Total Maximum Daily Load of Sediment in the Wills Creek Watershed, Garrett and Allegany Counties, Maryland

FINAL

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Submitted to:

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List of Abbreviations

BIBI	Benthic Index of Biotic Integrity
BIP	Buffer Incentive Program
BMP	Best Management Practices
CBP P5	Chesapeake Bay Program Phase V
CWA	Clean Water Act
DMR	Discharge Monitoring Report
EOF	Edge-of-Field
EOS	Edge-of-Stream
EPA	Environmental Protection Agency
EPSC	Environmental Permit Service Center
ETM	Enhanced Thematic Mapper
FIBI	Fish Index of Biologic Integrity
GIS	Geographic Information System
LA	Load Allocation
MDE	Maryland Department of the Environment
MBSS	Maryland Biological Stream Survey
MGD	Millions of Gallons per Day
mg/l	Milligrams per liter
MOS	Margin of Safety
MS4	Municipal Separate Stormwater System
NPS	Non-Point Source
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NRI	Natural Resources Inventory
PCS	Permit Compliance System
RESAC	Regional Earth Science Applications Center
S&E	Sediment & Erosion
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids

TM	Thematic Mapper
USGS	United Stated Geological Survey
WLA	Waste Load Allocation
WQA	Water Quality Analysis
WQIA	Water Quality Improvement Act
WQLS	Water Quality Limited Segment
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes a Total Maximum Daily Load (TMDL) for sediment in the Wills Creek watershed (basin number 02141003). Section 303(d) of the federal Clean Water Act (CWA) and the EPA's implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, the State is required to either establish a TMDL of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met (CWA, 2006).

The Maryland Department of the Environment (MDE) has identified the waters of Wills Creek (basin number 02141003) on the State's 303(d) List submitted to the EPA by MDE as impaired by nutrients (1996), sediments (1996), pH (1998 and 2004), bacteria (2002), toxics - Cyanide (1996), and portions of the basin for impacts to biological communities (2002) (MDE, 2006a). The designated use of Wills Creek is Use IV-P (Recreational Trout Waters and Public Water Supply) for the mainstem only and Use I (Water Contact Recreation and Protection of Aquatic Life) for all other tributaries (MDE 2006a and COMAR, 2006a; 2006b). This document proposes to establish a TMDL of sediment in Wills Creek to allow for the attainment of the above mentioned designated uses. The objective of the sediment TMDL established in this document is to ensure that there will be no sediment impacts affecting aquatic health, when aquatic health is evaluated based on Maryland's biocriteria (Roth *et al*., 2000, Roth *et al.*, 1998 and Stribling *et al.*, 1998), thereby establishing a sediment load that supports the Use I/IV-P designation for the Wills Creek watershed. The watershed sediment load includes the potential effects of water clarity and erosional and depositional impacts, thus accounting for all of the sediment impacts that indicate a sediment impairment per the Maryland 303(d) listing methodology (MDE, 2006b).

A data solicitation for sediments was conducted by MDE, and all readily available data from the past five years have been considered. A Water Quality Analysis (WQA) for low pH was approved by the EPA (2005). Also, a WQA of Cyanide and a TMDL to address the bacteria listing were submitted to the EPA (2005 and 2006, respectively). The listings for nutrients and impacts to biological communities will be addressed separately at a future date.

The computational framework chosen for the Wills Creek watershed TMDL is the Chesapeake Bay Program Phase V (CBP P5) watershed model target edge-of-field (EOF) land use sediment loading rate calculations combined with sediment delivery ratio. The edge-of-stream (EOS) sediment load is calculated per land use as a product of the land use area, land use target loading rate, and loss from the EOF to the main channel. The spatial effect of sediment delivery from EOF to EOS is captured as a function of the average transport distance from individual land uses within the model segment. Therefore, each land use category will have a specific sediment delivery ratio. The spatial domain of the CBP P5 model segmentation aggregates to the Maryland 8-digit watersheds.

Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic health of non-tidal stream systems. Therefore, to determine the assimilative capacity of the watershed stream system, a reference watershed approach was used and resulted in the establishment of a *sediment loading threshold* (Currey et al., 2006). This threshold is based on a detailed analysis of sediment loads from watersheds that are identified as supporting aquatic life (i.e., reference watersheds) based on Maryland's biocriteria (Roth *et al*., 2000, Roth *et al.*, 1998 and Stribling *et al.*, 1998).

The critical condition for this TMDL is inherently addressed based on the biological monitoring data used to determine the reference watersheds. Seasonality is captured in two components. First, it is implicitly included in biological sampling since results integrate the stress effects over the course of time. Second, the Maryland Biological Stream Survey (MBSS) sampling included benthic sampling in the spring and fish sampling in the summer.

All TMDLs must include a margin of safety (MOS) to account for any lack of knowledge and uncertainty concerning the relationship between loads and water quality (CWA, 2006). Analysis of the reference group forest normalized sediment loads indicates that approximately 75% of the reference watersheds have a value of less than 3.6, while 50% have a value of less than 3.3. The forest normalized reference sediment load (also referred to as the sediment loading threshold) was set at the median value of 3.3. This is an environmentally conservative estimate, since 50% of the reference watersheds have a load above this value, which results in an implicit margin of safety of approximately 8%.

The total sediment load from the Wills Creek watershed is 2,403.0 tons per year. The sediment TMDL for the Wills Creek watershed is 2,050.6 tons per year. The load allocation (LA) is 1,787.4 tons per year and the waste load allocation (WLA) is 2.3 tons per year, for the Maryland portion of the watershed. An allocation of 260.9 tons per year is given to upstream loads. This TMDL will ensure that the sediment loads and resulting effects are compatible with the use I/IV-P designations for the Wills Creek watershed, and more specifically, that they do not exceed levels insufficient to support aquatic health.

Once the EPA has approved this TMDL, and it is known what measures must be taken to reduce pollution levels, implementation of best management practices (BMPs) is expected to take place. MDE intends for the required reduction to be implemented in an iterative process that first addresses those sources with the largest impact to water quality, with consideration given to ease and cost of implementation.

Maryland has several well-established programs to draw upon, including the Water Quality Improvement Act of 1998 (WQIA) and the Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act). Several potential funding sources for implementation are available, such as the Buffer Incentive Program (BIP), the State Water Quality Revolving Loan Fund and the Stormwater Pollution Cost Share Program.

1.0 INTRODUCTION

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes a Total Maximum Daily Load (TMDL) for sediments in the Wills Creek Watershed (basin number 02141003). Section 303(d)(1)(C) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency (EPA) implementing regulations direct each State to develop a Total Maximum Daily Load (TMDL) for each impaired water quality limited segment (WQLS) on the Section 303(d) List, taking into account seasonal variations and a protective margin of safety (MOS) to account for uncertainty (CWA, 2006). A TMDL reflects the total pollutant loading of the impairing substance a waterbody can receive and still meet water quality standards.

TMDLs are established to determine the pollutant load reductions needed to achieve and maintain water quality standards. A water quality standard is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Designated uses include activities such as swimming, drinking water supply, protection of aquatic life, and shellfish propagation and harvest. Water quality criteria consist of narrative statements and numeric values designed to protect the designated uses. Criteria may differ among waters with different designated uses.

The Maryland Department of the Environment (MDE) has identified the waters of Wills Creek (basin number 02141003) on the State's 303(d) List submitted to the EPA by MDE as impaired by nutrients (1996), sediments (1996), pH (1998 and 2004), bacteria (2002), toxics - Cyanide (1996), and portions of the basin for impacts to biological communities (2002) (MDE, 2006a). The designated use of Wills Creek is Use IV-P (Recreational Trout Waters and Public Water Supply) for the mainstem only and Use I (Water Contact Recreation and Protection of Aquatic Life) for all other tributaries (MDE, 2006a and COMAR, 2006a; 2006b). This document proposes to establish a TMDL of sediment in Wills Creek to allow for the attainment of the above mentioned designated uses. The objective of the sediment TMDL established in this document is to ensure that there will be no sediment impacts affecting aquatic health, when aquatic health is evaluated based on Maryland's biocriteria (Roth *et al*., 2000, Roth *et al.*, 1998 and Stribling *et al.*, 1998), thereby establishing a sediment loading limit that supports the Use I/IV-P designation for the Wills Creek watershed. The watershed sediment load includes the potential effect for both water clarity and erosional and depositional impacts, thus accounting for all of the sediment impacts that indicate a sediment impairment per the Maryland 303(d) listing methodology (MDE, 2006b).

A data solicitation for sediments was conducted by MDE, and all readily available data from the past five years have been considered. A Water Quality Analysis (WQA) for low pH was approved by the EPA (2005). Also, a WQA of Cyanide and a TMDL to address the bacteria listing were submitted to the EPA (2005 and 2006, respectively). The listings for nutrients and impacts to biological communities will be addressed separately at a future date.

Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic health of non-tidal stream systems. Therefore, to determine the assimilative capacity of the watershed stream system, a reference watershed approach was used and resulted in the establishment of a sediment loading threshold (Currey et al., 2006). This threshold is based on a detailed analysis of sediment loads from watersheds that are identified as supporting aquatic health (i.e., reference watersheds) based on Maryland's biocriteria (Roth et al., 2000, Roth et al., 1998 and Stribling et al., 1998).

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1 General Setting

Location

Wills Creek is located in Allegany County and flows south from its headwaters in Pennsylvania to its confluence with the North Branch Potomac River at Cumberland, MD (see Figure 1). Jennings Run and Braddock Run are the two main tributaries to Wills Creek, draining western Allegany County and a small portion of northeastern Garrett County. The drainage area of Wills Creek totals 160,500 acres, with 38,500 acres in Maryland and 122,000 acres in Pennsylvania.

Geology/Soils

The Wills Creek watershed is situated within the Appalachian Plateau and the Ridge and Valley Province of western Maryland. The surficial geology of the western portion of the Ridge and Valley Province is characterized by strongly folded and faulted sedimentary rock, producing a rugged surface terrain. The surficial geology of the Appalachian Plateau Province is characterized by gently folded shale, siltstone, and sandstone. Folding has produced elongated arches across the region, which exposes Devonian rock at the surface. Coal-bearing strata are preserved in the intervening synclinal basins of these folds. Consequently, this region in western Allegany County has been a productive source for coal mining. The topography in the watershed is often steep and deeply carved by winding streams, with elevations ranging up to 3,360 feet.

The Wills Creek watershed is comprised of several different soil series including the Dekalb, Ernest and Hazleton series. The Dekalb soil series consists of moderately deep, well-drained, loamy soils that developed in material weathered in place from sandstone and some conglomerate and shale bedrock. These nearly level to very steep soils are normally found in stony, mountainous regions. Dekalb soils have rapid permeability and internal drainage. The Hazleton soil series consists of deep, well-drained, loamy soils. These soils developed in materials weathered in place from sandstone and shale bedrock. These nearly level to moderately steep soils occur on the top and upper and middle side slopes of hills and mountains. Hazleton soils have moderately rapid permeability and rapid internal drainage. The Ernest soil series consists of deep, moderately well-drained, loamy soils. These nearly level to moderately steep soils formed in materials that accumulated at the base of the steeper slopes. Ernest soils have moderately slow permeability and a moderate available moisture capacity (USDA – NRCS, 1977 and USDA – SCS, 1974).

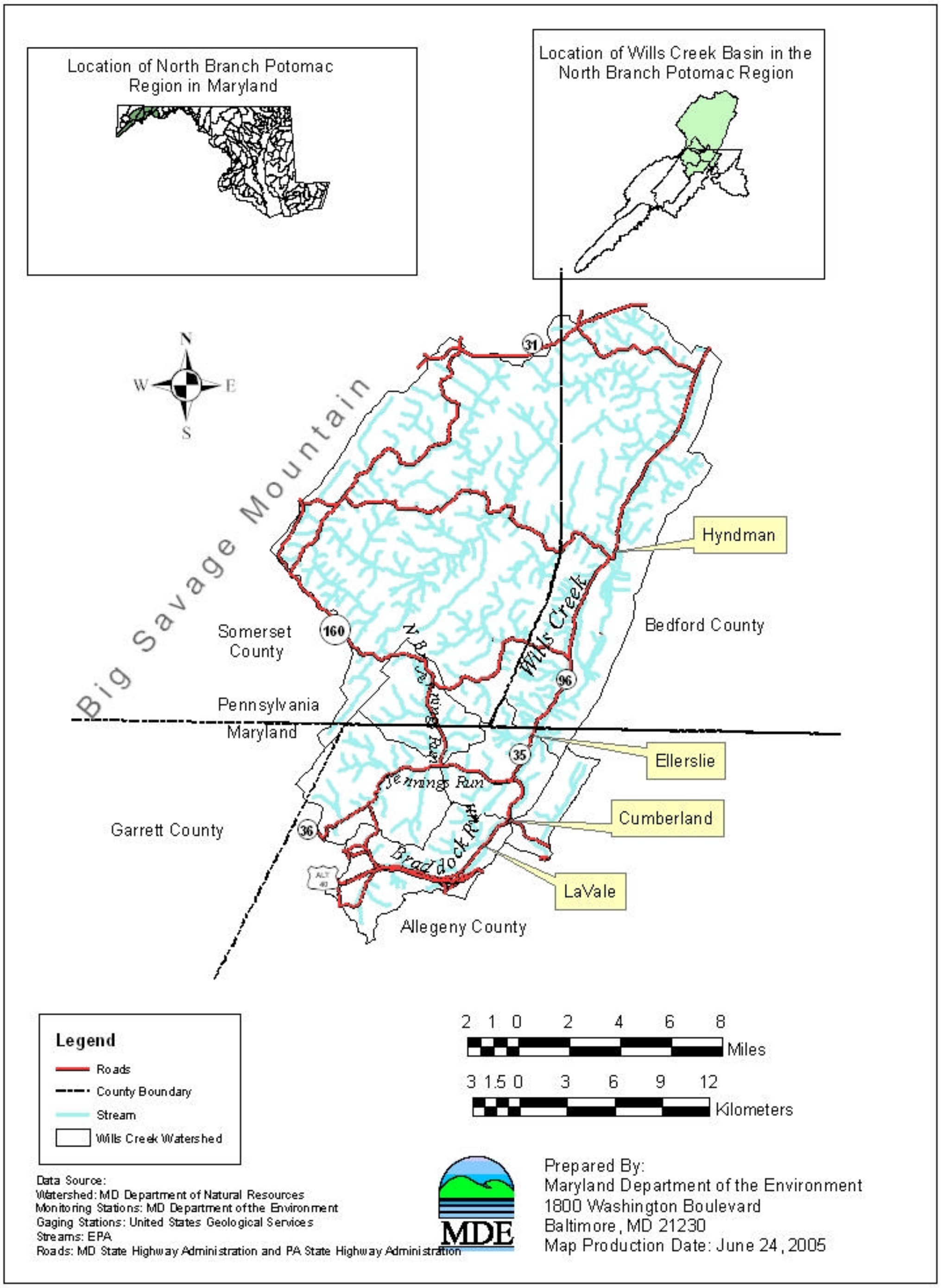

Figure 1: Location Map of Wills Creek in Garrett and Allegany Counties, Maryland

2.1.1 Land Use

Land Use Methodology

The land use framework used to develop this TMDL was originally developed for the Chesapeake Bay Program Phase V (CBP P5) watershed model.[1] The CBP P5 land use Geographic Information System (GIS) framework was based on two distinct layers of development. The first GIS layer was developed by the Regional Earth Science Applications Center (RESAC) at the University of Maryland and was based on satellite imagery (Landsat 7-Enchance Thematic Mapper (ETM) and 5-Thematic Mapper (TM)) (Goetz et al., 2004). This layer did not provide the required level of accuracy that is especially important when developing the agricultural land uses. In order to develop accurate agricultural land use calculations, the CBP P5 used county-level U.S. Agricultural Census data as a second layer (USDA, 1982, 1987, 1992, 1997 and 2002).

Given that land cover classifications based on satellite imagery are likely to be least accurate at edges (*i.e.*, boundaries between covers), the RESAC land uses bordering agricultural areas were analyzed separately. If the agricultural census data accounted for more agricultural use than the RESAC's data, appropriate acres were added to agricultural land from non-agricultural land uses. Similarly, if census agricultural land estimates were smaller than RESAC's, appropriate acres were added to non-agricultural land uses.

Adjustments were also made to the RESAC land cover to determine developed land uses. RESAC land cover was originally based on the United States Geological Survey (USGS) protocols used to develop the 2000 National Land Cover Database. The only difference between the RESAC and USGS approaches was RESAC's use of town boundaries and road densities to determine urban land covered by trees or grasses. This approach greatly improved the accuracy of the identified urban land uses, but led to the misclassification of some land adjacent to roads and highways as developed land. This was corrected by subsequent analysis. To ensure that the model accurately represented development over the simulation period, post-processing techniques that reflected changes in urban land use have been applied.

The result of this approach is that CBP P5 land use does not exist in a single GIS coverage; instead it is only available in a tabular format. The CBP P5 watershed model is comprised of 25 land uses. Most of these land uses are differentiated only by their nitrogen and phosphorus loading rates. The land uses are divided into 14 classes with distinct sediment erosion rates. Table 1 lists the CBP P5 generalized land uses and detailed land uses, which are classified by their erosion rates, and the acres of each land use in the Wills Creek watershed. Details of the land use development methodology have been summarized in the report entitled "Chesapeake Bay Phase V Community Watershed Model: Tracking Nutrient and Sediment Loads on a Regional and Local Scale" (USEPA - CBP, 2006b).

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[1] The EPA Chesapeake Bay Program developed the first watershed model in 1982. There have been many upgrades since the first phase of this model. The CBP P5 was developed to estimate flow, nutrient, and sediment loads to the Bay.

Wills Creek Watershed Land Use Distribution

The Wills Creek land use was evaluated for both Maryland and Pennsylvania. The predominant land use in both regions is forest (68% for Maryland and 84% for Pennsylvania). In Maryland the remaining land use is approximately 21% urban (developed), 6% pasture, and 5% crop. In Pennsylvania, the remaining land use distribution is 9% crop, 4% pasture, and 3% urban. A land use map is provided in Figure 2 and a summary of the watershed land use areas is presented in Table 1.

Table 1: Land Use Percentage Distribution for Wills Creek Basin

		Maryland			Pennsylvania		
General Land Use	**Detailed Land Use**	**Area (Acres)**	**Percent**	**Grouped Percent of Total**	**Area (Acres)**	**Percent**	**Grouped Percent of Total**
Crop	Animal Feeding Operations	3.0	0.0		20.3	0.0	
	Hay	1,745.7	4.5		6,664.4	5.5	
	High Till	39.0	0.1		4,353.5	3.6	
	Low Till	40.7	0.1		107.3	0.1	
	Nursery	58.6	0.2	4.9	105.6	0.1	9.2
Extractive	Extractive	186.8	0.5	0.5	9.8	0.0	0.0
Forest	Forest	25,903.4	67.3		101,792.8	83.4	
	Harvested Forest	261.7	0.7	68.0	1,028.2	0.8	84.3
Pasture	Natural Grass	21.0	0.1		17.0	0.0	
	Pasture	2,255.4	5.9		4,914.0	4.0	
	Trampled Pasture	11.8	0.0	5.9	25.7	0.0	4.1
Urban	Urban: Barren	21.1	0.1		9.4	0.0	
	Urban: Imp	765.6	2.0		122.8	0.1	
	Urban: perv	7,148.4	18.6	20.6	2,866.3	2.3	2.5
	Total	38,462.3	100.0	100.0	122,037.1	100.0	100.0

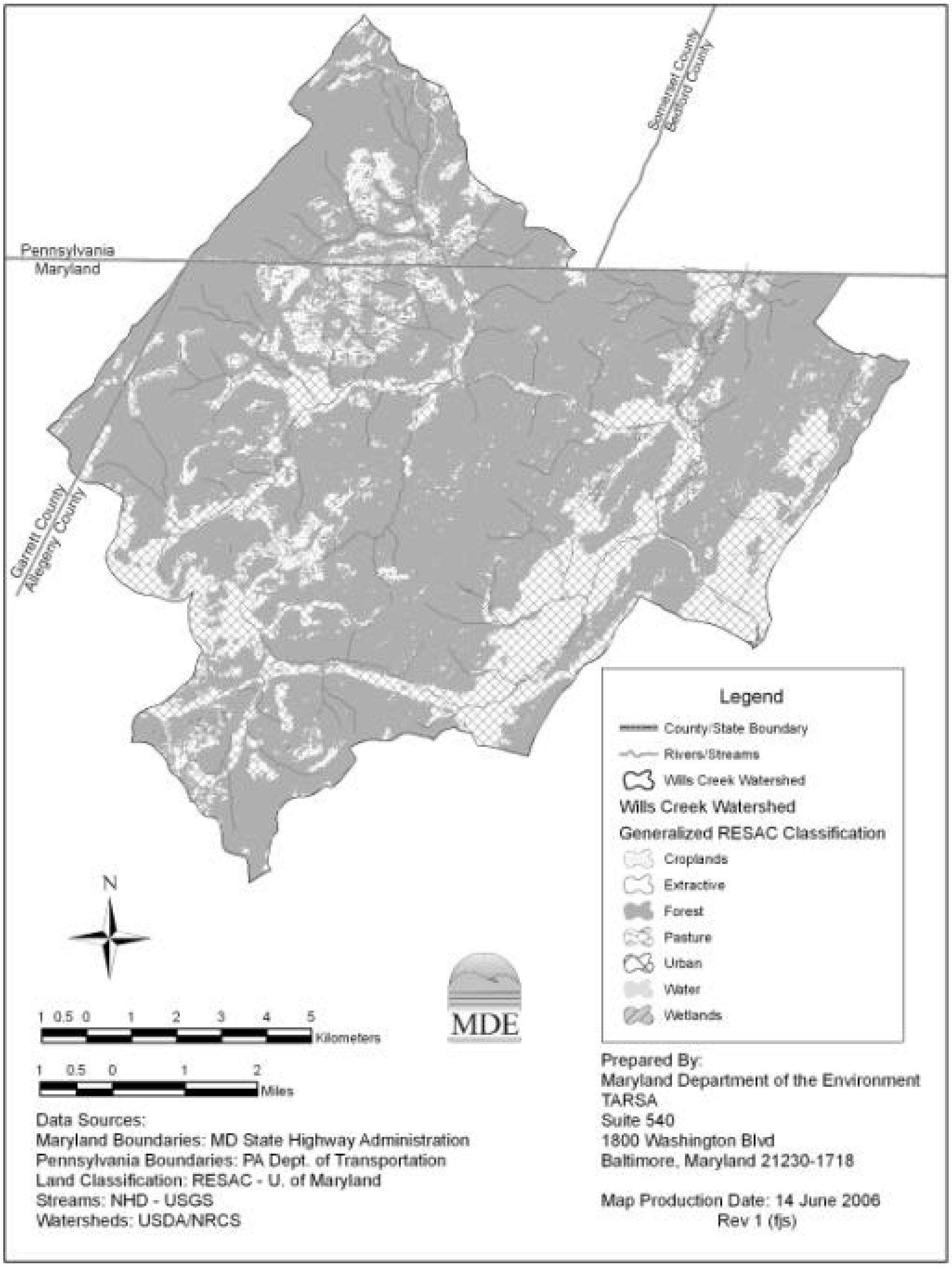


Figure 2: Land Use of the Wills Creek Watershed

2.2 Source Assessment

2.2.1 Nonpoint Source (NPS) Assessment

General load estimation methodology

Nonpoint source sediment loads in the Wills Creek watershed are estimated based on the *edge-of-stream (EOS) calibration target loading rates* from the CBP P5 model. This approach is based on the fact that not all of the *edge-of-field* (EOF) sediment load is delivered to the stream or river (some of it is stored on fields down slope, at the foot of hillsides, or in smaller rivers or streams that are not represented in the model). To calculate the actual EOS loads, a *sediment delivery ratio* (the ratio of sediment reaching a basin outlet compared to the total erosion within the basin) is used. Details of the methods used to calculate sediment load have been summarized in the report entitled "Chesapeake Bay Phase V Community Watershed Model: Tracking Nutrient and Sediment Loads on a Regional and Local Scale" (USEPA - CBP, 2006b).

Edge-of-Field Target Erosion Rate Methodology

EOF target erosion rates for agricultural land uses and forested land use were based on erosion rates determined by the National Resource Inventory (NRI). NRI is a statistical survey of land use and natural resource conditions conducted by the Natural Resources Conservation Service (USDA – NRCS, 2006). Sampling methodology is explained by Nusser and Goebel (1997).

Estimates of average annual erosion rates for pasture and cropland are available on a county basis at five-year intervals, starting in 1982. Erosion rates for forested land uses are not available on a county basis from NRI; however, for the purpose of the CBP Phase 2 watershed model, NRI calculated average annual erosion rates for forested land use on a watershed basis. These rates are still being used as targets in the CBP P5 model.

The average value of the 1982 and 1987 surveys was used as the basis for EOF target loads. The erosion rates from this period do not reflect best management practices (BMPs) or other soil conservation policies introduced in the wake of the effort to restore the Chesapeake Bay.

Rates for urban pervious, urban impervious and barren land were based on a combination of best professional judgment, literature analysis, and regression analysis. Table 2 lists erosion rates specific to the Wills Creek watershed.

Table 2: Summary of EOF Erosion Rate Calculations

Land Use	Data Source	Maryland (tons/acre/year)	Pennsylvania (tons/acre/year)
Forest	Phase 2 NRI	0.13	0.17 - 0.27
Harvested Forest[1]	Average Phase 2 NRI (x 10)	3.0	3.0
Natural Grass	Average NRI Pasture (1982-1987)	1.5	1.5
Pasture	Pasture NRI (1982-1987)	0.23 - 0.57	1.08 – 1.21
Trampled pasture[2]	Pasture NRI (x 9.5)	2.19 - 5.42	10.26 – 11.5
Animal Feeding Operations[2]	Pasture NRI (x 9.5)	2.19 - 5.42	10.26 – 11.5
Hay[2]	Crop NRI (1982-1987) (x 0.32)	1.04 - 1.11	1.04 – 1.47
High Till Without Manure[2]	Crop NRI (1982-1987) (x 1.25)	4.08 - 4.34	3.72 – 5.73
High Till With manure[2]	Crop NRI (1982-1987) (x 1.25)	4.08 - 4.34	3.72 – 5.73
Low till With Manure	0.75 * Crop NRI (1982-1987) (x 0.75)	2.45 – 2.6	2.23 – 3.44
Pervious Urban	Intercept Regression Analysis	0.74	0.74
Extractive	Best professional judgment	10	10
Barren	Literature survey	12.5 (w/ S&E[3] Controls) 25 (w/o S&E Controls)	12.5 (w/ S&E Controls) 25 (w/o S&E Controls)
Impervious	100% Impervious Regression Analysis	5.18	5.18

Notes: 1. Average based on Chesapeake Bay Basin NRI values.
2. NRI score data adjusted based on land use.
3. Sediment and erosion.

Sediment Delivery Ratio: The base formula for calculating sediment delivery ratios in the CBP P5 model is the same as the formula used by the NRCS (USDA-NRCS, 1983).

$$DF = 0.417762 * A^{-0.134958} - 0.127097 \qquad \text{(Equation 2.1)}$$

where
DF (delivery factor) = the sediment delivery ratio
A = drainage area in square miles

In order to account for the differences in sediment loads due to distance traveled to the stream, the CBP P5 model uses the sediment delivery ratio. Land use specific sediment delivery ratios were calculated for each river segment using the following procedure:

(1) Mean distance of each land use from the river reach was calculated;

(2) Sediment delivery ratios for each land use were calculated (drainage area in Equation 2.1 was assumed to be equal to the area of a circle with radius equal to the mean distance between the land use and the river reach).

Edge-of-Stream Loads

EOS loads are the loads that actually enter the river reaches (*i.e.*, the mainstem of a watershed). Such loads represent not only the erosion from the land but all of the intervening processes of deposition on hillsides and sediment transport through smaller rivers and streams.

Table 3 lists the current overall solids budget for Wills Creek in Maryland and Pennsylvania, respectively. It is broken down into nonpoint and point source loadings. The largest portion of the nonpoint source sediment load in Maryland is from urban land (56%), and in Pennsylvania from crop (51%). In Maryland, the next largest sediment sources are forest (20%), crop (10%), and extractive (10%). In Pennsylvania, the next largest sediment sources are forest (28%), pasture (13%) and urban (5%).

2.2.2 Point Source (PS) Assessment

A list of 11 active permitted sources in the Wills Creek watershed was compiled using MDE's Environmental Permit Service Center (EPSC) database. The types of permits identified were municipal surface discharges, industrial surface discharges, general mining, and general industrial stormwater. Permit information for municipal and industrial surface discharges was obtained from EPA's Permit Compliance System (PCS) database. Specifically, total suspended solids (TSS) permit limits and Discharge Monitoring Report (DMR) data (TSS and flow) were obtained. Permit information for general mining permits was obtained from MDE permit files. Specifically, site areas, TSS permit limits, and average flow data were obtained. The total TSS loading from permitted sources is 2.3 Tons/Yr (see section 4.6 for a detailed description of the calculation). A detailed list of the facilities appears in Appendix B.

2.2.3 Overall Solids Budget

Table 3 presents the current overall solids budget for the Wills Creek watershed.

Table 3: Current Solids[1] Budget for the Wills Creek Watershed

		Maryland			Pennsylvania		
General Land Use	**Description**	**Load (Ton/Yr)**	**Percent**	**Grouped Percent of Total**	**Load (Ton/Yr)**	**Percent**	**Grouped Percent of Total**
Crop	Animal Feeding Operations	0.7	0.0		1.1	0.4	
	Hay	180.4	8.6		40.3	13.3	
	High Till	15.8	0.8		108.5	35.8	
	Low Till	9.9	0.5		1.6	0.5	
	Nursery	12.7	0.6	10.5	3.0	1.0	51.0
Extractive	Extractive	226.6	10.8	10.8	8.8	2.9	2.9
Forest	Forest	349.8	16.7		71.7	23.7	
	Harvested Forest	81.5	3.9	20.5	12.8	4.2	27.9
Pasture	Natural Grass	2.4	0.1		0.0	0.0	
	Pasture	39.0	1.9		38.3	12.6	
	Trampled Pasture	1.9	0.1	2.1	1.9	0.6	13.3
Urban	Urban: Barren	26.3	1.3		0.6	0.2	
	Urban: Imp	501.6	23.9		1.8	0.6	
	Urban: perv	649.2	30.9	56.0	12.4	4.1	4.9
Permits	Process Load	2.3	0.1	0.1	NA	NA	NA
	Total	2,100.2	100.0	100.0	302.8	100.0	100.0

Note: 1. The word “solids” is used instead of “sediments” because the point source inputs are included.

2.3 Water Quality Characterization

The Wills Creek watershed was originally listed on Maryland’s 1996 303(d) List as impaired by elevated sediments from nonpoint sources, with supporting evidence cited in Maryland’s 1996 305(b) report. The 1996 305(b) report did not directly state elevated sediments were a concern (MDE, 2006a and DNR, 1996).

To provide a water quality characterization of the Wills Creek watershed, it must first be determined how elevated sediment loads are linked to degraded stream water quality. While currently in Maryland there are no specific numeric criteria that quantify the impact of sediment on the aquatic health of non-tidal stream systems, it was outlined in the Maryland 2004 303(d) report that degraded stream water quality resulting in a sediment impairment is characterized by erosional impacts, depositional impacts, and decreased water clarity (MDE, 2006a). For this report, cumulative erosional and depositional impacts were evaluated based on two site-specific water quality parameters – embeddedness and epifaunal substrate condition. Embeddedness is the fraction of surface area of larger particles surrounded by finer sediments, and epifaunal substrate is the amount and variety of hard, stable substrates used by benthic macroinvertebrates. In general, low embeddedness and high epifaunal substrate are beneficial to the aquatic life of a stream system. The analysis was based on the data collected by the Maryland Biological Stream Survey (MBSS) program (see Table 4, Figure 3, and Appendix A). In addition to the characterizations outlined in the Maryland 2004 303(d) report, sediment load was also used to characterize the watershed. Sediment load is a quantitative measure of the total sediment transported to the highest order stream draining the watershed.

Table 4: MBSS Round Two Data Stations in the Wills Creek Watershed

Site	Date Sampled Summer	Latitude (dec degrees)	Longitude (dec degrees)
WILL-105-R-2004	01JUN2004	39.66961	78.82227
WILL-107-R-2004	07JUL2004	39.71259	78.90433
WILL-109-R-2004	07JUL2004	39.69998	78.90514
WILL-110-R-2004	01JUN2004	39.65785	78.81497
WILL-115-R-2004	21JUL2004	39.67492	78.9197
WILL-120-R-2004	01JUN2004	39.66079	78.81545
WILL-212-R-2004	04AUG2004	39.64319	78.81956
WILL-219-R-2004	07JUL2004	39.64206	78.86109
WILL-306-R-2004	11AUG2004	39.69444	78.81179
WILL-404-R-2004	06SEP2004	39.69104	78.7809

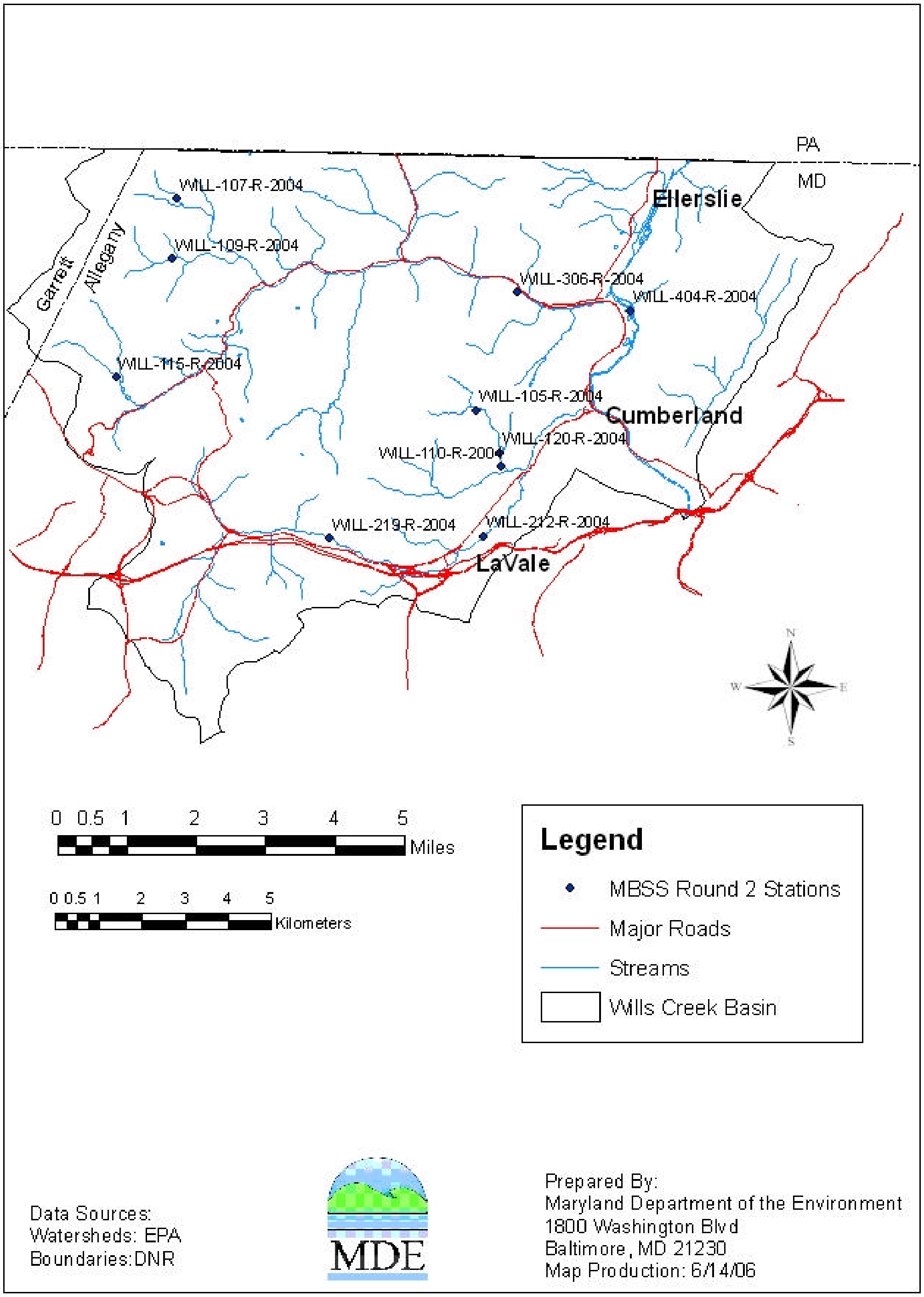


Figure 3: MBSS Stations in the Wills Creek Watershed

Increasing embeddedness and decreasing epifaunal substrate condition scores indicate possible erosional or depositional impacts from elevated sediment loads. There are no numeric criteria for embeddedness and epifaunal substrate condition. Instead, monitoring results were compared to values observed in streams identified as having a healthy benthic community (*i.e.*, reference sites). The benthic community was chosen for comparison because it is more directly impacted than are fish by the physical conditions of the streambed. Impacts or changes to the streambed could affect the benthic community by altering food quality, covering habitat, filling interstitial space and altering water movement (Minshall, 1984).

Reference sites for comparison were selected from the non-coastal physiographic region (Highland and Piedmont) and were required to have Benthic Index of Biotic Integrity (BIBI) scores significantly greater than 3.0 (based on a scale of 1 to 5). A threshold of 3.0 was selected because this is the level indicative of satisfactory water quality in Maryland's biocriteria (Roth *et al*., 2000, Roth *et al.*, 1998 and Stribling *et al.*, 1998). In determining if the site score is significantly greater than 3.0, a default confidence interval was applied that is based on the coefficient of variation from replicate samples. A comparison of MBSS sampling results to reference sites is presented in Figure 4.

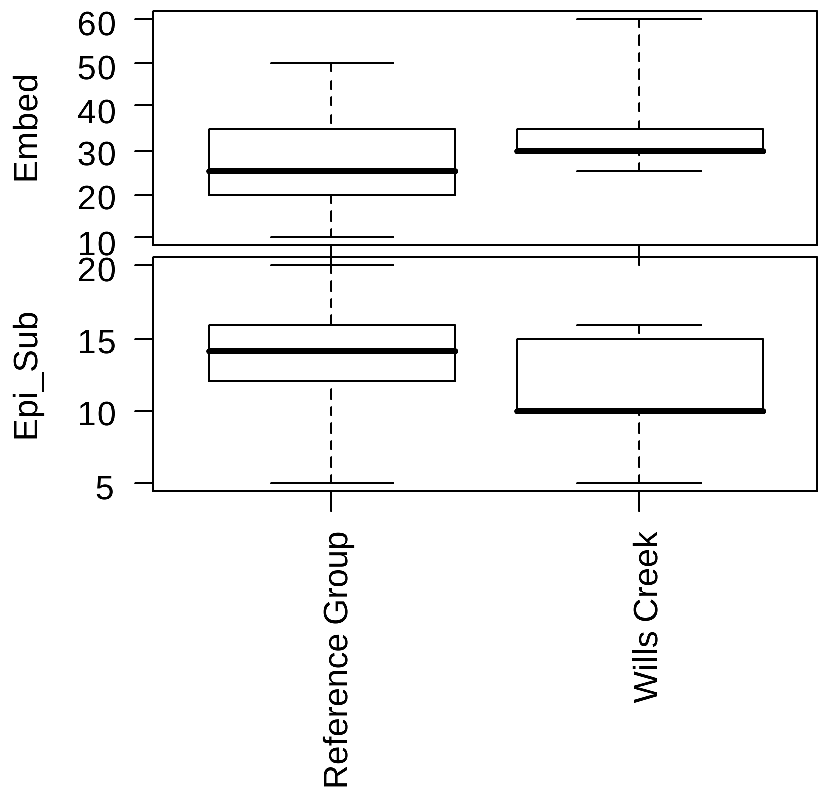


Figure 4: Wills Creek Embeddedness and Epifaunal Substrate Compared to Reference Sites

MBSS sampling also includes turbidity samples, which provide an instantaneous measure for evaluating water clarity. These samples were collected during the summer low flow period and are only collected one time per site. Since the representativeness of these samples to the overall stream water quality is limited, they were not used in this analysis.

In the absence of specific numeric criteria that quantify the impact of sediment on the aquatic health of non-tidal stream systems, the average annual sediment load is the only currently available target that accounts for the potential effect of both water clarity and erosional/depositional impacts to the aquatic community. Thus, it is used in this analysis as the final determining factor for assessing if there is a sediment impact to aquatic health. In general, an elevated sediment load results from increased total suspended solids (TSS) concentration with an effect of reduced water clarity in the water column. Sources of the increased sediment load (and TSS concentrations) are typically terrestrial and channel erosion. Increases in both sources potentially decrease water clarity and, based on stream transport capacity, increase the likelihood of depositional impacts, where an increase in the channel erosion load will result in physical alterations to the stream system. The combined effects of increased terrestrial and channel erosion are captured within the current watershed sediment load, which can be linked to the long term effects on aquatic health (i.e. water clarity, altered habitat through erosion and deposition).

The average annual watershed sediment load used in this analysis is an estimate from the CBP P5 model and provides a quantitative estimate of sediment to the highest order (largest) stream in the watershed. This sediment load is estimated for the rainfall driven sediment, which is the most significant sediment source in a non-tidal watershed. The watershed segmentation applied in the analysis is based on the CBP P5 model and results in two TMDL segments for the Wills Creek watershed (see Figure 5.)

Since there are no established numeric criteria for watershed sediment loads, the watershed sediment load in the Wills Creek watershed was compared to loads estimated in reference watersheds. Reference watersheds were determined based on the Benthic and/or Fish Index of Biotic Integrity (BIBI/FIBI) average watershed scores significantly greater than 3.0 (based on a scale of 1 to 5). A threshold of 3.0 was selected because this is the level indicative of satisfactory water quality per Maryland's biocriteria (Roth *et al.*, 2000; Roth *et al.*, 1998 and Stribling *et al.*, 1998). In determining if the average watershed score is significantly greater than 3.0, a 90% confidence interval was calculated for each watershed based on the individual MBSS sampling results.

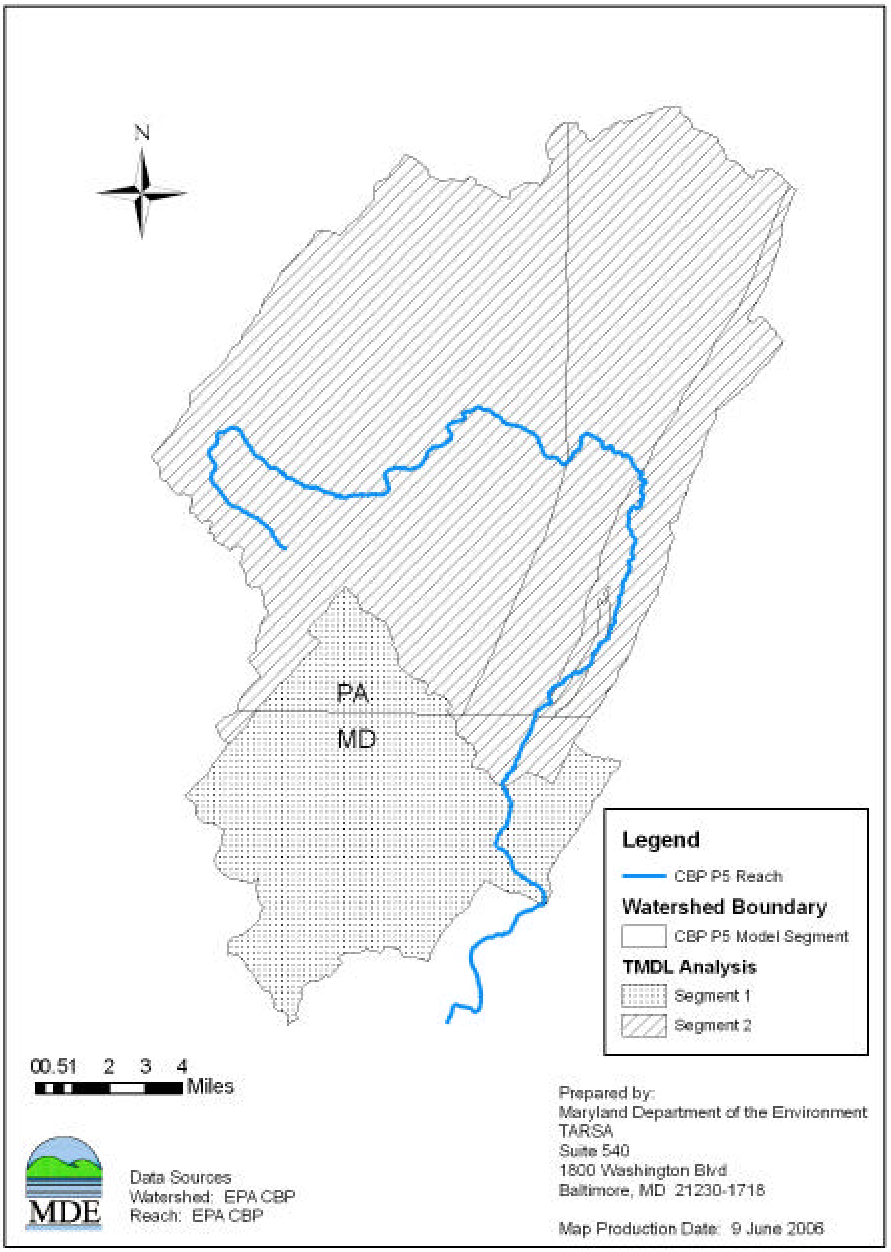
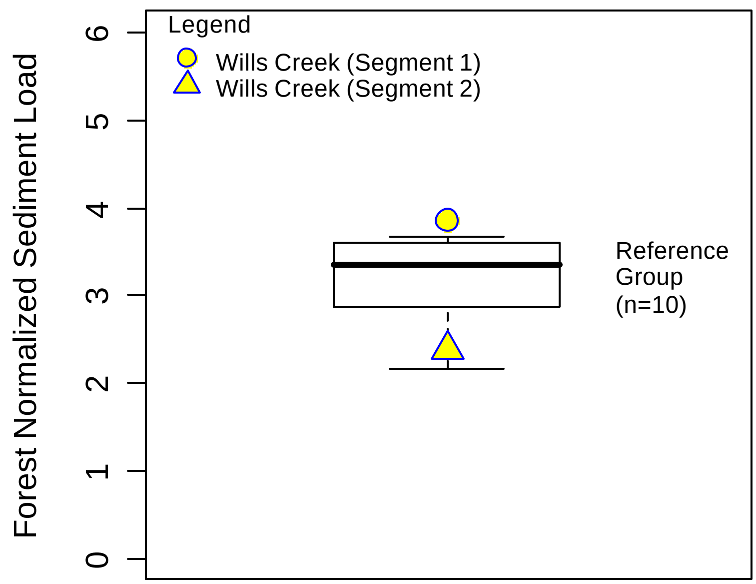


Figure 5: Wills Creek Watershed Characterization Segmentation

Comparison of watershed sediment loads to loads from reference watersheds requires that the watersheds be similar in physical and hydrological characteristics. To satisfy this requirement, reference watersheds were selected only from the Highland and Piedmont physiographic regions. This region is consistent with the non-coastal region that was identified in the 1998 development of FIBI and subsequently used in the development of the BIBI (Roth *et al.*, 1998 and Stribling *et al.*, 1998). To control for the variability in soil type, rainfall, and topography, individual watershed sediment loads were normalized by their all-forested condition sediment load. The normalization calculation divides the current watershed sediment load by the sediment load assuming an all forested condition.

This resulting factor, the forest normalized sediment load, represents how many times greater the current watershed sediment load is than the all forested sediment load.

For comparison, the Wills Creek watershed was divided into two TMDL segments. One TMDL segment represents the sediment loads generated in Maryland and includes the sediment loads from Pennsylvania that flow into Maryland in the Northwest portion of the watershed. The other TMDL segment represents the sediment loads transported from Pennsylvania across the Maryland state line via the Wills Creek mainstem. These latter loads flow directly into Maryland through the mainstem of Wills Creek near the Northeast quadrant of the watershed. A comparison of the Wills Creek forest normalized sediment load (estimated as 3.9 and 2.4 for TMDL Segments 1and 2 respectively) to the forest normalized reference sediment load (also referred to as the sediment loading threshold) is shown in Figure 6.



Note: 1. TMDL Segments 1 and 2 are defined in Figure 5.

Figure 6: Wills Creek Forest Normalized Sediment Load Compared to Reference Watershed Group

Finally, the distribution of land use for the Wills Creek watershed was compared to the reference watersheds and determined to be within the ranges found in the reference watersheds. Comparison of the Wills Creek land use to the range of land use in the reference watersheds is illustrated in Figure 7.

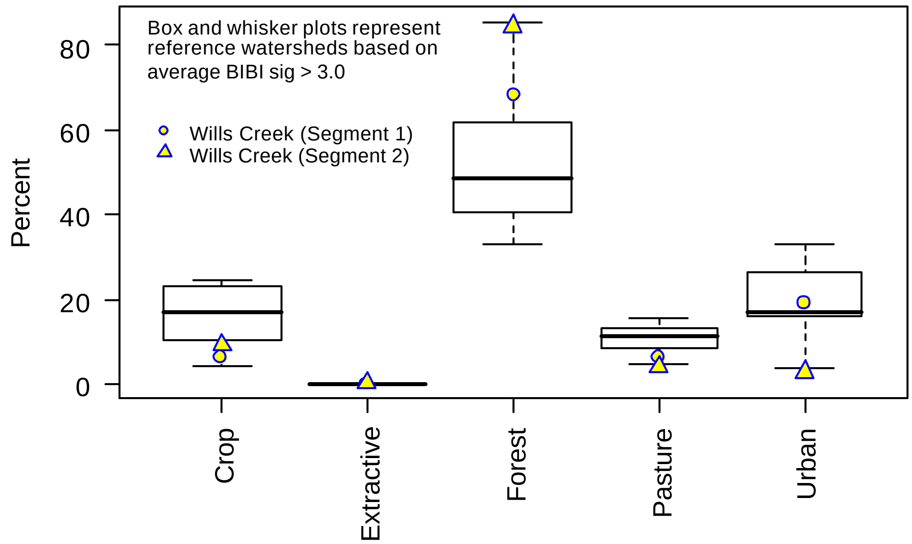


Figure 7: Wills Creek Land Use Compared to Reference Watershed Group

2.4 Water Quality Impairment

The Maryland water quality standards Surface Water Use Designation for the Wills Creek watershed is Use IV-P (Recreational Trout Waters and Public Water Supply) for the mainstem only and Use I (Water Contact Recreation and Protection of Aquatic Life) for all other tributaries (COMAR, 2006a and COMAR 2006b). The water quality impairment of the Wills Creek watershed addressed by this TMDL consists of an elevated sediment load beyond a level to support aquatic life. The sediment loading threshold was estimated using reference watersheds, where the assimilative capacity was determined to be approximately 3.3 times the sediment load assuming an all forested condition. This value is representative of watersheds in the Highland and Piedmont physiographic regions with land use distributions within the range of the reference watersheds. Further details can be found in Tables A-1 for reference watersheds and A-4 for Wills Creek.

The Wills Creek Watershed was evaluated using TMDL Segment 1 and 2 separately, both of which contain loads from Pennsylvania and Maryland. The current watershed sediment load in TMDL Segment 1 is approximately 3.9 times the all forested condition, while the current load in TMDL Segment 2 is approximately 2.4 times the all forested condition. This analysis indicates that in TMDL Segment 1, sediment loads exceed levels that support aquatic health, and confirms that this TMDL segment of the Wills Creek watershed is impaired by elevated sediment loads to the stream system. This analysis also indicates that the sediment loads in TMDL Segment 2 are at levels below the threshold and should be low enough to adequately support aquatic health. Therefore, a TMDL will be developed for the watershed area contained within TMDL Segment 1 only. As a caution, it is important to recognize that the methodology was not developed with instream water quality data for Pennsylvania, and any results for Pennsylvania are extrapolated beyond the range of the input parameters

3.0 TARGETED WATER QUALITY GOAL

The objective of the sediment TMDL established in this document is to ensure that the sediment loads and resulting effects are low enough to support the Use I/IV-P designation for the Wills Creek watershed, and more specifically support aquatic health (BIBI/FIBI = 3.0). Maryland's general water quality criteria prohibit pollution of waters of the State by any material in amounts sufficient to create nuisance or interfere with designated uses (COMAR, 2006c).

4.0 TOTAL MAXIMUM DAILY LOADS AND SOURCE ALLOCATION

4.1 Overview

This section describes how the sediment TMDLs and load allocations were developed for the Wills Creek watershed. Section 4.2 describes the analysis framework for estimating sediment loading rates, and the assimilative capacity of the watershed stream system. Section 4.3 summarizes the scenarios that were used in the analysis and presents results. Section 4.4 discusses critical conditions and seasonality. Section 4.5 explains the calculations of TMDL loading caps. Section 4.6 details the load allocations between point and nonpoint sources and Section 4.7 explains the rationale for the margin of safety. Finally, Section 4.8 summarizes the TMDL.

4.2 Analysis Framework

The computational framework chosen for the Wills Creek TMDL was the CBP P5 watershed model. The EOS sediment load is calculated for each land use as a product of the land use area, land use target loading rate, and loss from the edge-of-field (EOF) to the main channel. The sediment delivery ratio is used because not all of the EOF sediment load is delivered to the stream or river. Some of it is stored on fields down slope, at the foot of hillsides, or in smaller rivers or streams that are not represented in the model. The sediment delivery ratio is the ratio of the sediment load reaching a basin outlet compared to the total erosion within the basin.

The spatial domain of the watershed model segmentation aggregates to the Maryland 8-digit watersheds. TMDL Segment 1 (see Figure 5) of the Wills Creek watershed is represented by multiple CBP P5 model segments. The proximity of specific land use to that of the main channel is captured through the sediment delivery ratio. Details of the data sources for the unit loading rates can be found in Section 2.2 of this report, and complete details of the modeling approach will be included in the report entitled "Chesapeake Bay Phase V Community Watershed Model: Tracking Nutrient and Sediment Loads on a Regional and Local Scale" (USEPA - CBP, 2006b). Predicted sediment loads are based on CBP P5 2002 land use, and represent a long-term average loading rate.

To reduce the variability when comparing watersheds within and across regions, the watershed sediment load is normalized by a constant background condition. A similar approach was used by EPA Region 9 in sediment TMDLs in California (Navarro River, Trinity River), where the loading capacity was based on an analysis of the amount of human-caused sediment delivery that can occur in addition to natural sediment delivery, without causing adverse impacts to aquatic life. The forest normalized sediment load for this TMDL is calculated as the current watershed sediment load divided by the all forested sediment load. This new term, defined as the forest normalized sediment load (Y_n), represents how many times greater the current watershed sediment load is than the all forested sediment load. The equation is as follows:

$$Y_n = \frac{y_{ws}}{y_{for}} \qquad \text{(Equation 4.1)}$$

where
Y_n = forest normalized sediment load
y_{ws} = current watershed sediment load (Ton/Yr)
Y_{for} = all forested sediment load (Ton/Yr)

4.3 Scenario Descriptions and Results

The following analyses allow a comparison of baseline conditions (under which water quality problems exist) to a future condition that calculates the maximum average annual sediment load that supports the stream's designated use. The analyses are grouped according to *baseline conditions* and *future conditions* associated with TMDLs.

Baseline Conditions

The baseline conditions are intended to provide a point of reference by which to compare the future scenario that simulates conditions of a TMDL. The baseline conditions typically reflect an approximation of nonpoint source loads during the monitoring time frame, as well as estimated point source loads based on discharge data for the same period.

The Wills Creek watershed baseline sediment loads are estimated using the CBP P5 watershed model target EOS land use sediment loading rates with the CBP 2002 land use. Watershed loading calculations based on the CBP P5 segmentation scheme are represented by multiple CBP P5 model segments within TMDL Segment 1. The TSS loads from these segments are combined to represent the baseline condition. The sediment loads from the Maryland permitted sources are estimated using the permit information. Details of these loading source estimates can be found in Section 2.2, Section 4.6, and Appendix B of this report.

The total sediment load from the Wills Creek watershed is 2,403.0 tons per year.

Future (TMDL) Conditions

This scenario represents the future condition of maximum allowable sediment loads that will support a healthy biological community. In the TMDL calculation, the allowable load for the impaired watershed is calculated as the product of the sediment loading threshold (determined from watersheds with a healthy benthic community) and the Wills Creek all forested sediment load (for details see Section 2.3). The watershed area used in this analysis is based on both the Maryland 8-digit designations, and it includes the area of TMDL Segment 1 in Pennsylvania. The Pennsylvania area, included because the state's boundary does not depict a natural watershed divide, is a portion of the watershed containing mostly 1^{st} through 3^{rd} order streams. The resulting load is considered the maximum allowable load the watershed can assimilate and still attain water quality standards.

The TMDL loading and associated reductions are averaged at the Maryland 8-digit watershed scale, which is consistent with the original listing scale. It is important to recognize that in reality some subwatersheds may require higher reductions than others, depending on the distribution of the land use.

The formula for estimating the TMDL is as follows:

$$TMDL = \sum_{i=1}^{n} Yn_{ref} \cdot y_{forest_i} \qquad \text{(Equation 4.2)}$$

where
TMDL = allowable load for impaired watershed (Ton/Yr)
Yn_{ref} = sediment loading threshold = forest normalized reference sediment load (3.3)
y_{forest_i} = all forested sediment load for segment *i* (Ton /Yr)
i = CBP P5 model segment
n = number of CBP P5 model segments in watershed

4.4 Critical Condition and Seasonality

EPA's regulations require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters (CFR, 2006). The intent of this requirement is to ensure that the water quality of the waterbody is protected during times when it is most vulnerable. The biological monitoring data used to determine the reference watersheds integrate the stress effects over the course of time and thus inherently addresses critical conditions. Additionally, the MBSS sampling included benthic sampling collected in the spring and fish sampling collected in the summer. While fish results were not directly applied in the final analysis, Currey *et al.* (in preparation) reported that there was minimal difference in the forest normalized sediment loads between the reference group watersheds using benthic scores only and the group using both fish and benthic scores. Thus, this analysis has captured both spring and summer flow conditions.

4.5 TMDL Loading Caps

This section presents the TMDL of TSS for the Wills Creek watershed. This load is considered the maximum allowable load the watershed can assimilate and still attain water quality standards. This load is a long-term average.

The sediment TMDL for the Wills Creek watershed, based on Equation 4.2, is as follows:

TMDL = 2,050.6 Ton/Yr

4.6 Load Allocations Between Point and Nonpoint Sources

The allocations described in this section demonstrate how the TMDL of TSS can be implemented to meet the water quality criteria in the Wills Creek watershed. The State reserves the right to revise these allocations provided the revisions are consistent with achieving water quality standards.

There are two broad types of National Pollutant Discharge Elimination System (NPDES) permits considered in this analysis, individual and general.

In this TSS TMDL, the rationale for determining whether the permitted source is assigned to the LA or WLA is based on explicitly specified TSS permit limits, data availability, and scale. In the Wills Creek Watershed, permits with specific TSS limits, and corresponding flow information, are assigned to the WLA. In this case detailed information is available to accurately estimate the WLA. If specific TSS limits are not explicitly stated in the permit, then TSS loads are expected to be either (1) *de minimis* or (2) rainfall-driven and thus highly variable. If loads are *de minimis*, then they pose little or no risk to the aquatic environment and are not a significant source. Rainfall driven loads are difficult to quantify due to high variability in precipitation events and, in some cases, lack of available site-specific outfall information. Rainfall-driven loads will be assigned to the WLA at an appropriate scale.

The Department has decided to apply EPA's criterion for MS4 permitting requirements (population>100,000) as the appropriate scale for assigning rainfall-driven permitted TSS loads to the WLA. The justification is that as the areal extent of the permitted source increases relative to the total watershed size, the TSS load estimate will be more significant compared to the total watershed load and as a result will become more reliable in its estimate. Therefore, when a watershed includes a Municipal Separate Stormwater System (MS4) permitted jurisdiction, all rainfall driven permitted TSS sources within the MS4 permitted area, without explicit TSS limits, will be included in the WLA of the TMDL as one lumped allocation. At this scale, the TSS load is expected to be more significant compared to the total watershed load and more reliable in its estimate. It is also important to point out that discharges associated with industrial activity, whether in the WLA or LA of a TMDL, already include a specific set of best management practices (BMPs) as per the permit requirements.

There are no MS4 permits in the Wills Creek watershed. Therefore, all rainfall-driven TSS loads will be allocated to the LA. These include loads from agricultural land, extractive land, forested land, and developed land. There are 6 permitted sources with explicit TSS limits (see Tables B-2, B-3, and B-5), which include three mining permits, two industrial permits, and one municipal permit. The estimated TSS loads from these sources are assigned to the WLA using the current permit limits. For more information, see Table B-1 located in Appendix B, which lists the resulting allocation decision for the 11 permitted sources in the Wills Creek watershed.

Reductions

Reductions are estimated for the predominant controllable sources (i.e., significant contributors of sediment to the stream system). If only these predominant (generally the largest) sources are controlled, water quality standards can be achieved in the most effective and efficient manner. Predominant sources include urban land, high till crops, low till crops, hay, pasture, and harvested forest, but additional sources can be added and controlled until the water quality standard is attained.

A reduction of 14.7% from current estimated loads will be required to meet TMDL allocation and attain water quality standards. Table 5 summarizes the TMDL scenario results based on applying the 14.7% reduction equally to the predominant controllable sediment sources. The reductions in Table 5 are based on multiple sources (e.g. high till, low till, hay, animal feeding operations, and nursery all equal a crop source) and reflect that reductions were only applied to the predominant source categories (e.g. high till).

In this watershed, forest is the only non-controllable source, as it represents the most natural condition in the watershed. No reductions were applied to permitted sources because at 0.1% of the total load, such controls would produce no discernable water quality benefit.

Table 5: Point Source and Nonpoint Source Load Allocations (MD and PA)

Source	Baseline Load (Ton/Yr)	TMDL Scenario Load (Ton/Yr)	Reduction
Crop	374.1	311.9	16.6%
Extractive	235.4	190.8	18.9%
Forest	515.9	498.0	3.5%
Pasture	83.6	76.4	8.6%
Urban	1,191.8	971.2	18.5%
Permitted[1]	2.3	2.3	0.0%
Total	2,403.0	2,050.6	14.7%

Note: 1. Based on permit limits.

Table 6: Annual TMDL Load Summary

Source	Baseline Load (Ton/Yr)	TMDL Scenario Load (Ton/Yr)	Reduction
Maryland	2,176.0	1,789.7	17.8%
Upstream	302.8	260.9	13.8%

4.7 Margin of Safety

All TMDLs must include a margin of safety (MOS) to account for any lack of knowledge and uncertainty concerning the relationship between loads and water quality (CWA, 2006). It is proposed that the estimated variability around the reference watershed group used in this analysis already accounts for such uncertainty. Analysis of the reference group forest normalized sediment loads indicates that approximately 75% of the reference watersheds have a value of less than 3.6, while 50% have a value of less than 3.3. Based on this analysis, the forest normalized reference sediment load (also referred to as the sediment loading threshold) was set at the median value of 3.3. This is considered an environmentally conservative estimate, since 50% of the reference watersheds have a load above this value, which results in an implicit margin of safety of approximately 8%.

4.8 Summary of Total Maximum Daily Loads

The TMDL for the Maryland 8-digit Wills Creek watershed and Pennsylvania streams draining to the watershed is summarized in Table 6.

Table 7: Wills Creek Watershed TMDL Summary

	TMDL (Ton/yr)[1]	**LA**	**WLA**	**MOS**
Maryland	1,789.7	1,787.4	2.3	Implicit

Note: 1. An additional TMDL of 260.9 ton/yr is given to upstream loads, for a total TMDL of 2,050.6 ton/yr.

5.0 ASSURANCE OF IMPLEMENTATION

This section provides the basis for reasonable assurances that the sediment TMDL will be achieved and maintained. Section 303(d) of the Clean Water Act and current EPA regulations require reasonable assurance that the TMDL load and wasteload allocations can and will be implemented (CWA, 2006). Maryland has several well-established programs to draw upon, including the Water Quality Improvement Act of 1998 (WQIA) and the Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act).

Potential funding sources for implementation include the Buffer Incentive Program (BIP) and the Maryland Agriculture water quality cost share program (MACS). Other funding available for local governments includes the State Water Quality Revolving Loan Fund and the Stormwater Pollution Cost Share Program. Details of these programs and additional funding sources can be found at
http://www.dnr.state.md.us/bay/services/summaries.html

Potential best management practices for reducing sediment loads and resulting impacts can be summarized in three general categories. The first is directed toward agricultural lands, the second to urban (developed) land, and the third applies to all land uses.

In agricultural areas comprehensive soil conservation plans can be developed that meet criteria of the USDA-NRCS Field Office Technical Guide (USDA – NRCS, 1983). Soil conservation plans help control erosion by modifying cultural practices or structural practices. Cultural practices may change from year to year and include changes to crop rotations, tillage practices, or use of cover crops. Structural practices are long-term measures that include, but are not limited to, the installation of grass waterways (in areas with concentrated flow), terraces, diversions, sediment basins, or drop structures. The reduction percentage attributed to cultural practices is determined based on changes in land use, while structural practice reductions are up to 25%. In addition, controlled livestock watering can be applied, which includes stream fencing and rotational grazing. Sediment reduction efficiencies of methods applicable to pasture land use range from 40% to 75% (USEPA - CBP, 2004).

Sediment from urban areas can be reduced by stormwater retrofits, impervious surface reduction, and stream restoration. Stormwater retrofits include modification of existing stormwater structural practices to address water quality. Reductions range from as low as 10% for dry detention to approximately 80% for wet ponds, wetlands, infiltration practices and filtering practices. Impervious surface reduction results in a change in hydrology that could reduce stream erosion (USEPA – CBP, 2003).

All non-forested land uses can benefit from improved riparian buffer systems. A riparian buffer reduces the effects of upland sediment sources through trapping and filtering. Riparian buffer efficiencies vary depending on type (grass or forested), land use (urban or agriculture) and physiographic region. The CBP estimates riparian buffer sediment reduction efficiencies in the Wills Creek region to be approximately 50% (USEPA - CBP, 2006a).

In summary, through the use of the aforementioned funding mechanisms and best management practices, there is reasonable assurance that this TMDL can be implemented.

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APPENDIX A

Table A-1: Reference Watersheds

MD 8-digit Name[1]	MD 8-digit	FIBI n	BIBI n	FIBI	BIBI	Forest Normalized[2] Sediment Load
Deer Creek	2120202	28	28	Ind.	Pass	3.63
Broad Creek	2120205	10	10	Ind.	Pass	3.67
Little Gunpowder Falls	2130804	19	20	Ind.	Pass	3.26
Prettyboy Reservoir	2130806	11	11	Pass	Pass	2.87
Liberty Reservoir	2130907	31	31	Pass	Pass	3.28
S Branch Patapsco	2130908	10	10	Pass	Pass	3.57
Rocky Gorge Dam	2131107	10	10	Pass	Pass	3.43
Brighton Dam	2131108	11	11	Ind.	Pass	3.61
Town Creek	2140512	16	20	Ind.	Pass	2.17
Savage River	2141006	13	14	Pass	Pass	2.48
Median[3]						3.3
75th Percentile						3.6

Notes:
1. Potomac River Lower North Branch determined to be an outlier through statistical analysis and best professional judgment; Fifteen Mile Creek Watershed was removed because the majority of the watershed is in Pennsylvania.
2. Forest Normalized Sediment Load based on Maryland watershed area only (Consistent with MBSS random monitoring data).
3. Median rounded down (3.36 to 3.3) as conservative estimate
4. Ind.=Indeterminate

Table A-2: Reference Watersheds Land Use

MD 8-digit Name	MD 8-digit	Crop	Extractive	Forest	Pasture	Urban
Deer Creek	2120202	23	0	50	11	16
Broad Creek	2120205	24	0	48	10	17
Little Gunpowder Falls	2130804	15	0	45	16	23
Prettyboy Reservoir	2130806	20	0	50	14	16
Liberty Reservoir	2130907	22	0	38	10	30
S Branch Patapsco	2130908	23	0	33	11	33
Rocky Gorge Dam	2131107	15	0	40	12	33
Brighton Dam	2131108	17	0	41	25	17
Town Creek	2140512	5	0	84	7	4
Savage River	2141006	5	0	86	4	5

Note: 1. All values have been rounded to nearest whole number percentage.

Table A-3: MBSS Data for Sites with BIBI Sig > 3

MBSS Site	Epifaunal Substrate	Embeddedness
PRMO-110-R-2002	14	30
PRMO-115-R-2002	16	25
PRMO-202-R-2002	13	35
PRMO-304-R-2002	13	25
SENE-104-R-2001	10	25
UMON-119-R-2000	18	25
UMON-221-R-2000	16	30
UMON-230-R-2000	20	20
UMON-304-R-2000	16	30
DOUB-116-R-2002	16	20
DOUB-119-R-2002	12	35
DOUB-221-R-2002	14	35
DOUB-407-R-2002	8	45
CATO-104-R-2003	14	15
CATO-106-R-2003	14	30
CATO-214-R-2003	12	40
PRWA-103-R-2000	10	30
PRWA-122-R-2000	12	20
PRWA-124-R-2002	11	35
ANTI-113-R-2003	14	35
ANTI-208-R-2003	9	30
LCON-119-R-2004	15	25
LIKG-103-R-2004	18	20
LIKG-113-R-2004	16	25
LIKG-115-R-2004	8	42
LIKG-211-R-2004	16	30
PRAL-107-R-2001	14	15
PRAL-208-R-2001	16	10
SIDE-402-R-2001	16	15
SIDE-410-R-2001	16	20
FIMI-106-R-2000	12	10
FIMI-109-R-2000	17	10
FIMI-110-R-2000	14	10
FIMI-202-R-2000	14	10
FIMI-401-R-2000	17	10
FIMI-407-R-2000	18	10
TOWN-101-R-2000	11	25
TOWN-102-R-2000	10	10
TOWN-108-R-2002	15	20
TOWN-110-R-2000	15	10
TOWN-113-R-2000	11	15

MBSS Site	Epifaunal Substrate	Embeddedness
TOWN-116-R-2002	12	40
TOWN-205-R-2002	14	20
TOWN-408-R-2000	17	15
TOWN-409-R-2000	16	15
TOWN-412-R-2000	18	10
TOWN-417-R-2002	18	20
TOWN-419-R-2002	17	20
TOWN-420-R-2002	16	20
PRLN-104-R-2003	11	35
PRLN-107-R-2003	8	35
PRLN-108-R-2003	11	35
PRLN-109-R-2003	19	15
PRLN-113-R-2003	19	15
PRLN-115-R-2003	16	20
PRLN-119-R-2003	13	25
PRLN-122-R-2003	17	30
PRLN-201-R-2003	11	35
PRLN-306-R-2003	13	25
PRLN-316-R-2003	12	35
PRLN-318-R-2003	17	20
PRLN-321-R-2003	13	40
EVIT-102-R-2004	6	30
EVIT-110-R-2004	9	35
WILL-105-R-2004	10	35
WILL-109-R-2004	10	35
WILL-115-R-2004	15	30
WILL-120-R-2004	14	30
WILL-404-R-2004	10	25
GEOR-103-R-2003	16	45
GEOR-106-R-2003	13	35
GEOR-107-R-2003	12	35
GEOR-114-R-2003	12	35
GEOR-211-R-2003	12	30
PRUN-102-R-2001	14	45
PRUN-107-R-2001	17	15
PRUN-205-R-2001	18	15
SAVA-103-R-2002	12	30
SAVA-104-R-2002	19	15
SAVA-105-R-2002	13	35
SAVA-116-R-2002	15	25
SAVA-117-R-2002	12	20
SAVA-119-R-2002	18	15
SAVA-120-R-2002	17	15

MBSS Site	**Epifaunal Substrate**	**Embeddedness**
SAVA-206-R-2002	12	20
SAVA-308-R-2002	18	20
SAVA-312-R-2002	18	15
SAVA-401-R-2002	18	20
SAVA-410-R-2002	17	25
SAVA-414-R-2002	18	20
YOUG-101-R-2001	13	20
YOUG-106-R-2001	16	15
YOUG-107-R-2001	15	38
YOUG-117-R-2001	11	35
YOUG-123-R-2001	14	20
YOUG-208-R-2001	16	25
YOUG-221-R-2001	18	35
YOUG-320-R-2001	13	25
LYOU-110-R-2004	5	50
LYOU-118-R-2004	9	50
LYOU-219-R-2004	8	50
DCRL-109-R-2004	6	40
CASS-104-R-2000	17	15
CASS-106-R-2000	12	35
CASS-307-R-2000	14	25

Table A-4: Wills Creek MBSS data

Site	Date Sampled Summer	Date Sampled Spring	FIBI	BIBI	Epifaunal Substrate	Percent Embeddedness
WILL-105-R-2004	01JUN2004	11MAR2004	1.50	4.50	10	35
WILL-107-R-2004	07JUL2004	07APR2004	NS	1.25	NS	NS
WILL-109-R-2004	07JUL2004	11MAR2004	2.00	4.00	10	35
WILL-110-R-2004	01JUN2004	11MAR2004	2.50	3.00	16	30
WILL-115-R-2004	21JUL2004	25MAR2004	2.00	4.00	15	30
WILL-120-R-2004	01JUN2004	11MAR2004	2.50	4.75	14	30
WILL-212-R-2004	04AUG2004	07APR2004	2.00	1.25	8	60
WILL-219-R-2004	07JUL2004	11MAR2004	2.00	2.00	5	50
WILL-306-R-2004	11AUG2004	25MAR2004	3.67	2.50	15	30
WILL-404-R-2004	06SEP2004	07APR2004	4.33	3.75	10	25
Average			2.5± 0.39	3.1± 0.53		

Notes: 1. Summer sampling includes FIBI, epifaunal substrate, and embeddedness.
2. Spring sampling includes BIBI.
3. NS = No sample collected.

APPENDIX B

Table B-1: Wills Creek Permit Summary

MDE Permit #	NPDES	County	Facility	City	Type	TMDL
01DP0678	MD0000272	ALLEGANY	MT. SAVAGE FIREBRICK COMPANY	FROSTBURG	Industrial	WLA
02DP0023	MD0020818	ALLEGANY	STONER QUALITY WATER, INC., T/A CULLIGAN WATER CON	CORRINGANVILLE	Industrial	WLA
02DP3164	MD0067547	ALLEGANY	LAVALE SANITARY COMMISSION COMBINED SEWER OVERFLOW	LAVALE	Municipal	N/A [2]
01DP0567	MD0021598	ALLEGANY	CUMBERLAND WWTP [3]	CUMBERLAND	Municipal	WLA
00CM1719A	MDG851719A	ALLEGANY	UNITED ENERGY COAL - BRODE MINE #368	CLARYSVILLE	General - Mining	WLA
06CM0918	MDG850918	ALLEGANY	UNITED ENERGY COAL - PIG TOE MINE	FROSTBURG	General - Mining	WLA
06CM9608	MDG859608	ALLEGANY	MOUNTAINEER MINING - PORTER MINE	ECKHART MINES	General - Mining	WLA
02SW0208	N/A	ALLEGANY	CUMBERLAND CONCRETE CORPORATION	LAVALE	General - Industrial Stormwater	LA
02SW1127	N/A	ALLEGANY	IA CONSTRUCTION CORPORATION - ROCK CUT PLANT	CUMBERLAND	General - Industrial Stormwater	LA
02SW1130	N/A	ALLEGANY	MT. SAVAGE SPECIALTY REFRACTORIES	MT. SAVAGE	General - Industrial Stormwater	LA
02SW1336	N/A	ALLEGANY	SHA - FROSTBURG SHOP	FROSTBURG	General - Industrial Stormwater	LA

Notes: 1. TMDL column identifies how the permit was considered in the TMDL allocation.
2. The LaVale Sanitary Commission CSO was not considered in the TMDL, based on its published Long Term Control Plan, indicating complete elimination by 2023.

3. Though the Cumberland WWTP is officially permitted to the Lower North Branch Potomac River watershed, CSO data indicates overflows to the Georges Creek Watershed, and it is therefore assigned a WLA.

Table B-2: Municipal Permits

NPDES #	Facility	Observed flow (MGD)	Observed TSS (mg/l)	Observed TSS Load (ton/yr)	Design flow (MGD)	Permit TSS	Permit TSS Load (ton/yr)
MD0021598	CUMBERLAND WWTP[1]	0.008	100	1.2	N/A	N/A	N/A
	Total	0.008		1.2			

Note: 1. CSO estimated using MDE CSO overflow data from 2002 - 2006 with 100 mg/L TSS concentration.

Table B-3: Industrial Permits

Notes	NPDES	Facility	Design flow (MGD)	Permit TSS (mg/l)	Permit TSS Load (ton/yr)
1	MD0000272	MT. SAVAGE FIREBRICK COMPANY	0.0009	60	0.0822
2	MD0020818	STONER QUALITY WATER, INC., T/A CULLIGAN WATER CON	0.002	20	0.0152
		Total			0.14

Notes: 1. Permit TSS load calculated using design flow and permit TSS concentration limit.
2. Permit TSS load calculated using design flow and permit TSS concentration limit.

Table B-4: General Mining Permits

NPDES#	Permit #	Facility	Current Acres	Total Acres	Total Flow (gpd)	TSS Limit (mg/l)	TSS Load (Ton/yr)
MDG850918	06CM0918	UNITED ENERGY COAL – PIG TOE MINE	219.0	200.0	450.0	45	0.03
MDG851719A	00CM1719A	UNITED ENERGY COAL – BRODE MINE #368	48.0	48.0	0.0	45	0
MDG859608	06CM9608	MOUNTAINEER MINING – PORTER MINE	0.0	14.6	13,354.0	45	0.92
		Total	**267.0**	**262.6**	**13,804.0**		**0.95**