times 10^6 * Q$
0306	Harrington Creek	TN08010210001 – 0100	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	0	$2.79 \times 10^6 * Q$	$2.79 \times 10^6 * Q$
	Workhouse Bayou	TN08010210001 – 0300	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	0	$1.34 \times 10^7 * Q$	$1.34 \times 10^7 * Q$

Table C-1. TMDLs, WLAs, & LAs for the Wolf River Watershed (Cont.)

HUC-12 Subwatershed (08010210__)	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	MOS	WLAs ^a			LAs
					WWTFs ^b	Leaking Collection Systems	MS4s	
			[CFU/day]	[CFU/day]	[CFU /day]	[CFU /day]	[CFU/day/acre]	[CFU/day/acre]
0306 (cont.)	Wolf River	TN08010210001 – 1000	$1.19 \times 10^{10} * Q$	$1.19 \times 10^9 * Q$	4.31×10^{11}	0	$2.04 \times 10^4 * Q - 8.22 \times 10^5$	$2.04 \times 10^4 * Q - 8.22 \times 10^5$
	Cypress Creek	TN08010210032 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	0	$1.72 \times 10^6 * Q$	$1.72 \times 10^6 * Q$
0307	Wolf River	TN08010210002 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	4.31×10^{11}	0	$4.47 \times 10^4 * Q - 1.16 \times 10^6$	$4.47 \times 10^4 * Q - 1.16 \times 10^6$
0308	Unnamed Tributary to Fletcher Creek	TN08010210023 – 0100	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	0	$3.01 \times 10^6 * Q$	$3.01 \times 10^6 * Q$
	Unnamed Tributary to Fletcher Creek	TN08010210023 – 0200	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	0	$8.10 \times 10^6 * Q$	$8.10 \times 10^6 * Q$
	Fletcher Creek	TN08010210023 – 1000	$2.30 \times 10^{10} * Q$	$2.30 \times 10^9 * Q$	NA	0	$1.00 \times 10^6 * Q$	$1.00 \times 10^6 * Q$

Note: NA = Not applicable.

Q = Mean Daily In-stream Flow (cfs).

a. There are no CAFOs in impaired subwatersheds of the Wolf River watershed.

b. WLAs for WWTFs expressed as E. coli loads (CFU/day). Future WWTFs must meet water quality standards at the point of discharge as specified in their NPDES permits. At no time shall concentration exceed appropriate, site-specific (487 CFU/100 mL or 941 CFU/100 mL) water quality standards.

APPENDIX D

Hydrodynamic Modeling Methodology

D.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for flow simulation of E. coli-impaired waters in the Wolf River watershed. LSPC is a watershed model capable of performing flow routing through stream reaches. LSPC is a dynamic watershed model based on the Hydrologic Simulation Program - Fortran (HSPF).

D.2 Model Set Up

The impaired waterbodies were delineated into subwatersheds in order to facilitate model hydrologic calibration. Boundaries were constructed so that subwatershed “pour points” coincided with HUC-12 delineations, 303(d)-listed waterbodies, USGS monitoring stations (see Section C.1), and water quality monitoring stations. Watershed delineation was based on the National Hydrography Dataset (NHD) stream coverage and Digital Elevation Model (DEM) data. This discretization facilitates simulation of daily flows at water quality monitoring stations.

Several computer-based tools were utilized to generate input data for the LSPC model. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display, analyze, and compile available information to support water quality model simulations for selected subwatersheds. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics.

An important factor influencing model results is the precipitation data contained in the meteorological data files used in these simulations. Weather data from the Memphis Airport, Mason, and Bolivar Waterworks meteorological stations were available for the time period from January 1970 through December 2005. Meteorological data for a selected 11-year period was used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (1/1/96 – 12/31/05) used for TMDL analyses.

D.3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from USGS stream gaging stations (<http://waterdata.usgs.gov/tn/nwis/sw>) for the same period of time. Due to the size variation of impaired waterbody drainage areas and dissimilarities in ecoregion flow characteristics, three USGS continuous record stations located in the Wolf River watershed were selected as the basis of the hydrology calibration. The calibrations at each station involved comparison of simulated and observed hydrographs until discrepancies in statistical stream volumes and flows were minimized, as reported in the literature (Lumb, et al., 1994).

Initial values for hydrologic variables were taken from an EPA developed default data set. During the calibration process, model parameters were adjusted within reasonable constraints until acceptable agreement was achieved between simulated and observed streamflow. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

The results of the hydrologic calibrations for Wolf River at LaGrange (USGS 07030392), Wolf River at Germantown (USGS 07031650), and Fletcher Creek at Sycamore View Road (USGS 07031692) are shown in Tables D-1 through D-3 and Figures D-1 through D-3, respectively.

Table D-1. Hydrologic Calibration Summary: Wolf River at LaGrange (USGS 07030392)

Simulation Name:		WolfGS20 (calibration)	Simulation Period:	
Period for Flow Analysis		Wolf River at LaGrange (USGS 07030392)	Watershed Area (ac):	
Begin Date:		10/01/95	Baseflow PERCENTILE:	
End Date:		09/30/05	2.5 <i>Usually 1%-5%</i>	
Total Simulated In-stream Flow:	191.55	Total Observed In-stream Flow:	203.68	
Total of highest 10% flows:	74.85	Total of Observed highest 10% flows:	80.68	
Total of lowest 50% flows:	47.38	Total of Observed Lowest 50% flows:	43.41	
Simulated Summer Flow Volume (months 7-9):	30.89	Observed Summer Flow Volume (7-9):	27.10	
Simulated Fall Flow Volume (months 10-12):	47.83	Observed Fall Flow Volume (10-12):	51.44	
Simulated Winter Flow Volume (months 1-3):	64.54	Observed Winter Flow Volume (1-3):	74.36	
Simulated Spring Flow Volume (months 4-6):	48.29	Observed Spring Flow Volume (4-6):	50.78	
Total Simulated Storm Volume:	132.10	Total Observed Storm Volume:	157.17	
Simulated Summer Storm Volume (7-9):	15.95	Observed Summer Storm Volume (7-9):	15.42	
Errors (Simulated-Observed)		Recommended Criteria		Last run
Error in total volume:	-5.95	10		
Error in 50% lowest flows:	9.15	10		
Error in 10% highest flows:	-7.23	15		
Seasonal volume error - Summer:	13.99	30		
Seasonal volume error - Fall:	-7.02	30		
Seasonal volume error - Winter:	-13.20	30		
Seasonal volume error - Spring:	-4.90	30		
Error in storm volumes:	-15.95	20		
Error in summer storm volumes:	3.40	50		

Table D-2. Hydrologic Calibration Summary: Wolf River at Germantown (USGS 07031650)

Simulation Name:		WolfGS20 (calibration)	Simulation Period:	
		Wolf River at Germantown	Watershed Area (ac):	
Period for Flow Analysis		(USGS 07031650)	447360.00	
Begin Date:		10/01/95	Baseflow PERCENTILE:	
End Date:		09/30/05	2.5	
			Usually 1%-5%	
Total Simulated In-stream Flow:		202.36	Total Observed In-stream Flow:	210.45
Total of highest 10% flows:		102.49	Total of Observed highest 10% flows:	90.51
Total of lowest 50% flows:		34.82	Total of Observed Lowest 50% flows:	38.36
Simulated Summer Flow Volume (months 7-9):		25.55	Observed Summer Flow Volume (7-9):	27.31
Simulated Fall Flow Volume (months 10-12):		55.73	Observed Fall Flow Volume (10-12):	54.78
Simulated Winter Flow Volume (months 1-3):		72.62	Observed Winter Flow Volume (1-3):	77.03
Simulated Spring Flow Volume (months 4-6):		48.45	Observed Spring Flow Volume (4-6):	51.34
Total Simulated Storm Volume:		160.74	Total Observed Storm Volume:	165.81
Simulated Summer Storm Volume (7-9):		15.10	Observed Summer Storm Volume (7-9):	16.08
<i>Errors (Simulated-Observed)</i>		<i>Recommended Criteria</i>		Last run
Error in total volume:		-3.85	10	
Error in 50% lowest flows:		-9.23	10	
Error in 10% highest flows:		13.23	15	
Seasonal volume error - Summer:		-6.42	30	
Seasonal volume error - Fall:		1.74	30	
Seasonal volume error - Winter:		-5.71	30	
Seasonal volume error - Spring:		-5.63	30	
Error in storm volumes:		-3.06	20	
Error in summer storm volumes:		-6.14	50	

Table D-3. Hydrologic Calibration Summary: Fletcher Creek at Sycamore View Road (USGS 07031692)

Simulation Name:		WolfGS11 (calibration)	Simulation Period:	
		Fletcher Cr. at Sycamore View Rd.	Watershed Area (ac):	
Period for Flow Analysis		(USGS 07031692)	19520.00	
Begin Date:		10/01/96	Baseflow PERCENTILE:	
End Date:		09/30/05	2.5	
			Usually 1%-5%	
Total Simulated In-stream Flow:	245.07	Total Observed In-stream Flow:	245.85	
Total of highest 10% flows:	201.28	Total of Observed highest 10% flows:	208.58	
Total of lowest 50% flows:	3.83	Total of Observed Lowest 50% flows:	3.65	
Simulated Summer Flow Volume (months 7-9):	23.46	Observed Summer Flow Volume (7-9):	35.76	
Simulated Fall Flow Volume (months 10-12):	77.86	Observed Fall Flow Volume (10-12):	82.12	
Simulated Winter Flow Volume (months 1-3):	87.80	Observed Winter Flow Volume (1-3):	76.62	
Simulated Spring Flow Volume (months 4-6):	55.95	Observed Spring Flow Volume (4-6):	51.36	
Total Simulated Storm Volume:	245.04	Total Observed Storm Volume:	245.53	
Simulated Summer Storm Volume (7-9):	23.45	Observed Summer Storm Volume (7-9):	35.67	
Errors (Simulated-Observed)		Recommended Criteria		Last run
Error in total volume:	-0.32	10		
Error in 50% lowest flows:	4.85	10		
Error in 10% highest flows:	-3.50	15		
Seasonal volume error - Summer:	-34.39	30		
Seasonal volume error - Fall:	-5.18	30		
Seasonal volume error - Winter:	14.59	30		
Seasonal volume error - Spring:	8.94	30		
Error in storm volumes:	-0.20	20		
Error in summer storm volumes:	-34.26	50		

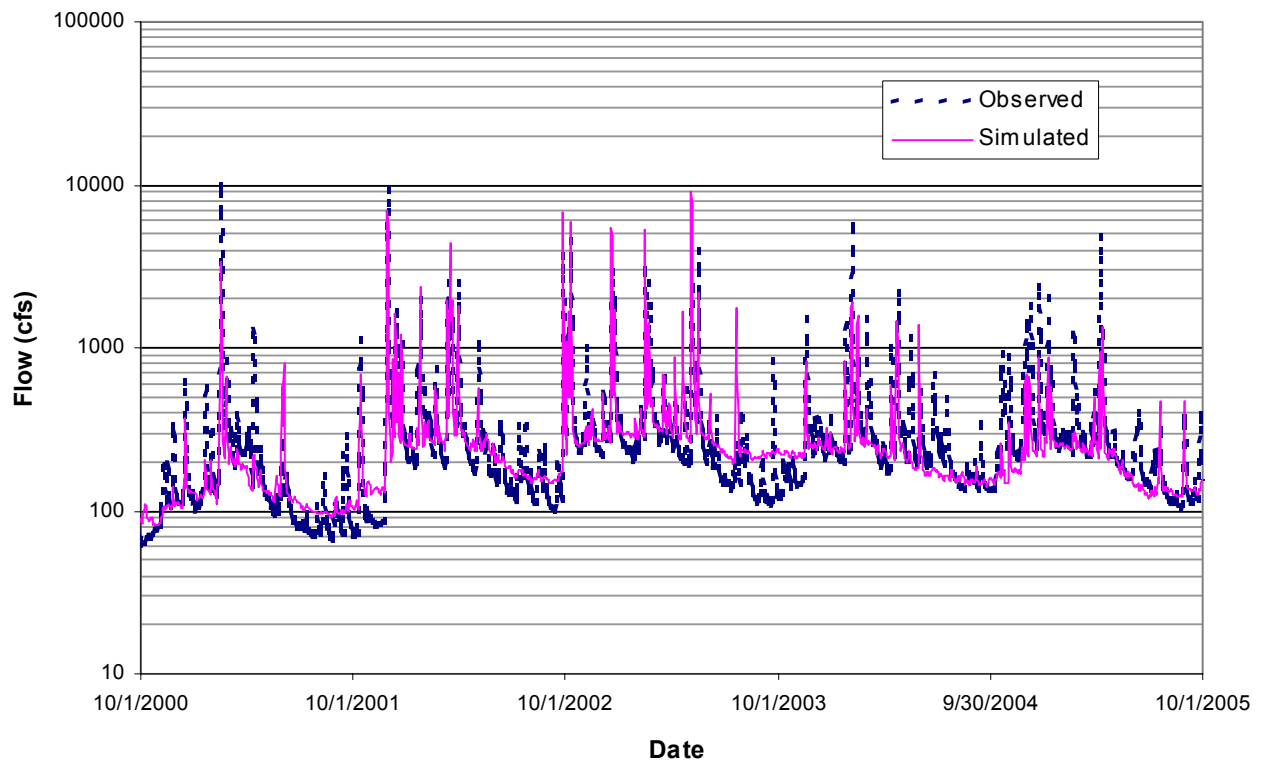
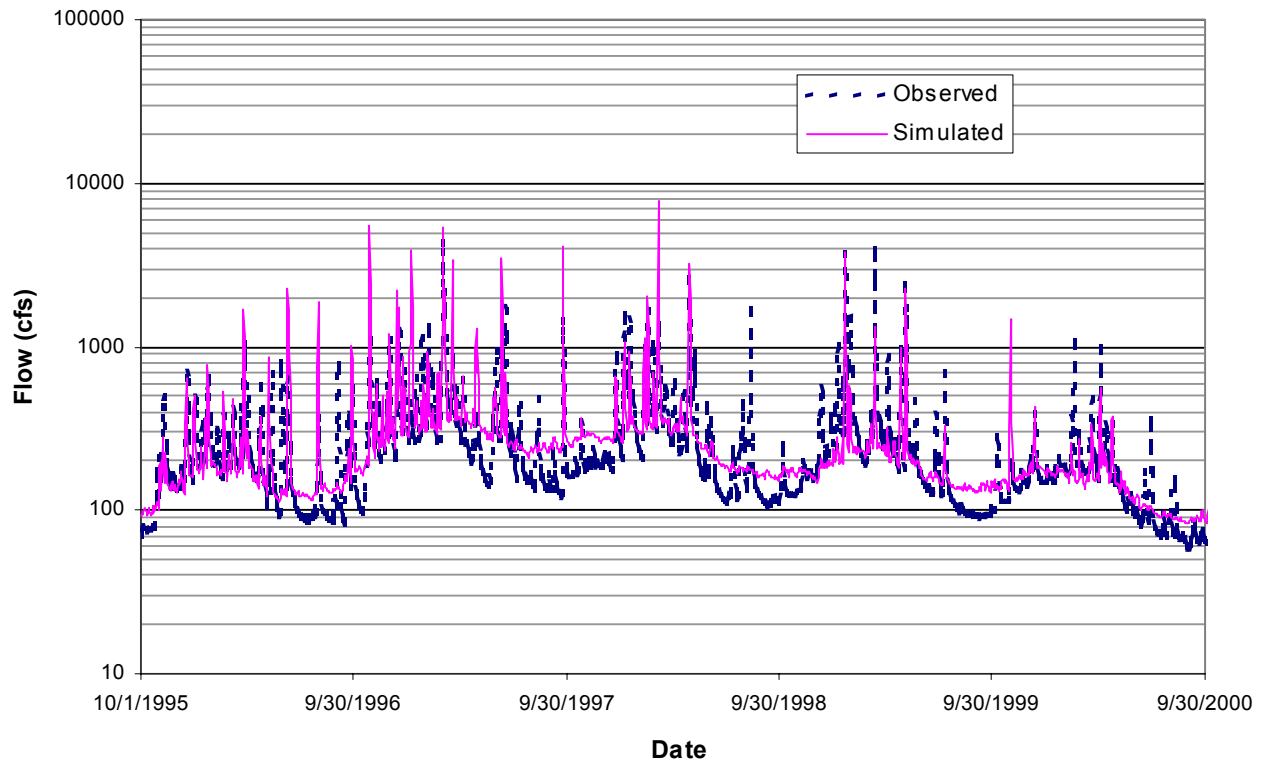


Figure D-1. Hydrologic Calibration: Wolf River at LaGrange (USGS 07030392)

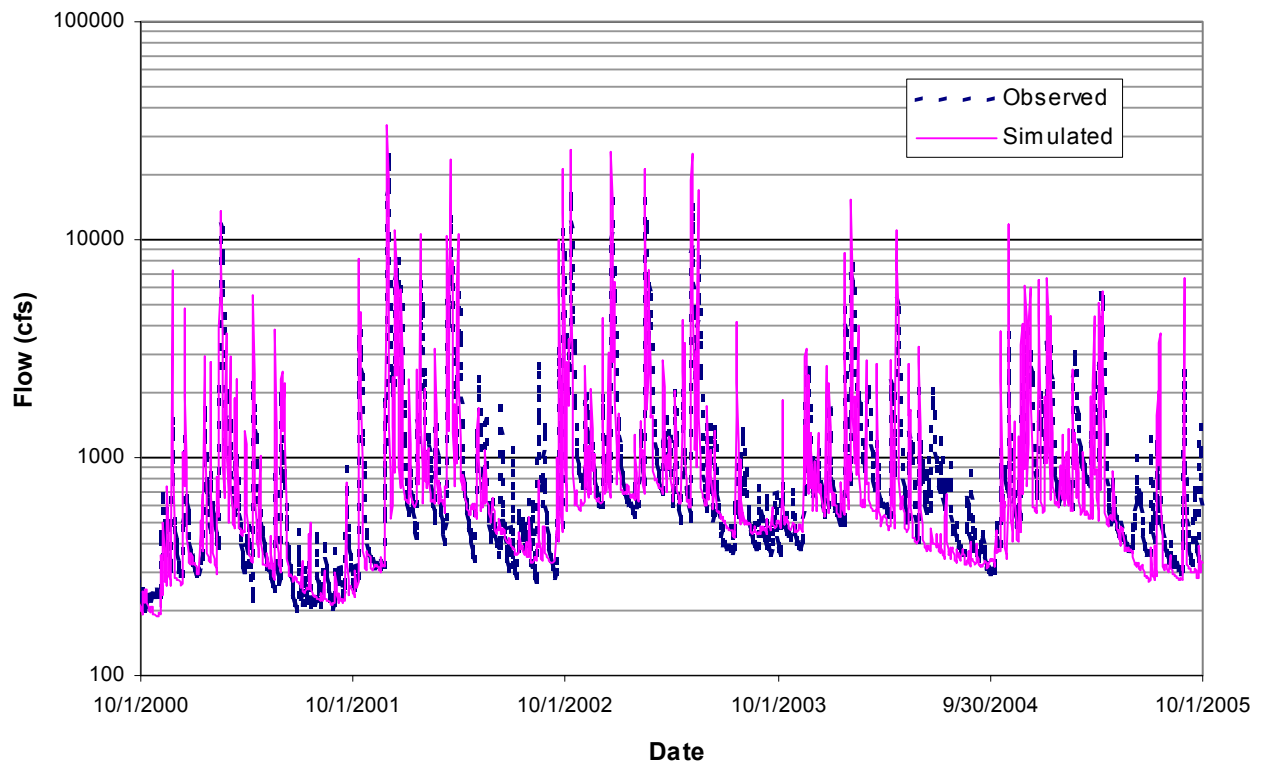
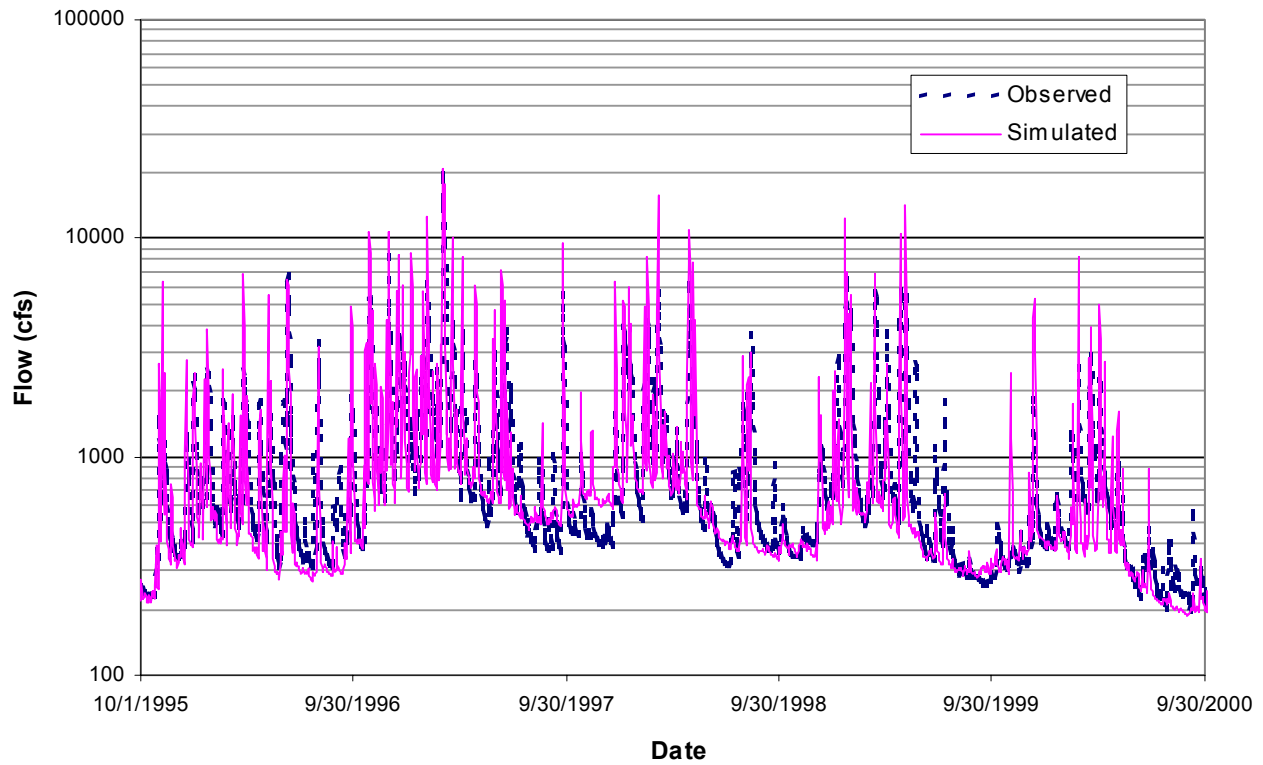


Figure D-2. Hydrologic Calibration: Wolf River at Germantown (USGS 07031650)

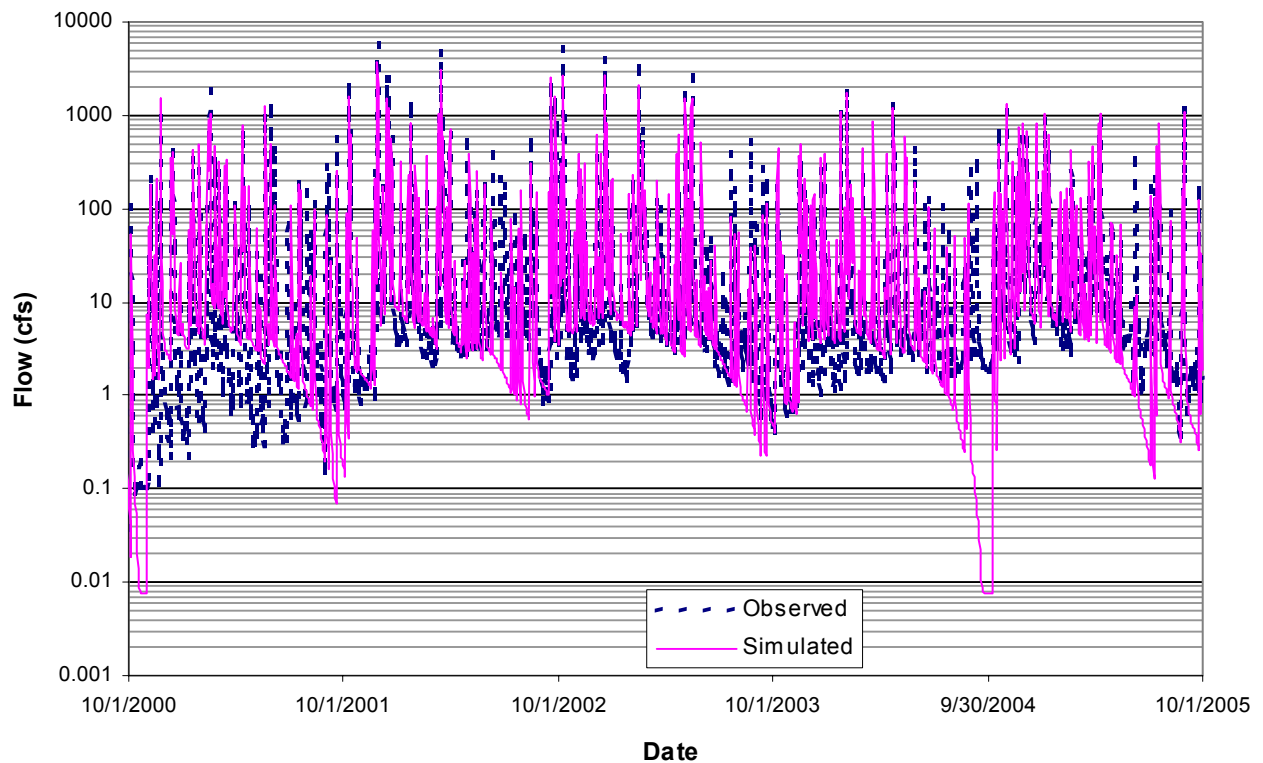
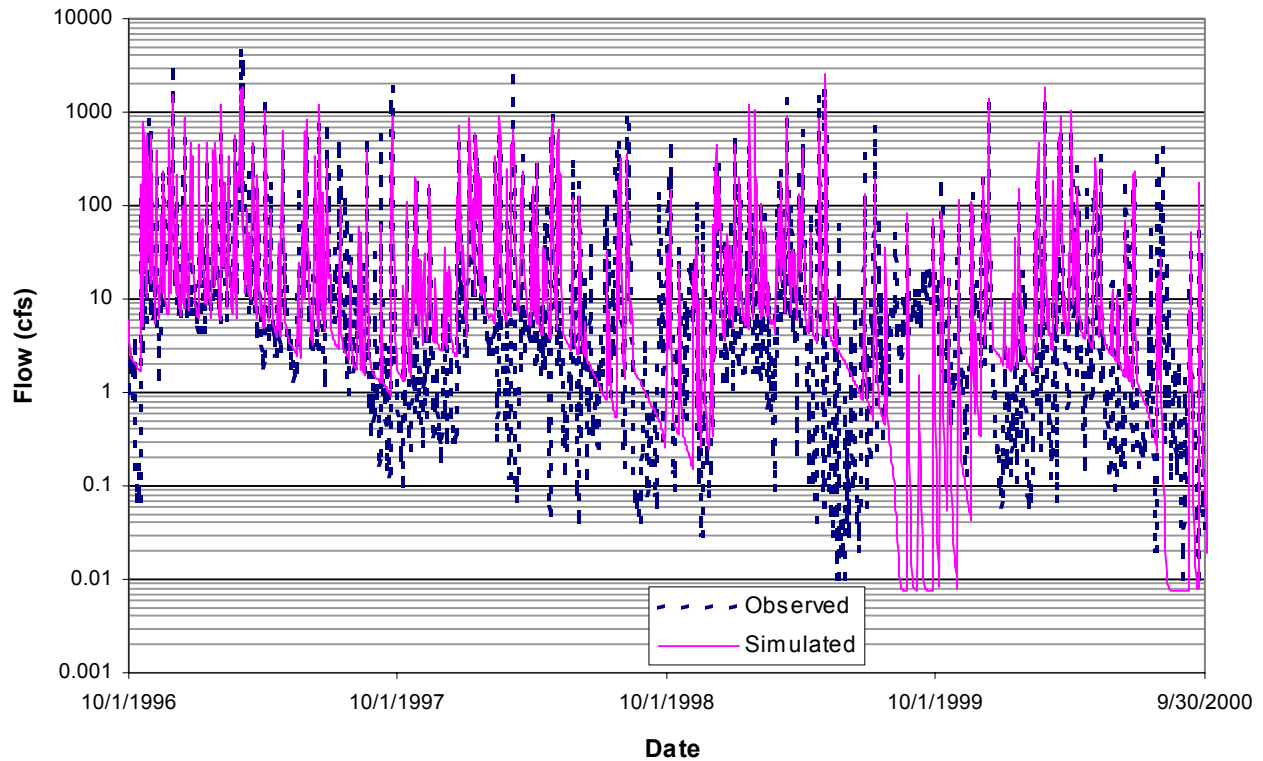


Figure D-3. Hydrologic Calibration: Fletcher Creek at Sycamore View Road (USGS 07031692)

APPENDIX E

Source Area Implementation Strategy

All impaired waterbodies and corresponding HUC-12 subwatersheds or drainage areas have been classified according to their respective source area types in Section 9.5, Table 9. The implementation for each area will be prioritized according to the guidance provided in Sections 9.5.1 and 9.5.2, with examples provided in Sections E.1 and E.2, below. For all impaired waterbodies, the determination of source area types serves to identify the predominant sources contributing to impairment (i.e., those that should be targeted initially for implementation). However, it is not intended to imply that sources in other landuse areas are not contributors to impairment and/or to grant an exemption from addressing other source area contributions with implementation strategies and corresponding load reduction. For mixed use areas, implementation will follow the guidance established for both urban and agricultural areas, at a minimum.

E.1 Urban Source Areas

For impaired waterbodies and corresponding HUC-12 subwatersheds or drainage areas identified as predominantly urban source area types, the following example for Fletcher Creek provides guidance for implementation analysis:

The Fletcher Creek watershed, HUC-12 080102100308, lies almost entirely within the City of Memphis Urban Area District. The drainage area for Fletcher Creek at mile 1.5 is approximately 20,558 acres (32.1 mi²) and zero flows occur during a significant percentage of time under baseflow conditions; therefore, four flow zones were used for the duration curve analysis (see Sect. 9.1.1). The landuse for Fletcher Creek is greater than 50% urban, as defined above. Agricultural areas make up less than 20% of total area. Therefore, the predominate landuse type and sources are urban.

Note: The Final 2006 303(d) List includes Pasture Grazing as a Pollutant Source category for Fletcher Creek; therefore, Fletcher Creek is listed in the Mixed use source area type in Section 9.5, Table 9.

The flow duration curve for Fletcher Creek at mile 1.5 was constructed using simulated daily mean flow for the period from 1/1/96 through 12/31/05 (mile 1.5 corresponds to the location of monitoring station 6W, City of Memphis monitoring station). This flow duration curve is shown in Figure E-1 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record. Flow duration curves for other impaired waterbodies were developed using a similar procedure (Appendix C) and are shown in Figures E-3 and E-5 to E-27.

The E. coli LDC for Fletcher Creek at Mile 1.5 (Figure E-2) was analyzed to determine the frequency with which observed daily water quality loads exceed the E. coli target maximum daily loading (941 CFU/100 mL x flow [cfs] x conversion factor) under four flow conditions (low, mid-range, moist, and high). Observation of the plot illustrates that exceedances occur under all flow zones indicating the Fletcher Creek watershed is impacted by point and non-point-type sources. LDCs for other impaired waterbodies were developed using a similar procedure (Appendix C) and are shown in Figures E-4 and E-28 to E-50.

Critical conditions for the Fletcher Creek watershed (HUC-12 080102100308) occur during low flows, typically indicative of point source contributions (see Table E-3, Section E.4). However, the high and mid-range flow conditions have equal or higher percentages of exceedances, while the moist and mid-range flow conditions have comparable percent load reduction goals (PLRGs) to meet WQS. In addition, exceedances of the E. coli water quality standard are well distributed across the full range of flows and all flow zones, though the magnitude of exceedances varies widely.

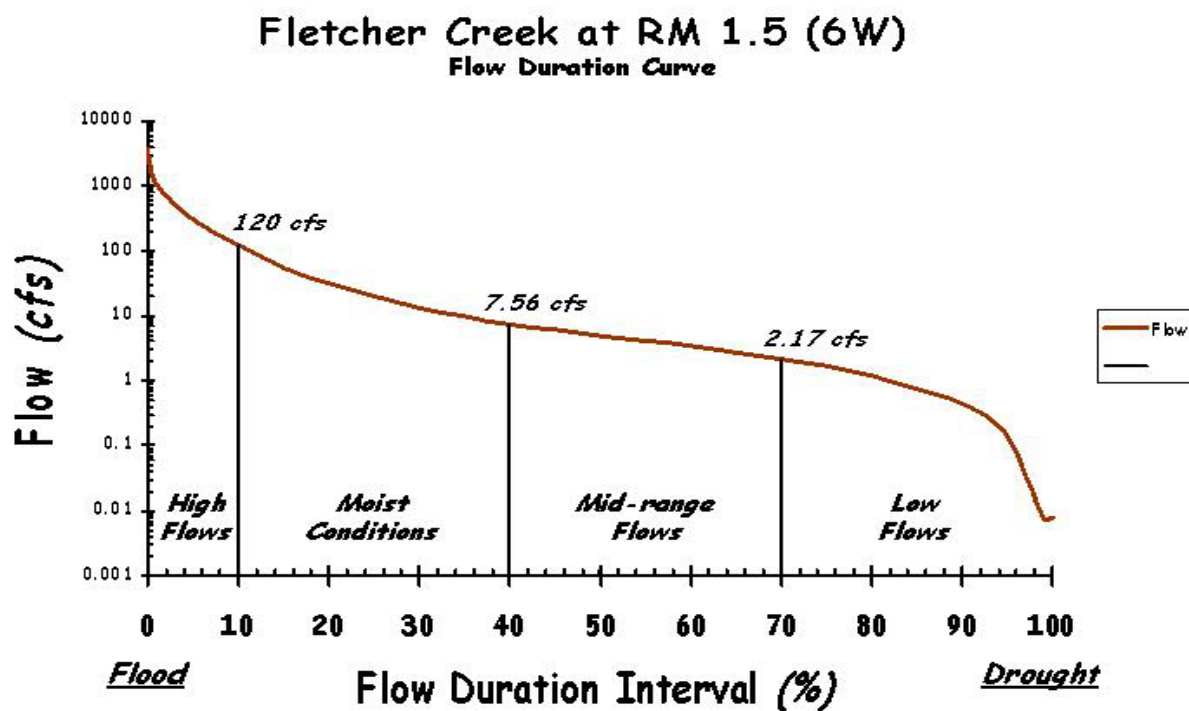


Figure E-1. Flow Duration Curve for Fletcher Creek at Mile 1.5 (6W).

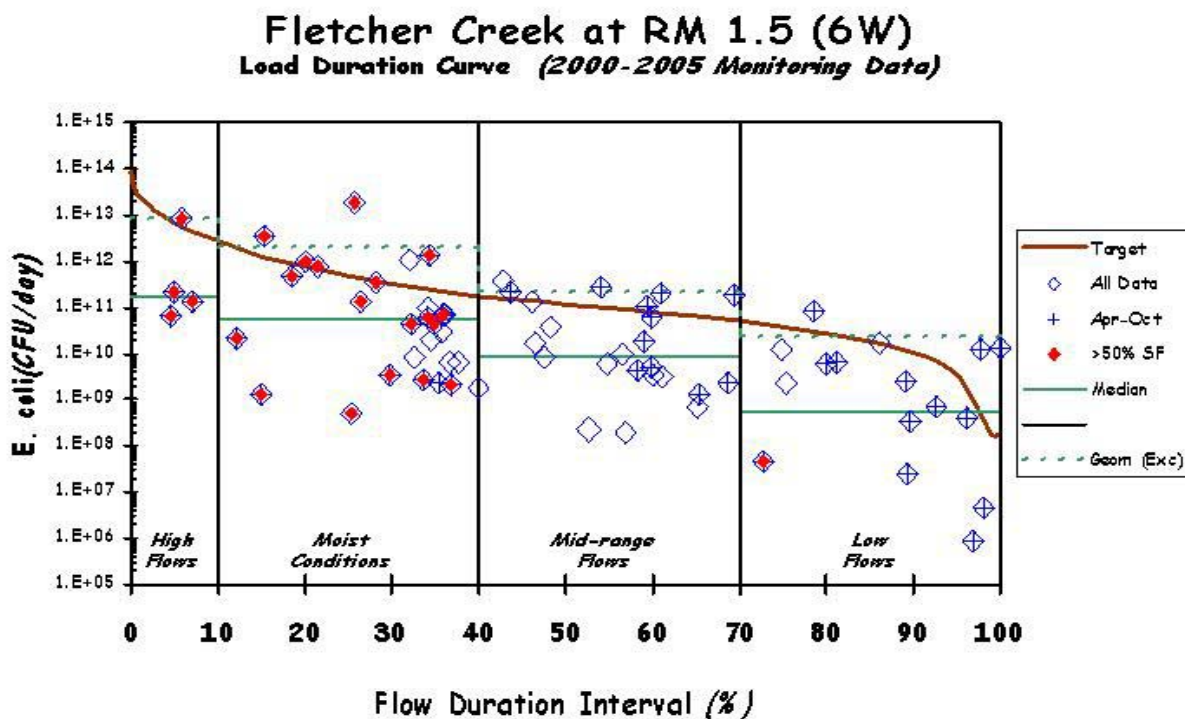


Figure E-2. E. Coli Load Duration Curve for Fletcher Creek at Mile 1.5 (6W).

According to hydrograph separation analysis, most of the exceedances (6 of 7) in the moist and high-flow ranges occur during stormflow events while the majority of the exceedances occurring in the mid-range and low-flow ranges occur during non-storm (baseflow) periods. These factors indicate that non-point sources are also significant contributors to impairment in the Fletcher Creek watershed. Therefore, it is reasonable to say that point and non-point type sources contribute to exceedances of the E. coli standard in Fletcher Creek.

Results indicate the implementation strategy for the Fletcher Creek watershed will require BMPs targeting point sources (dominant under low flow/baseflow conditions) and non-point sources (dominant under high flow/runoff conditions). Table E-1 presents an allocation table of LDC analysis statistics for Fletcher Creek E. coli and implementation strategies for each source category covering the entire range of flow (Stiles, 2003). The implementation strategies listed in Table E-1 are a subset of the categories of BMPs and implementation strategies available for application to the Wolf River watershed for reduction of E. coli loading and mitigation of water quality impairment from urban sources. Targeted implementation strategies and LDC analysis statistics for other impaired waterbodies and corresponding HUC-12 subwatersheds and drainage areas identified as predominantly urban source area types can be derived from the information and results available in Tables 10 and E-4.

Table E-4 presents LDC analyses (TMDLs, WLAs, LAs, and MOS) and PLRGs for all flow zones for all E. coli impaired waterbodies in the Wolf River watershed.

E.2 Agricultural Source Areas

For impaired waterbodies and corresponding HUC-12 subwatersheds or drainage areas identified as predominantly agricultural source area types, the following example for Russell Creek provides guidance for implementation analysis:

The Russell Creek drainage area, a subwatershed of HUC-12 080102100301, lies in a non-urbanized area in Fayette County, TN and Marshall County, MS. The drainage area for Russell Creek at mile 1.5 is approximately 4,898 acres (7.7 mi²) and zero flows occur during a significant percentage of time under baseflow conditions; therefore, four flow zones were used for the duration curve analysis (see Sect. 9.1.1). The landuse for Russell Creek is greater than 75% agricultural, with most of the remainder being forested. Urban areas make up less than 1% of the total area. Therefore, the predominate landuse type and sources are agricultural.

The flow duration curve for Russell Creek at mile 1.5 was constructed using simulated daily mean flow for the period from 1/1/96 through 12/31/05. This flow duration curve is shown in Figure E-3 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record. Flow duration curves for other impaired waterbodies were developed using a similar procedure (see Appendix C) and are shown in Figures E-5 to E-27.

The E. coli LDC for Russell Creek at Mile 1.5 (Figure E-4) was analyzed to determine the frequency with which observed daily water quality loads exceed the E. coli target maximum daily loading (941 CFU/100 mL x flow [cfs] x conversion factor) under four flow conditions (low, mid-range, moist, and high). Observation of the plot illustrates that exceedances occur under all flow zones indicating the Russell Creek watershed is impacted by point and non-point-type sources. LDC s for other impaired waterbodies were developed using a similar procedure (Appendix C) and are shown in Figures E-28 to E-50.

Table E-1. Load Duration Curve Summary for Implementation Strategies (Example: Fletcher Creek subwatershed, HUC-12 080102100308) (4 Flow Zones).

Hydrologic Condition		High	Moist	Mid-range	Low*
% Time Flow Exceeded		0-10	10-40	40-70	70-100
Fletcher Creek (080102100308)	Number of Samples	4	29	23	16
	% > 941 CFU/100 mL ¹	25.0	20.7	26.1	25.0
	Load Reduction ²	8.2%	12.3%	13.4%	16.6%
TMDL (CFU/day)		6.71E+12	4.72E+11	9.46E+10	1.77E+10
Margin of Safety (CFU/day)		6.71E+11	4.72E+10	9.46E+09	1.77E+09
WLA (WWTFs) (CFU/day)		NA	NA	NA	NA
WLAs (MS4s) (CFU/day/acre) ³		2.92E+08	2.05E+07	4.12E+06	7.70E+05
LA (CFU/day/acre) ³		2.92E+08	2.05E+07	4.12E+06	7.70E+05
Implementation Strategies ⁴					
Municipal NPDES			L	M	H
Stormwater Management			H	H	
SSO Mitigation		H	H	M	
Collection System Repair			L	M	H
Septic System Repair			L	M	M
Potential for source area contribution under given flow condition (H: High; M: Medium; L: Low)					

* The Low flow zone represents the critical conditions for E. coli loading in the Fletcher Creek subwatershed.

¹ Tennessee Maximum daily water quality criterion for E. coli.

² Reductions (percent) based on mean of observed percent load reductions in range.

³ LAs and MS4s are expressed as daily load per unit area in order to provide for future changes in the distribution of LAs and MS4s (WLAs).

⁴ Watershed-specific Best Management Practices for Urban Source reduction. Actual BMPs applied may vary and should not be limited according to this grouping.

Critical conditions for the Russell Creek drainage area (a subwatershed of HUC-12 080102100301) occur during low flows, typically indicative of point source contributions (see Table E-3, Section E.4). Exceedances of the E. coli water quality standard are fairly well distributed across the full range of flows and all flow zones, though the magnitude of exceedances varies widely.

According to hydrograph separation analysis, two exceedances in the moist and high-flow ranges occur during stormflow events while the remaining five (5) exceedances occurring in the mid-range and low-flow ranges occur during non-storm (baseflow) periods. These factors indicate that non-point sources are also significant contributors to impairment in the Russell Creek watershed. Therefore, it is reasonable to say that point and non-point type sources contribute to exceedances of the E. coli standard in Russell Creek.

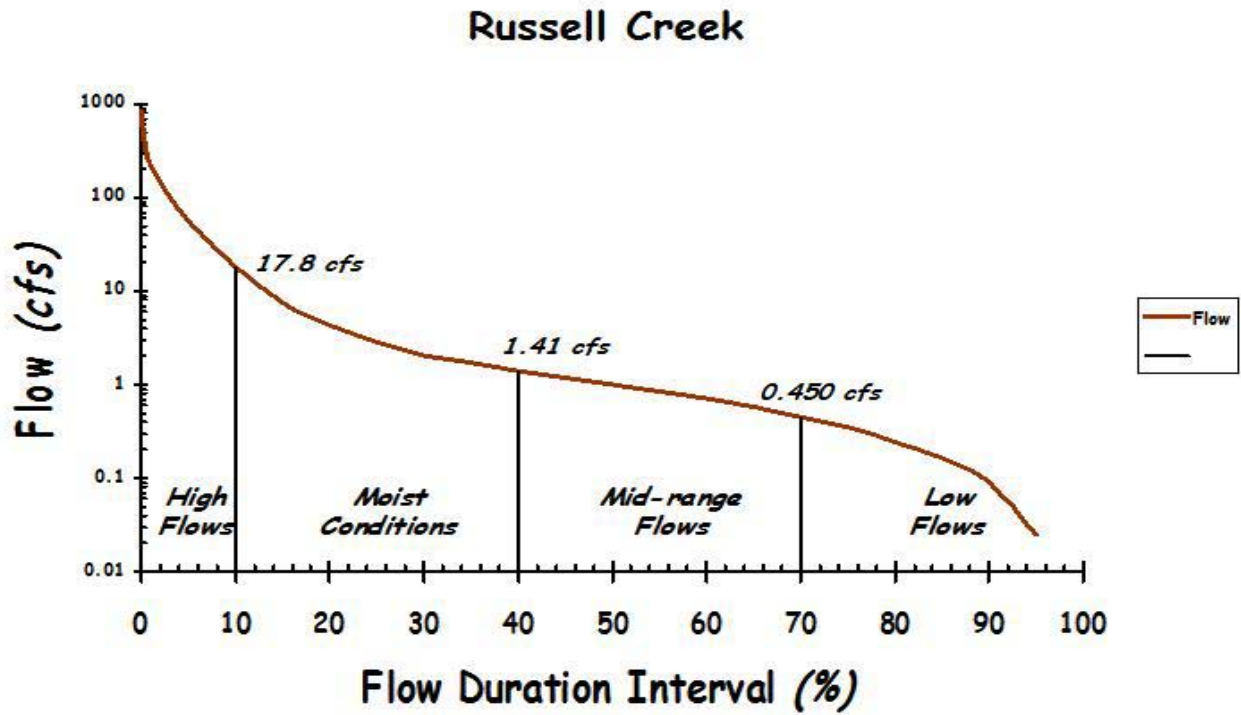


Figure E-3. Flow Duration Curve for Russell Creek.

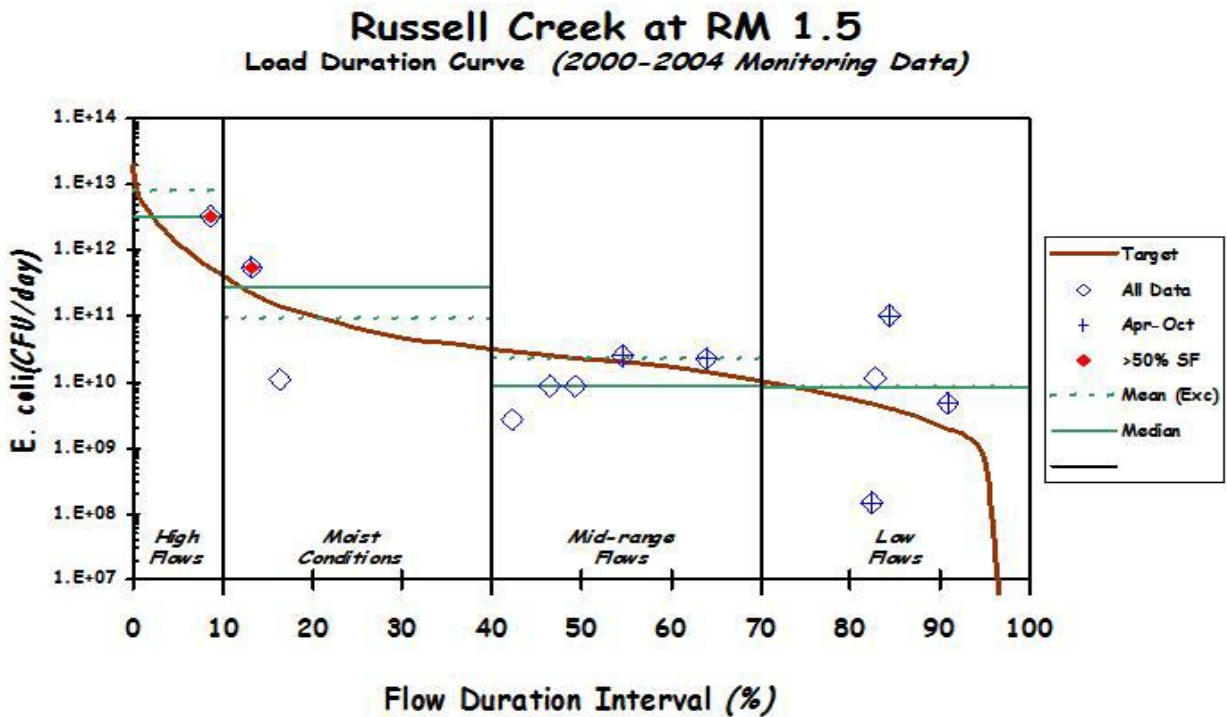


Figure E-4. E. Coli Load Duration Curve for Russell Creek at Mile 1.5.

E. Coli TMDL

Wolf River Watershed (HUC 08010210)

(8/1/07 – Final)

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Results indicate the implementation strategy for the Russell Creek watershed will require BMPs targeting point-type sources (dominant under low flow/baseflow conditions) and non-point sources (dominant under high flow/runoff conditions). Table E-2 presents an allocation table of Load Duration Curve analysis statistics for Russell Creek E. coli and targeted implementation strategies for each source category covering the entire range of flow (Stiles, 2003). The implementation strategies listed in Table E-2 are a subset of the categories of BMPs and implementation strategies available for application to the Wolf River watershed for reduction of E. coli loading and mitigation of water quality impairment from agricultural sources. Targeted implementation strategies and LDC analysis statistics for other impaired waterbodies and corresponding HUC-12 subwatersheds and drainage areas identified as predominantly agricultural source area types can be derived from the information and results available in Tables 11 and E-4.

Table E-7 presents LDC analyses (TMDLs, WLAs, LAs, and MOS) and PLRGs for all flow zones for all E. coli impaired waterbodies in the Wolf River watershed.

Table E-2. Load Duration Curve Summary for Implementation Strategies (Example: Russell Creek drainage area, HUC-12 080102100301) (4 Flow Zones).

Hydrologic Condition		High	Moist	Mid-range	Low*
% Time Flow Exceeded		0-10	10-40	40-70	70-100
Russell Creek (080102100301)	Number of Samples	1	2	5	4
	% > 941 CFU/100 mL ¹	100	50.0	40.0	75.0
	Load Reduction ²	83.8	30.6	12.2	54.6
TMDL (CFU/day)		1.28E+12	6.47E+10	1.97E+10	3.74E+09
Margin of Safety (CFU/day)		1.28E+11	6.47E+09	1.97E+09	3.74E+08
WLA (WWTFs) (CFU/day)		NA	NA	NA	NA
WLA (MS4s) (CFU/day/acre) ³		NA	NA	NA	NA
LAs (CFU/day/acre) ³		2.35E+08	1.19E+07	3.62E+06	6.88E+05
Implementation Strategies ⁴					
Pasture and Hayland Management		H	H	M	L
Livestock Exclusion				M	H
Fencing				M	H
Manure Management		H	H	M	L
Riparian Buffers		L	M	H	M
Potential for source area contribution under given flow condition (H: High; M: Medium; L: Low)					

* The Low flow zone represents the critical conditions for E. coli loading in the Russell Creek subwatershed.

¹ Tennessee Maximum daily water quality criterion for E. coli.

² Reductions (percent) based on mean of observed percent load reductions in range.

³ LAs and MS4s are expressed as daily load per unit area in order to provide for future changes in the distribution of LAs and MS4s (WLAs).

⁴ Example Best Management Practices for Agricultural Source reduction. Actual BMPs applied may vary and should not be limited according to this grouping.

E.3 Forestry Source Areas

There are no impaired waterbodies with corresponding HUC-12 subwatersheds or drainage areas classified as source area type predominantly forested, with the predominate source category being wildlife, in the Wolf River watershed.

E.4 Calculation of Percent Load Reduction Goals and Determination of Critical Flow Zones

In order to facilitate implementation, corresponding percent reductions in loading required to decrease existing, in-stream E. coli loads to TMDL target levels (percent load reduction goals) were calculated. The following example is from Russell Creek at mile 1.5:

- For each flow zone, the mean of the percent exceedances of individual loads relative to their respective target maximum loads (at their respective PDFEs) was calculated. Each negative percent exceedance was assumed to be equal to zero.

Example: Under Low Flow Conditions (Low Flow Zone):

Date	Sample Conc. (CFU/100 mL)	Flow (cfs)	Existing Load (CFU/Day)	Target (TMDL) Load (CFU/Day)	Percent Reduction
8/18/03	30.6	0.201	1.51E+08	4.63E+09	0 (-2975)
9/10/03	2419.2	0.198	1.17E+10	4.56E+09	61.1
10/8/03	24192	0.171	1.01E+11	3.94E+09	96.1
11/5/03	2419.2	0.0817	4.84E+09	1.88E+09	61.1
Percent Load Reduction Goal (PLRG) for Low-Flow Zone (Mean)					54.6

- The PLRGs calculated for each of the flow zones, not including the high flow zone, were compared and the PLRG of the greatest magnitude indicates the critical flow zone for prioritizing implementation actions for Russell Creek.

Example: High Flow Zone Percent Load Reduction Goal = 83.8%
 Moist Flow Zone Percent Load Reduction Goal = 30.6%
 Mid-Range Flow Zone Percent Load Reduction Goal = 12.2%
Low Flow Zone Percent Load Reduction Goal = 54.6%

Therefore, the critical flow zone for prioritization of Russell Creek implementation activities is the Low Flow Zone and subsequently actions targeting point source controls.

PLRG s and critical flow zones of the other impaired waterbodies were derived in a similar manner and are shown in Table E-4.

Table E-3. Summary of Critical Conditions for impaired waterbodies in the Wolf River watershed.

Waterbody ID	Moist	Mid-range	Dry	Low
Early Grove Creek ^a		ò		
McKinnie Creek ^a		ò		
May Creek ^a	ò			
North Fork Creek ^a		ò		
North Fork Wolf River ^a		ò		
Hurricane Creek ^b		ò		
UT to Wolf River ^b				ò
Russell Creek ^b				ò
Teague Branch ^b		ò		
Grissum Creek ^b		ò		
Alexander Creek ^b		ò		
Shaws Creek ^a		ò		
Wolf River #1 ^a	ò			
Johnson Creek ^b	ò			ò
UT to Grays Creek ^b	ò			
Marys Creek ^b	ò			
Marys Creek Headwaters ^b		ò		
Harrington Creek ^b	ò			
Workhouse Bayou ^a		ò		
Wolf River #2 ^a				ò
Cypress Creek ^b		ò		
Wolf River #3 ^a	ò			
UT #1 to Fletcher Creek ^b		ò		
UT #2 to Fletcher Creek ^b	ò			
Fletcher Creek ^b				ò

^a Waterbody(ies) with 5 flow zones.

^b Waterbody(ies) with 4 flow zones.

Geometric Mean Data

For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean E. coli concentration was determined and compared to the target geometric mean E. coli concentration of 126 CFU/100mL. If the sample geometric mean exceeded the target geometric mean concentration, the reduction required to reduce the sample geometric mean value to the target geometric mean concentration was calculated.

Example: Insufficient monitoring data were available for Fletcher Creek. In addition, insufficient data were available for all Wolf River watershed impaired waterbody monitoring stations. The following example is from the Obion River watershed:

Sampling Period = 9/7/05 – 10/4/05 (5 samples: 108.6, 228.2, 259.5, 770, 520)
Geometric Mean Concentration = 303 CFU/100 mL
Target Concentration = 126 CFU/100 mL
Reduction to Target = 58.5%

For impaired waterbodies where monitoring data are limited to geometric mean data only, results can be utilized for general indication of relative impairment and, when plotted on a load duration curve, may indicate areas for prioritization of implementation efforts. For impaired waterbodies where both types of data are available, geometric mean data may be utilized to supplement the results of the individual flow zone calculations.

Early Grove Creek

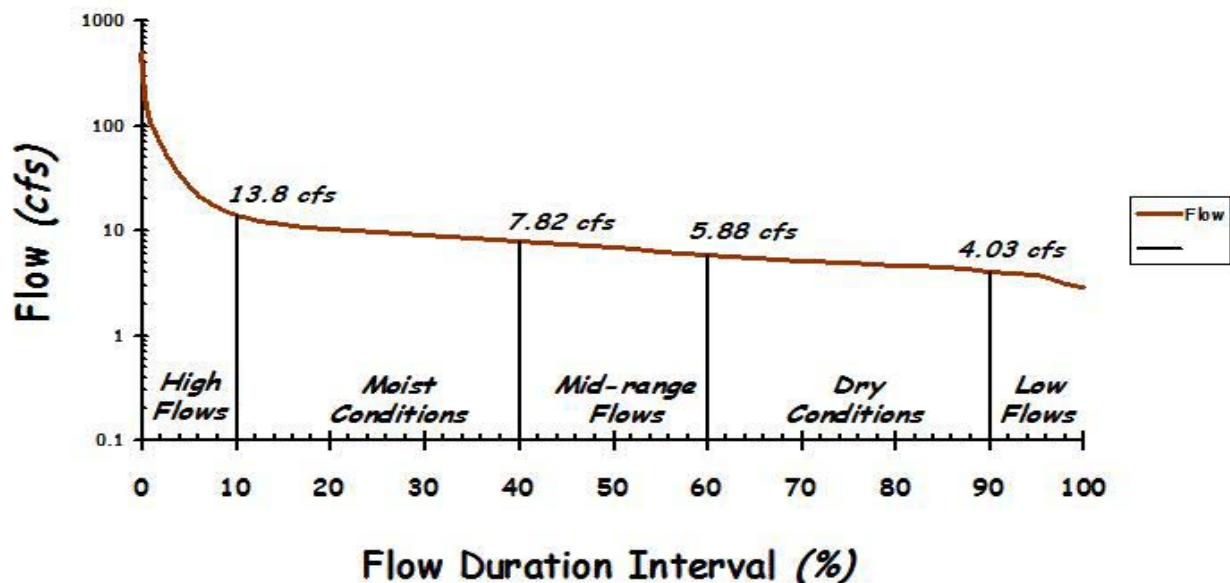


Figure E-5. Flow Duration Curve for Early Grove Creek.

McKinnie Creek

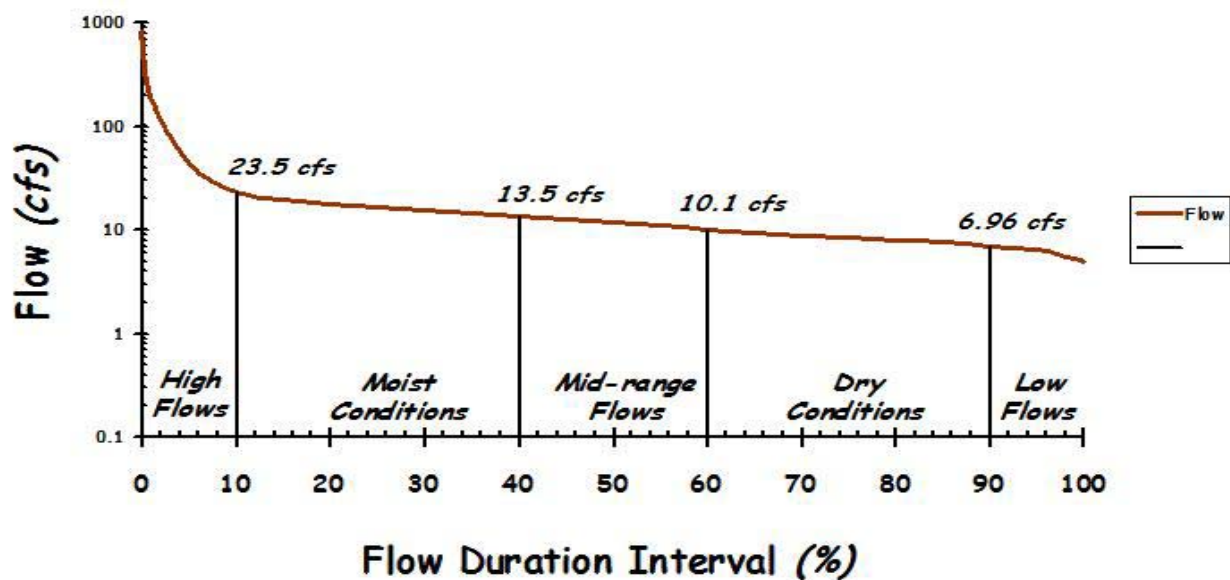


Figure E-6. Flow Duration Curve for McKinnie Creek.

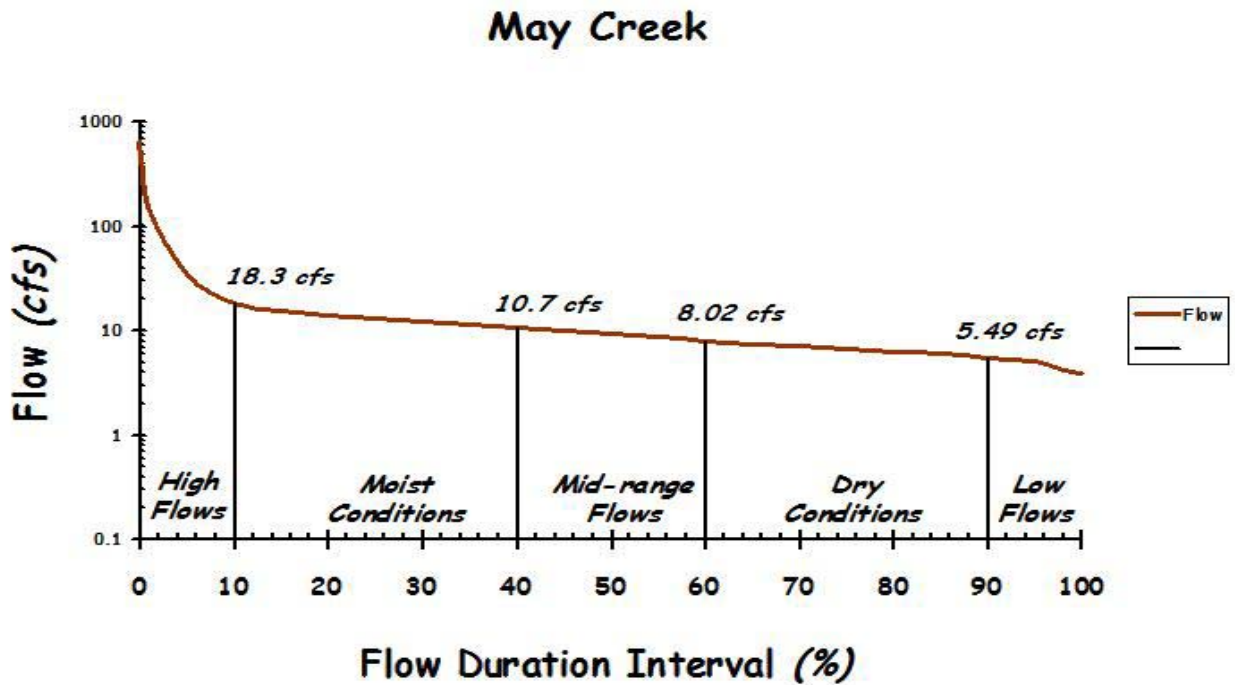


Figure E-7. Flow Duration Curve for May Creek.

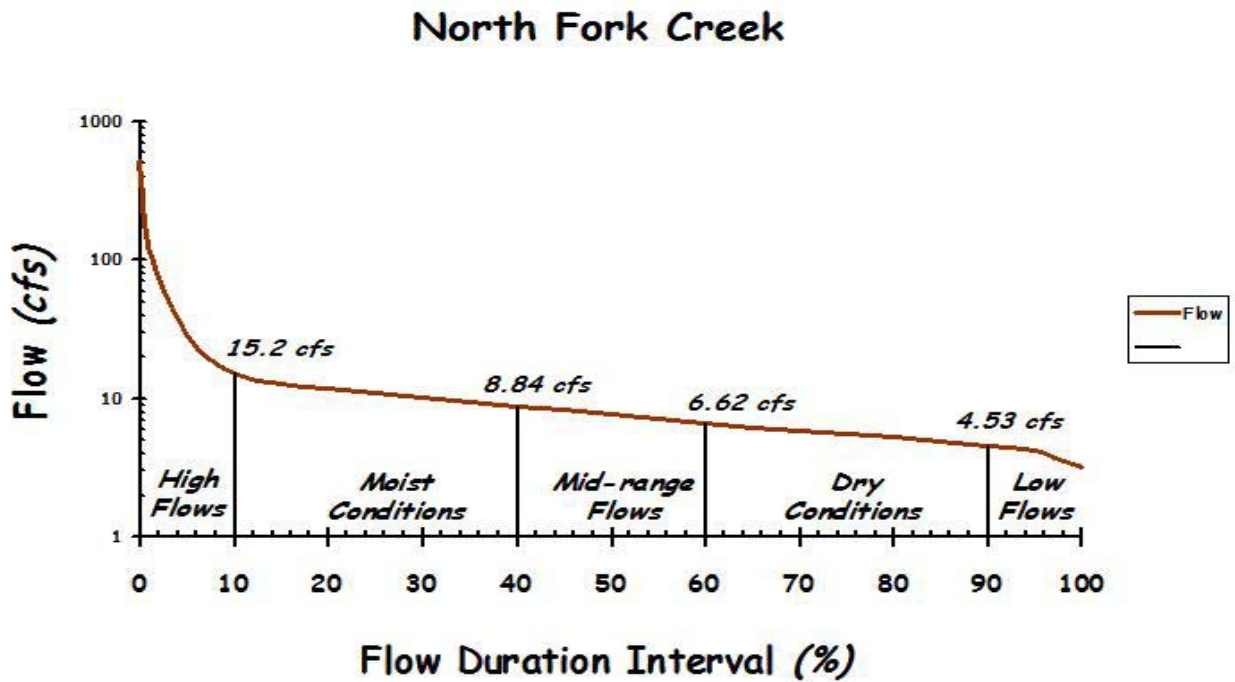


Figure E-8. Flow Duration Curve for North Fork Creek.

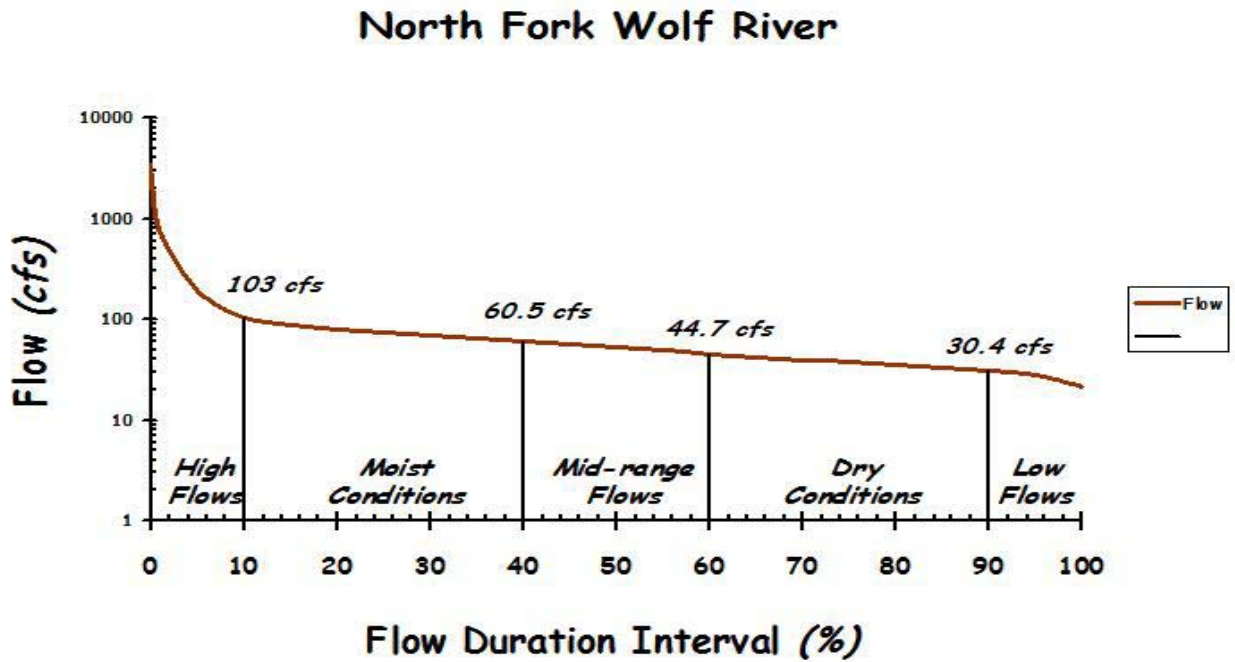


Figure E-9. Flow Duration Curve for North Fork Wolf River.

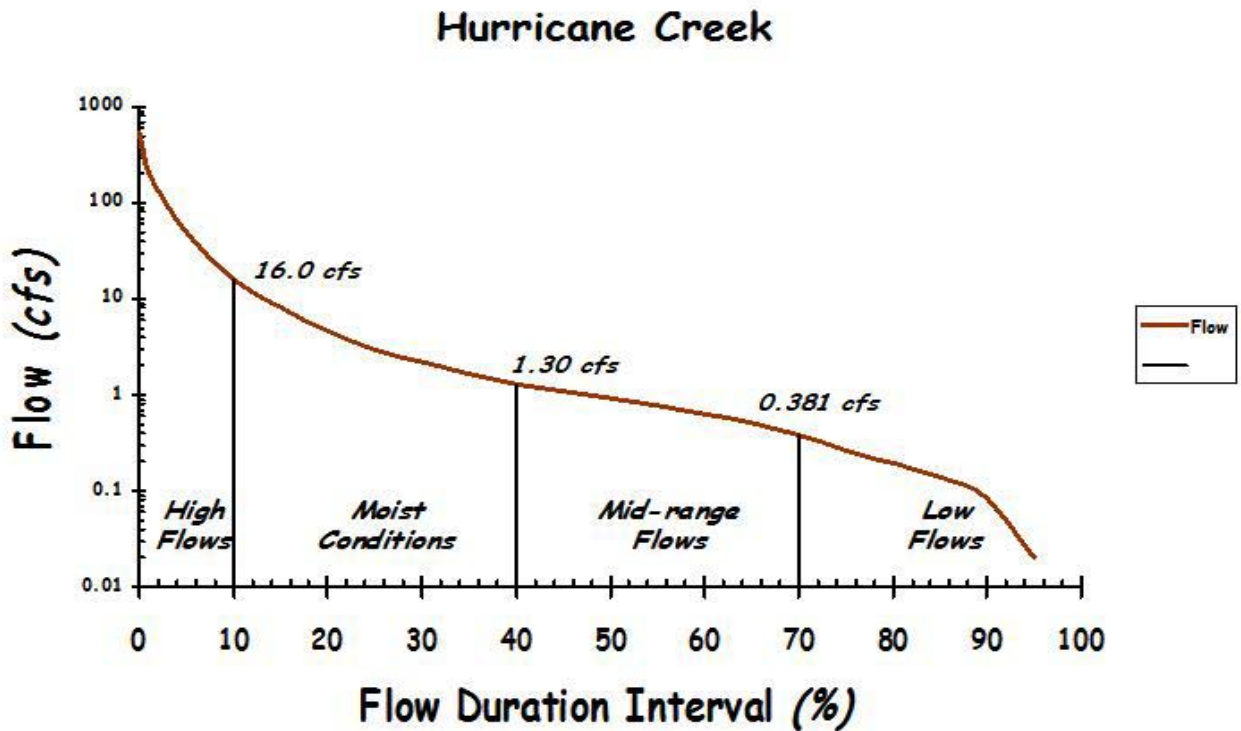


Figure E-10. Flow Duration Curve for Hurricane Creek.

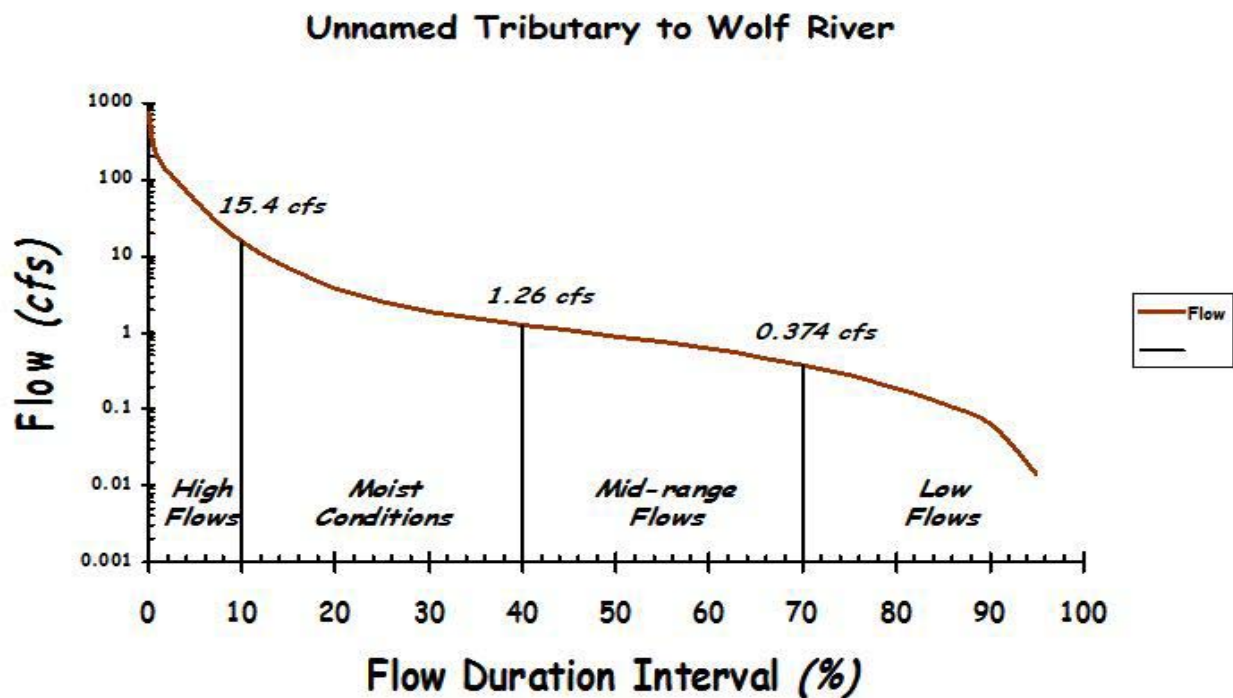


Figure E-11. Flow Duration Curve for Unnamed Tributary to Wolf River.

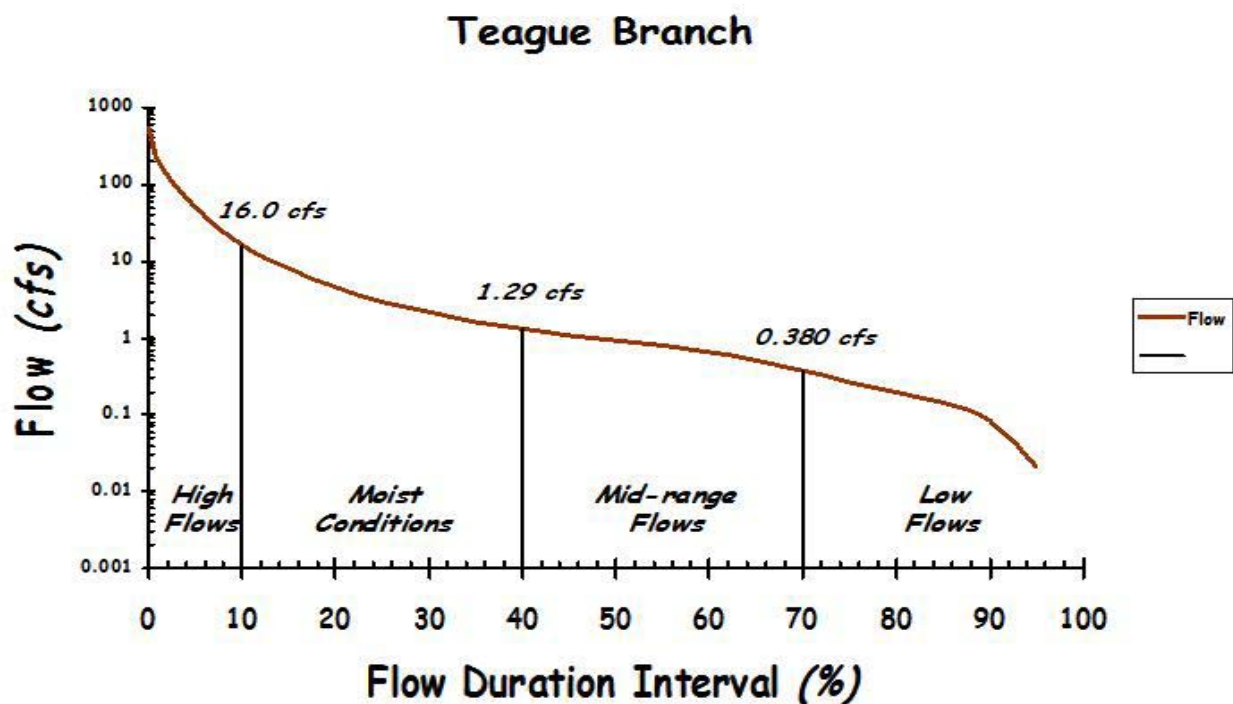


Figure E-12. Flow Duration Curve for Teague Branch.

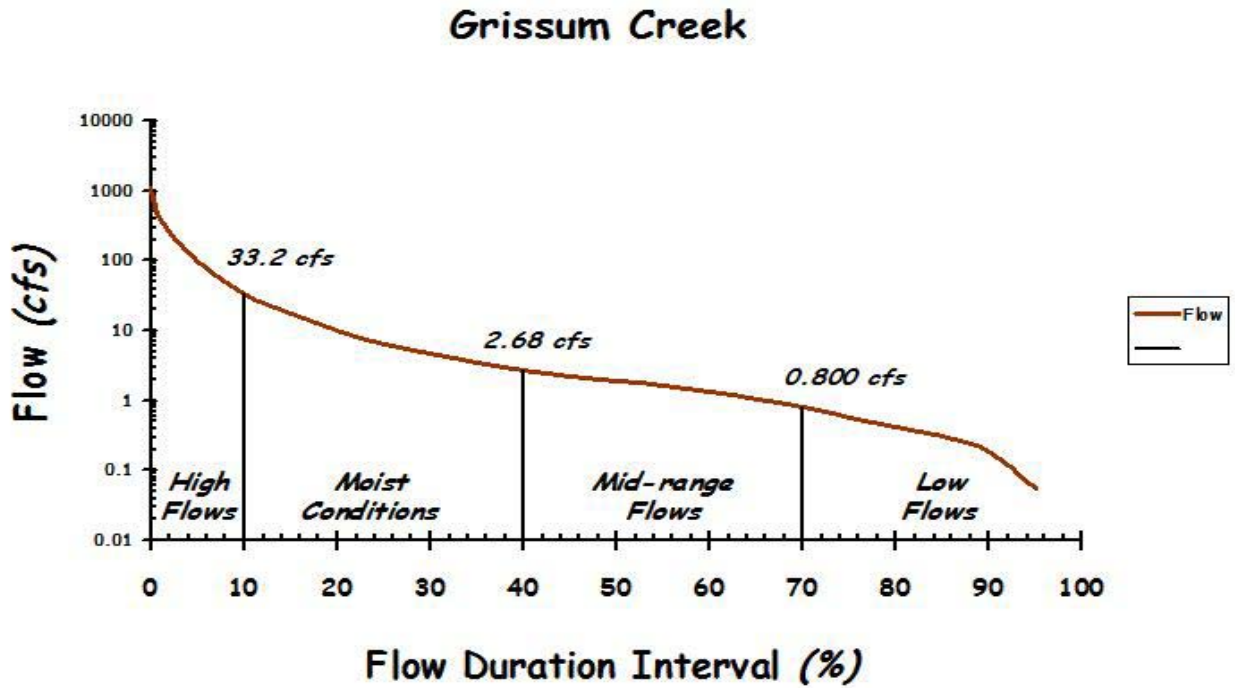


Figure E-13. Flow Duration Curve for Grissum Creek.

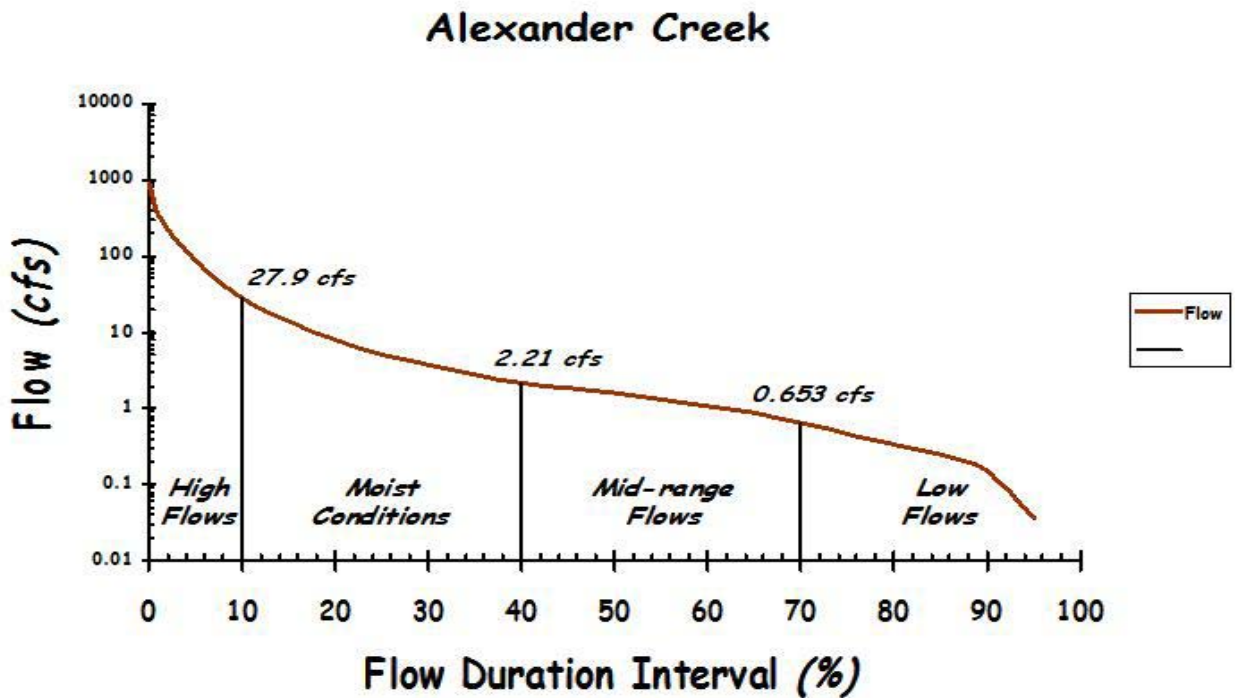


Figure E-14. Flow Duration Curve for Alexander Creek.

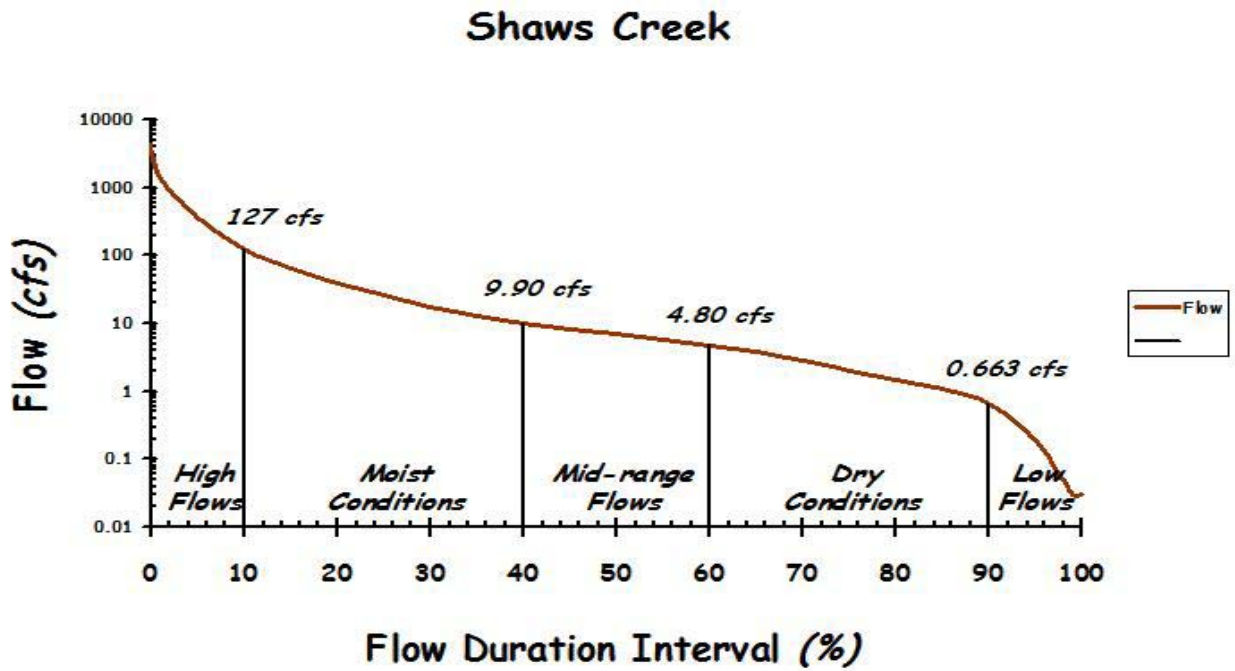


Figure E-15. Flow Duration Curve for Shaws Creek.

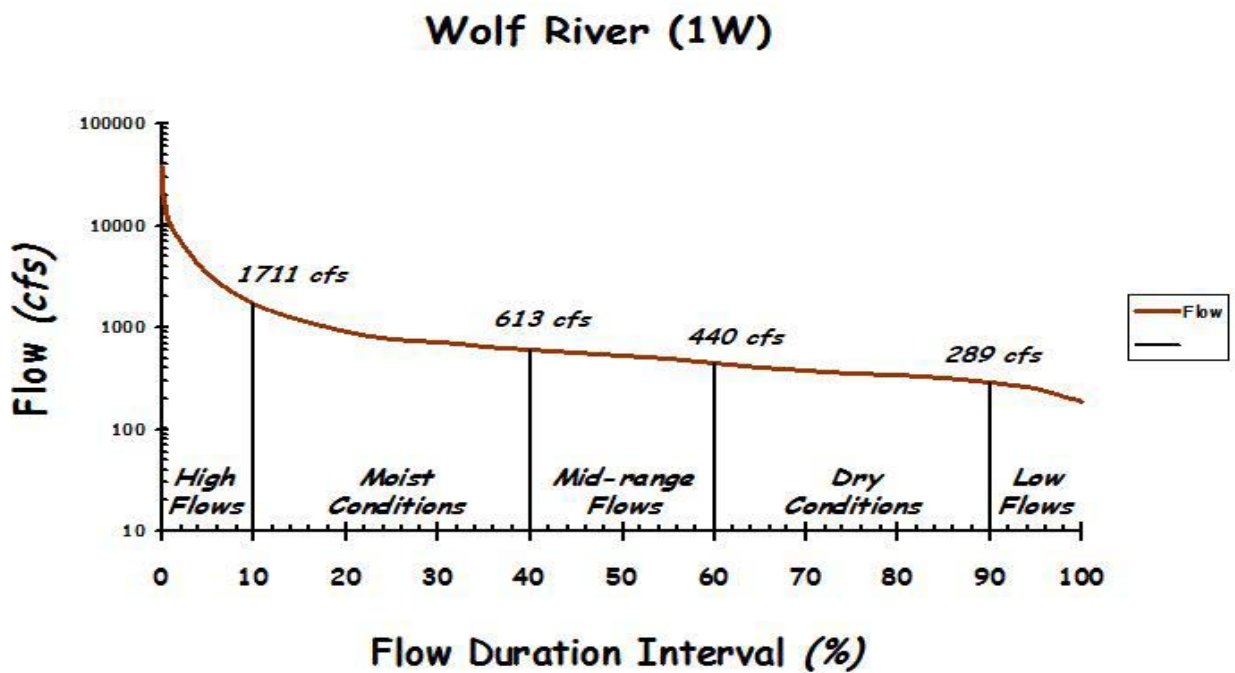


Figure E-16. Flow Duration Curve for Wolf River (1W).

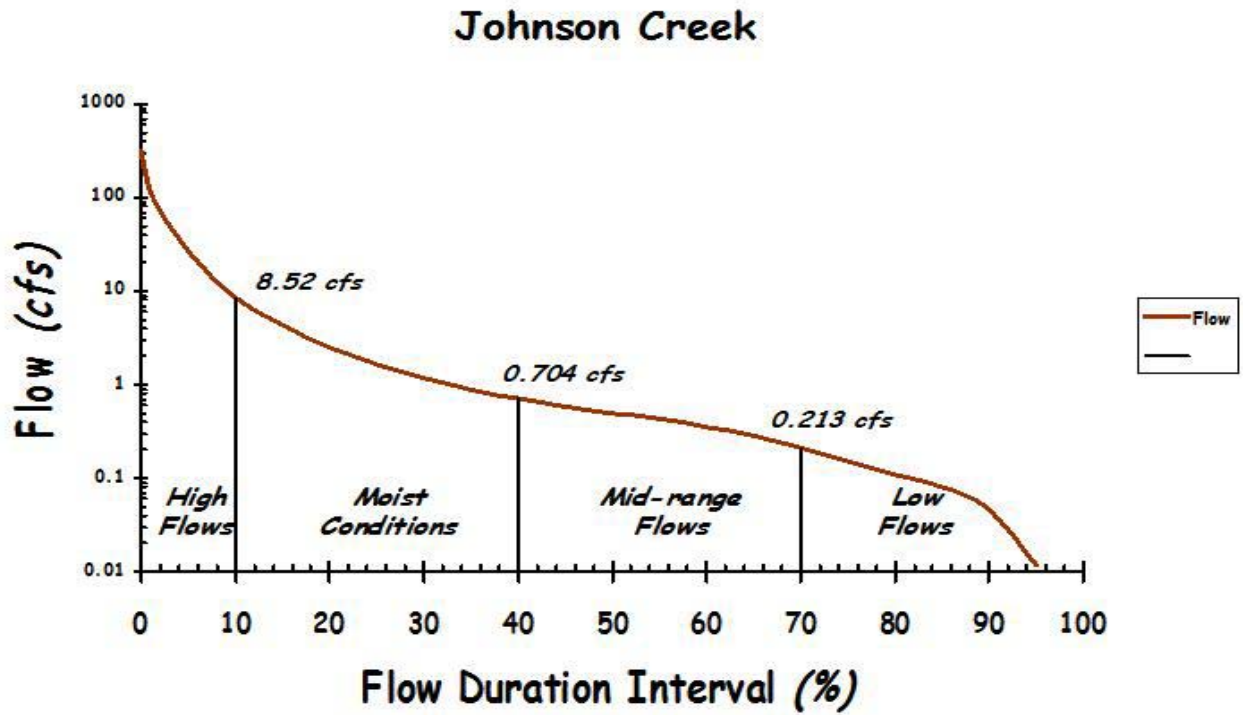


Figure E-17. Flow Duration Curve for Johnson Creek.

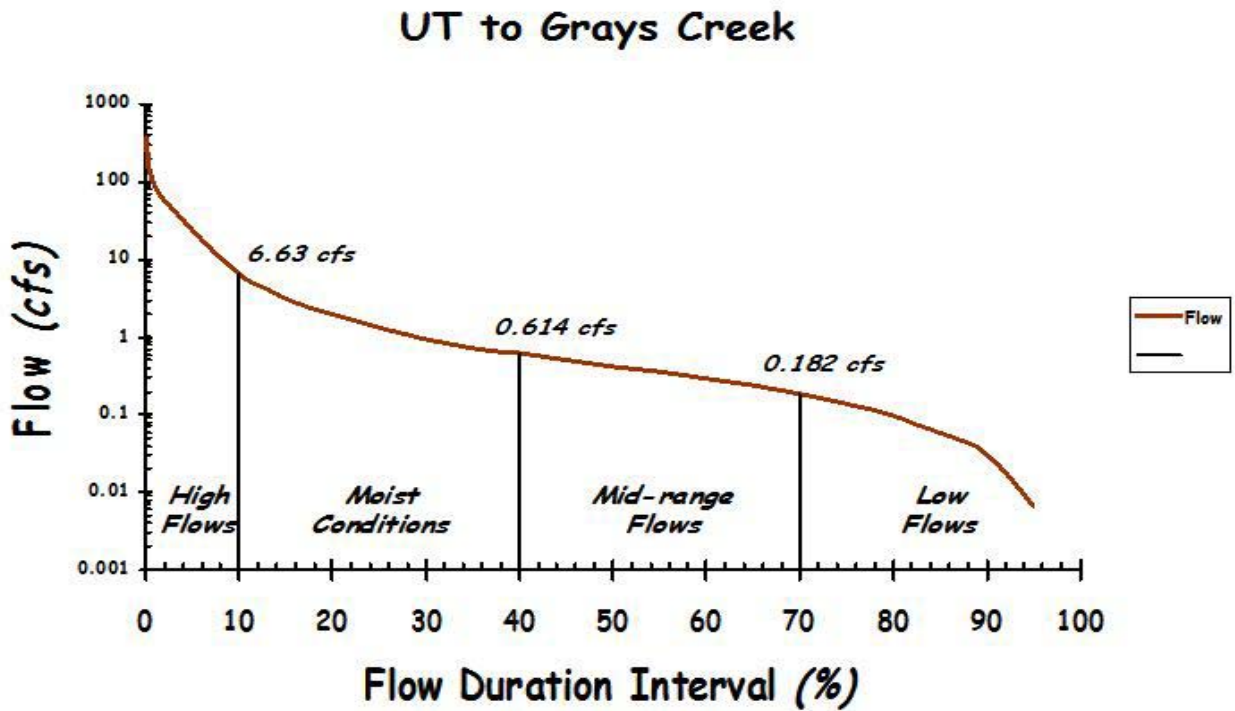


Figure E-18. Flow Duration Curve for Unnamed Tributary to Grays Creek.

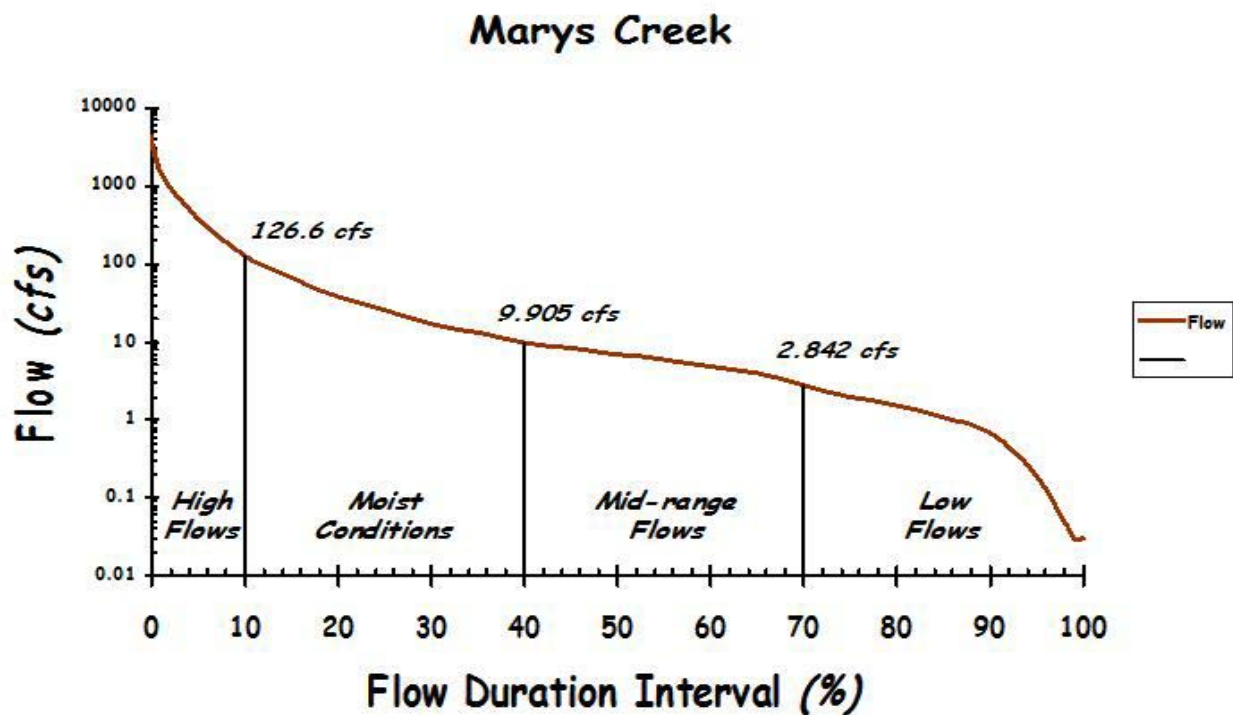


Figure E-19. Flow Duration Curve for Marys Creek.

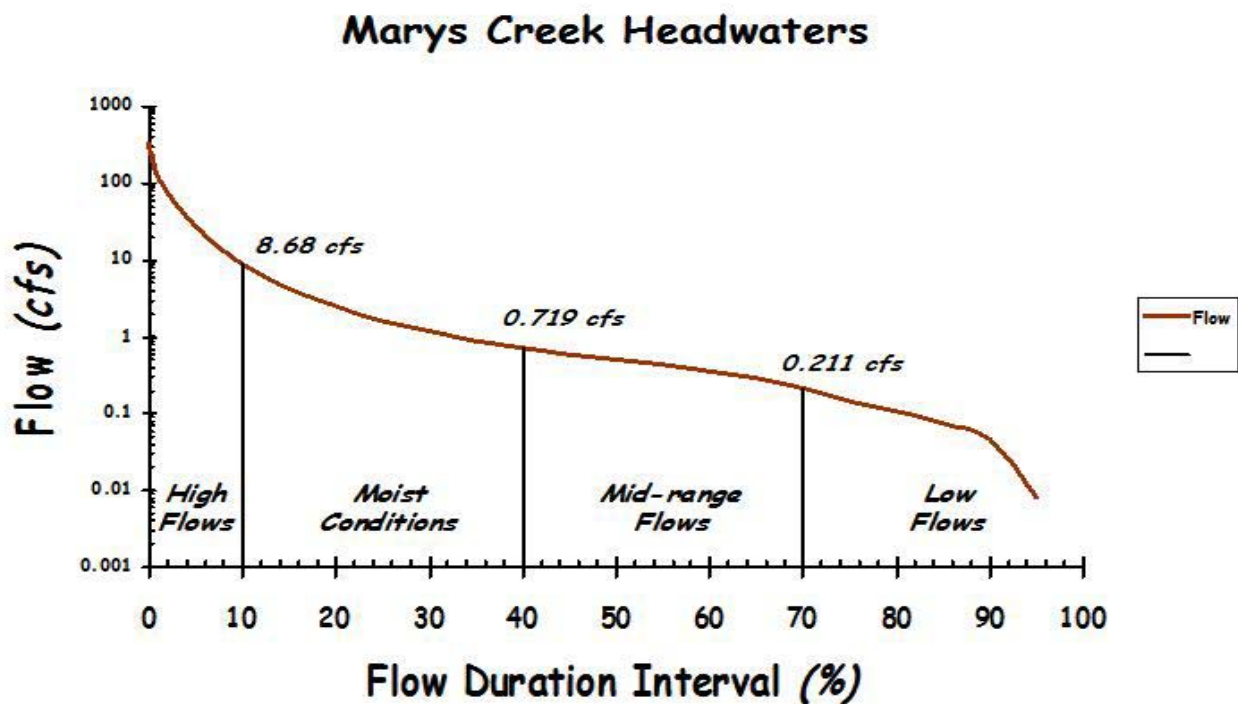


Figure E-20. Flow Duration Curve for Marys Creek Headwaters.

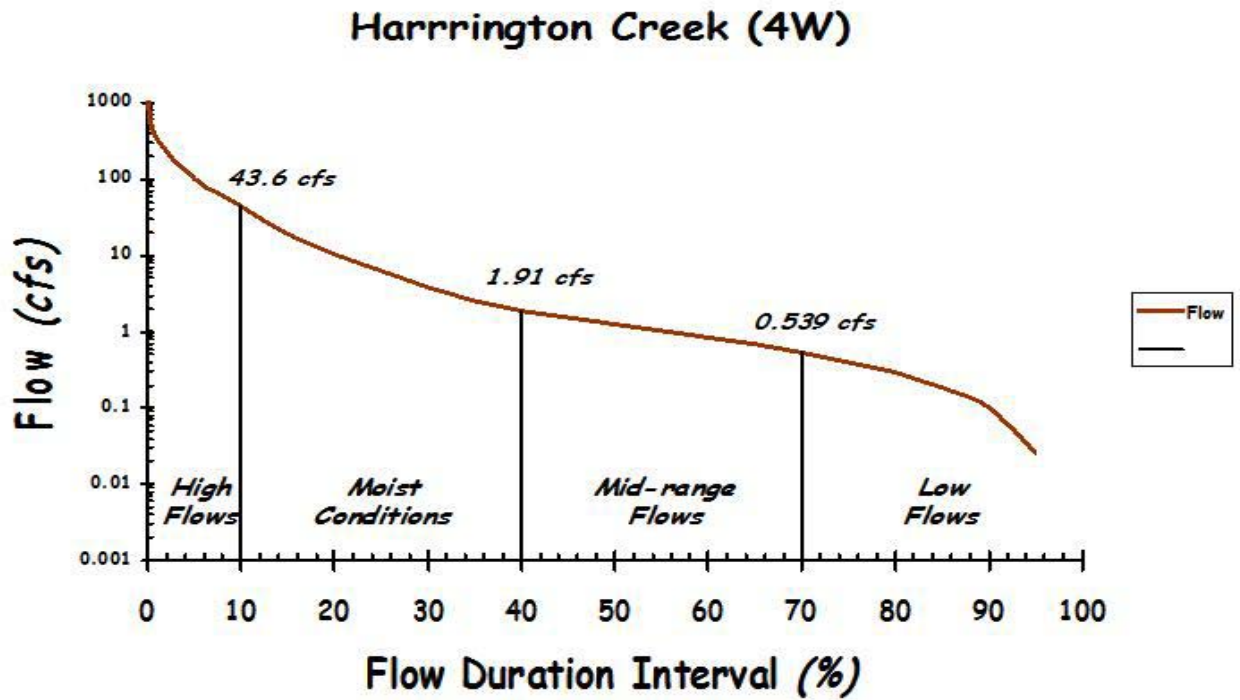


Figure E-21. Flow Duration Curve for Harrington Creek.

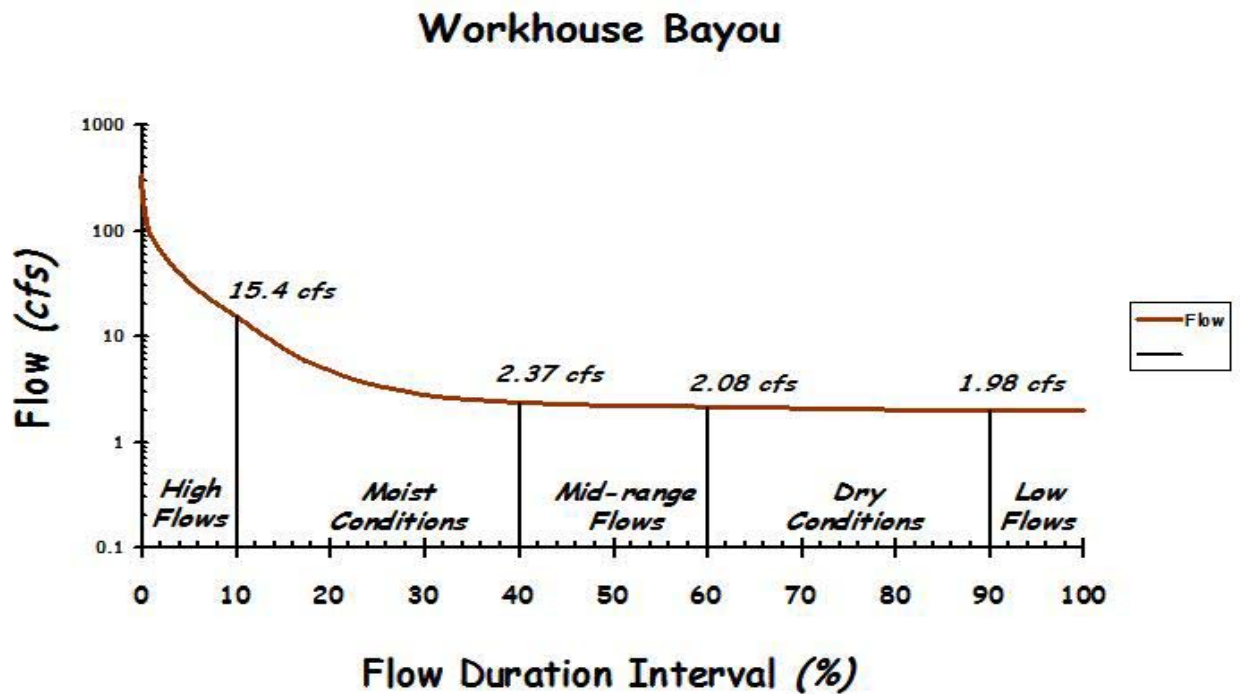


Figure E-22. Flow Duration Curve for Workhouse Bayou.

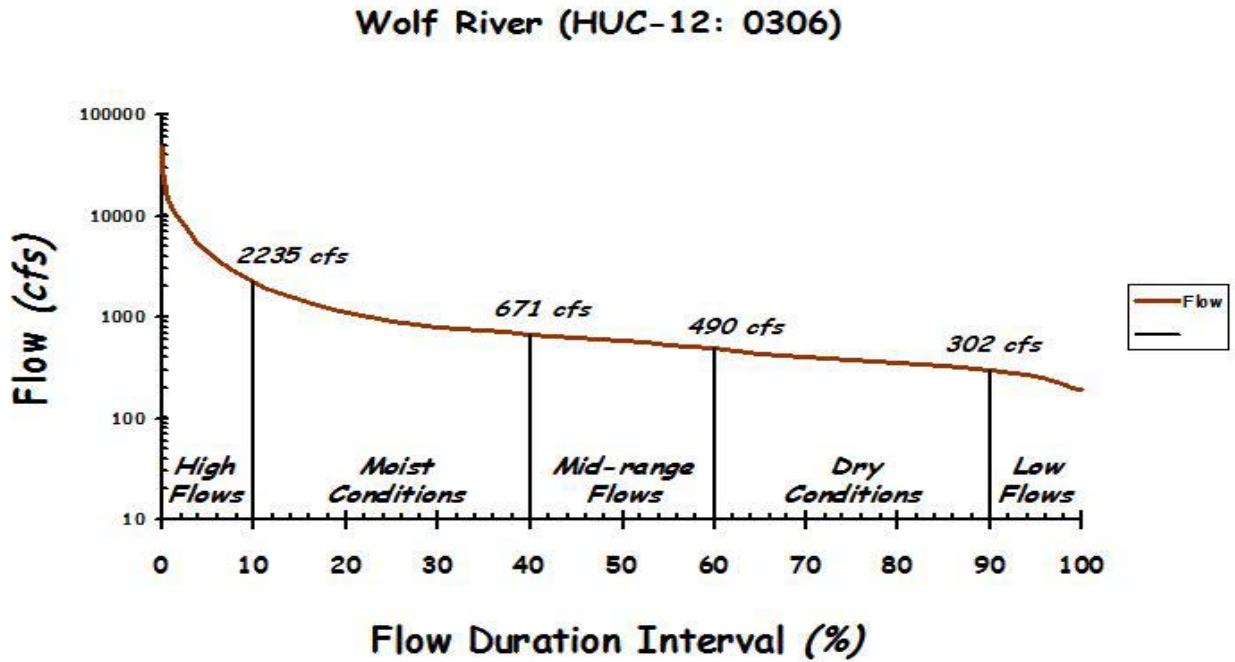


Figure E-23. Flow Duration Curve for Wolf River (HUC-12: 0306).

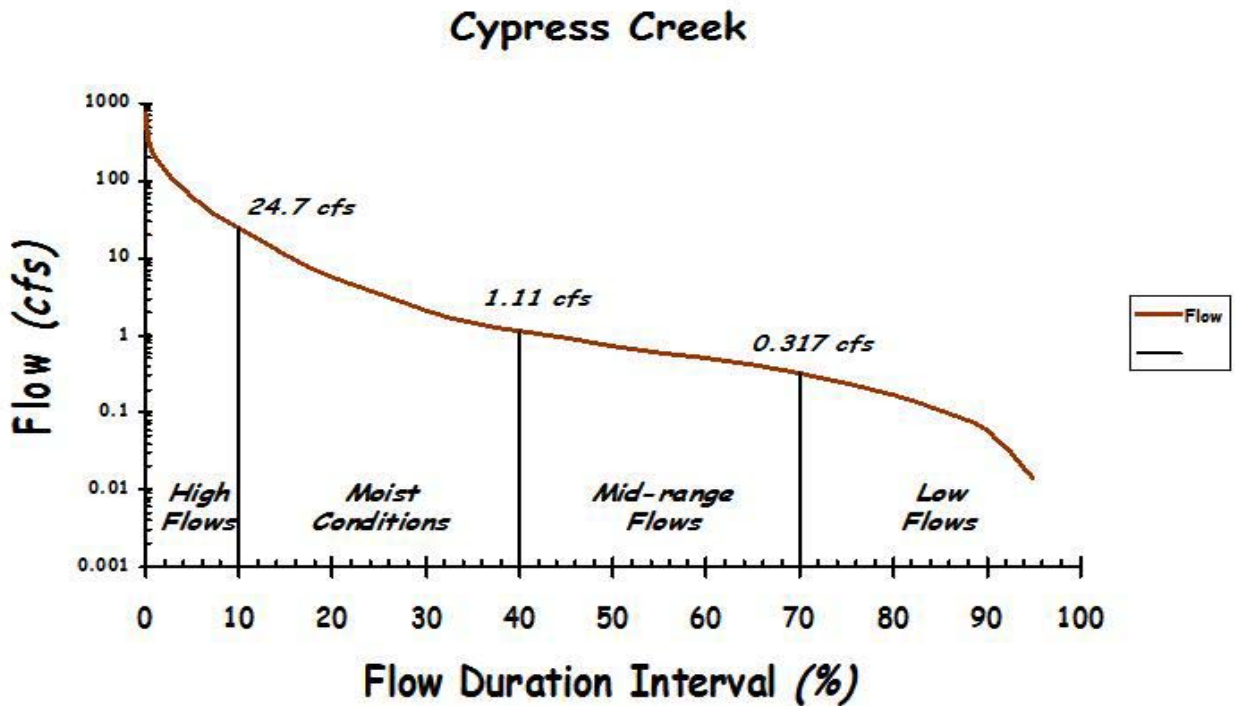


Figure E-24. Flow Duration Curve for Cypress Creek.

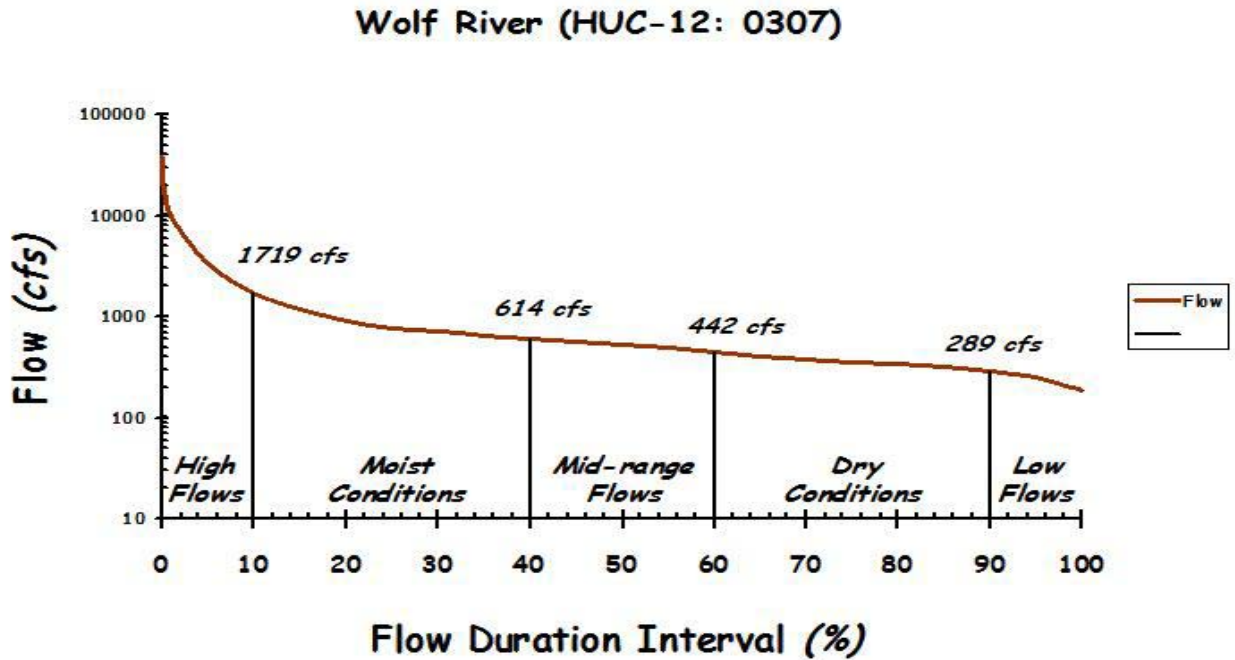


Figure E-25. Flow Duration Curve for Wolf River (HUC-12: 0307).

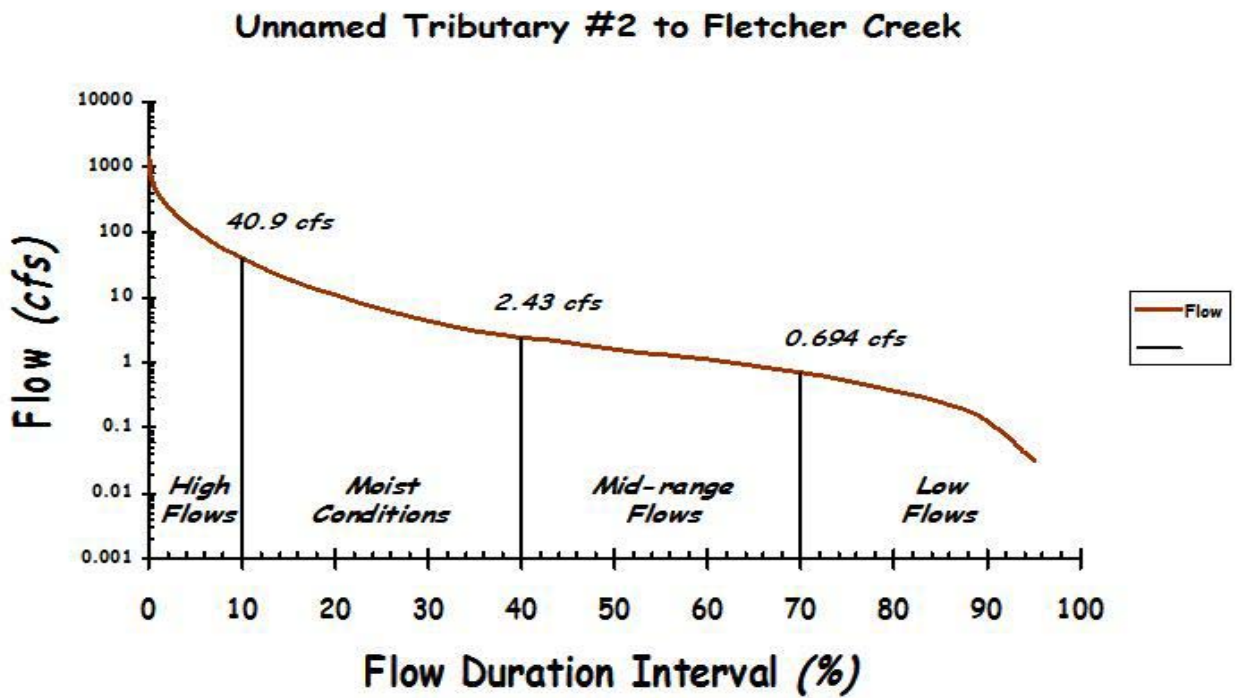


Figure E-26. Flow Duration Curve for Unnamed Tributary #2 to Fletcher Creek.

UT #1 to Fletcher Creek

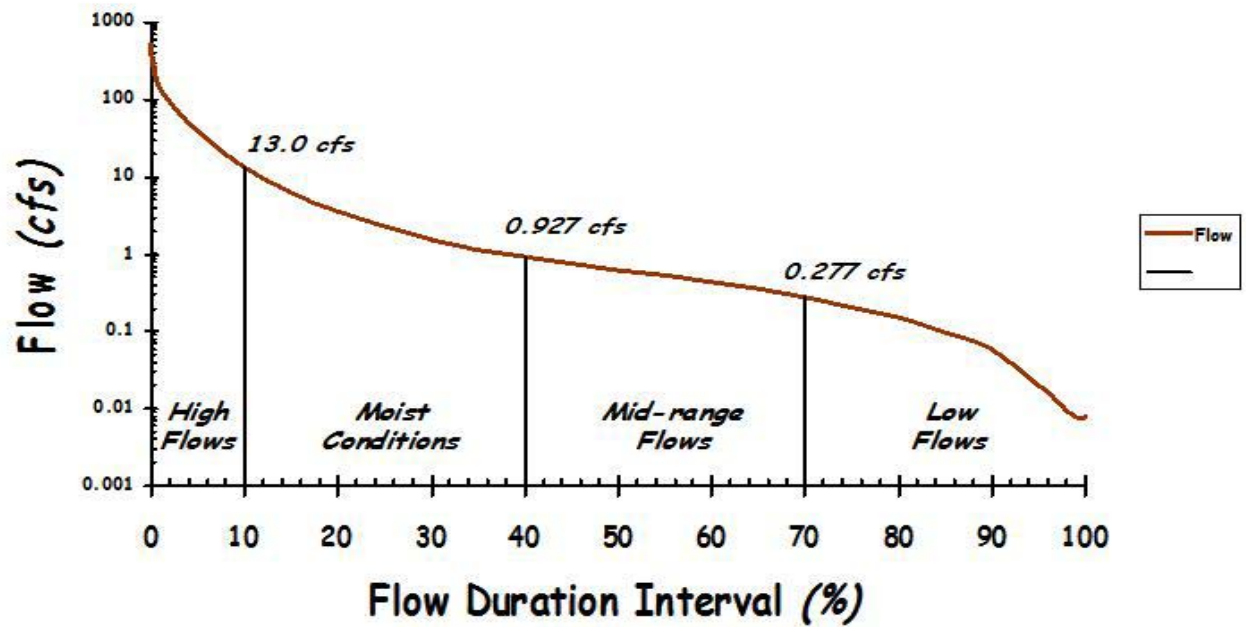


Figure E-27. Flow Duration Curve for Unnamed Tributary #1 to Fletcher Creek.

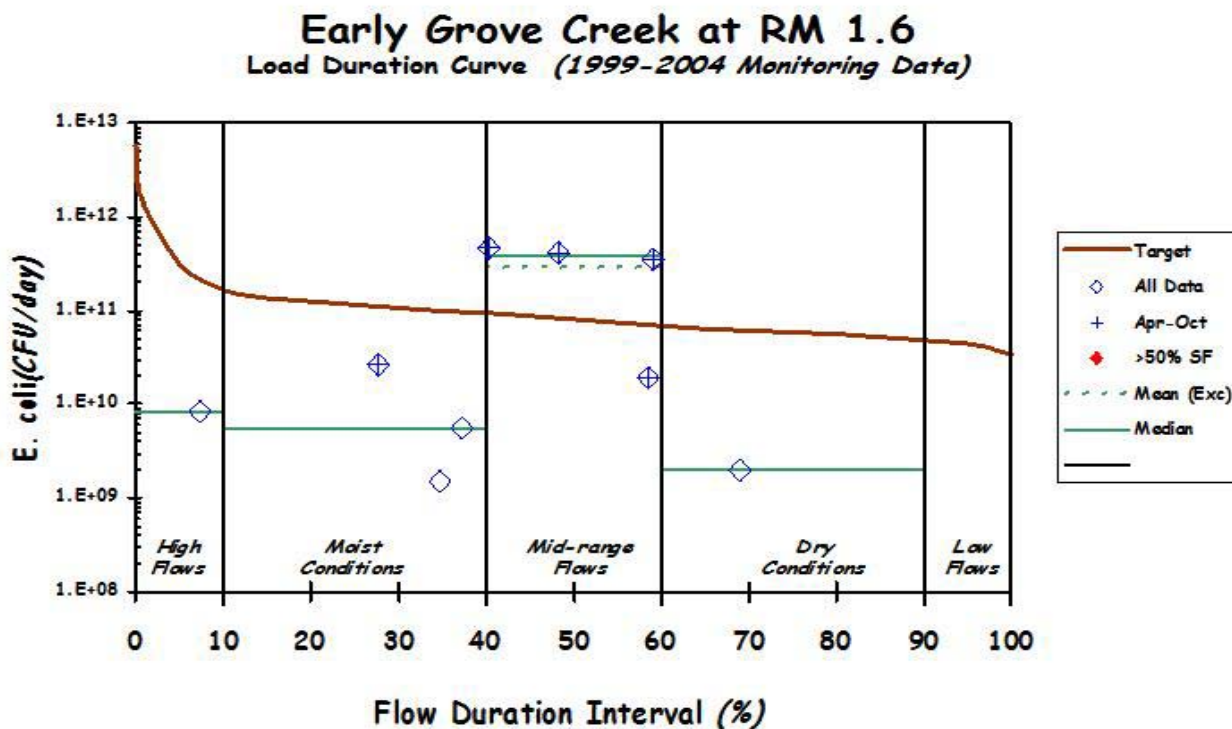


Figure E-28. E. Coli Load Duration Curve for Early Grove Creek at Mile 1.6.

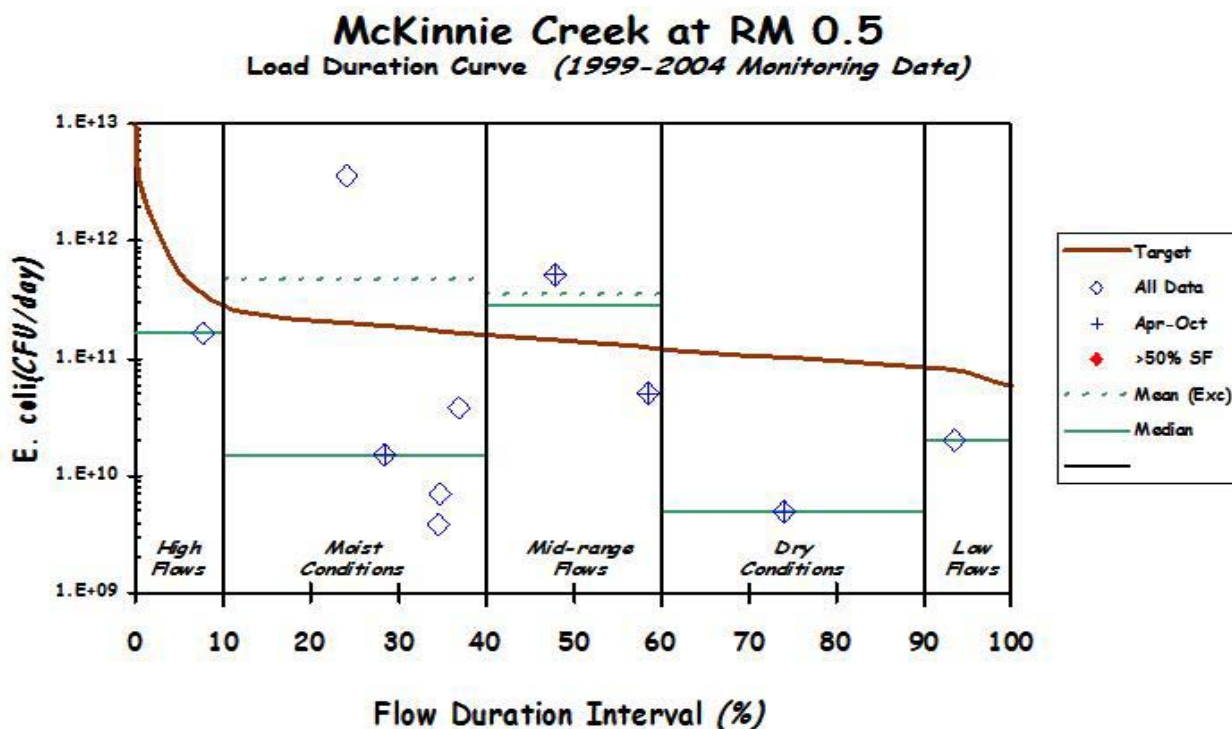


Figure E-29. E. Coli Load Duration Curve for McKinnie Creek at Mile 0.5.

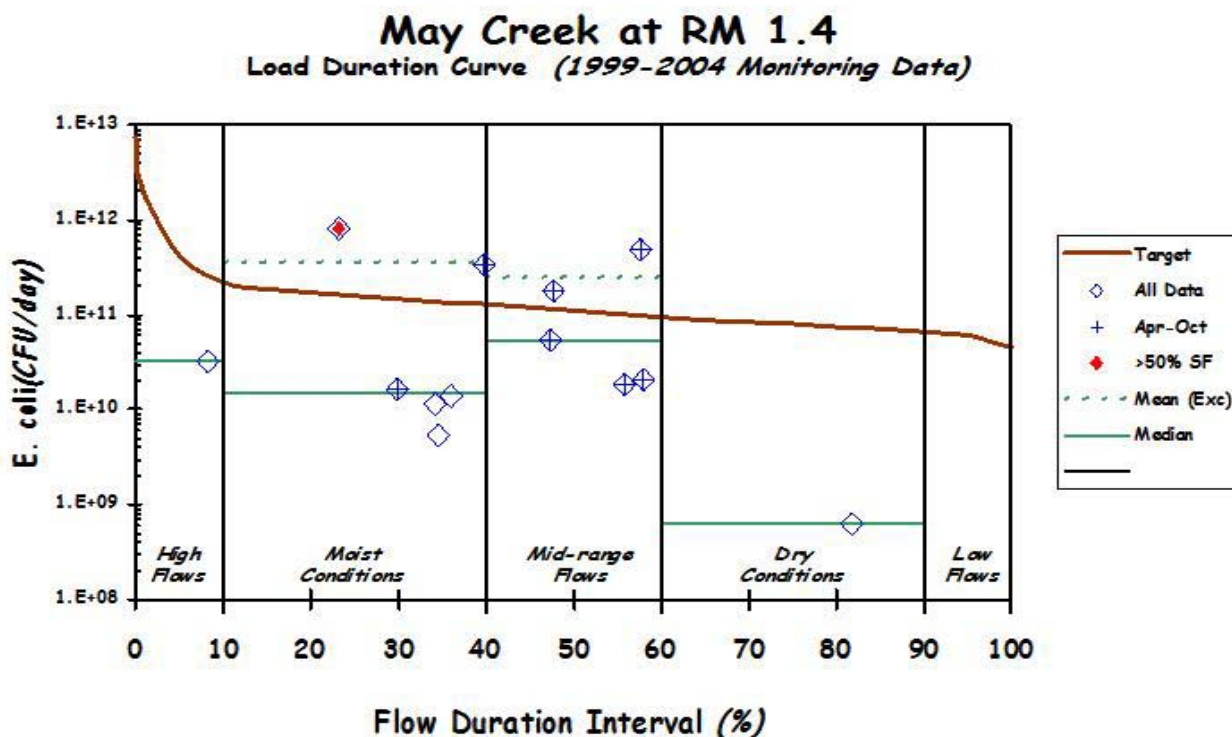


Figure E-30. E. Coli Load Duration Curve for May Creek at Mile 1.4.

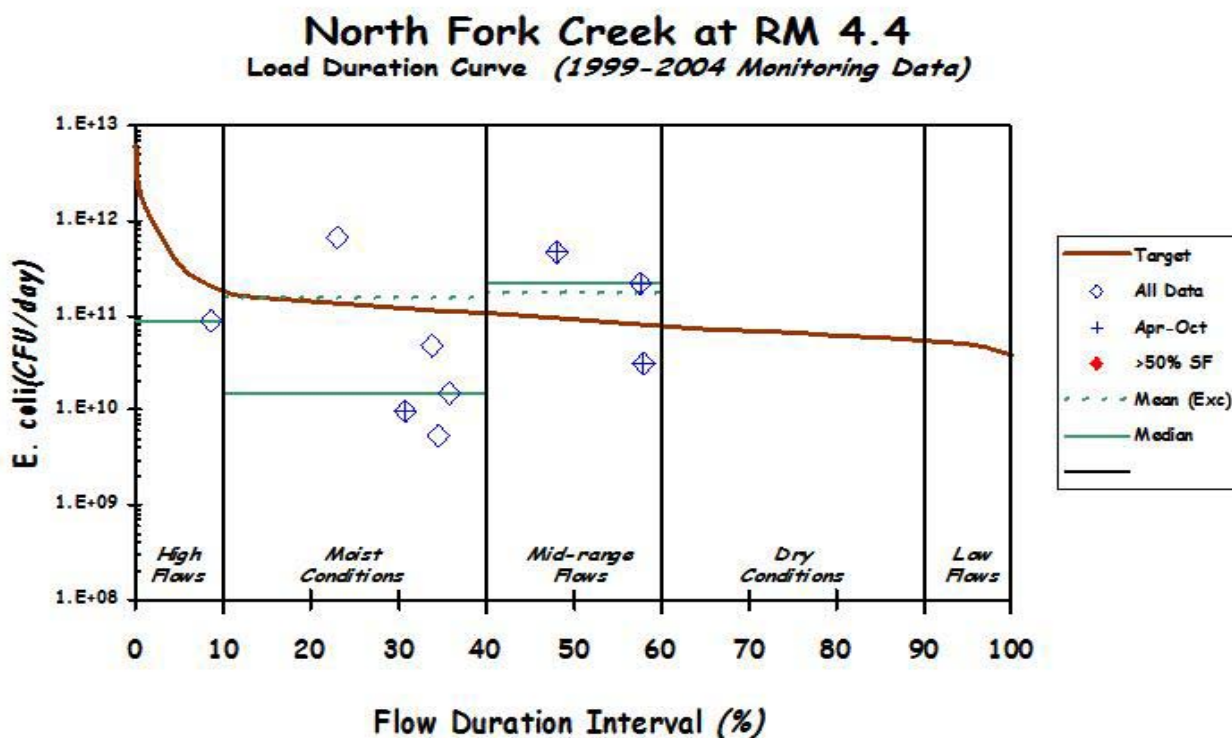


Figure E-31. E. Coli Load Duration Curve for North Fork Creek at Mile 4.4.

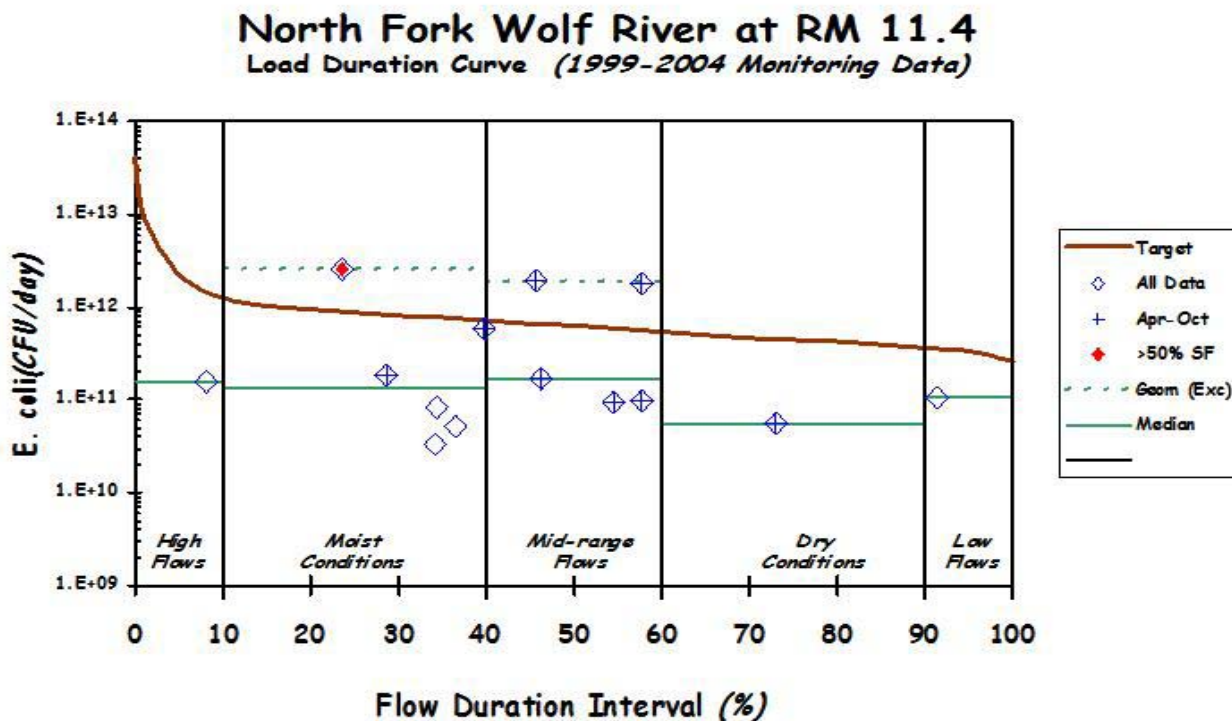


Figure E-32. E. Coli Load Duration Curve for North Fork Wolf River at Mile 11.4.

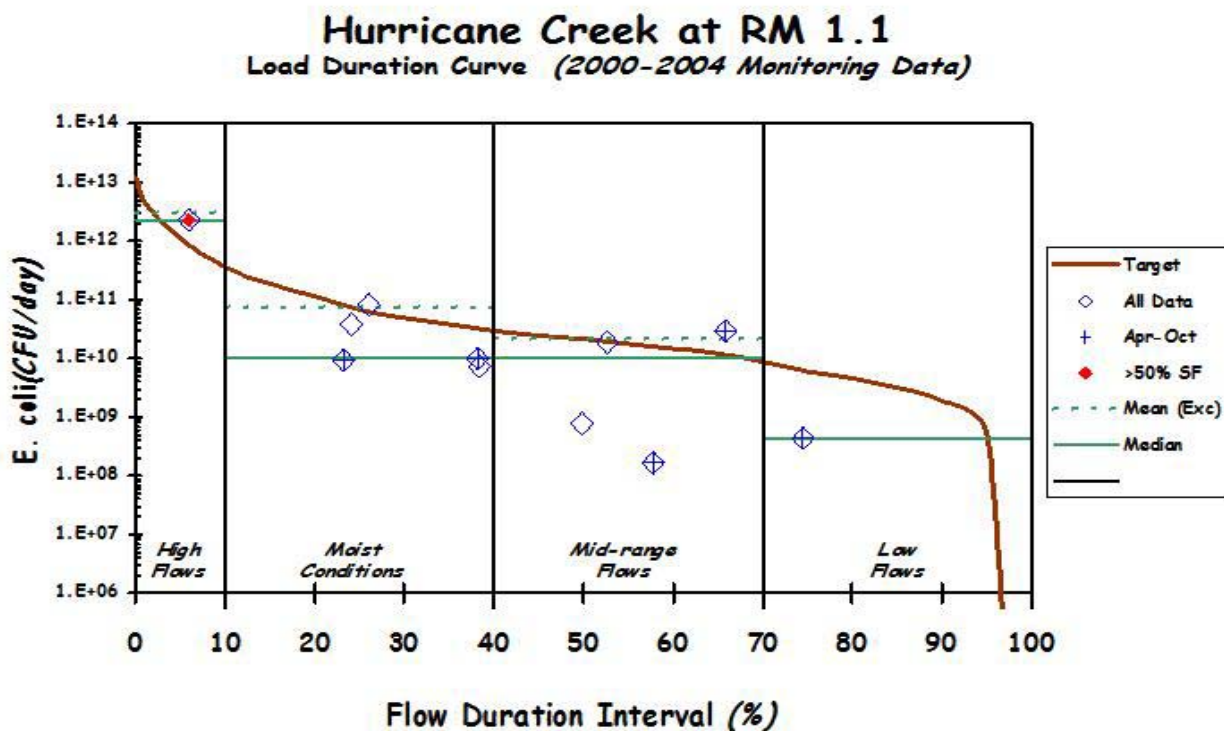


Figure E-33. E. Coli Load Duration Curve for Hurricane Creek at Mile 1.1.

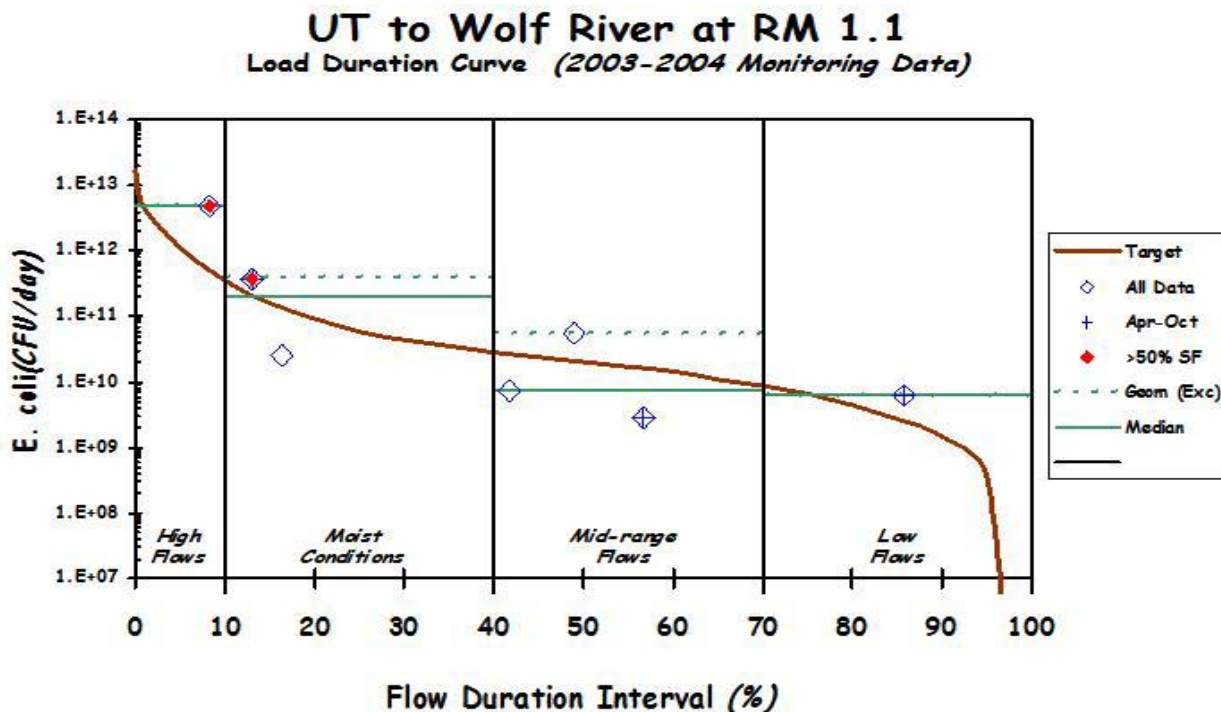


Figure E-34. E. Coli Load Duration Curve for Unnamed Tributary to Wolf River at Mile 1.1.

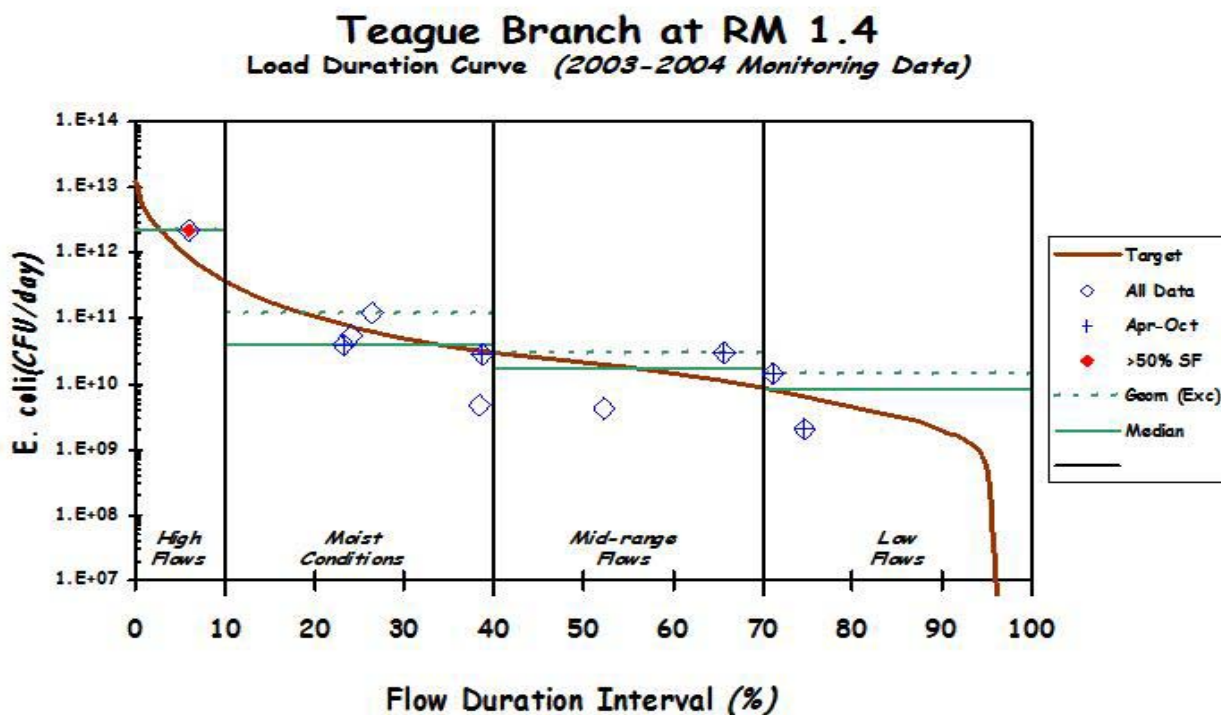


Figure E-35. E. Coli Load Duration Curve for Teague Branch at Mile 1.4.

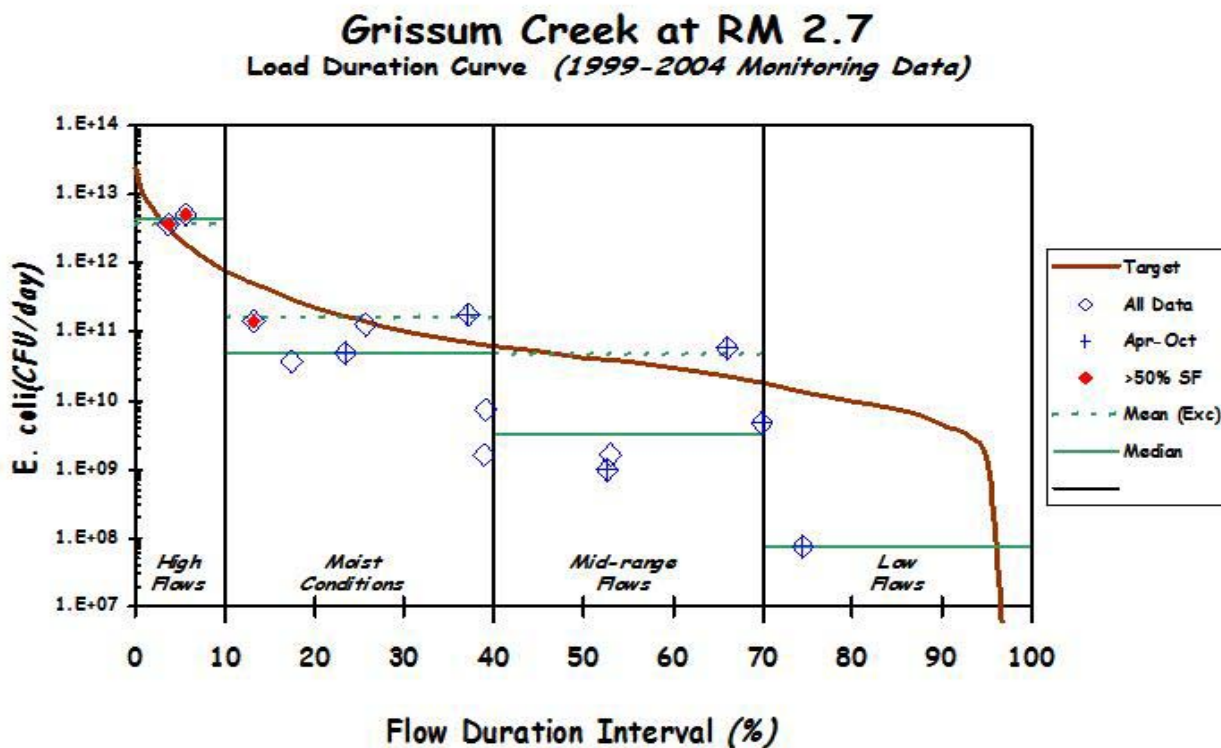


Figure E-36. E. Coli Load Duration Curve for Grissum Creek at Mile 2.7.

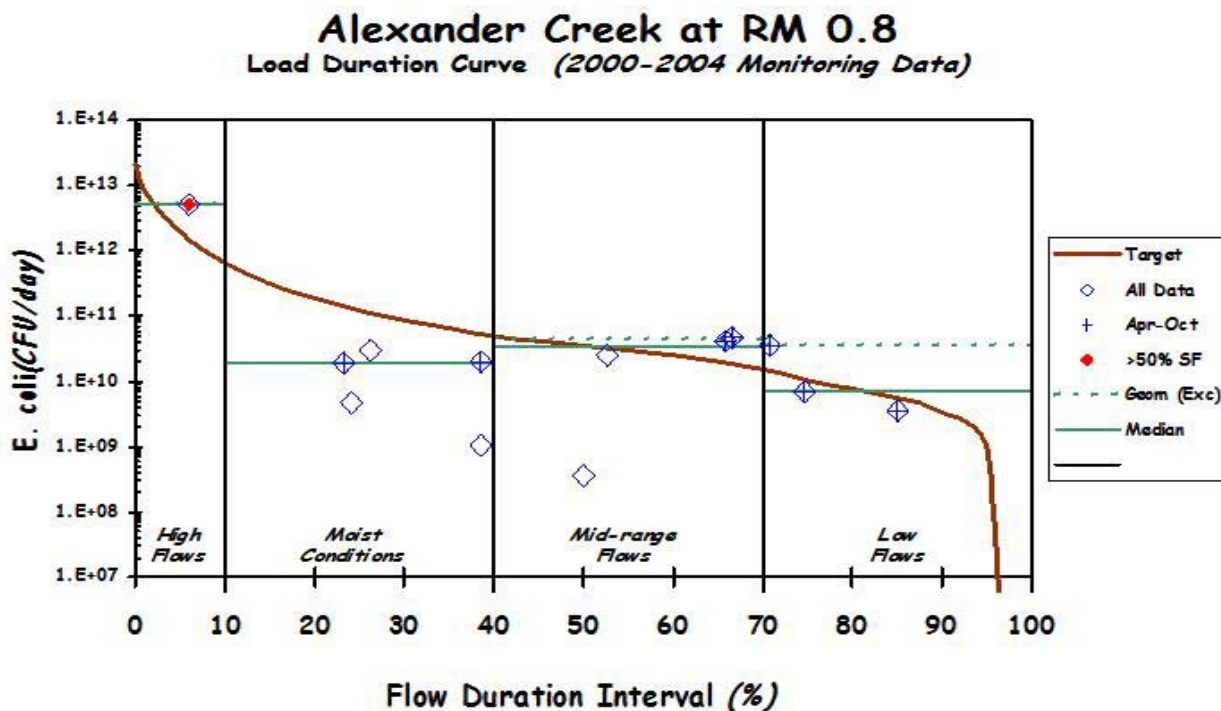


Figure E-37. E. Coli Load Duration Curve for Alexander Creek at Mile 0.8.

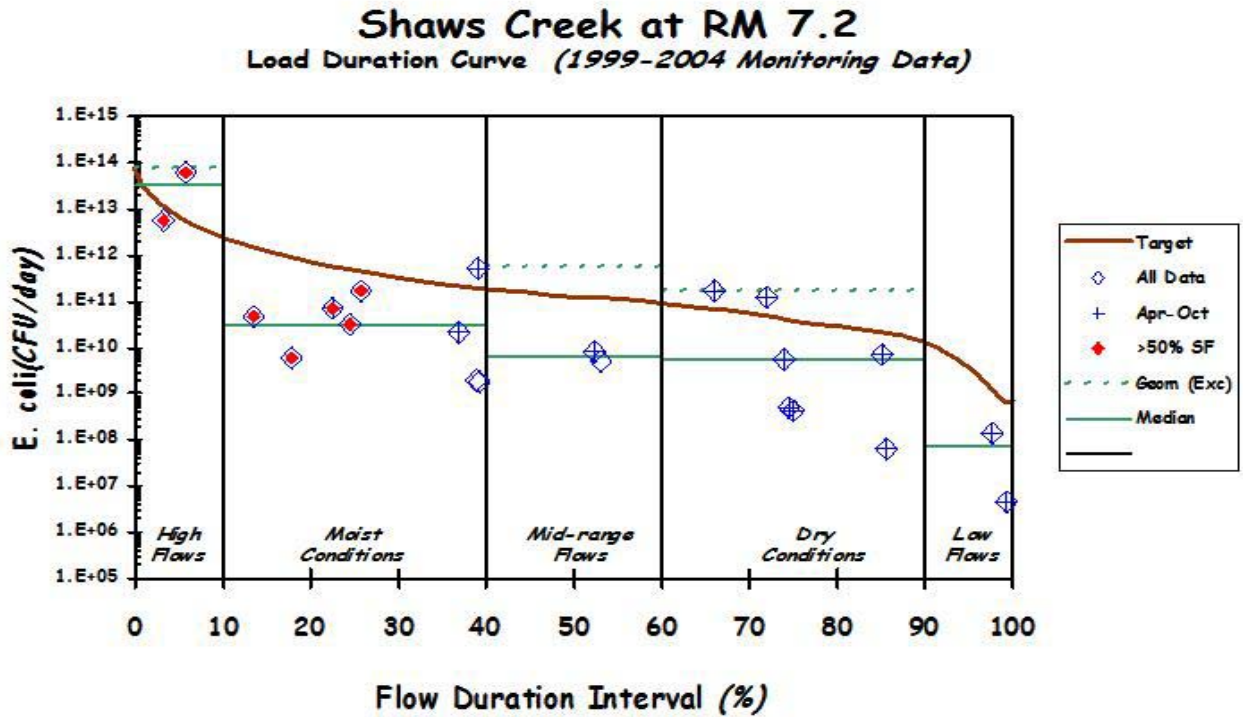


Figure E-38. E. Coli Load Duration Curve for Shaws Creek at Mile 7.2.

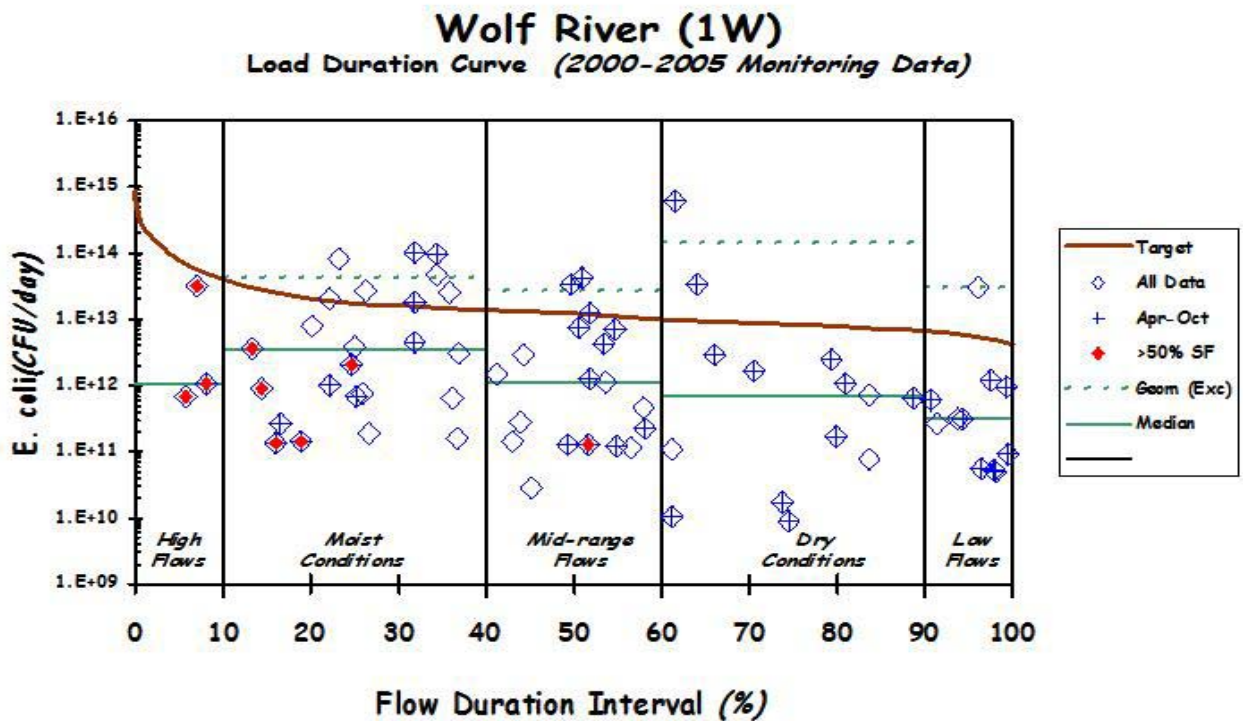


Figure E-39. E. Coli Load Duration Curve for Wolf River (1W).

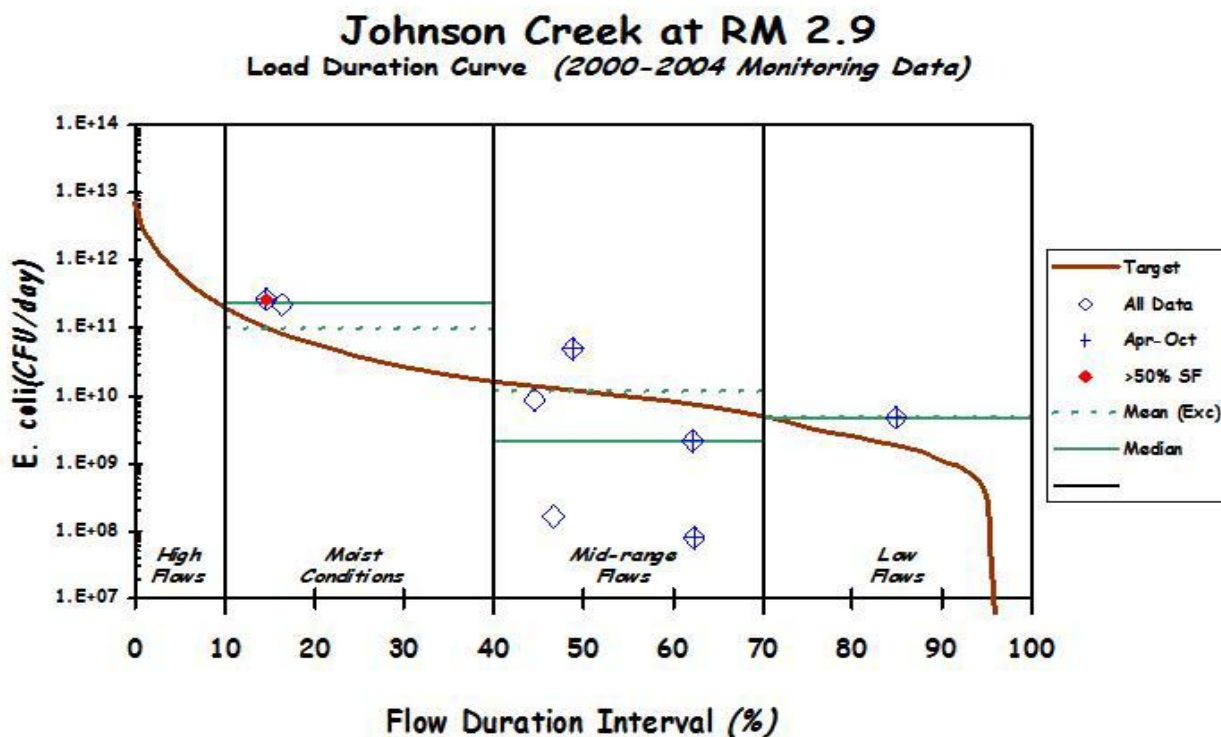


Figure E-40. E. Coli Load Duration Curve for Johnson Creek at Mile 2.9.

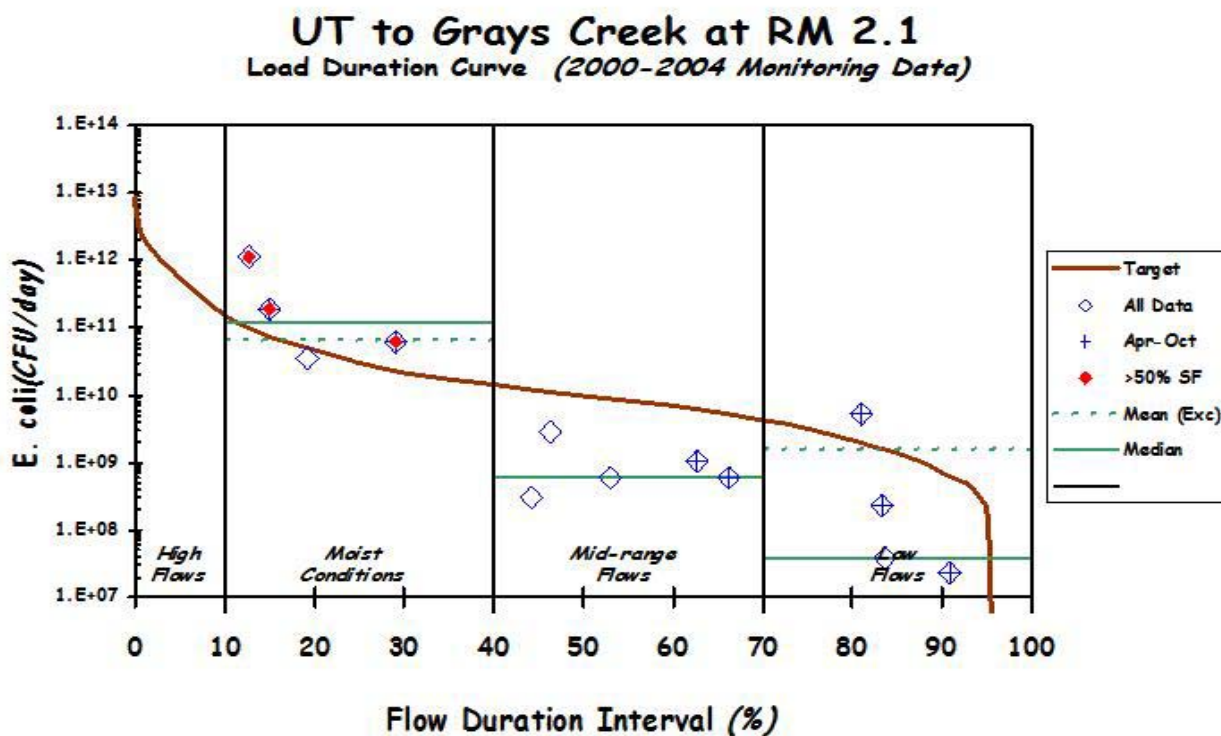


Figure E-41. E. Coli Load Duration Curve for Unnamed Tributary to Grays Creek at Mile 2.1.

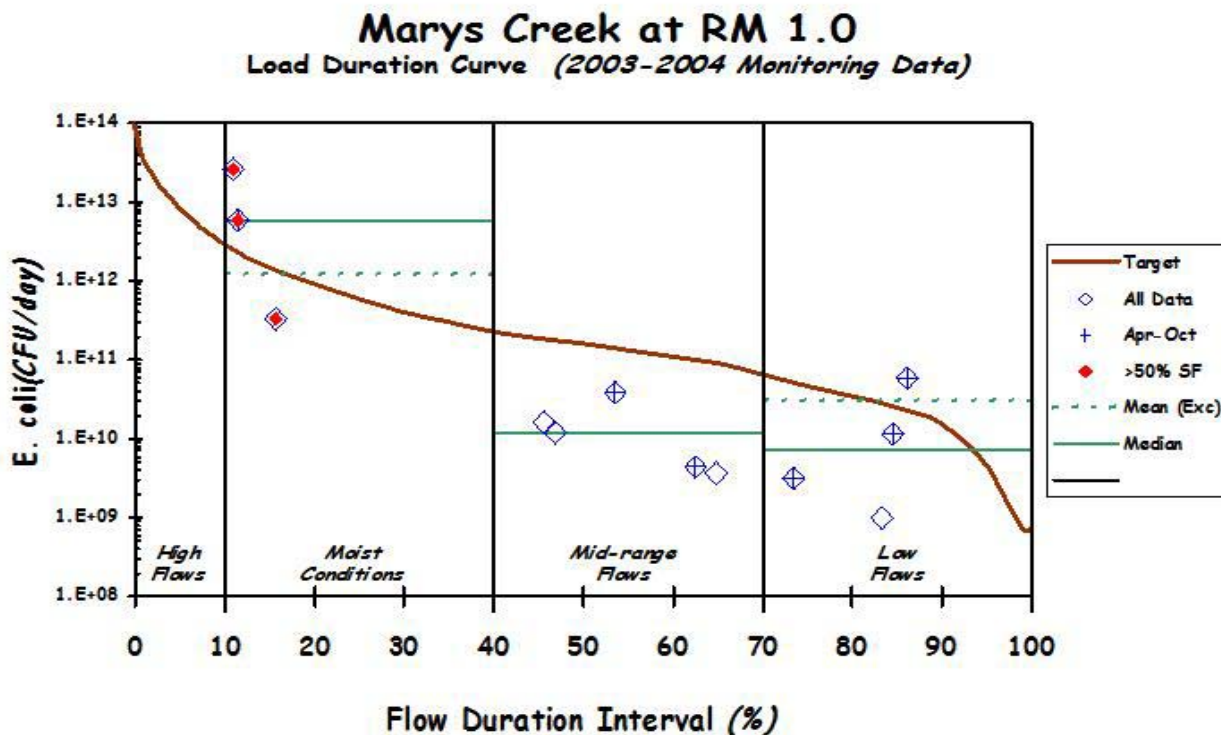


Figure E-42. E. Coli Load Duration Curve for Marys Creek at Mile 1.0.

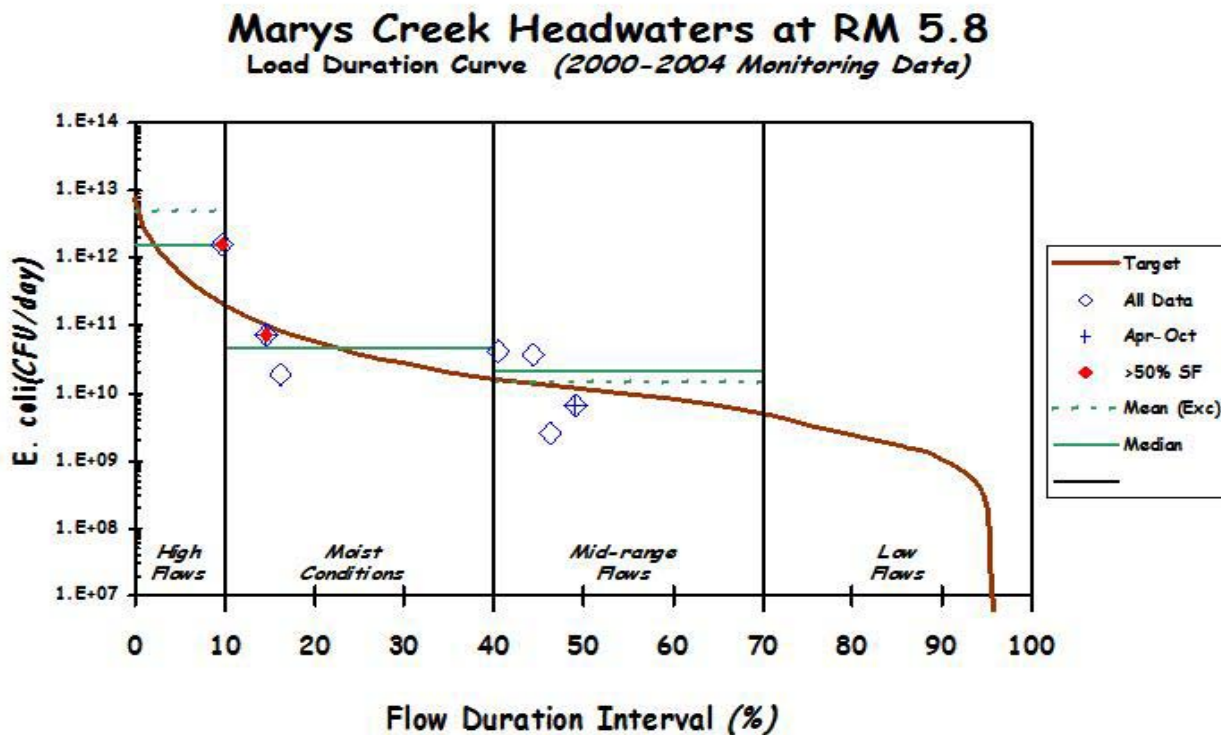


Figure E-43. E. Coli Load Duration Curve for Marys Creek Headwaters at Mile 5.8.

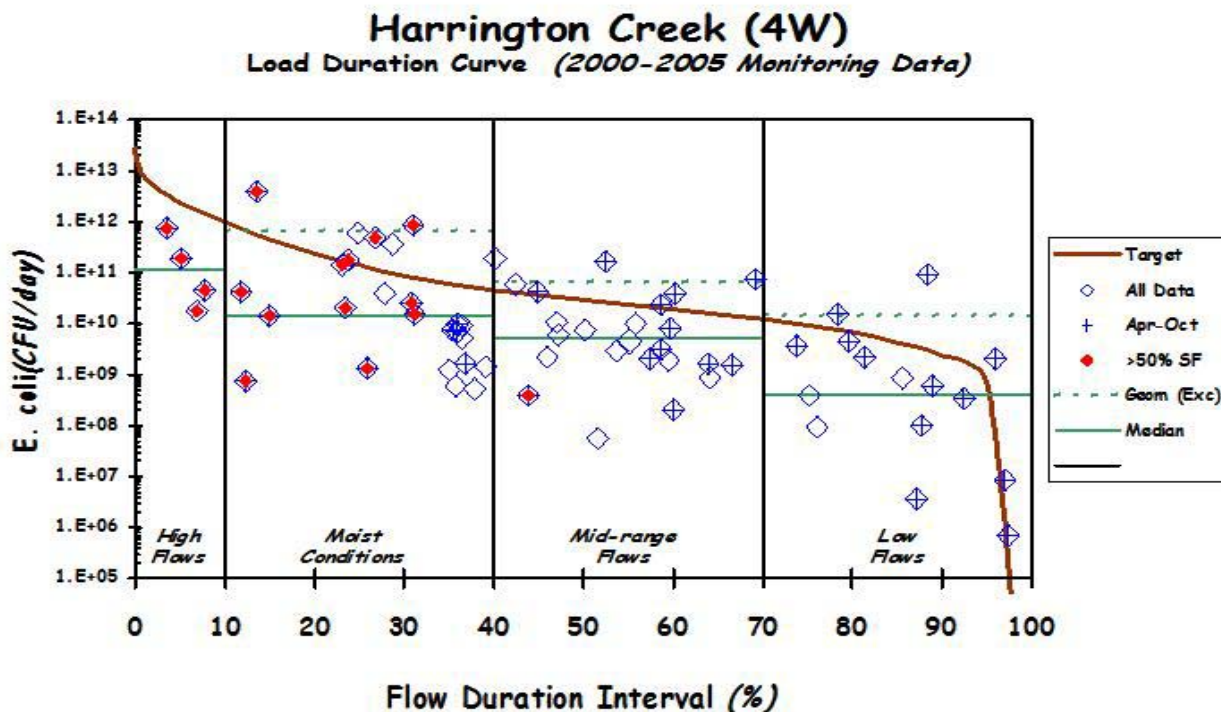


Figure E-44. E. Coli Load Duration Curve for Harrington Creek (4W).

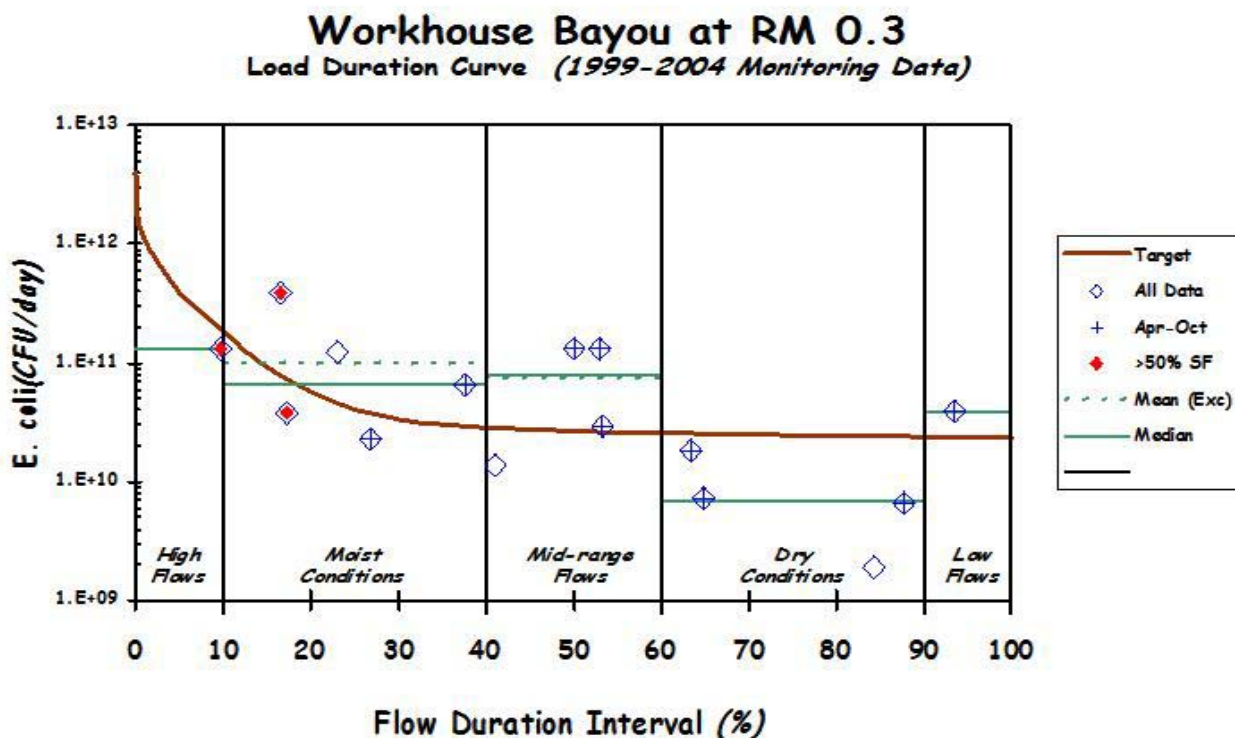


Figure E-45. E. Coli Load Duration Curve for Workhouse Bayou Mile 0.3.

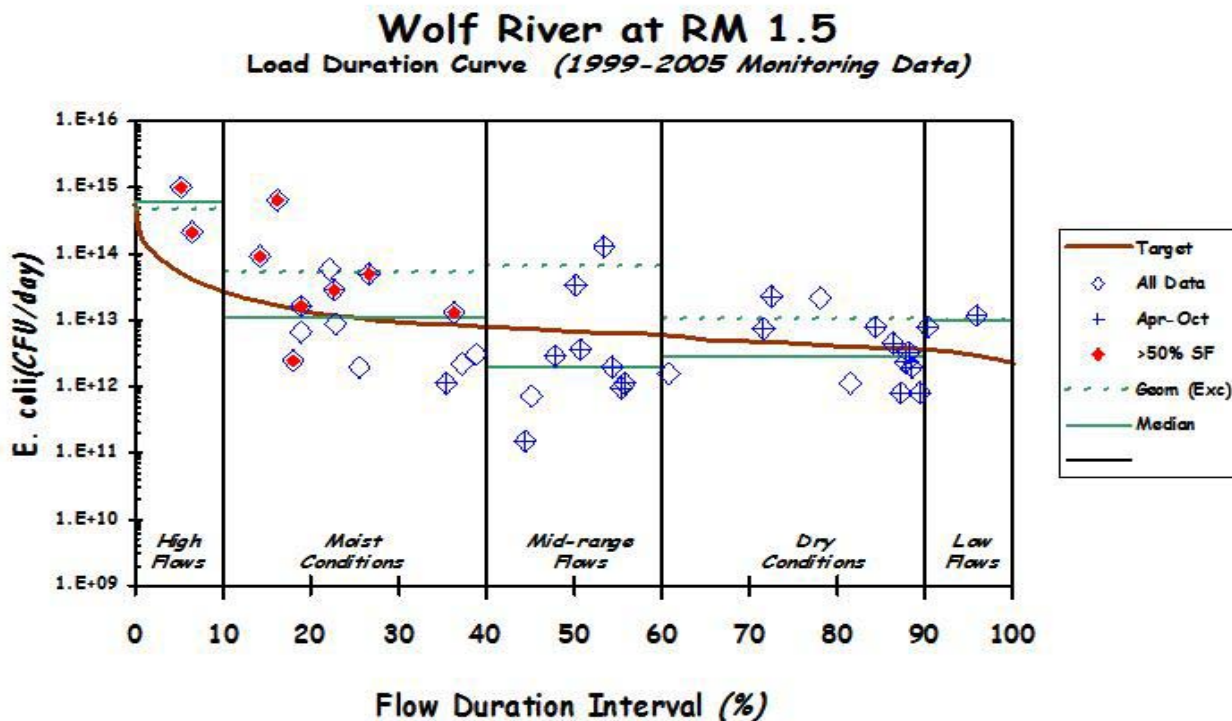


Figure E-46. E. Coli Load Duration Curve for Wolf River at Mile 1.5.

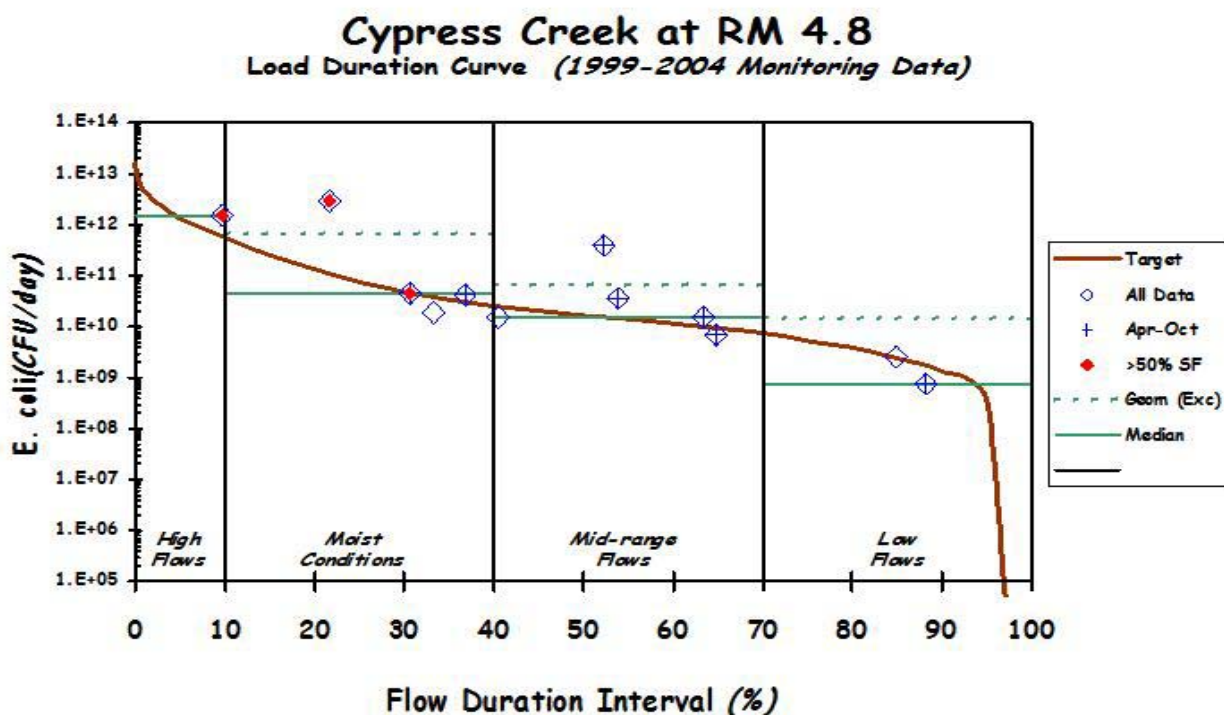


Figure E-47. E. Coli Load Duration Curve for Cypress Creek at Mile 4.8.

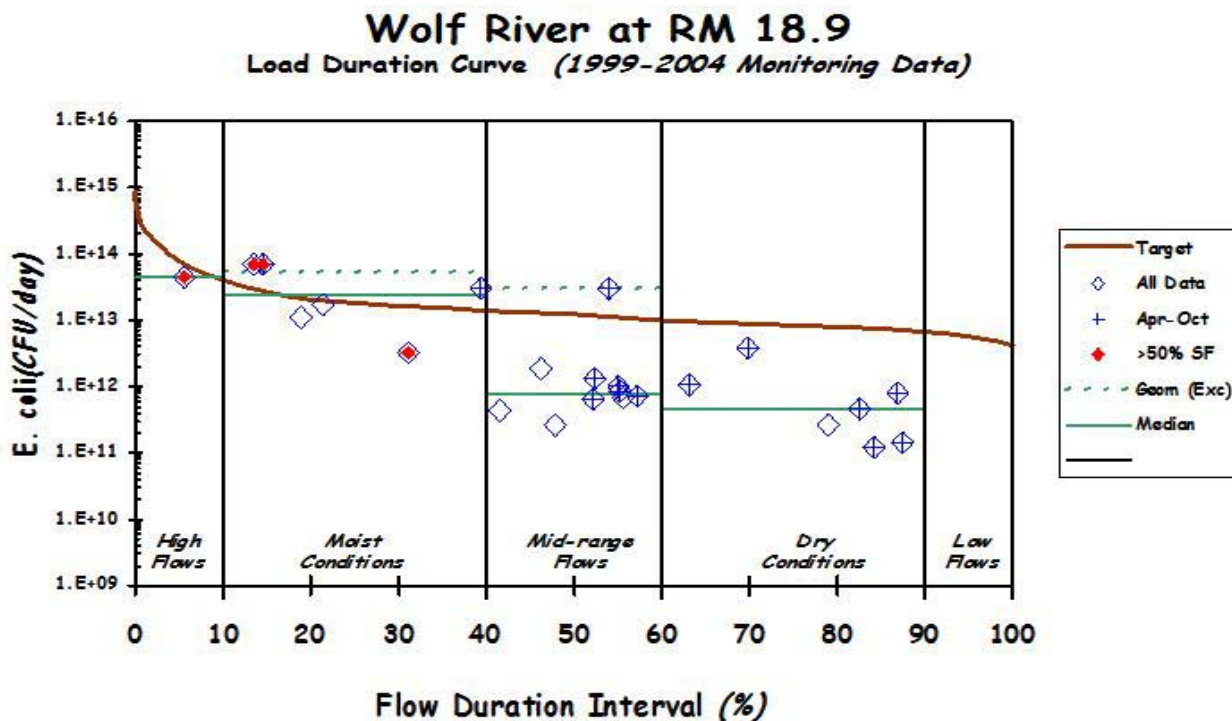


Figure E-48. E. Coli Load Duration Curve for Wolf River at Mile 18.9.

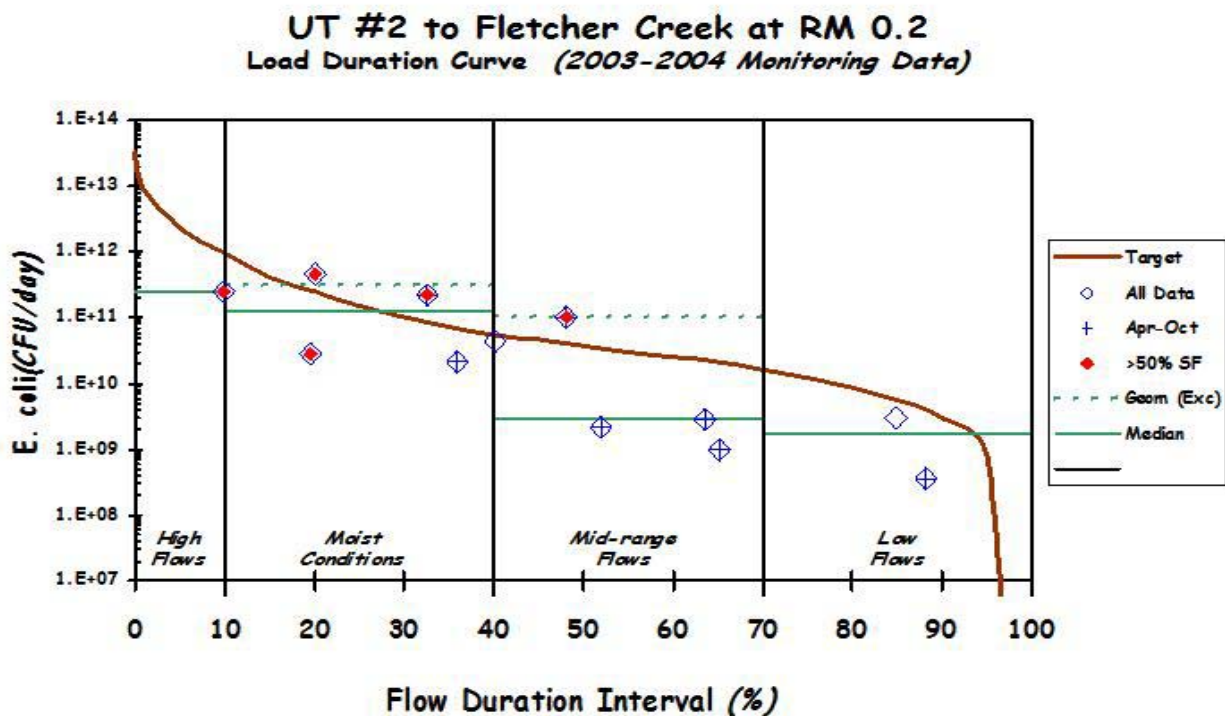


Figure E-49. E. Coli Load Duration Curve for Unnamed Tributary #2 to Fletcher Creek at Mile 0.2.

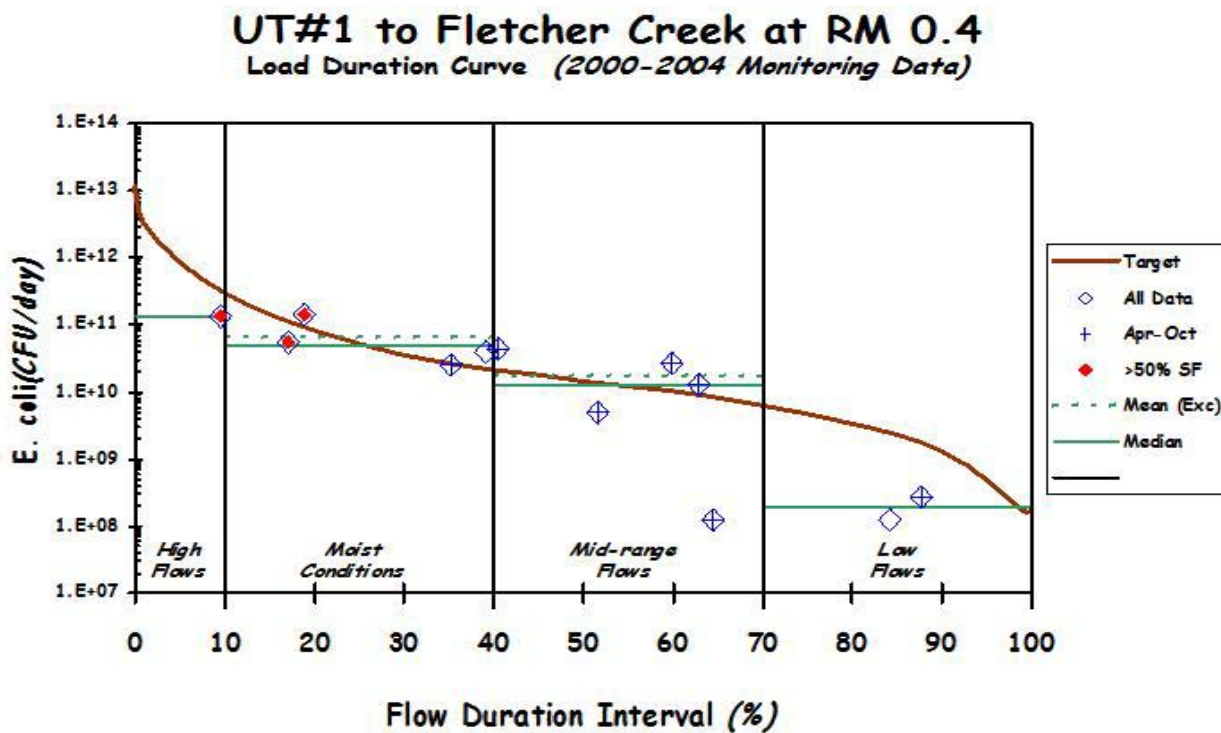


Figure E-50. E. Coli Load Duration Curve for Unnamed Tributary #1 to Fletcher Creek at Mile 0.4.

Table E-4. Summary of TMDLs, MOS, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Wolf River Watershed (HUC 08010210)

Waterbody Description	Hydrologic Condition			Flow ^a	PLRG	TMDL	MOS	WLAs				LAs
	Flow Zone	PDFE Range	Flow Range					WWTFs ^b	LCS	CAFOs	MS4s	
		(%)	(cfs)					[CFU/d]	[CFU/d]	[CFU/d]	[CFU/d/ac]	
Early Grove Creek Waterbody ID: TN08010210009 – 0300 HUC-12: 0105	High Flows	0–10	13.8 - 488	26.41	0	6.07×10^{11}	6.07×10^{10}	NA	NA	NA	NA	8.55×10^7
	Moist	10–40	7.82 - 13.8	9.664	0	2.22×10^{11}	2.22×10^{10}	NA	NA	NA	NA	3.13×10^7
	Mid-Range	40–60	5.88 - 7.82	6.801	45.8	1.56×10^{11}	1.56×10^{10}	NA	NA	NA	NA	2.20×10^7
	Dry	60–90	4.04 - 5.88	4.896	0	1.13×10^{11}	1.13×10^{10}	NA	NA	NA	NA	1.59×10^7
	Low Flows	90–100	2.86 - 4.04	3.761	0	8.65×10^{10}	8.65×10^9	NA	NA	NA	NA	1.22×10^7
McKinnie Creek Waterbody ID: TN08010210020 – 0300 HUC-12: 0201	High Flows	0–10	23.5 - 829	44.38	0	1.02×10^{12}	1.02×10^{11}	NA	NA	NA	NA	9.08×10^7
	Moist	10–40	13.5 - 23.5	16.68	17.8	3.84×10^{11}	3.84×10^{10}	NA	NA	NA	NA	3.41×10^7
	Mid-Range	40–60	10.1 - 13.5	11.75	22.8	2.70×10^{11}	2.70×10^{10}	NA	NA	NA	NA	2.40×10^7
	Dry	60–90	6.96 - 10.1	8.438	0	1.94×10^{11}	1.94×10^{10}	NA	NA	NA	NA	1.73×10^7
	Low Flows	90–100	4.90 - 6.96	6.438	0	1.48×10^{11}	1.48×10^{10}	NA	NA	NA	NA	1.32×10^7
May Creek Waterbody ID: TN08010210020 – 0310 HUC-12: 0201	High Flows	0–10	18.3 - 638	34.16	0	7.86×10^{11}	7.86×10^{10}	NA	NA	NA	NA	7.81×10^7
	Moist	10–40	10.7 - 18.3	13.24	14.8	3.05×10^{11}	3.05×10^{10}	NA	NA	NA	NA	3.03×10^7
	Mid-Range	40–60	8.02 - 10.7	9.326	12.2	2.15×10^{11}	2.15×10^{10}	NA	NA	NA	NA	2.13×10^7
	Dry	60–90	5.49 - 8.02	6.669	0	1.54×10^{11}	1.54×10^{10}	NA	NA	NA	NA	1.52×10^7
	Low Flows	90–100	3.87 - 5.49	5.079	0	1.17×10^{11}	1.17×10^{10}	NA	NA	NA	NA	1.12×10^7
North Fork Creek Waterbody ID: TN08010210020 – 0400 HUC-12: 0201	High Flows	0–10	15.2 - 520	28.41	0	3.38×10^{11}	3.38×10^{10}	NA	NA	NA	NA	2.35×10^7
	Moist	10–40	8.84 - 15.2	10.93	16.0	1.30×10^{11}	1.30×10^{10}	NA	NA	NA	NA	9.05×10^6
	Mid-Range	40–60	6.62 - 8.84	7.718	47.5	9.18×10^{10}	9.18×10^9	NA	NA	NA	NA	6.39×10^6
	Dry	60–90	4.53 - 6.62	5.499	0	6.54×10^{10}	6.54×10^9	NA	NA	NA	NA	4.55×10^6
	Low Flows	90–100	3.20 - 4.53	4.192	0	4.99×10^{10}	4.99×10^9	NA	NA	NA	NA	3.47×10^6

Table E-4. Summary of TMDLs, MOS, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Wolf River Watershed (HUC 08010210) (Cont.)

Waterbody Description	Hydrologic Condition			Flow ^a	PLRG	TMDL	MOS	WLAs				LAs
	Flow Zone	PDFE Range	Flow Range					WWTFs ^b	LCS	CAFOs	MS4s	
		(%)	(cfs)					[CFU/d]	[CFU/d]	[CFU/d]	[CFU/d/ac]	
North Fork Wolf River Waterbody ID: TN08010210020 – 2000 HUC-12: 0202	High Flows	0–10	103 - 3,440	186.5	0	2.22×10^{12}	2.22×10^{11}	NA	NA	NA	NA	5.89×10^8
	Moist	10–40	60.6 - 103	73.89	10.9	8.79×10^{11}	8.79×10^{10}	NA	NA	NA	NA	2.33×10^8
	Mid-Range	40–60	44.8 - 60.6	52.70	26.8	6.27×10^{11}	6.27×10^{10}	NA	NA	NA	NA	1.66×10^8
	Dry	60-90	30.4 - 44.8	37.48	0	4.46×10^{11}	4.46×10^{10}	NA	NA	NA	NA	1.18×10^8
	Low Flows	90–100	21.4 - 30.4	28.11	0	3.35×10^{11}	3.35×10^{10}	NA	NA	NA	NA	8.87×10^7
Hurricane Creek Waterbody ID: TN08010210004 – 0100 HUC-12: 0301	High Flows	0–10	16.0 - 529	49.13	61.1	1.13×10^{12}	1.13×10^{11}	NA	NA	NA	NA	2.31×10^8
	Moist	10-40	1.30 – 16.0	3.026	4.3	6.96×10^{10}	6.96×10^9	NA	NA	NA	NA	1.42×10^7
	Mid-Range	40–70	0.381 - 1.30	0.7807	15.3	1.80×10^{10}	1.80×10^9	NA	NA	NA	NA	3.66×10^6
	Low Flows	70–100	0.0 - 0.381	0.1413	0	3.25×10^8	3.25×10^7	NA	NA	NA	NA	6.63×10^5
UT to Wolf River Waterbody ID: TN08010210004 – 0400 HUC-12: 0301	High Flows	0–10	15.4 - 724	50.35	88.5	1.16×10^{12}	1.16×10^{11}	NA	0	NA	NA	1.48×10^8
	Moist	10–40	1.26 - 15.4	2.553	22.8	5.87×10^{10}	5.87×10^9	NA	0	NA	NA	7.49×10^6
	Mid-Range	40–70	0.374 - 1.26	0.7508	20.4	1.73×10^{10}	1.73×10^9	NA	0	NA	NA	2.20×10^6
	Low Flows	70–100	0.0 - 0.374	0.1194	61.1	2.75×10^9	2.75×10^8	NA	0	NA	NA	3.50×10^5
Russell Creek Waterbody ID: TN08010210004 – 0500 HUC-12: 0301	High Flows	0–10	17.8 - 842	55.63	83.8	1.28×10^{12}	1.28×10^{11}	NA	NA	NA	NA	2.35×10^8
	Moist	10-40	1.41 - 17.8	2.813	30.6	6.47×10^{10}	6.47×10^9	NA	NA	NA	NA	1.19×10^7
	Mid-Range	40–70	0.450 - 1.41	0.8573	12.2	1.97×10^{10}	1.97×10^9	NA	NA	NA	NA	3.62×10^6
	Low Flows	70–100	0.0 - 0.450	0.1627	54.6	3.74×10^9	3.74×10^8	NA	NA	NA	NA	6.88×10^5

Table E-4. Summary of TMDLs, MOS, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Wolf River Watershed (HUC 08010210) (Cont.)

Waterbody Description	Hydrologic Condition			Flow ^a	PLRG	TMDL	MOS	WLAs				LAs
	Flow Zone	PDFE Range	Flow Range					WWTFs ^b	LCS	CAFOs	MS4s	
		(%)	(cfs)									
Teague Branch Waterbody ID: TN08010210005 – 0100 HUC-12: 0302	High Flows	0–10	16.0 - 545	49.60	61.1	1.14 x 10 ¹²	1.14 x 10 ¹¹	NA	NA	NA	NA	1.57 x 10 ⁸
	Moist	10–40	1.29 - 16.0	2.964	9.5	6.82 x 10 ¹⁰	6.82 x 10 ⁹	NA	NA	NA	NA	9.40 x 10 ⁶
	Mid-Range	40–70	0.381 - 1.29	0.7791	30.6	1.79 x 10 ¹⁰	1.79 x 10 ⁹	NA	NA	NA	NA	2.47 x 10 ⁶
	Low Flows	70–100	0.0 - 0.381	0.1417	22.8	3.26 x 10 ⁹	3.26 x 10 ⁸	NA	NA	NA	NA	4.49 x 10 ⁵
Grissum Creek Waterbody ID: TN08010210005 – 1000 HUC-12: 0302	High Flows	0–10	33.2 - 1,094	98.00	38.5	2.25 x 10 ¹²	2.25 x 10 ¹¹	NA	NA	NA	NA	1.24 x 10 ⁸
	Moist	10-40	2.68 - 33.2	6.443	8.7	1.48 x 10 ¹¹	1.48 x 10 ¹⁰	NA	NA	NA	NA	8.14 x 10 ⁶
	Mid-Range	40–70	0.800 - 2.68	1.605	20.4	3.69 x 10 ¹⁰	3.69 x 10 ⁹	NA	NA	NA	NA	2.03 x 10 ⁶
	Low Flows	70–100	0.0 - 0.800	0.0565	0	1.30 x 10 ⁹	1.30 x 10 ⁸	NA	NA	NA	NA	7.14 x 10 ⁴
Alexander Creek Waterbody ID: TN08010210021 – 0100 HUC-12: 0303	High Flows	0–10	27.9 - 911	84.15	71.1	1.94 x 10 ¹²	1.94 x 10 ¹¹	NA	NA	NA	NA	2.31 x 10 ⁸
	Moist	10–40	2.21 - 27.9	5.160	0	1.19 x 10 ¹¹	1.19 x 10 ¹⁰	NA	NA	NA	NA	1.41 x 10 ⁷
	Mid-Range	40–70	0.654 - 2.21	1.334	28.4	3.07 x 10 ¹⁰	3.07 x 10 ⁹	NA	NA	NA	NA	3.66 x 10 ⁶
	Low Flows	70–100	0.0 - 0.654	0.2469	20.4	5.68 x 10 ⁹	5.68 x 10 ⁸	NA	NA	NA	NA	6.77 x 10 ⁵
Shaws Creek Waterbody ID: TN08010210021 – 1000 HUC-12: 0303	High Flows	0–10	102 - 3,330	297.4	45.2	6.84 x 10 ¹²	6.84 x 10 ¹¹	7.13 x 10 ⁸	NA	NA	NA	2.69 x 10 ⁸
	Moist	10–40	7.95 - 102	19.95	0	4.59 x 10 ¹¹	4.59 x 10 ¹⁰	7.13 x 10 ⁸	NA	NA	NA	1.80 x 10 ⁷
	Mid-Range	40–60	3.89 - 7.95	5.538	20.4	1.27 x 10 ¹¹	1.27 x 10 ¹⁰	7.13 x 10 ⁸	NA	NA	NA	4.97 x 10 ⁶
	Dry	60-90	0.554 - 3.89	1.620	17.5	3.73 x 10 ¹⁰	3.73 x 10 ⁹	7.13 x 10 ⁸	NA	NA	NA	1.43 x 10 ⁶
	Low Flows	90–100	0.0309 - 0.554	0.1606	0	3.69 x 10 ⁹	3.69 x 10 ⁸	7.13 x 10 ⁸	NA	NA	NA	1.32 x 10 ⁵

Table E-4. Summary of TMDLs, MOS, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Wolf River Watershed (HUC 08010210) (Cont.)

Waterbody Description	Hydrologic Condition			Flow ^a	PLRG	TMDL	MOS	WLAs				LAs
	Flow Zone	PDFE Range	Flow Range					WWTFs ^b	LCS	CAFOs	MS4s	
		(%)	(cfs)					[CFU/d]	[CFU/d]	[CFU/d]	[CFU/d/ac]	
Wolf River Waterbody ID: TN08010210002 – 2000 HUC-12: 0304	High Flows	0–10	1,711 - 37,231	3318	0	7.63×10^{13}	7.63×10^{12}	4.31×10^{11}	0	NA	1.52×10^8	1.52×10^8
	Moist	10–40	613 - 1,711	773.7	17.2	1.78×10^{13}	1.78×10^{12}	4.31×10^{11}	0	NA	3.47×10^7	3.47×10^7
	Mid-Range	40–60	440 - 613	526.0	7.5	1.21×10^{13}	1.21×10^{12}	4.31×10^{11}	0	NA	2.33×10^7	2.33×10^7
	Dry	60–90	289 - 440	354.7	12.2	8.16×10^{12}	8.16×10^{11}	4.31×10^{11}	0	NA	1.54×10^7	1.54×10^7
	Low Flows	90–100	187 - 289	248.0	7.5	5.70×10^{12}	5.70×10^{11}	4.31×10^{11}	0	NA	1.05×10^7	1.05×10^7
Johnson Creek Waterbody ID: TN08010210003 – 0100 HUC-12: 0304	High Flows	0–10	8.52 - 312	26.58	0	6.11×10^{11}	6.11×10^{10}	NA	NA	NA	1.36×10^7	1.36×10^7
	Moist	10–40	0.704 – 8.52	1.621	61.1	3.73×10^{10}	3.73×10^9	NA	NA	NA	8.27×10^6	8.27×10^6
	Mid-Range	40–70	0.213 - 0.704	0.4288	15.1	9.86×10^9	9.86×10^8	NA	NA	NA	2.19×10^6	2.19×10^6
	Low Flows	70–100	0.0 - 0.213	0.0802	61.1	1.85×10^9	1.85×10^8	NA	NA	NA	4.09×10^5	4.09×10^5
UT to Grays Creek Waterbody ID: TN08010210022 – 0100 HUC-12: 0305	High Flows	0–10	6.64 - 363	23.62	0	5.43×10^{11}	5.43×10^{10}	NA	0	NA	2.10×10^8	2.10×10^8
	Moist	10–40	0.614 - 6.64	1.316	53.7	3.03×10^{10}	3.03×10^9	NA	0	NA	1.17×10^7	1.17×10^7
	Mid-Range	40–70	0.182 - 0.614	0.3546	0	8.16×10^9	8.16×10^8	NA	0	NA	3.15×10^6	3.15×10^6
	Low Flows	70–100	0.0 - 0.182	0.0582	12.2	1.34×10^9	1.34×10^8	NA	0	NA	5.17×10^5	5.17×10^5
Marys Creek Waterbody ID: TN08010210022 – 0300 HUC-12: 0305	High Flows	0–10	127 - 4317	362.8	0	8.34×10^{12}	8.34×10^{11}	NA	NA	NA	7.38×10^8	7.38×10^8
	Moist	10–40	9.91 - 127	25.57	50.5	5.88×10^{11}	5.88×10^{10}	NA	NA	NA	5.20×10^7	5.20×10^7
	Mid-Range	40–70	2.84 - 9.91	5.855	0	1.35×10^{11}	1.35×10^{10}	NA	NA	NA	1.19×10^7	1.19×10^7
	Low Flows	70–100	0.0 - 2.84	1.091	15.3	2.51×10^{10}	2.51×10^9	NA	NA	NA	2.22×10^4	2.22×10^4

Table E-4. Summary of TMDLs, MOS, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Wolf River Watershed (HUC 08010210) (Cont.)

Waterbody Description	Hydrologic Condition			Flow ^a	PLRG	TMDL	MOS	WLAs				LAs
	Flow Zone	PDFE Range	Flow Range					WWTFs ^b	LCS	CAFOs	MS4s	
		(%)	(cfs)					[CFU/d]	[CFU/d]	[CFU/d]	[CFU/d/ac]	
Marys Creek Headwaters Waterbody ID: TN08010210022 – 0350 HUC-12: 0305	High Flows	0–10	8.68 - 325	27.34	87.1	6.29×10^{11}	6.29×10^{10}	NA	NA	NA	2.37×10^8	2.37×10^8
	Moist	10-40	0.719 – 8.68	1.622	0	3.73×10^{10}	3.73×10^9	NA	NA	NA	1.41×10^7	1.41×10^7
	Mid-Range	40–70	0.211 - 0.719	0.4346	30.6	1.00×10^{10}	1.00×10^9	NA	NA	NA	3.77×10^6	3.77×10^6
	Low Flows	70–100	0.0 - 0.211	0.0766	0	1.76×10^9	1.76×10^8	NA	NA	NA	6.65×10^5	6.65×10^5
Harrington Creek Waterbody ID: TN08010210001 – 0100 HUC-12: 0306	High Flows	0–10	43.6 - 1,189	99.71	0	2.29×10^{12}	2.29×10^{11}	NA	0	NA	2.78×10^8	2.78×10^8
	Moist	10-40	1.91 - 43.6	6.133	16.7	1.41×10^{11}	1.41×10^{10}	NA	0	NA	1.71×10^7	1.71×10^7
	Mid-Range	40–70	0.541 - 1.91	1.018	14.9	2.34×10^{10}	2.34×10^9	NA	0	NA	2.84×10^6	2.84×10^6
	Low Flows	70–100	0.0 - 0.541	0.1860	13.9	4.28×10^9	4.28×10^8	NA	0	NA	5.18×10^4	5.18×10^4
Workhouse Bayou Waterbody ID: TN08010210001 – 0300 HUC-12: 0306	High Flows	0–10	15.4 - 329	32.89	0	7.57×10^{11}	7.57×10^{10}	NA	0	NA	4.41×10^8	4.41×10^8
	Moist	10-40	2.37 – 15.4	3.409	20.5	7.84×10^{10}	7.84×10^9	NA	0	NA	2.99×10^7	2.99×10^7
	Mid-Range	40–60	2.15 - 2.37	2.231	30.6	5.13×10^{10}	5.13×10^9	NA	0	NA	2.75×10^7	2.75×10^7
	Dry	60-90	1.99 – 2.15	2.050	0	4.72×10^{10}	4.72×10^9	NA	0	NA	2.64×10^7	2.64×10^7
	Low Flows	90–100	1.97 - 1.99	1.969	0	4.52×10^{10}	4.52×10^9	NA	0	NA	2.64×10^7	2.64×10^7
Wolf River Waterbody ID: TN08010210001 – 1000 HUC-12: 0306	High Flows	0–10	2,236 - 48,112	4448	87.5	5.29×10^{13}	5.29×10^{12}	4.31×10^{11}	0	NA	2.04×10^8	2.04×10^8
	Moist	10–40	672 - 2,236	907.8	32.1	1.08×10^{13}	1.08×10^{12}	4.31×10^{11}	0	NA	4.11×10^7	4.11×10^7
	Mid-Range	40–60	491 - 672	578.0	19.4	6.88×10^{12}	6.88×10^{11}	4.31×10^{11}	0	NA	2.58×10^7	2.58×10^7
	Dry	60-90	302 – 491	373.7	22.1	4.45×10^{12}	4.45×10^{11}	4.31×10^{11}	0	NA	1.64×10^7	1.64×10^7
	Low Flows	90–100	190 - 302	260.0	65.2	3.09×10^{12}	3.09×10^{11}	4.31×10^{11}	0	NA	1.12×10^7	1.12×10^7

Table E-4. Summary of TMDLs, MOS, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Wolf River Watershed (HUC 08010210) (Cont.)

Waterbody Description	Hydrologic Condition			Flow ^a	PLRG	TMDL	MOS	WLAs				LAs
	Flow Zone	PDFE Range	Flow Range					WWTFs ^b	LCS	CAFOs	MS4s	
		(%)	(cfs)					[CFU/d]	[CFU/d]	[CFU/d]	[CFU/d/ac]	
Cypress Creek Waterbody ID: TN08010210032 – 1000 HUC-12: 0306	High Flows	0–10	24.7 - 737	59.85	61.1	1.38×10^{12}	1.38×10^{11}	NA	0	NA	1.03×10^8	1.03×10^8
	Moist	10–40	1.11 - 24.7	3.340	31.2	7.68×10^{10}	7.68×10^9	NA	0	NA	5.74×10^6	5.74×10^6
	Mid-Range	40–70	0.317 - 1.11	0.6047	38.1	1.39×10^{10}	1.39×10^9	NA	0	NA	1.04×10^6	1.04×10^6
	Low Flows	70–100	0.0 - 0.317	0.1064	12.5	2.45×10^9	2.45×10^8	NA	0	NA	1.83×10^5	1.83×10^5
Wolf River Waterbody ID: TN08010210004 – 0100 HUC-12: 0301	High Flows	0–10	1,719 - 37,453	3343	0	7.69×10^{13}	7.69×10^{12}	4.31E+11	0	NA	1.53×10^8	1.53×10^8
	Moist	10–40	614 - 1,719	776.0	28.3	1.79×10^{13}	1.79×10^{12}	4.31E+11	0	NA	3.49×10^7	3.49×10^7
	Mid-Range	40–60	443 - 614	526.2	6.1	1.21×10^{13}	1.21×10^{12}	4.31E+11	0	NA	2.33×10^7	2.33×10^7
	Dry	60–90	289 - 443	355.4	0	8.17×10^{12}	8.17×10^{11}	4.31E+11	0	NA	1.55×10^7	1.55×10^7
	Low Flows	90–100	187 - 289	248.4	0	5.71×10^{12}	5.71×10^{11}	4.31E+11	0	NA	1.05×10^7	1.05×10^7
UT to Fletcher Creek Waterbody ID: TN08010210023 – 0100 HUC-12: 0308	High Flows	0–10	41.0 - 1,384	104.6	0	2.41×10^{12}	2.41×10^{11}	NA	0	NA	3.15×10^8	3.15×10^8
	Moist	10–40	2.43 - 41.0	6.739	27.0	1.55×10^{11}	1.55×10^{10}	NA	0	NA	2.03×10^7	2.03×10^7
	Mid-Range	40–70	0.695 - 2.43	1.333	12.2	3.07×10^{10}	3.07×10^9	NA	0	NA	4.01×10^6	4.01×10^6
	Low Flows	70–100	0.0 - 0.695	0.2402	0	5.53×10^9	5.53×10^8	NA	0	NA	7.23×10^5	7.23×10^5
UT to Fletcher Creek Waterbody ID: TN08010210023 – 0200 HUC-12: 0308	High Flows	0–10	13.0 - 520	37.36	0	8.59×10^{11}	8.59×10^{10}	NA	0	NA	3.02×10^8	3.02×10^8
	Moist	10–40	0.927 - 13.0	2.307	19.8	5.31×10^{10}	5.31×10^9	NA	0	NA	1.87×10^7	1.87×10^7
	Mid-Range	40–70	0.277 - 0.927	0.5254	28.0	1.21×10^{10}	1.21×10^9	NA	0	NA	4.25×10^6	4.25×10^6
	Low Flows	70–100	0.008 - 0.277	0.0077	0	2.24×10^9	2.24×10^8	NA	0	NA	7.89×10^5	7.89×10^5

E. Coli TMDL

Wolf River Watershed (HUC 08010210)

(8/1/07 – Final)

Page E-41 of E-41

Table E-4. Summary of TMDLs, MOS, WLAs, & LAs expressed as daily loads for Impaired Waterbodies in the Wolf River Watershed (HUC 08010210) (Cont.)

Waterbody Description	Hydrologic Condition			Flow ^a	PLRG	TMDL	MOS	WLAs				LAs
	Flow Zone	PDFE Range	Flow Range					WWTFs ^b	LCS	CAFOs	MS4s	
		(%)	(cfs)					[CFU/d]	[CFU/d]	[CFU/d]	[CFU/d/ac]	[CFU/d/ac]
Fletcher Creek Waterbody ID: TN08010210023 – 1000 HUC-12: 0308	High Flows	0–10	120 - 3,669	291.7	8.2	6.71×10^{12}	6.71×10^{11}	NA	0	NA	2.92×10^8	2.92×10^8
	Moist	10–40	7.56 - 120	20.50	12.3	4.72×10^{11}	4.72×10^{10}	NA	0	NA	2.05×10^7	2.05×10^7
	Mid-Range	40–70	2.17 - 7.56	4.111	13.4	9.46×10^{10}	9.46×10^9	NA	0	NA	4.12×10^6	4.12×10^6
	Low Flows	70–100	0.008 - 2.17	0.7687	16.6	1.77×10^{10}	1.77×10^9	NA	0	NA	7.70×10^5	7.70×10^5

Note: NA = Not applicable.

PDFE = Percent Days Flow Exceeded.

PLRG = Percent Load Reduction Goal.

LCS = Leaking Collection Systems.

Shaded Flow Zone for each waterbody represents the critical flow zone.

- a. Flow applied to TMDL, MOS, and allocation (WLA [MS4] and LA) calculations. Flows represent the median value in the respective hydrologic flow zone.
- b. WLAs for WWTFs expressed as E. coli loads (CFU/day). Current and future WWTFs must meet water quality standards at the point of discharge as specified in their NPDES permits. At no time shall concentration exceed appropriate, site-specific (487 CFU/100 mL or 941 CFU/100 mL) water quality criteria.

APPENDIX F

**Public Notice of Proposed Total Maximum Daily Loads (TMDLs) for E. Coli
in the Wolf River Watershed (HUC 08010210)**

DIVISION OF WATER POLLUTION CONTROL

**PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY
LOAD (TMDL) FOR E. COLI IN THE
WOLF RIVER WATERSHED (HUC 08010210), TENNESSEE**

Announcement is hereby given of the availability of Tennessee's proposed total maximum daily load (TMDL) for E. coli in the Wolf River watershed, located in western Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

A number of waterbodies are listed on Tennessee's Final 2006 303(d) List as not supporting designated use classifications due, in part, to discharge of E. coli from MS4 areas, pasture grazing, livestock feeding operations, and sources outside of the state. The TMDL utilizes Tennessee's general water quality criteria, recently collected site specific water quality data, continuous flow data from three USGS discharge monitoring stations located in the watershed, a calibrated hydrologic model, and load duration curves to establish allowable loadings of E. coli which will result in reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions of E. coli loading on the order of 15-65% for the listed waterbodies.

The proposed Wolf River E. coli TMDL document can be downloaded from the following website:

<http://www.state.tn.us/environment/wpc/tmdl/>

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

Dennis M. Borders, P.E., Watershed Management Section
Telephone: 615-532-0706

Sherry H. Wang, Ph.D., Watershed Management Section
Telephone: 615-532-0656

Persons wishing to comment on the proposed TMDL are invited to submit their comments in writing no later than July 16, 2007 to:

**Division of Water Pollution Control
Watershed Management Section
7th Floor L & C Annex
401 Church Street
Nashville, TN 37243-1534**

All comments received prior to that date will be considered when revising the TMDL for final submittal to the U.S. Environmental Protection Agency.

The TMDL and supporting information are on file at the Division of Water Pollution Control, 7th Floor L & C Annex, 401 Church Street, Nashville, Tennessee. They may be inspected during normal office hours. Copies of the information on file are available on request.

APPENDIX G

Public Comments Received

G.1 Shelby County

From: "Masin, Chris" <Chris.Masin@shelbycountyttn.gov>
To: <dennis.borders@state.tn.us>
Date: 7/5/2007 8:37 AM
Subject: Written public comments

Mr. Borders,

I am with the Shelby County SW program and have some questions concerning the TMDL proposed for the Wolf River Watershed.

1.) With regards to the monitoring requirements, if an MS4 has only one listed impaired stream segment within its boundaries, then it needs to complete one round of 5 samples once every five years. Is that correct? And if a municipality is within the watershed, but has no impaired stream segments then there is no requirement to sample.

What is involved and what recordable data is required from Visual Stream Surveys.

2.) Whom should public comments be addressed to and what the best address. Do you except email comments? If so, to whom can those comments be addressed to and what is the address?

Thank you for your help in this matter.

Chris Masin, Senior Engineer

Office (901) 545-4086
Fax (901) 545-3963
Shelby County Engineering Dept.
160 N. Main, Suite 350
Memphis, TN 38103

Comments from Shelby County MS4

From: Chris Masin, P.E. 'Chris.Masin@shelbycountyttn.gov'
To: Dennis Borders, P.E. 'Dennis.Borders@state.tn.us'
Date: July 13, 2007
Subject: Proposed TMDL for E. Coli
Wolf River Watershed (HUC 08010210)
Public Comments

Below are comments received from engineering staff and other local stakeholder groups:

- 3.) Introduction XI, in the Critical Conditions, it states that water quality data for a period of up to nearly seven years is used for the load duration curve analysis, however, a 10-year period is used for the model simulation. What amount of deviation does this cause in the results and why is that not accounted for in the Las?
- 4.) Section 3.0, Land Use data used in the analysis is from the period 1990-1993. The land use characteristics of unincorporated Shelby County have change drastically during the last 14 years. The Memphis/Shelby County Planning Organization has up-to-date data. Could the updated classification percentages be reentered into the appropriate local models and LAs be updated prior to a five year period?
- 5.) Section 6.0, We believe that the model only incorporates data from three City of Memphis sites. Data should exist for collected samples at:
 - a. Wolf River at McLean Ext.
 - b. Wolf River at Austin Peay
 - c. Grays Creek at Walnut Grove
 - d. Cypress Creek at EvergreenIf the data exists and in the watershed, why is it not considered?
- 6.) Regarding the sampling point located at Fletcher Creek at Sycamore view, on occasion, the Wolf River would crest and it would result in stagnant water and the sampling point was moved upstream to North Shelby Oaks Dr. Would that cause any significant change in LAs?
- 7.) Section 6.0, The paragraph starting:
"Most of the water quality monitoring stations have at least one E. Coli sample value reported as > 2419.2. In addition, at many of these sites, the maximum E. Coli sample value is > 2419.2" is confusing and in Table 3 and the corresponding data in the appendix on page B-12 show a value of 24192 for CYPRE004.8SH. Is this a data entry error, or is the value correct?
- 8.) Not enough data was collected to calculate geometric means at any of the monitoring stations. What amount of deviation does this cause in the results and why is that not accounted for in the LAs?

- 9.) Section 7.1.1, WWTFs considered in the 2003 Wolf River Watershed TMDL included:
- Alpha Corporation (TN0000442)
 - Troxel Manufacturing Moscow (TN0000451)
Number of quarter years in non-compliance (out of 13 possible): 6
 - Grand Junction Oxidation Pond (TN0022560)
 - Moscow STP (TN0021164)
Number of quarter years in non-compliance (out of 13 possible): 6
 - Northwest TN Headstart Center (TN0065293)
 - Rocky Woods Estates (TN0056391)
 - Dogwood Village (TN0055069)
- Have these sites quit operating and are no longer discharging any wastes?
- In addition, the Springhill School Moscow (TN 0023752) is a listed WWTP that is not considered.
- 10.) It is noted that a WWTF listed within this proposed TMDL is the Maynard Stiles STP in Memphis. This plant discharges does not discharge into the Wolf River Watershed, but rather, directly into the Mississippi River. Loading from this source should not be included in the model.
- 11.) Section 7.1.3, there is suspected to be a large pig CAFO north of Moscow that is operational, however a permit could not be found and, unfortunately, an address or location could not be found in time before the closing of the public comment period. If they are found to be a contributor can the model be adjusted?

General Comments

- 12.) As cited, 30% of the Wolf River Watershed is within Mississippi. Unless the jurisdictions within Mississippi are being held to the same standard that the communities in Tennessee are, it would appear that Shelby County must remediate for other communities.
- 13.) As cited, 80% of all E. Coli contamination is non-human related. Should the MS4s be tasked with eliminating a pathogen that it has low control over? A number of stream segments list "discharge from the MS4" as the only source of pollution. Since humans contribute only a small amount of the pathogen, it appears that Shelby County must remediate the stream for contamination that is caused upstream.
- 14.) The model seems to be very precise in terms of significant digits used and required, however, with so many factors affecting the data it may not be very accurate. How can the County be held to such a precise LA when number may not be accurate?

G.2 City of Memphis

12 July 2007

Mr. Dennis Borders
Tennessee Department of Environment and Conservation
Division of Water Pollution Control
401 Church Street
L&C Annex, Seventh Floor
Nashville, Tennessee 37243-1534

**Re: Comments for Proposed Total Maximum Daily Load for E. Coli
 Wolf River Watershed, Tennessee**

Dear Mr. Borders:

On 14 June 2007, the City of Memphis received a draft copy of the proposed Total Maximum Daily Load (TMDL) for Escherichia coli (E. coli) for the Wolf River Watershed (HUC 08010210) in Tennessee. We have reviewed the above referenced document and have several questions and concerns.

1.) As stated, a monitoring plan for a Pathogen TMDL must include visual stream surveys and impairment inventories. The accessibility to and safety concerns for traversing miles of watershed boundaries is impractical. We are funding the Storm Water Program locally and have a small staff. If we are compelled to conduct visual stream assessments, we will be forced to redirect our efforts from tasks such as monitoring construction activities or spend valuable funds hiring consultants to complete this work. The City believes it would be more productive to periodically repeat work such as our Infrared Flyover Project which looks for anomalies in the streams. The City of Memphis completed an infrared flyover of approximately 250 miles of waterways in January 2005. The City determined that utilization of infrared thermography technology to conduct an aerial seep survey of waterways, which are co-located with sewer lines, followed by field reconnaissance to inspect discovered thermal anomalies would be an efficient and effective method to detect and eliminate illicit discharges. This study helped us find and resolve several widely scattered problem areas that would have taken much longer to find using visual techniques and might not have been readily visible at ground level. This method could be used in place of the visual stream surveys to save time, personnel costs, and equipment costs.

2.) The City of Memphis Storm Water Program currently samples four more locations than those shown in this document. Since we are more familiar with those locations, we suggest substitution of our sites for the Tennessee Department of Environment and Conservation (TDEC) locations if a more rigorous sampling program is to be implemented. Also, the other four stations seem like they would provide relevant data for the proposed TMDL.

3.) The document states that the Wolf River watershed has approximately 30% of its area lying in Mississippi. The City believes that this large area contained in Mississippi could leave substantial room for error if E. coli were originating within Mississippi before crossing the State line. Are there similar strictures being placed upon the agencies in

Mississippi? If not, are we being expected to "clean up" after Mississippi?

4.) In a similar aspect, is it realistic to label all of the Wolf River as a recreation use water body, one of the most stringent categories? Shelby County is highly urbanized and the Wolf's stream characteristics, especially in large parts of Shelby County, differ markedly from more rural areas upstream due to the land use and the fact that the Wolf River has been straightened and essentially used as a drainage channel for approximately 50 years?

5.) Loading Simulation Program in C++ is a model that is based on a 10-year period for seasonal variation. The period used for the model only contained six years worth of data. Also, the land use distribution period from 1990 - 1993 that was used for the study is not reflective of the current uses within the City and Shelby County. The land use has drastically changed in the past fourteen years within the entire County, primarily as a result of development. What effect does this have on the output of the model?

6.) As stated in the document, the City of Memphis completed a Microbial Source Tracking (MST) Study on South Cypress Creek. The City has done a total of three MST studies. The results indicated that nonhuman sources of E. coli accounted for more than 80% of the total occurrences. How has this been taken into account in the model? Are we expected to "remove" this source from the stream? The City feels that a similar test on the Wolf River Watershed would yield similar results. Since forest and open grass areas are abundant around the water bodies, reducing the impact of wildlife pathogen concentrations would be very difficult. Two areas stated in the document would be, reducing the wildlife concentration in an area or reducing their proximity to the water body. These two options are physically and socially unacceptable.

7.) The document also states that the calculated results are estimates. The geometric mean was not calculated at any of the monitoring stations due to the fact that there was not enough data collected. Also, there is a NPDES Regulated Wastewater Treatment Facility that is not listed in Table 4. The facility not listed is the Moscow Treatment Facility. An abandoned hog Concentrated Animal Feeding Operation along the Wolf River on the north side of Moscow should also be considered as a point source of E. coli. In Table 2, one of the only sources of pollution for locations in Shelby County considered is "discharge from the MS4." Is the "natural" component considered within this descriptor? What about other sources that may already be in the water when it enters our area?

If you have any questions concerning this correspondence, please contact Scott Morgan at (901) 576-4345 or Ron Kirby at (901) 576-7125.

Sincerely,

Paul Patterson
Administrator Environmental Engineering

C: Scott Morgan
Ron Kirby

G.3 Tennessee Water Sentinels

Tennessee Chapter

Chickasaw Group, Sierra Club – Water Sentinels Program

P.O. Box 111094, Memphis, TN 38111

July 14, 2007

**Attn.: Division of Water Pollution Control
Watershed Management Section
7th Floor L & C Annex
401 Church Street
Nashville, TN 37243-1534**

RE: Comments on Proposed TMDL for E.coli in Wolf River Watershed – HUC 08010210

WRITTEN RESPONSE REQUESTED

Dear Sir or Madam,

On behalf of the Tennessee Water Sentinels, I am pleased to be able to participate in the process of making comments of the above referenced documents. I offer the following comments on behalf of the Tennessee Water Sentinels program of the Tennessee Chapter and the Chickasaw Group – Sierra Club.

Comment 1:

3.0 Watershed Description, in the second and third sentences

Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1993. Although changes in the land use of the Wolf River watershed have occurred since 1993 as a result of development, this is the most current land use data readily available for GIS-interfaced hydrologic model input.

It is our contention that using data on land use that is from 14 to 17 years old presents challenges with accurately calculating an accurate TMDL based on land use. Since 1990, the change in land use due to development within the Wolf River watershed in eastern Shelby County has been nothing short of phenomenal. One good example of this is the Gray's Creek watershed in the area surrounding the intersection of Houston Levee Rd. and Macon Rd., Memphis handy map page 160-G¹, **(35° 09' 36" N by 89° 43' 40" W)**. Many hundreds of homes have been built in this area since the early 1990's, with more being built each day. Gray's Creek is not the only area in the watershed experiencing explosive growth. Water Pollution Control needs to utilize its resources and acquire more recent satellite images and land use data and use it to refine this TMDL. After briefing her on the situation and receiving her okay, may I suggest that WPC contact Dr. Esra Ozdenerol-Garner at the University of Memphis, who may be able to assist WPC in these efforts. Her contact information is:

**Department of Earth Sciences
236 Johnson Hall, 488 Patterson Street
University of Memphis
Memphis, TN 38152
Ph: 901-678-2787 Fax: 901-678-2178
Email: eozenrl@memphis.edu
Website: <http://des.memphis.edu/esra/>**

Comment 2:

Based on Table 3 on page 12 of the TMDL document and Appendix B, pages B-6, 7, 8, 9, 10, 14 & 15, I see that Water Pollution Control apparently did not consider all the monthly ambient monitoring samples that were collected by the City of Memphis' storm water program.

Question 1: Will WPC be considering the results from those samples in addition to the ones listed on the above pages of the TMDL document?

Point to notice: See the comments about sample point 6W below.

1W: Wolf River at Germantown Parkway: Memphis handy map page 49-B ¹, (35° 07' 01" N by 89° 48' 06" W). 1W was the storm water program's "upstream" sample on the main stem of the Wolf River as it flowed into Memphis' city limits.

4W: Harrington Creek at Raleigh-Lagrange Road: Memphis handy map page 24-D ¹, (35° 11' 14" N by 89° 53' 13" W).

6W: Fletcher Creek at North Shelby Oaks:

Unless this sample point was changed after August 2002, the sampling location that was approved by TDEC/WPC and used by the City of Memphis storm water personnel was Fletcher Creek at Sycamore View, Memphis handy map page 25-P ¹, (35° 10' 11" N by 89° 51' 56" W). Regarding Fletcher Creek at Sycamore View, on occasion, the Wolf River would have a high river stage and it would result in stagnant water conditions at Sycamore View. When that occurred, the next sample point upstream was used, located at North Shelby Oaks Dr., Memphis handy map page 25-R ¹, (35° 10' 20" N by 89° 51' 17" W). At any time the sampling location was changed due to high water and/or stagnant water conditions, those deviations were noted on the chain-of-custody and/or a sample log as well as the data spreadsheets.

The City of Memphis' storm water program also collected monthly ambient samples at:

Wolf River at Old Austin Peay: Memphis handy map page 16-H ¹, (35° 12' 07" N by 89° 55' 21" W). This was the City's "mid-point" sample on the main stem of the Wolf River.

Wolf River at McLean Ext.: Memphis handy map page 14-R ¹, (35° 11' 27" N by 89° 59' 35" W). The only time this sample was omitted is if the Mississippi River was at a high river stage and that resulted in stagnant water conditions at McLean). This was the City's "downstream sample" on the main stem of the Wolf River. At any time the sampling location was changed due to high water and/or stagnant water conditions, those deviations were noted on the chain-of-custody and/or a sample log as well as the data spreadsheets.

Grays Creek at Walnut Grove Rd.: Memphis handy map page 328-F ¹, (35° 07' 46" N by 89° 44' 18" W).

Cypress Creek at Evergreen (the end of the concrete channeled section): Memphis handy-map 21-P ¹, (35° 10' 08" N by 90° 00' 01" W). The only time this sample was omitted is if the Wolf River/Mississippi River was at a high river stage and that resulted in stagnant water conditions at this sample location. If stagnant water existed, sampling was attempted where Cypress Creek was bridged at McLean, Memphis handy map page 21-P ¹, (35° 10' 06" N by 89° 59' 45" W). If stagnant water existed there, that particular sample was omitted. At any time the sampling location was changed due to high water and/or stagnant water conditions, those deviations were noted on the chain-of-custody and/or a sample log as well as the data spreadsheets.

Comment 3:

Section 7.1.1: NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

The Maynard C. Stiles Wastewater Treatment Plant (NPDES Permit # TN0020711) discharges directly into the Mississippi River as shown in table 4, NOT into the Wolf River.

Question 1: Is that plant's discharge part of any TMDL calculation for the Wolf River?

Question 2: Is the Stiles Plant now disinfecting its effluent?

Comment 4:

Section 7.1.3: NPDES Concentrated Animal Feeding Operations (CAFOs)

Animal feeding operations (AFOs) are agricultural enterprises where animals are kept and raised in confined situations.... There were two Class II CAFOs (TNA000022 and TNA000100) in the Wolf River watershed with coverage under the general NPDES permit during the TMDL analysis period. Both of these CAFO permits have been terminated. One of the two (TNA000022) was located in the drainage area of the (E. coli) 303(d)-listed waterbody Cypress Creek, TN08010210032-1000.

Tennessee Water Sentinels respectfully submits that the above information is incorrect with regards to location of CAFO # TNA000022. WPC's map on page 13 of the TMDL document shows TNA000022 as being within the Memphis City Limits, somewhere in residential mid-town Memphis. A bit of searching with a November 2004 download of the "List of General and Individual Sites with Coverage under the General NPDES Permit for Concentrated Animal Feeding Operations (CAFOs) November 2004" lists TNA000022 as "Thomas Dairy, at 15920 Highway 196 in Eads, TN, in Fayette County". A quick search on *Google Earth* revealed a high resolution aerial photo of the CAFO at **(35° 12' 37" N by 89° 35' 07" W)**. The CAFO is listed as discharging to "Cypress Creek", but that is another Cypress Creek, which according to the FINAL 2006 303d list, displays a HUC number of 08010209003-1000, which is in the Loosahatchie River watershed.

Comment 5:

Table 8, WLAs & Las for Wolf River, Tennessee

Question: Where is Gray's Creek listed with the Rocky Woods Estates WWTF (NPDES Permit # TN0056391) in this table?

Comment 6:

Table 8, WLAs & Las for Wolf River, Tennessee, see note "b" on page 28 of the TMDL document and Table E-4 of the Appendices

WLAs for WWTFs expressed as E. coli loads (CFU/day). Future WWTFs must meet water quality standards at the point of discharge as specified in their NPDES permits. At no time shall concentration exceed appropriate, site-specific (487 CFU/100 mL or 941 CFU/100 mL) water quality criteria.

The wording for the second sentence should be changed to read, "**Current** and future WWTFs must meet water quality standards at the point of discharge as specified in their NPDES permits."

Comment 7:

Section 9.3: Non-point Sources

The Tennessee Department of Environment & Conservation has no direct regulatory authority over most non-point source (NPS) discharges.

Question: Please explain where in the Tennessee Water Quality Control Act of 1977 at § 69-3-101 et seq. that TDEC/WPC does not have "direct regulatory authority over most non-point source (NPS) discharges."?

Comment 8:

more Section 9.3: Non-point sources

Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired waters.

Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs.

Question: Based on the experience TDEC/WPC has gained from the TMDL for *E.coli* on the Nonconnah Creek watershed, what voluntary, incentive-based mechanisms will work in the Wolf River watershed and that you will plan to pass along to government leaders of Memphis, Collierville, Germantown, City of Lakeland, Shelby County and Bartlett, industry, business leaders, and the general public?

Comment 9:

Section 9.3.1: Urban Non-point Sources

Illicit discharges: Removal of illicit discharges to storm sewer systems, particularly of sanitary wastes, is an effective means of reducing pathogen loading to receiving waters (ENSR, 2005). These include intentional illegal connections from commercial or residential buildings, failing septic systems, and improper disposal of sewage from campers and boats.

Tennessee Water Sentinels requests that the City of Memphis storm water program inspect, on a routine basis, the segment of Cypress Creek between Sam Cooper Blvd. on the south to Tutwiler Ave. on the north, Memphis handy map page 30-P & L ¹, **(35° 08' 50" N by 89° 57' 33" W to 35° 09' 12" N by 89° 57' 40" W)**. In the late 1990's, Memphis' storm water program personnel discovered a broken private sanitary sewer line that was discharging raw sewage into Cypress Creek. They required the owners of the private line, Leahy's Weekly Rentals, 3070 Summer Ave., Memphis 38112, to repair their line. Copies of letters on this issue should be in the files at Memphis' storm water management. However, continued vigilance is needed in this particular segment of Cypress Creek.

Tennessee Water Sentinels requests that the City of Memphis storm water program inspect, on a routine basis, the segment of Lick Creek between Madison Ave. on the south to Jefferson Ave. on the north, Memphis handy map page 36-G & C ¹, **(35° 08' 13" N by 89° 59' 32" W to 35° 08' 20" N by 89° 59' 31" W)**. There is a large diameter public sewer line that has an inverted siphon crossing of Lick Creek, and the upstream siphon manhole is located just off the western edge of the parking lot of the Malco Studio on the Square movie theater at 2105 Court Ave., Memphis 38104. That manhole is located at **(35° 08' 16.21" N by 89° 59' 30.76" W)**. That manhole has been known to overflow into that segment of Lick Creek when the siphon gets blocked.

Tennessee Water Sentinels would like to see incorporated into Table 10 that Memphis, Collierville, Germantown, City of Lakeland, Shelby County and Bartlett pledge to review the "as-built" plans, and as needed, conduct smoke testing, dye testing, and camera analysis of their inverted sewer siphon crossings of the various creeks in the Wolf River watershed, with an eye to looking for what I call, for lack of a better name, an "engineered relief", which is a bypass pipe that is in the barrel of the upstream sewer siphon manhole that can discharge raw sewage into the creek or river when the sewer is in a surcharged condition. If any of these reliefs are located, then it is paramount to seal those reliefs off so they cannot operate as the discharge point of the relief may be under water and sewage can discharge undetected.

The tasks of searching for potential reliefs should occur within verifiable timelines and the results of those tasks documented within the Annual Storm Reports of the storm water programs of these entities.

Do these reliefs exist? I know of one "engineered relief" that the City of Memphis' storm water program observed discharging in the late 1990's. Its location was immediately reported to the City of Memphis' Sewer Maintenance Department and the relief was sealed off, I believe in the upstream siphon manhole itself. That relief was located at Ten Mile Creek at Knight Arnold Memphis handy map page 66-K ¹, **(35° 03' 54" N by 89° 56' 15" W)**. In addition, there was a possible engineered relief or a damaged sewer line that discharged into Fletcher Creek at North Shelby Oaks Dr. Memphis handy map page 25-R ¹. That one was discovered in the early fall of 2000. That one was also sealed off by Sewer Maintenance. The reason I include their exact locations here is that if the relief seal(s) fail, then everyone is back to "square one", trying to locate the source of E.coli.

Comment 10:

more Section 9.3.1: Urban Non-point Sources

Pet waste: If the waste is not properly disposed of, these bacteria can wash into storm drains or directly into water bodies and contribute to pathogen impairment. Encouraging pet owners to properly collect and dispose of pet waste is the primary means for reducing the impact of pet waste (USEPA 2002b).

Comment 10, cont.:

Tennessee Water Sentinels would like to see incorporated into Table 10 that Memphis, Collierville, Germantown, City of Lakeland, Shelby County and Bartlett pledge to have periodic stories in the local print media and on TV about pet waste and its proper disposal. These could be local news interest stories rather than paid ads if money is an object.

Informational stories on the proper disposal of pet waste should be done quarterly and documented within the Annual Storm Reports of the storm water programs of these entities.

Comment 11:

Section 9.4.2 Source Identification

An important aspect of E. coli load reduction activities is the accurate identification of the actual sources of pollution. In cases where the sources of E. coli impairment are not readily apparent, Microbial Source Tracking (MST) is one approach to determining the sources of fecal pollution and E. coli affecting a waterbody.

Tennessee Water Sentinels strongly encourages Memphis, Collierville, Germantown, City of Lakeland, Shelby County and Bartlett to pool resources and conduct microbial source tracking to determine source(s) of fecal pollution in the Wolf River watershed.

Sincerely,

James H. Baker
Project Director – Tennessee Water Sentinels
Phone: 901-826-2448
Website: <http://sierraclub.org/watersentinels/tennessee/>

- c. Ms. Katherine Pendleton – Chair, Tennessee Chapter – Sierra Club
Ms. Gloria Griffith – vice-Chair, Tennessee Chapter – Sierra Club
Mr. Gary Bowers – Conservation Chair, Tennessee Chapter – Sierra Club
Mr. Axel Ringe – Water Quality Chair, Tennessee Chapter – Sierra Club
Mr. Tom Lawrence – Chair, Chickasaw Group – Sierra Club
Ms. Juliet Jones – vice Chair, Chickasaw Group – Sierra Club
Ms. Naomi Van Tol – Conservation Chair, Chickasaw Group – Sierra Club
Ms. Renée Hoyos – Executive Director, Tennessee Clean Water Network
Mr. Keith Kirkland – Executive Director, Wolf River Conservancy
Mr. Scott Dye – Director, Sierra Club Water Sentinels Program

¹ Memphis Handy Map - 2007 Ed. by Stacey Map Corporation, 50 South Prescott St., Memphis, TN 38111-0061

All latitudes and longitudes gathered from *Google Earth*.

G.4 City of Bartlett

July 16, 2007

Dennis Borders
Tennessee Department of Environment & Conservation
Division of Water Pollution Control
401 Church Street
L & C Annex, Seventh Floor
Nashville, Tennessee 37243-1534

RE: Comments on Proposed TMDL for E.coli in Wolf River Watershed – HUC 08010210

Dear Mr. Borders,

The following are our comments on the proposed TMDL for *E. coli* in the Wolf River Watershed.

Comment 1:

1.0 The TMDL may then be used to develop controls for reducing pollution from both point and nonpoint sources in order to restore and maintain the quality of water resources (USEPA, 1991).

What is being done to address non-point source pollution in areas who are not a Phase I or Phase II community? (See percentages in Comment 2)

Comment 2:

2.0 The majority of the Wolf River Watershed lies in the state of Tennessee with approximately 30% lying in Mississippi.

According to the “Wolf River Watershed (08010210) of the Tennessee River Basin Watershed Water Quality Management Plan”, found at <http://state.tn.us/environment/wpc/watershed/wsmplans/wolf/>, of the 70% of the watershed inside of the State of Tennessee 38.6% lies within Shelby County. This means that of the total watershed, only 26.74% lies within Shelby County. However, all of the actions to be taken are located within Shelby County.

It seems that the actions proposed are aimed at Shelby County with no other action being proposed throughout the rest of the Watershed. This means that 73.26% of the watershed has no actions directed towards it.

Comment 3:

2.0 Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1993.

The data on land use is 14 – 17 years old. There have been many changes to the landscape in that time. Any assumptions made about the contribution due to landscape usages will be miscalculated.

Comment 4:

5.0 As previously stated, the designated use classifications for the Wolf River waterbodies include industrial water supply, fish & aquatic life, irrigation, livestock watering & wildlife, recreation, and navigation. Of the use classifications with numeric criteria for E. coli, the recreation use classification is the most stringent and will be used to establish target levels for TMDL development.

The classification of “recreation use” of waterbodies within our municipality limits seems unwarranted. Most of the water ways are creeks that are not large or deep enough for recreational usages. Additionally the stream side vegetation does not lend to use for recreation. Having a target TMDL using the classification of “recreational use” will set a standard that is more stringent than what our waterbodies are used for; fish & aquatic life and wildlife are the two main usages of the water in our portion of the watershed.

Comment 5:

9.2.2 In order to evaluate SWMP effectiveness and demonstrate compliance with specified WLAs, MS4s must develop and implement appropriate monitoring programs. An effective monitoring program could include:

- *Effluent monitoring at selected outfalls that are representative of particular land uses or geographical areas that contribute to pollutant loading before and after implementation of pollutant control measures.*
- *Analytical monitoring of pollutants of concern (e.g., monthly) in receiving waterbodies, both upstream and downstream of MS4 discharges, over an extended period of time. In addition, intensive collection of pollutant monitoring data during the recreation season (June – September) at sufficient frequency to support calculation of the geometric mean.*

Question 1. What is the frequency of sampling to be required? Will it be monthly or so many times a year or so many times a permit cycle?

Question 2. Will this be based on a watershed wide plan or per municipality or area?

Question 3. What about water ways that enter, leave, and re-enter our MS4? Will we be required to test when they enter, when they leave, and when they reenter?

Comment 6:

9.2.2 “When applicable, the appropriate Division of Water Pollution Control Environmental Field Office should be consulted for assistance in the determination of monitoring strategies, locations, frequency, and methods within 12 months after the approval date of TMDLs or designation as a regulated MS4.”

What will the local field office use to determine the monitoring strategies, locations, frequency, and methods to be used?

Comment 7

9.0 The TMDLs, WLAs, and LAs developed in Section 8 are intended to be the first phase of a long term effort to restore the water quality of impaired waterbodies in the Wolf River watershed through reduction of excessive E. coli loading.

9.3 The Tennessee Department of Environment & Conservation has no direct regulatory

authority over most nonpoint source (NPS) discharges. . . . Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired waters. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs.

Most of the watershed, 73.26%, lies in an area where nonpoint source pollution is the main source. If this is the part that is, as is stated, "critical to successful implementation of TMDLs" why is it not the first phase being implemented?

Comment 8:

Visual assessments of streams would be a very laborious job, both in the field and in the office. Our streams run through private properties, all of whose owners would have to be notified of an inspection to be done. The stream banks are not walkable in all areas and the stream beds themselves may be dangerous due to high water or snakes. Most of our waterways are too shallow to be navigational, so the whole length would have to be walked. With our limited manpower, we want to make sure this is the most efficient use of our time and manpower. What is the goal of this recommended requirement? Would sample spot visual inspections provide the same results?

Thank you for taking the time to look over our comments on the proposed TMDL. We hope that you will take into consideration our concerns and questions.

Sincerely,
Stephanie Kruger
City of Bartlett, Storm Water Coordinator
3585 Altruria Road
Bartlett, TN 38135
901-385-6499

APPENDIX H
Response to Public Comments

H.1 Responses to Shelby County

Note: responses correspond to numbered comments (see Appendix G, Section G.1)

- 1.) The Division of Water Pollution Control has developed guidance for interpretation of TMDL monitoring minimum requirements for Municipal Separate Storm Sewer Systems (MS4s). According to Sect. 9.2.2, “the appropriate Division of Water Pollution Control Environmental Field Office (EFO) should be consulted for assistance in the determination of monitoring strategies, locations, frequency, and methods within 12 months after the approval date of TMDLs or designation as a regulated MS4.” In addition, the Statewide Storm Water Coordinator can be contacted for assistance with TMDL monitoring requirements.
- 2.) See the Public Notice, Appendix F, for contact information, including the Division address for TMDL comments, and a website address for downloading the document. In addition, Section 11.0 provides contact information, including e-mail addresses. TMDL comments are also accepted via these e-mail addresses.
- 3.) The LSPC model was utilized to simulate flow (only) for the Wolf River watershed. Typically, a minimum of 10 years of flow data is desirable in order to have confidence that the full range of flows are reasonably represented. We had up to nearly 7 years (variable by site) of water quality data for load duration curve development. No significant deviation in results is expected because the TMDLs, WLAs, and LAs are flow based.
- 4.) According to the Multi-Resolution Land Characteristics (MRLC) Consortium (http://www.mrlc.gov/mrlc2k_faq.asp), regarding comparison of NLCD 92 with land cover from NLCD 2001, “Direct comparison is not recommended. Each dataset was mapped with different methods and slightly different classes. While the two NLCD products are designed to be similar, the slight differences in classification, combined with the final accuracy of the mapping (from 70-80%), result in two distinct products.” Efforts will be made in the near future to adapt the new data products to TMDL methodologies and models.
- 5.) All available data, including samples collected at the four City of Memphis monitoring stations listed, were considered during development of the TMDLs. Many of the impaired waterbodies have multiple water quality monitoring stations. For each individual impaired segment, the station providing the most conservative (most protective) results was utilized for analysis and subsequent development of the TMDL.
- 6.) The TMDLs, WLAs, and LAs are expressed at the pour point (outlet of the drainage area or HUC-12 subwatershed) as a function of daily mean flow for a particular segment. Therefore, the location of the water quality monitoring station on an impaired segment will have no bearing on the LA for that segment.

Implementation results (percent reductions, critical zones) are evaluated at the monitoring stations. The two stations on Fletcher Creek are very close in proximity, resulting in an insignificant difference in drainage area. Combining sample data from both locations for implementation evaluation should result in insignificant differences in percent reductions and expression of the critical zone.

The data provided by the City of Memphis were provided as hardcopy with station 6W identified as “Fletcher Creek at North Shelby Oaks”. No notes were provided indicating that

any of the (6W) samples were collected at any other location. In addition, no entries were labeled "Not Sampled", "Flooded", or "No Flow" as were occasional entries at stations 4W, 5W, and 7W.

- 7.) The data value of "24192" for CYPRE004.8SH on 3/2/04 is correct as is the value of ">24192" on 5/5/04.
- 8.) The current E. coli TMDL methodology is a Load Duration Curve approach based on daily values (maximum water quality criterion). The TMDLs, WLAs, and LAs are expressed as daily values (load as a function of daily mean flow). More or less data (geometric mean, monthly, etc.) would not change the expression of the LAs. The value of geometric mean data is in evaluating compliance with (or exceedance of) the 30-day geometric mean criterion. In addition, more frequent data, or more data in general, provide for more effective and accurate implementation analyses (determination of percent reduction in loading required, identification of the critical zone, source identification, etc.).
- 9.) All seven (7) facilities were included in the analyses. The only facility on this list that is/was located in an impaired subwatershed (waterbody drainage area or HUC-12) was Rocky Woods Estates (TN0056391). It, like Ridgeway Country Club (TN0023094), was listed in Table 4 but was not assigned a WLA or notified of the proposed TMDL because each has been terminated. Each of the seven facilities was included in the LSPC (hydrologic) model for the purposes of calibrating flow. The facilities with E. coli permits were included in the WLAs of the mainstem (Wolf River) waterbodies because they discharge to the full-scale drainage areas of these segments.

The Division's records indicate the Springhill School (TN0023752) facility is inactive with a permit expiration date of 4/29/90.

- 10.) The Maynard C. Stiles STP (TN0020711) is located in a Wolf River impaired subwatershed. Hence, it is listed in Table 4. Section 7.1.1, describing the facilities listed in Table 4, states, "two of the facilities (**TN0020711** and TN0064092) are located in impaired watersheds but discharge to unimpaired waterbodies." There is no WLA provided for this facility in the Wolf River watershed. Please note that there is no loading model utilized in the development of these TMDLs.
- 11.) The permit for MCOSA Farms (TNA000100), a hog CAFO located north of Moscow, expired 4/30/04. Permit notes indicate the site is no longer a CAFO and removal of biosolids is (was) scheduled for the spring of 2007.
- 12.) For waterbodies that originate in Mississippi, the state of Mississippi is required to meet Tennessee's water quality standards at the state line.
- 13.) The NPDES General Permit for Small Municipal Separate Storm Sewer Systems, Permit No. TNS000000, Section 1.5, Limitations on Coverage, states, "This permit does not authorize:
 - 1.5.6 Discharges that would cause or contribute to in-stream exceedances of water quality standards. Your storm water management program must include a description of the BMPs that you will be using to ensure that this will not occur. The division may require corrective action or an application for an individual permit or alternative

general permit if an MS4 is determined to cause an in-stream exceedance of water quality standards.

- 1.5.7 Discharges of any pollutant into any water for which a [Total Maximum Daily Load \(TMDL\)](#) has been approved by EPA, where the TMDL applies to storm water discharges from the MS4 a specific wasteload allocation and recommends it be incorporated into an individual NPDES permit.”

An MS4 is only responsible for sources within the area covered by their respective jurisdiction. Monitoring at the jurisdictional boundaries can be an effective method for delineating responsibility.

- 14.) For consistency, the TMDLs, WLAs, and LAs are all expressed in 3 significant digits (WLAs and LAs reduced from 4). This level of precision allows the terms to balance (add up). Ultimately, the water quality standards are either in-stream or effluent (for facilities) requirements.

H.2 Responses to City of Memphis

Note: responses correspond to numbered comments (see Appendix G, Section G.2)

- 1.) Please refer to Section H.1, response #1.
- 2.) Please refer to Section H.1, responses #1 and #5.
- 3.) Please refer to Section H.1, response #12.
- 4.) The TMDL analyses were conducted according to the currently promulgated designated use of the waterbodies and the subsequent most stringent water quality criteria. To change or remove (declassify) a designated use of a waterbody, a Use Attainability Analysis must be conducted and submitted to EPA for approval. See 40 CFR, Parts 131.3(g) and 131.10(j). States are strongly discouraged from removing designated uses of waterbodies due to impairment according to the water quality standards imposed by those uses.
- 5.) Please refer to Section H.1, responses #3 and #4.

The LSPC model is calibrated against observed streamflow data from three USGS monitoring stations located in the Wolf River watershed. Two of three station calibrations meet all recommended calibration criteria while the third meets 8 of 9 criteria. Utilizing more recent land use data may result in marginal improvement in model calibration; however, TMDL results are not likely to differ significantly.

- 6.) The Load Duration Curve methodology does not differentiate between human and non-human sources. Please refer to City of Memphis NPDES Permit No. TNS068276:

PART I, A. PERMIT AREA, states, “This permit covers all areas located within the corporate boundary of The City of Memphis, located in Shelby County, Tennessee.”

PART III, D. RECEIVING WATER LIMITATIONS, states (in part), “This SWMP shall reduce

the discharge of pollutants to the Maximum Extent Practicable (MEP) and shall not cause or contribute to violations of State water quality standards of the receiving streams. If exceedance(s) of water quality objectives or water quality standards (collectively, WQS) persist notwithstanding implementation of the SWMP and other requirements of this permit, the permittees shall comply with the following procedure:

a. Upon a determination by either the permittees or the Division of Water Pollution Control that discharges are causing or contributing to an exceedance of an applicable WQS, the permittees shall promptly notify and thereafter submit a report to the division that describes BMPs that are currently being implemented and additional BMPs that will be implemented to prevent or reduce any pollutants that are causing or contributing to the exceedance of WQSs."

- 7.) The calculated summary data statistics referred to in Section 6.0, Water Quality Assessment and Deviation from Target, and percent load reduction goals based, in part, on values of >2419, were considered to be estimates because the absolute value of these samples is not known.

Please refer to Section H.1, responses #9, #11, and #13.

Please refer to City of Memphis NPDES Permit No. TNS068276:

PART I, B. AUTHORIZED DISCHARGES, states, "Except for discharges prohibited under Part I(E), this permit authorizes existing or new storm water point source discharges to Waters of the State of Tennessee from those portions of the Municipal Separate Storm Sewer System (MS4) owned or operated by The City of Memphis."

PART I, E. LIMITATIONS ON COVERAGE, states, "The following discharges are not authorized by this permit:

1. Discharges of non-storm water, except where such discharges are as follows:
 - a. in compliance with a separate NPDES permit (or the discharger has applied for such a permit); or,
 - b. identified by and in compliance with 40 CFR 122.26(d)(2)(iv)(B)(1); and,
2. Discharges of materials resulting from a spill, except emergency discharges required to prevent imminent threat to human health or to prevent severe property damage, provided reasonable and prudent measures have been taken to minimize the impact of the discharges.

H.3 Responses to Tennessee Water Sentinels

Note: responses correspond to numbered comments (see Appendix G, Section G.3)

- 1.) Please refer to Section H.1, response #4. As urban areas expand within local jurisdictions, or local municipalities annex expanding urban areas, the local municipalities (MS4s) are responsible for these areas within their jurisdictions.

- 2.) Please refer to Section H.1, responses #5 and #6.
- 3.) Please refer to Section H.1, response #10. It is unknown if the Maynard C. Stiles STP (TN0020711) is disinfecting its effluent. This is a permit issue and not within the scope of the TMDL.
- 4.) TDEC's permit database indicates the Thomas Dairy (TNA000022) was located in the Wolf River watershed. The receiving waterbody is listed as Cypress Creek and the permit was terminated; therefore, no further verification was conducted. This has been corrected in the TMDL and the Division's Permit Section has been notified of the error. Since CAFOs are not permitted to discharge, this has no impact on the TMDL.
- 5.) This permit has also been terminated; therefore, no WLA is assigned to Grays Creek. This has been clarified in Sections 7.1.1 and 10.0.
- 6.) The footnote has been changed, as suggested, on page 28 as well as on pages xiii and E-41.
- 7.) See The Tennessee Water Quality Control Act of 1977, including the 1998 amendments, § 69-3-120:

(g) Nothing whatsoever in this part shall be construed as applying to any agricultural or forestry activity or the activities necessary to the conduct and operations thereof or to any lands devoted to the production of any agricultural or forestry products, unless there is a point source discharge from a discernible, confined, and discrete water conveyance.

(h) The passage of the "Water Quality Control Act of 1977" shall grant no new authority over non-point sources to the department which was not previously established by the "Water Quality Control Act of 1971."
- 8.) Memphis, Collierville, Germantown, the City of Lakeland, the City of Bartlett, and Shelby County have NPDES (MS4) permits. As stated in Section 7.0, the NPDES program regulates point source discharges. In addition, as stated in Section 7.1.2, "(MS4s) are considered to be point sources of E. coli."
- 9.) The issues listed are permit and/or compliance issues. Specific requests may be conveyed to the Memphis Environmental Field Office or via a formal complaint to the Division of Water Pollution Control.

Table 10 lists example urban area management practices and is not intended to convey specific requirements for individual permittees.
- 10.) This would be a voluntary and discretionary effort to satisfy general goals and requirements of MS4 permits.
- 11.) See #10 above.

H.4 Responses to City of Bartlett

Note: responses correspond to numbered comments (see Appendix G, Section G.4)

- 1.) Efforts are largely voluntary. These are the areas where local, citizen-lead efforts can be particularly effective where problems exist. A number of resources are provided in Section 9.3; however, this is not an exhaustive list. In addition, the Clean Water Act, Section 319, established the Nonpoint Source Management Program (<http://www.epa.gov/OWOW/NPS/cwact.html>). Under Section 319, States, Territories, and Indian Tribes receive grant money which supports a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific nonpoint source implementation projects. Historically, 319 grants have focused on the implementation of projects that are designed to improve waters that have been listed as impaired under Section 303(d) of the CWA.
- 2.) Impaired waterbodies outside of and not influenced by sources in Shelby County are not the responsibility of Shelby County or entities located therein. All impaired waterbodies outside of Shelby County, primarily impaired by agricultural non-point sources, are required to meet water quality standards. Therefore, corrective actions must be taken in order to achieve reductions in loading.
- 3.) Please refer to Section H.1, response #4.
- 4.) Please refer to Section H.2, response #4.
- 5.) Please refer to Section H.1, response #1.
- 6.) Please refer to Section H.1, response #1.
- 7.) Development of the TMDLs, including WLAs and LAs represents the first phase. Because many, if not most, NPS measures require voluntary, incentive-based mechanisms to achieve reductions in pollutant loading, they tend to take longer to implement than mandatory, regulatory-driven (e.g., NPDES) measures. Also, see #1, above.
- 8.) Please refer to Section H.1, response #1.