

APPENDIX 1

A-1. OPEQUON CREEK

A-1.1 Watershed Information

Opequon Creek is in the eastern portion of the Potomac Direct Drains nonpoint total maximum daily loads (TMDL) study area and drains approximately 341 square miles (218,281 acres), as shown in Figure A-1-1. Approximately 56 percent of the watershed is in West Virginia and 44 percent is in Virginia. The dominant landuse in the watershed is grassland, which covers 37 percent of the watershed. Other important landuse types include forest (28 percent), urban/residential (13 percent), pasture (eight percent), and cropland (seven percent). Each of the other individual land cover types accounts for less than seven percent of the total watershed area. There are 18 impaired West Virginia streams in the watershed, including Opequon Creek, addressed by this TMDL development effort. Figure A-1-2 shows the impaired streams and associated pollutants.

Before establishing (TMDLs), WVDEP performed monitoring throughout the Potomac Direct Drains watershed to better characterize water quality and refine impairment listings. Monthly samples were taken at 67 stations (station locations can be viewed using the ArcExplorer project) in the Opequon Creek watershed from July 1, 2003 through June 30, 2004. Monitoring suites at each site were determined based on the types of impairments observed in each stream. Monthly samples from streams impaired by fecal coliform bacteria were analyzed for fecal coliform bacteria, pH, and specific conductance. In addition, benthic macroinvertebrate assessments were performed at specific locations on the biologically impaired streams during the pre-TMDL monitoring period. Instantaneous flow measurements were also taken at strategic locations during pre-TMDL monitoring.

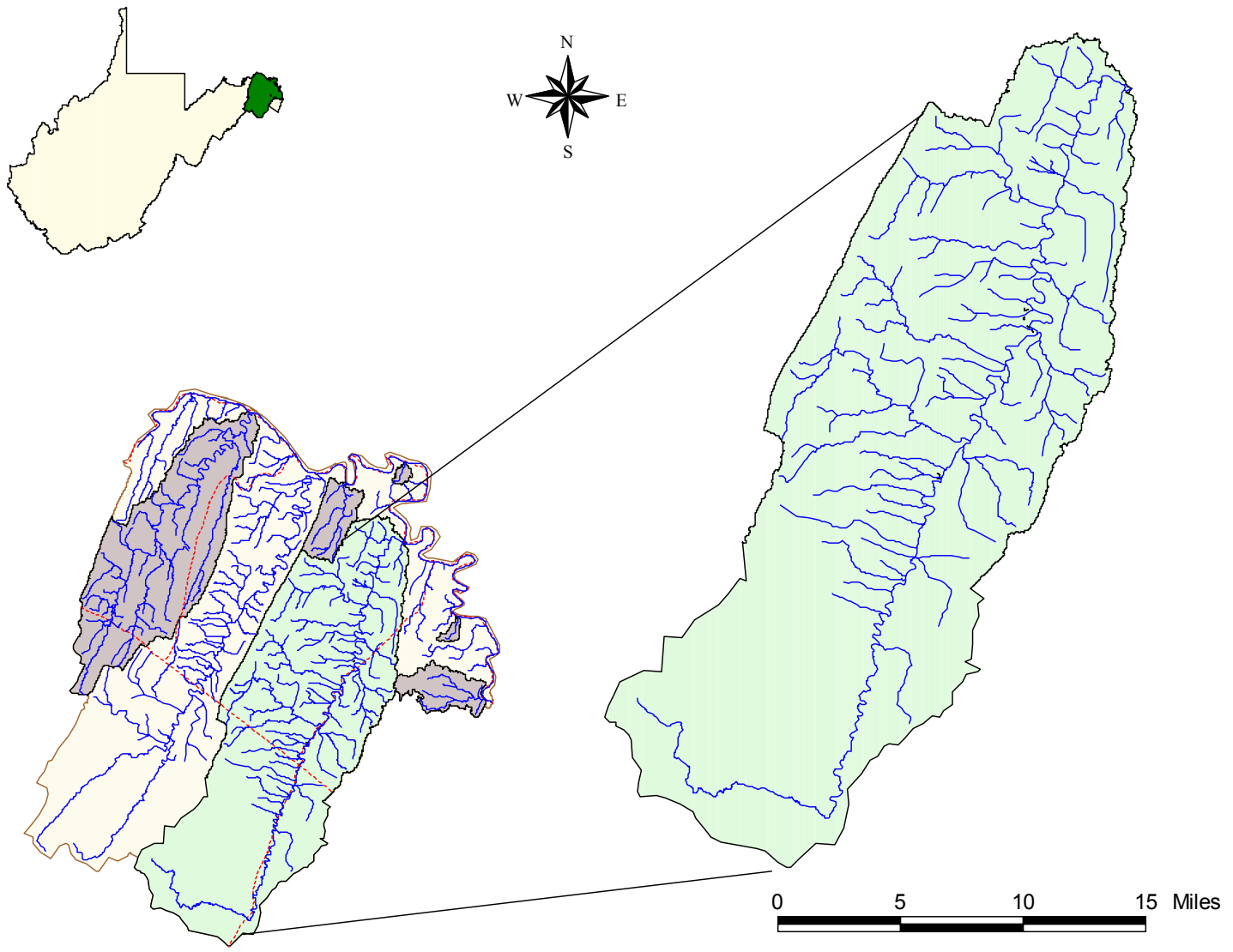
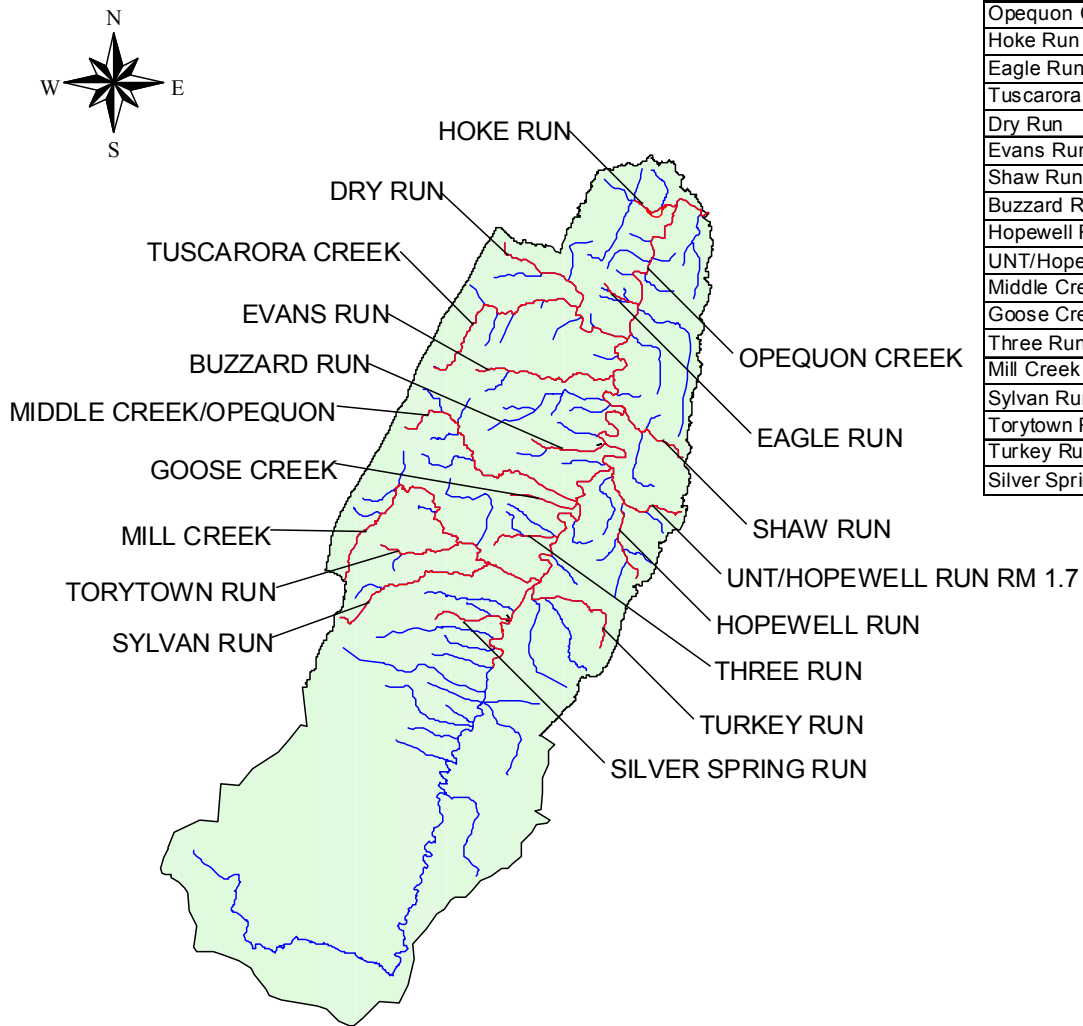


Figure A-1-1. Location of the Opequon Creek watershed



TMDL Stream Name	Impairment	
	Fecal Coliform	Biological
Opequon Creek	x	x
Hoke Run	x	x
Eagle Run	x	x
Tuscarora Creek	x	x
Dry Run	x	x
Evans Run		x
Shaw Run	x	x
Buzzard Run	x	
Hopewell Run	x	x
UNT/Hopewell Run RM 1.7	x	x
Middle Creek	x	x
Goose Creek	x	
Three Run	x	
Mill Creek	x	x
Sylvan Run		x
Torytown Run	x	x
Turkey Run	x	x
Silver Spring Run	x	x

Figure A-1-2. Waterbodies and impairments under TMDL development in the Opequon Creek watershed

A-1.2 Fecal Coliform Bacteria Sources

This section identifies and examines the potential sources of fecal coliform bacteria in the West Virginia portion of the Opequon Creek watershed. Sources can be classified as either point sources or nonpoint sources. Publicly and privately owned sewage treatment facilities are point sources of fecal coliform. Combined Sewer Overflows (CSOs) and discharges from Municipal Separate Storm Sewer systems (MS4s) are additional point sources that may contribute loadings of fecal coliform bacteria to receiving streams. Nonpoint sources of fecal coliform bacteria include failing or nonexistent on-site sewage disposal systems, stormwater runoff from pasture and cropland, direct deposition of wastes from livestock, and stormwater runoff from residential and urbanized areas that are not subject to MS4 permitting requirements.

A-1.2.1 Fecal Coliform Bacteria Point Sources

Berkeley County Public Service Sewer District (BCPSSD) operates seven sewage treatment facilities in the Opequon Creek watershed regulated by three Individual NPDES Permits. The City of Martinsburg operates a sewage treatment facility under an Individual NPDES Permit with outlets associated with the treatment plant effluent and a CSO. One private entity operates a sewage treatment plant under an Individual NPDES Permit. Nine sewage treatment facilities in the watershed are operated under the General Sewage Permit. Some of these facilities are operated by private entities and some are operated by BCPSSD. Additionally, four industrial facilities operate under Individual NPDES Permits that include nine outlets with effluent limitations for fecal coliform bacteria. The NPDES permit locations are in Figure A-1-3.

Runoff from residential and urbanized areas during storm events can be a significant fecal coliform source. USEPA's stormwater permitting regulations require public entities to obtain NPDES permit coverage for stormwater discharges from MS4s in specified urbanized areas. The City of Martinsburg, Berkeley County and the West Virginia Department of Transportation (WVDOT) are designated MS4 entities. Each entity will be registered under, and subject to the requirements of General Permit Number WV0110625. MS4 source representation was based upon precipitation and runoff from landuses determined from the modified GAP 2000 landuse data, the jurisdictional boundaries of the City and County, and the associated drainage area for the WVDOT MS4s.

The pollutant loadings associated with precipitation and runoff from most land within the corporate boundaries of Berkeley County and the City of Martinsburg were aggregated to represent their respective baseline MS4 conditions and wasteload allocations. Only the precipitation-induced loadings from the drainage areas associated with agricultural landuses and the WVDOT MS4s were excluded from the City of Martinsburg's allocation. Only the precipitation-induced loadings from agricultural landuses, the drainage area within the City of Martinsburg corporate boundary, and the drainage areas associated with the WVDOT MS4s were excluded from Berkeley County's allocation. The WVDOT MS4 baseline conditions and wasteload allocations were based upon the drainage areas associated with the roads and MS4s for which WVDOT is responsible, as determined by information provided in their application for registration under General NPDES Permit Number WV0110625.

Under this approach, the fecal coliform bacteria loading associated with precipitation and runoff from approximately 67 percent of the land area of the Opequon Creek watershed in West Virginia is subject to MS4 wasteload allocations. The fecal coliform bacteria loading associated with precipitation and runoff from the remaining 33 percent is addressed by load allocations for nonpoint sources. The spatial distribution of MS4 and non-MS4 areas is shown in Figure A-1-3.

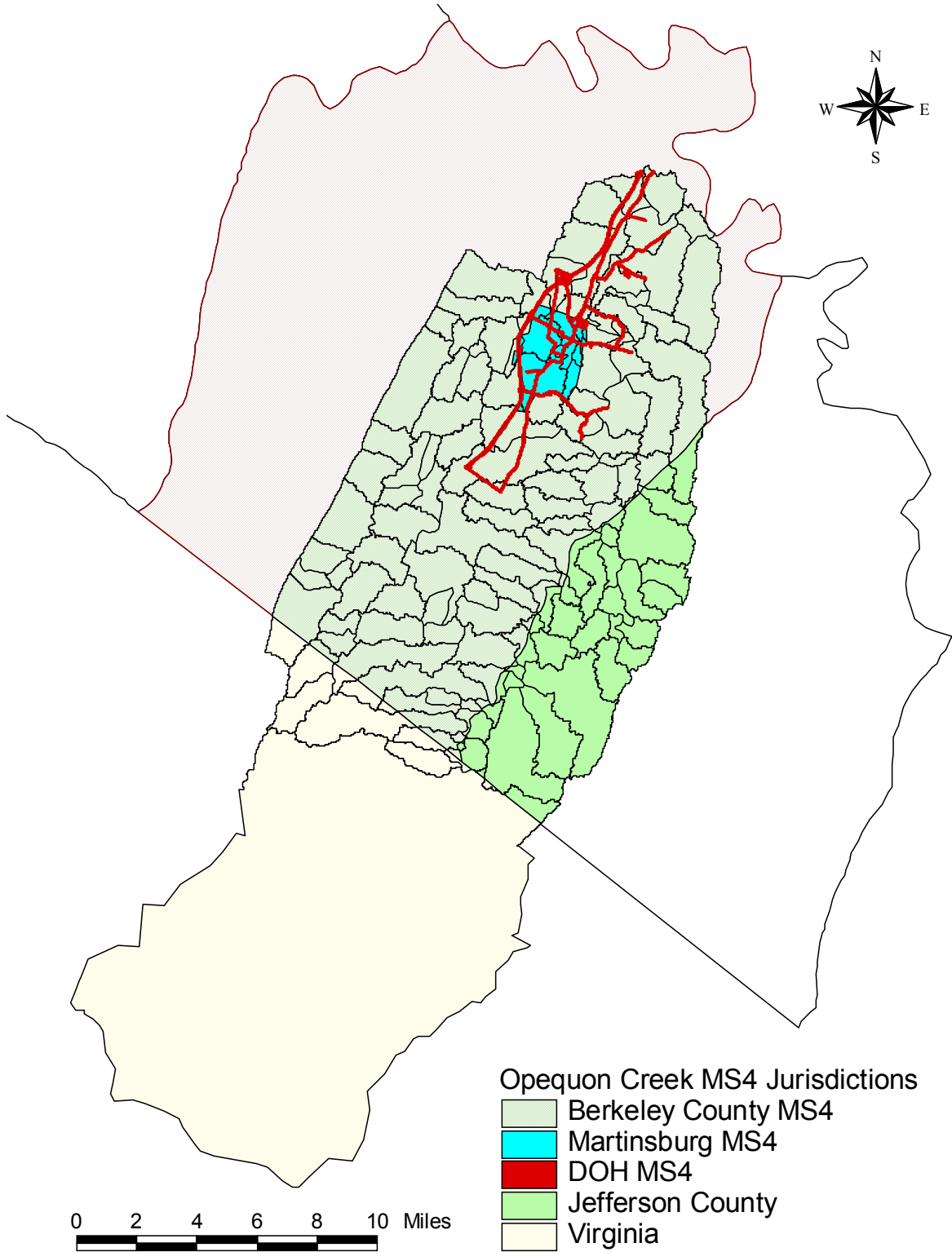


Figure A-1-3. Spatial distribution of MS4 and non-MS4 areas

A-1.2.2 Fecal Coliform Bacteria Nonpoint Sources

Pollutant source tracking by WVDEP personnel identified scattered areas of high population density without access to public sewers in the Opequon Creek watershed. Human sources of fecal coliform bacteria in these areas include sewage discharges from failing septic systems, and possible direct discharges of sewage from residences (straight pipes). An analysis of 911 emergency response addressable structure data combined with WVDEP source tracking information yielded an estimate of 31,767 homes not connected to a publicly owned treatment facility in the Opequon Creek watershed. A septic system failure rate derived from geology and soil type was applied to the number of unsewered homes to calculate nonpoint source fecal coliform loading from failing septic systems. For a more detailed description of failing septic system fecal coliform modeling, please refer to the Potomac Direct Drains watershed TMDL Technical Report. Figure A-1-4 shows the estimated cumulative untreated flow from failing septic systems in each modeled subwatershed.

Stormwater runoff from non-MS4 areas is another potential nonpoint source of fecal coliform bacteria in both residential/urban and rural areas. Although the majority of the Opequon Creek watershed's urban/residential landuses are encompassed by areas that are subject to the MS4 General NPDES Permit, a significant fecal coliform loading is associated with agricultural landuses and urban/residential landuses in Jefferson County. In rural areas, agricultural activities can contribute fecal coliform bacteria to receiving streams through surface runoff or direct deposition. Cropland and pasture landuses constitute 18.6 percent of the West Virginia portion of the Opequon Creek watershed.

A certain "natural background" contribution of fecal coliform bacteria can be attributed to deposition by wildlife in forested areas. Accumulation rates for fecal coliform bacteria in forested areas were developed using reference numbers from past TMDLs, incorporating wildlife estimates obtained from West Virginia's Division of Natural Resources (DNR). In addition, WVDEP conducted storm sampling on a 100 percent forested subwatershed (Shrewsbury Hollow) within the Kanawha State Forest, Kanawha County, West Virginia to determine wildlife contributions of fecal coliform. These results were used during the model calibration process. On the basis of the low fecal accumulation rates for forested areas, the stormwater sampling results, and model simulations, wildlife is not considered to be a significant nonpoint source of fecal coliform bacteria in the Opequon Creek watershed.

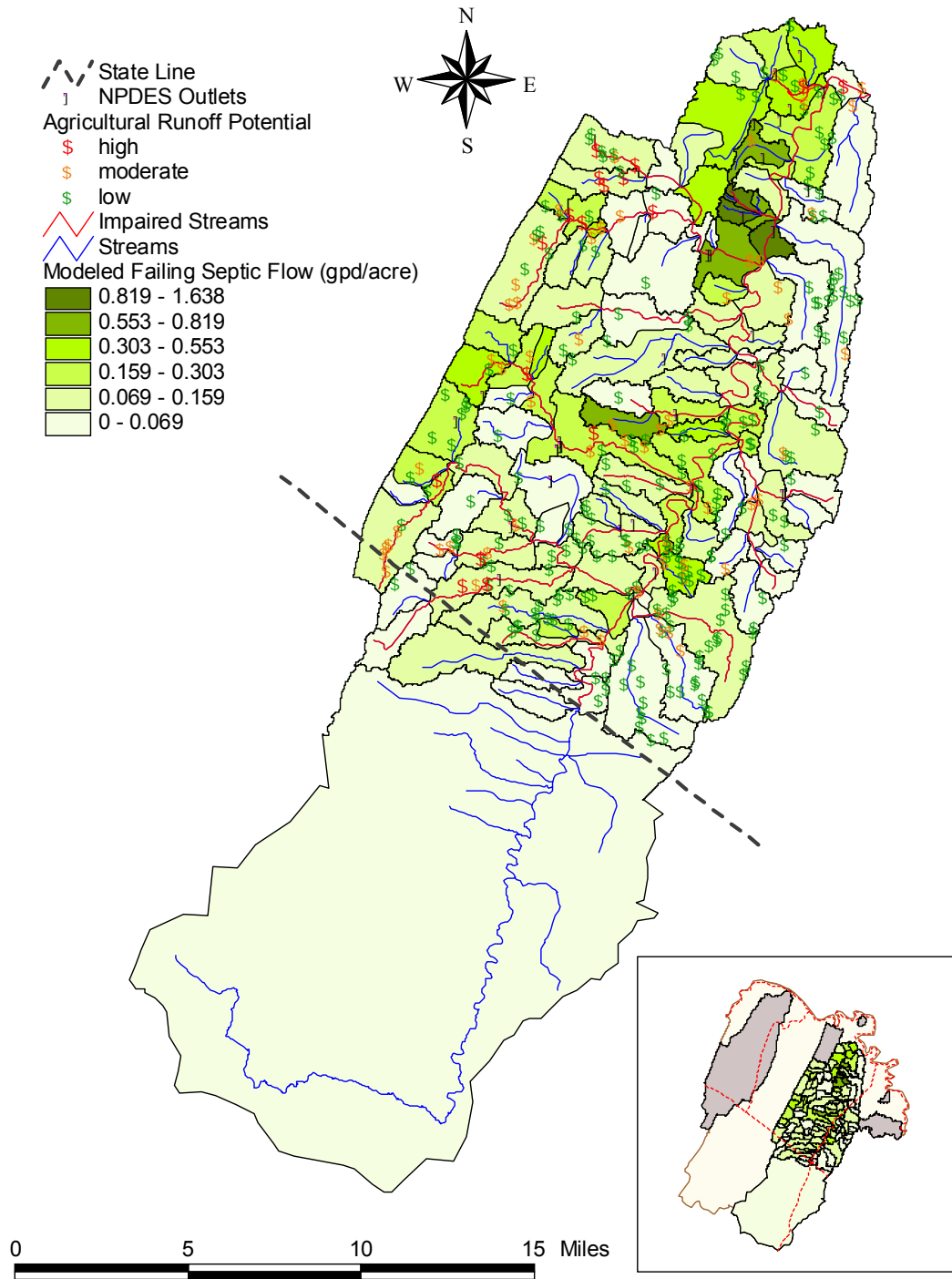


Figure A-1-4. Fecal coliform sources in the Opequon Creek watershed

A-1.3 Sediment Sources

Sediment TMDLs are presented herein for Opequon Creek and its thirteen biologically-impaired tributaries. Excess sediment has been identified as a significant stressor in relation to biological impairment of these waters.

Table A-1-1 displays the areas of landuses considered to be significant sediment sources in the watersheds of sediment-impaired waters. In addition to those upland sources of sediment, streambank erosion constitutes a significant sediment source throughout the watershed. This section discusses point and nonpoint sources of sediment that are present in the West Virginia portion of the Opequon Creek watershed.

Table A-1-1. Upland sediment sources in the Opequon Creek TMDL watershed

Stream	Residential/Urban/ Roads Area (MS4 and non-MS4) (acres)	Cropland Area (acres)	Pasture Area (acres)	Barren Area (acres)	Stormwater Construction GP Sites (acres)
Opequon Creek	25,074	11,704	12,427	84	7,304
Hoke Run	1,881	404	459	0.129	896
Eagle Run	455	5	0	0.023	71
Tuscarora Creek (includes Dry Run)	6,257	875	1,458	28	1,254
Dry Run	1,986	366	823	0.099	496
Evans Run	749	456	140	0.124	77
Shaw Run	639	1,019	260	0.106	406
Hopewell Run	627	1,424	1,056	25	39
Middle Creek	1,751	687	800	0.329	447
Mill Creek	2,375	629	876	4	842
Sylvan Run	476	92	548	3	0
Torytown Run	333	50	120	0.068	198
Turkey Run	943	2,526	2,009	0.174	24
Silver Spring Run	423	122	102	0.025	165

A-1.3.1 Sediment Point Sources

Point sources of sediment include permitted loadings from traditional NPDES permit outlets with effluent limitations for Total Suspended Solids (TSS), and the precipitation-induced loadings associated with Stormwater NPDES Permits.

Individual and General NPDES Permits for sewage treatment facilities and industrial process wastewater contain technology-based TSS effluent limitations. Twenty-one such permits (32 outlets) are located throughout the watershed. All are recognized in the sediment modeling process and are assigned wasteload allocations that allow for continued discharge under existing permit conditions.

Five facilities are subject to the Multi-Sector Stormwater General Permit with discharges that are subject to TSS benchmarks of 100 (mg/L). They are also recognized in the sediment modeling process and are assigned wasteload allocations that allow for continued discharge under existing permit conditions.

The City of Martinsburg, Berkeley County and WVDOT are designated MS4 entities in the Opequon Creek watershed. Similar to the fecal coliform bacteria source representation described in Section A-1.2.1, the sediment pollutant loadings associated with precipitation and runoff from most land within the corporate boundaries of Martinsburg and Berkeley County were aggregated to represent their respective baseline MS4 conditions and wasteload allocations. Upland sediment sources related to pasture and croplands were excluded from MS4 wasteload allocations and prescribed as load allocations to nonpoint sources. The baseline and allocated loads associated with bank erosion were generally included in the MS4 wasteload allocations. Only in a limited number of MS4 subwatersheds, where WVDEP source tracking determined moderate and high water quality impact from agricultural landuses, were the bank erosion components prescribed as nonpoint source load allocations. The subdivision of the bank erosion component between multiple MS4 entities is proportional to their respective drainage areas within each subwatershed.

261 existing and pending site registrations under the Construction Stormwater General Permit, constituting 7305 disturbed acres, were represented in the watershed. Model representation is precipitation-based and couples the design precipitation with the disturbed acreages and an assumption that proper installation and implementation of the Best Management Practices (BMPs) associated with the permit will achieve an approximate 60 percent reduction of barren land sediment loadings.

A-1.3.2 Sediment Nonpoint Sources

Land disturbance can increase sediment loading to impaired waters. Significant upland nonpoint sources of sediment in the watershed include barren land, cropland, unpaved roads, and pasture lands for which pre-TMDL source tracking determined moderate or high water quality impact. Residential and urban landuses are not considered significant upland sediment sources, but the increased percentage of impervious area associated with those landuses can increase the volume and velocity of stormwater runoff and accelerate streambank erosion.

Streambank erosion is a significant sediment source throughout the watershed. For streams with poor riparian habitat and/or unstable streambanks, streambank erosion allocations reduce the loading to the characteristics of the reference stream, Buzzard Run. The baseline and allocated loads associated with bank erosion are generally included in the MS4 wasteload allocations in subwatersheds where MS4 entities have areas of responsibility. In non-MS4 subwatersheds, the sediment loadings from bank erosion are considered to be nonpoint sources and are assigned load allocations. In a limited number of MS4 subwatersheds, where WVDEP source tracking determined moderate and high water quality impact from agricultural landuses, the bank erosion components are also prescribed as nonpoint source load allocations.

The sediment loadings from non-pasture grassland and forested areas are not considered to be significant sediment sources. These sediment contributions are categorized as “background” in the load allocations. Forestry and oil and gas production are not prevalent in the watershed and are also included in the background loadings.

A-1.4 Stressors of Biologically Impaired Streams

The Opequon Creek watershed has 15 biologically impaired streams for which TMDLs have been developed. These streams are identified in Table A-1-2 along with the biological stressors of the streams’ benthic communities and the TMDLs required to address these impairments. A stressor identification process was used to evaluate and identify the significant stressors of impaired benthic communities.

Where identified as the biological stressor, organic enrichment was linked to violations of the numeric criteria for fecal coliform bacteria. WVDEP determined that implementation of fecal coliform TMDLs would remove untreated sewage and animal waste, thereby reducing the organic and nutrient loading causing the biological impairment. Therefore, fecal coliform TMDLs will serve as a surrogate where organic enrichment was identified as a stressor. Where the stressor identification process indicated sedimentation as a causative stressor, WVDEP developed sediment TMDLs. The stressor identification process is detailed in Section 6 of the main TMDL Report with additional information provided in the Technical Report.

Table A-1-2. Significant stressors of biologically impaired streams in the Opequon Creek watershed

Stream	Biological Stressors	TMDLs Required
Opequon Creek	Organic enrichment Sedimentation	Fecal coliform Sediment
Hoke Run	Organic enrichment Sedimentation	Fecal coliform Sediment
Eagle Run	Organic enrichment Sedimentation	Fecal coliform Sediment
Tuscarora Creek	Organic enrichment Sedimentation	Fecal coliform Sediment
Dry Run	Organic enrichment Sedimentation	Fecal coliform Sediment
Evans Run	Sedimentation	Sediment
Shaw Run	Organic enrichment Sedimentation	Fecal coliform Sediment

Opequon Creek Watershed Appendix

Stream	Biological Stressors	TMDLs Required
Hopewell Run	Organic enrichment Sedimentation	Fecal coliform Sediment
UNT/Hopewell Run RM 1.7	Organic enrichment	Fecal coliform
Middle Creek	Organic enrichment Sedimentation	Fecal coliform Sediment
Mill Creek	Organic enrichment Sedimentation	Fecal coliform Sediment
Sylvan Run	Sedimentation	Sediment
Torytown Run	Organic enrichment Sedimentation	Fecal coliform Sediment
Turkey Run	Organic enrichment Sedimentation	Fecal coliform Sediment
Silver Spring Run	Organic enrichment Sedimentation	Fecal coliform Sediment

A-1.5 TMDLs for the Opequon Creek Watershed

A-1.5.1 TMDL Development

TMDLs and source allocations were developed for the impairments displayed in Figure A-1-2. Refer to Section 7 of the main TMDL Report for a detailed description of the allocation methodologies used in developing the pollutant-specific TMDLs.

The TMDLs for fecal coliform bacteria and sediment are shown in Tables A-1-3 and A-1-4. The TMDLs for fecal coliform bacteria are presented in number of colonies per day. The TMDLs for sediment are presented in tons per day.

Detailed source allocations are provided in the allocation spreadsheets associated with this report. The filterable spreadsheets include multiple display formats that allow comparison of pollutant loadings among categories and facilitate implementation. Displays include mass-based allocations for point and nonpoint sources, concentration-based allocations for traditional point sources, and area allocations for Construction Stormwater General Permit registrations. Displays also include mass-based allocations by source category, subwatershed and jurisdiction, and source category area by subwatershed and jurisdiction. A brief description of presented information is included on the “Introduction” tab of each spreadsheet. Section 7.4.1 and 7.4.2 of the main TMDL report provides a more detailed discussion and identifies the operable allocations for point sources.

A-1.6 TMDL Tables: Fecal Coliform Bacteria

Table A-1-3. Fecal coliform bacteria TMDLs for the Opequon Creek watershed

Major Watershed	Stream Code	Stream Name	Parameter	Load Allocation (counts/day)	Wasteload Allocation (counts/day)	Margin of Safety (counts/day)	TMDL (counts/day)
Opequon Creek	WVP-4	Opequon Creek	Fecal coliform	2.18E+11	3.96E+11	3.23E+10	6.46E+11
Opequon Creek	WVP-4-A	Hoke Run	Fecal coliform	5.41E+09	3.04E+10	1.89E+09	3.77E+10
Opequon Creek	WVP-4-B	Eagle Run	Fecal coliform	3.34E+07	1.68E+10	8.84E+08	1.77E+10
Opequon Creek	WVP-4-C	Tuscarora Creek	Fecal coliform	1.92E+10	1.03E+11	6.42E+09	1.28E+11
Opequon Creek	WVP-4-C-1	Dry Run	Fecal coliform	1.14E+10	2.64E+10	1.99E+09	3.98E+10
Opequon Creek	WVP-4-F	Shaw Run	Fecal coliform	1.20E+10	3.86E+09	8.35E+08	1.67E+10
Opequon Creek	WVP-4-H	Buzzard Run	Fecal coliform	4.37E+09	1.07E+10	7.94E+08	1.59E+10
Opequon Creek	WVP-4-I	Hopewell Run	Fecal coliform	2.30E+10	9.09E+09	1.69E+09	3.38E+10
Opequon Creek	WVP-4-I-2	UNT/Hopewell Run RM 1.7	Fecal coliform	6.42E+09	9.09E+09	8.16E+08	1.63E+10
Opequon Creek	WVP-4-J	Middle Creek/Opequon	Fecal coliform	8.21E+09	2.62E+10	1.81E+09	3.63E+10
Opequon Creek	WVP-4-J-1	Goose Creek	Fecal coliform	4.40E+08	3.09E+09	1.86E+08	3.72E+09
Opequon Creek	WVP-4-L	Three Run	Fecal coliform	1.47E+09	9.01E+09	5.51E+08	1.10E+10
Opequon Creek	WVP-4-M	Mill Creek	Fecal coliform	2.33E+10	5.69E+10	4.23E+09	8.45E+10
Opequon Creek	WVP-4-M-2	Torytown Run	Fecal coliform	2.02E+09	7.55E+09	5.04E+08	1.01E+10
Opequon Creek	WVP-4-N	Turkey Run	Fecal coliform	5.04E+10	NA	2.65E+09	5.31E+10
Opequon Creek	WVP-4-P	Silver Spring Run	Fecal coliform	9.66E+08	4.94E+09	3.11E+08	6.22E+09

NA = not applicable; UNT = unnamed tributary.

“Scientific notation” is a method of writing or displaying numbers in terms of a decimal number between 1 and 10 multiplied by a power of 10. The scientific notation of 10,492, for example, is 1.0492×10^4 .

A-1.7 TMDL Tables: Biological

Table A-1-4. Biological TMDLs for the Opequon Creek watershed

Stream	Biological Stressor	Parameter	Load Allocation	Wasteload Allocation	Margin of Safety	TMDL	Units
Opequon Creek	Organic enrichment	Fecal coliform	2.18E+11	3.96E+11	3.23E+10	6.46E+11	(counts/day)
	Sedimentation	Sediment	1044.89	1336.77	125.35	2507.02	(tons/day)
Hoke Run	Organic enrichment	Fecal coliform	5.41E+09	3.04E+10	1.89E+09	3.77E+10	(counts/day)
	Sedimentation	Sediment	11.28	12.33	1.24	24.86	(tons/day)
Eagle Run	Organic enrichment	Fecal coliform	3.34E+07	1.68E+10	8.84E+08	1.77E+10	(counts/day)
	Sedimentation	Sediment	0.03	5.45	0.29	5.77	(tons/day)
Tuscarora Creek	Organic enrichment	Fecal coliform	1.92E+10	1.03E+11	6.42E+09	1.28E+11	(counts/day)
	Sedimentation	Sediment	16.39	99.14	6.08	121.62	(tons/day)
Dry Run	Organic enrichment	Fecal coliform	1.14E+10	2.64E+10	1.99E+09	3.98E+10	(counts/day)
	Sedimentation	Sediment	4.06	21.54	1.35	26.95	(tons/day)
Evans Run	Sedimentation	Sediment	1.49	10.28	0.62	12.39	(tons/day)
Shaw Run	Organic enrichment	Fecal coliform	1.20E+10	3.86E+09	8.35E+08	1.67E+10	(counts/day)
	Sedimentation	Sediment	7.64	3.56	0.59	11.79	(tons/day)

Table A-1-4. Biological TMDLs for the Opequon Creek watershed (continued)

Stream	Biological Stressor	Parameter	Load Allocation	Wasteload Allocation	Margin of Safety	TMDL	Units
Hopewell Run	Organic enrichment	Fecal coliform	2.30E+10	9.09E+09	1.69E+09	3.38E+10	(counts/day)
	Sedimentation	Sediment	22.95	0.24	1.22	24.41	(tons/day)
UNT/Hopewell Run RM 1.7	Organic enrichment	Fecal coliform	6.42E+09	9.09E+09	8.16E+08	1.63E+10	(counts/day)
Middle Creek	Organic enrichment	Fecal coliform	8.21E+09	2.62E+10	1.81E+09	3.63E+10	(counts/day)
	Sedimentation	Sediment	14.31	43.75	3.06	61.12	(tons/day)
Mill Creek	Organic enrichment	Fecal coliform	2.33E+10	5.69E+10	4.23E+09	8.45E+10	(counts/day)
	Sedimentation	Sediment	18.54	54.15	3.83	76.51	(tons/day)
Sylvan Run	Sedimentation	Sediment	5.78	1.79	0.40	7.97	(tons/day)
Torytown Run	Organic enrichment	Fecal coliform	2.02E+09	7.55E+09	5.04E+08	1.01E+10	(counts/day)
	Sedimentation	Sediment	1.95	3.00	0.26	5.21	(tons/day)
Turkey Run	Organic enrichment	Fecal coliform	5.04E+10	NA	2.65E+09	5.31E+10	(counts/day)
	Sedimentation	Sediment	23.46	0.05	1.24	24.75	(tons/day)
Silver Spring Run	Organic enrichment	Fecal coliform	9.66E+08	4.94E+09	3.11E+08	6.22E+09	(counts/day)
	Sedimentation	Sediment	0.71	4.18	0.26	5.15	(tons/day)