Volume II

Sediment TMDLs for the Accotink Creek Watershed, Fairfax County, Virginia

Prepared for
Virginia Department of Environmental Quality

Prepared by
Interstate Commission on the Potomac River Basin

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Cover Photo

Accotink Creek near Hooes Road, Virginia. 2008. Photo by Virginia Department of Environmental Quality

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Acronyms

ASCE	American Society of Civil Engineers
AVGWLF	ArcView interface for the Generalized Watershed Loading Function (GWLF)
BMP	Best Management Practices
BRAC	Base Realignment and Closure Act
CBP	Chesapeake Bay Program
CEM	Channel Evolution Model
CL	Chloride
CV	Coefficient of Variation
CWA	Clean Water Act
DCR	Virginia Department of Conservation and Recreation
DEQ	Virginia Department of Environmental Quality
DMR	Discharge Monitoring Reports
DW	Soil Dry Weight
E. coli	*Escherichia coli*
ELU	Existing Land Use
EOP	End-of-pipe
EPA	U. S. Environmental Protection Agency
FBNA	Fort Belvoir Northern Area
FCDPWES	Fairfax County Department of Public Works and Environmental Services
FDC	Flow Duration Curve
GHCND	Global Historical Climatology Network Daily
GIS	Geographic Information System
GP	General Permit
GWLF	Generalized Watershed Loading Function
ICPRB	Interstate Commission on the Potomac River Basin
INRMP	Integrated Natural Resource Management Plan
IP	Individual Permit
LA	Load Allocation
LER	Lateral Erosion Rate
LID	Low-impact Development
LTA	Long-term Average
MDE	Maryland Department of the Environment
MDL	Maximum Daily Load
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer Systems
NED	National Elevation Dataset
NEIEN	National Environmental Information Echange Network
NHDPlus	National Hydrography Dataset Plus
NLCD	National Land Cover Data
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resource Conservation Service
NRPC	Nashua Regional Planning Commission
NSQD	National Stormwater Quality Database
NVBIA	Northern Virginia Building Industry Association
NVRC	Northern Virginia Regional Commission

PADEP	Pennsylvania Department of Environmental Protection
PCB	Polychlorinated Biphenyl
PEST	Model-Independent Parameter Estimation Package
POC	Pollutants of Concern
PS	Point Source
Q	Flow
QA/QC	Quality Assurance/Quality Control
R^2	Coefficient of Determination
RA	Remaining Allocation
SaMS	Salt Management Strategy
SCS	Soil Conservation Service
SDR	Sediment Delivery Ratio
SI	Stressor Identification Analysis
SPA	Stream Physical Assessment
SS	Suspended Sediment
SSURGO	Soil Survey Geographic Database
STEPL	Spreadsheet Tool for the Estimation of Pollutant Loads
SWCB	State Water Control Board
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Loads
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
UNT	Unnamed Tributary
USGS	U. S. Geological Survey
USLE	Universal Soil Loss Equation
VDOT	Virginia Department of Transportation
VDP	Vision and Development Plan
VPDES	Virginia Pollutant Discharge Elimination System
VSCI	Virginia Stream Condition Index
VSMP	Virginia Stormwater Management Program
WLA	Wasteload Allocation
WQIF	Virginia Water Quality Improvement Fund
WQMP	Water Quality Management Plan
WSSI	Wetland Studies and Solutions, Inc.

Units of Measure

cfs	Cubic feet per second
cm	Centimeter
du/ac	Dwelling unit per acre
FNU	Formazin nephelometric units
ft	Foot
ft/yr	Feet per year
kg	Kilogram
kg/m^3	Kilogram per cubic meter
km	Kilometer
m	Meter
m^3/s	Cubic meter per second
mg/l	Milligrams per liter
MGD	Million gallons per day
mi	Miles
mi^2	Square mile
tons/d	Tons per day
$tons/ft^3$	Tons per cubic feet
tons/yr	Tons per year

Executive Summary

Introduction

Accotink Creek drains 52 square miles (mi^2) of Northern Virginia before entering first Accotink Bay, then Gunston Cove, an embayment on the tidal Potomac River. **Figure ES-1** shows the location of Accotink Creek. The study area for this project is the watershed draining the non-tidal portion of Accotink Creek upstream of Route 1, as shown in **Figure ES-1**.

The Accotink Creek watershed is highly developed. Overall, 87% of the watershed draining to non-tidal Accotink Creek consists of commercial, industrial, transportation, or residential land. Impervious surface covers 28% of the non-tidal watershed.

Biological Impairments in Accotink Creek

Virginia Department of Environmental Quality (DEQ) uses biological monitoring of benthic macroinvertebrate communities as one way to assess the ecological health of wadeable freshwater streams and to determine whether the Aquatic Life Use is supported. DEQ has conducted biological assessments of the mainstem of Accotink Creek at four locations. In addition, DEQ has conducted biological assessments in Long Branch (Central), a tributary of Accotink Creek that joins the mainstem just upstream of Lake Accotink, an impoundment on Accotink Creek. While there are three tributaries named Long Branch in the Accotink Creek watershed, the tributary focused on in this study is Long Branch (Central), hereafter simply referred to as Long Branch. Based on benthic macroinvertebrate monitoring and assessments in the Accotink Creek watershed, DEQ has placed Accotink Creek, both above and below Lake Accotink, and Long Branch on Virginia's List of Impaired Waters (Category 5 of the Integrated List) because they are not supporting their Aquatic Life Use. **Figure ES-1** shows the location of the impaired stream segments. Hereafter, impaired segment A15R-01-BEN, as shown in **Figure ES-1**, will be referred to as lower Accotink Creek, segment A15R-04-BEN as upper Accotink Creek, and A15R-05-BEN as Long Branch. **Table ES-1** summarizes the impairment listings for upper Accotink Creek, lower Accotink Creek, and Long Branch in Virginia's 2014 Integrated Report.

Section 303(d) of the Clean Water Act (CWA) and the United States Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR part 130) generally require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without exceeding water quality standards.

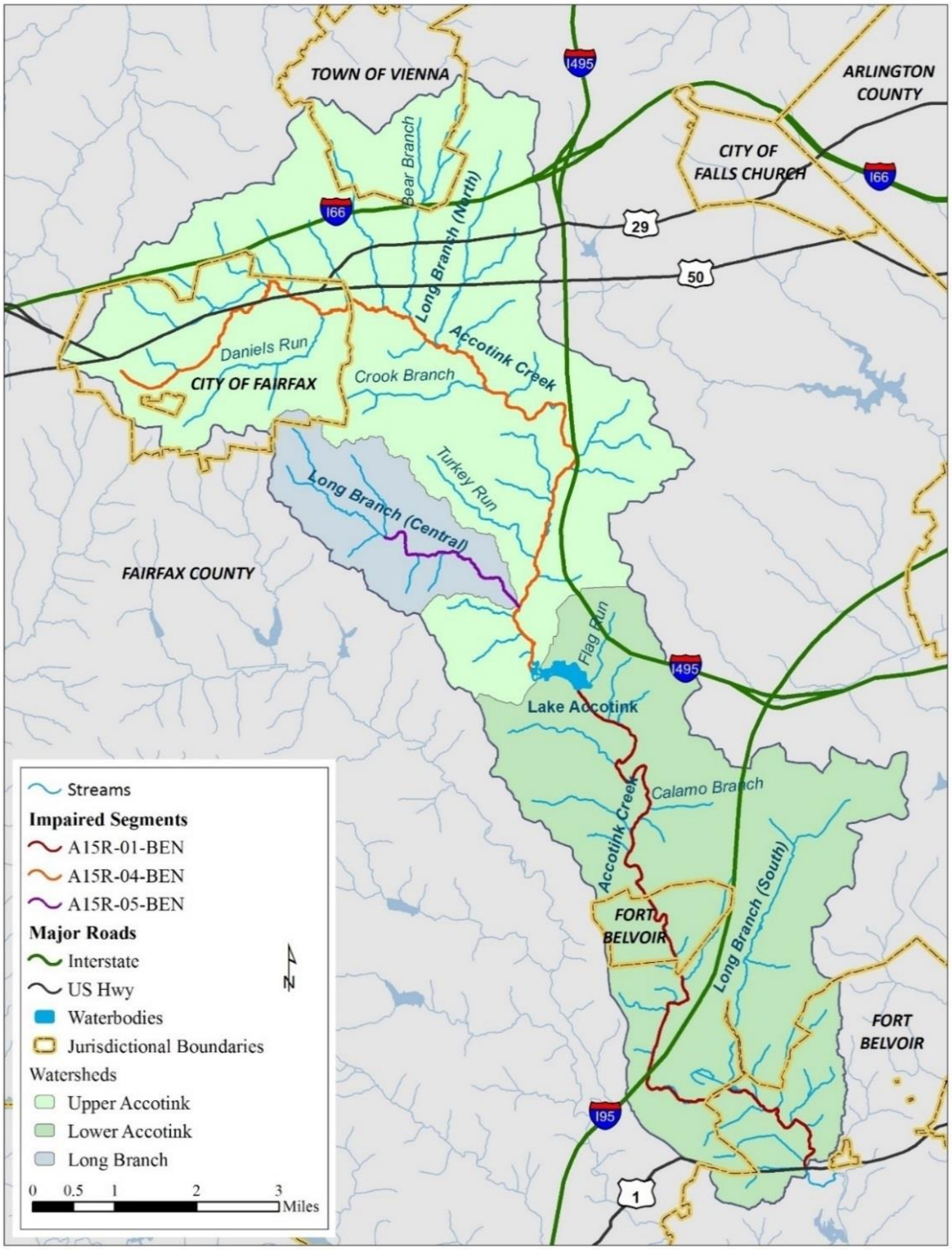


Figure ES-1: Location of the Impaired Segments in Accotink Creek Watershed

Table ES-1: Accotink Creek Benthic Impairments

TMDL Watershed	Stream Name	Cause Group Code 303(d) Impairment ID	Description	Size	Assessment Unit 305(b) Segment ID	Initial Listing
Lower Accotink Creek	Accotink Creek	A15R-01-BEN	Begins at the outlet of Lake Accotink and continues downstream until the tidal waters of Accotink Bay.	10.09 mi	VAN-A15R_ACO01B10 VAN-A15R_ACO01A00	2010 1996
Upper Accotink Creek	Accotink Creek	A15R-04-BEN	Begins at the headwaters of Accotink Creek and continues downstream until the start of Lake Accotink.	11.59 mi	VAN-A15R_ACO05A04 VAN-A15R_ACO04A02 VAN-A15R_ACO03A02 VAN-A15R_ACO02A00	2008 2010 2010 2010
Long Branch	Long Branch	A15R-05-BEN	Begins at the confluence with an unnamed tributary (UT) to Long Branch, at the Route 651 (Guinea Road) bridge, and continues downstream until the confluence with Accotink Creek, just below Braddock Road.	2.37 mi	VAN-A15R_LOE01A02	2008

Stressor Identification Analysis

Biological monitoring in the Accotink Creek watershed has determined that these waterbodies are not supporting their Aquatic Life Use, but the biological monitoring does not determine the cause of the biological impairments in these waterbodies. Until the underlying cause(s) of the biological impairments have been determined, there is uncertainty as to what actions will most effectively address the impairment. A Stressor Identification analysis (SI) was performed to determine the stressor(s) to the biological community in the Accotink Creek watershed (DEQ, 2017). The SI report is **Volume I** of this report.

The SI for upper Accotink Creek, lower Accotink Creek, and Long Branch examined ten potential stressors to determine the strength of the evidence linking them to the biological impairments in these streams. Based on an evaluation of the monitoring data and the scientific literature, chlorides, hydromodification, habitat modification, and sediment have been identified as the most probable stressors of the biological communities in the Accotink Creek watershed. Once the stressor(s) have been identified, TMDLs can be developed for any pollutant identified as a stressor of the biological community; however, not all stressors are pollutants amenable to TMDL development. The CWA distinguishes the general class of pollution, defined as “the man-made or man-induced alteration of physical, biological, chemical, and radiological integrity of water and other media (CWA, Section 502, General Definitions)," from pollutants, which are restricted to "[d]redged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dust and industrial, municipal, and agricultural waste discharge into water (CWA, Section 502, General Definitions)." TMDLs can only be developed for pollutants.

Of the four most probable stressors, only chloride (CL) and sediment are pollutants. TMDLs are being developed for sediment and chloride for each of the three impaired segments in the Accotink Creek watershed. The chloride TMDLs are described in **Volume III** of this report. This volume, **Volume II**, describes the development of sediment TMDLs for upper Accotink Creek, lower Accotink Creek, and Long Branch, to help address the biological impairments in those watersheds.

TMDL Development

Virginia does not have numeric water quality criteria for sediment to protect aquatic life. TMDLs developed for sediment in Virginia use the reference watershed approach, in which the sediment loads from unimpaired watersheds, which are similar in other respects to the impaired watershed, are used to set the TMDL for the impaired watershed. The current implementation of the reference watershed approach is the AllForX approach (Benham et al., 2014; Yagow et al.; 2015a; Yagow et al., 2015b). An all-forest load multiplier (AllForX) is the ratio of current sediment loads to the loads which would occur under all-forested conditions. In other words, the AllForX multiplier is an indication of how much higher current sediment loads are above an undeveloped condition. These multipliers are calculated for both impaired watersheds and a set of unimpaired watersheds, and the Virginia Stream Condition Index (VSCI) scores are then regressed against the AllForX values. Using the regression line, a threshold multiplier is identified for a VSCI score of 60, which is the assessment threshold that indicates a healthy benthic macroinvertebrate community. That AllForX threshold, multiplied by the all-forested sediment load of an impaired watershed, becomes the TMDL endpoint for the impaired watershed.

Loading rates for both the impaired and unimpaired watersheds are determined using the Generalized Watershed Loading Functions (GWLF) model (Haith and Shoemaker, 1987; Haith et al., 1992). GWLF is a continuous simulation model that can be used to represent streamflow, sediment loads, and nitrogen and phosphorus loads from point and nonpoint sources on a watershed basis. GWLF's strength is that it uses accepted engineering practices and techniques to calculate key variables like runoff and erosion. The simulation of runoff is based on the Natural Resource

Conservation Service (NRCS) Curve Number method, and the simulation of erosion is based on the Universal Soil Loss Equation (USLE). AVGWLF, a version of GWLF developed by Pennsylvania State University (Evans et al., 2003) for use in Pennsylvania's nonpoint source TMDLs, added a channel erosion component to the original GWLF model.

GWLF is best characterized as a planning level model that does not require as much input data as many continuous simulation models, nor does it require the calibration of model parameters. Although GWLF is supposed to require little or no calibration, the models used for the Accotink Creek watersheds were adjusted in the following manner:

- Hydrology parameters were calibrated using the parameter estimation software, PEST (Doherty, 2001);
- All land uses in Accotink Creek except open space and construction were calibrated to average event mean concentrations taken from the National Stormwater Quality Database (NSQD) (Pitt et al., 2004);
- Target sediment loads for land under construction were taken from the most recent Chesapeake Bay Program estimate of sediment exported under current sediment and erosion controls; and
- Total sediment loads were compared to sediment load estimates from Fairfax County's Watershed Management Plan for Accotink Creek and to sediment load estimates based on monitoring data collected at the USGS gauge on Accotink Creek near Annandale (01654000) and the gauge on Long Branch near Annandale (01654500).

Four GWLF models simulating baseline conditions were developed: a model used primarily to calibrate the hydrology parameters, which represents the Accotink Creek watershed above the USGS gauge on Accotink Creek near Annandale (01654000); and a model for each of the three watersheds draining to the impaired sections of upper Accotink Creek, lower Accotink Creek, and Long Branch. The model for calibration of hydrology was used to parameterize the three models for the impaired watersheds. The models for upper Accotink Creek, lower Accotink Creek, and Long Branch were used to simulate baseline loads for the TMDL calculations for the corresponding impairments. The upper Accotink Creek model also includes Long Branch, although the TMDL allocations for Long Branch were excluded from the TMDL allocations for upper Accotink Creek. The lower Accotink Creek model is simulated separately from the upper Accotink Creek watershed; sediment loads from the upper Accotink Creek are input into lower Accotink Creek as a point source after sediment trapping in Lake Accotink is taken into account. An average trapping efficiency of 47% was used for Lake Accotink, based on an analysis performed by Wetland Studies and Solutions, Inc. (WSSI) (2016) for the Fairfax County Park Authority. All four baseline models take into account the effect of the current (2015) level of implementation of Best Management Practices (BMPs).

There are also three GWLF models representing upper Accotink Creek, lower Accotink Creek, and Long Branch under all-forested conditions. The all-forested models do not include BMP effects. Both the models simulating baseline conditions and the models simulating all-forested conditions use the streambank erosion formulation from AVGWLF.

Hydrology Simulation. The simulation period for the four Accotink Creek GWLF models is April 1, 1996 through March 31, 2016. The hydrology simulation requires daily precipitation and average daily temperature as inputs. These were obtained from Washington Reagan National Airport (00013743). The GWLF hydrology simulation was calibrated against monthly flow data collected at the USGS gauge on Accotink Creek near Annandale (01654000). Because of the potential for a large degree of local variation in precipitation during extreme events, the daily precipitation from the Global Historical Climatology Network Daily (GHCND) gauge at Mantua, VA, was substituted for the precipitation record at Reagan National Airport for three storms: a June, 2006, storm; Tropical Storm Hanna in September, 2008; and Tropical Storm Lee in September 2011.

The PEST optimization, supplemented by the adjustment in monthly evapotranspiration cover coefficients and the substitution of Mantua precipitation for Reagan National data during extreme events, produced a satisfactory simulation of monthly flow volumes, when compared to the volumes observed at the USGS gage on Accotink Creek. **Table ES-2** summarizes the hydrology calibration statistics. **Figure ES-2** shows a scatter plot of paired observed and simulated monthly average flow. Generally, the data falls along the one-to-one line with a coefficient of determination (R^2) of 0.74. Total simulated flow volume is only 3% higher than the total observed volume.

Table ES-2: Hydrology Calibration Statistics

Statistic	Value
Percent Difference in Total Flow Volume (Simulated Volume –Observed Volume)	3%
Coefficient of Determination (R^2) between Simulated and Observed Monthly Flow Volumes	0.74
Coefficient of Determination (R^2) between Simulated and Observed Average Monthly Flow Volumes	0.80
Percent Difference in Winter Flow Volume (Simulated Volume –Observed Volume)	-2%
Percent Difference in Spring Flow Volume (Simulated Volume –Observed Volume)	10%
Percent Difference in Summer Flow Volume (Simulated Volume –Observed Volume)	-7%
Percent Difference in Fall Flow Volume (Simulated Volume –Observed Volume)	12%

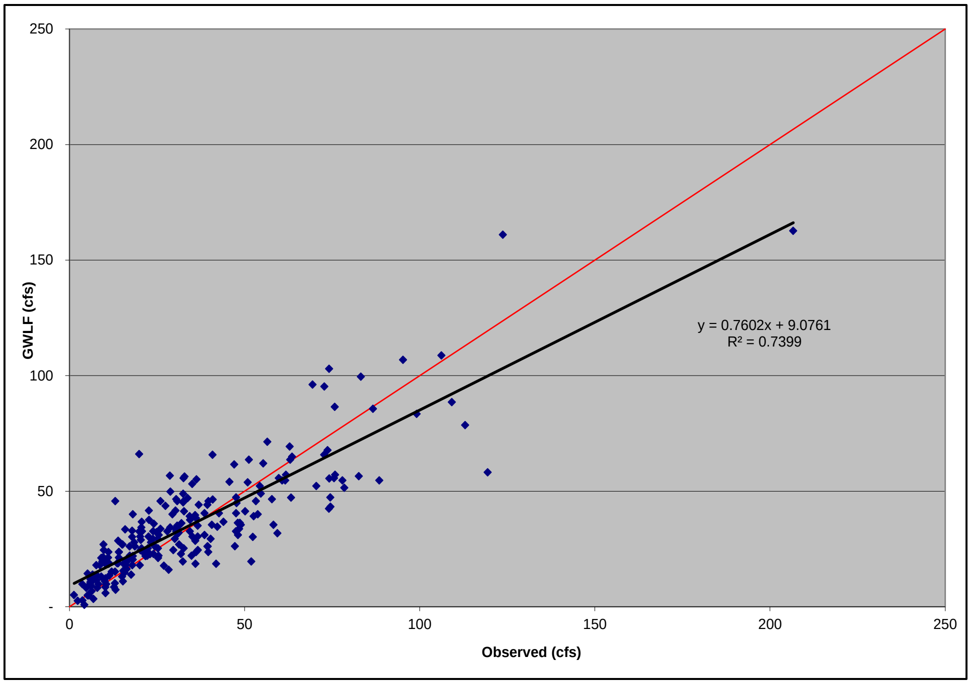


Figure ES-2: Scatter Plot of Observed and Simulated Monthly Flow, Accotink Creek near Annandale. (The red line represents a one-to-one relationship).

Sediment Transport Targets. The combination of the USLE and delivery factors does not capture the dynamics of sediment transport in highly developed watersheds. Developed watersheds have a high percentage of impervious surfaces, which are not subject to erosion, but still generate sediment loads from the deposition of wind-blown particulates. Some of these same surfaces serve as transport paths for sediment eroded from pervious surfaces, and that are often part of a larger network of storm sewers, which convey both flow and sediment. For these reasons sediment loads from developed land are best characterized as the loads delivered at the storm sewer outfalls, or alternatively, as the product of flow and an average or typical event mean concentration measured at the end-of-pipe (EOP). Average event mean concentrations from the NSQD, shown in **Table ES-3**, were used as sediment calibration targets for developed land uses.

Table ES-3: Sediment Concentration Calibration Targets for Accotink Creek Watershed

Land Use	Target Average Annual Sediment Concentration (mg/l)
Transportation	112
Other Developed Land	88

The Chesapeake Bay Program's Expert Panel on Removal Rates for Erosion and Sediment Control Practices estimated that the average annual sediment load discharged from land under construction operating under current erosion and sediment control regulations is 1.8 tons/acre/year (Clark et al., 2014).

Comparison of Estimates of Total Sediment Load. Total sediment loads were estimated using monitoring data collected at the USGS gauge on Accotink Creek near Annandale (01654000) and the gauge on Long Branch near Annandale (01654500) using a two-step method. The first step is to estimate a regression model that predicts suspended sediment concentration as a function of flow and/or turbidity; the second step is to estimate loads as the product of the estimated concentrations, measured flow or turbidity, and suitable conversion factors[1]. For Accotink Creek, a regression model was developed relating suspended sediment concentrations to instantaneous flows, and, using that model, sediment loads were estimated from continuous flow monitoring data. For Long Branch, the regression model related suspended sediment concentrations to both turbidity and flow, so that sediment loads could be estimated from continuous monitoring data of flow and turbidity.

Figure ES-3 compares average annual sediment loads from the four GWLF models to estimated average annual sediment loads from the regression models and annual sediment loads estimated for the Accotink Creek Watershed Management Plan developed by Fairfax County's Department of Public Works and Environmental Services (FCDPWES) in 2011. For each watershed, the loads from the regression models and the Watershed Management Plan are expressed as a percent of the corresponding load from GWLF, to facilitate the comparison. This comparison was prepared to gauge the relative agreement of the four GWLF model estimates of baseline loads. Given the differences in method, there is reasonable agreement in the estimates for all watersheds except Long Branch, where the average annual load from GWLF is about five times smaller than the estimated load from the regression model and almost four times smaller than the estimated load from the Watershed Management Plan.

[1] For example, the flux of sediment (lbs/s) is equal to the concentration (mg/l) times the flow rate (cfs) times 28.3168 l/ft^3 times 2.2046E-6 mg/lb. To get the rate in lbs/d, multiply by 86,400 s/d.

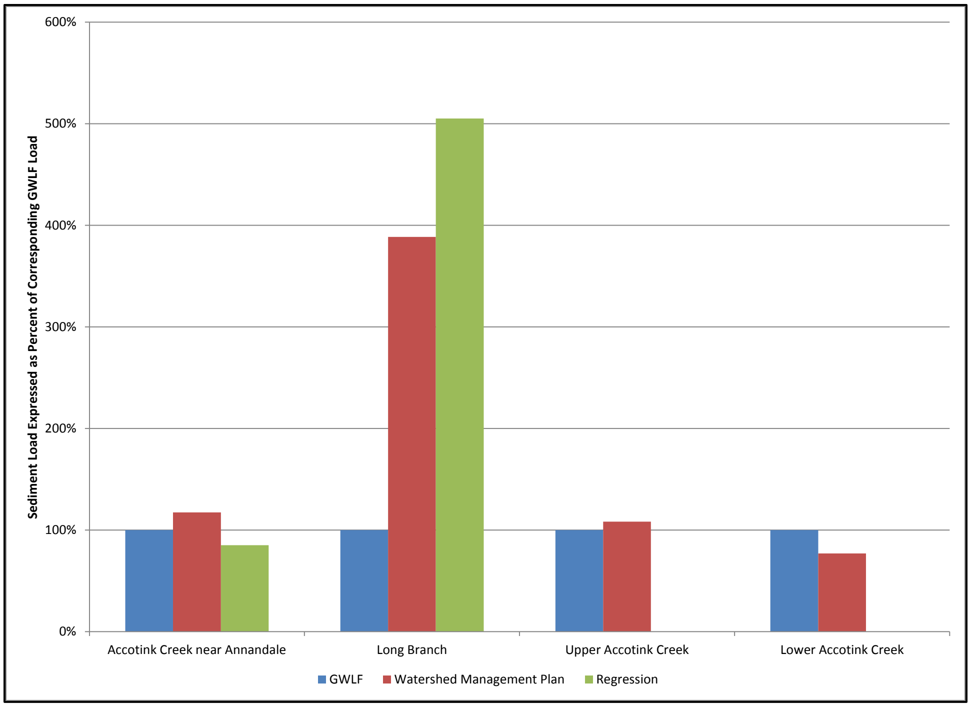


Figure ES-3: Comparison of Sediment Load Estimates in Accotink Creek Watershed[2]

The difference between the Watershed Management Plan's estimate and GWLF for Long Branch seems to reside in their estimates of streambank erosion. For Long Branch, GWLF estimates that the average annual sediment load from land-based sources is 282 tons/yr, which is comparable to the estimate of land-based sources in the Watershed Management Plan of 312 tons/yr. The GWLF streambank erosion rate, on the other hand, is over five times smaller than the erosion rate calculated for the Management Plan.

To bring the GWLF loads for Long Branch in line with the other estimates, the streambank erosion rate in Long Branch was adjusted so that the average annual load equals the adjusted average annual load estimated by the regression model. The streambank adjustment factor for Long Branch was 7.45. The streambank adjustment factor was also applied to streambank erosion loads under the all-forested conditions. All Long Branch sediment loads presented in the remainder of the Executive Summary have the streambank adjustment factor applied.

GWLF Results for Accotink Creek. **Table ES-4** shows the average annual sediment load for upper Accotink Creek, lower Accotink Creek, and Long Branch under baseline conditions and all-

[2] GWLF loads shown here do not have the streambank adjustment factor applied.

forested conditions. It also shows the AllForX multiplier for each impairment. **Figures ES-4**, **ES-5**, and **ES-6** show the contribution of sources to total baseline load, for Long Branch, upper Accotink Creek, and lower Accotink Creek, respectively. The dominant source of sediment generated in each watershed is streambank erosion.

Table ES-4: Average Annual Sediment Loads in the Accotink Creek Watershed

Watershed	Baseline Conditions (tons/yr)	All-Forested Conditions (tons/yr)	AllForX (unitless ratio)
Upper Accotink Creek[1]	14,856	811	18.31
Lower Accotink Creek[2]	14,579	1,241	11.75
Long Branch	3,882	226	17.16

[1]Includes loads from Long Branch
[2]Includes loads from Upper Accotink Creek and Long Branch with a 47% reduction due to trapping of sediment in Lake Accotink under the baseline condition

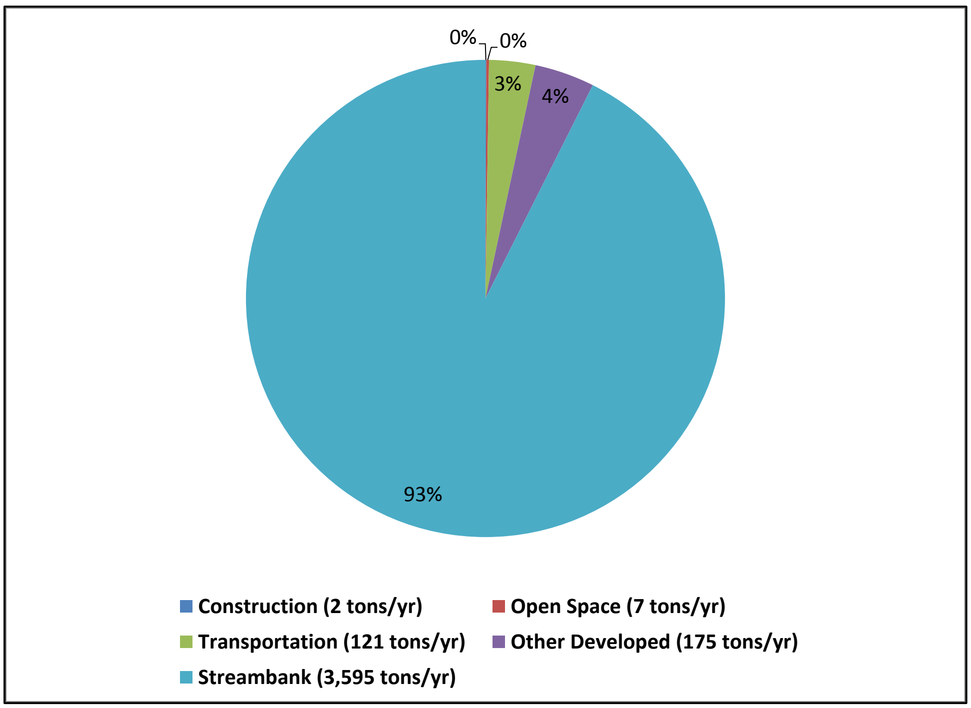


Figure ES-4: Contribution of Sources to Sediment Load in Long Branch

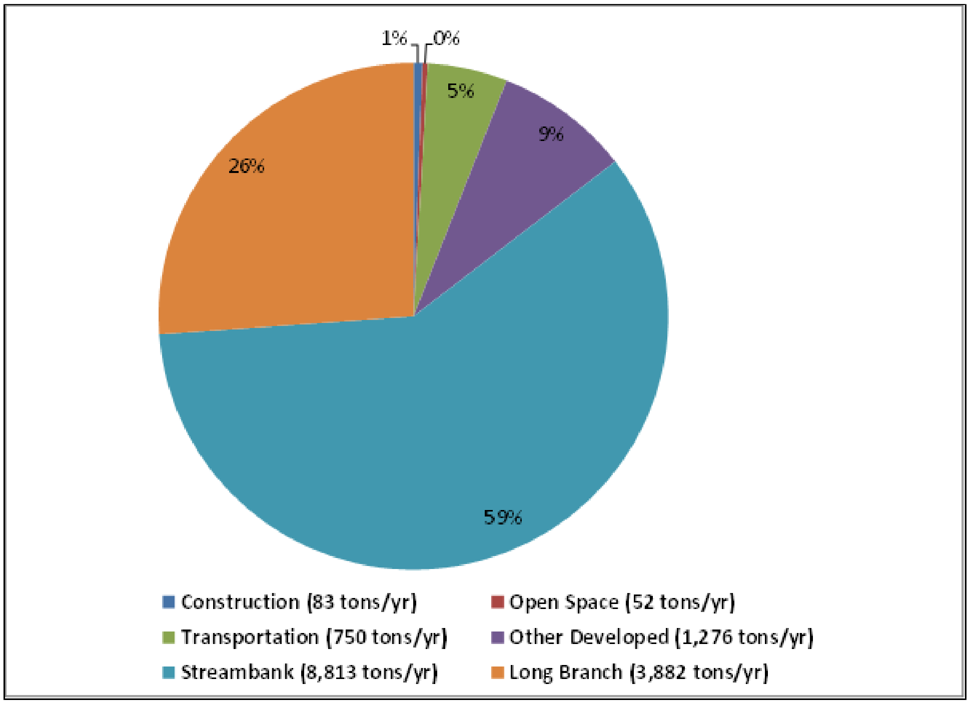


Figure ES-5: Contribution of Sources to Sediment Load in Upper Accotink Creek

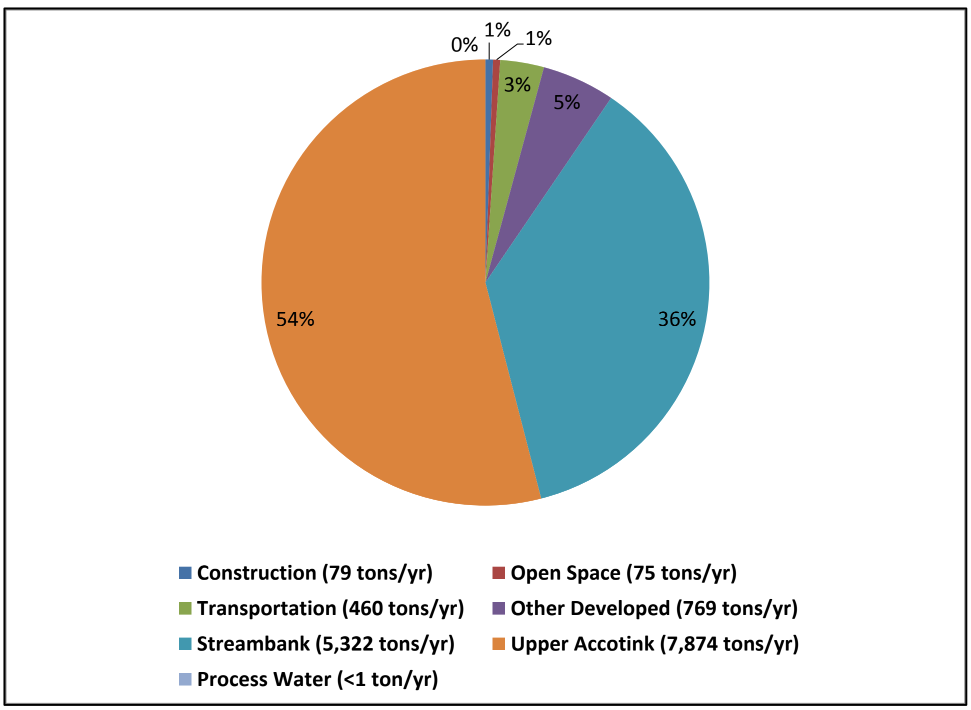


Figure ES-6: Contribution of Sources to Sediment Load in Lower Accotink Creek

Determination of AllForX Threshold. The minimum AllForX value, which on average meets water quality standards, was determined by developing a regression equation relating AllForX multipliers to average VSCI scores. The regression equation was developed using the GWLF estimates of sediment loads for the three impaired watersheds in the Accotink Creek watershed and estimated sediment loads based on GWLF models for a set of unimpaired, comparison watersheds. Six comparison watersheds were ultimately selected based on criteria described in Appendix A. Information related to the six comparison watersheds, including modeled loads, AllForX values, and Average VSCI scores can be also be found in Appendix A.

The AllForX values for the six comparison watersheds and the three impaired watersheds in Accotink Creek were regressed against the corresponding VSCI scores, as shown in **Figure ES-7**. The AllForX value (x-axis) at the point where the regression line crosses the VSCI score (y-axis) of 60 is the AllForX threshold. This represents the AllForX value at or below which water quality standards are met. The AllForX threshold for the Accotink and associated comparison watersheds is 5.07.

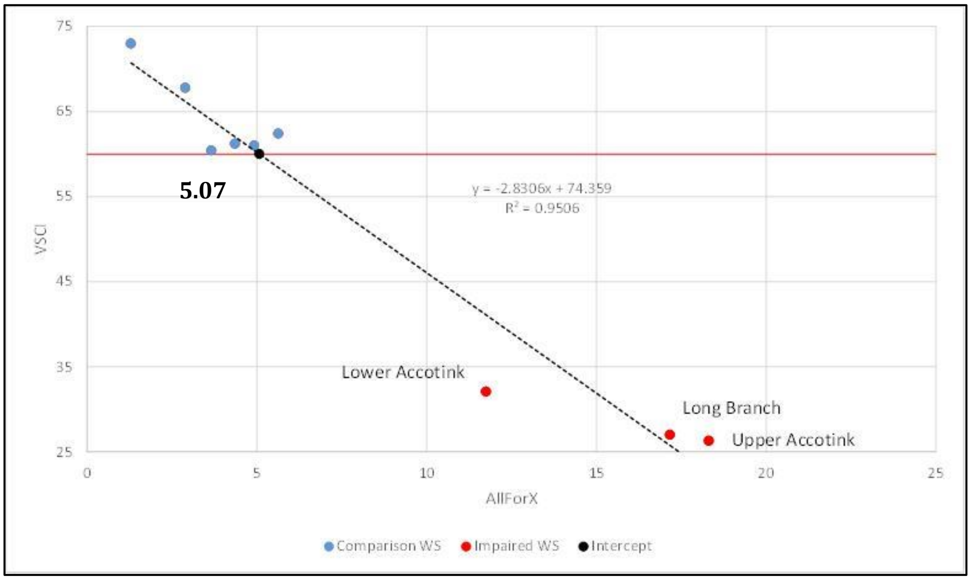


Figure ES-7: Regression of VSCI Scores against AllForX Multipliers

Determination of TMDLs. The AllforX threshold multiplied by the All-Forested sediment load that was estimated using GWLF models for the impaired watersheds gives the maximum sediment load that can meet water quality standards. This is the average annual sediment TMDL. **Table ES-5** gives TMDLs for the impaired watersheds in Accotink Creek and the percent reduction required to meet the TMDL. The loads from upstream TMDL watershed(s) that contribute to downstream

TMDL watersheds are treated as separate loads and are not included in the downstream TMDL. In other words, the TMDL for upper Accotink Creek does not include loads from Long Branch and the TMDL for lower Accotink Creek does not include loads from upper Accotink Creek and Long Branch.

Table ES-5: Average Annual Sediment TMDLs (tons/yr) for Accotink Creek Watersheds with Upstream Allocations from Impaired Watersheds Removed

Watershed	TMDL (upstream watershed load removed)	Percent Reduction on Sources in TMDL Watershed (upstream watershed load removed)
Upper Accotink Creek	2,969	73%
Lower Accotink Creek[1]	4,113	39%
Long Branch	1,148	70%

[1]Incorporates 47% trapping efficiency of Lake Accotink

TMDL Allocations

A TMDL is the amount of pollutant a waterbody can assimilate and still meet water quality standards. According to EPA regulations (CFR 130.2, 130.7), the TMDL must be assigned or allocated among regulated and non-regulated sources, according to the following equation:

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

where

WLA = Wasteload Allocation, which is the portion of the TMDL assigned to regulated or permitted sources;
LA = Load Allocation, which is the portion of the TMDL assigned to non-regulated sources
MOS = Margin of Safety

Each of the components of the TMDL is discussed in more detail below.

Margin of Safety. A MOS is necessary to take into account the uncertainty in the relation between pollutant loading rates and water quality. The MOS can be implicit or explicit. An implicit MOS is based on the conservative assumptions used to determine the TMDL. An explicit MOS reserves a portion of the TMDL to the MOS. A 10% explicit margin of safety was used in addressing the sediment impairments in Accotink Creek to account for uncertainty.

Wasteload Allocations. Wasteload allocations are assigned to regulated, point source discharges. DEQ issues Virginia Pollutant Discharge Elimination System (VPDES) permits for all point source discharges to surface waters, to dischargers of stormwater from Municipal Separate Storm Sewer Systems (MS4s), and to dischargers of stormwater from Industrial Activities. DEQ issues Virginia Stormwater Management Program (VSMP) permits to dischargers of stormwater from Construction Activities. There are two broad types of discharge permits; individual permits and general permits.

DEQ issues individual permits to both municipal and industrial facilities. Permit requirements, special conditions, effluent limitations and monitoring requirements are determined for each facility on a site specific basis in order to meet applicable water quality standards. General permits are written for a general class of dischargers where operations and activities are similar. These permits are also prepared to protect and maintain applicable water quality standards. In Virginia, general permits are adopted as regulations.

Within the Accotink Creek watershed, there are seven individual permits authorizing discharges to surface waters. Five of the individual permits are classified as industrial discharges. Four of these permits govern the discharges from bulk petroleum storage facilities. One permit governs the industrial stormwater discharges from Fort Belvoir. Lastly, there are two individual permits issued to Municipal Separate Storm Sewer Systems (MS4) which govern the stormwater discharges from municipal operations. Fairfax County currently has an individual permit; it is anticipated that the Virginia Department of Transportation (VDOT) will have an individual permit by the completion of this TMDL study.

There are discharges from eight general permit categories authorized in the Accotink Creek watershed. These include:

- three (3) Vehicle Wash and Laundry facilities;
- one (1) Non-contact Cooling Water permittees;
- three (3) Concrete Products Facilities;
- two (2) permittees under the Domestic Sewage Discharge of Less Than or Equal to 1,000 Gallons per Day;
- two (2) facilities authorized under the permit for Petroleum Contaminated Sites and Hydrostatic Tests;
- 12 permits for Discharges of Stormwater Associated with Industrial Activity;
- numerous transitory permits for stormwater discharges associated with land disturbance or construction activities;
- five (5) MS4 general permits issued to either small or non-traditional MS4 entities.

Not all of the authorized general permit discharges are considered to discharge the pollutant of concern (e.g. sediment) in significant amounts which may cause or contribute to the impairments in the Accotink Creek watershed. Accordingly, insignificant discharges are not assigned wasteload allocations. Additionally, there is a distinction recognized throughout this document that authorized discharges may result from stormwater (e.g. precipitation) and/or process water. An example of a process water discharge is that resulting from the mixing and preparing of concrete products, or the blow-down from a heating and air conditioning ventilation system. These discharges are not related to a storm event.

The following sources will receive sediment wasteload allocations:

- Municipal separate storm sewer systems (MS4s) discharges authorized under both individual and general permits;
- Individual VPDES permitted facilities;
- Industrial stormwater discharges authorized under the general permit as contained in 9VAC25-151 (VAR05) - Discharges of Stormwater Associated with Industrial Activity;
- Concrete product facilities authorized to discharge under the general permit 9VAC25-193 (VAG11) - Concrete Products Facilities;
- Carwash facilities authorized to discharge under the general permit 9VAC25-194 (VAG75) - Vehicle Wash and Laundry Facilities;
- Domestic sewage discharges less than 1000 gallons per day authorized under 9VAC25-110 (VAG40) - Domestic Sewage Discharges of Less Than or Equal To 1,000 Gallons Per Day;
- Stormwater discharges associated with land disturbance, or construction activities, authorized under 9VAC25-880 - General VPDES Permit for Discharges of Stormwater from Construction Activities.

Note that the regulatory citations for the general permits noted above are current as of the preparation of this TMDL. The established WLA for each facility is applicable to the regulated discharge(s) and shall remain valid should the regulatory citation for a given permit category be updated or changed in the future.

Additionally, it is important to note that the WLA also includes an allocation for future growth.

For industrial stormwater discharges and process water discharges from permitted facilities, the allocation is determined as the product of an established concentration and the estimated average annual flow. The sources for the concentration and flows are discussed below, and summarized in **Table ES-6**.

Table ES-6: Summary of Basis for Calculating Annual Wasteload Allocations for Permitted Facilities

Permit Type	Concentration (mg/l)	Source of Concentration Value	Flow
Individual Permit – Process Water or Managed Discharges (Bulk Terminals)	60 mg/l	Maximum permitted concentration	Permit Documentation
Individual Permit –Industrial Stormwater Discharges (Fort Belvoir)	100 mg/l	Benchmark concentration	GWLF Model Flows
General Industrial Stormwater Permit	100 mg/l	Benchmark concentration	GWLF Model Flows
Car Wash Process Water	60 mg/l	Maximum permitted concentration	Reported Average Flows
Concrete Process Water	30 mg/l	Average permitted concentration	Average DMR Flows
Concrete Stormwater	100 mg/l	Benchmark concentration	GWLF Model Flows
Concrete Comingled Process and Stormwater[1]	30 mg/l	Average permitted concentration	GWLF Model Flows
Domestic Sewer Discharge	30 mg/l	Maximum permitted concentration	Maximum permitted flow

[1]Process water for VAG110355 is comingled with stormwater. Process water is reused, thus the discharge is based on stormwater flows.

The baseline loads for land under construction represent implementation of current erosion and sediment controls, adjusted for the occurrence of precipitation events in which the controls are not effective. No additional reductions to loads for land under construction were required, so the WLA for land under construction was set equal to the baseline load.

For each impairment, all of the MS4s within a jurisdiction receive an aggregated allocation. This reflects the fact that MS4 service areas overlap to a great extent (See **Figure 2-7** in **Section 2.2.3**).

The aggregated jurisdictional MS4 was determined by first calculating the overall percent reduction required to meet the TMDL after the MOS, Construction WLA, and Process Water WLA are accounted for. The overall percent reduction required from MS4s among other sources was calculated as follows:

1. Calculate Remaining Allocation (RA) =
   TMDL – MOS –Construction WLA –WLAs for Process Water;
2. Percent of Remaining Allocation (PRA)=

$$\frac{RA}{\text{Total Baseline Load} - \text{Construction Baseline Load} - \text{Baseline Load for Process Water}}$$

The percent reduction required on the remaining sources is 1 – PRA. The baseline load from the area in a jurisdiction covered by the combined service areas of the MS4s was then multiplied by percent of the remaining sources allocated, calculated above, and any industrial stormwater allocations from facilities within the combined service area in that jurisdiction were subtracted from the product, to obtain the final aggregated MS4 WLA for that jurisdiction. In other words

3. MS4 Allocation = PRA*MS4 Baseline Load – Industrial Stormwater Allocation within combined service area

Baseline loads within a combined service area were determined from the GWLF model simulation. Land-use loads were determined using the acreage of land use in the combined service area. Construction loads were excluded from MS4 baseline loads, because the WLA for land under construction applies to not just current but future land disturbance activity and therefore it cannot be determined whether that activity will take place inside of a service area. Sediment loads from streambank erosion were allocated to MS4s (or to the LA) in proportion to the percent of the total impervious surface in the impaired watershed that was in the combined service area in each jurisdiction. Impervious area, rather than total area, was used because impervious surfaces are primarily responsible for the increased magnitude and frequency of peak flow events which reshape stream channels in developed areas.

In the upper Accotink Creek and lower Accotink Creek watersheds, future growth was accounted for by setting aside 5% of the TMDL for the creation of new point sources and any growth in MS4 service areas or other regulated stormwater. A future growth of 5% was chosen due to the large proportion of these watersheds that are already covered by MS4 service areas and the anticipated expansion in regulated stormwater. However, in the Long Branch watershed, since there is little room for MS4s or other regulated stormwater to grow, a future growth of 1% of the TMDL was used to account for any future growth in point sources. Most of these watersheds are highly developed. Therefore, any potential expansion of an MS4 service area or other regulated stormwater would not likely entail a change in existing land-use. Rather, it would simply be a reallocation of loadings from the LA portion of the TMDL to the WLA component. Accordingly, in all three watersheds the future growth was taken from the LA and provides flexibility to the permitting authority to implement changes to regulated stormwater as they occur over time.

Load Allocation. The load allocation primarily covers loads from areas outside either MS4 service areas or the drainage areas to industrial stormwater outfalls. The formula for the LA is

LA = TMDL – MOS – WLA

Allocations for Individual Impairments. **Table E-7** provides a summary of the sediment TMDL, MOS, WLAs, and LA for upper Accotink Creek. **Table ES-8** gives the average annual baseline

MS4 loads, aggregated MS4 WLAs, and MS4 percent reduction from baseline conditions. **Table ES-9** gives the wasteload allocations for facilities for permitted process water and permitted stormwater. **Table ES-10** gives the average annual baseline loads for nonregulated lands by source type, in addition to the LAs and percent reduction from baseline conditions by source type.

Table ES-7: Upper Accotink Creek Average Annual TMDL Allocations

Source	Load (tons/yr)	Percent of TMDL
Total WLA	**2,338**	79%
City of Fairfax Aggregate MS4 WLA	634	21%
Fairfax County Aggregate MS4 WLA	1,282	43%
Town of Vienna Aggregate MS4 WLA	174	6%
Total Process Water WLA	<1	<1%
Total Industrial Stormwater WLA	16	1%
Construction	83	3%
Future Growth	148	5%
LA	**334**	11%
MOS	**297**	10%
TMDL (not including Long Branch)	**2,969**	100%
Long Branch Upstream TMDL	1,148	NA[1]
Total TMDL (including Long Branch)	4,116	NA[1]

[1]Not Applicable

Table ES-8: Upper Accotink Creek Aggregated MS4 Wasteload Allocations

Jurisdiction	Permit No	Facility Name	Baseline Load (tons/yr)	WLA (tons/yr)	Percent Reduction
Fairfax County	VA0088587	Fairfax County	5,394	1,282	76%
	VA0092975	Virginia Department of Transportation			
	VAR040095	Northern Virginia Community College			
	VAR040104	Fairfax County Public Schools			
City of Fairfax	VA0092975	Virginia Department of Transportation	2,667	634	76%
	VAR040064	City of Fairfax			
Town of Vienna	VA0092975	Virginia Department of Transportation	733	174	76%
	VAR040066	Town of Vienna			

Table ES-9: Upper Accotink Creek Sediment Permitted Stormwater Water and Process Water Wasteload Allocations

Type	Permit No	Facility Name	Annual (tons/yr)	Daily (tons/d)
Individual[1]	VA0001872	Joint Basin Corporation – Fairfax Terminal Complex	9.14	0.426
Individual[1]	VA0002283	Motiva Enterprises LLC - Fairfax	4.39	0.245
General[1]	VAR051770	Fairfax County - Jermantown Maintenance Facility	1.22	0.020
General[1]	VAR051066	USPS Merrifield Vehicle Maintenance Facility	0.94	0.015
General[1]	VAR052188	Milestone Metals	0.70	0.011
General Car Wash[2]	VAG750226	Enterprise Rent-A-Car- 3055 Nutley St	0.09	0.0003
General Car Wash[2]	VAG750238	Ravensworth Collision Center	0.004	0.00003
General Single Family Home[2]	VAG406519	Single Family Home	0.05	0.0001
Total			**16.54**	**0.717**

[1]Included in the industrial stormwater WLA
[2]Included in the process water WLA

Table ES-10: Upper Accotink Creek Load Allocations by Source Type

Source	Baseline Load (tons/yr)	LA (tons/yr)	Percent Reduction
Transportation	17	2	85%
Other Developed	338	50	85%
Open Space	28	28	0%
Streambank	1,714	253	85%
Total	2,097	334	84%

Table ES-11 gives the sediment TMDL, MOS, WLAs, and LA for lower Accotink Creek. **Table ES-12** provides a summary of the average annual baseline MS4 loads, aggregated MS4 WLAs, and MS4 percent reduction from baseline conditions. **Table ES-13** gives the wasteload allocations for facilities for permitted process water and permitted stormwater. **Table ES-14** gives the average annual baseline loads for nonregulated lands by source type, in addition to the LAs and percent reduction from baseline conditions by source type.

Table ES-11: Lower Accotink Creek Average Annual TMDL Allocations

Source	Load (tons/yr)	Percent of TMDL
Total WLA	**3,073**	75%
Fairfax County Aggregate MS4 WLA	2,457	59%
Fort Belvoir Aggregate MS4 WLA	235	6%
Total Process Water WLA	1	<1%
Total Industrial Stormwater WLA	95	3%
Construction	79	2%
Future Growth	206	5%
LA	**629**	15%
MOS	**411**	10%
TMDL (not including upper Accotink Creek)	**4,113**	100%
Upper Accotink Creek and Long Branch Upstream	2,182	NA[1]
Total TMDL (including upper Accotink Creek)	6,294	NA[1]

[1]Not Applicable

Table ES-12: Lower Accotink Creek Aggregated MS4s Wasteload Allocations

Jurisdiction	Permit No	Facility Name	Baseline Load (tons/yr)	WLA (tons/yr)	Percent Reduction
Fairfax County	VA0088587	Fairfax County	4,456	2,457	45%
	VA0092975	Virginia Department of Transportation			
	VAR040104	Fairfax County Public Schools			
Fort Belvoir	VA0092975	Virginia Department of Transportation	519	235	55%
	VAR040093	Fort Belvoir			

Table ES-13: Lower Accotink Creek Sediment Permitted Stormwater Water and Process Water Wasteload Allocations

Type	Permit No	Facility Name	Annual (tons/yr)	Daily (tons/d)
Individual[1]	VA0092771	Fort Belvoir	48.98	0.782
Individual[1]	VA0001945	Kinder Morgan Southeast Terminals LLC-Newington	16.09	0.351
Individual[1]	VA0001988	Kinder Morgan Southeast Terminals LLC-Newington 2	3.29	0.303
General[1]	VAR051042	SICPA Securink Corporation	3.52	0.056
General[1]	VAR051047	Fairfax County – Connector Bus Yard (Huntington Garage)	2.94	0.047
General[1]	VAR051771	Fairfax County - Newington Maintenance Facility	7.87	0.126
General[1]	VAR051772	Fairfax County - DVS – Alban Maintenance Facility	0.81	0.013
General[1]	VAR051795	HD Supply - White Cap	0.08	0.001
General[1]	VAR052223	Newington Solid Waste Vehicle Facility	2.30	0.037
General[1]	VAR051565	Rolling Frito Lay Sales LP - South Potomac DC	0.56	0.009
General[1]	VAR051863	United Parcel Service - Newington	7.00	0.112
General[1]	VAR052366	Ready Refresh by Nestle – Lorton Branch	1.22	0.020
General Concrete[3]	VAG110069	Virginia Concrete, Mid-Atlantic Materials	0.62	0.015
General Concrete[2]	VAG110046	Virginia Concrete, Newington Plant	0.33	0.031
General Concrete[2]	VAG110355	Superior Concrete Materials	0.41	0.013
General Car Wash	VAG750255	Enterprise Rent A Car – Loisdale Road	0.091	0.0003
Total			**96.14**	**1.915**

[1]Included in the industrial stormwater WLA
[2]Included in the process water WLA
[3]VAG110069 has two outfalls. Outfall 001 discharges process water and outfall 002 discharges industrial stormwater. The annual process water WLA for outfall 001 is 0.366 tons/yr and the annual industrial stormwater WLA for outfall 002 is 0.25 tons/yr. The daily process water WLA for outfall 001 is 0.011 tons/d and the daily industrial stormwater WLA for outfall 002 is 0.004 tons/d.

Table ES-14: Lower Accotink Creek Load Allocations by Source Type

Source	Baseline Load (tons/yr)	LA (tons/yr)	Percent Reduction
Transportation	13	5	63%
Other Developed	208	76	63%
Open Space	31	31	0%
Streambank	1,411	517	63%
Total	**1,663**	**629**	**62%**

Table ES-15 provides a summary of the sediment TMDL, MOS, WLAs, and LA for Long Branch. **Table ES-16** gives the average annual baseline MS4 loads, aggregated MS4 WLAs, and MS4 percent reduction from baseline conditions. **Table ES-17** gives the wasteload allocations for facilities for permitted process water. **Table ES-18** gives the average annual baseline loads for nonregulated lands by source type, in addition to the LAs and percent reduction from baseline conditions by source type. Currently, there are no facilities in the Long Branch watershed permitted for industrial stormwater.

Table ES-15: Long Branch Average Annual TMDL Allocations

Source	Load (tons/yr)	Percent of TMDL
Total WLA	**936**	82%
City of Fairfax Aggregate MS4 WLA	42	4%
Fairfax County Aggregate MS4 WLA	880	77%
Total Industrial Stormwater WLA	NA[1]	NA[1]
Total Process Water WLA	<1	<1%
Construction	2	<1%
Future Growth	11	1%
LA	**97**	8%
MOS	**115**	10%
TMDL	**1,148**	100%

[1]Not Applicable

Table ES-16: Long Branch Aggregated MS4 Wasteload Allocations

Jurisdiction	Permit No	Facility Name	Baseline Load (tons/yr)	WLA (tons/yr)	Percent Reduction
City of Fairfax	VA0092975	Virginia Department of Transportation	158	42	73%
	VAR040064	City of Fairfax			
Fairfax County	VA0088587	Fairfax County	3,313	880	73%
	VA0092975	Virginia Department of Transportation			
	VAR040104	Fairfax County Public Schools			

Table ES-17: Long Branch Sediment Permitted Process Water Wasteload Allocations

Type	Permit No	Facility Name	Annual (tons/yr)	Daily (tons/d)
General Single Family Home[1]	VAG406613	Single Family Home	0.05	0.0001
Total			**0.05**	**0.0001**

[1]Included in the process water WLA

Table ES-18: Long Branch Load Allocations by Source Type

Source	Baseline Load (tons/yr)	LA (tons/yr)	Percent Reduction
Transportation	2	1	77%
Other Developed	26	6	77%
Open Space	5	5	0%
Streambank	375	85	77%
Total	**409**	**97**	**76%**

<u>Daily Load Expressions:</u> The TMDLs and allocations were also expressed on a daily basis. Daily expressions of the WLAs were given to permitted facilities based on permit type.

Tables ES-19, **ES-20**, and **ES-21** present the maximum daily sediment loads for upper Accotink Creek, lower Accotink Creek, and Long Branch, respectively. Daily load expressions for WLAs for individual facilities are given in **Tables ES-9, ES-13,** and **ES-17**, for upper Accotink Creek, lower Accotink Creek, and Long Branch, respectively. The total maximum daily load is the sum of the allocations and wasteload allocations. Just as for the average annual expression, the MOS is 10% of the total TMDL, 5% of the TMDL has been set aside for future growth in upper Accotink Creek and lower Accotink Creek, and 1% of the TMDL has been set aside for future growth in Long Branch.

Table ES-19: Maximum Daily Loads for Upper Accotink Creek

Source	Load (tons/day)	Percent of TMDL
Total WLA	**37.933**	79%
City of Fairfax Aggregate MS4 WLA	10.154	21%
Fairfax County Aggregate MS4 WLA	20.539	43%
Town of Vienna Aggregate MS4 WLA	2.792	6%
Total Process Water WLA	<0.001	<1%
Total Industrial Stormwater WLA	0.717	1%
Construction	1.328	3%
Future Growth	2.404	5%
LA	**5.345**	11%
MOS	**4.809**	10%
TMDL (not including Long Branch)	**48.086**	100%
Long Branch Upstream TMDL	18.087	NA[1]
Total TMDL (including Long Branch)	66.173	NA[1]

[1]Not Applicable.

Table ES-20: Maximum Daily Loads for Lower Accotink Creek

Source	Load (tons/day)	Percent of TMDL
Total WLA	**49.486**	75%
Fairfax County Aggregate MS4 WLA	39.244	59%
Fort Belvoir Aggregate MS4 WLA	3.751	6%
Total Process Water WLA	0.055	<1%
Total Industrial Stormwater WLA	1.860	3%
Construction	1.268	2%
Future Growth	3.307	5%
LA	**10.041**	15%
MOS	**6.614**	10%
TMDL (not including upper Accotink Creek)	**66.141**	100%
Upper Accotink Creek and Long Branch Upstream TMDLs	35.072	NA[1]
Total TMDL (including upper Accotink Creek)	101.213	NA[1]

[1]Not Applicable.

Table ES-21: Maximum Daily Loads for Long Branch

Source	Load (tons/day)	Percent of TMDL
Total WLA	**14.748**	82%
City of Fairfax Aggregate MS4 WLA	0.663	4%
Fairfax County Aggregate MS4 WLA	13.869	77%
Total Industrial Stormwater WLA	NA[1]	NA[1]
Total Process Water WLA	<0.001	<1%
Construction	0.035	<1%
Future Growth	0.181	1%
LA	**1.530**	8%
MOS	**1.809**	10%
TMDL	**18.087**	100%

[1]Not Applicable. Currently there are no industrial stormwater discharges in the watershed.

TMDL Implementation

The framework used in Virginia to provide reasonable assurance that the required pollutant reductions can be achieved is outlined below. 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.

For the implementation of the WLA component of the TMDL, the Commonwealth utilizes the Virginia Pollutant Discharge Elimination System (VPDES) program and the Virginia Stormwater Management Program (VSMP). There are no municipal wastewater treatment plants in the Accotink Creek watershed. Process water discharged from concrete plants, car washes, or other activities regulated by general permits are required to meet the sediment concentration limits at the point of discharge as stipulated in the VPDES permit.

DEQ authorizes the discharges of stormwater associated with industrial activities, construction sites, and MS4s through the issuance of VPDES permits. Authorization for the issuance of VPDES permits to address stormwater discharges from construction sites and MS4s is included in the VSMP Regulation. While the authorization to issue VPDES permits is housed in two different regulations, permits allowing the discharge of industrial stormwater, construction stormwater, and municipal stormwater all implement the requirements of the federal NPDES program. All new or revised permits must be consistent with the assumptions and requirements of any applicable TMDL WLA.

For MS4/VSMP individual and general permits, DEQ expects the permittee to specifically address the TMDL wasteload allocations (WLA) for stormwater through the iterative implementation of BMPs to the maximum extent practicable. Permittee implementation of an individual control strategy includes determining BMP effectiveness. The implementation of the WLAs for MS4 permits will be through the iterative implementation of structural and programmatic BMPs aimed at meeting the designated percent reductions from baseline conditions.

To implement the load allocation from nonpoint sources, 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 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. DEQ expects that implementation of the sediment TMDLs will occur in stages, and that full implementation of the TMDLs is a long-term goal. The measures for nonpoint source reductions, which can include the use of better technology and the adoption of BMPs, are implemented in an iterative process that is described along with specific BMPs in the TMDL implementation plan. Many of the BMPs that address sediment also address the two non-pollutant stressors hydromodification and habitat modification. If the measures to reduce sediment also address the non-pollutant stressors, then they should be considered priority BMPs for implementing this TMDL.

Implementation of this TMDL will contribute to on-going water quality improvement efforts aimed at restoring water quality in the Accotink Creek watershed, the Potomac River, and the Chesapeake Bay. Fairfax County, the City of Fairfax, and the Town of Vienna all have adopted Chesapeake Bay Program Ordinances, which require stormwater BMPs for all new development or redevelopment. Under their MS4 permits, these jurisdictions are also required to develop Action Plans to address attaining reductions in sediment under the Chesapeake Bay TMDLs. The Fairfax County Board of Supervisors approved a Watershed Plan for Accotink Creek on February 8, 2011. The plan identifies a list of structural projects and non-structural actions that could be implemented in the next 25 years (FCDPWES, 2011). The plan 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 and the overall biological goals of this TMDL and water quality standards.

Public Participation

Public participation was an essential element in the development of the sediment TMDLs for upper Accotink Creek, Lower Accotink Creek, and Long Branch. Three public meetings and six Technical Advisory Committee (TAC) meetings were held over the course of the project. The following agencies, businesses, and organizations attended TAC meetings and participated in the development of the TMDLs for the Accotink Creek watershed:

Representation in Attendance at TAC Meetings

Braddock District Board of Supervisors[1]	Joint Basin Corporation - Fairfax Terminal Complex
Buckeye Partners[1]	Metropolitan Council of Governments
Catholic Diocese of Arlington	Northern Virginia Community College
Chesapeake Bay Foundation	Northern Virginia Building Industry Association (NVBIA) - Fairfax Chapter
City of Fairfax	Northern Virginia Regional Commission (NVRC)
Fairfax County Department of Public Works and Environmental Services	Stantec[1]
Fairfax County Department of Transportation	Town of Vienna - Public Works
Fairfax County Department of Vehicle Services	United Parcel Service - Newington
Fairfax County Park Authority	United States Geological Survey (USGS)
Fort Belvoir Department of Public Works	VA Department of Environmental Quality
Friends of Accotink Creek	Virginia Concrete Company Inc.
Friends of Lake Accotink Park	Virginia Department of Forestry
GKY & Associates, Inc.[1]	Virginia Department of Transportation (VDOT)
Regency Centers	Watershed residents[1]
Interstate Commission on the Potomac River Basin	Wetland Studies and Solutions, Inc.[1]

[1]Not official TAC members, but attended at least one meeting

1 Introduction

The Clean Water Act (CWA) requires that all waters of the United States support swimming, sustain and protect aquatic life, and maintain other beneficial uses such as water supply or shellfish propagation and harvest. Virginia has adopted water quality standards to meet the goals of the CWA. These standards specify (1) designated uses for waterbodies, such as a primary contact recreation use, to support swimming, or an aquatic life use, to sustain and protect aquatic life; (2) the water quality criteria necessary to support these uses; and (3) antidegradation policy to preserve existing uses, maintain waters whose quality exceeds standards, and protect waters of exceptional quality. The CWA also requires states to assess their waters to determine if they are meeting water quality standards. Waterbodies not meeting standards, i.e. impaired waterbodies, are documented in a state's biennial Integrated Assessment on the state's Integrated List (305(b)/303(d)).

Accotink Creek drains 52 square miles of Northern Virginia before entering first Accotink Bay, then Gunston Cove, on the tidal Potomac River. Long Branch (Central) is a tributary to Accotink Creek, joining it just upstream of Lake Accotink, an impoundment on Accotink Creek. While there are three tributaries named Long Branch in the Accotink Creek watershed, the tributary focused on in this study is Long Branch (Central), hereafter simply referred to as Long Branch. Based on benthic macroinvertebrate monitoring and assessments in the Accotink Creek watershed, the Virginia Department of Environmental Quality (DEQ) has placed Accotink Creek, both above and below Lake Accotink, and Long Branch on Virginia's 303(d) List of Impaired Waters (Category 5 of the Integrated List) because they are not supporting their Aquatic Life Use. **Figure 1-1** shows the location of the monitoring stations used in the assessment and the impaired stream segments. Hereafter, impaired segment A15R-01-BEN, as shown in **Figure 1-1**, will be referred to as lower Accotink Creek, segment A15R-04-BEN as upper Accotink Creek, and A15R-05-BEN as Long Branch.

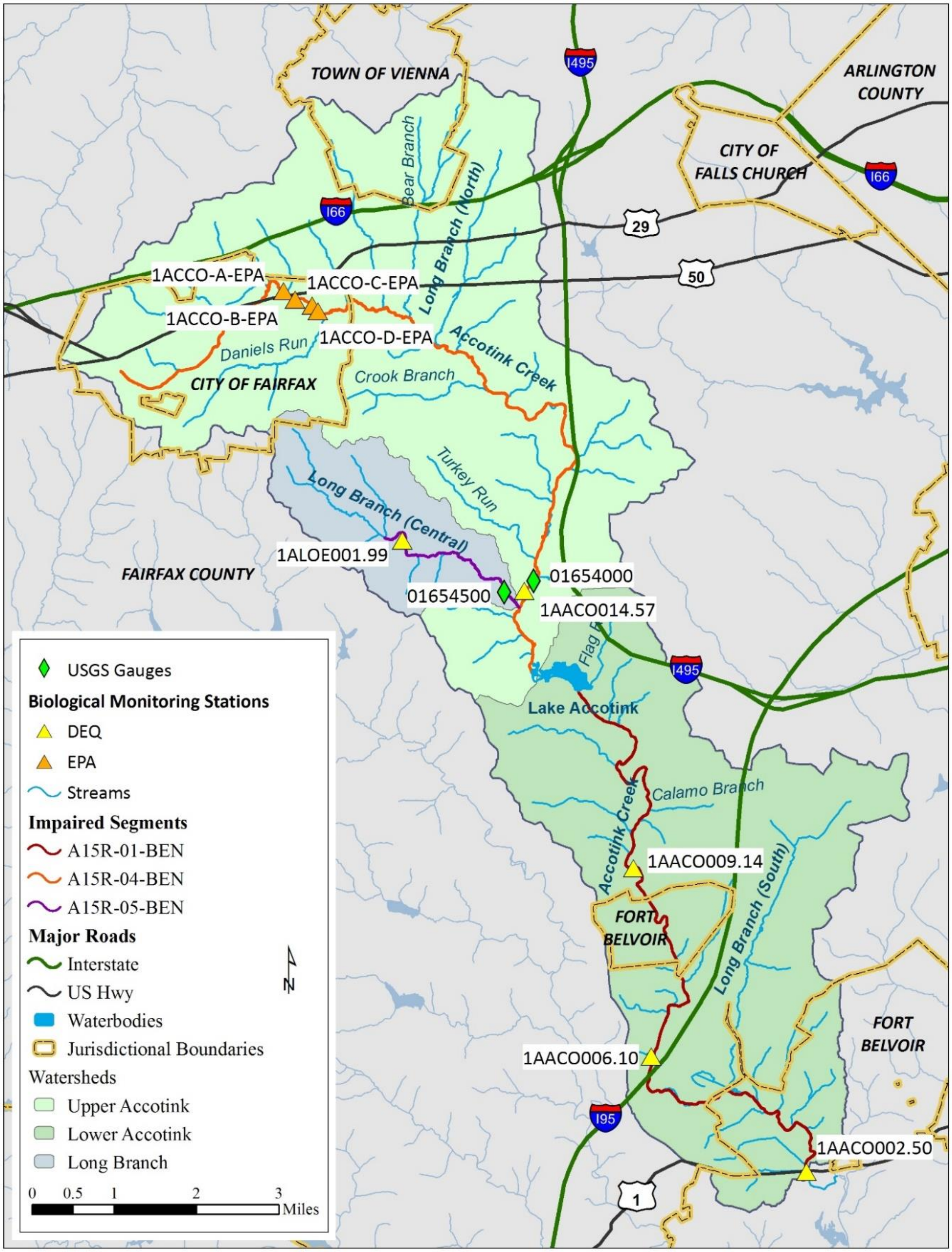


Figure 1-1: Location of the Impaired Segments in Accotink Creek Watershed

Because the benthic macroinvertebrate monitoring demonstrates that upper Accotink Creek, lower Accotink Creek, and Long Branch are not supporting their Aquatic Life Use, a Stressor Identification analysis (SI) was performed to determine the stressor(s) to the biological community in the Accotink Creek watershed (DEQ, 2017). SI is an analysis of evidence provided by monitoring data and scientific literature which attempts to identify the most likely stressors to the biological community, i.e. the causes of the biological impairment. While presented in detail as **Volume I** of this report, **Section 1.3** summarizes the results of the SI. Additionally, **Section 1.1** discusses the regulatory background to listing upper Accotink Creek, lower Accotink Creek, and Long Branch as biologically impaired, whereas **Section 1.2** reviews the biological impairment listing.

1.1 Applicable Water Quality Standards

Virginia's water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. The standards applicable to the impairments in upper Accotink Creek, lower Accotink Creek, and Long Branch are discussed below.

1.1.1 Designated Uses

Designated uses are statutory management objectives for a waterbody. The CWA specifies that all waters must be "fishable and swimmable," that is, support their use for contact recreation and for sustaining a healthy aquatic community. According to Virginia water quality standards (9 VAC 25-260-5):

"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)."

1.1.2 Water Quality Criteria

Water quality criteria can be numerical or narrative. The General Standard defined in Virginia water quality standards (9 VAC 25-260-20) provides general, narrative criteria for the protection of designated uses from substances that may interfere with attainment of such uses. The General Standards states:

"All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life."

1.1.3 Aquatic Life Use

DEQ uses biological monitoring of benthic macroinvertebrate communities as one way to evaluate the ecological health of wadeable freshwater streams and to help determine whether the Aquatic Life Use is supported. For non-coastal streams, assessment of the benthic macroinvertebrate community is based on the Virginia Stream Condition Index (VSCI). The VSCI is a multi-metric index of the biological integrity of the benthic community (Burton and Gerritsen, 2003). The benthic community at a monitoring location is measured against the benthic communities found in reference streams (streams with minimum anthropogenic impacts) using a suite of eight metrics. The VSCI combines these metrics into a single score. The VSCI and its component metrics are discussed in more detail in **Section 3.1** of **Volume I**.

Potential VSCI scores range from 0 to 100, with higher scores indicating relatively better ecological health. DEQ has set a score of 60 as the threshold for impairment. Scores below 60 indicate an impaired biological community.

1.2 Impairment Listings

Table 1-1 summarizes the impairment listings for upper Accotink Creek, lower Accotink Creek, and Long Branch in Virginia's 2016 Integrated Report (DEQ, 2016). The lower mainstem of Accotink Creek was first listed in 1996. The initial listing of the impairment started at the confluence of Calamo Branch and included the tidal waters of Accotink Bay. The downstream boundary of this impairment was adjusted in subsequent Water Quality Assessment Reports to cover only the free-flowing portion of the mainstem. The upstream boundary was extended to the outlet of Lake Accotink in 2010. In 2008, a 0.85 mile section of upper Accotink Creek, from an unnamed tributary in Ranger Park to the confluence with Daniels Run, was listed based on benthic macroinvertebrate assessments performed by the U.S. Environmental Protection Agency (EPA) at stations 1ACCO-A-EPA, 1ACCO-B-EPA, 1ACCO-C-EPA, and 1ACCO-D-EPA. The impairment was extended in the 2010 Integrated Report to include all of Accotink Creek from the headwaters to Lake Accotink, based on DEQ's benthic assessments at station 1ACCO014.57. Long Branch was listed in 2008, based on benthic assessments at station 1ALOE001.99.

Table 1-1: Accotink Creek Benthic Impairments

TMDL Watershed	Stream Name	Cause Group Code303(d) Impairment ID	Description	Size	Assessment Unit 305(b) Segment ID	Initial Listing
Lower Accotink Creek	Accotink Creek	A15R-01-BEN	Begins at the outlet of Lake Accotink and continues downstream until the tidal waters of Accotink Bay.	10.09 mi	VAN-A15R_ACO01B10 VAN-A15R_ACO01A00	2010 1996
Upper Accotink Creek	Accotink Creek	A15R-04-BEN	Begins at the headwaters of Accotink Creek and continues downstream until the start of Lake Accotink	11.59 mi	VAN-A15R_ACO05A04 VAN-A15R_ACO04A02 VAN-A15R_ACO03A02 VAN-A15R_ACO02A00	2008 2010 2010 2010
Long Branch	Long Branch	A15R-05-BEN	Begins at the confluence with an unnamed tributary (UT) to Long Branch, at the Route 651 (Guinea Road) bridge, and continues downstream until the confluence with Accotink Creek, just below Braddock Road.	2.37 mi	VAN-A15R_LOE01A02	2008

Table 1-2 summarizes the VSCI scores from DEQ and EPA benthic assessments in the Accotink Creek watershed. **Figure 1-2** shows the VSCI scores by impairment. Scores from monitoring conducted on the same date in the same impaired waterbody have been averaged. All VSCI scores from sampling in upper Accotink Creek, lower Accotink Creek, and Long Branch are below 60, the VSCI impairment threshold score.

Table 1-2: Accotink Creek Watershed VSCI Scores

Impaired Segment	Date	Station	VSCI
Upper Accotink Creek	11/03/2005	1ACCO-A-EPA	21.2
	11/03/2005	1ACCO-B-EPA	29.1
	11/03/2005	1ACCO-C-EPA	24.3
	11/03/2005	1ACCO-D-EPA	24.0
	11/03/2005	1ACCO-D-EPA	27.8
	12/07/2005	1ACCO-A-EPA	21.5
	12/07/2005	1ACCO-B-EPA	25.1
	12/07/2005	1ACCO-C-EPA	30.7
	12/07/2005	1ACCO-D-EPA	23.1
	12/07/2005	1ACCO-D-EPA	28.0
	03/13/2006	1ACCO-A-EPA	25.2
	03/13/2006	1ACCO-B-EPA	23.9
	03/13/2006	1ACCO-C-EPA	26.3
	03/13/2006	1ACCO-D-EPA	28.7

Impaired Segment	Date	Station	VSCI
	03/13/2006	1ACCO-D-EPA	25.6
	05/23/2007	1AACO014.57	31.6
	11/07/2007	1AACO014.57	30.9
Lower Accotink Creek	11/04/1994	1AACO006.10	38.3
	05/18/1995	1AACO006.10	38.9
	11/29/1995	1AACO006.10	30.6
	05/30/1996	1AACO006.10	38.2
	11/18/1996	1AACO006.10	28.3
	06/01/2006	1AACO002.50	35.3
	06/01/2006	1AACO006.10	24.3
	11/21/2006	1AACO002.50	26.6
	11/21/2006	1AACO006.10	41.9
	04/30/2007	1AACO002.50	33.5
	04/30/2007	1AACO006.10	36.6
	11/01/2007	1AACO002.50	28.3
	11/01/2007	1AACO006.10	29.7
	05/30/2008	1AACO006.10	25.7
	05/30/2008	1AACO009.14	22.8
	10/31/2008	1AACO006.10	35.9
	10/31/2008	1AACO009.14	30.7
Long Branch	06/01/2006	1ALOE001.99	29.5
	09/19/2006	1ALOE001.99	24.5

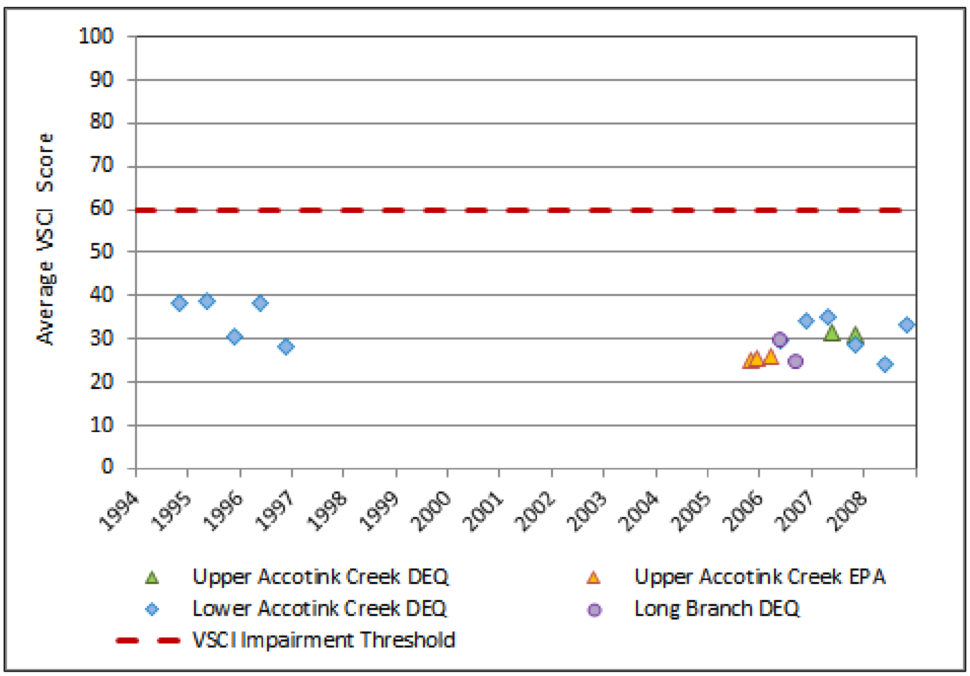


Figure 1-2: Average VSCI Scores for Upper Accotink Creek, Lower Accotink Creek, and Long Branch

The 2014 Integrated Report identifies other impairments in the Accotink Creek watershed. Lake Accotink is not meeting its Fish Consumption Use because of mercury and polychlorinated biphenyls (PCBs) in fish tissue. Both of these impairments were first listed in 2010. Accotink Creek from the outlet of Lake Accotink downstream to tidal waters is also not meeting its Fish Consumption Use because of PCBs in fish tissue. This impairment was also first listed in 2010. The Fish Consumption Use impairments in Lake Accotink and lower Accotink Creek remain on the 303(d) list and will be addressed at a future date.

Other impairments, identified in previous Assessment Reports, have already been addressed. Total Maximum Daily Loads (TMDLs) have been developed for fecal coliform in upper Accotink Creek and *E. coli* in lower Accotink Creek to address Recreational Use impairments. The impaired segment in upper Accotink Creek was first listed in 1998. It extended from the confluence with Crook Branch to Lake Accotink. The TMDL for fecal coliform was approved by the EPA in 2002. The impairment in lower Accotink Creek extended from Calamo Branch to tidal waters. It was first listed in 2004. The EPA approved the TMDL for *E. coli* in 2008. Tidal Accotink Creek, which was not meeting its Fish Consumption Use because of PCBs in fish tissue, was included in an interstate TMDL developed to address PCB impairments in the tidal Potomac River and its embayments. That TMDL was approved by the EPA in 2007.

1.3 Results of the Stressor Identification Analysis for the Accotink Creek Watershed

Section 303(d) of the CWA and the EPA's Water Quality Planning and Management Regulations (40 CFR part 130) generally require states to develop TMDLs for waterbodies that are not meeting water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without exceeding water quality standards. Impaired waterbodies requiring TMDLs are listed in Category 5 of the Integrated Report. Currently, upper Accotink Creek, lower Accotink Creek, and Long Branch are listed for aquatic life use impairments in Category 5 on Virginia's Integrated Report.

Biological monitoring in the Accotink Creek watershed has determined that these waterbodies are not supporting their Aquatic Life Use, but the biological monitoring does not determine the cause of the biological impairments in these waterbodies. Until the underlying cause(s) of the biological impairments have been determined, there is no way of knowing what actions will most effectively address the impairment. A Stressor Identification analysis (SI) was performed to determine the stressor(s) to the biological community in the Accotink Creek watershed (DEQ, 2017). The SI report is **Volume I** of this report.

The SI for upper Accotink Creek, lower Accotink Creek, and Long Branch examined ten potential stressors to determine the strength of the evidence linking them to the biological impairments in these streams. Based on an evaluation of the monitoring data and the scientific literature, the potential stressors were divided into three categories:

1) **Least Probable Stressors**: Stressors with data indicating normal conditions, without water quality exceedances, or without any observable impacts usually associated with stressors.
2) **Possible Stressors**: Stressors with evidence indicating possible link to the biological impairment, but the evidence is inconclusive.
3) **Most Probable Stressors**: Stressor(s) with the most consistent evidence linking them to the biological impairment.

Table 1-3 gives the results of the stressor identification analysis for upper Accotink Creek, lower Accotink Creek, and Long Branch.

Table 1-3: Categorization of Potential Stressors in Accotink Creek Watershed

Category	Stressor	
Least Probable Stressors	Temperature Dissolved Oxygen	pH Metals
Possible Stressors	Nutrients	Toxics
Most Probable Stressors	Chloride Sediment	Hydromodification Habitat Modification

Chlorides, hydromodification, habitat modification, and sediment have been identified as the most probable stressors of the biological communities in the Accotink Creek watershed. Once the stressor(s) have been identified, TMDLs can be developed for any pollutant identified as a stressor of the biological community; however, not all stressors are pollutants amenable to TMDL development. The CWA distinguishes the general class of pollution, defined as “the man-made or man-induced alteration of physical, biological, chemical, and radiological integrity of water and other media (CWA, Section 502, General Definitions),” from pollutants, which are restricted to “[d]redged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dust and industrial, municipal, and agricultural waste discharge into water (CWA, Section 502, General Definitions).” TMDLs can only be developed for pollutants. If a stressor is not a pollutant, EPA guidance (EPA, 2015) provides an alternative category in the Integrated List, 4C, for waterbodies impaired by pollution not caused by a pollutant.

Of the four most probable stressors, only chloride and sediment are pollutants. As specified in the CWA, TMDLs should be developed for sediment and chloride for each of the three impaired segments in the Accotink Creek watershed. The chloride TMDLs are described in **Volume III** of this report. This volume, **Volume II**, describes the development of sediment TMDLs for upper Accotink Creek, lower Accotink Creek, and Long Branch, to help address the biological impairments in those watersheds. The following section reviews the evidence that sediment is most probably a stressor of the biological community in the Accotink Creek watershed.

1.3.1 Evidence for a Sediment Impairment in the Accotink Creek Watershed

Both suspended sediment and deposited sediment can adversely impact stream biota. Suspended sediment contributes to increased turbidity, which limits the light available for photosynthesis and reduces visibility for predators. Elevated sediment concentrations can interfere with filter-feeding organisms by reducing the quality of available food or directly clogging filtering organs. Increased suspended sediment concentrations during high flows enhance the scour of periphyton and macroinvertebrates. Suspended sediment also enhances drift, making colonization by macroinvertebrates less likely (Bilotta and Brazier, 2008). The abrasive action of suspended sediment can also damage stalks and other plant structures, the bodily parts of invertebrates, and the gills of fish. Deposited sediment can directly bury periphyton, macroinvertebrates, and fish eggs or larvae. In addition, deposited sediment can cover larger substrate that is favored as habitat by many sensitive macroinvertebrates, fill in spaces between substrate that provide refuge for macroinvertebrates and small fishes, or reduce the supply of gravel or clean substrate necessary for spawning by trout or other species.

There is ample evidence that in the mainstem of Accotink Creek and its tributaries, sediment is being transported and deposited in sufficient quantities to adversely impact the aquatic community. The primary sources of evidence are (1) DEQ habitat assessments and (2) the stream physical assessment (SPA) performed by CH2MHill (2005) on behalf of Fairfax County Department of Public Works and Environmental Services (FCDPWES).

DEQ routinely performs a habitat assessment of the biological monitoring site as part of its biological assessment. The SI in Volume 1 analyzed a total of sixteen habitat assessments which DEQ performed from 2006 through 2008 at the biological monitoring stations shown in **Figure 1-1**:

six at 1AACO006.10, four at 1AACO02.50, and two each at the remaining stations (1AACO009.14, 1AACO014.57, & 1ALOE001.99). Habitat is evaluated using ten metrics[3], each scored on a scale from 0 to 20. Scores from 0 to 5 are considered Poor, between 6 and 10 are Marginal, 11 to 15 are Suboptimal, and 16 through 20 are Optimal. **Table 1-4** defines the habitat metrics and describes the metrics under Optimal and Poor conditions. The bank stability, embeddedness, and sediment deposition metrics give evidence of sediment impairment. Bank stability was assessed as Marginal or Poor in all but one of the sixteen habitat assessments that DEQ performed since 2000 in the Accotink Creek watershed. The degree of sediment deposition is indicated by the embeddedness and sediment deposition habitat metrics. In habitat assessments DEQ has conducted since 2006, seven of 16 have Marginal or Poor embeddedness scores, and 12 of 16 have Marginal or Poor scores for sediment deposition.

Table 1-4: Habitat Metrics (Burton and Gerritsen, 2003)

Metric	Definition	Optimal Conditions	Poor Conditions
ALTER	Channel Alteration	Not channelized	Extensively channelized
BANKS	Bank stability	Low erosion	High erosion
BANKVEG	Bank vegetative protection	Well-armored banks	No bank protection
EMBED	Embeddedness	Little or no fine sediment	Abundant fine sediment
FLOW	Channel flow	Channel filled	Low wetted width
RIFFLES	Frequency of riffles	Frequent riffle/run sequence	Infrequent riffles
RIPVEG	Riparian vegetation zone width	>18 meter width	<6 meter width
SEDIMENT	Sediment deposition	No sediment deposition	High deposition
SUBSTRATE	Epifaunal substrate	Mixed rubble, extensive	Rubble lacking
VELOCITY	Velocity/depth regimes	Diverse velocity/depth regimes	One regime (slow/deep)

The SPA was a comprehensive assessment of the Fairfax County streams. Field work for the SPA was performed 2002-2005. The SPA had three components: (1) habitat assessment; (2) a stream survey to inventory infrastructure (crossings, pipes and ditches, buffers, etc.) and problems like erosion and head cuts; and (3) a geomorphic assessment which classifies stream reaches according to the Channel Evolution Model (CEM).

CEM is a visual assessment which classifies reaches into one of five stages of channel transformation, shown in **Table 1-5**. Each stage is characterized by a type of channel. Type I represents a stable stream with a single terrace. Type II represents a stream which is actively

[3] Two additional metrics were originally used: COVER, which measures instream cover for fish, and GRAZE, which measures grazing or mowing of riparian vegetation (Burton and Gerritsen, 2003). These metrics were not used in the Accotink Creek watershed after 1996 and have been excluded from the analysis to facilitate comparison.

eroding its bed and incising a new channel. In Type III, the incision of a new channel has stopped but the stream is actively widening its channel. Type IV represents the phase in which the new channel is stabilizing. Type V is a stream with a new stable configuration of channel and floodplain marked by a second terrace where the original floodplain had been. These stages are typical of streams whose watersheds are undergoing urbanization and need to readjust to the changes in flow brought about by development and the increase in impervious surface.

Table 1-5: Stages of Channel Evolution Model (CEM)

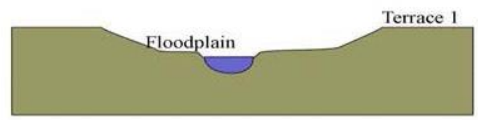
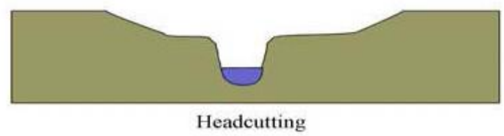
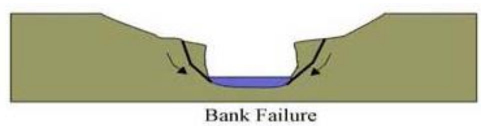
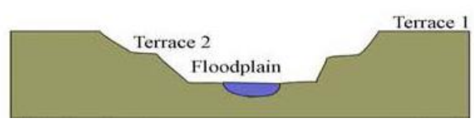
Type	Definition	Illustration
Type I Stable	Well-developed baseflow and bankfull channel; consistent floodplain features easily identified; one terrace apparent above active floodplain; predictable channel morphology; floodplain covered by diverse vegetation; streambanks ≤ 45°.	
Type II Incision	Head cuts; exposed cultural features (along channel bottom); sediment deposits absent or sparse; exposed bedrock (parts of reach); streambank slopes > 45°.	
Type III Widening	Streambank sloughing, sloughed material eroding; streambank slopes > 60° or vertical/undercut; erosion on inside of bends; accelerated bend migration; exposed cultural features (along channel banks); exposed bedrock (majority of reach).	
Type IV Stabilizing	Streambank aggrading; sloughed material not eroded; sloughed material colonized by vegetation; baseflow, bankfull and floodplain channel developing; predictable channel morphology developing; streambank slopes ≤ 45 °.	
Type V Stable	Well-developed baseflow and bankfull channel; consistent floodplain features easily identified; two terraces apparent above active floodplain; predictable channel morphology; streambanks ≤ 45°.	

Table 1-6 summarizes the CEM classification of Accotink Creek. Over 90% of the assessed stream reaches in the Accotink Creek watershed were classified as Type III. These are unstable channels that are actively widening by eroding their banks.

Table 1-6: Summary of Channel Evolution Model Assessment of Accotink Creek Watershed

Watershed	Waterbody	Type II (ft)	Type III (ft)	Type IV (ft)	Total Assessed (ft)
Upper Accotink	Mainstem	456	59,866	1,676	61,997
	Tributaries	12,745	153,291	0	166,036
Lower Accotink	Mainstem	0	46,798	8,190	54,988
	Tributaries	0	34,444	12,680	47,124
Long Branch	Mainstem	0	24,603	0	24,603
	Tributaries	0	15,752	0	15,752
Total		**13,200**	**334,754**	**22,546**	**370,500**

The SPA habitat survey, which assessed almost 80% of the reaches in the Accotink Creek watershed, confirms the results of the DEQ habitat assessments. The average embeddedness scores were Marginal everywhere in the Piedmont portion of the watershed, except in lower mainstem Accotink Creek and the mainstem of Long Branch. Length-averaged sediment deposition scores were also marginal in the mainstem and tributaries of upper Accotink Creek and the tributaries to Long Branch.

The SPA survey also found that in the upper and lower mainstem of Accotink Creek, the percent of stream length in which sand or finer material were the dominant grain size was 36% and 32%, respectively. In the tributaries to the upper mainstem, the percent of stream length in which sand or finer material were the dominant grain size was 32%. In Long Branch and the lower mainstem tributaries, bed material was coarser: in Long Branch and the lower mainstem tributaries, the percent stream reaches with sand or finer material as the dominant grain size was 15% and 16%, respectively, whereas there were no reaches with sand or finer material as the dominant grain size in Long Branch tributaries.

Biological monitoring performed by FCDPWES provides additional evidence that sediment is a stressor of the biological community in the Accotink Creek watershed. County-wide monitoring at 114 fixed sites, including 12 sites in the Accotink Creek watershed, began in 1999; however, in 2004, FCDPWES switched to a probabilistic monitoring site selection strategy. At both fixed and randomly selected sites, FCDPWES biological monitoring found that generally pollution-tolerant Oligochaeta and Chironomidae were the dominant taxa in the Accotink Creek watershed. Many of the members of these two taxa are burrowers whose preferred habitat is sand, silt, mud, or detritus. Their dominance may be due to the availability of their preferred habitat or to the fact that sand, silt, or mud provides better refuge from high flow events that scour more sensitive taxa, which prefer larger substrate as their habitat.

2 Watershed Description

This section describes the Accotink Creek watershed in greater detail. **Section 2.1** discusses topography, hydrogeomorphic regions, soils, land use, population, and housing. **Section 2.2** describes permitted facilities, regulated stormwater, and waste disposal.

2.1 Watershed Description and Identification

Accotink Creek drains approximately 52 mi^2 of Northern Virginia. **Figure 2-1** shows the location of Accotink Creek and its watershed. The mainstem of Accotink Creek begins in the City of Fairfax and flows southeast through Fairfax County and Fort Belvoir[4] before entering first Accotink Bay and then Gunston Cove, an embayment on the tidal Potomac River. Seventy-seven percent of the Accotink Creek watershed is in Fairfax County; the remainder is in the City of Fairfax (11%), Fort Belvoir (8%), and the Town of Vienna (4%). The headwaters of Accotink Creek are along Interstate 66. Most of the watershed is just outside the Capital Beltway. Accotink Creek crosses Interstate 95 near Springfield, VA, before entering the main post of Fort Belvoir.

The Accotink Creek watershed is highly developed. Overall, according to the analysis of zoning and planimetric data described in **Section 2.1.4**, 87% of the Accotink Creek watershed draining to the impaired segments consists of commercial, industrial, transportation, or residential land, and impervious surface covers 28% of the watershed draining to impaired segments.

[4] Fort Belvoir is a U.S. Army installation that is the headquarters of the National Geospatial-Intelligence Agency and many other Defense Department agencies. It is divided into two sections: Fort Belvoir North Area (803 acres) and the main post (9,530 acres). Under the 2005 Base Realignment and Closure (BRAC) Act, many defense department agencies were relocated to Fort Belvoir. It is currently one of the largest employers in Fairfax County and is expected to generate extensive development in the surrounding area (Fairfax County, 2013).

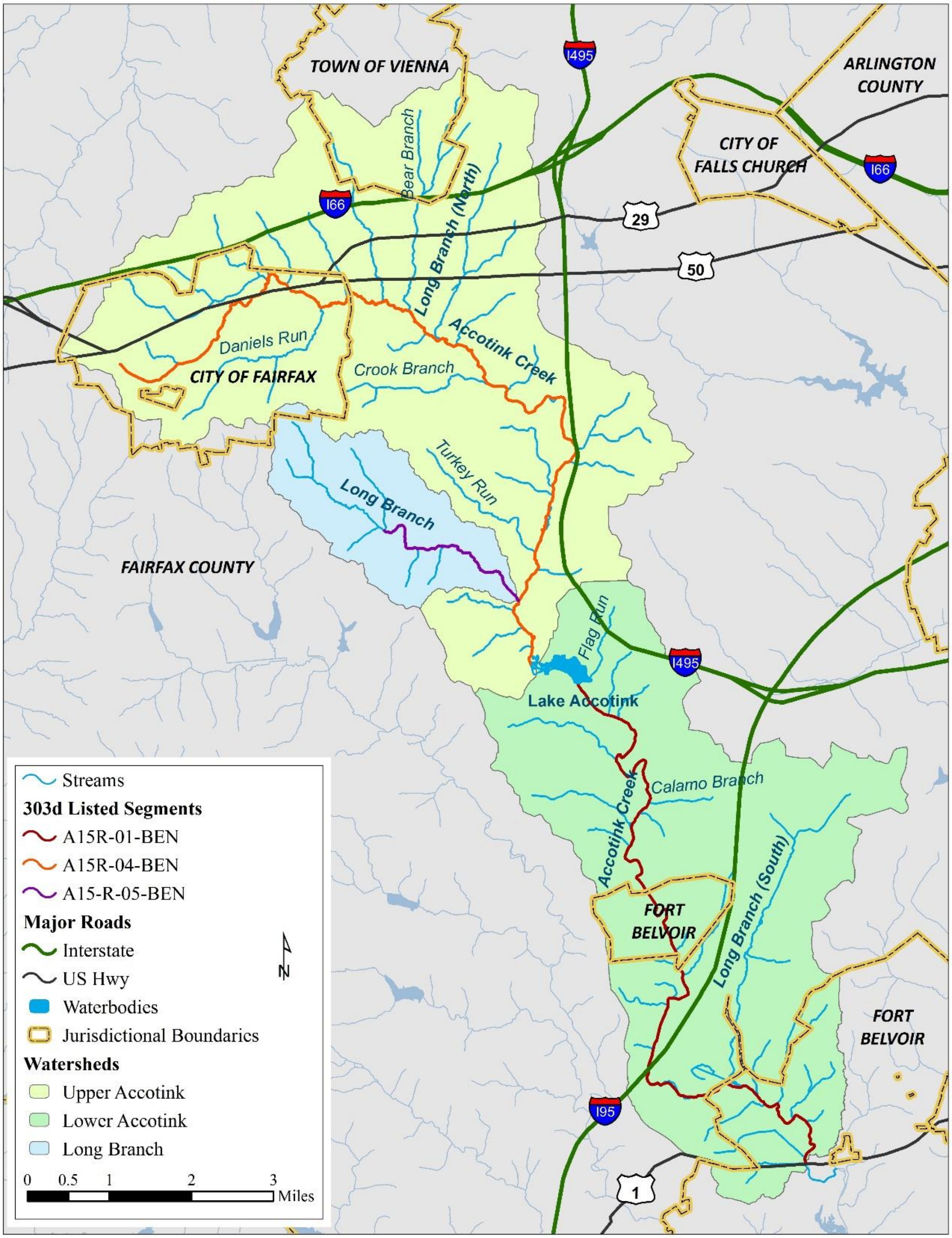


Figure 2-1: Location and Boundaries of the Accotink Creek Watersheds

Lake Accotink is a 55 acre impoundment on Accotink Creek in the middle of the watershed (Fairfax County, 2014). It was originally built in the 1940's as a drinking water reservoir for Fort Belvoir. The army stopped using it as a source of drinking water in the 1960's (Fairfax County Public Schools, 1976), and it is currently operated by the Fairfax County Park Authority for recreational use as part of the 493 acre Lake Accotink Park.

Figure 2-1 shows the impaired sections of Accotink Creek and Long Branch. Lake Accotink separates the two impaired sections of the mainstem Accotink Creek, A15R-01-BEN and A15R-04-BEN, which will be referred to as "lower Accotink Creek" and "upper Accotink Creek," respectively. **Figure 2-1** also shows the drainage areas associated with the two impairments. The drainage area for the upper Accotink Creek impairment terminates at the inlet to Lake Accotink. The drainage area for the lower Accotink Creek impairment includes the upper Accotink Creek drainage, the drainage of the tributaries to Lake Accotink, and direct drainage to the lake. The drainage areas above and below the inlet to Lake Accotink will also be referred to as the upper Accotink Creek watershed and the lower Accotink Creek watershed, respectively.

In addition, **Figure 2-1** shows the impaired section of Long Branch and the Long Branch watershed. There are two other tributaries to Accotink Creek named Long Branch: one has its headwaters north of Interstate 66, and the other runs parallel to Interstate 95 until it joints with Accotink Creek in Fort Belvoir (see **Figure 2-1**). These will be referred to as "Long Branch North" and "Long Branch South," respectively, while "Long Branch" will always refer to the impaired segment and its watershed.

2.1.1 Topography

A National Elevation Dataset (NED) was used to characterize the topography in the watershed (USGS, 1999). NED data obtained from the United States Geological Survey (USGS) show that elevation in the upper Accotink watershed, excluding the Long Branch watershed, ranges from approximately 184 to 492 ft above mean sea level, with an average elevation of 343 ft above mean sea level, while the elevation in the lower Accotink Creek watershed below Lake Accotink ranges from approximately eight to 384 ft above mean sea level, with an average elevation of 194 ft. The elevation in the Long Branch watershed ranges from 186 to 462 ft above mean sea level, with an average elevation of 337 ft.

2.1.2 Hydrogeomorphic Regions

The USGS has divided the Chesapeake Bay watershed into hydrogeomorphic regions, based on physiography or geological structure, and underlying rock type (USGS, 2000). **Figure 2-2** shows the hydrogeomorphic regions in the Accotink Creek watershed. Three hydrogeomorphic regions are found in the watershed, Piedmont Crystalline, Coastal Plain Dissected Uplands, and Coastal Plain Lowlands.

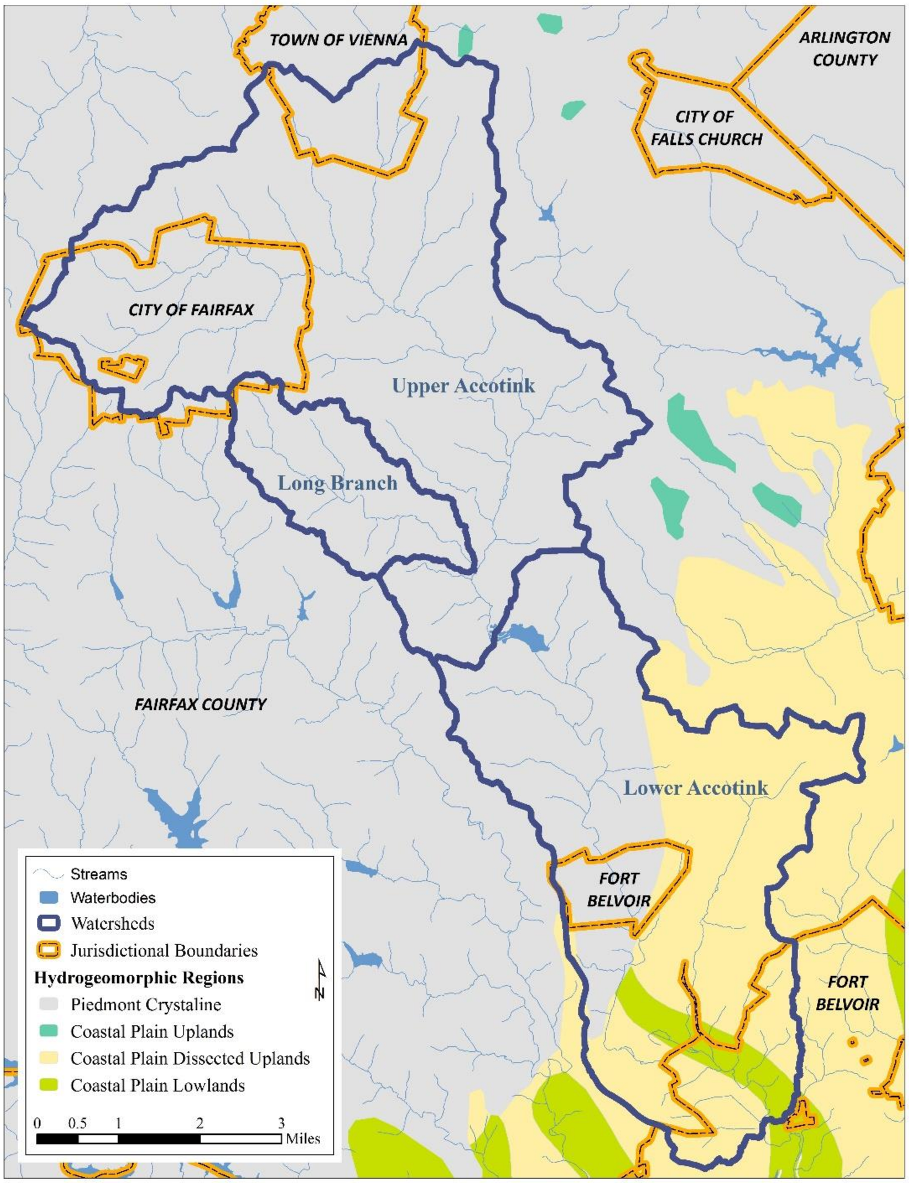


Figure 2-2: Accotink Creek Watersheds with Hydrogeomorphic Regions

The watershed of upper Accotink Creek, including Long Branch, is entirely within the Piedmont Crystalline region, as is 44% of the lower Accotink Creek watershed. Fifty percent of the lower Accotink Creek watershed is in the dissected uplands of the Coastal Plain; the remainder is in the Coastal Plain Lowlands.

2.1.3 Soils

The soil characterization of the Accotink Creek watershed was based on data obtained from the Soil Survey Geographic (SSURGO) database (NRCS, 2015). According to SSURGO, there are 63 soil series represented in the watershed (**Table 2-1**).

Table 2-1: Soils Series in Accotink Creek Watersheds

Soil Name	Upper Accotink[1]		Lower Accotink[2]		Long Branch	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Barkers Crossroads loam	156	1.0%	100	0.8%	2	0.1%
Barkers Crossroads-Nathalie complex	73	0.4%	622	5.1%	40	1.6%
Barkers Crossroads-Rhodhiss complex	47	0.3%	441	3.6%	9	0.3%
Barkers Crossroads-Rhodhiss-Rock outcrop complex	0	0.0%	0	0.0%	1	0.0%
Beltsville silt loam	15	0.1%	390	3.2%	0	0.0%
Codorus and Hatboro soils	763	4.7%	1,181	9.6%	193	7.8%
Codorus silt loam	484	3.0%	54	0.4%	22	0.9%
Downer loamy sand	0	0.0%	10	0.1%	0	0.0%
Elkton silt loam	0	0.0%	29	0.2%	0	0.0%
Elsinboro loam	21	0.1%	1	0.0%	0	0.0%
Fairfax loam	46	0.3%	75	0.6%	15	0.6%
Glenelg silt loam	1,576	9.7%	144	1.2%	288	11.7%
Grist Mill sandy loam	0	0.0%	251	2.0%	0	0.0%
Grist Mill-Matapeake complex	0	0.0%	19	0.2%	0	0.0%
Grist Mill-Mattapex complex	0	0.0%	12	0.1%	0	0.0%
Gunston silt loam	0	0.0%	111	0.9%	0	0.0%
Hatboro silt loam	150	0.9%	94	0.8%	5	0.2%
Hattontown - Elbert complex	0	0.0%	0	0.0%	0	0.0%
Hattontown - Orange complex	23	0.1%	0	0.0%	0	0.0%
Hattontown silt loam	2	0.0%	0	0.0%	0	0.0%
Hattontown-Haymarket complex	4	0.0%	0	0.0%	1	0.0%
Hattontown-Orange complex	9	0.1%	0	0.0%	0	0.0%
Haymarket silt loam	0	0.0%	0	0.0%	3	0.1%
Kingstowne sandy clay loam	1	0.0%	295	2.4%	0	0.0%
Kingstowne-Beltsville complex	70	0.4%	125	1.0%	1	0.0%
Kingstowne-Danripple complex	7	0.0%	77	0.6%	0	0.0%
Kingstowne-Sassafras-Marumsco complex	0	0.0%	291	2.4%	0	0.0%
Kingstowne-Sassafras-Neabsco complex	0	0.0%	1,168	9.5%	0	0.0%
Kingstowne-Sassfras complex	0	0.0%	4	0.0%	0	0.0%
Lunt-Marumsco complex	0	0.0%	117	0.9%	0	0.0%
Matapeake silt loam	0	0.0%	43	0.4%	0	0.0%

Soil Name	Upper Accotink[1]		Lower Accotink[2]		Long Branch	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Mattapex loam	0	0.0%	128	1.0%	0	0.0%
Meadowville loam	155	0.9%	46	0.4%	16	0.7%
Meadowville silt loam	5	0.0%	0	0.0%	0	0.0%
Nathalie gravelly loam	87	0.5%	206	1.7%	3	0.1%
Orange silt loam	9	0.1%	0	0.0%	0	0.0%
Pits	0	0.0%	6	0.0%	0	0.0%
Rhodhiss sandy loam	72	0.4%	436	3.5%	0	0.0%
Rhodhiss-Rock outcrop complex	1	0.0%	27	0.2%	0	0.0%
Sassafras sandy loam	0	0.0%	79	0.6%	0	0.0%
Sassafras-Marumsco complex	0	0.0%	1,021	8.3%	0	0.0%
Sassafras-Neabsco complex	0	0.0%	123	1.0%	0	0.0%
Sumerduck loam	112	0.7%	1	0.0%	18	0.7%
Sumerduck silt loam	17	0.1%	0	0.0%	0	0.0%
Urban land	2,898	17.8%	2,710	22.0%	135	5.5%
Urban land-Barker Crossroads complex	184	1.1%	43	0.3%	0	0.0%
Urban land-Grist Mill	0	0.0%	67	0.5%	0	0.0%
Urban land-Kingstowne complex	42	0.3%	471	3.8%	0	0.0%
Urban land-Wheaton complex	1,230	7.5%	0	0.0%	46	1.9%
Water	20	0.1%	81	0.7%	0	0.0%
Wheaton - Codorus complex	55	0.3%	0	0.0%	0	0.0%
Wheaton - Fairfax complex	23	0.1%	0	0.0%	0	0.0%
Wheaton - Glenelg complex	1,533	9.4%	0	0.0%	8	0.3%
Wheaton - Meadowville complex	112	0.7%	0	0.0%	0	0.0%
Wheaton - Sumerduck complex	73	0.4%	0	0.0%	0	0.0%
Wheaton loam	308	1.9%	4	0.0%	55	2.2%
Wheaton-Codorus complex	160	1.0%	115	0.9%	59	2.4%
Wheaton-Fairfax complex	302	1.8%	165	1.3%	198	8.0%
Wheaton-Glenelg complex	4,879	29.9%	606	4.9%	1,140	46.4%
Wheaton-Hatboro complex	6	0.0%	0	0.0%	2	0.1%
Wheaton-Meadowville complex	442	2.7%	209	1.7%	106	4.3%
Wheaton-Sumerduck complex	142	0.9%	4	0.0%	90	3.7%
Woodstown sandy loam	0	0.0%	116	0.9%	0	0.0%
Total	**16,317**	**100.0%**	**12,321**	**100.0%**	**2,457**	**100.0%**

[1]Excluding Long Branch
[2]Excluding Upper Accotink

Hydrologic soil groups represent different levels of infiltration capacity of the soils. Descriptions of the hydrologic soil groups are presented in **Table 2-2**. Hydrologic soil group "A" designates soils that are well to excessively well drained, whereas hydrologic soil group "D" designates soils that are poorly drained. More rainfall becomes surface water runoff when soils are poorly drained. The acreage of each hydrologic soil group in Accotink Creek is presented in **Table 2-3**. **Figure 2-3** also shows the hydrological soil groups in the Accotink Creek watershed. As **Table 2-3** and **Figure 2-3** show, soils in the watersheds of the impaired waterbodies in Accotink Creek are predominately soils of hydrologic group C, or have been disturbed by development.

Table 2-2: 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.

Table 2-3: Soil Hydrologic Groups in Accotink Creek Watersheds

Hydrologic Group – Dominant Condition	Upper Accotink[1]		Lower Accotink[2]		Long Branch	
	Acres	**Percent of Total**	**Acres**	**Percent of Total**	**Acres**	**Percent of Total**
A	233	1.4%	519	4.2%	17	0.7%
B	1,730	10.6%	1,925	15.6%	306	12.4%
B/D	1,397	8.6%	1,329	10.8%	220	8.9%
C	8,573	52.5%	5,031	40.8%	1,733	70.6%
C/D	0	0.0%	141	1.1%	0	0.0%
D	9	0.1%	0	0.0%	0	0.0%
Pits/Gravel[3]	0	0.0%	6	0.0%	0	0.0%
Urban Land[4]	4,354	26.7%	3,290	26.7%	181	7.4%
Water	20	0.1%	81	0.7%	0	0.0%
Total	**16,317**	**100.0%**	**12,321**	**100.0%**	**2,457**	**100.0%**

[1]Excluding Long Branch

[2]Excluding Upper Accotink

[3]"Pits are open excavations from which soil and commonly underlying material have been removed, exposing either rock or other material" (NRCS 1993).

[4] "Urban land is land mostly covered by streets, parking lots, buildings, and other structures of urban areas" (NRCS 1993). Here, this category also includes several urban land-soil complexes (e.g., Urban land-Barker Crossroads complex and others listed **Table 2-1**), which have no assigned soil hydrologic group.

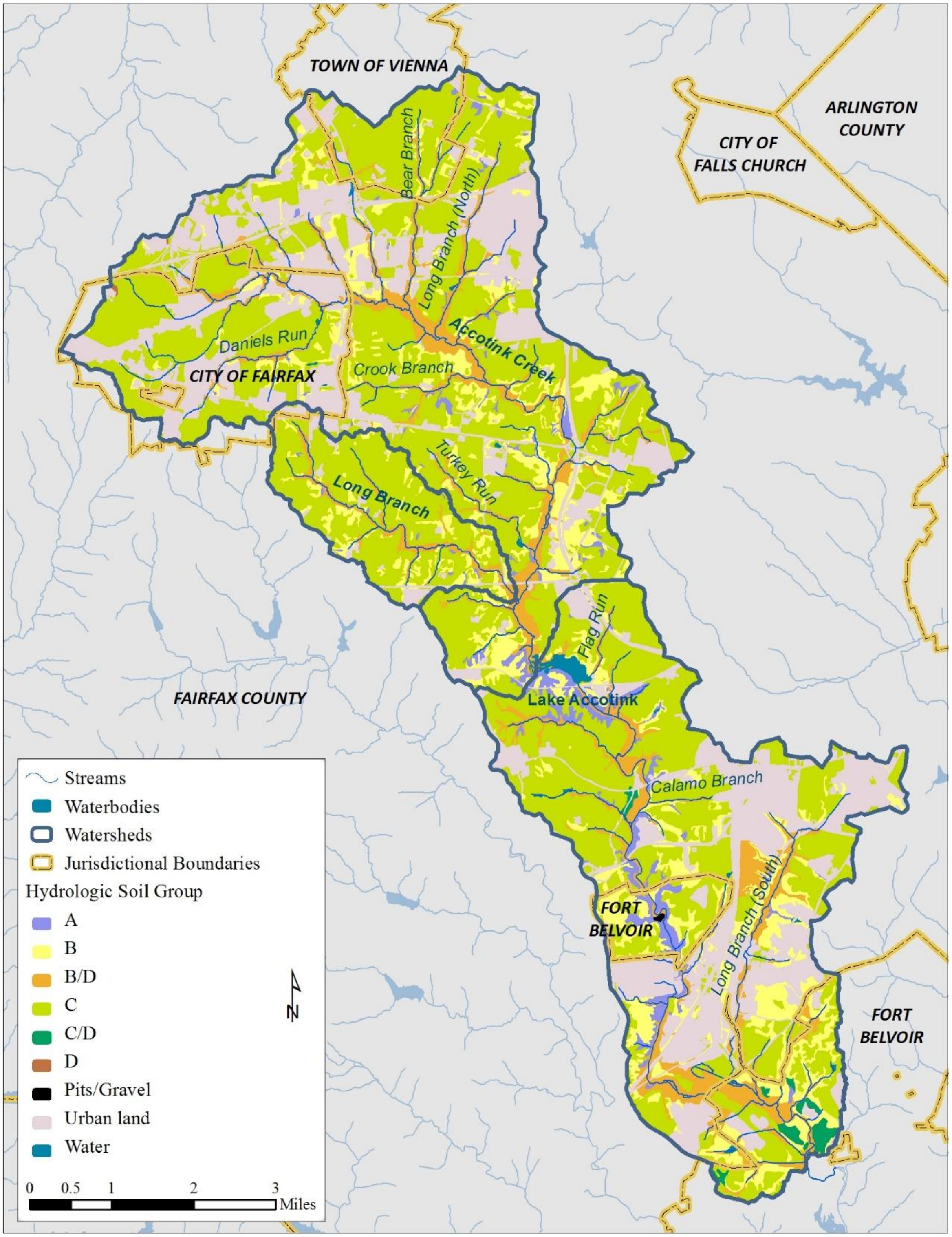


Figure 2-3: Soil Hydrologic Groups in Accotink Creek Watersheds

2.1.4 Land Use

The land use characterization for the Accotink Creek watershed, excluding Fort Belvoir, was based on (1) Fairfax County geospatial zoning data provided by K. Bennett (FCDPWES. Personal communication, 2009) and (2) City of Fairfax geospatially represented existing land use (ELU) and zoning data made available by Maurice Riou (GIS Manager, City of Fairfax, VA. Personal communication, 12/16/2015). The zoning codes and ELU were combined into a set of four major land use categories—commercial, industrial, residential, and open space—and subdivided into seven minor categories as shown in **Tables 2-4 and 2-5** for Fairfax County and the City of Fairfax data respectively.

Table 2-4: Classification of Land Use Categories based on Fairfax County Zoning

Zone Type	Zoning Code	Short Description	Land Use Category	Land Use Type
Commercial	C-1	Office commercial district	Commercial	Commercial
	C-2	Retail commercial district		
	C-3	General commercial district		
	C-4	High intensity office district		
	C-5	Neighborhood retail commercial district		
	C-6	Community retail commercial district		
	C-7	Regional retail commercial district		
	C-8	Highway commercial district		
Industrial	I-2	Industrial research district	Industrial	Industrial
	I-3	Light intensity industrial district		
	I-4	Medium intensity industrial district		
	I-5	General industrial district		
	I-6	Heavy industrial district		
Residential	R-C	Residential-conservation district	Residential	Low Density
	R-1	Residential district for single family dwelling types at a density not to exceed 1 dwelling unit per acre (du/ac)		
	R-2	Residential district for single family dwelling types at a density not to exceed 2du/ac		
	R-3	Residential district for single family dwelling types at a density not to exceed 3 du/ac		Medium Density
	R-4	Residential district for single family dwelling types at a density not to exceed 4 du/ac		
	R-5	Residential district for single family dwelling types at a density not to exceed 5 du/ac		
	R-8	Residential district for a mixture of single family residential dwelling types at a density not to exceed 8 du/ac		High Density
	R-12	Residential district for a mixture of residential dwelling types at a density not to exceed 12 du/ac		
	R-16	Residential district for a mixture of residential dwelling types at a density not to exceed 16 du/ac		
	R-20	Residential district for a mixture of residential		

Zone Type	Zoning Code	Short Description	Land Use Category	Land Use Type
		dwelling types at a density not to exceed 20 du/ac		
	R-30	Residential district for multiple family dwellings at a density not to exceed 30 du/ac		
	RTH	Townhouse district		
	RM-2	Multifamily district		
Planned Units	CPD	Commercial planned development district	Commercial	Commercial
	PDC	Planned development commercial district		
	PDH-2	Planned development housing district residential district for single family dwelling types at a density not to exceed 2du/ac	Residential	Low Density
	PDH-3	Planned development housing district residential district for single family dwelling types at a density not to exceed 3 du/ac		Medium Density
	PDH-4	Planned development housing district residential district for single family dwelling types at a density not to exceed 4 du/ac		
	PDH-5	Planned development housing district residential district for single family dwelling types at a density not to exceed 5 du/ac		
	PDH-8	Residential district for a planned mixture of single family residential dwelling types at a density not to exceed 8 du/ac		High Density
	PDH-12	Residential district for a planned mixture of residential dwelling types at a density not to exceed 12 du/ac		
	PDH-16	Residential district for a planned mixture of residential dwelling types at a density not to exceed 16 du/ac		
	PDH-20	Residential district for a planned mixture of residential dwelling types at a density not to exceed 20 du/ac		
	PDH-30	Residential district for a planned mixture of residential dwelling types at a density not to exceed 30 du/ac		
	PDH-40	Residential district for a planned mixture of residential dwelling types at a density not to exceed 40 du/ac		
	PRC	Planned residential community district		
	PRM	Planned residential mixed use district		Mixed Use
Other	PR	Other	Open Space	Open Space

Table 2-5: Classification of Land Use Categories based on the City of Fairfax Existing Land Use

Existing Land Use (ELU)	Land Use Category	Land Use Type
Auto Dealer	Commercial	Commercial
Auto Repair		
Commercial - Lodging		
Commercial - Office		
Commercial - Retail		
Institutional - City of Fairfax		
Institutional - General		
Industrial	Industrial	Industrial
Open Space - Preserved	Open Space	Open Space
Open Space - Recreation & Historic		
Open Space - Undesignated		
Vacant		
Residential - Multifamily	Residential	High Density
Residential - Single Attached		Medium Density[1]
Residential - Single Detached		
Residential - Single Attached		Low Density[1]
Residential - Single Detached		

[1]The distinction between medium density and low density residential was based on zoning codes.

Additional geospatial data, including parkland (PARKS_FCPA, PARKS_NON_FCPA layers) and open water (extracted from the HYDRO_AREAS_4000 layer), were downloaded from the Fairfax County Geoportal (http://www.fairfaxcounty.gov/maps/data.htm). Major paved transportation areas were also provided by K. Bennett (FCDPWES. Personal communication, 2009). Using standard GIS tools and procedures, parkland, which was used as a surrogate for open space, open water, and paved major transportation areas were combined with the zoning layer to yield the overall land use for the Accotink watershed, excluding Fort Belvoir, as shown in **Figure 2-4** and summarized in **Tables 2-6 through 2-8** for the upper Accotink, lower Accotink, and Long Branch watersheds respectively.

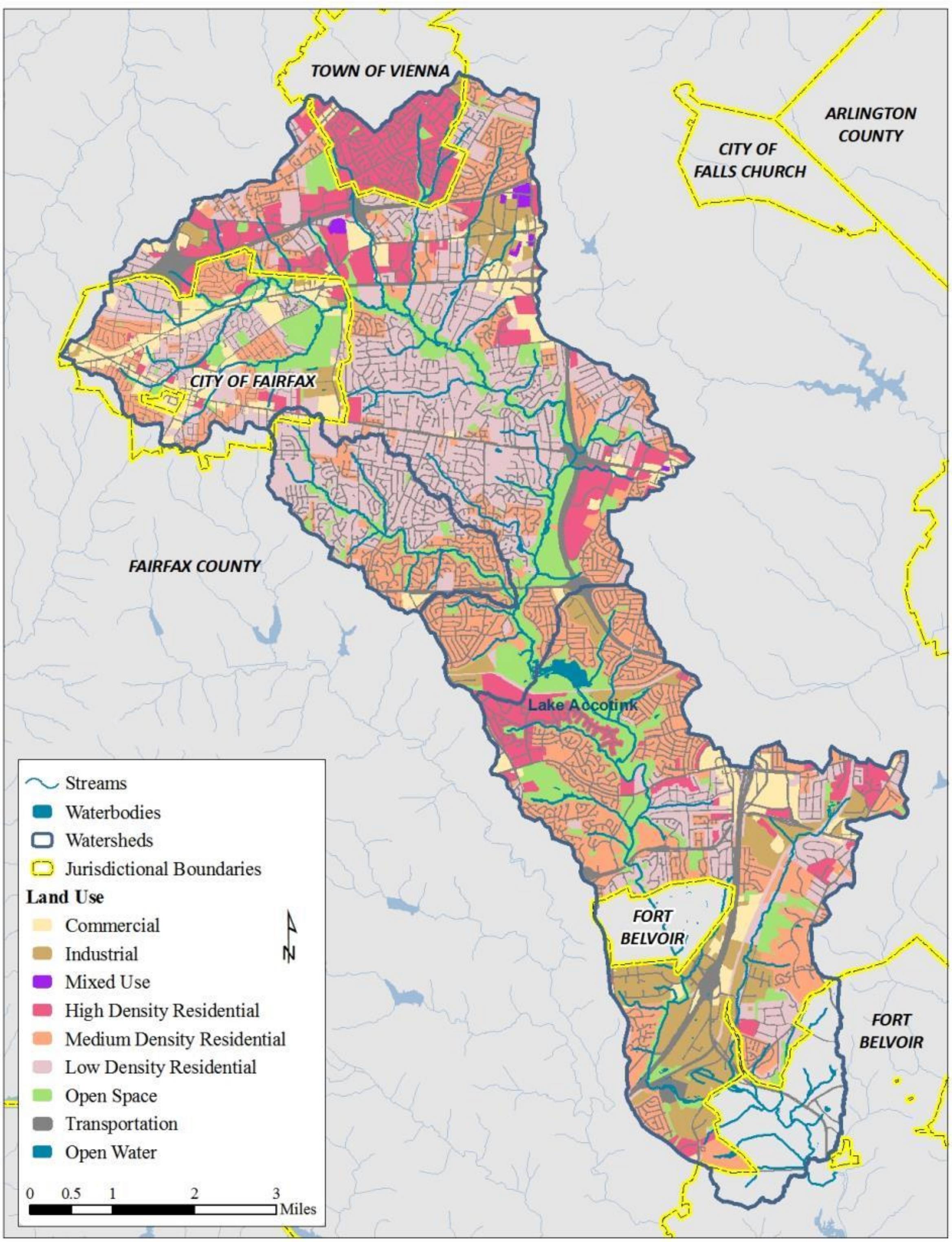


Figure 2-4: Land Use in Accotink Creek Watershed

Table 2-6. Land Use in Upper Accotink Creek Watershed[1]

Land Use Category	Zoning Category	City of Fairfax		Fairfax County		Town of Vienna		Total	
		Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Commercial	Commercial	739	21%	593	5%	28	2%	1,360	8%
Industrial	Industrial	127	4%	363	3%	19	2%	509	3%
Residential	Mixed Use	0	0%	76	1%	0	0%	76	0%
	Low Density	876	25%	4,282	37%	1	0%	5,159	32%
	Medium Density	627	18%	2,232	19%	2	0%	2,861	18%
	High Density	98	3%	1,305	11%	895	78%	2,298	14%
Transportation	Transportation	503	14%	1,463	13%	135	12%	2,101	13%
Open Space	Open Space	518	15%	1,294	11%	61	5%	1,873	11%
Water	Water	17	0%	70	1%	0	0%	88	1%
Total		**3,505**	**100%**	**11,679**	**100%**	**1,142**	**100%**	**16,326**	**100%**

[1]Excluding Long Branch

Table 2-7. Land Use in Lower Accotink Creek Watershed[1]

Land Use Category	Zoning Category	Fairfax County		Fort Belvoir		Total	
		Acres	Percent	Acres	Percent	Acres	Percent
Commercial	Commercial	530	5%	956	41%	1,487	12%
Industrial	Industrial	1,538	15%	0	0%	1,538	12%
Residential	Low Density	1,511	15%	0	0%	1,511	12%
	Medium Density	2,986	30%	0	0%	2,986	24%
	High Density	794	8%	0	0%	794	6%
Transportation	Transportation	1,297	13%	90	4%	1,387	11%
Open Space	Open Space	1,180	12%	1,273	54%	2,453	20%
Water	Water	145	1%	27	1%	173	1%
Total		**9,981**	**100%**	**2,348**	**100%**	**12,328**	**100%**

[1]Excluding Upper Accotink

Table 2-8. Land Use in Long Branch Watershed

Land Use Category	Zoning Category	City of Fairfax		Fairfax County		Total	
		Acres	Percent	Acres	Percent	Acres	Percent
Commercial	Commercial	11	22%	27	1%	37	2%
Residential	Low Density	21	46%	1,222	51%	1,243	51%
	Medium Density	0	0%	629	26%	629	26%
	High Density	4	8%	0	0%	4	0%
Transportation	Transportation	11	24%	266	11%	277	11%
Open Space	Open Space	0	0%	257	11%	257	10%
Water	Water	0	0%	10	0%	10	0%
Total		**47**	**100%**	**2,411**	**100%**	**2,458**	**100%**

The watersheds are highly developed with developed land accounting for 88% of the upper Accotink watershed, 87% of lower Accotink watershed, and 89% of the Long Branch watershed. Residential land use comprises the largest category of land use in the upper Accotink (64%), lower Accotink (58%), and Long Branch (76%) watersheds. Transportation is the next largest category of land use in upper Accotink and Long Branch watersheds, accounting for about 13% and 11% of the watersheds, respectively, whereas industrial land use (12%) is the second largest category in the lower Accotink watershed, followed by open space (12%) and transportation (11%).

An estimation of the impervious area within each watershed was based on planimetric data provided by Fairfax County, VA (K. Bennett, FCDPWES. Personal communication, 2009). Polygon and line geospatial data representing building footprints, building additions, and paved areas (e.g. roads, parking lots, driveways, and sidewalks) were combined using standard GIS tools and procedures to obtain a representation of the impervious area in each subwatershed as shown in **Table 2-9.**

Table 2-9: Percent Imperviousness by Watershed and Jurisdiction

Jurisdiction	Watershed			Total
	Upper Accotink[1]	Lower Accotink[2]	Long Branch	
City of Fairfax	35.7%		47.9%	35.8%
Fairfax County	27.5%	31.2%	21.6%	28.5%
Fort Belvoir		10.8%		10.8%
Town of Vienna	30.8%			30.8%
Total	**29.5%**	**27.4%**	**22.1%**	**28.1%**

[1]Excluding Long Branch
[2]Excluding Upper Accotink

Land use for Fort Belvoir was not available in a GIS representation, so the land use was determined based on Fairfax County planimetric data, the Fort Belvoir Integrated Natural Resource Management Plan (INRMP) (Horne Engineering Services, Inc., 2001), and Fort Belvoir Real Master Property Plan Installation Vision and Development Plan (VDP) (Atkins, 2014). The INRMP reported acres of impervious surface, open space, forest, and wetlands for the Fort Belvoir Northern Area (FBNA) and for the Accotink Creek drainage on the main base. The Accotink Creek drainage on the main base includes tidal waters outside of the impairment, so the acreage could not be used directly. The acreages represent conditions prior the Base Realignment and Closure Act (BRAC) of 2005, which transferred many military functions to Fort Belvoir and led to additional development on the base. The VDP includes estimates of impervious areas in 2017 for the FBNA and the drainage on the main base.

Based on information in the VDP, the Fairfax County planimetric data has a representation of the impervious surfaces in Fort Belvoir prior to the BRAC. Impervious surfaces in the FBNA, based on the planimetric data, were adjusted to match the INRMP. It was assumed that the open space reported in the INRMP was developed pervious land, and that the ratio of impervious surface to open space was characteristic of Fort Belvoir development. Using this ratio, the amount of pervious developed land prior to the BRAC could be estimated for FBNA and the portion of the main base within the impaired watershed. The remainder of the land was assumed to be forest. To get the final Fort Belvoir land use representing current conditions, the percent change in impervious area from the INRMP to the VDP was calculated, and that ratio applied to the pre-BRAC estimates of developed pervious and impervious developed land to get current estimates of their acreage. The change in acreage was subtracted from the pre-BRAC estimate of forested land.

All developed land in Fort Belvoir except transportation was classified as commercial. The forested land was classified as open space. The resulting land use is shown in **Table 2-7**.

2.1.5 Population and Households

Spatial data at the Virginia state level that incorporates the 2010 Census block geography and the 2010 Census population and housing unit counts were downloaded from the Fairfax County Geoportal (http://www.fairfaxcounty.gov/maps/data.htm). The aerial extent of census blocks located within or intersecting a watershed were determined using routine GIS analysis. The fraction of each census block within a watershed was calculated and then used to obtain an area-weighted number of households for each watershed. Summaries of the population and household estimates for the Accotink Creek watershed are presented in **Table 2-10**.

Table 2-10: 2010 Census Data Summary for the Accotink Creek Watersheds

Watershed	Estimated Households	Estimated Population
Upper Accotink[1]	44,439	116,554
Lower Accotink[2]	20,954	55,633
Long Branch	4,581	13,319
Total	69,973	185,506

[1]Excluding Long Branch
[2]Excluding Upper Accotink

2.2 Permitted Facilities

DEQ issues Virginia Pollutant Discharge Elimination System (VPDES) permits for all point source discharges to surface waters, to dischargers of stormwater from Municipal Separate Storm

Sewer Systems (MS4s), and to dischargers of stormwater from Industrial Activities. DEQ issues Virginia Stormwater Management Program (VSMP) permits to dischargers of stormwater from Construction Activities. There are two broad types of discharge permits; individual permits and general permits.

DEQ issues individual permits to both municipal and industrial facilities. Permit requirements, special conditions, effluent limitations and monitoring requirements are determined for each facility on a site specific basis in order to meet applicable water quality standards. General permits are written for a general class of dischargers where operations and activities are similar. These permits are also prepared to protect and maintain applicable water quality standards. In Virginia, general permits are adopted as regulations.

There are four types of permits issued in the Accotink Creek watershed: (1) individual Virginia Pollutant Discharge Elimination System (VPDES) permits; (2) general VPDES permits; (3) municipal separate storm sewer system (MS4) permits; and (4) general construction stormwater control permits. These are discussed in subsequent sections.

Most of the watershed is served by sanitary sewers. The wastewater treatment plant discharges into a different watershed than Accotink Creek.

2.2.1 Facilities with Individual Permits

Individual VPDES permits have conditions that apply to a specific facility, including effluent limits and monitoring requirements. There are five, individual industrial permits authorizing discharge in the Accotink Creek watershed. Four of them are issued to bulk petroleum storage operations; these are classified as minor permits. They are listed in **Table 2-11**, along with their receiving stream and their discharge flows, where applicable. In addition, Fort Belvoir has an individual VPDES permit for industrial stormwater. It is classified as a major permit. The average flow for Fort Belvoir industrial VPDES permit, shown in **Table 2-11,** was based on results from the Generalized Watershed Loading Functions (GWLF) model, used in the development of the Accotink Creek sediment TMDLs (See **Section 3**). **Figure 2-5** shows the location of these facilities

.

Table 2-11: Individual VPDES Industrial Permits within Accotink Creek Watershed

Watershed	Permit No	Facility Name	Major/ Minor	Municipal/ Industrial	Discharge Source	Receiving Stream	Average Flow (MGD)
Upper Accotink	VA0001872	Joint Basin Corporation – Fairfax Terminal Complex	Minor	Industrial	Process Wastewater and Stormwater	Daniels Run, UNT	0.100
	VA0002283	Motiva Enterprises LLC – Fairfax	Minor	Industrial	Process Wastewater and Stormwater	Crook Branch	0.048
Lower Accotink	VA0001945	Kinder Morgan Southeast Terminals LLC-Newington	Minor	Industrial	Process Wastewater and Stormwater	Accotink Creek, UNT	0.176
	VA0001988	Kinder Morgan Southeast Terminals LLC-Newington 2	Minor	Industrial	Process Wastewater and Stormwater	Accotink Creek, UNT	0.036
	VA0092771	Fort Belvoir	Major	Industrial	Stormwater	Accotink Creek	0.322[1]

[1]Based on results from GWLF model discussed in **Section 3**.

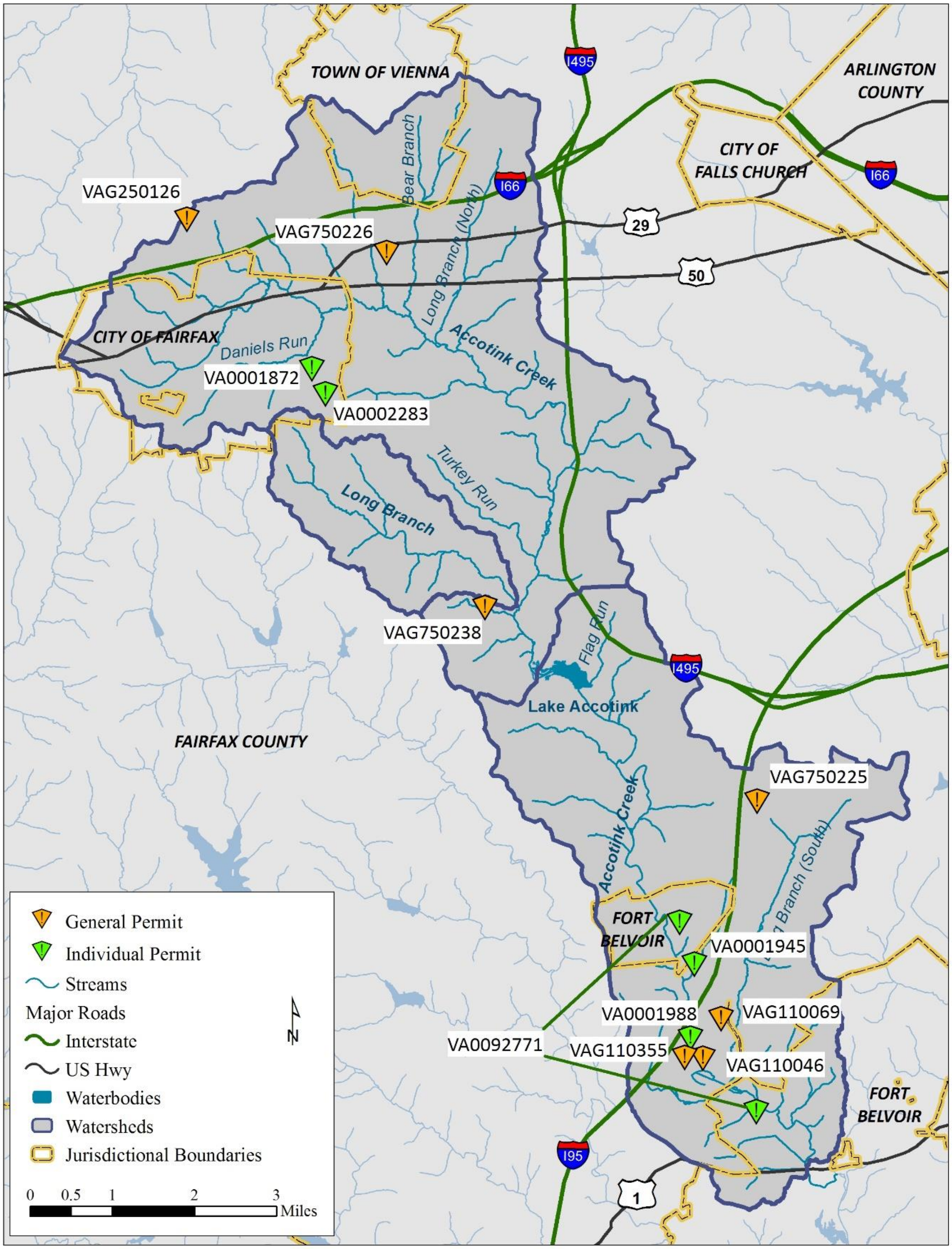


Figure 2-5: Location of Facilities with Individual and General VPDES Permits within Accotink Watershed

2.2.2 Facilities with General Permits

General permits apply to a class of dischargers. Facilities in Accotink Creek watershed are registered under the following general permits, excluding the MS4 general permit:

- three (3) Vehicle Wash and Laundry facilities;
- one (1) Non-contact Cooling Water permittees;
- three (3) Concrete Products Facilities;
- two (2) permittees under the Domestic Sewage Discharge of Less Than or Equal to 1,000 Gallons per Day;
- two (2) facilities authorized under the permit for Petroleum Contaminated Sites and Hydrostatic Tests;
- twelve (12) permits for Discharges of Stormwater Associated with Industrial Activity;

Table 2-12 shows the facilities in Accotink Creek registered under these general permits, not including discharges of industrial stormwater, the two domestic sewage dischargers, or the two permits for petroleum contaminated sites and hydrostatic tests. **Figure 2-5** shows the location of facilities with general permits that are identified in **Table 2-12**. The twelve facilities registered under the general permit for industrial stormwater are identified in **Table 2-13** with their locations shown in **Figure 2-6**. One household under the general domestic sewage permit for discharges less than 1,000 gallons per day is in the upper Accotink Creek watershed, and the other is in the Long Branch watershed. Facilities authorized to discharge under the general permit for petroleum contaminated sites, groundwater remediation and/or hydrostatic testing are not presented in the referenced maps or tables. These permits may be short-lived, depending on the specific activity. Additionally, a registration statement is not required for certain activities, such as short-term projects and hydrostatic testing discharges. Because of the nature of permitting these sources and because these are insignificant sources of sediment, they are not presented in the referenced maps or tables. Nonetheless, the two permits that were active at the time of writing this report were both located in the upper Accotink Creek watershed. Permits for discharge of stormwater from construction activities are discussed in **Section 2.2.4**.

Table 2-12: Cooling Water, Car Wash and Concrete General VPDES Permitted Facilities within Accotink Creek Watershed

Watershed	Permit No	Facility Name	Type
Upper Accotink	VAG250126	AT&T Oakton Office Park	Cooling Water
	VAG750226	Enterprise Rent A Car - 3055 Nutley St	Car Wash
	VAG750238	Ravensworth Collision Center	Car Wash
Lower Accotink	VAG110046	Virginia Concrete Company Inc - Newington Plant 1	Concrete
	VAG110069	VA Concrete Co - Mid Atlantic Materials-Newington	Concrete
	VAG750255	Enterprise Rent A Car – 6701Loisdale Rd	Car Wash
	VAG110355	Superior Concrete	Concrete

Table 2-13: Industrial Stormwater General VPDES Permitted Facilities within Accotink Creek Watershed

Watershed	Permit No	Facility	Area of Industrial Activity (Acres)	SIC (Standard Industrial Classification Code) Description
Upper Accotink	VAR051066	US Postal Service – Merrifield Vehicle Maintenance	2	United States Postal Service
	VAR051770	Fairfax County – Jermantown Maintenance Facility	12.4	Local and Suburban Transit
	VAR052188	Milestone Metals	1.5	Scrap and Waste Materials
Lower Accotink	VAR051042	SICPA Securink Corporation	1.1	Printing Ink
	VAR051047	Fairfax County – Connector Bus Yard	6.25	Local and Suburban Transit
	VAR051565	Rolling Frito Lay Sales LP – South Potomac DC	1.2	Trucking, Except Local
	VAR051771	Fairfax County – Newington Maintenance Facility	25.4	Local and Suburban Transit
	VAR051772	Fairfax County-DVS – Alban Maintenance Facility	5.5	Local and Suburban Transit
	VAR051795	HD Supply-White Cap	1	Brick, Stone, and Related Materials
	VAR051863	United Parcel Service – Newington	9.1	Courier Services, Except Air
	VAR052223	Newington Solid Waste Vehicle Facility	4.9	Local Trucking without Storage
	VAR052366	Ready Refresh by Nestle - Lorton Branch	3.0	Local Trucking with Storage

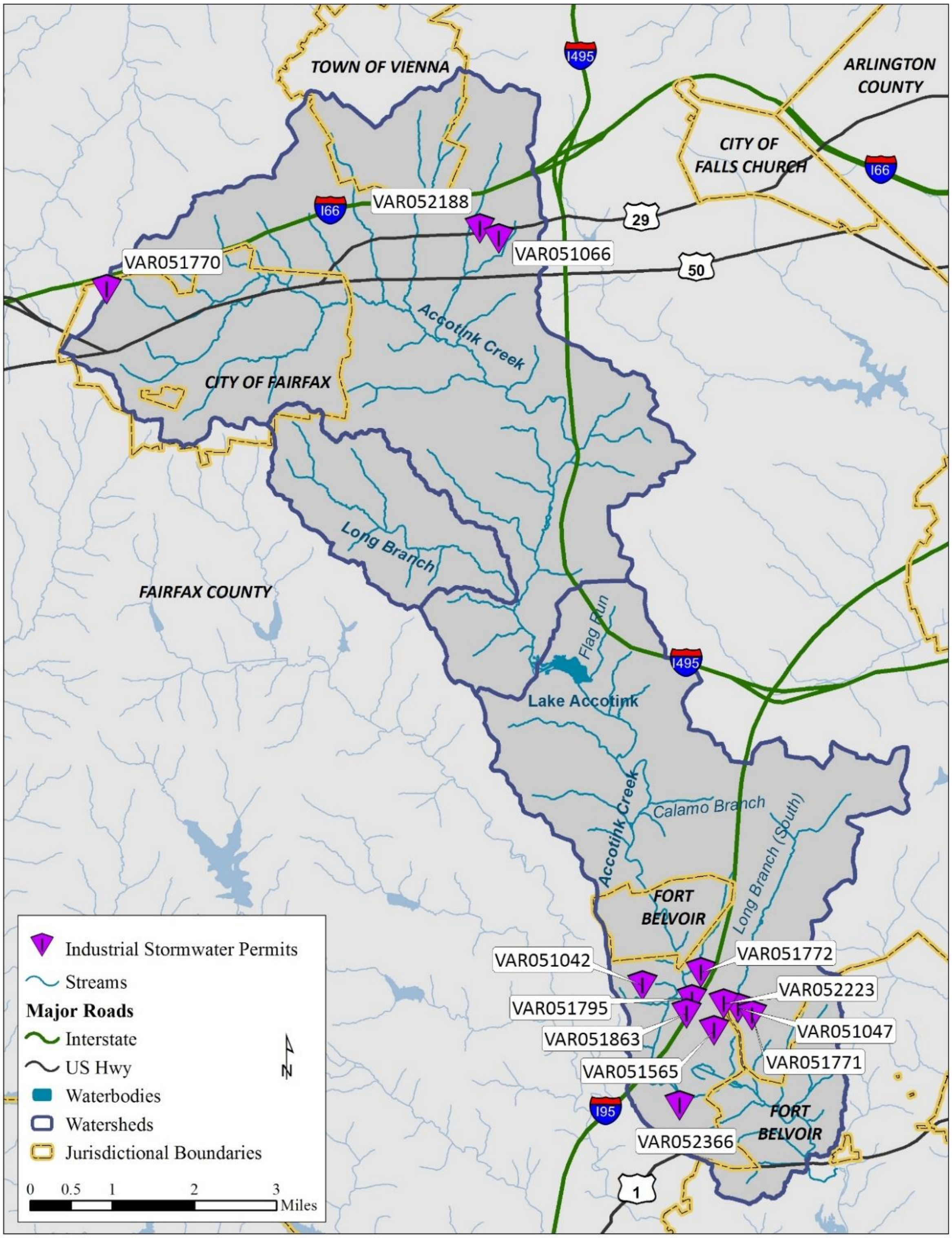


Figure 2-6: Location of Industrial Stormwater General Permits within Accotink Watershed

2.2.3 Municipal Separate Storm Sewer Systems (MS4s)

MS4 permits in the Accotink Creek watershed are listed in **Table 2-14**. Fairfax County has a Phase I, individual permit and it is anticipated that VDOT will have an individual MS4 by completion of this TMDL study. While VDOT remains a Phase II MS4 entity, DEQ is preparing an individual permit to govern its operations. The rest of the MS4s have Phase II, general permits. **Table 2-14** also shows the watershed of the impaired segment associated with the MS4s.

Table 2-14: MS4 Permits within Accotink Creek Watershed

Watershed	Permit No	Facility Name	Phase
All	VA0088587	Fairfax County	I
All	VA0092975	Virginia Department of Transportation	II
All	VAR040104	Fairfax County Public Schools	II
Long Branch & Upper Accotink	VAR040064	City of Fairfax	II
Upper Accotink	VAR040066	Town of Vienna	II
Lower Accotink	VAR040093	Fort Belvoir	II
	VAR040095	Northern Virginia Community College	II

A MS4 can be defined by its service area, which represents the drainage areas of the storm sewers and outfalls owned or operated by the MS4. Service areas can overlap. **Figure 2-7** shows the overlapping service areas in one portion of the Accotink Creek watershed. In particular, the service area for the Virginia Department of Transportation (VDOT) has significant overlap with jurisdictional MS4s like Fairfax County, the Town of Vienna, or the City of Fairfax.

VDOT, Fairfax County, the Town of Vienna, Fort Belvoir, and the Fairfax County Public School System all provided GIS representations of their service areas. Service areas for the City of Fairfax and the Northern Virginia Community College, Annandale Campus, were digitized from maps documented in the City of Fairfax Chesapeake Bay Action Plan (City of Fairfax, 2015) and the Municipal Separate Storm Sewer System Manual (NOVA, 2014), respectively. Because of the overlap in service areas, it is sometimes more useful to consider the combined service area, that is the area drained by the storm sewer system of at least one MS4, if not more. **Figure 2-8** shows the combined MS4 service area in the Accotink Creek watershed.

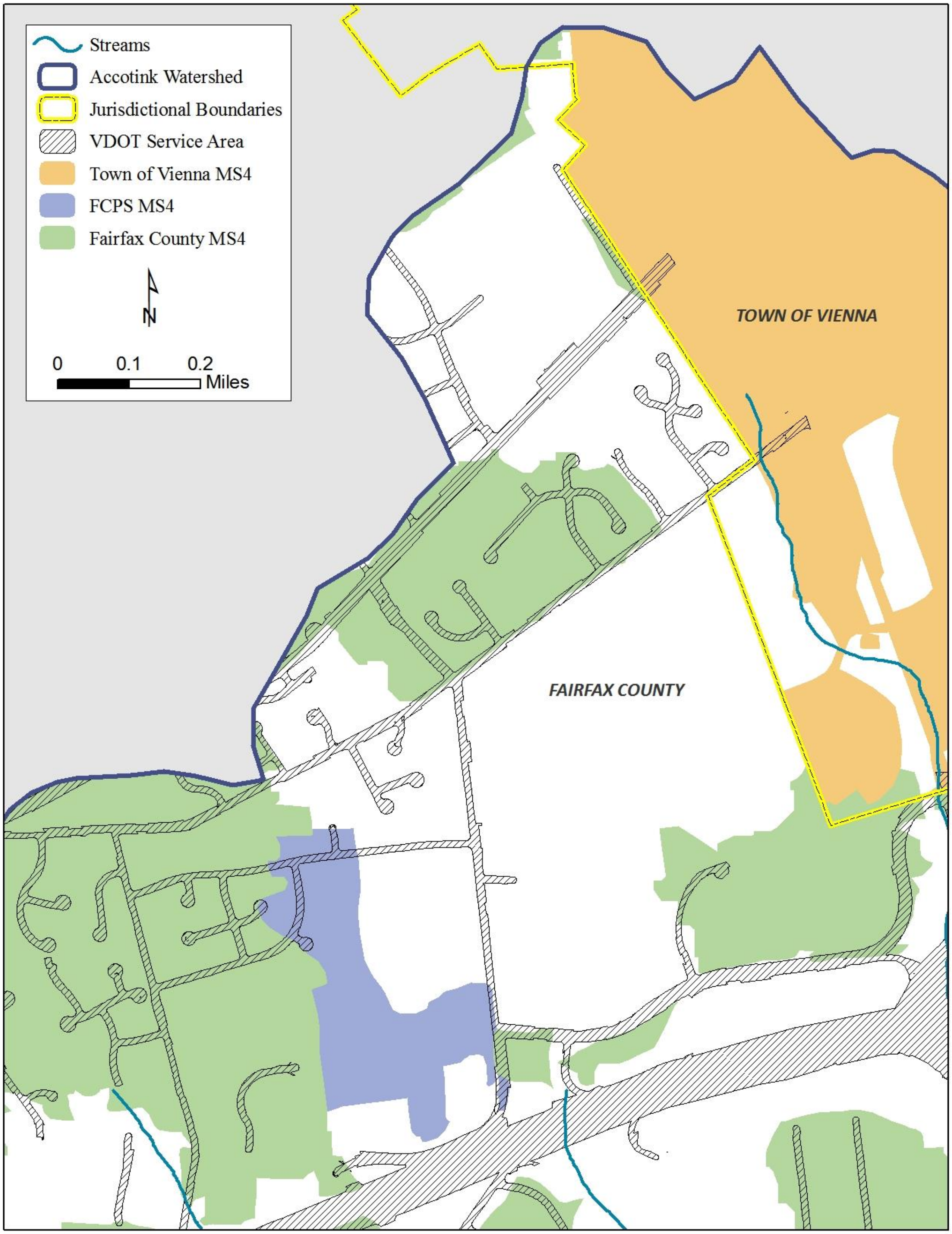


Figure 2-7: Individual MS4 Service Areas

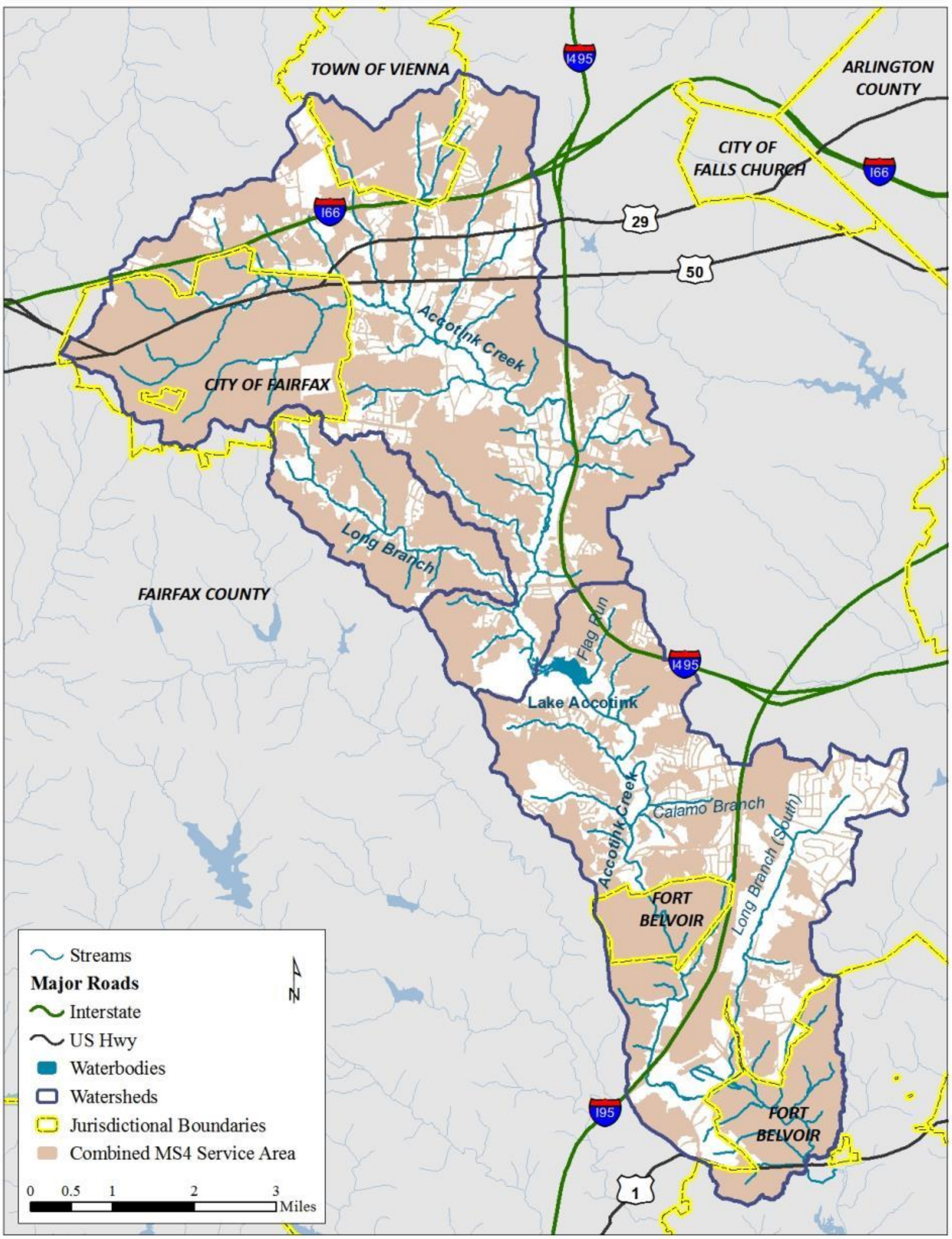


Figure 2-8: Combined MS4 Service Areas

2.2.4 Construction Permits

Under the VSMP, DEQ also issues general permits to control stormwater from construction sites. **Table 2-15** summarizes the number of active construction permits in the Accotink Creek watershed, the total acreage under development, and the total disturbed area at the inception of this project in December, 2014. Information on current construction permits can be obtained from an on-line database on the VSMP website, which is currently available at the following: http://www.deq.virginia.gov/Programs/Water/StormwaterManagement/VSMPPermits/ConstructionGeneralPermit.aspx

Table 2-15: Construction Stormwater Permits within Accotink Creek Watershed (December, 2014)

Watershed	Number of Permits	Total Area of Sites (acres)	Total Disturbed Area (acres)
Upper Accotink[1]	44	704	315
Lower Accotink[2]	33	648	265
Long Branch	1	11	5

[1]Excludes Long Branch
[2]Excludes upper Accotink Creek and Long Branch

2.2.5 Sewers

The population in Accotink Creek watershed is primarily served by sanitary sewers. Most of the wastewater is treated at Fairfax County's Norman J. Cole Jr. Pollution Control Plant, which discharges into Pohick Creek, which is the watershed adjacent to Accotink Creek.

3 TMDL Development

Virginia does not have numeric water quality criteria for sediment to protect aquatic life. TMDLs developed for sediment in Virginia use the reference watershed approach, in which the sediment loads from unimpaired watersheds, which are similar in other respects to the impaired watershed, are used to set the TMDL for the impaired watershed. The current implementation of the reference watershed approach is the AllForX approach (Benham et al., 2014; Yagow et al.; 2015a; Yagow et al., 2015b). An all-forest load multiplier (AllForX) is the ratio of current sediment loads to the loads which would occur under all-forested conditions. In other words, the AllForX multiplier is an indication of how much higher current sediment loads are above an undeveloped condition. These multipliers are calculated for both impaired and unimpaired watersheds, and the Virginia Stream Condition Index (VSCI) scores are then regressed against the AllForX values. Using the regression line, a threshold multiplier is identified for a VSCI score of 60, which is the assessment threshold that indicates a healthy benthic macroinvertebrate community. That AllForX threshold, multiplied by the all-forested sediment load of an impaired watershed, becomes the TMDL endpoint for the impaired watershed.

3.1 Overview of the Generalized Watershed Loading Functions (GWLF) Model

Loading rates for both the impaired and unimpaired watersheds are determined by computer simulation models. In Virginia, the Generalized Watershed Loading Functions (GWLF) model (Haith et al., 1992) or updated versions of GWLF developed at Penn State (Evans et al., 2001; Evans and Corradini, 2014) or Virginia Tech (Yagow et al., 2015a) are often used to simulate sediment loads. Both updated versions of GWLF have added the capacity to simulate streambank erosion.

GWLF is a continuous simulation model that can be used to represent streamflow, sediment loads, and nitrogen and phosphorus loads from point and nonpoint sources on a watershed basis. It has played a key role in the reference watershed approach to the development of sediment and nutrient TMDLs to address benthic impairments in Virginia and other states, such as Pennsylvania.

GWLF's strength is that it uses accepted engineering practices and techniques to calculate key variables like runoff and erosion. It is best characterized as a planning level model that does not require as much input data as many continuous simulation models, nor does it require the calibration of model parameters. GWLF operates on a daily timestep, although flow and loads are most often reported on a monthly or annual basis. Runoff, erosion, and the nutrients transported in them are simulated by land use; groundwater flows and their loads are simulated on a watershed scale.

GWLF was originally developed at Cornell University (Haith and Shoemaker, 1997; Haith et al., 1992). AVGWLF, a version of GWLF developed by Pennsylvania State University (Evans et al., 2003) for use in Pennsylvania's nonpoint source TMDLs, added a channel erosion component to the original GWLF model.

The key elements in GWLF's simulation of watershed hydrology and sediment transport are discussed below. For more details on the GWLF model, see Haith et al. (1992) and Evans et al. (2003).

3.1.1 Simulation of Watershed Hydrology

GWLF represents all phases of the hydrological cycle: precipitation, runoff, infiltration, percolation, evapotranspiration, and groundwater discharge. It requires daily times series of average temperature and rainfall.

The cornerstone of the hydrology model is use of the Natural Resource Conservation Service (NRCS--formerly Soil Conservation Service (SCS)) Curve Number method for computing runoff from daily rainfall. Curve numbers for each land use represented are adjusted on a daily basis according to precipitation over the previous five days. Snowfall, snowpack, and snowmelt are also simulated.

While runoff is computed on a distributed basis over the land uses represented in the watershed, subsurface processes are lumped on a watershed scale. Precipitation that does not runoff infiltrates into the shallow unsaturated zone. There it is subject to evapotranspiration. Potential evapotranspiration is calculated daily according to Hamon's method, on the basis of average temperature and latitude. Monthly cover coefficients determine how much of potential evapotranspiration can be satisfied by the vegetative cover.

When the unsaturated zone reaches its maximum water capacity, additional inflow enters saturated storage. Saturated storage is modeled as a linear reservoir; the recession coefficient is the ratio of the change in storage, discharged as baseflow, and the saturated storage. Total streamflow is the sum of baseflow and runoff. There is no hydraulic routing in GWLF.

The key parameters that characterize a hydrology simulation are (1) curve numbers for each land use represented, (2) maximum unsaturated storage, (3) cover coefficients, and (4) the recession coefficient. More details on the hydrology component of GWLF can be found in Haith et al. (1992).

3.1.2 Simulation of Erosion and Sediment Transport

Just as curve numbers are the cornerstone of the hydrology simulation, the universal soil loss equation (USLE) forms the cornerstone of the representation of erosion and sediment transport. Erosion from the Universal Soil Loss Equation is calculated as follows:

$$A = R*K*LS*C*P$$

where

R = Rainfall erosivity
K = Soil erodibility
LS = Topographic factor, based on slope and slope length
C = Cover and management factor
P = Support practice factor
A = Soil loss per unit of time

USLE was originally intended to provide annual or seasonal estimates of erosion from land uses such as forests, cropland, pasture, and pervious developed land. In GWLF, the USLE was modified to calculate erosion on an event basis by calculating the erosivity factor (R) for daily precipitation. Other factors in the USLE are input to the model for each land use.

Not all the sediment eroded in a watershed is transported out of the watershed. The sediment delivery ratio, the proportion of the eroded sediment transported out of the watershed, is a function of watershed size. The delivery of sediment is proportional to the relative size of the monthly runoff that occurs over the remainder of the year from the time the erosion took place. Again, for more details, see Haith et al. (1992).

Evans et al. (2003) introduced a channel erosion component into GWLF. Channel erosion is the product of a total stream length in the watershed, bank height, the bulk density of the bank soil, and a lateral erosion rate. The lateral erosion rate (LER), in cm/month, is a function of average monthly streamflow (Q), in m^3/s, and a factor “a”

$$LER = a*Q^{0.6}$$

The “a” factor was determined by regression as a function of the following watershed characteristics: (1) percent developed land, (2) animal equivalent unit density, (3) average curve number, (4) average K-factor, and (5) mean slope.

Sediment loads from point sources can also be represented in GWLF. These are not subject to the sediment delivery ratio.

3.1.3 Seasonal Variability and Critical Conditions

Any TMDL is required to take into account the seasonal factors that impact loading rates and critical conditions that exacerbate the impact of the pollutant in question, in this case sediment. The GWLF model can incorporate seasonal variability and critical conditions into its simulation of watershed sediment loads.

First, several GWLF parameters, including rainfall erosivity and evaporation cover coefficients, are modified on a monthly basis to take into account their seasonal variation. Second, using a daily model over a twelve-year simulation period represents a wide variety of meteorological and hydrological conditions and seasonal effects. Wet springs, dry hot summers, or even wet cool summers are represented over a long simulation period.

With respect to sediment, critical conditions are (1) heavy rainfalls that erode sediment from fields and (2) high flows that scour streambanks. Both types of events are represented in GWLF if the simulation period includes a sufficient variety of meteorological and hydrological conditions. Therefore, using GWLF to develop TMDL allocations satisfies the requirements that TMDLs take into account the seasonality of loads and critical conditions.

3.1.4 Implementation of GWLF in the Accotink Creek Watershed

Although GWLF is supposed to require little or no calibration, hydrology parameters have been calibrated against observed flow data in most Virginia TMDLs where GWLF has been used. For Accotink Creek, hydrology parameters were calibrated using the parameter estimation software, PEST (Doherty, 2001). PEST requires a version of the model that can run under the DOS operating system. GWLF 2.0 is the most recent version of the model that can be run as a stand-alone model under DOS. The hydrology calibration is described in **Section 3.2**.

Accotink Creek is a highly developed watershed. Eighty-four percent of the watershed is occupied by developed land uses. As described in **Section 2.1.4**, most jurisdictions made their zoning and land cover data available for use in developing the Accotink Creek TMDLs. The most recent Penn State version of GWLF, Mapshed, which, as is described in Appendix A, was used to model the comparison watersheds, is unable to accommodate the seven categories of developed land used to characterize Accotink Creek. GWLF 2.0 is able to simulate seven developed land uses, however, and therefore was used to simulate both hydrology and sediment in Accotink Creek. On the other hand, GWLF 2.0 does not include the simulation of streambank erosion, which is often the dominant source of sediment in highly developed watersheds. A spreadsheet version of Evans et al.'s (2003) streambank erosion model was implemented using flow output from the GWLF 2.0 model.

The combination of the USLE and delivery factors does not capture the dynamics of sediment transport in highly developed watersheds. Developed watersheds have a high percentage of impervious surfaces, which are not subject to erosion, but still generate sediment loads from the deposition of wind-blown particulates. Some of these same surfaces serve as transport paths for sediment eroded from pervious surfaces, and which are often part of a larger network of storm sewers that convey both flow and sediment. For these reasons sediment loads from developed land are best characterized as the loads delivered at the storm sewer outfalls, or alternatively, as the product of flow and an average or typical event mean concentration measured at the end-of-pipe (EOP). The USLE parameters for all land uses in Accotink Creek except open space and construction were set so that the simulated average annual sediment concentrations in runoff from these land uses were equal to average event mean concentrations taken from the National Stormwater Quality Database (NSQD). Calculation of calibration targets and estimates of total watershed load, based on observed data, are also described in **Section 3.3**.

Four GWLF models simulating baseline conditions were developed: a model used primarily for calibration of hydrology parameters, which represents the Accotink Creek watershed above the USGS gauge on Accotink Creek near Annandale (01654000); and a model for each of the three watersheds draining to the impaired sections of upper Accotink Creek, lower Accotink Creek, and Long Branch. The model for calibration of hydrology was used to parameterize the three models for the impaired watersheds. **Section 3.4** will describe the development of the sediment simulations in these models. As **Section 3.4** will explain, the upper Accotink Creek model includes Long Branch but the lower Accotink Creek model does not include the upper Accotink Creek watershed. There are also three GWLF models representing upper Accotink Creek, lower Accotink Creek, and Long Branch under all-forested conditions. The development of these models is also described in **Section 3.4**.

Section 3.5 presents the resulting baseline and all-forested sediment loads for each of the three impaired watersheds. It also calculates the AllForX ratio for each impairment and the TMDL required to meet water quality standards, based on the AllforX method.

3.2 Hydrology Calibration

The simulation period for the Accotink Creek GWLF models is April 1, 1996 through March 31, 2016 (GWLF 2.0 simulations begin in April). The hydrology simulation requires daily precipitation and average daily temperature as inputs. These were obtained from Washington Reagan National Airport (00013743). The GWLF hydrology simulation was calibrated against monthly flow data collected at the USGS gauge on Accotink Creek near Annandale (01654000). **Figure 3-1** shows the location of the USGS gauge and the weather station at Washington Reagan National Airport in relation to the portion of Accotink Creek simulated in the calibration.

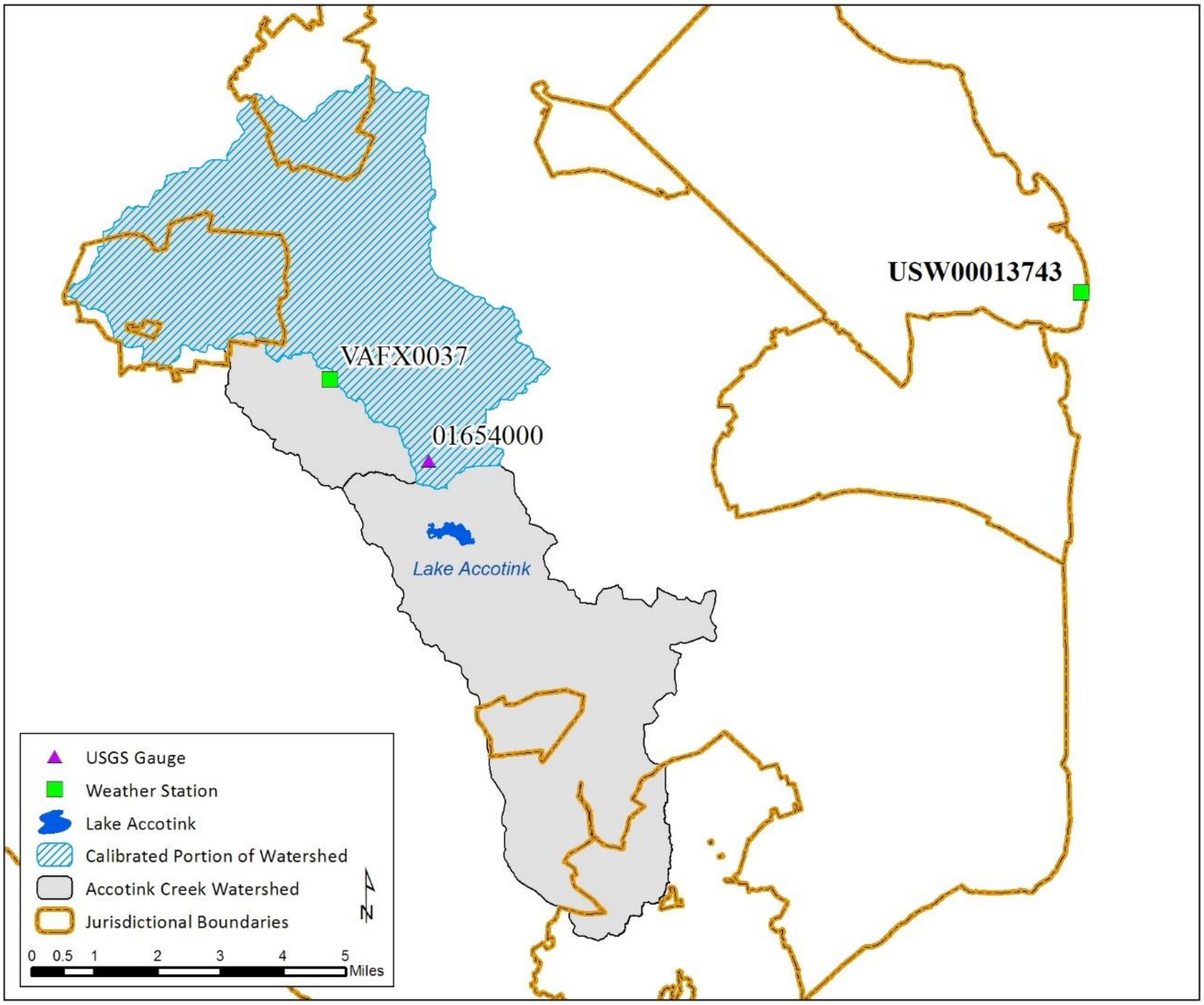


Figure 3-1: Location of Reagan National Airport (USW00013743) and Mantua (VAFX0037) Weather Stations with respect to Hydrology Calibration Watershed

3.2.1 Hydrology Parameter Optimization

The values of key hydrology parameters were calibrated using Version 10 of PEST, the model-independent parameter estimation software developed by J. Doherty (Doherty, 2001). PEST determines the values of parameters that optimize a user-specified objective function. In these simulations, the objective function was the sum of the squares of the differences between monthly observed and simulated flow volumes in centimeters (cm). This is equivalent to maximizing the coefficient of determination (R^2) between observed and simulated flows.

The following parameters were optimized: (1) maximum unsaturated zone storage; (2) groundwater recession coefficient; (3) monthly evapotranspiration cover coefficients; and (4) curve numbers for forest (open space), pervious developed land, and impervious developed land. For each parameter, **Table 3-1** gives the range of values permitted, the initial value used in the optimization, and the final value.

Table 3-1: Hydrology Simulation Parameters Optimized Using PEST

Parameter	Range for PEST Optimization	Initial Value	Final Value
Recession Constant	0.01-0.2	0.1	0.017426588
Maximum Unsaturated Storage (cm)	1-25	10	6.82862810
Forest Curve Number	63.7-81.7	72.7	65.0576335
Pervious Curve Number	68.7-86.7	77.7	70.0576335
Impervious Curve Number	85.0-100.0	92.5	99.9687474
January ET Cover Coefficient	0.15 -1.5	0.765	1.0
February ET Cover Coefficient	0.15 -1.5	0.765	1.0
March ET Cover Coefficient	0.15 -1.5	0.765	1.0
April ET Cover Coefficient	0.325-1.5	0.7825	1.5
May ET Cover Coefficient	0.5-1.5	0.85	1.8[1]
June ET Cover Coefficient	0.5-1.5	0.85	1.8[1]
July ET Cover Coefficient	0.5-1.5	0.85	1.8[1]
August ET Cover Coefficient	0.5-1.5	0.85	1.8[1]
September ET Cover Coefficient	0.5-1.5	0.85	1.0
October ET Cover Coefficient	0.325-1.5	0.7825	1.0
November ET Cover Coefficient	0.15 -1.5	0.765	1.0
December ET Cover Coefficient	0.15 -1.5	0.765	1.0

[1]Calibrated by hand outside of PEST optimization.

For pervious developed land, the range of curve numbers was determined by an analysis of soil hydrologic groups given in **Section 2.1.3**. The forest curve number was set 5 less than the curve number for pervious developed land. The Chesapeake Bay Program (EPA, 2010) found during the development of the Phase 5 Watershed Model that Hamon's method could underestimate potential evapotranspiration, so the monthly cover coefficients were allowed to have values greater than one.

After several PEST runs, the monthly cover coefficients were adjusted by hand to provide a good match in average monthly and average seasonal flow volumes. PEST was then run with fixed values for monthly cover coefficients to obtain optimum values for the other parameters.

3.2.2 Extreme Events

The initial optimization runs produced unsatisfactory results due to the error in the two largest monthly flows in the simulation period: June, 2006 and September, 2011. The parameters determined by PEST tended to oversimulate the former and undersimulate the latter. These months contain extreme precipitation events which lead to extreme flows. In September, 2011, Tropical Storm Lee led to the largest average daily flow (3,600 cfs) and the largest instantaneous flow (14,000 cfs) recorded at the USGS gauge on Accotink Creek near Annandale (01654000), while in June, 2006, an unnamed storm led the largest average daily flow (1,280 cfs) and the largest instantaneous flow (18,100 cfs) at the USGS gauge in the neighboring Four Mile Run watershed (01652500).

Livingston (2011) showed that the cumulative precipitation totals for Tropical Storm Lee could vary from 15 inches in Occoquan, VA to five inches in City of Fairfax. **Figure 3-2** shows the cumulative precipitation totals for Tropical Storm Lee at Global Historical Climatology Network Daily (GHCND) gauges in and around the Accotink Creek watershed. Precipitation totals range at stations near the watershed range from 20 cm to 39 cm; in contrast, the cumulative precipitation total at Reagan National Airport was 17.6 cm.

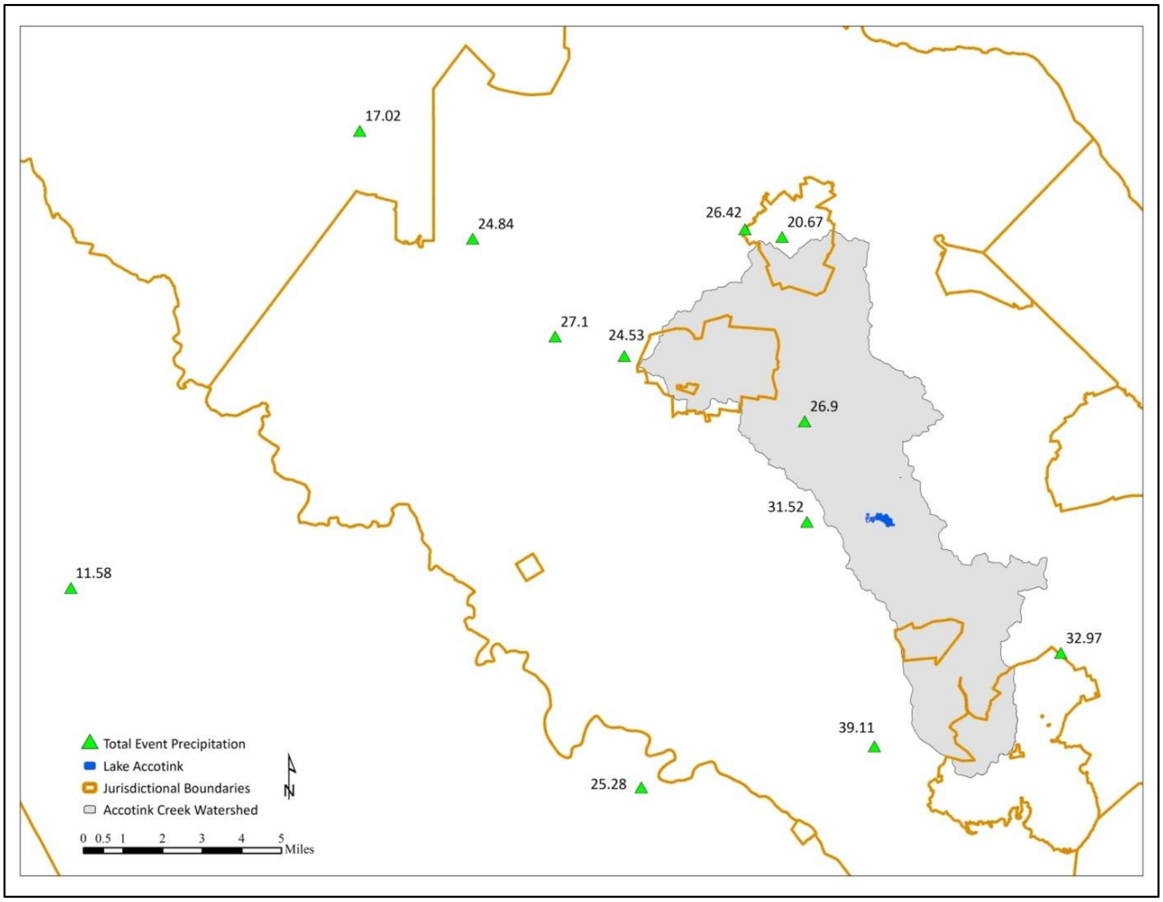


Figure 3-2: Cumulative Precipitation (cm), September 5-10, 2011, at NOAA GHCND Stations in or near Accotink Creek Watershed

Because of the potential for a large degree of local variation in precipitation for these extreme events, the daily precipitation from the GHCND station at Mantua, VA, was substituted for the precipitation record at Reagan National Airport. **Figure 3-1** shows the location of the Mantua gauge, which is the only GHCND station located in the Accotink Creek watershed. The substitution was also performed for a third event, Tropical Storm Hanna, which took place in September, 2008. **Table 3-2** contrasts the cumulative precipitation at the Mantua gauge with the Reagan Airport totals over the duration of the storms.

Table 3-2: Cumulative Precipitation (cm) at Reagan Airport and Mantua over Duration of Selected Extreme Events

Dates	Event Name	Reagan Airport	Mantua
June 25-28, 2006	Unnamed	26.3	24.5
September 5-7, 2008	Tropical Storm Hanna	9.9	19.6
September 5-10, 2011	Tropical Storm Lee	17.6	26.9

After the substitution, the PEST optimization still oversimulated June, 2006, and undersimulated September 2011, but overall, as shown in the next section, the parameterization produced a satisfactory hydrology simulation.

3.2.3 Hydrology Calibration Results

The PEST optimization, supplemented by the adjustment in monthly evapotranspiration cover coefficients and the substitution of Mantua precipitation for Reagan National data during extreme events, produced a satisfactory simulation of monthly flow volumes, when compared to the volumes observed at the USGS gauge on Accotink Creek. **Table 3-3** summarizes the hydrology calibration statistics. **Figure 3-3** shows a scatter plot of paired observed and simulated average monthly flows. There is a slight tendency to undersimulate larger flows, as also shown by the time series plot in **Figure 3-4**, but generally the data falls along the one-to-one line with a coefficient of determination (R^2) of 0.74. Total simulated flow is only 3% higher than the total observed flow.

Table 3-3: Hydrology Calibration Statistics

Statistic	Value
Percent Difference in Total Flow Volume (Simulated Volume –Observed Volume)	3%
Coefficient of Determination (R^2) between Simulated and Observed Monthly Flow Volumes	0.74
Coefficient of Determination (R^2) between Simulated and Observed Average Monthly Flow Volumes	0.80
Percent Difference in Winter Flow Volume (Simulated Volume –Observed Volume)	-2%
Percent Difference in Spring Flow Volume (Simulated Volume –Observed Volume)	10%
Percent Difference in Summer Flow Volume (Simulated Volume –Observed Volume)	-7%
Percent Difference in Fall Flow Volume (Simulated Volume –Observed Volume)	12%

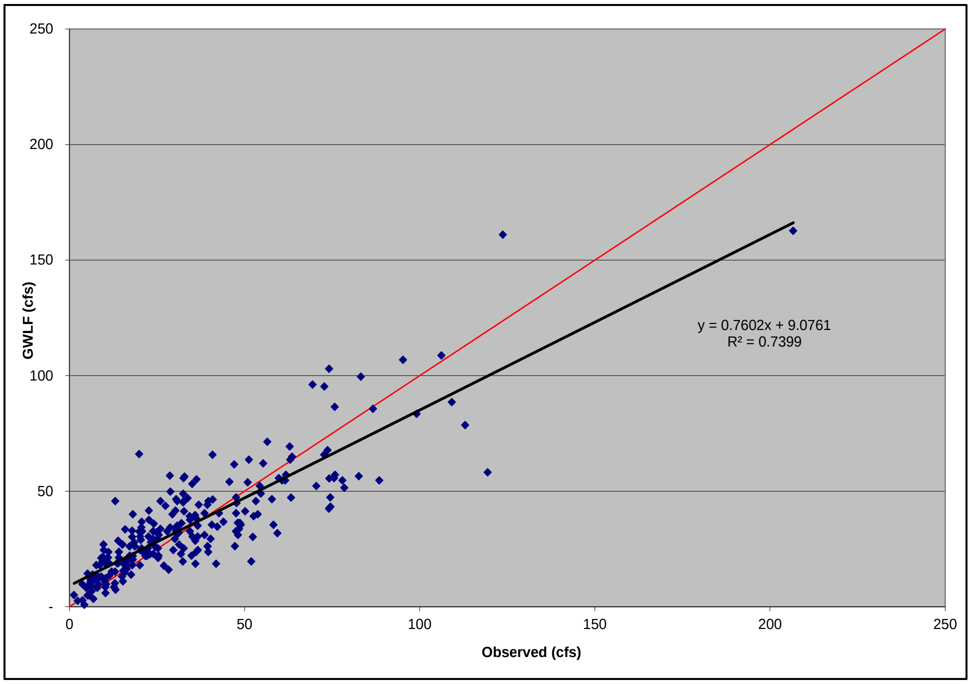


Figure 3-3: Scatter Plot of Observed and Simulated Monthly Flows, Accotink Creek near Annandale. (The red line represents a one-to-one relationship.)

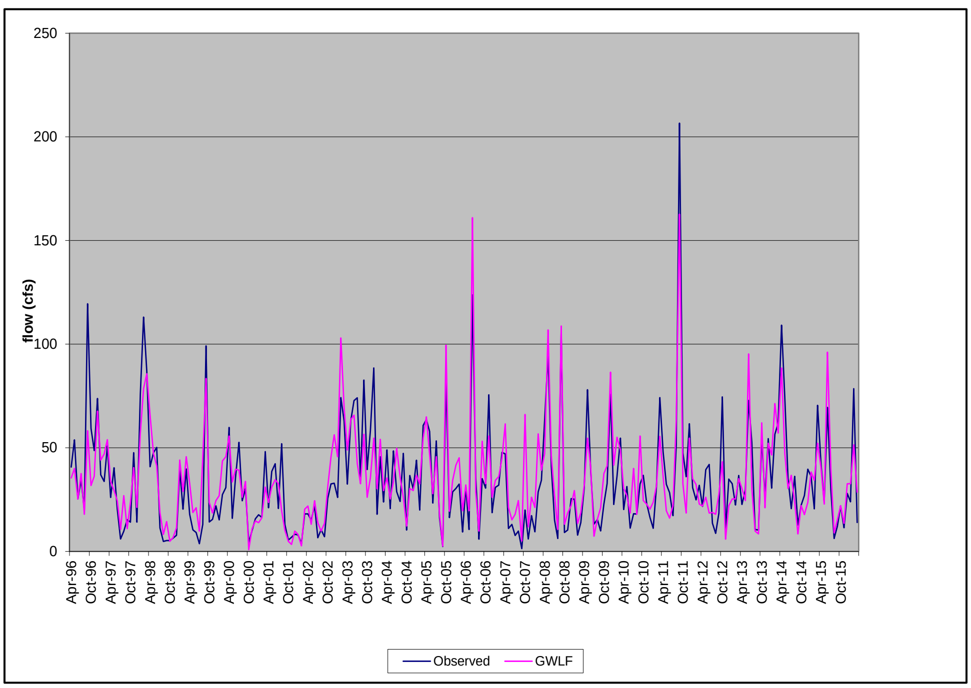


Figure 3-4: Time Series of Observed and Simulated Monthly Flows, Accotink Creek near Annandale

Figure 3-5 compares the simulated and observed monthly average flows. Simulated flows capture the trend in observed monthly average flows. The coefficient of determination (R^2) is 0.80. Seasonal average flows differ by less than 10% for all seasons.

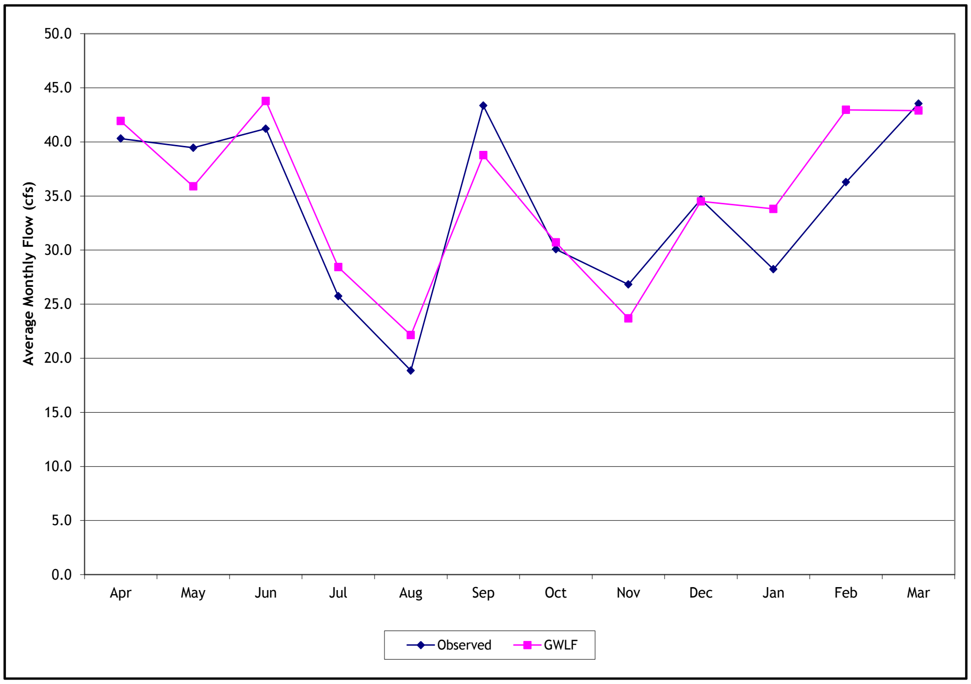


Figure 3-5: Observed and Simulated Average Monthly Flows, Accotink Creek near Annandale

3.3 Sediment Calibration Targets

As discussed in **Section 3.1.4**, GWLF is intended to require little or no calibration. Because Accotink Creek watersheds are highly developed, however, sediment loading rates from developed land were calibrated against EOP concentration targets derived from the NSQD. The derivation of these targets is discussed in **Section 3.3.1**. Sediment loads from land under construction were also calibrated to match the average load rate recommended by the Chesapeake Bay Program's Expert Panel on Sediment Erosion and Control Practices, as described in **Section 3.3.2**. In addition, monitoring data collected at the USGS gauges on Accotink Creek near Annandale (01654000) and Long Branch near Annandale (01654500) permitted the estimation of total sediment loads at those locations. Those load estimates could be compared to the simulated loads from GWLF as a check on model performance. Estimation of sediment loads at the gauges is described in **Section 3.3.3**. As part of its Watershed Management Plan for Accotink Creek, FCDPWES (2011) also estimated average annual sediment loads exported from land uses and instream processes. These estimates are also compared to targets in **Section 3.3.4**.

3.3.1 Developed Land Sediment Concentrations Targets

Calibration targets for developed land uses were calculated from monitoring data in the NSQD. The NSQD is a database of monitoring data collected under the permit requirements of Municipal Separate Storm Sewer Systems. The original database was developed in 2001-2004 by the University of Alabama and the Center for Watershed Protection under sponsorship of the EPA. It included monitoring data from 3,770 distinct storm events from 66 jurisdictions across the country with Phase I MS4 permits (Pitt et al., 2004). The data in the NSQD is subject to extensive Quality Assurance/Quality Control (QA/QC) procedures. It includes extensive auxiliary data about monitoring locations, such as land use. The database has been updated since its original release and is currently maintained in conjunction with the International Stormwater BMP Database, which is sponsored by the EPA, the American Society of Civil Engineers (ASCE), and other partners. Version 4.02 was used to develop sediment concentration targets for Accotink Creek.

NSQD contains data from across the county. Data from arid regions, like the southwest, is likely to be less relevant to conditions in Virginia than neighboring states. Data was restricted to EPA Rain Zone 2 (EPA, 1986), which includes the state of Virginia, Maryland, North Carolina, Kentucky, Tennessee, and West Virginia, in order to provide a wide-range of monitoring data without including data collected under conditions significantly different than those found in Accotink Creek watershed. Only stations without reported BMPs were used in the analysis. In additions, a station was required to have at least five samples to be included in the analysis.

Based on a literature review by Sievers (2014), the Chesapeake Bay Program decided against simulating distinct land use loading rates for any developed land use class except transportation. Since it will be necessary to manage sediment loads for Chesapeake Bay TMDL implementation, for the sake of consistency only two target sediment concentrations were estimated for the Accotink Creek TMDLs from the NSQD: one for transportation and one for the other developed land uses—commercial, industrial, mixed, and residential. For transportation, the average concentration of station averages of event mean concentrations was calculated for all sites where “Freeways” were the principle land use type. In other words, first a station average was calculated over all the events for a station classified as “Freeway,” and then the station averages were themselves averaged to obtain an overall mean concentration for the transportation land use class. For the other developed land use types, the station averages for all other land use types were calculated, and the average of the station averages was obtained, representing the overall mean concentration for the aggregate developed land use type, excluding transportation. **Table 3-4** gives the sediment calibration targets for developed land uses.

Table 3-4: Sediment Concentration Calibration Targets for Accotink Creek Watershed

Land Use	Target Average Annual Sediment Concentration (mg/l)
Transportation	112
Other Developed Land	88

3.3.2 Land under Construction

The Chesapeake Bay Program's Expert Panel on Removal Rates for Erosion and Sediment Control Practices estimated that the average annual sediment load discharged from land under construction operating under current erosion and sediment control regulations is 1.8 tons/acre/year (Clark et al., 2014). The estimated load includes the effects of moderately sized storms that are greater than the design capacity of sediment controls. It does not include the impact of extreme events, which they defined as rainfall in excess of 2.5 inches/day or 1.5 inches/hour.

There are 19 days in the 1996-2016 simulation period when rainfall exceeded 2.5 inches/day. To take into account the impact of these events, a precipitation time series was created in which days with rainfall exceeding 2.5 inches/day were assigned rainfall equal to 2.5 inches/day. USLE parameters for land under construction were set so that the average annual edge-of-field load equaled 1.8 tons/acre/year when GWLF was run with the adjusted time series. The resulting USLE parameters were then used in GWLF models with the unadjusted meteorological time series. The average annual edge-of-field load from land under construction in these models was 2.12 tons/acre/year. The excess load above the 1.8 tons/acre/year represents the effect of days when rainfall exceeded 2.5 inches/day.

3.3.3 Estimation of Total Sediment Loads

If sufficient constituent concentrations have been measured at a location where daily or instantaneous flow measurements have also been taken, a regression model that estimates concentrations as a function of flow can be used to estimate loads at that location. The first step is to estimate a regression model that predicts concentration as a function of flow; the second step is to estimate loads as the product of the estimated concentrations, measured flow, and suitable conversion factors[5]. The load estimate is only as good as the regression model. A necessary condition for a satisfactory regression model is the collection of constituent data at a wide variety of flow regimes, and particularly during high flow events when concentrations may vary widely.

The USGS has analyzed samples for suspended sediment (SS) at the USGS gauges on Accotink Creek near Annandale (01654000) and on Long Branch near Annandale (01654500). Samples have been collected across a wide variety of flow conditions, and storm events have been targeted for sampling. Thus, it is possible to estimate sediment loads at those locations.

This method can be taken a step further, if continuous monitoring of turbidity is also performed at gauges. As shown in **Section 3.5.8** of **Volume I**, the correlation between turbidity and suspended sediment can be stronger than the correlation between flow and suspended sediment. Thus, in theory, turbidity can be a better predictor of sediment than flow, or at least strengthen the predictive relation between flow and sediment. Rasmussen et al. (2009) suggest procedures for using continuous turbidity measurements to estimate sediment loads.

The USGS only began the continuous monitoring of turbidity at the gauge on Accotink Creek near Annandale in 2015, so there is not enough turbidity data to include turbidity in the regression model predicting sediment concentrations at that location. **Section 3.3.3.1** describes a regression model relating sediment concentrations to instantaneous flow, which was developed to help estimate sediment loads at the gauge on Accotink Creek. On the other hand, the USGS has performed continuous monitoring of turbidity on Long Branch since 2013, providing the data to estimate a regression model relating suspended sediment to instantaneous flow and turbidity measurements at that location. **Section 3.3.3.2** describes the development of the regression model and its use in estimating sediment loads in Long Branch.

3.3.3.1 Estimation of Sediment Loads in Accotink Creek near Annandale

A regression relation was estimated between the log of SS and the log of instantaneous flow (Q). **Figure 3-6** shows a scatter plot of the relation.

[5] For example, the flux of sediment (lbs/s) is equal to the concentration (mg/l) times the flow rate (cfs) times 28.3168 l/ft^3 times 2.2046E-6 mg/lb. To get the rate in lbs/d, multiply by 86,400 s/d.

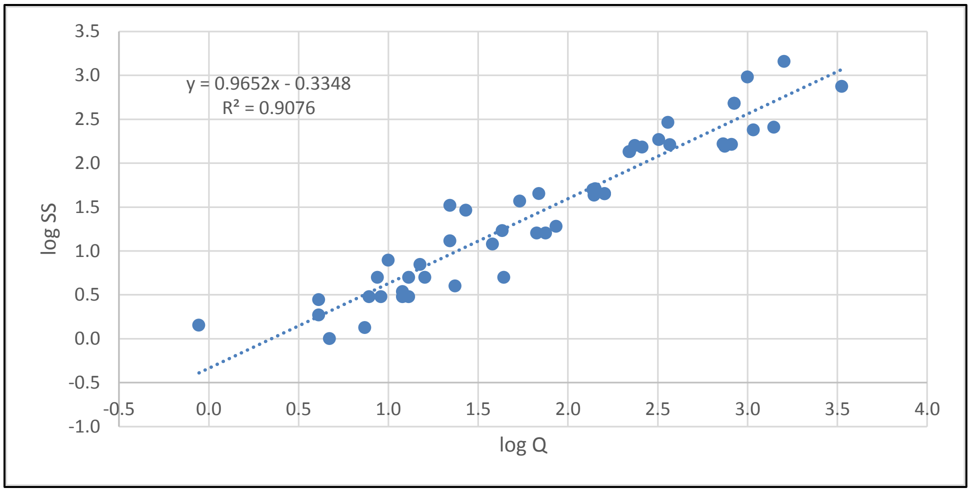


Figure 3-6: Relation between log Suspended Sediment and log Flow, Accotink Creek near Annandale

Table 3-5 shows estimated parameters and key regression statistics. The residuals pass all graphical tests for normality and homoscedasticity. To calculate loads using this regression equation it is necessary to back transform the predicted log SS. Helsel and Hirsch (2002) point out that simply taking the antilog of the log-transformed variable gives the median, not the mean estimated value. They recommend using Duan's smearing estimate to overcome transformation bias. The smearing estimate multiplies the antilog of the predicted SS by the average of the antilogs of the residuals, or

$$\frac{\sum_{i=1}^{n} exp(e_i)}{n}$$

where e_i is the ith residual.

Duan's smearing estimate was used to back transform the predictions of the regression model.

Table 3-5: Regression Parameters and Statistics for Relation between Sediment and Flow, Accotink Creek near Annandale

Statistic or Parameter	Value
Number of Observations	49
Adjusted R^2	0.906
Standard Error	0.263
F-statistic	451.56
p-value	6.01E-26
Intercept	-0.335
Coefficient of log Flow	0.965

Continuous flow data was available starting in October, 2007. Sediment loads were estimated using continuous flow data and the regression model for the period 2008-2015. To avoid problems with missing flow data, daily loads were calculated first based on the average sediment concentration for the day, then monthly loads were calculated by linear extrapolation from the days in the month on which sediment loads could be calculated. In other words, if sediment loads could be calculated for 28 days in April, the load for that April was set to 30/28 times the original load estimate. **Figure 3-7** shows the resulting annual sediment loads.

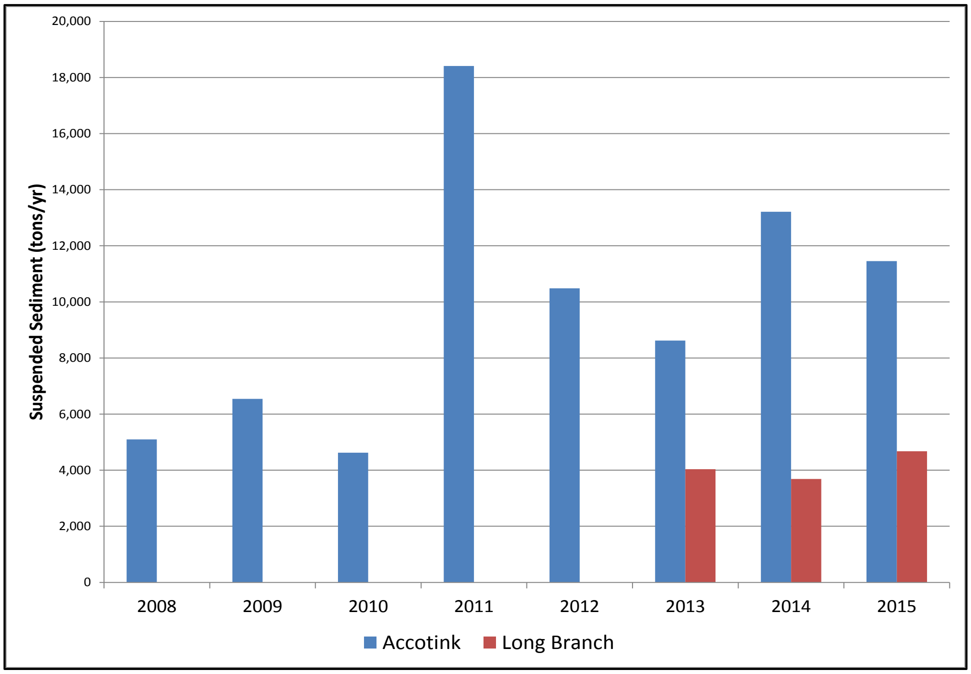


Figure 3-7: Annual Sediment Loads from Accotink Creek and Long Branch Regression Models

3.3.3.2 Estimation of Sediment Loads in Long Branch near Annandale

A regression relation was estimated between log of SS and the log of instantaneous flow (Q) and instantaneous turbidity (FNU). **Table 3-6** shows estimated parameters and key regression statistics. The residuals pass all graphical tests for normality and homoscedasticity. Duan's smearing estimate was used to back transform the predictions of the regression model.

Table 3-6: Regression Parameters and Statistics for Relation between Sediment and Flow, Long Branch near Annandale

Statistic or Parameter	Value
Number of Observations	101
Adjusted R^2	0.909
Standard Error	0.311
F-statistic	497.6
p-value	4.69E-52
Intercept	0.236
Coefficient of log Flow	0.430
Coefficient of log Turbidity (FNU)	0.723

Continuous monitoring data was available starting in February, 2013. Sediment loads were estimated using continuous monitoring data and the regression model for the period 2013-2015. The method of calculating loads used for Accotink Creek was also used for Long Branch. **Figure 3-7** shows the resulting annual sediment loads for Long Branch.

To facilitate comparison to the GWLF simulation, average annual loads, adjusted to 1996-2016 simulation period, were calculated for the estimated loads. The adjustment factor was based on monthly average flows, q, raised to the 0.6 power, because GWLF's estimate of streambank erosion is proportional to the sum of $q^{0.6}$ over the simulation period, and, as is shown in **Section 3.5**, streambank erosion is the dominant source of sediment in the Accotink Creek watershed. The formula for the adjustment factor is

$$\frac{\frac{\sum_{i=1}^{N} q_i^{0.6}}{N}}{\frac{\sum_{j=1}^{M} q_j^{0.6}}{M}}$$

where

q = observed monthly average flow (m^3/s)
N = number of months in the 1996-2016 simulation period
M = number of months where continuous monitoring data is available to estimate a load

The adjustment factor for Accotink Creek was 0.9165 and the factor for Long Branch was 0.9393. The average annual estimated load for the years shown in **Figure 3-7** was multiplied by the adjustment factor to obtain the adjusted average annual load over the 1996-2016 simulation period. The adjusted average annual load for Accotink Creek near Annandale is 9,428 tons/yr and the adjusted average annual load for Long Branch is 3,882 tons/yr.

3.3.4 Fairfax County Load Estimates

FCDPWES (2011) developed a watershed management plan for Accotink Creek, as part of its effort to develop management plans for all 30 watersheds covering the county. The Accotink Creek plan was approved by the Fairfax County Board of Supervisors in 2011.

Each management plan has a modeling component. The models represent sediment and nutrient loads under conditions that would be achieved if the BMPs and other environmental improvements recommended in the plan were implemented. The model used in the Accotink Creek Watershed Management Plan is the Spreadsheet Tool for the Estimation of Pollutant Loads (STEPL) (Tetra Tech, 2011). As the names suggests, STEPL is a spreadsheet model that estimates average annual loads. Its theoretical underpinning is similar to GWLF: curve numbers are used to calculate annual runoff and the USLE is used to calculate erosion. For developed land uses, however, STEPL also has the option of calculating loads from a representative concentration, and this option was used for developed land in Accotink Creek. Unlike the target concentrations discussed in **Section 3.3.1**, different representative concentrations were used for different land use types. **Figure 3-8** compares the concentrations used to represent developed land uses in STEPL with the target concentrations from **Section 3.3.1**.

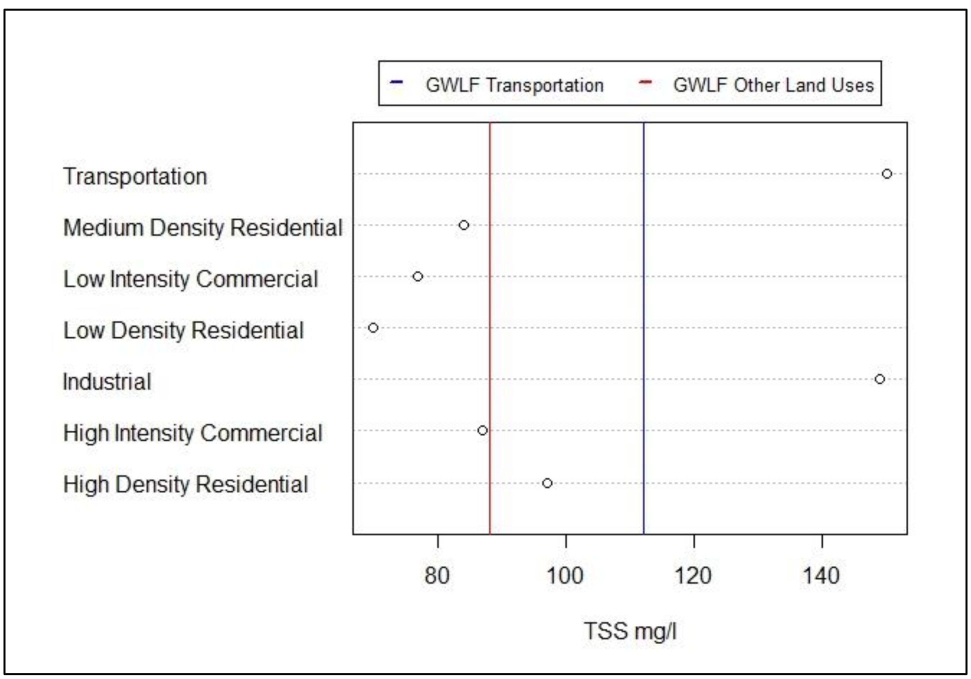


Figure 3-8: Comparison of Sediment Concentrations used in the Accotink Creek STEPL Model, compared to the Concentrations used in the Accotink Creek GWLF Models

FCDPWES also estimated streambank erosion for the Accotink Creek Watershed Management Plan. The method used is broadly similar to the method employed in GWLF. Streambank erosion (ton/yr) is equal to L*H*RR*DW,

where

L = reach length (ft)
H = bank height (ft)
RR = lateral erosion rate (ft/yr) and
DW = soil dry weight (tons/ft^3)

DW was determined from the county soil survey. H and L are given in the Fairfax County SPA. RR was also taken from the SPA, based on Michigan Department of Environment guidelines for estimating RR from visual survey of streambanks in **Table 3-7** (Steffen, 1982). This method of calculating streambank erosion is also implemented in STEPL, but FCDPWES chose to calculate streambank erosion outside of STEPL. The main difference from GWLF is that the lateral erosion rate is an annual rate based on visual inspection of stream banks, whereas the GWLF lateral erosion rate is a monthly rate that is a function of streamflow and a regression model relating the erosion rate to watershed characteristics.

Table 3-7: Guidelines for Visual Determination of Lateral Erosion Rate (Steffen, 1982)

Category	Description	Lateral Erosion Rate (ft/yr)
Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang. No exposed tree roots.	0.01-0.05
Moderate	Bank is predominantly bare with some rills and vegetative overhang.	0.06 - 0.2
Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.	0.3 - 0.5
Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and stream course or gully may be meandering.	0.5+

Table 3-8 summarizes the sediment loads reported in Appendix B to the Accotink Creek Watershed Management Plan. Streambank erosion is the dominant source of sediment in the Accotink Creek watersheds. As noted in the table, the watersheds derived from the Management Plan do not strictly correspond to the impairment watersheds.

Table 3-8: Streambank, and Total Sediment Loads (tons/yr) from the Accotink Creek Watershed Management Plan

Watershed	Streambank Erosion	Total Load
Accotink Creek near Annandale	11,729	13,001
Long Branch	2,674	2,986
Upper Accotink Creek[1](including Long Branch)	14,403	15,987
Lower Accotink Creek[2] (excluding upper Accotink Creek)	>3,519[3]	5,175

[1]Terminates at confluence of Accotink Creek and Long Branch, not inflow to Lake Accotink.
[2]Starts at confluence of Accotink Creek and Long Branch, and includes some tidal drainage in Ft. Belvoir.
[3]No estimate of streambank erosion in main base of Ft. Belvoir.

3.4 Development of GWLF Models of Upper Accotink Creek, Lower Accotink Creek, and Long Branch

Although the GWLF models of upper Accotink Creek, lower Accotink Creek, and Long Branch use the common parameter values and land sediment targets discussed in **Sections 3.2** and **3.3**, watershed–specific data is required to develop the specific models of each watershed. The following data is required for determining the individual GWLF models:

- Land use acreage
- Sediment delivery ratio
- USLE parameters for open space/forest
- Streambank erosion "a" factor
- BMPs
- Baseline point source loads

These are discussed in the following sections. The AllForX Method requires, in addition to the simulation of baseline conditions, the simulation of watershed sediment loads under all-forested conditions. Where the all-forest models require different inputs from the baseline models, the data for the all-forested models will also be presented below.

Calculation of the AllForX multiplier requires taking into account all the sediment loads upstream of the watershed outlet. For upper Accotink Creek, the GWLF models included Long Branch. The sediment loads from upper Accotink Creek, however, pass through Lake Accotink where they are subject to deposition. For this reason, GWLF models of lower Accotink Creek begin at the inlet to Lake Accotink. Upper Accotink Creek sediment loads are treated like a point source, after the sediment deposition losses in Lake Accotink are taken into account. The effect of Lake Accotink is discussed in **Section 3.4.7**.

TMDL allocations for downstream impaired watersheds do not include the contribution from upstream watersheds that contribute to them. In other words, the TMDL allocations for upper Accotink Creek do not include loads from Long Branch, and the TMDL allocations for lower Accotink Creek do not include loads from upper Accotink Creek and Long Branch.

3.4.1 Land Use

Model land use was based on the land use analysis described in **Section 2.1.4**. The only modification was to incorporate the current area under construction. Specific-construction projects are short-lived; however, it was assumed that the acreage of land under construction, based on total disturbed area in active permits shown in **Table 2-15** in **Section 2.2.4**, is typical of each watershed. Construction acreage was subtracted from the acreage of land classified in **Section 2.1.4** as pervious developed land, because open space in Accotink Creek is mostly forested park land not open to development. To accommodate the construction acreage, the acreage of pervious developed land was reduced in proportion to the area of each land use. **Table 3-9** shows the land use acreage for the baseline models for the impaired watersheds. In the all-forested models, as the name suggests, the only land use simulated is forest.

Table 3-9: Land Use in Baseline GWLF Models of Upper Accotink Creek, Lower Accotink Creek, and Long Branch

Type	Land Use	Upper Accotink (Acres)[1]	Lower Accotink (Acres)[2]	Long Branch (Acres)
Pervious	Commercial	486.26	959.77	12.60
	High Density Residential	1,511.88	505.99	2.41
	Industrial	1,265.38	695.15	1,062.09
	Low Density Residential	4,821.49	1,274.88	528.70
	Medium Density Residential	2,570.30	2,366.67	0.00
	Mixed	35.76	0.00	0.00
	Open Space	2,046.44	2,418.99	253.02
	Transportation	521.67	295.88	40.19
	Construction	319.30	265.24	4.60
Impervious	Commercial	894.83	485.16	9.97
	High Density Residential	738.86	266.07	0.48
	Industrial	477.30	812.24	72.07
	Low Density Residential	820.59	180.94	40.15
	Medium Density Residential	470.01	516.03	0.00
	Mixed	38.98	0.00	0.00
	Open Space	83.31	34.32	1.68
	Transportation	1,840.54	1,078.38	95.87
Total		**18,942.91**	**12,155.70**	**2,123.85**
Sediment Delivery Ratio		0.1238	0.1413	0.2277

[1]Includes Long Branch
[2]Excludes Upper Accotink Creek and Long Branch

3.4.2 Sediment Delivery Ratio

The sediment delivery ratio (SDR) was calculated using a formula found in MapShed (Evans and Corradini, 2014):

$$SDR = 0.451*A^{-0.298}$$

where

A is the area of the watershed in square kilometers.

The formula is intended to replicate the graphic representation of Vanoni (1975) recommended by the GWLF 2.0 documentation (Haith et al., 1992). Since SDR is a function of watershed area alone, the same value is used for the baseline and all-forest models; however, since developed land uses are simulated as end-of-pipe loads, the SDR is applied only to open space and land under construction in the baseline models. The SDR for each watershed model is shown in **Table 3-9**.

3.4.3 USLE Parameters

USLE is used under baseline conditions to simulate sediment losses from open space land. GWLF requires the product of the CKLSP factors as a model input. Open space was simulated as forest and, following the GWLF manual (Haith et al., 1992), the C factor was set 0.001. The P factor was set equal to 1. The K factor was calculated from the SSURGO soil data described in **Section 2.1.3** by intersecting soil types with the zoning information. The LS factor was calculated using a formula from Haith et al. (1992), originally from Wischmeier and Smith (1978):

$$LS = (0.045 * L)^b(65.41 * \sin^2 S + 4.56 * \sin S + 0.065)$$

where

S = inverse tangent of slope
L = slope length
b = factor that varies with slope

The percent slope was calculated using the NED described in **Section 2.1.1**. The slope length was calculated using the formula from Evans and Corradini (2014):

$$L = (0.5*A)/TSL$$

where

A = watershed area (km)
TSL = total length of streams in the watershed (m)

The factor b is = 0.5 for S >5%, b = 0.4 for 5% < S < 3%, b = 0.3 for 3% < S <1%, and b = 0.2 for S <1%.

Table 3-10 gives the USLE factors for open space under baseline conditions for each GWLF model in the Accotink Creek watershed. For the baseline conditions the topographic and soil properties were calculated on open space land, but for all-forested conditions the K and LS factors were calculated for the whole watershed. **Table 3-11** shows the USLE factors for the all-forest models.

Table 3-10: Baseline USLE Factors for Open Space for Accotink Creek GWLF Models

Watershed	C	K	LS	P	KLSCP
Upper Accotink	0.001	0.412086	1.385836	1.00	0.000571
Lower Accotink	0.001	0.354258	2.842788	1.00	0.001007
Long Branch	0.001	0.404373	1.15	1.00	0.000465

Table 3-11: All-Forest USLE Factors for Accotink Creek GWLF Models

Watershed	C	K	LS	P	KLSCP
Upper Accotink	0.001	0.454585	1.319951	1.00	0.0006
Lower Accotink	0.001	0.349487	1.815531	1.00	0.000635
Long Branch	0.001	0.46071	1.268818	1.00	0.000585

3.4.4 Streambank Erosion

The “a” factor used to calculate the lateral erosion rate described in **Section 3.1.2** was calculated for each individual watershed. Different values were calculated for baseline conditions and all-forested conditions. The formula for the “a” factor is

$$a = 0.00467 * PD + 0.000863 * AD + 0.000001 * CN + 0.000425 * KF + 0.000001 * MS - 0.000036$$

where

PD = fraction of developed land in watershed
AD = animal density in animal equivalent units
CN = average curve number
KF = average USLE K factor
MS = mean slope

The “a’ factor was calculated using the methods of Evans et al. (2003) to preserve the validity of the original regression. In particular, the average curve numbers were calculated from soil properties; they are not the calibrated curve numbers used in the model. **Table 3-12** gives the” a” factor for upper Accotink Creek, lower Accotink Creek, and Long Branch under baseline conditions, and **Table 3-13** gives the "a" factor under all-forested conditions. In addition, the default values for bank height (1.5 m) and bulk density (1,500 kg/m^3) which were used by Evans et al. (2003) to develop the original regression were also used in the Accotink Creek GWLF models.

Table 3-12: Baseline GWLF Streambank Erosion Factors

Factor	Upper Accotink	Lower Accotink	Long Branch
Fraction Developed Land	0.891968	0.801	0.896634
Animal Unit Density	0	0	0
Curve Number	78.14	76.51	78.10
K Factor	0.45	0.35	0.46
Slope	7.02	7.97	7.57
a	0.004408	0.003938	0.004433

Table 3-13: All-Forest GWLF Streambank Erosion Factors

Factor	Upper Accotink	Lower Accotink	Long Branch
Fraction Developed Land	0.0	0.0	0.0
Animal Unit Density	0.0	0.0	0.0
Curve Number	67.57	65.10	67.24
K Factor	0.45	0.35	0.46
Slope	7.02	7.97	7.57
a	0.000232	0.000186	0.000235

3.4.5 Best Management Practices

The baseline GWLF models represent current conditions. The simulation period, 1996-2015, is not intended to simulate historical conditions but to simulate current conditions under variable hydrology. Current conditions include BMPs installed prior to the end of 2015 in the Accotink Creek watershed which were reported and validated in DEQ's BMP Warehouse[6]. The major MS4 permittees—Fairfax County, VDOT, the City of Fairfax, and the Town of Vienna—provided information on historical BMP use as part of their annual reporting requirements. DEQ submits this information to the Chesapeake Bay Program (CBP) to help in the calibration of the Bay Program models. The jurisdictions reported the type of BMP, its location, the year it was installed, and usually the number of impervious acres treated, and either the number of pervious acres treated or the total number of acres treated. The Town of Vienna reported only total acres, not impervious acres. For the Town of Vienna, total acres were used instead of impervious acres in the calculations

[6] http://www.deq.virginia.gov/Programs/Water/ChesapeakeBay/ChesapeakeBayTMDL/BMPVerification.asp
.

described below. It was assumed that all BMPs installed in the watershed prior to 2015 are currently in operation.

The impacts of the installed BMPs were incorporated into the baseline GWLF models as follows: First the sediment reduction efficiency of each of type BMP reported was estimated from the literature. Sources of efficiency information included:

- Virginia TMDL Implementation Plan Guidance (DEQ, 2003)
- Chesapeake Bay Program (CBP, 2006)
- Chesapeake Bay Program Efficiencies (DEQ, 2015)
- Virginia Assessment Scenario Tool (VAST)
- International Stormwater BMP Database (ISBMP)
- Minnesota Pollution Control Agency (MPCA, 2015)
- Nashua Regional Planning Commission (NRPC)
- Pennsylvania Stormwater BMP Manual (PADEP, 2006)

Table 3-14 shows the sediment reduction efficiency for each type of BMP and the source of the estimate of the efficiency. The names of the types of BMPs in Table 3-14 may differ from the names of the types of BMPs submitted by the jurisdictions, because names of the types of BMPs in the BMP Warehouse must conform to the National Environmental Information Exchange Network (NEIEN) nomenclature.

Second, the location of each BMP was determined. For each BMP, the impaired watershed, the jurisdiction, and whether or not it was in the combined MS4 service area, shown in **Figure 2-8**, was identified. Third, the total effective impervious area treated was calculated by impairment, jurisdiction, and whether it was inside or outside the combined service area. The total effective impervious area is based on the product of the impervious area and BMP reduction efficiency summed for all BMPs in a defined area. It represents the equivalent amount of impervious area whose load is removed by BMPs. For example, if 100 acres are treated by a BMP with a reduction efficiency of 40%, that is equivalent to totally removing the sediment load from 40 acres of impervious land. The percent reduction from impervious area is the ratio of total effective impervious area to total impervious area. The percent reduction can be reported by impairment, jurisdiction, or service area. **Table 3-15** shows the percent reduction from impervious land loads by impairment and jurisdiction combined service area, since wasteload allocations for MS4s are aggregated by jurisdiction as described in **Section 4.2** under the MS4 subsection. **Table 3-15** also shows the percent reduction from areas outside of a combined service area, which are given by impairment only. To be conservative, BMP reductions were applied only to sediment loads from impervious surfaces, because runoff from pervious surfaces, which represents only a small fraction of total surface runoff, is more likely to occur under high flow storm events when BMPs are less effective .

Streambank restoration projects in Accotink Creek were not among the BMPs submitted to DEQ by the jurisdictions, so no BMP reductions were applied to streambank erosion in simulating current conditions in the Accotink Creek watershed.

Table 3-14: BMP Sediment Reduction Efficiencies

Unique BMP Names	Sediment Reduction Efficiency	Source(s)
Bioretention	85%	VA TMDL IP Guidance; CBP 2006
Bioretention A/B soils, underdrain	80%	CBP BMP Efficiencies (2015)
Bioretention C/D soils, underdrain	55%	CBP BMP Efficiencies (2015)
Bioswale	80%	CBP BMP Efficiencies (2015)
Dry Basin	10%	VAST; VA TMDL IP Guidance; CBP 2006
Dry Detention Ponds	10%	CBP BMP Efficiencies (2015)
Dry Detention Ponds and Hydrodynamic Structures	10%	CBP BMP Efficiencies (2015)
Dry Extended Detention Ponds	60%	CBP BMP Efficiencies (2015)
Dry Pond (Peak Shaver)	10%	VAST; VA TMDL IP Guidance; CBP 2006
Enhanced Extended Detention Dry Pond	60%	VAST
Erosion & Sediment Control	80%	International Stormwater BMP Database
Extended Detention Dry Basin	60%	CBP BMP Efficiencies (2015)
Extended Detention Dry Pond	60%	CBP BMP Efficiencies (2015)
Filter Strips	85%	VA TMDL IP Guidance
Filtering Practice	80%	CBP BMP Efficiencies (2015)
Filtering Practices	80%	CBP BMP Efficiencies (2015)
Hydrodynamic Structures	10%	CBP BMP Efficiencies (2015)
Impervious Urban Surface Reduction	85%	VA TMDL IP Guidance; CBP 2006; MPCA (2015)
Infiltration Basin	90%	VA TMDL IP Guidance
Infiltration Practice	95%	CBP BMP Efficiencies (2015)
Infiltration Practices w/ Sand, Veg	95%	CBP BMP Efficiencies (2015)
Infiltration Practices w/o Sand, Veg	95%	CBP BMP Efficiencies (2015)
Infiltration Trench	90%	VA TMDL IP Guidance
Parking Lot Detention	48%	EPA 1999
Paved Swale	89%	EPA 1999
Permeable Pavement	85%	PA Stormwater BMP Manual
Permeable Pavement w/ Sand, Veg. C/D soils, underdrain	55%	CBP BMP Efficiencies (2015)
Rooftop Detention	100%	PA Stormwater BMP Manual, BMP 6.5.2
Tree Box Filter	82%	Nashua Regional Planning Commission
Underground Detention	10%	CBP 2006
Underground Infiltration System	90%	CBP 2006
Vault	10%	CBP 2006
Vegetated Roof (Extensive)	85%	MPCA (2015)
Vegetated Roof	85%	MPCA (2015)
Vegetated Swale	85%	CBP 2006
Wet Basin	60%	VAST
Wet Pond	60%	CBP BMP Efficiencies (2015)
Wet Ponds and Wetlands	60%	CBP BMP Efficiencies (2015)

Table 3-15: BMP Effective Impervious Area and Sediment Reductions

Impairment	Inside/Outside Service Area	Effective Treated Impervious Area (acres)	Total Impervious Area (acres)	Percent Reduction
Upper Accotink Creek	City of Fairfax Aggregated MS4 Service Area	328.41	1,215.65	27%
	Fairfax County Aggregated MS4 Service Area	161.95	2,339.10	7%
	Town of Vienna Aggregated MS4 Service Area	47.78	324.41	15%
	Outside MS4 Service Area	237.17	936.92	25%
Lower Accotink Creek	Fairfax County Aggregated MS4 Service Area	211.99	2,231.55	9%
	Fort Belvoir	115.88	253.47	46%
	Outside MS4 Service Area	512.67	888.10	58%
Long Branch	City of Fairfax Aggregated MS4 Service Area	2.30	22.49	10%
	Fairfax County Aggregated MS4 Service Area	15.48	465.01	3%
	Outside MS4 Service Area	7.35	56.69	13%

3.4.6 Loads from Permitted Process Water Dischargers

Sediment loads in process water from permitted dischargers were included in the baseline models. Sediment loads in discharges from facilities with industrial stormwater permits or loads from outfalls that were predominately stormwater are presumably already captured by loads from industrial land uses were not estimated for baseline calculations. Discharges from the four bulk terminal storage operations with individual permits (VA0001872, VA0002283, VA0001945, and VA0001988) as well as discharges from outfall 002 of the concrete production facility VAG110069 predominately discharge stormwater.

Baseline sediment loads in process water discharges were calculated from discharge monitoring reports (DMRs) required under the facilities' permits. Baseline loads from facilities which are not required to report flow and sediment concentrations in DMRs were assumed to be relatively small and not included in baseline load calculations. Discharges from car washes and single family homes fall into this category.

Only two concrete production facilities had available monitoring data and both of these were in the lower Accotink Creek watershed. Data was used only from months in which both sediment concentrations and flow rates were reported. Calculations were performed by outfall. **Table 3-16** shows the average annual sediment loads in process water by facility. The permit for the third concrete product facility in the watershed, VAG110355, is a new permit and no monitoring data was available for that facility.

Process water loads were not included in the all-forest models.

Table 3-16: Average Annual Process Water Sediment Loads in the Accotink Creek Watershed

Permit	Facility	Outfall	Sediment (ton/yr)
VAG110046	Virginia Concrete, Newington Plant	001	0.24
VAG110069	VA Concrete Co - Mid Atlantic Materials-Newington	001	0.08
Total Lower Accotink			**0.32**

3.4.7 Lake Accotink Trapping Efficiency

The lower Accotink Creek watershed is represented as a separate watershed, starting downstream of the inlet to Lake Accotink. Loads from upper Accotink Creek are input into the lower Accotink Creek like a point source and in that way included in the representation. An average trapping efficiency is applied to the loads from upper Accotink Creek to account for sediment losses in Lake Accotink. The trapping efficiency is also applied to sediment loads from land uses and stream bank erosion in the portion of the lower Accotink Creek watershed draining to the lake.

On behalf of the Fairfax County Park Authority, Wetland Studies and Solutions, Inc. (WSSI) provided an estimate of the average annual trapping efficiency of Lake Accotink over the GWLF simulation period of 1996-2015 (WSSI, 2016). According to WSSI, the average trapping efficiency of Lake Accotink is 47%. WSSI used the method previously employed by HDR Engineering in their study of Lake Accotink trapping efficiency for the period 1986-2000 (HDR, 2002). The method is based on an annual application of Brune's Curve, which relates sediment trapping efficiency to the ratio of lake volume to annual inflow (Brune, 1953). Annual flows for 1996-2015 were obtained from the USGS gauge on Accotink Creek near Annandale (01654000), and area-adjusted to the drainage area at the lake inlet. The volume of sediment entering the lake was determined using methods employed in the 2002 HDR study and used to adjust the lake volume on an annual basis. Predicted lake volume compared favorably with the bathymetric surveys taken in 2001, 2011, and 2015.

3.5 Summary of Average Annual Baseline Loads, All-Forest Loads, and Sediment TMDLs

This section summarizes the results of the GWLF models of the Accotink Creek watershed. **Section 3.5.1** compares simulated average annual sediment loads from the GWLF models with estimated sediment loads from the regression models and estimated loads calculated for the Accotink Creek Watershed Management Plan. On the basis of this comparison, simulated loads from Long Branch were adjusted to bring them more in line with the other estimates. **Section 3.5.2** present the average annual baseline sediment loads by source, all-forest loads, the AllForX multiplier, and the average annual sediment TMDL for Long Branch, upper Accotink Creek, and lower Accotink Creek.

3.5.1 Comparison of Sediment Load Estimates

Figure 3-9 compares average annual sediment loads from the four GWLF models to estimated average annual sediment loads from the regression models discussed in **Section 3.3.3** and annual sediment loads estimated for FCDPWES's Accotink Creek Watershed Management Plan, discussed in **Section 3.3.4**. For each watershed, the loads from the regression models and the Watershed Management Plan are expressed as a percent of the corresponding load from GWLF, to facilitate the comparison. This comparison was prepared to gauge the relative agreement of the four GWLF model estimates of baseline loads. Given the differences in method, there is reasonable agreement in the estimates for all watersheds except Long Branch, where the average annual load from GWLF is about five times smaller than the estimated load from the regression model and almost four times smaller than the estimated load from the Watershed Management Plan.

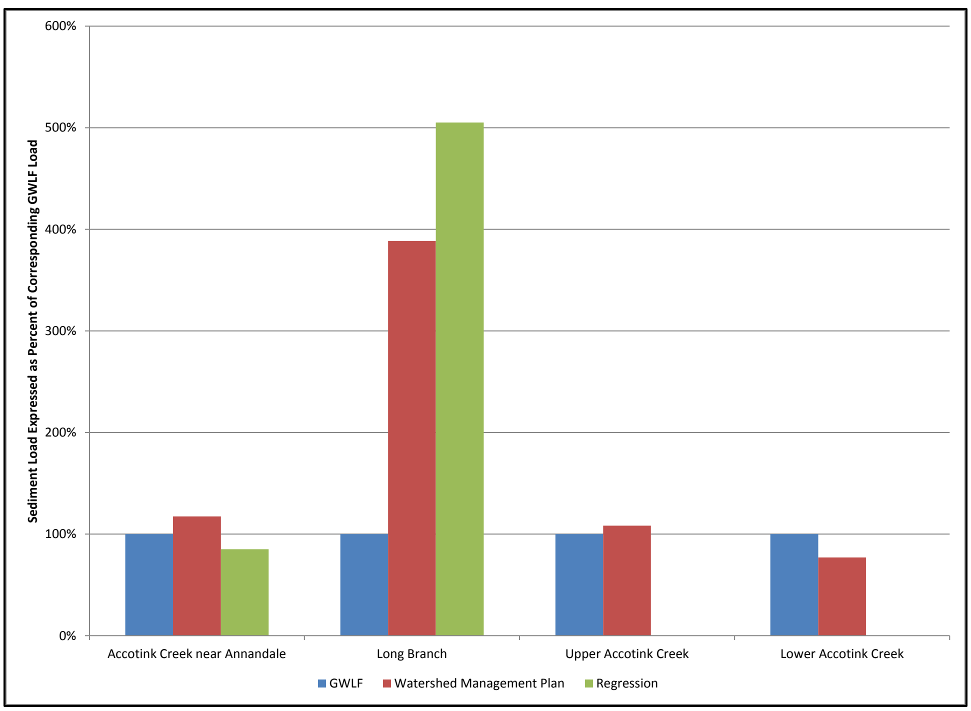


Figure 3-9: Comparison of Sediment Load Estimates in Accotink Creek Watershed

The difference between the Watershed Management Plan's estimate and GWLF for Long Branch seems to reside in their estimates of streambank erosion. For Long Branch, GWLF estimates that the average annual sediment load from land-based sources is 282 tons/yr, which is comparable to the estimate of land-based sources in the Watershed Management Plan of 312 tons/yr (assuming, that is, that the land-based load in the Management Plan can be identified with the difference between total load and streambank erosion). The GWLF streambank erosion rate, on the other hand, is over five times smaller than the erosion rate calculated for the Management Plan.

To bring the GWLF loads for Long Branch into line with the other estimates, the streambank erosion rate in Long Branch was adjusted so that the average annual load equals the adjusted average annual load estimated by the regression model. This is tantamount to calibrating the Long Branch “a” factor against the estimated loads. The streambank adjustment factor for Long Branch was 7.45.

The streambank adjustment factor was also applied to streambank erosion loads under the all-forested conditions. By applying the adjustment factor under all-forested conditions, Long Branch’s share of the total streambank load in upper Accotink Creek remains about the same. When the adjustment factor is applied, Long Branch’s share of total streambank erosion is about 30% under both baseline conditions and all-forested conditions. If the adjustment factor were not applied under all-forested conditions, Long Branch’s share of total streambank erosion would be about 4%, making it difficult to account for the source of streambank erosion in upper Accotink Creek watershed under all-forest conditions.

3.5.2 Average Annual Baseline Sediment Loads, All-Forest Loads, and TMDLs

Average annual baseline loads were simulated based on the sediment calibration targets discussed in **Section 3.3**, the watershed-specific land use (**Section 3.4.1**), model parameters (**Sections 3.4.2-3.4.4**), BMP reductions in loads from impervious land (**Section 3.4.5**), and regulated process water loads (**Section 3.4.6**). All-Forest loads were simulated with a single land use, forest, and the watershed-specific parameters in **Sections 3.4.2** through **3.4.4**. No point sources or BMPs are simulated under all-forested conditions. All simulations used the calibrated hydrology parameters from **Section 3.2**.

The ratio of average annual sediment loads under baseline conditions to sediment loads under all-forested conditions is the AllForX multiplier. As shown in **Appendix A**, AllForX multipliers from the Accotink Creek watershed were used to calculate a threshold AllForX multiplier. The threshold AllForX multiplier is the multiplier that is projected to achieve a VSCI score of 60, and thus meet Virginia’s water quality standards for supporting aquatic life. As shown in **Appendix A**, the AllForX threshold is 5.07, which means sediment loads can be a little more than five times the All-Forest loads and meet the standards for supporting aquatic life. The average annual TMDL is the load with the AllForX value equal to this threshold. In other words, the TMDL is equal to the product of the All-Forest load and 5.07.

Table 3-17 presents the average annual baseline sediment loads by source for Long Branch. The streambank adjustment factor, discussed in the previous section, has been applied to streambank erosion loads under baseline conditions and all-forested conditions. **Figure 3-10** represents each source's share of the total load with commercial, low density residential, medium density residential, and high density residential sources lumped under Other Developed. As **Figure 3-10** demonstrates, streambank erosion accounts for most of the sediment load in Long Branch.

Table 3-17: Average Annual Baseline Sediment Loads, All-Forest Loads, and TMDL for Long Branch

Source	Average Annual Sediment Load (tons/year)	Percent Baseline
Construction	2	<1%
Commercial	10	<1%
Transportation	121	3%
Low Density Residential	95	2%
Medium Density Residential	52	1%
High Density Residential	0.5	<1%
Open Space	7	<1%
Streambank[1]	3,595	93%
Permitted Process Water	0	0%
Total	3,882	100%
All-Forest[1]	226	6%
AllForX Multiplier	17.16[2]	NA
AllForX Threshold	5.07[2]	NA
TMDL	1,148	30%

[1]Streambank Adjustment Factor Applied
[2] Unitless ratio (not in tons/year)

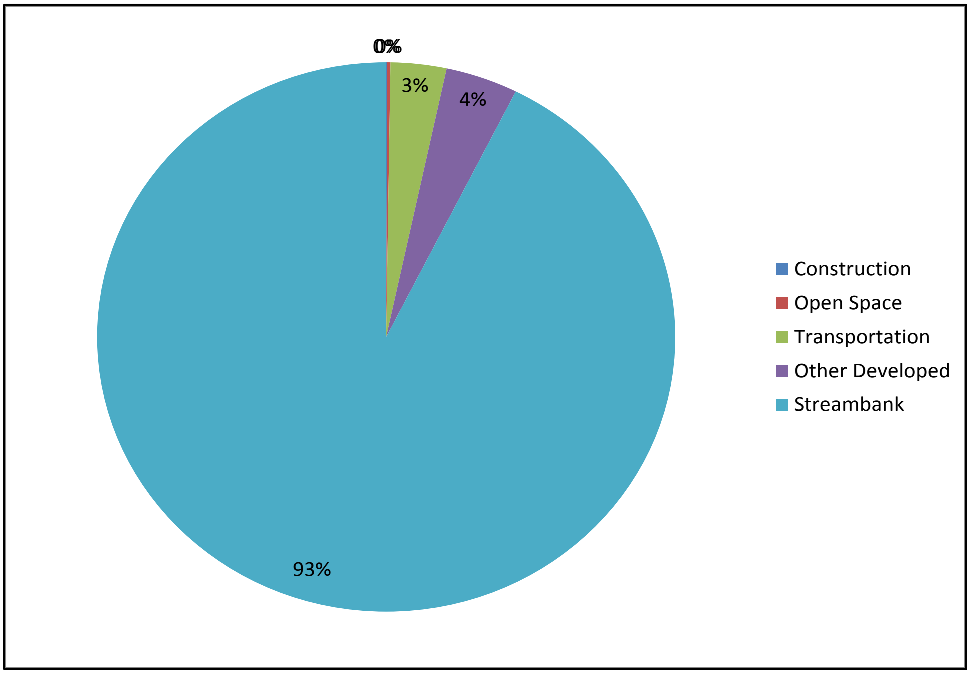


Figure 3-10: Contribution of Sources to Sediment Load in Long Branch

Under All-Forest conditions, the total load is only 6% of the total baseline average annual load. The AllForX multiplier is 17.16. It will require a reduction in sediment loads of 70%, or an average annual sediment TMDL of 1,148 tons/yr, to meet the AllForX threshold in Long Branch.

Table 3-18 presents the average annual baseline sediment loads by source for upper Accotink Creek. **Figure 3-11** represents each source's share of the total load with commercial, industrial, mixed, low density residential, medium density residential, and high density residential sources lumped under Other Developed. As **Figure 3-11** shows, about a quarter of the sediment in upper Accotink Creek comes from Long Branch. When Long Branch loads are included eighty-four percent of the sediment load in upper Accotink Creek comes from streambank erosion.

Table 3-18: Average Annual Baseline Sediment Loads, All-Forest Loads, and TMDL for Upper Accotink Creek

Source	Average Annual Sediment Load (tons/year)	Percent Baseline[1]
Construction	83	1%
Commercial	293	2%
Industrial	103	1%
Transportation	750	5%
Mixed	13	<1%
Low Density Residential	351	2%
Medium Density Residential	220	1%
High Density Residential	295	2%
Open Space	52	<1%
Streambank	8,813	59%
Permitted Process Water	0	0%
Baseline Load (excluding Long Branch)	10,974	74%
Long Branch	3,882	26%
Total Baseline Load (including Long Branch)	14,856	100%
All-Forest	811	5%
AllForX Multiplier	18.31[2]	NA
AllForX Threshold	5.07[2]	NA
TMDL (including Long Branch)	4,116	28%
TMDL	2,969	20%

[1]Including Long Branch
[2] Unitless ratio (not in tons/year)

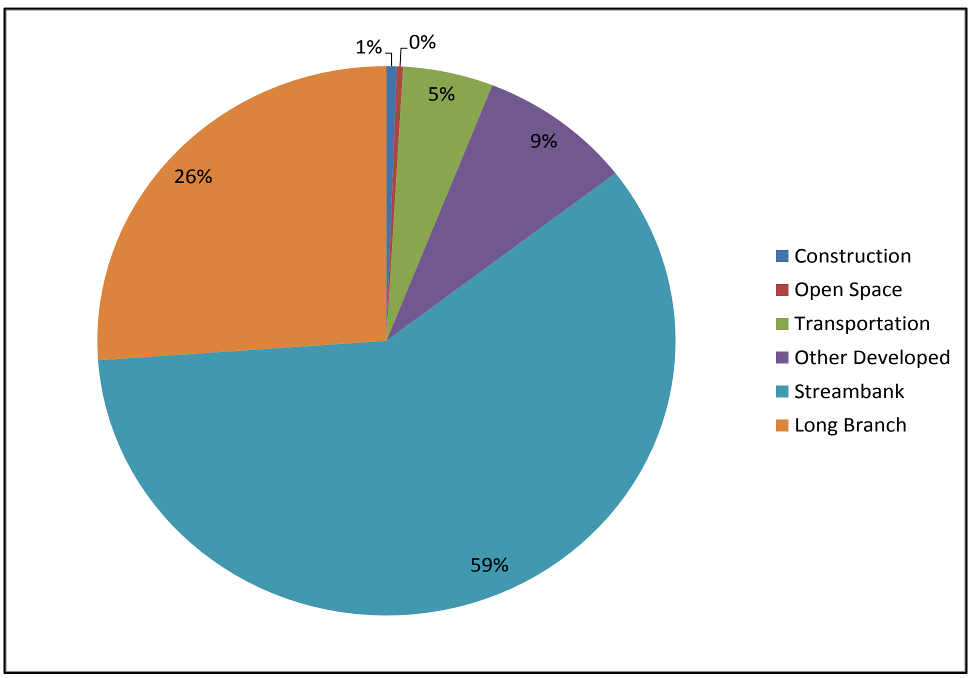


Figure 3-11: Contribution of Sources to Sediment Load in Upper Accotink Creek

Under All-Forest conditions, the total load is only 5% of the total baseline average annual load. The AllForX multiplier is 18.31. Including Long Branch, it will require a reduction in sediment loads of 72%, or an average annual sediment TMDL of 4,116 tons/yr, to meet the AllForX threshold in upper Accotink Creek. TMDL allocations will be based on upper Accotink Creek loads excluding Long Branch. Excluding Long Branch, the average annual sediment TMDL load is 2,969 tons/yr, or a 73% reduction from baseline conditions that do not include Long Branch basline loads.

Lower Accotink Creek was simulated as a watershed distinct from upper Accotink Creek. Loads from upper Accotink Creek were introduced into lower Accotink Creek as a separate source, subject to a reduction of 47% to account for sediment trapping in Lake Accotink, as described in **Section 3.4.7**. Sediment loads from the portion of the lower Accotink Creek watershed that drains to Lake Accotink were also subject to this reduction.

Table 3-19 presents the average annual baseline sediment loads by source for lower Accotink Creek. **Figure 3-12** represents each source's share of the total load with commercial, industrial, low density residential, medium density residential, and high density residential sources lumped under Other Developed. As **Figure 3-12** shows, more than half the sediment in lower Accotink Creek comes from upper Accotink Creek. Thirty-six percent of the sediment load in lower Accotink Creek comes from streambank erosion originating in the lower Accotink Creek watershed. Overall, including the loads from upper Accotink Creek, 82% of the sediment load in lower Accotink Creek comes from streambank erosion.

Table 3-19: Average Annual Baseline Sediment Loads, All-Forest Loads, and TMDL for Lower Accotink Creek

Source	Average Annual Sediment Load (tons/year)	Percent Baseline[1]
Construction	79	1%
Commercial	156	1%
Industrial	245	2%
Transportation	460	3%
Low Density Residential	75	1%
Medium Density Residential	205	1%
High Density Residential	88	1%
Open Space	75	1%
Streambank	5,322	37%
Point Sources	<1	<1%
Baseline Load (excluding Upper Accotink Creek)	6,706	46%
Upper Accotink Creek	7,874	54%
Total Baseline Load (including Upper Accotink Creek)	14,579	100%
All-Forest Load	1,241	9%
AllForX Multiplier	11.75[2]	NA
AllForX Threshold	5.07[2]	NA
TMDL (including upper Accotink Creek)	6,294	43%
TMDL	4,113	28%

[1]Including upper Accotink Creek
[2] Unitless ratio (not in tons/year)

Under All-Forest conditions, the total load is only 9% of the total baseline average annual load. The AllForX multiplier is 11.75. Including upper Accotink Creek, it will require a reduction in sediment loads of 57%, or an average annual sediment TMDL of 6,294 tons/yr, to meet the AllForX threshold in lower Accotink Creek. TMDL allocations will be based on lower Accotink Creek loads excluding the loads from upper Accotink Creek. Excluding upper Accotink Creek, the average annual sediment TMDL load is 4,113 tons/yr, or a 39% reduction from baseline conditions that do not include upper Accotink Creek basline loads. This 39% reduction from baseline conditions is lower than the reductions necessary for Long Branch and Upper Accotink Creek due to the 47% trapping efficiency of Lake Accotink that was discussed in **Section 3.4.7.** TMDL allocations in **Chapter 4** are based on these assumptions. While the TMDL does not prescribe that the Lake will be maintained exactly as has been done in the past, it does assume that there will be an average sediment removal of 47% provided by dredging, or an equivalent management practice.

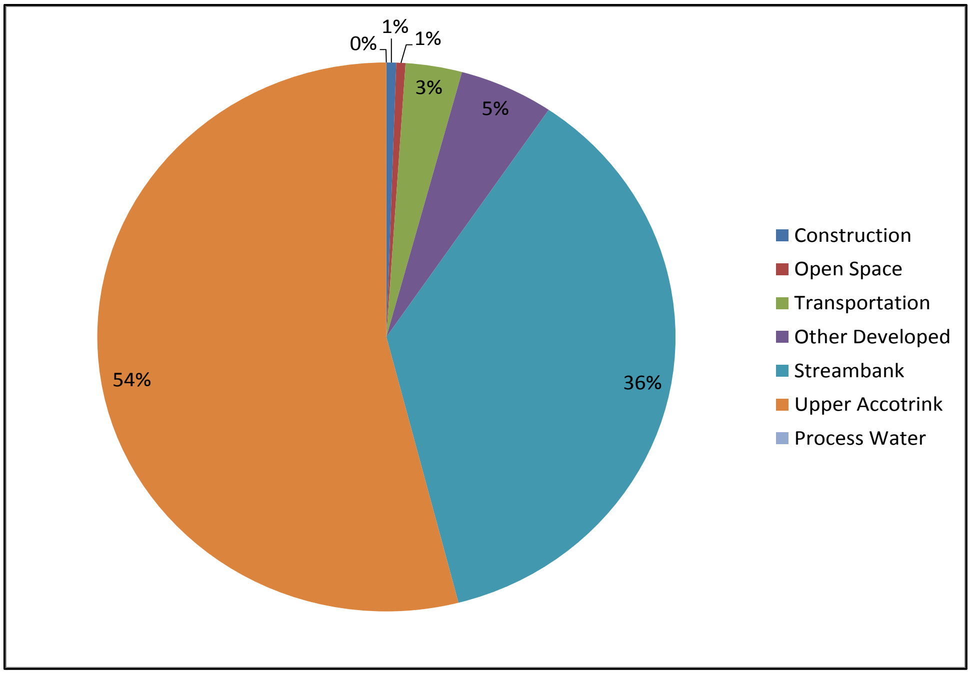


Figure 3-12: Contribution of Sources to Sediment Load in Lower Accotink Creek

4 TMDL Allocations

A TMDL is the amount of pollutant a waterbody can assimilate and still meet water quality standards. According to EPA regulations (CFR 130.2, 130.7), the TMDL must be assigned or allocated among regulated and non-regulated sources, according to the following equation:

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

where

WLA = Wasteload Allocation, which is the portion of the TMDL assigned to regulated or permitted sources;
LA = Load Allocation, which is the portion of the TMDL assigned to non-regulated sources
MOS = Margin of Safety

Each of the components of the TMDL is discussed in more detail below.

4.1 Margin of Safety

A MOS is necessary to take into account the uncertainty in the relation between pollutant loading rates and water quality. The MOS can be implicit or explicit. An implicit MOS is based on the conservative assumptions used to determine the TMDL. An explicit MOS reserves a portion of the TMDL to the MOS. A 10% explicit margin of safety was used in addressing the sediment impairments in Accotink Creek.

4.2 Wasteload Allocation

Wasteload allocations are assigned to regulated, point source discharges. DEQ issues Virginia Pollutant Discharge Elimination System (VPDES) permits for all point source discharges to surface waters, to dischargers of stormwater from Municipal Separate Storm Sewer Systems (MS4s), and to dischargers of stormwater from Industrial Activities. DEQ issues Virginia Stormwater Management Program (VSMP) permits to dischargers of stormwater from Construction Activities. There are two broad types of discharge permits; individual permits and general permits.

DEQ issues individual permits to both municipal and industrial facilities. Permit requirements, special conditions, effluent limitations and monitoring requirements are determined for each facility on a site specific basis in order to meet applicable water quality standards. General permits are written for a general class of dischargers where operations and activities are similar. These permits are also prepared to protect and maintain applicable water quality standards. In Virginia, general permits are adopted as regulations.

Within the Accotink Creek watershed, there are seven individual permits authorizing discharges to surface waters. Five of the individual permits are classified as industrial discharges. Four of these permits govern the discharges from bulk petroleum storage facilities. One permit governs the industrial stormwater discharges from Fort Belvoir. Lastly, there are two individual permits issued to Municipal Separate Storm Sewer Systems (MS4) which govern the stormwater discharges from municipal operations. Fairfax County currently has an individual permit; it is anticipated that the Virginia Department of Transportation will have an individual permit by the completion of this TMDL study.

There are discharges from eight general permit categories authorized in the Accotink Creek watershed. These include:

- three (3) Vehicle Wash and Laundry facilities;
- one (1) Non-contact Cooling Water permittees;
- three (3) Concrete Products Facilities;
- two (2) permittees under the Domestic Sewage Discharge of Less Than or Equal to 1,000 Gallons per Day;
- two (2) facilities authorized under the permit for Petroleum Contaminated Sites and Hydrostatic Tests;
- 12 permits for Discharges of Stormwater Associated with Industrial Activity;
- numerous transitory permits for stormwater discharges associated with land disturbance or construction activities;
- five (5) MS4 general permits issued to either small or non-traditional MS4 entities.

Not all of the authorized general permit discharges are considered to discharge the pollutant of concern (e.g. sediment) in significant amounts which may cause or contribute to the impairments in the Accotink Creek watershed. Accordingly, insignificant discharges are not assigned wasteload allocations. Additionally, there is a distinction recognized throughout this document that authorized discharges may result from stormwater (e.g. precipitation) and/or process water. An example of a process water discharge is that resulting from the mixing and preparing of concrete products, or the blow-down from a heating and air conditioning ventilation system. These discharges are not related to a storm event.

The following sources will receive sediment wasteload allocations:

- Municipal separate storm sewer systems (MS4s) discharges authorized under both individual and general permits;
- Individual VPDES permitted facilities;
- Industrial stormwater discharges authorized under the general permit as contained in 9VAC25-151 (VAR05) - Discharges of Stormwater Associated with Industrial Activity;
- Concrete product facilities authorized to discharge under the general permit 9VAC25-193 (VAG11) - Concrete Products Facilities;
- Carwash facilities authorized to discharge under the general permit 9VAC25-194 (VAG75) - Vehicle Wash and Laundry Facilities;
- Domestic sewage discharges less than 1000 gallons per day authorized under 9VAC25-110 (VAG40) - Domestic Sewage Discharges of Less Than or Equal To 1,000 Gallons Per Day;
- Stormwater discharges associated with land disturbance, or construction activities, authorized under 9VAC25-880 - General VPDES Permit for Discharges of Stormwater from Construction Activities.

Note that the regulatory citations for the general permits noted above are current as of the preparation of this TMDL. The established WLA for each facility is applicable to the regulated discharge(s) and shall remain valid should the regulatory citation for a given permit category be updated or changed in the future.

Not all of the authorized general permit discharges are considered to discharge the pollutant of concern (e.g. sediment) in significant amounts which may cause or contribute to the impairments in the Accotink Creek watershed. Accordingly, insignificant discharges are not assigned wasteload allocations. For this TMDL, sediment discharges from the general permit categories of non-contact cooling water discharges as well as petroleum contaminated sites and hydrostatic discharges are considered to be insignificant. These pollutants are not governed in either of these general permit categories as they are not considered to have a reasonable potential to cause or contribute to excursions of water quality standards. This TMDL study acknowledges and concurs with these findings.

Individual Permits Governing Discharge from Petroleum Bulk Storage Operations. The discharges associated with bulk terminal operations include both stormwater-derived discharges as well as process water discharges. These discharges are generally controlled, or managed, through containment areas and/or stormwater ponds. The allocations are based on (1) a maximum total suspended solids (TSS) concentration of 60 mg/l and (2) average daily flow rates reported in permit documentation, which including the permit application, fact sheet, permit and monthly Discharge Monitoring Reports (DMRs).

Individual and General Industrial Stormwater Permits. Allocations for facilities discharging stormwater exposed to industrial activity under an individual permit or the general industrial stormwater permit were based on (1) a benchmark concentration of 100 mg/l, and (2) simulated runoff in the drainage area of their outfalls. Simulated runoff was based on pervious and impervious area in outfalls and average annual runoff per acre for developed pervious and impervious land, taken from the GWLF hydrology simulation. Runoff was calculated in the same way for the individual stormwater permit for Fort Belvoir, and a benchmark concentration of 100 mg/l was also used to calculate the allocation.

Car Wash General Permits. The sediment allocations for the three general car wash permit in the watershed were calculated using a maximum permitted concentration of 60 mg/l and assumed average discharges of 0.001 MGD, 0.00004 MDG, and 0.001 MGD for VAG750226, VAG750238, and VAG750255, respectively.

Concrete Product General Permits. The allocations for concrete facilities were made by outfall, depending on whether stormwater or process water (or both) were discharged through the outfall. For VAG110046, the only outfall discharges process water. The allocation was calculated from a permitted average concentration of 30 mg/l and an average daily flow of 0.00728 MGD. For VAG110069, outfall 001 discharges process water and outfall 002 discharges stormwater. The stormwater discharge was calculated using a concentration of 100 mg/l and simulated runoff from GWLF. The allocation for the process water discharge was based on the permitted average concentration of 30 mg/l and an average daily flow of 0.008 MGD. For VAG110355, there is a single outfall (001) discharging process water comingled with stormwater. Since the majority of process water is reused, the allocation was based on simulated runoff from GWLF and the process water permitted average concentration of 30 mg/l.

Domestic Sewage Discharges General Permits. The sediment allocations for the two single family homes discharging sewage under a general permit were calculated using a maximum permitted concentration of 30 mg/l and a maximum permitted flow of 1000 gallons a day (0.001 MGD).

<u>Construction</u>. As described in **Section 3.3.2**, the baseline loads for land under construction represent implementation of current erosion and sediment controls, adjusted for the occurrence of precipitation events in which the controls are not effective. No additional reductions to loads for land under construction were required, so the WLA for land under construction was set equal to the baseline load. It was assumed that the current rate of land disturbance activities is the best estimate of the long-term rate; otherwise, the allocation for land under construction is not necessarily associated with current permits.

Table 4-1: Summary of Basis for Calculating Allocations for Permitted Facilities

Permit Type	Concentration (mg/l)	Type of Concentration Value	Flow
Individual Permit – Process Water or Managed Discharges (Bulk Terminals)	60 mg/l	Maximum permitted concentration	Permit Documentation
Individual Permit – Industrial Stormwater Discharges (Fort Belvoir)	100 mg/l	Benchmark concentration	GWLF Model Flows
General Industrial Stormwater Permit	100 mg/l	Benchmark concentration	GWLF Model Flows
Car Wash Process Water	60 mg/l	Maximum permitted concentration	Reported Average Flows
Concrete Process Water	30 mg/l	Average permitted concentration	Average DMR Flows
Concrete Stormwater	100 mg/l	Benchmark concentration	GWLF Model Flows
Concrete Comingled Process and Stormwater	30 mg/l	Average permitted concentration	GWLF Model Flows[1]
Domestic Sewage Discharge	30 mg/l	Maximum permitted concentration	Maximum permitted flow

[1]The majority of the process water is reused

<u>MS4s</u>. For each impairment, all of the MS4s within a jurisdiction receive an aggregated allocation. This reflects the fact that MS4 service areas overlap to a great extent, as was illustrated by **Figure 2-7** in **Section 2.2.3**.

The aggregated jurisdictional MS4 was determined by first calculating the overall percent reduction required to meet the TMDL after the MOS, Construction WLA, and Process Water WLA are accounted for. The overall percent reduction required from MS4s among other sources was calculated as follows:

1. Calculate Remaining Allocation (RA) =
   TMDL – MOS –Construction WLA –WLAs for Process Water;
2. Percent of Remaining Allocation (PRA) =

$$\frac{\text{RA}}{\text{Total Baseline Load} - \text{Construction Baseline Load} - \text{Baseline Load for Process Water}}$$

The percent reduction required on the remaining sources is 1 – PRA. The baseline load from the area in a jurisdiction covered by the combined service areas of the MS4s was then multiplied by percent of the remaining sources allocated, calculated above, and any industrial stormwater allocations from facilities within the combined service area in that jurisdiction were subtracted from the product, to obtain the final aggregated MS4 WLA for that jurisdiction. In other words

3. MS4 Allocation = PRA*MS4 Baseline Load – Industrial Stormwater Allocation within combined service area

Baseline loads within a combined service area were determined from the GWLF model simulation. Land-use loads were determined using the acreage of land use in the combined service area. Construction loads were excluded from MS4 baseline loads, because the WLA for land under construction applies to not just current but future land disturbance activity and therefore it cannot be determined whether that activity will take place inside of a service area. Sediment loads from streambank erosion were allocated to MS4s (or to the LA) in proportion to the percent of the total impervious surface in the impaired watershed that was in the combined service area in each jurisdiction. Impervious area, rather than total area, was used because impervious surfaces are primarily responsible for the increased magnitude and frequency of peak flow events which reshape stream channels in developed areas. **Table 4-2** gives the percent of each impaired watershed's impervious area that is in the combined service area for each jurisdiction.

Table 4-2: Percent of Impervious Area in Impaired Watersheds within MS4 Combined Service Area by Jurisdiction

Jurisdiction	**Upper Accotink Creek**	**Lower Accotink Creek**	**Long Branch**
City of Fairfax	25.2%	NA[1]	4.1%
Fairfax County	48.6%	66.2%	85.4%
Fort Belvoir	NA[1]	7.5%	NA[1]
Town of Vienna	6.7%	NA[1]	NA[1]
Outside Combined MS4 Service Area	19.5%	26.3%	10.4%
Total	100.0%	100.0%	100.0%

[1] NA: Not Applicable. No portion of jurisdiction is within impaired watershed.

Table 4-3 gives the RA, PRA, and WLA for the aggregated MS4s.

Table 4-3: Remaining Allocation (RA), Percent of Remaining Allocation (PRA), and Wasteload Allocations for Aggregated MS4s

Impairment	Remaining Allocation (tons/yr)	Percent of Remaining Allocation	Jurisdiction	Aggregate WLA (tons/yr)
Upper Accotink Creek	2,589	24%	City of Fairfax	634
			Fairfax County	1,282
			Town of Vienna	174
Lower Accotink Creek	3,621	55%	Fairfax County	2,457
			Fort Belvoir	235
Long Branch	1,031	27%	City of Fairfax	42
			Fairfax County	880

Future Growth. In the upper Accotink Creek and lower Accotink Creek watersheds, future growth was accounted for by setting aside 5% of the TMDL for the creation of new point sources and any growth in MS4 service areas or other regulated stormwater. A future growth of 5% was chosen due to the large proportion of these watersheds that are already covered by MS4 service areas and the anticipated expansion in regulated stormwater. However, in the Long Branch watershed, since there is little room for MS4s or other regulated stormwater to grow, a future growth of 1% of the TMDL was used to account for any future growth in point sources. Most of these watersheds are highly developed. Therefore, any potential expansion of an MS4 service area or other regulated stormwater would not likely entail a change in existing land-use. Rather, it would simply be a reallocation of loadings from the LA portion of the TMDL to the WLA component. Accordingly, in all three watersheds the future growth was taken from the LA and provides flexibility to the permitting authority to implement changes to regulated stormwater as they occur over time.

4.3 Load Allocation

The load allocation primarily covers loads from areas outside either MS4 service areas or the drainage areas to industrial stormwater outfalls. The formula for the LA is

$$LA = TMDL - MOS - WLA$$

4.4 Allocations for Individual Impairments

Table 4-4 provides a summary of the sediment TMDL, MOS, WLAs, and LA for upper Accotink Creek. **Table 4-5** gives the average annual baseline MS4 loads, aggregated MS4 WLAs, and MS4 percent reduction from baseline conditions. **Table 4-6** gives the wasteload allocations for facilities for permitted process water and permitted stormwater. **Table 4-7** gives the average annual baseline loads from nonregulated lands by source type, in addition to the LAs and percent reduction from baseline conditions by source type.

Table 4-4: Upper Accotink Creek Average Annual TMDL Allocations

Source	Load (tons/yr)	Percent of TMDL
Total WLA	**2,338**	79%
City of Fairfax Aggregate MS4 WLA	634	21%
Fairfax County Aggregate MS4 WLA	1,282	43%
Town of Vienna Aggregate MS4 WLA	174	6%
Total Process Water WLA	<1	<1%
Total Industrial Stormwater WLA	16	1%
Construction	83	3%
Future Growth	148	5%
LA	**334**	11%
MOS	**297**	10%
TMDL (not including Long Branch)	**2,969**	100%
Long Branch Upstream TMDL	1,148	NA[1]
Total TMDL (including Long Branch)	4,116	NA[1]

[1]Not Applicable

Table 4-5: Upper Accotink Creek Aggregated MS4 Wasteload Allocations

Jurisdiction	Permit No	Facility Name	Baseline Load (tons/yr)	WLA (tons/yr)	Percent Reduction
Fairfax County	VA0088587	Fairfax County	5,394	1,282	76%
	VA0092975	Virginia Department of Transportation			
	VAR040095	Northern Virginia Community College			
	VAR040104	Fairfax County Public Schools			
City of Fairfax	VA0092975	Virginia Department of Transportation	2,667	634	76%
	VAR040064	City of Fairfax			
Town of Vienna	VA0092975	Virginia Department of Transportation	733	174	76%
	VAR040066	Town of Vienna			

Table 4-6: Upper Accotink Creek Sediment Permitted Stormwater Water and Process Water Wasteload Allocations

Type	Permit No	Facility Name	Annual (tons/yr)	Daily (tons/d)
Individual[1]	VA0001872	Joint Basin Corporation – Fairfax Terminal Complex	9.14	0.426
Individual[1]	VA0002283	Motiva Enterprises LLC - Fairfax	4.39	0.245
General[1]	VAR051770	Fairfax County - Jermantown Maintenance Facility	1.22	0.020
General[1]	VAR051066	USPS Merrifield Vehicle Maintenance Facility	0.94	0.015
General[1]	VAR052188	Milestone Metals	0.70	0.011
General Car Wash[2]	VAG750226	Enterprise Rent-A-Car- 3055 Nutley St	0.09	0.0003
General Car Wash[2]	VAG750238	Ravensworth Collision Center	0.004	0.00003
General Single Family Home[2]	VAG406519	Single Family Home	0.05	0.0001
Total			**16.54**	**0.717**

[1]Included in the industrial stormwater WLA
[2]Included in the process water WLA

Table 4-7: Upper Accotink Creek Load Allocations

Source	Baseline Load (tons/yr)	LA (tons/yr)	Percent Reduction
Transportation	17	2	85%
Other Developed	338	50	85%
Open Space	28	28	0%
Streambank	1,714	253	85%
Total	**2,097**	**334**	**84%**

Table 4-8 gives the sediment TMDL, MOS, WLAs, and LA for lower Accotink Creek. **Table 4-9** provides a summary of the average annual baseline MS4 loads, aggregated MS4 WLAs, and MS4 percent reduction from baseline conditions. **Table 4-10** gives the wasteload allocations for facilities for permitted process water and permitted stormwater. **Table 4-11** gives the average annual baseline loads for nonregulated lands by source type, in addition to LAs and percent reduction from baseline conditions by source type.

Table 4-8: Lower Accotink Creek Average Annual TMDL Allocations

Source	Load (tons/yr)	Percent of TMDL
Total WLA	**3,073**	75%
Fairfax County Aggregate MS4 WLA	2,457	59%
Fort Belvoir Aggregate MS4 WLA	235	6%
Total Process Water WLA	1	<1%
Total Industrial Stormwater WLA	95	3%
Construction	79	2%
Future Growth	206	5%
LA	**629**	15%
MOS	**411**	10%
TMDL (not including upper Accotink Creek)	**4,113**	100%
Upper Accotink Creek and Long Branch Upstream TMDLs	2,182	NA[1]
Total TMDL (including upper Accotink Creek)	6,294	NA[1]

[1]Not Applicable

Table 4-9: Lower Accotink Creek Aggregated MS4s Wasteload Allocations

Jurisdiction	Permit No	Facility Name	Baseline Load (tons/yr)	WLA (tons/yr)	Percent Reduction
Fairfax County	VA0088587	Fairfax County	4,456	2,457	45%
	VA0092975	Virginia Department of Transportation			
	VAR040104	Fairfax County Public Schools			
Fort Belvoir	VA0092975	Virginia Department of Transportation	519	235	55%
	VAR040093	Fort Belvoir			

Table 4-10: Lower Accotink Creek Sediment Permitted Stormwater Water and Process Water Wasteload Allocations

Type	Permit No	Facility Name	Annual (tons/yr)	Daily (tons/d)
Individual[1]	VA0092771	Fort Belvoir	48.98	0.782
Individual[1]	VA0001945	Kinder Morgan Southeast Terminals LLC-Newington	16.09	0.351
Individual[1]	VA0001988	Kinder Morgan Southeast Terminals LLC-Newington 2	3.29	0.303
General[1]	VAR051042	SICPA Securink Corporation	3.52	0.056
General[1]	VAR051047	Fairfax County – Connector Bus Yard (Huntington Garage)	2.94	0.047
General[1]	VAR051771	Fairfax County - Newington Maintenance Facility	7.87	0.126
General[1]	VAR051772	Fairfax County - DVS – Alban Maintenance Facility	0.81	0.013
General[1]	VAR051795	HD Supply - White Cap	0.08	0.001
General[1]	VAR052223	Newington Solid Waste Vehicle Facility	2.30	0.037
General[1]	VAR051565	Rolling Frito Lay Sales LP - South Potomac DC	0.56	0.009
General[1]	VAR051863	United Parcel Service - Newington	7.00	0.112
General[1]	VAR052366	Ready Refresh by Nestle – Lorton Branch	1.22	0.020
General Concrete[3]	VAG110069	Virginia Concrete, Mid-Atlantic Materials	0.62	0.015
General Concrete[2]	VAG110046	Virginia Concrete, Newington Plant	0.33	0.031
General Concrete[2]	VAG110355	Superior Concrete Materials	0.41	0.013
General Car Wash	VAG750255	Enterprise Rent A Car – Loisdale Road	0.091	0.0003
Total			**96.14**	**1.915**

[1]Included in the industrial stormwater WLA
[2]Included in the process water WLA
[3]VAG110069 has two outfalls. Outfall 001 discharges process water and outfall 002 discharges industrial stormwater. The annual process water WLA for outfall 001 is 0.366 tons/yr and the annual industrial stormwater WLA for outfall 002 is 0.25 tons/yr. The daily process water WLA for outfall 001 is 0.011 tons/d and the daily industrial stormwater WLA for outfall 002 is 0.004 tons/d.

Table 4-11: Lower Accotink Creek Load Allocations

Source	Baseline Load (tons/yr)	LA (tons/yr)	Percent Reduction
Transportation	13	5	63%
Other Developed	208	76	63%
Open Space	31	31	0%
Streambank	1,411	517	63%
Total	**1,663**	**629**	**62%**

Table 4-12 provides a summary of the sediment TMDL, MOS, WLAs, and LA for Long Branch. **Table 4-13** gives the average annual baseline MS4 loads, aggregated MS4 WLAs, and MS4 percent reduction from baseline conditions. **Table 4-14** gives the wasteload allocations for facilities for permitted process water. **Table 4-15** gives the average annual baseline loads for nonregulated lands by source type, in addition to LAs and percent reduction from baseline conditions by source

type. Currently, there are no facilities in the Long Branch watershed permitted for industrial stormwater.

Table 4-12: Long Branch Average Annual TMDL Allocations

Source	Load (tons/yr)	Percent of TMDL
Total WLA	**936**	82%
City of Fairfax Aggregate MS4 WLA	42	4%
Fairfax County Aggregate MS4 WLA	880	77%
Total Industrial Stormwater WLA	NA[1]	NA[1]
Total Process Water WLA	<1	<1%
Construction	2	<1%
Future Growth	11	1%
LA	**97**	8%
MOS	**115**	10%
TMDL	**1,148**	100%

[1]Not Applicable

Table 4-13: Long Branch Aggregated MS4 Wasteload Allocations

Jurisdiction	Permit No	Facility Name	Baseline Load (tons/yr)	WLA (tons/yr)	Percent Reduction
City of Fairfax	VA0092975	Virginia Department of Transportation	158	42	73%
	VAR040064	City of Fairfax			
Fairfax County	VA0088587	Fairfax County	3,313	880	73%
	VA0092975	Virginia Department of Transportation			
	VAR040104	Fairfax County Public Schools			

Table 4-14: Long Branch Sediment Permitted Process Water Wasteload Allocations

Type	Permit No	Facility Name	Annual (tons/yr)	Daily (tons/d)
General Single Family Home[1]	VAG406613	Single Family Home	0.05	0.0001
Total			**0.05**	**0.0001**

[1]Included in the process water WLA

Table 4-15: Long Branch Load Allocations

Source	Baseline Load (tons/yr)	LA (tons/yr)	Percent Reduction
Transportation	2	1	77%
Other Developed	26	6	77%
Open Space	5	5	0%
Streambank	375	85	77%
Total	**409**	**97**	**76%**

4.5 Daily Load Expressions

The TMDLs and allocations were expressed on a daily basis. As described below, daily expressions of the WLAs were given to permitted facilities based on permit type, according to the following categories:

- Individual Permit Process Water or Managed Discharges (Bulk Terminals)
- Car Wash Process Water
- Single Family Home Domestic Sewage
- Concrete Product Process Water
- Industrial Stormwater (under both Individual and General Permits); Concrete Stormwater; MS4s; and Land under Construction
- Concrete Comingled Process Water and Stormwater

The LAs were also expressed on a daily basis using the method applied to MS4s and industrial stormwater.

Individual Permit Process Water or Managed Discharges (Bulk Terminals). The process water and managed discharges from bulk terminals with individual permits have a maximum permitted concentration. The WLA for these facilities was expressed on a daily basis as the product of the maximum permitted concentration and maximum flow reported in their DMRs during the last five years.

Car Wash Process Water. Car wash facilities under a general permit have maximum permitted concentrations. The daily WLA was calculated as the product of the maximum permitted concentration and expected average flow. The expected average flow was set at 0.0001 MGD, 0.001 MGD, and 0.001 MGD for VAG750238, VAG750226, and VAG750255, respectively.

Domestic Sewage under a General Permit. The discharge from a Single Family Home under a domestic sewage general permit has a maximum permitted concentration of 30 mg/l, and a maximum permitted discharge of 1000 gallons (0.001 MGD). The daily WLA was calculated as the product of the maximum permitted concentration and maximum permitted flow.

Concrete Product Process Water. Concrete facilities under a general permit have a maximum permitted sediment concentration of 60 mg/l. The daily WLA for outfalls discharging process water only was calculated as the product of the maximum permitted concentration and maximum flow reported in their DMRs during the last five years.

Industrial Stormwater, Concrete Stormwater, MS4s, Land under Construction, and Load Allocations. Hydrology is the primary source of the variation of daily loads in stormwater, runoff, and streambank erosion. For these sources, the WLAs were expressed on a daily basis using the following equation from EPA's (2007) guidance on daily loads:

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

where

MDL = maximum daily limit (tons/day)
LTA = long-term average (tons/day)
z = 97th percentile of standard normal probability distribution (z-score)
$\sigma^2 = \ln(CV^2+1)$
CV = coefficient of variation of daily loads

The LTA is the long-average daily load, which is the annual WLA divided by the number of days in the year, 365.25, taking into account leap years**.** The coefficient of variation, which is the standard deviation divided by the mean of the distribution of daily loads, is a measure of the variability of the daily loads. The 97th percentile was selected as the probability of occurrence, for consistency with limits set in VPDES permits. Virginia's WQS generally allow one exceedance of a criterion for pollutants like toxics every three years. Given that DMRs are required monthly, one exceedance every three years (36 months), or approximately 3%, is consistent with WQS. By using the 97th percentile, the MDL can be expected to be exceeded no more than 3% of the time.

The GWLF model, as used in the development of the Accotink Creek sediment TMDLs, does not determine a time series of daily sediment loads under baseline conditions or TMDLs. As discussed in **Section 3.3.3**, time series of daily sediment loads under baseline conditions were estimated using observed flows and monitoring data at the USGS gages on Accotink Creek near Annandale (0165400) and Long Branch near Annandale (01654500). The variation in loads under the TMDL are likely to be driven by the same variation in hydrology which contribute to the variation in loads under baseline conditions, so it is likely that the CV of TMDL loads will be similar to the CV of baseline loads. In these circumstances, the CV calculated from baseline loads has been an acceptable substitute for the unknown CV under the TMDL (MDE, 2011).

Table 4-16 gives the CV for estimated loads from upper Accotink Creek, lower Accotink Creek, and Long Branch, as well as the z score, and the multiplier for converting LTAs to MDLs ($Exp[z\sigma-0.5\sigma^2]$). The CVs for upper Accotink Creek and Long Branch were taken from the CVs for baseline loads estimated at at the USGS gages on Accotink Creek near Annandale (0165400) and Long Branch near Annandale (01654500), respectively. Since the CV is an expression of the flashiness of flow, which is a function of watershed size, the CV for lower Accotink Creek was interpolated by area from the upper Accotink Creek and Long Branch CVs. Only the area below the inlet to Lake Accotink was used in the interpolation.

Table 4-16: Components of Maximum Daily Load Calculations for MS4s, Stormwater, and LAs

Component	Upper Accotink Creek	Lower Accotink Creek	Long Branch
CV	6.57	7.04	8.50
z-score (97th percentile)	1.88	1.88	1.88
LTA-to-MDL multiplier	5.85	5.83	5.76

Since the LAs represent sediment loads in stormwater, runoff, and streambank erosion from areas outside the MS4 service areas, this method was also applied to calculate daily expressions of the LAs.

Concrete Comingled Process Water and Stormwater. Concrete facility VAG110355 discharges stormwater comingled with process water. The facility has a maximum permitted concentration of 60 mg/l, twice the average permitted concentration of 30 mg/l which was used in calculating the WLA expressed on an annual basis. The variability in loads is due to the variability in stormwater flows, so the method used to calculate the daily expressions for MS4s, industrial stormwater, etc. is appropriate to use for the comingled water. Since the maximum permitted concentration is twice the concentration used to calculate the LTA for this facility, however, the daily WLA was set at twice LTA × $\mathrm{Exp}[z\sigma - 0.5\sigma^2]$.

Maximum Daily Loads for Individual Impairments. **Tables 4-17**, **4-18**, and **4-19** present the maximum daily sediment loads for upper Accotink Creek, lower Accotink Creek, and Long Branch, respectively. Daily load expressions for WLAs for individual facilities are given in **Tables 4-6**, **4-10**, and **4-14** for upper Accotink Creek, lower Accotink Creek, and Long Branch, respectively. For concrete product facilities, the daily WLA is the sum of the WLAs calculated by outfall, according to the methods described above. The maximum daily load total is the sum of the allocations and wasteload allocations. Just as for the average annual expression, the MOS is 10% of the total TMDL, 5% of the TMDL has been set aside for future growth in upper Accotink Creek and lower Accotink Creek, and 1% of the TMDL has been set aside for future growth in Long Branch.

Table 4-17: Maximum Daily Loads for Upper Accotink Creek

Source	Load (tons/day)	Percent of TMDL
Total WLA	**37.933**	79%
City of Fairfax Aggregate MS4 WLA	10.154	21%
Fairfax County Aggregate MS4 WLA	20.539	43%
Town of Vienna Aggregate MS4 WLA	2.792	6%
Total Process Water WLA	<0.001	<1%
Total Industrial Stormwater WLA	0.717	1%
Construction	1.328	3%
Future Growth	2.404	5%
LA	**5.345**	11%
MOS	**4.809**	10%
TMDL (not including Long Branch)	**48.086**	100%
Long Branch Upstream TMDL	18.087	NA[1]
Total TMDL (including Long Branch)	66.173	NA[1]

[1]Not Applicable.

Table 4-18: Maximum Daily Loads for Lower Accotink Creek

Source	Load (tons/day)	Percent of TMDL
Total WLA	**49.486**	75%
Fairfax County Aggregate MS4 WLA	39.244	59%
Fort Belvoir Aggregate MS4 WLA	3.751	6%
Total Process Water WLA	0.055	<1%
Total Industrial Stormwater WLA	1.860	3%
Construction	1.268	2%
Future Growth	3.307	5%
LA	**10.041**	15%
MOS	**6.614**	10%
TMDL (not including upper Accotink Creek)	**66.141**	100%
Upper Accotink Creek and Long Branch Upstream TMDLs	35.072	NA[1]
Total TMDL (including upper Accotink Creek)	101.213	NA[1]

[1]Not Applicable.

Table 4-19: Maximum Daily Loads for Long Branch

Source	Load (tons/day)	Percent of TMDL
Total WLA	**14.748**	82%
City of Fairfax Aggregate MS4 WLA	0.663	4%
Fairfax County Aggregate MS4 WLA	13.869	77%
Total Industrial Stormwater WLA	NA[1]	NA[1]
Total Process Water WLA	<0.001	<1%
Construction	0.035	<1%
Future Growth	0.181	1%
LA	**1.530**	8%
MOS	**1.809**	10%
TMDL	**18.087**	100%

[1]Not Applicable. Currently there are no industrial stormwater discharges in the watershed.

5 TMDL Implementation

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

5.1 Continuing Planning Process and Water Quality Management Planning

As part of the Continuing Planning Process, DEQ 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.

DEQ staff will also request that the SWCB adopt TMDL WLAs as part of the Water Quality Management Planning Regulation (9 VAC 25-720). This regulatory action is in accordance with §2.2-4006A.14 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 DEQ's web site under http://deq.state.va.us/Portals/0/DEQ/Water/TMDL/FeaturedTopics/WQMP_PPP_Final.pdf.

5.2 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. Enables tracking of water quality improvements following implementation through follow-up stream monitoring.
2. Provides a measure of quality control, given the uncertainties inherent in TMDL development.
3. Provides a mechanism for developing public support through periodic updates on implementation levels and water quality improvements.
4. Helps ensure that the most cost effective practices are implemented first.

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

Many of the BMPs that address sediment also address the two non-pollutant stressors, hydromodification and habitat modification. Proposed measures to reduce sediment that also address the non-pollutant stressors should be considered priority BMPs for implementing this TMDL. Furthermore, with streambank erosion being the predominant source of sediment in all of the impaired watersheds, BMPs that work to stabilize the streambanks are also recommended priority BMPs.

5.3 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, DEQ utilizes the Virginia Pollutant Discharge Elimination System (VPDES) program and the Virginia Stormwater Management Program (VSMP). Requirements of the permit process should not be duplicated in the TMDL process; depending on the type and nature of a point source discharge. The WLA implementation process may be informed through the development of a TMDL implementation plan, or it may be addressed solely through the discharge permit. However, it is recognized that implementation plan development may help to coordinate the efforts of permitted stormwater sources through the collaborative process involved in development of the plan.

5.3.1 Wastewater Treatment Plants and Process Water from Industrial Facilities

There are no municipal wastewater treatment plants in the Accotink Creek watershed. There are two small single family home discharge governed under the general permit for small domestic discharges less than or equal to 1,000 gallons per day. Process water dischargers in the watershed that discharge the POC include concrete plants and carwashes. Process water discharged from concrete plants, car washes, or other activities regulated by general permits are required to meet the sediment concentration limits at the point of discharge as stipulated in the VPDES permit. The discharge concentration limits serve as an effective surrogate to demonstrate that permittees are meeting established sediment wasteload allocations. Direct measurement and evaluation of concentration end-points, whether established as effluent limits are benchmark concentrations, is the expected method for demonstrating permitted discharges are consistent with the assumptions and requirements of this TMDL.

5.3.2 Stormwater

DEQ authorizes the discharges of stormwater associated with industrial activities, construction sites, and MS4s through the issuance of VPDES permits. Authorization for the issuance of VPDES permits to address stormwater discharges from construction sites and MS4s is included in the VSMP Regulation. While the authorization to issue VPDES permits is housed in two different regulations, permits allowing the discharge of industrial stormwater, construction stormwater, and municipal stormwater all implement the requirements of the federal NPDES program. All new or revised permits must be consistent with the assumptions and requirements of any applicable TMDL WLA.

Municipal Separate Storm Sewer Systems – MS4s. For MS4 individual and general permits, DEQ expects the permittee to address the TMDL wasteload allocations for stormwater through the iterative implementation of BMPs to the maximum extent practicable. Permittee implementation of an individual control strategy includes determining BMP effectiveness. If BMPs are determined to not be effective, then the permit could require the MS4 to expand or better tailor its stormwater management program to achieve the TMDL wasteload allocation.

There is not a precise regulatory definition of maximum extent practicable. MS4s have the flexibility to optimize reductions in stormwater pollutants by implementing BMPs and other requirements of the MS4 permit in an iterative process. Successive permits continually adapt to current conditions, BMP effectiveness and technology, on a location-by-location basis, taking into consideration such factors as condition of receiving waters, specific local concerns, a comprehensive watershed plan, MS4 size, current ability to finance the program, beneficial uses of receiving water, hydrology, geology, and capacity to perform operation and maintenance. Permittees will be strongly encouraged to participate in the development of TMDL implementation plans since recommendations from stakeholder input may provide a basis for modifications to the stormwater management plan in order to meet the TMDL.

For MS4 individual and general permits, the DEQ plans to specifically address the TMDL WLAs for stormwater through the iterative implementation of BMPs to the maximum extent practicable.

Industrial Stormwater. As noted, industrial stormwater discharges are regulated under the VPDES program. These discharges are derived from precipitation, as opposed to process wastewaters. In the Accotink Creek watershed there are both individual VPDES permits for industrial stormwater discharges, such as Fort Belvoir, as well as general permits for industrial stormwater discharges. The individual permits are regulated based on 9VAC25-31-120, whereas the general permits are regulated under 9VAC25-151 et al. Discharge concentration limits and/or benchmark endpoints serve as an effective surrogate to demonstrate that permittees are meeting established sediment wasteload allocations. Direct measurement and evaluation of sediment concentration end-points, whether established as effluent limits are benchmark concentrations, is the expected method for demonstrating permitted discharges are consistent with the assumptions and requirements of this TMDL.

5.3.3 Insignificant Dischargers

Wasteload allocations are assigned to permittees considered to be significant dischargers of the pollutant of concern (POC). Significant discharges of the POC have reasonable potential to cause or contribute to the instream impairment. Conversely, incidental or insignificant discharges of the POC may occur but not at levels considered to cause or contribute to the impairment, therefore not necessitating the establishment of wasteload allocations for these dischargers. For example, there may be a small sediment load coming from the AT&T Oakton Office Park cooling water facility. However, discharges of this sediment from these sources are considered to be negligible and are therefore not included in the TMDL WLAs.

5.3.4 TMDL Modifications for New or Expanding Dischargers

Permits issued for facilities with WLAs developed as part of a TMDL must be consistent with the assumptions and requirements of these WLAs, per EPA regulations. In cases where a new permit or proposed permit modification occurs in a TMDL watershed and is therefore affected by a TMDL WLA, permit and TMDL staff will coordinate to ensure that new or expanding discharges meet this requirement. In 2014, DEQ issued Guidance Memorandum No. 14-2015 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 DEQ's web site at http://www.deq.virginia.gov/Programs/Water/Laws,Regulations,Guidance/Guidance/TMDLGuidance.aspx.

5.4 Implementation of Load Allocations

The TMDL program does not impart new implementation authorities. Therefore, DEQ intends to use existing programs to the fullest extent in order to attain its water quality goals. The measures for unregulated, nonpoint source reductions are implemented in an iterative process that is described along with specific BMPs in a TMDL implementation plan. In the highly developed, urbanized Accotink Creek watershed, the nature of the unregulated, nonpoint source discharges is very similar to that of the regulated, point source discharges. Namely, it is stormwater generated from highly developed land-uses with a high percentage of impervious surfaces. Pollutants entering surface waters not conveyed through an MS4-owned system are generally non-regulated, nonpoint source loadings. It is very similar in nature to that of the MS4 discharges. Accordingly, the management measures and structural controls that may be used to control the regulated stormwater would also apply to the non-regulated NPS discharges. It should be noted that the design and operational requirements of the VSMP program, as applicable, to development and re-development projects in the Accotink Creek watershed will also serve to mitigate sediment loadings as well as stormwater energy over time. The VSMP requirements are implemented by the local authority to all applicable projects, regardless of whether they are located in regulated or non-regulated areas. Furthermore, many of the BMPs that address sediment also address the two non-pollutant stressors hydromodification and habitat modification. Measures to reduce sediment that also address the non-pollutant stressors should be considered priority BMPs for implementing this TMDL.

5.4.1 Implementation Plan Development

A TMDL implementation plan must address, 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," that is available at http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/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 DEQ, DCR, and other cooperating agencies are technical resources that can 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.

5.4.2 Staged Implementation Scenarios

The purpose of the staged implementation scenarios is to identify one or more combinations of implementation actions that will result in the reduction of controllable sources to the maximum extent practicable using cost-effective, reasonable BMPs for nonpoint source control. The types of BMPs that may be considered to address unregulated, nonpoint source loads are stream restoration, stream bank stabilization, and other BMPs that work to capture stormwater and promote infiltration of that stormwater.

DEQ expects that implementation of the sediment TMDLs will occur in stages, and that full implementation of the TMDLs is a long-term goal. Specific goals for phased implementation will be determined as part of implementation plan development.

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.

5.4.3 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 Accotink Creek watershed, the Potomac River, and the Chesapeake Bay. Links to on-going restoration efforts are described in more detail below.

Chesapeake Bay Program Action Plans. Under their MS4 permits, Fairfax County, the City of Fairfax, and the Town of Vienna are required to develop Action Plans to address attaining reductions in Pollutants of Concern (POCs) under the Chesapeake Bay TMDLs. Sediment is among the POCs in the Bay TMDLs.

Stormwater Management Ordinances. Fairfax County, the City of Fairfax, and the Town of Vienna have adopted Stormwater Management Ordinances, becoming local Virginia Stormwater Management Program (VSMP) authorities in 2014. These ordinances require Stormwater BMPs for all new development or redevelopment.

Accotink Creek Watershed Plan. The Fairfax County Board of Supervisors approved a Watershed Plan for Accotink Creek on February 8, 2011. The plan will help identify strategies to control stormwater runoff and its associated pollutant loads. The plan identifies a list of structural projects and non-structural actions that could be implemented in the next 10 to 25 years (FCDPWES, 2011). Types of structural projects include

- Stormwater management ponds or pond retrofits
- Stream restoration
- Drainage improvements
- Culvert retrofits
- Low-impact development (LID) or LID retrofits
- Outfall improvements

Buffer restoration, rain barrels, disconnecting impervious areas, and street sweeping are among the non-structural actions included in the plan. The Watershed Plan lists 120 high priority projects included in a ten-year planning horizon and 109 lower priority projects included in a 25-year planning horizon. Implementation of the plan is contingent on available funding.

Implementation of the plan will help not only meet the sediment load reductions set forth in this TMDL but also help meet the overall biological goals of this TMDL and water quality standards. Many of the structural projects and non-structural actions will help address adverse impacts of two other most probable stressors of the aquatic community in Accotink Creek: habitat modification and hydromodification.

5.4.4 Implementation Funding Sources

The implementation of pollutant reductions from non-regulated nonpoint sources relies heavily on incentive-based programs, while the funding sources for regulated discharges can be varied depending on the type of discharge. 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 and government agencies that might support implementation efforts, as well as suggestions for integrating TMDL implementation with other watershed planning efforts.

Some of the major potential sources of funding for non-regulated implementation actions include EPA Section 319 funds, Stormwater Local Assistance Fund (SLAF), Virginia State Revolving Loan Program (also available for permitted activities), Virginia Water Quality Improvement Fund (WQIF) (available for both point and nonpoint source pollution), tax credits and landowner contributions. Information on WQIF projects and allocations can be found at http://www.deq.virginia.gov/Programs/Water/CleanWaterFinancingAssistance/WaterQualityImprovementFund.aspx.

5.5 Follow-Up Monitoring

Following the development of the TMDL, DEQ will continue to monitor the impaired streams in accordance with its ambient monitoring program. To demonstrate that the watershed is meeting water quality standards in watersheds where corrective actions have taken place, DEQ 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 biological monitoring is two consecutive samples (one in the spring and one in the fall) in a one year period. Since there may be a lag time of one-to-several years before any improvements in the benthic community will be evident, follow-up biological monitoring may not have to occur in the year immediately following the implementation of the control measures. The purpose, location, parameters, frequency, and duration of the monitoring will be determined by DEQ staff, in cooperation with local stakeholders. The details of the follow-up monitoring will be outlined in the Annual Water Monitoring Plan prepared by each DEQ Regional Office. Other agency personnel, watershed stakeholders, etc. may provide input on the Annual Water Monitoring Plan. These recommendations must be made to the DEQ regional TMDL coordinator by September 30 of each year. **Figure 5-1** shows the location of the water quality monitoring stations in the upper Accotink Creek, lower Accotink Creek, and Long Branch watersheds, and **Table 5-1** provides a description of the station locations.

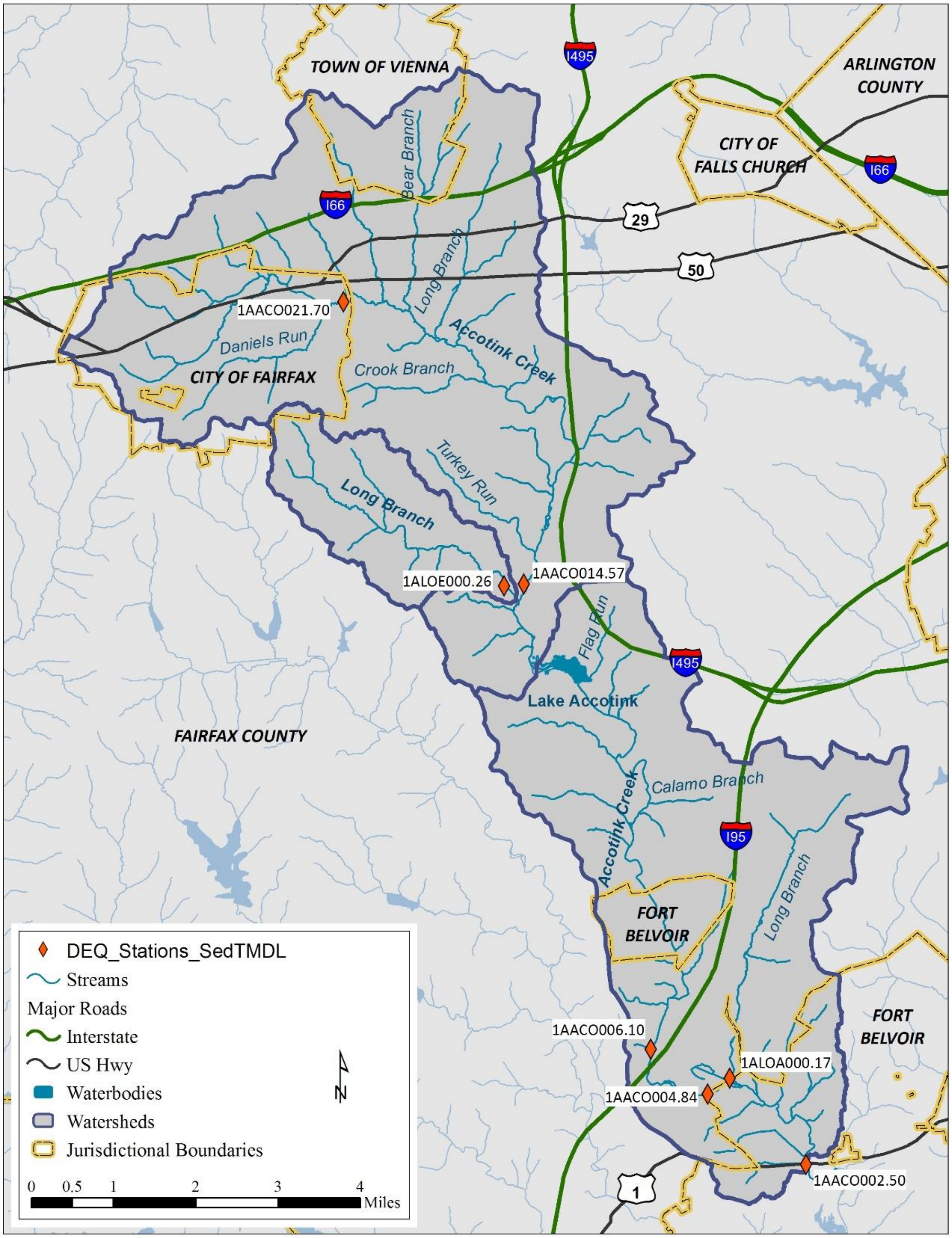


Figure 5-1: DEQ Water Quality Monitoring Stations in the Accotink Creek Watershed

Table 5-1: DEQ Water Quality Monitoring Stations in the Accotink Creek Watershed

Station ID	Station Description	Stream Name
1AACO002.50	Route 1 (Richmond Hwy)	Accotink Creek (Lower)
1AACO004.84	Route 611 (Telegraph Rd)	Accotink Creek (Lower)
1AACO006.10	Route 790 (Alban Rd)	Accotink Creek (Lower)
1AACO014.57	Route 620 (Braddock Rd)	Accotink Creek (Upper)
1AACO021.70	Route 237 (Pickett Road)	Accotink Creek (Upper)
1ALOA000.17	Route 611 (Telegraph Rd)	Long Branch (South)
1ALOE000.26	Route 620 (Braddock Rd)	Long Branch (Central)

While the ultimate goal of this TMDL is to restore the biological community, sediment represent just one of the four most probable stressors of the benthic community. Therefore, monitoring only the biological community may fail to observe improvements in water quality related to sediment concentrations. In order to monitor the effectiveness of sediment BMP implementation, sediment loads can be estimated using continuous monitoring data from the two USGS gauges in the Accotink Creek and Long Branch watersheds. Sediment load estimation methods are discussed in **Section 3.3.3** for USGS gauge 01654000 near the outlet of the Upper Accotink Creek watershed and gauge 01654500 near the outlet of the Long Branch watershed. For both biological monitoring and the monitoring of chloride concentrations, recommendations may be made, when necessary, to target implementation efforts in specific areas and continue or discontinue monitoring at established stations.

In some cases, watersheds will require monitoring above and beyond what is included in DEQ's standard monitoring plan. Ancillary monitoring by local government, 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 DEQ 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/Programs/Water/WaterQualityInformationTMDLs/WaterQualityMonitoring/CitizenMonitoring.aspx

5.6 Attainability of Designated Uses

The goal of a TMDL is to restore impaired waters so that water quality standards are attained. Water quality standards consist of statements that describe water quality requirements and include three components: (1) designated uses, (2) water quality criteria to protect designated uses, and (3) an antidegredation policy. In the case of these sediment TMDLs, pollutant load reductions were developed for one of the four most probable stressors impairing the aquatic life use. Implementing cost-effective and reasonable best management practices to reduce sediment loads to the maximum extent practicable are expected to ultimately attain the TMDLs for sediment. However, 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, a subcategory of a use, or a tiered 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 of one or more of the following reasons:

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 pollutant 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.
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 Use Attainability Analysis (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, are able to provide comment.

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 of all pollutants and non-pollutants causing or contributing to the biological impairment will be implemented. In addition, measures should be taken to ensure that discharge permits are fully implementing provisions required in the TMDL. The expectation would be for the reductions of all controllable sources to be to the maximum extent practicable. DEQ will continue to monitor water quality in the impaired streams during and subsequent to the implementation of these measures to determine if water quality standards are being attained. This effort will also help to evaluate if the modeling assumptions used in the TMDL were correct. In the best-case scenario, water quality goals will be met and the stream's uses fully restored using pollution controls and BMPs. If, however, water quality standards are not being met, and no additional pollution 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, subcategory of a use, or tiered 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."

6 Public Participation

Public participation was an essential element in the development of the sediment TMDLs for upper Accotink Creek, lower Accotink Creek, and Long Branch. Three public meetings and six Technical Advisory Committee (TAC) meetings were held over the course of the project. Topics discussed at these meetings are summarized below.

The first TAC meeting was held on August 26, 2014, at the Richard Byrd Library, 7250 Commerce Street, Springfield, VA. The meeting covered an overview of the TMDL process and the role of SI in TMDL development. The presentation for the meeting included a discussion of the data required for the SI and for characterizing the Accotink watershed.

The first public meeting was held on September 10, 2014, at Kings Park Library, 9000 Burke Lake Road, Burke, VA. The meeting also provided an overview of the TMDL development process, with an emphasis on the role of biological monitoring in determining that upper Accotink Creek, lower Accotink Creek, and Long Branch are not supporting their Aquatic Life Uses. The concept of an SI was introduced.

The second TAC meeting was held on June 24, 2015 at the Kings Park Library in Burke. At that meeting the results of the SI were presented in detail. Emphasis was placed on explaining the evidence that sediment, chloride, hydromodification, and habitat modification are the most probable stressors of the biological community in the Accotink Creek watershed.

The second public meeting was held on July 6, 2015 at the Kings Park Library in Burke. This meeting also presented the results of the SI in detail.

The third TAC meeting was held on December 14, 2015 at the Kings Park Library in Burke. The meeting presented in detail the steps in developing sediment and chloride TMDLs in the Accotink Creek watershed. Two potential approaches to developing sediment TMDLs were discussed: (1) the AllForX method, which has been used to develop most of the recent sediment TMDLs in VA, and (2) a method based on Fairfax County's Uniform Stormwater Design Standard, which was also under development. DEQ's plan for performing continuous monitoring of specific conductance and collecting additional chloride data in the winter of 2016 was also discussed.

The fourth TAC meeting was held on July 28, 2016 at the Richard Byrd Library in Springfield. At the meeting the use of the AllForX method to develop sediment TMDLs were explained in detail.

The computer simulation model that was proposed to be used to develop the chloride TMDLs was also presented. The meeting included a discussion of possible alternatives to using computer simulation modeling to develop the chloride TMDLs.

The fifth TAC meeting was held on October 18, 2016 at the offices of the Northern Virginia Regional Commission, 3040 Williams Drive, Fairfax, VA. The load duration approach to developing the chloride TMDLs was presented to the TAC members. Progress on sediment TMDL development was also reviewed, with a focus on changes in the approach to modeling the lower Accotink Creek watershed and the impact of Lake Accotink. The meeting also included a detailed discussion of the principles used in developing load and wasteload allocations for the sediment and chloride TMDLs. Draft allocations based on these principles were presented to the TAC.

The sixth TAC meeting was held on June 7, 2017 at the Richard Byrd Library in Springfield. The allocation methodology for both the chloride TMDLs and the sediment TMDLs was reviewed and proposed allocations for both sets of TMDLs presented. The meeting also included a discussion of establishing a regional Salt Management Strategy (SaMS) to implement the chloride TMDLs.

The third and final public meeting was held on June 28, 2017 at the Kings Park Library in Burke. The meeting reviewed all of the steps in the development of chloride and sediment TMDLs in the Accotink Creek watershed. The implementation of the chloride TMDLs through a regional SaMS was also introduced.

The following agencies, businesses, and organizations attended TAC meetings and participated in the development of the TMDLs for the Accotink Creek watershed:

Representation in Attendance at TAC Meetings

Braddock District Board of Supervisors[1]	Joint Basin Corporation - Fairfax Terminal Complex
Buckeye Partners[1]	Metropolitan Council of Governments
Catholic Diocese of Arlington	Northern Virginia Community College
Chesapeake Bay Foundation	Northern Virginia Building Industry Association (NVBIA) - Fairfax Chapter
City of Fairfax	Northern Virginia Regional Commission (NVRC)
Fairfax County Department of Public Works and Environmental Services	Stantec[1]
Fairfax County Department of Transportation	Town of Vienna - Public Works
Fairfax County Department of Vehicle Services	United Parcel Service - Newington
Fairfax County Park Authority	United States Geological Survey (USGS)
Fort Belvoir Department of Public Works	VA Department of Environmental Quality
Friends of Accotink Creek	Virginia Concrete Company Inc.
Friends of Lake Accotink Park	Virginia Department of Forestry
GKY & Associates, Inc.[1]	Virginia Department of Transportation (VDOT)
Regency Centers	Watershed residents[1]
Interstate Commission on the Potomac River Basin	Wetland Studies and Solutions, Inc.[1]

[1]Not official TAC members, but attended at least one meeting

Appendix A

ALLFORX Approach for the Accotink Creek Sediment TMDLs

Introduction

The Accotink Creek sediment TMDLs were developed using the AllForX approach (Benham et al., 2014; Yagow et al., 2015a, Yagow et al., 2015b). The method, described in detail in this appendix, is based on quantifying unimpaired conditions using comparison watersheds and using that information to set sediment reductions needed to meet water quality standards. The methodology included the following steps:

- selecting comparison watersheds,
- developing and running the GWLF model under current and all-forested conditions for comparison and impaired watersheds,
- calculating AllForX values for comparison and impaired watersheds,
- regressing the Virginia Stream Condition Index (VSCI) scores against the AllForX values,
- identifying a threshold multiplier for a VSCI score of 60, which indicates a healthy benthic macroinvertebrate community, and
- multiplying the AllForX threshold by the all-forested sediment load for impaired watersheds to establish the TMDL endpoint for the impaired watersheds.

The methodology and results are discussed in more detail in the sections below. Whenever possible, the modeling process for the comparison watersheds was developed using the same assumptions as those described for the Accotink models (**Section 3**). Where differences exist, they are highlighted in this appendix.

Watershed Selection

The comparison watersheds were selected using an approach similar to those documented in Yagow (2014), Yagow et al. (2013), and Yagow et al. (2015a). Specifically, the DEQ biological monitoring database for the Northern Virginia Region was queried to identify monitoring locations (1) in the Piedmont physiographic province, (2) with monitoring data after the year 2004, (3) whose average VSCI score was greater than or equal to 60, and (4) with greater than or equal to three sampling events. The monitoring locations meeting these criteria were then screened spatially using GIS software to identify only monitoring locations (1) within 45 miles of the

Accotink watersheds, (2) in the Potomac basin, (3) not nested (i.e. non-overlapping watershed areas), (4) having stream orders 1 through 4, and (5) with a watershed size between 4 and 150 square miles. Eight comparison watersheds were identified using this selection approach (**Figure A-1**). Characteristics of the comparison watersheds are provided in **Table A-1**.

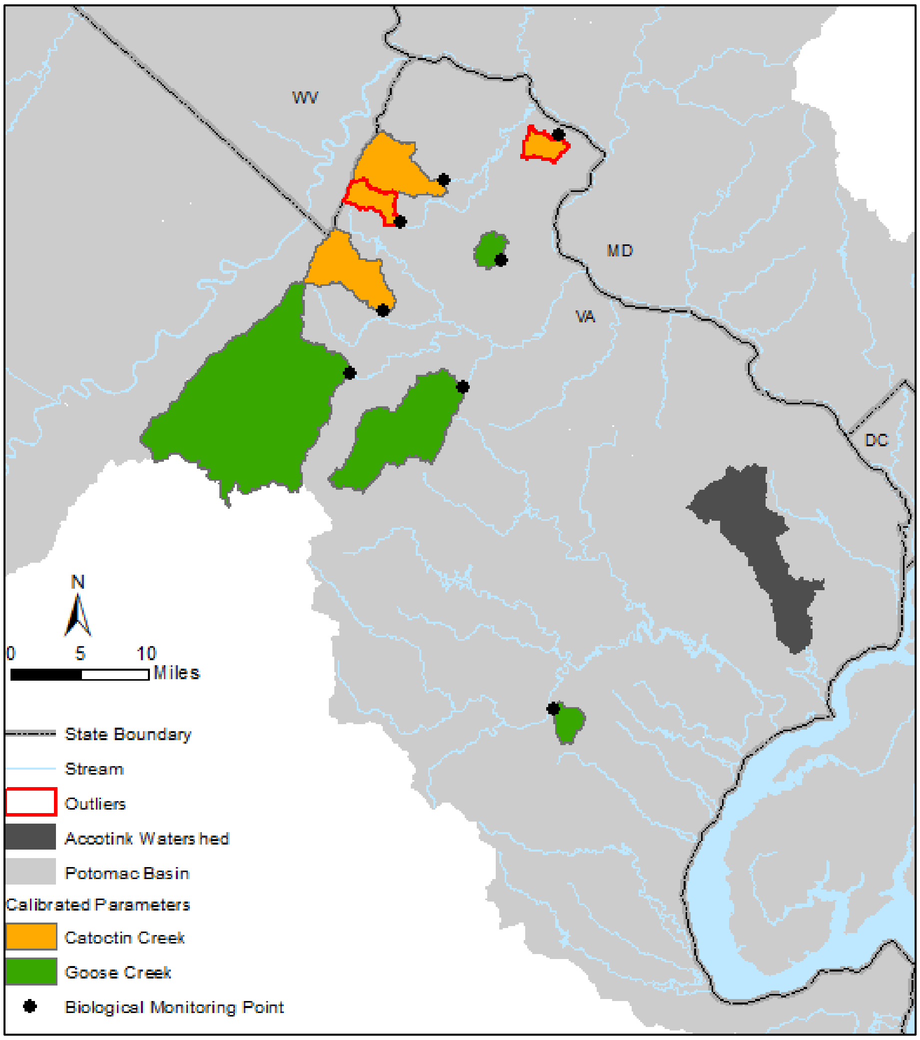


Figure A-1: Location of Comparison Watersheds (orange and green) in relation to the Accotink watershed (dark grey).

Table A-1: Comparison Watershed Characteristics

WS No	DEQ Monitoring Station ID	Name	Calibration WS	WS Area (mi^2)	Stream Order	No. Samples
1	1AGOO030.75	Goose Creek	Goose	122	4	3
2	1ACLK002.40	Clark's Run	Catoctin	5	2	4
3	1ADRL001.00	Dry Mill Branch	Goose	5	2	4
4	1ALIV004.78	Little River	Goose	40	3	9
5	1ANOB000.75	North Fork Beaverdam Creek	Catoctin	20	3	4
6	1ANOC004.38	North Fork Catoctin	Catoctin	18	3	4
7	1ASOC013.05	South Fork Catoctin	Catoctin	7	2	17
8	1AXMJ000.42	Tributary to Cedar Run	Goose	5	2	4

MapShed

For the purpose of the comparison watershed GWLF models, MapShed (Evans and Corradini, 2012) was used as the initial geospatial interface with the GWLF model. MapShed analyzes user-supplied geospatial data to automatically generate GWLF inputs. The regional geospatial data sets listed below were loaded into MapShed to generate the GWLF model inputs.

MapShed inputs for the comparison watersheds:

- Soils: USDA NRCS Soil Survey Geographic Database (SSURGO) (NRCS, 2015)
- Streams: National Hydrography Dataset, specifically NHDPlus V2.1[7]
- Weather stations: Six stations were selected based on geographic distribution, number of missing records, and the length of records. Missing records were filled in using information from nearby stations. Lincoln (444909), Mt. Weather (445851), Dulles International Airport (448903), Piedmont Research Station (446712), Reagan National Airport (13743), Front Royal (443229)
- Land use: 2011 NLCD (Homer et al., 2015) (See **Table A-2**.)
- Elevation: USGS DEM (USGS, 2016)
- Physiographic province: (Fenneman and Johnson, 1946)

[7] U.S. Geological Survey, National Hydrography Dataset available at http://www.horizon-systems.com/nhdplus/NHDplusV2_data.php, accessed 1/9/2017.

Table A-2: Current Scenario Land Uses for the Comparison Watersheds, Generated by Mapshed Using 2011 NLCD Data (acres).

	Land Use	Goose Creek	Clark's Run	Dry Mill Branch	Little River	North Fork Beaverdam Creek	North Fork Catoctin	South Fork Catoctin	Tributary to Cedar Run
Rural	Hay/Pasture	36,507	1,072	1,292	13,356	7,102	5,295	1,752	12
	Cropland	400	539	5	77	106	168	131	5
	Forest	36,362	1,082	1,394	10,858	4,389	5,471	1,866	2,773
	Wetland	42	57	15	84	30	79	136	109
	Disturbed	47	12	20	20	418	0	109	0
	Turf/Golf	0	0	0	0	0	0	0	0
	Open Land	3,842	452	190	1,421	398	615	188	74
	Bare Rock	0	0	0	0	0	0	0	0
	Sandy Areas	0	0	0	0	0	0	0	0
	Unpaved Road	0	0	0	0	0	0	0	0
Urban	LD Mixed	0	0	0	0	0	0	0	0
	MD Mixed	67	0	0	12	2	5	0	0
	HD Mixed	7	0	0	0	0	0	0	0
	LD Residential	576	17	25	37	74	49	25	2
	MD Residential	0	0	0	0	0	0	0	0
	HD Residential	0	0	0	0	0	0	0	0
Total		**77,850**	**3,232**	**2,941**	**25,864**	**12,518**	**11,683**	**4,206**	**2,975**

GWLF

GWLF, described in detail in **Section 3**, was utilized to simulate hydrology and sediment transport in the comparison watersheds. The GWLF input files generated with MapShed were modified in the GWLF user interface to include animals, Best Management Practices (BMPs), and construction sources. The final GWLF current scenario inputs for each comparison watershed are provided at the end of this appendix. Point sources were added to final simulated sediment loads outside of the modeling environment; however, a description of the point source information is also discussed in this section.

Animal data for beef and dairy cows, horses, and sheep were obtained from the 2012 USDA Agricultural Census county tables (USDA, 2012) and are provided in **Table A-3**. The Goose Creek and Little River watersheds have the largest number of animals with 3,504 and 1,214, respectively. The tributary to Cedar Run watershed has the fewest with only 64.

Table A-3: Animal Numbers for the Comparison Watersheds (USDA, 2012).

WS No	DEQ Monitoring Station ID	Name	Beef	Dairy	Horses	Sheep
1	1AGOO030.75	Goose Creek	387	1,005	1,665	447
2	1ACLK002.40	Clark's Run	83	2	55	24
3	1ADRL001.00	Dry Mill Branch	77	2	50	22
4	1ALIV004.78	Little River	300	233	518	163
5	1ANOB000.75	North Fork Beaverdam Creek	326	7	214	94
6	1ANOC004.38	North Fork Catoctin	306	6	201	88
7	1ASOC013.05	South Fork Catoctin	109	2	72	32
8	1AXMJ000.42	Tributary to Cedar Run	16	15	25	8

BMP information was obtained from DEQ on 03/15/2016 for counties containing comparison watersheds. The Goose Creek watershed was the only comparison watershed containing BMPs. Five practices are located in the watershed. The total drainage area for the five practices is 6.13 acres. Three of the practices have a sediment removal efficiency of 60% and a total drainage area of 4.01 acres. The remaining two practices have a 95% sediment removal efficiency and a total drainage area of 2.12 acres. The BMPs for this watershed were incorporated into the current scenario by assigning a new support practice factor (P) (described in **Section 3.4.5**). Unlike the impaired watershed BMPs, the comparison watershed BMPs are not assumed to be on developed lands due to their rural nature (**Table A-2**).

Construction permit information was obtained from the DEQ (**Table A-4**) Stormwater Management Program (VSMP) database on 04/20/2016[8]. The number of disturbed acres ranges from 0 to 169 acres in the comparison watersheds. The North Fork Catoctin and Tributary to Cedar Run watersheds did not have any construction permits in place at the time of this study. The North Fork Beaverdam Creek watershed had the largest disturbed area at approximately 169 acres.

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[8] http://www.deq.virginia.gov/Programs/Water/StormwaterManagement/VSMPPermits/ConstructionGeneralPermit.aspx, accessed 1/9/2017.

Table A-4: Construction Permit Summary Information, Including Developed and Disturbed Areas, by Comparison Watershed. There are no construction permits in effect in the North Fork Catoctin and the Tributary to Cedar Run watersheds and are therefore left out of this table.

WS No	Name	Developed Acres	Disturbed Acres
1	Goose Creek	134.19	19.07
2	Clark's Run	33.66	5.32
3	Dry Mill Branch	263.90	90.70
4	Little River	90.57	7.67
5	North Fork Beaverdam Creek	774.67	168.57
7	South Fork Catoctin	574.27	43.60
Total		**1,871.26**	**334.93**

Information on point sources was obtained from DEQ staff (04/21/2016) from the DEQ VPDES Discharge Monitoring Reports (DMRs) for the 2005-2015 time period. For this time period, there were five VPDES permits for outfalls located in three comparison watersheds; namely, Goose Creek, Clark's Run, and South Fork Catoctin. The average annual TSS loads from the permitted sources in these watersheds were 72,849 kg, 53 kg, and 133 kg, respectively.

Hydrology Calibration and Verification

Unlike the Accotink watersheds, observed historic streamflow information was not available for each of these comparison watersheds to enable calibration of the hydrology simulations. Fortunately, two of the comparison watersheds (Goose Creek and Catoctin Creek) had USGS gauge data (01643700 Goose Creek at Middleburg and 01638480 Catoctin Creek at Taylorstown) as well as previously developed and calibrated GWLF models (ICPRB, 2004). The calibrated parameters from one of these two watersheds was assigned to each comparison watershed based on proximity and hydrologic similarity. The assigned calibration watershed for each comparison watershed is documented in **Table A-1** and shown spatially in **Figure A-1**. Methodologies for developing the calibrated parameters are documented in Chapter 5 of ICPRB (2004).

The hydrology simulation period was April 1, 1996 through December 31, 2015. Since the input data sets and simulation periods are different in this effort from the original ICPRB (2004) study, the hydrology simulation for the Goose Creek and Catoctin Creek watersheds as part of this study were compared to the observed historic USGS flows (**Figures A-2** and **A-3**). The R^2 values for observed versus simulated monthly flows were greater than 0.7 for both watersheds, indicating an acceptable fit (Donigian, 2002).

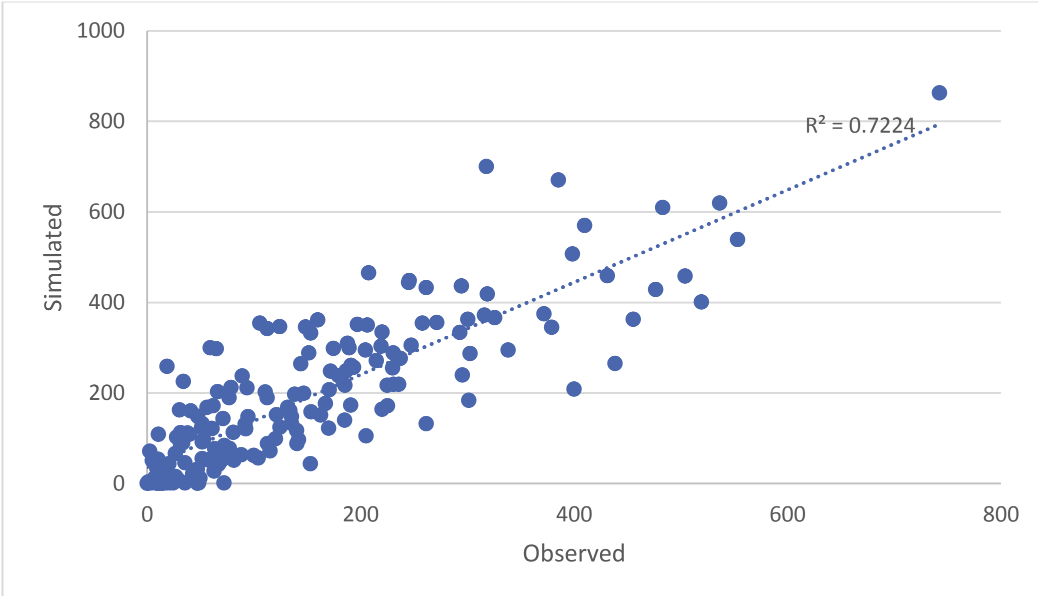

Figure A-2: Observed Versus Simulated Monthly Flows, Goose Creek (cfs) (1996-2015)

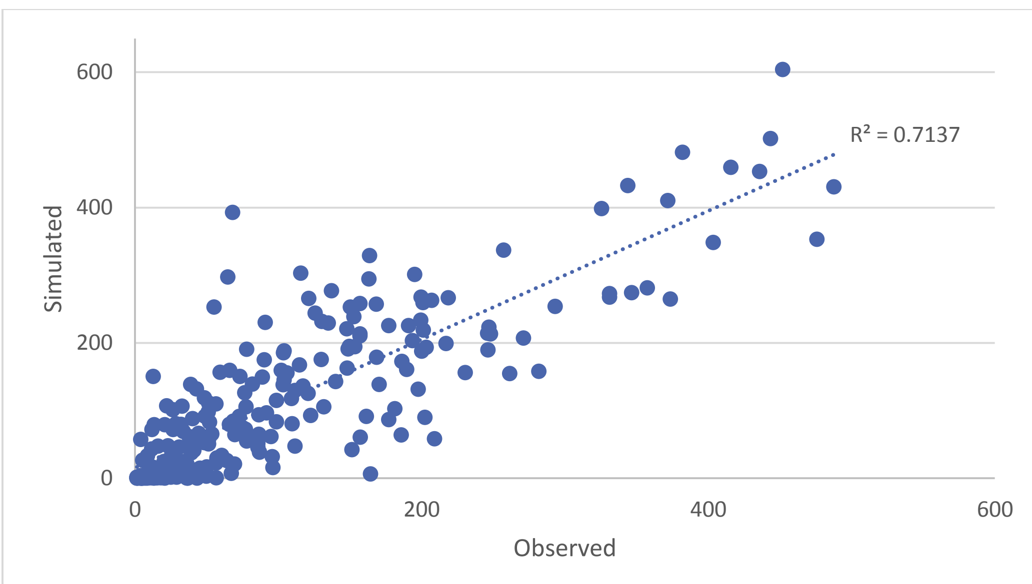

Figure A-3: Observed Versus Simulated Monthly Flows, Catoctin Creek (cfs) (1996-2015)

After verification of the hydrology simulation, current scenario hydrology and sediment loads were simulated for each comparison watershed.

All-Forest Model Runs

The all-forest scenario was created for each comparison watershed by modifying the current scenario model inputs in several ways. Specifically, the land use area was set equal to 100% forest, animals were removed, and the GWLF calculated a-factors were accepted based on the all-forested conditions (as described in **Section 3.4.4**). In addition, BMPs, point sources, and construction areas were not included in the all-forest scenario.

Calculate AllForX

The AllForX value was calculated for each comparison watershed as the average annual current sediment load (both point and non-point sources) divided by the average annual all forest load (**Table A-5**).

Table A-5: GWLF non-point source (NPS) and point source (PS) sediment loads and average VSCI scores used to calculate AllForX values for each watershed.

WS No	DEQ Monitoring Station ID	Name	Current NPS Sediment Load (kg)	Current PS Sediment Load (kg)	All-Forest Sediment Load (kg)	AllForX	Avg VSCI
1	1AGOO030.75	Goose Creek	10,882,937	72,849	3,788,720	2.9	67.8
2	1ACLK002.40	Clark's Run	801,526	53	41,508	19.3	63.8
3	1ADRL001.00	Dry Mill Branch	248,685	0	44,175	5.6	62.4
4	1ALIV004.78	Little River	2,490,123	0	681,131	3.7	60.4
5	1ANOB000.75	North Fork Beaverdam Creek	1,311,336	0	266,613	4.9	61
6	1ANOC004.38	North Fork Catoctin	936,894	0	215,041	4.4	61.2
7	1ASOC013.05	South Fork Catoctin	422,676	133	49,361	8.6	65.7
8	1AXMJ000.42	Tributary to Cedar Run	38,651	0	29,996	1.3	73

Based on the AllForX values, two outlier comparison watersheds were identified (South Fork Catoctin and Clark's Run) (**Figure A-4**). For geographic reference, the outlier watersheds are outlined in orange in **Figure A-1**. The watersheds are outliers because, given the difference in sediment loads between current and all-forested conditions, a more degraded biological condition (represented by the VSCI scores) would be expected. It is unclear why these watersheds do not exhibit expected amounts of biological degradation; however, site specific conditions not captured in the model may be influencing the local sediment loads and the observed biological conditions. These outlier watersheds were removed from further consideration, in line with previous applications of the AllForX methodology (e.g. Yagow, 2014).

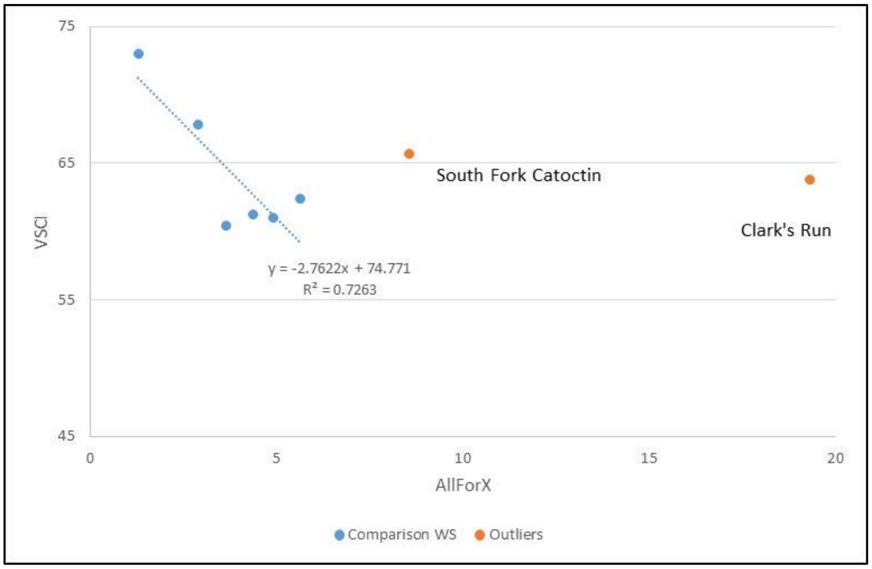

Figure A-4: Comparison Watersheds, AllForX Versus VSCI scores.

AllForX Regression

The AllForX values for the six non-outlier watersheds and three impaired watersheds were regressed against the corresponding VSCI scores (**Figure A-5**). The AllForX value (x-axis) at the point where the regression line crosses the VSCI score (y-axis) of 60 is the AllForX threshold. This represents the AllForX value at or below which water quality standards are met. The AllForX threshold for the Accotink and associated comparison watersheds is 5.07 (**Figure A-5**).

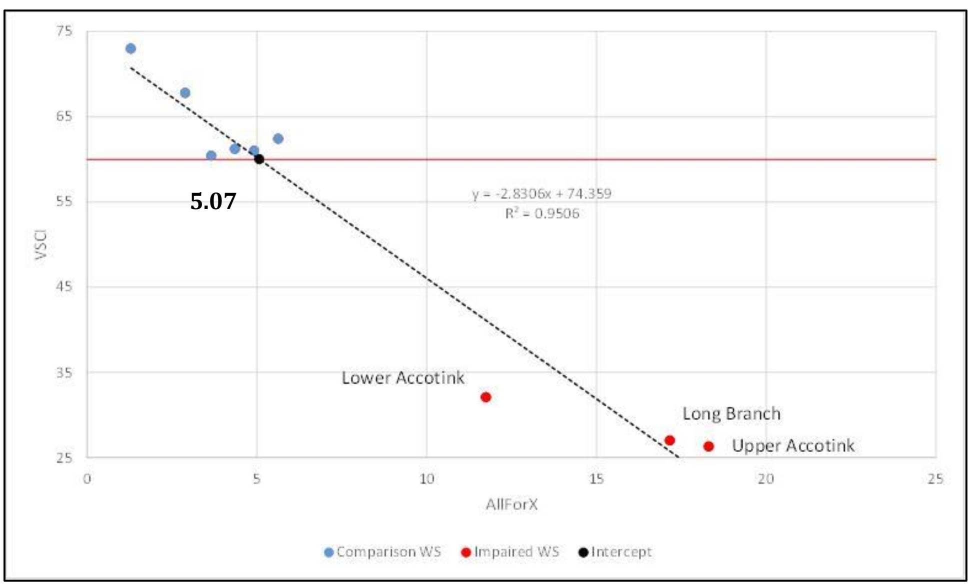

Figure A-5: Regression of AllForX values against corresponding VSCI scores.

The red horizontal line in **Figure A-5** is located at the 60 VSCI score. The black dot is the AllForX threshold. Data for comparison (unimpaired) watersheds are displayed with blue dots. Red dots represent Accotink impaired watersheds.

Current Scenario GWLF Inputs for Each Comparison Watershed

Goose Creek

Urban Land	Area (ha)	%Imp	CNI	CNP
LD Mixed	0	0.0	0	0
MD Mixed	27	0.52	98	79
HD Mixed	3	0.87	98	79
LD Residential	233	0.15	92	74
MD Residential	0	0.0	0	0
HD Residential	0	0.0	0	0

Rural Land	Area (ha)	CN	K	LS	C	P
Hay/Pasture	14774	80	0.379	1.799	0.018	0.99
Cropland	162	75	0.378	0.6	0.42	1.0
Forest	14715	72	0.381	4.428	0.001	0.52
Wetland	17	0	0.387	0.472	0.01	0.1
Disturbed	19	82	0.387	1.794	0.013	0.52
Turf/Golf	0	0	0.0	0.0	0.0	0.0
Open Land	1555	82	0.387	1.794	0.04	0.52
Bare Rock	0	0	0.0	0.0	0.0	0.0
Sandy Areas	0	0	0.0	0.0	0.0	0.0
Unpaved Road	0	0	0.0	0.0	0.0	0.0

Month	Ket	Adjust %ET	Day Hours	Grow Seas	Eros Coef	Stream Extract	Ground Extract
Jan	0.5	1.0	9.5	0	0.18	0.0	0.0
Feb	0.5	1.0	10.4	0	0.18	0.0	0.0
Mar	0.5	1.0	11.8	0	0.28	0.0	0.0
Apr	0.71	1.0	13.2	1	0.28	0.0	0.0
May	1.0	1.0	14.3	1	0.28	0.0	0.0
Jun	1.0	1.0	14.8	1	0.28	0.0	0.0
Jul	0.93	1.0	14.5	1	0.28	0.0	0.0
Aug	0.93	1.0	13.6	1	0.28	0.0	0.0
Sep	0.93	1.0	12.2	1	0.18	0.0	0.0
Oct	0.71	1.0	10.8	0	0.18	0.0	0.0
Nov	0.5	1.0	9.7	0	0.18	0.0	0.0
Dec	0.5	1.0	9.2	0	0.18	0.0	0.0

Sediment A Factor	2.5695E-04
Sed A Adjustment	1.0
Avail Water Cap (cm)	19.97
Sed Delivery Ratio	0.081

Values 0 - 1

GW Recess Coeff	0.066
GW Seepage Coeff	0.0
% Tile Drained (Ag)	0.0

Clark's Run

Urban Land	Area (ha)	%Imp	CNI	CNP
LD Mixed	0	0.0	0	0
MD Mixed	0	0.0	0	0
HD Mixed	0	0.0	0	0
LD Residential	7	0.15	92	74
MD Residential	0	0.0	0	0
HD Residential	0	0.0	0	0

Rural Land	Area (ha)	CN	K	LS	C	P
Hay/Pasture	434	79	0.364	0.583	0.03	0.45
Cropland	218	82	0.376	0.723	0.42	0.45
Forest	438	73	0.371	1.762	0.001	0.45
Wetland	23	87	0.399	0.461	0.01	0.1
Disturbed	5	82	0.368	0.844	0.041	0.45
Turf/Golf	0	0	0.0	0.0	0.0	0.0
Open Land	183	82	0.368	0.844	0.04	0.45
Bare Rock	0	0	0.0	0.0	0.0	0.0
Sandy Areas	0	0	0.0	0.0	0.0	0.0
Unpaved Road	0	0	0.0	0.0	0.0	0.0

Month	Ket	Adjust %ET	Day Hours	Grow Seas	Eros Coef	Stream Extract	Ground Extract
Jan	0.5	1.0	9.5	0	0.18	0.0	0.0
Feb	0.5	1.0	10.4	0	0.18	0.0	0.0
Mar	0.5	1.0	11.8	0	0.28	0.0	0.0
Apr	0.75	1.0	13.2	1	0.28	0.0	0.0
May	1.0	1.0	14.3	1	0.28	0.0	0.0
Jun	1.0	1.0	14.8	1	0.28	0.0	0.0
Jul	1.0	1.0	14.5	1	0.28	0.0	0.0
Aug	1.0	1.0	13.6	1	0.28	0.0	0.0
Sep	1.0	1.0	12.2	1	0.18	0.0	0.0
Oct	0.75	1.0	10.8	0	0.18	0.0	0.0
Nov	0.5	1.0	9.7	0	0.18	0.0	0.0
Dec	0.5	1.0	9.2	0	0.18	0.0	0.0

Sediment A Factor	2.4424E-04
Sed A Adjustment	1.0
Avail Water Cap (cm)	19.52
Sed Delivery Ratio	0.181

Values 0 - 1

GW Recess Coeff	0.084
GW Seepage Coeff	0.0
% Tile Drained (Ag)	0.0

Dry Mill Branch

Urban Land	Area (ha)	%Imp	CNI	CNP
LD Mixed	0	0.0	0	0
MD Mixed	0	0.0	0	0
HD Mixed	0	0.0	0	0
LD Residential	10	0.15	92	74
MD Residential	0	0.0	0	0
HD Residential	0	0.0	0	0

Rural Land	Area (ha)	CN	K	LS	C	P
Hay/Pasture	523	80	0.449	1.26	0.018	0.52
Cropland	2	75	0.47	0.978	0.42	0.52
Forest	564	72	0.463	1.451	0.001	0.52
Wetland	6	80	0.479	1.221	0.01	0.1
Disturbed	8	82	0.441	0.917	0.027	0.52
Turf/Golf	0	0	0.0	0.0	0.0	0.0
Open Land	77	82	0.441	0.917	0.04	0.52
Bare Rock	0	0	0.0	0.0	0.0	0.0
Sandy Areas	0	0	0.0	0.0	0.0	0.0
Unpaved Road	0	0	0.0	0.0	0.0	0.0

Month	Ket	Adjust %ET	Day Hours	Grow Seas	Eros Coef	Stream Extract	Ground Extract
Jan	0.5	1.0	9.5	0	0.18	0.0	0.0
Feb	0.5	1.0	10.4	0	0.18	0.0	0.0
Mar	0.5	1.0	11.8	0	0.28	0.0	0.0
Apr	0.71	1.0	13.1	1	0.28	0.0	0.0
May	1.0	1.0	14.2	1	0.28	0.0	0.0
Jun	1.0	1.0	14.8	1	0.28	0.0	0.0
Jul	0.93	1.0	14.5	1	0.28	0.0	0.0
Aug	0.93	1.0	13.6	1	0.28	0.0	0.0
Sep	0.93	1.0	12.2	1	0.18	0.0	0.0
Oct	0.71	1.0	10.9	0	0.18	0.0	0.0
Nov	0.5	1.0	9.8	0	0.18	0.0	0.0
Dec	0.5	1.0	9.2	0	0.18	0.0	0.0

Sediment A Factor	2.9681E-04
Sed A Adjustment	1.0
Avail Water Cap (cm)	19.97
Sed Delivery Ratio	0.182

Values 0 - 1

GW Recess Coeff	0.066
GW Seepage Coeff	0.0
% Tile Drained (Ag)	0.0

Little River

Urban Land	Area (ha)	%Imp	CNI	CNP
LD Mixed	0	0.0	0	0
MD Mixed	5	0.52	98	79
HD Mixed	0	0.0	0	0
LD Residential	15	0.15	92	74
MD Residential	0	0.0	0	0
HD Residential	0	0.0	0	0

Rural Land	Area (ha)	CN	K	LS	C	P
Hay/Pasture	5405	80	0.401	1.238	0.03	0.45
Cropland	31	75	0.415	0.457	0.42	0.45
Forest	4394	72	0.38	2.522	0.001	0.45
Wetland	34	80	0.387	0.424	0.01	0.1
Disturbed	8	82	0.405	1.27	0.02	0.45
Turf/Golf	0	0	0.0	0.0	0.0	0.0
Open Land	575	82	0.405	1.27	0.04	0.45
Bare Rock	0	0	0.0	0.0	0.0	0.0
Sandy Areas	0	0	0.0	0.0	0.0	0.0
Unpaved Road	0	0	0.0	0.0	0.0	0.0

Month	Ket	Adjust %ET	Day Hours	Grow Seas	Eros Coef	Stream Extract	Ground Extract
Jan	0.5	1.0	9.5	0	0.18	0.0	0.0
Feb	0.5	1.0	10.5	0	0.18	0.0	0.0
Mar	0.5	1.0	11.8	0	0.28	0.0	0.0
Apr	0.71	1.0	13.1	1	0.28	0.0	0.0
May	1.0	1.0	14.2	1	0.28	0.0	0.0
Jun	1.0	1.0	14.7	1	0.28	0.0	0.0
Jul	0.93	1.0	14.5	1	0.28	0.0	0.0
Aug	0.93	1.0	13.5	1	0.28	0.0	0.0
Sep	0.93	1.0	12.2	1	0.18	0.0	0.0
Oct	0.71	1.0	10.9	0	0.18	0.0	0.0
Nov	0.5	1.0	9.8	0	0.18	0.0	0.0
Dec	0.5	1.0	9.3	0	0.18	0.0	0.0

Sediment A Factor	2.3858E-04
Sed A Adjustment	1.0
Avail Water Cap (cm)	19.97
Sed Delivery Ratio	0.113

Values 0 - 1

GW Recess Coeff	0.066
GW Seepage Coeff	0.0
% Tile Drained (Ag)	0.0

North Fork Beaverdam Creek

Urban Land	Area (ha)	%Imp	CNI	CNP
LD Mixed	0	0.0	0	0
MD Mixed	1	0.52	98	79
HD Mixed	0	0.0	0	0
LD Residential	30	0.15	92	74
MD Residential	0	0.0	0	0
HD Residential	0	0.0	0	0

Rural Land	Area (ha)	CN	K	LS	C	P
Hay/Pasture	2874	79	0.368	1.026	0.03	0.52
Cropland	43	64	0.338	0.448	0.42	0.52
Forest	1776	73	0.381	2.248	0.001	0.52
Wetland	12	80	0.367	0.213	0.01	0.1
Disturbed	169	82	0.366	0.893	0.028	0.52
Turf/Golf	0	0	0.0	0.0	0.0	0.0
Open Land	161	82	0.366	0.893	0.04	0.52
Bare Rock	0	0	0.0	0.0	0.0	0.0
Sandy Areas	0	0	0.0	0.0	0.0	0.0
Unpaved Road	0	0	0.0	0.0	0.0	0.0

Month	Ket	Adjust %ET	Day Hours	Grow Seas	Eros Coef	Stream Extract	Ground Extract
Jan	0.5	1.0	9.5	0	0.18	0.0	0.0
Feb	0.5	1.0	10.4	0	0.18	0.0	0.0
Mar	0.5	1.0	11.8	0	0.28	0.0	0.0
Apr	0.75	1.0	13.1	1	0.28	0.0	0.0
May	1.0	1.0	14.2	1	0.28	0.0	0.0
Jun	1.0	1.0	14.7	1	0.28	0.0	0.0
Jul	1.0	1.0	14.5	1	0.28	0.0	0.0
Aug	1.0	1.0	13.6	1	0.28	0.0	0.0
Sep	1.0	1.0	12.2	1	0.18	0.0	0.0
Oct	0.75	1.0	10.9	0	0.18	0.0	0.0
Nov	0.5	1.0	9.8	0	0.18	0.0	0.0
Dec	0.5	1.0	9.3	0	0.18	0.0	0.0

Sediment A Factor	2.4815E-04
Sed A Adjustment	1.0
Avail Water Cap (cm)	19.52
Sed Delivery Ratio	0.14

Values 0 - 1

GW Recess Coeff	0.084
GW Seepage Coeff	0.0
% Tile Drained (Ag)	0.0

North Fork Catoctin

Urban Land	Area (ha)	%Imp	CNI	CNP
LD Mixed	0	0.0	0	0
MD Mixed	2	0.52	98	79
HD Mixed	0	0.0	0	0
LD Residential	20	0.15	92	74
MD Residential	0	0.0	0	0
HD Residential	0	0.0	0	0

Rural Land	Area (ha)	CN	K	LS	C	P
Hay/Pasture	2143	79	0.362	0.968	0.03	0.45
Cropland	68	75	0.341	0.437	0.42	0.45
Forest	2214	73	0.35	2.57	0.001	0.45
Wetland	32	80	0.452	0.536	0.01	0.1
Disturbed	0	0	0.0	0.0	0.0	0.0
Turf/Golf	0	0	0.0	0.0	0.0	0.0
Open Land	249	82	0.37	1.012	0.04	0.45
Bare Rock	0	0	0.0	0.0	0.0	0.0
Sandy Areas	0	0	0.0	0.0	0.0	0.0
Unpaved Road	0	0	0.0	0.0	0.0	0.0

Month	Ket	Adjust %ET	Day Hours	Grow Seas	Eros Coef	Stream Extract	Ground Extract
Jan	0.5	1.0	9.5	0	0.18	0.0	0.0
Feb	0.5	1.0	10.4	0	0.18	0.0	0.0
Mar	0.5	1.0	11.8	0	0.28	0.0	0.0
Apr	0.75	1.0	13.2	1	0.28	0.0	0.0
May	1.0	1.0	14.3	1	0.28	0.0	0.0
Jun	1.0	1.0	14.8	1	0.28	0.0	0.0
Jul	1.0	1.0	14.5	1	0.28	0.0	0.0
Aug	1.0	1.0	13.6	1	0.28	0.0	0.0
Sep	1.0	1.0	12.2	1	0.18	0.0	0.0
Oct	0.75	1.0	10.8	0	0.18	0.0	0.0
Nov	0.5	1.0	9.7	0	0.18	0.0	0.0
Dec	0.5	1.0	9.2	0	0.18	0.0	0.0

Sediment A Factor	2.3600E-04
Sed A Adjustment	1.0
Avail Water Cap (cm)	19.52
Sed Delivery Ratio	0.143

Values 0 - 1

GW Recess Coeff	0.084
GW Seepage Coeff	0.0
% Tile Drained (Ag)	0.0

South Fork Catoctin

Urban Land	Area (ha)	%Imp	CNI	CNP
LD Mixed	0	0.0	0	0
MD Mixed	0	0.0	0	0
HD Mixed	0	0.0	0	0
LD Residential	10	0.15	92	74
MD Residential	0	0.0	0	0
HD Residential	0	0.0	0	0

Rural Land	Area (ha)	CN	K	LS	C	P
Hay/Pasture	709	79	0.383	0.6	0.03	0.45
Cropland	53	75	0.383	0.796	0.42	0.45
Forest	755	73	0.402	1.269	0.001	0.45
Wetland	55	80	0.435	0.221	0.013	0.1
Disturbed	44	82	0.376	0.42	0.066	0.45
Turf/Golf	0	0	0.0	0.0	0.0	0.0
Open Land	76	82	0.376	0.42	0.04	0.45
Bare Rock	0	0	0.0	0.0	0.0	0.0
Sandy Areas	0	0	0.0	0.0	0.0	0.0
Unpaved Road	0	0	0.0	0.0	0.0	0.0

Month	Ket	Adjust %ET	Day Hours	Grow Seas	Eros Coef	Stream Extract	Ground Extract
Jan	0.5	1.0	9.5	0	0.18	0.0	0.0
Feb	0.5	1.0	10.4	0	0.18	0.0	0.0
Mar	0.5	1.0	11.8	0	0.28	0.0	0.0
Apr	0.75	1.0	13.2	1	0.28	0.0	0.0
May	1.0	1.0	14.3	1	0.28	0.0	0.0
Jun	1.0	1.0	14.8	1	0.28	0.0	0.0
Jul	1.0	1.0	14.5	1	0.28	0.0	0.0
Aug	1.0	1.0	13.6	1	0.28	0.0	0.0
Sep	1.0	1.0	12.2	1	0.18	0.0	0.0
Oct	0.75	1.0	10.9	0	0.18	0.0	0.0
Nov	0.5	1.0	9.8	0	0.18	0.0	0.0
Dec	0.5	1.0	9.2	0	0.18	0.0	0.0

Sediment A Factor	2.5467E-04
Sed A Adjustment	1.0
Avail Water Cap (cm)	19.52
Sed Delivery Ratio	0.176

Values 0 - 1

GW Recess Coeff	0.084
GW Seepage Coeff	0.0
% Tile Drained (Ag)	0.0

Tributary to Cedar Run

Urban Land	Area (ha)	%Imp	CNI	CNP
LD Mixed	0	0.0	0	0
MD Mixed	0	0.0	0	0
HD Mixed	0	0.0	0	0
LD Residential	1	0.15	92	74
MD Residential	0	0.0	0	0
HD Residential	0	0.0	0	0

Rural Land	Area (ha)	CN	K	LS	C	P
Hay/Pasture	5	80	0.293	0.028	0.03	0.45
Cropland	2	85	0.224	0.044	0.42	0.45
Forest	1122	72	0.439	0.89	0.001	0.45
Wetland	44	87	0.358	0.706	0.01	0.1
Disturbed	0	0	0.0	0.0	0.0	0.0
Turf/Golf	0	0	0.0	0.0	0.0	0.0
Open Land	30	87	0.341	0.542	0.04	0.45
Bare Rock	0	0	0.0	0.0	0.0	0.0
Sandy Areas	0	0	0.0	0.0	0.0	0.0
Unpaved Road	0	0	0.0	0.0	0.0	0.0

Month	Ket	Adjust %ET	Day Hours	Grow Seas	Eros Coef	Stream Extract	Ground Extract
Jan	0.5	1.0	9.6	0	0.18	0.0	0.0
Feb	0.5	1.0	10.5	0	0.18	0.0	0.0
Mar	0.5	1.0	11.8	0	0.28	0.0	0.0
Apr	0.71	1.0	13.1	1	0.28	0.0	0.0
May	1.0	1.0	14.2	1	0.28	0.0	0.0
Jun	1.0	1.0	14.7	1	0.28	0.0	0.0
Jul	0.93	1.0	14.4	1	0.28	0.0	0.0
Aug	0.93	1.0	13.5	1	0.28	0.0	0.0
Sep	0.93	1.0	12.2	1	0.18	0.0	0.0
Oct	0.71	1.0	10.9	0	0.18	0.0	0.0
Nov	0.5	1.0	9.8	0	0.18	0.0	0.0
Dec	0.5	1.0	9.3	0	0.18	0.0	0.0

Sediment A Factor	2.3835E-04
Sed A Adjustment	1.0
Avail Water Cap (cm)	19.97
Sed Delivery Ratio	0.182

Values 0 - 1

GW Recess Coeff	0.066
GW Seepage Coeff	0.0
% Tile Drained (Ag)	0.0

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