Benthic TMDL Development for Bull Run, Virginia

Submitted to

Virginia Department of Environmental Quality

Prepared by

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Executive Summary

Introduction

As required by Section 303(d) of the Clean Water Act and current EPA regulations, states are required to develop Total Maximum Daily Loads (TMDLs) for waterbodies that exceed water quality standards. Bull Run was initially listed on Virginia's 1994 Section 303(d) List, and was subsequently included on Virginia's 1998 and 2002 Section 303(d) Lists of Impaired Waters (DEQ, 1998; 2002) and in the 2004 Water Quality Assessment 305(b)/303(d) Integrated Report (DEQ, 2004) because of violations of General Standard (benthic impairment). Bull Run was also listed on the 2004 Water Quality Assessment 305(b)/303(d) Integrated Report due to exceedances of the water quality standards for fecal coliform bacteria and PCB concentrations in fish tissue samples. This report addresses the benthic impairment; the bacteria and PCB impairments will be addressed in separate TMDL reports. Bull Run is located in the northern region of Virginia, and is a tributary of the Occoquan Reservoir drainage. Bull Run flows through sections of Loudoun, Prince William, and Fairfax Counties, as well as the Cities of Fairfax, Manassas, and Manassas Park.

Impairment Listing

The Virginia Department of Environmental Quality (DEQ) uses biological monitoring of benthic macroinvertebrates as one method to assess support of the aquatic life use for a waterbody. Bioassessments of the benthic macroinvertebrate community of Bull Run were performed by DEQ using modified Rapid Bioassessment Protocols (EPA, 1999). Biological assessments conducted at DEQ monitoring station 1ABUL010.28, located at the intersection of Bull Run and Route 28, indicate a moderately impaired benthic macroinvertebrate community, which resulted in the Section 303(d) listing. Although biological assessments indicated the creek is impaired, additional analyses described in this report were required to identify the causal pollutant (stressor) and sources within the watershed.

The impaired benthic segment of Bull Run (VAN-A23R-01) is 4.8 miles in length extending from the confluence of Cub Run with Bull Run and continuing downstream to the confluence of Popes Head Creek with Bull Run.

Watershed Characterization and Environmental Monitoring

The Bull Run watershed is approximately 118,951 acres. Developed lands (38.8%), forested lands (34.2%) and agricultural lands (22.6%) represent the dominant land uses in the Bull Run watershed. The majority of soils in the watershed are comprised of the Penn-Croton-Calverton and Brecknock-Kelly-Croton soil associations. Combined, these two soil associations account for almost 70 percent of the soils in the watershed.

Environmental monitoring data were vital to the identification of the pollutant stressor(s) impacting the benthic community of Bull Run. Environmental monitoring efforts in the Bull Run watershed include benthic community sampling and analysis, habitat condition assessments, ambient water quality sampling, and toxicity testing. Monitoring efforts have been conducted by agencies at both the state and local levels, including the Virginia Department of Environmental Quality (VADEQ), Occoquan Watershed Monitoring Laboratory (OWML), Fairfax County Stormwater Planning Division, Fairfax County Health Department, and the Upper Occoquan Sewage Treatment Authority (UOSA). In addition, two citizen monitoring groups, the Virginia Save Our Streams Program (VA SOS) and the Audubon Naturalist Society (ANS), have conducted monitoring efforts. Monitoring has been conducted by VADEQ at stations 1ABUL09.61, 1ABUL010.28, 1ABUL011.03 and 1ABUL011.12 on the biologically impaired segment of Bull Run, in addition to monitoring conducted at 14 other stations in the watershed. In addition, monitoring data contained in discharge monitoring reports were used to assess the impacts of the wastewater treatment facilities in the watershed.

Stressor Identification

Assessment of the primary stressor contributing to biological impairment in Bull Run was based on evaluations of candidate stressors that can potentially impact the river. The identification of the most probable cause of biological impairment in the Bull Run was based on evaluations of candidate stressors that can potentially impact the river. The evaluation includes candidate stressors such as dissolved oxygen, temperature, pH, metals, organic chemicals, nutrient, toxic compounds, and sediments. Each candidate stressor was evaluated based on available monitoring data, field observations, and consideration of potential sources in the watershed.

Furthermore, potential stressors were classified as:

Non-stressors: The stressors with data indicating normal conditions and without water quality standard violations, or without any apparent impact

Possible stressors: The stressors with data indicating possible links, however, with inconclusive data to show direct impact on the benthic community

Most probable stressors: The stressors with the conclusive data linking them to the poorer benthic community.

The data and analysis presented in this report indicate that dissolved oxygen, temperature, and pH, in the biologically impaired segment of Bull Run are adequate to support a healthy invertebrate community, and are not stressors contributing to the benthic impairment. Concentrations of metals and organic chemicals were generally low or below analytical detection limits and are classified as non-stressors. In addition, toxicity was also classified as a non-stressor since toxicity testing suggested the absence of toxicity in the impaired segment Bull Run.

Based on the evidence and data discussed in Section 4.0, The Stressor Identification Analysis, sedimentation, caused by higher runoff flows has been identified as a primary stressor impacting benthic invertebrates in the biologically impaired segments of the Bull Run. Habitat scores indicate decreased habitat quality in the impaired segments because of the surrounding urban environment. Potential sources of sediment loading in the watershed include urban stormwater runoff, stream bank erosion, and sediment loss from habitat degradation associated with urbanization.

The interrelation between sedimentation, higher runoff flows, and habitat alteration, allows a TMDL for sediments to address habitat degradation as well as increased urban runoff. Improvement of the benthic community in the biologically impaired segment of the Bull Run watershed is dependent upon reducing sediment loadings through stormwater control, as well as restoring instream and riparian habitat to alleviate the impacts of urbanization on the river.

To address these issues, a sediment TMDL will be developed for the biologically impaired segments of the Bull Run watershed.

Reference Watershed Approach

TMDL development requires determination of endpoints, or water quality goals/targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. Currently, Virginia does not have numeric criteria for sediment. Therefore, a reference watershed approach was used to establish the numeric TMDL endpoint for Bull Run.

The Goose Creek watershed draining to the DEQ biomonitoring station at Goose Creek river mile 22.44 (1AGOO022.44) was selected as the reference watershed for Bull Run benthic TMDL development. Reduction of sediment loading in the impaired watershed to the level determined for the reference watershed (adjusted for area) is expected to restore support of the aquatic life use for Bull Run.

Sediment Loading Determination

Sediment sources within Bull Run watershed include both point and non-point sources. Point sources include solids loading from permitted discharge facilities and land-based loading from areas covered by municipal separate storm sewer system (MS4) permits. Non-point sources include sediment derived from the erosion of lands present throughout the watershed and the erosion of stream banks.

Sediment loadings were determined for both the reference and impaired watersheds in order to quantify sediment loading reductions necessary to achieve the designated aquatic life use for Bull Run. Sediment loadings from land erosion were determined using the Generalized Watershed Loading Functions (GWLF) model. GWLF model simulations were performed for 1994 to 2004 in order to account for seasonal variations and to reflect the period of biomonitoring assessments that resulted in the impairment listing of Bull Run. Average annual sediment loads were computed for each land source based on the 10 year simulation period. In addition, average annual sediment loads from instream bank erosion, point sources, and MS4 permitted areas were determined. Point source loadings were computed based on the permitted discharge loading rate for total suspended solids. Instream erosion was estimated based on the streambank lateral erosion rate equation introduced by Evans, et al (2003). An area-weighted method was used to determine the land-based load attributed to MS4s present in the watershed.

Under the reference watershed approach, the TMDL endpoint is based on sediment loadings for the reference watershed. Sediment loadings computed for this area-adjusted watershed were used for TMDL allocations.

TMDL Allocation

Sediment TMDL allocations for Bull Run were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:

TMDL= Total Maximum Daily Load (Based on the Sediment Load of the Adjusted Reference Watershed)

WLA = Wasteload Allocation

LA = Load Allocation

MOS = Margin of Safety

The wasteload allocation represents the total sediment loading allocated to point sources. The load allocation represents the total sediment loading allocated to non-point sources. A margin of safety is applied to account for uncertainty in methodologies and determination of sediment loadings. An explicit margin of safety of 10% was used for the Bull Run benthic TMDL.

Out of the nine permitted facilities within the Bull Run watershed, three of these facilities have total suspended solids (TSS) permits (**Table E-1**). For the purpose of TMDL development, annual point source loadings were computed based on the permitted design discharge and the permitted concentration of total suspended solids for each facility.

Table E-1: Point Sources in the Bull Run Impaired Watershed with Permits for TSS

Facility Name	Permitted TSS Load (kg/day)	Annual Sediment Loading (ton/year)
UOSA	242.2	97.42
Golf Course	0.4	0.2
Sunoco	14.4	5.8
Total	**257.0**	**103.4**

The MS4 permits state that the Cities of Fairfax, Manassas, and Manassas Park as well as Fairfax, Prince William, and Loudoun Counties and the Manassas Campus of the Northern Virginia Community College, Prince William County Schools, and Fairfax County Schools, as well as VDOT road areas, and MWAA Washington Dulles International Airport are permitted to discharge into the Bull Run impaired watershed. However, stormwater permits typically do not have numeric limits for sediment. To separate sediment loading attributed to the MS4s from other land-based sediment loading, an area weighted sediment load was determined for the MS4s, in which the percentage of sediment loading from each source area attributed to the MS4s was proportional to the percentage of that source area in the Bull Run impaired watershed covered by the various MS4 permits. The MS4 acres present in the watershed by locality are presented in **Table E-2**. Additionally, stormwater runoff from MS4s results in increased stream bank erosion. Bank erosion resulting from MS4 stormwater runoff and bank erosion resulting from overland runoff were also separated using an area weighted approach, in which the percentage of sediment loading from bank erosion attributed to the MS4 was proportional to the percentage of the Bull Run impaired watershed covered by the MS4 permits. Since 65,456 acres of the 118,951 total acres in the Bull Run impaired watershed are covered by 5MS4 permits, 55% percent of the sediment load from instream erosion was attributed to the MS4s. Sediment from other land sources in the watershed and the remainder of the bank erosion sediment load were attributed to the land-based load.

Table E-2: MS4 Permit Acreage within the Bull Run Watershed

Permit Number	MS4 Permit Holder[1]	MS4 Locality	Acres
VA0088587	Fairfax County	Fairfax County	50,024.9
VAR040104	Fairfax County Public Schools		
VAR040062	VDOT Urban Area		
VAR040064	Fairfax City	Fairfax City	173.8
VAR040062	VDOT Urban Area		
VAR040067	Loudoun County	Loudoun County	5,156.2
VAR040062	VDOT Urban Area		
VAR040063	Manassas City	Manassas City	2,564.0
VAR040095	NOVA Manassas Campus		
VAR040062	VDOT Urban Area		
VAR040070	Manassas Park	Manassas Park	1,323.0
VAR040062	VDOT Urban Area		
VA0088595	Prince William County	Prince William County	6,214.2
VAR040100	Prince William County Public Schools		
VAR040062	VDOT Urban Area		
Total			**65,456.0**

[1] MWAA Washington Dulles International Airport is subject to regulation under the MS4 program. The individual VPDES permit for this facility, permit number VA0089541, establishes the regulatory requirements for industrial stormwater, construction stormwater and MS4 under a single permit. The MS4 acreage is not presented in this table as the stormwater regulated under this program cannot readily be distinguished from other activities.

The total load, wasteload allocations, and margin of safety for Bull Run are summarized in **Table E-3**. Recommended allocations for each source in the watershed are provided in **Table E-4**. A load equivalent to half a percent (0.5%) of the total TMDL sediment load (60 tons/year) was deducted from the load allocations (LA) set aside to account for future growth. Overall, the sediment load in the Bull Run watershed must be reduced by 76.8% to meet the established TMDL endpoint.

Table E-3: Sediment TMDL for Bull Run (tons/year)

TMDL	Load Allocation	Wasteload Allocation (Point Source + MS4s)	Margin of Safety (10%)
11,994.1	4,807.9	5,986.8	1,199.4

Table E-4: Summary of Existing and Allocated Sediment Loads for the Bull Run Watershed

Source	Land Use Type	Existing Load (tons/year)	Allocated Load (tons/year)	Percent Reduction
Non-point Source	Deciduous Forest	55.7	55.7	0
	Evergreen Forest	12.6	12.6	0
	Mixed Forest	7.8	7.8	0
	Pasture/Hay	1,005.5	224.5	77.6
	Row Crop	2,066.8	461.5	77.6
	Low Intensity Residential	2.9	0.7	77.6
	Medium High Intensity	124.9	27.9	77.6
	Commercial/Industrial	189.9	42.4	77.6
	Institutional	19.9	4.5	77.6
	Urban Recreational Grass	0.6	0.1	77.6
	Instream Erosion	17,755.9	3,970.3	77.6
MS4	Non-point Source	4,163.8	911.4	77.1
	Instream Erosion	20,324.8	4,448.8	77.1
Permitted Facilities	Individual VPDES Permits	103.4	163.4*	-
	Stormwater Permits#	987.9	463.1	-
	Total	**46,822.5**	**10,794.7**	**76.8**

(*)A load equivalent to half a percent (0.5%) of the Total TMDL Load (60 tons/year) was taken from the load allocations (LA) and added to the waste load allocation to account for future growth and the potential change in land-use from rural/open space to urban

(#) Breakdown of the loads by type of stormwater permit is shown in Table 7-3

Implementation

In general, Virginia intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the most efficient sediment BMPs for both urban and rural watersheds are infiltration and retention basins, riparian buffer zones, grassed waterways, streambank protection and stabilization, and wetland development or enhancement.

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

Public Participation

The development of the Bull Run benthic TMDL would not have been possible without public participation. Public meetings were held on March 30, 2005 at the Sully District Governmental Center in Chantilly, Virginia, on April 5, 2005, at the Pennington School in Manassas, on December 14, 2005, at the Sully District Governmental Center in Chantilly, Virginia, and on March 15, 2006 at the Central Community Library in Manassas, VA to discuss each step of the Bull Run TMDL. Copies of the presentation and the draft TMDL report executive summary were available for public distribution at each meeting. Also, each meeting was public noticed in *The Virginia Register of Regulations.*

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List of Acronyms

ANS	Audubon Naturalist Society
BMP	Best Management Practices
BNR	Biological Nutrient Removal
COD	Chemical Oxygen Demand
DCR	Department of Conservation and Recreation
DDD	Dichloro-diphenyl-dichloroethane
DDE	Dichloro-diphenyl-ethane
DDT	Dichloro-diphenyl-trichloroethane
DEM	Digital Elevation Model
DEQ	Department of Environmental Quality
DMR	Discharge Monitoring Report
DMME	Department of Mines, Minerals, and Energy

DO	Dissolved Oxygen
EPA	Environmental Protection Agency (discrepancy, also use USEPA) 2-7
GIS	Geographic Information System
GWLF	Generalized Watershed Loading Functions
IP	Implementation Plan
K	Soil Erodibility
LA	Load Allocation
LID	Low Impact Development
LS	Length-slope
MOS	Margin of Safety
MOU	Memorandum of Understanding
MS4	Municipal Separate Storm Sewer
NHD	National Hydrography Dataset
NLCD	National Land Cover Data
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
NVRC	Northern Virginia Regional Commission
OCR	Old Centreville Road
OWML	Occoquan Watershed Monitoring Laboratory
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PEC	Probable Effects Concentrations
RBPII	Rapid Bioassessment Protocol II
SCI	Stream Condition Index
SPD	Stormwater Planning Division
STATSGO	State Soil Geographic
SWCB	State Water Control Board
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
TSI	Tissue-Screening Value
TSS	Total Suspended Solids
TV	Tissue Value
VADEQ	Virginia Department of Environmental Quality
VA SOS	Virginia Save Our Streams Program
VDH	Virginia Department of Health
VDOT	Virginia Department of Transportation
VPDES	Virginia Pollutant Discharge Elimination System

VSMP	Virginia Stormwater Management Program Permits
UAA	Use Attainability Analysis
UOSA	Upper Occoquan Sewage Treatment Authority
USGS	U.S. Geological Survey
USLE	Universal Soil Loss Equation
WET	Whole Effluent Toxicity
WLA	Wasteload Allocation
WQMIRA	Water Quality Monitoring, Information, and Restoration Act
WQMP	Water Quality Management Plan

1.0 Introduction

Total Maximum Daily Load (TMDL) development for biological impairment requires a methodology to identify impairment causes and to determine pollutant reductions that will allow streams to attain their designated uses. The identification of the pollutant(s), or *stressor(s)*, responsible for the impaired biological communities is an important first step in developing a TMDL that accurately specifies the pollutant load reductions necessary for the stream to comply with Virginia's water quality standards. This report details the steps used to identify and characterize the stressor(s) responsible for biological impairments in Bull Run, Virginia. The first section of this report presents the regulatory guidance and defines the applicable water quality criteria for biological impairment. In the subsequent sections of this report, watershed and environmental monitoring data collected on Bull Run are presented and discussed. Stressors which may be impacting the creek are then analyzed in the stressor identification section. Based on this analysis, candidate stressors impacting benthic invertebrate communities in the creek are identified. A TMDL will be developed for the stressor identified as the primary source of biological impairment in Bull Run.

1.1 Regulatory Framework

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

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

As required by the Clean Water Act and WQMIRA, DEQ develops and maintains a listing of all impaired waters in the state that details the pollutant(s) causing each impairment and the potential source(s) of each pollutant. This list is referred to as the Section 303(d) List of Impaired Waters. In addition to Section 303(d) List development, WQMIRA directs DEQ to develop and implement TMDLs for listed waters (DEQ, 2001). DEQ also solicits participation and comments from watershed stakeholders and the public throughout the TMDL process. Once TMDLs have been developed and the public comment period has been completed, the TMDLs are submitted to EPA for approval.

1.2 Impairment Listing

Bull Run was initially listed on Virginia's 1994 Section 303(d) List, and was subsequently included on Virginia's 1998 and 2002 Section 303(d) Lists of Impaired Waters (DEQ, 1998; 2002) and in the 2004 Water Quality Assessment 305(b)/303(d) Integrated Report (DEQ, 2004) because of violations of General Standard (benthic impairment). Bull Run was also listed on the 2004 Water Quality Assessment 305(b)/303(d) Integrated Report due to exceedances of the water quality standards for fecal coliform bacteria and PCB concentrations in fish tissue samples. This report addresses the benthic impairment; the bacteria and PCB impairments will be addressed in separate TMDL reports. Biological assessments conducted at DEQ monitoring station 1ABUL010.28, located at the intersection of Bull Run and Route 28, indicate a moderately impaired benthic macroinvertebrate community, which resulted in the Section 303(d) listing.

Bull Run is located in the northern region of Virginia, and is a tributary of the Occoquan Reservoir drainage. Bull Run flows through sections of Loudoun, Prince William, and Fairfax Counties, as well as the Cities of Fairfax, Manassas, and Manassas Park. The impaired benthic segment of Bull Run (VAN-A23R-01) is 4.8 miles in length extending from the confluence of Cub Run with Bull Run and continuing downstream to the confluence of Popes Head Creek with Bull Run. Figure 1-1 depicts the impaired benthic segment of Bull Run, as well as the delineated watershed boundary.

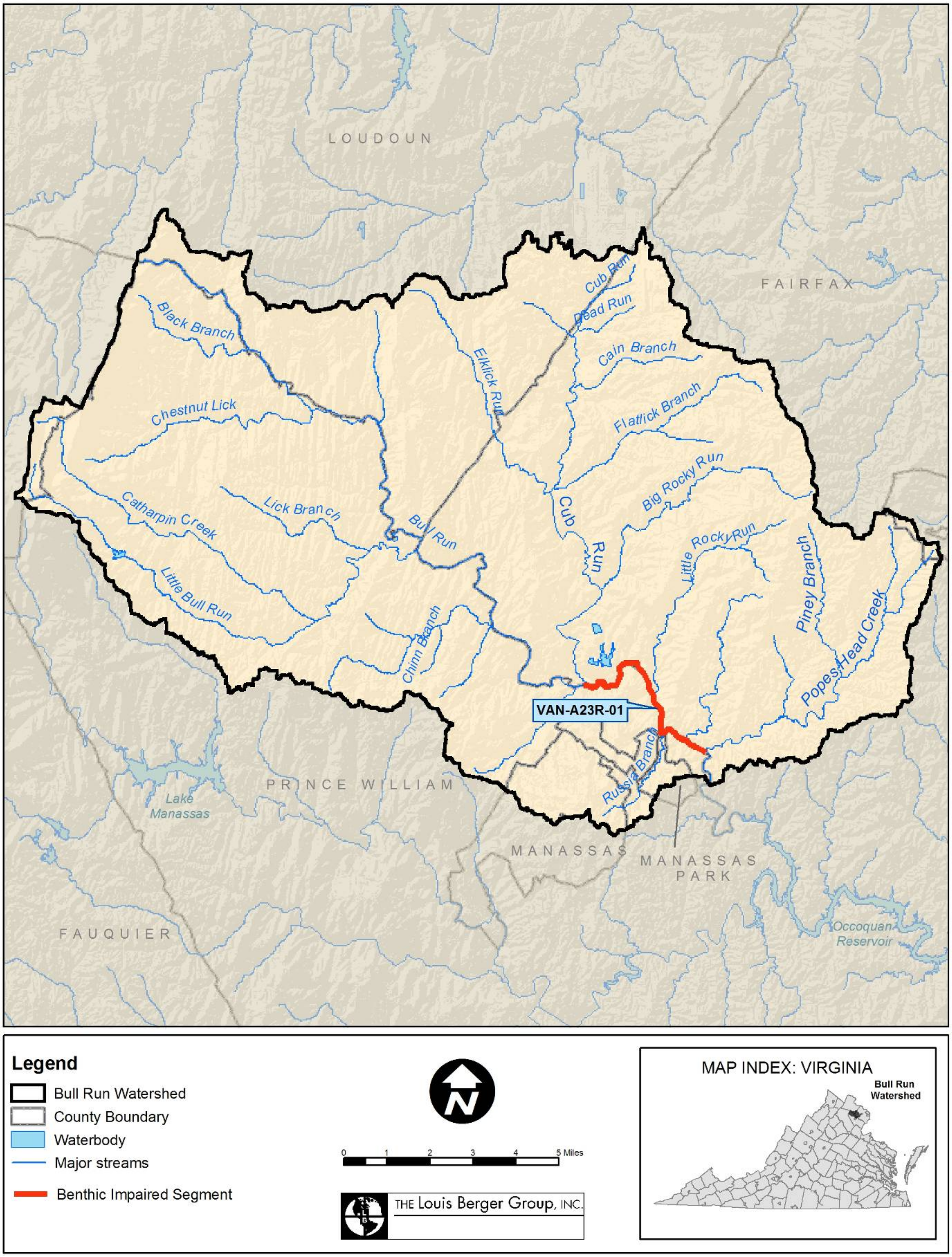

Figure 1-1: Bull Run Impaired Segment and Delineated Watershed

1.3 Applicable Water Quality Standard

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

1.3.1 Designated Uses

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

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

The listed segment defined in Section 1.2 does not support the propagation and growth of aquatic life in Bull Run, based on the biological assessment surveys conducted on the stream.

1.3.2 Water Quality Criteria

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 Standard 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."

The biological assessments conducted on Bull Run indicate that some pollutant(s) are interfering with attainment of the General Standard, as impaired invertebrate communities have been observed in the listed segment of the creek. Although biological assessments are indicative of the impacts of pollution, the specific pollutant(s) and source(s) are not necessarily known based on biological assessments alone.

2.0 Watershed Characterization

The physical conditions of Bull Run were characterized using a geographic information system (GIS) developed for the watershed. The purpose of the characterization was to provide an overview of the conditions in the watershed related to the benthic impairment present in the listed segment of the stream. Information contained in the watershed GIS was used in the stressor identification analysis, as well as for the subsequent TMDL development. In particular, physical watershed features such as topography, soils types, and land use conditions were characterized. In addition, the number and location of permitted discharge facilities and DEQ monitoring stations in the watershed were summarized.

2.1 Physical Characteristics

Important physical characteristics of the Bull Run watershed that may be contributing to the benthic impairment were analyzed using GIS coverages developed for the area. GIS coverages for the watershed boundary, stream network, topography, soils, land use, and ecoregion of the watershed were compiled and analyzed.

2.1.1 Watershed Location and Boundary

Bull Run is located in the northern region of Virginia, and is a tributary of the Occoquan River. Bull Run flows through sections of Loudoun, Prince William, and Fairfax Counties, as well as the Cities of Fairfax, Manassas, and Manassas Park (**Figure 2-1**). The watershed is approximately 118,096 acres or 184.5 square miles.

2.1.2 Stream Network

The stream network for the Bull Run watershed was obtained from the USGS National Hydrography Dataset (NHD). The stream network and benthic impairment segment are presented in **Figure 2-1**.

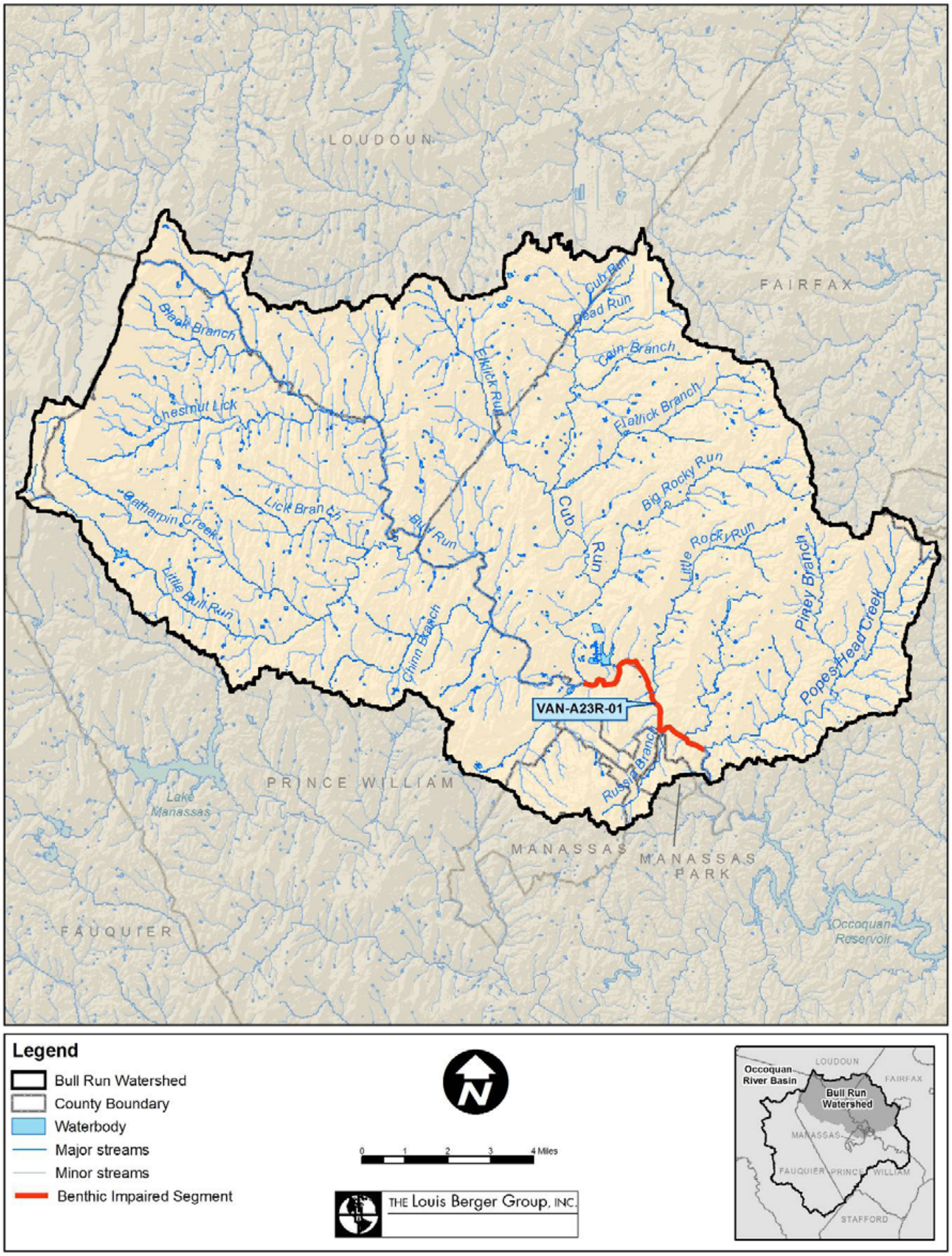

Figure 2-1: Stream Network for the Bull Run Watershed

2.1.3 Topography

A digital elevation model (DEM) was used to characterize topography in the watershed. DEM data obtained from BASINS show that elevation in the watershed ranges from approximately 108 to 1,242 feet above mean sea level, with an average elevation of 321 feet above mean sea level.

2.1.4 Soils

The Bull Run watershed soil characterization was based on the NRCS State Soil Geographic (STATSGO) Database for Virginia. There are six general soil associations present in the Bull Run watershed; Catoctin-Myersville-Rock Outcrop, Codorus-Hatboro-Kinkora, Braddock-Dyke, Buckhall-Occoquan-Meadowville, Penn-Croton-Calverton, Airmont-Stumptown-Weverton, Jackland-Waxpool-Catlett, Brecknock-Kelly-Croton, and Manor-Glenelg-Chester. The majority of soils in the watershed are comprised of the Penn-Croton-Calverton and Brecknock-Kelly-Croton soil associations. The distribution of soils in the Bull Run watershed, along with the hydrologic soil groups of each of the soils associations, is presented in **Table 2-1**.

Table 2-1: Soil Types in the Bull Run Watershed

Map Unit ID	Soil Association	Percent	Hydrologic Soil Group
VA006	Catoctin-Myersville-Rock Outcrop	0.1	B/C
VA010	Codorus-Hatboro-Kinkora	1.4	B/C/D
VA012	Braddock-Dyke	0.5	B
VA013	Buckhall-Occoquan-Meadowville	3.2	B
VA015	Penn-Croton-Calverton	45.3	B/C
VA021	Airmont-Stumptown-Weverton	3.0	B/C
VA022	Jackland-Waxpool-Catlett	11.2	B/C/D
VA023	Brecknock-Kelly-Croton	23.0	B/C/D
VA071	Manor-Glenelg-Chester	12.3	B/C/D
Source: State Soil Geographic (STATSGO) Database for Virginia			

Hydrologic soil groups represent the different levels of soil infiltration capacity. Hydrologic soil group "A" designates soils that are well to excessively well drained, whereas hydrologic soil group "D" designates soils that are poorly drained. This means that soils in hydrologic group "A" allow a larger portion of the rainfall to infiltrate and become part of the groundwater system. On the other hand, compared to the soils in hydrologic group "A", soils in hydrologic group "D" allow a smaller portion of the rainfall to infiltrate and become part of the groundwater, resulting in more rainfall delivered to surface waters in the form of runoff. Descriptions of the hydrologic soil groups are presented in **Table 2-2**.

Table 2-2: Descriptions of Hydrologic Soil Groups

Hydrologic Soil 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 high water table, or shallow to an impervious cover

2.1.5 Land Use

The land use characterization for the Bull Run watershed was based on land cover data from both the Northern Virginia Regional Commission (NVRC) 2000 Land Use Dataset, and the 1992 USGS National Land Cover Data (NLCD). The NVRC dataset was the most recent available land use dataset, and was also utilized in order to be consistent with other ongoing modeling efforts within the Occoquan watershed. However, the NVRC dataset does not specify forested or open (i.e., pasture) lands; therefore, the NLCD dataset was used to fill in the remaining areas. The distribution of land uses in the Bull Run watershed, by land area and percentage, is presented in **Table 2-3**. Developed lands (38.8%), forested lands (34.2%) and agricultural lands (22.6%) represent the dominant land use types in the watershed. **Figure 2-2** displays a map of the land uses within the watershed.

Table 2-3: Bull Run Watershed Land Use Distribution

General Land Use Category	Specific Land Use Type	Acres	Percent of Watershed	Total Percent
Water/ Wetlands	Open Water	364.5	0.3%	1.3%
	Woody Wetlands	161.7	0.1%	
	Emergent Herbaceous Wetlands	972.2	0.8%	
Developed	Low Intensity Residential	16,125.4	13.6%	38.8%
	Medium/High Intensity Residential	16,261.0	13.7%	
	Commercial/Industrial	11,161.3	9.4%	
	Institutional	2,595.7	2.2%	
Agriculture	Pasture/Hay/Livestock	18,389.7	15.5%	21.8%
	Row Crop	7,496.4	6.3%	
Forest	Deciduous Forest	29,977.9	25.2%	34.9%
	Evergreen Forest	7,114.1	6.0%	
	Mixed Forest	4,382.4	3.7%	
Other	Quarries/Strip Mines/Gravel Pits	54.0	0.0%	3.3%
	Transitional	622.7	0.5%	
	Urban/Recreational Grasses	375.3	0.3%	
	Golf Course	2,899.6	2.4%	
Total		**118,954**	**100.0%**	**100.0%**

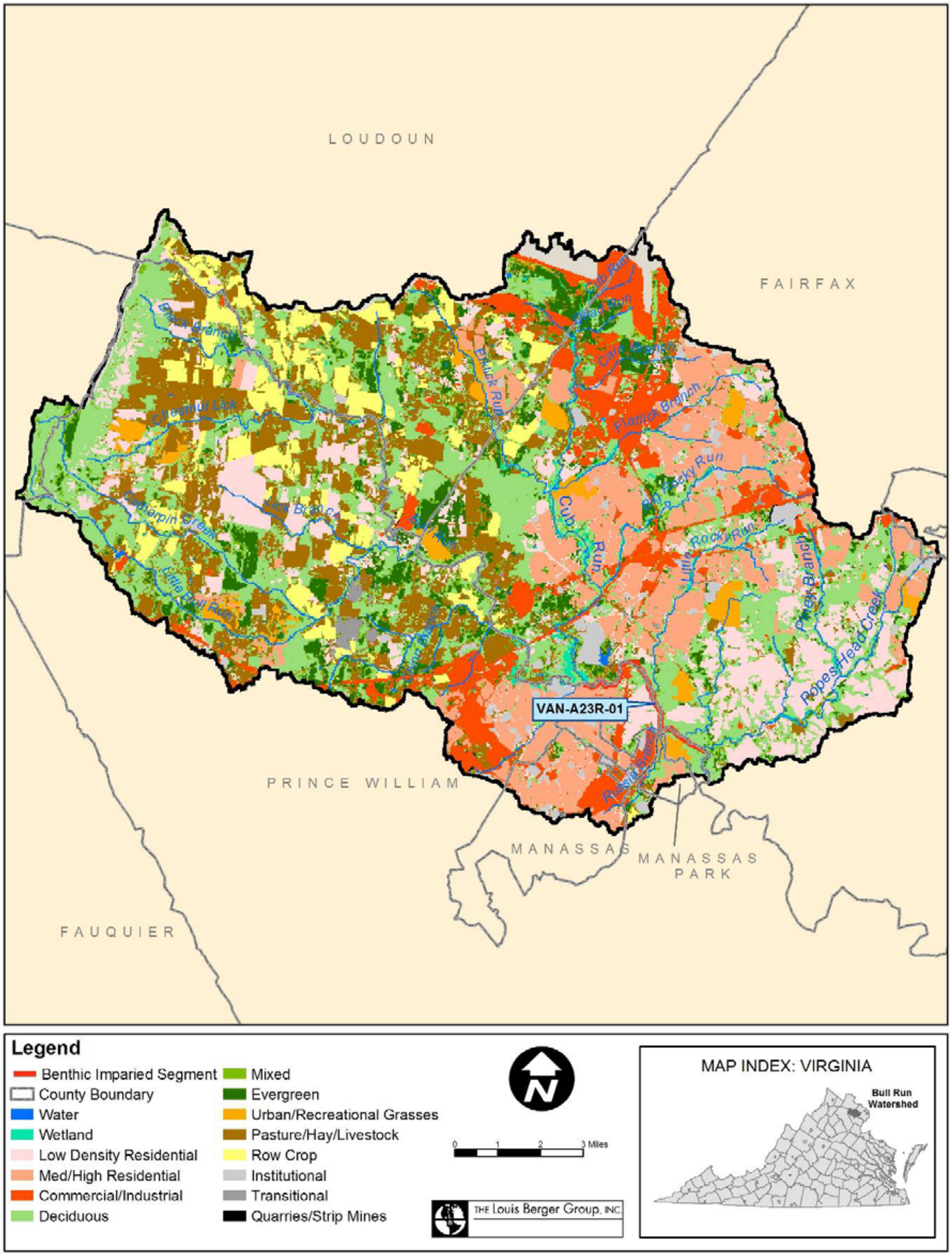

Figure 2-2: Land Use in the Bull Run Watershed

2.1.6 Ecoregion Classification

The Bull Run watershed is located in the Northern Piedmont and Piedmont ecoregions, USEPA Level III classification numbers 64 and 45, respectively (Woods et al., 1999). The location of the Bull Run watershed within these ecoregions is presented in **Figure 2-3**; the majority of the watershed is encompassed by the Northern Piedmont ecoregion. The Northern Piedmont ecoregion is transitional region of low rounded hills, irregular plains, and open valleys that serves as a transitional area between the low mountains to the north and west and the flat coastal plains to the east. Natural vegetation in the Northern Piedmont ecoregion is predominantly Appalachian oak forest, in contrast to the mostly oak-hickory-pine forests of the Piedmont ecoregion to the southwest.

The Piedmont ecoregion extends from Wayne County, Pennsylvania southwest through Virginia, and comprises a transitional area between the mostly mountainous ecoregions of the Appalachians to the northwest and the flat coastal plain to the southeast. Once largely cultivated, much of this region has reverted to pine and hardwood woodlands. The Piedmont ecoregion is characterized by shallow valleys, irregular plains, and low rounded hills and ridges. The underlying geology of this region consists of deeply weathered, deformed metamorphic rocks with intrusions by igneous material.

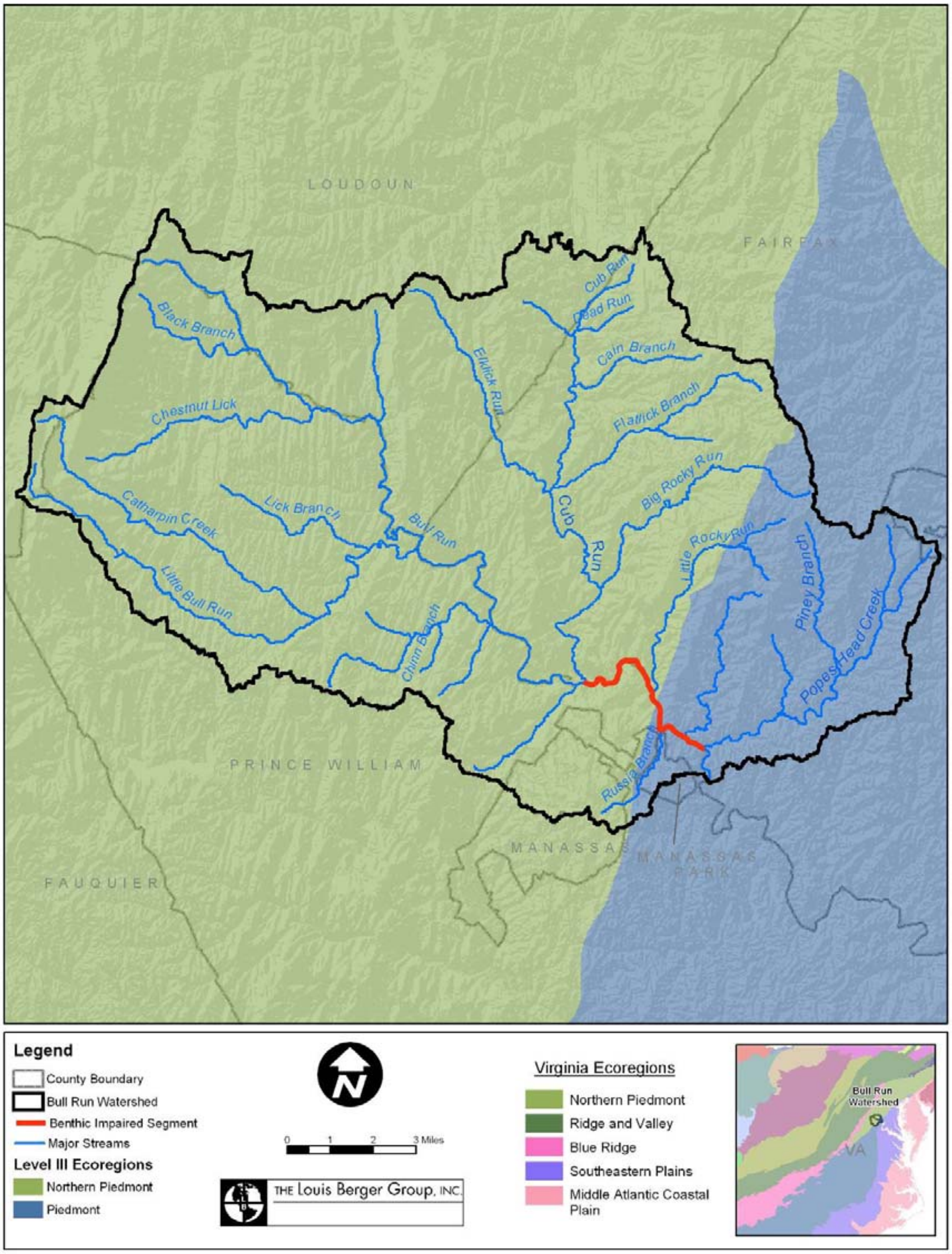

Figure 2-3: Virginia Level III Ecoregions

2.2 Permitted Discharge Facilities

There are 9 facilities holding active individual discharge VPDES permits, issued through the Virginia Pollutant Discharge Elimination System permitting program, in the Bull Run watershed. The permit number, outfall number, permitted flow, receiving waterbody, of the facilities holding individual permits are presented in **Table 2-4** and their locations are presented in **Figure 2-4**. There are also a total of approximately 116 active general stormwater permits in the watershed; 5 permits issued to individual facilities, 32 permits issued to domestic sewage facilities, 11 stormwater permits issued to industrial sites, 5 permits issued to concrete facilities, 3 permits issued to mines, 3 permits issued for petroleum-related activities and based on DCR data, there are approximately 60 stormwater permits issued to construction sites. A list of General permit holders is presented in Appendix A.

Table 2-4: Facilities Holding Individual Permits in the Bull Run Watershed

Permit No.	Facility Name	Outfall No.	Design Flow (MGD)	Facility Type	Receiving Waterbody
VA0024988	UOSA – Centreville	1	64	Municipal	Bull Run, UT
VA0051683	Colonial Pipeline - Chantilly	1	0.44	Industrial	Little Rocky Run, UT
		101	-	Industrial	Little Rocky Run, UT
		102	-	Industrial	Little Rocky Run, UT
VA0051691	Colonial Pipeline – Bull Run	1	0.06	Industrial	Bull Run, UT
		2	0.06	Industrial	Bull Run, UT
VA0085901	IBM Corp	3	0.504	Industrial	Flat Branch, UT
		4	0.504	Industrial	Flat Branch, UT
VA0087858	Sunoco - Manassas Terminal	1	2.215	Industrial	Bull Run, UT
		2	-	Industrial	Bull Run, UT
		101	-	Industrial	Bull Run, UT
VA0087891	Evergreen Country Club	1	0.008	Municipal	Chestnut Lick, UT
VA0089541	MWAA - Washington Dulles International Airport	22	-	Industrial	Cub Run
		23	-	Industrial	Cub Run, UT
		24	-	Industrial	Cub Run, UT
		25	-	Industrial	Dead Run
		27	-	Industrial	Cub Run, UT
		28	-	Industrial	Cub Run, UT
		29	-	Industrial	Cub Run, UT
		30	-	Industrial	Cub Run, UT
VA0090441	Adaptive Concrete Solutions	1	-	Industrial	Sand Branch
		2	-	Industrial	Sand Branch, UT
VA0091430	Loudoun Composting	1	-	Industrial	Sand Branch, UT

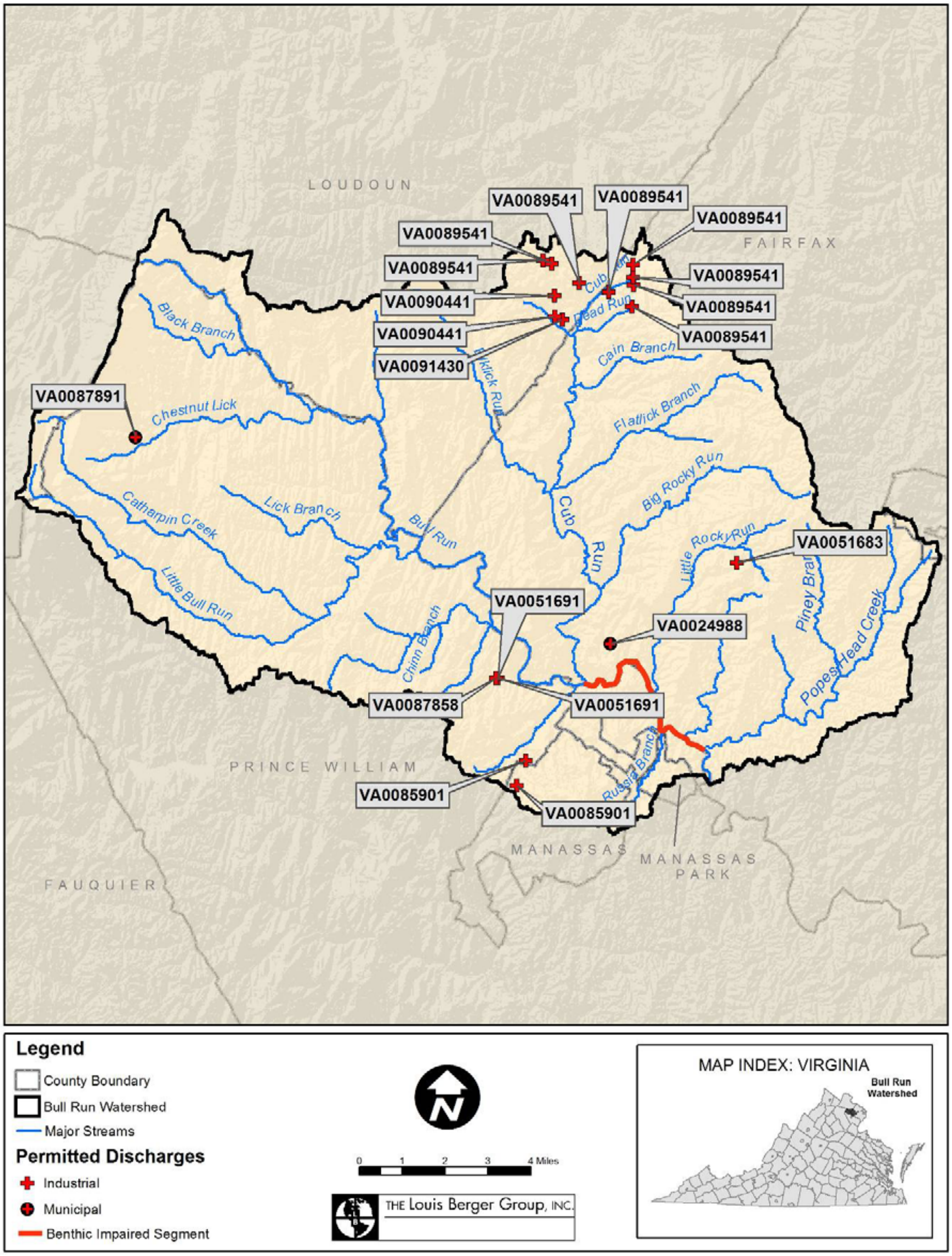

Figure 2-4: Location of Dischargers with Individual Permits in the Bull Run Watershed

In addition to the individual and general permits presented above, eleven (11) Municipal Separate Storm Sewer (MS4) permits have been issued to Cities, Towns, Counties, and other facilities within the Bull Run benthic impaired Watershed. **Table 2-5** lists all the MS4 permit holders with the area covered by each individual MS4. The MS4 County and City areas were calculated using the US Census Urban Areas and subtracting the acreages for the VDOT road areas. VDOT road areas were estimated using the roads length within the urban areas and assuming a 25 foot-road-width. Combined, these MS4 permits cover approximately 55% of the Bull Run benthic impaired watershed. **Figure 2-5** presents the major MS4 areas located within the Bull Run benthic impaired Watershed.

Table 2-5: MS4 Permits located within the Bull Run Watershed

Permit Number	MS4 Permit Holder[1]	MS4 Area	Acres
VA0088587	Fairfax County	Fairfax County	50,024.9
VAR040104	Fairfax County Public Schools		
VAR040062	VDOT Urban Area		
VAR040064	Fairfax City	Fairfax City	173.8
VAR040062	VDOT Urban Area		
VAR040067	Loudoun County	Loudoun County	5,156.2
VAR040062	VDOT Urban Area		
VAR040063	Manassas City	Manassas City	2,564.0
VAR040095	NOVA Manassas Campus		
VAR040062	VDOT Urban Area		
VAR040070	Manassas Park	Manassas Park	1,323.0
VAR040062	VDOT Urban Area		
VA0088595	Prince William County	Prince William County	6,214.2
VAR040100	Prince William County Public Schools		
VAR040062	VDOT Urban Area		
Total			**65,456.0**

[1] MWAA Washington Dulles International Airport is subject to regulation under the MS4 program. The individual VPDES permit for this facility, permit number VA0089541, establishes the regulatory requirements for industrial stormwater, construction stormwater and MS4 under a single permit. The MS4 acreage is not presented in this table as the stormwater regulated under this program cannot readily be distinguished from other activities.

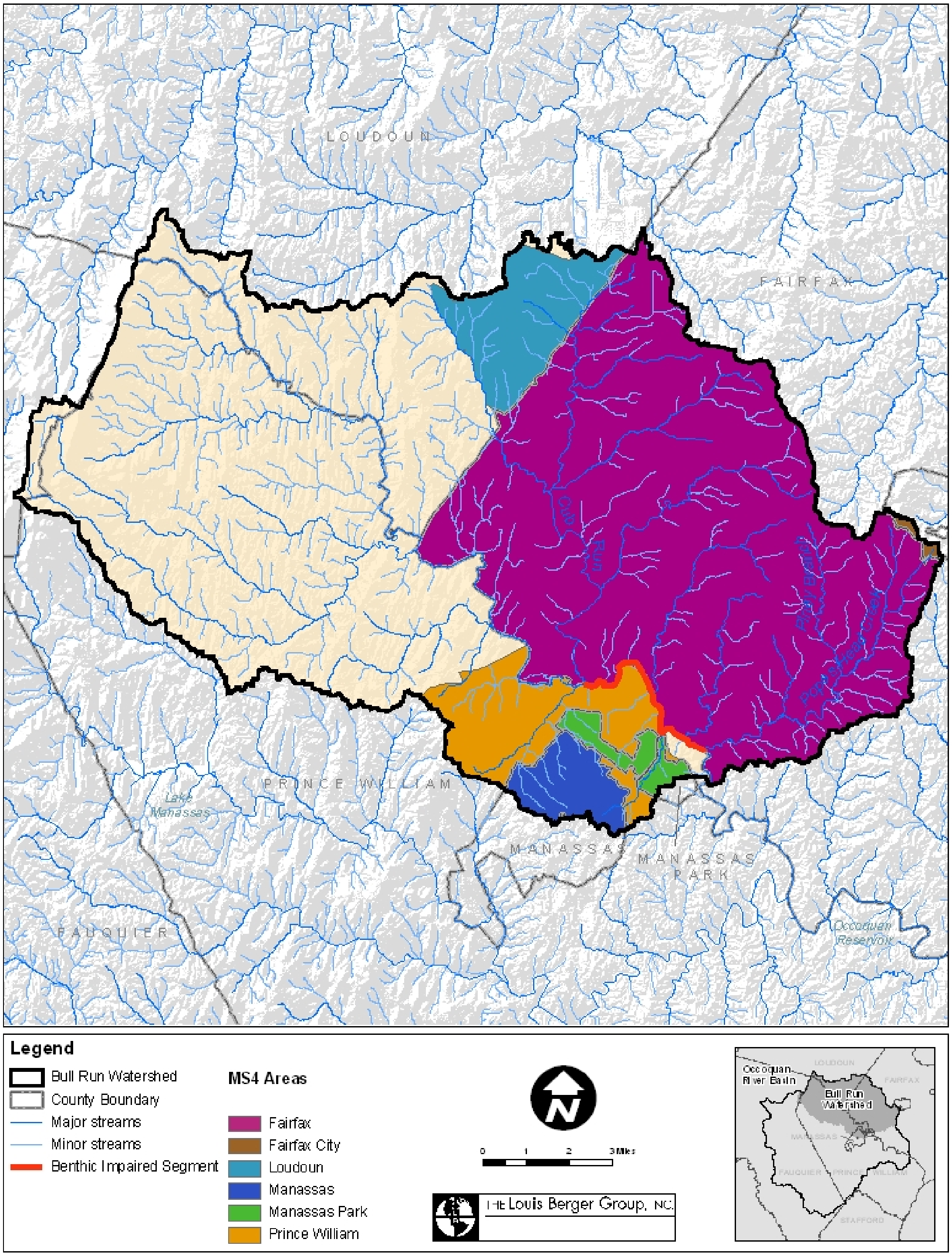

Figure 2-5: Municipal MS4 Areas Located within the Bull Run Watershed

2.3 DEQ Monitoring Stations

DEQ has monitored ambient water quality, macroinvertebrate communities, and/or sediment chemistry at 18 locations in the Bull Run watershed, 7 of which are located on the Bull Run mainstem. A list of those DEQ monitoring stations on the Bull Run mainstem is provided in **Table 2-6**. The locations of these mainstem stations, in addition to the other 11 stations in the watershed, are presented in **Figure 2-6**. Station identification numbers include the abbreviated creek name and the river mile on that creek where the station is located. The river mile number represents the distance from the mouth of the creek. Monitoring data from all stations in the watershed was evaluated as part of the benthic stressor analysis; however, those sites on the Bull Run mainstem are the primary focus for discussion and data presentation for this report.

Monitoring stations 1ABUL010.28, 1ABUL011.03, and 1ABUL025.94 all contain extensive ambient water quality data records; recent ambient monitoring data has also been collected at all of these stations. Biological monitoring data has been collected at station 1ABUL010.28 and recently at stations 1BUL009.61 and 1ABUL011.12. Bull Run was classified as impaired based on the results of bioassessment surveys conducted at station 1ABUL010.28. A detailed discussion of the available environmental monitoring data is presented in *Section 3.0.*

Table 2-6: Summary of VA DEQ Monitoring Stations on Bull Run

Station ID	Station Type	Period Of Record
1ABUL009.61	Biological	2005
1ABUL010.28	Ambient, Biological, and Sediment	1978-2004
1ABUL011.03	Ambient Water Quality	1971-2004
1ABUL011.12	Biological	2005
1ABUL013.40	Sediment	2004
1ABUL016.31	Ambient Water Quality	1975-1976
1ABUL025.94	Ambient Water Quality	1976-2004

Figure 2-6: Water Quality Monitoring Stations in the Bull Run Watershed

2.4 Overview of the Bull Run Watershed

Developed lands (38.8%), forested lands (34.2%) and agricultural lands (22.6%) represent the dominant land uses in the Bull Run watershed. There are 9 facilities holding active individual discharge permits in the watershed, and 116 facilities holding active general permits. Monitoring has been conducted by DEQ at stations 1ABUL09.61, 1ABUL010.28, 1ABUL011.03 and 1ABUL011.12 on the biologically impaired segment of Bull Run, in addition to monitoring conducted at 14 other stations in the watershed.

3.0 Environmental Monitoring

Environmental monitoring efforts in the Bull Run watershed include benthic community sampling and analysis, habitat condition assessments, ambient water quality sampling, and toxicity testing. Monitoring efforts have been conducted by agencies at both the state and local levels, including the Virginia Department of Environmental Quality (VADEQ), Occoquan Watershed Monitoring Laboratory (OWML), Fairfax County Stormwater Planning Division, Fairfax County Health Department, and the Upper Occoquan Sewage Treatment Authority (UOSA). In addition, two citizen monitoring groups, the Virginia Save Our Streams Program (VA SOS) and the Audubon Naturalist Society (ANS), have conducted monitoring efforts. **Figure 3-1** plots the location of all monitoring locations in the Bull Run watershed used for this analysis.

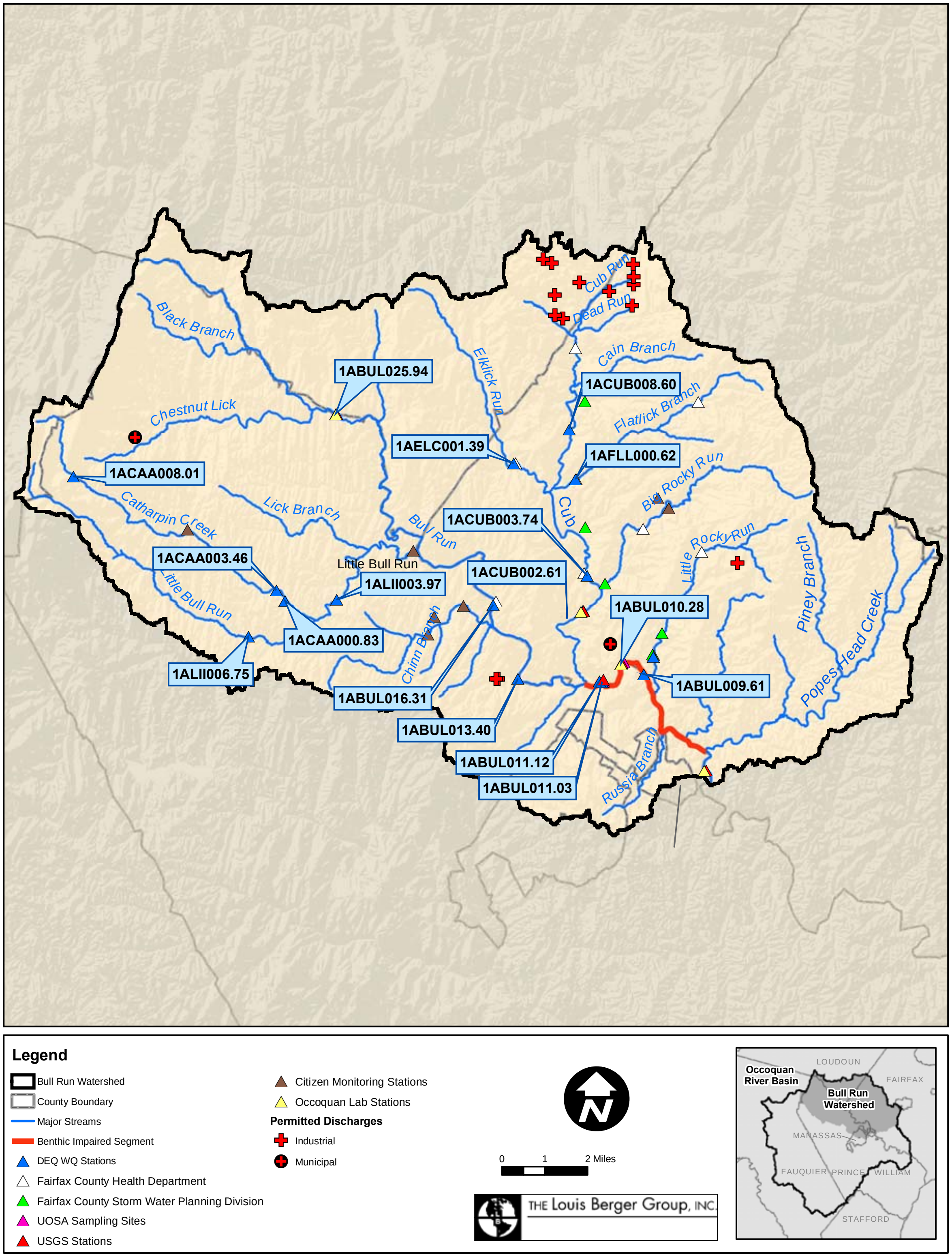

Figure 3-1: Monitoring Locations in the Bull Run Watershed

3.1 Virginia Department of Environmental Quality Data

The first step in benthic TMDL development is the identification of the pollutant stressor(s) that is impacting the benthic community. Environmental monitoring data are vital to this initial step. The following sections summarize and present the available monitoring data used to determine the primary stressor impacting the biologically impaired segment of Bull Run. Analyzed data included available biological and water quality monitoring data, Discharge Monitoring Reports (DMR) from the permitted facilities (*See Section 3.3*), and results from recent DEQ instream toxicity studies conducted on Bull Run. The collection period, content, and monitored sites for these data are summarized in **Table 3-1**. The locations of permitted discharge facilities and monitoring stations are presented in **Figure 3-1**.

Table 3-1: Inventory of VDEQ Environmental Monitoring Data for Bull Run

Data Type	Collection Period	Monitoring Stations																	
		1ABLU009.61	1ABUL010.28	1ABUL011.03	1ABUL011.12	1ABUL013.40	1ABUL016.31	1ABUL025.94	1ACAA000.83	1ACAA003.46	1ACUB002.61	1ACUB003.74	1ACUB008.60	1ALII003.97	1ACAA003.46	1AFLL000.62	1AELC001.39	1ACCL006.75	Permitted Facilities
Biological Monitoring	1994-2005	X	X		X														
Ambient Water Quality Monitoring	1971-2005	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	
Sediment Testing	1979-2004	X	X			X		X	X		X	X		X		X			
Fish Tissue Sampling	1996-2004		X			X													
Toxicity Study	April 2004, May 2005		X	X															
Discharge Monitoring Reports (DMR)	1999-2003																		X

3.1.1 Biological Monitoring Data

The impaired segment of Bull Run was included on Virginia's 1994 Section 303(d) List, and was subsequently included on Virginia's 1998 and 2002 Section 303(d) Lists of Impaired Waters and in the 2004 Water Quality Assessment 305(b)/303(d) Integrated

Report based on biomonitoring results obtained between 1994 and 2005. Biological monitoring data collected has been evaluated using two indicator metrics, the EPA's Rapid Bioassessment Protocol II (RBPII) and the Virginia Stream Condition Index (SCI).

RBPII Scores

A modified version of the EPA RBPII was used to assess the biological condition of the stream's benthic invertebrate communities. Candidate RBPII metrics, as specified in EPA's Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers, Second Edition (Barbour et al., 1999), are presented in **Table 3-2**. Virginia DEQ bioassessments follow a paired reference approach using upstream stations located in the same watershed. The DEQ protocol uses eight standard metrics to compare monitored and reference sites. These metrics include taxa richness, composition, and tolerance/intolerance measures (**Table 3-2**). RBPII assessment ratings for the biomonitoring surveys conducted on Bull Run are presented in **Table 3-3**.

DEQ field data sheets and bioassessment forms completed for each biological assessment conducted on Bull Run contained the following information:

- Assessment ratings for each station for each survey event
- The numbers and types of macroinvertebrates present at each station
- Habitat assessment scores taken during each survey
- Field water quality data collected as part of each survey

Table 3-2: Candidate RBPII Metrics Specified in Barbour et al. (2002)

Category	Metric	Definition	Response to Disturbance
Richness Measures	Total No. Taxa	Measures overall variety of invertebrate assemblage	Decrease
	No. EPT Taxa	Number of Ephemeroptera, Plecoptera, and Trichoptera taxa	Decrease
	No. Ephemeroptera Taxa	Number of mayfly taxa	Decrease
	No. Plecoptera Taxa	Number of stonefly taxa	Decrease
	No. Trichoptera Taxa	Number of caddisfly taxa	Decrease
Composition Measures	% EPT	Percent of the composite of mayfly, stonefly, and caddisfly larvae	Decrease
	% Ephemeroptera	Percent of mayfly nymphs	Decrease
Tolerance/ Intolerance Measures	No. Intolerant Taxa	Taxa richness of organisms considered to be sensitive to perturbation	Decrease
	% Tolerant Organisms	Percent of the macrobenthos considered to be tolerant of various types of perturbation	Increase
	% Dominant Taxon	Measures dominance of the most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa	Increase
Feeding Measures	% Filterers	Percent of the macrobenthos that filter FPOM from water column or sediment	Variable
	% Grazers and Scrapers	Percent of macrobenthos that scrape or graze upon periphyton	Decrease
Other Measures	Hilsenhoff Biotic Index	Uses tolerance values to weight abundance in an estimate of overall pollution	Increase

Table 3-3: RBPII Assessment Ratings for Bull Run Biomonitoring Surveys

Time Period	Assessment Rating by Station			
	1ABUL009.61	1ABUL010.28	1ABUL011.12	1ABUL025.94
Spring 1994	-	Moderate Impairment	-	-
Fall 1994	-	Moderate Impairment	-	-
Spring 1995	-	Moderate Impairment	-	-
Fall 1995	-	Moderate Impairment	-	-
Spring 1996	-	Moderate Impairment	-	-
Fall 1996	-	Moderate Impairment	-	-
Spring 1997	-	Moderate Impairment	-	-
Fall 1997	-	Moderate Impairment	-	-
Fall 1998	-	Moderate Impairment	-	-
Spring 1999	-	Moderate Impairment	-	-
Fall 1999	-	Moderate Impairment	-	-
Spring 2000	-	Slight Impairment	-	-
Spring 2004*	-	Slight Impairment	-	-
Fall 2004	-	Moderate Impairment	-	No Impact
Spring 2005	Moderate Impairment	-	Slight Impairment	-
* Note 4 year time gap				

Biomonitoring surveys were conducted biannually at 1ABUL010.28 between from 1994 to 2000. During this period, the benthic community was listed as moderately impaired for 12 of 14 sampling events. Monitoring data was not collected on Bull Bun between 2000 and 2004.

In 2004, biomonitoring at station 1ABUL010.28 showed a slight impairment of the benthic community in the spring and a moderate impairment in the fall. In contrast, during this same year, monitoring higher in the watershed at station 1ABUL025.94 showed that the biological community further upstream was not impaired.

Beginning in spring 2005, biomonitoring began at two new stations on Bull Run; station 1ABUL0009.61, which is just upstream of the confluence of Bull Run and Little Rocky Run, and station 1ABUL011.12, which is just below the confluence of Cub Run and Bull Run. Data from this most recent sampling event indicated that the upstream station 1ABUL011.12 was slightly impaired while the downstream station 1ABUL0009.6 was moderately impaired. Metrics calculated for the RBII scores at stations 1ABUL0009.61 and 1ABUL011.12 show distinct differences between these two stations for this sampling event. The metric for taxa richness, which measures the overall variety of invertebrate assemblage, was twice as high at 1ABUL011.12 in comparison to station 1ABUL0009.61. In addition, the percent of EPT taxa, which measures composition of mayfly, stonefly, and caddisfly larvae within the sample, was at 22.5% at 1ABUL011.12 while it was at 0.52% at 1ABUL0009.6. Since the majority of species of mayflies, stoneflies, and caddisflies are highly sensitive to pollution and environmental stress, this metric is used to determine the proportion of more sensitive species within the sample. The percent of dominance of the most abundant taxon within the sample was at 55% at station 1ABUL009.61 while this metric was at 22.6% at 1ABUL011.12. This indicates that only a few taxa dominate the sample at 1ABUL009.61 while at station 1ABUL011.12 there are a variety of taxa comprising the majority of the sample. Overall, these three metrics indicate that station 1ABUL009.61 had a less diverse and more tolerant benthic community than station 1ABUL011.12 during the 2004 sampling event. Although any observed differences are inconclusive from this one event, future sampling at these stations may provide insight into whether a difference between these two sites exists, and if so, what the potential stressors may be.

SCI Scores

Using the data collected during biomonitoring surveys, biological assessment scores were calculated using the SCI currently being developed by DEQ. The SCI is a regionally-calibrated index comprised of eight metrics that are listed in **Table 3-4**. The metrics used in calculation of an SCI score are similar to the metrics used in RBPII assessments.

However, unlike RBPII, the reference condition of the SCI is based on an aggregate of reference sites within the region, rather than a single paired reference site. Therefore, SCI scores provide a measure of stream biological integrity on a regional basis. An impairment cutoff score of 61.3 has been proposed for assessing results obtained with the SCI in the Occoquan watershed. Streams that score greater than 61.3 are considered to be non-impaired, whereas streams that score less than 61.3 are considered impaired.

Calculated SCI scores for the biomonitoring stations 1ABUL010.28, 1ABUL09.61, and 1ABUL11.12, all located on Bull Run between the confluence of Cub Run and Little Rocky Run, are presented in **Table 3-5**. Average SCI scores calculated for station 1ABUL010.28 between 1994 and 2004, and at Stations 1ABUL09.61 and 1ABUL09.61 in 2005 were below the proposed impairment cutoff score of 61.3; therefore, these stations the associated stream segment are considered to be impaired. Station 3RAP006.53, located on the Rapidan River, served as the reference station for the Bull Run biological assessments between 1994 and 2000, and throughout this period consistently showed scores well above the 61.3 benchmark. After 2000, however, stream conditions at station 3RAP006.53 began to decline, and as a result, the reference station for biological assessments conducted in 2004 and 2005 was changed to station 1AGOO022.44 on Goose Creek. SCI scores at this station have consistently been above the 61.3 aggregate SCI threshold value for the region.

Table 3-4: Metrics Used to Calculate the Virginia Stream Condition Index (SCI)

Candidate Metrics (by categories)	Expected Response to Disturbance	Definition of Metric
Taxonomic Richness		
Total Taxa	Decrease	Total number of taxa observed
EPT Taxa	Decrease	Total number of pollution sensitive Ephemoroptera, Plecoptera, and Trichoptera taxa observed
Taxonomic Composition		
% EPT Less Hydropsychidae	Decrease	% EPT taxa in samples, subtracting pollution-tolerant Hydropsychidae
% Ephemoroptera	Decrease	% Ephemoroptera taxa present in sample
% Chironomidae	Increase	% pollution-tolerant Chironomidae present
Balance/Diversity		
% Top 2 Dominant	Increase	% dominance of the 2 most abundant taxa
Tolerance		
HBI (Family level)	Increase	Hilsenhoff Biotic Index
Trophic		
% Scrapers	Decrease	% of scraper functional feeding group

Table 3-5: Virginia SCI Scores for Bull Run

Collection Period	SCI Score				
	1ABUL009.61	1ABUL010.28	1ABUL011.12	3RAP006.53[1]	1AGOO022.44[2]
Spring 1994	-	56.9	-	76.7	-
Fall 1994	-	55.6	-	68.9	-
Spring 1995	-	62.0	-	76.3	-
Fall 1995	-	54.6	-	74.0	-
Spring 1996	-	42.1	-	74.7	-
Fall 1996	-	55.8	-	75.7	-
Spring 1997	-	59.9	-	71.9	-
Fall 1997	-	50.8	-	78.1	-
Spring 1998	-	63.0	-	71.0	-
Fall 1998	-	-	-	70.2	-
Spring 1999	-	48.3	-	72.6	-
Fall 1999	-	48.8	-	69.0	-
Spring 2000	-	42.9	-	71.8	-
Fall 2000	-	60.5	-	70.8	-
Spring 2004	-	40.2	-	-	67.6
Fall 2004	-	57.2	-	-	62.6
Spring 2005	36.57	-	56.83	-	67.5
Average	**36.57**	**53.2**	**56.83**	**72.9**	**65.1**

1: Monitoring station 3RAP006.53 served as the reference station from 1994-2000
2: Monitoring station 1AGOO022.44 served as the reference station for 2004

3.1.2 Habitat Assessment Scores

A suite of habitat variables were visually inspected at station 1ABUL010.28, and recently in 2005 at stations 1ABUL09.61 and 1ABUL11.12 as part of the biological assessments conducted on Bull Run. In the spring of 2005, DEQ changed that reference station for the impaired segment of Bull Run from 3RAP006.53 to 1AGOO022.44. Habitat parameters that were examined include channel alteration, sediment deposition, substrate embeddedness, riffle frequency, channel flow and velocity, stream bank stability and vegetation, and riparian zone vegetation. Each parameter was assigned a score from 0 to 20, with 20 indicating optimal conditions, and 0 indicating very poor conditions. Habitat assessment scores for the three Bull Run biomonitoring stations and relevant reference stations are presented in **Table 3-6**.

Overall habitat assessment scores were generally lower at the impaired stations than at the reference stations. Specifically, scores for habitat metrics such as riparian zone vegetation, riffle frequency, and more recently, bank stabilization and protection were, on average, lower at the impaired stations than at the reference stations. Average assessment scores for other habitat metrics were similar between the reference and impaired stations.

Table 3-6: Habitat Scores for Reference and Impaired Stations

Station ID	Date	Total Habitat Score	Channel Alteration	Bank Stability	Bank Vegetative Protection	Substrate Embeddedness	Channel Flow	Riffles	Riparian Zone	Sediment Deposition	Velocity Regime
1ABUL010.28	Fall 1994	113	15	14	12	8	16	6	12	12	10
	Spring 1995	125	17	7	5	17	17	8	12	15	17
	Fall 1995	164	16	17	16	16	17	17	14	16	18
	Spring 1996	162	17	18	17	17	18	12	12	16	18
	Fall 1995	149	17	15	16	12	18	12	12	14	17
	Spring 1997	163	18	15	16	17	18	14	14	17	17
	Fall 1997	168	18	18	17	16	19	14	15	17	18
	Fall 1998	165	18	17	16	15	18	15	14	17	18
	Spring 1999	163	18	17	17	15	18	12	16	17	18
	Fall 1999	165	18	16	17	16	18	14	14	16	19
	Spring 2000	149	17	16	18	12	20	10	16	11	14
	Fall 2000	158	18	17	16	15	18	12	15	16	15
	Spring 2004	149	20	12	12	17	15	15	10	12	18
	Fall 2004	157	17	14	16	16	17	15	10	15	19
	AVG.	**153.6**	**17.4**	**15.2**	**15.1**	**14.9**	**17.6**	**12.6**	**13.3**	**15.1**	**16.9**
3RAP006.53 (Reference station)	Fall 1994	155	16	12	15	14	17	17	14	15	16
	Spring 1995	164	16	16	16	14	17	16	18	16	16
	Fall 1995	168	17	16	16	16	17	16	18	16	17
	Spring 1996	180	18	17	19	17	19	16	20	17	18
	Fall 1996	168	16	16	16	17	18	16	16	16	18
	Spring 1997	173	17	17	17	17	18	16	18	17	18
	Fall 1997	174	18	17	17	17	19	17	16	17	18
	Fall 1998	175	18	16	17	18	19	16	17	17	19
	Spring 1999	171	17	17	17	17	18	15	16	16	19
	Fall 1999	165	12	17	18	14	20	15	15	16	20
	Spring 2000	157	15	16	18	12	16	14	15	13	20
	Fall 2000	151	14	16	16	11	18	14	12	14	18
	AVG.	**166.8**	**16.2**	**16.1**	**16.8**	**15.3**	**18.0**	**15.7**	**16.3**	**15.8**	**18.1**
1AGOO022.44 (Reference Station)	Spring 2004	174	19	17	19	16	18	16	19	16	17
	Fall 2004	176	20	18	18	16	18	16	19	15	19
	AVG.	**175**	**19.5**	**17.5**	**18.5**	**16**	**18**	**16**	**19**	**15.5**	**18**
1ABUL009.61	Spring 2005	158	18	12	18	13	18	14	20	12	19
1ABUL011.12	Spring 2005	153	19	16	18	14	14	11	20	13	15

1: Monitoring station 3RAP006.53 served as the reference station from 1994-2000
2: Monitoring station 1AGOO022.44 served as the reference station for 2004

3.1.3 Ambient Water Quality Monitoring

There are 40 active and historic DEQ ambient water quality monitoring stations located in the Bull Run watershed (**Table 3-7**). Of these 40 stations, 16 have monitoring data within the last 10 years[1]. Monitoring data from 1 of these 16 stations, station 1APOE002.00 on Popes Head Creek, is removed from consideration within this analysis because: 1) Popes Head Creek provides input to Bull Run below the 303d listed segment, and 2) information from this station is currently being analyzed in a separate TMDL for Popes Head Creek. The remaining 15 water quality stations in the watershed represent the most recent DEQ water quality monitoring data available for the Bull Run watershed, and are therefore used in this analysis **(Table 3-7).**

Table 3-7: Ambient Water Quality Monitoring Stations Located in the Bull Run Watershed

Station ID[1]	Stream Name	Station Description	First Sample Date	Last Sample Date	Number of Samples
1ABIR000.76	Big Rocky Run	Intersection with Route 29/211	1974	1979	566
1ABIR005.21	Big Rocky Run	Intersection with Route 645	1976	1982	49
1ABUL009.61*	Bull Run	Downstream from Route 28	2005	2005	153
1ABUL010.28*	Bull Run	Intersection with Route 28	1978	2005	5386
1ABUL011.03*	Bull Run	Intersection with Route 616 (Old Centreville Rd)	1971	1999	846
1ABUL016.31*	Bull Run	Intersection with Route 29/211	1975	2005	52
1ABUL025.94*	Bull Run	Intersection with Route 705	1976	2005	1735
1ACAA000.83*	Catharpin Creek	Intersection with Route (~0.35 Miles below)	2003	2003	129
1ACAA003.46*	Catharpin Creek	Intersection with Route 676	1975	2005	84
1ACAA008.01	Catharpin Creek	Intersection with Route 600	1975	1994	75
1ACUB002.61*	Cub Run	Intersection with Route 658 (Compton Rd)	2001	2005	477
1ACUB003.74*	Cub Run	Intersection with Route 29/211	1974	2001	2017
1ACUB008.60*	Cub Run	Intersection with Route 661 (Old Lee Highway)	1976	2003	281
1ACUB011.25	Cub Run	Intersection with Route 50	1976	1982	32
1AELC001.39*	Elklick Run	Intersection with Route 609 (Pleasant Valley Rd)	2001	2005	303
1AFLB000.64	Flat Branch	Intersection with Route 1501	1974	1979	307
1AFLB001.40	Flat Branch	Intersection with Route 1530	1974	1979	231
1AFLB002.53	Flat Branch	Intersection with Route 234	1977	1983	38

[1] To be inclusive and to allow for processing delays in the most recent water quality monitoring data, "the last 10 years" includes data from 1994 to the present day, in this case 1994 – 2005.

Station ID[1]	Stream Name	Station Description	First Sample Date	Last Sample Date	Number of Samples
1AFLL000.62*	Flatlick Branch	Between Route 609 and Route 620	2001	2001	64
1AFLL000.88	Flatlick Branch	Intersection with Route 620	1976	1982	48
1AFLL001.98	Flatlick Branch	Intersection with Route 28	1977	1977	16
1AFLL002.76	Flatlick Branch	Intersection with Route 657	1977	1977	17
1AFLL004.37	Flatlick Branch	Intersection with Route 645	1977	1977	16
1AJOH002.42	Johnny Moore Creek	Intersection with Route 658	1976	1989	53
1AJOH004.08	Johnny Moore Creek	Intersection with Route 3546	1989	1989	33
1AJOH005.04	Johnny Moore Creek	Intersection with Route 645	1989	1989	33
1ALID002.60	Little Difficult Run	Intersection with Route 669	1976	1980	30
1ALII000.14	Little Bull Run	Intersection with Route 234	1975	1976	34
1ALII003.97*	Little Bull Run	Intersection with Route 705	1976	2005	1468
1ALII006.75*	Little Bull Run	Intersection with Route 676	2005	2005	21
1ALIP001.00*	Little Rocky Run	Intersection with Route 658 (Compton Rd.)	2003	2005	77
1APIY000.05	Piney Branch	Intersection with Route 660	1977	1977	17
1APIY002.72	Piney Branch	Intersection with Route 620	1977	1977	17
1APOE001.55	Pope's Head Creek	Intersection with Route 659	1977	1988	35
1APOE002.00[2]	Pope's Head Creek	Intersection with Route 645 (Clifton Rd.)	1990	2005	1923
1APOE005.40	Pope's Head Creek	Intersection with Route 660	1977	1988	34
1APOE007.20	Pope's Head Creek	Intersection with Route 654	1988	1988	17
1APOE008.36	Pope's Head Creek	Intersection with Route 620	1977	1988	34
1AXAC000.09	Tributary to Flat Branch	Intersection with Route 1501	1976	1983	64
1AXGB000.07	Tributary to Flat Branch	Intersection with Route 1530	1976	1983	36

*Stations represented the most recent data sources within the watershed and were therefore used for analysis.

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

[2] Data collected at1APOE002.00 is currently being addressed in a separate TMDL.

Streams within the Bull Run watershed are classified as Class III waterbodies (Nontidal Waters), as defined in Virginia Water Quality Standards (9 VAC 25-260-50). Thus, water quality parameters in the impaired segment must meet the Class III standards (**Table 3-8**).

Table 3-8: Virginia Water Quality Standards for streams in the Bull Run Watershed

Class	Description of Waters	Dissolved Oxygen (mg/L)		pH	Maximum Temperature (Deg. C)
		Minimum	Daily Average		
III	Nontidal Waters	4.0	5.0	6.0-9.0	32

Of the monitoring stations in the watershed with data in the last decade, 6 are located on Bull Run, and 4 of these have been sampled more than once between 1994 and 2005. Data collected at these four stations, 1ABUL009.61, 1ABUL010.28, 1ABUL016.13, and 1ABUL025.94 between 1994 to 2005 are presented in **Figures 3-2** to **3-12**. A bulleted summary of the data derived from all monitoring data collected on the Bull Run mainstem is listed below:

- Field dissolved oxygen data presented in **Figure 3-2** indicates that, in general, adequate DO levels are found in the Bull Run watershed.
- The DO diurnal study conducted between August 3 and August 5, 2005 (**Figure 3-3**) shows DO levels above the minimum standard with normal diurnal swings of 2 mg/L (or ~30% of saturation).
- Field pH and temperature values have been in compliance with numeric criteria for Class III waters (**Figures 3-4, 3-5**).
- Conductivity levels measured were low at 1ABUL025.94 but were higher at station 1ABUL010.28 and 1ABUL009.61 (**Figure 3-6**).
- Biochemical oxygen demand concentrations are generally low across all stations (**Figure 3-7**).
- Suspended solids concentrations were variable; observed concentrations were low for most sampling events, but elevated suspended solids concentrations were observed in some instances (**Figure 3-8**).
- Nitrate concentrations were low at station 1ABUL025.94 and ranged between 5 mg/L and 15 mg/L at station 1ABUL010.28 (**Figure 3-9**). This shift in nitrate concentration along the length of Bull Run is likely attributed to the Upper Occoquan Sewer Authority (UOSA) treatment plant, which is located below

station 1ABUL025.94 but above station 1ABUL010.28. UOSA discharges nitrogen in the form of nitrate, which has been show to be beneficial to the Occoquan Reservoir water quality by preventing anoxic conditions in the bottom layers of the reservoir during periods of stratification and thus preventing the dissolution of sediment-bound phosphorus. UOSA currently has a total nitrogen (TN) allocation for the protection of the Chesapeake Bay of 596,819 kg/year and a VPDES permit narrative denitrification requirement for the protection of the water supply.

- Ammonia and total phosphorus concentrations were generally low across all sampling events (**Figures 3-10, 3-11**).
- Several violations of the Virginia fecal coliform instantaneous standard occurred at the monitoring stations (**Figure 3-12**). A bacteria TMDL is currently being developed for Bull Run and will be presented in a separate report.

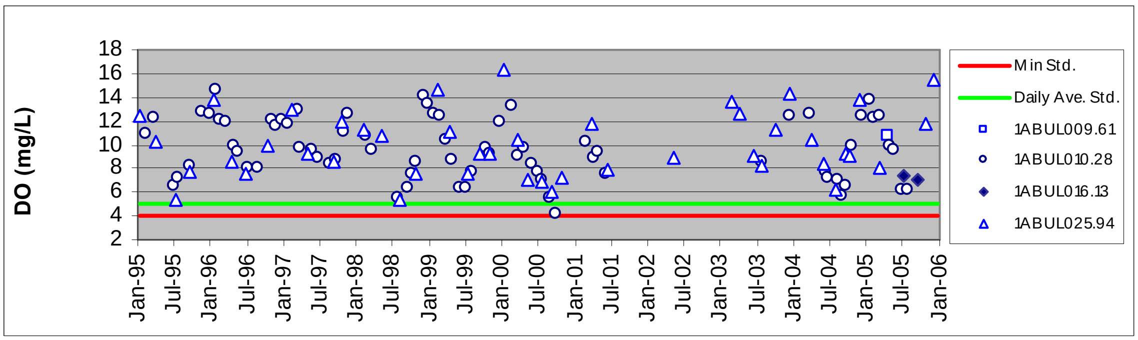

Figure 3-2: Bull Run Field Dissolved Oxygen Concentrations

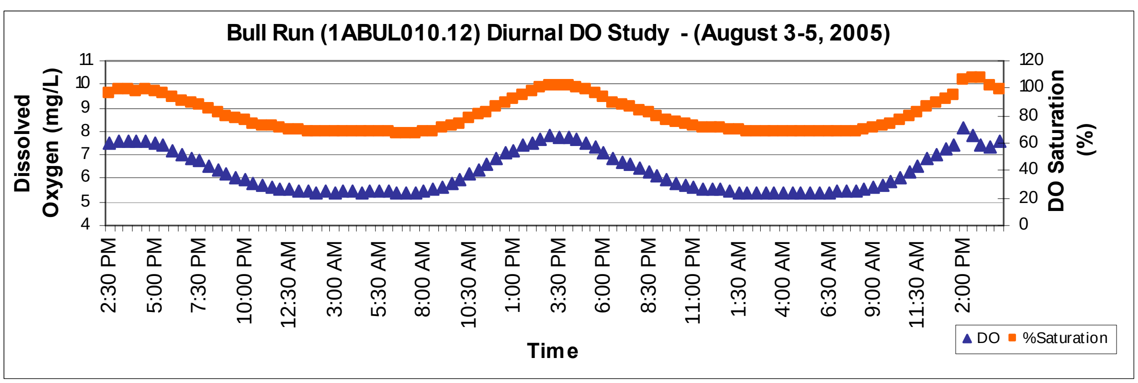

Figure 3-3: Bull Run Diurnal DO Concentrations

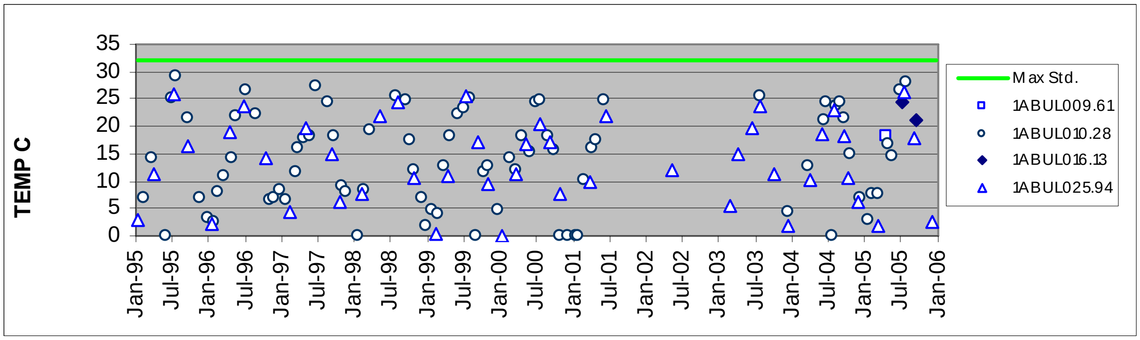

Figure 3-4: Bull Run Temperature Values

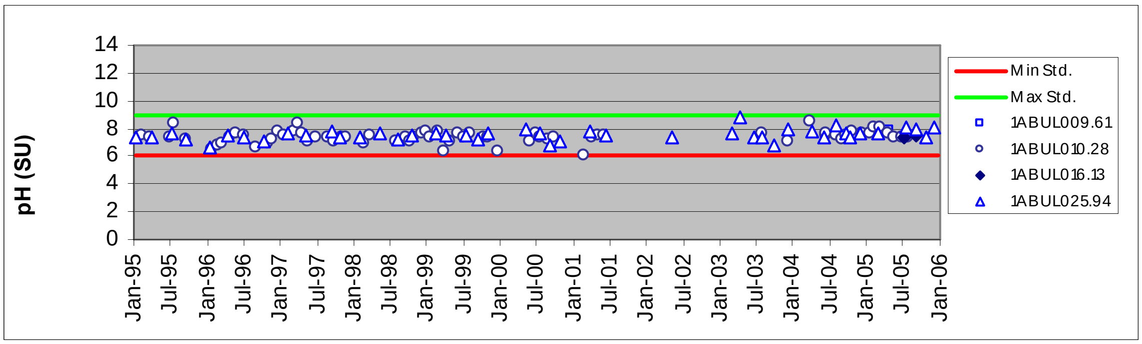

Figure 3-5: Bull Run Field pH Data

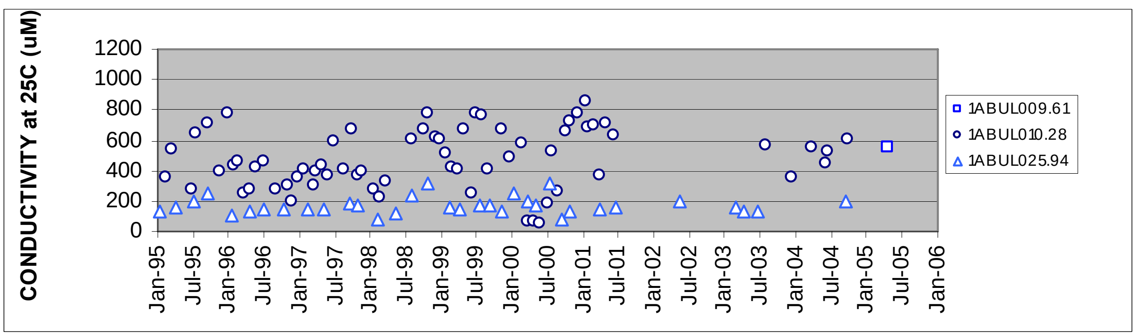

Figure 3-6: Bull Run Conductivity Data

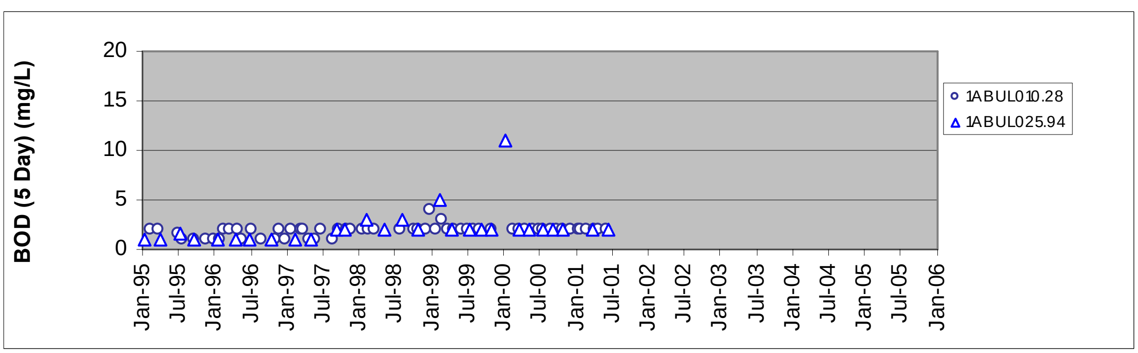

Figure 3-7: Bull Run Biochemical Oxygen Demand Concentrations

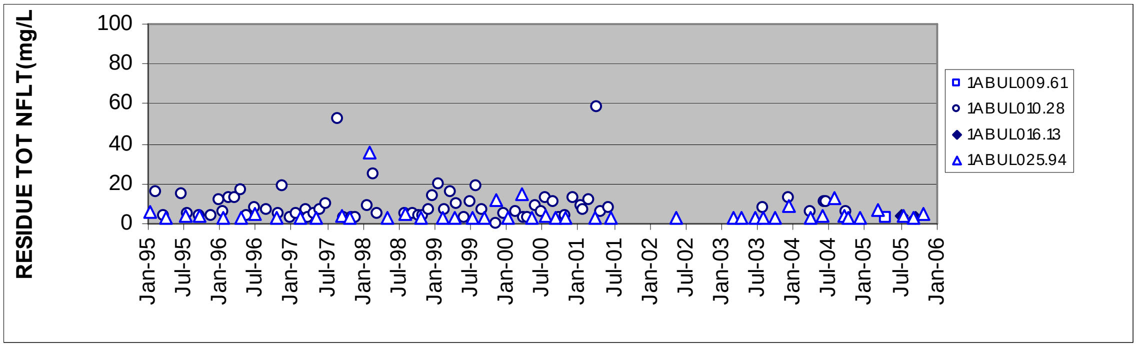

Figure 3-8: Bull Run Total Residue Concentrations

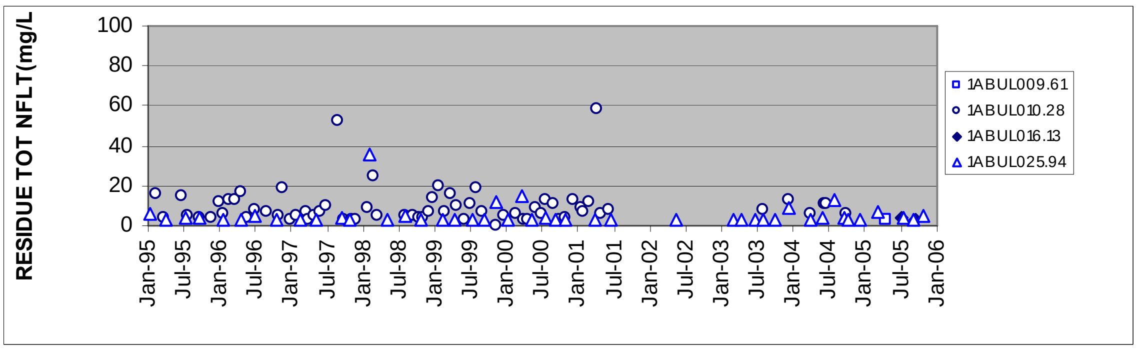

Figure 3-9: Bull Run Nitrate Concentrations

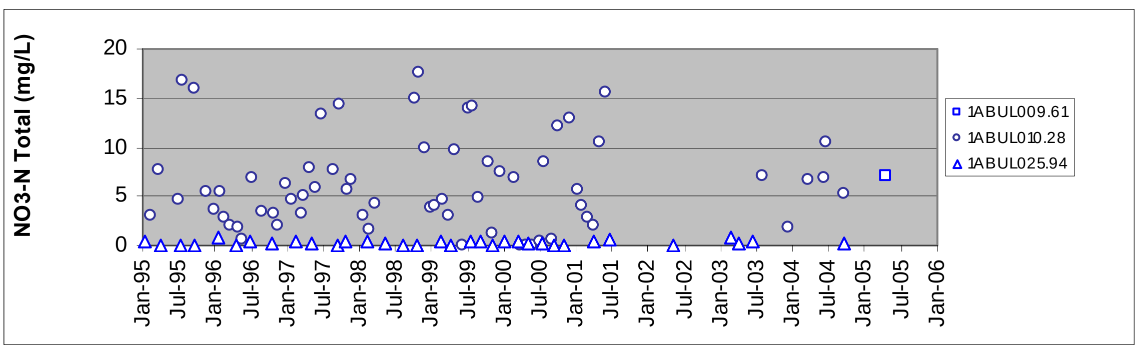

Figure 3-10: Bull Run Ammonia Concentrations

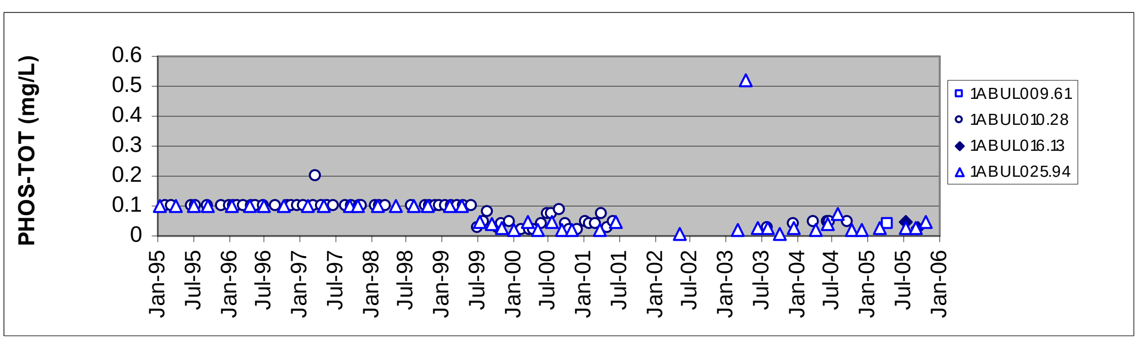

Figure 3-11: Bull Run Total Phosphorus Concentrations

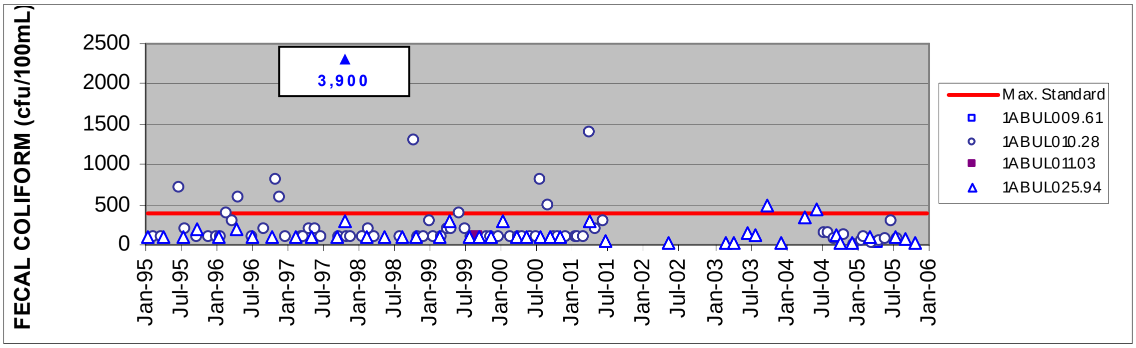

Figure 3-12: Bull Run Fecal Coliform Concentrations

Ambient water quality monitoring data for the 10 stations located on tributaries that provide input to Bull Run above the listed segment was also analyzed. Monitoring data from these stations shows that in general, ambient water quality parameters were observed within ranges similar to that observed on the Bull Run mainstem with some notable observations.

- Field dissolved oxygen levels exceeded the minimum daily average minimum for two stations on Cub Run in August of 1998 (ACUB003.74) and in June of 2003 (ACUB008.60).
- Several violations of the Virginia fecal coliform instantaneous standard occurred at monitoring stations on Cub Run, Little Bull Run, and Elklick Run. Due to fecal coliform violations in the main stem of Bull Run, a bacteria TMDL is being developed for Bull Run and will be presented in a separate report.

3.1.3 Metals Data

Dissolved metals parameters were examined at stations 1ABUL010.28, 1ABUL011.03, 1ABUL025.94, and 1ACAA008.01 in the Bull Run watershed. Metals measured included arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. All available dissolved metals data collected were analyzed to determine whether the examined parameters complied with Virginia's established water quality standards. No monitored metals parameters violated the acute or chronic dissolved freshwater criteria specified in Virginia's aquatic life use standards for dissolved metals. Almost all metals parameters analyzed were below analytical detection limits.

Additionally, although there are currently no water quality standards established for sediment metals, the 2006 DEQ assessment guidance memorandum (DEQ, 2006) establishes consensus based Probable Effects Concentrations (PEC) (99^{th} percentile of results throughout Virginia) for use in determining aquatic life use support. Sediment metals data collected in the Bull Run watershed were analyzed to determine whether they complied with the consensus based screening values. Though many compounds were noted in sediment testing, none exceeded the thresholds for the PEC.

Fish tissue sampling was also conducted in 2001 and 2004 and analyzed for metals. Results from these tests did not show any exceedences of the risk-based Tissue Screening Value for metals.

3.1.4 Organics Data

Organics data collected in the Bull Run watershed include water column (stations 1ABUL010.28 and 1ABUL025.94) and sediment samples (stations 1ABUL025.94, 1ABUL010.28, 1ABUL009.61, 1ABUL000.62, 1ACAA000.83, 1ALLII003.97, and 1ACUB003.74) analyzed for aldrin, dieldrin, endosulfan, endrin, dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyltrichloroethane (DDT), polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs).

All available organics data collected in the Bull Run watershed were analyzed to determine whether the examined parameters complied with Virginia's established water quality standards and sediment screening values. Based on the available data, no violations of the acute or chronic dissolved freshwater criteria were observed, and the majority of dissolved organic parameters measured fell below detection limits. In contrast, although many of the available sediment organics data were also below detection limits, sediment PAH (sediment non-halogenated organics) samples at station 1ABUL013.40 were recorded as exceeding the screening criteria for dibenz [A,H]anthracene in 2004 (using the 99^{th} percentile for statewide data). In addition, although monitored levels were below the consensus based sediment screening values specified in the DEQ 2004 assessment guidance memorandum, the presence of several

PAH compounds at station 1ABUL010.28 were also noted (chrysene, pyrene, and fluoranthene).

Results from fish tissue data collected in 2001 and 2004 revealed exceedances of the water quality criterion based tissue value (TV) of 54 parts per billion for polychlorinated biphenyls (PCBs). In 2001, at station 1ABUL010.28 fish tissue samples not only revealed exceedences of the TV criterion for PCBs and but also the risk-based tissue-screening values (TSI) of 10 ppb for heptachlor epoxide. In 2004, exceedence of the TV criterion of PCBs were found in flathead catfish samples from 1ACUB002.61 and channel catfish samples from 1ABUL010.28.

3.1.5 Toxicity Testing

Toxicity testing was performed on water samples collected on Bull Run by DEQ on April 12th, 14th, and 16th, 2004 at stations 1ABUL010.28 and 1ABUL011.03. The EPA Region 3 laboratory in Wheeling, West Virginia performed chronic toxicity testing on samples using fathead minnows and *Ceriodaphnia dubia* as test organisms. Results indicated *Ceriodaphnia* mortality and reproduction in the Bull Run water samples were not statistically different than mortality and reproduction in the control samples, thus indicating that there were no toxic water column effects to *Ceriodaphnia* in the Bull Run samples.

Fathead minnow growth in the Bull Run water samples was not statistically different from growth in the control samples. Fathead minnow survival in samples collected at station 1ABUL011.03 was also not statistically different than survival in the control samples. However, fathead minnow survival in samples collected at station 1ABUL010.28 was 65%, which was statistically different from the laboratory control. The EPA Region 3 laboratory in Wheeling indicated that in their professional judgment, this result "was probably biologically significant", and that it was necessary to compare the observed toxicity testing results with other water quality data collected at this site to determine the presence of toxicity.

Additional samples were collected for toxicity testing by DEQ at stations 1ABUL010.28 and 1ABUL011.03 on May 2nd – 6th, 2005. Results from samples collected in May 2005 also indicated *Ceriodaphnia* and fathead minnow mortality and reproduction in the Bull Run water samples were not statistically different than mortality and reproduction in the control samples, thus indicating that there were no toxic water column effects to either *Ceriodaphnia* or fathead minnows.

3.2 Supplemental Water Quality Monitoring Data

3.2.1 Occoquan Watershed Monitoring Lab

The Occoquan Watershed Monitoring Laboratory (OWML), which is operated by the Virginia Polytechnic Institute of Engineering and was established by mandate of the Occoquan Policy, has conducted water quality monitoring efforts throughout the Occoquan River Basin since its establishment in 1972. **Table 3-9** lists the OWML stations found in the watershed, the type of monitoring conducted, the period of record, and the number of sampling events conducted.

Table 3-9: OWML Sampling in the Bull Run Watershed

Site ID	Location	Data Type	Sampling Period	Number of Sampling Events
ST45	Bull Run, below Cub Run confluence	Ambient	January 1994- September 2004	726
		Flow	January 1994-December 2004	4018
ST50	Bull Run above Cub Run confluence	Ambient	January 1994- September 2004	672
		Flow	January 1994- September 2004	3904
ST60	Bull Run below Chestnut Lick	Flow	January 1994- September 2004	3978

Data Summary:

Instream water quality data collected at stations ST45 and ST50 shows that pH, temperature, and DO values have been in compliance with numeric criteria for Class III waters. Suspended solids concentrations were variable (Min: 0.5 mg/L, Max: 1220 mg/L, Avg.: 65 mg/L) observed concentrations were low for most sampling events, but elevated suspended solids concentrations were observed in some instances. Ammonia (Min: 0.005 mg/L, Max: 1.00 mg/L, Avg.: 0.05 mg/L) and total phosphorus (Min: 0.005 mg/L, Max: 0.92 mg/L, Avg.: 0.11 mg/L) concentrations were generally low across all sampling events. In addition, no monitored dissolved organics parameters violated acute or chronic dissolved freshwater criteria specified in Virginia's water quality standards[2]. However, on January 12, 1998 the sample collected at ST40 exceeded the Virginia's human health standards for all surface waters other than those used for public water supply for the following parameters: benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene and pyrene Indeno(1,2,3-cd)pyrene.

3.2.2 Fairfax County Stormwater Planning Division

In 1999, the Fairfax County Stormwater Planning Division (SPD) prepared a Stream Protection Strategy Baseline Study that was designed to support the development of biological indicators of stream quality. The SPD collected detailed biological and habitat condition information on 138 stream reaches in the county. Each reach was assigned a qualitative ranking overall stream quality, either Excellent, Good, Fair, Poor, or Very Poor. Additional biological monitoring data was also collected in 2001. The stream reaches sampled in the Bull Run watershed for this study are presented in **Table 3-10**. Note, qualitative rankings of habitat and biotic community condition were only provided for the 1999 sampling effort.

[2] It should be noted that only 20 of the 53 organics parameters tested by OWML currently have Virginia State water quality standards.

Table 3-10: Fairfax County Stormwater Site Condition Assessments

Site ID	Stream Name	Type/ Freq.	Date	SCI Score Below Regional Standard ? (Y/N)	Site Condition Ranking	Index of Biotic Integrity	Habitat Score	Fish Taxa Richness
CUSB 01	Cub Run	Biological/ Yearly	2001	Y	N/A	N/A	N/A	N/A
CURL 01	Cub Run	Biological/ Yearly	2001	Y	N/A	N/A	N/A	N/A
CUBR 02	Big Rocky Run	Biological/ Yearly	1999	Y	Fair	Fair	Fair	Moderate
			2001	Y	N/A	N/A	N/A	N/A
LRLR 03	Little Rocky Run	Biological/ Yearly	1999	Y	Fair	Poor	Good	Moderate
			2001	Y	N/A	N/A	N/A	N/A
LRLR 04	Little Rocky Run	Biological/ Yearly	2001	Y	N/A	N/A	N/A	N/A

3.2.3 Fairfax County Health Department, Division of Environmental Health

The Fairfax County Health Department's mission is to protect and improve the health of Fairfax County citizens by preventing or eliminating their exposure to biological, chemical and physical hazards in their present or future environment. As part of this mission, the Health Department monitors chemical and biologic (bacteria) water quality parameters regularly throughout Fairfax County. The Health Department has monitored water quality parameters at 11 sites in the watershed, the majority of which have records dating back to 1986. After 2004, this monitoring program was taken over by the SWPD (Stormwater Protection Division). **Table 3-11** lists the Health Department stations in the Bull Run watershed with the type of monitoring, the period of record, and number of sampling events conducted.

Table 3-11: Fairfax County Health Department Sampling in the Bull Run Watershed

STA. ID	Stream Sampled	Parameters Sampled	Date Range	Number of Observations
27-01	Johnny More Creek	Chemical (Temp, pH, $N0_3$-N, PO_4-P, dissolved oxygen)	January 1986-August 2002	330
		Bacteria (Fecal Coliform)	January 1986-December 2002	331
28-01	Little Rocky Run	Chemical	January 1986-August 2002	346
		Bacteria	January 1986-December 2002	349
28-02	Little Rocky Run	Chemical	January 1986-September 2002	337
		Bacteria	January 1986-December 2002	338
29-02	Big Rocky Run	Chemical	January 1986-August 2002	350
		Bacteria	January 1986-December 2002	353
29-03	Cub Run	Chemical	January 1986-August 2002	351
		Bacteria	January 1986-December 2002	354
29-04	Cub Run	Chemical	January 1986-September 2002	346
		Bacteria	January 1986-December 2002	347
29-05	Fatlick Branch	Chemical	January 1986-August 2002	341
		Bacteria	January 1986-December 2002	347
29-06	Fatlick Branch	Chemical	January 1986-September 2002	350
		Bacteria	January 1986-December 2002	354
29-07	Elklick Branch	Chemical	February 2000-August 2002	51
		Bacteria	January 2000-December 2002	53
29-08	Cub Run	Chemical	January 1986-August 2002	351
		Bacteria	January 1986-December 2002	351
29-09	Cub Run	Chemical	January 2001-August 2002	50
		Bacteria	January 2000-December 2002	50
30-01	Bull Run	Chemical	January 1986-August 2002	175
		Bacteria	January 1986-December 2002	357

Data Summary:

Instream water quality data collected at the 14 stations within the watershed all show that pH and temperature values have been in compliance with numeric criteria for Class III waters. In addition, nitrogen (Min: 0.01 mg/L, Max: 9.3 mg/L, Avg.: 0.67 mg/L) and phosphorous (Min: 0.01 mg/L, Max: 1.07 mg/L, Avg.: 0.12 mg/L) concentrations were generally low at all stations. However, dissolved oxygen levels were observed to violate the instantaneous standard at least once at 9 of the 11 stations (Min: 1.8 mg/L, Max: 26.3 mg/L, Avg.: 8.84 mg/L). The following table, **Table 3-12**, lists the observed DO instantaneous oxygen violations at the eleven Health Department Stations.

Table 3-12: Fairfax County Health Department Dissolved Oxygen Violations

Station ID	Year Sampled							
	1995	1996	1997	1998	1999	2000	2001	2002
27-01								
28-01	X			X		X	X	X
28-02	X							
29-02								
29-03	X							X
29-04	X							
29-05	X							
29-06	X			X				
29-07							X	X
29-08	X					X		
29-09						X		
30-01	X			X				
X= Violation of the instantaneous dissolved oxygen minimum standard for Class III waters								

3.2.4 Upper Occoquan Sewage Authority Ambient Water Quality Data

The Upper Occoquan Sewage Authority (UOSA) is the largest permitted discharger in the Bull Run Watershed. In addition to its discharge monitoring requirements, UOSA also monitors instream water quality on Bull Run upstream from its discharge at Old Centreville Road (OCR) and downstream of its discharge at Route 28. Sample data from January 2004 to September 2005 was provided by UOSA for this study, and inventory of this data is presented in **Table 3-13**.

Table 3-13: UOSA Ambient Water Quality Data

Site ID	Location on Bull Run	Data Type/ Frequency	Sampling Period	Number of Sampling Events
OCR	Old Centreville Road	Ambient/ Monthly	January 2004-September 2005	18
Route 28	Route 28	Ambient/ Monthly	January 2004-September 2006	18

Data Summary:

The data collected by UOSA consists of ambient monthly observations of dissolved oxygen, temperature, pH, chemical oxygen demand (COD), E-coli, hardness, total suspended sediments, and nutrients (ammonia, nitrate, nitrite, TKN, total phosphorus, and total nitrogen concentrations). At both stations, temperature and pH complied with the VADEQ water quality standards. Dissolved oxygen concentrations (Min: 3.2 mg/L, Max: 11.8 mg/L, Avg.: 6.55 mg/L) twice violated the instantaneous water quality standard at the Route 28 station over the 18 month period (3.9 and 3.2 mg/L). Although nitrate levels increased downstream of the UOSA discharge, nitrate concentrations remained relatively low (Min: 0.07 mg/L, Max: 19.10 mg/L, Avg.: 3.3 mg/L). All other nutrient concentrations as well as the level of total dissolved solids remained relatively low at both stations.

3.2.5 Citizen Monitoring Groups

Biological and habitat monitoring data was collected within the Bull Run Watershed by two citizen monitoring groups, the Virginia Save Our Streams Program (VA SOS) and the Audubon Naturalist Society (ANS). It should be noted that the two citizen monitoring groups did not conduct any sampling on the main stem of Bull Run. In 2001, VA SOS began using a modified method of the traditional Save Our Streams monitoring method. This resulted in changes to the collection and identification procedures that yields results comparable to data collected using professional methods (Engel and Voshell, 2002). A summary of the SOS data collected using this modified method is presented in **Table 3-14**. ANS uses a modified version of the U. S. Environmental Protection Agency (EPA) Rapid Bioassessment II Protocol for macroinvertebrate collection and habitat assessment. Results obtained using the ANS methods are also used by DEQ for water quality assessments. A summary of ANS data is shown in **Table 3-15**.

Table 3-14: SOS Biological Monitoring Data

Station #	Stream	DEQ Station ID	Total Monitoring Events *	# Rated Unacceptable *	Dates	Type
CR5	Big Rocky Run	1ABIR-CR5-SOS	3	2	4/2001, 2/2002, 4/2002	Biological, Habitat
CR1	Cub Run	1ACUB-CR1-SOS	3	1	4/2001, 2/2002, 4/2002	Biological, Habitat
CR3	Cub Run	1ACUB-CR3-SOS	3	0	4/2001, 4/2002, 7/2002	Biological, Habitat

Station #	Stream	DEQ Station ID	Total Monitoring Events *	# Rated Unacceptable *	Dates	Type
CR6	Cub Run	1ACUB-CR6-SOS	3	1	4/2001, 2/2002, 4/2002	Biological, Habitat
JMC1	Johnny Moore Creek	1AJOH-JMC1-SOS	2	0	3/2001, 1/2002	Biological, Habitat
JMC2	Johnny Moore Creek	1AJOH-JMC2-SOS	1	1	4/2001	Biological, Habitat
JMC3	Johnny Moore Creek	1AJOH-JMC3-SOS	1	0	4/2002	Biological, Habitat
JMC4	Johnny Moore Creek	1AJOH-JMC4-SOS	3	0	4/2001, 8/2001, 1/2002	Biological, Habitat
PIM1	Little Pimmit Run	1ALIO-PIM1-SOS	2	2	4/2001, 8/2001	Biological, Habitat
* Modified method						

Table 3-15: ANS Biological Monitoring Data

Station #	DEQ Site Number	Stream Name	Type	No. of Monitoring Events	Date	Quality Rating
4	1AYOU-4-ANS	Young's Branch	Biological, Habitat	4	1998-1999	Fair
5	1AYOU-5-ANS	Young's Branch	Biological, Habitat	16	1998-2002	Fair (borderline with good)
7	1ACAA-7-ANS	Catharpin Creek	Biological, Habitat	18	1998-2002	Good
9	1AWAL*-9-ANS	Walney Creek (unnamed trib to Big Rocky Run)	Biological, Habitat	17	1998-2002	Excellent
10	1ABIR-10-ANS	Big Rocky Run	Biological, Habitat	18	1998-2002	Poor (borderline with fair)
13	1ALII-13-ANS	Little Bull Run	Biological, Habitat	11	1998-2002	Good
15	1AYOU-15-ANS	Young's Branch	Biological, Habitat	15	1999-2002	Fair
* "Overall Stream Quality Rating" - Cumulative rating based on all monitoring events						

Data summary

Five out of the nine stations where VA SOS conducted biomonitoring efforts received at least one unacceptable rating between 2001 and 2002. Out of the seven streams sampled by ANS, one was ranked as poor (borderline with fair), three stations located on Young's

Branch were all ranked as fair, one station on Little Bull Run and one station on Catharpin Creek were ranked as good, and the station on Walney Creek was ranked as excellent. The ANS station on Big Rocky Run is located near the SOS station on Big Rocky Run. ANS assessed Big Rocky Run as poor (borderline with fair) which corresponds to the SOS assessment of this stream as being unacceptable two out of three times sampled.

3.3 Discharge Monitoring Reports

Discharge Monitoring Reports (DMR) for each of the individual permitted facilities discharging into the Bull Run watershed were obtained and analyzed. Permit information and limits are presented in Appendix B; DMR data are presented in Appendix C. A summary of permit exceedances is presented in Table 3-16. These violations include:

- Sunoco Manassas (permit # VA0087858), which exceeded its permit limits for total suspended solids.
- Evergreen Country Club (permit # VA0087891), which exceeded its permit limits for total suspended solids, dissolved oxygen, total Kjeldahl nitrogen, and biochemical oxygen demand.
- Upper Occoquan Sewage Authority (UOSA; permit # VA0024988), which exceeded its permit limits for total suspended solids, chemical oxygen demand, phosphorous, total Kjeldahl nitrogen, and turbidity.

Whole Effluent Toxicity (WET) data was collected at the IBM Corporation facility from December 2001 through June 2004. This facility does not have a maximum WET concentration limit specified in its current NPDES permit.

Table 3-16: Permit Exceedances from Facilities Discharging in the Bull Run Watershed

Facility Name	Permit No. (Outfall No.)	Parameter Description	Period of DMR Records	No. DMRs	DMR Reported Values (Averages)				Permit Limits (Monthly Average)		No. Exceedances of Permit Limits	
					Quantity (kg/day)		Concentration (mg/L)		Quantity (kg/day)	Concentration (mg/L)	Quantity (kg/day)	Concentration (mg/L)
					Avg	Max	Avg	Max				
Sunoco Manassas	VA0087858 (1)	Total Suspended Solids	3/00 – 4/05	21	-	-	30.11	87.2	-	60	-	1
Evergreen Country Club	VA0087891 (1)	Total Suspended Solids	2/05 - 6/05	77	0.12	0.56	10.76	29.3	0.43	15	1	17
		Dissolved Oxygen	2/99 – 6/05	76	-	-	7.99	11	-	6.5	-	6
		Total Kjeldahl Nitrogen	2/99 – 6/05	76	0.08	0.34	7.2	23.8	0.14	5	11	42
		cBOD (5 day)	2/99 – 6/05	77	0.11	0.71	10.2	51	0.28	10	4	25
Upper Occoquan Sewage Authority	VA0024988 (1)	Total Suspended Solids	2/99 – 5/05	76	46.5	319	0.42	2	121.1	1	4	4
		Chemical Oxygen Demand	2/99 – 5/05	76	722	1617	7.31	12.6	1211.2	10	3	7
		Total Phosphorous	2/99 – 5/05	76	5.17	22.1	0.05	0.14	12.1	0.1	2	3
		Total Kjeldahl Nitrogen	2/99 – 5/05	76	45.5	260	0.43	1.9	121.1	1	4	2
		Turbidity	2/99 – 5/05	76	-	-	0.29	0.65	-	0.5 (NTU)	-	3

4.0 Stressor Identification Analysis

TMDL development for benthic impairment requires identification of pollutant stressor(s) affecting the benthic macroinvertebrate community. Stressor identification for the biologically impaired segment of the Bull Run was performed using the available environmental monitoring and watershed characterization data discussed in previous sections. The stressor identification follows guidelines outlined in the EPA Stressor Identification Guidance (EPA 2000).

The identification of the most probable cause of biological impairment in the Bull Run was based on evaluations of candidate stressors that can potentially impact the river. The evaluation includes candidate stressors such as dissolved oxygen, temperature, pH, metals, organic chemicals, nutrient, toxic compounds, and sediments. Each candidate stressor was evaluated based on available monitoring data, field observations, and consideration of potential sources in the watershed. Furthermore, potential stressors were classified as:

Non-stressors: The stressors with data indicating normal conditions and without water quality standard violations, or without any apparent impact

Possible stressors: The stressors with data indicating possible links, however, with inconclusive data to show direct impact on the benthic community

Most probable stressors: The stressors with the conclusive data linking them to the poorer benthic community. Table 4.1 summarizes the results of the analysis.

Table 4.1: Summary of Stressor Identification in the Bull Run

Parameter	Location in Document
Non-Stressors	
Dissolved Oxygen	Section 4.1.1
Temperature and pH	Section 4.1.2
Metals and Dissolved Organic Chemicals	Section 4.1.3
Nutrients	Section 4.1.4
Possible Stressors	
Toxicity	Section 4.2.1
Most Probable Stressors	
Sedimentation and Urban Runoff	Section 4.3.1

4.1 Non-Stressors

4.1.1. Dissolved Oxygen

Adequate dissolved oxygen (DO) levels are necessary for invertebrates and other aquatic organisms to survive in the benthic sediments of rivers or streams. Decreases in instream oxygen levels can result in oxygen depletion or anoxic sediments, which adversely impact the river's benthic community.

Field dissolved oxygen data presented in Figure 3-1 indicates adequate DO levels in the Bull Run. In addition, the DO diurnal study conducted between August 3 and August 5, 2005 shows DO levels above the minimum DO standards with normal diurnal swings of 1 mg/L. Dissolved oxygen does not appear to be adversely impacting benthic communities in the Bull Run, therefore, it is classified as a non-stressor.

4.1.2. Temperature and pH

Benthic invertebrates require a suitable range of temperature and pH conditions. Although these ranges may vary by invertebrate phylogeny, high instream temperature values and either very high or very low pH values may result in a depauperate invertebrate assemblage comprised predominantly of tolerant organisms. The Virginia Class IV water quality standards identify the acceptable pH and temperature ranges for the Bull Run. Field measurements indicated adequate temperature and pH values on and upstream of the biologically impaired segment (Figures 3.2 and 3.4). There have been no observed violations of Class III water quality standards for pH and temperature. Temperature and pH do not appear to be adversely impacting benthic communities in the Bull Run and are therefore classified as non-stressors.

4.1.3. Metals and Dissolved Organic Chemicals

All available dissolved metals data (arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc) were below the acute or chronic dissolved freshwater criteria specified in Virginia's aquatic life use standards. In fact, almost all metals parameters analyzed were below analytical detection limits.

Additionally, the sediment metals data collected in the Bull Run watershed complied with the sediment screening values specified in the DEQ 2004 assessment guidance memorandum.

Dissolved organics parameters (aldrin, dieldrin, endosulfan, endrin, DDD, DDE, DDT, PAHs, and PCBs) did not exceed acute or chronic dissolved freshwater criteria specified in Virginia's water quality standards.

Consequently, metals and dissolved organic chemicals do not appear to be primary stressors affecting the benthic macroinvertebrates in the Bull Run.

4.1.4 Nutrients

High nitrogen and phosphorus concentrations can stimulate algal growth, which may result in eutrophic conditions, high organic loading, and decreased dissolved oxygen. Low nutrient concentrations were observed in Bull Run, and do not appear to be resulting in significant periphyton growth, which may impact the benthic macroinvertebrates present in the stream. The absence of eutrophication in Bull Run is confirmed by the continuous DO data showing normal diurnal swings of 1 mg/L.

Based on the nutrient data collected and the diurnal DO data suggesting the absence of eutrophication in the Bull Run watershed, nutrients are therefore considered as a non-stressor in the impaired segment of the Bull Run watershed.

4.2 Possible Stressors

4.2.1 Toxicity

Levels of ammonia, which is toxic to aquatic organisms in high concentrations, were low across all monitoring stations, and suggests that ammonia is not adversely impacting benthic invertebrates in the biologically impaired segments of the Bull Run watershed.

Instream toxicity testing by EPA Region 3 Laboratory indicated no toxic effects on Ceriodaphnia survival and reproduction, or fathead minnow growth. However, minnow survival rates in samples collected at the two monitoring stations on the Bull Run watershed were statistically different than survival rates in the control samples. The EPA Region 3 laboratory indicated that in their professional judgment, the difference in mortality rates between the sample taken at station 1ABUL010.28 and the control was "probably biologically significant." In both instances, the EPA Region 3 laboratory emphasized that these results were qualitative in nature, and needed to be compared to other available water quality data.

Although the EPA toxicity test results presented above are generally insufficient evidence to suggest the possibility of a direct toxicity effect, the DEQ data suggested the presence of potential toxic pollutants in the watershed. Organic chemicals (non-dissolved) have been noted in sediment samples above screening values specified in the DEQ 2004 assessment guidance memorandum. Sediment PAH (non-halogenated organics) samples at station 1ABUL013.40 were recorded as exceeding the screening criteria for dibenz [A,H]anthracene in 2004. In addition, though below the consensus based sediment screening values specified in the DEQ 2004 assessment guidance memorandum, several PAH compounds at station 1ABUL010.28 have also been noted in samples (chrysene, pyrene, and fluoranthene).

Fish tissue samples from Bull Run have also indicated the presence of PCBs. However, sediment PCB concentrations upstream of the benthic impaired segment are generally low, whereas those downstream of the benthic impaired segment have exceeded sediment screening criteria. Therefore, the source of PCBs identified in fish tissue samples is likely downstream of the segment listed for benthic impairment.

Based on the data presented above and EPA toxicity test results, toxicity cannot be ruled out as a non-stressor and is therefore considered a possible stressor in the impaired segment of the Bull Run.

4.3 Most Probable Stressors

4.3.1 Sedimentation and Urban Runoff

In the Bull Run watershed, habitat assessment scores indicate relatively low riparian-vegetation and riffles-frequency scores in the impaired segment of the Bull Run watershed (Table 3-6). These habitat alterations are a result of increased runoff and stream-bank erosion. In fact, the loss of riparian vegetation and riffle frequency is usually caused by increased urbanization and impervious surfaces in the watershed, which leads to increased overland flow and channel erosion.

The observed biological impairment corresponds with an increase in impervious surfaces as the stream drains higher impervious areas from Cub Run, Big Rocky Run, and Little Rocky Run. The increased imperviousness of urban areas results in less infiltration during precipitation events, and consequently a higher volume of runoff that enters the creek. In fact, the entire Bull Run watershed is 40 percent developed, with much higher development within the immediate drainage area of the impaired segment.

Consequently, the habitat assessment scores indicate that high runoff flows and stream bank erosion are the most probable stressors causing the habitat alterations in the Bull Run watershed.

4.4 Stressor Identification Summary

The data and analysis presented in this report indicate that dissolved oxygen, temperature, and pH, in the biologically impaired segment of Bull Run are adequate to support a healthy invertebrate community, and are not stressors contributing to the benthic impairment. Concentrations of metals and organic chemicals were generally low or below analytical detection limits and are classified as non-stressors. In addition, toxicity was also classified as a possible stressor because DEQ data suggests the presence of toxic pollutants in the impaired segment Bull Run.

Based on the evidence and data discussed in the preceding sections, sedimentation, caused by higher runoff flows has been identified as a primary stressor impacting benthic invertebrates in the biologically impaired segments of the Bull Run. Habitat scores indicate decreased habitat quality in the impaired segments because of the surrounding urban environment. Potential sources of sediment loading in the watershed include urban stormwater runoff, stream bank erosion, and sediment loss from habitat degradation associated with urbanization.

The interrelation between sedimentation, higher runoff flows, and habitat alteration, allows a TMDL for sediments to address habitat degradation as well as increased urban runoff. Improvement of the benthic community in the biologically impaired segment of the Bull Run watershed is dependent upon reducing sediment loadings through stormwater control, as well as restoring instream and riparian habitat to alleviate the impacts of urbanization on the river.

Consequently and to address these issues, a sediment TMDL will be developed for the biologically impaired segments of the Bull Run watershed.

5.0 TMDL Endpoint Identification

TMDL development requires the determination of endpoints, or water quality goals/targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. Endpoints are normally expressed as the numeric water quality criteria for the pollutant causing the impairment. Compliance with numeric water quality criteria, such as a maximum allowable pollutant concentration, is expected to achieve full use support for the waterbody. However, not all pollutants have established numeric water quality criteria. In these cases, a reference watershed approach may be used to define the TMDL endpoint.

Bull Run was initially included on the Virginia Section 303(d) list for violations of the General Standard (benthic impairment). As detailed in Section 4.0, sedimentation and urban runoff were identified as the primary stressor causing the benthic impairment in the stream. Currently, Virginia does not have numeric criteria for sediment. Therefore, a reference watershed approach was used to establish the numeric sediment TMDL endpoint for Bull Run.

5.1 Reference Watershed Approach

Under the reference watershed approach, the TMDL endpoint for an impaired watershed is established based on conditions in a similar, but non-impaired reference watershed. In terms of benthic impairment caused by excessive sediment, the TMDL endpoint is the sediment loading rate in the non-impaired reference watershed. Reduction of the sediment loading rate in the impaired watershed to levels comparable to the reference watershed is assumed to be sufficient for recovery of the benthic community in the impaired watershed.

Selection of an appropriate reference watershed is based on similarities in watershed characteristics such as soils, topography, land uses, and ecology. Similar watersheds help to ensure similarities in the benthic communities that potentially may inhabit the streams. Similar watersheds also provide for similar watershed hydrology which influences pollutant loading rates to the stream.

5.2 Selected Reference Watershed

The Goose Creek watershed draining to the DEQ biomonitoring station at Goose Creek river mile 22.44 (1AGOO022.44) was selected as the reference watershed for Bull Run benthic TMDL development. The Upper Goose Creek watershed is located about 20 miles northwest of the Bull Run watershed. Both the Bull Run and the Upper Goose Creek watersheds are located primarily in the Northern Piedmont ecoregion. The Bull Run watershed is 118,954 acres while the Goose Creek watershed above river mile 22.44 is 100,614 acres. **Table 5-1** summarizes important criteria considered in the selection of the reference watershed for the Bull Run. **Figure 5-1** displays a map of the reference watershed.

Table 5-1 Criteria Used in Reference Watershed Selection

Criteria	Relevance
Biomonitoring Data	Biomonitoring data is required to confirm the non-impairment status of the reference watershed and allows for comparisons with the impaired watershed.
Ecoregion	The reference and impaired watersheds should belong to the same ecoregion to help ensure similarities in stream ecology.
Topography	Topography influences hydrology and is a major component of stream habitat that affects the structure and composition of benthic communities.
Land Uses	The selected reference watersheds should reflect similar land use distributions. The water quality of streams in a watershed is greatly influenced by land use. Similar land use distributions help to establish achievable TMDL endpoints.
Soils	Soil composition influences watershed runoff, erosion, and stream ecology.
Watershed Size	The reference watershed should be similar in size to the impaired watershed since watershed area influences pollutant loading rates to the stream.
Location	Close proximity to the impaired watershed generally improves overall watershed similarity. In addition, the reference watershed should be near a weather station that may be used to characterize precipitation at both watersheds in order to standardize model simulations.

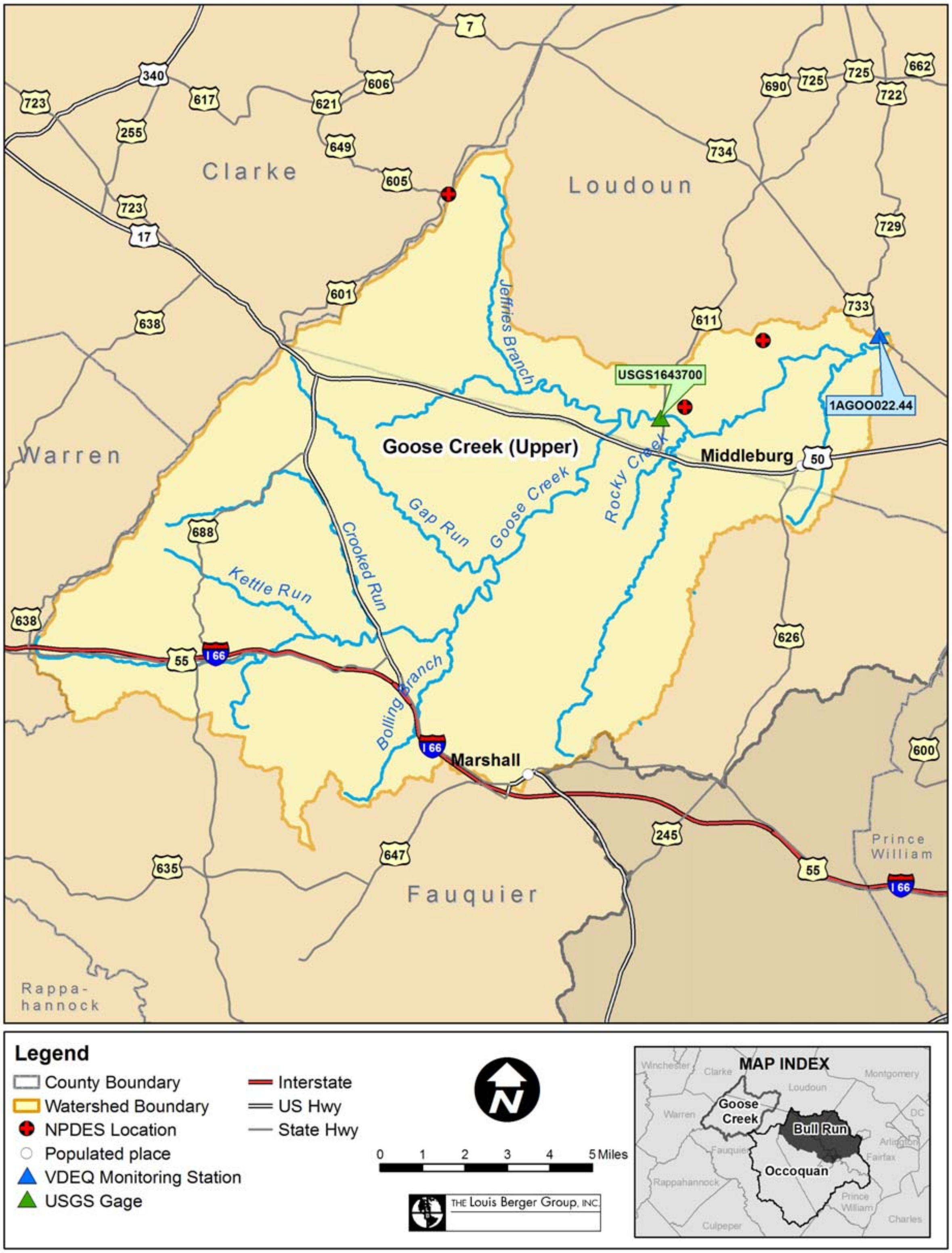

Figure 5-1: Goose Creek Reference Watershed

5.2.1 Biomonitoring Data

Virginia SCI scores were calculated for three biomonitoring stations on Bull Run and the 1AGOO022.44 Goose Creek reference station. Scores recorded at Goose Creek Station 1AGOO022.44 were compared with scores at biomonitoring stations located on Bull Run (**Table 5-2**). SCI scores provide a measure of stream biological integrity on a regional basis and an impairment cutoff score of 61.3 has been proposed for assessing results obtained with the SCI in the Occoquan watershed. Streams that score greater than 61.3 are considered to be non-impaired, whereas streams that score less than 61.3 are considered impaired. For the last 2 years, Goose Creek monitoring station 1AGOO022.44 has received SCI scores above the regional cutoff. Therefore, Goose Creek above river mile 22.44 is considered non-impaired and fully supporting the creek's aquatic life use.

Table 5-2: Biomonitoring SCI Scores for Bull Run and Goose Creek

Collection Period	SCI Scores			
	Bull Run Impaired Stations			Reference Station
	1ABUL009.61	1ABUL010.28	1ABUL011.12	1AGOO022.44[2]
Spring 1994	-	56.9	-	-
Fall 1994	-	55.6	-	-
Spring 1995	-	62	-	-
Fall 1995	-	54.6	-	-
Spring 1996	-	42.1	-	-
Fall 1996	-	55.8	-	-
Spring 1997	-	59.9	-	-
Fall 1997	-	50.8	-	-
Spring 1998	-	63	-	-
Fall 1998	-	-	-	-
Spring 1999	-	48.3	-	-
Fall 1999	-	48.8	-	-
Spring 2000	-	42.9	-	-
Fall 2000	-	60.5	-	-
Spring 2004	-	40.2	-	67.6
Fall 2004	-	57.2	-	62.6
Spring 2005	36.57	-	56.83	67.5
Average	**36.57**	**53.2**	**56.83**	**65.1**

1: Monitoring station 3RAP006.53 served as the Bull Run reference station from 1994-2000

2: Monitoring station 1AGOO022.44 served as the Bull Run reference station for 2004

5.2.2 Land Use

A comparison of land use distributions in the Bull Run and Upper Goose Creek watersheds is provided in **Table 5-3**. Bull Run and Goose Creek watersheds are forested at 35% and 43%, respectively. The Upper Goose Creek watershed is composed of 55% agricultural lands in comparison to 24% of agricultural lands in the Bull Run watershed. Also, the Bull Run watershed has a higher percentage of urban land use at 39% in comparison to 2% in the Upper Goose Creek watershed. This difference in the percentage of urban land use is expected since Bull Run flows through the developed areas of Loudoun, Prince William, and Fairfax Counties, as well as the Cities of Fairfax, Manassas, and Manassas Park. It is typically difficult to find an unimpaired reference watershed with a high percentage of urban land use. In addition, it is expected that the sediment loads from the more rural watershed, which has a higher percentage of agricultural land uses, will be balanced by the instream erosion load from the more urban watershed.

Table 5-3: Summary of Land Use Distributions for Bull Run Impaired and Goose Creek Reference Watersheds

Land Use Category	% of Total Watershed	
	Bull Run	Goose Creek
Forest	35	43
Agricultural	23	55
Developed	40	2
Water/Wetlands	1	0
Other	1	0
Total	**100**	**100**

5.2.3 Soils Distribution

A summary of the soils distributions for the Bull Run watershed and Upper Goose Creek watershed are provided in **Table 5-4**. The soils in the Upper Goose Creek watershed tend to be composed mainly of hydrologic group B, predominately well drained soils. In comparison, the Bull Run watershed is composed of several different hydrologic groups with ranging infiltration rates (Section 2.1.4). The Bull Run watershed has a higher percentage of hydrologic group D soils which results in lower infiltration and more runoff in some areas. However, the majority of soils in both watersheds tend to be composed of hydrologic groups B and C, which are considered to be well to moderately well drained soils.

Table 5-4: Summary of Soil Distributions for Roanoke River Impaired and Reference Watersheds

Hydrologic Group	% of Total Watershed	
	Bull Run	Goose Creek
A	1	0
B	29	83
C	43	16
D	24	1
C/D	3	0

6.0 Sediment Load Determination

A reference watershed approach was used to develop the sediment TMDL for the Bull Run watershed as discussed in the previous section. The reference watershed identified for this impaired segment was the Goose Creek watershed above river mile 22.44 **(Figure 5-1)**. The sediment loadings for the reference watershed define the numeric TMDL endpoint for the impaired watershed. Therefore, sediment loadings were determined for both the reference and impaired watersheds in order to quantify sediment loading reductions necessary to achieve the designated aquatic life use for Bull Run.

6.1 Sediment Source Assessment

Excessive sedimentation can adversely affect benthic invertebrate communities through the loss of habitat or food sources. Sediment can be delivered to the stream from point sources located in the watershed and it can be carried in the form of non-point source runoff from non-vegetated or protected land areas. In addition, sediment can be generated in the stream through the processes of scour and deposition which are primarily a function of stream flow. During periods of high flow, erosion of the stream channel occurs. The eroded materials are deposited downstream as stream flow decreases. These processes adversely impact the benthic macroinvertebrate community through loss of habitat and degradation of water quality.

Potential sediment sources within the Bull Run watershed are discussed in the next section followed by a presentation of the methodology used to quantify these sources for the TMDL development.

6.1.1 Non-Point Sources

The erosion of land is dependent upon many factors including land use type and cover, soils type, and topography. The land use types in the Bull Run watershed were characterized using NLCD and NVRC data, while soil types were characterized using the STATSGO database. The land use distribution for the Bull Run watershed was previously shown in **Table 2-3** and a summary of soil types was provided in **Table 2-1**. The delivery of eroded soils to the stream is primarily influenced by watershed size.

Sediment loadings from generalized land use types present in the Bull Run watershed are discussed below.

Forested Lands

Sediment loads from forested lands are typically low due to extensive root systems and vegetative cover that serve to stabilize soils. In addition, forest canopies intercept and dampen rainfall impacts.

Agricultural lands

Sediment loads from agricultural lands tend to be elevated due to the exposure of soil that occurs in agricultural practices. Cropland and pastureland are two sources of elevated sediment loads.

Developed Lands

Developed lands consist of both pervious and impervious surfaces. Impervious surfaces are not subject to soil erosion, but sediment loads may result from the washoff of solids deposited on impervious surfaces. Sediment loads from developed lands tend to be high. In addition, elevated levels of uncontrolled stormwater runoff from developed lands contribute to streambank erosion as discussed below.

Water/Wetlands

The amount of sediment loading from water and wetland areas typically is not significant.

Barren Lands

Transitional lands represent areas of sparse vegetative cover often due to land use activities such as forest clearcuts and construction lands. Due to increased levels of soil exposure, sediment loads from transitional lands typically are high.

6.1.2 Point Sources

Sediment loadings from point sources are attributable to the suspended solids present in discharge effluent. There are 9 facilities located in the watershed, however, only 3 facilities have a permit limit for TSS (**Table 6-1**). In addition, municipal separate storm sewer systems (MS4s) transport storm water runoff that is ultimately discharged into local rivers and streams without treatment. Loudoun, Prince William, and Fairfax Counties, as well as the Cities of Fairfax, Manassas, and Manassas Park, and VDOT road areas are covered by MS4 permits which regulate their stormwater discharges. In addition, the Manassas Campus of the Northern Virginia Community College, Prince William County Schools, and Fairfax County Schools each have separate MS4 permits. MWAA Washington Dulles International Airport is subject to regulation under the MS4 program. The individual VPDES permit for this facility, permit number VA0089541, establishes the regulatory requirements for industrial stormwater, construction stormwater and MS4 under a single permit. Common pollutants from MS4s include oil and grease from roadways, pesticides from lawns, trash, and sediments. Combined, these MS4 permits cover approximately 54% of the Bull Run benthic impaired watershed (**Table 6-1**). There are also a total of approximately 116 active general stormwater permits in the watershed; 5 permits issued to individual facilities, 32 permits issued to domestic sewage facilities, 11 stormwater permits issued to industrial sites, 5 permits issued to concrete facilities, 3 permits issued to mines, 3 permits issued for petroleum-related activities and based on DCR data, there are approximately 60 stormwater permits issued to construction sites.

6.1.3 Instream Bank Erosion

Sediment derived from instream bank erosion is also dependent upon numerous watershed characteristics. Land use types present in the watershed may affect hydrology. In particular, highly developed lands may lead to increased stream flows that erode the stream channel and banks. Likewise, watersheds defined by steep topography may experience high levels of runoff that cause instream erosion. The level of instream erosion is dependent on the erodibility of the soil, normally defined as the soil K factor. Since the Bull Run benthic impairment watershed contains a significant percentage of developed lands, the overall amount of sediment generated by instream erosion would be expected to be high.

6.2 Technical Approach for Estimating Sediment Loads

6.2.1 Non-Point Source Sediment

For the purpose of TMDL development, annual sediment loadings from land erosion were determined using the Generalized Watershed Loading Functions (GWLF) model.

GWLF is a time variable simulation model that simulates hydrology and sediment loadings on a watershed basis. Observed daily precipitation data is required in GWLF as the basis for water budget calculations. Surface runoff, evapotranspiration and groundwater flows are calculated based on user specified parameters. Stream flow is the sum of surface runoff and groundwater discharge. Surface runoff is computed using the Soil Conservation Service Curve Number Equation. Curve numbers are a function of soils and land use type. Evapotranspiration is computed based on the method described by Hamon (1961) and is dependent upon temperature, daylight hours, saturated water vapor pressure, and a cover coefficient. Groundwater discharge to the stream is described by a lumped parameter watershed water balance for unsaturated and shallow saturated water zones. Infiltration to the unsaturated zone occurs when precipitation exceeds surface runoff and evapotranspiration. Percolation to the shallow saturated zone occurs when the unsaturated zone capacity is exceeded. The shallow saturated zone is modeled as a linear reservoir to calculate groundwater discharge. In addition, the model allows for seepage to a deep saturated zone.

Erosion and sediment loading is a function of the land source areas present in the watershed. Multiple source areas may be defined based on land use type, the underlying soils type, and the management practices applied to the lands. Sediment loadings from each source area are summed to obtain a watershed total. The Universal Soil Loss Equation (USLE) is used to compute erosion for each source area and a sediment delivery ratio is applied to determine the sediment loadings to the stream (USLE, Wischmeier and Smith, 1978), and is expressed as:

A =R K LS C P

Where:

A =Average annual soil loss in tons per acre per year

R =Rainfall/runoff erosivity

K =Soil erodibility

LS = Field slope length and steepness

C =Cover/management factor

P =Conservation practice factor

The R factor is an expression of the erosivity of rainfall and runoff in the area of interest; the R factor increases as the amount and intensity of rainfall increases. The K factor represents the inherent erodibility of the soils in the area of interest under standard experimental conditions. The K factor is expressed as a function of the particle-size distribution, organic-matter content, structure, and permeability of the soils. The LS factor represents the effect of topography, specifically field slope length and steepness, on rates of soil loss at a particular site. The LS factor increases as field slope length and steepness increase due to accumulation and acceleration of surface runoff as it flows in a downslope direction. The C factor represents the effects of surface cover and roughness, soil biomass, and soil-disturbing activities on rates of soil loss at the area of interest. The C factor decreases as surface cover and soil biomass increase. The P factor represents the effects of supporting conservation practices, such as contouring, buffer strips, and terracing, on soil loss at the area of interest.

6.2.2 Point Source Loadings

Out of the nine permitted facilities within the Bull Run watershed, three of these facilities have total suspended solids (TSS) permits (**Table 6-1**). Three point sources are also located within the Goose Creek watershed with TSS permits (**Table 6-2**). For the purpose of TMDL development, annual point source loadings were computed based on the permitted design discharge and the permitted concentration of total suspended solids for each facility. Additionally, stormwater sediment loads allocated to the general stormwater permits present in the watershed are presented in Appendix D**.**

Table 6-1: Point Sources in the Bull Run Impaired Watershed with Permits for TSS

Facility Name	Permitted TSS Load (kg/day)	Annual Sediment Loading (ton/year)
UOSA	242.2	97.42
Golf Course	0.4	0.2
Sunoco	14.4	5.8
Total	257.0	103.4

Table 6-2: Point Sources in the Goose Creek Watershed with Permits for TSS

Facility Name	Permitted TSS Load (kg/day)	Annual Sediment Loading (ton/year)
Foxcroft School	0.6	0.25
Middleburg WWTP	2.7	1.1
Notre Dame Academy	0.1	0.05
Total	3.5	1.4

The MS4 permits state that the Cities of Fairfax, Manassas, and Manassas Park as well as Fairfax, Prince William, and Loudoun Counties and the Manassas Campus of the Northern Virginia Community College, Prince William County Schools, Fairfax County Schools, VDOT road areas and MWAA Washington Dulles International Airport are permitted to discharge into the Bull Run impaired watershed. However, stormwater permits typically do not have numeric limits for sediment. To separate sediment loading attributed to the MS4s from other land-based sediment loading, an area weighted sediment load was determined for the MS4s, in which the percentage of sediment loading from each source area attributed to the MS4s was proportional to the percentage of that source area in the Bull Run impaired watershed covered by the various MS4 permits. The MS4 acres present in the watershed are presented in **Table 6-3**. Additionally, stormwater runoff from MS4s results in increased stream bank erosion. Bank erosion resulting from MS4 stormwater runoff and bank erosion resulting from overland runoff were also separated using an area weighted approach, in which the percentage of sediment loading from bank erosion attributed to the MS4 was proportional to the percentage of the Bull Run impaired watershed covered by the MS4 permits. Since approximately 64,456 acres of the 118,954 total acres in the Bull Run impaired watershed are covered by MS4 permits, 55% percent of the sediment load from instream erosion was attributed to the MS4s. Sediment from other land sources in the watershed and the remainder of the bank erosion sediment load were attributed to the land-based load.

Table 6-3: MS4 Permit Acreage within the Bull Run Watershed

Permit Number	MS4 Permit Holder[1]	MS4 Area	Acres
VA0088587	Fairfax County	Fairfax County	50,024.9
VAR040104	Fairfax County Public Schools		
VAR040062	VDOT Urban Area		
VAR040064	Fairfax City	Fairfax City	173.8
VAR040062	VDOT Urban Area		
VAR040067	Loudoun County	Loudoun County	5,156.2
VAR040062	VDOT Urban Area		
VAR040063	Manassas City	Manassas City	2,564.0
VAR040095	NOVA Manassas Campus		
VAR040062	VDOT Urban Area		
VAR040070	Manassas Park	Manassas Park	1,323.0
VAR040062	VDOT Urban Area		
VA0088595	Prince William County	Prince William County	6,214.2
VAR040100	Prince William County Public Schools		
VAR040062	VDOT Urban Area		
Total			**65,456.0**

[1] MWAA Washington Dulles International Airport is subject to regulation under the MS4 program. The individual VPDES permit for this facility, permit number VA0089541, establishes the regulatory requirements for industrial stormwater, construction stormwater and MS4 under a single permit. The MS4 acreage is not presented in this table as the stormwater regulated under this program cannot readily be distinguished from other activities.

6.2.3 Instream Erosion

Instream erosion in the Bull Run was calculated using a spatial technique developed by Evans et al. (2003) that estimates streambank erosion based on watershed characteristics. Using this method, a watershed-specific lateral erosion rate is calculated as follows:

$$LER = aQ^{0.6}$$

Where:
LER = an estimated lateral erosion rate, expressed as meters per month
a = an empirically-derived “erosion potential factor”

Q = monthly stream flow, expressed as cubic meters per second.

The *'a'* factor is computed based on a wide variety of watershed parameters including the fraction of developed area of the watershed, average field slope, mean soil erodibility (K factor), average curve number value, and the mean livestock density for the watershed.

$$A = (0.00147*PD) + (0.000143*AD) + (0.000001*CN) + (0.000425*KF) + (0.000001*MS) – 0.00016$$

Where:
PD = fraction developed land
AD = animal density measured in animal equivalent units/acre
CN = area-weighted runoff curve number value
KF = area-weighted K factor
MS = mean field slope

The fraction of developed land in the Bull Run watershed was obtained from NLCD data. The mean soil erodibility K factor and mean field slope of the watershed were computed from the STATSGO database. The average watershed curve number was developed based on curve numbers applied in the GWLF model. Livestock densities for the watershed were based on county livestock inventories. The 'a' factors for the Bull Run reference and impaired watersheds were computed.

LER values were calculated using predicted stream flow from the GWLF model. Monthly sediment loads from streambank erosion (kg/month) were then calculated as the product of the LER (meters/month), total stream length (meters), average streambank height (meters), and average soil bulk density (kg/m^3). The total stream length for the Bull Run was obtained from the National Hydrography Dataset (NHD). Bank height was estimated from field surveys of the Bull Run watershed. Mean soil bulk density was obtained from the STATSGO database. Annual sediment loads from streambank erosion were computed as the summation of monthly loads.

6.3 GWLF Model Setup and Calibration

6.3.1 GWLF Model Development

GWLF model simulations were performed for 1994 to 2004 in order to reflect the period of biomonitoring assessments that resulted in the impairment listing for the Bull Run watershed. In addition, the 10 year simulation period accounts for both seasonal and annual variations in hydrology and sediment loading. Models were developed for both the reference and impaired watersheds. Model simulations were performed using BasinSim 1.0, which is a windows interface program for GWLF that facilitates the creation of model input files and processing of model results.

As stated previously, under the reference watershed approach the TMDL endpoint is based on sediment loadings for the reference watershed. Since the Bull Run reference watershed is slightly larger than the impaired watershed, sediment loadings for the reference watershed were adjusted to reflect the size of the impaired watershed. This was accomplished by running the GWLF model for an area-adjusted reference watershed. The area of each land use in the reference watershed was multiplied by the ratio of the impaired watershed to the reference watershed. In addition, instream erosion for the adjusted reference watershed was calculated using the total stream length of the impaired watershed.

6.3.2 Weather Data

Daily precipitation and temperature data for the period of 1994-2004 were obtained from Upper Occoquan Sewage Authority (UOSA) and was used for model simulations. This weather station is located within the Bull Run watershed and near to the Goose Creek watershed, and thus provided the most accurate precipitation and temperature coverage.

6.3.3 Model Input Parameters

In addition to weather data, GWLF requires specification of input parameters relating to hydrology, erosion, and sediment yield. In general, Appendix B of the GWLF manual (Haith et al., 1992) served as the primary source of guidance in developing input parameters.

Runoff curve numbers and USLE erosion factors are specified as an average value for a given source area. The land use types present in the watershed (**Table 6-4**) were used to define model source areas. Therefore, a total of 12 source areas were defined in the model. As necessary, GIS analyses were employed to obtain area weighted parameter values for each given source area.

Table 6-4: Land Use Distribution Used in GWLF Model for the Bull Run Watershed

General Land Use Category	Land Use Category	Acres
Forested	Deciduous Forest	31,017.0
	Evergreen Forest	7,010.9
	Mixed Forest	4,320.0
Agricultural	Pasture/Hay/Livestock	18,389.7
	Row Crop	7,496.4
Developed	Low Intensity residential	16,125.7
	Commercial/Industrial	11,161.3
	Transitional	1,245.0
	Medium/High Residential	16,261.0
	Institutional	2,595.7
Barren	Urban/Recreational Grass	3,274.1
	Quarries/Strip Mine	54.4
Total		**118,951.2**

Runoff curve numbers were developed for each model source area in the watershed based on values published in the NRCS Technical Release 55 (NRCS, 1986). STATSGO soils GIS coverages were analyzed to determine the dominant soil hydrologic groups for each model source area. Evapotranspiration cover coefficients were developed based on values provided in the GWLF manual (Haith et al., 1992) for each model source area. Average watershed monthly evapotranspiration cover coefficients were computed based on an area weighted method. Initialization and groundwater hydrology parameters were set to default values recommended in the GWLF manual.

USLE factors for soil erodibility (K), length-slope (LS), cover and management (C), and supporting practice (P) were derived from multiple sources based on data availability. Average KLSCP values for model source areas were determined based on GIS analysis of soils and topographic coverages and literature review. The rainfall erosivity coefficient was determined from values given in the GWLF manual. The sediment delivery ratio was computed directly in BasinSim.

Developed lands include impervious surfaces that are not subject to soil erosion. Rather, sediment loads from developed lands result from the buildup and washoff of solids deposited on the surface. Therefore, sediment loads from developed lands were not modeled using the USLE. Instead, sediment loads from developed lands were computed based on typical loading rates from developed lands (Horner et al., 1994).

6.3.4 Hydrology Calibration

GWLF was originally developed as a planning tool for estimating nutrient and sediment loadings on a watershed basis. Designers of the model intended for it to be implemented without calibration. Nonetheless, comparisons were made between predicted and observed stream flow for the Bull Run impaired and reference watersheds to ensure the general validity of the model.

The Occoquan Watershed Monitoring Laboratory (OWML) station ST40 located on Bull Run below the confluence with Pope's Head Creek was selected for hydrology calibration based on the period of available monitoring data, its location in the watershed, and the proximity of the gage to the weather station used to develop the model precipitation inputs. Flow data from USGS gauging station USGS 01644000 located on Goose Creek near Leesburg, VA was used to calibrate the flow for the Goose Creek Watershed. **Figure 6-1** provides the location of the flow gage and weather station in relation to the Bull Run watershed.

GWLF parameters relating to hydrology were calibrated based on the Bull Run flow data collected at ST40. The groundwater seepage coefficient and the unsaturated zone available water capacity were adjusted to obtain a best fit with observed data. Results of the hydrology calibration for impaired and reference watersheds are shown in **Figures 6-2** and **6-3**. **Table 6-5** shows the calibration statistics. In general, model predictions reflect the flow variations observed at ST40.

Table 6-5: Hydrology Calibration Statistics

Statistic	Bull Run Waterhsed	Goose Creek Watershed
R Squared (R^2)	**0.7**	**0.671**
% Error	**7%**	**2%**

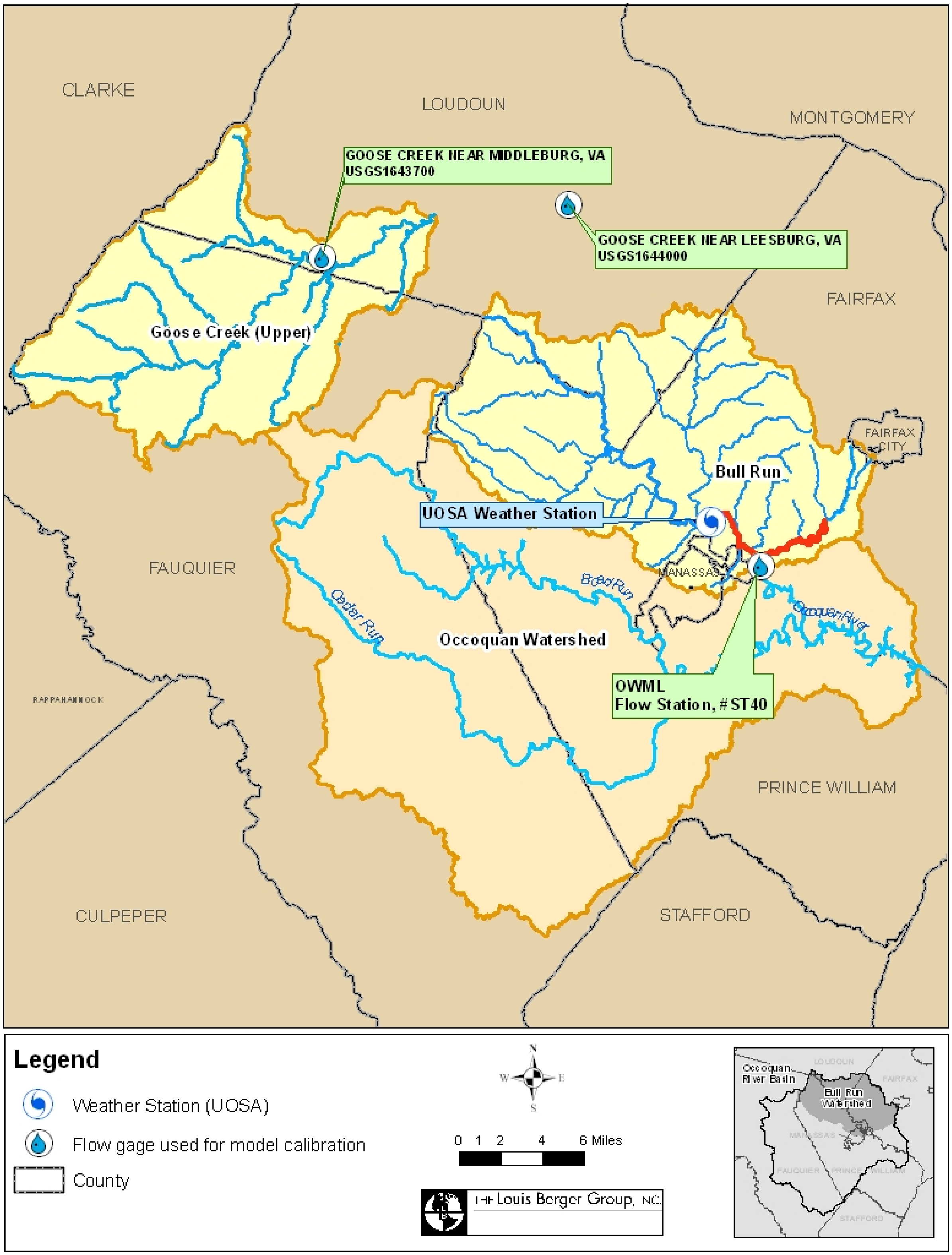

Figure 6-1: Location of Weather and Flow Gauges Used in Model Development

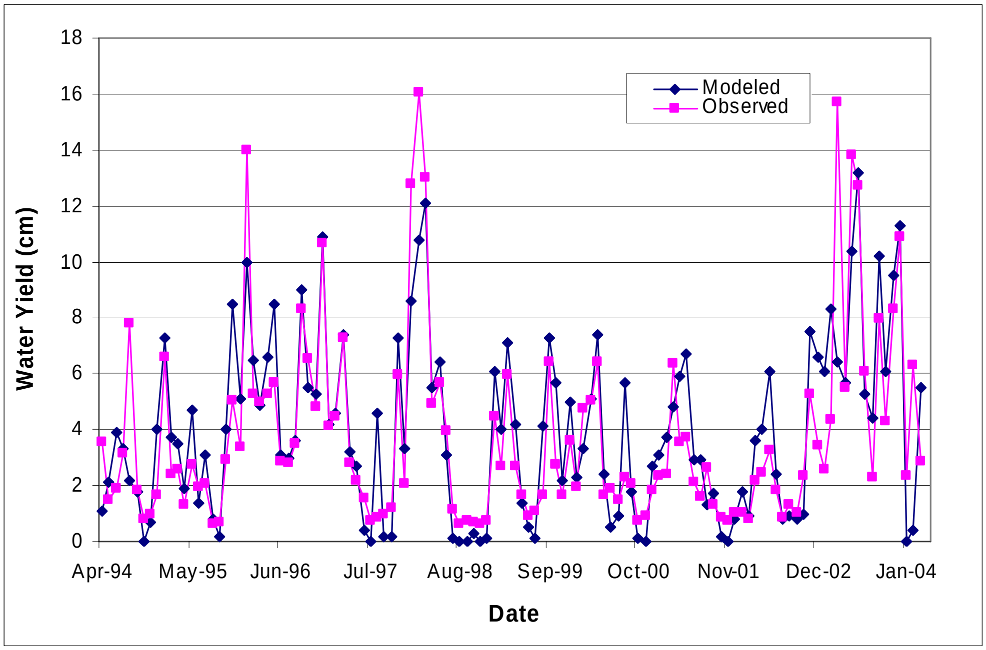

Figure 6-2: Hydrology Calibration Results for the Bull Run Watershed

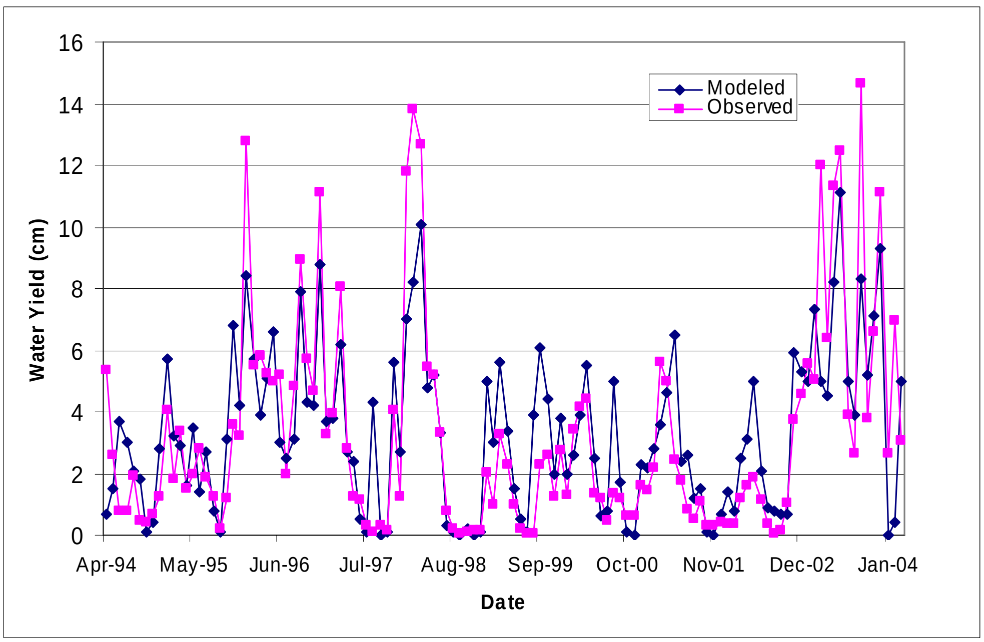

Figure 6-3: Hydrology Calibration Results for the Goose Creek Watershed

6.4 Sediment Load Estimates

6.4.1 Sediment Loads from Point Sources

Existing sediment loads from point sources within the watershed are described in Section 6.2.2.

6.4.2 Sediment Loads from Non-Point Sources

The hydrologically calibrated model was used to estimate sediment loadings from each source area in the Bull Run and Goose Creek watersheds. Based on the 10 year simulation period from 1994 to 2004, average annual sediment loads were computed for each land source in each watershed. These results are presented **Table 6-6.**

Table 6-6: Bull Run Average Annual Sediment Loads from Land Sources (tons/yr)

Source	Impaired Watershed	Reference Watershed	Adjusted Reference Watershed
Transitional	678.1	55.6	62.0
Quarries/Strip Mine	0.0	0.0	0.0
Deciduous Forest	120.7	107.2	119.7
Evergreen Forest	27.3	4.2	4.7
Mixed Forest	16.8	65.5	73.1
Pasture/Hay/Livestock	2179.4	6,923.9	7,726.1
Row Crop	4479.6	459.9	513.2
Low intensity residential	6.4	0.6	0.6
Commercial/Industrial	411.5	15.3	17.0
Medium/High Residential	270.8	0.2	0.2
Institutional	43.2	0.0	0.0
Urban/Recreational Grass	1.3	0.0	0.0
Total	**8235.0**	**7,632.3**	**8,516.6**

6.4.3 Sediment Loads from Instream Erosion

Instream erosion was estimated based on the streambank lateral erosion rate equation introduced by Evans, et al. (2003), as described in Section 6.2.3. The 'a' factor used in the streambank erosion equation was computed using watershed specific data for the impaired and reference watersheds. Computed 'a' factors and annual sediment loads from streambank erosion are presented in **Table 6-7**.

Table 6-7: Bull Run Annual Instream Erosion Estimates

Watershed	Computed 'a' Factor	Instream Erosion (tons/yr)
Impaired Watershed	6.81E-04	38,484
Reference Watershed	8.14E-05	2,659
Reference Watershed (Area Adjusted)	8.14E-05	3,476

6.5 Existing Sediment Loadings – All Sources

In summary, average annual sediment loads for the Bull Run impaired and reference watersheds were determined as follows:

- Erosion and sediment yield from land sources were modeled using GWLF.
- Instream bank erosion was computed based on the method described by Evans et al. (2003).
- Sediment loads from point sources were calculated based on the permitted total suspended solids loading rate for each facility.
- An area-weighted percentage of the land based and bank erosion sediment load was used to partition sediment loading attributed to the MS4s and sediment loading attributed to other sources.
- Stormwater sediment loadings from general permit categories were calculated according to the methodology outlined in Appendix D.

Average annual sediment loads from all sources for the Bull Run impaired and reference watersheds are summarized in **Table 6-8**. The total existing sediment load in the impaired watershed is 46,482.4 tons per year. The area-adjusted reference watershed load of 11,994.1 tons per year represents the TMDL endpoint. Reduction of sediment loading in the impaired watershed to the level computed for the area-adjusted reference watershed is expected to restore support of the aquatic life use for the Bull Run.

Table 6-8: Bull Run Average Annual Sediment Loadings (tons/yr)

Source	Impaired Watershed	Reference Watershed	Adjusted Reference Watershed
Transitional	678.1	55.6	62.0
Quarries/Strip Mine	0.0	0.0	0.0
Deciduous Forest	120.7	107.2	119.7
Evergreen Forest	27.3	4.2	4.7
Mixed Forest	16.8	65.5	73.1
Pasture/Hay/Livestock	2,179.4	6,923.9	7,726.1
Row Crop	4,479.6	459.9	513.2
Low intensity residential	6.4	0.6	0.6
Commercial/Industrial	411.5	15.3	17.0
Medium/High Residential	270.8	0.2	0.2
Institutional	43.2	0.0	0.0
Urban/Recreational Grass	1.3	0.0	0.0
Instream Erosion	38,483.9	2,659.2	3,476.2
Point Sources	103.4	1.4	1.4
Total	**46,822.3**	**10,292.9**	**11,994.1**

As stated previously, the existing sediment load in the Bull Run impaired watershed was distributed between the existing MS4-permitted areas and other non-point sources using an area weighted method. **Table 6-9** presents the existing sediment loading in the impaired watershed attributed to the MS4s and other non-point sources. The MS4 sediment loads shown in **Table 6-9**, include the loads from individual MS4s permits for urban areas, and also loads from Individual Stormwater Permits, General Stormwater Permits, General Permits for Mines, General Permits for Concrete Facilities, and General Permits for Construction Sites and transitional land uses.

Table 6-9: Existing Sediment Loading in the Bull Run Attributed to MS4s

Permit Number	MS4 Permit Holder[1]	MS4 Locality	Acres	Land Based Load (ton/yr)	Instream Erosion (ton/year	Total Load (ton/year)
VA0088587	Fairfax County	Fairfax County	50,024.9	3,310.5	16,160.0	19,470.5
VAR040104	Fairfax County Public Schools					
VAR040062	VDOT Urban Area					
VAR040064	Fairfax City	Fairfax City	173.8	11.5	56.0	67.6
VAR040062	VDOT Urban Area					
VAR040067	Loudoun County	Loudoun County	5,156.2	341.2	1,665.6	2,006.8
VAR040062	VDOT Urban Area					
VAR040063	Manassas City	Manassas City	2,564.0	169.7	828.3	998.0
VAR040095	NOVA Manassas Campus					
VAR040062	VDOT Urban Area					
VAR040070	Manassas Park	Manassas Park	1,323.0	87.6	427.4	514.9
VAR040062	VDOT Urban Area					
VA0088595	Prince William County	Prince William County	6,214.2	411.2	2,007.4	2,418.7
VAR040100	Prince William County Public Schools					
VAR040062	VDOT Urban Area					
Total			**65,456.0**	**4,331.7**	**21,144.8**	**25,476.5**

[1] MWAA Washington Dulles International Airport is subject to regulation under the MS4 program. The individual VPDES permit for this facility, permit number VA0089541, establishes the regulatory requirements for industrial stormwater, construction stormwater and MS4 under a single permit. The MS4 acreage is not presented in this table as the stormwater regulated under this program cannot readily be distinguished from other activities.

7.0 TMDL Allocation

The purpose of TMDL allocation is to quantify pollutant load reductions necessary for each source to achieve water quality standards. Sediment was identified as the primary stressor to the benthic community in the Bull Run impaired watershed and a reference watershed approach was used for TMDL development. The total average annual sediment loading for the area-adjusted reference watershed (**Table 6-8**) represents the TMDL endpoint for the Bull Run impaired watershed. Reduction of sediment loading in the impaired watershed to the level computed for the area-adjusted reference watershed is expected to restore support of the aquatic life use for Bull Run.

7.1 Basis for TMDL Allocations

Sediment TMDL allocations for the Bull Run impaired watershed were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:

TMDL= Total Maximum Daily Load (Based on the Sediment Load of the Area-Adjusted Reference Watershed)

WLA = Wasteload Allocation

LA = Load Allocation

MOS = Margin of Safety

The wasteload allocation represents the total sediment loading allocated to point sources. The load allocation represents the total sediment loading allocated to non-point sources. The margin of safety is a required TMDL element to account for uncertainties in TMDL development.

7.1.1 Margin of Safety

An explicit margin of safety of 10% was used for the Bull Run to account for uncertainties in the methodologies used to determine sediment loadings.

7.1.2 Wasteload Allocation

The wasteload allocated to point sources in the watershed was based on the permitted discharge loading rate for total suspended solids for each facility as shown in **Table 7-1**. Because the facilities typically contribute only non-settleable solids, and their overall contribution to the total annual watershed sediment load is small, no reductions are required for these sources.

Table 7-1: Point Source Wasteload Allocations for Bull Run

Facility Name	Permitted TSS Load (kg/day)	Annual Sediment Loading (ton/year)	Percent Reduction
UOSA	242.2	97.42	0
Golf Course	0.4	0.2	0
Sunoco	14.4	5.8	0
Total	**257.0**	**103.4**	**0**

The Cities of Manassas, Manassas Park, and the City of Fairfax as well as portions of Fairfax, Loudoun, and Prince William Counties, VDOT road areas, MWAA Washington Dulles International Airport and the Prince William County Schools, Fairfax County Schools, and Northern Virginia Community College (Manassas Campus), are covered by MS4 permits which are included in the wasteload allocations. As discussed in Section 6.0, land-based loads were allocated to the MS4 based on an area weighted method. **Table 7-2** presents the contribution of sediment from all permitted stormwater sources including stormwater regulated under the municipal separate storm sewer system (MS4) program as well as stormwater regulated under general VPDES permits for construction and industrial activities. As presented in **Table 7-2**, a 77.1 percent reduction in land-based sources and instream erosion allocated to the MS4s is required to achieve the TMDL endpoint. Waste load allocations were based on an equal percent reduction from controllable sources. Loads from forested lands within the MS4 areas are not subject to reduction.

Table 7-2: Wasteload Allocation by MS4 Areas including General Stormwater Permits

Permit Number	MS4 Permit Holder[1]	MS4 Area	Existing Load (tons/year	Allocated Load (tons/year)	Percent Reduction(*)
VA0088587	Fairfax County	Fairfax County	19,470.5	4,450.6	77.1
VAR040104	Fairfax County Public Schools				
VAR040062	VDOT Urban Area				
VAR040064	City of Fairfax	City of Fairfax	67.6	15.4	77.1
VAR040062	VDOT Urban Area				
VAR040067	Loudoun County	Loudoun County	2,006.8	458.7	77.1
VAR040062	VDOT Urban Area				
VAR040063	Manassas City	Manassas City	998.0	228.1	77.1
VAR040095	NOVA Manassas Campus				
VAR040062	VDOT Urban Area				
VAR040070	Manassas Park	Manassas Park	514.9	117.7	77.1
VAR040062	VDOT Urban Area				
VA0088595	Prince William County	Prince William County	2,418.7	552.9	77.1
VAR040100	Prince William County Public Schools				
VAR040062	VDOT Urban Area				
Total			**25,476.5**	**5,823.4**	**77.1**

(*) The percent load reduction for the MS4s accounts for loads from all land sources including forested areas.
(1) MWAA Washington Dulles International Airport is subject to regulation under the MS4 program. The individual VPDES permit for this facility, permit number VA0089541, establishes the regulatory requirements for industrial stormwater, construction stormwater and MS4 under a single permit. The MS4 acreage is not presented in this table as the stormwater regulated under this program cannot readily be distinguished from other activities.

It should be noted that stormwater from the Metropolitan Washington Airport Authority (MWAA), Washington Dulles International Airport is subject to regulation under several regulatory programs. These include the MS4, industrial, and construction stormwater programs. All regulatory requirements governing the airport stormwater discharges are contained in the individual VPDES permit number VA0089541.

The MS4 sediment allocations shown in **Table 7-2** cover the entire MS4 urban areas, therefore include the loads from individual MS4s permits, and also load from Individual Stormwater Permits, General Stormwater Permits, General Permits for Mines, General Permits for Concrete Facilities, and General Permits for Construction Permits and the transitional land use category. The existing and allocated loads for the construction permits were estimated based on the loads from the transitional land-use category. Therefore, the transitional land-use category is assumed to be entirely comprised of construction sites. **Table 7-3** presents the sediment wasteload allocation for the sources regulated under the industrial and construction VPDES general permits. The waste load allocation for each individual and general stormwater permit is presented in Appendix D. The majority of the facilities holding general stormwater permits is located in areas covered by MS4 permits, and is thus included in the MS4 wasteload allocation. Appendix D provides a finer breakdown of the wasteload allocation by providing specific wasteload allocations for each facility holding a general stormwater permit.

Table 7-3: Wasteload Allocation for Stormwater Permits *

Category	Number of Permits	Existing Load (ton/year)	Allocated Load (ton/year)
Stormwater for Individual Permits	5	281.5	281.5[#]
General Stormwater Permit - Concrete Facilities	5	8.1	8.1
General Stormwater Permit Residences	32	1.46	1.46
General Stormwater Mine/Quarries	3	0.92	0.92
General Stormwater Industrial Facilities	11	17.8	17.8
General Stormwater Construction Permits (Transitional Land-use category)	-	678.1	153.4[#]
Total	-	**987.9**	**463.2**

* the breakdown of the sediment load allocations by permit is based on assumptions shown in Appendix D
[#] these totals include the MWAA Dulles Airport's allocated load; which are depicted in Appendix D.

The wasteload allocation presented in **Table 7-4** includes regulated stormwater discharges from Phase I and Phase II MS4 regulated entities. Phase I MS4 operators include Fairfax County and Prince William County. Phase II MS4 entities include: Loudoun County; the City of Manassas; the City of Manassas Park; the City of Fairfax; MWAA Washington Dulles International Airport; Prince William County Schools; Fairfax County Schools; Northern Virginia Community College (Manassas Campus); Virginia Department of Transportation, Northern Virginia Urban Area. As discussed in Section 6.0, land-based loads were allocated to the MS4 based on an area weighted method. The MS4 wasteload allocation is aggregated and presented in **Table 7-4** by locality. The allocation represents the allowable loadings from all MS4 entities contained within the jurisdictional area of the locality. Due to the spatial overlap between the MS4 entities and the resulting uncertainty of the appropriate operator of the system, the MS4 loads are aggregated in the TMDL. For instance, certain roads within a county are maintained by VDOT, some by the county, and some by private subdivisions. Thus, it was not practical to separate out individual allocations to each MS4 permit holder. The wasteload allocation for all stormwater sources, including MS4, industrial, and construction stormwater is aggregated by category based on the type of VPDES permit.

The wasteload allocation computed for each permit category (e.g. MS4, construction stormwater, mines/quarries) shall be allocated to the individual permit holders at the discretion of the permitting regulatory agency through the issuance of VPDES stormwater permits. As presented in **Table 7-2**, a 77.1 percent reduction in land-based sources and instream erosion allocated to the MS4s is required to achieve the TMDL endpoint. Waste load allocations were based on an equal percent reduction from controllable sources. Loads from forested lands within the MS4 areas are not subject to reduction. **Table 7-5** summarizes the wasteload allocations.

Table 7-4: Wasteload Allocation by MS4 Areas Excluding General Stormwater Permits

Permit Number	MS4 Permit Holder[1]	MS4 Locality	Existing Load (tons/year)	Allocated Load (tons/year)
VA0088587	Fairfax County	Fairfax County	18,715.5	4,096.6
VAR040104	Fairfax County Public Schools			
VAR040062	VDOT Urban Area			
VAR040064	City of Fairfax	City of Fairfax	64.9	14.2
VAR040062	VDOT Urban Area			
VAR040067	Loudoun County	Loudoun County	1,929.0	422.2
VAR040062	VDOT Urban Area			
VAR040063	Manassas City	Manassas City	959.3	210.0
VAR040095	NOVA Manassas Campus			
VAR040062	VDOT Urban Area			
VAR040070	Manassas Park	Manassas Park	495.0	108.3
VAR040062	VDOT Urban Area			
VA0088595	Prince William County	Prince William County	2,324.9	508.9
VAR040100	Prince William County Public Schools			
VAR040062	VDOT Urban Area			
Total			**24,488.6**	**5,360.2**

Table 7-5: Wasteload Allocation Summary

WLA Category	Existing Load (ton/yr)	Allocated Load (ton/yr)
VPDES Point Source	103.4	103.4
MS4s	24,488.6	5,360.2
Stormwater Permits	987.9	463.2
Total	**25,579.9**	**5,926.9**

7.1.3 Load Allocation

Load allocations for non-point sources not covered under the MS4 permits were based on an equal percent reduction from controllable sources. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions. The existing and allocated sediment loads for each non-point source in the Bull Run impaired watershed are presented in **Table 7-6**. In addition, the necessary percent reduction is shown for each source.

Table 7-6: Load Allocations Summary for Bull Run

Source	Land Use Type	Existing Load (tons/year)	Allocated Load (tons/year)
Non-point Source	Deciduous Forest	55.7	55.7
	Evergreen Forest	12.6	12.6
	Mixed Forest	7.8	7.8
	Pasture/Hay	1,005.5	227.4
	Row Crop	2,066.8	467.3
	Quarries Strip Mine	0.0	0.0
	Low Intensity Residential	2.9	0.7
	Medium High Intensity	124.9	28.2
	Commercial/Industrial	189.9	42.9
	Institutional	19.9	4.5
	Urban Recreational Grass	0.6	0.1
	Instream Erosion	17,755.9	4,020.6
	Total	**21,242.5**	**4,867.8**

7.2 Overall Recommended TMDL Allocations

The total load, wasteload allocations, and margin of safety for Bull Run are summarized in **Table 7-7**. Recommended allocations for each source in the watershed are provided in **Table 7-8**. A load equivalent to half a percent (0.5%) of the total TMDL sediment load (60 tons/year) was deducted from the load allocations (LA) set aside to account for future growth. Overall, the sediment load in the Bull Run watershed must be reduced by 76.8% to meet the established TMDL endpoint.

Table 7-7: Sediment TMDL for Bull Run (tons/year)

TMDL	Load Allocation	Wasteload Allocation (Point Source + MS4s)	Margin of Safety (10%)
11,994.1	4,807.9	5,986.8	1,199.4

Table 7-8: Summary of Existing and Allocated Sediment Loads for the Bull Run Watershed

Source	Land Use Type	Existing Load (tons/year)	Allocated Load (tons/year)	Percent Reduction
Non-point Source	Deciduous Forest	55.7	55.7	0
	Evergreen Forest	12.6	12.6	0
	Mixed Forest	7.8	7.8	0
	Pasture/Hay	1,005.5	224.5	77.6
	Row Crop	2,066.8	461.5	77.6
	Low Intensity Residential	2.9	0.7	77.6
	Medium High Intensity	124.9	27.9	77.6
	Commercial/Industrial	189.9	42.4	77.6
	Institutional	19.9	4.5	77.6
	Urban Recreational Grass	0.6	0.1	77.6
	Instream Erosion	17,755.9	3,970.3	77.6
MS4	Non-point Source	4,163.8	911.4	77.1
	Instream Erosion	20,324.8	4,448.8	77.1
Permitted Facilities	Individual VPDES Permits	103.4	163.4*	-
	Stormwater Permits#	987.9	463.1	-
	Total	**46,822.5**	**10,794.7**	**76.8**

(*)A load equivalent to half a percent (0.5%) of the Total TMDL Load (60 tons/year) was taken from the load allocations (LA) and added to the waste load allocation to account for future growth and the potential change in land-use from rural/open space to urban

(#) Breakdown of the loads by type of stormwater permit is shown in Table 7-3

7.3 Consideration of Critical Conditions

EPA regulations at 40 CFR 130.7 (c) (1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that designated uses are protected throughout the year, including vulnerable periods.

In the case of the Bull Run, the primary stressor resulting in the benthic impairment in the river is excessive sediment loading, which has led to siltation and the loss of benthic habitat. On an average annual basis, land-based sources and in-stream erosion account for 99.8% of the total sediment load to the stream; this includes non-point source loading, and loading attributed to the MS4s present in the watershed. Point source facilities contribute only 0.2% of the sediment load, based on the permitted TSS concentrations and design flows for permitted facilities. Therefore, most of the sediment load is delivered under high flow conditions associated with stormwater runoff.

Since sediment loading occurs throughout the year, primarily due to land-based runoff, and its impacts on benthic invertebrates are often a function of cumulative loading, it is appropriate to consider sediment loading on an annual basis. Therefore, TMDL allocations were developed based on average annual loads determined from the 10 year simulation period performed using the GWLF model.

7.4 Consideration of Seasonal Variability

Seasonal variations involve changes in stream flow and sediment loading as a result of hydrologic and climatological patterns. Seasonal variations were explicitly incorporated in the modeling approach for this TMDL. GWLF is a continuous simulation model that incorporates seasonal variations in hydrology and sediment loading by using a daily time-step for water balance calculations. Therefore, the 10 year simulation performed with GWLF adequately captures seasonal variations.

8.0 TMDL Implementation

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels from both point and nonpoint sources in the stream (see section 7.4.2). For point sources, all new or revised VPDES/NPDES permits must be consistent with the TMDL WLA, which includes a set aside for future growth, pursuant to 40 CFR 122.44 (d)(1)(vii)(B) and must be submitted to EPA for approval. The measures for non point source reductions, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.virginia.gov/tmdl/implans/ipguide.pdf 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.

8.1 Staged Implementation

In general, Virginia intends for the required BMPs to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the most efficient sediment BMPs for both urban and rural watersheds are infiltration and retention basins, riparian buffer zones, grassed waterways, streambank protection and stabilization, and wetland development or enhancement. The iterative implementation of BMPs in the watershed has several benefits:

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

2. It provides a measure of quality control, given the uncertainties inherent in

computer simulation modeling;

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

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

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

quality standards.

Watershed stakeholders will have opportunity to participate in the development of the TMDL implementation plan. Specific goals for BMP implementation will be established as part of the implementation plan development.

8.2 Stage 1 Scenarios

The TMDL allocation scenario to reduce sediment loading to the Bull Run was presented in Section 7.0. Under this scenario, the sediment TMDL endpoint is achieved by reducing sediment loads from agricultural, transitional, and developed lands by 77.6%, as well as reducing instream erosion and sediment loads attributed to MS4s 77.1% to meet this scenario. Allocated sediment loads and the percent reduction required for all watershed sources are presented in **Table 8-1**.

Table 8-1: Summary of Existing and Allocated Sediment Loads for the Bull Run Watershed

Source	Land Use Type	Existing Load (tons/year)	Allocated Load (tons/year)	Percent Reduction
Non-point Source	Deciduous Forest	55.7	55.7	0
	Evergreen Forest	12.6	12.6	0
	Mixed Forest	7.8	7.8	0
	Pasture/Hay	1,005.5	224.5	77.6
	Row Crop	2,066.8	461.5	77.6
	Low Intensity Residential	2.9	0.7	77.6
	Medium High Intensity	124.9	27.9	77.6
	Commercial/Industrial	189.9	42.4	77.6
	Institutional	19.9	4.5	77.6
	Urban Recreational Grass	0.6	0.1	77.6
	Instream Erosion	17,755.9	3,970.3	77.6
MS4	Non-point Source	4,163.8	911.4	77.1
	Instream Erosion	20,324.8	4,448.8	77.1
Permitted Facilities	Individual VPDES Permits	103.4	163.4*	-
	Stormwater Permits#	987.9	463.1	-
	Total	**46,822.5**	**10,794.7**	**76.8**

(*)A load equivalent to half a percent (0.5%) of the Total TMDL Load (60 tons/year) was taken from the load allocations (LA) and added to the waste load allocation to account for future growth and the potential change in land-use from rural/open space to urban

(#) Breakdown of the loads by type of stormwater permit is shown in Table 7-3

8.3 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 Chesapeake Bay. Several BMPs known to be effective in controlling sediment have also been identified for implementation as part of the Tributary Strategy for the Potomac River basin. Examples of sediment pollution reduction practices include:

- Agricultural Best Management Practices (BMP) includes practices to reduce or eliminate soil loss, prevent runoff, and provide for the proper application rates of nutrients to cropland, vegetated buffer strips at the edge of crop fields, conservation tillage, strip cropping, animal waste management, and stream bank fencing
- Urban Best Management Practices which include erosion and sediment BMPs to control runoff from areas under development and stormwater controls in developed areas. These practices are applied across a broad spectrum from industrial, commercial, and residential facility construction sites to the management of lawns and open spaces, reducing nutrient runoff.
- Stormwater Management controls including Low Impact Development (LID)

- Upgrades made to wastewater treatment plants, many which are performed during the installation of biological nutrient removal (BNR) process to meet Bay nutrients allocations
- Septic system maintenance
- Stream Buffers. Streamside forest to reduce or remove excess nutrients and sediment from surface runoff and shallow groundwater and aid in shading streams to optimize light and temperature conditions for aquatic plants and animals.

Fairfax County is in the process of developing watershed management plans countywide, and the plan for Cub Run and the Fairfax County portions of Bull Run is scheduled for completion in Summer 2006. The Cub and Bull Run Watershed Management Plan is being developed with the help of a citizens' advisory committee and other public input, and it lays out the county's strategy for improving stormwater management in the watershed over the next 25 years. The plan includes proposed projects throughout the watershed that fall into the following categories: regional ponds or equivalent alternative controls, dry pond retrofits, low impact development practices, stream and buffer restoration projects, dump site removal and road crossing replacements or upgrades. The plan also includes non-structural projects such as public education and outreach, monitoring, and proposed policy changes. The recommendations made in the Cub and Bull Run Watershed Management Plan will be considered during the implementation planning process for this TMDL and incorporated as appropriate.

8.3.1 Follow-Up Monitoring

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

The purpose, location, parameters, frequency, and duration of the monitoring will be determined by the DEQ staff, in cooperation with DCR staff, the Implementation Plan Steering Committee and local stakeholders. Whenever possible, the location of the follow-up monitoring station(s) will be the same as the listing station. At a minimum, the monitoring station must be representative of the original impaired segment. The details of the follow-up monitoring will be outlined in the Annual Water Monitoring Plan prepared by each 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.

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

In some cases, watersheds will require monitoring above and beyond what is included in DEQ's standard monitoring plan. Ancillary monitoring by citizens' or watershed groups, local government, or universities is an option that may be used in such cases. An effort should be made to ensure that ancillary monitoring follows established QA/QC guidelines in order to maximize compatibility with 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/cmonitor/.

To demonstrate that the watershed is meeting water quality standards in watersheds where corrective actions have taken place (whether or not a TMDL or Implementation plan has been completed), 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 conventional pollutants (bacteria, dissolved oxygen, etc) is bimonthly monitoring for two consecutive years. For biological monitoring, the minimum requirement is two consecutive samples (one in the spring and one in the fall) in a one year period.

8.3.2 Regulatory Framework

While section 303(d) of the Clean Water Act and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. EPA also requires that all new or revised National Pollutant Discharge Elimination System (NPDES) permits must be consistent with the TMDL WLA pursuant to 40 CFR §122.44 (d)(1)(vii)(B). All such permits should be submitted to EPA for review.

Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

For the implementation of the WLA component of the TMDL, the Commonwealth intends to utilize the Virginia NPDES (VPDES) program, which typically includes consideration of the WQMIRA requirements during the permitting process. Requirements of the permit process should not be duplicated in the TMDL process, and with the exception of stormwater related permits, permitted sources are not usually addressed during the development of a TMDL implementation plan.

For the implementation of the TMDL's LA component, a TMDL implementation plan addressing at a minimum the WQMIRA requirements will be developed. An exception are the municipal separate storm sewer systems (MS4s) which are both covered by NPDES permits and expected to be included in TMDL implementation plans, as described in the stormwater permit section below.

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 to assist in this endeavor.

In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the state's Water Quality Management Plans. The WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

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

8.3.3 Stormwater Permits

DEQ and DCR coordinate separate State programs that regulate the management of pollutants carried by storm water runoff. DEQ regulates storm water discharges associated with "industrial activities", while DCR regulates storm water discharges from construction sites, and from municipal separate storm sewer systems (MS4s).

EPA approved DCR's VPDES storm water program on December 30, 2004. DCR's regulations became effective on January 29, 2005. DEQ is no longer the regulatory agency responsible for administration and enforcement of the VPDES MS4 and construction storm water permitting programs. More information is available on DCR's web site through the following link: http://www.dcr.virginia.gov/sw/vsmp

It is the intention of the Commonwealth that the TMDL will be implemented using existing regulations and programs. One of these regulations is DCR’s Virginia Stormwater Management Program (VSMP) Permit Regulation (4 VAC 50-60-10 et. seq). Section 4VAC 50-60-380 describes the requirements for stormwater discharges. Also, federal regulations state in 40 CFR §122.44(k) that NPDES permit conditions may consist of “Best management practices to control or abate the discharge of pollutants when:…(2) Numeric effluent limitations are infeasible,…”.

Part of the Bull Run watershed is covered by permits for the small municipal separate storm sewer systems (MS4s) owned by The Cities of Manassas, Manassas Park, and the City of Fairfax as well as portions of Fairfax, Loudoun, and Prince William Counties, VDOT road areas and the Prince William County Schools, Fairfax County Schools, and Northern Virginia Community College (Manassas Campus). The permits state, under Part

II.A., that the "permittee must develop, implement, and enforce a stormwater management program designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable (MEP), to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act and the State Water Control Law."

The permit also contains a TMDL clause that states: "If a TMDL is approved for any waterbody into which the small MS4 discharges, the Board will review the TMDL to determine whether the TMDL includes requirements for control of stormwater discharges. If discharges from the MS4 are not meeting the TMDL allocations, the Board will notify the permittee of that finding and may require that the Stormwater Management Program required in Part II be modified to implement the TMDL within a timeframe consistent with the TMDL." ("Board" means the Soil and Water Conservation Board)

For MS4/VSMP general permits, the Commonwealth expects the permittee to specifically address the TMDL wasteload allocations for stormwater through the implementation of programmatic BMPs. BMP effectiveness would be determined through ambient in-stream monitoring. This is in accordance with recent EPA guidance (EPA Memorandum on TMDLs and Stormwater Permits, dated November 22, 2002). If future monitoring indicates no improvement in stream water quality, the permit could require the MS4 to expand or better tailor its stormwater management program to achieve the TMDL wasteload allocation. However, only failing to implement the programmatic BMPs identified in the modified stormwater management program would be considered a violation of the permit. Any changes to the TMDL resulting from water quality standards changes on Bull Run would be reflected in the permit.

Wasteload allocations for stormwater discharges from storm sewer systems covered by a MS4 permit will be addressed in TMDL implementation plans. An implementation plan will identify types of corrective actions and strategies to obtain the wasteload allocation for the pollutant causing the water quality impairment. Permittees need to participate in the development of TMDL implementation plans since recommendations from the process may result in modifications to the stormwater management plan in order to meet the TMDL.

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

8.3.4 Implementation Funding Sources

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". Potential sources for implementation may include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, EPA Section 319 funds, the Virginia State Revolving Loan Program, Virginia Agricultural Best Management Practices Cost-Share Programs, the Virginia Water Quality Improvement Fund, tax credits and landowner contributions. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

8.3.5 Attainability of Designated Uses

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

In order for a stream to be assigned a new designated use, the current designated use must be removed. To remove a designated use, the state must demonstrate 1) that the use is not an existing use, 2) that downstream uses are protected, and 3) that the source of the contamination is natural and uncontrollable by effluent limitations and by implementing cost-effective and reasonable best management practices for non-point source control (9

VAC 25-260-10). 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 as amendments to the water quality standards regulations. Watershed stakeholders and EPA will be able to provide comment during this process. Additional information can be obtained at http://www.deq.virginia.gov/wqs/WQS03AUG.pdf

The process to address potentially unattainable reductions based on the above is as follows: First is the development of a stage 1 scenario such as those presented previously in this chapter. The pollutant reductions in the stage 1 scenario are targeted only at the controllable, anthropogenic sources identified in the TMDL. During the implementation of the stage 1 scenario, all controllable sources would be reduced to the maximum extent practicable using the iterative approach described in Section 8.2 above. DEQ will re-assess water quality in the stream during and subsequent to the implementation of the stage 1 scenario to determine if the water quality standard is attained. This effort will also evaluate if the modeling assumptions were correct. If water quality standards are not being met, and no additional cost-effective and reasonable best management practices can be identified, a UAA may be initiated with the goal of re-designating the stream for a more appropriate use.

9.0 Public Participation

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

TAC Meeting No. 1. The first TAC meeting was held on March 1, 2005 at the DEQ office in Woodbridge to present and review the steps and the data used in the development of the benthic TMDLs for the Bull Run listed segment.

TAC Meeting No. 2. The second TAC meeting was held on November 3, 2005 at the DEQ office in Woodbridge, VA to discuss the preliminary benthic stressors identified for Bull Run.

TAC Meeting No. 3. The third TAC meeting was held on March 1, 2006 at the DEQ office in Woodbridge VA to discuss the completed TMDL for the Bull Run listed segment.

Public Meeting No. 1. The first public meetings were held in on March 30, 2005 at the Sully District Governmental Center in Chantilly, Virginia and on April 5, 2005 at the Pennington School in Manassas, Virginia to present the process for TMDL development, the Bull Run benthic impaired segment, data that caused the segment to be on the 303(d) list, data and information needed for TMDL development, and preliminary findings regarding potential stressors. Nineteen people attended these meetings. Copies of the presentation were available for public distribution. This meeting was publicly noticed in the *Virginia Register*.

Public Meeting No. 2. The second public meeting was held in on December 14, 2005 at the Sully District Governmental Center in Chantilly, Virginia to discuss the preliminary benthic stressors identified for Bull Run. Six people attended this public meeting. Copies of the presentation and the draft TMDL report executive summary were available for public distribution. The meeting was public noticed in *The Virginia Register of Regulations.*

Public Meeting No. 3. The third public meeting on the development of the Occoquan Basin Streams TMDLs was held on March 15, 2006 at the Central Community Library in Manassas, VA to discuss the identified pollutant stressor, the methodology employed to determine watershed loadings of the stressor, and the Draft TMDL. Ten people attended this meeting. Copies of the presentation and the draft TMDL report executive summary were available for public distribution. The meeting was public noticed in *The Virginia Register of Regulations.*

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APPENDIX A: General Permits Issued in the Bull Run Benthic Impairment Watershed

Table A-1: General Concrete Facility Permits Issued in the Bull Run Benthic Impairment Watershed

Permit Number	Facility Name	Receiving Waterbody	Status
VAG110074	Titan Virginia Ready Mix LLC - Centreville	Bull Run, UT	Active
VAG110070	Mid Atlantic Materials Incorporated – Manassas	Chinn Branch	Active
VAG110096	Atlantic Contracting and Material Company Inc	Cub Run, UT	Active
VAG110094	DuBrook Concrete - Loudoun	Sand Branch	Active
VAG110089	Virginia Concrete Company Incorporated - Chantilly	Sand Branch, UT	Active

Table A-2: General Mining Permits Issued in the Bull Run Watershed

Permit Number	Facility Name	Receiving Waterbody	Status
VAG840089	Luck Stone - Bull Run	Bull Run	Active
VAG840093	Luck Stone - Fairfax Plant	Bull Run, UT	Active
VAG840092	Vulcan Construction Materials - Manassas	Flat Branch	Active

Table A-3: General Stormwater Industrial Permits Issued in the Bull Run Watershed

Permit Number	Facility Name	Receiving Waterbody	Status
VAR051566	Rolling Frito Lay Sales LP - Manassas	Bull Run	Active
VAR051011	Superior Paving Corporation - Centreville	Bull Run, UT	Active
VAR051036	United Parcel Service - Dulles Center	Cub Run	Active
VAR051044	Pulse Communications Incorporated	Dead Run, UT	Active
VAR050995	Manassas City - Department of Public Works	Flat Branch	Active
VAR051084	MIFCO - Manassas Ice and Fuel	Flat Branch, UT	Active
VAR051074	Interstate 66 - Solid Waste Management Facility	Little Rocky Run, UT	Active
VAR050863	Virginia Paving Company - Chantilly	Sand Branch	Active
VAG830019	Bethlehem Baptist Church	Big Rocky Run	Active
VAG830067	Texaco - Scotties	Flat Branch	Active
VAG830056	E E Wine Bulk Facility - Manassas	Russia Branch	Active

Table A-4: General Domestic Sewage Permits Issued in the Bull Run Watershed

Permit Number	Facility Name	Design Flow (gpd)[1]	Receiving Waterbody	Status
VAG406315	Residence	450	Black Branch UT	Active
VAG406236	Residence	450	Black Branch, UT	Active
VAG406272	Residence	50	Bull Run	Active
VAG406295	Residence	600	Bull Run UT	Active
VAG406300	Residence	450	Bull Run UT	Active
VAG406329	Residence	450	Bull Run UT	Active
VAG406330	Residence	600	Bull Run UT	Active
VAG406094	Residence	600	Bull Run, UT	Active
VAG406099	Residence	500	Bull Run, UT	Active
VAG406273	Residence	600	Bull Run, UT	Active
VAG406065	Residence	300	Catharpin Creek, UT	Active
VAG406076	Residence	800	Catharpin Creek, UT	Active
VAG406240	Commercial	1000	Chestnut Lick	Active
VAG406221	Commercial	600	Chestnut Lick, UT	Active
VAG406247	Residence	450	Chestnut Lick, UT	Active
VAG406259	Residence	600	Chestnut Lick, UT	Active
VAG406270	Residence	260	Chestnut Lick, UT	Active
VAG406209	Residence	550	Chestnut Lick, UT	Active
VAG406162	Residence	500	Chestnut Lick - UT	Active
VAG406297	Residence	600	Chestnut Lick UT	Active
VAG406319	Residence	450	Chestnut Lick UT	Active
VAG406280	Residence	600	Chestnut Lick, UT	Active
VAG406057	Residence	400	Elklick Run	Active
VAG406171	Commercial	500	Elklick Run - UT	Active
VAG406224	Residence	450	Little Bull Run	Active
VAG406109	Commercial	75	Little Bull Run	Active
VAG406165	Residence	450	Little Bull Run - UT	Active
VAG406298	Residence	450	Little Bull Run UT	Active
VAG406040	Residence	500	Little Bull Run, UT	Active
VAG406296	Residence	600	Piney Branch UT	Active
VAG406202	Residence	450	Piney Branch, UT	Active
VAG406252	Residence	1000	Pope's Head Creek, UT	Active

APPENDIX B: Permitted Discharge Limits for Facilities Holding Individual Permits

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow (MGD)	Outfall No.	Parameter Description (Units)	Quantity Average (Current/ Expanded)	Quantity Maximum (Current/ Expanded)	Concentra-tion Avg. (Current/ Expanded)	Concentra-tion Min. (Current/ Expanded)	Concentra-tion Max. (Current/ Expanded)
Colonial Pipeline - Chantilly	VA0051683	Minor	Industrial	0.44	1	Flow (mgd)	NL	N/A	N/A	N/A	NL
						pH (SU)	N/A	N/A	N/A	6	9
				-	101	Flow (mgd)	NL	N/A	N/A	N/A	NL
						pH (SU)	N/A	N/A	N/A	6	9
						TPH (mg/L)	N/A	N/A	N/A	N/A	15
				-	102	Flow (mgd)	NL	N/A	N/A	N/A	NL
						Total Organic Carbon (mg/L)	N/A	N/A	N/A	N/A	110
						TPH (mg/L)	N/A	N/A	N/A	N/A	15
						Benezene (ug/L)	N/A	N/A	N/A	N/A	50
						Toluene (ug/L)	N/A	N/A	N/A	N/A	175
						Ethylbenzene (ug/L)	N/A	N/A	N/A	N/A	320
						Total Xylenes (ug/L)	N/A	N/A	N/A	N/A	74
						Naphthalene (ug/L)	N/A	N/A	N/A	N/A	62
						Total Residual Chloride (mg/L)	N/A	N/A	N/A	N/A	0.16
Colonial Pipeline - Bull Run	VA0051691	Minor	Industrial	0.06	1	Flow (mgd)	NL	N/A	N/A	N/A	N/A
						pH (SU)	N/A	N/A	N/A	6	9
						TPH (mg/L)	N/A	N/A	N/A		15
				0.06	2	Flow (mgd)	NL	N/A	N/A	N/A	N/A
						Total Organic Carbon (mg/L)	N/A	N/A	N/A	N/A	110
						TPH (mg/L)	N/A	N/A	N/A	N/A	15
						Benzene (ug/L)	N/A	N/A	N/A	N/A	50
						Toluene (ug/L)	N/A	N/A	N/A	N/A	175

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow (MGD)	Outfall No.	Parameter Description (Units)	Quantity Average (Current/ Expanded)	Quantity Maximum (Current/ Expanded)	Concentra-tion Avg. (Current/ Expanded)	Concentra-tion Min. (Current/ Expanded)	Concentra-tion Max. (Current/ Expanded)
Colonial Pipeline - Bull Run	VA0051691	Minor	Industrial	0.06	2	Ethylbenzene (ug/L)	N/A	N/A	N/A	N/A	320
						Total Xylenes (ug/L)	N/A	N/A	N/A	N/A	74
						Naphthalene (ug/L)	N/A	N/A	N/A	N/A	62
						Total Residual Chlorine (ug/L)	N/A	N/A	N/A	N/A	0.016
IBM Corp	VA0085901	Minor	Municipal	0.504	4	Flow (mgd)	NL	N/A	N/A	N/A	N/A
						pH (SU)	N/A	N/A	N/A	6	9
						Tetrachloroethylene (ug/L)	N/A	N/A	N/A	N/A	1
						Tricholoroethylene (ug/L)	N/A	N/A	N/A	N/A	1
						Trans 1,2 Dichloroethylene (ug/L)	N/A	N/A	N/A	N/A	1
						1,1,1-Trichloroethane (ug/L)	N/A	N/A	N/A	N/A	1
				0.504	3	Flow (mgd)	NL	N/A	N/A	N/A	NL
						pH (SU)	N/A	N/A	N/A	6	9
						Tetrachloroethylene (ug/L)	N/A	N/A	N/A	N/A	1
						Tichloroethylene (ug/L)	N/A	N/A	N/A	N/A	1
						Trans 1,2 Dichloroethylene (ug/L)	N/A	N/A	N/A	N/A	1
						1,1,1 Tichloroethane (ug/L)	N/A	N/A	N/A	N/A	1
						Acute Toxicity- C. dubia (TU_a)	NL	NL	N/A	N/A	N/A

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow (MGD)	Outfall No.	Parameter Description (Units)	Quantity Average (Current/ Expanded)	Quantity Maximum (Current/ Expanded)	Concentra-tion Avg. (Current/ Expanded)	Concentra-tion Min. (Current/ Expanded)	Concentra-tion Max. (Current/ Expanded)
IBM Corp	VA0085901	Minor	Municipal	0.504	3	Acute Toxicity- P. promelas (TU_a)	NL	NL	N/A	N/A	N/A
						Chronic Toxicity- C. dubia (TU_a)	NL	NL	N/A	N/A	N/A
						Chronic Toxicity- P. promelas (TU_a)	NL	NL	N/A	N/A	N/A
Sunoco Manassas Terminal	VA0087858	Minor	Industrial	2.215	1	Flow (mgd)	NL	N/A	N/A	N/A	N/A
						pH (SU)	N/A	N/A	N/A	6	9
						Total Petroleum Hydrocarbons (mg/L)	N/A	N/A	N/A	N/A	15
						Total Suspended Soils (mg/L)	N/A	N/A	N/A	N/A	60
				-	2	Flow (mgd)	NL	N/A	N/A	N/A	N/A
						pH (SU)	N/A	N/A	N/A	6	9
						Total Petroleum Hydrocarbons (mg/L)	N/A	N/A	N/A	N/A	15
						Total Suspended Soils (mg/L)	N/A	N/A	N/A	N/A	60
				-	101	Flow (mgd)	NL	N/A	N/A	N/A	NL
						pH (SU)	N/A	N/A	N/A	6	9
						Total Petroleum Hydrocarbons (mg/L)	N/A	N/A	N/A	N/A	15
						Benzene (ug/L)	N/A	N/A	N/A	N/A	53

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow (MGD)	Outfall No.	Parameter Description (Units)	Quantity Average (Current/ Expanded)	Quantity Maximum (Current/ Expanded)	Concentra-tion Avg. (Current/ Expanded)	Concentra-tion Min. (Current/ Expanded)	Concentra-tion Max. (Current/ Expanded)
Sunoco Manassas Terminal	VA0087858	Minor	Industrial	-	101	Ethylbenzene (ug/L)	N/A	N/A	N/A	N/A	320
						Toluene (ug/L)	N/A	N/A	N/A	N/A	175
						Total Xylenes (ug/L)	N/A	N/A	N/A	N/A	82
						Napthalene (ug/L)	N/A	N/A	N/A	N/A	62
						Methyl Tert Butyl Ether (ug/L)	N/A	N/A	N/A	N/A	1840
						Total Residual Chloride mg/L)	N/A	N/A	N/A	N/A	0.016
						Total Organic Carbon (mg/L)	NL	N/A	N/A	N/A	N/A
						Total Suspended Solids (mg/L)	NL	N/A	N/A	N/A	N/A
Evergreen Country Club	VA0087891	Minor	Municipal	0.008	1	Flow (mgd)	NL	N/A	N/A	N/A	N/A
						pH (SU)	N/A	N/A	N/A	6	9
						DO (mg/L for concentration kg/day for quantity)	N/A	N/A	N/A	6.5	0
						$cBOD_5$ (mg/L for concentration kg/day for quantity)	0.28	N/A	10	N/A	N/A
						TSS (mg/L for concentration kg/day for quantity)	0.43	N/A	15	N/A	N/A
						TKN (mg/L for concentration kg/day for quantity)	0.14	N/A	5	N/A	N/A

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow (MGD)	Outfall No.	Parameter Description (Units)	Quantity Average (Current/ Expanded)	Quantity Maximum (Current/ Expanded)	Concentration Avg. (Current/ Expanded)	Concentration Min. (Current/ Expanded)	Concentration Max. (Current/ Expanded)
Evergreen Country Club	VA0087891	Minor	Municipal	0.008	1	Total Residual Chlorine (After Chlorine Contact Tank) mg/L for concentration and kg/day for quantity)	N/A	N/A	N/A	1	N/A
						Total Residual Chlorine (After Dechlorination) mg/L for concentration kg/day for quantity)	N/A	N/A	0.008	N/A	N/A
						E. coli (n/100 mL)	N/A	N/A	N/A	N/A	235
MWAA - Washington Dulles Int'l Air	VA0089541	Minor	Industrial	-	22, 23, 24, 25, 27, 28, 29, 30	Flow (mgd)	NL	N/A	N/A	N/A	N/A
						pH (SU)	N/A	N/A	N/A	N/A	N/A
						BOD5 (mg/L)	N/A	N/A	NL	N/A	N/A
						COD (mg/L)	N/A	N/A	NL	N/A	N/A
						TSS (mg/L)	N/A	N/A	NL	N/A	N/A
						Total Petroleum Hydrocarbons (mg/L)	N/A	N/A	NL	N/A	N/A
						Propylene Glycol (Oct- April) (mg/L)	N/A	N/A	NL	N/A	N/A
						Conductivity (umho/cm)	N/A	N/A	NL	N/A	N/A
Adaptive Concrete Solutions	VA0090441	Minor	Industrial	-	1, 2	Flow (mgd)	N/A	N/A	N/A	N/A	NL
						Total Petroleum Hydrocarbons (mg/L)	N/A	N/A	N/A	N/A	NL

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow (MGD)	Outfall No.	Parameter Description (Units)	Quantity Average (Current/ Expanded)	Quantity Maximum (Current/ Expanded)	Concentration Avg. (Current/ Expanded)	Concentration Min. (Current/ Expanded)	Concentration Max. (Current/ Expanded)
Adaptive Concrete Solutions	VA0090441	Minor	Industrial	-	1,2	Chemical Oxygen Demand (mg/L)	N/A	N/A	N/A	N/A	NL
						Total Suspended Solids (mg/L)	N/A	N/A	N/A	N/A	NL
						pH (SU)	N/A	N/A	N/A	NL	NL
Loudoun Composting	VA0091430	Minor	Industrial	-	1	Flow (mgd)	NL	NL	N/A	N/A	N/A
						BOD5 (mg/L)	NL	NL	N/A	N/A	N/A
						TSS (mg/L)	NL	NL	N/A	N/A	N/A
						COD (mg/L)	NL	NL	N/A	N/A	N/A
						pH (mg/L)	N/A	N/A	N/A	6	9
						Total Phosphorous (mg/L)	NL	NL	N/A	N/A	N/A
						Ammonia as Nitrogen (mg/L)	NL	NL	N/A	N/A	N/A
						Total Nitrogen (mg/L)	NL	NL	N/A	N/A	N/A
						Whole Effluent Toxicity- Acute C. Dubia (TU_a)	N/A	N/A	N/A	N/A	NL
						Whole Effluent Toxicity- Acute P. Promelas (TU_a)	N/A	N/A	N/A	N/A	NL
Upper Occoquan Sewage Authority[1,2]	VA0024988	Major	Municipal	54	1	Flow (mgd)	NL	N/A	N/A	N/A	NL
						pH (SU)	N/A	N/A	N/A	6	9
						Dissolved Oxygen (mg/L)	N/A	N/A	N/A	5	N/A

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow (MGD)	Outfall No.	Parameter Description (Units)	Quantity Average (Current/ Expanded)	Quantity Maximum (Current/ Expanded)	Concentra-tion Avg. (Current/ Expanded)	Concentra-tion Min. (Current/ Expanded)	Concentra-tion Max. (Current/ Expanded)
Upper Occoquan Sewage Authority[1,2]	VA0024988	Major	Municipal	54	1	Total Residual Chlorine (TRC) (after contact tank) (mg/L)	N/A	N/A	N/A	0.6	N/A
						Total Residual Chlorine (TRC) (final effluent) (mg/L)	N/A	N/A	0.008	N/A	N/A
						Total Residual Chlorine (TRC) (final effluent weekly average) (mg/L)	N/A	N/A	0.01	N/A	N/A
						Total Suspended Solids	204.4/242.2	N/A	1	N/A	N/A
						COD	2,043.9/ 2,422.4	N/A	10	N/A	N/A
						Total Phosphorous	20.4/24.2	N/A	0.1	N/A	N/A
						Surfactants	20.4/24.2	N/A	0.1	N/A	N/A
						Total Kjeldahl Nitrogen	204.4/242.2	N/A	1	N/A	N/A
						Total Nitrogen	NL/49,734.9	NL	NL	NL	N/A
						Turbidity	N/A	N/A	0.5	N/A	N/A
						Fecal Coliform (#/100 mL)	N/A	NL	2	N/A	N/A
						E. coli (#/100 mL)	N/A	N/A	NL/126	N/A	N/A
						Sludge Monitoring Requirements					
						Total Arsenic (mg/kg)	N/A	N/A	41	N/A	75
						Total Cadmium (mg/kg)	N/A	N/A	39	N/A	85

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow (MGD)	Outfall No.	Parameter Description (Units)	Quantity Average (Current/ Expanded)	Quantity Maximum (Current/ Expanded)	Concentra-tion Avg. (Current/ Expanded)	Concentra-tion Min. (Current/ Expanded)	Concentra-tion Max. (Current/ Expanded)
Upper Occoquan Sewage Authority[1,2]	VA0024988	Major	Municipal	54	1	Total Copper (mg/kg)	N/A	N/A	1,500	N/A	4,300
						Total Lead (mg/kg)	N/A	N/A	300	N/A	840
						Total Mercury (mg/kg)	N/A	N/A	17	N/A	57
						Total Molybdenum (mg/kg)	N/A	N/A	NL	N/A	75
						Total Nickel (mg/kg)	N/A	N/A	420	N/A	420
						Total Selenium (mg/kg)	N/A	N/A	100	N/A	100
						Total Zinc (mg/kg)	N/A	N/A	2,800	N/A	7,500
						pH (SU)	N/A	N/A	NL	N/A	NL
						Percent Solids	N/A	N/A	NL	N/A	NL

[1]Unless otherwise specifies in the "Parameter Description" column, the units of quantity are kg/day, for concentration are mg/L, and for sludge monitoring are mg/kg
[2]The UOSA plant is currently rated at 54-mgd. This facility is also permitted for an expansion of 10-mgd for a total capacity of 64-mgd. The quantity values shown in the Quantity columns as "(Current/Expanded)" refer to the 54-mgd/64-mgd capacities, respectively.

APPENDIX C: DMR Data for Bull Run Facilities

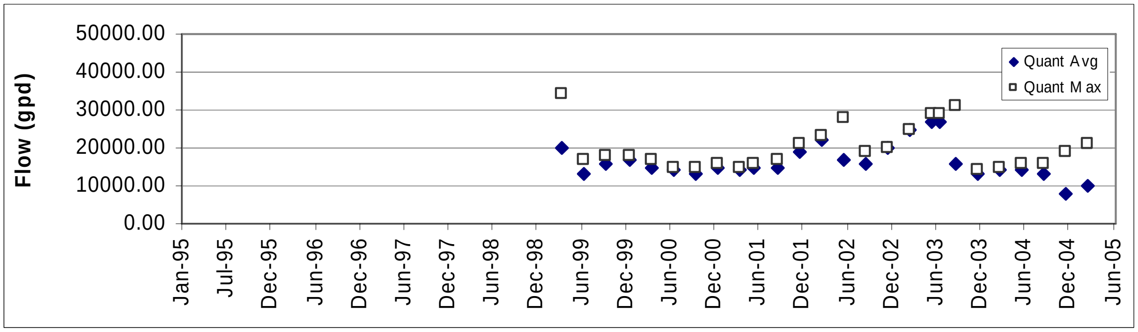

Figure C-1: IBM Corporation Flow Values from Outfall 1

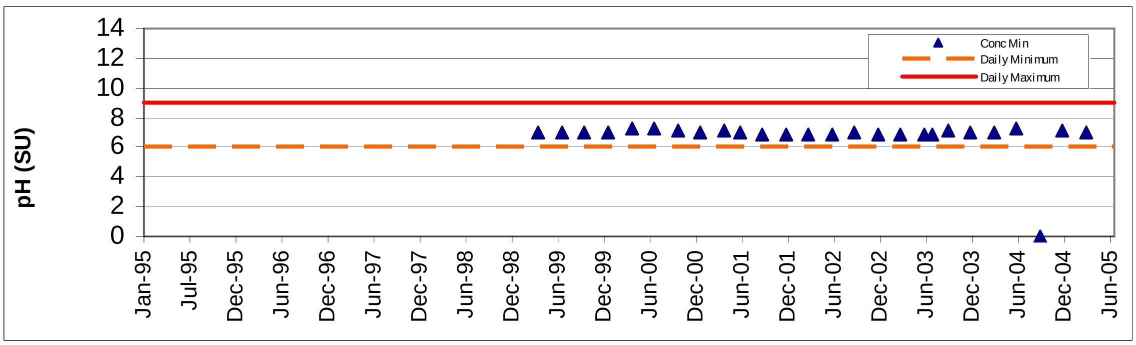

Figure C-2: IBM Corporation pH Values from Outfall 1

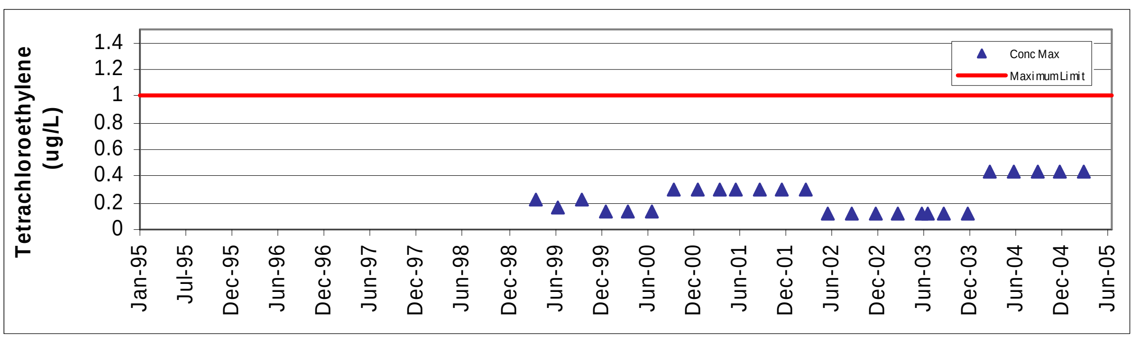

Figure C-3: IBM Corporation Trichloroethylene Concentrations from Outfall 1

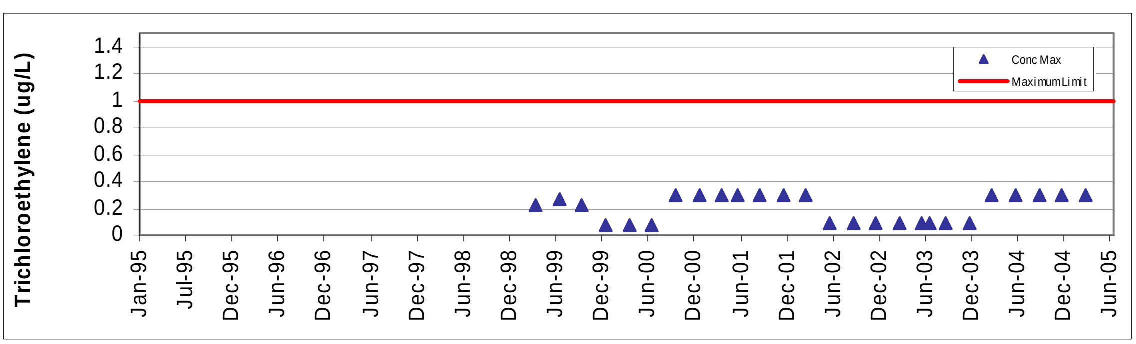

Figure C-4: IBM Corporation 1,1,1 Trichloroethane Concentrations from Outfall 1

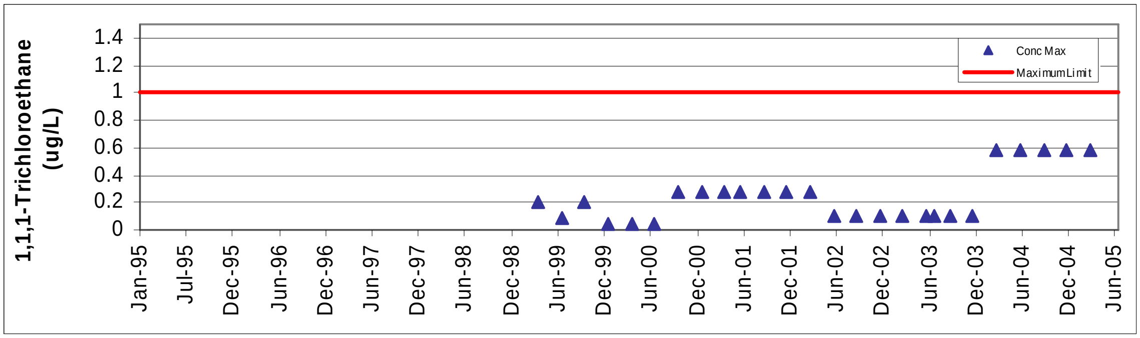

Figure C-5: IBM Corporation Tetrachloroethylene Concentrations from Outfall 1

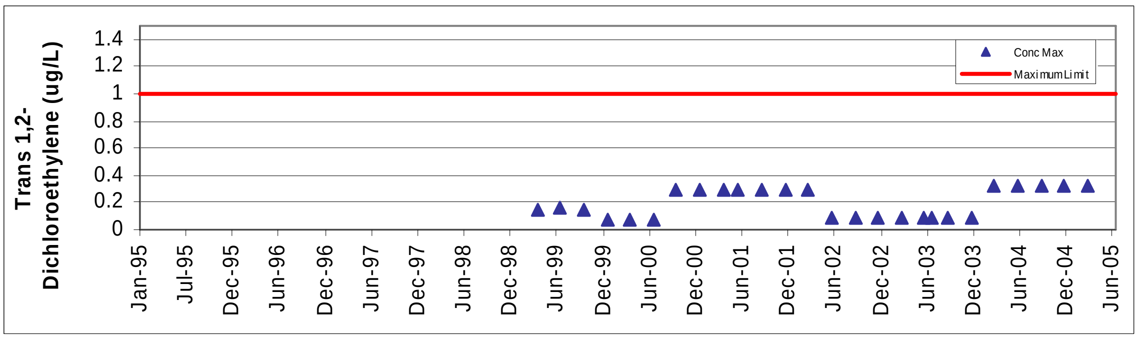

Figure C-6: IBM Corporation Trans 1,2- Dichloroethylene Concentrations from Outfall 1

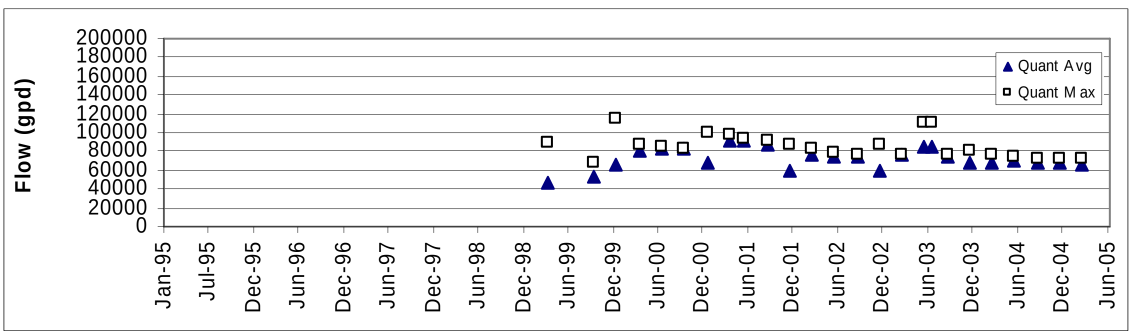

Figure C-7: IBM Corporation Flow Values From Outfall 2

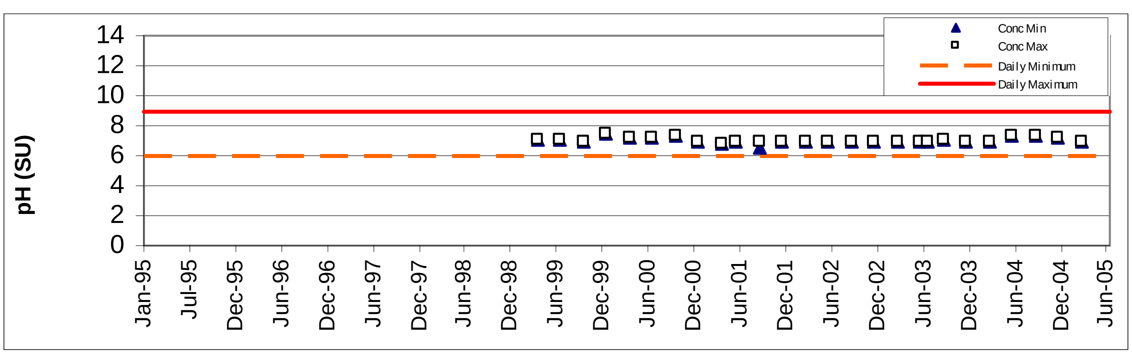

Figure C-7: IBM Corporation pH Values from Outfall 2

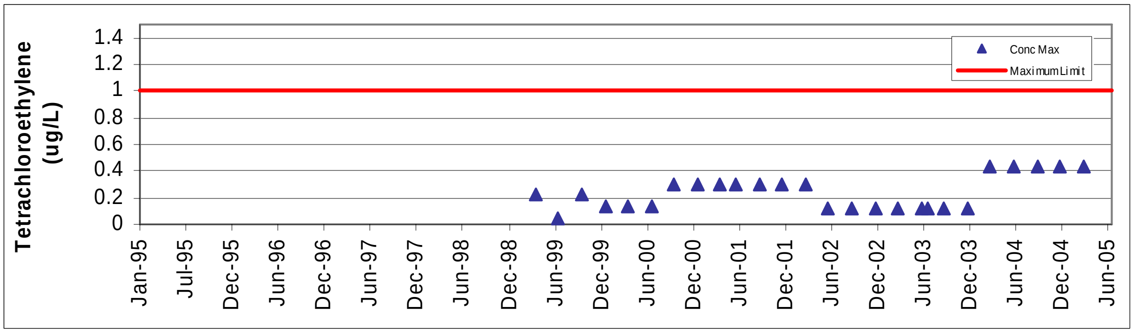

Figure C-8: IBM Corporation Trichloroethylene Concentrations from Outfall 2

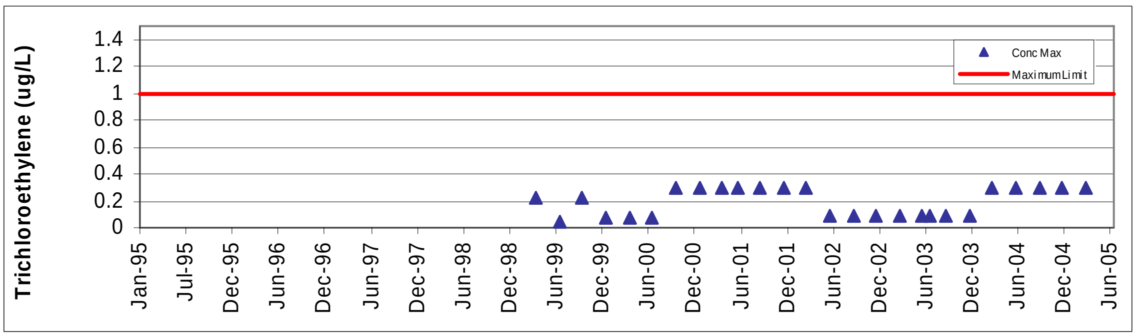

Figure C-9: IBM Corporation Tetrachloroethylene Concentrations from Outfall 2

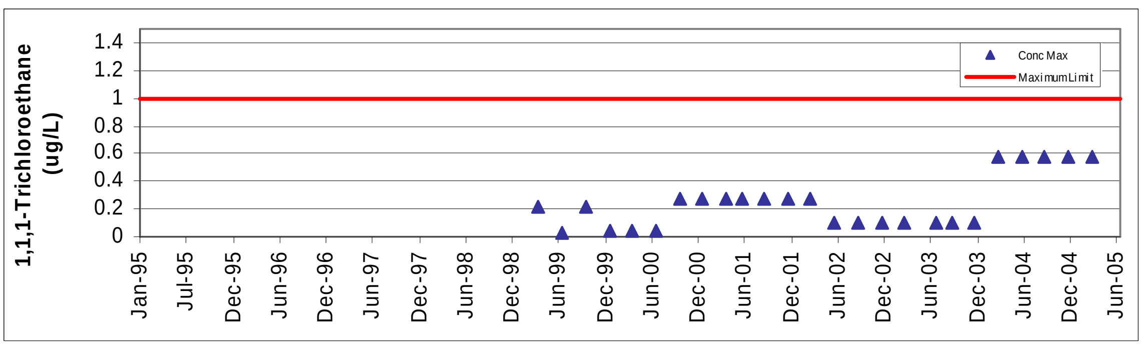

Figure C-10: IBM Corporation 1,1,1- Trichloroethane Concentrations from Outfall 2

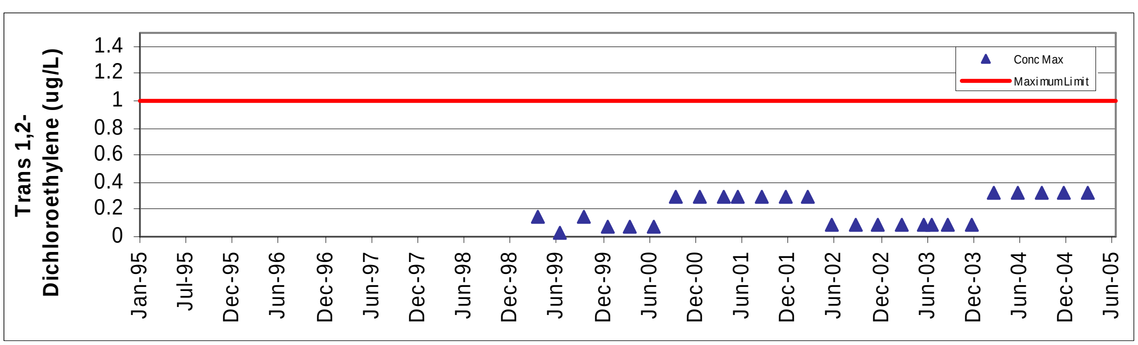

Figure C-11: IBM Corporation Trans 1,2 Dichloroethylene Concentrations from Outfall 2

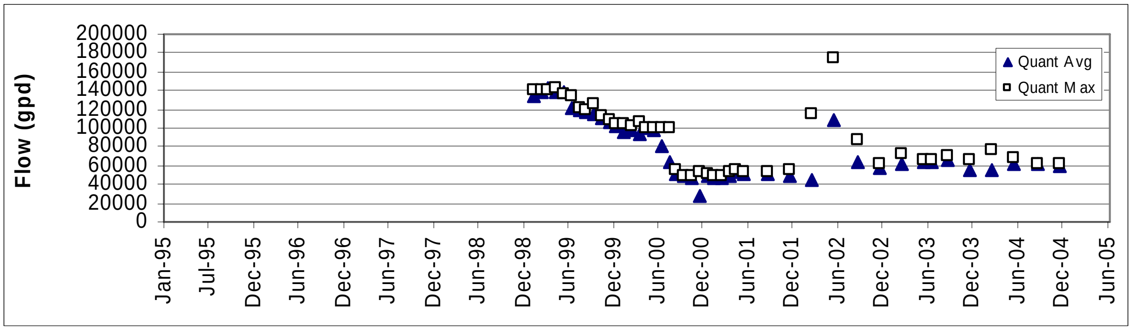

Figure C-12: IBM Corporation Flow Values from Outfall 3

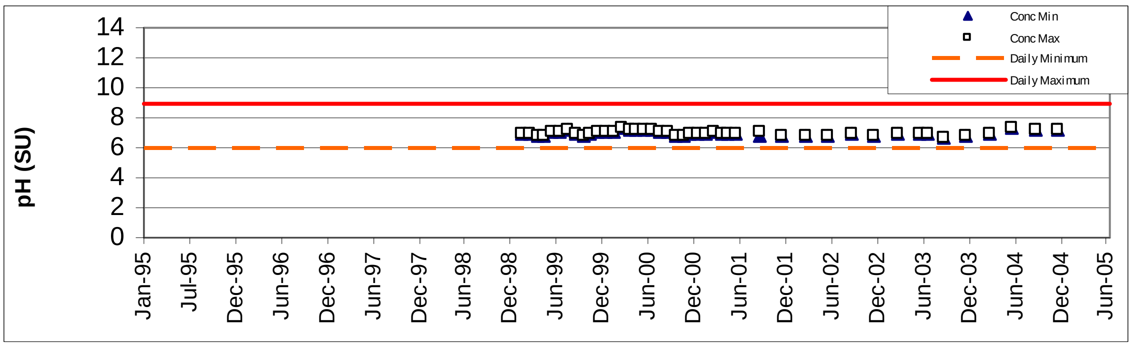

Figure C-13: IBM Corporation pH Values from Outfall 3

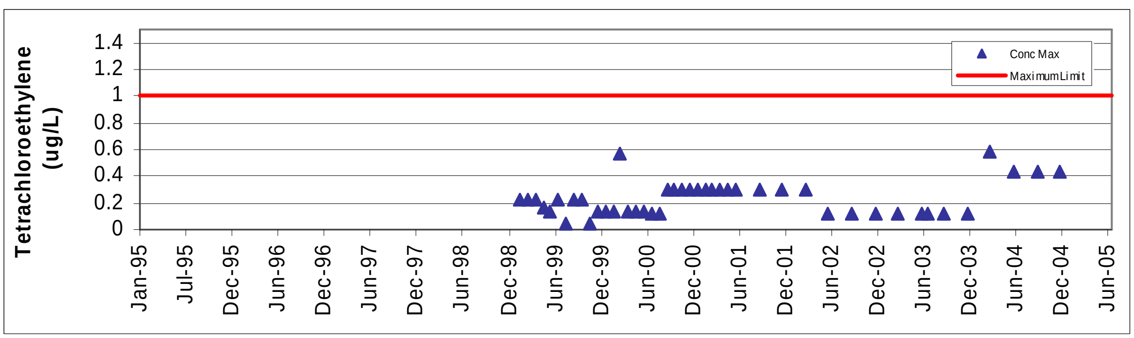

Figure C-14: IBM Corporation Trichloroethylene Concentrations from Outfall 3

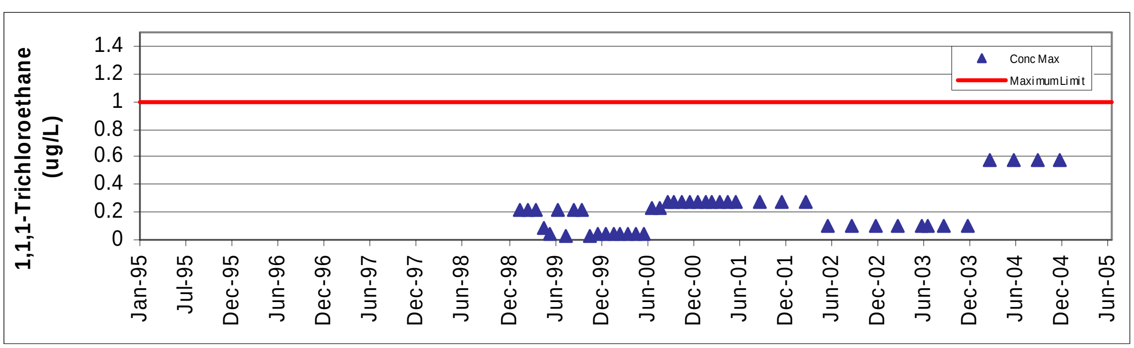

Figure C-15: IBM Corporation 1,1,1- Trichloroethane Concentrations from Outfall 3

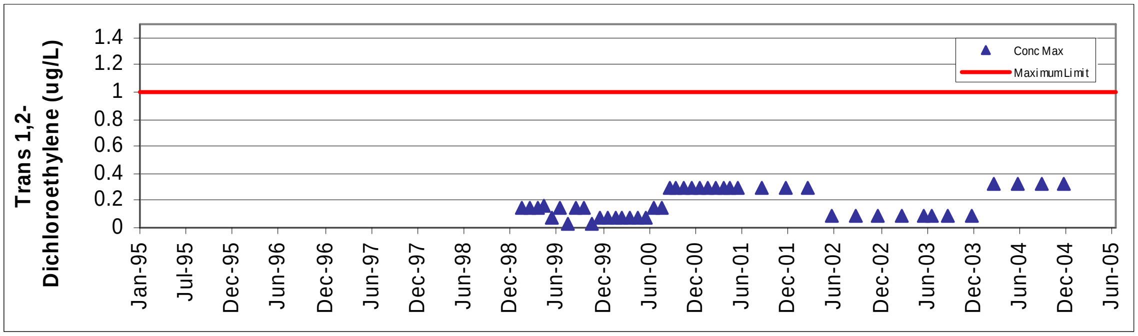

Figure C-16: IBM Corporation Trans 1,2 Dichloroethylene Concentrations from Outfall 3

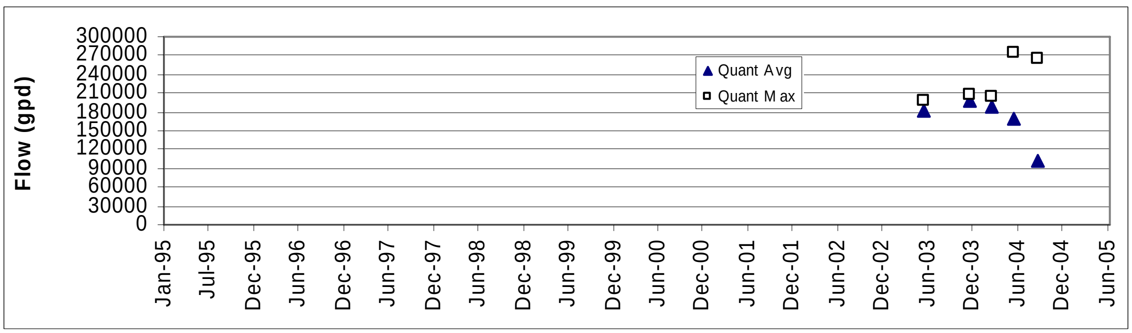

Figure C-17: IBM Corporation Flow Values from Outfall 4

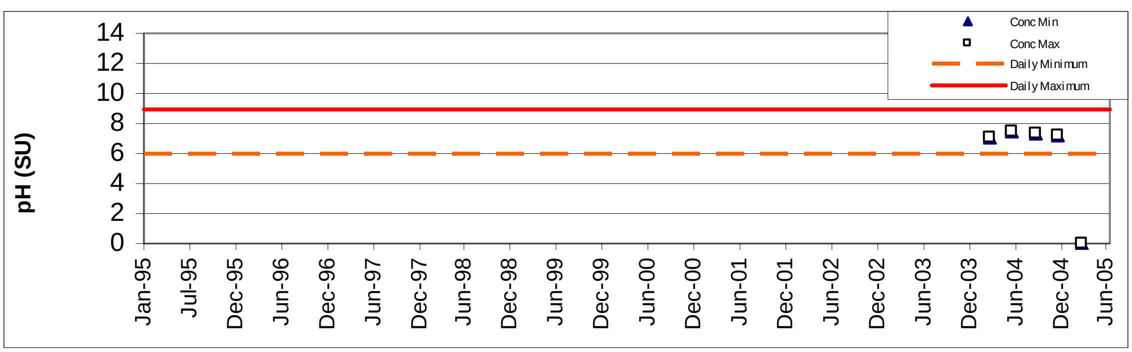

Figure C-18: IBM Corporation pH Values from Outfall 4

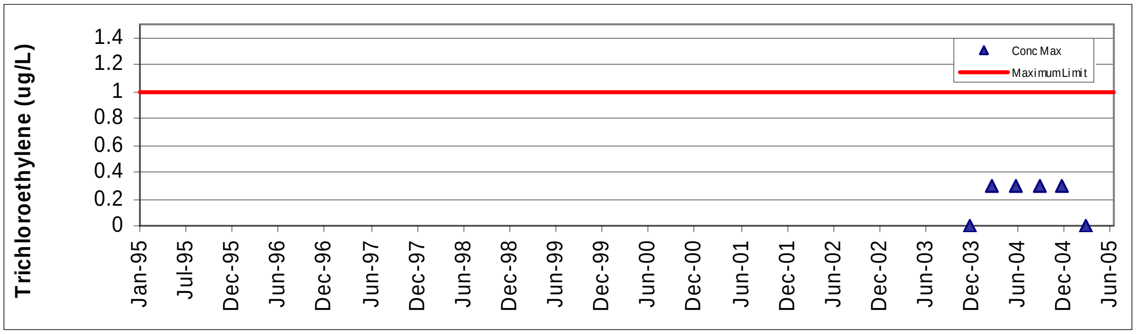

Figure C-19: IBM Corporation Trichloroethylene Concentrations from Outfall 4

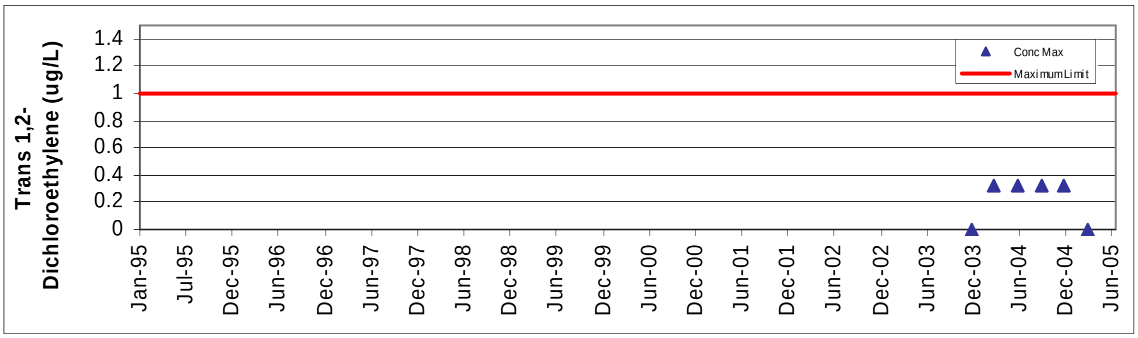

Figure C-20: IBM Corporation Trans 1,2 Dichloroethylene Concentrations from Outfall 4

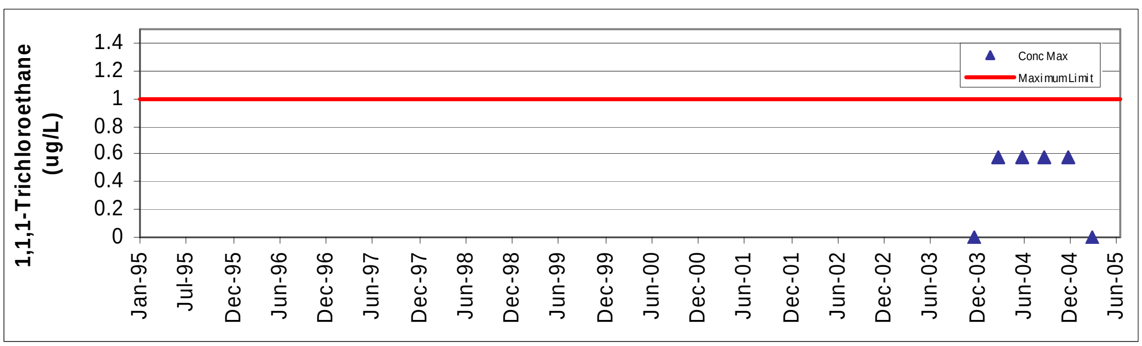

Figure C-21: IBM Corporation 1,1,1- Trichloroethane Concentrations from Outfall 4

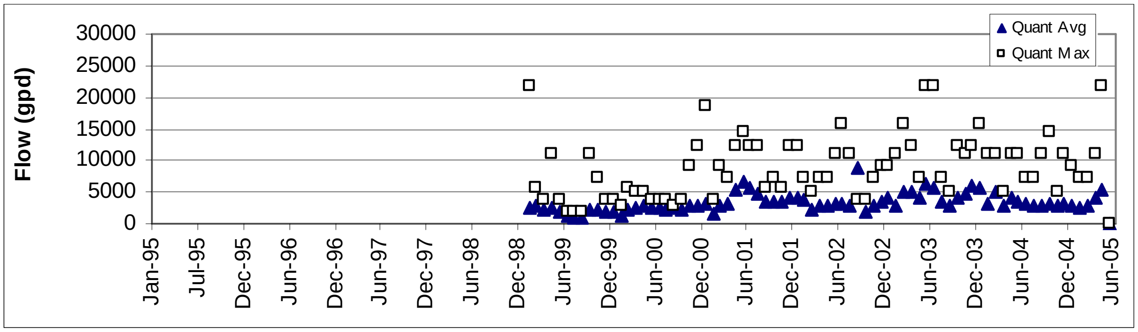

Figure C-22: Evergreen Country Club Flow Values

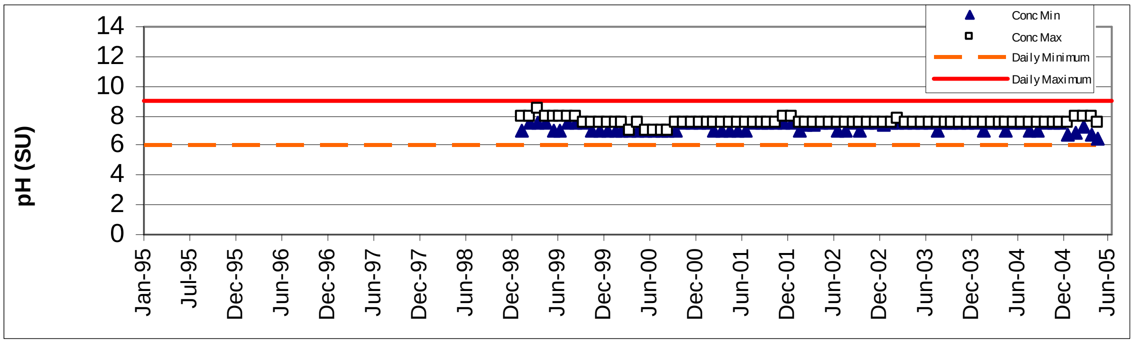

Figure C-23: Evergreen Country Club pH Values

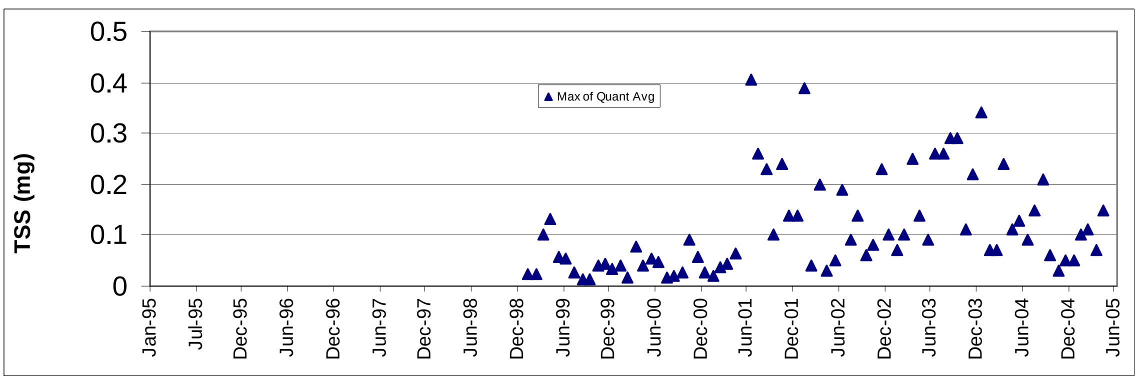

Figure C-24: Evergreen Country Club Total Suspended Solid Quantities

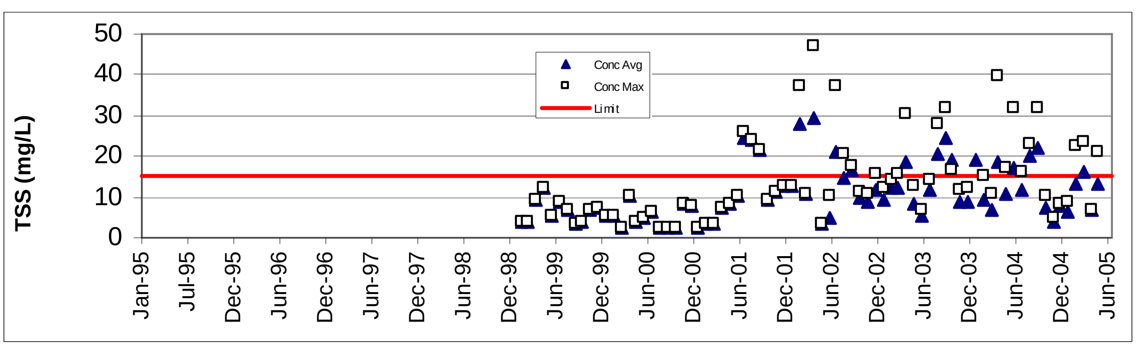

Figure C-25: Evergreen Country Club Total Suspended Solids Concentrations

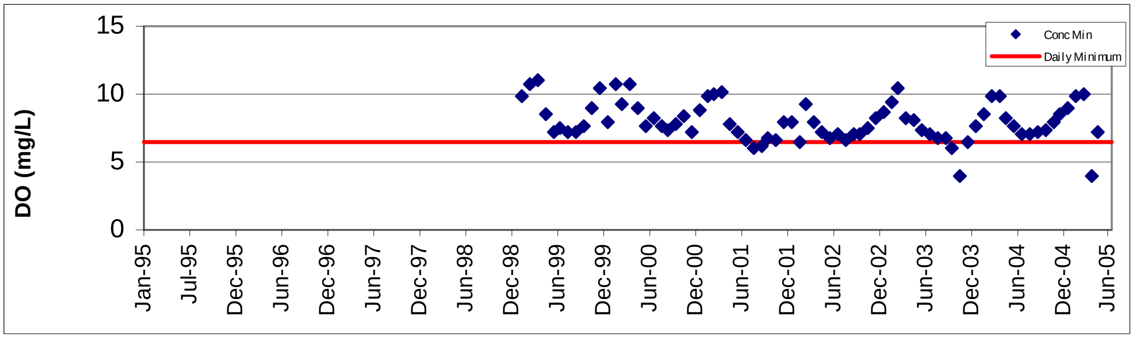

Figure C-26: Evergreen Country Club Dissolved Oxygen Concentrations

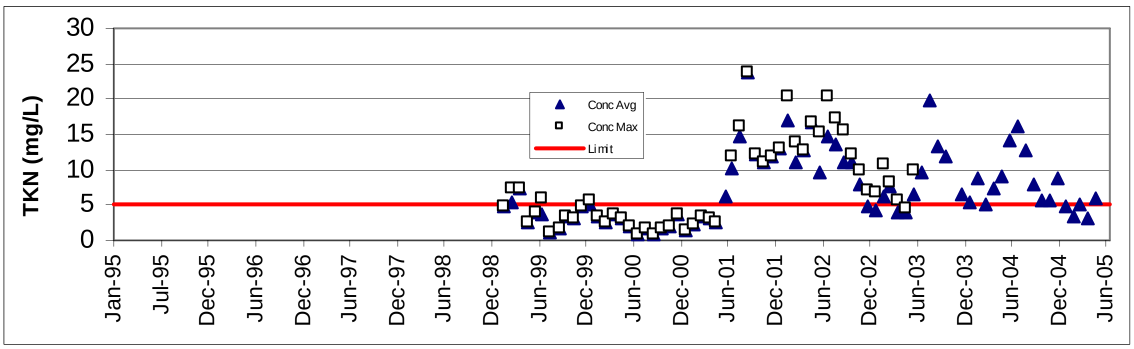

Figure C-27: Evergreen Country Club Total Kjeldahl Nitrogen Concentrations

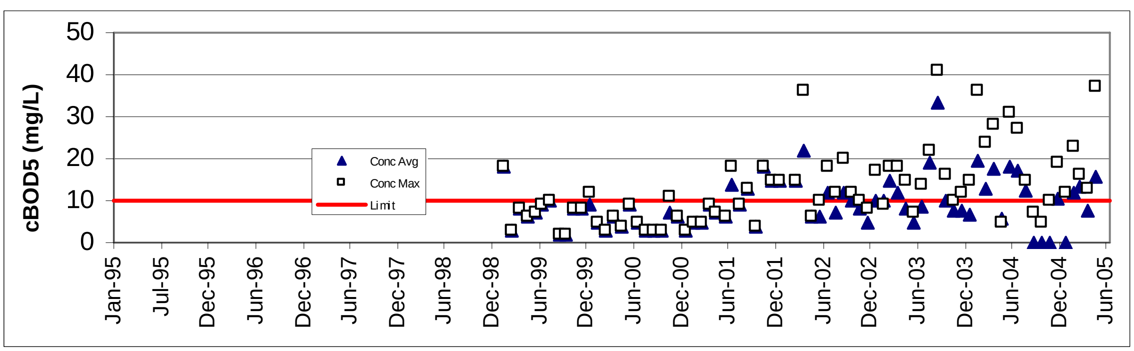

Figure C-28: Evergreen Country Club Biochemical Oxygen Demand Concentrations

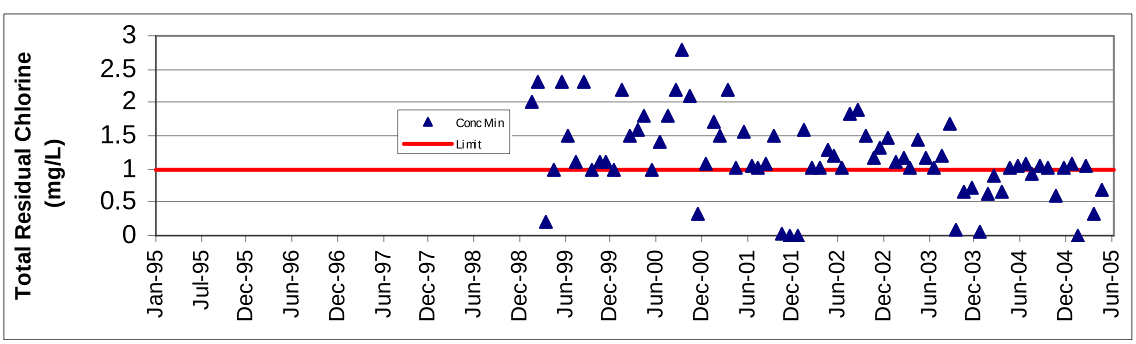

Figure C-29: Evergreen Country Club Cl2 Instant Tech Min Limit Concentrations

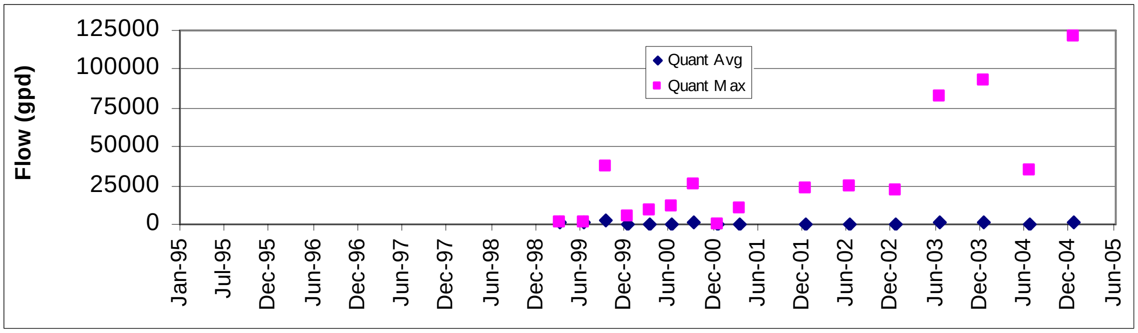

Figure C-30: Colonial Pipeline- Bull Run Flow Values

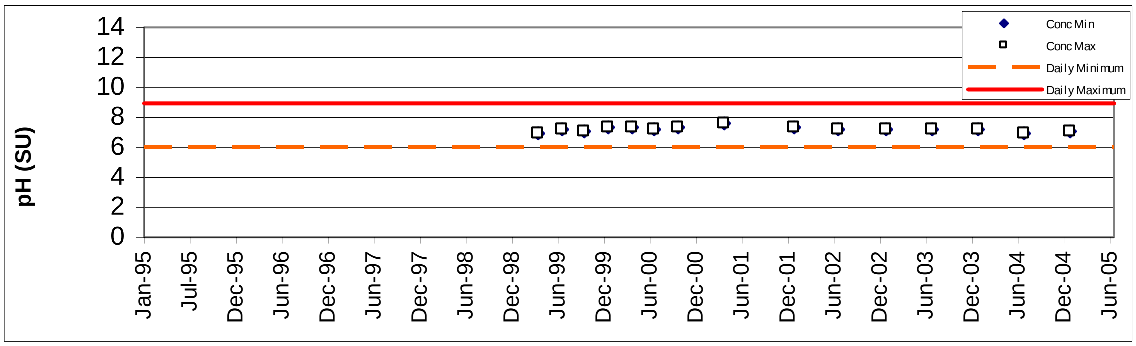

Figure C-31: Colonial Pipeline-Bull Run pH Values

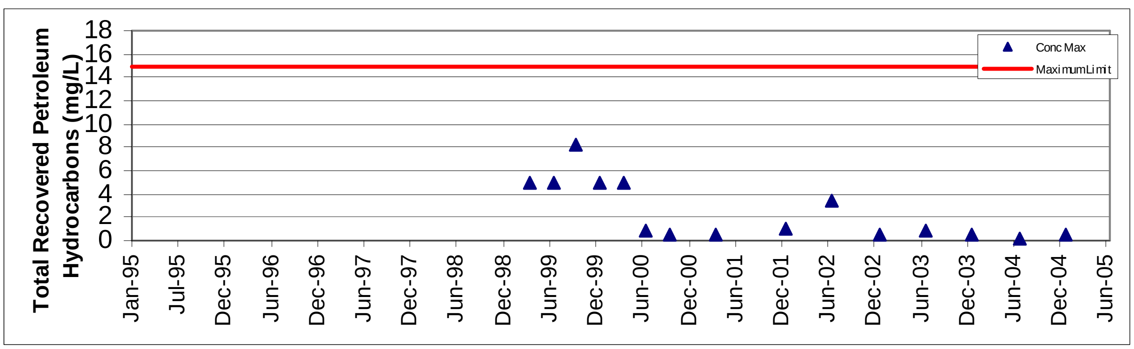

Figure C-32: Colonial Pipeline- Bull Run Total Petroleum Hydrocarbon Concentrations

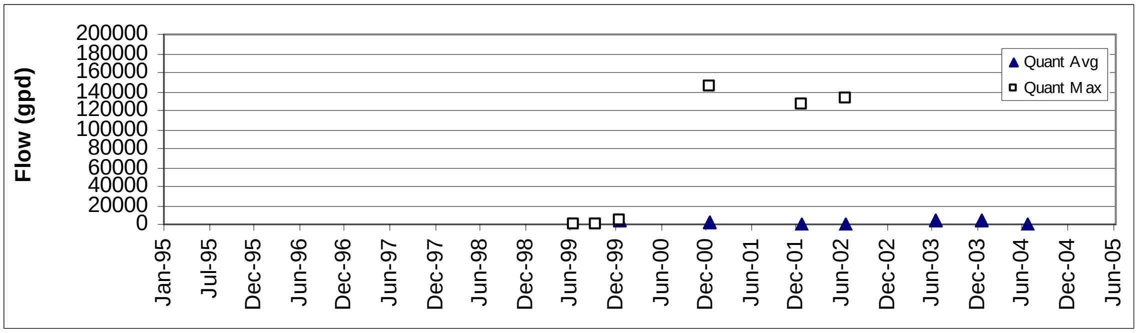

Figure C-33: Colonial Pipeline- Chantilly Flow Data from Outfall 1

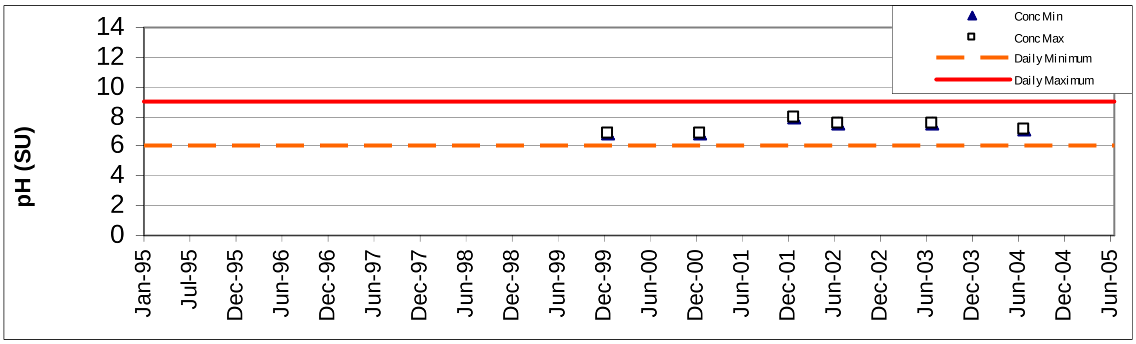

Figure C-34: Colonial Pipeline-Chantilly pH values from Outfall 1

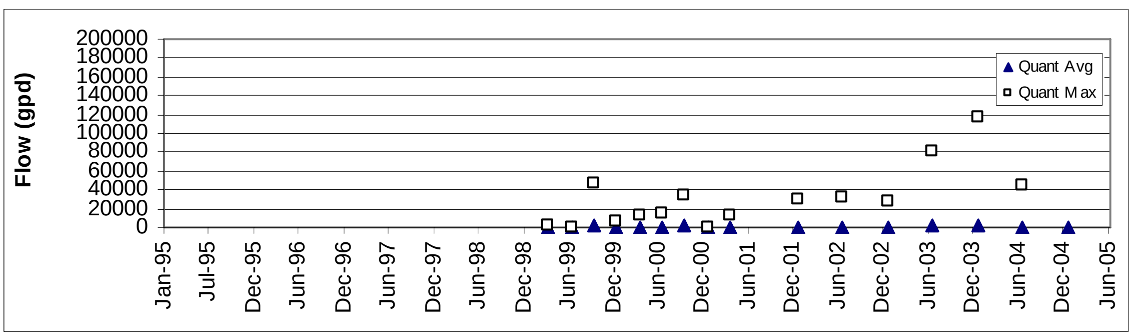

Figure C-35: Colonial Pipeline- Chantilly Flow Data from Outfall 101

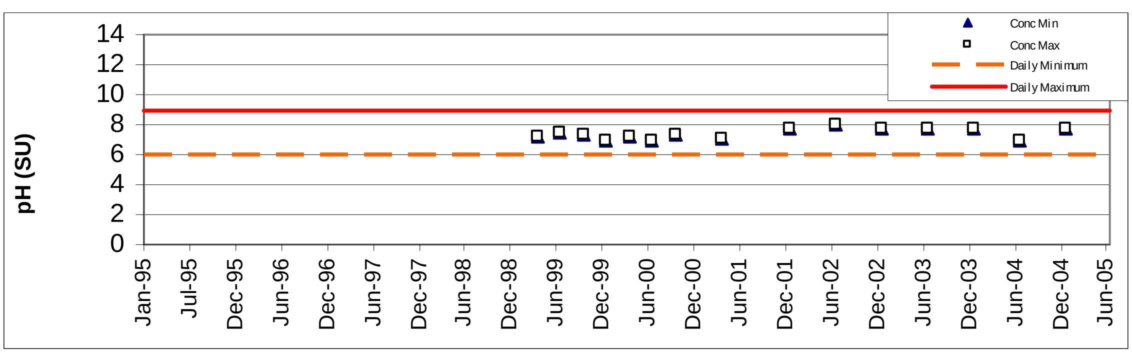

Figure C-36: Colonial Pipeline- Chantilly pH data from Outfall 101

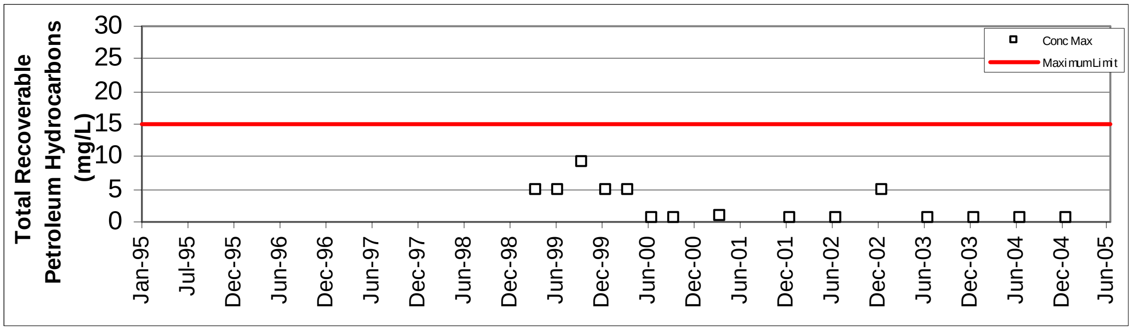

Figure C-37: Colonial Pipeline- Chantilly Total Petroleum Hydrocarbon Concentrations from Outfall 101

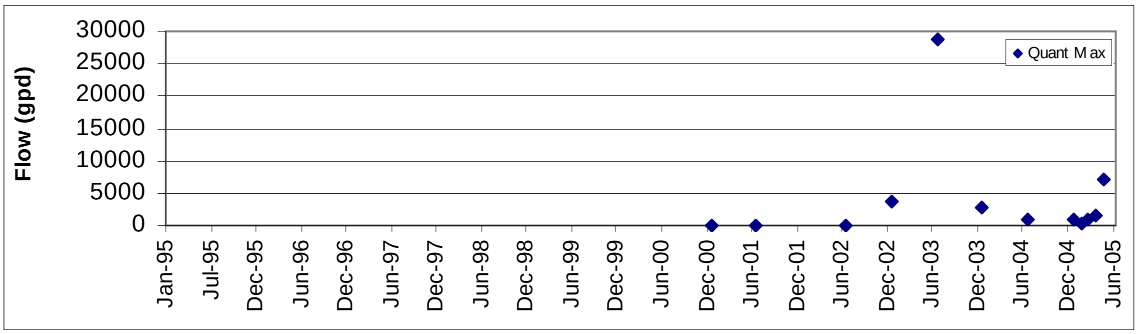

Figure C-38: Adaptive Concrete Flow Values from Outfall 1

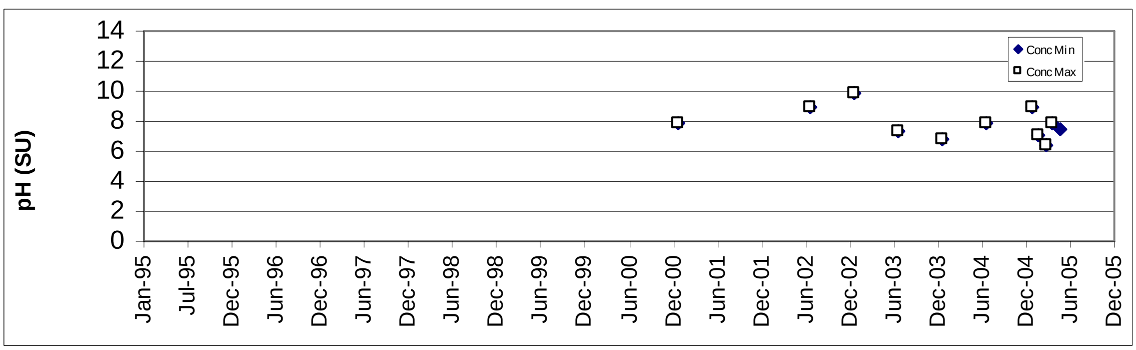

Figure C-39: Adaptive Concrete pH values from Outfall 1

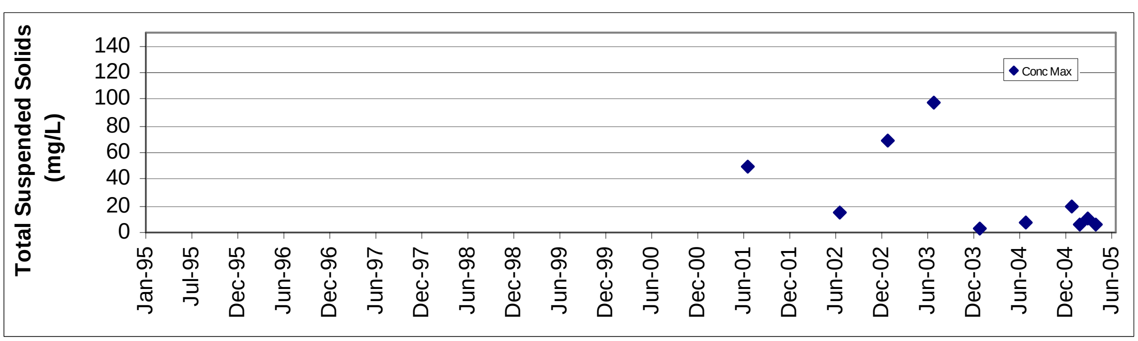

Figure C-40: Adaptive Concrete Total Suspended Solids Concentrations from Outfall 1

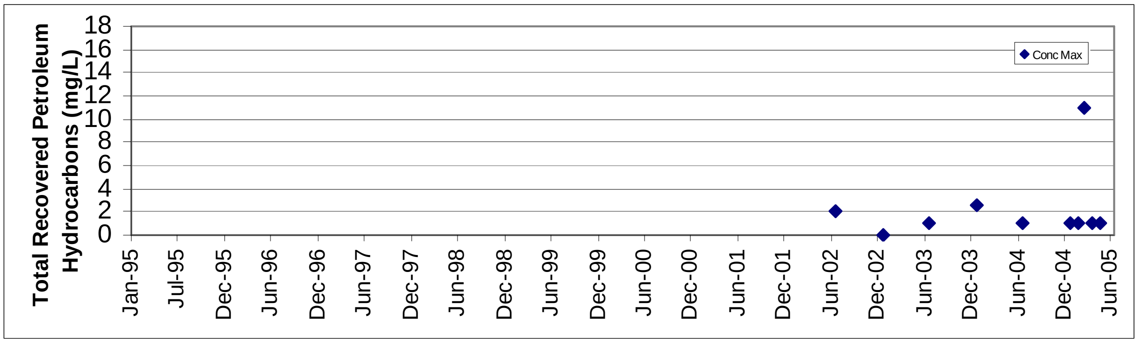

Figure C-41: Adaptive Concrete Petroleum Hydrocarbons Concentrations from Outfall 1

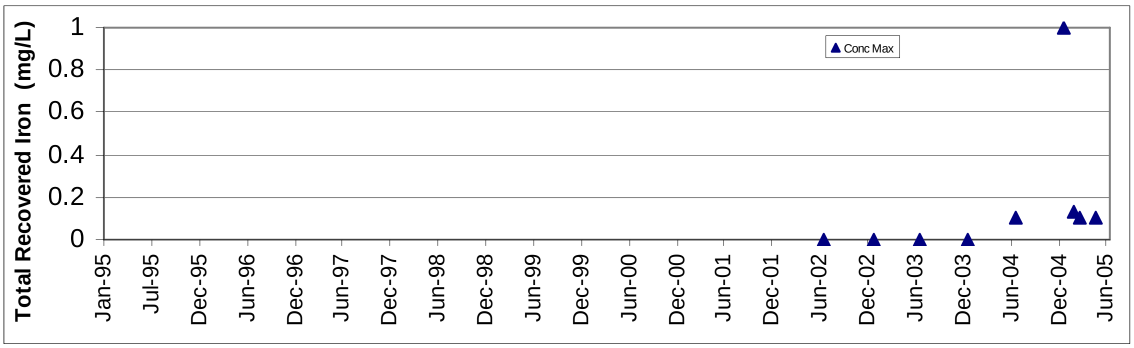

Figure C-42: Adaptive Concrete Iron Concentrations from Outfall 1

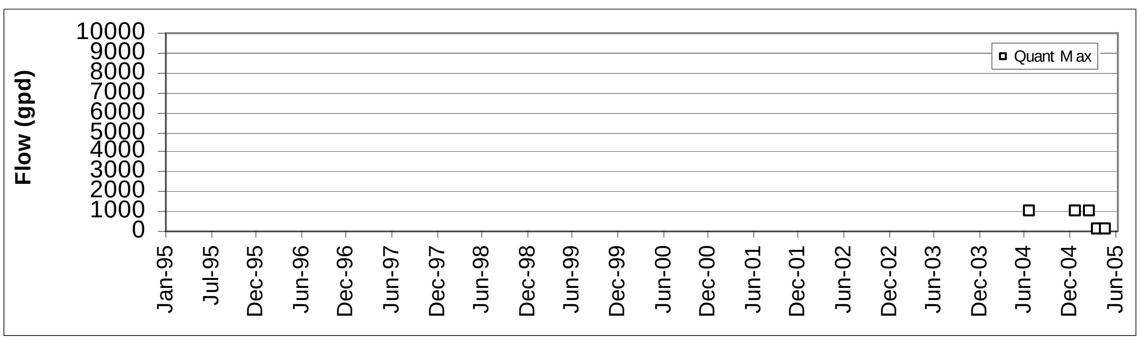

Figure C-43: Adaptive Concrete Flow Data from Outfall 2

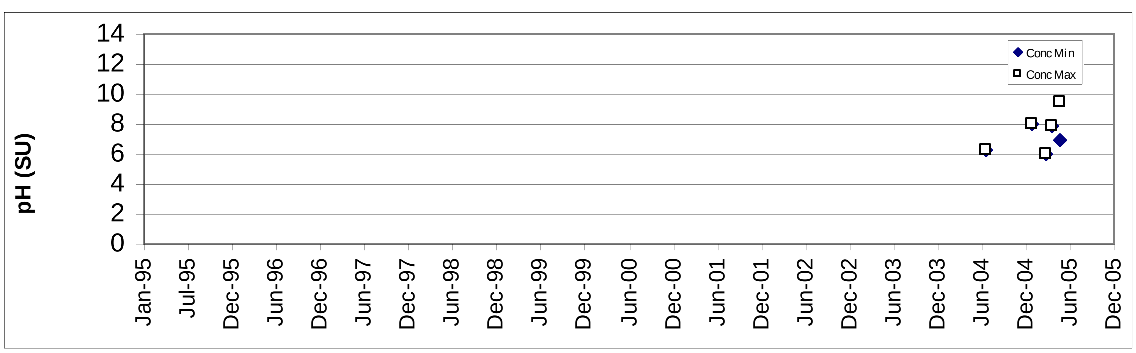

Figure C-44: Adaptive Concrete pH Values from Outfall 2

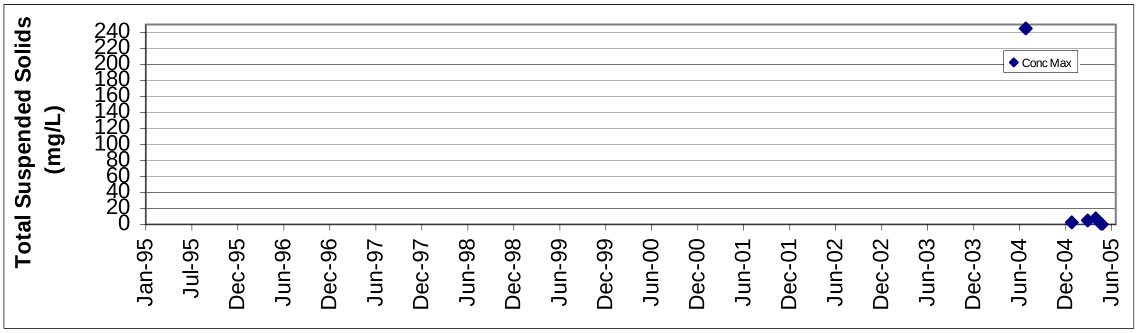

Figure C-45: Adaptive Concrete Total Suspended Solids Concentrations from Outfall 2

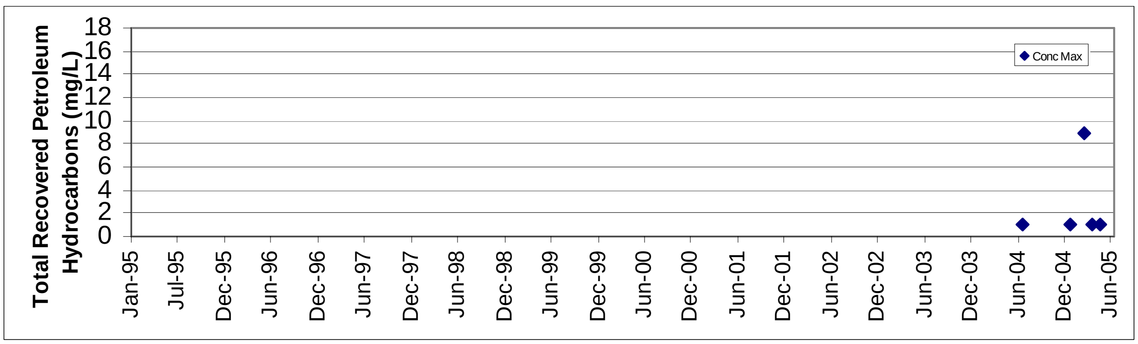

Figure C-46: Adaptive Concrete Petroleum Hydrocarbon Concentrations from Outfall 2

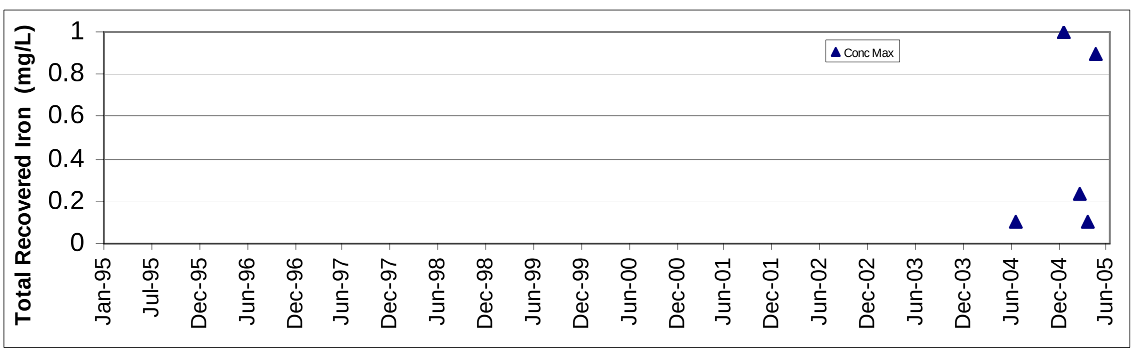

Figure C-47: Adaptive Concrete Total Recoverable Iron Concentrations from Outfall 2

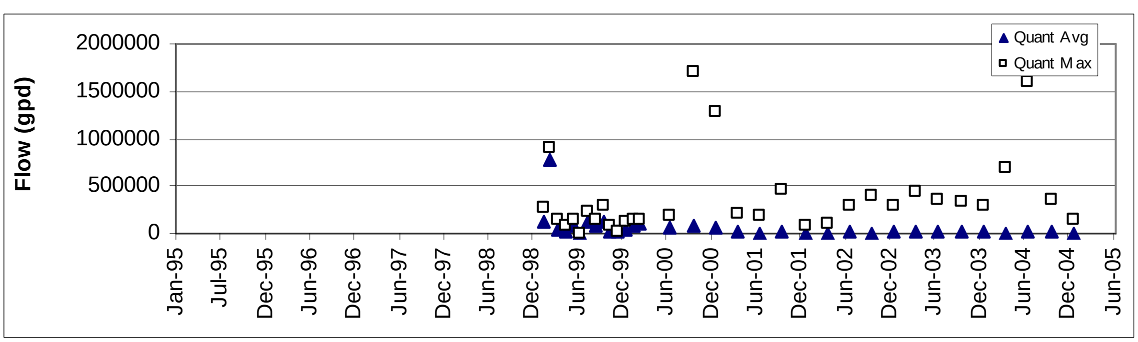

Figure C-48: Sunoco Manassas Flow Values

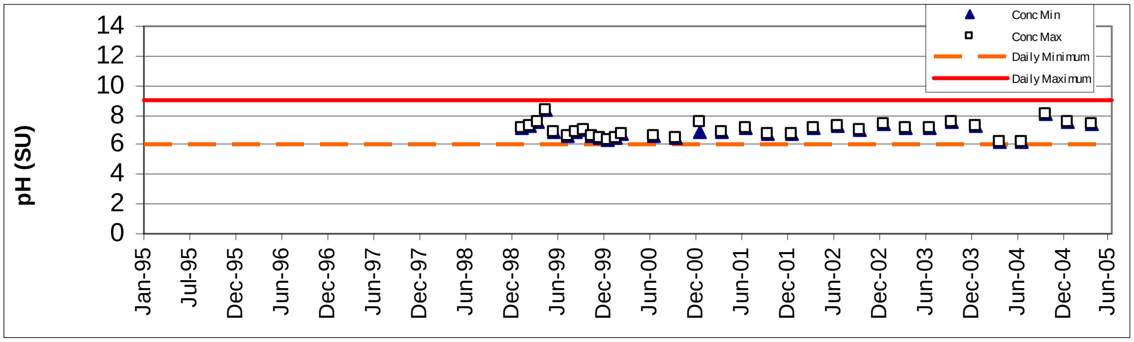

Figure C-49: Sunoco Manassas pH Values

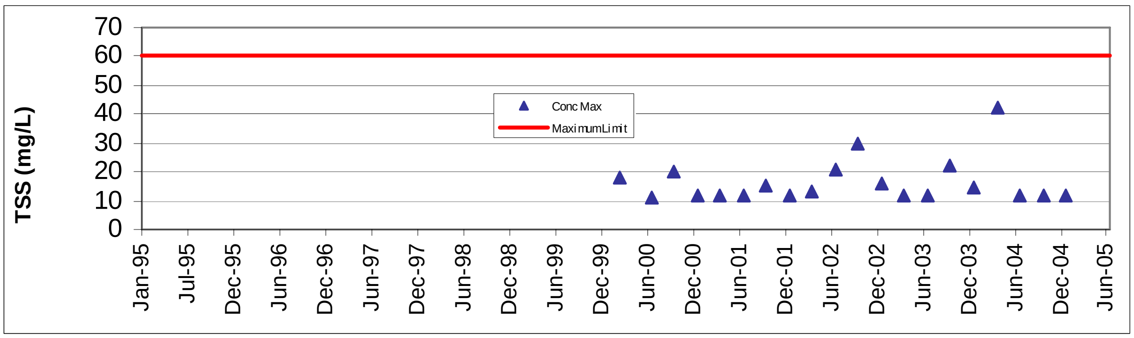

Figure C-50: Sunoco Manassas Total Suspended Solid Concentrations

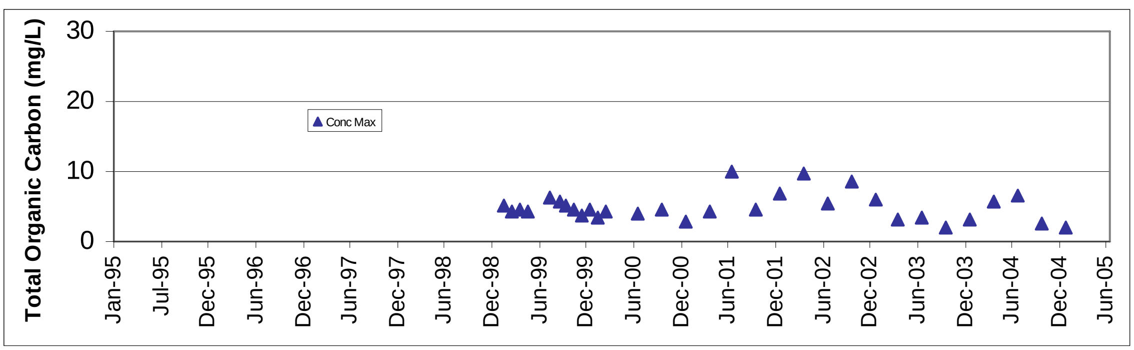

Figure C-51: Sunoco Manassas Total Organic Carbon Concentrations

Figure C-52: Sunoco Manassas Oil and Grease Concentrations

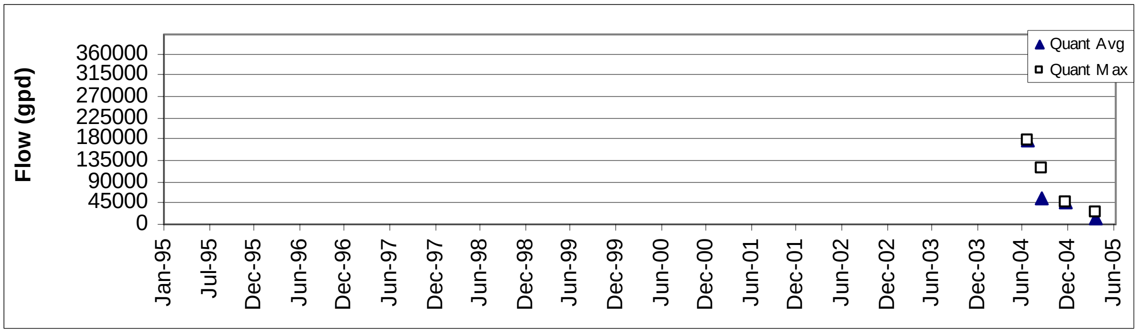

Figure C-53: Loudoun Composting Flow Values

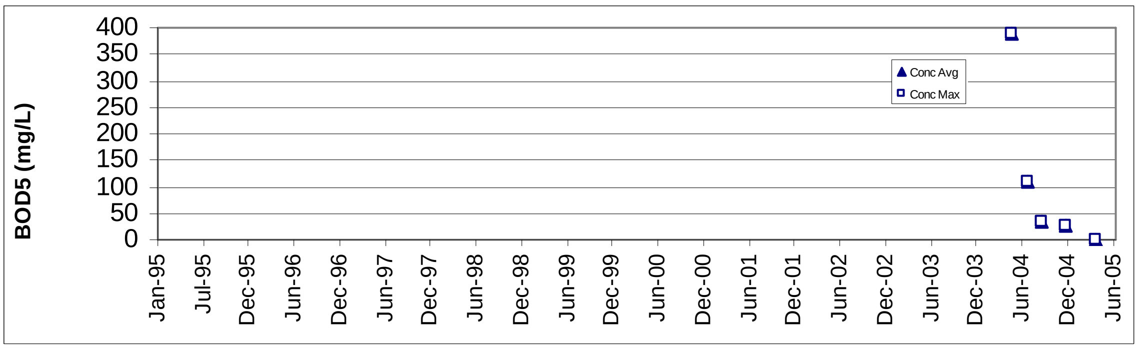

Figure C-54: Loudoun Composting BOD5 Concentrations

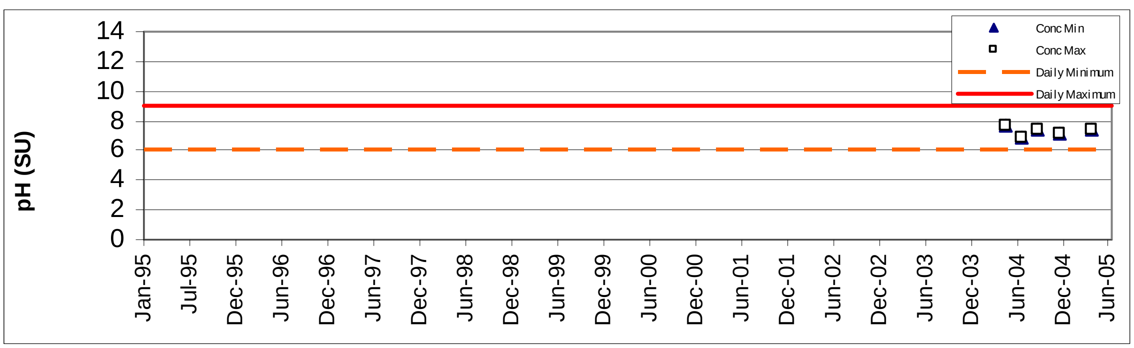

Figure C-55: Loudoun Composting pH Values

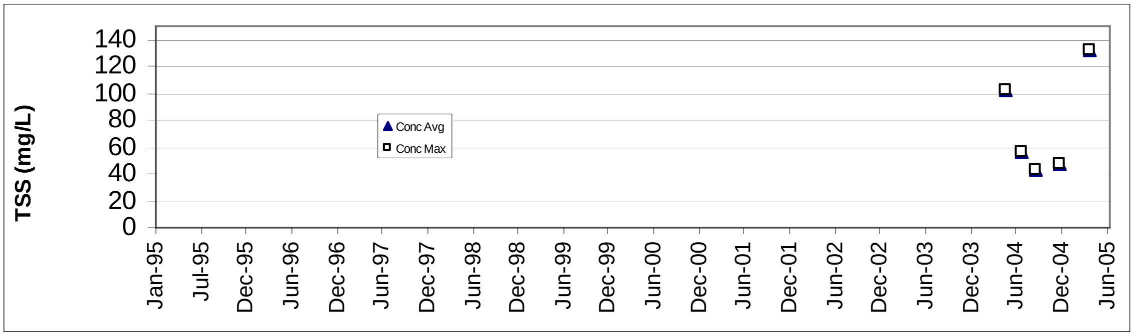

Figure C-56: Loudoun Composting Total Suspended Solids Concentrations

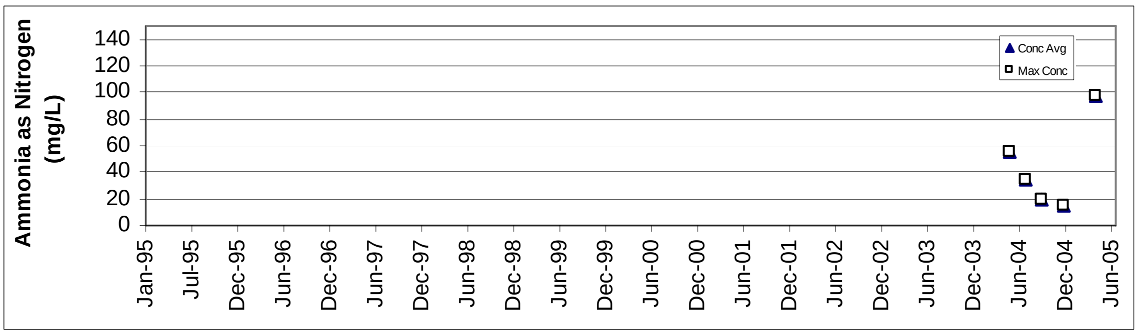

Figure C-57: Loudoun Composting Ammonia Concentrations

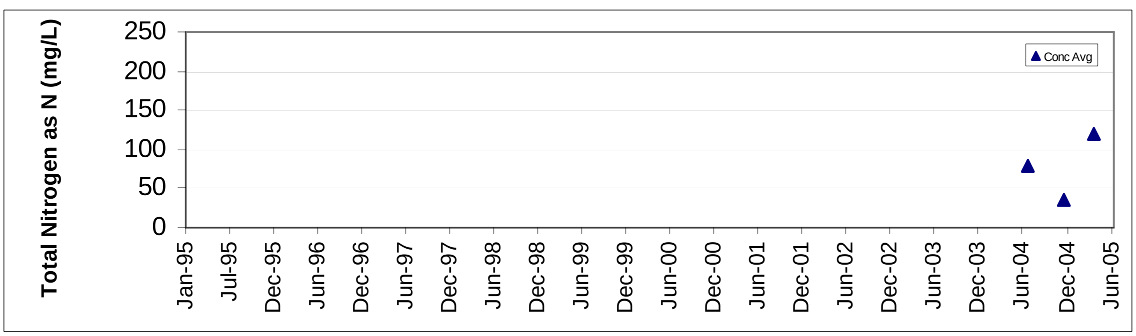

Figure C-58: Loudoun Composting Nitrogen Concentrations

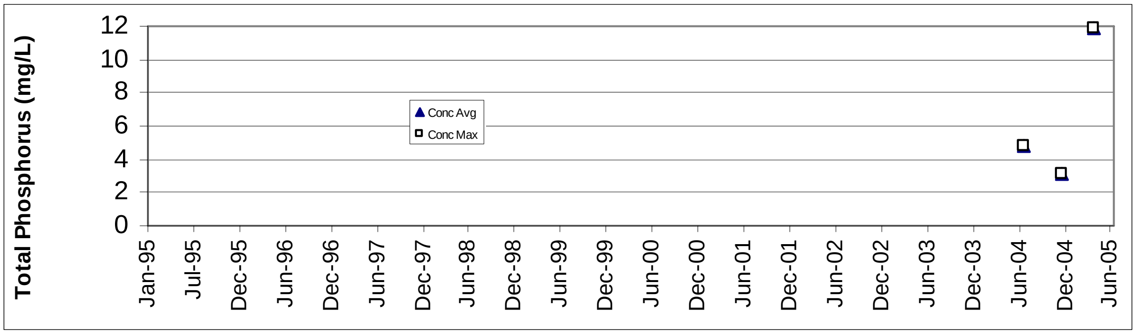

Figure C-59: Loudoun Composting Phosphorus Concentrations

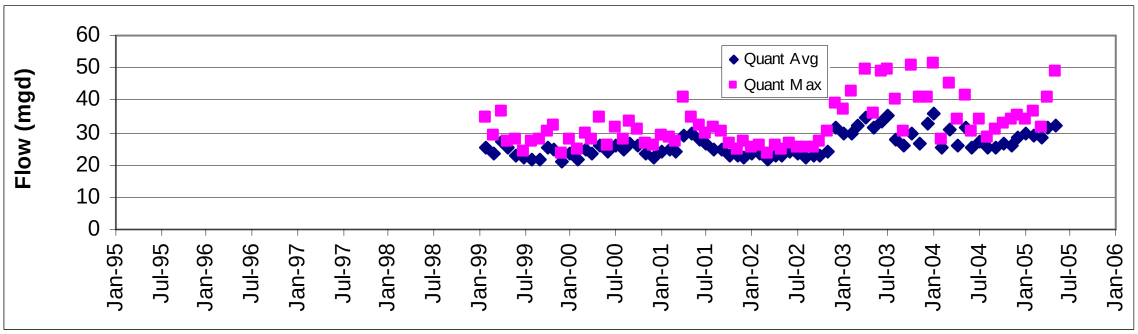

Figure C-60: UOSA Flow Values

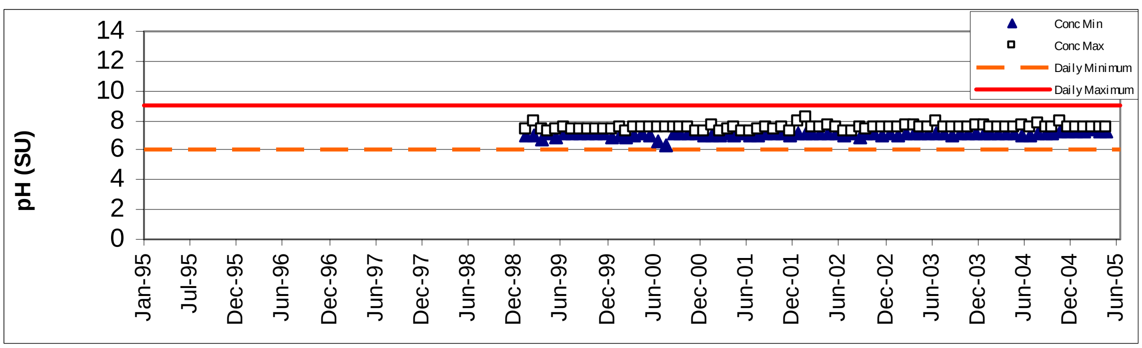

Figure C-61: UOSA pH Values

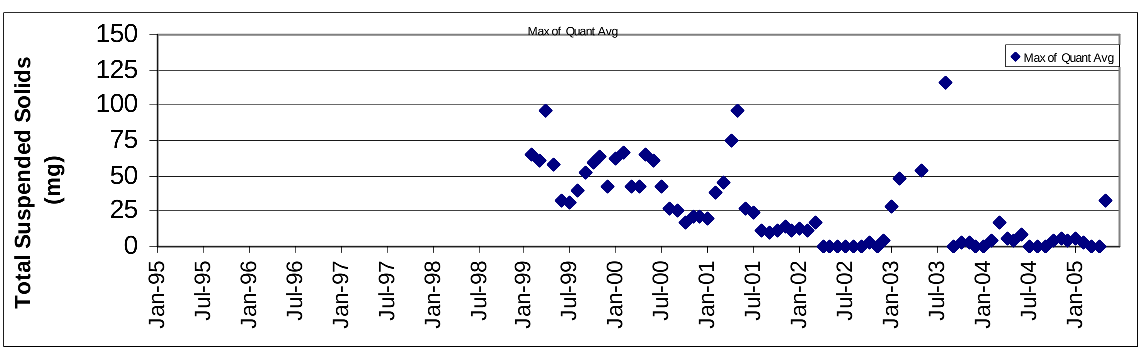

Figure C-62: UOSA Total Suspended Solids Quantities

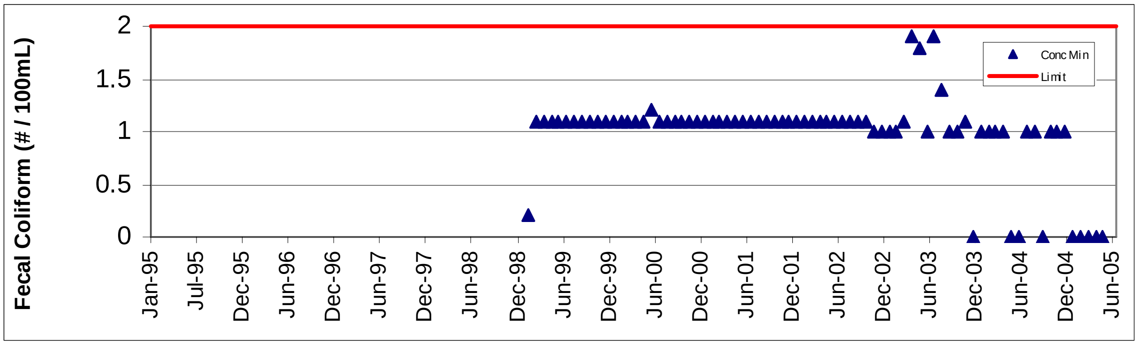

Figure C-63: UOSA Fecal Coliform Concentrations

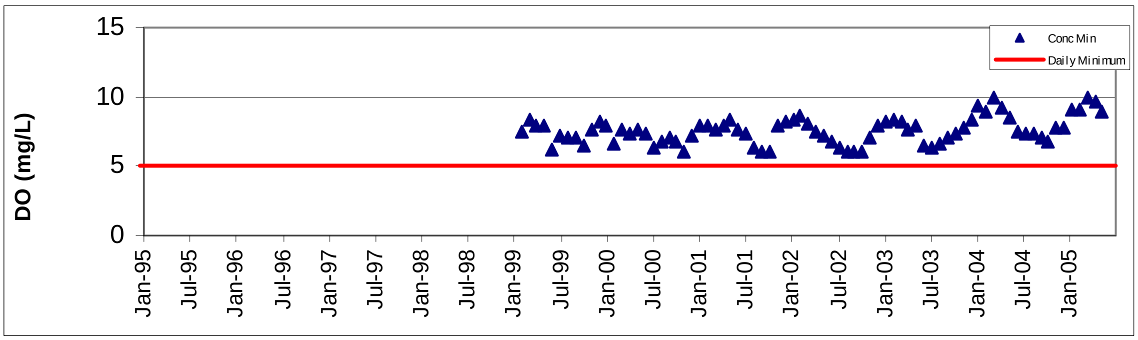

Figure C-64: UOSA Dissolved Oxygen Concentrations

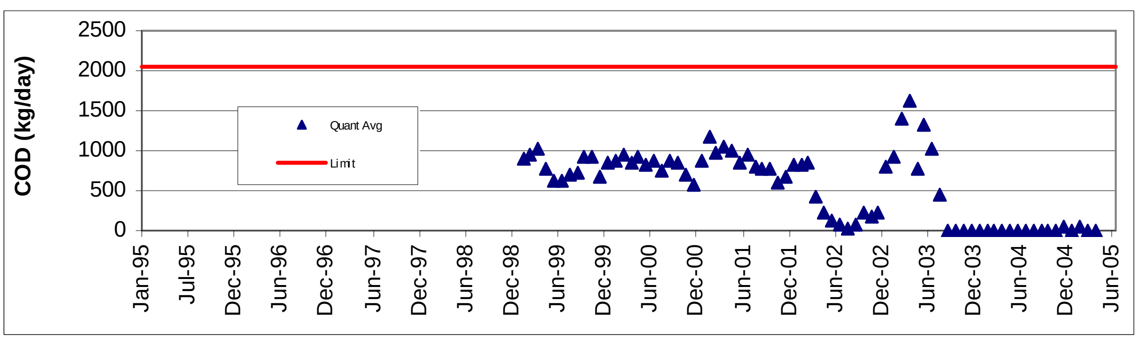

Figure C-65: UOSA Chemical Oxygen Demand Quantities

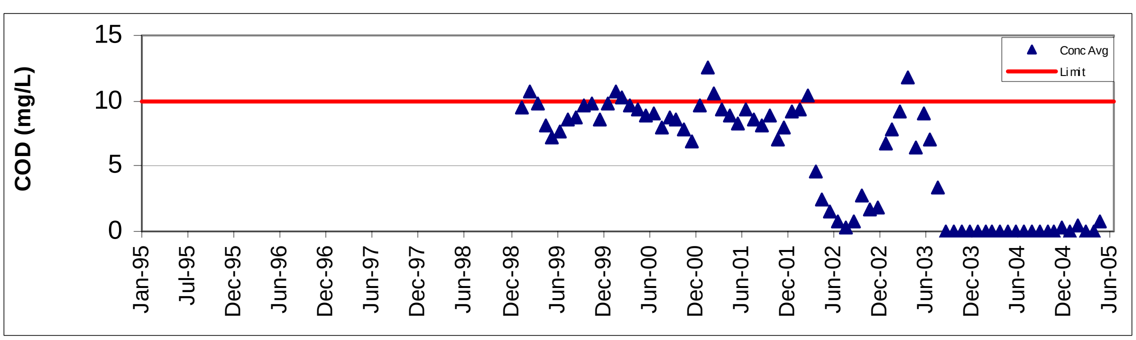

Figure C-66: UOSA Chemical Oxygen Demand Concentrations

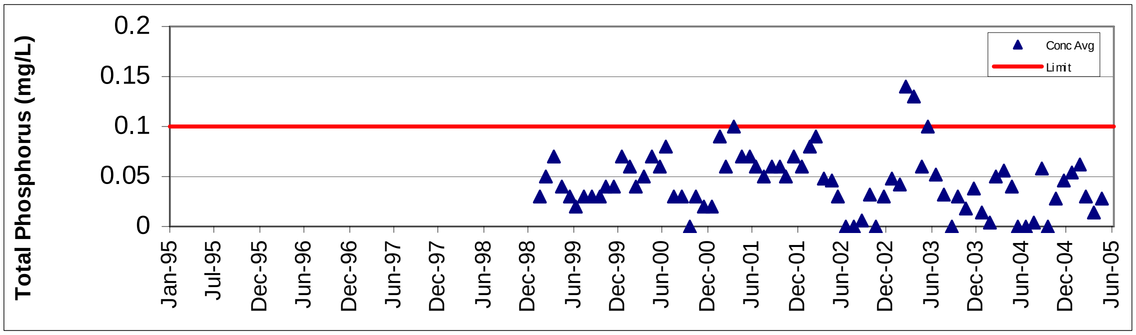

Figure C-67: UOSA Total Phosphorous Concentrations

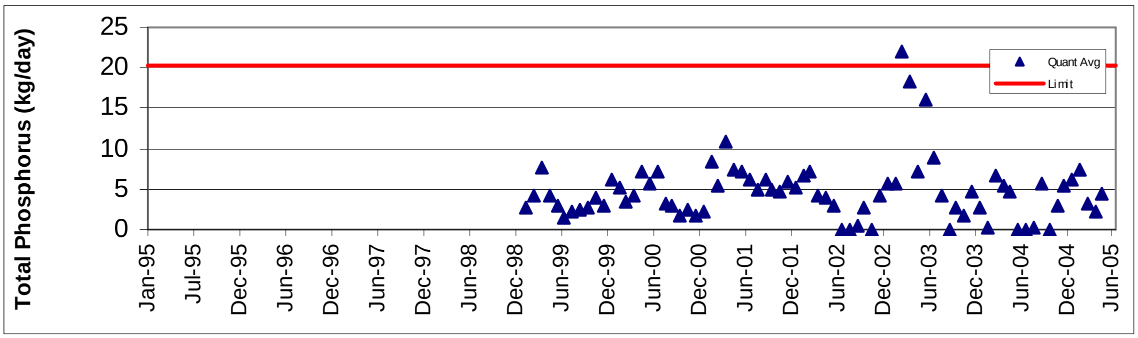

Figure C-68: UOSA Total Phosphorous Quantities

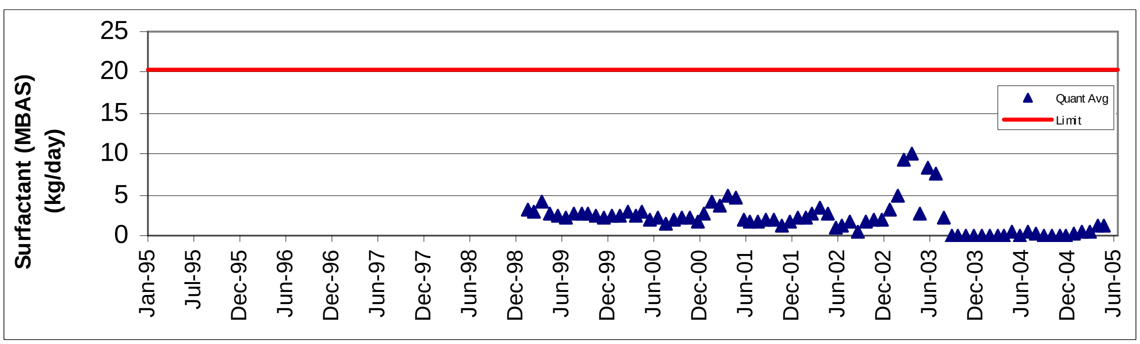

Figure C-69: UOSA Surfactant Quantities

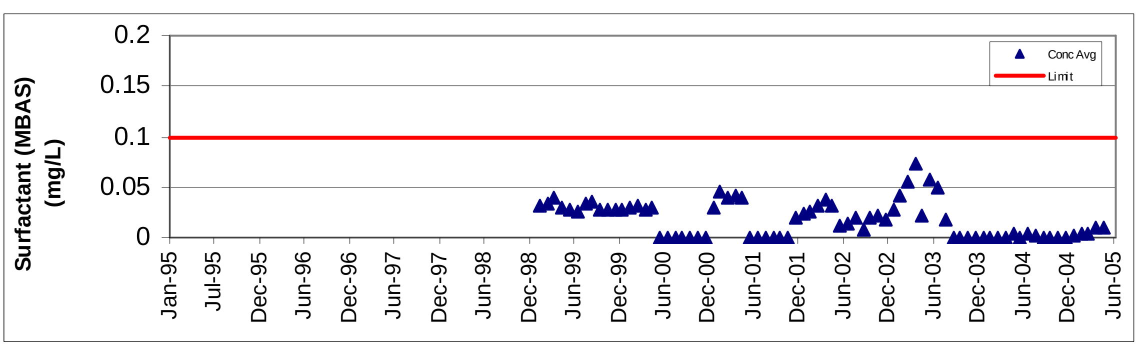

Figure C-70: UOSA Surfactant Concentrations

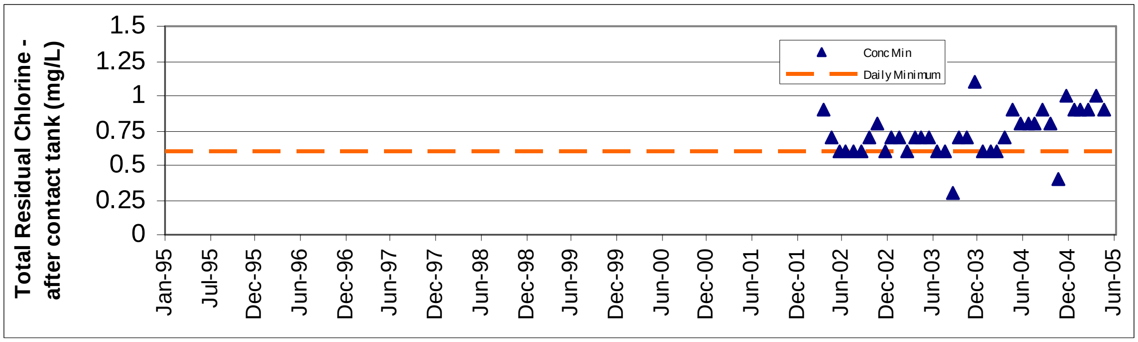

Figure C-71: UOSA Chloride Instant Tech Limit Concentrations

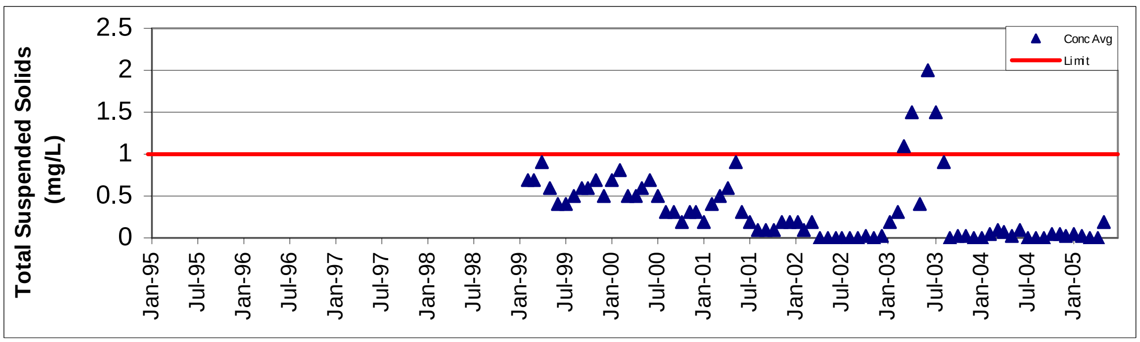

Figure C-72: UOSA Total Suspended Solids Concentrations

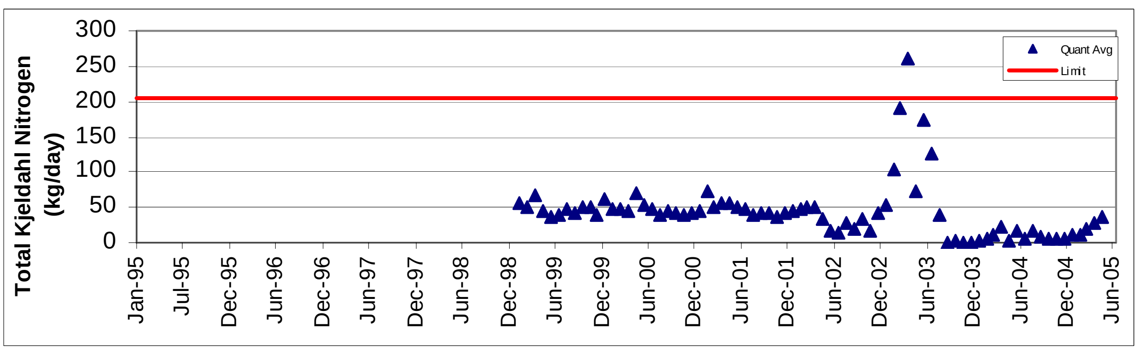

Figure C-73: UOSA Total Kjeldahl Nitrogen Quantities

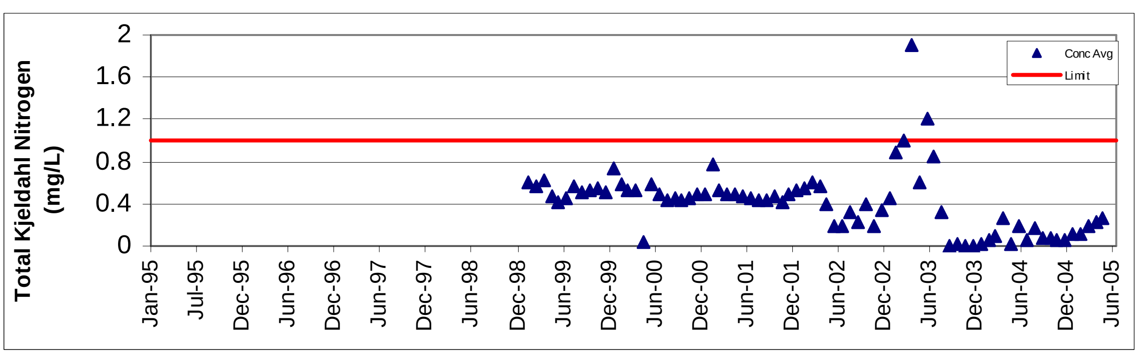

Figure C-74: UOSA Total Kjeldahl Nitrogen Concentrations

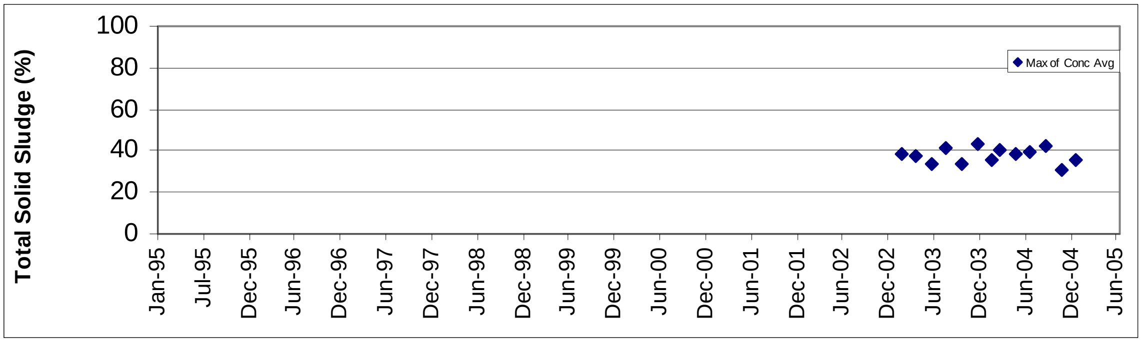

Figure C-75: UOSA Total Solids Sludge

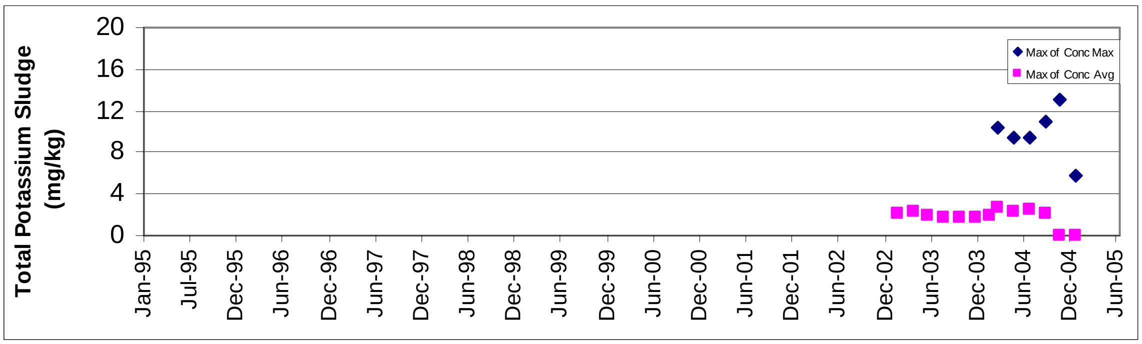

Figure C-76: UOSA Total Potassium as Sludge

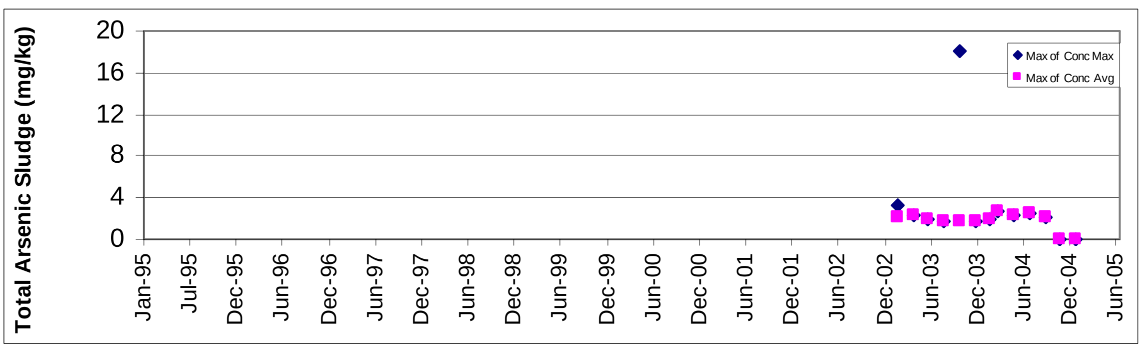

Figure C-77: UOSA Total Arsenic as Sludge

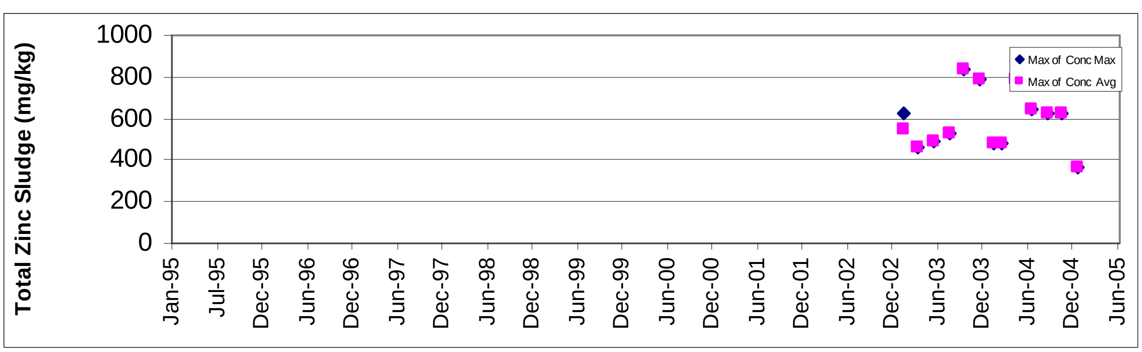

Figure C-78: UOSA Total Zinc as Sludge

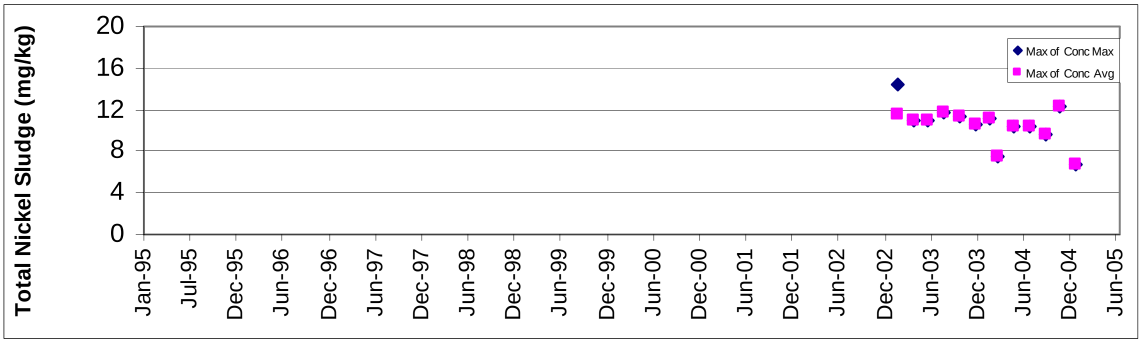

Figure C-79: UOSA Nickel as Sludge

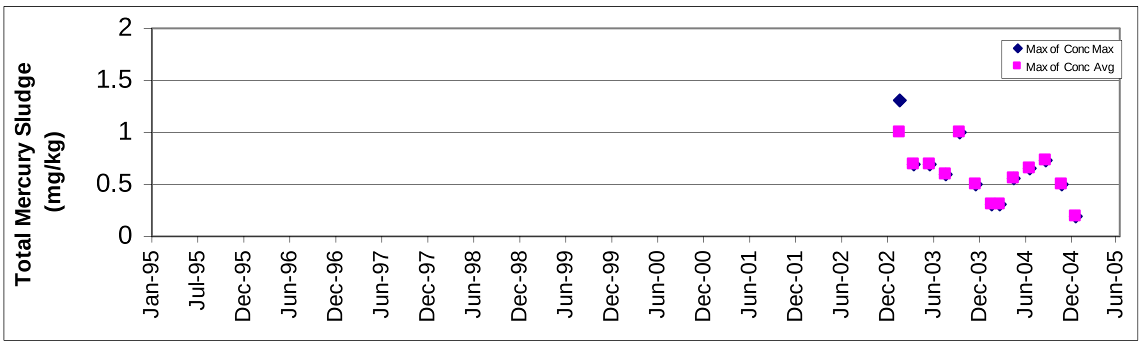

Figure C-80: UOSA Mercury as Sludge

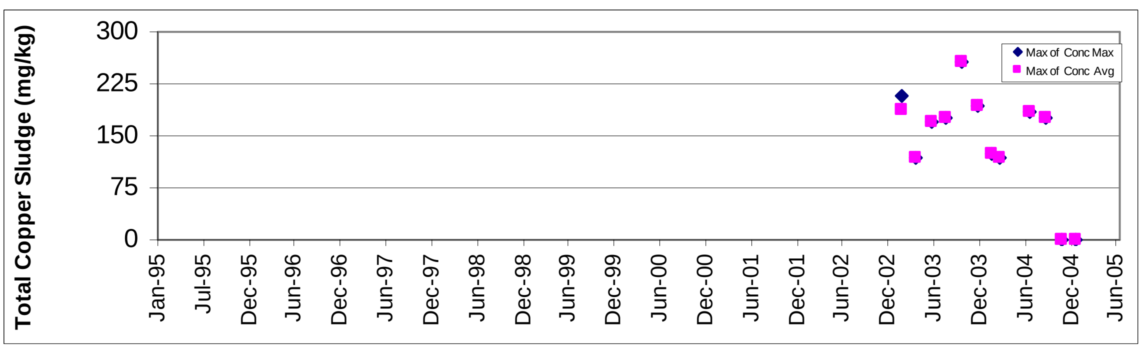

Figure C-81: UOSA Copper as Sludge

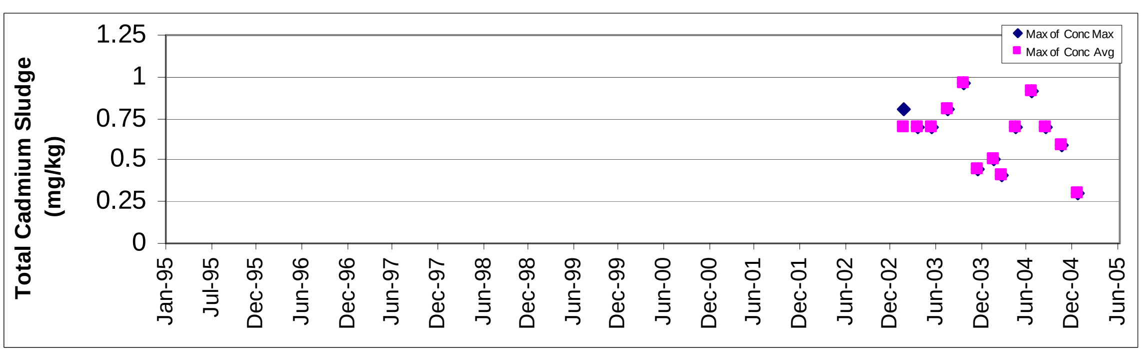

Figure C-82: UOSA Cadmium as Sludge

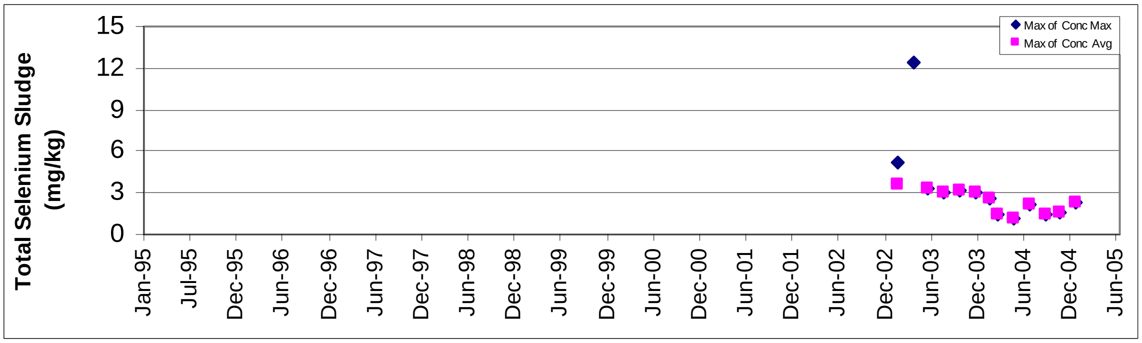

Figure C-83: UOSA Selenium as Sludge

APPENDIX D: General Permit & Individual Permit Stormwater TMDL Allocations

The TSS allocation for each permitted facility was calculated using a DEQ assigned TSS concentration and the corresponding runoff amount generated on the site based on the facility area or the facility discharge. The TSS allocated load for each permit type was calculated as follows:

- For individual permitted facilities and general stormwater permits issued to industrial facilities the allocated load was calculated based on a TSS concentration of 100 mg/L, and 72.54 cm of runoff per year. The annual average runoff of 72.54 cm corresponds to an annual average rainfall of 40.8 inches (103.63 cm) and an industrial land cover with 70 percent imperviousness. The facility area was assumed to be 5 acres of impervious surface for each permittee, except MWAA Dulles Airport where an estimate of 850 acres of impervious surface was used.

$$Q_{sed}(tons/year) = impervious\,surface(acres)\frac{4{,}046.87m^2}{acre}x\frac{0.7254\,m\,runoff}{yr}x\frac{1000\,liter}{m^3}x\frac{100\,mg}{liter}x\frac{kg}{10^6\,mg}x\frac{2.204\,lbs}{kg}x\frac{ton}{2000\,lbs}$$

- For general permits issued to domestic sewage facilities, the allocated load was calculated based on a TSS concentration of 30 mg/L and a discharge flow value of 1,000 gpd.

$$Q_{general\ permit}(tons/year) = 1000\frac{gallons}{day}x\frac{3.785\,liter}{gallon}x\frac{365\,day}{yr}x\frac{30\,mg}{liter}x\frac{kg}{10^6\,mg}x\frac{2.204\,lbs}{kg}x\frac{ton}{2000\,lbs}$$

- For general permits issued to quarries/mines and concrete facilities, the allocated load was calculated based on a TSS concentration of 30 mg/L, and 45.9 cm of runoff per year. The facility area was assumed to be 5 acres for each facility.

$$Q_{sed}(tons/year) = 5(acres)\frac{4{,}046.87m^2}{acre}x\frac{0.459\,m\,runoff}{yr}x\frac{1000\,liter}{m^3}x\frac{30\,mg}{liter}x\frac{kg}{10^6\,mg}x\frac{2.204\,lbs}{kg}x\frac{ton}{2000\,lbs}$$

- For general stormwater permits issued to construction sites, the total allocated load was calculated based on the allocated loads from the transitional land-use category. In other words, transitional land use was considered as representing the construction activities within the watershed. The actual acreage attributed to transitional land (construction activities) is 622.4 acres. To account for the construction activities within Dulles Airport, the disturbed-land's acreage was doubled to 1,245 acres. This is a conservative and realistic estimate since there is an ongoing construction activity for a new runway.

Table D-1: Stormwater TMDL Allocations for Individual Permitted Facilities

Permit Number	Facility Name	TSS Stormwater Allocation (tons/yr)
VA0024988	UOSA - Centreville	1.62
VA0051691	Colonial Pipeline - Bull Run	1.62
VA0087858	Sunoco - Manassas Terminal	1.62
VA0089541	MWAA - Washington Dulles Int'l Airport	275.1
VA0085901	IBM Corp	1.62

Table D-2: Stormwater TMDL Allocations for General Mining Permits

Permit	Facility Name	Receiving Stream	TSS Stormwater Allocation (tons/yr)
VAG840089	Luck Stone - Bull Run	Bull Run	0.31
VAG840093	Luck Stone - Fairfax Plant	Bull Run, UT	0.31
VAG840092	Vulcan Construction Materials - Manassas	Flat Branch	0.31

Table D-3 TMDL Allocations for Industrial Facilities

Permit	Facility Name	Receiving Stream	TSS Stormwater Allocation (tons/yr)
VAR051011	Superior Paving Corporation - Centreville Plant	Bull Run, UT	1.62
VAR051566	Rolling Frito Lay Sales LP - Manassas Bin	Bull Run	1.62
VAR051036	United Parcel Service - Dulles Center	Cub Run	1.62
VAR050995	Manassas City - Department of Public Works	Flat Branch	1.62
VAR051084	MIFCO - Manassas Ice and Fuel Company	Flat Branch, UT	1.62
VAR051074	Interstate 66 - Solid Waste Management Facility	Little Rocky Run, UT	1.62
VAR051044	Pulse Communications Incorporated	Dead Run, UT	1.62
VAR050863	Virginia Paving Company - Chantilly	Sand Branch	1.62
VAG830019	Bethlehem Baptist Church	Big Rocky Run	1.62
VAG830067	Texaco - Scotties	Flat Branch	1.62
VAG830056	E E Wine Bulk Facility - Manassas	Russia Branch	1.62

Table D-4: TMDL Allocations for General Permits Issued to Domestic Sewage Facilities

Permit	Facility Name	Receiving Stream	TSS Stormwater Allocation (tons/yr)
VAG406094	Residence	Bull Run, UT	0.046
VAG406099	Residence	Bull Run, UT	0.046
VAG406272	Residence	Bull Run	0.046
VAG406273	Residence	Bull Run, UT	0.046
VAG406295	Residence	Bull Run UT	0.046
VAG406300	Residence	Bull Run UT	0.046
VAG406329	Residence	Bull Run UT	0.046
VAG406330	Residence	Bull Run UT	0.046
VAG406057	Residence	Elklick Run	0.046
VAG406315	Residence	Black Branch UT	0.046
VAG406076	Residence	Catharpin Creek, UT	0.046
VAG406259	Residence	Chestnut Lick, UT	0.046
VAG406247	Residence	Chestnut Lick, UT	0.046
VAG406221	Commercial	Chestnut Lick, UT	0.046
VAG406240	Commercial	Chestnut Lick	0.046
VAG406270	Residence	Chestnut Lick, UT	0.046
VAG406252	Residence	Pope's Head Creek, UT	0.046
VAG406202	Residence	Piney Branch, UT	0.046
VAG406296	Residence	Piney Branch UT	0.046
VAG406040	Residence	Little Bull Run, UT	0.046
VAG406298	Residence	Little Bull Run UT	0.046
VAG406165	Residence	Little Bull Run - UT	0.046
VAG406109	Commercial	Little Bull Run	0.046
VAG406224	Residence	Little Bull Run	0.046
VAG406280	Residence	Chestnut Lick, UT	0.046
VAG406319	Residence	Chestnut Lick UT	0.046
VAG406297	Residence	Chestnut Lick UT	0.046
VAG406162	Residence	Chestnut Lick - UT	0.046
VAG406209	Residence	Chestnut Lick, UT	0.046
VAG406065	Residence	Catharpin Creek, UT	0.046
VAG406236	Residence	Black Branch, UT	0.046
VAG406171	Commercial	Elklick Run - UT	0.046

Table D-5: TMDL Allocations for General Permits Issued to Concrete Facilities

Permit	Facility Name	Receiving Stream	TSS Stormwater Allocation (tons/yr)
VAG110074	Titan Virginia Ready Mix LLC - Centreville	Bull Run, UT	1.62
VAG110096	Atlantic Contracting and Material Company Inc	Cub Run, UT	1.62
VAG110070	Mid Atlantic Materials Incorporated - Manassas	Chinn Branch	1.62
VAG110094	DuBrook Concrete - Loudoun	Sand Branch	1.62
VAG110089	Virginia Concrete Company Incorporated - Chantilly	Sand Branch, UT	1.62

Table D-6: TMDL Allocation for General Stormwater Permits Issued to Construction Sites

Permit	Annual Average Disturbed Area (acres)	Total TSS Allocation (tons/yr)
Dulles Airport (VA0089541)	622.5	76.7
Other Construction Permits	622.5	76.7