APPENDIX 1

A-1. ARMSTRONG CREEK

A-1.1 Watershed Description

Armstrong Creek is in the central portion of the Upper Kanawha watershed, as shown in Figure A-1-1, and drains approximately 22.85 square miles (14,626 acres). Figure A-1-2 shows the land use distribution for the watershed. The dominant land use is forest, which covers 93.98 percent of the watershed. Other important land use types include urban/residential (3.41 percent) and barren/mining land (2.14 percent). All other individual land cover types account for less than 2 percent of the total watershed area.

There are eight impaired streams in the Armstrong Creek watershed. Figure A-1-3 shows the impaired segments and the pollutants for which each is impaired.

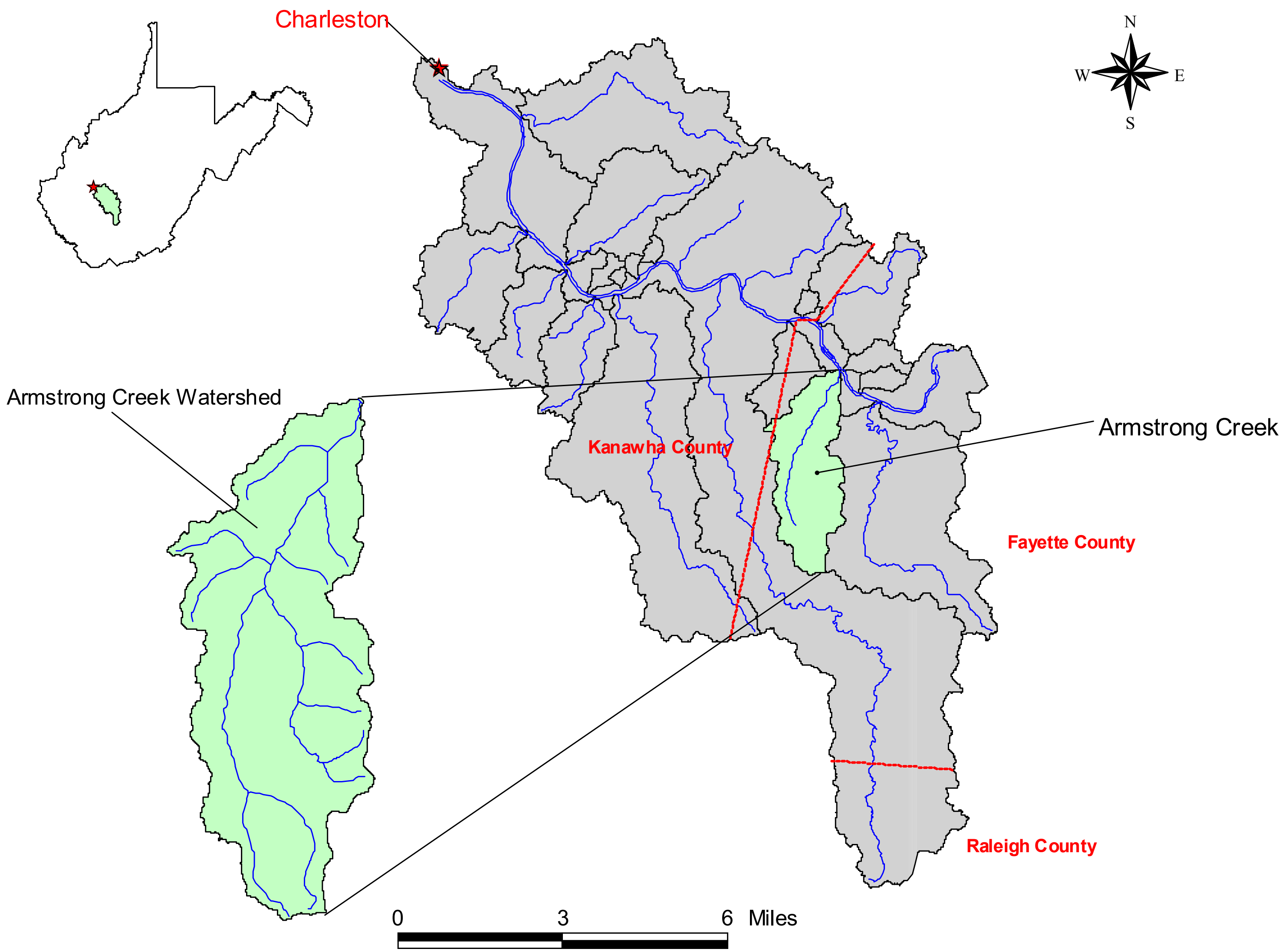


Figure A-1-1. Location of the Armstrong Creek watershed

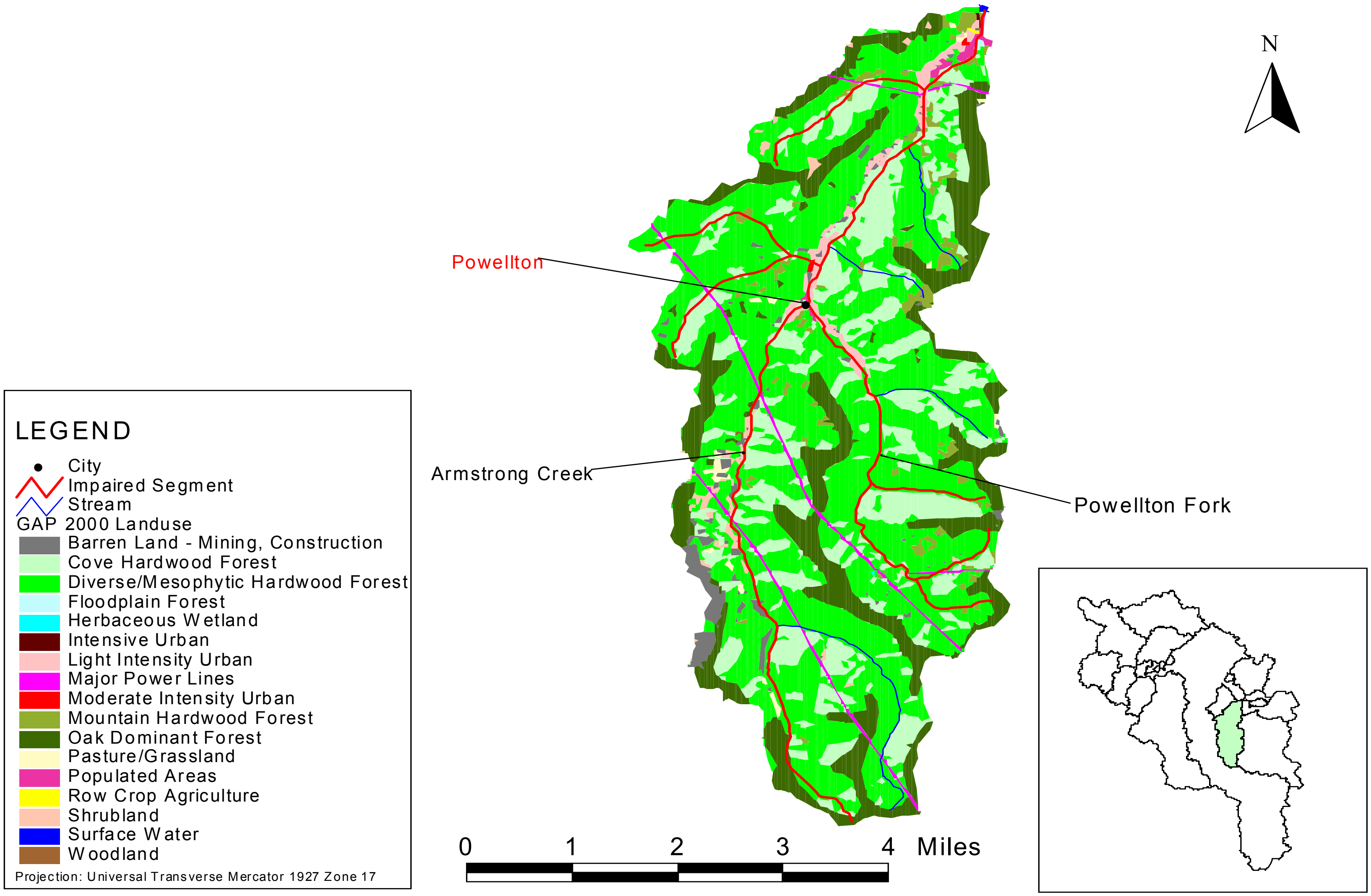
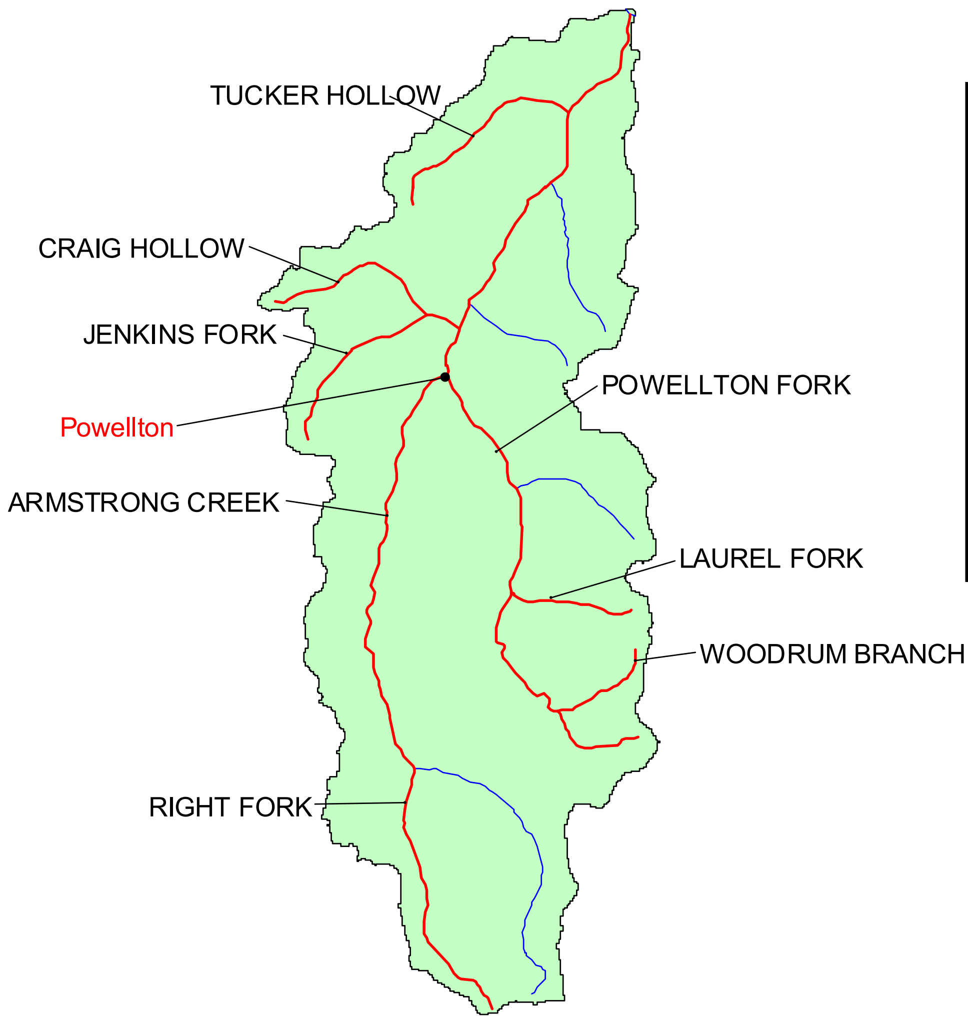


Figure A-1-2. Land use distribution in the Armstrong Creek watershed



Stream	Aluminum	Iron	Manganese	pH	Biological	Fecal Coliforms
Armstrong Creek	X			X	X	
Tucker Hollow	X			X		
Jenkins Fork	X		X	X	X	
Craig Hollow	X		X	X		
Powellton Fork	X	X				
Laurel Fork of Powellton Fork		X	X			
Woodrum Branch		X				
Right Fork of Armstrong Creek	X		X	X		

Figure A-1-3. Impaired waterbodies in the Armstrong Creek watershed

A-1.2 Pre-TMDL Monitoring

Before establishing Total Maximum Daily Loads (TMDLs), WVDEP performed monitoring in each of the impaired streams in the Upper Kanawha watershed to better characterize water quality and to refine impairment listings. Monthly samples were taken at 339 stations throughout the Upper Kanawha watershed from July 1, 2001, through June 30, 2002. The locations of pre-TMDL monitoring stations in the Armstrong Creek watershed are shown in Figure A-1-4. Monitoring suites at each site were based on the types of impairments observed in each stream. Streams impaired by metals and low pH were sampled monthly and analyzed for a suite of parameters (including total iron, dissolved iron, total aluminum, dissolved aluminum, total manganese, total suspended solids, pH, sulfate, and specific conductance). Monthly samples from streams impaired by fecal coliform bacteria were analyzed for this parameter, pH, and specific conductance. Appropriate monitoring suites were also selected for streams with multiple impairments. For example, if a stream was impaired by metals and fecal coliform bacteria, the samples were analyzed for total iron, dissolved iron, total aluminum, dissolved aluminum, total manganese, total suspended solids, pH, sulfate, specific conductance, and fecal coliform bacteria. In addition, benthic macroinvertebrate assessments were performed at specific locations on the biologically impaired streams during the pre-TMDL monitoring period. When conditions allowed, instantaneous flow measurements were also taken at the pre-TMDL sampling locations.

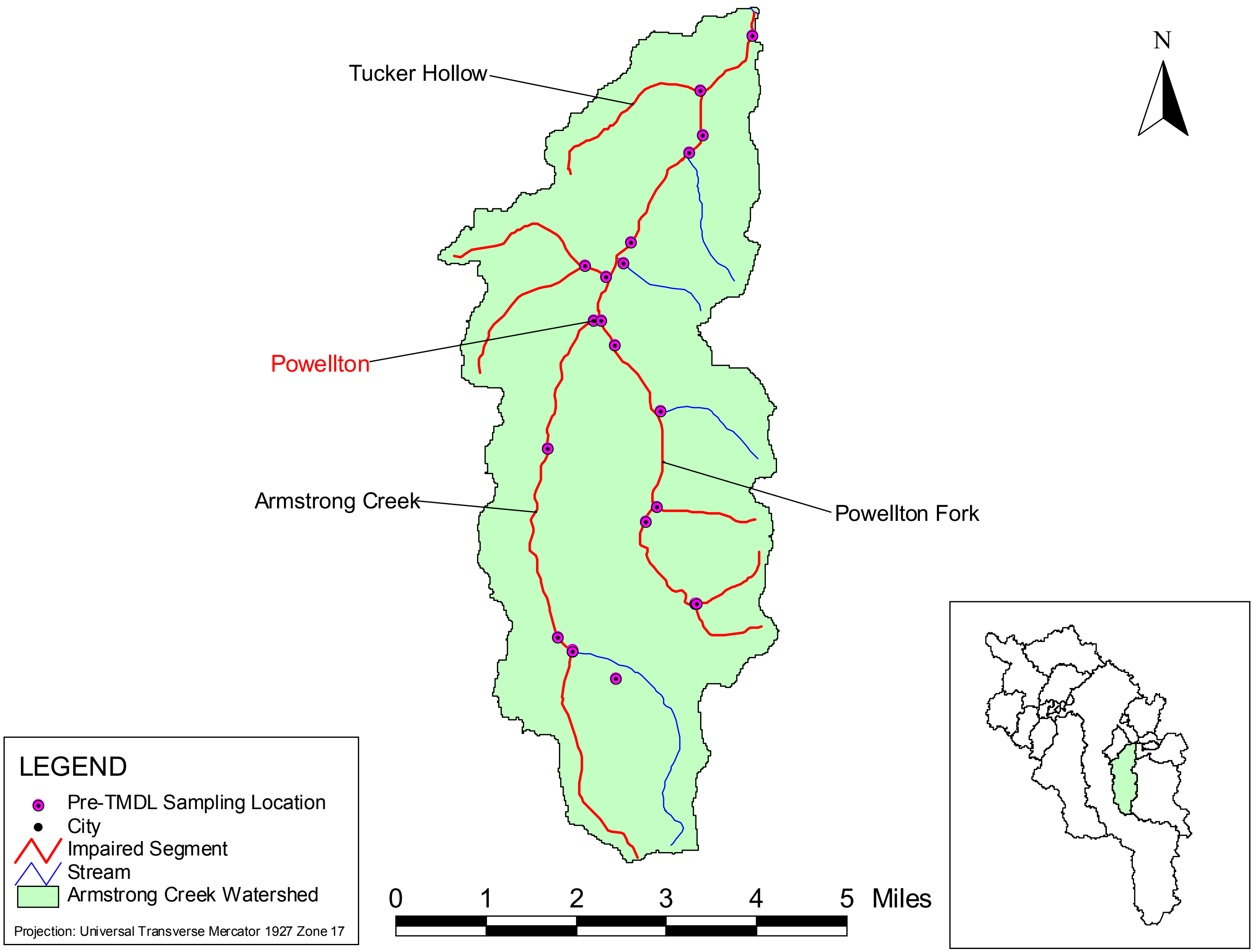


Figure A-1-4. Pre-TMDL monitoring stations in the Armstrong Creek watershed

A-1.3 Metals and pH Sources

This section identifies and examines the potential sources of aluminum, iron, manganese, and pH impairment in the Armstrong Creek watershed. Sources can be classified as either point sources (specific sources not subject to a permit) or nonpoint sources (diffuse sources). Metals and pH point sources are classified by mining- and non-mining-related permits. Metals and pH nonpoint sources are diffuse, non-permitted sources such as abandoned or forfeited mine sites.

Pollution sources were identified using statewide geographic information system (GIS) coverages of point and nonpoint sources and through field reconnaissance. As part of the TMDL process, WVDEP documented pollution sources by describing the pollution source in detail, collecting Global Positioning System data, and, if necessary, collecting a water quality sample for laboratory analysis. WVDEP personnel recorded physical descriptions of the pollutant sources, such as the number of outfalls, the source of the outfalls, and the general condition of the stream in the vicinity of the outfall. These records were compiled and electronically plotted on maps using GIS software. This information was used in conjunction with other information to characterize pollutant sources.

Based on scientific knowledge of sediment/metal interactions and knowledge of West Virginia's soils, it is reasonable to conclude that sediments contain high levels of aluminum and iron, and, to a lesser extent, manganese. Control of sediment-producing sources may be necessary to meet water quality criteria for dissolved aluminum, total iron, and total manganese during critical high flow conditions.

A-1.3.1 Metals Point Source Inventory

As described in the main report, the National Pollutant Discharge Elimination System (NPDES) program, established under Clean Water Act sections 318, 402, and 405, requires permits for the discharge of pollutants from point sources. Metals and pH point sources can be classified into two major categories: permitted non-mining point sources and permitted mining point sources. Both types of point sources exist in the Armstrong Creek watershed.

Permitted Non-mining Metals Point Sources

WVDEP's *OWRNPDES* GIS coverage was used to determine the locations of the non-mining permits; the detailed permit information was obtained from WVDEP's *ERIS* database system. One non-mining NPDES permit is located in the Armstrong Creek watershed; this is a Stormwater Industrial discharge permit. The details of this permitted point source can be seen in the appendices of the Technical Report.

Permitted Mining Metals Point Sources

WVDEP's *HPU* GIS coverage was used to determine the locations of the mining permits; the detailed permit information was taken from WVDEP's *ERIS* database system. Seventy-two mining-related NPDES outlets were found in the Armstrong Creek watershed (Figure A-1-5).

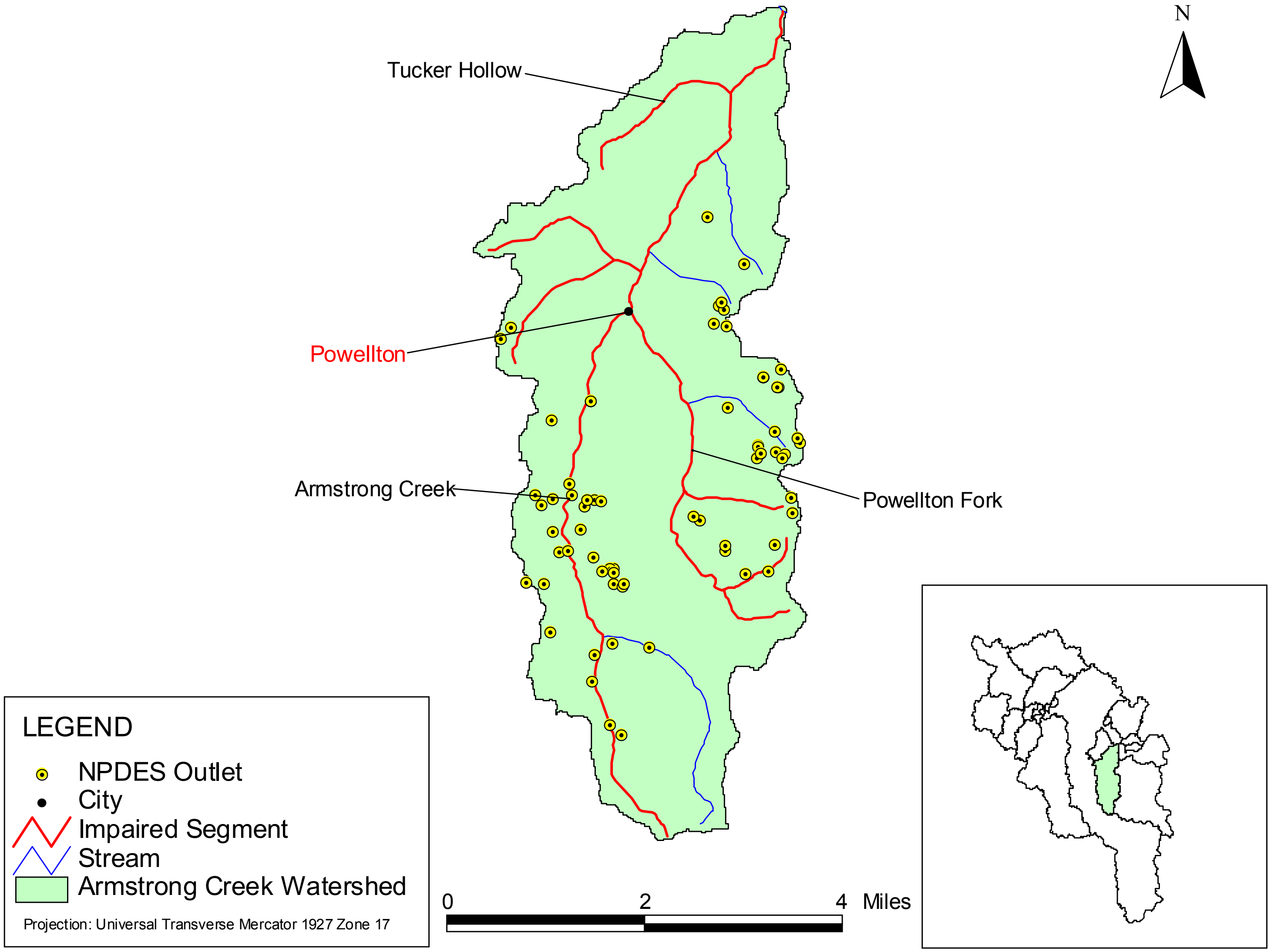


Figure A-1-5. NPDES outlets in the Armstrong Creek watershed

The permits related to these outlets are listed in the Technical Report, which shows the name of each responsible party and the total number of outlets that discharge into the Armstrong Creek watershed. The Technical Report also contains detailed information regarding NPDES/Article 3 permit relationships, specific data for each permitted outlet, and permit limits for each mining-related NPDES outlet.

A-1.3.2 Metals Nonpoint Source Inventory

In addition to point sources, nonpoint sources contribute to metals-related water quality impairments in the Armstrong Creek watershed. Nonpoint sources are diffuse, non-permitted sources. Abandoned mines can contribute acid mine drainage, which produces low pH and high metals concentrations to surface and subsurface waters; therefore, abandoned mine lands can be a significant non-permitted source of metals and pH impairment. Similarly, facilities that were subject to the Surface Mining Control and Reclamation Act of 1977 and forfeited their bonds or abandoned operations can be a significant mining-related, non-permitted source. Non-mining land disturbance activities can also be a nonpoint source of metals, causing metals to enter waterbodies as a component of sediment. Examples of such land disturbance activities are agriculture, forestry, oil and gas wells, and the construction and use of roads.

Abandoned Mine Lands and Bond Forfeiture Sites

Based on the identification of a number of abandoned mining activities in the Armstrong Creek watershed, abandoned mine lands are a significant non-permitted source of metals and pH impairment in the watershed. WVDEP's Office of Abandoned Mine Lands identified locations of abandoned mine lands in the Armstrong Creek watershed. In addition, source-tracking efforts by WVDEP's Division of Water and Waste Management identified and characterized 13 abandoned mine sources (discharges, seeps, portals, culverts, refuse piles, diversion ditches, and ponds).

WVDEP's Division of Land Restoration, Office of Special Reclamation, made bond forfeiture data available. The information provided included the status of both land reclamation and water treatment activities. There are no bond forfeiture sites in the Armstrong Creek watershed.

The locations of the abandoned mine lands are shown in Figure A-1-6.

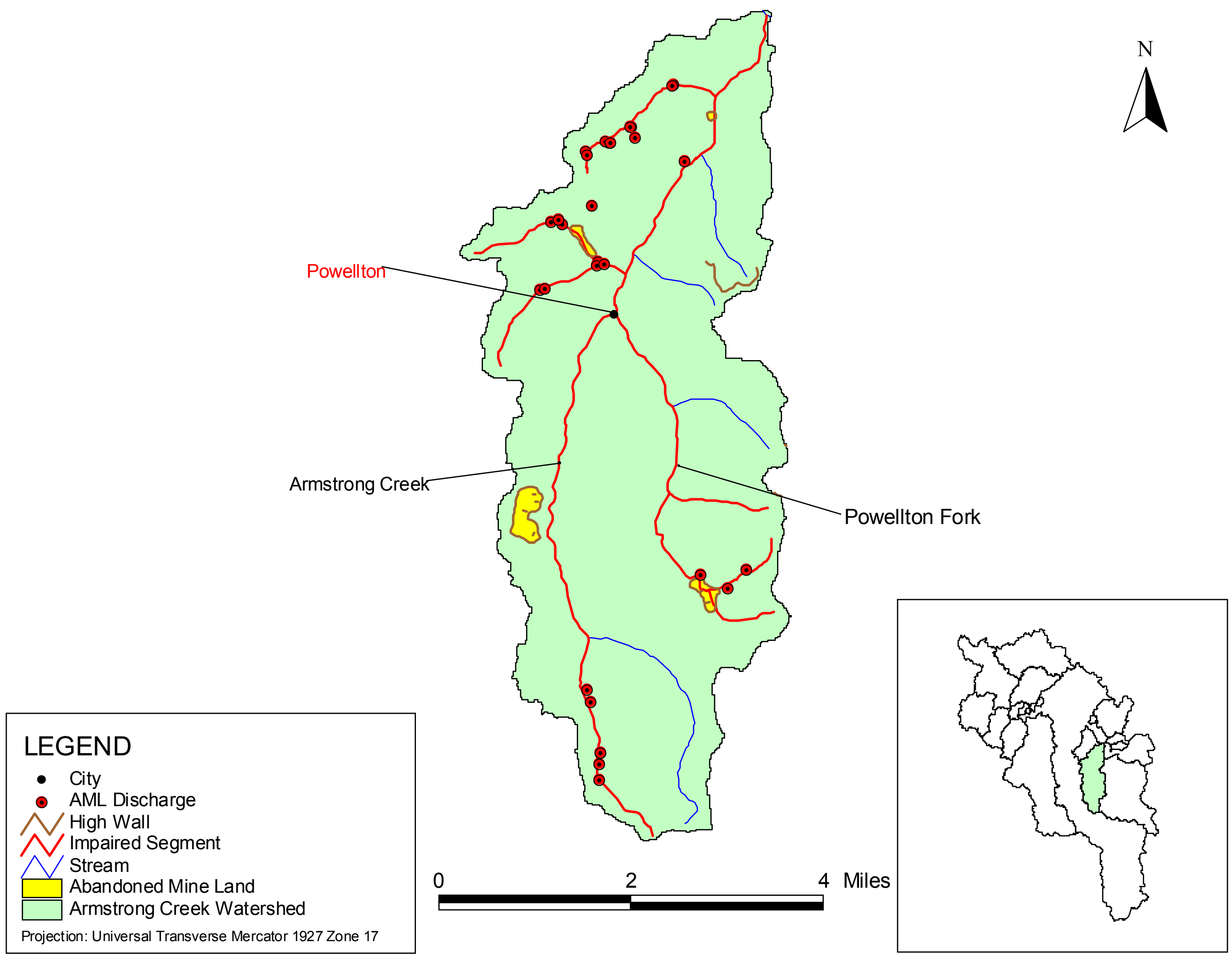


Figure A-1-6. Abandoned mine lands in the Armstrong Creek watershed

Land Disturbance Activities

Land disturbance resulting from agriculture, forestry, oil and gas operations, and the construction and use of roads can contribute metals to streams; areas in the watershed related to these activities are discussed below.

Agriculture
Based on the GAP 2000 land use coverage, agricultural areas cover 65.9 acres (0.45 percent) of the watershed.

Forestry
The active logging operations in the Armstrong Creek watershed are identified in Table A-1-1. The disturbed areas associated with these operations are estimated to cover 555 acres (3.8 percent) of the total watershed area.

Table A-1-1. Logging sites in the Armstrong Creek watershed

Logging Site ID	Area of Logging Sites (acres)	Percentage of Watershed	Logged Area that Consists of Roads/ Landings (acres)	Percentage of Total Logging Area that Consists of Roads/Landings
K-73: L-1	125	0.9%	8.0	6.4%
K-73: L-2	200	1.4%	12.5	6.3%
K-73: L-3	230	1.6%	15.3	6.7%
Total	**555**	**3.8%**	**35.8**	**6.5%**

Oil and Gas Wells
There are 52 active oil and gas wells in the Armstrong Creek watershed, the locations of which are shown in Figure A-1-7. Based on the survey by WVDEP's Office of Oil and Gas, it is estimated that that 8.34 acres (0.06 percent) of the Armstrong Creek watershed are disturbed by the active well sites (including areas associated with access roads).

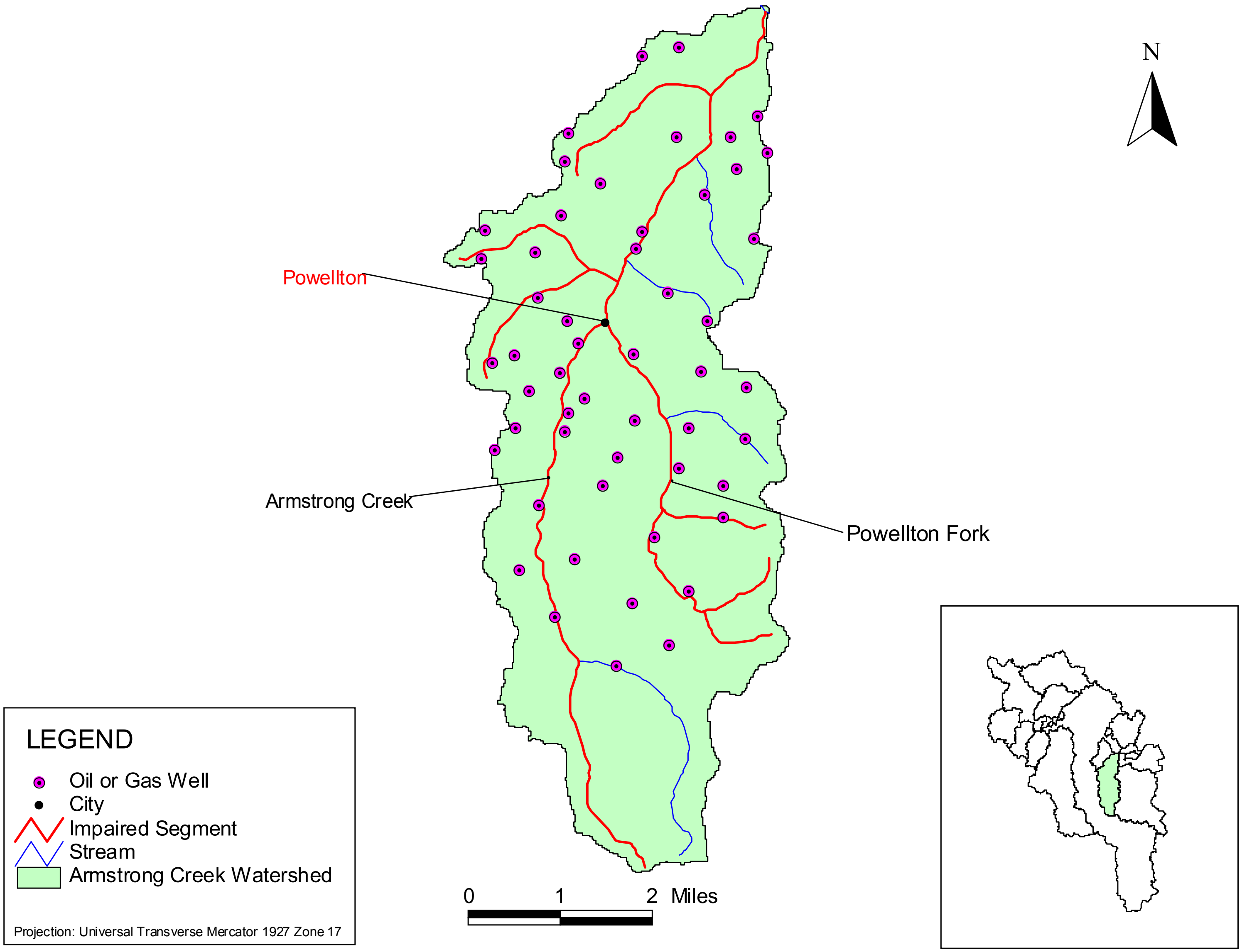


Figure A-1-7. Oil and gas wells in the Armstrong Creek watershed

Roads
The length and area of paved roads were calculated using the Census 2000 TIGER/Line files roads coverage for West Virginia. Information on paved roads from TIGER was supplemented by digitizing any unpaved roads on topographic maps that were not included in the shapefile. Table A-1-2 summarizes the length, area, and percentage of total watershed area for both paved and unpaved roads in the watershed.

Table A-1-2. Road miles by type in the Armstrong Creek watershed

Road Type	Road Distance (miles)	Road Area (acres)	Road Area as Percentage of Watershed
Total paved	19.93	38.45	0.26%
Total unpaved	88.24	5.18	0.92%

A-1.4 Fecal Coliform Bacteria Sources

Fecal coliform impairments are not present in this watershed.

A-1.5 Stressors of Biologically Impaired Streams

The Armstrong Creek watershed has two biologically impaired streams for which TMDLs have been developed. These streams are identified in Table A-1-3 along with the primary stressors of the streams' benthic communities and the TMDLs required to address the cause of biological impairment. A stressor identification process was used to evaluate and identify the primary stressors of the impaired benthic communities.

Table A-1-3. Primary stressors of biologically impaired streams in the Armstrong Creek watershed

Stream	Primary Stressors	TMDLs Required
Armstrong Creek	Aluminum toxicity Acidity (pH)	Aluminum pH
Jenkins Fork	Aluminum toxicity Acidity (pH)	Aluminum pH

The aluminum TMDLs presented in Table A-1-6 are surrogates for the aluminum toxicity biological stressor. Please refer to section A-1.3 for source information.

A-1.6 TMDLs for the Armstrong Creek Watershed

A-1.6.1 TMDL Development

As stated in section 7.4, TMDLs and source allocations were developed for impaired streams in the Armstrong Creek watershed. A top-down methodology was followed to develop TMDLs and allocate loads to sources. Headwaters were analyzed first because they have a profound effect on downstream water quality. Loading contributions were reduced from applicable sources in these waterbodies and TMDLs were developed. Refer to section 7.4 of the main report for a detailed description of the allocation methodologies used in the development of the pollutant-specific TMDLs.

The TMDLs for iron, manganese, aluminum, and pH are shown in Tables A-1-4 through A-1-7. The TMDLs for iron, manganese, and aluminum are presented as annual loads, in terms of pounds per year. They are presented as average annual loads because they were developed to meet TMDL endpoints under a range of conditions observed throughout the year.

As stated in section 7.4.1, a surrogate approach was used to develop pH TMDLs. It was assumed that reductions in metals concentrations to TMDL endpoints would result in compliance with the pH water quality standard. To verify this assumption, the Dynamic Equilibrium In-stream Chemical Reactions (DESC-R) model was run for an extended period under TMDL conditions—conditions where TMDL endpoints for metals were met. A median equilibrium pH was calculated based on the daily equilibrium pH output from the DESC-R model. The results, shown in Table A-1-7, are the TMDLs for the pH-impaired streams in the watershed. Refer to the Technical Report for a detailed description of the pH modeling approach.

A-1.6.2 TMDL Tables: Metals

Table A-1-4. Iron TMDLs for the Armstrong Creek watershed

Major Watershed	Stream Code	Stream Name	Metal	Load Allocation (lb/yr)	Wasteload (lb/yr)	Margin of Safety (lb/yr)	TMDL (lb/yr)
ARMSTRONG CREEK	K-73-E	Powellton Fork	Iron	15,635	672	858	17,165
ARMSTRONG CREEK	K-73-E-1	Laurel Fork of Powellton Fork	Iron	388	99	26	513
ARMSTRONG CREEK	K-73-E-2	Woodrum Branch	Iron	1,609	94	90	1,793

NA = not applicable

Table A-1-5. Manganese TMDLs for the Armstrong Creek watershed

Major Watershed	Stream Code	Stream Name	Metal	Load Allocation (lb/yr)	Wasteload (lb/yr)	Margin of Safety (lb/yr)	TMDL (lb/yr)
ARMSTRONG CREEK	K-73-D	Jenkins Fork	Manganese	2,854	164	159	3,177
ARMSTRONG CREEK	K-73-D-1	Craig Hollow	Manganese	1,130	NA	59	1,189
ARMSTRONG CREEK	K-73-E-1	Laurel Fork of Powellton Fork	Manganese	73	83	8	164
ARMSTRONG CREEK	K-73-F	Right Fork of Armstrong Creek	Manganese	1,036	1,362	126	2,525

NA = not applicable

Table A-1-6. Aluminum TMDLs for the Armstrong Creek watershed

Major Watershed	Stream Code	Stream Name	Metal	Load Allocation (lb/yr)	Wasteload (lb/yr)	Margin of Safety (lb/yr)	TMDL (lb/yr)
ARMSTRONG CREEK	K-73	Armstrong Creek	Total Aluminum	27,231	6,864	1,794	35,889
ARMSTRONG CREEK	K-73-A	Tucker Hollow	Total Aluminum	1,451	NA	76	1,527

Table A-1-6 (continued)

Major Watershed	Stream Code	Stream Name	Metal	Load Allocation (lb/yr)	Wasteload (lb/yr)	Margin of Safety (lb/yr)	TMDL (lb/yr)
ARMSTRONG CREEK	K-73-D	Jenkins Fork	Total Aluminum	3,640	168	200	4,008
ARMSTRONG CREEK	K-73-D-1	Craig Hollow	Total Aluminum	1,436	NA	76	1,511
ARMSTRONG CREEK	K-73-E	Powellton Fork	Total Aluminum	9,243	451	510	10,204
ARMSTRONG CREEK	K-73-F	Right Fork of Armstrong Creek	Total Aluminum	1,417	1,394	148	2,959

NA = not applicable; UNT = unnamed tributary.

Table A-1-7. pH TMDLs for the Armstrong Creek watershed

Major Watershed	Stream Code	Stream Name	Parameter	pH* (Under TMDL conditions)
ARMSTRONG CREEK	K-73	Armstrong Creek	pH	7.45
ARMSTRONG CREEK	K-73-A	Tucker Hollow	pH	7.51
ARMSTRONG CREEK	K-73-D	Jenkins Fork	pH	7.44
ARMSTRONG CREEK	K-73-D-1	Craig Hollow	pH	7.46
ARMSTRONG CREEK	K-73-F	Right Fork of Armstrong Creek	pH	7.40

*Predicted pH assumes that all metals (aluminum, iron, manganese) meet TMDL endpoints.

A-1.6.3 TMDL Tables: Fecal Coliform Bacteria

Table A-1-8. Fecal coliform bacteria TMDLs for the Armstrong Creek watershed

There are no fecal coliform impairments in this watershed.

A-1.6.4 TMDL Tables: Sediment

Table A-1-9. Sediment TMDLs for the Armstrong Creek watershed

There are no sediment impairments in this watershed.