# FINAL

# Roanoke River PCB TMDL Development (Virginia)

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# EXECUTIVE SUMMARY

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

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

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

The objective of the Roanoke River PCB TMDL study is to identify the sources of Polychlorinated Biphenyl (PCB) contamination in the watershed and determine the reductions in pollutant loadings necessary to achieve the applicable water quality standards. The TMDL study drainage area is approximately 2,379 square miles and includes two sections of the Roanoke River watershed—from its headwaters downstream to Niagra Dam (upper Roanoke) and from Leesville Dam downstream to its confluence with the Dan River [lower Roanoke (Staunton)]. The mainstem lengths of the upper and lower sections of the river are approximately 29 and 96 miles, respectively, and run through several Virginia counties, including Montgomery, Roanoke, Bedford, Franklin, Campbell, Pittsylvania, Charlotte, and Halifax.

The impairment listings for stream and reservoir segments in the study area are based on the historical fish tissue and sediment monitoring data record. This TMDL study was designed to address select PCB impairments included on Virginia's 1998 303(d) list. More recent monitoring studies have resulted in the listing of additional PCB-impaired stream and reservoir segments in the watershed, including updates on Virginia's 2008 303(d) list (Table ES-1) and a forthcoming violation listing (2010) of the public water supply use. The framework developed for these TMDLs does not include allocations for impaired segments outside of the study watersheds described above. It does include allocations for all stream segments in the study area, however, and if no other significant sources of PCBs are found, it can be assumed that these TMDLs will significantly improve the more recent PCB impairment listings, as well.

**Table ES-1. 2008 303(d) PCB impaired segments**

| Waterbody | Impaired segment description | County/city | Miles/acres[b] | Initial listing[b] | 2008 303(d) list ID |
|---|---|---|---|---|---|
| Roanoke River | Near Dixie Caverns – Mason Creek confluence | Roanoke, City of Salem, City of Roanoke | 12.88 miles | 2002 | L12L-01-PCB |
| Roanoke River | Mason Creek confluence – Back Creek mouth | City of Salem, City of Roanoke | 15.47 miles | 1996 | |
| Peters Creek | Peters Creek headwaters – Roanoke River confluence | Roanoke, City of Roanoke | 7.17 miles | 2004 | |
| Tinker Creek | Deer Branch confluence – Roanoke River confluence | Roanoke, City of Roanoke | 5.35 miles | 2006 | |
| Smith Mountain Lake[a] | Back Creek mouth – Smith Mountain Lake Dam (includes Blackwater arm up to Rt. 122 bridge) | Bedford, Franklin | 17,157 acres | 2002 | |

| Waterbody | Impaired segment description | County/city | Miles/acres[b] | Initial listing[b] | 2008 303(d) list ID |
|---|---|---|---|---|---|
| Blackwater River[a] | Maggodee Creek confluence – Blackwater River arm of Smith Mountain Lake | Franklin | 11.43 miles | 2006 | |
| Staunton (Roanoke) River | Leesville Dam – Pipeline crossing 5.4 miles downstream of Rt. 360 bridge | Charlotte, Halifax, Campbell, Pittsylvania | 83.9 miles | 1998 | L19R-01-PCB |
| Staunton (Roanoke) River | Pipeline crossing 5.4 miles downstream of Rt. 360 bridge – Kerr Reservoir | Halifax, Charlotte | 4.49 miles | 1998 | |
| Cub Creek | Rough Creek Rd. – Roanoke River confluence | Charlotte | 14.25 miles | 2008 | |
| Little Otter River | West of Rt. 680 at Cobbs Mountain – mouth of the Little Otter River on the Big Otter River | Bedford | 14.36 miles | 2002 | L26R-01-PCB |

a. These segments are not included in the TMDL study area
b. Source: http://www.deq.state.va.us/wqa/ir2008.html

TMDL reductions were calculated on the basis of meeting water quality targets in the upper and lower sections of the Roanoke (Staunton). Water quality targets were derived from Bioaccumulation Factors (BAF) and the Virginia Department of Environmental Quality (VADEQ) fish tissue criterion for total PCBs (tPCBs). BAFs allow for the back-calculation of a water concentration equivalent from a fish tissue concentration, in this case a threshold level of 54 parts per billion (ppb). Two endpoints were developed corresponding to the upper [390 picograms per liter (pg/L)] and lower (140 pg/L) sections of the Roanoke (Staunton) River basin on the basis of the available water quality and fish tissue monitoring data. The decision to evaluate the upper and lower sections separately was made because of the large reservoirs that separate them and the differences in the magnitude and composition of PCB contamination.

The TMDL endpoints have been developed to be protective of fish for human consumption and are more stringent than the 1,700 pg/L state criterion for human health. The human health criterion applies to waterbodies used for public water supply, in addition to all other surface waters. The TMDL endpoints, therefore, are more than adequate to protect the water supply use and address the forth coming violation listing (2010) of the public water supply use in the Roanoke River watershed.

A watershed modeling framework, consisting of the Loading Simulation Program C++ (LSPC) with sediment PCB modeling enhancements was developed, calibrated, and validated for the Roanoke River study watershed. LSPC is a dynamic watershed model that generates precipitation-driven simulation of time-variable flow and water quality. The LSPC model was configured to simulate PCBs in both the dissolved- and sediment-associated states. Sediment-associated PCB loading and in-stream transport, deposition, burial and resuspension processes, along with partitioning of PCBs in the water and sediment layer were incorporated into the model simulations. A summary of the TMDLs, LAs, and WLAs developed for streams in the Roanoke River watershed is presented in Table ES-2. Streams listed as impaired for PCBs on Virginia's 2008 303(d) list are identified by their associated list ID. A summary of the TMDLs, LAs, and WLAs by source category is presented in Table ES-3.

**Table ES-2. Average annual tPCBs TMDLs for Roanoke River watershed streams**

| Stream | 2008 303(d) list ID | Baseline (mg/yr) | WLA (mg/yr) | LA (mg/yr) | MOS (mg/yr) | TMDL (mg/yr) | % Reduction |
|---|---|---|---|---|---|---|---|
| **Upper Roanoke River** | | | | | | | |
| North Fork Roanoke River | Not listed | 4,923.2 | 28.2 | 630.3 | 34.7 | 693.2 | 85.9 |
| South Fork Roanoke River | Not listed | 3,532.2 | 230.2 | 788.6 | 53.6 | 1,072.5 | 69.6 |
| Masons Creek | Not listed | 1,777.5 | 9.1 | 193.2 | 10.6 | 212.9 | 88.0 |

| Stream | 2008 303(d) list ID | Baseline (mg/yr) | WLA (mg/yr) | LA (mg/yr) | MOS (mg/yr) | TMDL (mg/yr) | % Reduction |
|---|---|---|---|---|---|---|---|
| Peters Creek | L12L-01-PCB | 1,742.6 | 65.4 | 31.2 | 5.1 | 101.7 | 94.2 |
| Tinker Creek | L12L-01-PCB | 16,593.6 | 103.9 | 3,414.2 | 185.2 | 3,703.2 | 77.7 |
| Wolf Creek | Not listed | 1,078.4 | 10.0 | 20.3 | 1.6 | 31.9 | 97.0 |
| Unnamed Trib to Roanoke River | Not listed | 59.4 | 0.5 | 1.3 | 0.1 | 1.9 | 96.8 |
| Roanoke River | L12L-01-PCB | 133,207.2 | 28,157.7 | 3,455.7 | 1,663.9 | 33,277.3 | 75.0 |
| **Upper Total** | | **162,914.1** | **28,605.0** | **8,534.8** | **1,954.7** | **39,094.5** | **76.0** |
| **Lower Roanoke (Staunton) River** | | | | | | | |
| Goose Creek | Not listed | 5,400.9 | 0.1 | 1,812.4 | 95.4 | 1,907.9 | 64.7 |
| Sycamore Creek | Not listed | 93,226.4 | 1.4 | 186.3 | 9.9 | 197.6 | 99.8 |
| Lynch Creek | Not listed | 7,670.6 | 0.1 | 17.8 | 0.9 | 18.8 | 99.8 |
| Reed Creek | Not listed | 253.4 | 0.0 | 75.9 | 4.0 | 79.9 | 68.5 |
| X-trib | Not listed | 215,127.2 | 0.1 | 1.3 | 0.1 | 1.5 | 100.0 |
| Unnamed Trib to Roanoke River | Not listed | 12,848.6 | 0.1 | 19.1 | 1.0 | 20.2 | 99.8 |
| Little Otter River | L26R-01-PCB | 3,934.3 | 0.0 | 596.2 | 31.4 | 627.6 | 84.0 |
| Big Otter River | Not listed | 7,630.9 | 0.0 | 2,462.8 | 129.6 | 2,592.4 | 66.0 |
| Straightstone Creek | Not listed | 464.8 | 0.0 | 279.0 | 14.7 | 293.7 | 36.8 |
| Seneca Creek | Not listed | 692.9 | 0.0 | 400.8 | 21.1 | 421.9 | 39.1 |
| Whipping Creek | Not listed | 398.4 | 0.0 | 157.7 | 8.3 | 166.0 | 58.3 |
| Falling River | Not listed | 4,135.2 | 0.0 | 1,746.5 | 91.9 | 1,838.4 | 55.5 |
| Childrey Creek | Not listed | 390.2 | 0.0 | 201.3 | 10.6 | 211.9 | 45.7 |
| Catawba Creek | Not listed | 168.8 | 0.0 | 94.8 | 5.0 | 99.8 | 40.9 |
| Turnip Creek | Not listed | 376.2 | 0.0 | 272.6 | 14.3 | 286.9 | 23.7 |
| Hunting Creek | Not listed | 86.6 | 0.0 | 65.2 | 3.4 | 68.6 | 20.7 |
| Cub Creek | L19R-01-PCB | 1,376.7 | 0.0 | 997.4 | 52.5 | 1,049.9 | 23.7 |
| Black Walnut Creek | Not listed | 181.9 | 0.8 | 46.5 | 2.5 | 49.7 | 72.7 |
| Roanoke Creek | Not listed | 2,446.8 | 0.0 | 1,429.6 | 75.2 | 1,504.8 | 38.5 |
| Difficult Creek | Not listed | 823.2 | 0.0 | 462.1 | 24.3 | 486.5 | 40.9 |
| Roanoke River | L19R-01-PCB | 239,207.9 | 1,931.8 | 11,961.7 | 731.2 | 14,624.8 | 93.9 |
| **Lower Total** | | **596,841.9** | **1,934.3** | **23,287.0** | **1,327.4** | **26,548.8** | **95.6** |

**Table ES-3. Average annual tPCBs TMDLs for Roanoke River source categories**

| Source Category | Baseline (mg/yr) | WLA (mg/yr) | LA (mg/yr) | % Reduction[a] |
|---|---|---|---|---|
| **Upper Roanoke River** | | | | |
| VPDES Dischargers | 17,665.8 | 28,267.1 | | -60.0 |
| Individual Industrial/General Permits | 6,827.4 | 5.3 | | 99.9 |
| MS4 | 109,622.4 | 332.7 | | 99.7 |
| Contaminated Sites | 7,853.5 | | 1.0 | 100.0 |
| Urban background (unknown sites) | 12,082.4 | | 114.4 | 99.1 |
| Atmospheric Deposition | 8,862.5 | | 8,419.4 | 5.0 |
| **Total** | **162,914.1** | **28,605.0** | **8,534.8** | **77.2** |
| **Lower Roanoke (Staunton) River** | | | | |
| VPDES Dischargers | 78,305.9 | 1,926.7 | | 97.5 |

| Source Category | Baseline (mg/yr) | WLA (mg/yr) | LA (mg/yr) | % Reduction [a] |
|---|---|---|---|---|
| Individual Industrial/General Permits | 388,012.2 | 7.5 | | 100.0 |
| MS4 | 11.7 | 0.1 | | 99.3 |
| Contaminated Sites | 83,901.8 | | 1.2 | 100.0 |
| Urban background (unknown sites) | 22,244.9 | | 138.7 | 99.4 |
| Atmospheric Deposition | 24,365.4 | | 23,147.2 | 5.0 |
| **Total** | **596,841.9** | **1,934.3** | **23,287.0** | **95.8** |

a. WLA and LA percent reductions differ from TMDL percent reductions because they do not include an MOS load

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# 1. INTRODUCTION AND BACKGROUND

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

Virginia's 2008 section 303(d) list classifies several waterbodies in the Roanoke River basin as impaired for Polychlorinated Biphenyls (PCB) from elevated PCB concentrations found in fish tissue and sediment samples. The Virginia Department of Environmental Quality (VADEQ) first collected monitoring data on PCB contamination in the basin in 1971. Regular fish tissue and sediment sampling for PCBs began in 1993, and a rotating basin monitoring schedule is ongoing as part of the Statewide Fish Tissue and Sediment monitoring program. The Virginia Department of Health (VDH) has issued fish consumption advisories for several sections of the Roanoke River and tributaries since 1998 on the basis of the fish tissue data collected by VADEQ.

Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters that do not meet water quality standards. The objective of the Roanoke PCB TMDL study is to identify the sources of PCB contamination in the watershed and to determine the reductions required to achieve water quality standards for PCB impaired segments.

PCBs are a group of synthetic chemicals that consist of 209 individual compounds (known as congeners). Physically, they are either oily liquids or solids and are colorless to light yellow in color with no known smell or taste. PCBs made in the United States were marketed under the trade name Aroclor and most are identified by a four-digit numbering code in which the first two digits indicate that the parent molecule is a biphenyl. Each of the 209 possible PCB compounds consists of two sigma bonded, chlorine substituted phenyl groups. Individual PCB congeners differ in the number and position of the chlorine substituents. PCBs possess excellent dielectric and flame-resistant properties derived from their stable molecular structure. These same properties cause PCBs to accumulate in the fatty tissue of biota and bioaccumulate in the food chain (http://www.epa.gov/ttn/atw/hlthef/polychlo.html).

Although it is now illegal to manufacture, distribute, or use PCBs, before 1974 they were used in numerous products including, capacitors, transformers, plasticizers, surface coatings, inks, adhesives, pesticide extenders, paints, carbonless duplicating paper, etc. After 1974, PCB use was restricted to producing capacitors and transformers, and in 1979 the manufacture and use of PCBs was completely banned. Historically, PCBs had been introduced into the environment through discharges from point sources and through spills and releases. Although point source contributions are now controlled, facilities could be unknowingly discharging PCB loads as a result of historical contamination. Sites with PCB-contaminated soils can also act as precipitation-driven nonpoint sources. In addition, the widespread use of PCBs before their ban coupled with their stable molecular structure has caused a generalized distribution of the pollutant in air, soil, and water at background concentrations. Once in a waterbody, PCBs become associated with sediment particles. PCBs are very resistant to breakdown and thus remain in river and lake sediments for many years.

PCB concentrations in environmental media tend be very small, particularly in water due to its hydrophobic properties. Throughout the remainder of this document the units presented in Table 1-1 are used to describe PCB concentrations in fish tissue, sediments, and water.

**Table 1-1. Common PCB concentration units and abbreviations**

| Media | Unit | Unit abbreviation | Parts-per description | Part-per abbreviation |
|---|---|---|---|---|
| Fish tissue, sediment | micrograms per kilogram | µg/kg | parts per billion | ppb |
| Water | micrograms per liter | µg/L | parts per billion | ppb |
| | picograms per liter | pg/L | parts per quadrillion | ppq |

## 1.1. Watershed Description

The Roanoke River watershed drains a largely rural area of the coastal plain from the eastern edge of the Appalachian Mountains in southern Virginia, southeast across the Piedmont to the Albemarle Sound in northeastern North Carolina. The drainage area of the Roanoke River from its headwaters to the Dan River confluence is approximately 3,343 square miles with a length of approximately 227 miles, spanning three physiographic provinces along its course.

Moving southeast from the headwaters, these include the Valley and Ridge, Blue Ridge, and Piedmont. The river also crosses through several Virginia counties—including Montgomery, Roanoke, Franklin, Bedford, Pittsylvania, Campbell, Halifax, and Charlotte—in addition to two reservoirs, Smith Mountain Lake and Leesville Lake. The major tributaries to the Roanoke River, in downstream order, are the North and South Fork Roanoke River, Mason Creek, Peters Creek, Tinker Creek, Back Creek, Falling Creek, Blackwater River, Pigg River, Goose Creek, Sycamore Creek, Lynch Creek, Big Otter River, Seneca Creek, Falling River, Catawba Creek, Turnip Creek, Cub Creek, Roanoke Creek, and Difficult Creek.

The TMDL study area includes two sections of the Virginia portion of the watershed beginning at the river headwaters in the Blue Ridge Mountains downstream to Niagra Dam about 1.5 miles east of the city of Roanoke (upper Roanoke) and from Leesville Dam downstream to its confluence with the Dan River at approximately river mile 46 [lower Roanoke (Staunton)] (Figure 1-1). For the remainder of this document when the Roanoke River watershed/basin is discussed, it is in reference to the TMDL study portion of the watershed. Figure 1-2 presents the general location and major streams and lakes of the Roanoke River watershed and the TMDL study area.

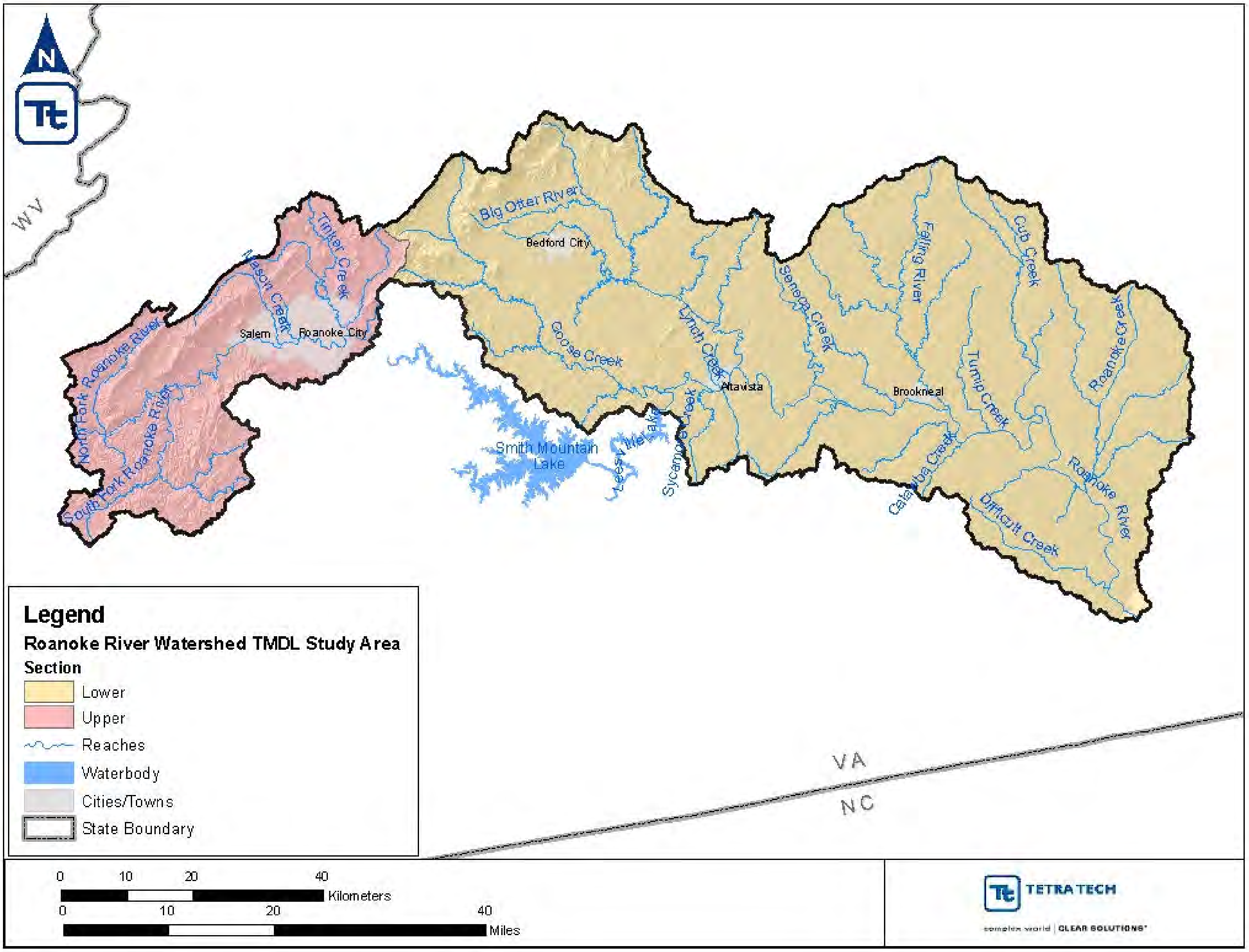


**Figure 1-1. Roanoke River basin sections.**

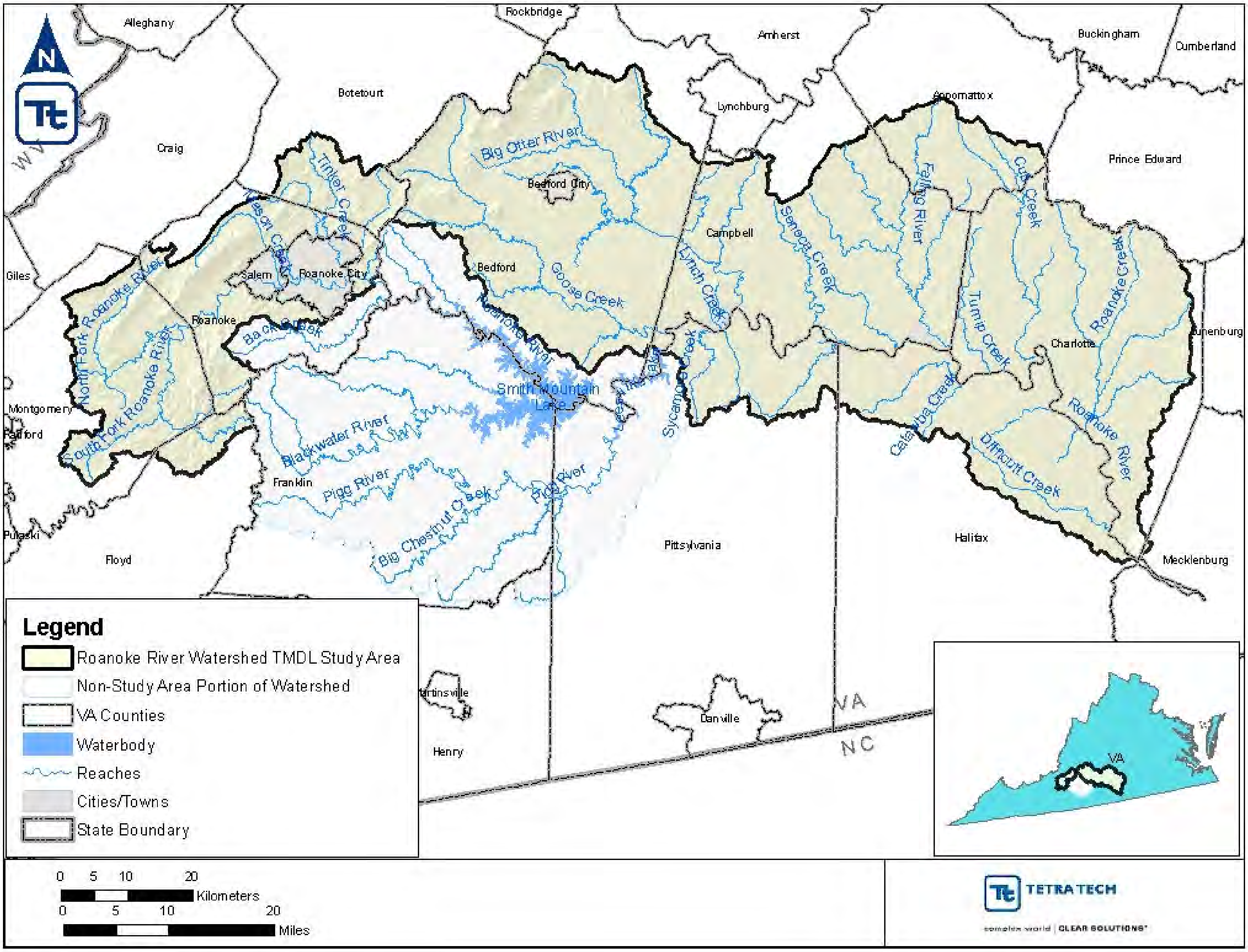


**Figure 1-2. Location and major waterbodies of the Roanoke River basin.**

## 1.2. Impaired Waterbodies

Impairment listings for stream and reservoir segments in the Roanoke basin are based on the historical monitoring data record. Investigation of PCB contamination in the watershed began in 1971 and continues today.

In 1971 the Virginia State Water Control Board (SWCB) conducted a study to determine the extent of pesticide contamination in Virginia waterbodies. As part of the study, elevated PCB concentrations were found in fish tissue samples collected from the Roanoke and Dan Rivers. These results were published in a 1973 report, *The Occurrence of Polychlorinated Biphenyls (PCBs) in the Roanoke and Dan Rivers, A Preliminary Report* (Wallmeyer 1973).

Between 1979 and 1991, the SWCB and EPA continued to monitor state waters, including fish tissue monitoring in the Roanoke River watershed. Fish samples collected in several segments of the river indicated a persistent presence of PCBs. In late 1992, the Virginia Department of Health (VDH) recommended collecting additional fish in the Roanoke basin to better characterize the extent of the contamination. SWCB conducted an extensive fish tissue study from February to August 1993 and issued a final report in June 1996 that concluded the occurrence of PCBs in resident fish species was widespread.

Under a Memorandum of Understanding between VADEQ and VDH, all fish tissue data generated by the Virginia Fish Tissue and Sediment Contaminants Monitoring Program are provided to VDH. VDH reviews the data and provides recommendations to VADEQ regarding the need for follow-up tissue studies and whether there is a potential unacceptable risk to human consumers. VDH uses a fish tissue contaminant screening level to determine potential risk. If fish tissue sample contaminant concentrations exceed the screening level, a fish consumption advisory is issued for the affected waterbodies. Where VDH issues a fishing ban or advisory, limiting consumption, the waterbody is designated as either partially or not supporting for fish consumption use based on the severity of the advisory. An advisory limiting fish consumption is considered partially supporting and an advisory prohibiting consumption is considered not supporting the fish consumption use (VADEQ n.d.).

The first PCB fish consumption advisory for basin waters was issued on July 24, 1998, for a segment of the Roanoke (Staunton) River beginning 29 miles below Leesville Dam and extending downstream to the Kerr Reservoir. The health advisory was issued on the basis of monitoring results from a 1998–1999 study that showed fish tissue PCB concentrations in the advisory area to be greater than the formerly applicable screening level of 600 parts per billion (ppb). On December 2, 1999, the fish consumption advisory was expanded to include the 29-mile segment upstream to the Leesville Dam.

On the basis of results of sampling studies conducted in 2000 and 2002, consumption advisories for the basin were expanded again on October 29, 2003 to include the segment of the Roanoke River from the Niagara Dam downstream to Smith Mountain Lake (Smith Mountain Lake segment). The most recent modifications (August 31, 2007) to the spatial extent of fish consumption advisories for the Roanoke River basin were a result of VDH adopting tiered screening levels that specify a *do not eat* PCB concentration threshold of 500 ppb and a limited consumption (fewer than two 8 ounce meals a month) PCB concentration range between 50 and 500 ppb and additional monitoring efforts by the state. Stream segments in the basin under fish consumption advisories include the following:

- Roanoke River (upper section): From the confluence of the North and South Forks of the Roanoke River (near the Lafayette gaging station) downstream to the Niagara dam, including tributaries Peters Creek upstream to the Route 460 bridge crossing, and Tinker Creek upstream to the confluence with Deer Branch (near Route 115).
- Roanoke River/Smith Mountain Lake: From the Niagara dam downstream to Smith Mountain Dam, including the Blackwater River arm of Smith Mountain Lake upstream to the Route 122 bridge.
- Roanoke (Staunton) River: From below Leesville Dam downstream to the confluence with Dan River including Cub Creek up to Rough Creek Road (State Route 695).

This TMDL study was designed to address select PCB impairments included on Virginia’s 1998 303(d) list. The collection of additional fish tissue and sediment data since 1993 has resulted in a growing list of river and lake segments that are considered impaired for human health and aquatic life concerns, including updates on Virginia’s 2008 303(d) list and a forthcoming violation listing (2010) of the public water supply use in the watershed. Table 1-2 and Figure 1-3 show the VADEQ 1998 and 2008 303(d) PCB impaired segments and the current VDH fish consumption advisory segments (as of August 31, 2007)

**Table 1-2. 2008 303(d) PCB impaired segments and associated VDH fish consumption advisories**

| Waterbody | Impaired segment description | County/city | Miles/acres[b] | Initial listing[b] | 2008 303(d) list ID | VDH advisory[c] |
|---|---|---|---|---|---|---|
| Roanoke River | Near Dixie Caverns – Mason Creek confluence | Roanoke, City of Salem, City of Roanoke | 12.88 miles | 2002 | L12L-01-PCB | Roanoke River (upper section) |
| Roanoke River | Mason Creek confluence – Back Creek mouth | City of Salem, City of Roanoke | 15.47 miles | 1996 | | |
| Peters Creek | Peters Creek headwaters – Roanoke River confluence | Roanoke, City of Roanoke | 7.17 miles | 2004 | | |
| Tinker Creek | Deer Branch confluence – Roanoke River confluence | Roanoke, City of Roanoke | 5.35 miles | 2006 | | |
| Smith Mountain Lake[a] | Back Creek mouth – Smith Mountain Lake Dam (includes Blackwater arm up to Rt. 122 bridge) | Bedford, Franklin | 17,157 acres | 2002 | | Roanoke River/Smith Mountain Lake |
| Blackwater River[a] | Maggodee Creek confluence – Blackwater River arm of Smith Mountain Lake | Franklin | 11.43 miles | 2006 | | |
| Staunton (Roanoke) River | Leesville Dam – Pipeline crossing 5.4 miles downstream of Rt. 360 bridge | Charlotte, Halifax, Campbell, Pittsylvania | 83.9 miles | 1998 | L19R-01-PCB | Roanoke (Staunton) River |
| Staunton (Roanoke) River | Pipeline crossing 5.4 miles downstream of Rt. 360 bridge – Kerr Reservoir | Halifax, Charlotte | 4.49 miles | 1998 | | |
| Cub Creek | Rough Creek Rd. – Roanoke River confluence | Charlotte | 14.25 miles | 2008 | | |
| Little Otter River | West of Rt. 680 at Cobbs Mountain – mouth of the Little Otter River on the Big Otter River | Bedford | 14.36 miles | 2002 | L26R-01-PCB | None |

a. These segments are not included in the TMDL study area
b. Source: http://www.deq.state.va.us/wqa/ir2008.html
c. Source: http://www.vdh.state.va.us/epidemiology/DEE/publichealthtoxicology/advisories/RoanokeRiver.htm

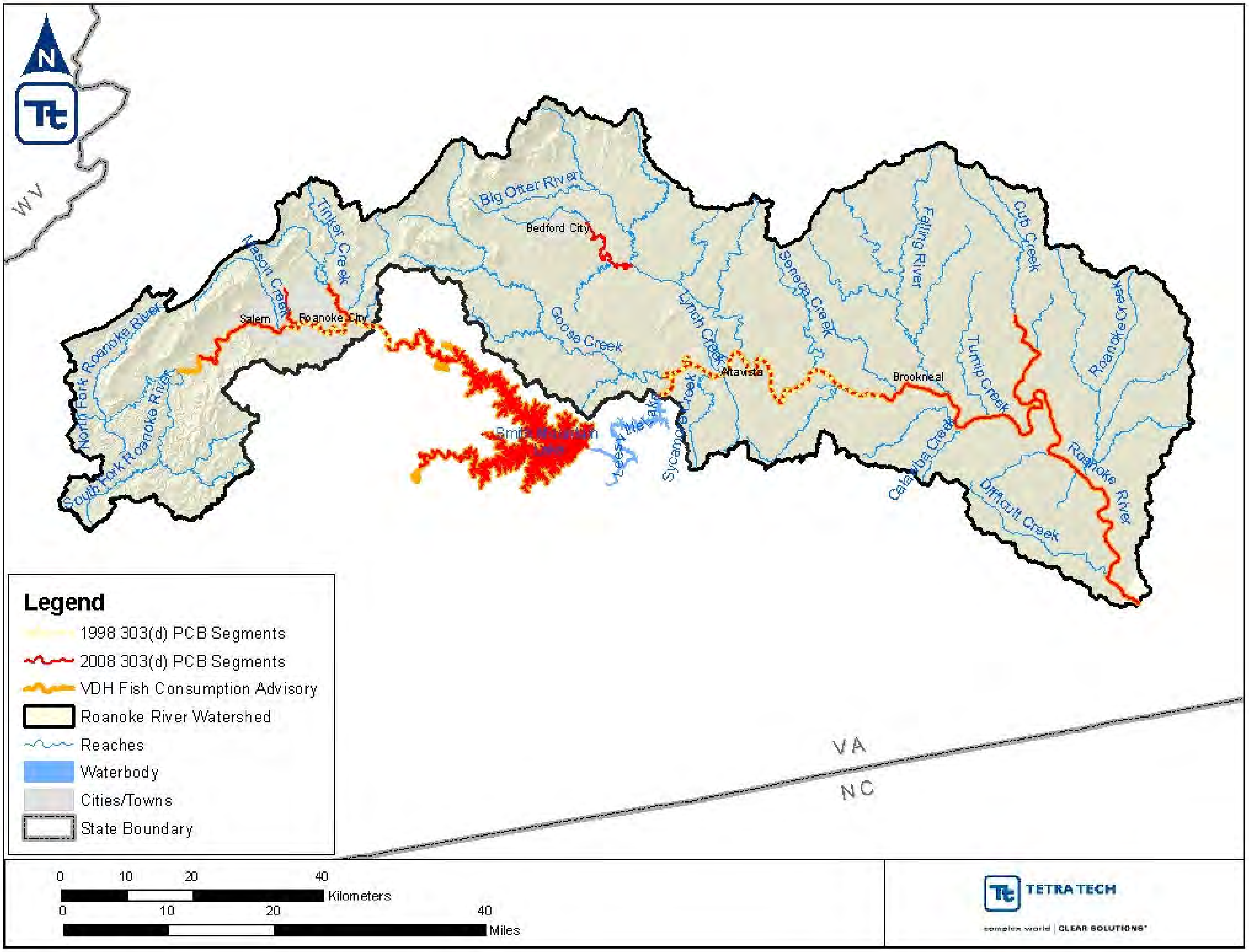


**Figure 1-3. 1998 and 2008 303(d) PCB impaired segments and current fish consumption advisories.**

## 1.3. Endangered Species Concerns

In addition to the human health concerns, there are concerns about the effects of PCB pollution on biota in the Roanoke River basin. The resident bald eagle population and the endangered Roanoke Logperch (*Percina rex*) have been identified by the Virginia Branch of the U.S. Fish and Wildlife Service (USFWS) as species that are potentially at risk from the effects of PCB contamination. The Roanoke Logperch is a federally endangered species that occurs only in the upper Roanoke drainage, Pigg River, Smith River, and larger tributaries. The Orangefin Madtom (*Nocturus gilberti*) is also found only locally and is listed as threatened in Virginia and as a species of special concern nationally.

## 1.4. Applicable Water Quality Standards

All surface waters in Virginia have the designated uses of contact recreation, propagation of fish and game, and production of edible and marketable natural resources (9 VAC 25-260-10). Virginia's water quality standards for the maintenance of designated uses include numeric Aroclor PCBs criteria for the protection of aquatic life and a total PCBs (tPCBs) criterion for the protection of human health (9 VAC-25-260-140.B). The state criteria are based on criteria developed by EPA as issued in its 1999 Final Rule: *Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance—Revision of Polychlorinated Biphenyls (PCBs) Criteria* (USEPA 1999).

The 1999 final rule is an update to the human health criterion and a restatement of the aquatic life criteria both established as part of the National Toxics Rule (NTR) issued in 1992. The reassessment used revised PCB cancer study results and information on environmental processes, representative classes of environmental PCB mixtures, and different exposure pathways to develop a range of cancer slope factors—0.07 per milligram per kilogram per day (mg/kg-d) (lowest risk and persistence) to 2.0 per mg/kg-d (high risk and persistence)—that indicate the potency of a cancer-causing chemical. EPA determined that the major pathway of human exposure to PCBs is fish consumption and that bioaccumulated PCBs are the most toxic. As a result, the upper-bound cancer slope factor (2.0 per mg/kg-d) was selected to develop the 1999 human health criterion. The EPA criterion incorporates a bioconcentration factor (BCF) to account for the uptake and accumulation of PCBs in fish tissues from contaminated waters.

VADEQ has also developed a numeric criterion for tPCBs concentrations in fish tissue [54 micrograms per kilogram (µg/kg)]. Called a screening value (SV), it was developed using the same toxicological, exposure, and risk data used to develop the human health PCB criterion. The SV represents the fish tissue concentration that the Virginia water quality criterion is designed to protect and is considered by VADEQ to be its fish tissue concentration equivalent (VADEQ n.d.).

The hydrophobic properties of PCBs make them difficult to detect in water quality samples. As a result, VADEQ uses fish tissue monitoring data as a surrogate to determine whether a waterbody is attaining the human health PCB criterion. If a fish tissue composite sample exceeds the SV, the water is classified as threatened for fish consumption. Fish containing a contaminant at or below the screening value concentration are considered to pose minimal risk to the average consumer. Related VDH fish consumption advisory guidelines specify a *do not eat* PCB concentration threshold of 500 ppb and a limited consumption (not more than 2 meals a month) PCB concentration range between 50 and 500 ppb. Advisories limiting and prohibiting fish consumption define waters as not supporting the fish consumption use (VADEQ, 2008.).

VADEQ uses sediment PCB contamination data to assess the likelihood of an observed effect on aquatic life. Sediment monitoring data are compared to the Probable Effects Concentration (PEC) SV for sediment (MacDonald et al. 2000). This SV is considered to be protective of aquatic organisms exposed to PCBs in the sediment.

PCBs also have the potential to affect non-aquatic wildlife that consume contaminated fish. The USFWS conducted a study in the summer of 2003 to determine the acceptable concentration of PCBs in bald eagle eggs and forage fish (Kane 2004). The reported No Observed Adverse Effect Level (NOAEL) for bald eagles eggs was a tPCBs concentration of 40.0 µg/kg (wet weight). The World Health Organization (WHO) defines NOAEL "as the greatest concentration or amount of a chemical found by experiment or observation that causes no detectable adverse alteration of morphology, functional capacity, growth, development, or life span of the target." Considering potential bioaccumulation in the food chain, the acceptable tPCBs concentration in forage fish was calculated to be 4.52 µg/kg. This value represents the Total Dietary Concentration of PCBs in forage fish that would meet the above NOAEL. All PCB criteria and guidelines developed and adopted by regulatory agencies considered for use as the TMDL target are presented in Table 1-3.

**Table 1-3. Applicable water quality, fish tissue, and sediment criteria/guidelines for PCBs**

| Agency | Criteria description | Pollutant | Aquatic life (ppb) | Human health (ppb) |
|---|---|---|---|---|
| | | | Chronic | |
| **Water Column** | | | | |
| Virginia Department of Environmental Quality (VADEQ) | State water quality criteria[a] | PCB-1260 | 0.014 | |
| | | PCB-1254 | 0.014 | |
| | | PCB-1248 | 0.014 | |
| | | PCB-1242 | 0.014 | |
| | | PCB-1232 | 0.014 | |
| | | PCB-1221 | 0.014 | |
| | | PCB-1016 | 0.014 | |
| | | tPCBs | | 0.0017 |
| **Fish Tissue** | | | | |
| VADEQ | State screening value[b] | tPCBs | | 54 |
| Virginia Department of Health (VDH) | Limited consumption threshold[b] | tPCBs | | 50–500 |
| | Do not eat threshold[b] | tPCBs | | > 500 |
| U.S. Fish and Wildlife Service (USFWS) | No Observed Adverse Effects Level (NOAEL)[c] | tPCBs | 4.5 | |
| **Sediment** | | | | |
| VADEQ | State screening value based on Probable Effects Concentration[d] | tPCBs | 676 | |

a. Source: Virginia State Code 9 VAC-25-260-140.B
b. Source: (VADEQ n.d)
c. Source: (Kane 2004)
d. Source: (MacDonald et al. 2000)

## 1.5. Targeted Water Quality Goal

VADEQ assesses stream segments for PCB impairments through its fish tissue monitoring program. PCBs are hydrophobic and are thus difficult to detect in water quality samples. As a result, VADEQ uses fish tissue monitoring data as a surrogate to evaluate PCB water quality. The threshold fish tissue PCB concentration for designating a waterbody as impaired is based on toxicological, exposure, and risk data used to develop the numeric water column human health PCB criterion. The human health criterion includes a BCF component that takes into account the uptake and accumulation of PCBs in fish tissues from contaminated waters.

Development of the applicable human health criterion relied on guidance issued by EPA in 1980 (45 *Federal Register* [FR] 79347, November 28, 1980). However, in 1998 EPA proposed revisions to the methodology it uses to derive water quality criteria for human health (63 FR 43755, August 14, 1998) and issued revised guidance in a 2003 technical support document (USEPA 2003a). The revised methodology recommends the use of bioaccumulation factors (BAFs) in place of BCFs. Bioaccumulation considers multiple pathways of exposure to a contaminant (i.e., uptake from water, food, and sediments) as opposed to bioconcentration, which considers uptake from water only. This approach was also used in the development of PCB TMDLs for the tidal Potomac River (ICPRB, 2007).

The methods recommended by EPA were used to develop TMDL endpoints for the protection of human health specific to conditions in the Roanoke River basin employing analysis of the relationships between water column PCB concentrations and fish tissue concentrations. Water concentrations were related to fish tissue concentrations by calculating BAFs. BAFs allow for the back-calculation of a water concentration equivalent from a fish tissue concentration, in this case a threshold level of 54 ppb. BAFs were calculated for fish species for which requisite supporting data were available. A target species was selected from this group taking into account species of special concern to the basin stakeholders and relative BAF values with greater importance given to species with higher BAFs. A higher BAF results in a lower water concentration; therefore, the target species should be protective of all fish species with lower BAFs.

Watershed-section-specific BAF converted fish tissue concentrations are recommended for the TMDL target water quality criteria. Two endpoints were developed corresponding to the upper [390 picograms per liter (pg/L)] and lower (140 pg/L) sections of the Roanoke (Staunton) River basin on the basis of the available water quality and fish tissue monitoring data. The decision to evaluate the upper and lower sections separately was made because of the large reservoirs that separate them and the differences in the magnitude and composition of PCB contamination. The TMDL endpoints are more protective than the 1,700 pg/L state criterion for human health. The human health criterion applies to waterbodies used for public water supply, in addition to all other surface waters. The TMDL endpoints, therefore, are more than adequate to protect the water supply use and address the forth coming violation listing (2010) of the public water supply use in the Roanoke River watershed. The species used to derive the endpoints for the upper and lower sections of the Roanoke (Staunton) were carp and striped bass, respectively. The methods and results for calculating BAFs are described in Appendix A.

# 2. DATA INVENTORY AND ANALYSIS

TMDL development requires a complete review of existing data to characterize the extent of pollutant contamination and sources in the watershed. Data from numerous sources were used to characterize the watershed and water quality conditions, identify pollutant sources, and support the calculation of PCB TMDLs for the Roanoke River watershed. The development of PCB TMDLs in the Roanoke River watershed is subject to adaptive implementation and on-going source investigation whereby sources of PCB contamination are continuously being reviewed and updated based on the best available information. The following discussion of PCB sources, therefore, should be considered the most up-to-date information at the time of the development of these TMDLs, rather than a complete and final characterization.

## 2.1. General Data Inventory

The following inventories include physical and monitoring data used to characterize general conditions in the Roanoke River watershed as they relate to the development of PCB TMDLs within the framework of the technical approach. For discussion of the context in which each is incorporated into the technical approach, see Section 5.0 and Appendix G.

### 2.1.1. Land Use

Land use information for the Roanoke River basin is shown in Table 2-1 and Figure 2-1. Estimates of land use areas in the watershed were derived from the 2001 Multi-Resolution Land Characteristics (MRLC 2001) Consortium's National Land Cover Dataset (NLCD) developed by the U.S. Geological Survey (USGS). The NLCD was derived from satellite imagery taken circa 2001 and is the most current, detailed land use data available for the study area. Each 30-meter by 30-meter pixel in the satellite image is classified according to its reflective characteristics.

Both sections of the Roanoke (Staunton) watershed are predominantly forested with 64 and 63 percent of land area for the upper and lower classified as such, respectively. The cities of Salem and Roanoke are the largest population centers in the watershed and are in the upper segment. Consequently, though it has the smaller land area, the upper Roanoke has a larger area of urban land uses (49,431 acres). Further downstream, the watershed becomes largely pastoral with land cover in the lower segment 24 percent pasture or grassland compared with 11 percent in the upper segment. Cultivated crops and wetlands make up a small portion of the upper and lower watershed area at less than 2 percent each in both sections.

**Table 2-1. 2001 NLCD land use distribution in the Roanoke River basin**

| Detailed land use description | Group land use description | Upper land use area (acre) | | | Lower land use area (acre) | | |
|---|---|---|---|---|---|---|---|
| | | Detailed | Grouped | Grouped % | Detailed | Grouped | Grouped % |
| Open Water | Water/Wetland | 1,100 | | | 6,051 | | |
| Woody Wetlands | | 27 | | | 21,005 | | |
| Herbaceous Wetlands | | 60 | 1,187 | 0.3 | 487 | 27,543 | 1.9 |
| Pasture/Hay | Pasture | 36,823 | | | 308,084 | | |
| Grassland | | 15 | 36,838 | 11.3 | 26,726 | 334,810 | 24.4 |
| Row Crops | Cropland | 2,048 | 2,048 | 0.6 | 14,125 | 14,125 | 1.1 |
| Deciduous Forest | Forest | 189,706 | | | 523,242 | | |
| Evergreen Forest | | 14,318 | | | 149,118 | | |
| Mixed Forest | | 5,199 | | | 51,915 | | |
| Shrub/Scrub | | 26 | 209,250 | 64.1 | 25,246 | 749,521 | 63.0 |
| Barren Land | Other | 99 | | | 2,932 | | |
| Developed, Open Space | | 27,482 | 27,582 | 8.5 | 49,233 | 52,165 | 5.2 |
| Developed, Low Intensity | Developed | 34,303 | | | 15,263 | | |
| Developed, Medium Intensity | | 11,050 | | | 2,146 | | |
| Developed, High Intensity | | 4,078 | 49,431 | 15.1 | 731 | 18,140 | 4.4 |
| **Total** | | **326,336** | | **100.0** | **1,196,304** | | **100.0** |

Source: (MRLC 2001)

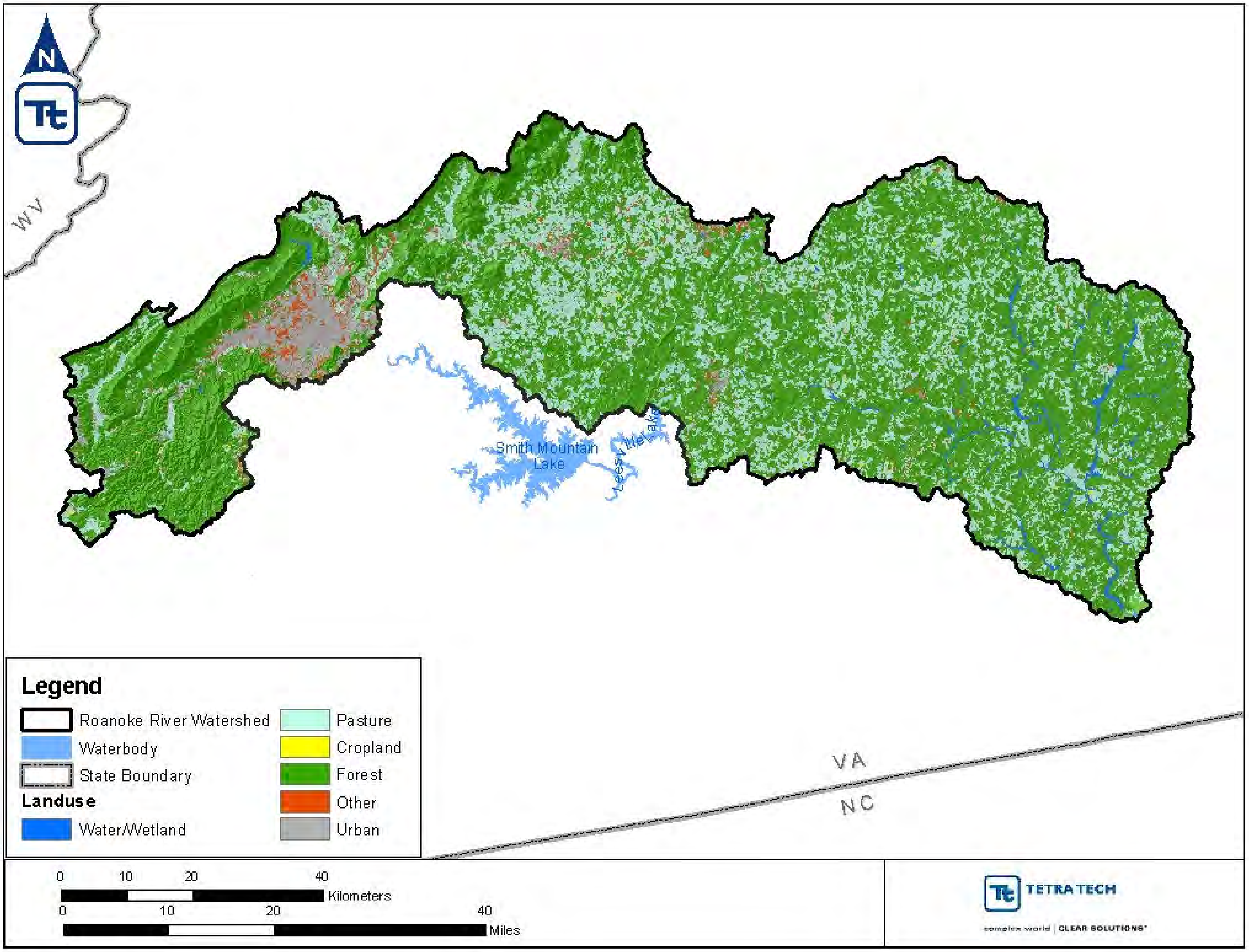


**Figure 2-1. Land use in the Roanoke River basin (MRLC 2001).**

### 2.1.2. Soils

Soils data developed by the Natural Resources Conservation Service (NRCS) were used to characterize soils in the Roanoke River basin. General soils data are available as map unit delineations for the United States provided as part of the State Soil Geographic (STATSGO) database. The geographic information system (GIS) data coverages provide accurate locations for the soil map units at a scale of 1:250,000 (USDA 1995). A map unit is composed of several soil series having similar properties. Identification fields in the GIS coverage can be linked to a database that provides information on chemical and physical soil characteristics. Because multiple soil series characterize each soil map unit, a weighted sum of soil series parameters was calculated to describe the general properties of interest for each soil map unit.

#### Hydrologic Soil Group

Hydrologic soil classifications group soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils that are poorly drained have lower infiltration rates, while well-drained sandy soils have the greatest infiltration rates. NRCS has defined four hydrologic groups for soils (Table 2-2) (USDA 1993). Figure 2-2 shows the distribution of hydrologic soil groups in the Roanoke River basin.

**Table 2-2. NRCS hydrologic soil groups**

| Hydrologic soils group | Description |
|---|---|
| A | Soils with high infiltration rates. Usually deep, well drained sands or gravels. Little runoff |
| B | Soils with moderate infiltration rates. Usually moderately deep, moderately well drained soils. |
| C | Soils with slow infiltration rates. Soils with finer textures and slow water movement |
| D | Soils with very slow infiltration rates. Soils with high clay content and poor drainage. High amounts of runoff. |

Source: (USDA 1993)

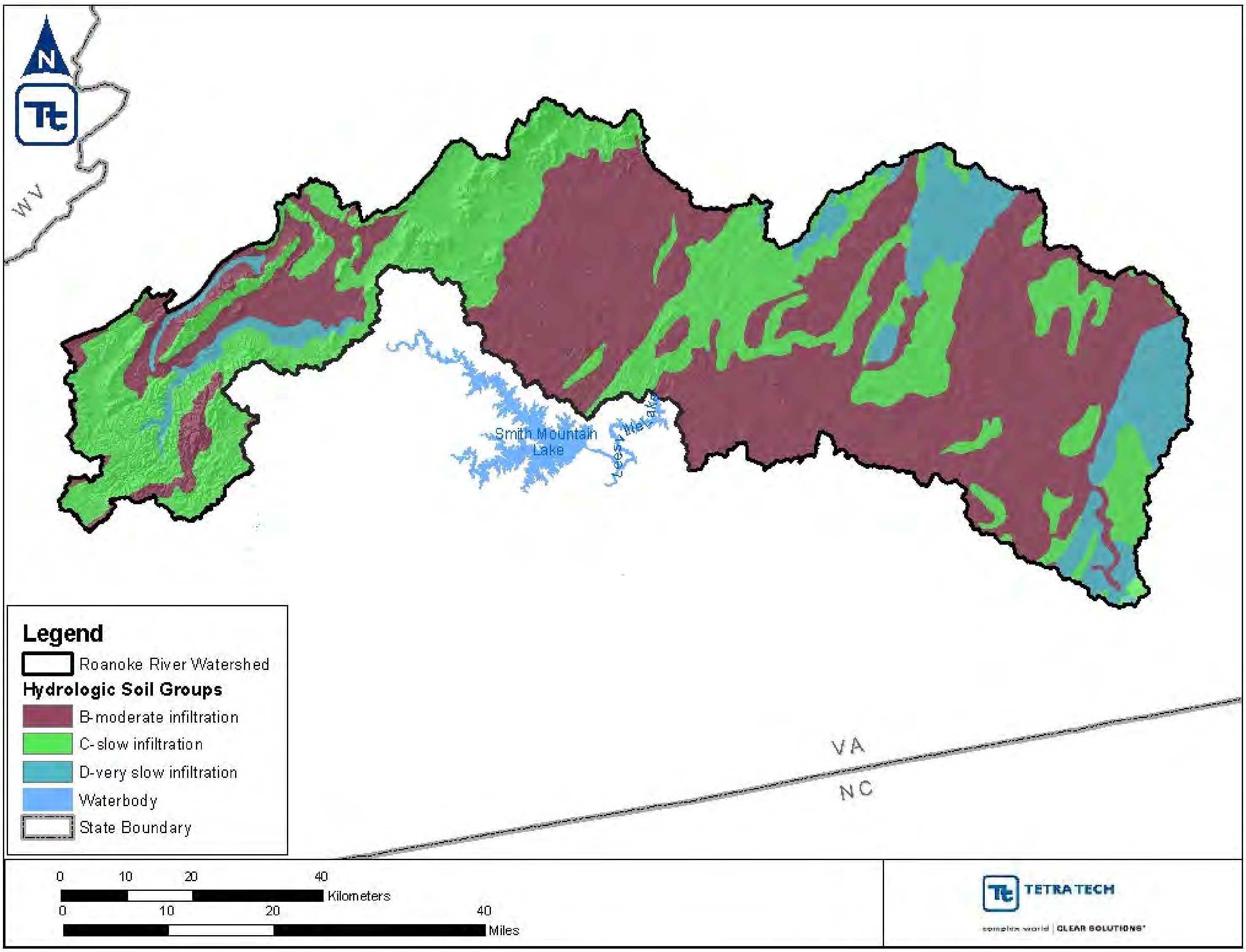


**Figure 2-2. Hydrologic soil groups in the Roanoke River basin (USDA 1995).**

### 2.1.3. Topography

Stream types, precipitation, and soil types can vary dramatically by elevation. The National Elevation Dataset (NED), developed by the USGS, was used to characterize the topography in the Roanoke River basin (USGS 2009). The NED consists of 30-meter grid resolution elevation data for the conterminous United States. Topography in the basin varies from the steep slopes and valleys in the Valley and Ridge Province to gently sloping terrain in the Piedmont Province. Figure 2-3 shows the elevation distribution in the watershed. Elevation ranges from 1,282 meters (4,206 feet) above mean sea level (AMSL) in the headwaters of Big Otter River to 85 meters (80 feet) AMSL at the Dan River confluence.

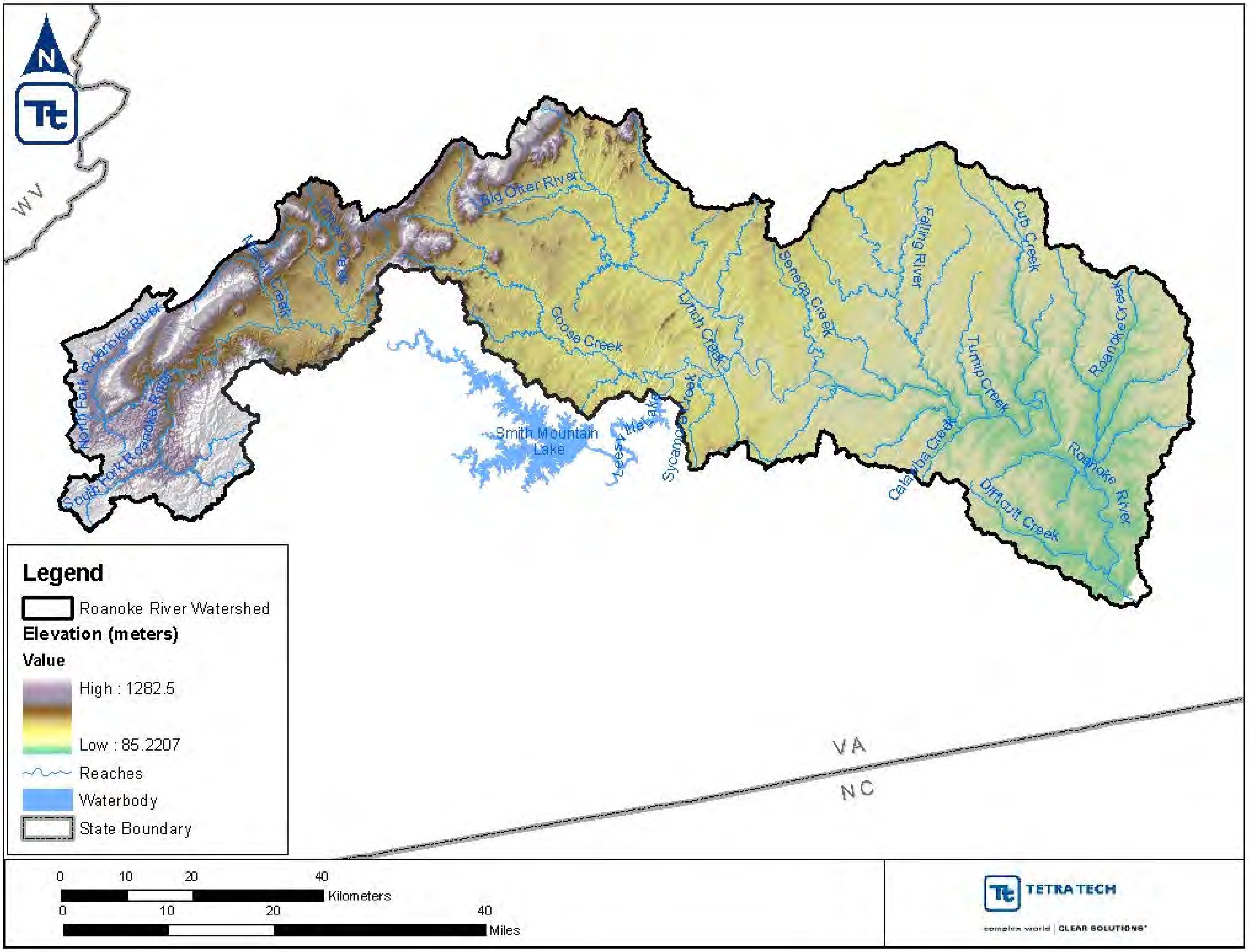


**Figure 2-3. Elevation in the Roanoke River basin (USGS 2009).**

### 2.1.4. USGS Stream Flow Gages

USGS flow gage data were compiled to characterize the hydrology of the Roanoke River and its major tributaries. Data of interest included daily average continuous stream flow data, which were obtained through the USGS National Water Information System. Stream gages with data available for the watershed are presented in Table 2-3 with associated statistics for period of record and percent completeness. Figure 2-3 presents the locations of gages in the watershed.

**Table 2-3. USGS continuous stream flow gages in the Roanoke River basin**

| Site ID | Station name | Drainage area (square miles) | Period of record | % Complete |
|---|---|---|---|---|
| 02053800 | South Fork Roanoke River near Shawsville, VA | 109 | 1/1/1980-9/9/2006 | 100.0% |
| 02054500 | Roanoke River at Lafayette, VA | 254 | 1/1/1980–9/9/2006 | 100.0% |
| 02054510 | Roanoke River near Wabun, VA | 270 | 1/1/1995–9/9/1999 | 100.0% |
| 02054530 | Roanoke River at Glenvar, VA | 281 | 1/1/1992–9/9/2006 | 99.9% |
| 02055000 | Roanoke River at Roanoke, VA | 384 | 1/1/1980–9/9/2006 | 100.0% |
| 02055100 | Tinker Creek near Daleville, VA | 11.7 | 1/1/1980–9/9/2006 | 99.9% |
| 02056000 | Roanoke River at Niagra, VA | 509 | 1/1/1980–9/9/2006 | 100.0% |
| 02059500 | Goose Creek near Huddleston, VA | 188 | 1/1/1980–9/9/2006 | 99.9% |
| 02060500 | Roanoke River at Altavista, VA | 1,782 | 1/1/1980–9/9/2006 | 100.0% |
| 02061500 | Big Otter River near Evington, VA | 315 | 1/1/1980–9/9/2006 | 99.9% |
| 02062500 | Roanoke (Staunton) River at Brookneal, VA | 2,404 | 1/1/1980–9/9/2006 | 99.3% |
| 02064000 | Falling River near Naruna, VA | 165 | 1/1/1980–9/9/2006 | 100.0% |
| 02065500 | Cub Creek at Phenix, VA | 97.6 | 1/1/1980–9/9/2006 | 100.0% |
| 02066000 | Roanoke (Staunton) River at Randolph, VA | 2,966 | 1/1/1980–9/9/2006 | 99.9% |

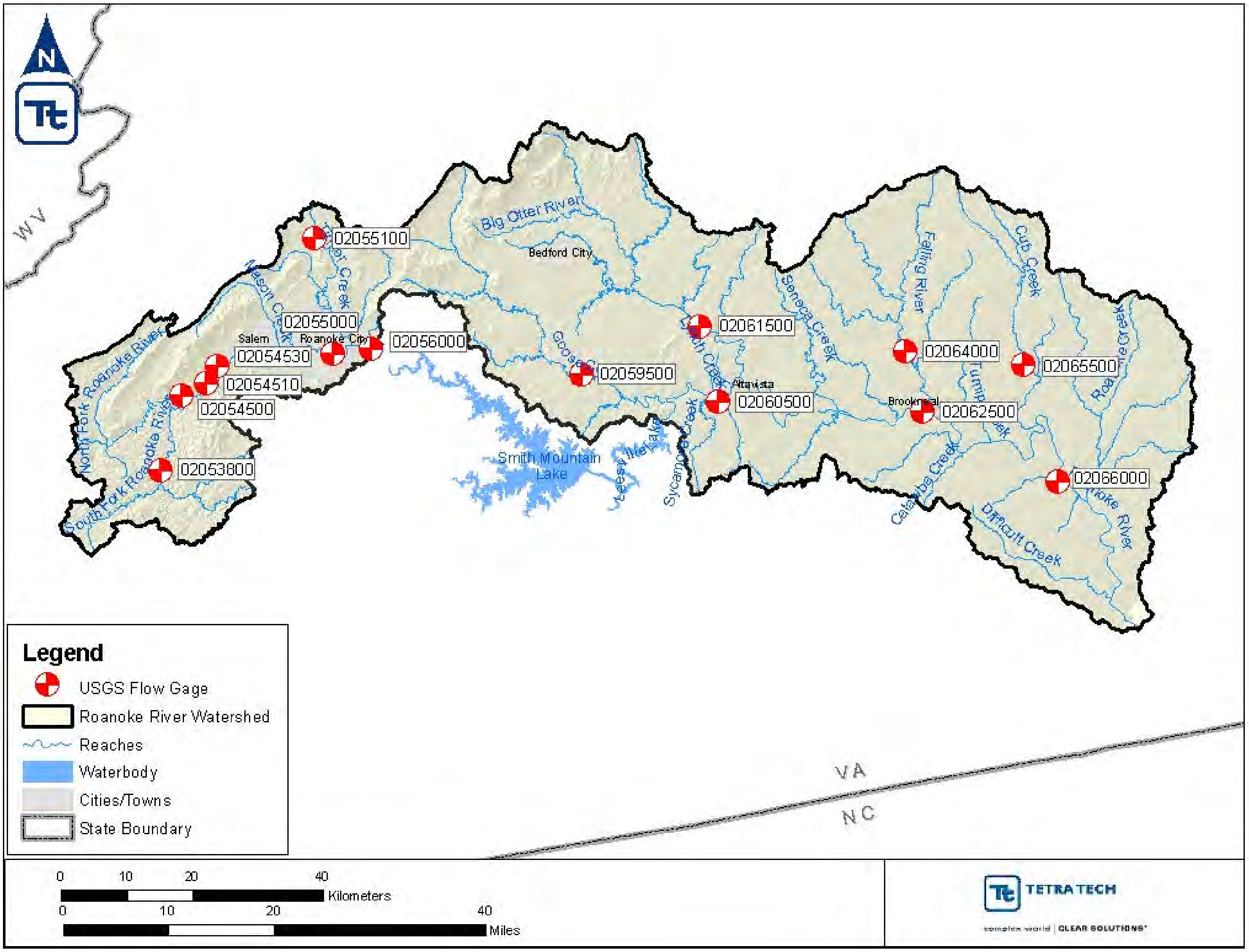


**Figure 2-4. USGS continuous stream flow gages in the Roanoke River basin.**

### 2.1.5. TSS Monitoring

VADEQ conducted total suspended solids (TSS) monitoring for waters in the Roanoke River watershed as part of VADEQ's Ambient Water Quality Monitoring Program (AWQMP) and various special studies. The primary function of the AWQMP is to provide data for the National Water Quality Inventory Report on the quality of state waters as required by section 305(b) of the Clean Water Act. From 1990 to 2008, 64 water quality stations were sampled for TSS in the Roanoke River basin (Figure 2-5). For a complete list of these stations and associated location descriptions and statistics, see Table B-4 in Appendix B. Note that the monitoring station IDs in Figure 2-5 follow a standard format. The first three letters identify the stream on which the station is located, followed by five digits specifying the river mile. A river mile identifies the station's distance from the mouth of the river measured along the route of the river.

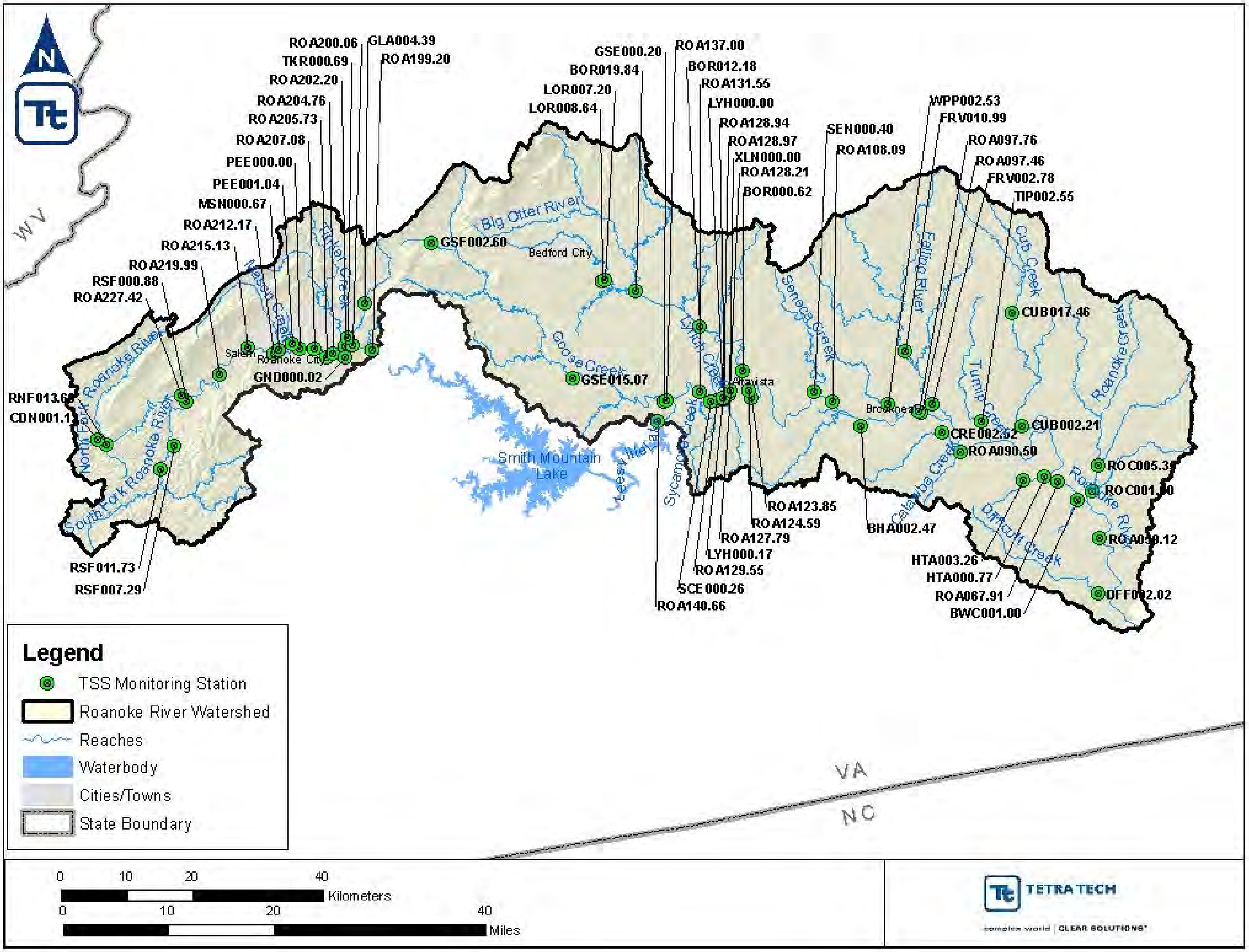


**Figure 2-5. TSS monitoring stations in the Roanoke River basin.**

## 2.2. PCB Monitoring Data Inventory

The following PCB data summary was developed on the basis of the fish tissue, sediment, and water quality monitoring data reviewed as part of TMDL development. Fish tissue PCB data collected in 1971 and presented in the 1973 report, *The Occurrence of Polychlorinated Biphenyls in the Roanoke and Dan Rivers—A Preliminary Report* (Wallmeyer 1973), are not included because of significant advances in analytical detection sensitivity since the 1970s. Ambient water quality monitoring conducted before 2006, though discussed, has also been excluded from the proceeding analysis because of concerns of background contamination and unknown analytical methods. Table 2-4 presents the available sources of PCB monitoring data for the Roanoke River basin.

To support TMDL development, additional PCB data were collected in fall 2005 through spring 2008 at selected monitoring locations in the watershed. Sampling included the use of semi-permeable membrane devices (SPMDs) and a high-resolution, low-detection level analysis method (1668A) to assess water column PCB concentrations, as well as effluent concentrations at selected facility outfalls. Details of the development of the 2005 special study are presented in the October 2005 *Sampling and Analysis Plan, Roanoke River Basin PCB TMDL Development (Virginia)* (Tetra Tech 2005).

Note that the monitoring station IDs in Figures 2-6 through 2-8 presented in Section 2.2.1 follow a standard format. The first three letters identify the stream on which the station is located, followed by five digits specifying the river mile. A river mile identifies the station's distance from the mouth of the river measured along the route of the river.

**Table 2-4. PCB data sources for the Roanoke River basin**

| Data set | VADEQ data source | Period of record | Sample count |
|---|---|---|---|
| PCB water column data | Parameter specific data set submitted by VADEQ | 1978–1996 | 40 |
| PCB fish tissue data | Online data post | 1993–2006 | 678 |
| PCB sediment data | Online data post | 1996–2008 | 127 |
| Semi-permeable Membrane Devices | TMDL special study | 2006 | 21 |
| High Resolution Low Detection Level Analysis Method (1668a) | TMDL special study | 2005–2008 | 59 water column, 12 effluent samples |

### 2.2.1. PCB Monitoring Locations

VADEQ collects fish tissue and sediment samples as part of the Virginia Fish Tissue and Sediment Contaminants Monitoring Program. Under the program, data are collected to assess the human health risks for individuals who might consume fish from state waters and to identify impaired aquatic ecosystems. The sampling program is charged with monitoring every major watershed in Virginia at least once within a 2–3 year cycling period. In addition to *routine* samples taken as a part of the standard cycling period, monitoring at study sites can take place as part of the special Virginia Environmental Emergency Response Fund or in the case of a special request approved by VADEQ (VADEQ 2004).

From 1993 to 2008, 40 fish tissue and 108 sediment stations were sampled in the Roanoke River basin. Of these, 24 fish tissue and 56 sediment stations are on the Roanoke River mainstem (including the North and South Forks) with the remainder on tributaries. Fish tissue station locations are presented in Figure 2-6. Sediment station locations are presented in Figure 2-7a and 2-7b. Appendix B presents a summary of available fish tissue and sediment data, as well as station descriptions.

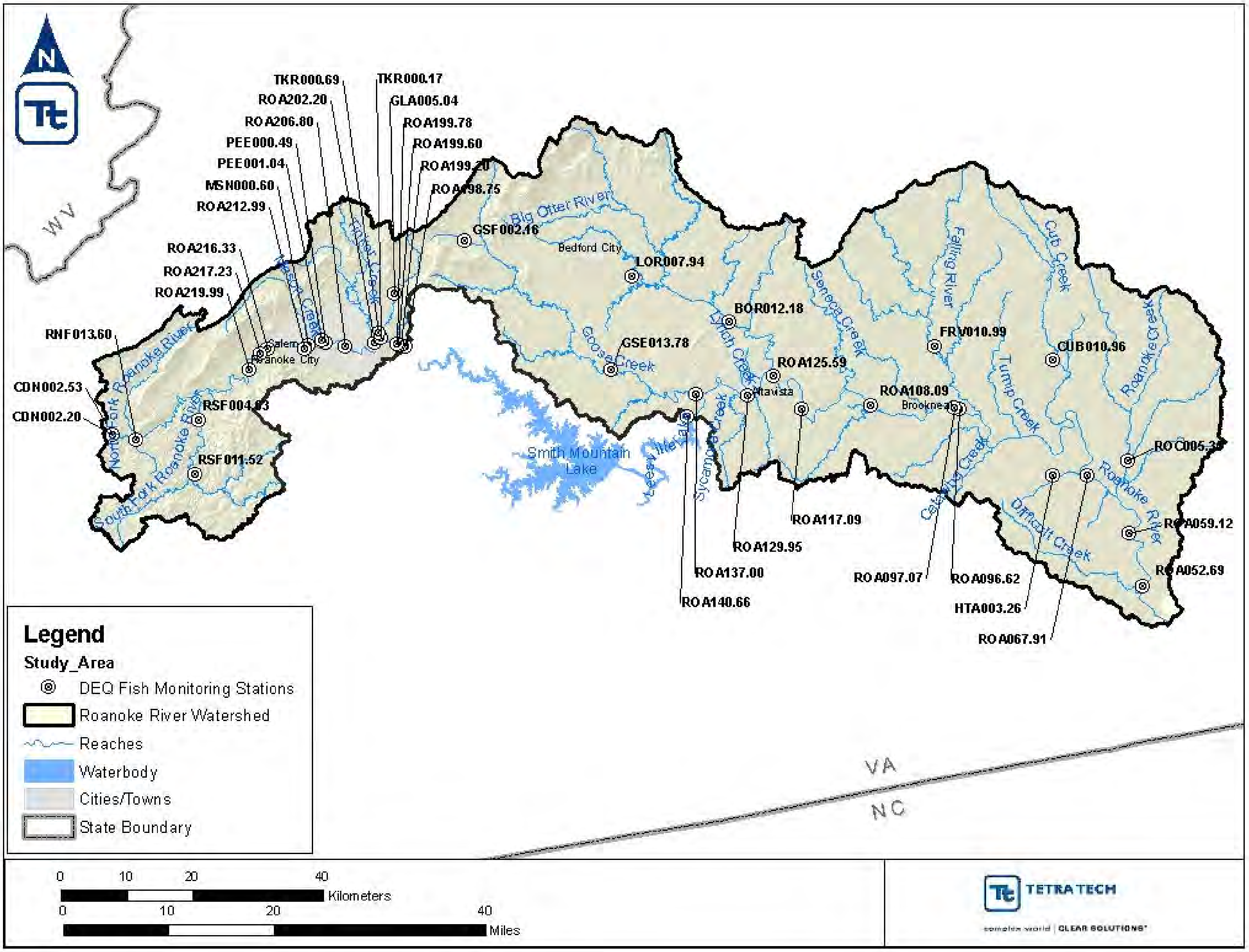


**Figure 2-6. VADEQ fish tissue monitoring stations.**

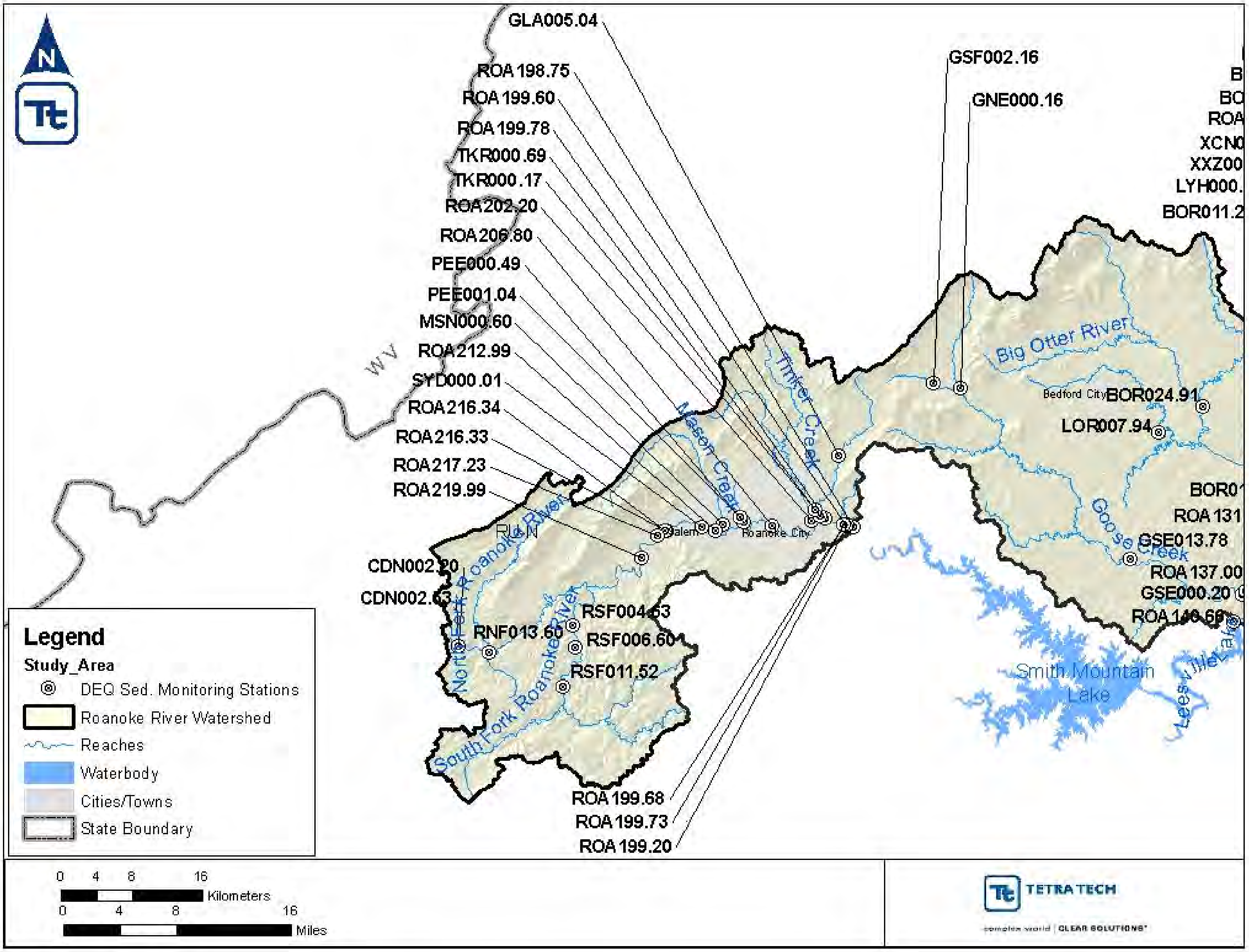


**Figure 2-7a. VADEQ sediment monitoring stations-upper Roanoke.**

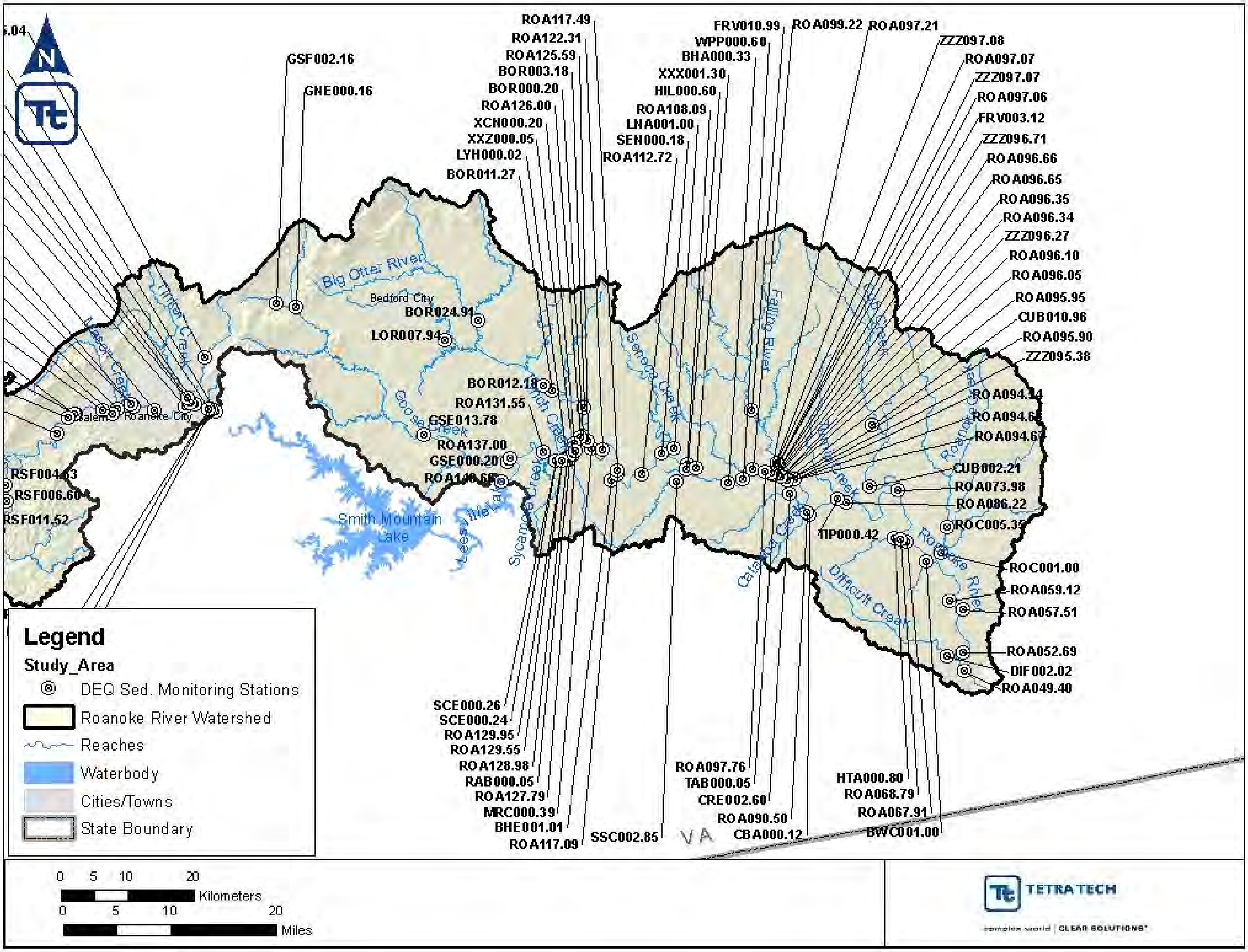


**Figure 2-7b. VADEQ sediment monitoring stations-lower Roanoke (Staunton).**

VADEQ collects water column samples as part of its AWQMP. The primary function of the AWQMP is to provide data for the National Water Quality Inventory Report on the quality of state waters as required by section 305(b) of the Clean Water Act. From 1978 to 1996, 21 water quality stations were sampled for PCBs in the Roanoke River basin. The analytical methods used to process samples during this period routinely failed to detect measurable concentrations of PCBs in contaminated waters because of their hydrophobic properties. A single record from the data set reported PCB concentrations above the detection limit. Because of the age and uncertainty associated with these data, they have been excluded from the analysis that follows.

A special study was conducted by VADEQ in the Roanoke River basin in fall 2005 through spring 2008 that included water column PCB monitoring. The special study was designed, in part, to augment the existing water quality record in support of TMDL development. Water quality samples were collected at low-flow and high-flow conditions at 29 monitoring locations throughout the watershed. The special study results were processed using a high-resolution, low-detection level analysis method (1668A) specifically to account for the hydrophobic properties of PCBs. The special study water quality station locations are shown in Figure 2-8, and the data summary and station descriptions are provided in Table B-3 in Appendix B.

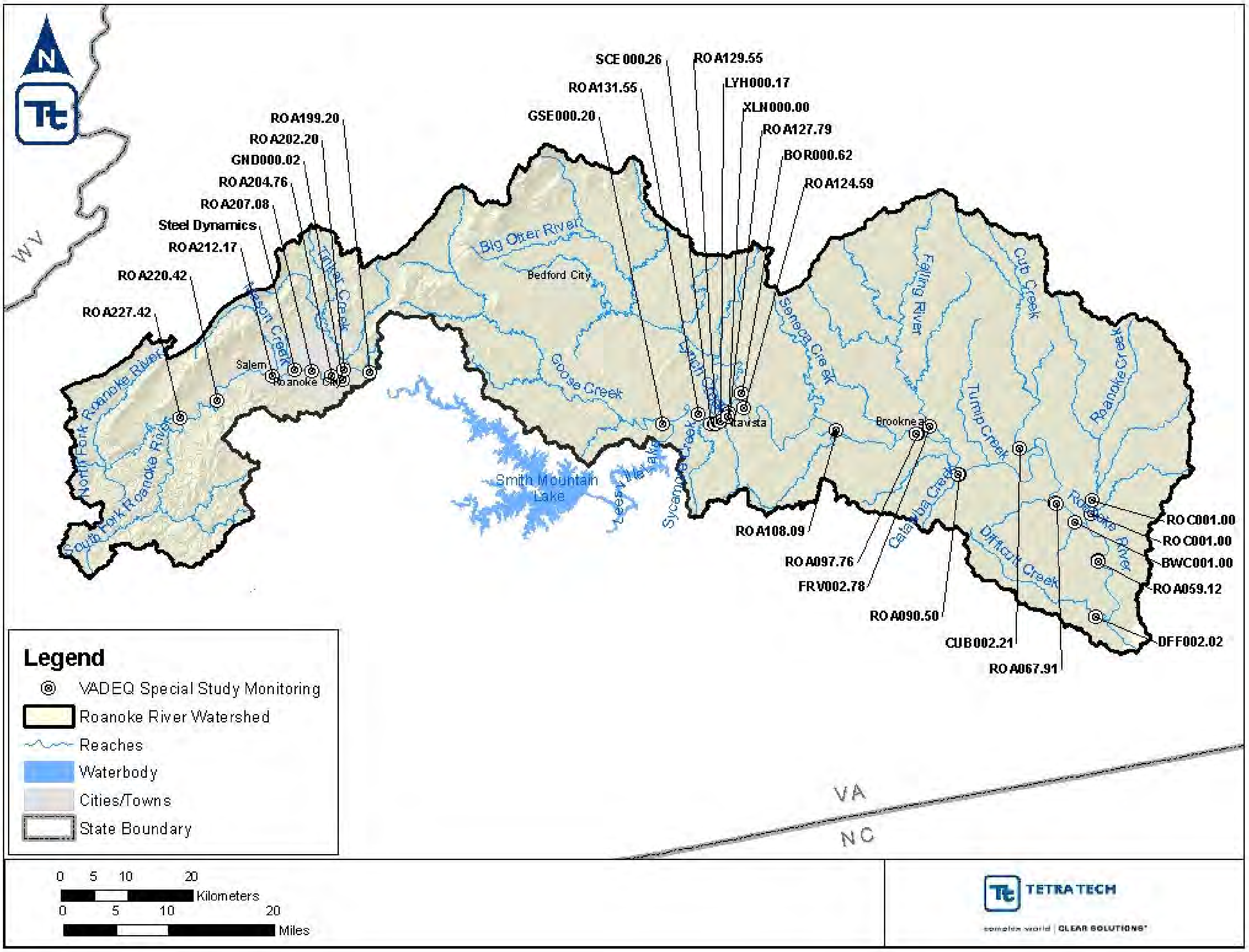


**Figure 2-8. Special study water quality monitoring stations.**

### 2.2.2. Fish Tissue and Sediment PCB Results

VADEQ collects and analyzes fish tissue and sediment samples under the Fish Tissue and Sediment Monitoring Program. Data collected in the Roanoke River basin were compiled and summarized to help identify spatial trends and help identify potential PCBs sources in the watershed. Note that the mobility and seasonal migration patterns of various fish species can limit the conclusions that can be drawn from analyzing the spatial distribution of PCB concentrations in fish tissue samples. The location of dams, tributaries, and other physical characteristics can influence the PCB signature in fish tissue samples. These and other factors are also considered in the analysis of sediment PCB data.

PCBs typically adsorb to sediment particles, which are transported into streams and rivers through erosion, stormwater runoff, and other processes. Although the in-stream transport of sediment can cause uncertainty as to the source of contamination, its movement is relatively predictable, and the presence of PCBs can be assumed to be an indicator of an upstream source (active or legacy). In lieu of reliable water column monitoring results, areas with high fish tissue and sediment concentrations provide the strongest evidence of local PCB contamination problems. The Roanoke River basin was divided into upper and lower sections for data analysis purposes as described in Section 1.1 and presented in Figure 1-2. Data analysis observations are noted at the end of this section.

### Fish Tissue PCB Results

Figures 2-9 through 2-12 present the $25^{th}$–$75^{th}$ percentile, range, average, and median tPCBs concentrations of fish species collected at fish tissue monitoring stations summarized for the entire period of record (fish species abbreviations are presented in Table 2-5). The VADEQ fish tissue screening value (54 µg/L) is also provided to give a point of comparison between the figures. Monitoring results are grouped by watershed section and have been broken out into mainstem (North and South Fork Roanoke and Roanoke rivers) and tributary stations. Stations are presented in an upstream–downstream progression for spatial analysis purposes according to the station river-mile code. Data summaries and location descriptions for fish tissue monitoring stations are presented in Appendix B.

Station IDs have been condensed for Figures 2-9 through 2-12 for the purpose of presentation. Station IDs differ from those presented in the map of fish tissue monitoring station locations (Figure 2-6) as follows:

- River miles are expressed at the highest significant digit, not as a standard five digits (eg. 56.1 vs. 056.10).
- With the exception of stations on the North and South Forks of the Roanoke (NF and SF), mainstem Roanoke monitoring stations are presented as the river mile only. The North and South Fork stations IDs begin with an NF and SF, respectively, followed by the river mile.
- Tributary monitoring stations are presented as the river mile first, followed by the three letter code for the waterbody on which the station is located. Waterbody codes and associated waterbody names are presented in Table 2-6.

**Table 2-5. Fish species abbreviations**

| Fish abbreviation | Fish name | Fish abbreviation | Fish name |
|---|---|---|---|
| BC | black crappie | RES | redear sunfish |
| BJS | black jumprock sucker | RHS | redhorse sucker |
| BLC | blue catfish | RWD | riverweed darter |
| BGS | bluegill sunfish | RB | roanoke bass |
| BHC | bluehead chub | RD | roanoke darter |
| C | carp | RHG | roanoke hogsucker |
| CC | channel catfish | RB | rock bass |
| CHB | chub | SRS | shorthead redhorse sucker |
| FD | fantail darter | SMB | smallmouth bass |
| FHC | flathead catfish | SPB | spotted bass |
| GS | gizzard shad | STB | striped bass |
| GRS | golden redhorse sucker | SF | sunfish |
| GSF | green sunfish | WE | walleye |
| LMB | largemouth bass | WB | white bass |
| MM | margined madtom | WC | white crappie |
| MS | mixed sunfish species | WP | white perch |
| NHS | northern hogsucker | WS | white sucker |
| QCS | quillback carpsucker | YP | yellow perch |
| RBS | redbreast sunfish | | |

**Table 2-6. Monitoring station waterbody ID codes**

| Station waterbody code | Waterbody name |
|---|---|
| BHA | Buffalo Creek |
| BHE | Beechtree Creek |
| BOR | Big Otter River |
| BWC | Black Walnut Creek |
| CBA | Catawba Creek |
| CDN | Cedar Run |
| CRE | Childrey Creek |
| CUB | Cub Creek |
| DIF | Difficult Creek |
| FRV | Falling River |
| GLA | Glade Creek |
| GNE | North Fork Goose Creek |
| GSE | Goose Creek |
| GSF | South Fork Goose Creek |
| HIL | Hill Creek |
| HTA | Hunting Creek |
| LNA | Long Branch |
| LOR | Little Otter River |
| LYH | Lynch Creek |
| MRC | Mill Creek |

| Station waterbody code | Stream name |
|---|---|
| MSN | Mason Creek |
| PEE | Peters Creek |
| RAB | Reed Creek |
| RNF | North Fork |
| ROA | Roanoke River |
| ROC | Roanoke Creek |
| RSF | South Fork Roanoke River |
| SCE | Sycamore Creek |
| SEN | Seneca Creek |
| SSC | Straightstone Creek |
| SYD | Snyders Branch |
| TAB | Tanyard Branch |
| TIP | Turnip Creek |
| TKR | Tinker Creek |
| WPP | Whipping Creek |
| XCN | Unnamed Tributary to Roanoke River |
| XXX | Unnamed Tributary to Roanoke River |
| XXZ | Unnamed Tributary to Roanoke River |
| ZZZ | Unnamed Tributary to Roanoke River |

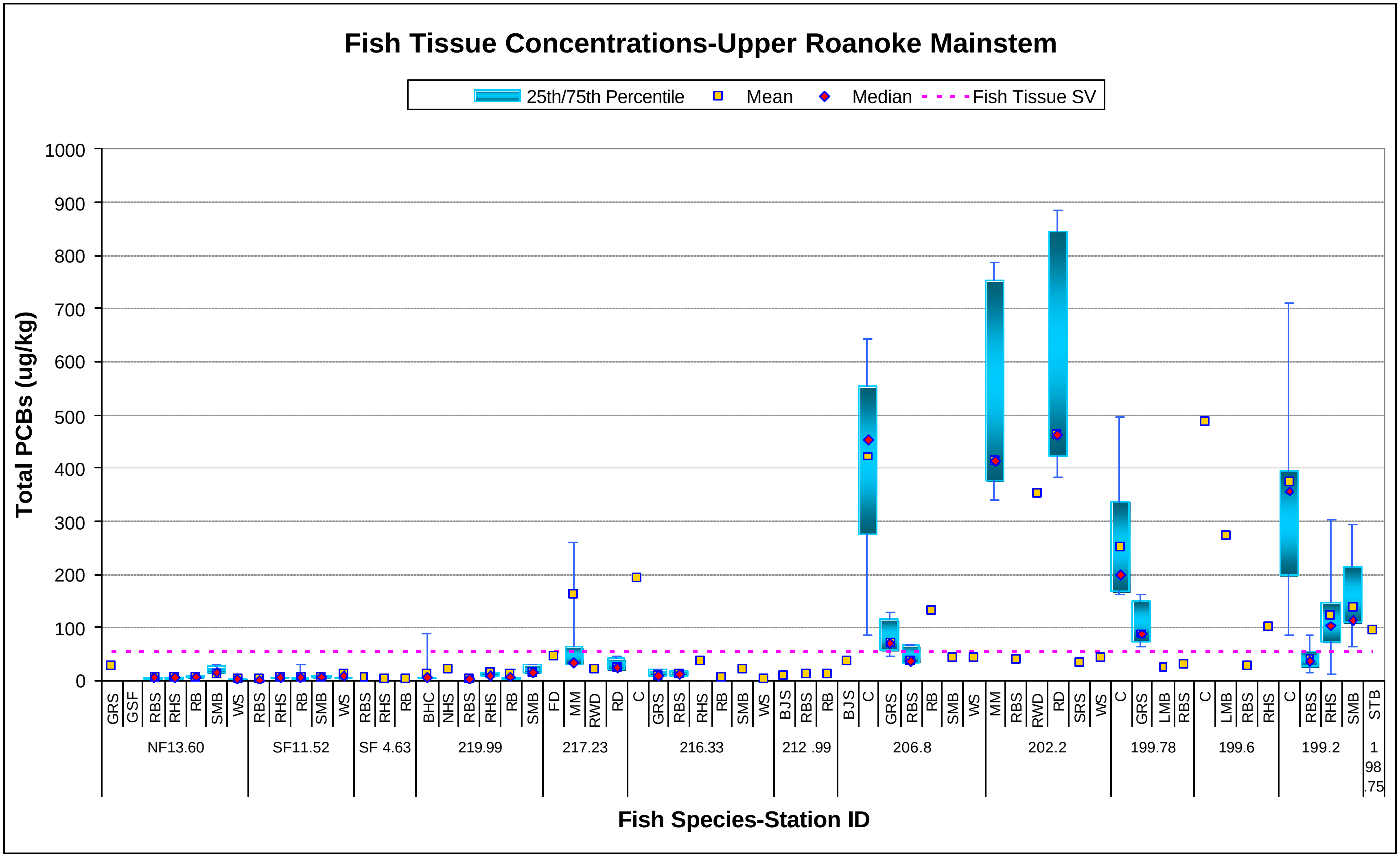


**Figure 2-9. Fish tissue monitoring results for upper Roanoke River mainstem.**

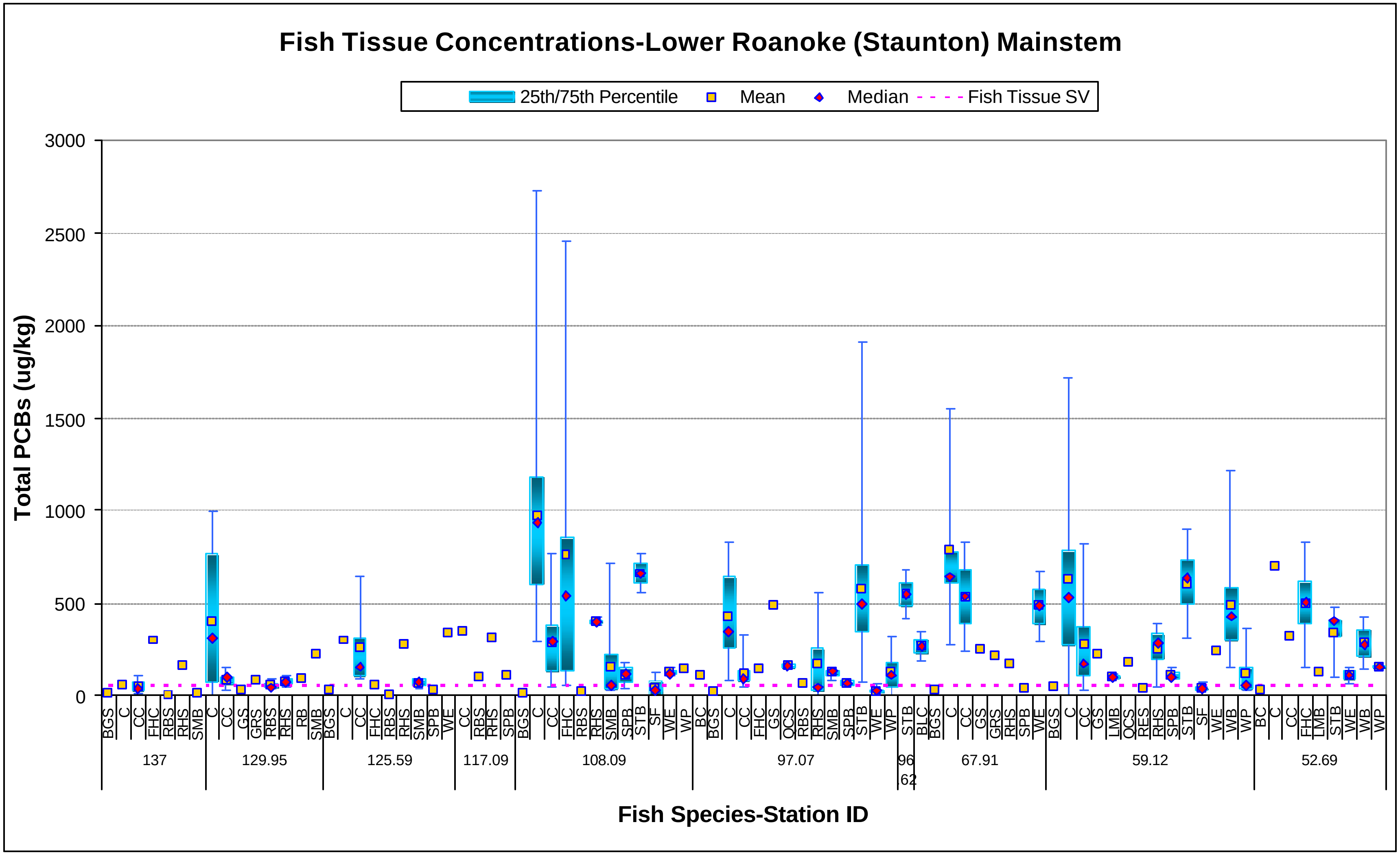


**Figure 2-10. Fish tissue monitoring results for lower Roanoke (Staunton) River mainstem.**

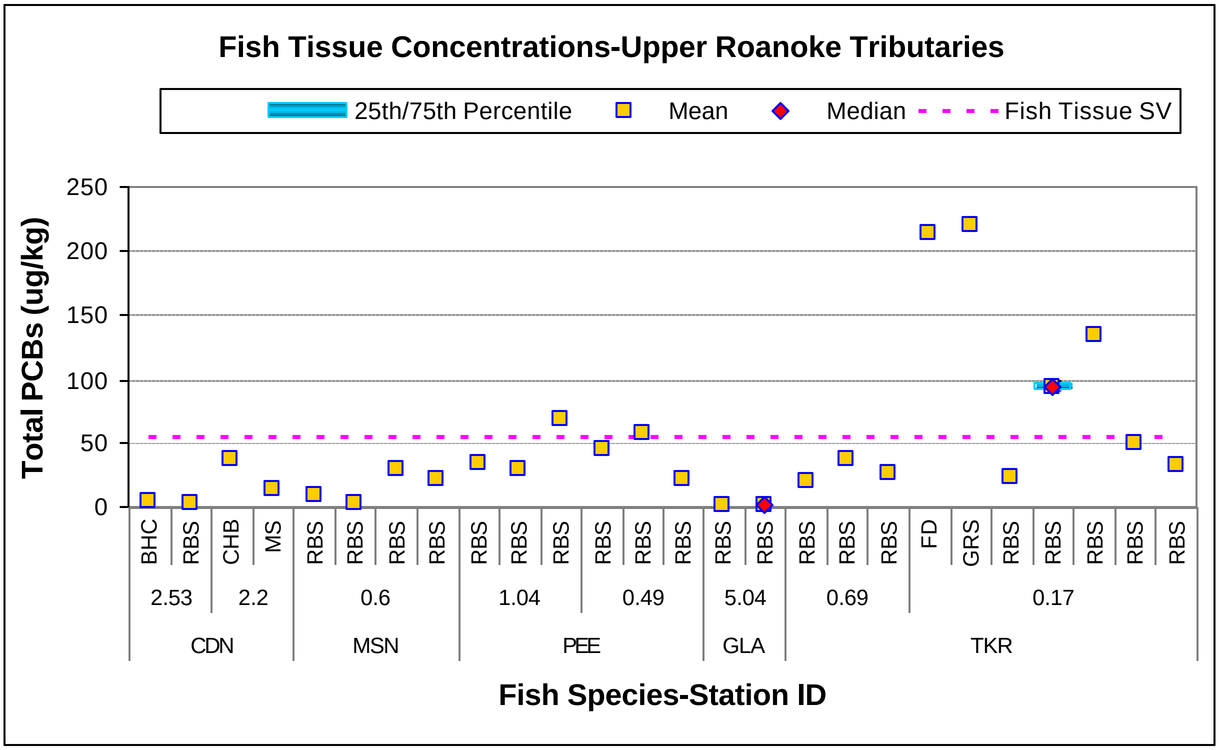


**Figure 2-11. Fish tissue monitoring results for upper Roanoke River tributaries.**

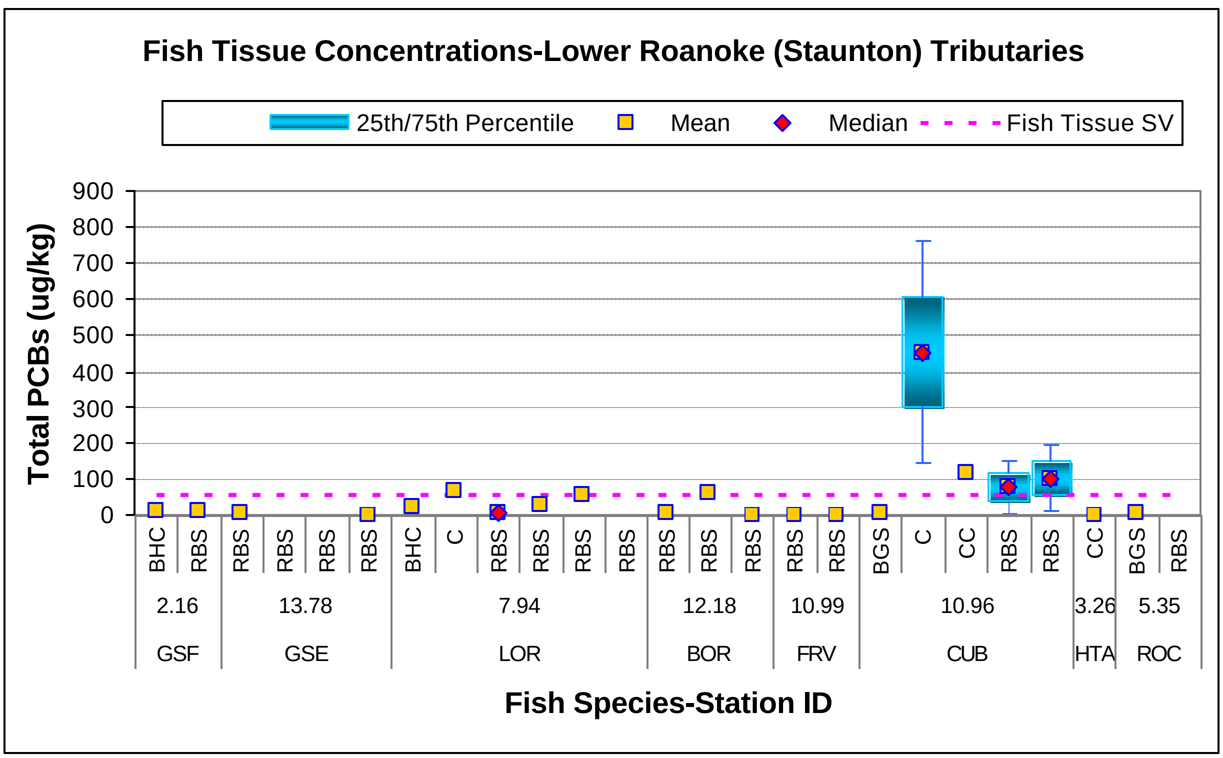


**Figure 2-12. Fish tissue monitoring results for lower Roanoke (Staunton) River tributaries.**

#### Sediment PCB Results

Figures 2-13 and 2-14 present the 25th–75th percentile, range, average, and median of tPCBs concentrations recorded at sediment monitoring stations summarized for the entire period of record. To maintain a reasonable scale, outliers in the dataset are represented as text boxes that give the average tPCBs concentration at a monitoring station. Monitoring results are grouped by watershed section and have been broken out into mainstem (Figure 2-13) and tributary stations (Figure 2-14). Stations are presented in an upstream–downstream progression for spatial analysis purposes according to the station river-mile code. Station IDs are given as presented in Figures 2-7a and 2-7b, which show the locations of sediment monitoring stations (see Section 2.2.1). Station ID waterbody codes and associated waterbody names are given in Table 2-6. Data summaries and location descriptions for sediment monitoring stations are presented in Appendix B.

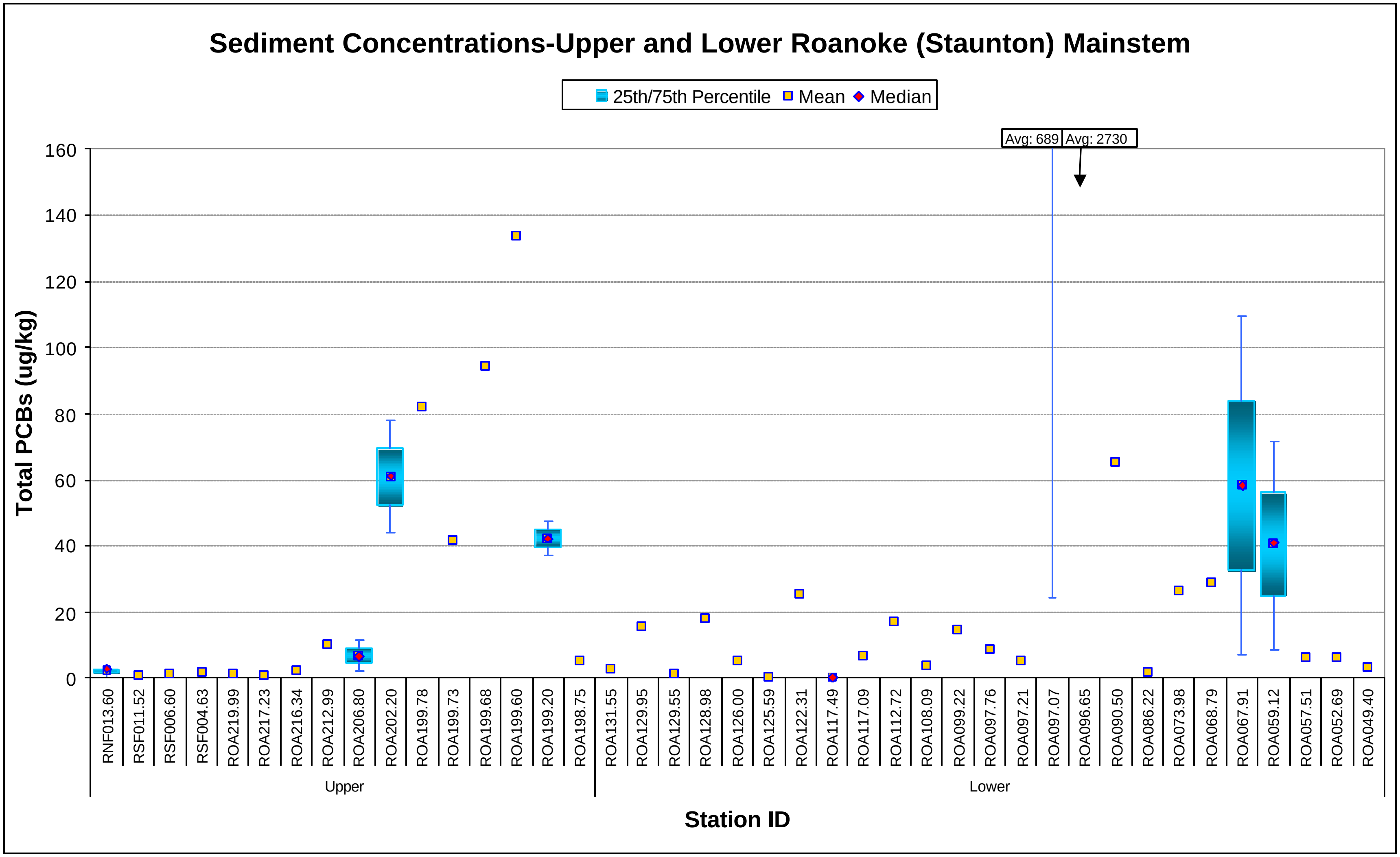


**Figure 2-13. Sediment monitoring results for upper and lower Roanoke (Staunton) River mainstem.**
Note: To maintain figure scale, text boxes present the average tPCBs concentration at stations with values significantly higher than other stations

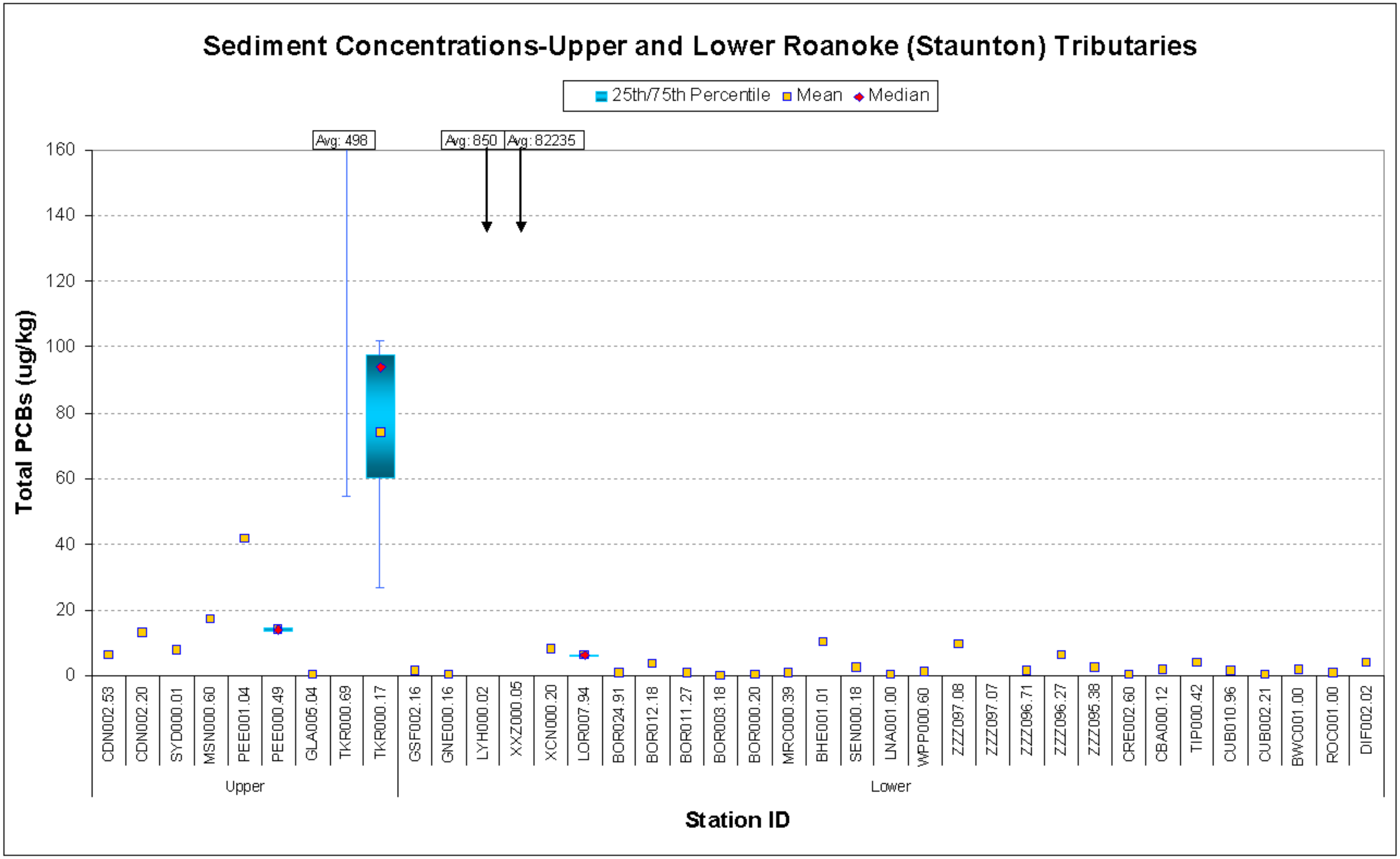


**Figure 2-14. Sediment monitoring results for upper and lower Roanoke (Staunton) River tributaries.**
Note: To maintain figure scale, text boxes present the average tPCBs concentration at stations with values significantly higher than other stations

### 2.2.3. Fish Tissue and Sediment Data Analysis Summary

Upper Roanoke Segment (headwaters to Roanoke arm of Smith Mountain Lake):

- Flathead catfish, margined madtom, and carp had the highest average PCB concentrations.
- The highest average fish tissue concentration was observed at station ROA202.20 (Roanoke River near the 13th St. Bridge).
- In general, average fish tissue PCB concentration levels are higher at stations farther downstream. PCB concentrations are observed in fish species collected along the entire VADEQ impaired segment but become > 500 ppb downstream of Peters Creek at station ROA206.80 (Roanoke River near Wasena Park at Route 11 bridge). Peters Creek coincides with the city limits of Roanoke.
- Higher PCB levels were noted downstream of Roanoke River mile 206.80 for all species that were collected both above and below this location.
- Average PCB concentrations exceeded the VADEQ impairment threshold (54 ppb) for at least one species at all stations downstream of Roanoke River mile 206.80.
- Tinker Creek—station TKR000.17 (Tinker Creek near Route 24)—recorded the highest average fish tissue PCB concentrations for a tributary.
- An increasing trend in average sediment PCB concentration is also observed downstream of Peters Creek. Concentrations reach a maximum at station ROA199.60 (Roanoke River above Niagra Dam). The dam is likely an area of suspended solids deposition.
- The only location of high sediment PCB concentrations in a tributary is observed at the mouth of Tinker Creek. High fish tissue and sediment PCB concentrations on and directly downstream of Tinker Creek suggest the possibility of PCB source(s) in this general location.

Lower Roanoke (Staunton) Segment (Leesville Dam downstream to Kerr Reservoir):

- The highest average PCB concentrations in the Roanoke River Basin were noted for lower Roanoke (Staunton) stations.
- The majority of fish species had average concentrations greater than the VADEQ impairment threshold. For fish species with more than 10 samples, sunfish had the lowest concentrations overall.
- Carp, striped bass, and flathead catfish had the highest average PCB concentrations.
- Downstream of Seneca Creek, station ROA108.09 (Roanoke River near Long Island) recorded the highest fish tissue PCB concentrations.
- In general, average fish tissue PCB concentrations are higher downstream of station ROA108.09 between the towns of Altavista and Brookneal.
- Average fish tissue concentrations seem to decrease between mainstem stations ROA108.09 and 97.07, near the town of Brookneal, before increasing again downstream at river mile 67.91, near Route 746, and generally decreasing thereafter.
- Exceedances of the VADEQ fish tissue threshold PCB concentration were observed on three tributaries, Little and Big Otter rivers and Cub Creek. The Little Otter River is a tributary to the Big Otter and flows through the city of Bedford. Sediment data collected at stations on the Big Otter River and its tributaries showed a maximum concentration of 5 ppb.
- Cub Creek recorded the highest average fish tissue PCB concentrations of any tributary stream segment, although the only sediment sample collected in the area was found to have concentration of less than 2 ppb.
- The only sediment monitoring stations on tributaries to record exceedances of the VADEQ SV were on Lynch Creek near Altavista Park (LYH000.02), an unnamed tributary located just west of the

Altavista STP that flows through the known PCB contaminated site BGF Industries (XXZ000.05), and an unnamed tributary near the town of Brookneal at Route 501 (ZZZ097.07).

- Two sediment monitoring stations on the Roanoke River mainstem recorded concentrations exceeding the VADEQ SV (ROA097.07 and 96.65). Both of these are near the town of Brookneal.
- Sediment and fish tissue monitoring data suggest that PCB sources might be in the towns of Altavista and Brookneal.

## 2.3. Water Column PCB Results

VADEQ conducted a special study in the Roanoke River basin in fall 2005 through spring 2008. The study was designed, in part, to augment the existing water quality record in support of TMDL development. Water quality samples were collected during low-flow and high-flow conditions at 29 monitoring locations throughout the watershed. Because of the hydrophobic properties of PCBs, earlier analytical methods used to process samples collected for prior monitoring studies routinely failed to detect measurable concentrations of PCBs. The special study results were processed using a high-resolution, low-detection level analysis method (1668A) specifically to account for PCBs' hydrophobic properties.

Figures 2-15 and 2-16 present the 25$^{th}$–75$^{th}$ percentile, range, average, and median of tPCBs concentrations recorded during high- and low-flow conditions at the special study water quality monitoring stations for the upper and lower Roanoke (Staunton). Where measured PCB concentrations at a station were significantly higher than at other stations located in the same section, the average concentration is given in a text box to maintain the scale of the figure. The TMDL water quality targets for the upper and lower sections are also included for points of reference. Stations are presented in an upstream–downstream progression for spatial analysis purposes according to the station river mile code and tributary point of confluence with the Roanoke River mainstem. Note that data collected in fall 2005 have been excluded from the analysis because of concerns of sample contamination. Data summaries for the special study water quality monitoring stations are presented in Appendix B.

Station IDs have been condensed for Figures 2-15 and 2-16 for the purpose of presentation where monitoring was done for only high- or low-flow conditions. Station IDs differ from those presented in the map of water column monitoring station locations (Figure 2-8) in that river miles are expressed as the highest significant digit, not as a standard five digits (eg. 56.1 vs. 056.10). Station ID waterbody codes and associated waterbody names are given in Table 2-6.

Trends in the water quality monitoring data are very similar to those observed in the fish tissue and sediment monitoring record. In the upper section of the Roanoke, a significant increase in tPCBs concentrations occurs between river mile 207.08 and 204.76. Along this length of the mainstem, the surrounding urban land use becomes progressively denser as one moves toward the city center of Roanoke. Many of the suspected contaminated sites in the upper section are also in this area, as discussed in Section 3.1. Upstream of river mile 207.08, all monitoring data is below the water quality target. High- and low-flow PCB concentrations peak at river mile 202.20 just upstream of the Tinker Creek confluence. High-flow concentrations decrease at river mile 199.20 at Niagra Dam, which could be due to the backwater effect of the dam and the reduction of flow turbulence and the resuspension of contaminated sediments. In addition, at all monitoring locations, low-flow tPCBs concentrations are lower than high-flow concentrations. This gives strong evidence of increased loading during storm events, which cause stormwater runoff and streambed sediment resuspension.

In the lower section of the Roanoke (Staunton), increases in water column tPCBs concentrations also correspond to the locations of suspected contaminated sites. At river mile 129.55, along the town of Altavista, a noticeable increase in tPCBs concentrations is seen. This increase becomes significant as one moves downstream to river mile 124.59 where high-flow concentrations exceeded 4,000 picograms per liter (pg/L). Very high water concentrations were recorded on two tributaries to the mainstem above this point at the mouth of Lynch Creek (LYH000.17) and an unnamed tributary (XLN000.00) that drains industrial sites in Altavista.

Water column concentrations remain elevated moving downstream to river mile 97.76, adjacent to the town of Brookneal, where the measured high-flow concentration also exceeded 4,000 pg/L. Downstream of Brookneal high-flow concentrations monitored on the Roanoke mainstem decrease, but remain well above the water quality target. Interestingly, below river mile ROA90.50 as the river approaches the Kerr Reservoir and the water starts to slacken, low-flow PCB concentrations begin to exceed high-flow concentrations. This could be because the reservoir is causing contaminated sediment to settle out and accumulate in these areas, which then contributes PCBs to the water column at a steady rate that is more apparent during low-flow conditions. Sediment monitoring data seem to generally support this conclusion, with an increase in PCB concentration noticeable downstream of river mile 97.07 (see Figure 2-13). Monitoring results for tributaries in the lower section are generally below the water quality target, with the exception of the two that run through the town of Altavista and the Big Otter River (BOR000.62), which exceeded criteria during high-flow conditions.

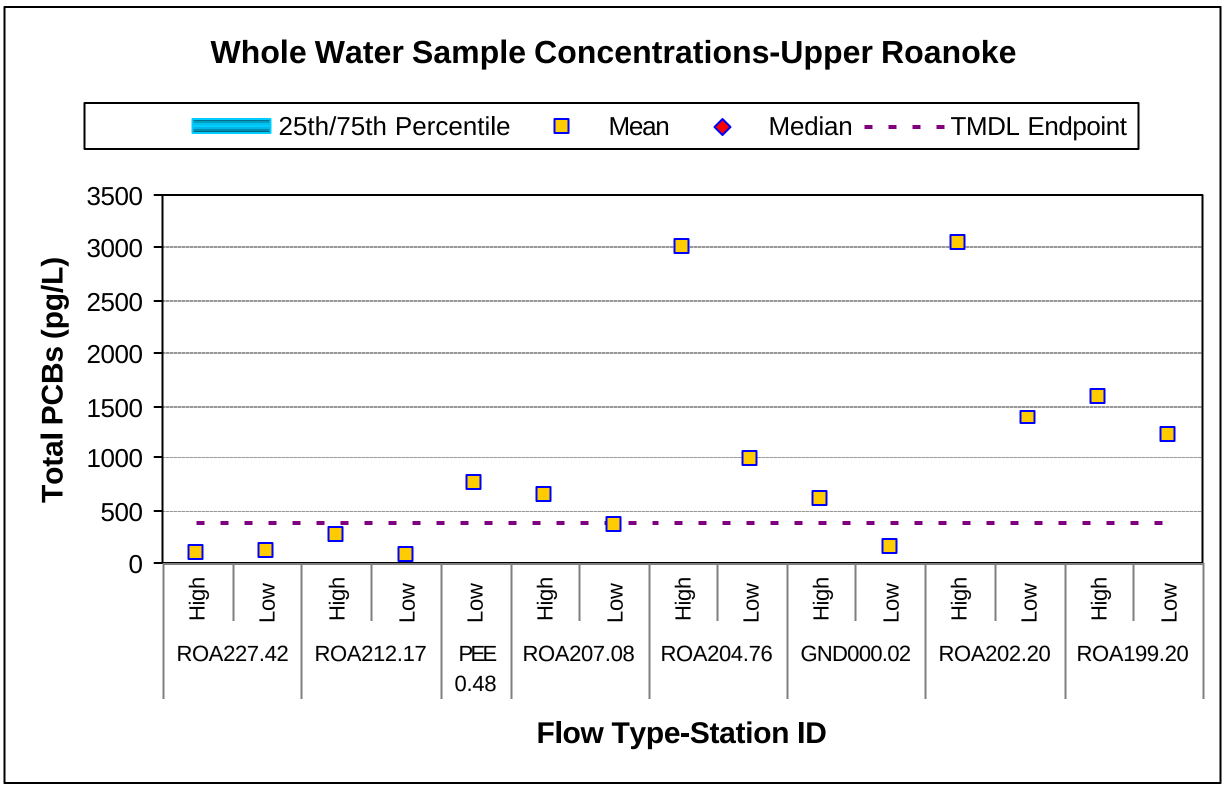


**Figure 2-15. Special study water column monitoring results for the upper Roanoke River.**

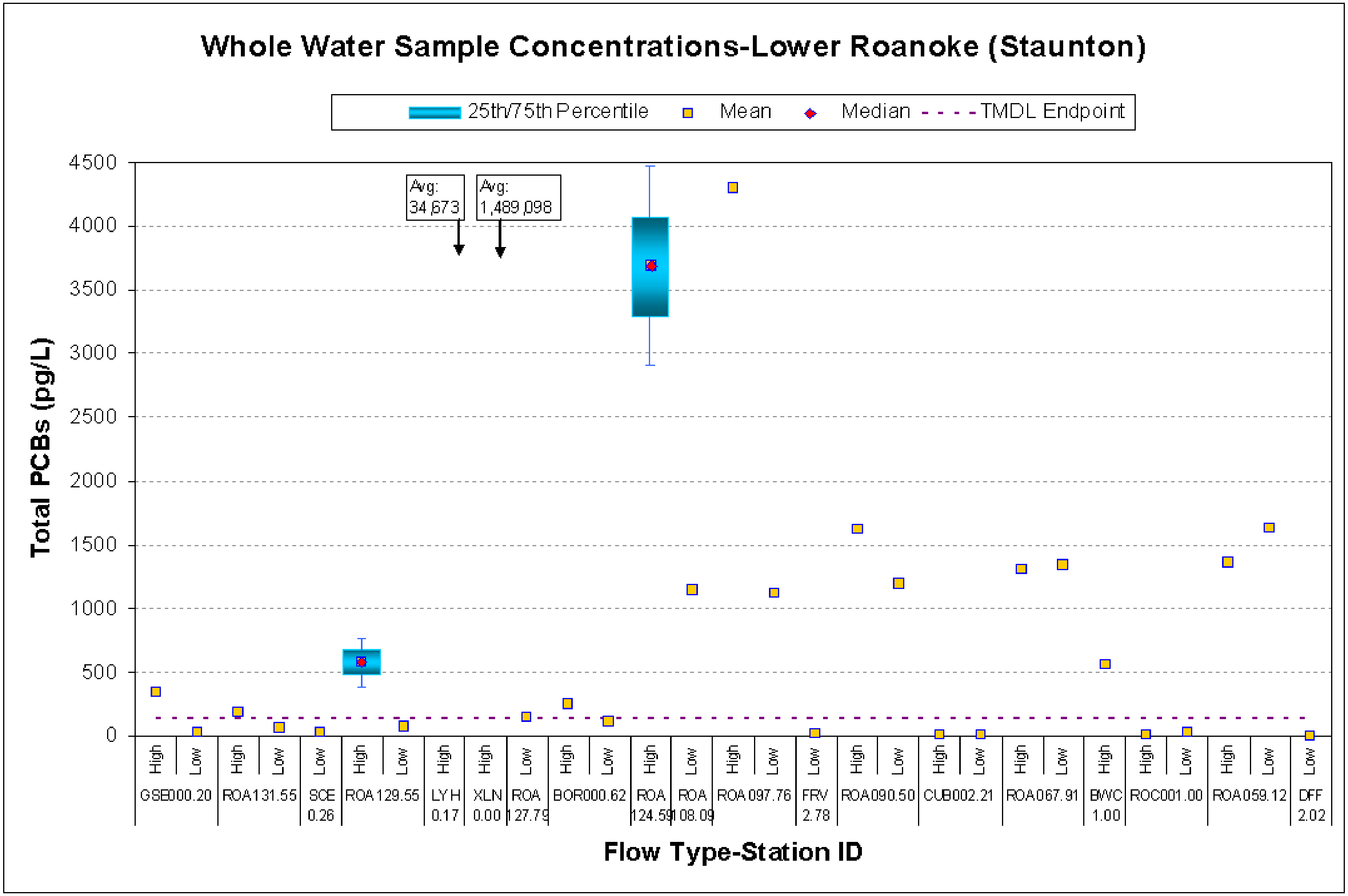


**Figure 2-16. Special study water column monitoring results for the lower Roanoke (Staunton) River.**
Note: To maintain figure scale, text boxes present the average tPCBs concentration at stations with values significantly higher than other stations

# 3. SOURCE ASSESSMENT

This section presents the information collected to date on point and nonpoint sources of PCBs in the Roanoke River basin. The development of PCB TMDLs in the Roanoke River watershed is subject to adaptive implementation and on-going source investigation whereby sources of PCB contamination are continuously being reviewed and updated based on the best available information. The following discussion of PCB sources, therefore, should be considered the most up-to-date information at the time of the development of these TMDLs, rather than a complete and final characterization. The discussion that follows is limited to identifying the sources represented in the TMDL. Discussion of the representation of sources within the TMDL model framework is presented in Section 5.0 and Appendix G.

For the purposes of this TMDL, sources of PCB loadings to a waterbody are defined as either current or legacy. Current sources generate PCB loads that have a defined, disruptable pathway to a waterbody. Such sources, in theory, can be controlled without eliminating the source of PCBs by blocking the pathway. Examples of current sources include PCB-contaminated soils that wash off from upland areas, leachate from landfills and industrial disposal areas, leaking transformers and storage containers, discharges of PCB-contaminated effluent, local deposition of atmospheric PCBs accumulated from off-gassing contaminated sites, and a variety of other sources.

Legacy sources generate PCB loads to a waterbody that cannot be easily controlled because there is no disruptable pathway from the source to the affected waterbody. Control of the source requires its direct removal. In all cases, the source exists at an interface with the waterbody where there is continuous exchange of material. Examples of legacy sources include in-stream contaminated sediments, stream bank soils that are not part of a contaminated site, biota, and background atmospheric deposition to surface waters.

Both current and legacy sources are represented in the TMDL model framework. For discussion of the methodology used to define source loads, see Section 5.0 and Appendix G.

## 3.1. Source Inventory/Current Sources

VADEQ has conducted several site investigations and special studies in recent years to assess the spatial extent of PCB contamination in the Roanoke basin and to identify current sources generating PCB loads in the watershed. An inventory was created to organize all existing data related to efforts to identify and characterize facilities/sites where PCBs may have been used, stored, or disposed of.

The information compiled includes various memos and other correspondence, public meeting records, site investigations, VADEQ monitoring data and special studies, pollution complaint records, solid waste facility information, VPDES facility information, Toxic Substance Control Act (TSCA) data, Comprehensive Environmental Response Compensation and Liability Act (CERCLA) records, Resource Conservation and Recovery Act (RCRA) database records, and other available information. Such records were examined in conjunction with the available PCB fish tissue and sediment monitoring data to identify possible sources of PCBs in the Roanoke River watershed. In the early stages of the TMDL study, a PCB source database was created to inventory historical PCB monitoring data at facilities in the upper Roanoke watershed.

After a review of the collected records and monitoring data, the conclusions that were drawn were used to design a 2005 special study that included monitoring effluent at selected facilities, collecting water column samples, and deploying SPMDs at various locations throughout the watershed. This special study was ultimately expanded into the fall 2005 through spring 2008 special study, which included three rounds of sampling conducted October 13, 2005–January 31, 2006, August 7, 2007–September 10, 2007, and July 1, 2007–May 9, 2008. Monitoring for the expanded study included the media originally planned to be sampled in 2005, as well as sediment and facility sludge monitoring.

### 3.1.1. Point Sources

Thirteen point sources are represented as current PCB sources in the TMDL. Three sites (Dan River, Inc.; Burlington Industries; and the town of Altavista Sewage Treatment Plant) are also represented as nonpoint sources (see Section 3.1.2). Table 3-1 lists the sites represented as point sources and Figure 3-1 shows their locations.

Facility outfalls were represented as PCB point sources if results from the 2005–2008 VADEQ special study found the facility has contributed a PCB load. VADEQ also requested that applicable facilities be included as determined using their PCB point source monitoring guidance (VADEQ, 2009).

**Table 3-1. Model PCB point source dischargers**

| NPDES facility name | Facility type | NPDES ID | Outfall | Design flow (MGD) | Receiving stream |
|---|---|---|---|---|---|
| **Upper Roanoke River** | | | | | |
| Blacksburg Country Club | Sewerage systems | VA0027481 | 001 | 0.035 | NF Roanoke River |
| Montgomery County PSA - Shawsville STP | Sewerage systems | VA0024031 | 001 | 0.2 | SF Roanoke River |
| Montgomery County PSA - Elliston Lafayette WWTP | Sewerage systems | VA0062219 | 001 | 0.25 | SF Roanoke River |
| Steel Dynamics | Steel works | VA0001589 | 005 | 0.067 | Peters Creek |
| Norfolk Southern Railway Co – Shaffers Crossing | Railroads, line-haul operating | VA0001597 | 002 | 0.07 | Peters Creek |
| WVWA Roanoke Regional Water Pollution Control Plant | Sewerage systems | VA0025020 | 001 | 55 | Roanoke River |
| **Lower Roanoke (Staunton) River** | | | | | |
| ITG Burlington Industries LLC Hurt Plant | Fabrics finishing | VA0001678 | 001 | 3.42 | Roanoke (Staunton) River |
| Old Dominion Pittsylvania Power Station | Electric services | VA0083399 | 001 | 0.192 | Roanoke (Staunton) River |
| Altavista - Wastewater Treatment Plant | Sewerage systems | VA0020451 | 001 | 3.6 | Roanoke River |
| Old Dominion Altavista Power Station | Electric services | VA0083402 | 001 | 0.117 | Roanoke (Staunton) River |
| Dan River, Inc - Brookneal | Fabrics finishing | VA0001538 | 001 | 1.326 | Roanoke (Staunton) River |
| Brookneal - Staunton River Lagoon | Sewerage systems | VA0022241 | 001 | 0.078 | Roanoke (Staunton) River |
| Old Dominion Clover Power Station | Electric services | VA0083097 | 001 | 1.735 | Roanoke (Staunton) River |

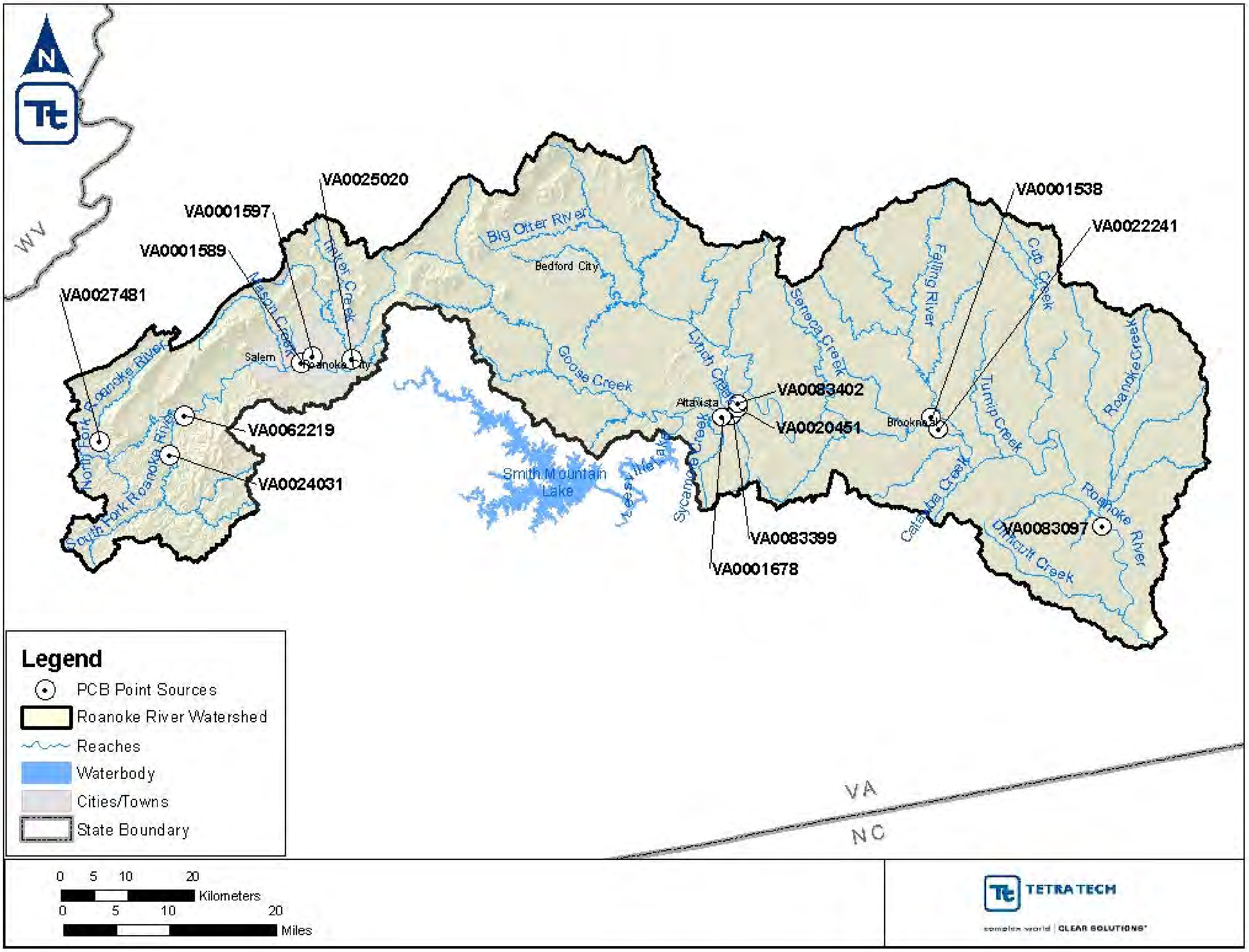


Figure 3-1. Model PCB point sources.

### 3.1.2. Nonpoint Sources

Twenty-one nonpoint sources are represented as current PCB sources in the TMDL. Three sites (Dan River, Inc.; Burlington Industries; and the town of Altavista Sewage Treatment Plant) are both point and nonpoint sources (see Section 3.1.1). Table 3-2 lists the sites represented as nonpoint sources and Figures 3-2 through 3-4 present their locations.

Areas represented as nonpoint sources include sites where analysis of on-site soil samples found measurable concentrations of PCBs. Available results for on-site soil sampling were obtained from four sources: *PCB Source Investigation: Altavista and Hurt* (VADEQ 1999), *Analysis of Brownfield Cleanup Alternatives Former Virginia Scrap Iron & Metal Company, Inc. Property* (City of Roanoke 2008), a *Site File Review for PCBs in the Roanoke River Watershed* that was completed as part of a CERCLA preliminary assessment (USEPA 1999a), and the VADEQ PCB source survey database.

Not all TMDL-represented nonpoint sources have available soil sampling results confirming PCB contamination. The Altavista east- and west-town dumps and Dan River, Inc., are characterized as contaminated sites because of the following considerations:

- The Altavista east- and west-town dumps were included as sampling sites in the *Altavista/Hurt PCB Source Investigation* (VADEQ 1999) but were ultimately not sampled because of concerns of safety risks. Numerous facilities adjacent to the dumps are known contaminated sites, however, and the dumps are known to be historical disposal areas for local industry.
- Dan River, Inc., is a fabrics finishing plant similar to the known contaminated site BGF industries. Effluent monitoring results also show that the facility has contributed a PCB load.

Research has also shown that off-gassing from PCB-contaminated sites can cause local deposition of atmospheric PCBs and contribute loads to a waterbody (Totten et al. 2004). Although no data exists to represent this process for the Roanoke River watershed, it could be considered in future TMDL studies if data become available. Background atmospheric deposition of PCBs represented as a legacy source is represented in the TMDL. For further information, see the discussion of legacy sources.

**Table 3-2. Model PCB contaminated sites**

| Site name | NPDES ID | Site/facility description | County/city | Receiving stream |
|---|---|---|---|---|
| **Upper Roanoke River** | | | | |
| Dixie Caverns Landfill | VAD980552095[b] | Landfill | Roanoke | Roanoke River |
| Roanoke River Floodway Bench Cuts | | Areas along the Roanoke River mainstem where the floodplain has been expanded | Roanoke | Roanoke River |
| Norfolk Southern 12 | | Railroads, line-haul operating | Roanoke City | Roanoke River |
| Evans Paint | VASFN0305570[b] | Former chemical manufacturing plant (Evans Chemical) | Roanoke City | Roanoke River |
| Virginia Scrap Iron Co. | VRP00408[c] | Site of an old metal scrap yard | Roanoke City | Roanoke River |
| Norfolk Southern 1 | | Railroads, line-haul operating | Roanoke City | Roanoke River |
| Tinker-American Electric Power (AEP) property | | Electric Services | Roanoke City | Roanoke River |
| Riverdale Development (formerly American Viscose Co.) | VRP00394[c] | Fabrics finishing plant | Roanoke City | Roanoke River |
| Appalachian Power Co. (APCO) Yard | | Electric Services | Roanoke City | Roanoke River |
| Jacob Webb | | Personal residence (unknown location) | Roanoke City | Roanoke River |
| **Lower Roanoke (Staunton) River** | | | | |
| Burlington Industries-Altavista Hurt[a] | VA0001678 | Fabrics finishing plant | Pittsylvania | Sycamore Creek |
| English Construction | | Landfill | Pittsylvania | Roanoke (Staunton) River |
| West town dump-Altavista | | Landfill | Campbell | Lynch Creek |
| Oil distributors-Altavista | | Current location of three adjacent oil distributors and common *wet* area | Campbell | Lynch Creek |
| Lane Furniture Co. | | Site of old furniture manufacturing plant | Campbell | Roanoke (Staunton) River |
| BGF Industries[a] | | Fabrics finishing plant | Campbell | Roanoke (Staunton) River, UT |
| East town Dump-Altavista | | Landfill | Campbell | Roanoke (Staunton) River |
| Altavista STP | VA0020451 | Sewerage system | Campbell | Roanoke (Staunton) River |
| A. O. Smith | | Electric motor manufacturing | Campbell | Roanoke (Staunton) River, UT |
| Schrader Bridgeport[a] | | Metal plating and rubber valve manufacturing | Campbell | Roanoke (Staunton) River, UT |

| Site name | NPDES ID | Site/facility description | County/city | Receiving stream |
|---|---|---|---|---|
| Dan River, Inc. | VA0001538 | Fabrics finishing plant | Campbell | Roanoke (Staunton) River |

a. Where a contaminated site is covered by a stormwater permit, the source is considered a stormwater site for TMDL purposes (See Section 3.1.3)
b. EPA Superfund ID#
c. Virginia Voluntary Remediation Program (VRP) site#

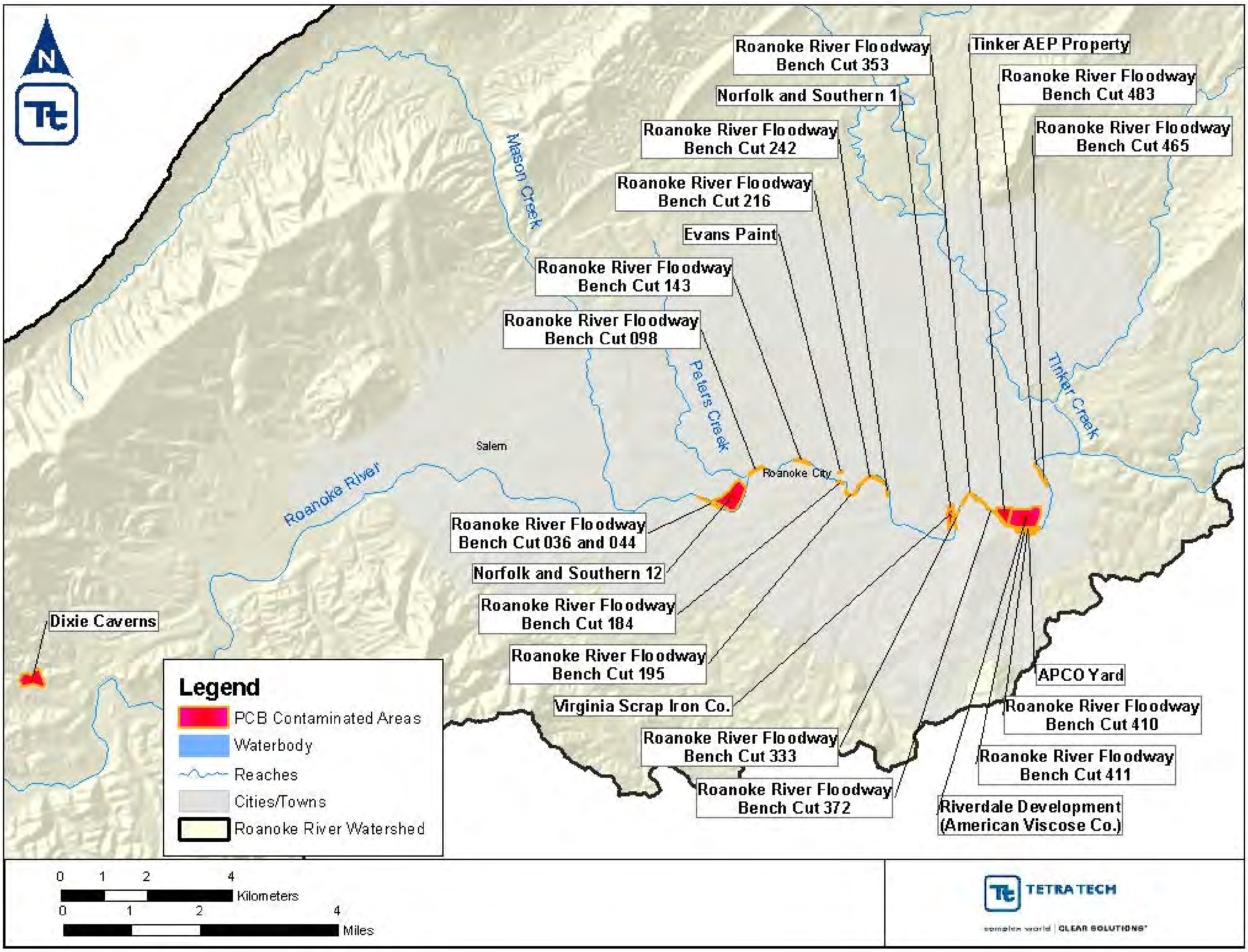


**Figure 3-2. Model nonpoint source areas—Roanoke.**

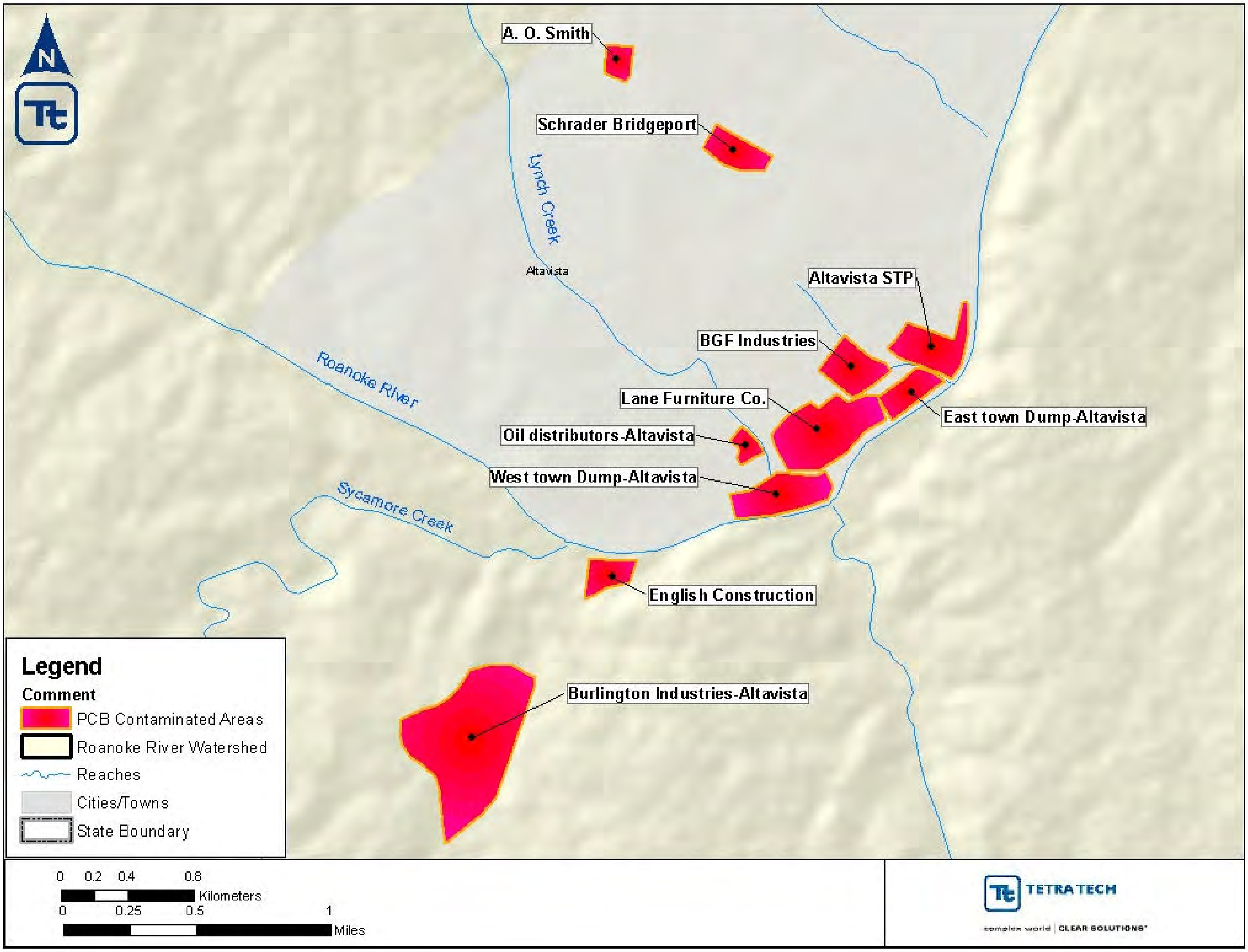


**Figure 3-3. Model nonpoint source areas—Altavista.**

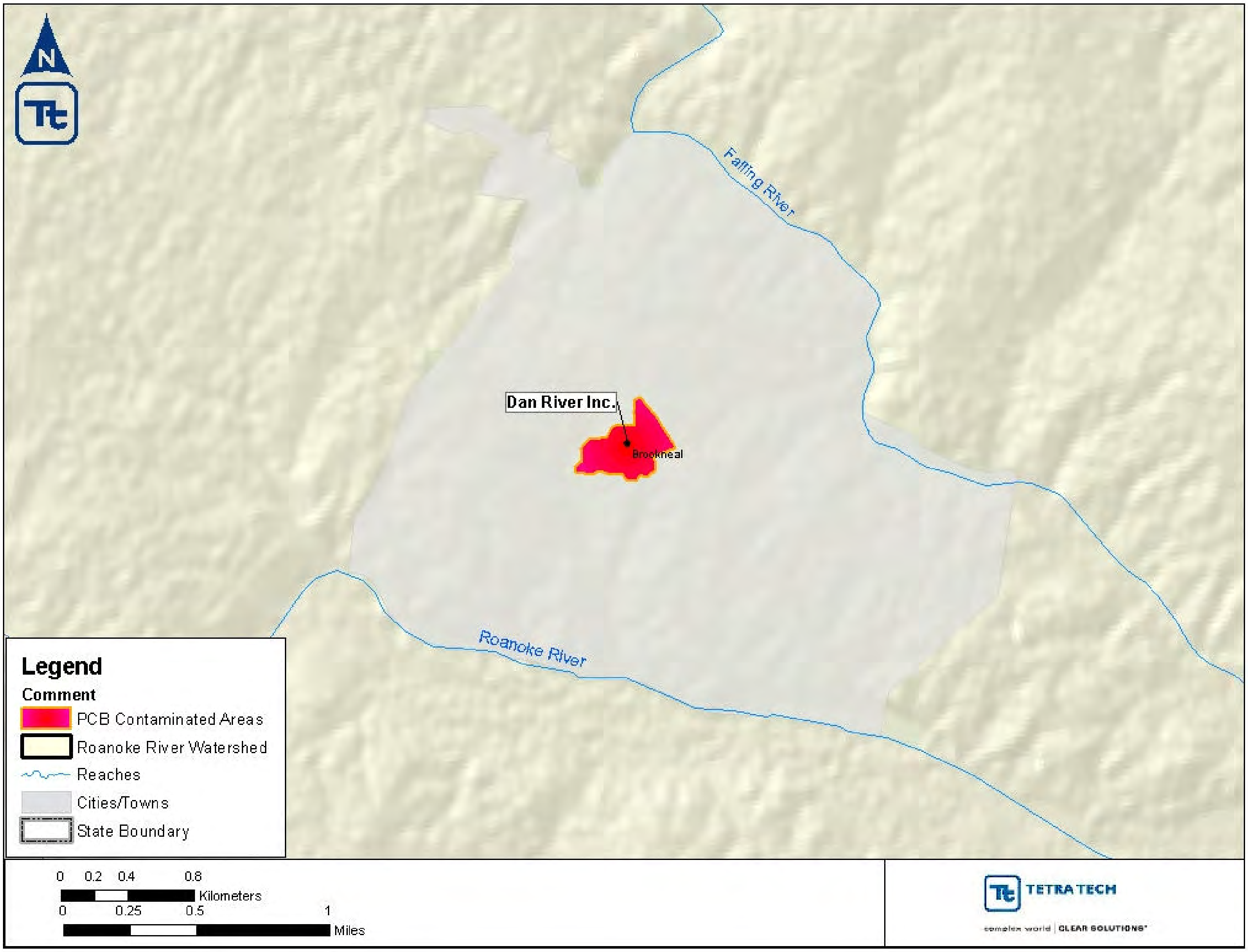


**Figure 3-4. Model nonpoint source areas—Brookneal.**

### 3.1.3. MS4s/Stormwater Permits

On November 22, 2002, EPA's Office of Wetlands, Oceans and Watersheds and Office of Wastewater Management issued a memorandum, *Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs* (USEPA 2002), that updated previous regulation and finalized requirements under which municipal separate storm sewer systems (MS4s) are treated as point sources when calculating TMDLs. As a result, pollutant loadings from MS4s and facilities and sites issued general stormwater permits must be explicitly accounted for when calculating TMDLs.

MS4s in the Roanoke River basin are listed in Table 3-3 and presented in Figure 3-5. A list of active stormwater permits issued to facilities and sites in the basin is provided in Appendix C. Loads from contaminated sites within the spatial extent of an MS4 or site permitted for stormwater are considered a component of the associated MS4 or general stormwater permit. Where a stormwater permit is located within an MS4, the load is assigned to the stormwater permit. Section 5.0 and Appendix G discuss the representation of loads generated by nonpoint source contaminated sites.

**Table 3-3. MS4s in the Roanoke River watershed**

| MS4 permit holder | Permit number | Area (acres) |
|---|---|---|
| Roanoke County | VAR040022 | 28,907 |
| City of Roanoke | VAR040004 | 23,577 |
| Botetourt County | VAR040023 | 5,180 |
| City of Salem | VAR040010 | 9,332 |
| Town of Blacksburg | VAR040019 | 1,613 |
| Town of Christiansburg | VAR040025 | 1,193 |

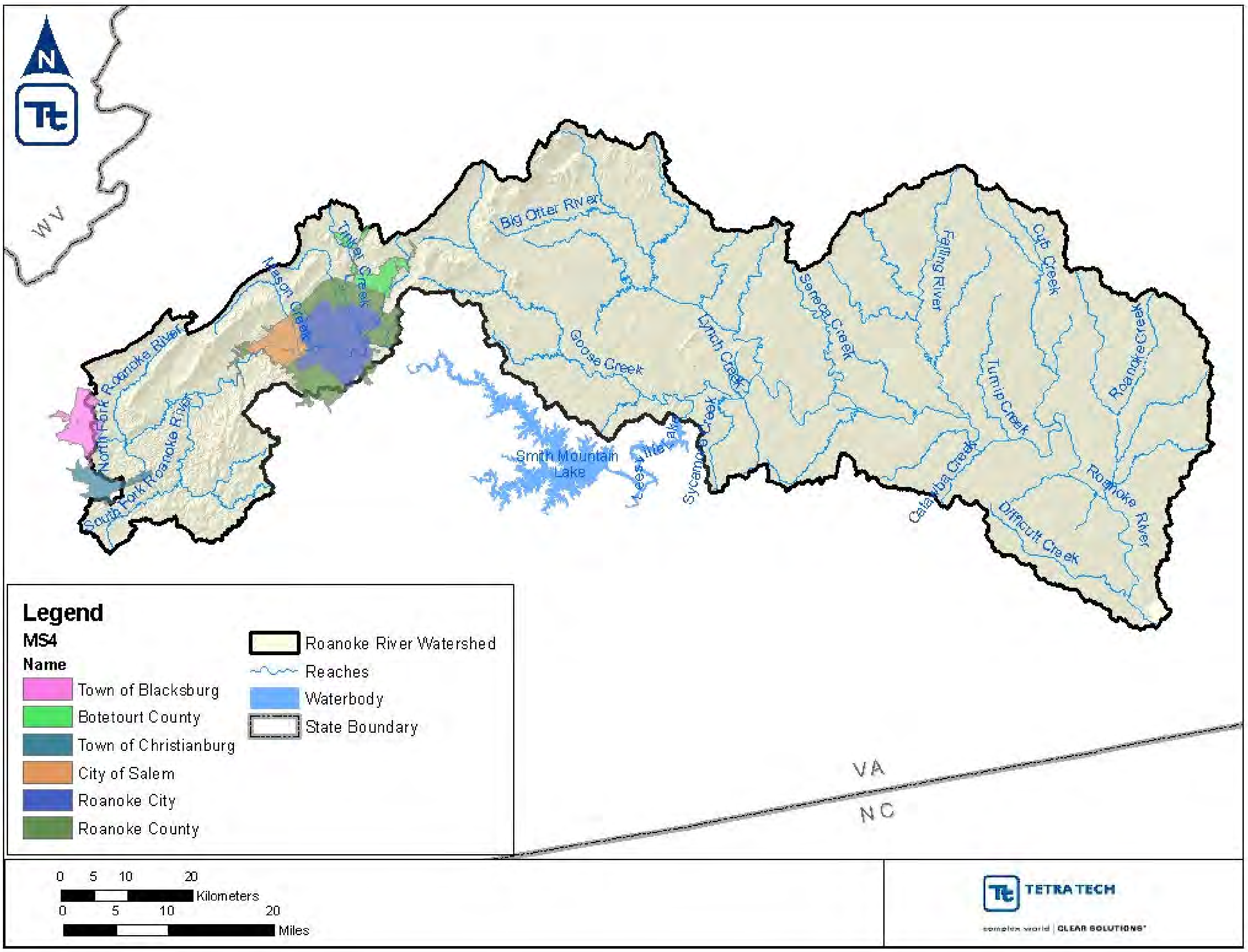


**Figure 3-5. Model MS4 areas.**

## 3.2. Legacy Sources

Legacy sources represented in the TMDL include loadings of PCBs from contaminated streambed and background atmospheric deposition of PCBs to surface waters. These sources exist at an interface with the affected waterbody and do not have a loading pathway that can be easily controlled.

### 3.2.1. Atmospheric Deposition

The wide-spread use of PCBs before their ban in the 1970s coupled with their stable molecular structure has caused a generalized distribution of the pollutant in air, soil, and water at background concentrations. The net flux of gaseous PCBs between the atmosphere and the surface of a waterbody is a function of the dynamic concentration gradient between the two. Atmospheric deposition has been shown to be a significant pathway of PCB cycling in freshwater systems (PADEP 2001).

### 3.2.2. Streambed Sediments

Streambed sediments can contain significant concentrations of PCBs from historical or current loadings or both. These PCBs can be released to the water column by resuspension of streambed sediments and desorption of PCBs, desorption of PCBs at the streambed-water column interface, and the direct diffusion of PCBs from lower contaminated sediment layers.

The movement and accumulation of streambed sediments are governed by in-stream processes. Contaminated streambed sediments are available for consumption by aquatic biota, are transported downstream, and can be buried under additional sediments. Downstream transport can result in sediments being flushed out of the system or being trapped behind downstream dams. Existing PCB projects, such as the Hudson River project in New York and the Housatonic River project in Massachusetts, have found that historical discharges have resulted in contaminated sediments, which tend to collect in slow river stretches or reservoirs. The contaminated sediments tend to remain in such depositional areas until they are dredged or dislodged by storms.

# 4. TMDL TECHNICAL APPROACH

Establishing the relationship between the in-stream water quality targets and source loadings is a critical component of TMDL development. It allows for evaluation of management options that will achieve the desired source load reductions necessary to meet water quality standards. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses with flow and loading conditions.

The objective of the Roanoke PCB TMDL study is to identify the sources of PCB contamination and to determine the reductions required to achieve water quality criteria for PCB impaired segments. This section presents an overview of the modeling approach for developing PCB TMDLs for the Roanoke River basin. For a more detailed discussion of the TMDL technical approach see Appendix G.

## 4.1. Critical Considerations

The pollutant of concern for the current modeling application is tPCBs. PCBs are a hydrophobic nonpolar organic chemical species that tend to associate with fine sediments. PCBs associate with sediments by the process of adsorption. Adsorption describes the tendency of PCBs to accumulate on the surface of sediments in an aqueous environment as a function of energetic favorability, where the strength of the PCB-sediment association is proportional to the availability of adsorption surfaces (TSS concentration), sediment organic content, and the PCB species degree of chlorination.

Land use in the Roanoke River basin includes extensive areas of largely undeveloped forest and pastoral lands and relatively small areas of concentrated development. Each land use affects the hydrology and sediment loads of the basin in a different way. Available monitoring data, as described in Section 2.2, suggests that potential sources of PCBs are often associated with developed land uses.

## 4.2. Modeling Framework

A watershed modeling framework, consisting of the Loading Simulation Program C++ (LSPC) with sediment PCB modeling enhancements, was used to develop PCB TMDLs for the Roanoke River basin. A watershed model is a series of algorithms that integrate meteorological forcing data and watershed characteristics to simulate upland and tributary routing processes, including hydrology and pollutant transport. Once a model has been adequately set up and calibrated and the dominant unit processes are deemed representative on the basis of comparison with available monitored conditions, it becomes a useful tool to quantify existing flows and loads from tributaries without gages and from diffuse overland flow sources.

### 4.2.1. Loading Simulation Program C++ (LSPC)

EPA-approved LSPC (http://www.epa.gov/athens/wwqtsc/html/lspc.html) was selected for Roanoke River watershed modeling. LSPC is a watershed modeling system that includes Hydrologic Simulation Program–FORTRAN (HSPF) algorithms for simulating watershed hydrology, erosion, and water quality processes, as well as in-stream transport processes. During the past several years it has been used to develop hundreds of EPA-approved TMDLs, and it is generally considered the most advanced hydrologic and watershed loading model available.

HSPF is a comprehensive watershed and receiving water quality modeling framework that was originally developed in the mid-1970s. The hydrologic portion of HSPF/LSPC is based on the Stanford Watershed Model (Crawford and Linsley 1966), which was one of the pioneering watershed models. The HSPF framework is composed of modules with components that can be assembled in different ways, depending on the objectives of the project. The model includes three major modules:

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

All three modules include many submodules that calculate the various hydrologic, sediment, and water quality processes in the watershed. Table 4-1 lists the modules from HSPF that are used in LSPC.

**Table 4-1. HSPF modules included in LSPC**

| | | |
|---|---|---|
| **Receiving water modules (RCHRES)** | HYDR | Simulates in-stream hydraulic behavior |
| | ADCALC | Simulates in-stream advection of dissolved or entrained constituents |
| | CONS | Simulates in-stream conservative constituents |
| | HTRCH | Simulates in-stream heat exchange |
| | SEDTRN | Simulates in-stream behavior of inorganic sediment |
| | GQUAL | Simulates in-stream behavior of a generalized quality constituent |
| **Watershed modules PERLND/IMPLND** | SNOW | Simulates snow fall, accumulation, and melting |
| | PWATER/IWATER | Simulates water budget for a pervious/impervious land segment |
| | SEDMNT/SOLIDS | Simulates production and removal of sediment for a pervious/impervious land segment |
| | PSTEMP | Simulates soil layer temperatures |
| | PWTGAS/IWTGAS | Estimates water temperature and dissolved gas concentrations in the outflows from pervious/impervious land segments |
| | PQUAL/IQUAL | Simulates water quality in the outflows from pervious/impervious land segments |

Source: (Bicknell et al. 1997)

Spatially, the watershed is divided into a series of subbasins or subwatersheds representing the drainage areas that contribute to each of the stream reaches. These subwatersheds are then further subdivided into segments representing different land uses. For the developed areas, the land use segments are further divided into pervious (PERLND) and impervious (IMPLND) fractions. The stream network (RCHRES) links the surface runoff and subsurface flow contributions from each of the land segments and subwatersheds and routes them through the waterbodies using storage-routing techniques. The stream network is constructed to represent all the major tributary streams, as well as different portions of stream reaches where significant changes in water quality occur.

Important routines for water quality simulation include the QUAL and SED modules, both of which have PERLND/IMPLND and RCHRES components that define the upland and in-stream characteristics of each. Together, these routines provide the basic framework for simulating pollutant loading and transport in a watershed.

# 5. MODEL SETUP

An LSPC model was configured for the areas contributing to TMDL impaired streams (see Section 1.2) in the Roanoke River basin as a series of hydrologically connected subwatersheds. Configuration of the model involved subdividing the watersheds into modeling units, followed by continuous simulation of flow and water quality for the units using meteorological, land use, soils, stream, and water quality data. Developing and applying the watershed model to address the project objectives involved the following major steps:

1. Watershed Segmentation
2. Configuration of Key Model Components
3. Representation of Watershed Sources
4. Model Calibration and Validation

The model configuration steps are presented briefly in the discussion that follows. For a more detailed explanation of each, see Appendix G.

## 5.1. Watershed Segmentation

Watershed segmentation refers to subdividing the entire watershed into small, discrete subwatersheds for modeling and analysis. Subwatersheds represent hydrologically connected modeling units and capture the drainage areas of their associated stream segments. The delineated subbasins represent the scale at which model simulations take place.

The Roanoke River watershed was divided into two separate segments for modeling purposes—the upper Roanoke, which extends from its headwaters downstream to Niagra Dam, and the lower Roanoke (Staunton), which includes the length of the River from Leesville Dam downstream to its confluence with the Dan River. These large segments were further subdivided into subbasins primarily using the watershed stream network, locations of PCB sources, and topographic variability, and secondarily using the locations of available water quality, fish tissue, and sediment PCB monitoring stations; the locations of USGS continuous stream flow gages; and existing watershed boundaries [Virginia subwatersheds (VAWATBOD) developed by VADEQ]. Delineating the Roanoke River watershed resulted in 45 and 107 model subwatersheds for the upper and lower Roanoke (Staunton) segments, respectively (Figures 5-1 and 5-2).

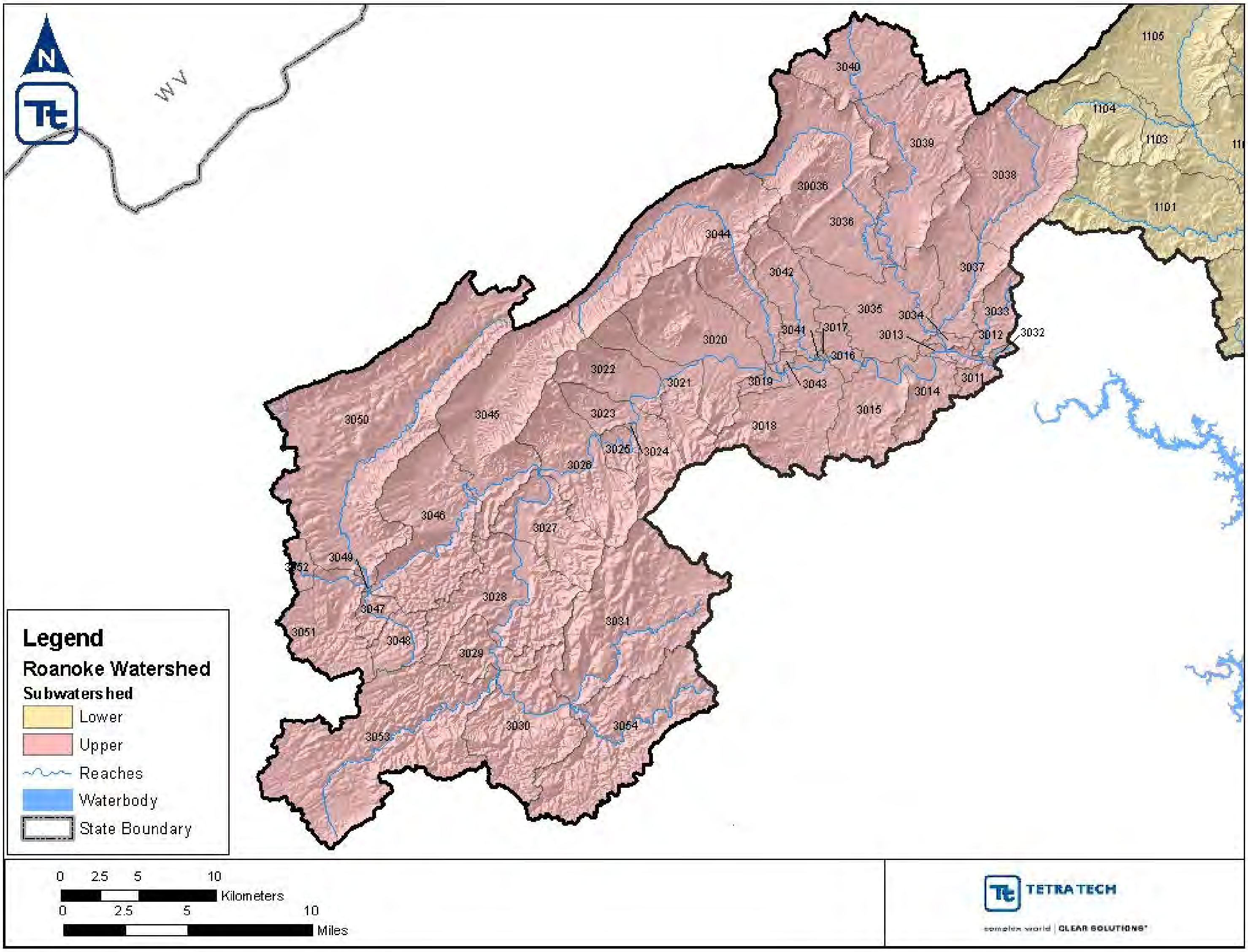


Figure 5-1. Subwatershed divisions of the upper Roanoke.

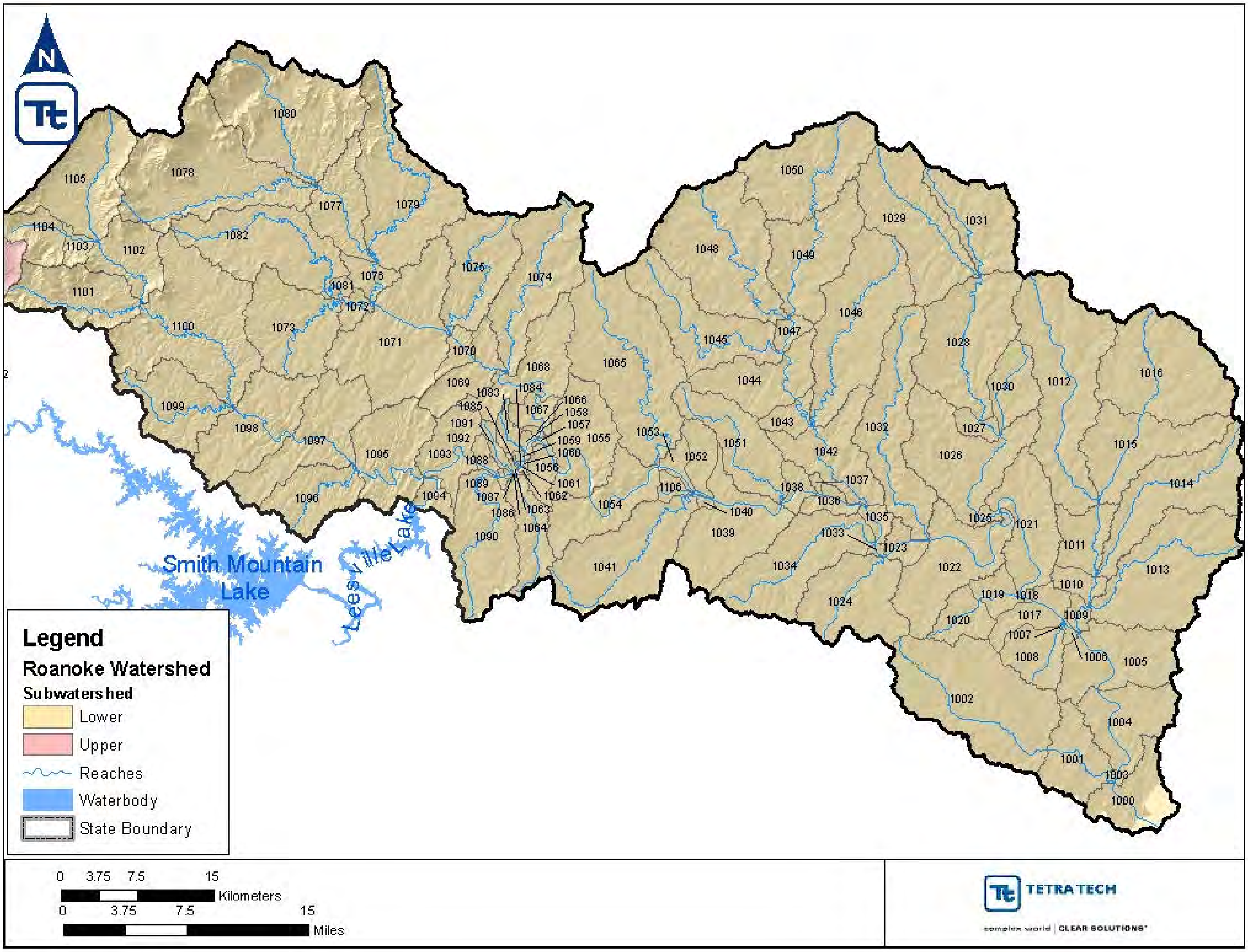


**Figure 5-2. Subwatershed divisions of the lower Roanoke (Staunton).**

## 5.2. Configuration of Key Model Components

Configuring the model involved considering three major components, all of which provide the basis for the model's ability to estimate stream flow:

- Meteorological data, which drives the watershed model
- Land use representation, which provides the basis for distributing soils and pollutant loading characteristics throughout the basin
- Watershed physical attributes, which provide the basis for estimating stream channel geometry

### 5.2.1. Meteorology

Hydrologic processes depend on changes in environmental conditions, particularly weather. As a result, meteorological data are a critical component of the watershed model. These data are the driver of LSPC algorithms simulating watershed hydrology and water quality; thus, accurately representing climactic conditions is required to develop a valid modeling system.

Key meteorological data were accessed from NOAA's National Climatic Data Center (NCDC) to develop a representative data set for the study area covering the modeling period. NCDC stores and distributes weather data gathered by the Cooperative Observer Network (COOP) and Weather Bureau Army-Navy (WBAN) airways stations throughout the United States. COOP stations record hourly or daily rainfall data, while airways stations record various climactic data at hourly intervals, including rainfall, temperature, wind speed, dew point, humidity, and cloud cover.

### 5.2.2. Land Use and Soils Data

LSPC requires a basis for distributing hydrologic parameters. This is necessary to appropriately represent hydrologic variability throughout the watershed, which is influenced by land surface and subsurface characteristics. It is also necessary to represent variability in pollutant loading, which is highly correlated to land practices. The basis for this distribution was provided by land use and soils GIS data coverages for the watershed.

General land use/land cover data sets for the Roanoke River watershed were extracted from the NLCD database (MRLC 2001) (see Section 2.1.1). The land use/land cover data were overlain with the hydrologic soil group data described in Section 2.1.1 to create a composite data layer that describes both land cover and soil group distribution in the watershed (Figure 5-3). The composite layer was used as the model land use allowing for the accurate representation of hydrologic variability at the subbasin level by taking into account both land surface and subsurface characteristics.

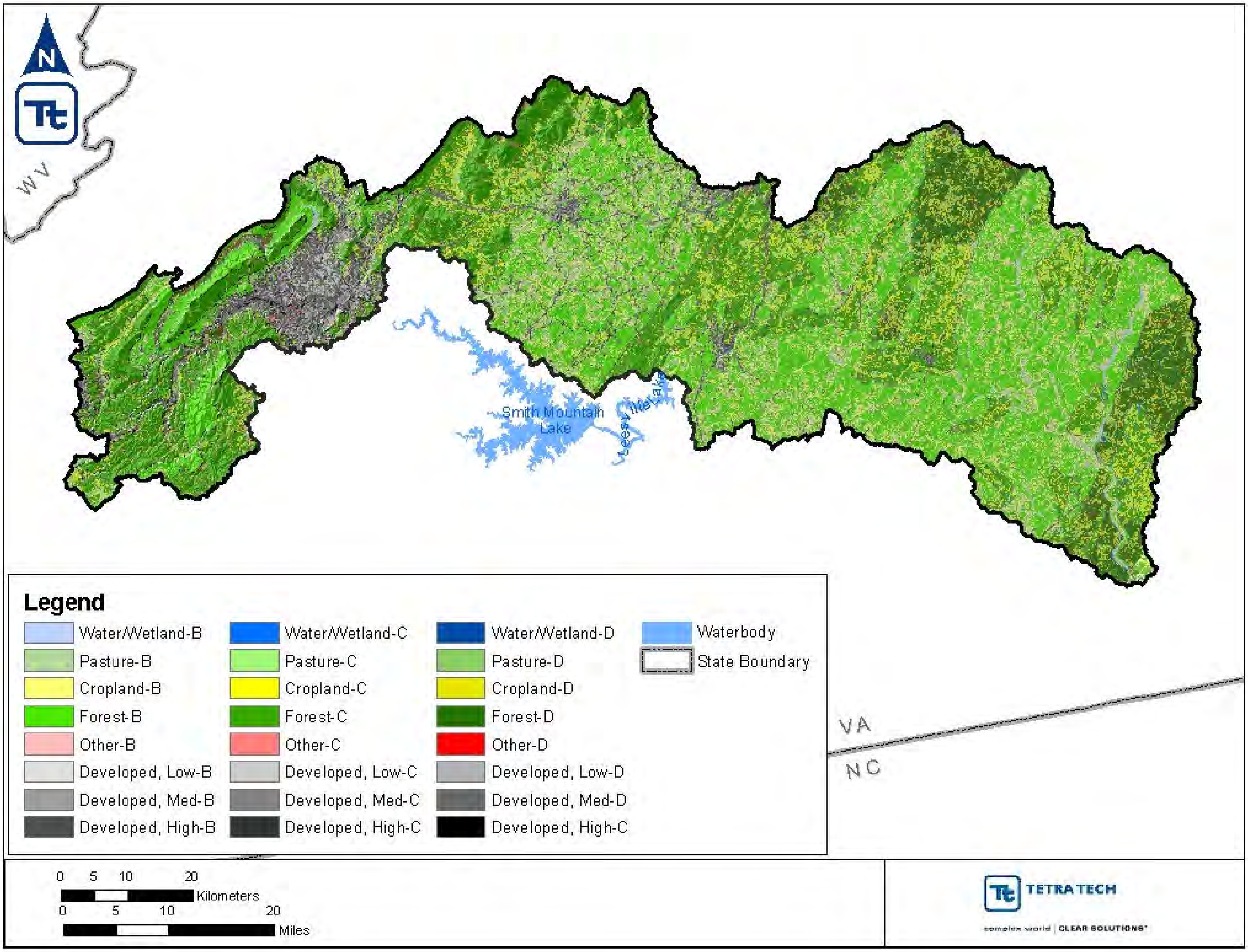


**Figure 5-3. Composite model land use.**

### 5.2.3. Elevation Data/Stream Characteristics

LSPC requires a representative stream reach for each subwatershed to route flow throughout the subwatershed network. The stream network connects all the subwatersheds represented in the watershed model. Watershed elevation data derived from the NED (see Section 2.1.3) was used to estimate stream channel slope (USGS 2009).

LSPC requires that each subwatershed-representative stream reach be assigned to a stream class. A stream class defines the model parameters related to the simulation of in-stream pollutant transport and fate processes. A single stream class can be used to define these parameters for all representative stream reaches, or multiple stream classes can be defined in the model allowing parameter variability between stream reaches. For the Roanoke River LSPC model, an individual stream class was defined for each representative stream reach. This approach allowed a unique set of parameters to be assigned to each of the 152 reaches, 107 in the lower and 45 in the upper, corresponding to each model subwatershed.

## 5.3. Source Representation

The Roanoke River PCB TMDL model considers TSS and PCB sources. Sources of TSS include nonpoint sources associated with the erosion and upland soils washoff and point source discharges from facilities. TSS sources are included in the model setup because the representation of TSS point sources is required to accurately represent watershed hydrology, and nonpoint sediment loadings are the vehicle for sediment-associated PCB loadings.

PCB sources are defined as either current or legacy as described in Section 3.0. Both current and legacy sources are considered by the LSPC model representation of the Roanoke River basin. Current sources are point source dischargers, contaminated sites, urban background including unidentified contaminated sites, and areas covered by general stormwater permits and MS4s. All legacy sources are nonpoint and include in-stream contaminated sediments and atmospheric deposition to surface waters. Available data were plotted in GIS and, as appropriate, assigned to the defined model subbasins, segments, and land uses.

The development of PCB TMDLs in the Roanoke River watershed is subject to adaptive implementation and ongoing source investigation whereby sources of PCB contamination are continuously being reviewed and updated on the basis of the best available information. The following discussion of PCB sources, therefore, should be considered the most up-to-date information at the time of the development of the TMDLs, rather than a complete and final characterization.

### 5.3.1. TSS Sources

An inventory of discharge monitoring reports (DMRs) for facilities permitted for point source discharges of TSS in the Roanoke River watershed was provided by VADEQ. In the Roanoke River watershed, 52 facilities representing 55 outfalls are permitted for discharging TSS loads. Effluent from such facilities is represented at the rate and concentrations presented in the DMRs, where available, or at design flow and concentration limits where records were unavailable. Tables 5-1 and 5-2 present the National Pollutant Discharge Elimination System (NPDES) IDs, names, receiving water, design flow, and average concentration limit for facilities in the upper and lower model segments, respectively.

**Table 5-1. Model TSS point sources—Upper Roanoke model segment**

| Facility name | NPDES ID | Outfall | Design flow (mgd) | Receiving stream | Avg. conc. limit (mg/L) |
|---|---|---|---|---|---|
| WVWA Falling Creek Water Treatment Plant | VA0001465 | 001 | 0 | Falling Creek | 30 |
| WVWA Carvins Cove Water Filtration Plant | VA0001473 | 001 | 0 | Carvins Creek, unnamed tributary 1 | 30 |
| WVWA Carvins Cove Water Filtration Plant | VA0001473 | 002 | 0 | Carvin Creek unnamed tributary 2 | 30 |
| WVWA Carvins Cove Water Filtration Plant | VA0001473 | 003 | 0 | Carvin Creek unnamed tributary 2 | 30 |
| Steel Dynamics | VA0001589 | 005 | 0.039 | Peters Creek | No limit |
| Norfolk Southern Railway Co - Shaffers Crossing | VA0001597 | 002 | 0 | Lick Run unnamed tributary | 30 |
| Shawsville Town - Sewage Treatment Plant | VA0024031 | 001 | 0.2 | South Fork Roanoke River | 30 |
| WVWA Roanoke Regional Water Pollution Control Plant | VA0025020 | 001 | 55 | Roanoke River | 2.5 |
| Blacksburg Country Club Sewage Treatment Plant | VA0027481 | 001 | 0.035 | North Fork Roanoke River | 30 |
| Montgomery County PSA - Elliston-Lafayette Waste Water Treatment Plant | VA0062219 | 001 | 0.25 | South Fork Roanoke River | 30 |
| Oak Ridge MHP Sewage Treatment Plant | VA0072389 | 001 | 0.015 | Falling Creek unnamed tributary | 30 |
| Roanoke Moose Lodge | VA0077895 | 001 | 0.0047 | Mason Creek | 30 |
| WVWA Crystal Spring Water Filtration Plant | VA0091065 | 001 | 0.092 | Roanoke River | 30 |

**Table 5-2. Model TSS point sources—Lower Roanoke (Staunton) model segment**

| Facility name | NPDES ID | Outfall | Design flow (mgd) | Receiving stream | Avg. conc. limit (mg/L) |
|---|---|---|---|---|---|
| Motiva Enterprises LLC - Montvale | VA0001490 | 001 | 0.065 | South Fork Goose Creek | No limit |
| Bedford City - Water Treatment Plant | VA0001503 | 001 | 0.038 | Little Otter River unnamed tributary | 30 |
| Dan River, Inc – Brookneal | VA0001538 | 001 | 1.326 | Roanoke (Staunton) River | No limit |
| ITG Burlington Industries, LLC, Hurt Plant | VA0001678 | 001 | 3.275 | Roanoke (Staunton) River | No limit |
| Appomattox Trickling Filter Plant | VA0020249 | 001 | 0.17 | Caldwells Creek | 30 |
| Altavista - Wastewater Treatment Plant | VA0020451 | 001 | 3.6 | Roanoke (Staunton) River | 30 |
| Bedford County Schools - Liberty High School | VA0020796 | 001 | 0.024 | Little Otter River unnamed tributary | 30 |
| Bedford County Schools - Body Camp Elem. School | VA0020818 | 001 | 0.005 | Wells Creek unnamed tributary | 30 |
| Bedford Co - New London Academy | VA0020826 | 001 | 0.006 | Buffalo Creek unnamed tributary | 30 |
| Bedford Co - Otter River Elem. School | VA0020851 | 001 | 0.005 | Big Otter River unnamed tributary | 30 |
| Bedford County Schools - Thaxton Elem. School | VA0020869 | 001 | 0.004 | Wolf Creek unnamed tributary | 30 |
| Brookneal - Staunton River Lagoon | VA0022241 | 001 | 0.078 | Roanoke (Staunton) River | 45 |
| Brookneal - Falling River Lagoon | VA0022250 | 001 | 0.082 | Falling River | 30 |
| Bedford City - Sewage Treatment Plant | VA0022390 | 001 | 2 | Little Otter River | 30 |
| Halifax County Schools Clays Mill Elem. School | VA0022748 | 001 | 0.0072 | Mill Branch unnamed tributary | 30 |
| DOC Rustburg Correctional Unit 9 | VA0023396 | 001 | 0.028 | Button Creek unnamed tributary | 30 |
| Moneta Adult Detention Facility | VA0023515 | 001 | 0.021 | Mattox Creek unnamed tributary | 30 |
| Campbell Co Util and Serv Auth - Rustburg | VA0023965 | 001 | 0.2 | Molley Creek | 30 |
| Keysville Waste Water Treatment Plant | VA0024058 | 001 | 0.5 | Ash Camp Creek | 30 |
| Charlotte County Schools Bacon District Elem. School | VA0029319 | 001 | 0.006 | Little Horsepen Creek unnamed tributary | 30 |
| Charlotte County Schools Phenix Elem. School | VA0029335 | 001 | 0.006 | Terrys Creek unnamed tributary | 30 |
| Briarwood Village Mobile Home Park Sewage Treatment Plant | VA0031194 | 001 | 0.024 | Smith Branch unnamed tributary | 30 |
| BP Products North America Incorporated | VA0054577 | 001 | 0 | South Fork Goose Creek | No limit |
| BP Products North America Incorporated | VA0054577 | 003 | 0 | South Fork Goose Creek unnamed tributary | No limit |
| Magellan Terminals Holdings LP - Montvale Terminal | VA0055328 | 001 | 0.008 | South Fork Goose Creek unnamed tributary | No limit |
| Camp Virginia Jaycees Sewage Treatment Plant | VA0060909 | 001 | 0.015 | Day Creek unnamed tributary | 30 |
| Charlotte County Schools Jeffress Elem. School | VA0063118 | 001 | 0.004 | Sandy Creek unnamed tributary | 30 |
| Southern Mobile Home Park | VA0063568 | 001 | 0.0096 | Piney Creek unnamed tributary | 30 |
| Bedford County Schools - Staunton River High School | VA0063738 | 001 | 0.026 | Shoulder Run unnamed tributary | 30 |
| Thousand Trails Lynchburg Preserve | VA0068543 | 001 | 0.0396 | Mollys Creek | 30 |
| Clover Waste Water Treatment Plant | VA0073733 | 001 | 0.035 | Clover Creek | 30 |
| Woodhaven Nursing Home - Montvale | VA0074870 | 001 | 0.005 | South Fork Goose Creek unnamed tributary | 30 |
| Campbell Co Utility and Service Authority - Otter River Water Filtration Plant | VA0078646 | 001 | 0.0428 | Big Otter River | 30 |

| Facility name | NPDES ID | Outfall | Design flow (mgd) | Receiving stream | Avg. conc. limit (mg/L) |
|---|---|---|---|---|---|
| Alum Springs Shopping Center | VA0078999 | 001 | 0.04 | Buffalo Creek | 30 |
| Old Dominion Clover Power Station | VA0083097 | 001 | 1.735 | Roanoke (Staunton) River | 30 |
| Old Dominion Pittsylvania Power Station | VA0083399 | 001 | 0.192 | Roanoke (Staunton) River | 30 |
| Old Dominion Altavista Power Station | VA0083402 | 001 | 0.117 | Roanoke (Staunton) River | 30 |
| Brookneal Town Water Treatment Plant | VA0084034 | 001 | 0.0006 | Phelps Creek | 30 |
| Drakes Branch Waste Water Treatment Plant | VA0084433 | 001 | 0.08 | Twitty's Creek | 30 |
| Montvale Wastewater Treatment Plant | VA0087238 | 001 | 0.05 | South Fork Goose Creek | 30 |
| Dillons Trailer Park - Sewage Treatment Plant | VA0087840 | 001 | 0.018 | Poorhouse Creek | 55 |
| Cedar Rock Waste Water Treatment Plant | VA0091553 | 001 | 0.015 | Elk Creek unnamed tributary | 30 |
| Moneta Regional Waste Water Treatment Plant | VA0091669 | 001 | 0.5 | Hunting Creek | 30 |

### 5.3.2. PCB Sources

#### Current Sources

The 13 point and 21 nonpoint sources described in Section 3.0 are represented as current PCB sources in the model. In addition to the known current sources, urban land areas throughout the model watershed have been assigned a level of contamination on the basis of available sediment monitoring data to account for unidentified contaminated sites. Such areas are referred to as *urban background/unidentified* sources for the purposes of this TMDL.

*Nonpoint Sources*

The LSPC model was set up to represent nonpoint source loading of PCBs as a sediment-associated process. For the representation of known contaminated sites, a PCB-contaminated land use was created. Using estimates of site footprints and locations, PCB land use areas were assigned to model subbasins. The areas of PCB land uses are shown in Figures 3-2 through 3-4.

Sites known to have PCB-contaminated soils were delineated into parcels as depicted in available aerial photography and USGS topoquads to estimate the contamination footprint. General model land use areas within the footprint were converted to corresponding PCB land uses and assigned a soils tPCBs concentration, or *potency factor*, on the basis of available monitoring data. The soils monitoring data from the literature sources listed in Section 3.1 were used to estimate potency factors for known contaminated sites. A potency factor calculated from available sediment monitoring data was also assigned to the remaining land areas in the watershed to capture loadings from urban background/unidentified contaminated sites. Table 5-3 lists the model-represented known contaminated sites, associated land area, and contamination level. For a discussion of contaminated site contamination levels (or potency factors), see Appendix G (Section G2.3.2).

**Table 5-3. Model PCB-contaminated sites[a]**

| Site name | NPDES ID | County/city | Receiving stream | Area (acres) | Contamination level |
|---|---|---|---|---|---|
| **Upper Roanoke River** | | | | | |
| Dixie Caverns Landfill | VAD980552095[c] | Roanoke | Roanoke River | 38.7 | Moderate |
| **Roanoke River Floodway Bench Cuts** | | Roanoke | Roanoke River | 47.4 | Moderate |
| **Norfolk Southern 12** | | Roanoke City | Roanoke River | 64.3 | Moderate |
| Evans Paint | VASFN0305570[c] | Roanoke City | Roanoke River | 1.7 | Moderate |
| Virginia Scrap Iron Co. | VRP00408[d] | Roanoke City | Roanoke River | 7 | Moderate |
| | | | | 0.17 | High |

| Site name | NPDES ID | County/city | Receiving stream | Area (acres) | Contamination level |
|---|---|---|---|---|---|
| **Norfolk Southern 1** | | Roanoke City | Roanoke River | 2.5 | Moderate |
| Tinker-American Electric Power (AEP) property | | Roanoke City | Roanoke River | 23 | Moderate |
| **Riverdale Development (formerly American Viscose Co.)** | VRP00394[d] | Roanoke City | Roanoke River | 81.1 | Moderate |
| Appalachian Power Co. (APCO) Yard | | Roanoke City | Roanoke River | 0.8 | Moderate |
| **Jacob Webb** | | Roanoke City | Roanoke River | 5.5 | Moderate |
| **Lower Roanoke (Staunton) River** | | | | | |
| Burlington Industries-Altavista[b] | VA0001678 | Pittsylvania | Sycamore Creek | 116.3 | Moderate |
| English Construction | | Pittsylvania | Roanoke (Staunton) River | 12 | Moderate |
| West town dump-Altavista | | Campbell | Lynch Creek | 28 | Moderate |
| Oil distributors-Altavista | | Campbell | Lynch Creek | 5.7 | Moderate |
| Lane Furniture Co. | | Campbell | Roanoke (Staunton) River | 49.6 | Moderate |
| BGF Industries[b] | | Campbell | Roanoke (Staunton) River unnamed tributary | 20.6 | High |
| East town Dump-Altavista | | Campbell | Roanoke (Staunton) River | 14.5 | Moderate |
| Altavista STP | VA0020451 | Campbell | Roanoke (Staunton) River | 25.6 | Moderate |
| A. O. Smith | | Campbell | Roanoke (Staunton) River unnamed tributary | 7.7 | Moderate |
| Schrader Bridgeport[b] | | Campbell | Roanoke (Staunton) River unnamed tributary | 16 | Moderate |
| Dan River, Inc. | VA0001538 | Campbell | Roanoke (Staunton) River | 37.7 | Moderate |

a. The site acreage and contamination levels are those used in the model. It should be noted that these data are based on best available information during the PCB Source investigation. Both acreage and contamination levels are estimated with emphasis on the boldfaced sites.
b. Where a contaminated site is covered by a stormwater permit, the source is considered a stormwater site for TMDL purposes (see *Point Sources* in Section 5.3.2)
c. EPA Superfund ID#
d. Virginia Voluntary Remediation Program (VRP) site#

*Point Sources*

PCB point sources for the TMDLs are traditional facility effluent, MS4s, and sites permitted for stormwater discharges. An inventory of the three types of point sources was provided by VADEQ to be included in the Roanoke River watershed model.

Facilities found to be discharging PCB contaminated effluent as part of the 2005–2008 Special Study monitoring are represented as PCB point sources in the model. In addition, several additional facilities were included as PCB point sources at the request of VADEQ. Facilities represented as PCB point sources and associated information including NPDES ID, mean monthly flow, and model represented effluent PCB concentration are presented in Table 5-4.

**Table 5-4. Model PCB point source dischargers**

| NPDES facility name | Facility type | NPDES ID | Outfall | Mean monthly flow (mgd) | Mean PCB conc. (pg/L) |
|---|---|---|---|---|---|
| **Upper Roanoke River** | | | | | |
| Blacksburg Country Club | Sewerage systems | VA0027481 | 001 | 0.02 | 390 |
| Montgomery County PSA - Shawsville Sewage Treatment Plant | Sewerage systems | VA0024031 | 001 | 0.06 | 390 |
| Montgomery County PSA - Elliston Lafayette Waste Water Treatment Plant | Sewerage systems | VA0062219 | 001 | 0.07 | 390 |

| NPDES facility name | Facility type | NPDES ID | Outfall | Mean monthly flow (mgd) | Mean PCB conc. (pg/L) |
|---|---|---|---|---|---|
| Steel Dynamics | Steel works | VA0001589 | 005 | 0.06 | 1,090 |
| Norfolk Southern Railway Co - Shaffers Crossing | Railroads, line-haul operating | VA0001597 | 002 | 0.009 | 390 |
| WVWA Roanoke Regional Water Pollution Control Plant | Sewerage systems | VA0025020 | 001 | 37.35 | 340 |
| **Lower Roanoke (Staunton) River** | | | | | |
| ITG Burlington Industries, LLC - Hurt Plant | Fabrics finishing | VA0001678 | 001 | 2.13 | 19,150 |
| Old Dominion Pittsylvania Power Station | Electric Services | VA0083399 | 001 | 0.11 | 140 |
| Altavista Town - Wastewater Treatment Plant | Sewerage systems | VA0020451 | 001 | 1.54 | 10,000 |
| Old Dominion Altavista Power Station | Electric Services | VA0083402 | 001 | 0.117 | 140 |
| Dan River, Inc. - Brookneal | Fabrics finishing | VA0001538 | 001 | 0.68 | 500 |
| Brookneal Town - Staunton River Lagoon | Sewerage systems | VA0022241 | 001 | 0.04 | 140 |
| Old Dominion Clover Power Station | Electric Services | VA0083097 | 001 | 0.75 | 190 |

VADEQ provided an inventory of MS4s and sites and facilities that were issued general permits for stormwater discharges in the Roanoke River basin. Such facilities are not subject to numerical criteria, but have responsibilities related to minimizing stormwater runoff and pollutant loads, and may be subject to monitoring requirements. These areas are not represented explicitly in the model but are assigned PCB WLAs in the TMDL. PCB loads for these areas are estimated as an area-weighted fraction of nonpoint source, land-use contributions.

Modeled land uses were overlain with GIS coverages of MS4s and sites covered by general stormwater permits to characterize the land use distributions of those areas. PCB loads for the permitted areas were calculated as the load generated by their respective land areas. Table 5-5 lists MS4s in the Roanoke River basin. Appendix C provides a list of sites and facilities covered by general stormwater permits. Loads from contaminated sites within the spatial extent of an MS4 or site permitted for stormwater are considered a component of the associated MS4 or general stormwater permit. Where a stormwater permit is located within an MS4, the load is assigned to the stormwater permit.

**Table 5-5. MS4s in the Roanoke River watershed**

| MS4 permit holder | Permit number | Area (acres) |
|---|---|---|
| Roanoke County | VAR040022 | 28,907 |
| City of Roanoke | VAR040004 | 23,577 |
| Botetourt County | VAR040023 | 5,180 |
| City of Salem | VAR040010 | 9,332 |
| Town of Blacksburg | VAR040019 | 1,613 |
| Town of Christiansburg | VAR040025 | 1,193 |

### Legacy Sources

Legacy sources represented in the model are PCB contributions from contaminated streambed sediments and background atmospheric deposition of PCBs to surface waters. Those sources exist at an interface with the affected waterbody and can be characterized as nonpoint sources.

#### *Contaminated Streambed Sediments*

Streambed sediments can contain significant concentrations of PCBs from historical loadings, current loadings, or both. The PCBs can be released to the water column by resuspension of streambed sediments and desorption of PCBs, desorption of PCBs at the streambed-water column interface, and the direct diffusion of PCBs from lower contaminated sediment layers.

The mass of PCBs in streambed sediments available for loading at the beginning of the simulation period is set as an initial condition in the LSPC model setup. It is defined by a sediment tPCBs concentration and streambed depth, density, and porosity assigned to each model-represented stream class. The Roanoke River basin model includes an individual stream class for each model subbasin-representative stream reach, as discussed in Section 5.2.3. Stream classes define critical in-stream parameters including initial sediment pollutant concentration, streambed depth, density, and porosity. Assigning individual stream classes to each subwatershed stream reach allows model parameters to be specific to each reach.

*Background Atmospheric Deposition*

The net exchange of gas-phase molecules between the atmosphere and a waterbody (dry atmospheric deposition) is a function of the relative concentrations of the chemical in each. There are no available data to characterize the atmospheric and water column concentrations of gaseous PCBs in the Roanoke River watershed. The Chesapeake Bay Program Atmospheric Deposition Study (Chesapeake Bay Program 1999) has estimated net dry atmospheric tPCBs deposition rates for urban and regional (nonurban) areas in the Chesapeake Bay watershed as 16.3 and 1.6 $\mu g/m^2/yr$, respectively (ICPRB 2007). The regional atmospheric deposition rate was applied to the entire Roanoke River watershed as an estimate of local conditions. If local data become available, they will be incorporated into future TMDL studies.

## 5.4. Model Boundary Condition

The Roanoke River watershed was divided into two separate segments for modeling purposes—the upper Roanoke, which extends from the River headwaters downstream to Niagra Dam, and the lower Roanoke (Staunton), which includes the length of the River from Leesville Dam to its confluence with the Dan River. Because there is no dynamic link between the two, to accurately represent the lower watershed, discharge data for the Leesville Dam, which represents all upstream flows to that point on the river, were incorporated as a model boundary condition.

To account for the PCB loadings from sources in the upper and middle Roanoke, a boundary condition PCB water concentration was assigned to the model-represented Leesville Dam discharge. The boundary water column concentration was estimated from available fish tissue data collected at monitoring station ROA140.66—which is the only monitoring station in Leesville Reservoir—using calculated BAFs for resident fish species. A BAF-converted fish tissue PCB concentration is an estimate of the ambient water quality that captures all upstream source contributions and associated watershed and in-stream processes.

Four fish tissue records were converted into equivalent water column concentrations, giving a concentration range of 40.0–120.0 pg/L and a median concentration of 79.0 pg/L. The median value was assigned as the model boundary condition. That value is significantly lower than the applicable state human health water quality criterion for PCBs (1,700 pg/L) and is indicative of Leesville Reservoir's status as unimpaired for PCBs. Discussion of the methodology for developing and applicability of BAFs is presented in Appendix A.

## 5.5. Existing Conditions/Model Calibration and Validation

The model was developed in a step-wise manner, beginning with basic watershed processes and building on them to ultimately represent PCB loading and transport. The foundation of the model is simulated hydrology. On the basis of the calibrated hydrology, sediment loading and transport were simulated and calibrated. Watershed hydrology and sediment simulations provide the framework for PCB loadings and transport modeling. The sections that follow discuss briefly the development of each aspect of the watershed model. For a more detailed explanation of each, see Appendix G.

### 5.5.1. Selecting a Representative Modeling Period

Selecting a representative modeling period was done using the availability of stream flow and water, fish tissue, and sediment monitoring data collected in the Roanoke River watershed that cover varying wet and dry periods. VADEQ has collected water, fish tissue, and sediment monitoring data for the Roanoke River since 1973, but the period of 1990–2008 was selected for modeling purposes. This period includes monitoring results in step with modern analytical methods and includes varying climatic and hydrologic conditions, including dry, average, and wet periods that typically occur in the area.

### 5.5.2. Hydrology

Hydrology and water quality calibration are performed in sequence, because water quality modeling is dependent on an accurate hydrology simulation. The driver of model hydrology is climatological data, described in Section 5.2.1 and Appendix G. Such data are used as input to simulate the watershed water balance within the LSPC model framework that describes the watershed subbasin network, topology, land use, soils, and reach characteristics.

#### Hydrology Calibration/Validation

Land use-specific hydrology parameters are used to calibrate modeled hydrology. Calibration involves comparing the modeled and observed flow rates at locations in the watershed where observed data are available. Appendix D presents LSPC Hydrology parameters and the range of values used for the Roanoke River watershed model.

STATSGO served as a starting point for designating infiltration and groundwater flow parameters. Starting values were refined through the hydrologic calibration process. As discussed in Section 5.2.2, a custom land use data layer was developed that accounted for the variability of hydrologic characteristics throughout the watershed. To account for topography variability in the upper and lower Roanoke (Staunton), two groups of land use parameters were configured in the model. This allowed for designating separate hydrology parameter values for the upper and lower segments. Assigning appropriate parameter values was dependent on the composite hydrologic soil group/land cover distribution of each subwatershed.

Average daily flow discharge data were available for eight and seven USGS gages in the upper and lower Roanoke (Staunton) River, respectively (Figure 5-4). The upper Roanoke watershed model was calibrated using daily stream flow data from USGS gages 02056000 and 02053800, while the lower Roanoke (Staunton) was calibrated using gages 02066000 and 02061500. USGS gages 02056000 and 02066000 were selected as calibration points because they represent the farthest downstream locations in the upper and lower sections and capture the distribution of land uses and soil groups in each. An accurate model calibration at these points would capture the overall water budget for the upper and lower Roanoke (Staunton) and reflect the cumulative range of flows for their entire stream networks.

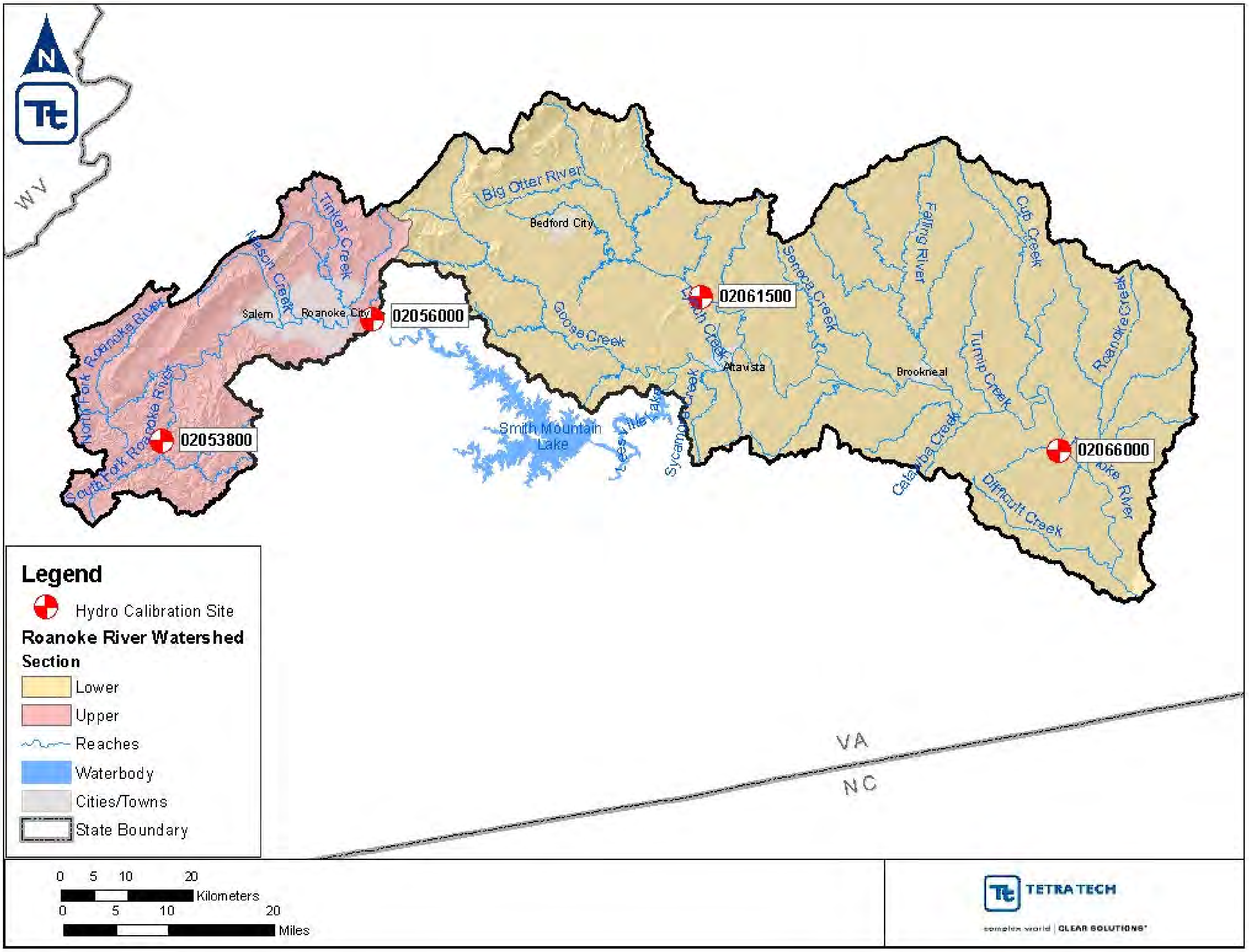


**Figure 5-4. Locations of hydrology calibration USGS gages.**

USGS gages 02053800 and 02061500 are on tributaries to the upper and lower Roanoke (Staunton)—South Fork Roanoke River and Big Otter River, respectively—and were used as calibration points to verify the applicability of the calibration to smaller areas within watersheds. Agreement between simulated and observed flows at both mainstem and tributary points would suggest an accurate hydrologic system representation of the upper and lower Roanoke (Staunton) watersheds. The USGS gages used for calibration are listed in Table 5-6.

**Table 5-6. USGS continuous daily discharge gages used for hydrology calibration**

| Site ID | Station name | Drainage area (square miles) | Period of record |
|---|---|---|---|
| **Upper Roanoke River** | | | |
| 02053800 | South Fork Roanoke River near Shawsville, VA | 109 | 1/1/1990–5/31/2008 |
| 02056000 | Roanoke River at Niagra, VA | 509 | 1/1/1990–5/31/2008 |
| **Lower Roanoke (Staunton) River** | | | |

| Site ID | Station name | Drainage area (square miles) | Period of record |
|---|---|---|---|
| 02061500 | Big Otter River near Evington, VA | 315 | 1/1/1990–5/31/2008 |
| 02066000 | Roanoke (Staunton) River at Randolph, VA | 2,966 | 1/1/1990–5/31/2008 |

Model calibration years were selected using the following four criteria:

1. Completeness of the weather data available for the selected period
2. Representation of low-flow, average-flow, and high-flow water years
3. Consistency of selected period with key model inputs (i.e., land use coverage)
4. Quality of initial modeled versus observed data correlation

After a review of the data for those four selection criteria, the years 2004 and 1996 were chosen as calibration periods for the upper and lower Roanoke (Staunton), respectively. The NLCD land use coverage used in the model was developed in 2001; therefore, the selected calibration periods are consistent with that key model input. The model was validated for long-term and seasonal representation of hydrologic trends using a period of 18.5 years (January 1, 1991, through May 31, 2008) for both the upper and lower watersheds.

Model calibration was performed using the error statistics criteria specified in HSPEXP, temporal comparisons, and comparisons of seasonal, high flows, and low flows. Calibration involved adjusting infiltration, subsurface storage, evapotranspiration, surface runoff, and interception storage parameters. After adjusting the appropriate parameters within acceptable ranges, good correlations were found between model results and observed data. Hydrology calibration and validation results are presented in Appendix E. It is important to note that although the included log plots allow for comparative visualization of flows that span several orders of magnitude, that type of graph tends to diminish the differences in high flows, while exaggerating the differences in low flows.

Overall, the calibrated model predicted the watershed water budget well. All model validations showed the modeled water budget to be within 9 percent of observed conditions. Predicted seasonal volumes were also within recommended ranges at every location. Predicted storm volumes and storm peaks also closely matched observed data. Because the runoff and resulting stream flow are highly dependent on rainfall, occasional storms were over-predicted or under-predicted depending on the spatial variability of the meteorological and gage stations.

### 5.5.3. Sediment

In-stream sediment concentrations are modeled as a function of discrete processes including erosion of soil particles from land areas; transport of eroded sediments to streams; and in-stream transport, scour, and deposition of sediments. Sediment loadings are dependent on hydrologic conditions, particularly the amount and timing of surface runoff, while in-stream processes are dependent on the unique hydraulics of each reach.

#### Sediment Calibration

Land use and stream class-specific sediment parameters are used to calibrate modeled sediment loading and in-stream processes, respectively. Calibration involves comparing the modeled and observed sediment loads and TSS concentrations at locations in the watershed where observed data are available. Appendix D presents LSPC sediment parameters and the range of values used for the Roanoke River watershed model.

Sediment land use parameters are closely related to the factors of the Universal Soil Loss Equation (USLE) (Wischmeier and Smith 1978), which served as a starting point for designating related soil detachment and washoff parameters. Appropriate values were assigned to the composite land use on the basis of the land cover description and hydrologic soil group. Starting values were refined through the sediment calibration process. Event mean concentrations were also defined to represent background concentrations not captured by the discrete erosive processes simulated by the model, particularly for low-flow conditions. All sediments and soils represented in the model are assigned particle class fractions (e.g. % sand, silt, clay). Analysis of the distribution of STATSGO soil groups in the watershed was used to estimate the particle class fractions of eroded upland soils.

In-stream sediment parameters are based primarily on the physical properties of the particle class fractions including particle diameter, fall velocity, and density. Such properties were estimated from the range of literature values presented in *EPA BASINS Technical Note 8, Sediment Parameter and Calibration Guidance for HSPF* (USEPA 2006).

Observed TSS data are available for 21 and 43 monitoring stations in the upper and lower Roanoke (Staunton), respectively. On the basis of the number of data records and co-location with USGS continuous flow gages, the Roanoke River watershed model was calibrated for sediment using TSS monitoring stations ROA227.42, ROA204.76, ROA97.46, and ROA67.91 (Figure 5-5). Stations at river mile 227.42 and 204.76 are in the upper Roanoke model segment, while stations at river mile 97.46 and 67.91 are in the lower Roanoke (Staunton) model segment. General descriptions of these monitoring locations are presented in Table 5-7.

**Table 5-7. TSS monitoring station used for TSS calibration**

| Station ID | Station description | Period of record | Associated flow gage |
|---|---|---|---|
| **Upper Roanoke River** | | | |
| 4AROA227.42 | Rt. 773 at gaging station in Lafayette, VA | 1/10/1990–5/9/2007 | USGS 02054500 |
| 4AROA204.76 | Roanoke River at Roanoke City, VA | 10/13/2005–11/22/2005 | USGS 02055000 |
| **Lower Roanoke (Staunton) River** | | | |
| 4AROA097.46 | Roanoke River at Brookneal gage, Rt. 50 | 1/24/1990–5/1/2007 | USGS 02062500 |
| 4AROA067.91 | Rt.746 bridge (Watkina Bridge) near Randolph, VA | 2/1/1990–9/10/2007 | USGS 02066000 |

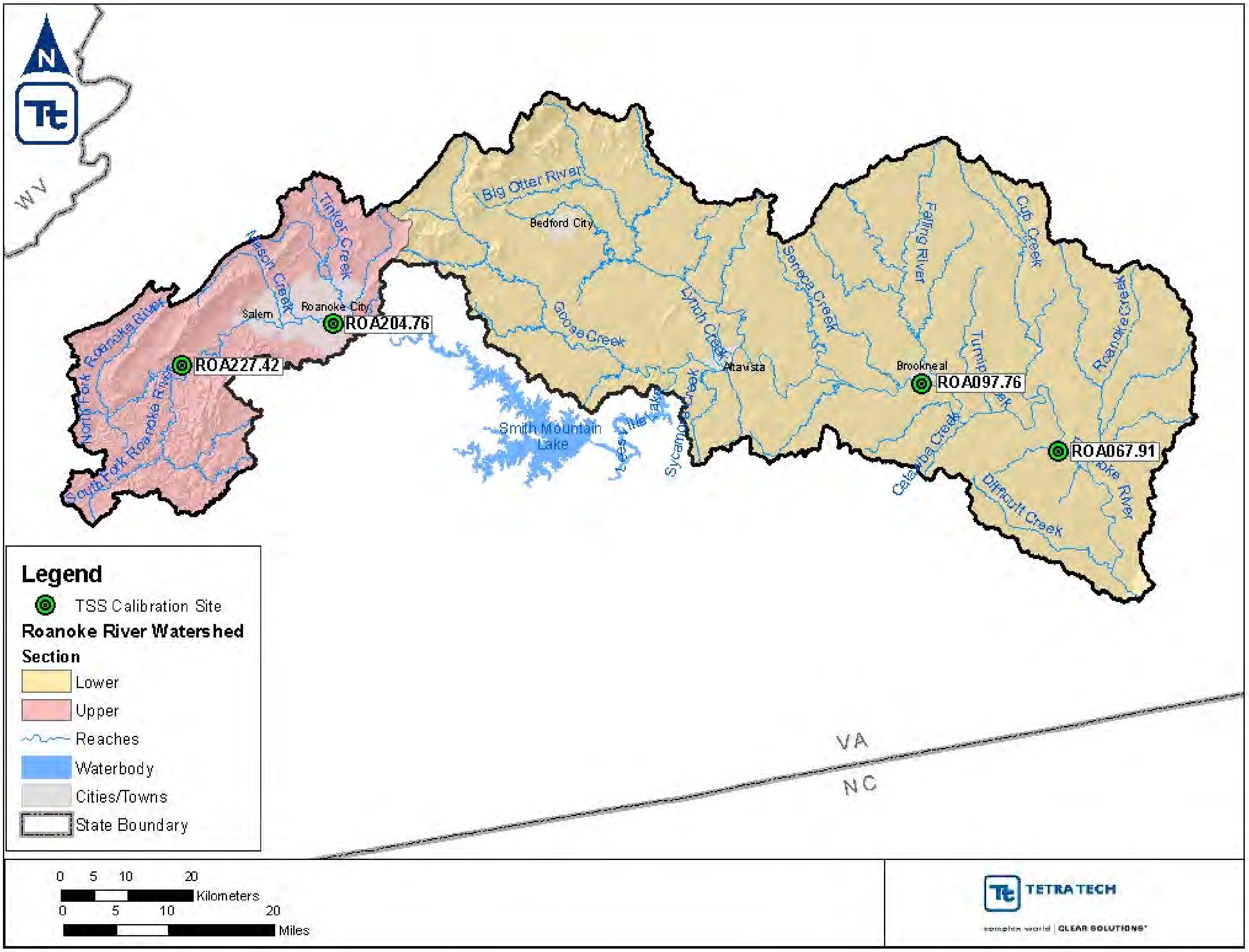


**Figure 5-5. Locations of TSS monitoring calibration stations.**

Sediment simulations were run for the model time series as described in Section 5.5.1. Antilog plots of flow versus sediment loads for observed and modeled data are presented for the selected calibration locations in Appendix F. In general, the magnitude of sediment loadings for observed and modeled data increase at a similar rate and are within the same range for the gradient of flow conditions. Observed loadings are, generally, more variable in relation to flow conditions than in modeled scenarios. Log plots comparing model output to observed TSS concentrations at the selected locations are also presented in Appendix F. Note that observed concentrations reported as detection limits have been assigned a concentration of 3 mg/L.

### 5.5.4. PCBs

LSPC was configured to simulate tPCBs in both the dissolved- and sediment-associated states to characterize water quality conditions in the Roanoke River watershed. The simulation of loadings and in-stream behavior of tPCBs as a sediment-associated pollutant is dependent on the hydrologic and TSS calibrations that serve as its foundations.

The model was set up to represent a unique stream class for each subwatershed stream reach as discussed in Section 5.2.3. Each model stream class defines critical in-stream parameters, including the conditions related to the mass balance of tPCBs for the sediment-water system in each stream reach. tPCBs are partitioned into dissolved and particulate fractions in both the water (PCB with suspended sediment interaction) and sediment layers (PCB with bed sediment interaction). LSPC simulates deposition (settling) and scour (resuspension) of PCBs with sediment in addition to sorption/desorption and in-stream losses.

### PCB Calibration

Land use and stream class-specific PCB parameters are used to calibrate modeled tPCB loading and in-stream processes, respectively. Calibration involves comparing the modeled and observed tPCB concentrations at locations in the watershed where observed data are available. Appendix D presents LSPC PCB parameters and the range of values used for the Roanoke River watershed model.

Monitoring data collected by VADEQ were used to define the model's design and representation of critical parameters required for simulating tPCBs in each stream class. Such parameters include the following:

- Particle class fractions of upland soils and streambed sediments
- The initial tPCBs concentration of particle class fractions
- Partition coefficients as a function of the fraction of the organic carbon content in stream sediments and homolog composition of PCB contamination
- Adsorption/desorption rates as a function of the homolog composition of PCB-contaminated suspended sediments

Observed water column tPCB data are available for 29 monitoring stations throughout Roanoke River watershed. These stations were sampled as part of the 2005–2008 PCB monitoring special study conducted by VADEQ (see Section 2.3). On the basis of the confidence in the analytical results of the sampling data, the Roanoke River watershed model was calibrated at the 24 PCB monitoring stations shown in Figures 5-6 and 5-7. General descriptions of the monitoring locations are presented in Table 5-8.

**Table 5-8. PCB monitoring stations used for PCB calibration**

| Monitoring station | Station description | Sample dates |
|---|---|---|
| **Upper Roanoke River** | | |
| 4AROA227.42 | Rt. 773 at gaging station in Lafayette | 3/3/08, 4/7/08 |
| 4AROA212.17 | 419 Bridge near Lewis Gale | 3/3/08, 4/7/08 |
| 4AROA207.08 | Roanoke River at Memorial Bridge | 3/3/08, 4/7/08 |
| 4AROA204.76 | Roanoke River at Walnut Ave. in Roanoke City | 3/3/08, 4/7/08 |
| 4AROA199.20 | Roanoke River below Niagara Dam | 3/3/08, 4/7/08 |
| **Lower Roanoke (Staunton) River** | | |
| 4AGSE000.20 | Goose Creek | 9/10/07, 10/26/07 |
| 4AROA131.55 | Rt. 29 Bridge bypass, Altavista | 8/8/07, 5/9/08 |
| 4ALYH000.17 | Lynch Creek at Riverside Park | 5/9/2008 |
| 4ASCE000.26 | Sycamore Creek near Pocket Road | 8/27/2007 |
| 4AROA129.55 | Roanoke River near business Rt. 29 bridge at USGS gage | 8/8/07, 10/26/07, 5/9/08 |
| 4AXLN000.00 | Unnamed trib on BGF property | 12/1/2007 |
| 4ABOR000.62 | Big Otter River at Rt. 712 | 8/21/07, 10/26/07 |
| 4AROA127.79 | Roanoke River downstream of Altavista STP | 8/9/2007 |
| 4AROA124.59 | Roanoke River downstream Altavista | 3/10/08, 5/9/08 |

| Monitoring station | Station description | Sample dates |
|---|---|---|
| 4AROA108.09 | Roanoke River near Long Island | 9/10/2007 |
| 4AFRV002.78 | Falling River downstream of lagoon outfall | 9/10/2007 |
| 4AROA097.76 | Roanoke River upstream of Brookneal | 8/8/07, 3/6/08 |
| 4AROA090.50 | Roanoke River at Rt. 620 South of Brookneal | 8/8/07, 10/26/07 |
| 4ACUB002.21 | Cub Creek at Rt. 649 (Coles Ferry Road) | 8/28/07, 10/26/07 |
| 4AROA067.91 | Roanoke River near Rt. 746 | 9/10/07, 10/26/07 |
| 4AROC001.00 | Roanoke Creek near Saxe | 8/28/07, 10/26/07 |
| 4ABWC001.00 | Black Walnut Creek | 10/26/2007 |
| 4AROA059.12 | Roanoke River near Rt. 360 - Clover | 9/10/07, 10/26/07 |
| 4ADFF002.02 | Difficult Creek at Rt. 716 | 8/28/2007 |

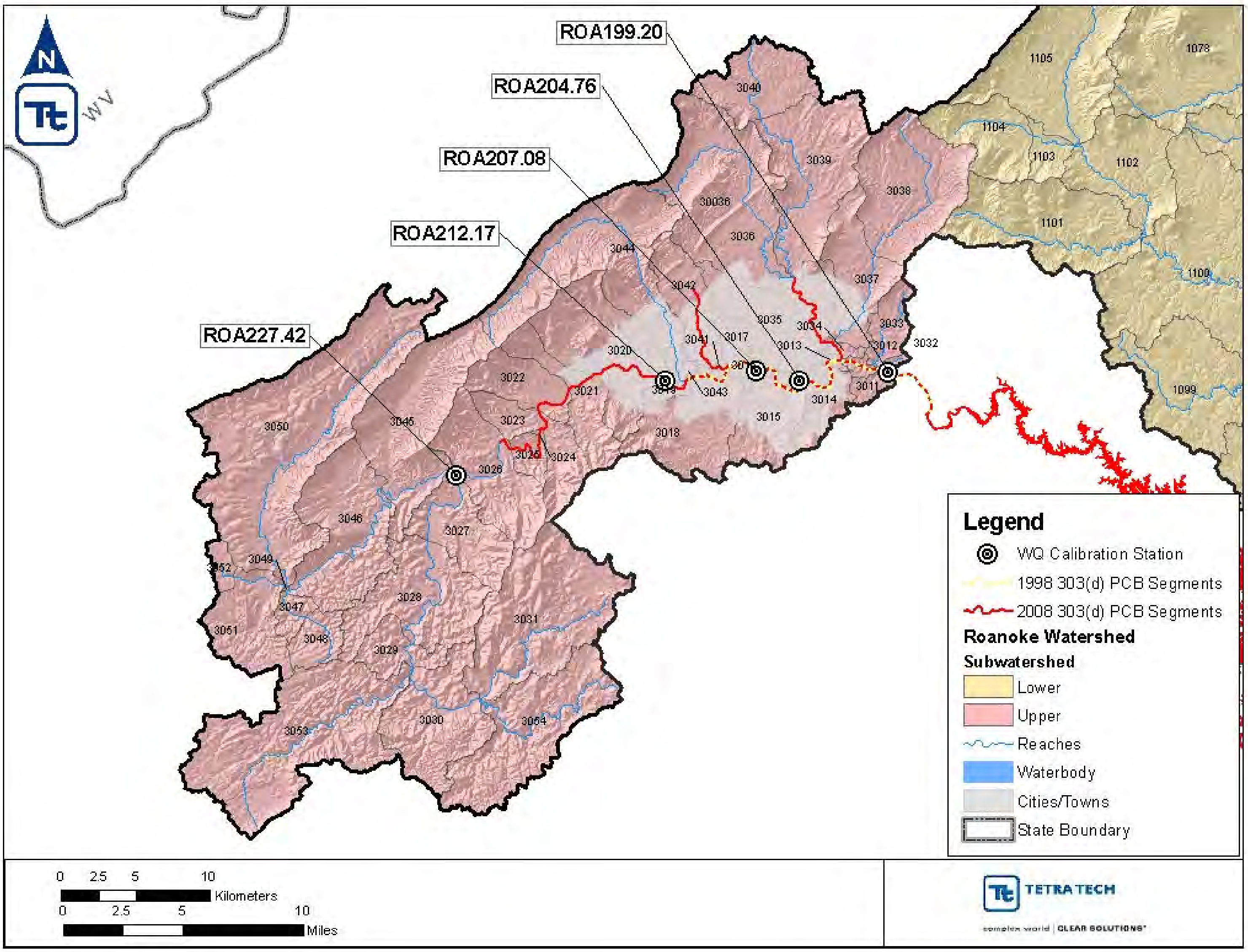


**Figure 5-6. Locations of upper Roanoke tPCB-monitoring calibration stations.**

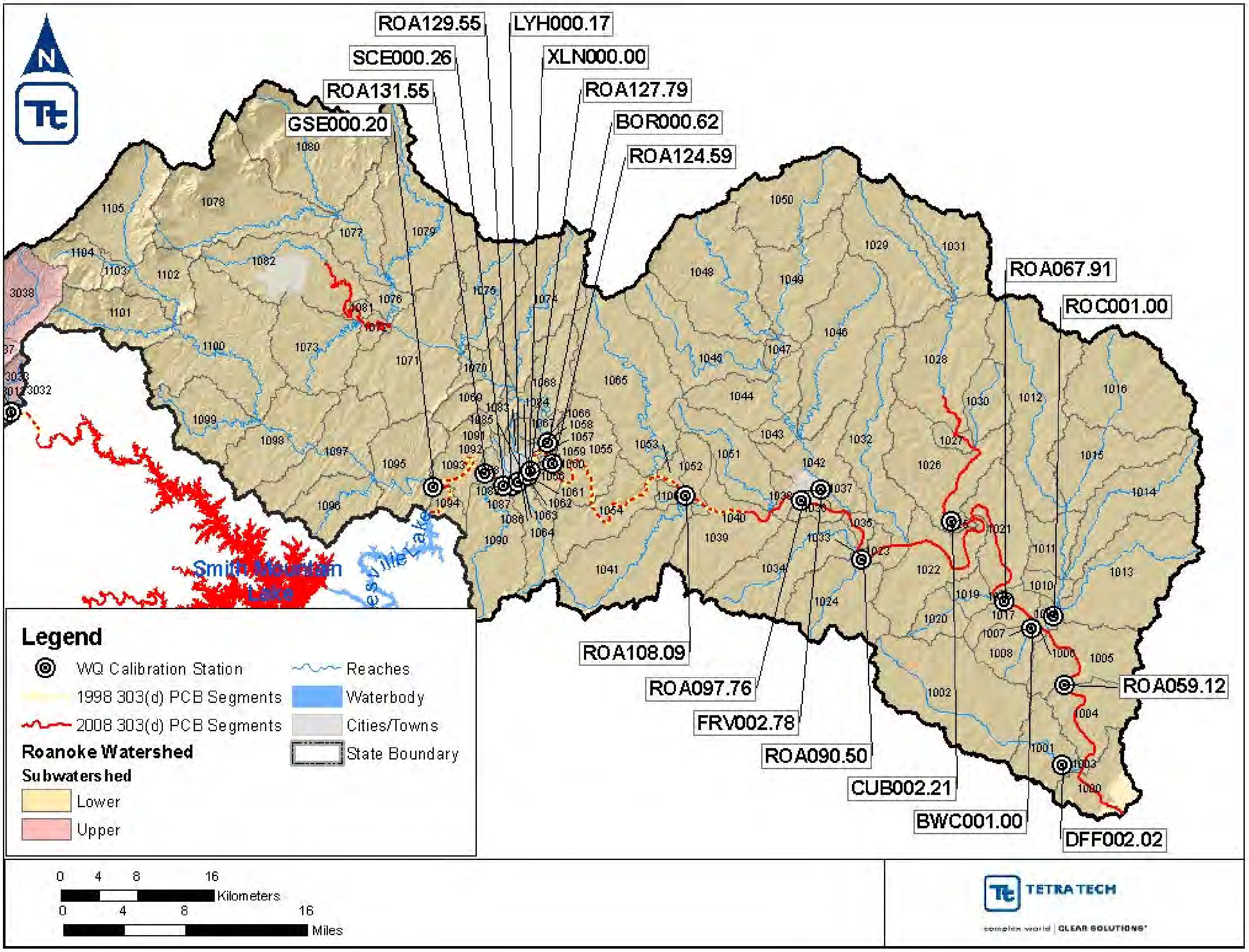


**Figure 5-7. Locations of lower Roanoke (Staunton) tPCB-monitoring calibration stations.**

PCB simulations were run for the model time series as described in Section 5.5.1. Log plots for observed and modeled tPCBs are presented at the selected calibration locations in Appendix F. In general, the model captures the trends and magnitude of contamination observed in the monitoring data.

At locations with significant upstream contaminated sources and high in-stream shear stresses, storm events cause in-stream concentration spikes as contaminated soils are transported to streams and contaminated streambed sediments are resuspended, releasing associated PCBs. In areas where there are few or no contaminated sites or streambed sediments, storm events cause in-stream tPCBs concentrations to decrease as clean inflows dilute the PCB concentrations directly fluxing from streambed sediments and atmospheric deposition. Finally, in areas where there are highly contaminated streambed sediments and relatively low in-stream shear stresses, the direct flux of PCBs from streambed sediments dominate water column concentrations, whereby storm events cause in-stream tPCBs concentrations to decrease even though there could be significant areas of upstream contaminated soil.

In addition, the magnitude of modeled low-flow and high-flow tPCBs concentrations are generally within the same magnitude as the observed data. This suggests that upland soils contamination areas and PCB concentrations, initial streambed sediment PCB concentrations, and water column-streambed sediment dynamics are being represented appropriately.

# 6. TMDL ALLOCATION ANALYSIS

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

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

In TMDL development, allowable loadings from pollutant sources are established and when summed, are equivalent to the TMDL which forms the basis for the requirement of water quality-based controls. TMDLs can be expressed on a mass loading basis (e.g., grams of pollutant per day) or as a concentration in accordance with 40 CFR 130.2(l).

The goal of the model application was to determine allowable source contributions that meet the targeted tPCBs water quality TMDL endpoints specific to the upper and lower sections of the watershed. Boundary conditions and source inputs were adjusted to achieve in-stream whole water column tPCBs concentrations that meet the TMDL targets of 390 and 140 pg/L for the upper and lower sections, respectively. Baseline loads represent the existing condition where no load reductions have been applied to the source categories. WLAs and LAs were assigned on the basis of meeting the assimilative capacity of each subwatershed drainage area delineated for the Roanoke River watershed.

Sources were reduced to meet the TMDL endpoints in the worst case scenario subwatersheds in each watershed section. The worst case scenario subwatersheds were 3013 and 1000, both representing the Roanoke River mainstem in the upper and lower Roanoke (Staunton) sections, respectively (See Figures 5-1 and 5-2). Source reductions started with the current sources (point sources and contaminated sites) that can be reasonably reduced, followed by reductions to legacy sources where eliminating current sources was not sufficient to meet the TMDL. The WLAs, LAs, and TMDLs that follow are presented by stream/river segments in the watershed. The model subbasins associated with watershed streams are presented in Table D-8 in Appendix D.

Tables 6-1 and 6-2 present a summary of the WLAs, LAs, and TMDLs, developed for streams in the upper and lower watershed sections on an average annual and daily basis, respectively. As tPCBs bioaccumulate in fish tissue over time, it is more appropriate to express the loads on an annual basis. WLAs and LAs were assigned on the basis of the assimilative capacity of the Roanoke River watershed. Source load allocations for this TMDL scenario are presented in the following sections. Source loads are calculated as the average annual load produced by a source category as simulated in the LSPC model (see Chapter 5 and Appendix G). Average daily loads were calculated as the average annual load divided by 365.

Loadings from contaminated streambed sediments have been excluded from the TMDLs. The rationale for this exclusion is due to the dynamic relationship between the sediment and water column tPCB processes where the flux from sediments is a function of tPCBs concentrations in the stream water-sediment system as a whole (see Appendix G). Rather than a direct loading, the flux of tPCBs to-and-from streambed sediments can be characterized as an internal model mechanism. For this reason the loadings are not comparable to the direct loads contributed by the other sources. Table D-7 in Appendix D presents the initial streambed sediment concentration reductions applied to meet the TMDL condition in the upper and lower Roanoke (Staunton) subwatersheds.

**Table 6-1. Average annual tPCBs TMDLs for Roanoke River watershed streams**

| Stream | 2008 303(d) list ID | Baseline (mg/yr) | WLA (mg/yr) | LA (mg/yr) | MOS (mg/yr) | TMDL (mg/yr) | % Reduction |
|---|---|---|---|---|---|---|---|
| **Upper Roanoke River** | | | | | | | |
| North Fork Roanoke River | Not listed | 4,923.2 | 28.2 | 630.3 | 34.7 | 693.2 | 85.9 |
| South Fork Roanoke River | Not listed | 3,532.2 | 230.2 | 788.6 | 53.6 | 1,072.5 | 69.6 |
| Masons Creek | Not listed | 1,777.5 | 9.1 | 193.2 | 10.6 | 212.9 | 88.0 |
| Peters Creek | L12L-01-PCB | 1,742.6 | 65.4 | 31.2 | 5.1 | 101.7 | 94.2 |
| Tinker Creek | L12L-01-PCB | 16,593.6 | 103.9 | 3,414.2 | 185.2 | 3,703.2 | 77.7 |
| Wolf Creek | Not listed | 1,078.4 | 10.0 | 20.3 | 1.6 | 31.9 | 97.0 |
| Unnamed Trib to Roanoke River | Not listed | 59.4 | 0.5 | 1.3 | 0.1 | 1.9 | 96.8 |
| Roanoke River | L12L-01-PCB | 133,207.2 | 28,157.7 | 3,455.7 | 1,663.9 | 33,277.3 | 75.0 |
| **Upper Total** | | **162,914.1** | **28,605.0** | **8,534.8** | **1,954.7** | **39,094.5** | **76.0** |
| **Lower Roanoke (Staunton) River** | | | | | | | |
| Goose Creek | Not listed | 5,400.9 | 0.1 | 1,812.4 | 95.4 | 1,907.9 | 64.7 |
| Sycamore Creek | Not listed | 93,226.4 | 1.4 | 186.3 | 9.9 | 197.6 | 99.8 |
| Lynch Creek | Not listed | 7,670.6 | 0.1 | 17.8 | 0.9 | 18.8 | 99.8 |
| Reed Creek | Not listed | 253.4 | 0.0 | 75.9 | 4.0 | 79.9 | 68.5 |
| X-trib | Not listed | 215,127.2 | 0.1 | 1.3 | 0.1 | 1.5 | 100.0 |
| Unnamed Trib to Roanoke River | Not listed | 12,848.6 | 0.1 | 19.1 | 1.0 | 20.2 | 99.8 |
| Little Otter River | L26R-01-PCB | 3,934.3 | 0.0 | 596.2 | 31.4 | 627.6 | 84.0 |
| Big Otter River | Not listed | 7,630.9 | 0.0 | 2,462.8 | 129.6 | 2,592.4 | 66.0 |
| Straightstone Creek | Not listed | 464.8 | 0.0 | 279.0 | 14.7 | 293.7 | 36.8 |
| Seneca Creek | Not listed | 692.9 | 0.0 | 400.8 | 21.1 | 421.9 | 39.1 |
| Whipping Creek | Not listed | 398.4 | 0.0 | 157.7 | 8.3 | 166.0 | 58.3 |
| Falling River | Not listed | 4,135.2 | 0.0 | 1,746.5 | 91.9 | 1,838.4 | 55.5 |
| Childrey Creek | Not listed | 390.2 | 0.0 | 201.3 | 10.6 | 211.9 | 45.7 |
| Catawba Creek | Not listed | 168.8 | 0.0 | 94.8 | 5.0 | 99.8 | 40.9 |
| Turnip Creek | Not listed | 376.2 | 0.0 | 272.6 | 14.3 | 286.9 | 23.7 |
| Hunting Creek | Not listed | 86.6 | 0.0 | 65.2 | 3.4 | 68.6 | 20.7 |
| Cub Creek | L19R-01-PCB | 1,376.7 | 0.0 | 997.4 | 52.5 | 1,049.9 | 23.7 |
| Black Walnut Creek | Not listed | 181.9 | 0.8 | 46.5 | 2.5 | 49.7 | 72.7 |
| Roanoke Creek | Not listed | 2,446.8 | 0.0 | 1,429.6 | 75.2 | 1,504.8 | 38.5 |
| Difficult Creek | Not listed | 823.2 | 0.0 | 462.1 | 24.3 | 486.5 | 40.9 |
| Roanoke River | L19R-01-PCB | 239,207.9 | 1,931.8 | 11,961.7 | 731.2 | 14,624.8 | 93.9 |
| **Lower Total** | | **596,841.9** | **1,934.3** | **23,287.0** | **1,327.4** | **26,548.8** | **95.6** |

**Table 6-2. Average daily tPCBs TMDLs for Roanoke River watershed streams**

| Stream | 2008 303(d) list ID | Baseline (mg/d) | WLA (mg/d) | LA (mg/d) | MOS (mg/d) | TMDL (mg/d) | % Reduction |
|---|---|---|---|---|---|---|---|
| **Upper Roanoke River** | | | | | | | |
| North Fork Roanoke River | Not listed | 13.488 | 0.077 | 1.727 | 0.095 | 1.899 | 85.9 |
| South Fork Roanoke River | Not listed | 9.677 | 0.631 | 2.161 | 0.147 | 2.938 | 69.6 |
| Masons Creek | Not listed | 4.870 | 0.025 | 0.529 | 0.029 | 0.583 | 88.0 |
| Peters Creek | L12L-01-PCB | 4.774 | 0.179 | 0.086 | 0.014 | 0.279 | 94.2 |
| Tinker Creek | L12L-01-PCB | 45.462 | 0.285 | 9.354 | 0.507 | 10.146 | 77.7 |
| Wolf Creek | Not listed | 2.955 | 0.027 | 0.056 | 0.004 | 0.087 | 97.0 |
| Unnamed Trib to Roanoke River | Not listed | 0.163 | 0.001 | 0.004 | 0.000 | 0.005 | 96.8 |
| Roanoke River | L12L-01-PCB | 364.951 | 77.144 | 9.468 | 4.559 | 91.171 | 75.0 |
| **Upper Total** | | **446.340** | **78.370** | **23.383** | **5.355** | **107.108** | **76.0** |
| **Lower Roanoke (Staunton) River** | | | | | | | |
| Goose Creek | Not listed | 14.797 | 0.000 | 4.966 | 0.261 | 5.227 | 64.7 |
| Sycamore Creek | Not listed | 255.415 | 0.004 | 0.510 | 0.027 | 0.541 | 99.8 |
| Lynch Creek | Not listed | 21.015 | 0.000 | 0.049 | 0.003 | 0.051 | 99.8 |
| Reed Creek | Not listed | 0.694 | 0.000 | 0.208 | 0.011 | 0.219 | 68.5 |
| X-trib | Not listed | 589.389 | 0.000 | 0.004 | 0.000 | 0.004 | 100.0 |
| Unnamed Trib to Roanoke River | Not listed | 35.202 | 0.000 | 0.052 | 0.003 | 0.055 | 99.8 |
| Little Otter River | L26R-01-PCB | 10.779 | 0.000 | 1.633 | 0.086 | 1.719 | 84.0 |
| Big Otter River | Not listed | 20.906 | 0.000 | 6.747 | 0.355 | 7.102 | 66.0 |
| Straightstone Creek | Not listed | 1.273 | 0.000 | 0.764 | 0.040 | 0.805 | 36.8 |
| Seneca Creek | Not listed | 1.898 | 0.000 | 1.098 | 0.058 | 1.156 | 39.1 |
| Whipping Creek | Not listed | 1.092 | 0.000 | 0.432 | 0.023 | 0.455 | 58.3 |
| Falling River | Not listed | 11.329 | 0.000 | 4.785 | 0.252 | 5.037 | 55.5 |
| Childrey Creek | Not listed | 1.069 | 0.000 | 0.552 | 0.029 | 0.581 | 45.7 |
| Catawba Creek | Not listed | 0.463 | 0.000 | 0.260 | 0.014 | 0.273 | 40.9 |
| Turnip Creek | Not listed | 1.031 | 0.000 | 0.747 | 0.039 | 0.786 | 23.7 |
| Hunting Creek | Not listed | 0.237 | 0.000 | 0.179 | 0.009 | 0.188 | 20.7 |
| Cub Creek | L19R-01-PCB | 3.772 | 0.000 | 2.733 | 0.144 | 2.876 | 23.7 |
| Black Walnut Creek | Not listed | 0.498 | 0.002 | 0.127 | 0.007 | 0.136 | 72.7 |
| Roanoke Creek | Not listed | 6.704 | 0.000 | 3.917 | 0.206 | 4.123 | 38.5 |
| Difficult Creek | Not listed | 2.255 | 0.000 | 1.266 | 0.067 | 1.333 | 40.9 |
| Roanoke River | L19R-01-PCB | 655.364 | 5.293 | 32.772 | 2.003 | 40.068 | 93.9 |
| **Lower Total** | | **1,635.183** | **5.299** | **63.800** | **3.637** | **72.736** | **95.6** |

## 6.1. Wasteload Allocations

Federal regulations (40 CFR 130.7) require TMDLs to include individual WLAs for each point source. WLAs contain the allowable loadings from existing and future point sources. The WLA portion of the TMDL includes the traditional point source discharges, individually permitted stormwater dischargers, and MS4s. WLAs for point source categories in Roanoke River watershed streams grouped by watershed section are presented in Table 6-3. WLA's for individual point sources, permitted stormwater dischargers, and MS4s are presented in Tables 6-4 through 6-6. Note that the loads calculated for all WLA sources are estimates. Loads assigned to traditional point sources were derived from one or two samples of effluent tPCBs concentrations and loads attributed to stormwater dischargers and MS4s are based on estimates of upland soil tPCBs concentrations (see Appendix G). In all cases additional PCB monitoring will have to be performed.

For this TMDL, the VADEQ agreed to apply a consistent approach to all traditional point sources for determining WLAs. The allocations are derived as facility design flow multiplied by the applicable watershed section water column target. In some cases, because current flows are less than facility design flows, this approach results in a TMDL WLA that is larger than the estimated baseline load, which is indicated by negative reduction values in Table 6-4. In addition, for one point source, VA0025020 Western Virginia Water Authority, the existing concentration at which it is discharging is lower than the applicable water quality target. This also contributed to its negative reduction value.

**Table 6-3. Average annual tPCBs WLAs for Roanoke River watershed streams**

| | Point sources | | | Stormwater dischargers[a] | | | MS4s | | |
|---|---|---|---|---|---|---|---|---|---|
| Stream | Baseline (mg/yr) | WLA (mg/yr) | % Reduction[b] | Baseline (mg/yr) | WLA (mg/yr) | % Reduction[b] | Baseline (mg/yr) | WLA (mg/yr) | % Reduction[b] |
| **Upper Roanoke River** | | | | | | | | | |
| North Fork Roanoke River | 10.7 | 17.8 | -66.3 | 105.5 | 1.0 | 99.1 | 990.5 | 9.4 | 99.1 |
| South Fork Roanoke River | 68.4 | 228.6 | -234.0 | 0.0 | 0.0 | 0.0 | 177.4 | 1.7 | 99.1 |
| Masons Creek | 0.0 | 0.0 | 0.0 | 5.9 | 0.1 | 99.1 | 950.6 | 9.0 | 99.1 |
| Peters Creek[c] | 90.7 | 50.8 | 44.0 | 1.4 | 0.0 | 99.1 | 1,542.2 | 14.6 | 99.1 |
| Tinker Creek[c] | 0.0 | 0.0 | 0.0 | 135.6 | 1.3 | 99.1 | 10,799.4 | 102.6 | 99.1 |
| Wolf Creek | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1,053.7 | 10.0 | 99.1 |
| Unnamed Trib to Roanoke River | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 52.8 | 0.5 | 99.1 |
| Roanoke River[c] | 17,495.9 | 27,969.9 | -59.9 | 6,579.0 | 3.0 | 100.0 | 94,055.7 | 184.8 | 99.8 |
| **Upper Total** | **17,665.8** | **28,267.1** | **-60.0** | **6,827.4** | **5.3** | **99.9** | **109,622.4** | **332.7** | **99.7** |
| **Lower Roanoke (Staunton) River** | | | | | | | | | |
| Goose Creek | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 11.7 | 0.1 | 99.3 |
| Sycamore Creek | 0.0 | 0.0 | 0.0 | 92,387.5 | 1.4 | 100.0 | 0.0 | 0.0 | 0.0 |
| Lynch Creek | 0.0 | 0.0 | 0.0 | 8.2 | 0.1 | 99.3 | 0.0 | 0.0 | 0.0 |
| Reed Creek | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 99.3 | 0.0 | 0.0 | 0.0 |
| X-trib | 0.0 | 0.0 | 0.0 | 208,892.4 | 0.1 | 100.0 | 0.0 | 0.0 | 0.0 |
| Unnamed Trib to Roanoke River | 0.0 | 0.0 | 0.0 | 3,885.9 | 0.1 | 100.0 | 0.0 | 0.0 | 0.0 |
| Little Otter River[d] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Big Otter River | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Straightstone Creek | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Seneca Creek | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Whipping Creek | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Falling River | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Childrey Creek | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Catawba Creek | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Turnip Creek | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Hunting Creek | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Cub Creek[e] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Black Walnut Creek | 0.0 | 0.0 | 0.0 | 112.1 | 0.8 | 99.3 | 0.0 | 0.0 | 0.0 |
| Roanoke Creek | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Difficult Creek | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

| Stream | Point sources | | | Stormwater dischargers[a] | | | MS4s | | |
|---|---|---|---|---|---|---|---|---|---|
| | Baseline (mg/yr) | WLA (mg/yr) | % Reduction[b] | Baseline (mg/yr) | WLA (mg/yr) | % Reduction[b] | Baseline (mg/yr) | WLA (mg/yr) | % Reduction[b] |
| Roanoke River[e] | 78,305.9 | 1,926.7 | 97.5 | 82,724.2 | 5.1 | 100.0 | 0.0 | 0.0 | 0.0 |
| **Lower Total** | **78,305.9** | **1,926.7** | **97.5** | **388,012.2** | **7.5** | **100.0** | **11.7** | **0.1** | **99.3** |

a. Stormwater loads were assigned to streams based on the spatial orientation of the permitted area within the subbasin network
b. WLA percent reductions differ from TMDL percent reductions because they do not include an MOS load
c. 2008 303(d) segment L12L-01-PCB
d. 2008 303(d) segment L26R-01-PCB
e. 2008 303(d) segment L19R-01-PCB

### Table 6-4. Point source tPCBs WLAs

| Stream | NPDES ID | Facility | Pipe | Baseline (mg/yr) | WLA (mg/yr) | % Reduction[a] |
|---|---|---|---|---|---|---|
| **Upper Roanoke River** | | | | | | |
| North Fork Roanoke River | VA0027481 | Blacksburg Country Club | 1 | 10.7 | 17.8 | -66.3 |
| **North Fork Roanoke River Total** | | | | **10.7** | **17.8** | **-66.3** |
| South Fork Roanoke River | VA0062219 | Montgomery County PSA - Elliston Lafayette WWTP | 1 | 38.5 | 127.0 | -229.6 |
| South Fork Roanoke River | VA0024031 | Montgomery County PSA - Shawsville STP | 1 | 29.9 | 101.6 | -239.6 |
| **South Fork Roanoke River Total** | | | | **68.4** | **228.6** | **-234.0** |
| Peters Creek | VA0001589 | Steel Dynamics | 5 | 90.7 | 50.8 | 44.0 |
| **Peters Creek Total[b]** | | | | **90.7** | **50.8** | **44.0** |
| Roanoke River | VA0025020 | WVWA Roanoke Regional Water Pollution Control Plant | 1 | 17,491.1 | 27,934.4 | -59.7 |
| Roanoke River | VA0001597 | Norfolk Southern Railway Co - Shaffers Crossing | 2 | 4.8 | 35.6 | -642.0 |
| **Roanoke River Total[b]** | | | | **17,495.9** | **27,969.9** | **-59.9** |
| ***Upper Total*** | | | | ***17,665.8*** | ***28,267.1*** | ***-60.0*** |
| **Lower Roanoke (Staunton) River** | | | | | | |
| Roanoke River | VA0083097 | Old Dominion Clover Power Station | 1 | 197.4 | 319.3 | -61.8 |
| Roanoke River | VA0022241 | Brookneal Town - Staunton River Lagoon | 1 | 8.2 | 14.4 | -74.2 |
| Roanoke River | VA0001538 | Dan River, Inc - Brookneal | 1 | 474.8 | 244.1 | 48.6 |
| Roanoke River | VA0083402 | Old Dominion Altavista Power Station | 1 | 22.7 | 21.5 | 5.0 |
| Roanoke River | VA0020451 | Town of Altavista-STP | 1 | 21,311.1 | 662.6 | 96.9 |
| Roanoke River | VA0083399 | Old Dominion Pittsylvania Power Station | 1 | 21.3 | 35.3 | -66.0 |
| Roanoke River | VA0001678 | ITG Burlington Ind. LLC Hurt Plant | 1 | 56,270.5 | 629.5 | 98.9 |
| **Roanoke River Total[c]** | | | | **78,305.9** | **1,926.7** | **97.5** |
| ***Lower Total*** | | | | ***78,305.9*** | ***1,926.7*** | ***97.5*** |

a. WLA percent reductions differ from TMDL percent reductions because they do not include an MOS load
b. 2008 303(d) segment L12L-01-PCB
c. 2008 303(d) segment L19R-01-PCB

### Table 6-5. Permitted stormwater dischargers tPCBs WLAs[a]

| Stream | NPDES ID[b] | Stormwater discharger | Baseline (mg/yr) | WLA (mg/yr) | % Reduction[c] |
|---|---|---|---|---|---|
| **Upper Roanoke River** | | | | | |
| North Fork Roanoke River | VAR050204 | Wolverine Advanced Materials | 12.70 | 0.12 | 99.050 |
| North Fork Roanoke River | VAR051352 | MRSWA Solid Waste Transfer Station MRF | 54.91 | 0.52 | 99.050 |

| Stream | NPDES ID[b] | Stormwater discharger | Baseline (mg/yr) | WLA (mg/yr) | % Reduction[c] |
|---|---|---|---|---|---|
| North Fork Roanoke River | VAR050251 | Federal Mogul Corp - Blacksburg | 30.12 | 0.29 | 99.050 |
| North Fork Roanoke River | VAR050340 | Wolverine Advanced Materials - Blacksburg | 7.78 | 0.07 | 99.050 |
| **North Fork Roanoke River Total** | | | **105.50** | **1.00** | **99.050** |
| Masons Creek | VAR050174 | Carbone of America Corporation | 4.09 | 0.04 | 99.050 |
| Masons Creek | VAR050762 | Novozymes Biologicals, Inc. | 1.76 | 0.02 | 99.050 |
| **Masons Creek Total** | | | **5.85** | **0.06** | **99.050** |
| Peters Creek | VA0001589 | Steel Dynamics | 1.44 | 0.01 | 99.050 |
| **Peters Creek Total[d]** | | | **1.44** | **0.01** | **99.050** |
| Tinker Creek | VAR050027 | Auto Salvage and Sales Incorporated | 0.78 | 0.01 | 99.050 |
| Tinker Creek | VAR050275 | Old Dominion Auto Salvage | 3.12 | 0.03 | 99.050 |
| Tinker Creek | VAR050436 | Norfolk Southern Corp - Roadway Material Yard | 0.68 | 0.01 | 99.050 |
| Tinker Creek | VAR050520 | O'Neal Steel Inc | 16.12 | 0.15 | 99.050 |
| Tinker Creek | VAR050530 | Shenandoah Auto Parts | 0.88 | 0.01 | 99.050 |
| Tinker Creek | VAR050747 | Parts Unlimited | 3.43 | 0.03 | 99.050 |
| Tinker Creek | VAR051262 | Shorewood Packaging Corporation - Roanoke | 2.18 | 0.02 | 99.050 |
| Tinker Creek | VAR051315 | A D Weddle Company Inc | 4.04 | 0.04 | 99.050 |
| Tinker Creek | VAR051460 | Dynax America Corp USA | 6.74 | 0.06 | 99.050 |
| Tinker Creek | VAR051478 | Precision Steel | 2.07 | 0.02 | 99.050 |
| Tinker Creek | VAR051492 | Virginia Transformer Corp | 4.49 | 0.04 | 99.050 |
| Tinker Creek | VAR051518 | East End Shops | 41.49 | 0.39 | 99.050 |
| Tinker Creek | VAR051570 | Altec Industries Inc | 13.60 | 0.13 | 99.050 |
| Tinker Creek | VAR520005 | Vishay Vitramon Inc | 15.19 | 0.14 | 99.050 |
| Tinker Creek | VAR520156 | Freightcar America | 12.40 | 0.12 | 99.050 |
| Tinker Creek | | Advanced Metal Finishing | 0.42 | 0.00 | 99.050 |
| Tinker Creek | | NSW | 3.75 | 0.04 | 99.050 |
| Tinker Creek | | Packaging Corp. of America | 3.11 | 0.03 | 99.050 |
| Tinker Creek | | The Roanoke Times | 1.15 | 0.01 | 99.050 |
| **Tinker Creek Total[d]** | | | **135.62** | **1.29** | **99.050** |
| Roanoke River | VAR050135 | Virginia Scrap Iron & Metal Company Inc | 4,896.27 | 0.23 | 99.995 |
| Roanoke River | VAR050150 | Graham White Manufacturing Company | 19.75 | 0.19 | 99.050 |
| Roanoke River | VAR050176 | John W Hancock Jr LLC dba New Millennium Bldg Syst | 1.75 | 0.02 | 99.050 |
| Roanoke River | VAR050208 | Walker Machine and Foundry Corp | 6.82 | 0.06 | 99.050 |
| Roanoke River | VAR050273 | Ralph Smith Inc | 2.77 | 0.03 | 99.050 |
| Roanoke River | VAR050515 | Yokohama Tire Corp | 50.20 | 0.48 | 99.050 |
| Roanoke River | VAR050522 | Progress Rail Services Corp - Roanoke | 6.08 | 0.06 | 99.050 |
| Roanoke River | VAR050526 | RR Donnelley and Sons Company - Roanoke | 94.87 | 0.90 | 99.050 |
| Roanoke River | VAR050717 | Cycle Systems Incorporated | 3.97 | 0.04 | 99.050 |
| Roanoke River | VAR050741 | Medeco Security Locks Inc | 17.64 | 0.17 | 99.050 |
| Roanoke River | VAR050775 | Star City Auto Parts Inc | 0.49 | 0.00 | 99.050 |
| Roanoke River | VAR520200 | Hancock Rack Syst dba New Millenium Building Syst | 3.14 | 0.03 | 99.050 |
| Roanoke River | | Accellent Cardiology, Inc.-Main Bldg | 4.52 | 0.04 | 99.050 |
| Roanoke River | | Accellent Cardiology, Inc.-West Bldg | 3.31 | 0.03 | 99.050 |
| Roanoke River | | Allied Tool & Machine Co., of Virginia | 0.61 | 0.01 | 99.050 |
| Roanoke River | | Fabricated Metals Ind., Inc. | 2.89 | 0.03 | 99.050 |
| Roanoke River | | Packaging Corp. of America | 1,415.49 | 0.19 | 99.987 |

| Stream | NPDES ID[b] | Stormwater discharger | Baseline (mg/yr) | WLA (mg/yr) | % Reduction[c] |
|---|---|---|---|---|---|
| Roanoke River | | Patterson Avenue CDD Landfill - Norfolk Southern Railway | 14.44 | 0.14 | 99.050 |
| Roanoke River | | Roanoke Regional Landfill | 0.53 | 0.01 | 99.050 |
| Roanoke River | | Sanitary Landfill at Mowles Spring Park (closed) | 10.70 | 0.10 | 99.050 |
| Roanoke River | VA0001589 | Steel Dynamics | 6.84 | 0.07 | 99.050 |
| Roanoke River | | Tecton Products, Roanoke VA | 15.06 | 0.14 | 99.050 |
| Roanoke River | | Wise Recycling, LLC | 0.86 | 0.01 | 99.050 |
| **Roanoke River Total[d]** | | | **6,578.99** | **2.95** | **99.955** |
| ***Upper Total*** | | | ***6,827.41*** | ***5.31*** | ***99.922*** |
| **Lower Roanoke (Staunton) River** | | | | | |
| Sycamore Creek | VA0001678 | Burlington Industries - Hurt | 92,387.54 | 1.40 | 99.998 |
| **Sycamore Creek Total** | | | **92,387.54** | **1.40** | **99.998** |
| Lynch Creek | VAR051341 | Graham Packaging Plastic Products, Inc. | 8.22 | 0.06 | 99.326 |
| **Lynch Creek Total** | | | **8.22** | **0.06** | **99.326** |
| Reed Creek | VA0083399 | Old Dominion Pittsylvania Power Station | 1.82 | 0.01 | 99.326 |
| **Reed Creek Total** | | | **1.82** | **0.01** | **99.326** |
| X-trib | | BGF Industries | 208,892.36 | 0.12 | 100.000 |
| **X-trib Total** | | | **208,892.36** | **0.12** | **100.000** |
| Unnamed Trib to Roanoke River | VAR050529 | Schrader Bridgeport | 3,885.88 | 0.06 | 99.999 |
| **Unnamed Trib to Roanoke River Total** | | | **3,885.88** | **0.06** | **99.999** |
| Black Walnut Creek | VA0083097 | Old Dominion Clover Power Station | 112.13 | 0.76 | 99.326 |
| **Black Walnut Creek Total** | | | **112.13** | **0.76** | **99.326** |
| Roanoke River | VAR050525 | Abbott Labs | 15.37 | 0.10 | 99.325 |
| Roanoke River | | BGF Industries | 81,933.90 | 0.05 | 100.000 |
| Roanoke River | VA0083402 | Old Dominion Altavista Power Station | 7.66 | 0.05 | 99.325 |
| Roanoke River | VA0083097 | Old Dominion Clover Power Station | 725.61 | 4.89 | 99.326 |
| Roanoke River | VA0083399 | Old Dominion Pittsylvania Power Station | 3.21 | 0.02 | 99.325 |
| Roanoke River | VAR050529 | Schrader Bridgeport | 38.47 | 0.00 | 99.999 |
| **Roanoke River Total[e]** | | | **82,724.24** | **5.12** | **99.994** |
| ***Lower Total*** | | | ***388,012.19*** | ***7.51*** | ***99.998*** |

a. Stormwater loads were assigned to streams based on the spatial orientation of the permitted area within the subbasin network
b. General stormwater permit NPDES IDs were not available for no-exposure sites and other select facilities
c. WLA percent reductions differ from TMDL percent reductions because they do not include an MOS load
d. 2008 303(d) segment L12L-01-PCB
e. 2008 303(d) segment L19R-01-PCB

**Table 6-6. MS4 tPCBs WLAs**

| Stream | MS4 | Baseline (mg/yr) | WLA (mg/yr) | % Reduction[a] |
|---|---|---|---|---|
| **Upper Roanoke River** | | | | |
| North Fork Roanoke River | Blacksburg | 823.7 | 7.8 | 99.050 |
| North Fork Roanoke River | Christianburg | 166.8 | 1.6 | 99.050 |
| **North Fork Roanoke River Total** | | **990.5** | **9.4** | **99.050** |
| South Fork Roanoke River | Christianburg | 177.4 | 1.7 | 99.050 |
| **South Fork Roanoke River Total** | | **177.4** | **1.7** | **99.050** |
| Masons Creek | City of Salem | 923.7 | 8.8 | 99.050 |
| Masons Creek | Roanoke City | 14.6 | 0.1 | 99.050 |
| Masons Creek | Roanoke County | 12.4 | 0.1 | 99.050 |
| **Masons Creek Total** | | **950.6** | **9.0** | **99.050** |

| Stream | MS4 | Baseline (mg/yr) | WLA (mg/yr) | % Reduction[a] |
|---|---|---|---|---|
| Peters Creek | City of Salem | 18.6 | 0.2 | 99.050 |
| Peters Creek | Roanoke City | 1,033.7 | 9.8 | 99.054 |
| Peters Creek | Roanoke County | 490.0 | 4.7 | 99.050 |
| **Peters Creek Total[b]** | | **1,542.2** | **14.6** | **99.053** |
| Tinker Creek | Botetourt County | 1,672.7 | 15.9 | 99.050 |
| Tinker Creek | Roanoke City | 5,081.3 | 48.3 | 99.050 |
| Tinker Creek | Roanoke County | 4,045.4 | 38.4 | 99.050 |
| **Tinker Creek Total[b]** | | **10,799.4** | **102.6** | **99.050** |
| Wolf Creek | Roanoke City | 0.5 | 0.0 | 99.050 |
| Wolf Creek | Roanoke County | 1,053.2 | 10.0 | 99.050 |
| **Wolf Creek Total** | | **1,053.7** | **10.0** | **99.050** |
| Unnamed Trib to Roanoke River | Roanoke County | 52.8 | 0.5 | 99.050 |
| **Unnamed Trib to Roanoke River Total** | | **52.8** | **0.5** | **99.050** |
| Roanoke River | City of Salem | 4,451.6 | 42.3 | 99.050 |
| Roanoke River | Roanoke City | 84,565.4 | 94.7 | 99.888 |
| Roanoke River | Roanoke County | 5,038.7 | 47.9 | 99.050 |
| **Roanoke River Total[b]** | | **94,055.7** | **184.8** | **99.804** |
| ***Upper Total*** | | ***109,622.4*** | ***332.7*** | ***99.697*** |
| **Lower Roanoke (Staunton) River** | | | | |
| Goose Creek | Botetourt County | 11.7 | 0.1 | 99.325 |
| **Goose Creek Total** | | **11.7** | **0.1** | **99.325** |
| ***Lower Total*** | | ***11.7*** | ***0.1*** | ***99.325*** |

a. WLA percent reductions differ from TMDL percent reductions because they do not include an MOS load
b. 2008 303(d) segment L12L-01-PCB

## 6.2. Load Allocations

Generally, the LA is the amount of a pollutant contributed to the waterbody by nonpoint sources. For the purposes of this TMDL, nonpoint sources have been grouped into current and legacy sources. Current nonpoint sources include contributions of PCBs to the Roanoke River watershed from runoff of contaminated sites not within the spatial extent of MS4s or areas permitted for stormwater discharges. Contaminated sites have been categorized as known contaminated sites and urban background including unidentified contaminated sites. Legacy nonpoint sources include atmospheric deposition to surface waters and historically contaminated streambed sediment in the river.

Loadings from contaminated streambed sediments have been excluded from the TMDLs. The rationale for this exclusion is due to the dynamic relationship between the sediment and water column tPCB processes where the flux from sediments is a function of tPCBs concentrations in the stream water-sediment system as a whole (see Appendix G). Rather than a direct loading, the flux of tPCBs to-and-from streambed sediments can be characterized as an internal model mechanism. For this reason the loadings are not comparable to the direct loads contributed by the other sources. Table D-7 in Appendix D presents the initial streambed sediment concentration reductions applied to meet the TMDL condition in the upper and lower Roanoke (Staunton) subwatersheds.

LAs for nonpoint source categories in Roanoke River watershed streams grouped by watershed section are presented in Table 6-7. LAs for individual known contaminated sites not covered by MS4 or stormwater permits are presented in Table 6-8. Note that the loads calculated for all LA sources are estimates. Loads assigned to contaminated sites are based on estimates of upland soil PCB concentrations, while loads attributed to atmospheric deposition are based on literature sources (see Appendix G). In both cases additional PCB monitoring will have to be performed.

**Table 6-7. Average annual tPCBs LAs for Roanoke River watershed streams**

| Stream | Known contaminated sites | | | Urban background/unidentified contaminated sites | | | Atmospheric deposition | | |
|---|---|---|---|---|---|---|---|---|---|
| | Baseline (mg/yr) | LA (mg/yr) | % Reduction[a] | Baseline (mg/yr) | LA (mg/yr) | % Reduction[a] | Baseline (mg/yr) | LA (mg/yr) | % Reduction[a] |
| **Upper Roanoke River** | | | | | | | | | |
| North Fork Roanoke River | 0.0 | 0.0 | 0.0 | 3,184.8 | 30.3 | 99.1 | 631.6 | 600.1 | 5.0 |
| South Fork Roanoke River | 0.0 | 0.0 | 0.0 | 2,481.1 | 23.6 | 99.1 | 805.3 | 765.0 | 5.0 |
| Masons Creek | 0.0 | 0.0 | 0.0 | 623.9 | 5.9 | 99.1 | 197.1 | 187.3 | 5.0 |
| Peters Creek[b] | 0.0 | 0.0 | 0.0 | 76.1 | 0.7 | 99.1 | 32.1 | 30.5 | 5.0 |
| Tinker Creek[b] | 0.0 | 0.0 | 0.0 | 2,085.6 | 19.8 | 99.1 | 3,573.0 | 3,394.4 | 5.0 |
| Wolf Creek | 0.0 | 0.0 | 0.0 | 3.4 | 0.0 | 99.1 | 21.3 | 20.2 | 5.0 |
| Unnamed Trib to Roanoke River | 0.0 | 0.0 | 0.0 | 5.2 | 0.0 | 99.1 | 1.3 | 1.3 | 5.0 |
| Roanoke River[b] | 7,853.5 | 1.0 | 100.0 | 3,622.4 | 34.0 | 99.1 | 3,600.7 | 3,420.7 | 5.0 |
| **Upper Total** | **7,853.5** | **1.0** | **100.0** | **12,082.4** | **114.4** | **99.1** | **8,862.5** | **8,419.4** | **5.0** |
| **Lower Roanoke (Staunton) River** | | | | | | | | | |
| Goose Creek | 0.0 | 0.0 | 0.0 | 3,506.3 | 23.6 | 99.3 | 1,882.9 | 1,788.8 | 5.0 |
| Sycamore Creek | 0.0 | 0.0 | 0.0 | 647.3 | 4.4 | 99.3 | 191.5 | 181.9 | 5.0 |
| Lynch Creek | 7,034.0 | 0.1 | 100.0 | 612.8 | 2.9 | 99.5 | 15.5 | 14.7 | 5.0 |
| Reed Creek | 0.0 | 0.0 | 0.0 | 172.8 | 1.2 | 99.3 | 78.7 | 74.8 | 5.0 |
| X-trib | 6,065.5 | 0.1 | 100.0 | 168.4 | 0.4 | 99.7 | 0.9 | 0.8 | 5.0 |
| Unnamed Trib to Roanoke River | 8,349.1 | 0.1 | 100.0 | 595.8 | 2.1 | 99.6 | 17.8 | 16.9 | 5.0 |
| Little Otter River[c] | 0.0 | 0.0 | 0.0 | 3,330.4 | 22.5 | 99.3 | 603.9 | 573.7 | 5.0 |
| Big Otter River | 0.0 | 0.0 | 0.0 | 5,074.5 | 34.2 | 99.3 | 2,556.4 | 2,428.6 | 5.0 |
| Straightstone Creek | 0.0 | 0.0 | 0.0 | 172.3 | 1.2 | 99.3 | 292.5 | 277.9 | 5.0 |
| Seneca Creek | 0.0 | 0.0 | 0.0 | 272.9 | 1.8 | 99.3 | 420.0 | 399.0 | 5.0 |
| Whipping Creek | 0.0 | 0.0 | 0.0 | 234.1 | 1.6 | 99.3 | 164.3 | 156.1 | 5.0 |
| Falling River | 0.0 | 0.0 | 0.0 | 2,313.2 | 15.6 | 99.3 | 1,822.0 | 1,730.9 | 5.0 |
| Childrey Creek | 0.0 | 0.0 | 0.0 | 179.5 | 1.2 | 99.3 | 210.6 | 200.1 | 5.0 |
| Catawba Creek | 0.0 | 0.0 | 0.0 | 69.5 | 0.5 | 99.3 | 99.3 | 94.4 | 5.0 |
| Turnip Creek | 0.0 | 0.0 | 0.0 | 90.0 | 0.6 | 99.3 | 286.3 | 272.0 | 5.0 |
| Hunting Creek | 0.0 | 0.0 | 0.0 | 18.1 | 0.1 | 99.3 | 68.5 | 65.1 | 5.0 |
| Cub Creek[d] | 0.0 | 0.0 | 0.0 | 329.2 | 2.2 | 99.3 | 1,047.5 | 995.2 | 5.0 |
| Black Walnut Creek | 0.0 | 0.0 | 0.0 | 21.0 | 0.1 | 99.3 | 48.8 | 46.3 | 5.0 |
| Roanoke Creek | 0.0 | 0.0 | 0.0 | 948.8 | 6.4 | 99.3 | 1,498.1 | 1,423.2 | 5.0 |
| Difficult Creek | 0.0 | 0.0 | 0.0 | 339.2 | 2.3 | 99.3 | 484.0 | 459.8 | 5.0 |
| Roanoke River[d] | 62,453.1 | 0.9 | 100.0 | 3,148.7 | 13.6 | 99.6 | 12,576.0 | 11,947.2 | 5.0 |
| **Lower Total** | **83,901.8** | **1.2** | **100.0** | **22,244.9** | **138.7** | **99.4** | **24,365.4** | **23,147.2** | **5.0** |

a. LA percent reductions differ from TMDL percent reductions because they do not include an MOS load
b. 2008 303(d) segment L12L-01-PCB
c. 2008 303(d) segment L26R-01-PCB
d. 2008 303(d) segment L19R-01-PCB

**Table 6-8. Known contaminated site tPCBs LAs**

| Stream | Contaminated site | Baseline (mg/yr) | LA (mg/yr) | % Reduction[a] |
|---|---|---|---|---|
| **Upper Roanoke River** | | | | |
| Roanoke River | Dixie Caverns | 7,853.517 | 1.046 | 99.987 |
| **Roanoke River Total[b]** | | **7,853.517** | **1.046** | **99.987** |
| ***Upper Total*** | | ***7,853.517*** | ***1.046*** | ***99.987*** |
| **Lower Roanoke (Staunton) River** | | | | |
| Lynch Creek | Lane Furniture Co. | 1,654.530 | 0.024 | 99.999 |
| Lynch Creek | Oil distributors-Altavista | 1,846.731 | 0.027 | 99.999 |
| Lynch Creek | West town Dump-Altavista | 3,532.784 | 0.050 | 99.999 |
| **Lynch Creek Total** | | **7,034.044** | **0.101** | **99.999** |
| X-trib | Altavista STP | 3,977.088 | 0.057 | 99.999 |
| X-trib | East town Dump-Altavista | 1,991.809 | 0.028 | 99.999 |
| X-trib | Lane Furniture Co. | 96.643 | 0.001 | 99.999 |
| **X-trib Total** | | **6,065.540** | **0.087** | **99.999** |
| Unnamed Trib to Roanoke River | A. O. Smith | 3,760.673 | 0.055 | 99.999 |
| Unnamed Trib to Roanoke River | Schrader Bridgeport[d] | 4,588.422 | 0.065 | 99.999 |
| **Unnamed Trib to Roanoke River Total** | | **8,349.095** | **0.120** | **99.999** |
| Roanoke River | Altavista STP | 8,750.517 | 0.125 | 99.999 |
| Roanoke River | Dan River Inc. | 28,703.655 | 0.411 | 99.999 |
| Roanoke River | East town Dump-Altavista | 3,256.645 | 0.046 | 99.999 |
| Roanoke River | English Construction | 3,930.367 | 0.058 | 99.999 |
| Roanoke River | Lane Furniture Co. | 10,990.042 | 0.158 | 99.999 |
| Roanoke River | Schrader Bridgeport | 186.755 | 0.003 | 99.998 |
| Roanoke River | West town Dump-Altavista | 6,635.100 | 0.096 | 99.999 |
| **Roanoke River Total[c]** | | **62,453.079** | **0.897** | **99.999** |
| ***Lower Total*** | | ***83,901.758*** | ***1.205*** | ***99.999*** |

a. LA percent reductions differ from TMDL percent reductions because they do not include an MOS load
b. 2008 303(d) segment L12L-01-PCB
c. 2008 303(d) segment L19R-01-PCB
d. Schrader Bridgeport is characterized as a contaminated site and stormwater site because the contaminated area extends beyond the area permitted for stormwater discharges

## 6.3. Margin of Safety

The MOS is the portion of the pollutant loading reserved to account for any uncertainty in the data. There are two ways to incorporate the MOS: (1) implicitly incorporate the MOS by using conservative model assumptions to develop allocations or (2) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. A 5 percent explicit MOS was applied to account for uncertainty in this TMDL. LAs and WLAs were reduced by 5 percent to offset the loading attributed to MOS. In addition, other implicit MOS factors were inherently included in the modeling analysis because of the requirements of the models and input data properties, including not simulating the decay of PCBs.

## 6.4. Critical Conditions and Seasonal Variation

TMDLs must be developed with consideration of critical conditions and seasonal variation. The critical condition is the set of environmental conditions, which, if met, will ensure the attainment of objectives for all other conditions. The critical conditions for PCB loading to the Roanoke River watershed include both storm magnitude precipitation, which causes uplands soil erosion and streambed scour, and low-flow conditions, which cause water quality target exceedances at locations where highly contaminated sediments have accumulated. The LSPC model simulates precipitation variability throughout the watershed as represented by the weather time-series used to drive the model. Thus, the model inherently covers the range of hydrologic conditions that occur in the watershed, including storm-flow and low-flow conditions. Seasonal variation is also captured in the time variable simulation, which represents seasonal precipitation on a year-to-year basis.

# 7. Reasonable Assurance

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels from both point sources and nonpoint sources. The following sections outline the framework used in Virginia to provide reasonable assurance that the required pollutant reductions can be achieved. While neither the Clean Water Act nor current EPA regulations direct states to develop a detailed implementation plan as part of the TMDL development and approval process, reasonable assurance for implementing the allocated loadings is required as part of the TMDL process. The TMDL IP is a requirement of Virginia's 1997 Water Quality Monitoring, Information, and Restoration Act or WQMIRA (§62.1-44.19:4 through 19:8 of the Code of Virginia). Adaptive Implementation, TMDL WLA implementation through VPDES permitting and conventional Implementation Plan development are all strategies discussed in this chapter to achieve reasonable assurance.

## 7.1. Adaptive Implementation Strategy

VADEQ intends to implement this TMDL using an adaptive implementation strategy. As described by Wong (2006), adaptive implementation is an iterative implementation process that makes progress toward achieving water quality goals while using new data and information to reduce uncertainty and adjust implementation activities. The focus of this approach is oriented towards increasingly efficient management and restoration and is not generally anticipated to lead to a re-opening of the TMDL. However, the TMDL and allocation scenarios can be changed if warranted by new data and information.

Adaptive implementation will be particularly useful for the Roanoke River PCB TMDL because of the complexities and uncertainties involved in understanding the fate and transport of PCBs. New data and information will be used to direct control strategies aimed to mitigate PCB loadings to the watershed. Additional information will also help to better understand and characterize PCB loadings from key sources, many of which are still unknown or unconfirmed in the upper Roanoke River watershed. Ultimately, this strategy allows responsiveness to new information while providing the flexibility in implementing the TMDL.

## 7.2. Implementation of Waste Load Allocations

To implement the WLA component of the TMDL, Virginia utilizes the National Pollutant Discharge Elimination System (NPDES) program administered by the Commonwealth (known as Virginia Pollution Discharge Elimination System, or VPDES) under the authority delegated by EPA. Federal regulations require that all new or revised NPDES permits be consistent with the assumptions and requirements of any applicable TMDL WLA (40 CFR §122.44 (d)(1)(vii)(B)). These regulations allow permits to use best management practices (BMPs) in lieu of numeric effluent limitations under certain conditions (40 CFR 122.44(k)). The regulation, in subsections 3 and 4, states that BMP-based water quality based effluent limits (WQBELs) can be used where "Numeric effluent limitations are infeasible; or [t]he practices are reasonably necessary to achieve effluent limitations and standards or to carry out the purposes and intent of the CWA."

In circumstances where final effluent PCB data do not exist or additional characterization is necessary to determine attainment of the WLA, special conditions shall be incorporated into VPDES permits (including municipalities, industrial wastewater, industrial stormwater under individual or general permits) either during modification or re-issuance. To ensure the PCB monitoring requirements are consistently applied, VADEQ has developed PCB point source monitoring guidance (VADEQ, 2009). The document provides guidelines on selecting applicable facilities, final effluent sample collection, PCB analysis using a low-level PCB method (EPA Method 1668), monitoring frequency, and data reporting requirements. This requirement shall also apply to MS4 systems as WLAs have been included in the TMDL.

As mentioned previously, non-numeric WQBELs (BMPs) will be used to comply with the WLA provisions of the Roanoke River PCB TMDL. Where warranted, non numeric BMPs shall be implemented and will focus on PCB source tracking and elimination at the site of contamination, rather than end-of-pipe controls. These BMPs, also referred to as Pollutant Minimization Plans (PMP) would be submitted by the permittee for review and approval. The permittee would be required to execute and periodically update the plan until monitoring and/or compliance with approved BMPs demonstrate that the assigned WLA is consistently met. Essential components of a PMP are as follows:

- Dischargers provide a framework for tracking sources of PCBs within their system. An important component includes the review of historical activities on properties under their control for past presence or known spills of PCBs.
- PMPs must contain specific actions, timetables, and assessment of the effectiveness of the actions. An example of action(s) can include steps needed to locate and control unknown PCB sources.
- Measurement and demonstration of progress in reducing PCBs.

## 7.3. Implementation of Load Allocations

LAs are assigned to nonpoint sources, including known contaminated sites, urban background and unidentified contaminated sites, and atmospheric contamination. Contaminated streambed sediments can also be considered within this category but are not expressed within this TMDL as a direct (or external) source. Under the adaptive implementation approach, the Commonwealth intends to use existing programs in order to attain water quality goals. Available programmatic options include a combination of regulatory authorities, such as the NPDES (WLA component) and Toxics Substances Control Act (TSCA), as well as state programs including the Voluntary Remediation Program (VRP), *Toxics Contamination Source Assessment Policy*, and the Virginia Environmental Emergency Response Fund (VEERF). The *PCB Strategy for the Commonwealth of Virginia*, published in October 2004, establishes the general strategy and outlines the regulatory framework and state initiatives that Virginia will use to address PCB impaired waterbodies. This document is available at: www.deq.virginia.gov/fishtissue/pcbstrategy.html.

Atmospheric deposition sources of PCBs can be numerous and difficult to quantify. PCBs enter the air through a variety of pathways, and the deposition of PCBs from the atmosphere to the land surface and the volatilization of PCBs from the land to the atmosphere are not well understood. Atmospheric deposition studies will help identify these pathways, and efforts to remediate contaminated sites will help reduce possible atmospheric contributions.

tPCBs in streambed sediments are contributing to the system through the dynamic relationship between the sediment and waster processes. This occurs through sediment resuspension and/or partitioning from sediment through desorption. PCB desorption was especially evident during low river flows where water quality target violations occurred within the water column. To address contaminated bed sediments where hot spots exist, mechanical or vacuum dredging could be explored as an option to permanently remove PCBs from the system.

### 7.3.1. Implementation Plan Development

For the implementation of the TMDL's LA component, a TMDL implementation plan will be developed that addresses at a minimum the requirements specified in the Code of Virginia, Section 62.1-44.19.7. Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (the "Act") directs the State

Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters". The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards (US EPA 1999).

In order to qualify for other funding sources, such as EPA's Section 319 grants, additional plan requirements may need to be met. The detailed process for developing an implementation plan has been described in the "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the VADEQ and Virginia Department of Conservation and Recreation (VADCR) TMDL project staff or at http://www.deq.virginia.gov/tmdl/implans/ipguide.pdf

Watershed stakeholders will have opportunities to provide input and to participate in the development of the TMDL implementation plan. Regional and local offices of VADEQ, VADCR, the Virginia Department of Game and Inland Fisheries and other cooperating agencies are technical resources to assist in this endeavor. With successful completion of implementation plans, local stakeholders will have a blueprint to restore impaired waters and enhance the value of their land and water resources. Additionally, development of an approved implementation plan may enhance opportunities for obtaining financial and technical assistance during implementation.

## 7.4. Follow-up monitoring

Following the development of the TMDL, VADEQ will make every effort to continue to monitor the PCB impaired waterbodies in accordance with the fish tissue, sediment, and special study monitoring programs. The objectives are twofold: 1) to assess progress made toward achieving the Roanoke River PCB TMDL, and 2) with the Statewide Fish Tissue and Sediment Monitoring Program to systematically assess and evaluate, using a multi-tier screening, waterbodies in Virginia in order to identify toxic contaminant(s) accumulation that may adversely affect human users of the resource. As funding is available, it is also suggested that monitoring of water column and streambed sediment PCB concentrations be continued by VADEQ through special studies.

The purpose, location, parameters, frequency, and duration of the monitoring will be determined by the VADEQ staff, in cooperation with stakeholders. Whenever possible, the location of the follow-up monitoring station(s) will be in similar locations as the listing stations. At a minimum, the monitoring stations should be representative of the original impaired segments. The details of the follow-up monitoring will be outlined in the annual Fish Tissue and Sediment Monitoring Plan prepared by VADEQ's Water and Biological Monitoring Program. Other agency personnel, watershed stakeholders, etc. may provide input on the annual water monitoring plan.

The long term monitoring of fish tissue, sediment and, as resources allow, ambient water concentrations for PCBs will be used to evaluate trends in PCB concentrations in different environmental media, better characterize PCB loadings into the watershed and identify potential PCB hotspots for remedial activity. New information will be considered in light of the TMDL reduction goals. Recommendations may then be made, when necessary, to target implementation efforts in specific areas and continue or discontinue monitoring at follow-up stations.

### 7.4.1. On-going efforts to characterize and reduce PCB loadings

In 2006, the General Assembly passed legislation requiring the Secretary of Natural Resources to develop a plan for the cleanup of the Chesapeake Bay and Virginia's waters (HB 1150). This plan was completed in 2007 (Commonwealth of Virginia 2007). The plan addresses both point and non-point sources of pollution and includes measurable and attainable objectives for water cleanup, attainable strategies, a specified timeline, funding sources, and mitigation strategies. Additionally, challenges to meeting the clean up plan goals (i.e. lack of program funding, staffing needs, monitoring needs) are identified. Information regarding Virginia's Water Clean-Up Plan can be found at http://www.naturalresources.virginia.gov/Initiatives/WaterCleanupPlan/.

Reductions in sediment from construction sites and development areas will also be of benefit for reducing PCBs. The Virginia Erosion and Sediment Control and Virginia Stormwater Management Programs—administered by the Department of Conservation and Recreation and delegated to local jurisdictions—provide the framework for implementing sediment reduction BMPs throughout localities. More information regarding these programs can be found at http://www.dcr.virginia.gov/soil_&_water/e&s.shtml.

# 8. PUBLIC PARTICIPATION

It is the policy of the Commonwealth of Virginia and EPA to require public participation as part of the TMDL development process. The public comment period for this TMDL begins on July 29, 2009 and ends August 27, 2009. A public notice was published in the *Virginia Register* on July 20, 2009. Two separate public meetings will be held for presentation and discussion of the PCB TMDL development. The upper Roanoke River meeting is scheduled for Wednesday, July 29, at 7 p.m. at the DEQ Blue Ridge Regional Office conference room located at 3019 Peters Creek Road in Roanoke. The lower Roanoke (Staunton) River meeting is scheduled for Thursday, July 30, at 7 p.m. at the Brookneal Elementary School gymnasium located at 1330 Charlotte St. in Brookneal.

Following the final public meetings, comments from interested parties and the general public were submitted to DEQ's Roanoke and Lynchburg Regional Offices by August 27$^{th}$, 2009. Comments with responses are attached to this TMDL.

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