Bacteria TMDL for the Lower Accotink Creek Watershed

Submitted by

Virginia Department of Environmental Quality

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Table of Contents

List of Figures

List of Tables

List of Acronyms

BMP	Best Management Practices
DCR	Department of Conservation and Recreation
DEM	Digital Elevation Model
DEQ	Department of Environmental Quality
DMR	Discharge Monitoring Report
DMME	Department of Mines, Minerals, and Energy
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
GIS	Geographic Information System
IP	Implementation Plan
LA	Load Allocation
LID	Low Impact Development
MOS	Margin of Safety
MOU	Memorandum of Understanding
MS4	Municipal Separate Storm Sewer
NHD	National Hydrography Dataset
NLCD	National Land Cover Data
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
NVRC	Northern Virginia Regional Commission
SPD	Stormwater Planning Division
STATSGO	State Soil Geographic
SWCB	State Water Control Board
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load

VADEQ	Virginia Department of Environmental Quality
VDH	Virginia Department of Health
VDOT	Virginia Department of Transportation
VPDES	Virginia Pollutant Discharge Elimination System
VSMP	Virginia Stormwater Management Program Permits
USGS	U.S. Geological Survey
WLA	Wasteload Allocation
WQMIRA	Water Quality Monitoring, Information, and Restoration Act
WQMP	Water Quality Management Plan

Executive Summary

This report presents the development of the bacteria TMDL for the Lower Accotink Creek watershed. This waterbody was listed as impaired on Virginia's 303(d) Total Maximum Daily Load Priority List and Reports (VADEQ 2004, 2006) because of exceedances of the state's water quality criteria for *E. coli* and fecal coliform bacteria.

Description of the Study Area

The Lower Accotink Creek watershed is located within the borders of Fairfax County in Northern Virginia. For purposes of TMDL development, the portion of Accotink Creek below Lake Accotink is regarded as the Lower Accotink Creek watershed. The impaired segment is located in the Potomac River basin (USGS Cataloging Unit 02070010). The entire Accotink Creek watershed is approximately 30,890 acres, while the lower bacteria-impaired portion of the watershed is 11,395 acres.

Impairment Description

Segment VAN-A15R-01 of Accotink Creek was listed as impaired for bacteria on Virginia's 2006 303(d) Water Quality Assessment Integrated Report (VADEQ, 2006) due to exceedances of the state's water quality criteria for fecal coliform bacteria. The segment was first listed on Virginia's 2004 305(b)/303(d) Water Quality Assessment Integrated Report.

The impaired segment of Accotink Creek (VAN-A15R-01) extends 7.35 miles from the confluence of Calamo Branch to the tidal waters of Accotink Bay. During the 2004 assessment period (January 1998 through December 2002), 6 out of 37 fecal coliform samples (16%) collected at listing station 1AACC006.10 exceeded the fecal coliform instantaneous criterion of 400 cfu/100 ml. This segment remained on the 303(d) list in the 2006 Water Quality Assessment Report.

Applicable Water Quality Standards

At the time of the initial listing of the Lower Accotink Creek segment, the Virginia Bacteria Water Quality Criteria was expressed in fecal coliform bacteria; however, the bacteria water quality criteria has been recently changed and is now expressed in *E. coli*. Virginia's bacteria water quality criteria currently states that *E. coli* bacteria shall not exceed a geometric mean of 126 *E. coli* counts per 100 mL of water for two or more samples within a calendar-month or an *E. coli* concentration of 235 counts per 100 mL of water at anytime. However, the loading rates for watershed-based modeling are available only in terms of the previous standard, fecal coliform bacteria. Therefore, the TMDL was expressed in *E. coli* by converting modeled daily fecal coliform concentrations to daily *E. coli* concentrations using an instream translator. This TMDL was required to meet both the geometric mean and instantaneous *E. coli* water quality standard.

Watershed Characterization

The land use characterization for the Lower Accotink Creek watershed was based on land cover data from the National Land Cover Data set (NLCD) using 2001 reference data and Virginia Department of Forestry 2005 land use data. The dominant land uses in the watershed are urban (77%) land uses.

Potential key sources of bacteria include run-off from point source dischargers, residential waste, pets, and wildlife. In an urban watershed like Accotink Creek, livestock grazing and manure spread on pasture can be very minor contributors of bacteria.

There are four facilities holding active individual Virginia Pollutant Discharge Elimination System (VPDES) permits, issued through the VPDES permitting program, in the bacteria-impaired Lower Accotink Creek watershed. These facilities are not expected to discharge the contaminant of concern (bacteria) and are only included in TMDL development to account for the flow contributed by these facilities. There are also general permits issued within the watershed associated with petroleum, concrete, and industrial stormwater. Because general permits for domestic sewage discharge are the only general permits to discharge the contaminant of concern, none of these other general permits will be included for TMDL development.

Bacteria Source Tracking

For the Lower Accotink Creek TMDL, the Antibiotic Resistance Analysis (ARA) method of Bacteria Source Tracking (BST) was used. ARA has been the most widely used and published BST method to date and has been employed in Virginia, Florida, Kansas, Oregon, South Carolina, Tennessee, and Texas. Advantages of ARA include low cost per sample, and fast turnaround times for analyzing samples. The method can also be performed on large numbers of isolates; typically 48 isolates per unknown source such as an instream water quality sample.

BST was conducted monthly from January 2006 to December 2006 at station 1AACO006.10. Results indicate that bacteria from human, livestock, wildlife, and pet sources are present in Lower Accotink Creek.

TMDL Technical Approach

The Hydrologic Simulation Program-Fortran (HSPF) model was selected and used as a tool to predict the instream water quality conditions of the delineated watershed under varying scenarios of rainfall and fecal coliform loading. HSPF is a hydrologic, watershed-based water quality model. The results from the model were used to develop the TMDL allocations based on the existing fecal coliform load. Basically, this means that HSPF can explicitly account for the specific watershed conditions, the seasonal variations in rainfall and climate conditions, and activities and uses related to fecal coliform loading.

The modeling process in HSPF starts with the following steps:

- delineating the watershed into smaller subwatersheds
- entering the physical data that describe each subwatershed and stream segment
- entering values for the rates and constants that describe the sources and the activities related to the fecal coliform loading in the watershed

Because a bacteria TMDL for the upper portion of Accotink Creek was completed in May of 2002, it was assumed that the bacteria loads from the upper portion would meet the water quality criteria. In addition, Lake Accotink was assumed to be a pass-through lake meaning that no flow retention was expressed in the model.

The Lower Accotink Creek bacteria-impaired watershed was delineated into 20 smaller subwatersheds to represent the watershed characteristics and to improve the accuracy of the HSPF model. This delineation was created using a Digital Elevation Model (DEM), stream reaches obtained from the National Hydrography Dataset (NHD), and stream flow and instream water quality data.

Stream flow data were available from the U.S. Geological Survey (USGS). Weather data were obtained from the National Climatic Data Center (NCDC). The data used in the model include meteorological data (hourly precipitation) and surface airways data (including wind speed/direction, ceiling height, dry bulb temperature, dew point temperature, and solar radiation).

The period of January 1997 to December 2001 was used for HSPF hydraulic calibration and January 2002 to December 2006 was used to validate the HSPF model. The hydrologic calibration parameters were adjusted until there was a good agreement between the observed and simulated stream flow, thereby indicating that the model parameterization is representative of the hydrologic characteristics of the study areas. The model results closely matched the observed flows during low flow conditions, base flow recession and storm peaks.

Instream water quality data for the calibration was retrieved from VADEQ, and was evaluated for potential use in the set-up, calibration, and validation of the water quality model. The existing fecal coliform loading was calculated based on current watershed conditions. Since Virginia has recently changed its bacteria standard from fecal coliform to *E. coli* the modeled fecal coliform concentrations were changed to *E. coli* concentrations using a translator.

TMDL Calculations

The TMDL represents the maximum amount of a pollutant that the stream can receive without exceeding the water quality standard. The load allocation for the selected scenarios was calculated using the following equation:

$$TMDL = \sum WLA + \sum LA + MOS$$

Where,

WLA = wasteload allocation (point source contributions);

LA = load allocation (non-point source allocation); and

MOS = margin of safety.

The margin of safety (MOS) is a required component of the TMDL to account for any lack of knowledge concerning the relationship between effluent limitations and water quality. The MOS was implicitly incorporated in this TMDL. Implicitly incorporating the MOS required that allocation scenarios be designed to meet a calendar-month geometric mean *E. coli* criterion of 126 cfu/100 mL and the instantaneous *E. coli* criterion of 235 cfu/100 mL with 0% exceedance.

Typically, there are several potential allocation strategies that would achieve the TMDL endpoint and water quality standards. A number of load allocation scenarios were developed to determine the final TMDL load allocation scenario.

After using the instream translator, the TMDL allocation plan was developed to meet geometric mean and instantaneous *E. coli* standards. Based on the load-allocation scenario analyses, the TMDL allocation plans that will meet the calendar-month *E. coli* geometric mean water quality criterion of 126 cfu/100 mL and the instantaneous *E. coli* water quality criterion of 235 cfu/100 mL are presented in **Table E-1**.

Table E-1: Lower Accotink Creek Load Reductions Under Calender-Month Geometric Mean and Instantaneous Standards for *E. coli*						
Failed Septics	**Direct Livestock**	**NPS (Agricultural)**	**NPS (Urban)**	**Direct Wildlife**	***E. coli* Percent exceedances of GM standard 126 #/100ml**	***E .coli* Percent exceedances of Inst. standard 235 #/100ml**
100%	**100%**	**97%**	**97%**	**70%**	**0%**	**0%**

The bacteria TMDL for Lower Accotink Creek are presented in **Table E-2** and **E-3**.

Table E-2: Lower Accotink Creek Bacteria TMDL (cfu/day) for *E. coli*			
WLA[1]	**LA**	**MOS**	**TMDL**
1.76E+10	1.54E+10	Implicit	3.30E+10
[1]Wasteload allocation includes allocated load for point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)			

Table E-3: Lower Accotink Creek Bacteria TMDL (cfu/year) for *E. coli*			
WLA[1]	**LA**	**MOS**	**TMDL**
1.76E+12	1.52E+12	Implicit	3.28E+12
[1]Wasteload allocation includes allocated load for point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)			

TMDL Implementation

The Commonwealth intends for this TMDL to be implemented through best management practices (BMPs) in the watershed. Implementation will occur in stages. The benefits of staged implementation are: 1) as stream monitoring continues to occur, it allows for water quality improvements to be recorded as they are being achieved; 2) it provides a measure of quality control, given the uncertainties that exist in any model; 3) it provides a mechanism for developing public support; 4) it helps to ensure the most cost effective practices are implemented initially, and 5) it allows for the evaluation of the TMDL's adequacy in achieving the water quality standard.

While section 303(d) of the Clean Water Act and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. Additionally, 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" (Section 62.1-44.19.7). 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.

Once developed, VADEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and VADEQ, VADEQ also submitted a draft Continuous Planning Process to EPA in which VADEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

1.0 Introduction

1.1 Regulatory Guidance

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollution sources and instream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of their water resources (EPA, 2001).

The main environmental regulatory agency for Virginia is the Department of Environmental Quality (VADEQ). VADEQ works in coordination with the Virginia Department of Conservation and Recreation (DCR), the Department of Mines, Minerals, and Energy (DMME), and the Virginia Department of `Health (VDH) to develop and regulate a more effective TMDL process. VADEQ is the lead agency for the development of TMDLs statewide and focuses its efforts on all aspects of reduction and prevention of pollution to state waters. VADEQ ensures compliance with the Federal Clean Water Act and the Water Quality Planning Regulations, as well as with the Virginia Water Quality Monitoring, Information, and Restoration Act (WQMIRA), passed by the Virginia General Assembly in 1997, and coordinates public participation throughout the TMDL development process. The role of DCR is to initiate nonpoint source pollution control programs statewide through the use of federal grant money. DMME focuses its efforts on issuing surface mining permits and National Pollution Discharge Elimination System (NPDES) permits for industrial and mining operations. Lastly, VDH monitors waters for fecal coliform, classifies waters for shellfish growth and harvesting, and conducts surveys to determine sources of bacterial contamination (VADEQ, 2001).

As required by the Clean Water Act and WQMIRA, VADEQ develops and maintains a listing of all impaired waters in the state that details the pollutant(s) causing each impairment and the potential source(s) of each pollutant. This list is referred to as the 303(d) List of Impaired Waters. In addition to 303(d) List development, WQMIRA directs VADEQ to develop and implement TMDLs for listed waters (VADEQ, 2001a). Once TMDLs have been developed, they are distributed for public comment and then submitted to the EPA for approval.

1.2 Impairment Listing

Segment VAN-A15R-01 of Accotink Creek was listed as impaired for bacteria on Virginia's 2006 303(d) Water Quality Assessment Integrated Report (VADEQ, 2006) due to exceedances of the state's water quality criteria for fecal coliform bacteria. The segment was first listed on Virginia's 2004 305(b)/303(d) Water Quality Assessment Integrated Report. The impaired segment is located within the Potomac River basin (USGS Cataloging Unit 02070010) in Fairfax County, Virginia (**Figure 1-1**).

The impaired segment of Accotink Creek (VAN-A15R-01) extends 7.35 miles from the confluence of Calamo Branch to the tidal waters of Accotink Bay. During the 2004 assessment period (January 1998 through December 2002), 6 out of 37 fecal coliform samples (16%) collected at listing station 1AACC006.10 exceeded the fecal coliform instantaneous criterion of 400 cfu/100 ml. This segment remained on the 303(d) list in the 2006 Water Quality Assessment Report. **Table 1-1** summarizes the details of the impaired segment.

Table 1-1: Impairment Summary for Accotink Creek (VAN-A15R-01)

TMDL ID	Stream Name	Length (mi)	Boundaries	Station ID:	Impairment for	Exceedance Rate*
VAN-A15R-01	Accotink Creek	7.35	Confluence of Calamo Branch to tidal waters of Accotink Bay	1AACC006.10	Fecal Coliform	6 of 37 16%

* based on the 2004 303 (d) fact sheets.

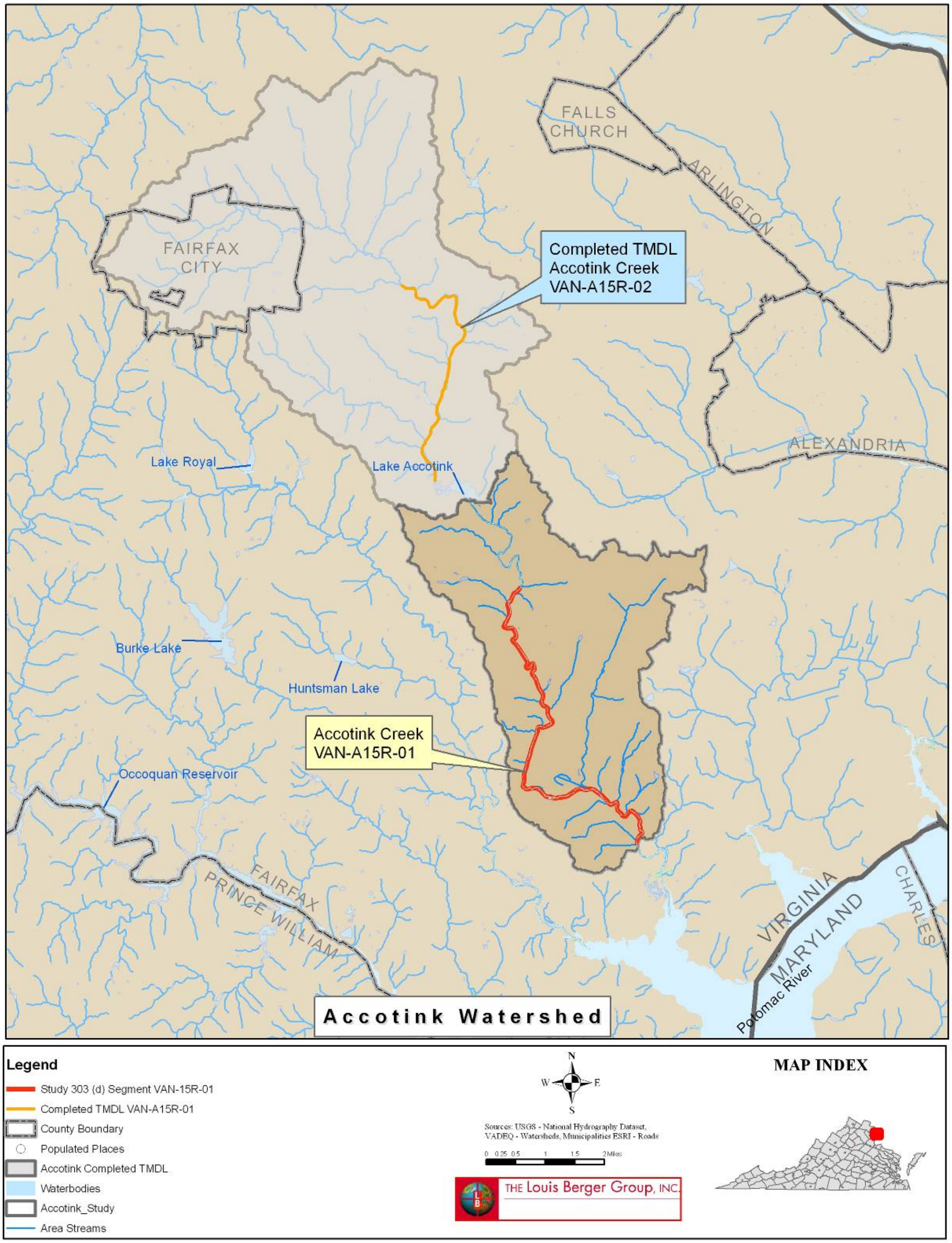

Figure 1-1: Location of the Accotink Creek Watershed

1.3 Applicable Water Quality Standard

Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term "water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."

1.3.1 Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10):

> *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

1.3.2 Applicable Water Quality Criteria

Effective January 15, 2003, VADEQ specified a new bacteria standard in 9 VAC 25-260-170.A, and also revised the disinfection policy in 9 VAC 25-260-170.B. These standards replaced the existing fecal coliform standard and disinfection policy of 9 VAC 25-260-170. For a non-shellfish supporting waterbody to be in compliance with Virginia bacteria standards for primary contact recreation, the current criteria are as follows:

> *"Fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 mL of water for two or more samples taken over a calendar month nor shall more than 10% of the total samples taken during any calendar month exceed 400 fecal coliform bacteria per 100 mL of water. This criterion shall not apply for a sampling station after the [E. coli] bacterial indicators have a minimum of 12 data points or after June 30, 2008, whichever comes first."*

"E. coli bacteria shall not exceed a geometric mean of 126 bacteria per 100 mL of water for two or more samples taken during any calendar month nor should it exceed 235 counts per 100 mL of water for a single sample maximum value. No single sample maximum for E. coli shall exceed a 75% upper one-sided confidence limit based on a site-specific log standard deviation. If site data are insufficient to establish a site-specific log standard deviation, then 0.4 shall be used as the log standard deviation in freshwater. Values shown are based on a log standard deviation of 0.4 in freshwater."

These criteria were adopted because there is a stronger correlation between the concentration of *E. coli* and the incidence of gastrointestinal illness than with fecal coliform. *E. coli* are bacteriological organisms that can be found in the intestinal tract of warm-blooded animals. Like fecal coliform bacteria, these organisms indicate the presence of fecal contamination.

For bacteria TMDL development after January 15, 2003, *E. coli* has become the primary applicable water quality target. However, the loading rates for watershed-based modeling are available only in terms of fecal coliform. Therefore, during the transition from fecal coliform to *E. coli* criteria, DCR, VADEQ and EPA have agreed to apply a translator to instream fecal coliform data to determine whether reductions applied to the fecal coliform load would result in meeting instream *E. coli* criteria. The fecal coliform model and instream translator are used to calculate *E. coli* TMDLs (VADEQ, 2003). The following regression based instream translator is used to calculate *E. coli* concentrations from fecal coliform concentrations:

$$E.\ coli\ conc.\ (cfu/100\ mL) = 2^{-0.0172} \times [fecal\ coliform\ conc.\ (cfu/100mL)]^{0.91905}$$

For Lower Accotink Creek, the TMDL is required to meet both the geometric mean and instantaneous criteria. The modeled daily fecal coliform concentrations are converted to daily *E. coli* concentrations using the instream translator. The TMDL development process also must account for seasonal and annual variations in precipitation, flow, land use, and pollutant contributions. Such an approach ensures that TMDLs, when implemented, do not result in exceedances under a wide variety of scenarios that affect fecal coliform loading.

2.0 TMDL Endpoint Identification

2.1 Selection of TMDL Endpoint and Water Quality Targets

One of the first steps in TMDL development is determining the numeric endpoints, or water quality targets, for each impaired segment. Water quality targets compare the current stream conditions to the expected restored stream conditions after TMDL load reductions are implemented. Numeric endpoints for the Accotink Creek TMDL are established in the Virginia Water Quality Standards (9 VAC 25-260). These standards state that all waters in Virginia should be free from any substances that can cause the water to violate the state numeric standards, interfere with its designated uses, or adversely affect human health and aquatic life. Therefore, the current water quality target for this impairment, as stated in 9 VAC 25-260-170, is an *E. coli* geometric mean no greater than 126 colony-forming units (cfu) per 100 ml for two or more water quality samples taken during any calendar month, and a single sample maximum of 235 cfu per 100 ml at all times.

2.2 Critical Condition

The critical condition is considered the “worst case scenario” of environmental conditions in the Accotink Creek watershed. If TMDLs are developed such that all water quality targets are met under the critical condition, then these targets would also be met under all other conditions.

EPA regulations, 40 CFR 130.7 (c)(1), require TMDLs to take critical conditions for stream flow, loading, and water quality parameters into account. The intent of this requirement is to ensure that the water quality of the Accotink Creek watershed is protected during times when it is most vulnerable. Critical conditions are important because they describe the combination of factors responsible for exceedances of water quality criteria. They will help in identifying the actions that may have to be undertaken in order to meet water quality standards.

The Accotink Creek watershed is mostly developed. Urban land uses are the predominant types of land use, covering 77% of the watershed’s area. The next most predominant type of land use is forest (17%). Potential key sources of bacteria include run-off from point source dischargers, residential waste, pets, and wildlife. In an urban watershed like Accotink Creek, livestock grazing and manure spread on pasture can be very minor contributors of bacteria.

Fecal coliform loadings result from sources that can contribute during wet weather and dry weather. The critical conditions were determined from the available instream water quality data, the bacteria source tracking (BST) data collected by VADEQ, and flow data obtained from USGS gauging stations located on each impaired segment.

Figures 2-1 and **2-2** show the concentrations of fecal coliform, in cfu/100 mL, and of *E. coli*, in cfu/100 mL, that were observed at 1AACO006.10, 1AACO004.84, and 1AACO002.50 under various flow conditions. It should be noted that there was one bacteria sampling event for station 1AACO002.50. The instantaneous standard (400 cfu/100 mL for fecal coliform and 235 cfu/100 mL for *E. coli*) are represented in each figure by a red line, while the geometric mean standard (200 cfu/100 mL for fecal coliform and 126 cfu/100 mL for *E. coli*) are represented by a green line.

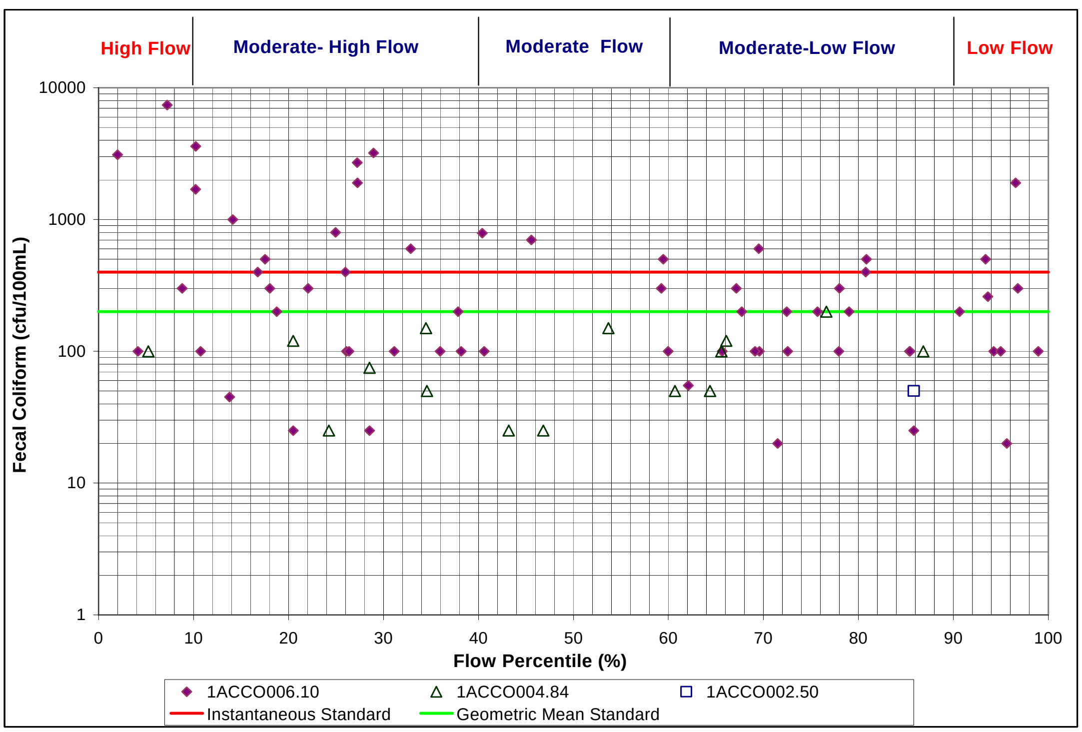

Figure 2-1: Flow Percentile and Fecal Coliform Concentrations (1991-2007)

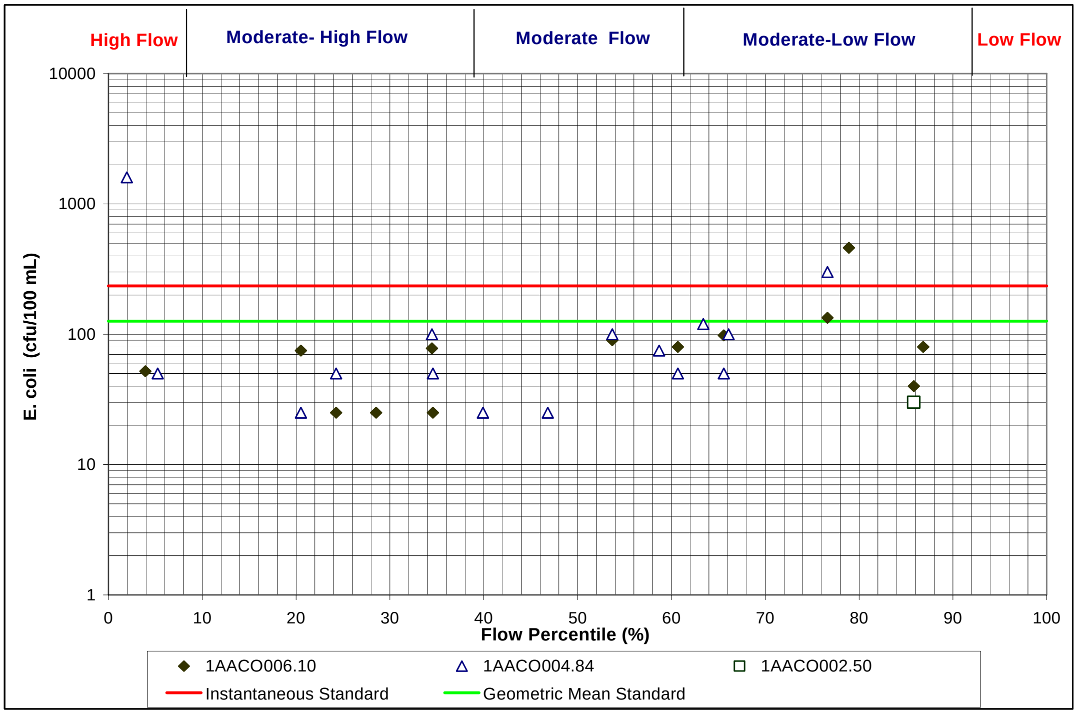

Figure 2-2: Flow Percentile and *E. coli* Concentrations (2005–2007)

Figure 2-1 shows that exceedances of the instantaneous criterion of 400 cfu/100 mL have occurred at 1AACO006.10 under all flow percentiles, including periods of high flow, moderate-high flow (moist conditions), mid-range flow, moderate-low flow (dry conditions), and low flow. However, the greatest number of exceedances occurred during moist conditions. 1AACO004.84 and 1AACO002.50 did not show exceedances under any flow conditions.

Figure 2-2 shows that 1AACO004.84 had two exceedances of the *E. coli* instantaneous standard of 235 cfu/100 mL, one under high flow conditions and one under moderate-low flow (dry conditions). 1AACO006.10 had one exceedance of the *E. coli* instantaneous standard under moderate-low flow (dry conditions). 1AACO002.50 did not show any exceedances under any flow conditions.

Exceedances under high-flow conditions would occur from indirect sources of bacteria, and would most likely exceed the instantaneous standard. Bacteria loads under low-flow conditions would likely occur from direct sources of bacteria, and would most likely violate the instantaneous and geometric mean standard. This TMDL is required to meet both the geometric mean and instantaneous bacteria standards. Therefore, it is necessary for the critical condition to consider both wet weather, high flow conditions and dry weather, low flow conditions in order to comply with both the instantaneous and geometric mean bacteria standards.

2.3 Consideration of Seasonal Variations

Seasonal variations involve changes in stream flow and water quality because of hydrologic and climatological patterns. Seasonal variations were explicitly included in the modeling approach for this TMDL. The continuous simulation model developed for this TMDL explicitly incorporates the seasonal variations of rainfall, runoff and fecal coliform wash-off by using an hourly time-step. In addition, fecal coliform accumulation rates for each land use were developed on a monthly basis. This allowed the consideration of temporal variability in fecal coliform loading within the watershed.

3.0 Watershed Description and Source Assessment

In this section, the types of data available and information collected for the development of the TMDL for Lower Accotink Creek are presented. This information was used to characterize the segment and its watershed and to inventory and characterize the potential point and nonpoint sources of fecal coliform in the watershed.

3.1 Data and Information Inventory

A wide range of data and information were used in the development of this TMDL. Categories of data that were used include the following:

(1) Physiographic data that describe physical conditions (i.e., topography, soils, and land use) within the watershed

(2) Hydrographic data that describe physical conditions within the stream, such as the stream reach network and connectivity, and the stream channel depth, width, slope, and elevation

(3) Data related to uses of the watershed and other activities in the basin that can be used in the identification of potential fecal coliform sources

(4) Environmental monitoring data that describe stream flow and water quality conditions in the stream

Table 3-1 shows the various data types and the data sources used in the TMDL development for the Lower Accotink Creek watershed.

Table 3-1: Inventory of Data and Information Used in the Lower Accotink Creek Bacteria TMDL		
Data Category	**Description**	**Source(s)**
Watershed physiographic data	Watershed boundary	USGS, VADEQ
	Land use/land cover	NLCD
	Soil data (SSURGO, STATSGO)	NRCS, BASINS
	Topographic data (USGS-30 meter DEM, USGS Quads)	USGS, DCR
Hydrographic data	Stream network and reaches (RF3)	BASINS, NHD, Field surveys
	Stream morphology	
Weather data	Hourly meteorological conditions	NCDC, Earth Info
Watershed activities/ uses data and information related to fecal coliform production	Information, data, reports, and maps that can be used to support fecal coliform source identification and loading	Fairfax County government, local groups and stakeholders
	Livestock inventory, grazing, stream access, and manure management	DCR, Fairfax SWCD, NRCS
	Wildlife inventory	DGIF
	Septic systems inventory and failure rates	Local Departments of Health, Utilities, U.S. Census Bureau
	Straight pipes	Census Data, USGS Quad maps
	Best management practices (BMPs)	DCR, NRCS, local SWCDs
Point sources and direct discharge data and information	Permitted facilities locations and discharge monitoring reports (DMRs)	EPA Permit Compliance System (PCS), VPDES, VADEQ
Environmental monitoring data	Ambient instream monitoring data	VADEQ
	Stream flow data	USGS, VADEQ

Notes
BASINS: Better Assessment Science Integrating Point and Nonpoint Sources
DCR: Virginia Department of Conservation and Recreation
VADEQ: Virginia Department of Environmental Quality
DGIF: Virginia Department of Game and Inland Fisheries
EPA: Environmental Protection Agency
NCDC: National Climatic Data Center
NHD: National Hydrography Dataset
NLCD: National Land Cover Data
NRCS: Natural Resources Conservation Service
SWCD: Soil and Water Conservation District
USGS: U.S. Geological Survey
VPDES: Virginia Pollutant Discharge Elimination System

3.2 Watershed Description and Identification

The Lower Accotink Creek watershed is located within the borders of Fairfax County in Northern Virginia. For purposes of TMDL development, the portion of Accotink Creek below Lake Accotink is regarded as the Lower Accotink Creek watershed. The impaired segment is located in the Potomac River basin (USGS Cataloging Unit 02070010). The impaired segment begins at the confluence of Calamo Branch and Accotink Creek, approximately three miles downstream of Lake Accotink. The entire Accotink Creek watershed is approximately 30,890 acres, while the lower bacteria-impaired portion of the watershed is 11,395 acres. As shown in **Figure 3-1**, the major roadways that run through the watershed include Interstate 95, running from North to South, Interstate 495, running from East to West along the northern portion of the watershed, and US Highway 1, running from East to West along the southern portion of the watershed. Other major roads include state highways 613, 617, and 638, running from North to South, as well as State Highway 644 running from East to West.

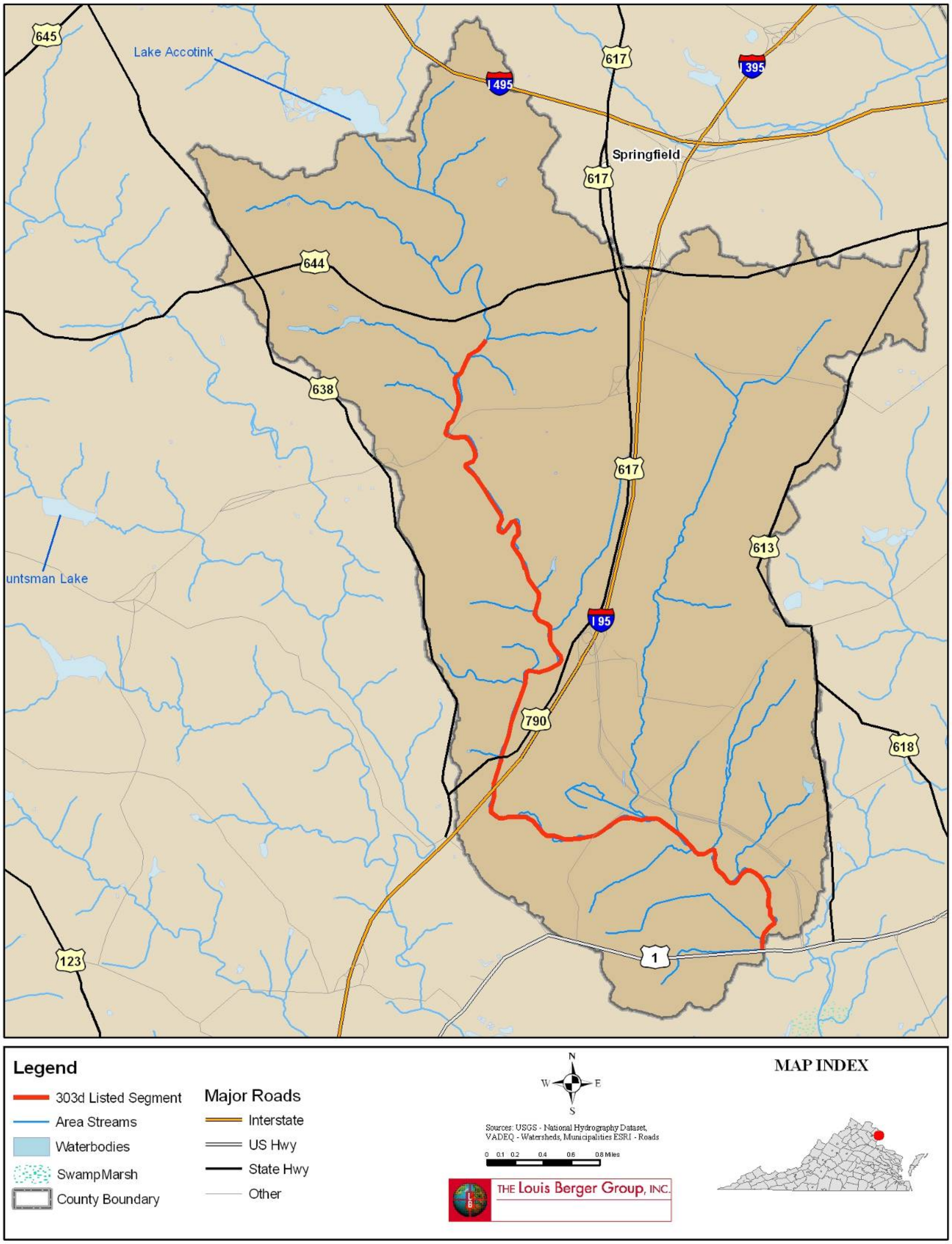

Figure 3-1: Location and Boundary of the Lower Accotink Creek Watershed

3.2.1 Topography

A digital elevation model (DEM) was used to characterize the topography in the watershed. DEM data obtained from USGS show that elevation in the watershed ranges from approximately 7 to 492 feet above mean sea level, with an average elevation of 282 feet above mean sea level.

3.2.2 Soils

The Lower Accotink Creek watershed soil characterization was based on data obtained from the U.S General Soil Map (STATSGO). There are four general soil associations located in the watershed (**Table 3-2)**. The Suffolk-Rumford-Emporia soils comprise 42% of the watershed and are very deep, well drained moderately permeable soils.

Table 3-2: Major Soil Associations within the Accotink Creek Watershed

Soil Name	Acres	Percentage of the Watershed
Manor-Glenelg (s3166)	161	1%
Occoquan-Meadowville-Buckhall (s8273)	3,690	32%
Quantico-Neabsco-Dumfries (s8285)	2,729	24%
Suffolk-Rumford-Emporia (s8287)	4,815	42%
Total	**11,395**	**100%**

The hydrologic soil group linked with each soil association is also presented in **Table 3-3**. The hydrologic soil groups represent different levels of infiltration capacity of the soils. Hydrologic soil group "A" designates soils that are well to excessively well drained, whereas hydrologic soil group "D" designates soils that are poorly drained. This means that soils in hydrologic group "A" allow a larger portion of the rainfall to infiltrate and become part of the ground water system, while soils in hydrologic group "D" allow a smaller portion of the rainfall to infiltrate and become part of the ground water. Consequently, more rainfall becomes part of the surface water runoff along poorly drained soils. Descriptions of the hydrologic soil groups are presented in **Table 3-4**.

Table 3-3: Soil Hydrologic Groups within the Lower Accotink Watershed

Hydrogroup	Acres	Percentage of Watershed
B	11,395	100%
Total	**11,395**	**100%**

Table 3-4: Descriptions of Soil Hydrologic Groups	
Soil Hydrologic Group	**Description**
A	High infiltration rates. Soils are deep, well-drained to excessively-drained sand and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well and well-drained soils with moderately coarse textures.
C	Moderate to slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.
D	Very slow infiltration rates. Soils are clayey, have a high water table, or shallow to impervious cover.

3.2.3 Land Use

The land use characterization for the Accotink Creek watershed was based on land cover data from NLCD using 2001 reference data. The distribution of land uses in Accotink Creek watershed, by land area and percentage, is presented in **Table 3-5**. The NLCD 2001 land use indicated that, as of 2001, the dominant land uses in the watershed were urban (44%) and forest (29%), and account for a combined 73% of the total land area in the watershed. Brief descriptions of land use classifications are presented in **Table 3-6**. **Figure 3-2** depicts the land use distribution within the Lower Accotink Creek watershed.

Table 3-5: NLCD 2001 Land Use Categories within the Lower Accotink Creek Watershed					
Land Use Category	**NLCD Land Use Type**	**Acres**		**Watershed's Land Use Area**	
Water/ Wetlands	Open Water	6	99	<1%	1%
	Woody Wetlands	57		<1%	
	Emergent Herbaceous Wetlands	36		<1%	
Urban	Developed, Low Intensity	2,533	5,056	22%	44%
	Developed, Medium Intensity	1,676		15%	
	Developed, High Intensity	847		7%	
Agriculture	Pasture/Hay	342	748	3%	7%
	Cultivated Crops	406		4%	
Forest	Deciduous Forest	2,992	3,292	26%	29%
	Evergreen Forest	290		3%	
	Mixed Forest	10		<1%	
Other	Developed, Open Space	1,990	2,200	17%	19%
	Barren Land (Rock/Sand/Clay)	210		2%	
Total		**11,395**		**100%**	

Table 3-6 Descriptions of the NLCD 2001 Land Use Types	
Land Use Type	**Description**
Open Water	Areas of open water, generally with less than 25 percent or greater cover of water.
Woody Wetlands	Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Low Intensity Residential	Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.
High Intensity Residential	Includes heavily built up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80-100 percent of the cover.
Commercial/ Industrial/ Transportation	Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as High Intensity Residential.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
Row Crop	Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.
Deciduous Forest	Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	Areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.
Quarries/Strip Mines/Gravel Pits	Areas of extractive mining activities with significant surface expression.
Transitional	Areas of sparse vegetative cover (less than 25 percent that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.)
Urban/Recreational Grasses	Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Source: Multi-Resolution Land Characteristics Consortium NLCD (2001)

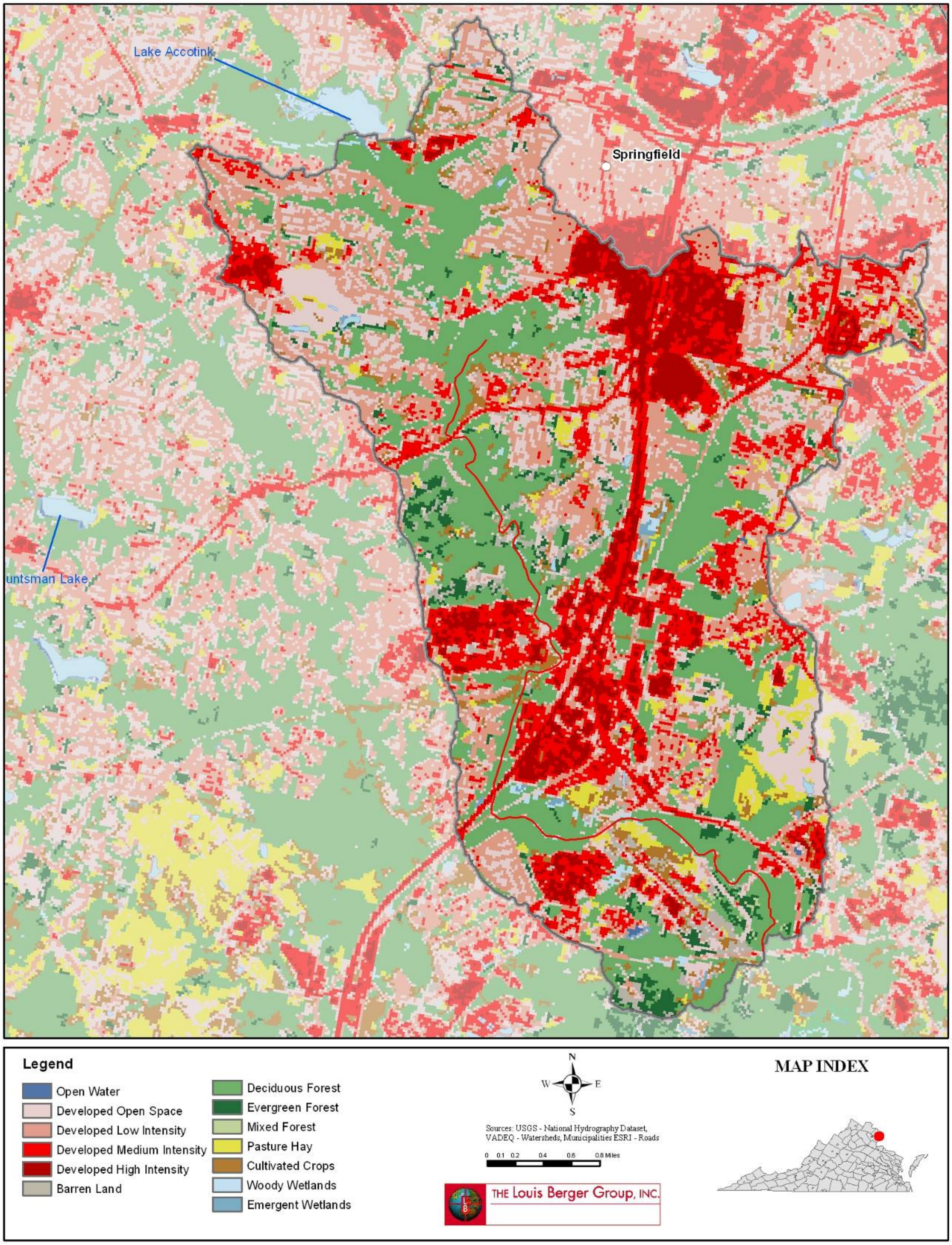

Figure 3-2: NLCD 2001 Land Use in the Lower Accotink Creek Watershed

3.2.4 Land Use Update

Increases in urban and impervious surface areas have large impacts on the watershed hydrology. Because of the urban growth since 2001, it was necessary to update the NLCD land use data to better reflect changes in the watershed. Land use data from 2004, developed by the Virginia Department of Forestry (DOF) for the Commonwealth of Virginia, was used to update the NLCD data. DOF's land use data was developed through segment-based classification of Landsat satellite imagery acquired from 03/10/2002 to 05/08/2005, and provides an up-to-date land use distribution for the commonwealth. The satellite imagery covering the Accotink Creek watershed is comprised of 2004 data.

The land cover classifications in the DOF land cover data set and the NLCD have different formats and land use classifications. The DOF land classifications have different break-downs of the urban land covers (pavement, rooftop, and residential/industrial as opposed to the low/medium/high intensity development in the NLCD classifications), have additional classifications not specifically included in the NLCD (mine/quarry, forest harvest, and salt marsh), and are lacking some of the NLCD classifications (freshwater wetland classifications and shrub/scrub). As such, only the urban classifications from the DOF data were incorporated into the NLCD 2001 data to produce a hybrid land use dataset that provides an update of land use distribution in the Accotink Creek watershed.

The result of incorporating the DOF's 2004 urban land use into the NLCD 2001 is shown in **Table 3-7**. **Figure 3-3** provides a visual comparison of the NLCD and hybrid datasets.

Table 3-7: NLCD 2001 and Hybrid Land Covers

Land Cover Type	NLCD 2001	Hybrid	Change in Acreage
Water/Wetlands	98	58	-40
Urban	7,023	8,794	+1,771
Agriculture	744	356	-388
Forest	3,293	1,991	-1,302
Barren	212	154.62	-58

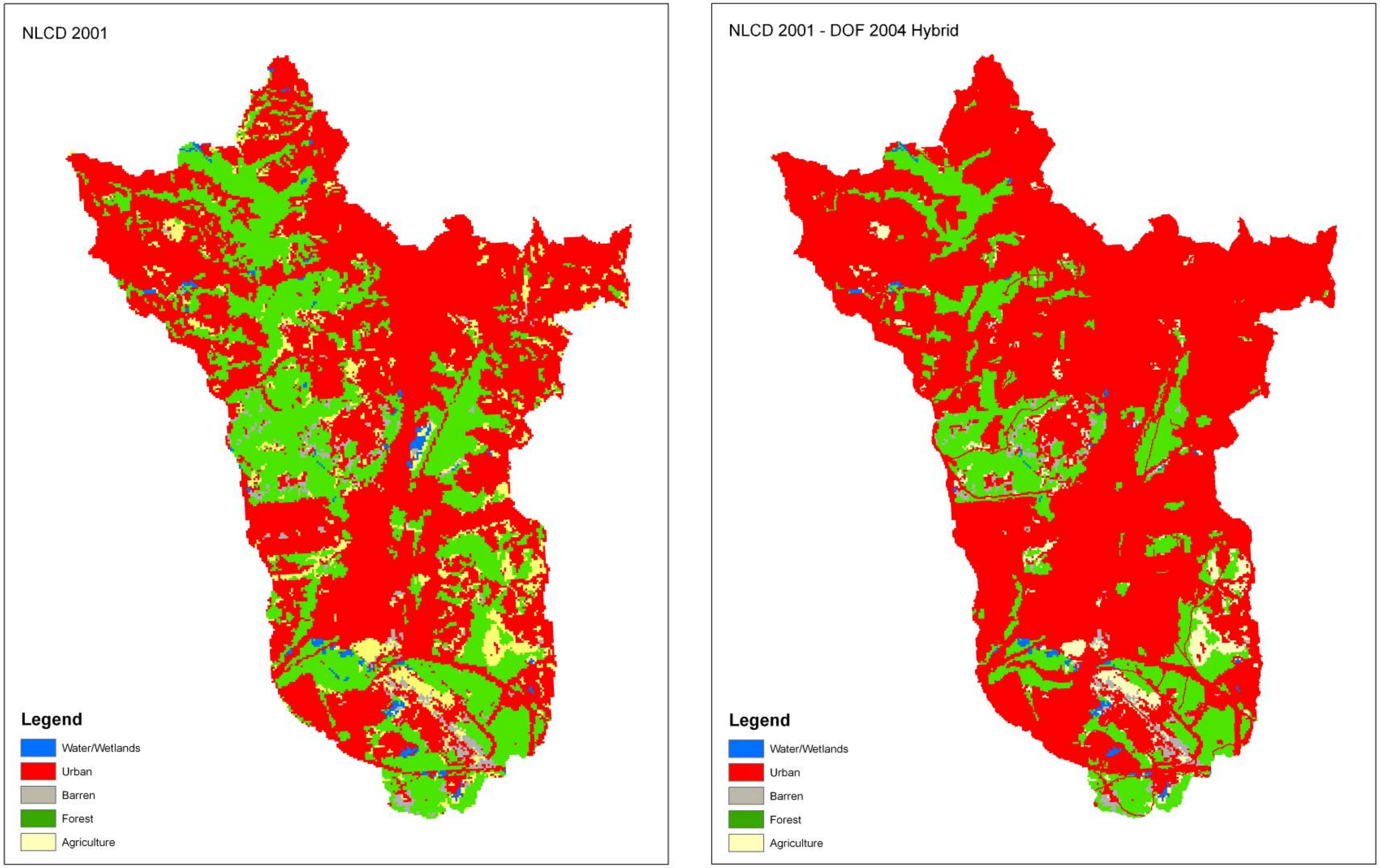

Figure 3-3: NLCD 2001 and Hybrid Land Use Layers for the Lower Accotink Creek Watershed

3.3 Stream Flow Data

Stream flow data were available at one USGS stream flow-gauging stations located within the full Accotink Creek watershed. This station is located above Lake Accotink in the Upper Accotink Creek watershed (**Figure 3-4**). Data collected at this station are shown in **Table 3-8.**

Table 3-8: USGS Stream Flow Data located Accotink Creek

Station ID	Station Name	Period of Daily-Mean Data	
		Start Date	End Date
01654000	Accotink Creek near Annandale, VA	10/1/1947	Present

3.4 VADEQ Ambient Water Quality Data

VADEQ has monitored ambient water quality at four locations in the Lower Accotink Creek watershed between 1991 and 2007. Although three stations were monitored, only 1AACO006.10 was monitored consistently for the period. A list of those monitoring stations is provided in **Table 3-9** and the locations of these stations are presented in **Figure 3-4**. Station identification numbers include the abbreviated creek name, and the river mile on that creek where the station is located. The river mile number represents the distance from the mouth of the creek.

Table 3-9: Lower Accotink Creek Water Quality Monitoring Stations

Station ID	Station Description	Stream Name
1AACO002.50	Rt. #1	Accotink Creek
1AACO004.84	Rt. # 611 (Telegraph Rd)	Accotink Creek
1AACO006.10	Rt. # 790	Accotink Creek

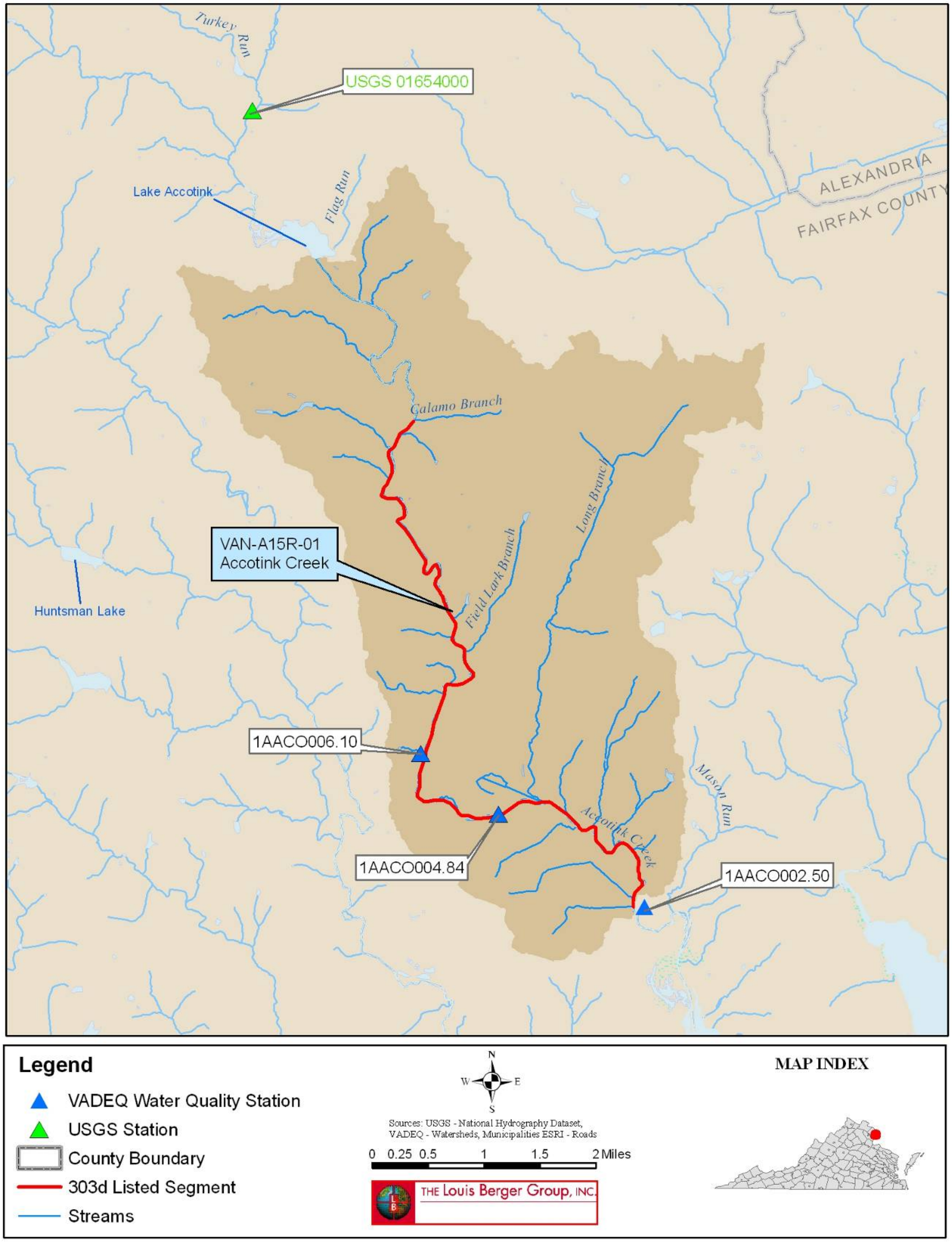

Figure 3-4: Lower Accotink Creek Watershed Monitoring Stations

Table 3-10 lists the water quality sampling period of record and the number and percentage of samples violating the water quality standards collected between 1998 and 2007. The stations formatted in bold text are stations located on the bacteria impaired segments. Analysis of the water quality data indicated that exceedances of the fecal coliform standard ranged between 5 and 15 percent for the instantaneous maximum criterion of 400 cfu/100 ml. Since two or more samples were not collected within a calendar month at these stations, geometric mean exceedances could not be calculated.

Table 3-10: VADEQ Fecal Coliform Data in the Lower Accotink Creek

Station	Date Range	No. of Samples	Min (cfu/ 100mL)	Max (cfu/ 100mL	Avg (cfu/ 100mL	Inst. Max (SSM) Exceedances	
						No.	%
1AACO002.50	**2006**	**1**	**50**	**50**	**50**	**0**	**0**
1AACO004.84	**2006-2007**	**21**	**25**	**2,000**	**170**	**1**	**5**
1AACO006.10	**1998-2007**	**18**	**25**	**7,400**	**815**	**5**	**15**

Three stations within the watershed were sampled between 2005 and 2007 for *E. coli* bacteria. **Table 3-11** lists the water quality sampling period of record, the number of samples, the minimum, maximum and average concentrations observed, and the number and percentage of samples exceeding the water quality standards. Two stations showed one exceedance of the instantaneous maximum during the period of sampling. Since two or more samples were not collected within a calendar month at these stations, geometric mean exceedances could not be calculated.

Table 3-11: VADEQ E. Coli Data in the Impaired Segments of Accotink Creek

Station	Date Range	No. of Samples	Min (cfu/ 100mL)	Max (cfu/ 100mL)	Avg (cfu/ 100mL)	Inst. Max (SSM) Exceedances	
						No.	%
1AACO002.50	**2006**	**1**	**30**	**30**	**30**	**0**	**0**
1AACO004.84	**2005-2006**	**6**	**25**	**1600**	**320**	**1**	**17**
1AACO006.10	**2006-2007**	**13**	**25**	**460**	**97**	**1**	**8**

3.4.1 VADEQ Bacterial Source Tracking (BST) Data

As part of the TMDL development, Bacterial Source Tracking (BST) sampling was conducted at one location in the Accotink Creek watershed. The objective of the BST study was to identify the sources of fecal coliform in the listed segments of the Accotink Creek Watershed. After identifying these sources, this information was used in the model set-up, and in the distribution of fecal coliform loadings among the various sources.

There are various methodologies used to perform BST, which fall into three major categories: molecular, biochemical and chemical. Molecular (genotype) methods are referred to as “DNA fingerprinting,” and are based on the unique genetic makeup of different strains, or subspecies, of fecal coliform bacteria. Biochemical (phenotype) methods are based on detecting biochemical substances produced by bacteria. The type and quantity of these substances are measured to identify the bacteria source. Chemical methods are based on testing for chemical compounds that are associated with human wastewaters, and are restricted to determining if sources of pollution are human or non-human.

For the Accotink Creek Watershed TMDL, the Antibiotic Resistance Analysis (ARA) method of BST was used. ARA has been the most widely used and published BST method to date and has been employed in Virginia, Florida, Kansas, Oregon, South Carolina, Tennessee, and Texas. Advantages of ARA include low cost per sample, and fast turnaround times for analyzing samples. The method can also be performed on large numbers of isolates; typically, 48 isolates per unknown source such as an instream water quality sample.

BST was conducted monthly from January 2006 to December 2006 at station 1AACO006.10, whose location was shown in **Figure 3-4**. Four categories of fecal bacteria sources were considered: wildlife, human, livestock and pet. Results from 12 sampling events at each station, are presented in **Table 3-12** and results are depicted in **Figure 3-5**. Results indicate that bacteria from human, livestock, wildlife, and pet sources are present in Accotink Creek. *E. coli* concentrations exceeded the instantaneous maximum *E. coli* bacteria criterion of 235 cfu/100mL once in the 12 samples collected at the station. In terms of percentages, the instantaneous *E .coli* standard was violated anywhere from 0 to 8.3% percent of the time.

Table 3-12: BST Data Collected During 2006 in the Accotink Creek Watershed

Station ID	Date of Sample	E. coli (cfu/100 mL)	Number of Isolates	Wildlife	Human	Livestock	Pet
1AACO006.10 1 out of 12 samples (8.3%) exceed 235 cfu/100mL	1/9/2006	16	12	58%	8%	17%	17%
	3/6/2006	10	1	0%	0%	0%	100%
	3/27/2006	2	1	0%	0%	0%	100%
	4/18/2006	78	24	84%	4%	8%	4%
	5/16/2006	80	24	96%	0%	0%	4%
	6/19/2006	52	9	0%	56%	11%	33%
	7/17/2006	90	24	50%	8%	17%	25%
	8/15/2006	80	24	84%	0%	4%	12%
	9/12/2006	134	23	87%	4%	9%	0%
	10/16/2006	460	11	9%	82%	0%	9%
	11/6/2006	98	12	0%	8%	0%	92%
	12/11/2006	30	16	50%	44%	0%	6%

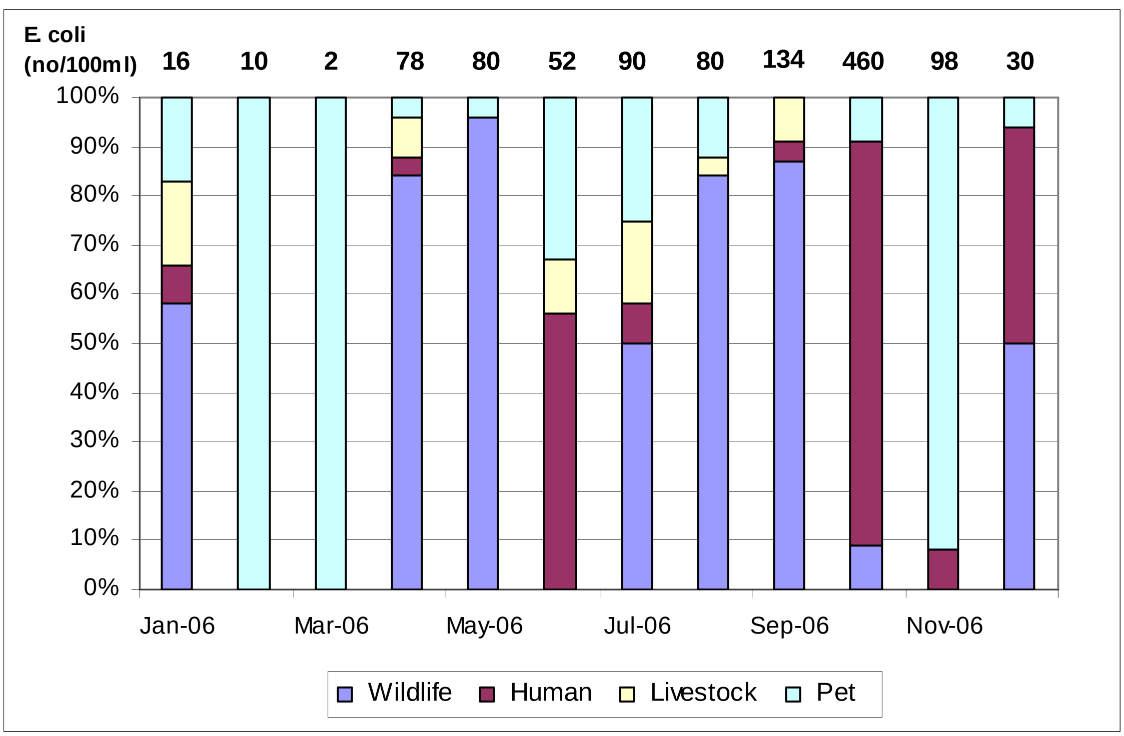

Figure 3-5: BST Source Distributions at 1AACO006.10

3.5 Bacteria Source Assessment

This section focuses on characterizing the sources that potentially contribute to the fecal coliform loading in the Accotink Creek watershed. These potential sources include permitted facilities, sanitary sewer systems and septic systems, livestock, wildlife, and pets. Chapter 4 includes a detailed presentation of how these sources are incorporated and represented in the model.

3.5.1 Permitted Facilities

There are four facilities holding active individual Virginia Pollutant Discharge Elimination System (VPDES) permits, issued through the VPDES permitting program, in the bacteria-impaired Accotink Creek watershed. The permit number, design flow, and status for each permit are presented in **Table 3-13** and the location is shown in **Figure 3-6**. These facilities are not expected to discharge the contaminant of concern (bacteria) and are only included in TMDL development to account for the flow contributed by these facilities. The available flow data for the permitted facilities was retrieved and analyzed. Average flows for the permitted facilities were used in the HSPF model set-up and calibration.

Table 3-13: Individual VPDES Permitted Facilities within the Accotink Creek Watershed

Permit No	Facility Name	Receiving Stream	Size	Category
VA0001988	Motiva Enterprises LLC - Springfield	Accotink Creek, UT	Minor	Industrial
VA0057380	Quarles Petroleum - Newington	Accotink Creek, UT	Minor	Industrial
VA0001945	Kinder Morgan Southeast Terminals LLC - Newington	Accotink Creek, UT	Minor	Industrial
VA0001872	Fairfax Terminal Complex	Daniels Run, UT	Minor	Industrial

There are also general permits issued within the watershed associated with petroleum, concrete, and industrial stormwater. Because general permits for domestic sewage discharge are the only general permits to discharge the contaminant of concern, none of these other general permits will be included for TMDL development.

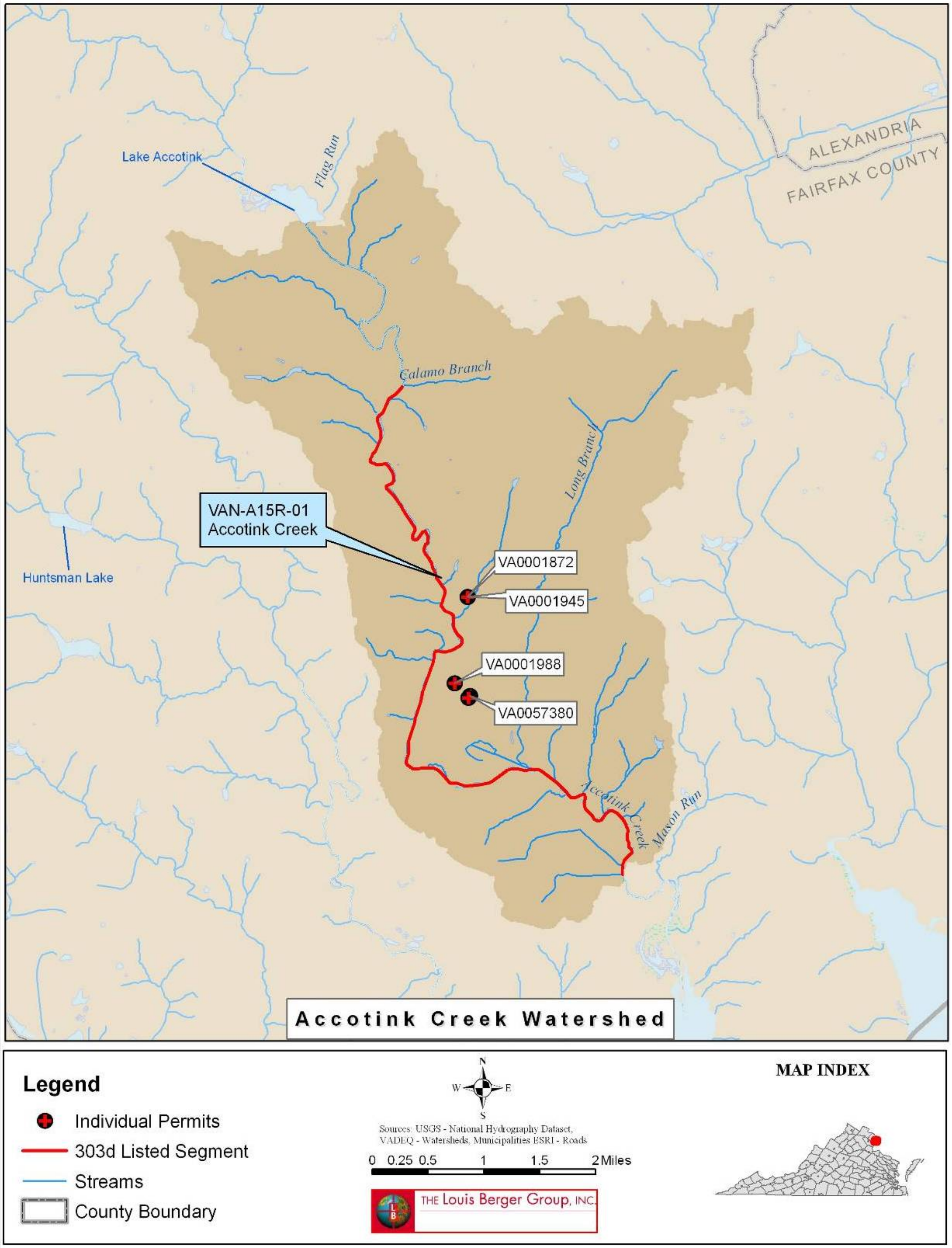

Figure 3-6: Location of Individual VPDES Permitted Facilities in the Accotink Creek Watershed

In addition to the individual permits presented above, Municipal Separate Storm Sewer System (MS4) permits have been issued to cities, counties, and other facilities within the bacteria impaired Lower Accotink Creek Watershed. **Table 3-14** lists all the MS4 permit holders in the Lower Accotink Creek watershed.

Table 3-14: MS4 Permits within the Lower Accotink Creek Watershed

Permit Number	MS4 Permit Holder
VA0088587	Fairfax County
VAR040062	VDOT Northern Urban Area
VAR040104	Fairfax County Public Schools
VAR040095	Northern Virginia Community College
VAR040093	Fort Belvoir

3.5.2 Extent of Sanitary Sewer Network

Houses can be connected to a public sanitary sewer, a septic tank, or the sewage can be disposed by other means. Estimates of the total number of households using each type of waste disposal are presented in the next section.

3.5.2.1 Septic Systems

Estimates of the total number of housing units located in the watershed and the identification of whether these housing units are connected to a public sewer or on septic systems were based U.S. Census Bureau data. The U.S. Census Bureau 2004 data for Fairfax County were reviewed to establish the population growth rates in the counties and to validate the housing units' calculation. A summary of the census data and population estimates used for the Lower Accotink Creek watershed are presented in **Table 3-15**.

Table 3-15: 2004 Census Data Summary for Lower Accotink Creek Watershed

County	Total Population	Total Households
Fairfax County	51,624	16,237

Source: U.S. Census Data

There are an estimated 486 septic systems and no known straight pipes in the watershed. This estimate was provided by the Fairfax County Health Department. However, since there are potentially some unknown straight pipes within the watershed, the load for straight pipes was incorporated into failure rate for failing septic systems in the watershed.

3.5.2.2 Failed Septic Systems

In order to determine the amount of fecal coliform contributed by human sources, the failure rates of septic systems must be estimated. Septic system failures are generally attributed to the age of a system. For this TMDL model, the failure rate was assumed to be 1.62 percent of the total septic systems in the watershed (Upper Accotink Creek TMDL, 2002). In order to determine the load of bacteria from these sources, it was assumed that the septic system design flow is 75 gallons per person per day (Horsley and Whitten, 1996). In addition, it was estimated that typical fecal coliform concentrations from a failed septic system is 10,000 cfu/100mL (Horsley and Whitten, 1996).

3.5.3 Livestock

An inventory of the livestock residing in the Accotink Creek watershed was conducted using data and information provided by United States Department of Agriculture (USDA) National Agricultural Statistics Service, Virginia's Department of Conservation and Recreation, NRCS, Virginia Agricultural Statistics Service (2002), the 2001 Virginia Equine Report, Soil and Water Conservation Districts (SWCD), as well as field surveys. Original estimates were reviewed by stakeholders. **Table 3-16** summarizes the livestock inventory in the watershed.

Table 3-16: Livestock Inventory for the Accotink Creek Watershed

Livestock Type	Total
Beef cows	3
Hogs and pigs inventory	1
Sheep and lambs inventory	1
Chickens	4
Horses and ponies, inventory	23

*Source: USDA, Virginia Equine Report

The livestock inventory was used to determine the fecal coliform loading by livestock in the watershed. **Table 3-17** shows the average fecal coliform production per animal per day contributed by each type of livestock.

Table 3-17: Daily Fecal Coliform Production of Livestock		
Livestock Type	**Daily Fecal Coliform Production (millions of cfu/day per animal)**	**Reference**
Cattle and calves	5,400	Metcalf and Eddy, 1991
Beef Cows	100,000	ASAE, 1998
Dairy Cows	100,000	ASAE, 1998
Hogs & Pigs	8,900	Metcalf and Eddy, 1991
	11,000	ASAE, 1998
Sheep & Lambs	18,000	Metcalf and Eddy, 1991
	12,000	ASAE, 1998
Horses & Ponies	420	ASAE, 1998

Source: USEPA Protocol for Developing Pathogen TMDLs, 2001

The impact of fecal coliform loading from livestock is dependent upon whether loadings are directly deposited into the stream, or indirectly delivered to the stream via surface runoff. For this TMDL, fecal coliform deposited while livestock were in confinement or grazing was considered indirect deposit, and fecal coliform deposited when livestock directly defecate into the stream was considered direct deposit. The distribution of daily fecal coliform loading between direct and indirect deposits was based on livestock daily schedules.

The daily schedule for beef cattle is presented in **Table 3-18**. The time beef cattle spend in the pasture or loafing was used to determine the fecal coliform load deposited indirectly. The directly deposited fecal coliform load from livestock was based on the amount of time they spend in the stream.

Table 3-18: Daily Schedule for Beef Cattle

Month	Time Spent in		
	Pasture (Hour)	Stream (Hour)	Loafing Lot (Hour)
January	23.50	0.50	0
February	23.50	0.50	0
March	23.25	0.75	0
April	23.00	1.00	0
May	23.00	1.00	0
June	22.75	1.25	0
July	22.75	1.25	0
August	22.75	1.25	0
September	23.00	1.00	0
October	23.25	0.75	0
November	23.25	0.75	0
December	23.50	0.50	0

Source: Dodd Creek TMDL Report, DCR 2002.

3.5.4 Land Application of Manure

Land application of the manure that cattle produce while in confinement is a typical agricultural practice. Beef cattle are present in the watershed. The manure produced by confined livestock was directly applied on the pasturelands, and was treated as an indirect source in the development of the Accotink Creek TMDL.

3.5.5 Land Application of Biosolids

Non-point human sources of fecal coliform can be associated with the spreading of biosolids. Data provided by Virginia Department of Health (VDH) indicated that there has been no biosolids application in Fairfax County.

3.5.6 Wildlife

Similar to livestock contributions, wildlife contributions of fecal coliform can be both indirect and direct. Indirect sources are those that are carried to the stream from the surrounding land via rain and runoff events, whereas direct sources are those that are directly deposited into the stream.

The wildlife inventory for this TMDL was developed based on a number of information and data sources, including: (1) habitat availability, (2) Department of Game and Inland

Fisheries (DGIF) harvest data and population estimates, and (3) stakeholder comments and observations.

A wildlife inventory was conducted based on habitat availability within the watershed. The number of animals in the watershed was estimated by combining typical wildlife densities with available stream wildlife habitat. Also, to be consistent with the approved TMDL completed for the upper portion of the watershed, the estimates used in this TMDL were also incorporated (USGS, 2003). Based on the typical wildlife densities, the population of geese, mallards, and wood ducks were determined to be less than what stakeholders had observed within the watershed. Therefore, these densities were increased based on information provided by DGIF and the Fairfax County Park Authority.

Table 3-19: Wildlife Densities

Wildlife type	Population Density	Habitat Requirements
Deer[1]	0.12 animals/acre	Entire watershed
Raccoon[1]	0.31 animals/acre	Entire watershed
Muskrat[1]	0.23 animals/acre	Within 60 feet of streams and ponds (urban, grassland, forest, wetlands)
Beaver[2]	4.8 animals/mile of stream	Within 66 feet of streams and ponds
Goose Summer[1]	2.34 animals/acre	Within 300 feet of streams and ponds (urban, grasslands, wetlands)
Goose Winter[1]	2.50 animals/acre	Within 300 feet of streams and ponds (urban, grasslands, wetlands)
Duck Summer[1]	0.06 animals/acre	Within 300 feet of streams and ponds (urban, grasslands, wetlands, forest)
Duck Winter[1]	0.37 animals/acre	Within 300 feet of streams and ponds (urban, grasslands, wetlands, forest)
Wild Turkey[2]	0.01 animals/acre	Entire watershed excluding urban land uses

[1]Source: Upper Accotink Creek TMDL USGS, 2002
[2]Source: Map Tech, Inc., 2001

The wildlife inventory presented in **Table 3-20** was calculated using the densities from **Table 3-19**, confirmed by DGIF and the Fairfax County Park Authority, and presented to stakeholders for approval.

Table 3-20: Accotink Creek Watershed Wildlife Inventory	
Wildlife Animal	**Total**
Deer	957
Raccoon	3,483
Muskrat	290
Beaver	73
Goose Summer	2,201
Goose Winter	4,647
Duck Summer	206
Duck Winter	305
Wild Turkey	2

The wildlife inventory was used to determine the fecal coliform loading by wildlife within the watershed. Separation of the wildlife daily fecal coliform load into direct and indirect deposits was based on estimates of the amount of time each type of wildlife spends on land versus time spent in the stream. **Table 3-21** shows the average fecal coliform production per animal, per day, contributed by each type of wildlife and the percent of time each type of wildlife spends in the stream on a daily basis.

Table 3-21: Fecal Coliform Production from Wildlife		
Wildlife	**Daily Fecal Production (in millions of cfu/day per animal)**	**Portion of the Day in Stream (%)**
Deer	347	1
Raccoon	113	10
Muskrat	25	50
Goose	799	50
Beaver	0.2	90
Duck	2,430	75
Wild Turkey	93	5

Source: ASAE, 1998; Map Tech, Inc., 2000; EPA, 2001.

3.5.7 Pets

The contribution of fecal coliform loading from pets was also examined in the assessment of fecal coliform loading to the Lower Accotink Creek Watershed. The two types of domestic pets that were considered as sources of bacteria in this TMDL were cats and dogs. The number of pets residing in the watershed was estimated by determining the number of households in the watershed, and multiplying this number by national average estimates of the number of pets as 0.543 dogs per household and 0.598 cats per household **(Table 3-24).**

Table 3-22: Pet Estimates in the Lower Accotink Creek Watershed	
Dogs	**Cats**
8,817	9,580

Fecal coliform loading from pets occurs primarily in residential areas. The load was estimated based on daily fecal coliform production rate of 5.04 $x10^2$ cfu/day per cat and 4.09 $x10^9$ cfu/day per dog.

4.0 Modeling Approach

This section describes the modeling approach used in the TMDL development. The primary focus is on the sources represented in the model, assumptions used, model set-up, calibration, and validation, and the existing load.

4.1 Modeling Goals

The goals of the modeling approach were to develop a predictive tool for the waterbody that can:

- represent the watershed characteristics
- represent the point and nonpoint sources of fecal coliform and their respective contribution
- use input time series data (rainfall and flow) and kinetic data (die-off rates of fecal coliform)
- estimate the instream pollutant concentrations and loadings under the various hydrologic conditions
- allow for direct comparisons between the instream conditions and the water quality standard

4.2 Watershed Boundaries

The impaired segment is located in the Lower Accotink Creek watershed (USGS Cataloging Unit 02070010). Lower Accotink Creek flows through Fairfax County. The entire Accotink Creek watershed is approximately 30,890 acres, while the lower bacteria-impaired portion of the watershed is 11,395 acres. **Figure 4-1** shows the boundaries of the Accotink Creek watershed. The TMDL for the upper portion of Accotink Creek was completed in May of 2002 (Fecal Coliform TMDL for Accotink Creek, 2002).

Because a bacteria TMDL for the upper portion of Accotink Creek was completed in May of 2002, it was assumed that the bacteria loads from the upper portion would meet the water quality criteria. In addition, Lake Accotink was assumed to be a pass-through lake meaning that no flow retention was expressed in the model.

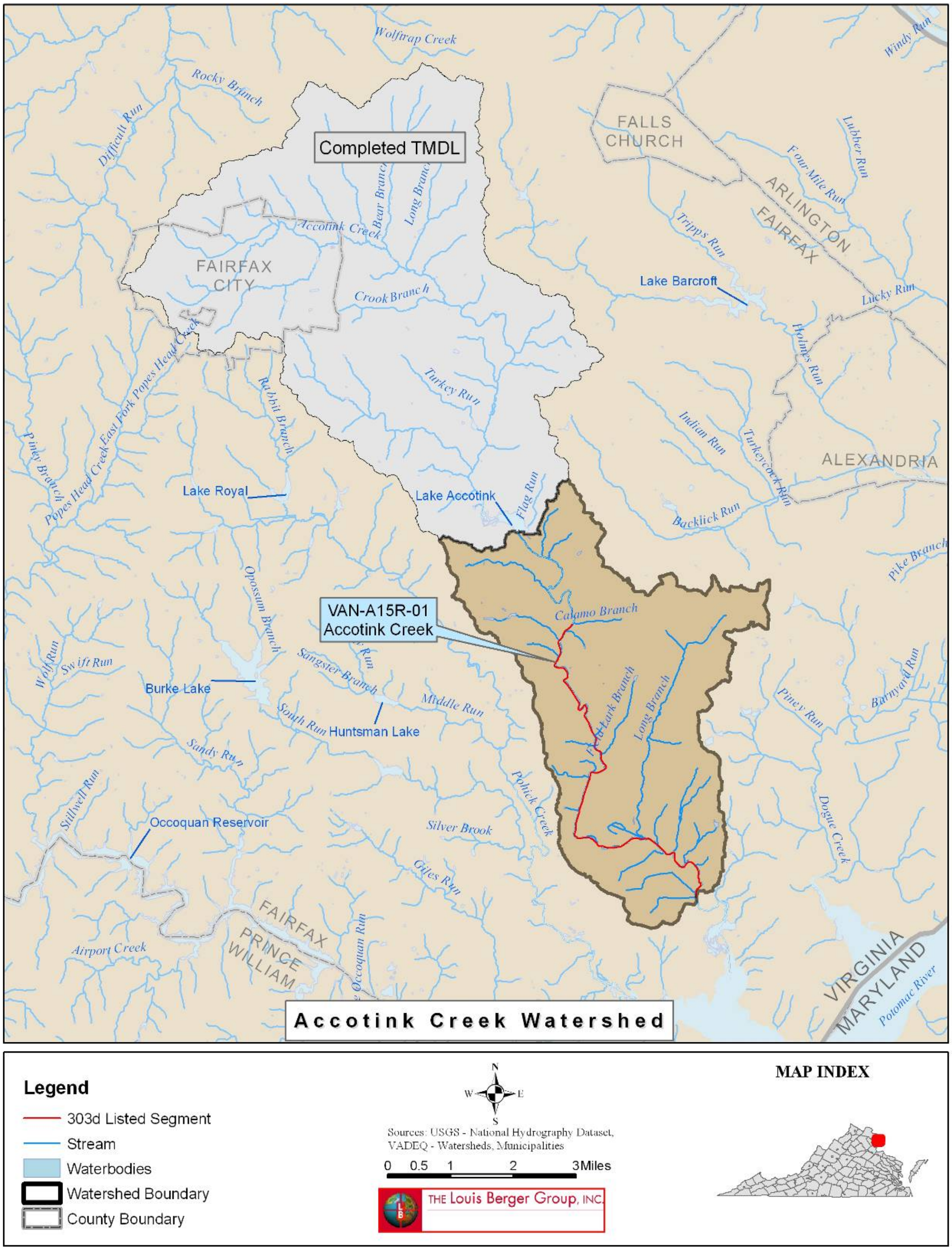

Figure 4-1: Watershed Boundary

4.3 Modeling Strategy

4.3.1 Model Selection

The Hydrologic Simulation Program-Fortran (HSPF) model was selected and used to predict the instream water quality conditions under varying scenarios of rainfall and fecal coliform loading. The results from the developed model are subsequently used to develop the TMDL allocations based on the existing fecal coliform load.

HSPF is a hydrologic, watershed-based water quality model. Consequently, HSPF can explicitly account for the specific watershed conditions, the seasonal variations in rainfall and climate conditions, and activities and uses related to fecal coliform loading.

The modeling process in HSPF starts with the following steps:

- delineate the watershed into smaller subwatersheds
- enter the physical data that describe each subwatershed and stream segment
- enter values for the rates and constants that describe the sources and the activities related to the fecal coliform loading in the watershed

These steps are discussed in the next sections.

4.4 Watershed Delineation

For this TMDL, the entire Accotink Creek watershed was delineated into 56 smaller subwatersheds, 20 of which subdivide the bacteria impaired portion of the watershed, to represent the watershed characteristics and to improve the accuracy of the HSPF model. This delineation was created using a Digital Elevation Model (DEM), stream reaches obtained from the National Hydrography Dataset (NHD), and stream flow and instream water quality data. Size distributions of the 20 bacteria-impaired subwatersheds are presented in **Table 4-1**. **Figure 4-2** is a map showing the delineated subwatersheds for the Accotink Creek watershed.

Table 4-1: Bacteria-Impaired Lower Accotink Creek (VAN-A15R-01) Subwatershed Acres	
Subwatershed	**Drainage Area (acres)**
1	17
2	521
3	519
4	464
5	894
6	1,037
7	677
8	478
9	223
10	418
11	624
12	376
13	1,399
14	265
15	582
16	346
17	900
54	577
55	561
56	517
Total Subwatershed Acres	**11,395**

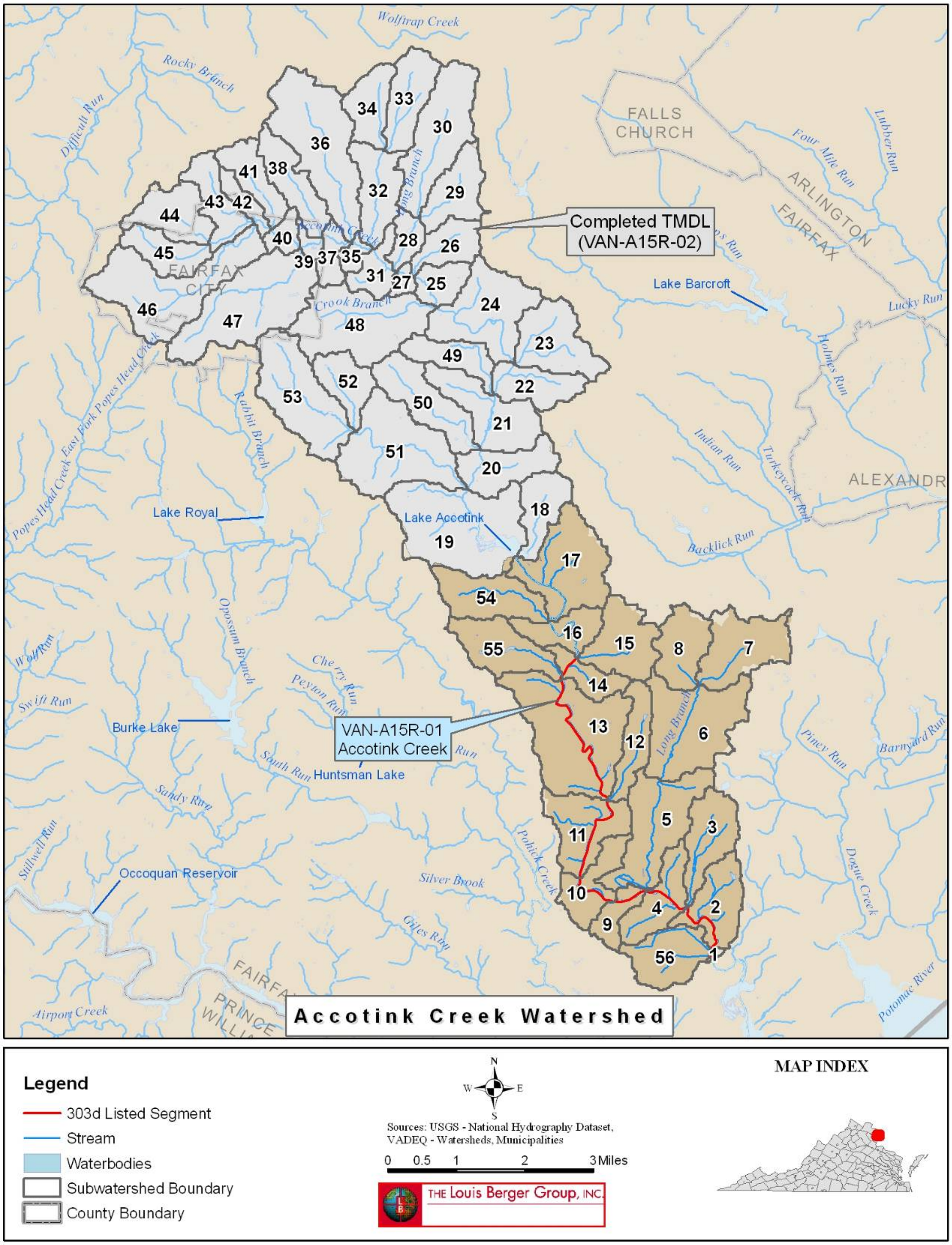

Figure 4-2: Modeled Subwatersheds

4.5 Land Use Reclassification

As previously mentioned, land use distribution in the study area was determined using NLCD 2001 and DOF 2005 data. The land use data and distribution of land uses were presented in Chapter 3. There are 13 land use classes present in the watershed; the dominant land use being urban land uses. The original 13 land use types were consolidated into eight land use categories to meet modeling goals, facilitate model parameterization, and reduce modeling complexity. This reclassification reduced the 13 land use types to a representative number of categories that best describe conditions and the dominant fecal coliform and *E. coli* source categories in the watersheds. Land use reclassification was based on similarities in hydrologic characteristics and potential fecal coliform production characteristics. The reclassified land uses are presented in **Table 4-2** for the impaired watershed.

Table 4-2: Lower Accotink Creek Land Use Reclassification

Land Use Category	Acres	Percent of Watershed's Land Area
High Density Residential	1,191	10%
Medium Density Residential	2,685	24%
Low Density Residential	4,476	39%
Commercial/Industrial	525	5%
Cropland	164	1%
Pasture	338	3%
Forest	1,959	17%
Water	57	<1%
Total	**11,395**	**100%**

4.6 Hydrographic Data

Hydrographic data describing the stream network were obtained from the National Hydrography Dataset (NHD). This data was used for HSPF model development and TMDL development. Accotink Creek and its tributaries were represented as trapezoidal channels. The channel slopes were estimated using the reach length and the corresponding change in elevation from DEM data. The flow was calculated using the Manning's equation using a 0.05 roughness coefficient. Model representation of the stream reach segments is presented in **Appendix A**.

4.7 Fecal Coliform Sources Representation

This section demonstrates how the fecal coliform sources identified in Chapter 3 were included or represented in the model. These sources include permitted sources, human sources (failed septic systems and straight pipes), livestock, wildlife, pets, and land application of manure and biosolids.

4.7.1 Permitted Facilities

There are four individual VPDES permitted facilities and 28 general permits located in the Lower Accotink Creek watershed. However, the individual VPDES permitted facilities are not expected to discharge the contaminant of concern and are only included in TMDL development to account for the flow contributed by these facilities. In addition, none of the 28 general permits were associated with domestic sewage discharge and therefore not included in TMDL development.

For TMDL development, average discharge flow values were considered representative of flow conditions at each permitted facility, and were used in HSPF model set-up and calibration.

4.7.2 Failed Septic Systems

Failed septic system loading to the watershed can be direct (point) or land-based (indirect or nonpoint), depending on the proximity of the septic system to the stream.

For TMDL development, it was assumed that a 1.62% failure rate for septic systems would be representative of conditions in the watershed (Upper Accotink TMDL, 2002). This corresponds to a total of eight failed septic systems in the study area. In each subwatershed, the load from failing septic systems was calculated as the product of the total number of septic systems, septic systems failure rate, flow rate of septic discharge, typical fecal concentration in septic outflow, and the average household size in the watershed. The septic systems' design flow of 75 gallons per person per day and a fecal coliform concentration of 10,000 cfu/100mL were used in the fecal coliform load calculations. **Table 4-3** shows the distribution of the septic systems in the watershed. According to the Health Department of Fairfax County, there are no known straight pipes in the watershed. Any unknown straight pipes would be accounted for under the failing septic system load in the model.

Table 4-3: Failed Septic Systems Assumed in Model Development[1]

Subwatershed	Septic Failures
1	0
2	0
3	0
4	0
5	1
6	1
7	1
8	0
9	0
10	0
11	1
12	0
13	1
14	0
15	1
16	0
17	1
54	1
55	0
56	0
Total	**8**

[1]This estimate of failed septic systems in the each subwatershed within Lower Accotink Creek watershed was calculated using an area-weighted approach

4.7.3 Livestock

Livestock contribution to the total fecal coliform load in the watershed was represented in a number of ways, which are presented in **Figure 4-3**. The model accounts for fecal coliform directly deposited in the stream, fecal coliform deposited while livestock are in confinement and later spread onto the crop and pasture lands in the watershed (land application of manure), and finally, land-based fecal coliform deposited by livestock while grazing.

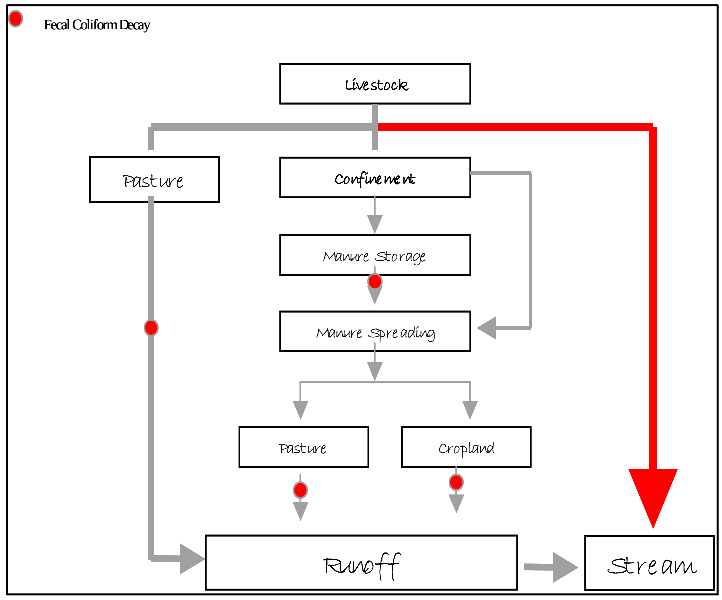

Figure 4-3: Livestock Contribution

Based on the inventory of livestock in the watershed, it was determined that horses are the predominant types of livestock, though small numbers of beef cows, pigs, chicken, and sheep are also present in the watershed.

The distribution of the daily fecal coliform load between direct instream and indirect (land-based) loading was based on livestock daily schedules. The direct deposition load from livestock was estimated from the number of livestock in the watershed, the daily fecal coliform production per animal, and the amount of time livestock spent in the stream. The amount of time livestock spend in the stream was presented in Chapter 3.

The land-based load of fecal coliform from livestock while grazing was determined based on the number of livestock in the watershed, the daily fecal coliform production per animal, and the percent of time each animal spends in pasture. The monthly loading rates are presented in **Appendix B.**

4.7.4 Land Application of Manure

Very few beef cattle are present in the watershed. Because there are no feedlots or large manure storage facilities present in the watershed, the daily produced manure is applied to pastureland in the watershed, and was treated as an indirect source in the development of the TMDLs. Beef cattle spend the majority of their time on pastureland and are not confined. Thus, fecal coliform loading from beef cattle was accounted for via the methods described above.

4.7.5 Wildlife

Fecal loading from wildlife was estimated in the same way as loading from livestock. As with livestock, fecal coliform contributions from wildlife can be both indirect and direct. The distribution between direct and indirect loading was based on estimates of the amount of time each type of wildlife spends on the surrounding land versus in the stream.

Daily fecal coliform production per animal and the amount of time each type of wildlife spends in the stream was presented previously in the wildlife inventory (Chapter 3). The direct fecal coliform load from wildlife was calculated by multiplying the number of each type of wildlife in the watershed by the fecal coliform production per animal per day, and by the percentage of time each animal spends in the stream. Indirect (land-based) fecal coliform loading from wildlife was estimated as the product of the number of each type of wildlife in the watershed, the fecal coliform production per animal per day, and the percent of time each animal spends on land within the watersheds. The resulting fecal coliform load was then distributed to forest and pasture land uses, which represent the most likely areas in the watershed where wildlife would be present and defecate. This was accomplished by converting the indirect fecal coliform load to a unit loading (cfu/acre), then multiplying the unit loading by the total area of forest and pasture in each subwatershed.

4.7.6 Pets

For the TMDLs, pet fecal coliform loading was considered a land-based load that was primarily deposited in urban land within the watershed. The daily fecal coliform loading was calculated as the product of the number of pets in the watershed and the daily fecal coliform production per type of pet.

4.8 Fecal Coliform Die-off Rates

Representative fecal coliform decay rates were included in the HSPF model developed for the watersheds. Three fecal coliform die-off rates required by the model to accurately represent watershed conditions included:

1. **In-storage fecal coliform die-off**. Fecal coliform concentrations are reduced while manure is in storage facilities.

2. **On-surface fecal coliform die-off**. Fecal coliform deposited on the land surfaces undergoes decay prior to being washed into streams.

3. **Instream fecal coliform die-off**. Fecal coliform directly deposited into the stream, as well as fecal coliform entering the stream from indirect sources, will also undergo decay.

For the TMDL, in-storage die-off was not included in the model because there is no manure storage facility located in the watershed. Decay rates of 1.37 and 1.152 per day were used to estimate die-off rates for on-surface and instream fecal coliform, respectively (EPA, 1985).

4.9 Model Set-up, Calibration, and Validation

Hydrologic calibration of the HSPF model involves the adjustment of model parameters to control various flow components (e.g. surface runoff, interflow and base flow, and the shape of the hydrographs) and make simulated values match observed flow conditions during the desired calibration period.

The model credibility and stakeholder faith in the outcome hinges on developing a model that has been calibrated and validated. Model calibration is a reality check. The calibration process compares the model results with observed data to ensure the model output is accurate for a given set of conditions. Model validation establishes the model's credibility. The validation process compares the model output to the observed data set, which is different from the one used in the calibration process, and estimates the model's prediction accuracy. Water quality processes were calibrated following calibration of the hydrologic processes of the model.

4.9.1 Model Set-Up

4.9.1.1 Stream Flow Data

The HSPF model was set up and calibrated based on flow data taken by USGS gage at Accotink Creek (USGS 01654000 – Accotink Creek near Annandale, VA). A 5-year period (1997-2001) was selected as the calibration period for the hydrologic model. The validation period selected was from 2002 to 2006.

4.9.1.2 Rainfall and Climate Data

Hourly precipitation data gathered from one weather station was used in the hydrological modeling. The station used was National Airport. Surface airways data (including wind speed/direction, ceiling height, dry bulb temperature, dew point temperature, and solar radiation) from January 1996 to December 2006 were also obtained from this station.

4.9.2 Model Hydrologic Calibration Results

The Expert System for Calibration of the Hydrological Simulation Program-FORTRAN (HSPEXP) software was used to calibrate the hydrology of the watershed. After each model's iteration, summary statistics were calculated to compare model results with observed values, in order to provide guidance on parameter adjustment according to built-in rules. The rules were derived from the experience of expert modelers and listed in the HSPEXP user manual (Lumb and Kittle, 1993).

Using the recommended default criteria as target values for an acceptable hydrologic calibration, the hydrologic model was calibrated from January 1997 to December 2001 at the flow station. Calibration results are presented in **Table 4-4**, showing the simulated and observed values for seven flow characteristics. An error statistics summary for five flow conditions is presented in **Table 4-5**. The model results and the observed daily average flow at the calibration station are plotted in **Figure 4-4**.

Table 4-4:Model Calibration Results		
Category	**Simulated**	**Observed**
Total runoff, in inches	79.470	79.572
Total of highest 10% flows, in inches	44.730	51.757
Total of lowest 50% flows, in inches	5.540	5.549
Total storm volume, in inches	4.230	4.132
Baseflow recession rate	0.910	0.910
Summer flow volume, in inches	15.580	16.926
Winter flow volume, in inches	21.390	21.437

Table 4-5: Model Calibration Error Statistics		
Category	**Current**	**Criterion**
Error in total volume	-0.100	± 10.000
Error in low flow recession	0.000	± 0.010
Error in 50% lowest flows	-0.200	± 10.000
Error in 10% highest Flow	-13.600	± 15.000
Seasonal volume error	7.800	± 10.000

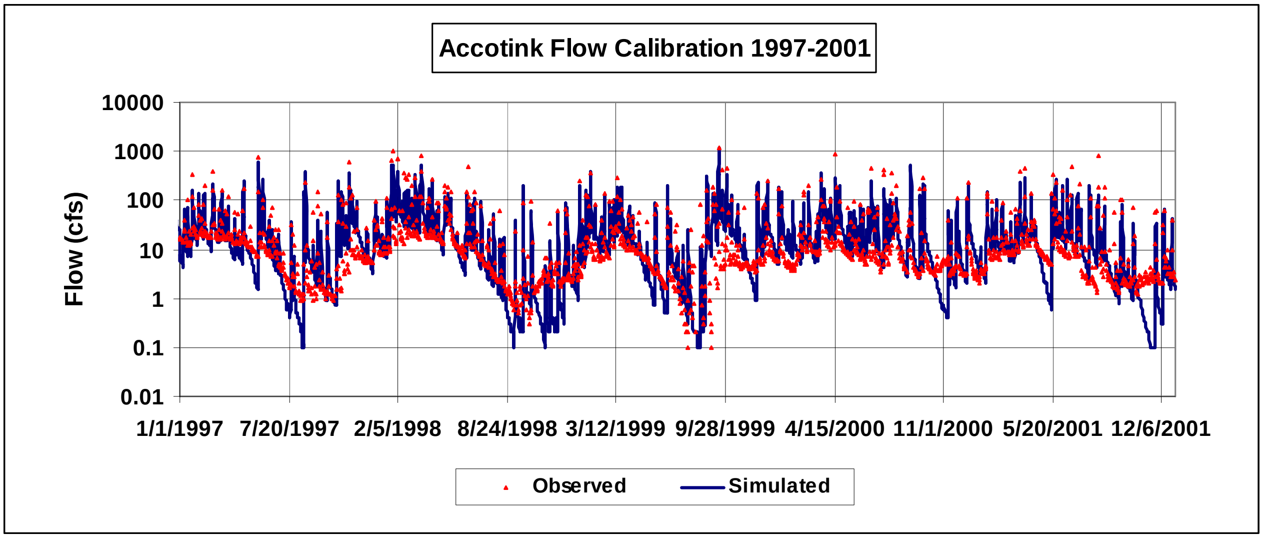

Figure 4-4: Model Hydrologic Calibration Results

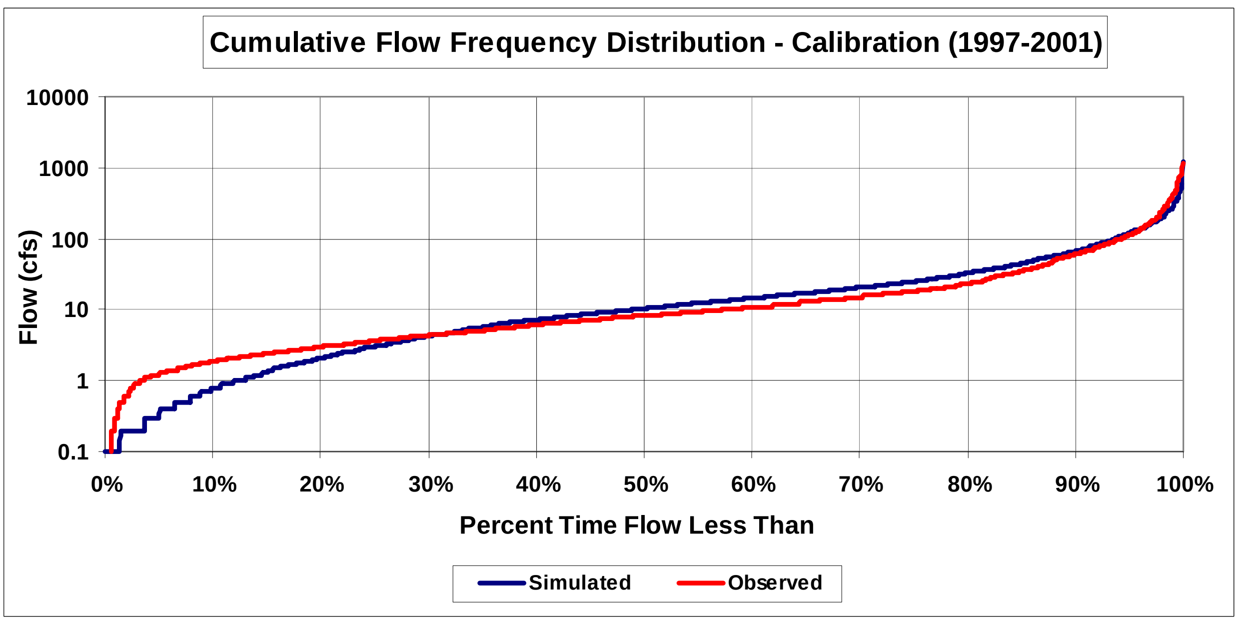

Figure 4-5: Cumulative Flow Frequency Distribution for Model Hydrologic Calibration Results

4.9.3 Model Hydrologic Validation Results

The period of January 2002 to December 2006 was used to validate the HSPF model. Model validation results at the Accotink Creek Station are presented in **Table 4-6**, showing the simulated and observed values for seven flow characteristics. An error statistics summary for five flow conditions is also presented for this station in **Table 4-7**. The error statistics indicate that the validation results were within the recommended ranges in HSPF. The model's hydrology validation results are plotted in **Figure 4-5**.

Table 4-6: Model Calibration Results Model Validation Results

Category	Simulated	Observed
Total runoff, in inches	107.600	104.043
Total of highest 10% flows, in inches	62.850	67.018
Total of lowest 50% flows, in inches	8.450	8.231
Total storm volume, in inches	9.870	10.821
Baseflow recession rate	0.910	0.910
Summer flow volume, in inches	26.570	27.535
Winter flow volume, in inches	24.650	23.428

Table 4-7: Model Calibration Results Model Validation Error Statistics

Category	Current	Criterion
Error in total volume	3.400	± 10.000
Error in low flow recession	0.000	± 0.010
Error in 50% lowest flows	2.700	± 10.000
Error in 10% highest Flow	-6.200	± 15.000
Seasonal volume error	8.700	± 10.000

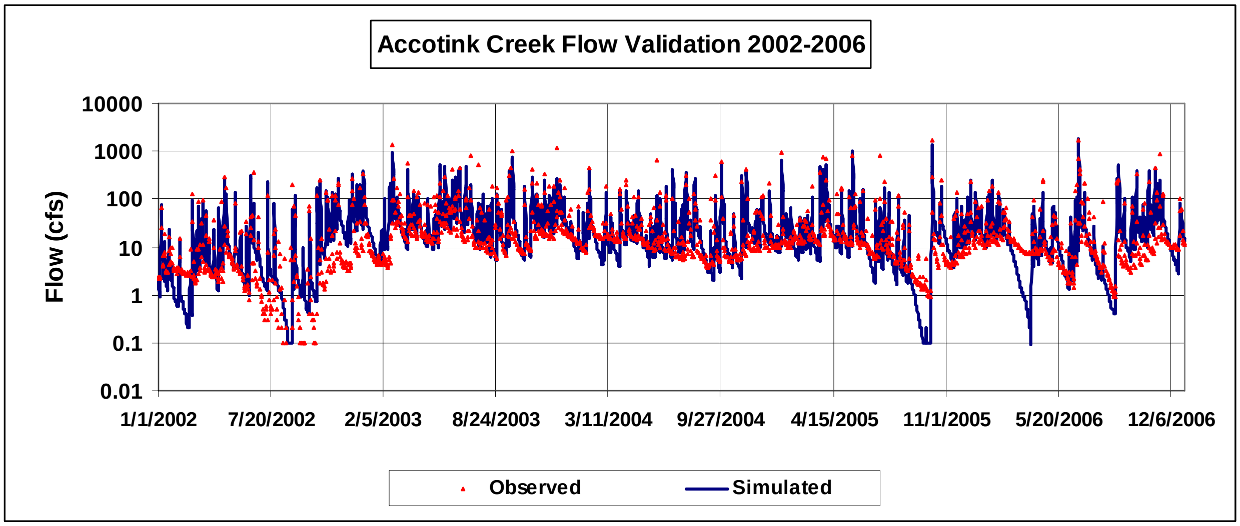

Figure 4-6: Model Hydrologic Validation Results

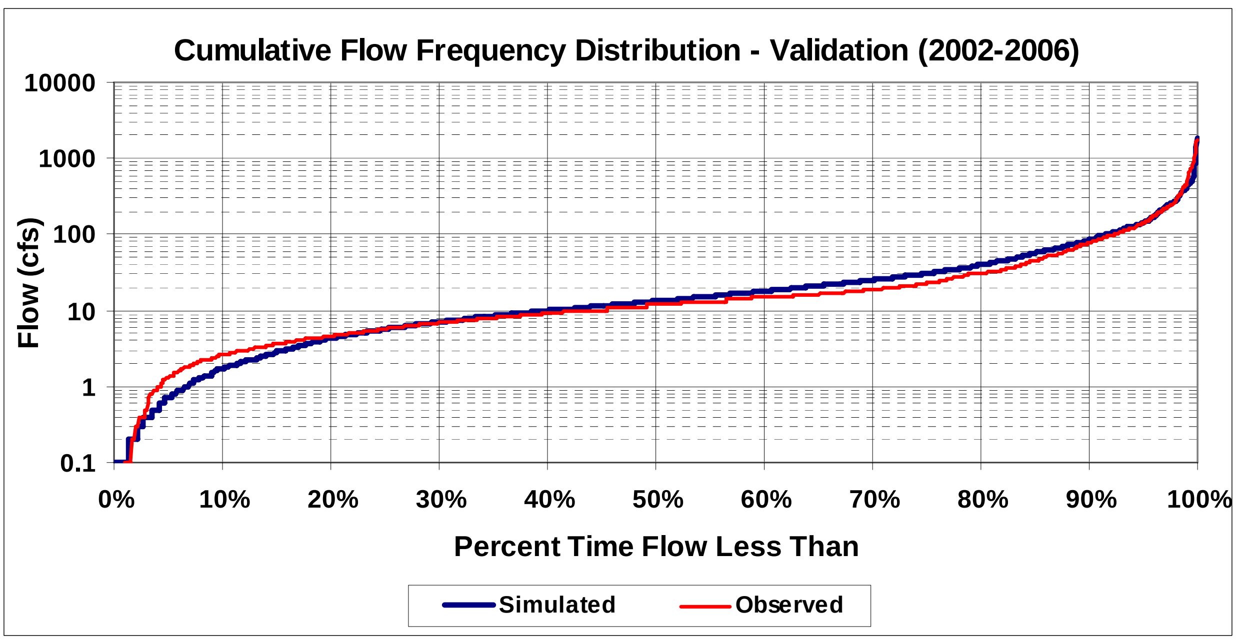

Figure 4-7: Cumulative Flow Frequency Distribution for Model Hydrologic Validation Results

There is good agreement between the observed and simulated stream flow, indicating that the model parameterization is representative of the hydrologic characteristics of the watershed. Model results closely match the observed flows during low flow conditions, base flow recession, and storm peaks. The final parameter values of the calibrated hydrology model are listed in **Table 4-8**.

Table 4-8: Accotink Creek HSPF Calibration Parameters (Typical, Possible and Final Values)

Parameter	Definition	Units	Typical		Possible		Accotink Creek
			Min	Max	Min	Max	
FOREST	Fraction forest cover	None	0.00	0.5	0	1.0	0.0-1.0
LZSN	Lower zone nominal soils moisture	inch	3	8	0.01	100	7.0 – 8.0
INFILT	Index to infiltration capacity	Inch/hour	0.01	0.25	0.0001	100	0.04 - 0.14
LSUR	Length of overland flow	Ft	200	500	1	None	300
SLSUR	Slope of overland flowpath	None	0.01	0.15	0.00001	10	0.009
KVARY	Groundwater recession variable	1/inch	0	3	0	None	0
AGWRC	Basic groundwater recession	None	0.92	0.99	0.001	0.999	0.90 – 0.93
PETMAX	Air temp below which ET is reduced	Deg F	35	45	None	None	40
PETMIN	Air temp below which ET is set to zero	Deg F	30	35	None	None	35
INFEXP	Exponent in infiltration equation	None	2	2	0	10	2
INFILD	Ratio of max/mean infiltration capacities	None	2	2	1	2	2
DEEPER	Fraction of groundwater inflow to deep recharge	None	0	0.2	0	1.0	0.1
BASETP	Fraction of remaining ET from base flow	None	0	0.05	0	1.0	0.00
AGWETP	Fraction of remaining ET from active groundwater	None	0	0.05	0	1.0	0

Table 4-8: Accotink Creek HSPF Calibration Parameters (Typical, Possible and Final Values)

CEPSC	Interception storage capacity	Inch	0.03	0.2	0.00	10.0	0.05
UZSN	Upper zone nominal soils moisture	inch	0.10	1	0.01	10.0	0.20
NSUR	Manning's n	None	0.15	0.35	0.001	1.0	0.10 - 0.35
INTFW	Interflow/surface runoff partition parameter	None	1	3	0	None	2.50 – 3.00
IRC	Interflow recession parameter	None	0.5	0.7	0.001	0.999	0.30
LZETP	Lower zone ET parameter	None	0.2	0.7	0.0	0.999	0.15 – 0.52
ACQOP*	Rate of accumulation of constituent	#/ac day					2.40E07 - 4.13E08
SQOLIM*	Maximum accumulation of constituent	#					4.32E07 – 7.42E08
WSQOP*	Wash-off rate	Inch/hour					0.45 - 1.00
IOQC*	Constituent concentration in interflow	#/CF					1416
AOQC*	Constituent concentration in active groundwater	#/CF					283
KS*	Weighing factor for hydraulic routing		0.5				0.5
FSTDEC*	First order decay rate of the constituent	1/day	1.152 (FC)				1.152
THFST*	Temperature correction coefficient for FSTDEC	none	1.07				1.07

*Typical values these parameters are unavailable because they are site-specific and determined through model calibration.

4.9.4 Water Quality Calibration

Calibrating the water quality component of the HSPF model involves setting up the build-up, wash-off, and kinetic rates for fecal coliform that best describe fecal coliform sources and environmental conditions in the watershed. It is an iterative process in which the model results are compared to the available instream fecal coliform data, and the model parameters are adjusted until there is an acceptable agreement between the observed and simulated instream concentrations and the build-up and wash-off rates are within the acceptable ranges.

The availability of water quality data is a major factor in determining calibration and validation periods for the model. In Chapter 3, instream monitoring stations on the impaired segments were listed and sampling events conducted on the Accotink Creek were summarized and presented. **Table 4-9** lists the stations used in the water quality calibration for each impaired segment.

Table 4-9: Water Quality Station used in the HSPF Fecal Coliform Simulations

Stream	Water Quality Station	HSPF Model Segment
Accotink Creek	1AACO006.10	10
Accotink Creek	1AACO014.57	20

The period used for water quality calibration of the model, and the period used for model validation depended on the time the water quality observations were collected. It is important to keep in mind that the observed fecal coliform concentrations are instantaneous values that are highly dependent on the time and location the sample was collected. The model-simulated fecal coliform concentrations represent the average daily values.

Water quality simulations depicting the simulated water quality at two stations on Accotink Creek are shown in **Figure 4-8** and **Figure 4-9**.

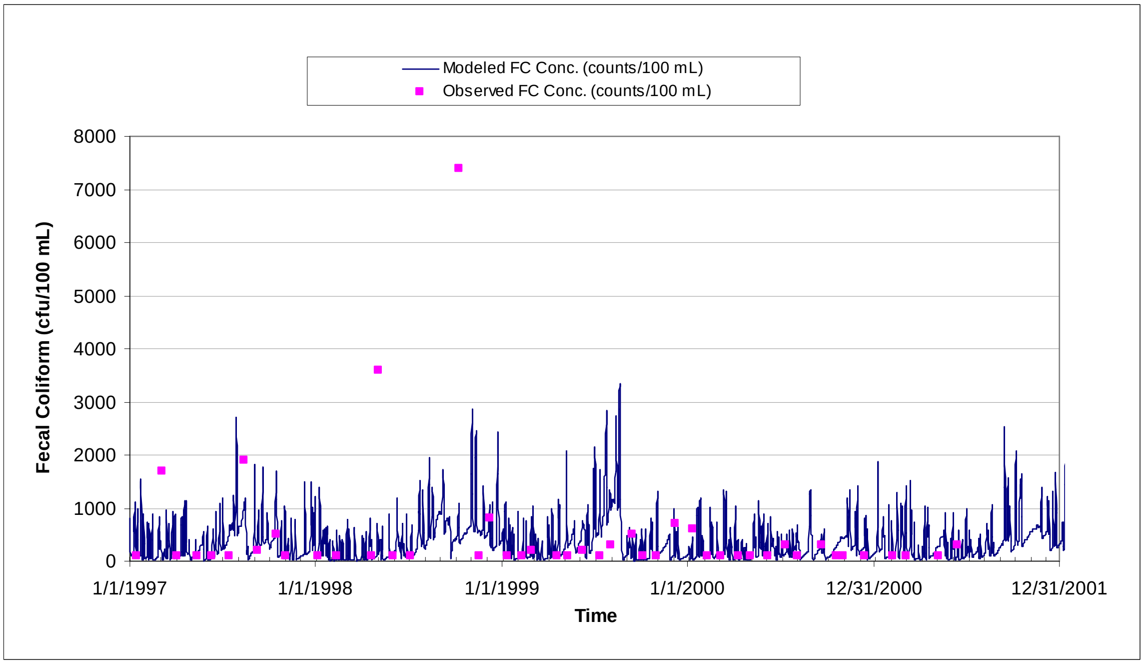

Figure 4-8: Fecal Coliform Calibration Accotink Creek (Reach 10)

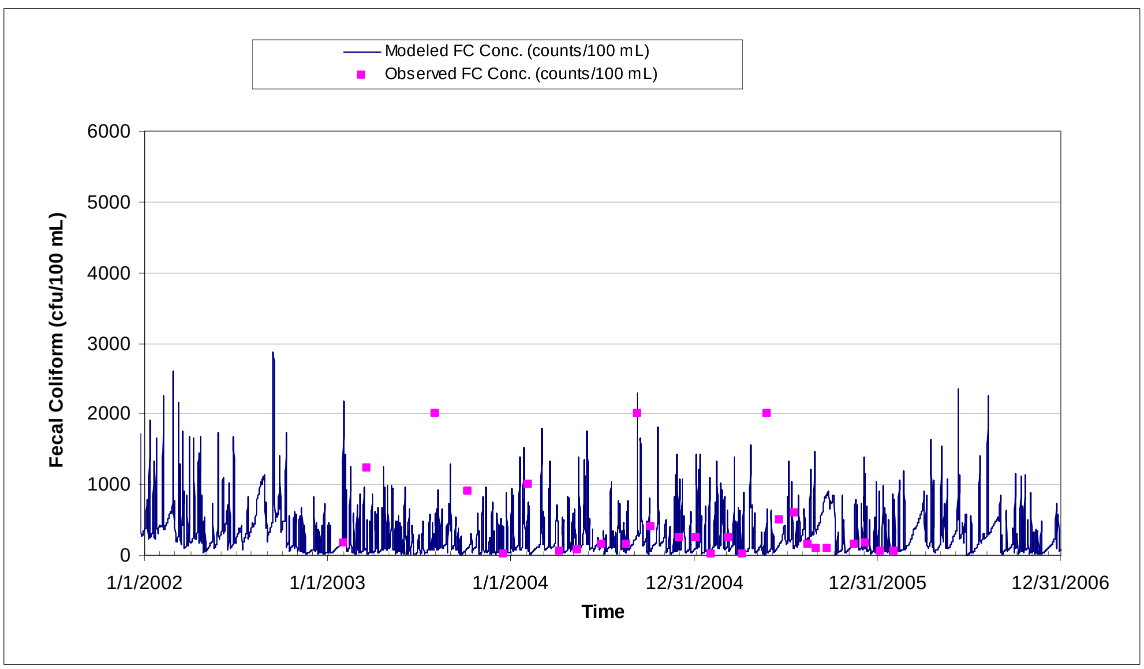

Figure 4-9: Fecal Coliform Validation Accotink Creek (Reach 20)

The goodness of fit for the water quality calibration was evaluated visually. Analysis of the model results indicated that the model was capable of predicting the range of fecal coliform concentrations under both wet and dry weather conditions, and thus was well-calibrated. **Table 4-10** shows the observed and simulated geometric mean fecal coliform concentration spanning the period from 1995 to 2005. **Table 4-11** shows the observed and simulated exceedance rates of the 400 cfu/100 ml instantaneous fecal coliform criteria.

Table 4-10: Observed and Simulated Geometric Mean Fecal Coliform Concentration

Station	Reach	Geometric Mean	
		Simulated	Observed
10	Accotink Creek	175	186
20	Accotink Creek	186	255

Table 4-11: Observed and Simulated Exceedance Rates of the 400 cfu/100ml Instantaneous Fecal Coliform Criterion

Station	Reach	Exceedances of the Instantaneous Criterion	
		Simulated	Observed
10	Accotink Creek	.29	.19
20	Accotink Creek	.29	.30

4.10 Existing Bacteria Loading

The existing fecal coliform loading for each watershed was calculated based on current watershed conditions. Model input parameters reflected conditions during the period of 2000 to 2005. The standards used for fecal coliform concentrations were a geometric mean criterion of 200 cfu/100 ml and an instantaneous criterion of 400 cfu/100 ml. For *E. coli* concentrations, the standards used were a geometric mean of 126 cfu/100ml and an instantaneous criterion of 235 cfu/100ml (VADEQ, 2006). The *E. coli* concentrations in the impaired segments were calculated from fecal coliform concentrations using a regression based instream translator, which is presented below:

$$E.\ coli\ concentration\ (cfu/100\ ml) = 2^{-0.0172} \times (FC\ concentration\ (cfu/100ml))^{0.91905}$$

Below are presented the fecal coliform and *E. coli* existing load distribution by source for the impaired segment.

Distribution of the existing fecal coliform load by source in Accotink Creek is presented in **Table 4-12**. The corresponding *E. coli* loading is presented in **Table 4-13**. *E. coli* concentrations in the impaired segment were calculated from fecal coliform concentrations using the instream translator. **Table 4-12** and **Table 4-13** show that direct deposition from wildlife as well as loading from residential areas (which includes the fecal load from pets) are the predominant sources of bacteria in the Accotink Creek watershed. However, both wet weather and dry weather conditions were identified as the critical condition. Under wet weather conditions, the indirect deposition loads from pets and wildlife in low residential areas will dominate. Under dry weather conditions, the direct deposition loads from wildlife will dominate.

Table 4-12: Lower Accotink Creek (Segment VAN-A15R-01) Fecal Coliform Existing Load Distribution

Source	Annual Average Fecal Coliform Loads	
	cfu/year	%
Forest	5.89E+11	0.57%
Cropland	3.40E+11	0.33%
Pasture	2.23E+11	0.22%
Low Density Residential	3.53E+13	34.33%
Medium Density Residential	3.63E+13	35.28%
High Density Residential	2.31E+13	22.44%
Commercial/Industrial	6.05E+11	0.59%
Cattle - Direct Deposition	2.63E+10	0.03%
Wildlife-Direct Deposition	6.37E+12	6.19%
Failed Septics	2.16E+10	0.02%
Point Source	0.00E+00	0.00%
Total	**1.03E+14**	**100%**

Table 4-13: Lower Accotink Creek (Segment VAN-A15R-01) *E. coli* Existing Load Distribution

Source	Annual Average *E. Coli* Loads	
	cfu/year	%
Forest	3.56E+11	0.57%
Cropland	2.05E+11	0.33%
Pasture	1.35E+11	0.22%
Low Density Residential	2.13E+13	34.33%
Medium Density Residential	2.19E+13	35.28%
High Density Residential	1.39E+13	22.44%
Commercial/Industrial	3.65E+11	0.59%
Cattle - Direct Deposition	1.59E+10	0.03%
Wildlife-Direct Deposition	3.85E+12	6.19%
Failed Septics	1.31E+10	0.02%
Point Source	0.00E+00	0.00%
Total	**6.21E+13**	**100%**

5.0 Allocation

Allocation analysis was the third stage in the development of the Lower Accotink Creek TMDL. The purpose of this third stage was to develop the framework for reducing bacteria loading under the existing watershed conditions so that water quality standards may be met. The TMDL represents the maximum amount of pollution that the stream can receive without exceeding the water quality criteria. The load allocations for the selected scenarios were calculated using the following equation:

$$TMDL = \sum WLA + \sum LA + MOS$$

Where,

WLA = waste load allocation (point source contributions);

LA = load allocation (nonpoint source allocation); and

MOS = margin of safety.

Typically, several potential allocation strategies would achieve the TMDL endpoint and water quality criteria. Available control options depend on the number, location, and character of pollutant sources.

5.1 Incorporation of Margin of Safety

The margin of safety (MOS) is a required component of the TMDL to account for any lack of knowledge concerning the relationship between effluent limitations and water quality and other uncertainties. According to EPA guidance (Guidance for Water Quality-Based Decisions: The TMDL Process, 1991), the MOS can be incorporated into the TMDL using two methods:

- Implicitly incorporating the MOS using conservative model assumptions to develop allocations; or
- Explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The MOS was implicitly incorporated into this TMDL by using conservative estimates for all known factors which would affect bacteria loadings in the watershed. These known factors include animal populations, bacteria production rates, contributions to the stream, bacteria decay rates instream and on land, and others. By using conservative estimates, these factors would describe the worst-case scenario for the watershed which would be the highest instream bacteria concentrations that could happen in the watershed.

By implicitly incorporating the MOS, the TMDL is ensured to meet the monthly *E. coli* geometric mean standard of 126 cfu/100 ml and the instantaneous *E. coli* standard of 235 cfu/100 ml with 0% exceedance if the TMDL plan is followed.

5.2 Sensitivity Analysis

The sensitivity analysis of the fecal coliform loadings and the waterbody response provides a better understanding of the watershed conditions that lead to the water quality criteria exceedances, and provides insight and direction in developing the TMDL allocations and implementation. Based on the sensitivity analysis, several allocation scenarios were developed. For each scenario developed, the percent of days water quality conditions violate the monthly geometric mean criterion and instantaneous criteiron for *E. coli* were calculated. The results of the sensitivity analysis are presented in **Appendix C**.

5.3 Allocation Scenario Development

Allocation scenarios were modeled using the calibrated HSPF model to adjust the existing conditions until the water quality criteria was attained. The TMDL developed for Lower Accotink Creek was based on the Virginia water quality criteria for *E. coli*. As detailed in Section 1.2, the *E. coli* standard states that the calendar-month geometric-mean concentration shall not exceed 126 cfu/100 mL, and that a maximum single sample concentration of *E. coli* shall not exceed 235 cfu/100 mL. According to the guidelines put forth by the VADEQ (VADEQ, 2003) for modeling *E. coli* with HSPF, the model was set up to estimate loads of fecal coliform. The fecal coliform model output then processed to convert concentrations to *E. coli* using the following equation:

$$\log_2 (C_{ec}) = -0.0172+0.91905*\log2(c_{fc})$$

Where C_{ec} is the concentration of *E. coli* in cfu/100 mL, and C_{fc} is the concentration of fecal *coli*form in cfu/100 mL.

The pollutant concentrations were simulated over the entire duration of a representative modeling period, and pollutant loads were adjusted until the standard was met. The pollutant loads were calculated at the outlet of the impaired segment and include the loads from all upstream reaches considered in the TMDL for the Upper Accotink Creek watershed (Fecal Coliform TMDL for Accotink Creek, 2002). The development of the allocation scenarios was an iterative process requiring numerous runs where each run was followed by an assessment of source reduction against the water quality target. The long-term average *E. coli* loads and coefficient of variations were determined to implement the final allocation scenarios and to express the TMDL on a daily basis. Assuming a log-normal distribution of data and a probability of occurrence of 95%, the maximum daily loads were determined using the following equation (*USEPA OWOW 2007 Options for Expressing Daily Loads in TMDLs*):

$$MDL = LTA \times Exp[z\sigma - 0.5\sigma^2]$$

Where;

MDL = maximum daily limit (cfu/day)

LTA = long-term average (cfu/day)

z = z statistic of the probability of occurrence

$\sigma^2 = \ln(CV^2+1)$

CV = coefficient of variation

The following sections present the waste load allocation (WLA) and load allocations (LA) for the impaired segment.

5.4 Wasteload Allocation

This section outlines the wasteload allocations (WLA) for the impaired segment. It presents the existing and allocated loads for each permitted (VPDES and MS4) facility contributing to the impaired segment.

There were no municipal or domestic sewage facilities in the bacteria-impaired Lower Accotink Creek watershed. Following VADEQ guidance, in watersheds where there are no VPDES permitted facilities that reasonably expected to discharge the contaminant of concern, the wasteload allocation for VPDES permits should not be shown as zero. This is to provide for the potential issuance of a permit in the future that would discharge the contaminant of concern. The wasteload allocation for VPDES point sources is therefore represented in the TMDL as "less than" a number equal to or smaller than 1% of the TMDL. For this TMDL, the wasteload allocation for VPDES point sources will be 3.25E+10 cfu/year (See Section 5.6). This will account for future growth of point sources in the impaired watershed.

5.4.1 MS4 Allocation

As discussed in the earlier section, loads associated with MS4 areas are considered part of the wasteload allocation. Five MS4 permits (Phase I permit for Fairfax County and four Phase II permits for smaller entities) have been issued for the lower portion of the Accotink Creek watershed. To separate bacteria loading attributed to the MS4s from other land-based bacteria loading, an area weighted method was used, in which the percentage of bacteria loading from land based runoff attributed to the MS4 was proportional to the percentage of developed area in the Lower Accotink Creek impaired watershed (77%). The allocated *E.coli* load from MS4 sources is 1.73E+12 cfu/year. This allocation represents the allowable loadings from all MS4 entities in the watershed. Due to the spatial overlap between the MS4 entities and the resulting uncertainty of the appropriate operator of the system, the MS4 loads are aggregated in the TMDL (**Table 5-1**).

Table 5-1: MS4 Wasteload Allocation for *E. coli*

Permit Number	MS4 Permit Holder	Wasteload Allocation (cfu/year)	Percent Reduction (%)
VA0088587	Fairfax County	1.73E+12	97.00
VAR040062	VDOT Northern Urban Area		
VAR040104	Fairfax County Public Schools		
VAR040095	Northern Virginia Community College		
VAR040093	Fort Belvoir		

5.5 Load Allocation Development

The reduction of loadings from nonpoint sources, including livestock and wildlife direct deposition, is incorporated into the load allocation. A number of load allocation scenarios were developed in order to determine the final TMDL load allocation. Fecal coliform loading and instream fecal coliform concentrations were estimated for each potential scenario using the HSPF model for the hydrologic period of January 1999 to December 2006. **Table 5-2** shows the key load allocation scenarios that were implemented to arrive at the final TMDL allocation. However, additional scenarios were also implemented when deemed necessary to attain the final TMDL. The following is a brief summary of the key scenarios:

- Scenario 0 is the existing load, no reduction of any of the sources.
- Scenario 1 represents elimination of human sources (failing septic systems).
- Scenario 2 represents the elimination of human sources (failing septic systems) as well as half the direct instream loading from livestock.
- Scenario 3 represents the elimination of the human sources (failing septic systems) as well as the direct instream loading from livestock.
- Scenario 4 represents the elimination of all nonpoint sources and direct instream loading from livestock.
- Scenario 5 represents the elimination of the human sources (failing septic systems) and direct instream loading from livestock as well as half of the wildlife contribution.
- Scenario 6 represents the elimination of the human sources (failing septic systems) and direct instream loading from livestock as well as 75% of the wildlife contribution.
- Scenario 7 represents the elimination of the human sources (failing septic systems), direct instream loading from livestock, 95% of the loading from agricultural nonpoint sources, 95% of the loading from urban nonpoint sources, and 75% of the wildlife contribution.
- Scenario 8 represents the elimination of the human sources (failing septic systems), direct instream loading from livestock, 97% of the loading from

agricultural nonpoint sources, 97% of the loading from urban nonpoint sources, and 70% of the wildlife contribution.

The scenarios considered for the Lower Accotink Creek load allocation are presented in **Table 5-2**. The following conclusions can be made:

1. In Scenario 0 (existing conditions), the water quality criteria resulted in a 33 percent exceedance of the *E. coli* geometric mean criterion and a 27 percent exceedance of the *E. coli* instantaneous criterion.
2. In Scenario 3, elimination of the human sources (failed septic systems) and the livestock direct instream loading resulted in a 33 percent exceedance of the *E. coli* geometric mean criterion and a 27 percent exceeance of the *E. coli* instantaneous criterion.
3. In Scenario 6, elimination of the human sources and livestock direct instream loading as well as 75 percent of the direct instream loading from wildlife resulted in a 4 percent exceedance of the *E. coli* geometric mean criterion and a 17 percent exceedance of the *E. coli* instantaneous criterion.
4. No exceedances of the *E. coli* geometric mean criterion and instantaneous criterion occurred in Lower Accotink Creek under Scenario 8.

Therefore, Scenario 8 was chosen as the final TMDL load allocation scenario for Lower Accotink Creek. Under this scenario, complete elimination of the human sources (failed septic systems) and livestock direct deposition, a 97 percent reduction of agricultural and urban non-point sources, and a 70 percent reduction of direct loading by wildlife are required.

Table 5-2: Lower Accotink Creek Load Reductions Under Calender-Month Geometric Mean and Instantaneous Standards for *E. coli*							
Scenario	**Failed Septics**	**Direct Livestock**	**NPS (Agricultural)**	**NPS (Urban)**	**Direct Wildlife**	***E. coli* Percent Exceedance of GM standard 126 #/100ml**	***E .coli* Percent Exceedance of Inst. standard 235 #/100ml**
0	0%	0%	0%	0%	0%	33%	27%
1	100%	0%	0%	0%	0%	33%	27%
2	100%	50%	0%	0%	0%	33%	27%
3	100%	100%	0%	0%	0%	33%	27%
4	100%	100%	100%	100%	0%	16%	9%
5	100%	100%	0%	0%	50%	17%	19%
6	100%	100%	0%	0%	75%	4%	17%
7	100%	100%	95%	95%	75%	0%	0%
8	**100%**	**100%**	**97%**	**97%**	**70%**	**0%**	**0%**

5.6 Lower Accotink Creek Allocation Plan and TMDL Summary

As shown in **Table 5-1**, Scenario 8 will meet calendar-month *E. coli* geometric mean water quality criterion of 126 cfu/100 ml and the instantaneous water quality criterion of 235 cfu/100ml for Lower Accotink Creek. The requirements for this scenario are:

- 100 percent reduction of the human sources (failed septic systems).
- 100 percent reduction of the direct instream loading from livestock.
- 97 percent reduction of bacteria loading from agricultural and urban nonpoint sources.
- 70 percent reduction of the direct instream loading from wildlife.

Table 5-3 shows the distribution of the annual average *E. coli* load under existing conditions and under the TMDL allocation, by land use and source.

Table 5-3: Lower Accotink Creek Distribution of Annual Average *E. coli* Load under Existing Conditions and TMDL Allocation				
Land Use/Source	**Average *E. coli* Loads (cfu/yr)**		**Allocation (cfu/day)**	**Percent Reduction (%)**
	Existing	**Allocation**		
Forest	3.56E+11	3.56E+11	3.61E+09	0.0%
Cropland	2.05E+11	6.15E+09	6.24E+07	97.0%
Pasture	1.35E+11	4.04E+09	4.10E+07	97.0%
Cattle - Direct Deposition	1.59E+10	0.00E+00	0.00E+00	100.0%
Wildlife-Direct Deposition	3.85E+12	1.15E+12	1.17E+10	70.0%
Failed Septics	1.31E+10	0.00E+00	0.00E+00	100.0%
MS4s[1]	5.75E+13	1.73+12	1.75+10	97.0%
Point Source	0.00E+00	3.25E+10	8.89E+07	0.0%
Total	**6.20E+13**	**3.27E+12**	**3.30E+10**	**94.7%**

[1]For this TMDL, the load from urban nonpoint sources was allocated to the MS4 areas, including Low Density Development, Medium Density Development, High Density Development, and Commercial lands.

The daily TMDL for Lower Accotink Creek is presented in **Table 5-4** and the yearly TMDL is presented in **Table 5-5**.

Table 5-4: Lower Accotink Creek Bacteria TMDL (cfu/day) for *E. coli*			
WLA[1]	**LA**	**MOS**	**TMDL**
1.76E+10	1.54E+10	Implicit	3.30E+10

[1]Wasteload allocation includes allocated load for point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)

Table 5-5: Lower Accotink Creek Bacteria TMDL (cfu/year) for *E. coli*			
WLA[1]	**LA**	**MOS**	**TMDL**
1.76E+12	1.52E+12	Implicit	3.28E+12

[1]Wasteload allocation includes allocated load for point sources (1% of total TMDL) and MS4 areas (load attributed to urban nonpoint sources)

The resulting geometric mean and instantaneous *E. coli* concentrations under the TMDL allocation plan are presented in **Figure 5-1** and **Figure 5-2**. **Figure 5-1** shows the calendar-month geometric mean *E. coli* concentrations after applying the allocations of Scenario 8, as well as geometric mean loading under existing conditions. **Figure 5-2** shows the instantaneous *E. coli* concentrations also under the allocations of Scenario 8 as well as the loading under existing conditions. For Lower Accotink Creek, allocation

Scenario 8 results in bacteria concentrations that are consistently below both the geometric mean and instantaneous standards for *E. coli*.

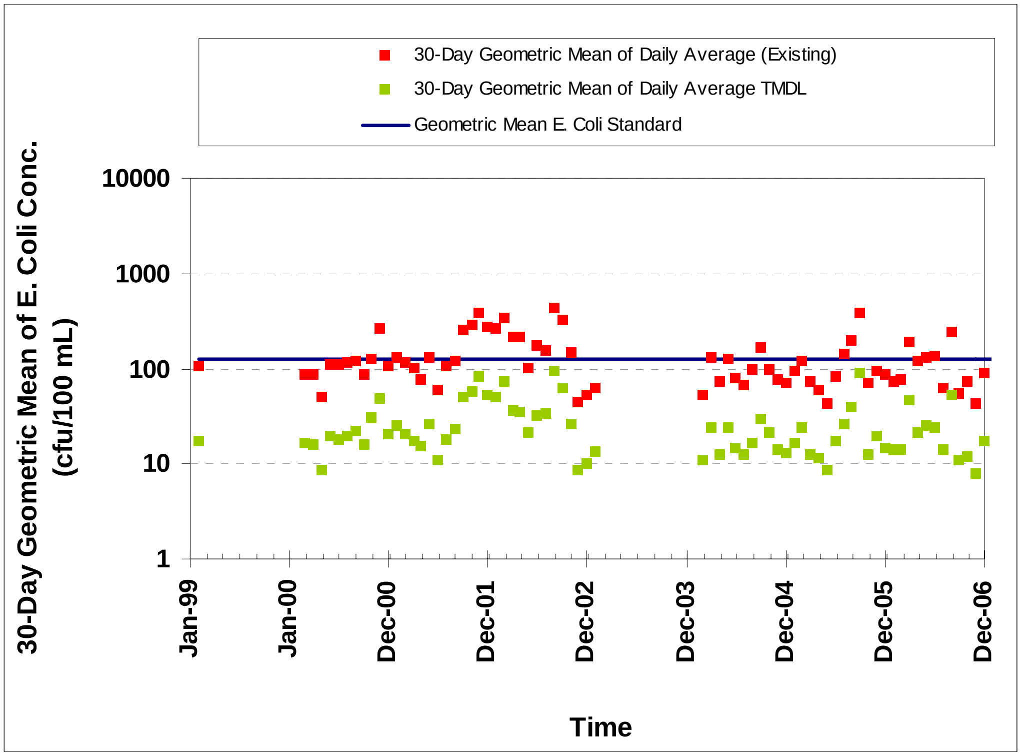

Figure 5-1: Lower Accotink Creek (Segment VAN-A15R-01) Geometric Mean *E. coli* Concentrations under Existing Conditions and the Allocation Scenario

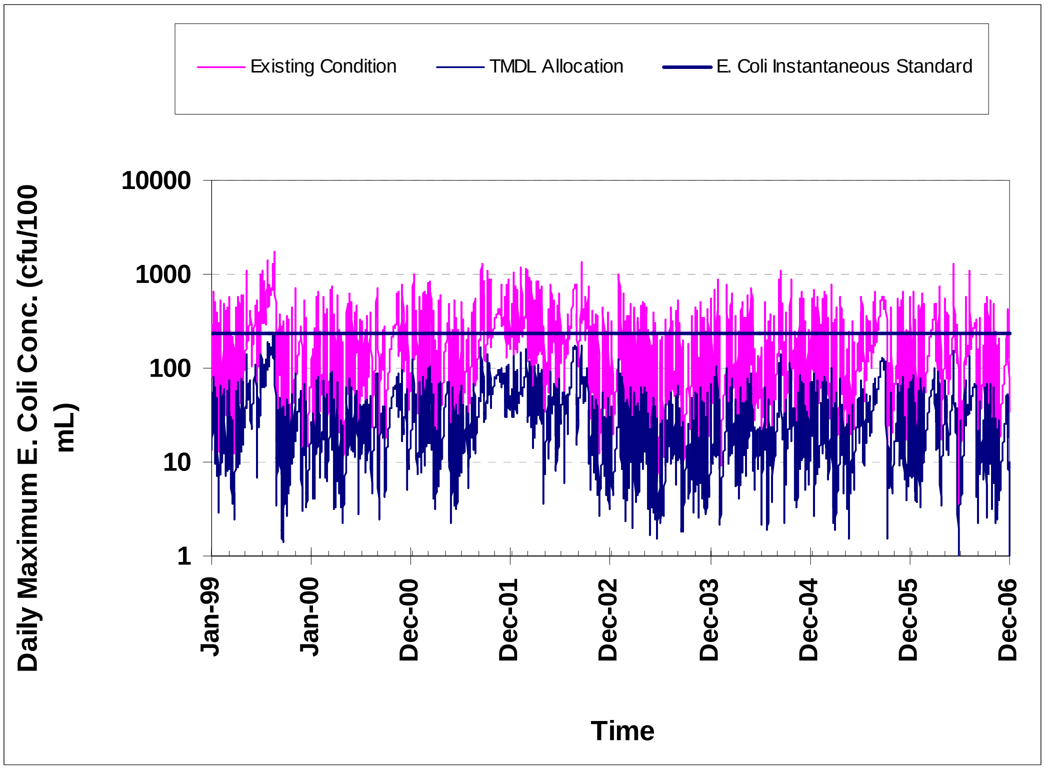

Figure 5-2: Lower Accotink Creek (Segment VAN-A15R-01) Instantaneous *E. coli* Concentrations under Existing Conditions and the Allocation Scenario

6.0 TMDL Implementation

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels from both point and nonpoint sources. The following sections outline the framework used in Virginia to provide reasonable assurance that the required pollutant reductions can be achieved

6.1 Continuing Planning Process and Water Quality Management Planning

As part of the Continuing Planning Process, VADEQ staff will present both EPA-approved TMDLs and TMDL implementation plans to the State Water Control Board (SWCB) for inclusion in the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e) and Virginia's Public Participation Guidelines for Water Quality Management Planning.

VADEQ staff will also request that the SWCB adopt TMDL WLAs as part of the Water Quality Management Planning Regulation (9VAC 25-720), except in those cases when permit limitations are equivalent to numeric criteria contained in the Virginia Water Quality Standards, such as in the case for bacteria. This regulatory action is in accordance with §2.2-4006A.4.c and §2.2-4006B of the Code of Virginia. SWCB actions relating to water quality management planning are described in the public participation guidelines referenced above and can be found on VADEQ's web site under http://www.deq.state.va.us/tmdl/pdf/ppp.pdf

6.2 Staged Implementation

In general, Virginia intends for the required control actions, including Best Management Practices (BMPs), to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. The iterative implementation of pollution control actions in the watershed has several benefits:

1. It enables tracking of water quality improvements following implementation through follow-up stream monitoring;

2. It provides a measure of quality control, given the uncertainties inherent in computer simulation modeling;

3. It provides a mechanism for developing public support through periodic updates on implementation levels and water quality improvements;

4. It helps ensure that the most cost effective practices are implemented first; and

5. It allows for the evaluation of the adequacy of the TMDL in achieving water quality standards.

6.3 Implementation of Wasteload Allocations

Federal regulations require that all new or revised National Pollutant Discharge Elimination System (NPDES) permits must be consistent with the assumptions and requirements of any applicable TMDL WLA (40 CFR §122.44 (d)(1)(vii)(B)). All such permits should be submitted to EPA for review.

For the implementation of the WLA component of the TMDL, the Commonwealth utilizes the Virginia NPDES program. Requirements of the permit process should not be duplicated in the TMDL process, and permitted sources are not usually addressed through the development of any TMDL implementation plans.

6.3.1 Treatment Plants

This TMDL does not require reductions from municipal or industrial treatment plants.

6.3.2 Stormwater

VADEQ and DCR coordinate separate state permitting programs that regulate the management of pollutants carried by stormwater runoff. VADEQ regulates stormwater discharges associated with industrial activities through its VPDES program, while DCR regulates stormwater discharges from construction sites, and from municipal separate storm sewer systems (MS4s) through the VSMP program. As with non-stormwater permits, all new or revised stormwater permits must be consistent with the assumptions and requirements of any applicable TMDL WLA. If a WLA is based on conditions specified in existing permits, and the permit conditions are being met, no additional actions may be needed. If a WLA is based on reduced pollutant loads, additional pollutant control actions will need to be implemented.

Municipal Separate Storm Sewer Systems – MS4s

For MS4/VSMP general permits, the Commonwealth expects the permittee to specifically address the TMDL wasteload allocations for stormwater through the iterative implementation of programmatic BMPs. BMP effectiveness would be determined through permittee implementation of an individual control strategy that includes a monitoring program that is sufficient to determine its BMP effectiveness. As stated in EPA's Memorandum on TMDLs and Stormwater Permits, dated November 22, 2002, "The NPDES permits must require the monitoring necessary to assure compliance under the permit limits." Ambient instream monitoring would not be an appropriate means of determining permit compliance. Ambient monitoring would be appropriate to determine if the entire TMDL is being met by all attributed sources. This is in accordance with recent EPA guidance. If future monitoring indicates no improvement in the quality of the regulated discharge, the permit could require the MS4 to expand or better tailor its stormwater management program to achieve the TMDL wasteload allocation. However, only failing to implement the programmatic BMPs identified in the modified stormwater management program would be considered a permit compliance issue. Any changes to the TMDL resulting from water quality standards changes on Accotink Creek would be reflected in the permit.

Wasteload allocations for stormwater discharges from storm sewer systems covered by a MS4 permit will be addressed as a condition of the MS4 permit. An implementation plan will identify types of corrective actions and strategies to obtain the load allocation for the pollutant causing the water quality impairment. Permittees will be required to participate in the development of TMDL implementation plans since recommendations from the process may result in modifications to the stormwater management plan in order to meet the TMDL. For example, MS4 permittees regulate erosion and sediment control programs that affect discharges that are not regulated by the MS4 permit. The implementation of the WLAs for MS4 permits will focus on achieving the percent reductions required by the TMDL, rather than the individual numeric WLAs.

Additional information on Virginia's Stormwater Phase 2 program and a downloadable menu of Best Management Practices and Measurable Goals Guidance can be found at http://www.dcr.virginia.gov/sw/vsmp.htm .

6.3.3 TMDL Modifications for New or Expanding Dischargers

Permits issued for facilities with wasteload allocations developed as part of a Total Maximum Daily Load (TMDL) must be consistent with the assumptions and requirements of these wasteload allocations (WLA), as per EPA regulations. In cases where a proposed permit modification is affected by a TMDL WLA, permit and TMDL staff must coordinate to ensure that new or expanding discharges meet this requirement. In 2005, VADEQ issued guidance memorandum 05-2011 describing the available options and the process that should be followed under those circumstances, including public participation, EPA approval, State Water Control Board actions, and coordination between permit and TMDL staff. The guidance memorandum is available on VADEQ's web site at http://www.deq.virginia.gov/waterguidance/

6.4 Implementation of Load Allocations

The TMDL program does not impart new implementation authorities. Therefore, the Commonwealth intends to use existing programs to the fullest extent in order to attain its water quality goals. The measures for non point source reductions, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the TMDL implementation plan.

6.4.1 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. State law directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters". 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.

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 DCR 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, DCR, 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.

6.4.2 Staged Implementation Scenarios

The purpose of the staged implementation scenarios is to identify one or more combinations of implementation actions that result in the reduction of controllable sources to the maximum extent practicable using cost-effective, reasonable BMPs for nonpoint source control. Among the most efficient sediment BMPs for both urban and rural watersheds are infiltration and retention basins, riparian buffer zones, grassed waterways, streambank protection and stabilization, and wetland development or enhancement.

Actions identified during TMDL implementation plan development that go beyond what can be considered cost-effective and reasonable will only be included as implementation actions if there are reasonable grounds for assuming that these actions will in fact be implemented.

If water quality standards are not met upon implementation of all cost-effective and reasonable BMPs, a Use Attainability Analysis may need to be initiated since Virginia's water quality standards allow for changes to use designations if existing water quality standards cannot be attained by implementing effluent limits required under §301b and §306 of Clean Water Act, and cost effective and reasonable BMPs for nonpoint source control. Additional information on UAAs is presented in section 6.6, Attainability of Designated Uses.

Three allocation scenarios are presented in **Table 6-1** for the bacteria TMDL for the Lower Accotink Creek watershed. Scenario 1 represents the required load reduction that will not exceed the instantaneous standard by more than 10%. Scenarios 2 and 3 represent the implementation of BMPs and management strategies such as livestock exclusion from streams, alternative water, manure storage, riparian buffers, and pet waste control that can be readily put in place in the watershed.

Table 6-1: Lower Accotink Creek (Segment VAN-A15R-01) Watershed Stage 1 Scenarios

Scenario	Failed Septics & Pipes	Direct Livestock	NPS (Agricultural)	NPS (Urban)	Direct Wildlife	Exceedance of GM standard 126 #/100ml	Exceedance of Inst. standard 235 #/100ml
1	100%	0%	87.5%	87.5%	0%	19%	10%
2	100%	0%	50%	50%	0%	23%	17%
3	100%	0%	75%	75%	0%	20%	11%

6.4.3 Link to Ongoing Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts aimed at restoring water quality in the watershed. As part of its efforts to protect and restore its streams and other natural resources, the City of Fairfax has developed the Accotink Creek Restoration Project aimed to restore portions of the creek. These portions of the creek are upstream of the bacteria-impaired watershed, but if successful, should improve waters downstream of the restoration as well.

Fairfax County is in the process of developing a Watershed Management Plan (WMP) for the Accotink Creek watershed. The WMP will help identify strategies to control stormwater runoff and its associated pollutant loads, which will help meet the load reductions set forth in this TMDL.

Friends of Accotink Creek, a local volunteer organization, participates in stream clean-ups, restoration, and water quality monitoring. Additional volunteer monitoring is performed through the Northern Virginia Soil and Water Conservation District at various locations throughout the watershed.

In March and April 2007, the Regional Stormwater Education Campaign ran radio advertisements to create awareness of pollution prevention with residents who engage in lawn care, dog walking, or oil changing in the Northern Virginia Area (City of Alexandria, Arlington County, City of Fairfax, Fairfax County, City of Falls Church, Herndon, Loudoun County, Prince William County, Vienna). In addition, the following materials were distributed to complement the radio advertisements:

- A pet waste postcard highlighting the importance of picking up pet waste and properly disposing of it in a trash receptacle. This postcard was distributed by the partners to homeowners associations, at county fairs, and other public events.

- A Public Service Announcement (PSA) accompanying the radio advertisement.

- A website (www.onlyrain.org) serving as a clearinghouse for information about the partners, the repository for different products, and additional information regarding solutions for disposing of pet waste, reducing the amount of fertilizer used on lawns, and recycling motor oil.

6.4.4 Implementation Funding Sources

The implementation on pollutant reductions from non-regulated nonpoint sources relies heavily on incentive-based programs. Therefore, the identification of funding sources for non-regulated implementation activities is a key to success. Cooperating agencies, organizations and stakeholders must identify potential funding sources available for implementation during the development of the implementation plan in accordance with the "Virginia Guidance Manual for Total Maximum Daily Load Implementation Plans". The TMDL Implementation Plan Guidance Manual contains information on a variety of funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

Some of the major potential sources of funding for non-regulated implementation actions may include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, EPA Section 319 funds, the Virginia State Revolving Loan Program (also available for permitted activities), Virginia Agricultural Best Management Practices Cost-Share Programs, the Virginia Water Quality Improvement Fund (available for both point and nonpoint source pollution), tax credits and landowner contributions.

With additional appropriations for the Water Quality Improvement Fund during the last two legislative sessions, the Fund has become a significant funding stream for agricultural BMPs and wastewater treatment plants. Additionally, funding is being made available to address urban and residential water quality problems. Information on WQIF projects and allocations can be found at http://www.deq.virginia.gov/bay/wqif.html and at http://www.dcr.virginia.gov/sw/wqia.htm

6.5 Follow-Up Monitoring

Following the development of the TMDL, VADEQ will make every effort to continue to monitor the impaired stream in accordance with its ambient and biological monitoring programs. VADEQ's Ambient Watershed Monitoring Plan for conventional pollutants calls for watershed monitoring to take place on a rotating basis, bi-monthly for two consecutive years of a six-year cycle. In accordance with DEQ Guidance Memo No. 03-2004, during periods of reduced resources, monitoring can temporarily discontinue until the TMDL staff determines that implementation measures to address the source(s) of impairments are being installed. Monitoring can resume at the start of the following fiscal year, next scheduled monitoring station rotation, or where deemed necessary by the regional office or TMDL staff, as a new special study. Since there may be a lag time of one-to-several years before any improvement in the benthic community will be evident, follow-up biological monitoring may not have to occur in the fiscal year immediately following the implementation of control measures.

The purpose, location, parameters, frequency, and duration of the monitoring will be determined by the VADEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee and local stakeholders. Whenever possible, the location of the follow-up monitoring station(s) will be the same as the listing station. At a minimum, the monitoring station must be representative of the original impaired segment. The details of the follow-up monitoring will be outlined in the Annual Water Monitoring Plan prepared by each VADEQ Regional Office. Other agency personnel, watershed stakeholders, etc. may provide input on the Annual Water Monitoring Plan. These recommendations must be made to the VADEQ regional TMDL coordinator by September 30 of each year. **Table 6-2** provides a summary of the water quality monitoring stations in the Accotink Creek bacteria-impaired watershed.

Table 6-2: Active VADEQ Water Quality Monitoring Stations in the Bacteria Impaired Accotink Creek Watershed

Station ID[1]	Station Description	Stream Name
1AACO002.50	Rt. #1	Accotink Creek
1AACO004.84	Rt. # 611 (Telegraph Rd)	Accotink Creek
1AACO006.10	Rt. # 790	Accotink Creek

[1]Note: The last 5 digits of the VADEQ station number corresponds to stream mile.

VADEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee and local stakeholders, will continue to use data from the ambient monitoring stations to evaluate reductions in pollutants ("water quality milestones" as established in the IP), the effectiveness of the TMDL in attaining and maintaining water quality standards, and the success of implementation efforts. Recommendations may then be made, when necessary, to target implementation efforts in specific areas and continue or discontinue monitoring at follow-up stations.

In some cases, watersheds will require monitoring above and beyond what is included in VADEQ's standard monitoring plan. Ancillary monitoring by citizens' or watershed groups, local government, or universities is an option that may be used in such cases. An effort should be made to ensure that ancillary monitoring follows established QA/QC guidelines in order to maximize compatibility with VADEQ monitoring data. In instances where citizens' monitoring data is not available and additional monitoring is needed to assess the effectiveness of targeting efforts, TMDL staff may request of the monitoring managers in each regional office an increase in the number of stations or monitor existing stations at a higher frequency in the watershed. The additional monitoring beyond the original bimonthly single station monitoring will be contingent on staff resources and available laboratory budget. More information on citizen monitoring in Virginia and QA/QC guidelines is available at http://www.deq.virginia.gov/cmonitor/.

To demonstrate that the watershed is meeting water quality standards in watersheds where corrective actions have taken place (whether or not a TMDL or Implementation plan has been completed), VADEQ must meet the minimum data requirements from the original listing station or a station representative of the originally listed segment. The minimum data requirement for conventional pollutants (bacteria, dissolved oxygen, etc) is bimonthly monitoring for two consecutive years. For biological monitoring, the minimum requirement is two consecutive samples (one in the spring and one in the fall) in a one year period.

6.6 Attainability of Designated Uses

In some streams for which TMDLs have been developed, factors may prevent the stream from attaining its designated use.

In order for a stream to be assigned a new designated use, or a subcategory of a use, the current designated use must be removed. To remove a designated use, the state must demonstrate that the use is not an existing use, and that downstream uses are protected. Such uses will be attained by implementing effluent limits required under §301b and §306 of Clean Water Act and by implementing cost-effective and reasonable best management practices for nonpoint source control (9 VAC 25-260-10 paragraph I).

The state must also demonstrate that attaining the designated use is not feasible because:

1. Naturally occurring pollutant concentration prevents the attainment of the use;

2. Natural, ephemeral, intermittent or low flow conditions prevent the attainment of the use unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating state water conservation
3. Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place
4. Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate the modification in such a way that would result in the attainment of the use;
5. Physical conditions related to natural features of the waterbody, such as the lack of proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life use protection; or
6. Controls more stringent than those required by §301b and §306 of the Clean Water Act would result in substantial and widespread economic and social impact.

This and other information is collected through a special study called a UAA. All site-specific criteria or designated use changes must be adopted by the SWCB as amendments to the water quality standards regulations. During the regulatory process, watershed stakeholders and other interested citizens, as well as the EPA, will be able to provide comment during this process. Additional information can be obtained at http://www.deq.virginia.gov/wqs/pdf/WQS05A_1.pdf

The process to address potentially unattainable reductions based on the above is as follows:

As a first step, measures targeted at the controllable, anthropogenic sources identified in the TMDL's staged implementation scenarios will be implemented. The expectation would be for the reductions of all controllable sources to the maximum extent practicable using the implementation approaches described above. VADEQ will continue to monitor biological health and water quality in the stream during and subsequent to the implementation of these measures to determine if water quality standard is attained. This effort will also help to evaluate if the modeling assumptions were correct. In the best-case scenario, water quality goals will be met and the stream's uses fully restored using effluent controls and BMPs. If, however, water quality standards are not being met, and no additional effluent controls and BMPs can be identified, a UAA would then be initiated with the goal of re-designating the stream for a more appropriate use or subcategory of a use.

A 2006 amendment to the Code of Virginia under 62.1-44.19:7E. provides an opportunity for aggrieved parties in the TMDL process to present to the State Water Control Board reasonable grounds indicating that the attainment of the designated use for a water is not feasible. The Board may then allow the aggrieved party to conduct a use attainability analysis according to the criteria listed above and a schedule established by the Board. The amendment further states that "If applicable, the schedule shall also address whether TMDL development or implementation for the water shall be delayed."

7.0 Public Participation

The development of the Accotink Creek bacteria TMDL would not have been possible without public participation. Three technical advisory committee (TAC) meetings and three public meetings were held. The following is a summary of the meetings.

TAC Meeting No. 1. The first TAC meeting was held on July 17, 2007 at the Fairfax County Government Center in Fairfax, Virginia to present and review the steps and the data used in the development of the bacteria TMDL for the Accotink Creek listed segment.

TAC Meeting No. 2. The second TAC meeting was held on November 28, 2007 at the Fairfax County Government Center in Fairfax, Virginia to discuss the preliminary bacteria source assessment for Accotink Creek.

TAC Meeting No. 3. The third TAC meeting was held on February 25, 2008 at the Northern Virginia Regional Planning Commission Office in Fairfax, Virginia to present draft TMDL allocations for the Accotink Creek listed segment.

Public Meeting No. 1. The first public meetings were held in on August 14, 2007 at the Fairfax County Government Center in Fairfax, Virginia to present the process for TMDL development, the Accotink Creek bacteria impaired segment, data that caused the segment to be on the 303(d) list, data and information needed for TMDL development. Three people attended these meetings. Copies of the presentation were available for public distribution. This meeting was publicly noticed in the *Virginia Register*.

Public Meeting No. 2. The second public meeting was held in on March 5, 2008 at the Fairfax County Government Center in Fairfax, Virginia to discuss the required TMDL reductions. Copies of the presentation and the draft TMDL report executive summary were available for public distribution. The meeting was public noticed in *The Virginia Register of Regulations.*

The following groups and agencies participated in the TMDL development for the Lower Accotink Creek watershed:

- Fairfax County Health Department
- Fairfax County Park Authority
- Fairfax County Public Schools
- Fairfax County Stormwater Planning Division
- Fort Belvoir Environmental Office
- Friends of Accotink Creek
- Newington Concrete/Virginia Concrete
- Northern Virginia Regional Commission
- Northern Virginia Soil Water Conservation District
- Shell/Motiva
- Virginia Department of Conservation and Recreation
- Virginia Department of Forestry

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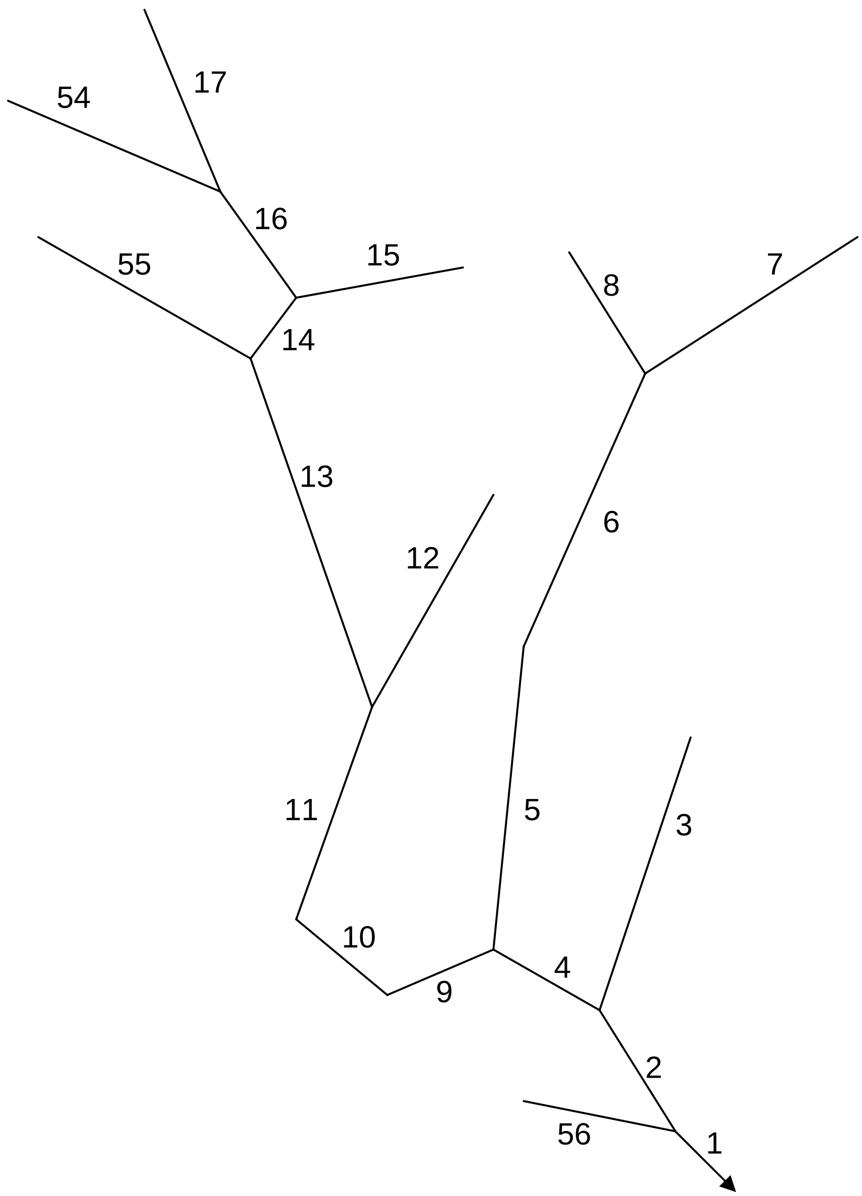
APPENDIX A:

Model Representation of Stream Reach Networks



Model Representation of the Lower Accotink Creek Bacteria-Impaired Watershed

APPENDIX B:

Monthly Fecal Coliform Build-up Rates and Direct Deposition Loads

Table B-1: Lower Accotink Creek Monthly Build-up Rates cfu/acre/day (January to June)						
Land Use	**Jan**	**Feb**	**Mar**	**April**	**May**	**Jun**
Commercial/Industrial	5.34E+10	4.46E+10	5.79E+10	5.44E+10	5.39E+10	6.27E+10
Cropland	2.88E+10	2.54E+10	2.98E+10	2.60E+10	2.94E+10	4.60E+10
Forest	4.35E+10	4.50E+10	4.47E+10	4.03E+10	4.33E+10	1.27E+11
High Density Residential	2.03E+12	1.70E+12	2.19E+12	2.08E+12	2.06E+12	2.41E+12
Medium Residential	3.16E+12	2.66E+12	3.36E+12	3.24E+12	3.27E+12	3.90E+12
Low Residential	3.04E+12	2.61E+12	3.20E+12	3.09E+12	3.16E+12	3.99E+12
Pasture	1.82E+10	1.68E+10	1.86E+10	1.30E+10	1.85E+10	3.94E+10

Table B-2: Lower Accotink Creek Monthly Build-up Rates cfu/acre/day (July to December)						
Land Use	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Commercial/Industrial	5.21E+10	3.90E+10	4.95E+10	3.94E+10	4.39E+10	4.84E+10
Cropland	2.65E+10	1.70E+10	4.27E+10	2.01E+10	2.00E+10	2.13E+10
Forest	4.06E+10	2.52E+10	6.65E+10	3.15E+10	3.08E+10	3.27E+10
High Density Residential	2.00E+12	1.50E+12	1.88E+12	1.49E+12	1.66E+12	1.84E+12
Medium Residential	3.15E+12	2.32E+12	3.16E+12	2.32E+12	2.52E+12	2.82E+12
Low Residential	3.02E+12	2.20E+12	3.27E+12	2.22E+12	2.38E+12	2.67E+12
Pasture	1.46E+10	6.71E+09	3.95E+10	1.18E+10	1.01E+10	9.30E+09

Table B-3: Lower Accotink Creek Monthly Direct Deposition Rates (cfu/month)			
Month	**Direct Cattle**	**Direct Septic**	**Direct Wildlife**
January	1.28E+09	1.84E+09	5.41E+11
February	1.73E+09	1.66E+09	4.89E+11
March	2.57E+09	1.84E+09	5.41E+11
April	2.48E+09	1.78E+09	5.24E+11
May	3.18E+09	1.84E+09	5.41E+11
June	3.09E+09	1.78E+09	5.24E+11
July	3.18E+09	1.84E+09	5.41E+11
August	2.57E+09	1.84E+09	5.41E+11
September	1.85E+09	1.78E+09	5.24E+11
October	1.92E+09	1.84E+09	5.41E+11
November	1.24E+09	1.78E+09	5.24E+11
December	1.28E+09	1.84E+09	5.41E+11

APPENDIX C:

Sensitivity Analysis

Sensitivity Analysis

The sensitivity analysis of the bacteria loadings and the waterbody response provides a better understanding of the watershed conditions that lead to the water quality criteria exceedance and provides insight and direction in developing the TMDL allocation and implementation. Potential sources of fecal coliform include non-point (land-based) sources such as runoff from livestock grazing, residential waste from failed septic systems, and wildlife. Some of these sources are dry weather driven and others are wet weather driven.

The objective of the sensitivity analysis was to assess the impacts of variation of model calibration parameters on the simulation of flow and the exceedance of the bacteria criteria in the impaired segment of Lower Accotink Creek. For the January 1998 to December 2006 period, the model was run with 110 percent and 90 percent of calibrated values of the parameters. The scenarios that were analyzed include the following:

- 10 percent increase in LZSN; the lower zone nominal storage
- 10 percent decrease in LZSN
- 10 percent increase in INFILT; index to the infiltration capacity of the soil
- 10 percent decrease in INFILT
- 10 percent increase in AGWRC; the basic groundwater recession rate
- 10 percent decrease in AGWRC
- 10 percent increase in UZSN; the upper zone nominal storage
- 10 percent decrease in UZSN
- 10 percent increase in INTFW; the interflow/surface runoff partition parameter
- 10 percent decrease in INTFW
- 10 percent increase in IRC; the interflow recession parameter
- 10 percent decrease in IRC
- 10 percent increase in LZETP; the lower zone evapotranspiration (ET) parameter
- 10 percent decrease in LZETP

The modeled flows for different sensitivity runs were compared with observed flows at the gage and the coefficients of determination of the hydrologic sensitivity analysis are presented in **Table C-1**. Based on these tables it can be seen that the calibration parameters affect the coefficient of determination in the decreasing order of AGWRC, IRC, INFILT, LZSN, INTFW, UZSN and LZETP.

The sensitivity analysis was also performed for two water quality parameters, WSQOP and FSTDEC, by simulating *E. coli* concentrations for 120 percent and 80 percent of their calibrated values. The rate of exceedance of the calendar-month geometric mean water quality criterion was determined for each scenario and compared with the rate of exceedance under the water quality calibration run. The changes in the rate of exceedance are presented in **Table C-2**. The results of the sensitivity analysis show that at the calibrated values of WSQOP and FSTDEC there is no measurable effect on the exceedance of the water quality criteria.

Table C-1: Sensitivity Analysis: Variation in Coefficient of Determination With Respect to Variation in Parameters For Simulation Period 1998-2006

Parameter	Coefficient of Determination	
	+10% change in parameter	-10% change in parameter
LZSN	0.837	0.838
INFILT	0.838	0.837
AGWRC	0.838	0.834
UZSN	0.839	0.835
INTFW	0.837	0.838
IRC	0.836	0.839
LZETP	0.840	0.834
Calibrated Parameters 0.837		

Table C-2: Sensitivity Analysis: Change in *E. coli* Exceedance Rate From 20% Change in Calibration Parameter Values

	WSQOP		FSTDEC	
Segment #	20%	-20%	20%	-20%
Accotink Creek (Segment 1)	0.0%	0.0%	-3.3%	1.7%