Total Maximum Daily Load of Sediment in the Potomac River Washington County Watershed, Washington County, 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
BSID	Biological Stressor Identification
CBP P4.3	Chesapeake Bay Program Model Phase 4.3
CBP P5.2	Chesapeake Bay Program Model Phase 5.2
CFS	Cubic Feet per Second
COMAR	Code of Maryland Regulations
CV	Coefficient of Variation
CWA	Clean Water Act
DNR	Maryland Department of Natural Resources
EOF	Edge-of-Field
EOS	Edge-of-Stream
EPA	Environmental Protection Agency
EPT	*Ephemeroptera*, *Plecoptera*, and *Trichoptera*
EPSC	Environmental Permit Service Center
ESD	Environmental Site Design
ETM	Enhanced Thematic Mapper
FIBI	Fish Index of Biologic Integrity
GIS	Geographic Information System
IBI	Index of Biotic Integrity
LA	Load Allocation
m	Meter
MAL	Minimum Allowable IBI Limit
MBSS	Maryland Biological Stream Survey
MD 8-Digit	Maryland 8-digit Watershed
MDE	Maryland Department of the Environment
MDL	Maximum Daily Load
MGD	Millions of Gallons per Day
mg/l	Milligrams per liter

MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NRI	Natural Resources Inventory
PCBs	Polychlorinated Biphenyls
PSU	Primary Sampling Unit
RESAC	Regional Earth Science Applications Center
SCS	Soil Conservation Service
TMDL	Total Maximum Daily Load
Ton/yr	Tons per Year
TSD	Technical Support Document
TSS	Total Suspended Solids
TM	Thematic Mapper
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WLA	Waste Load Allocation
WTP	Water Treatment Plant
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 Potomac River Washington County watershed (basin number 02140501) (2008 *Integrated Report of Surface Water Quality in Maryland* Assessment Unit ID: MD-02140501). 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 (CFR 2010b).

The Maryland Department of the Environment (MDE) has identified the waters of the Potomac River Washington County on the State's 2008 Integrated Report as impaired by nutrients – phosphorus (1996), sediments (1996), methylmercury (2002), impacts to biological communities (2002), and polychlorinated biphenyls (PCBs) in fish tissue (2008) (MDE 2008). The designated use of the Potomac River Washington County mainstem and its tributaries is Use I-P (water contact recreation, protection of aquatic life, and public water supply), except for Camp Spring Run, which is designated as Use III-P (nontidal cold water and public water supply) (COMAR 2010a,b,c).

The TMDL established herein by MDE will address the 1996 sediments listing, for which a data solicitation was conducted, and all readily available data from the past five years have been considered. A Water Quality Analysis (WQA) for eutrophication to address the nutrients/phosphorus listing is scheduled to be submitted to the EPA in 2010. In the 2012 Integrated Report, the listing for impacts to biological communities will include the results of a stressor identification analysis, and the PCBs in fish tissue and methylmercury listings will be addressed at a future date.

The Potomac River Washington County watershed aquatic life assessment scores, consisting of the Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI), indicate that the biological metrics for the watershed exhibit a significant negative deviation from reference conditions based on Maryland's biocriteria listing methodology. The biocriteria listing methodology assesses the overall average condition of Maryland's 8-digit (MD 8-digit) watersheds by measuring the percentage of sites, translated into watershed stream miles, that are assessed as having BIBI and/or FIBI scores significantly lower than 3.0 (on a scale of 1 to 5), and then calculating whether the percentage differs significantly from reference conditions (i.e., unimpaired watershed <10% of stream miles differ from reference conditions) (Roth et al. 2005; MDE 2008). The objective of the TMDL established herein is to ensure that watershed sediment loads are at a level to support the Use I-P/III-P designations for the Potomac River Washington County watershed, and more specifically, at a level to support aquatic life.

Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic life of nontidal stream systems. Therefore, to determine whether aquatic life is impacted by elevated sediment loads, MDE's *Biological Stressor Identification* (BSID) methodology was applied. The BSID identifies the most probable cause(s) for observed biological impairments throughout MD's 8-digit watersheds (1st though 4th order streams only, as assessed by the Maryland Biological Stream Survey (MBSS)) by ranking the likely stressors affecting a watershed using a suite of physical, chemical, and land use data. The ranking of stressors was conducted via a risk-based, systematic, weight-of-evidence approach. The risk-based approach estimates the strength of association between various stressors and an impaired biological community. The BSID analysis then identifies individual stressors (pollutants) as probable, possible, or unlikely causes of the poor biological conditions within a given MD 8-digit watershed and subsequently concludes whether or not these individual stressors or groups of stressors are contributing to the impairment (MDE 2009).

The BSID analysis for the Potomac River Washington County watershed concludes that biological communities are likely impaired due to flow/sediment related stressors. Individual stressors within the sediment and habitat parameters groupings that are associated with sediment related impacts and an altered hydrologic regime were identified as being probable causes of the biological impairment. Furthermore, the degradation of biological communities in the watershed is strongly associated with both agricultural and urban land use and their concomitant effects (MDE 2010a).

In order to quantify the impact of sediment on the aquatic life of non-tidal stream systems, a reference watershed TMDL 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. 1998, 2000; Stribling et al. 1998; MDE 2008). This threshold is then used to determine a watershed specific sediment TMDL.

The computational framework chosen for the Potomac River Washington County watershed TMDL was the Chesapeake Bay Program Phase 5.2 (CBP P5.2) watershed model target *edge-of-field* (EOF) land use sediment loading rate calculations combined with a *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 domain of the CBP P5.2 watershed model segmentation aggregates to the MD 8-digit watersheds, which is consistent with the impairment listing.

EPA's regulations require TMDLs to take into account seasonality and critical conditions for stream flow, loading, and water quality parameters (CFR 2010b). 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 reflect the impacts of stressors (i.e., sediment impacts to stream biota) over the course of time (i.e., captures the impacts of all high and low flow events).

Thus, critical conditions are inherently addressed. Seasonality is captured in two components. First, it is implicitly included in biological sampling as biological communities reflect the impacts of stressors over time, as described above. Second, the Maryland Biological Stream Survey (MBSS) dataset included benthic sampling in the spring and fish sampling in the summer.

All TMDLs need to be presented as a sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources generated within the assessment unit, accounting for natural background, tributary, and adjacent segment loads. Furthermore, 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 (CFR 2010a,b). The estimated variability around the reference watershed group used in this analysis already accounts for such uncertainty, and therefore the MOS is implicitly included.

The Potomac River Washington County Total Baseline Sediment Load is 16,215 tons per year (ton/yr), which can be further subdivided into a nonpoint source baseline load (Nonpoint Source BL_{PR}) and two types of point source baseline loads: National Pollutant Discharge Elimination System (NPDES) regulated stormwater (NPDES Stormwater BL_{PR}) and regulated process water (Process Water BL_{PR}) (see Table ES-1).

Table ES-1: Potomac River Washington County Baseline Sediment Loads (ton/yr)

Total Baseline Load (ton/yr)	=	Nonpoint Source BL_{PR}	+	NPDES Stormwater BL_{PR}	+	Process Water BL_{PR}
16,215	=	14,889	+	1,250	+	76

The Potomac River Washington County Average Annual TMDL of Sediment/Total Suspended Solids (TSS) is 14,196 tons per year. The Load Allocation (LA_{PR}) is 13,060 ton/yr, the NPDES Stormwater Waste Load Allocation (NPDES Stormwater WLA_{PR}) is 1,060 ton/yr, and the Process Water Waste Load Allocation (Process Water WLA_{PR}) is 76 ton/yr (see Table ES-2).

Table ES-2: Potomac River Washington County Average Annual TMDL of Sediment/Total Suspended Solids (ton/yr)

TMDL (ton/yr)	=	LA_{PR}	+	NPDES Stormwater WLA_{PR}	+	Process Water WLA_{PR}	+	MOS
14,196	=	13,060	+	1,060	+	76	+	Implicit

Table ES-3: Potomac River Washington County Baseline Load, TMDL, and Total Reduction Percentage

Baseline Load (ton/yr)	TMDL (ton/yr)	Total Reduction (%)
16,215	14,196	12.5

Since: 1) the BSID analysis only applies to the 1st through 4th order streams within a MD 8-Digit watershed, as assessed by the MBSS; and 2) the biological results from the Maryland Department of Natural Resources (DNR) Core/Trend stations along the mainstem of the Potomac River Washington County indicate that mainstem water quality can be classified as good, MDE concluded that the sediment impairment in the Potomac River Washington County watershed is restricted to the lower order streams within the watershed. Therefore, this sediment TMDL will be restricted to the tributaries in the watershed draining to the Potomac River and will exclude the mainstem of the Potomac River itself (also, the baseline loading calculations are restricted to the MD 8-digit watershed only and do not include upstream loads, which empty into the mainstem).

This TMDL will ensure that watershed sediment loads are at a level to support the Use I-P/III-P designations for the Potomac River Washington County watershed, and more specifically, at a level to support aquatic life. The TMDL, however, will not completely resolve the impairment to biological communities within the watershed. Since the BSID watershed analysis identifies other possible stressors (i.e., chlorides and sulfates) as impacting the biological conditions, this impairment remains to be fully addressed through the Integrated Report listing process and the TMDL development process, such that all impairing substances identified as impacting biological communities in the watershed are reduced to levels that will meet water quality standards, as established in future TMDLs for those substances (MDE 2009, 2010a).

In addition to the TMDL value, a Maximum Daily Load (MDL) is also presented in this document. The calculation of the MDL, which is derived from the TMDL average annual loads, is explained in Appendix C and presented in Table C-1.

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 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 are available for local governments for implementation, such as the Buffer Incentive Program (BIP), 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.

1.0 INTRODUCTION

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes a Total Maximum Daily Load (TMDL) for sediment in the Potomac River Washington County watershed (basin number 02140501) (2008 *Integrated Report of Surface Water Quality in Maryland* Assessment Unit ID: MD-02140501). Section 303(d)(1)(C) of the federal Clean Water Act (CWA) and the EPA's implementing regulations direct each state to develop a TMDL for each impaired water quality limited segment (WQLS) on the State's Integrated Report, taking into account seasonal variations, critical conditions, and a protective margin of safety (MOS) to account for uncertainty (CFR 2010b). 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 the Potomac River Washington County on the State's 2008 Integrated Report as impaired by nutrients – phosphorus (1996), sediments (1996), methylmercury (2002), impacts to biological communities (2002), and polychlorinated biphenyls (PCBs) in fish tissue (2008) (MDE 2008). The designated use of the Potomac River Washington County mainstem and its tributaries is Use I-P (water contact recreation, protection of aquatic life, and public water supply), except for Camp Spring Run, which is designated as Use III-P (nontidal cold water and public water supply) (COMAR 2010a,b,c).

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The objective of the TMDL established herein is to ensure that watershed sediment loads are at a level to support the Use I-P/III-P designations for the Potomac River Washington County watershed, and more specifically, at a level to support aquatic life. Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic life of nontidal stream systems. Therefore, to determine whether aquatic life is impacted by elevated sediment loads, MDE's *Biological Stressor Identification* (BSID) methodology was applied.

The BSID identifies the most probable cause(s) for observed biological impairments throughout Maryland's 8-digit (MD 8-digit) watersheds (1st though 4th order streams only, as assessed by the Maryland Biological Stream Survey (MBSS)) by ranking the likely stressors affecting a watershed using a suite of physical, chemical, and land use data. The ranking of stressors was conducted via a risk-based, systematic, weight-of-evidence approach. The risk-based approach estimates the strength of association between various stressors and an impaired biological community. The BSID analysis then identifies individual stressors (pollutants) as probable, possible, or unlikely causes of the poor biological conditions within a given MD 8-digit watershed and subsequently concludes whether or not these individual stressors or groups of stressors are contributing to the impairment (MDE 2009).

In order to quantify the impact of sediment on the aquatic life of non-tidal stream systems, a reference watershed TMDL 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. 1998, 2000; Stribling et al. 1998; MDE 2008). This threshold is then used to determine a watershed specific sediment TMDL.

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1 General Setting

Location

The Potomac River Washington County watershed is located in the Upper Potomac River sub-basin of the Chesapeake Bay watershed and covers approximately 58,580 acres (Figure 1). The Washington County portion of the Potomac River is defined as the reach that starts at the confluence of the Potomac River with the Little Tonoloway Creek and ends at the confluence with the Shenandoah River. The 68 mile southeastward journey of the river creates the border between Maryland and West Virginia. Major tributaries include Camp Spring Run, Ditch Run, Downey Branch, and Greenspring Run. The region is mostly forested and rural. The two largest urban centers in the watershed are Hancock and Williamsport.

The assessment unit identified on the Maryland 2008 Integrated Report and consequently addressed by this TMDL consists only of the Potomac River Washington County watershed and includes only those streams that drain directly to the Potomac River mainstem. There are no "high quality," or Tier II, stream segments (Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI) aquatic life assessment scores > 4 (scale 1-5)) located within the watershed requiring the implementation of Maryland's anti-degradation policy (COMAR 2010d; MDE 2010b). Approximately 5.4% of the watershed area is covered by water (i.e., streams, ponds, etc.), most of which is accounted for by the mainstem Potomac River. The total population in the Potomac River Washington County watershed is approximately 23,900 (US Census Bureau 2000).

Geology/Soils

The Potomac River Washington County watershed lies within the Eastern Valley and Ridge Physiographic Province and is characterized by numerous ridges and valleys that run generally northeast to southwest (Schmidt 1993). The Ridge and Valley Province, which extends from South Mountain in eastern Washington County to Dans Mountain in western Allegany County, contains strongly folded and faulted sedimentary rocks. In the eastern part of the Ridge and Valley Province in Washington County, a wide, open valley called the Great Valley, or the Hagerstown Valley, is formed on Cambrian and Ordovician age carbonate rocks. In Washington County west of Powell Mountain, a more rugged terrain has developed on shale and sandstone bedrock which ranges in age from Silurian to Mississippian. Some of the valleys in this region are underlain by Silurian and Devonian age limestones (MGS 2010). Limestones and shales, are susceptible to erosion and dissolution from ground water, creating surface sinkholes and underground caverns and streams (USDA 2001).

The soil structure of the watershed is very complex and includes the Hagerstown-Duffield-Clarksburg series (38% of watershed area), Berks-Weikert-Bedington series (18%), Waynesboro-Hagerstown-Huntington series (10%), and Wallen-Dekalb-Drypond series (7%). These series consist of deep to very deep, moderately well drained or well drained soils with moderate to moderately rapid permeability. These soils formed from limestones, shales, siltstones, or sandstones (USDA 2001, 2006). The Allegheny-Pope-Philo series, which covers seven percent of the watershed, occurs on floodplains along the Potomac River. It consists of moderately deep to very deep, moderately well drained to well drained soils with moderate or moderately rapid permeability (USDA 2001, 2006). Several other soil series each cover less than seven percent of the watershed.

Soil type for the Potomac River Washington County watershed is also characterized by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) via four hydrologic soil groups: Group A soils have high infiltration rates and are typically deep well drained/excessively drained sands or gravels; Group B soils have moderate infiltration rates and consist of moderately deep-to-deep and moderately well-to-well drained soils, with moderately fine/coarse textures; Group C soils have slow infiltration rates with a layer that impedes downward water movement, and they primarily have moderately fine-to-fine textures; Group D soils have very slow infiltration rates consisting of clay soils with a permanently high water table that are often shallow over nearly impervious material. The actual Potomac River Washington County watershed is comprised primarily of Group B soils (41.3%) and Group C soils (41.3%), with a small portion of the watershed consisting of Group D soils (10.4%) and Group A soils (3.0%) (USDA 2006).

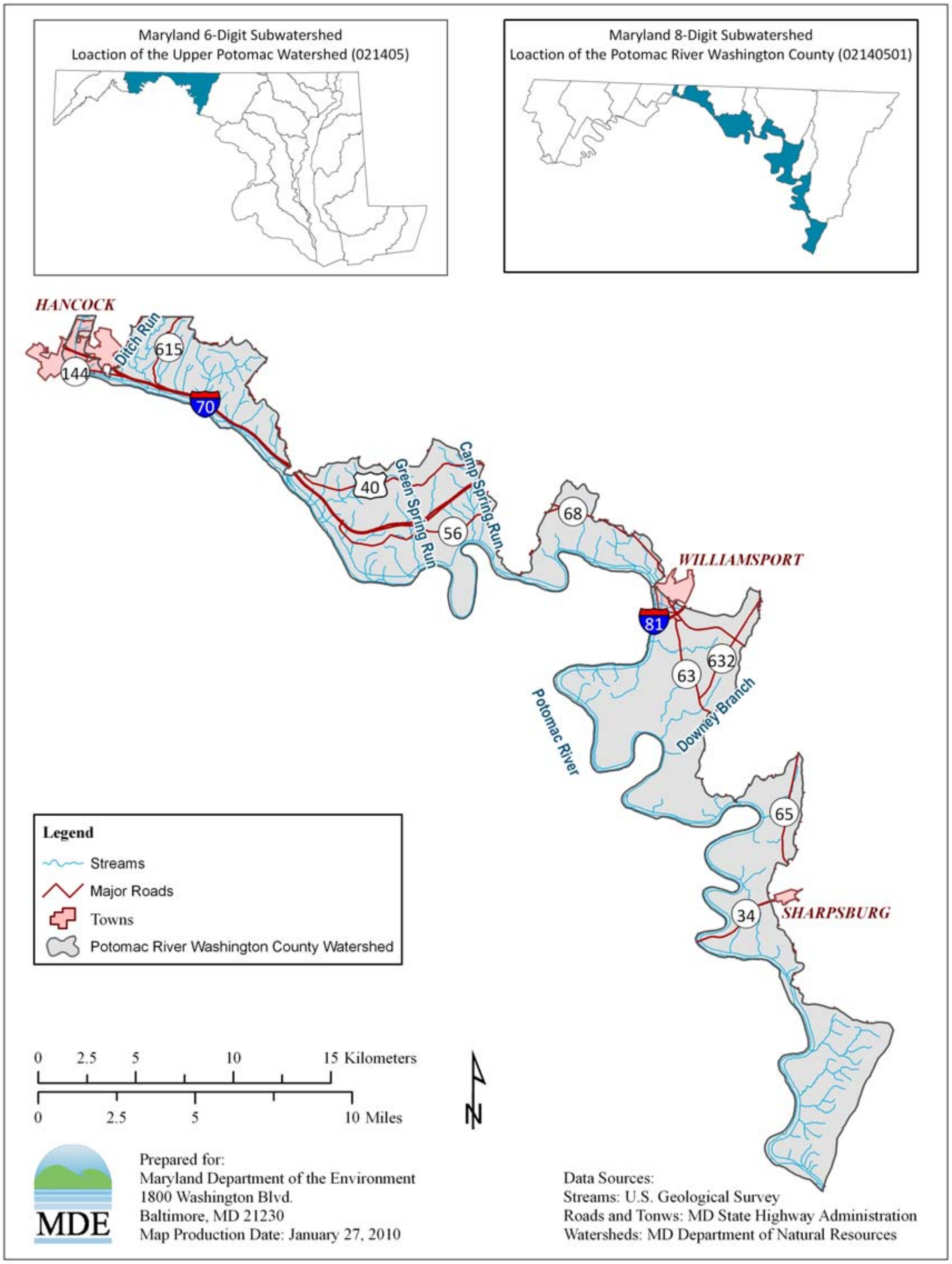

Figure 1: Location Map of the Potomac River Washington County in Washington County, Maryland

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 5.2 (CBP P5.2) watershed model.[1] The CBP P5.2 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 2001 satellite imagery (Landsat 7-Enhanced 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 agricultural land uses. In order to develop accurate agricultural land use calculations, the CBP P5.2 used county level U.S. Agricultural Census data as a second layer (USDA 1982, 1987, 1992, 1997, 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 uses 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 P5.2 land use does not exist in a single GIS coverage; instead it is only available in a tabular format. The CBP P5.2 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 13 classes with distinct sediment erosion rates. Table 1 lists the CBP P5.2 generalized land uses, detailed land uses, which are classified by their erosion rates, and the acres of each land use in the Potomac River Washington County watershed. Details of the land use development methodology have been summarized in the report entitled *Chesapeake Bay Phase 5 Community Watershed Model* (US EPA 2010).

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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.

Potomac River Washington County Watershed Land Use Distribution

The Potomac River Washington County watershed consists mostly of forest land use (52.9%) and crop land use (26.3%). There are also smaller amounts of urban (11.9%) and pasture (8.7%). A detailed summary of the watershed land use areas is presented in Table 1, and a land use map is provided in Figure 2.

Table 1: Land Use Percentage Distribution for the Potomac River Washington County Watershed

General Land Use	Detailed Land Use	Area (Acres)	Percent	Grouped Percent of Total
Forest	Forest	29,003.2	52.4	52.9
	Harvested Forest	293.0	0.5	
Crop	Animal Feeding Operations	39.0	0.1	26.3
	Hay	6,856.6	12.4	
	High Till	2,807.1	5.1	
	Low Till	4,890.8	8.8	
	Nursery	0.7	0.0	
Pasture	Pasture	4,820.3	8.7	8.7
	Trampled Pasture	0.0	0.0	
Extractive	Extractive	82.1	0.1	0.1
Urban	Barren	31.8	0.1	11.9
	Impervious	583.2	1.1	
	Pervious	5,990.6	10.8	
Total		**55,398.4**	**100.0**	**100.0**

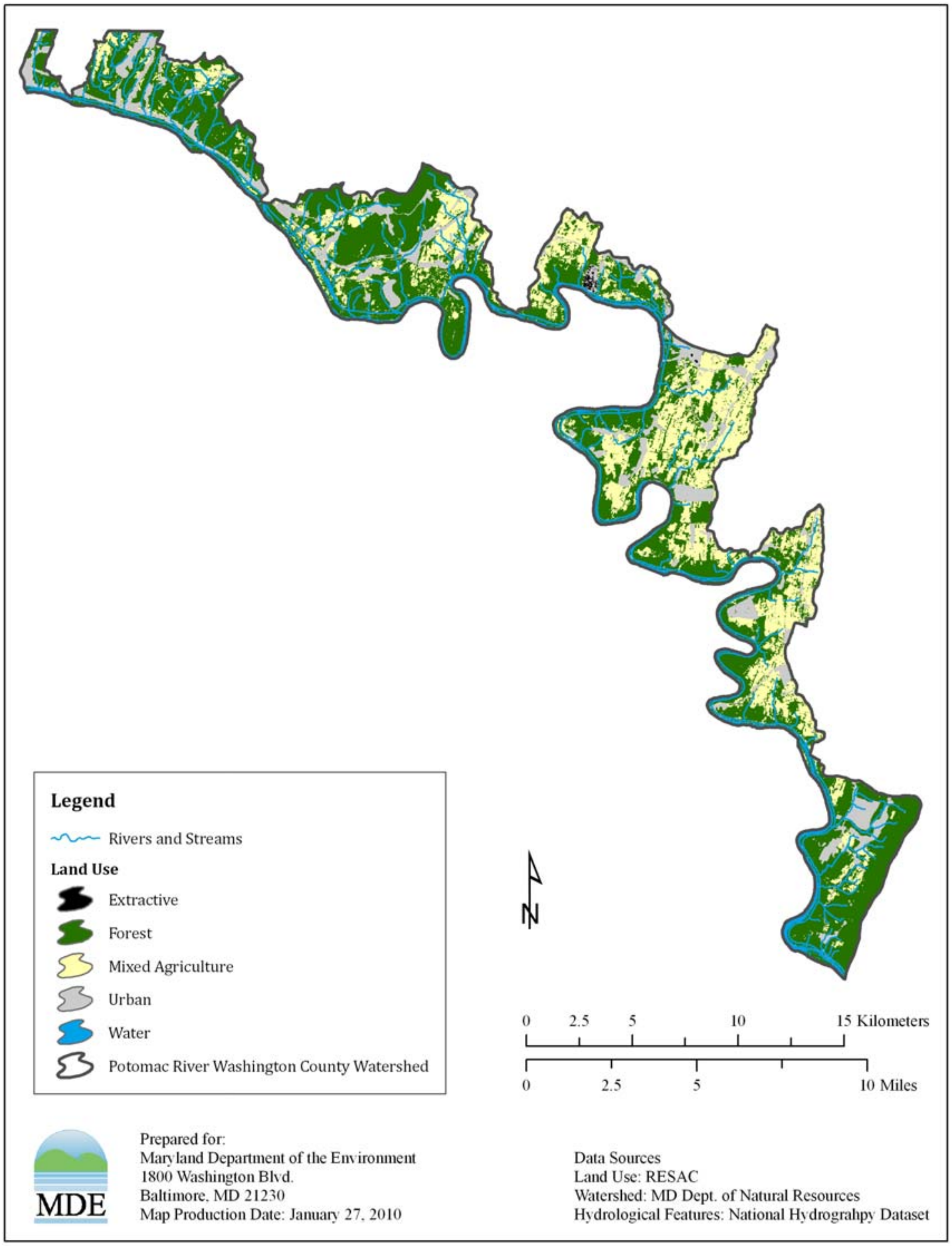

Figure 2: Land Use of the Potomac River Washington County Watershed

2.2 Source Assessment

The Potomac River Washington County Total Baseline Sediment Load only consists of loads generated within the 8-digit assessment unit and can be subdivided into nonpoint and point source loads. This section summarizes the methods used to derive each of these distinct source categories.

2.2.1 Nonpoint Source Assessment

In this document, the nonpoint source loads account for sediment loads from unregulated stormwater runoff within the Potomac River Washington County watershed. This section provides the background and methods for determining the nonpoint source baseline loads generated within the Potomac River Washington County watershed (Nonpoint Source BL_{PR}).

General Load Estimation Methodology

Nonpoint source sediment loads generated within the Potomac River Washington County watershed are estimated based on the *edge-of-stream (EOS) calibration target loading rates* from the CBP P5.2 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 5 Community Watershed Model* (US EPA 2010).

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 Natural Resource Inventory (NRI). NRI is a statistical survey of land use and natural resource conditions conducted by the Natural Resources Conservation Service (NRCS) (USDA 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 Chesapeake Bay Program Phase 4.3 (CBP P4.3) 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 P5.2 model.

The average value of the 1982 and 1987 surveys was used as the basis for EOF target rates for pasture and cropland. 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. To compensate for this, a BMP factor was included in the loading estimates using best available "draft" information from the CBP P5.2. For further details regarding EOF Erosion rates, please see Section 9.2.1 of the community watershed model documentation (US EPA 2010).

Rates for urban pervious, urban impervious, extractive, 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 Potomac River Washington County watershed.

Table 2: Summary of EOF Erosion Rate Calculations

Land Use	Data Source	Washington County (tons/acre/year)
Forest	Phase 2 NRI	0.31
Harvested Forest[1]	Average Phase 2 NRI (x 10)	3
Animal Feeding Operations[2]	Pasture NRI (x 9.5)	12.16
Hay[2]	Crop NRI (1982-1987) (x 0.32)	1.6
High Till[2]	Crop NRI (1982-1987) (x 1.25)	6.24
Low Till[2]	Crop NRI (1982-1987) (x 0.75)	3.74
Nursery[2]	Pasture NRI (x 9.5)	12.16
Pasture	Pasture NRI (1982-1987)	1.28
Trampled pasture[2]	Pasture NRI (x 9.5)	12.16
Extractive	Best professional judgment	10
Barren	Literature survey	12.50
Impervious	100% Impervious Regression Analysis	5.18
Pervious Urban	Intercept Regression Analysis	0.74

Notes: [1]Based on an average of NRI values for the Chesapeake Bay Phase 5 segments.
[2]NRI score data adjusted based on land use.

Sediment Delivery Ratio: The base formula for calculating *sediment delivery ratios* in the CBP P5.2 model is the same as the formula used by the NRCS (USDA 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 changes in sediment loads due to distance traveled to the stream, the CBP P5.2 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 ratio*s 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

Edge-of-stream (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. The formula for the EOS loads calculation is as follows:

$$\sum_{i}^{n} EOS = Acres_i * EOF_i * SDR_i * BMP_i \qquad \text{(Equation 2.2)}$$

where:
- n = number of land use classifications
- i = land use classification
- EOS = Edge of stream load, tons/yr
- Acres = acreage for land use i
- EOF = Edge-of-field erosion rate for land use i, tons/ac/yr
- SDR = sediment delivery ratio for land use i, per Equation 2.1
- BMP = BMP factor for land use i, as applicable

2.2.2 Point Source Assessment

A list of eight active permitted point sources that contribute to the sediment load in the Potomac River Washington County watershed was compiled using MDE's Environmental Permit Service Center (EPSC) database. The types of permits identified include individual industrial, individual municipal, individual municipal separate storm sewer systems (MS4s), general mineral mining, and general MS4s. The permits can be grouped into two categories, process water and stormwater. The process water category includes those loads generated by continuous discharge sources whose permits have TSS limits. Other permits that do not meet these conditions are considered *de minimis* in terms of the total sediment load. The stormwater category includes all National Pollutant Discharge Elimination System (NPDES) regulated stormwater discharges.

The sediment loads for the six process water permits (Process Water BL_{PR}) are calculated based on their total suspended solids TSS limits (average monthly or weekly concentration values) and corresponding flow information. The NPDES Phase I or Phase II stormwater permits identified throughout the Potomac River Washington County watershed are regulated based on BMPs and do not include TSS limits. In the absence of TSS limits, the NPDES regulated stormwater baseline load (NPDES Stormwater BL_{PR}) is calculated using the portion of the urban land use within the watershed representative of the NPDES regulated stormwater sources, Equation 2.2, and watershed specific urban land use factors. A detailed list of the permits appears in Appendix B.

2.2.3 Summary of Baseline Loads

Table 3 summarizes the Potomac River Washington County Baseline Sediment Load, reported in tons per year (ton/yr) and presented in terms of nonpoint and point source loadings.

Table 3: Potomac River Washington County Baseline Sediment Loads (ton/yr)

Total Baseline Load (ton/yr)	=	Nonpoint Source BL_{PR}	+	NPDES Stormwater BL_{PR}	+	Process Water BL_{PR}
16,215	=	14,889	+	1,250	+	76

Table 4 presents a breakdown of the Potomac River Washington County Total Baseline Sediment Load, detailing loads per land use. The largest portion of the sediment load is from crop land (57.5%). The remainder of the sediment load stems from forest (15.1%), pasture (14.4%), urban land (10.9%), and extractive (1.7%). Although process water sources account for 0.5% of the overall load, there is only one significant process water source in the watershed, the R. Paul Smith Power Plant in Williamsport, which discharges directly into the Potomac River. This source accounts for over 99% of the process water load.

Table 4: Detailed Baseline Sediment Budget Loads Within the Potomac River Washington County Watershed

General Land Use	Detailed Land Use	Load (ton/yr)	Percent	Grouped Percent of Total
Forest	Forest	2,225.7	13.7	15.1
	Harvested Forest	218.6	1.3	
Crop	Animal Feeding Operations	98.8	0.6	57.5
	Hay	2,181.8	13.5	
	High Till	3,323.2	20.5	
	Low Till	3,720.3	22.9	
	Nursery	1.9	0.0	
Pasture	Pasture	2,330.0	14.4	14.4
	Trampled Pasture	0.0	0.0	
Extractive	Extractive	274.2	1.7	1.7
Urban[1]	Barren	86.2	0.5	10.9
	Impervious	692.0	4.3	
	Pervious	986.5	6.1	
	Process Water	75.9	0.5	0.5
Total		**16,215.1**	**100.0**	**100.0**

Note: [1] The urban land use load includes, but is not limited to, the permitted stormwater load.

2.3 Water Quality Characterization

The Potomac River Washington County 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 that elevated sediments were a concern, and it has been determined that the sediment listing was based on best professional judgment (MDE 2004; DNR 1996).

Currently in Maryland, there are no specific numeric criteria for suspended sediments. Therefore, to determine whether aquatic life is impacted by elevated sediment loads, MDE's BISD methodology was applied. The primary goal of the BSID analysis is to identify the most probable cause(s) for observed biological impairments throughout MD's 8-digit watersheds (MDE 2009).

The BSID analysis applies a case-control, risk-based, weight-of-evidence approach to identify potential causes of biological impairment. The risk-based approach estimates the strength of association between various stressors and an impaired biological community. The BSID analysis then identifies individual stressors as probable or unlikely causes of the poor biological conditions within a given MD 8-digit watershed, and subsequently reviews ecological plausibility. Finally, the analysis concludes whether or not these individual stressors or groups of stressors are contributing to the impairment (MDE 2009).

The primary dataset for BSID analysis is Maryland Department of Natural Resources (DNR) MBSS round two data (collected between 2000-2004) because it provides a broad spectrum of paired data variables, which allow for a more comprehensive stressor analysis. The MBSS is a robust statewide probability-based sampling survey for assessing the biological conditions of wadeable, non-tidal streams (Klauda et al. 1998; Roth et al. 2005). It uses a fixed length (75 meter (m)) randomly selected stream segment for collecting site level information within a primary sampling unit (PSU), also defined as a watershed. The randomly selected stream segments, from which field data are collected, are selected using either stratified random sampling with proportional allocation, or simple random sampling (Cochran 1977). The random sample design allows for unbiased estimates of overall watershed conditions. Thus, the dataset facilitated case-control analyses because: 1) in-stream biological data are paired with chemical, physical, and land use data variables that could be identified as possible stressors; and 2) it uses a probabilistic statewide monitoring design.

The BSID analysis combines the individual stressors (physical and chemical variables) into three generalized parameter groups in order to assess how the resulting impacts of these stressors can alter the biological community and structure. The three generalized parameter groups include: sediment, habitat, and water chemistry. Identification of a sediment/flow stressor as contributing to the biological impairment is based on the results of the individual stressor associations within both the sediment and habitat parameter groups that reveal the effects of sediment related impacts or an altered hydrologic regime (MDE 2009).

The BSID applies only to 1st through 4th order streams in a MD 8-digit watershed, as assessed by the MBSS. In larger order rivers and streams, support of the aquatic life designated use has been evaluated based on assessments from DNR's Core/Trend program. The program collected benthic macroinvertebrate data between 1976 and 2006. This data was used to calculate four benthic community measures: total number of taxa, the Shannon Weiner diversity index, the modified Hilsenhoff biotic integrity index, and percent *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT). DNR has extensive monitoring data for two stations on the mainstem of the Potomac River Washington County through the Core/Trend program. These stations have between 19 and 26 years of benthic macroinvertebrate data (DNR 2007).

Potomac River Washington County Watershed Monitoring Stations

A total of 31 water quality monitoring stations were used to characterize the Potomac River Washington County watershed. Twenty-nine biological/physical habitat monitoring stations from the MBSS program round one and round two data collection were used to describe the Potomac River Washington County watershed in Maryland's 2008 Integrated Report[2]. The BSID analysis used the 24 biological/physical habitat

[2] The 2008 Integrated Report includes one extraneous site.

monitoring stations from the MBSS program round two data collection. Additionally, two biological monitoring stations from the Maryland Core/Trend monitoring network were applied within the TMDL analysis as well. All stations are presented in Figure 3 and listed in Table 5.

Table 5: Monitoring Stations in the Potomac River Washington County Watershed

Site Number	Sponsor	Site Type	Location	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
WA-A-005-118-95	DNR	MBSS ROUND 1	Ditch Run	39.6998	-78.1411
WA-A-022-120-95	DNR	MBSS ROUND 1	Potomac River Unnamed Tributary 4	39.7051	-78.0722
WA-A-101-219-95	DNR	MBSS ROUND 1	Ditch Run Unnamed Tributary 1	39.7051	-78.1379
WA-V-176-109-95	DNR	MBSS ROUND 1	Potomac River Unnamed Tributary 1	39.4346	-77.7651
WA-V-193-110-95	DNR	MBSS ROUND 1	Potomac River Unnamed Tributary 2	39.5703	-77.8172
PRWA-103-R-2000	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 8	39.6679	-78.0598
PRWA-104-R-2000	DNR	MBSS ROUND 2	Green Spring Run Unnamed Tributary 1	39.6290	-77.9682
PRWA-106-R-2000	DNR	MBSS ROUND 2	Downey Branch	39.5429	-77.8021
PRWA-119-R-2000	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 9	39.7011	-78.1761
PRWA-122-R-2000	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 10	39.7009	-78.1262
PRWA-102-R-2002	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 17	39.3881	-77.7298
PRWA-114-R-2002	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 15	39.3649	-77.7260
PRWA-120-R-2002	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 16	39.3776	-77.7245
PRWA-124-R-2002	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 17	39.3928	-77.7070
PRWA-125-R-2002	DNR	MBSS ROUND 2	Ditch Run Unnamed Tributary2	39.7202	-78.1317
PRWA-206-R-2002	DNR	MBSS ROUND 2	Green Spring Run	39.6238	-77.9757
PRWA-215-R-2002	DNR	MBSS ROUND 2	Camp Spring Run	39.6241	-77.9371
PRWA-217-R-2002	DNR	MBSS ROUND 2	Camp Spring Run	39.6311	-77.9384
COCA-101-N-2003	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 9	39.6969	-78.1738
COCA-105-N-2003	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 15	39.3608	-77.7392
COCA-106-N-2003	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 17	39.3862	-77.7352
COCA-110-N-2003	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 8	39.6572	-78.0607
COCA-114-N-2003	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 24	39.6727	-78.0827
COCA-115-N-2003	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 23	39.6161	-77.8764
COCA-203-N-2003	DNR	MBSS ROUND 2	Ditch Run	39.6906	-78.1335
COCA-118-N-2004	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 16	39.3670	-77.7383
COCA-119-N-2004	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 31	39.6100	-77.8417
COCA-121-N-2004	DNR	MBSS ROUND 2	Potomac River Unnamed Tributary 30	39.6372	-78.0325
NCRW-206-N-2004	DNR	MBSS ROUND 2	Green Spring Run	39.6083	-77.9706
POT1830	DNR	Core/Trend	Potomac River	39.4365	-77.8018
POT2386	DNR	Core/Trend	Potomac River	39.6974	-78.1763

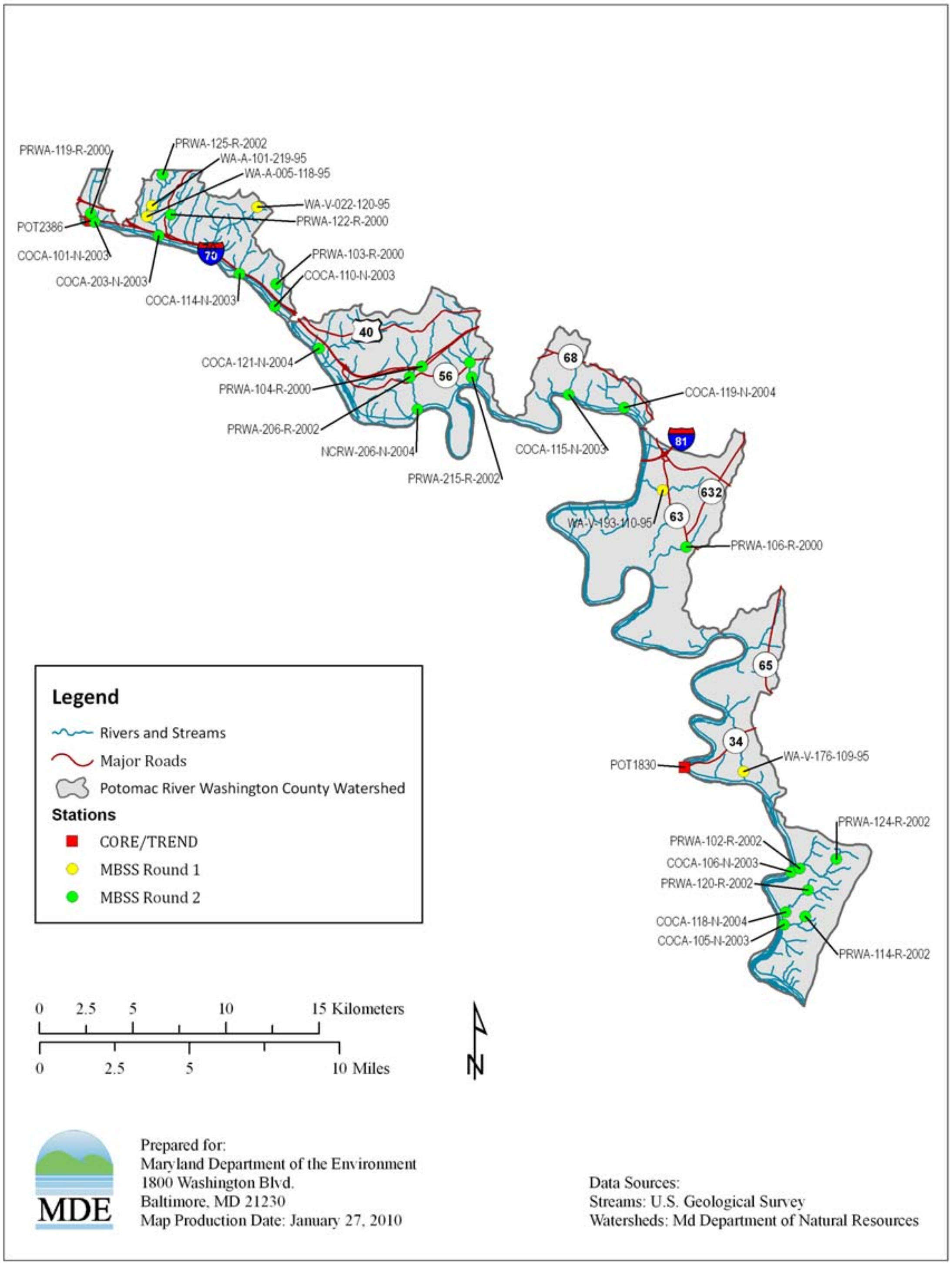

Figure 3: Monitoring Stations in the Potomac River Washington County Watershed

2.4 Water Quality Impairment

The Maryland water quality standards surface water use designation for the Potomac River Washington County and its tributaries is Use I-P (water contact recreation, protection of aquatic life, and public water supply), except for Camp Spring Run, which is designated as Use III-P (nontidal cold water and public water supply) (COMAR 2010a,b,c). The water quality impairment of the Potomac River Washington County watershed addressed by this TMDL is caused by an elevated sediment load beyond a level that the watershed can sustain, thereby causing sediment related impacts that can not support aquatic life. Assessment of aquatic life is based on benthic and fish Index of Biotic Integrity (IBI) scores, as demonstrated via the BSID analysis for the watershed.

The Potomac River Washington County watershed is listed on Maryland's 2008 Integrated Report as impaired for impacts to biological communities. The biological assessment is based on the combined results of MBSS round one (1995-1997) and round two (2000-2004) data, which includes 29 stations. Twenty-one of the 29 stations, or 73% of the stream miles in the watershed, are assessed as having BIBI and/or FIBI scores significantly lower than 3.0 (on a scale of 1 to 5) (MDE 2008). As mentioned in Section 2.3, however, only MBSS round two data were used in the BSID analysis. See Figure 3 and Table 5 for station locations and information.

The results of the BSID analysis for the Potomac River Washington County watershed are presented in a report entitled *Watershed Report for Biological Impairment of the Potomac River Watershed in Washington County, Maryland Biological Stressor Identification Analysis Results and Interpretation*. The report states that the degradation of biological communities in the Potomac River Washington County watershed is strongly associated with both agricultural and urban land use and its concomitant effects (MDE 2010a).

The BSID analysis has determined that the biological impairment in the Potomac River Washington County watershed is due in part to flow/sediment related stressors. Specifically, the analysis confirmed that individual stressors within the sediment and habitat parameter groupings were contributing to the biological impairment in the watershed. Overall, sediment and flow stressors within the sediment and habitat parameter groupings were identified as having a statistically significant association with impaired biological communities at approximately 73% and 56%, respectively, of the sites with BIB and/or FIBI scores significantly less than 3.0 throughout the watershed (MDE 2010a). Therefore, since sediment is identified as a stressor to the biological communities in the Potomac River Washington County watershed, a TMDL is required.

The BSID applies only to 1^{st} through 4^{th} order streams in a watershed, as assessed by the MBSS. DNR has assessed the mainstem Potomac River in Washington County for the Core/Trend program. As shown in Table 6, the biological monitoring results from the two DNR Core/Trend stations along the mainstem of the Potomac River Washington County indicate that mainstem water quality can be classified as good. Statistical analysis of the long term Core/Trend data indicates that since 1977, one station has shown improvement and one station has shown no change. Both stations are ranked as having good water quality based on percent EPT, taxa number, biotic index, and diversity index (DNR 2007).

Since the Core/Trend Data indicate that the mainstem Potomac River in Washington County is supporting its aquatic life designated use, it is not impaired by sediment, and MDE concludes that the sediment impairment identified via the BSID analysis is solely within the lower order (smaller) streams in the Potomac River Washington County watershed. Therefore, this sediment TMDL for the Potomac River Washington County will be restricted to the tributaries in the watershed draining to the Potomac River and will exclude the mainstem of the Potomac River itself (also, baseline loading calculations described in Section 2.2 are restricted to the MD 8-digit watershed only and do not include upstream loads, which empty into the mainstem).

Table 6: Potomac River Washington County Core/Trend Data

Site Number	Current Water Quality Status	Trend Since 1970's
POT1830	Good	Slight degradation
POT2386	Good/Very good	Moderate improvement

3.0 TARGETED WATER QUALITY GOAL

The objective of the sediment TMDL established herein is to reduce sediment loads, and subsequent effects on aquatic life in the 1st through 4th order streams in the Potomac River Washington County watershed, to levels that support the Use I-P/III-P designations (water contact recreation, protection of aquatic life, and public water supply/nontidal cold water and public water supply) (COMAR 2010a,b,c). Assessment of aquatic life is based on Maryland's biocriteria protocol, which evaluates both the amount and diversity of the benthic and fish community through the use of the IBI (Roth et al. 1998, 2000; Stribling et al. 1998; MDE 2008).

Reductions in sediment loads are expected to result from decreased watershed and streambed erosion, which will then lead to improved benthic and fish habitat conditions. Specifically, sediment load reductions are expected to result in an increase in the number of benthic sensitive species present, an increase in the available and suitable habitat for a benthic community, a possible decrease in fine sediment (fines), and improved stream habitat diversity, all of which will result in improved water quality.

The sediment TMDL, however, will not completely resolve the impairment to biological communities in the 1st through 4th order streams within the watershed. Since the BSID watershed analysis identifies other possible stressors (i.e., chlorides and sulfates) as impacting the biological conditions, this impairment remains to be fully addressed through the Integrated Report listing process and the TMDL development process, such that all impairing substances identified as impacting biological communities in the watershed are reduced to levels that will meet water quality standards, as established in future TMDLs for those substances (MDE 2009, 2010a).

The mainstem of the Potomac River in Washington County is not impaired by sediment. The TMDL will be restricted to the 1st through 4th order tributaries to the Potomac River in Washington County and exclude the mainstem Potomac River. Hereafter, unless otherwise noted, "Potomac River Washington County" will refer to these 1st through 4th order tributaries to the Potomac River. Process water facilities discharging to the mainstem Potomac River will receive wasteload allocations and be included in the overall process water wasteload allocation for information purposes only (also, baseline loading calculations described in Section 2.2 are restricted to the MD 8-digit watershed only and do not include upstream loads, which empty into the mainstem).

4.0 TOTAL MAXIMUM DAILY LOADS AND SOURCE ALLOCATION

4.1 Overview

This section describes how the sediment TMDL and the corresponding allocations were developed for the Potomac River Washington County 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, and Section 4.7 explains the rationale for the MOS. Finally, Section 4.8 summarizes the TMDL.

4.2 Analysis Framework

Since there are no specific numeric criteria that quantify the impact of sediment on the aquatic life of nontidal stream systems, a reference watershed approach will be used to establish the TMDL. Furthermore, as the BSID analysis established a link between biological impairment and sediment related stressors, the reference watershed approach will utilize a biological endpoint.

Watershed Model

The watershed model framework chosen for the Potomac River Washington County watershed TMDL was the CBP P5.2 long-term average annual watershed model EOS loading rates. The spatial domain of the CBP P5.2 watershed model segmentation aggregates to the MD 8-digit watersheds, which is consistent with the impairment listing. The EOS loading rates were used because actual time variable CBP P5.2 calibration and scenario runs were not available upon development of the nontidal sediment TMDL methodology (Currey et al. 2006). These target-loading rates have been used to calibrate the land use EOS loads within the CBP P5.2 model and thus should be consistent with future CBP modeling efforts.

The nonpoint source and NPDES stormwater baseline sediment loads generated within the Potomac River Washington County watershed are calculated as the sum of corresponding land use EOS loads within the watershed and represent a long-term average loading rate. Individual land use EOS loads are calculated as a product of the land use area, land use target loading rate, and loss from the EOF to the main channel. The loss from the EOF to the main channel is the *sediment delivery ratio* and is defined as the ratio of the sediment load reaching a basin outlet to the total erosion within the basin. A *sediment delivery ratio* is estimated for each land use type based on the proximity of the land use to the main channel. Thus, as the distance to the main channel increases, more sediment is stored within the watershed (i.e., *sediment delivery ratio* decreases). Details of the data sources for the unit loading rates can be found in Section 2.2 of this report.

The Potomac River Washington County was evaluated using one watershed TMDL Segment consisting of 11 CBP P5.2 model segments (See Figure 4).

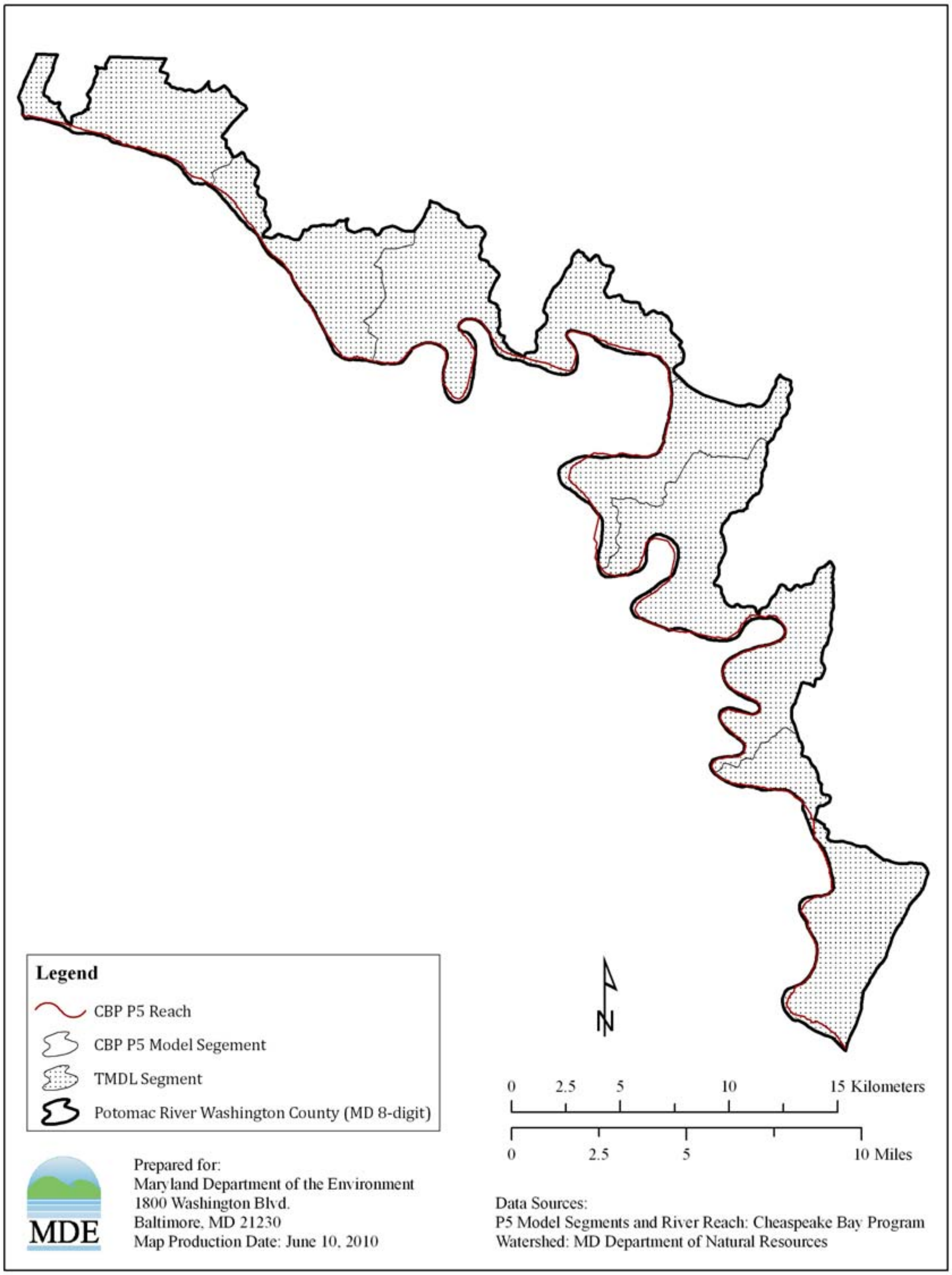

Figure 4: Potomac River Washington County TMDL Segmentation

Reference Watershed Approach

Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic life of non-tidal stream systems. Therefore, in order to quantify the impact of sediment on the aquatic life of non-tidal stream systems, a reference watershed TMDL approach was used and resulted in the establishment of a *sediment loading threshold* for watersheds within the Highland and Piedmont physiographic regions (Currey et al. 2006). Reference watersheds were determined based on Maryland's biocriteria methodology. The biocriteria methodology assesses biological impairment at the 8-digit watershed scale based on the percentage of MBSS monitoring stations, translated into watershed stream miles, that have BIBI and/or FIBI scores lower than the Minimum Allowable IBI Limit (MAL). The MAL is calculated based on the average annual allowable IBI value of 3.0 (on a scale of 1 to 5). It accounts for annual variability and helps to avoid classification errors (i.e., false positives) when assessing for biological impairments (Roth et al. 1998, 2000; Stribling et al. 1998; MDE 2008).

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, Currey et al. (2006) selected reference watersheds only from the Highland and Piedmont physiographic regions (see Appendix A for the list of reference watersheds). 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 BIBI (Roth et al. 1998; Stribling et al. 1998).

To reduce the effect of the variability within the Highland and Piedmont physiographic regions (i.e., soils, slope, etc.), the watershed sediment loads were then normalized by a constant background condition, the all forested watershed condition. This new normalized 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*. A similar approach was used by EPA Region IX for sediment TMDLs in California (e.g., Navarro River or Trinity River TMDLs), 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*. The equation for the *forest normalized sediment load* 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)

Nine reference watersheds were selected from the Highland/Piedmont region. Reference watershed *forest normalized sediment loads* were calculated using CBP P5.2 2000 land use in order to maintain consistency with MBSS sampling years. The median and 75th percentile of the reference watershed *forest normalized sediment loads* were calculated and found to be 3.3 and 4.2 respectively. These values are in close agreement with more complex methods used to determine the *sediment loading threshold* in previous nontidal sediment TMDLs. Therefore, the median value of 3.3 was established as the sediment loading threshold as an environmentally conservative approach to develop this TMDL (see Appendix A for more details).

The *forest normalized sediment load* for the Potomac River Washington County watershed (estimated as 3.8) was calculated using CBP P5.2 2005 land use, to best represent current conditions. A comparison of the Potomac River Washington County watershed *forest normalized sediment load* to the *forest normalized reference sediment load* (also referred to as the *sediment loading threshold*) demonstrates that the watershed exceeds the *sediment loading threshold*, indicating that it is receiving loads above the maximum allowable load that it can sustain and still meet water quality standards.

4.3 Scenario Descriptions and Results

The following analyses allow a comparison of baseline conditions (under which water quality problems exist) with future conditions, which project the water quality response to various simulated sediment load reductions. 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 Potomac River Washington County watershed baseline sediment loads are estimated using the CBP P5.2 target EOS land use sediment loading rates with 2005 land use. Watershed loading calculations, based on the CBP P5.2 segmentation scheme, are represented by multiple CBP P5.2 model segments within a TMDL segment. The sediment loads from these segments are combined to represent the baseline condition. The point source sediment loads are estimated based on the existing permit information. Details of these loading source estimates can be found in Section 2.2 and Appendix B of this report.

TMDL Conditions

This scenario represents the future conditions of maximum allowable sediment loads that will be at a level to support aquatic life. 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 biological community) and the Potomac

River Washington County *all forested sediment load* (see Section 4.2). The resulting load is considered the maximum allowable load the watershed can sustain and support aquatic life.

The TMDL loading and associated reductions are averaged at the MD 8-digit watershed scale, which is consistent with the original listing scale. It is important to recognize that 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 CBP P5.2 model segment *i* (ton /yr)
i = CBP P5.2 model segment
n = number of CBP P5.2 model segments in watershed

The Potomac River Washington County watershed allowable sediment load is estimated using equation 4.2. Also, in accordance with the conclusion drawn in Sections 2.4 and 3.0, the two point sources discharging to the mainstem Potomac River, the R. Paul Smith Power Station (MD0000582) and Sharpsburg Water Treatment Plant (WTP) (MD0067784), are given wasteload allocations for informational purposes only. Since they do not impact 1st through 4th order streams, their Wasteload Allocations (WLAs) are added to the forest normalized sediment threshold to make up the TMDL.

4.4 Critical Condition and Seasonality

EPA's regulations require TMDLs to take into account seasonality and critical conditions for stream flow, loading, and water quality parameters (CFR 2010b). 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 reflect the impacts of stressors (i.e., sediment impacts to stream biota) over the course of time and therefore depict an average stream condition (i.e., captures all high and low flow events). Since the TMDL endpoint is based on the median of forest normalized loads from watersheds assessed as having good biological conditions (i.e., passing Maryland's biocriteria), by the nature of the biological data described above, it must inherently include the critical conditions of the reference watersheds. Therefore, since the TMDL reduces the watershed sediment load to a level compatible with that of the reference watersheds, critical conditions are inherently addressed.

Seasonality is captured in two components. First, it is implicitly included through the use of the biological monitoring data as biological communities reflect the impact of stressors over time, as described above. Second, the MBSS dataset included benthic sampling in the spring (March 1 - April 30) and fish sampling in the summer (June 1 - September 30). Benthic sampling in the spring allows for the most accurate assessment of the benthic population, and therefore provides an excellent means of assessing the anthropogenic effects of sediment impacts on the benthic community. Fish sampling is conducted in the summer when low flow conditions significantly limit the physical habitat of the fish community, and it is therefore most reflective of the effects of anthropogenic stressors as well.

4.5 TMDL Loading Caps

This section presents the Potomac River Washington County watershed average annual sediment TMDL. This load is considered the maximum allowable long-term average annual load the watershed can sustain and support aquatic life.

The long-term average annual TMDL was calculated based on Equation 4.2 and set at a load 3.3 times the all forested condition. In order to attain the TMDL loading cap calculated for the watershed, constant reductions were applied to the predominant controllable sources (i.e., significant contributors of sediment to the stream system), independent of jurisdiction. If only these predominant (generally the largest) sources are controlled, the TMDL can be achieved in the most effective, efficient, and equitable manner. Predominant sources typically include urban land, high till crops, low till crops, hay, and pasture, but additional sources could be controlled as well in order to ensure that the TMDL is attained. Urban land, high till crops, low till crops, hay, and pasture were identified as the predominant controllable sources in the watershed. Thus, constant reductions were applied to these sources. Additionally, the majority of urban land within the watershed is considered to represent regulated stormwater sources (i.e., most urban stormwater in the watershed is regulated in some fashion via a permit).

In accordance with the conclusion drawn in Section 2.4 and 3.0, the two point sources discharging to the mainstem Potomac River are given wasteload allocations for informational purposes only. Table B.2 identifies the point sources discharging directly to the mainstem river. Since they do not impact 1st through 4th order streams, their WLAs are added to the forest normalized sediment threshold to make up the TMDL.

Relative to the estimated sediment load reductions applied to urban land, which are necessary to achieve the TMDL, MDE currently requires that Phase I MS4s retrofit 10% of their existing impervious area where there is failing, minimal, or no stormwater management (estimated to be areas developed prior to 1985) within a permit cycle (five years) (i.e., Phase I MS4s need to install/institute stormwater management practices to treat runoff from these existing impervious areas) (MDE 2010c). Washington County, however, is a Phase II MS4 jurisdiction. While Phase II MS4 permits require improved stormwater management programs, quantification of the effort similar to the 10% required in Phase I MS4s has not been enumerated. Theoretically extending the Phase I

MS4 permitting requirements to all urban stormwater sources (i.e., Phase II MS4s, industrial facilities regulated for stormwater discharges, other regulated urban stormwater sources, and even unregulated urban stormwater sources) would require that all impervious areas developed prior to 1985 be retrofit at this pace. Additionally, MDE estimates that future stormwater retrofits will have, on average, a 65% TSS reduction efficiency (Claytor and Schueler 1997; Baldwin et al. 2007; Baish and Caliri 2009). By default, these retrofits will also provide treatment of any adjacent urban pervious runoff within the applicable drainage area.

The Potomac River Washington County Baseline Load and TMDL are presented in Table 7.

Table 7: Potomac River Washington County Baseline Load and TMDL

Baseline Load (ton/yr)	TMDL (ton/yr)	Reduction (%)
16,215	14,196	12.5

4.6 Load Allocations Between Point and Nonpoint Sources

Per EPA regulation, all TMDLs need to be presented as a sum of WLAs for point sources and load allocations (LAs) for nonpoint source loads generated within the assessment unit, as accounting for natural background, tributary, and adjacent segment loads (CFR 2010a). In the case of the Potomac River Washington County, the assessment unit is restricted to the 1st through 4th order streams in the watershed draining to the Potomac River, and not the Potomac River itself. No loads from adjacent segments or upstream sources will be considered, since with respect to these 1st through 4th order streams there are no upstream or tributary loads. Consequently, the Potomac River Washington County watershed TMDL allocations are presented in terms of WLAs (i.e., point source loads identified within the watershed) and LAs (i.e., the nonpoint source loads within the watershed). The State reserves the right to allocate the TMDL among different sources in any manner that protects aquatic life from sediment related impacts.

As described in section 4.5, reductions were applied equally to the predominant controllable sources, which were identified as urban land, high till crops, low till crops, hay, and pasture. Forest is the only non-controllable source, as it represents the most natural condition in the watershed, and no reductions were applied to permitted process load sources, since such controls would produce no discernable water quality benefit when nonpoint sources and regulated stormwater sources comprise greater than 99% of the total watershed sediment load discharging into 1st through 4th order streams. WLAs for the two facilities, the R. Paul Smith Power Station (MD0000582) and Sharpsburg WTP (MD0067784), which discharge into the mainstem Potomac River have been given informational WLAs based on their design flow and permitted TSS concentrations, and have been included along with the other facilities in the process water WLA.

Washington County, a Phase II small MS4 jurisdiction, and other NPDES regulated stormwater sources in the watershed are required to implement improved stormwater management programs that will be consistent with TMDLs. Based on the discussion in

Section 4.5, it is anticipated that the required urban sediment load reductions will still be achieved by retrofitting impervious areas within the watershed developed prior to 1985 (i.e., approximate areas with failing, minimal, or no stormwater management), as this is the most feasible option for achieving these reductions. Also, it is expected that these future stormwater retrofits will have an estimated 65% TSS reduction efficiency (Claytor and Schueler 1997; Baldwin et al. 2007; Baish and Caliri 2009), and by default, they will provide treatment of any adjacent urban pervious runoff within the applicable drainage area.

Table 8 summarizes the TMDL results derived by applying equal percent reductions to the predominant controllable sediment sources. The TMDL results in an overall reduction of 12.5% for the Potomac River Washington County watershed. For more detailed information regarding the Potomac River Washington County Watershed TMDL nonpoint source LA, please see the technical memorandum to this document entitled "*Significant Sediment Nonpoint Sources in the Potomac River Washington County Watershed*". The reductions from the urban sector required to meet this TMDL would entail that at a 65% TSS reduction efficiency, approximately 34% of the urban area (impervious and pervious) within the watershed that was developed prior to 1985 (both regulated and unregulated) would need to be retrofit, or an equivalent reduction in sediment loads from other types of stormwater retrofits is necessary (see Section 5.0 for a detailed description of the other types of stormwater retrofits).

Table 8: Potomac River Washington County TMDL Reductions by Source Category

Baseline Load Source Categories		Baseline Load (ton/yr)	TMDL Components	TMDL (ton/yr)	Reduction (%)
Nonpoint Source		14,889	**LA**	13,060	12.3
Point Source	Urban[1]	1,250	**WLA**	1,060	15.0
	Process Water	76		76	0.0
Total		**16,215**		**14,196**	**12.5**

Note: [1] The entire urban land use load is not included in the point source baseline load source category and WLA component of the TMDL. A portion of the urban land use load is included in the nonpoint source baseline load source category and LA component of the TMDL. For more details, see the technical memoranda to this document entitled "*Significant Sediment Nonpoint Sources in the Potomac River Washington County Watershed*" and "*Significant Sediment Point Sources in the Potomac River Washington County*".

The WLA of the Potomac River Washington County watershed is allocated to two permitted source categories, Process Water WLA and Stormwater WLA. The categories are described below.

<u>Process Water WLA</u>

Process Water 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 process water permit, then TSS loads are expected to be *de minimis*. If loads are *de minimis*, then they pose little or no risk to the aquatic environment and are not a significant source.

Process Water permits with specific TSS limits include:

- Individual industrial facilities
- Individual municipal facilities
- General mineral mining facilities

There are six process water sources with explicit TSS limits, which include one industrial discharge, three municipal discharges, and two mineral mine discharge. The total estimated TSS load from all of the process water sources is based on current permit limits and is equal to 76 ton/yr, including the two facilities that discharge into the mainstem Potomac River. As mentioned above, no reductions were applied to this source, since such controls would produce no discernable water quality benefit when nonpoint sources and regulated stormwater sources comprise greater than 99% of the total watershed sediment load discharging into 1^{st} through 4^{th} order streams. For a detailed list of the seven process water permits including information on their permit limits, please see Appendix B. For information regarding the allocations to individual process water point sources, please see the technical memorandum to this document entitled "*Significant Sediment Point Sources in the Potomac River Washington County*".

Stormwater WLA

Per EPA requirements, "stormwater discharges that are regulated under Phase I or Phase II of the NPDES stormwater program are point sources that must be included in the WLA portion of a TMDL" (US EPA 2002). Phase I and II permits can include the following types of discharges:

- Small, medium, and large MS4s – these can be owned by local jurisdictions, municipalities, and state and federal entities (e.g., departments of transportation, hospitals, military bases),
- Industrial facilities permitted for stormwater discharges, and
- Small and large construction sites.

EPA recognizes that available data and information are usually not detailed enough to determine WLAs for NPDES regulated stormwater discharges on an outfall-specific basis (US EPA 2002). Therefore, NPDES regulated stormwater loads within the Potomac River Washington County watershed TMDL will be expressed as a single NPDES stormwater WLA. Upon approval of the TMDL, "NPDES-regulated municipal stormwater and small construction storm water discharges effluent limits should be expressed as BMPs or other similar requirements, rather than as numeric effluent limits" (US EPA 2002).

The Potomac River Washington County NPDES stormwater WLA is based on reductions applied to the sediment load from the regulated portion of the urban land use in the watershed and may include legacy or other sediment sources. Some of these sources may also be subject to controls from other management programs. The Potomac River Washington County NPDES stormwater WLA requires an overall reduction of 15% (see Table 8).

As stormwater assessment and/or other program monitoring efforts result in a more refined source assessment, MDE reserves the right to revise the current NPDES stormwater WLA provided the revisions protect aquatic life from sediment related impacts.

For more information on the methods used to calculate the NPDES regulated stormwater baseline sediment load, see Section 2.2.2. For a detailed list of all of the NPDES regulated stormwater discharges within the watershed, please see Appendix B, and for information regarding the NPDES stormwater WLA distribution amongst these discharges, please see the technical memorandum to this document entitled "*Significant Sediment Point Sources in the Potomac River Washington County*".

4.7 Margin of Safety

All TMDLs must include a margin of safety to account for any lack of knowledge and uncertainty concerning the relationship between loads and water quality (CFR 2010b). The MOS shall also account for any rounding errors generated in the various calculations used in the development of the TMDL. 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 4.2. Also, 50% of the reference watersheds have a value 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 (Currey et al. 2006). This is considered an environmentally conservative estimate, since 50% of the reference watersheds have a load above this value (3.3), which when compared to the 75% value (4.2), results in an implicit MOS of approximately 18%.

4.8 Summary of Total Maximum Daily Loads

The average annual Potomac River Washington County watershed TMDL is summarized in Table 9. The TMDL is the sum of the LA, NPDES Stormwater WLA, Process Water WLA, and MOS. The Maximum Daily Load (MDL) is summarized in Table 10 (See Appendix C for more details).

Table 9: Potomac River Washington County Watershed Average Annual TMDL of Sediment/TSS (ton/yr)

TMDL (ton/yr)	=	LA_{PR}	+	WLA			+	MOS
				NPDES Stormwater WLA_{PR}	+	Process Water WLA_{PR}		
14,196	=	13,060	+	1,060	+	76	+	Implicit

Table 10: Potomac River Washington County Maximum Daily Loads of Sediment/TSS (ton/day)

MDL (ton/yr)	=	**LA_{PR}**	+	**WLA**			+	**MOS**
				NPDES Stormwater WLA_{PR}	+	**Process Water WLA_{PR}**		
46.0	=	42.0	+	3.4	+	0.6	+	Implicit

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 WLAs can and will be implemented (CFR 2010b). 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 available for local governments for implementation include the Buffer Incentive Program (BIP), 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 BMPs for reducing sediment loads and resulting impacts can be grouped into two general categories. The first is directed toward agricultural lands and the second is directed toward urban (developed) lands.

In agricultural areas comprehensive soil conservation plans can be developed that meet criteria of the USDA-NRCS Field Office Technical Guide (USDA 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 practices have a reduction percentage of up to 25%. In addition, livestock can be controlled via stream fencing and rotational grazing. Sediment reduction efficiencies of methods applicable to pasture land use range from 40% to 75% (US EPA 2004). Lastly, riparian buffers can reduce the effect of agricultural sediment sources through trapping and filtering, and reforestation, whether adjacent to part of the watershed stream system or in a watershed’s interior, can decrease agricultural sediment sources as well.

Sediment from urban areas can be reduced by stormwater retrofits that address both water quality and flow control. Examples of these retrofits include the modification of existing stormwater structural practices, the construction of new stormwater BMPs in prior development where there is none, a reduction in impervious surfaces, street sweeping, inlet cleaning, increases in the urban tree canopy, stream restoration, and any other management practice that effectively addresses water quality and flow control (i.e., riparian buffers for urban areas and watershed reforestation adjacent to the watershed stream system or within a watershed’s interior). In terms of upland urban sediment loads, stormwater retrofit reductions range from as low as 10% for dry detention to approximately 80% for wet ponds, wetlands, infiltration practices, and filtering practices

(US EPA 2003). It is anticipated that the implementation of the TMDL will include the array of urban BMPs and practices outlined above.

It has been estimated that the average TSS removal efficiencies for BMPs installed between the years of 1985-2002 and post 2002, which are reflective of the stormwater management regulations in place during these time periods, is 50% and 80%, respectively (Claytor and Schueler 1997; Baldwin et al. 2007; Baish and Caliri 2009). Based on these average TSS reduction efficiencies, BMP specific reduction efficiencies as estimated by CBP, and best professional judgment, MDE estimates that future stormwater retrofits will have approximately a 65% reduction efficiency for TSS, which is subject to change over time. Additionally, any new development in the watershed will be subject to Maryland's Stormwater Management Act of 2007 and will be required to use environmental site design (ESD) to the maximum extent practicable.

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

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APPENDIX A – Watershed Characterization Data

Table A-1: Reference Watersheds

MD 8-digit Name	MD 8-digit	Percent stream mile BIBI/FIBI < 3.0 (%)[1,2]	Forest Normalized Sediment Load[3]
Deer Creek	02120202	11	3.9
Broad Creek	02120205	12	4.5
Little Gunpowder Falls	02130804	15	3.3
Prettyboy Reservoir	02130806	16	3.7
Middle Patuxent River	02131106	20	3.2
Brighton Dam	02131108	11	4.2
Sideling Creek	02140510	20	1.9
Fifteen Mile Creek	02140511	4	1.6
Savage River	02141006	7	2.5
Median			**3.3**
75th			**4.2**

Notes: [1] Based on the percentage of MBSS stations with BIBI and/or FIBI scores significantly lower than 3.0 within the MD 8-digit watershed (MDE 2008).

[2] The percent stream miles with BIBI and/or FIBI scores significantly lower than 3.0 threshold to determine if an 8-digit watershed is impaired for impacts to biological communities is based on a comparison to reference conditions (MDE 2008).

[3] Forest normalized sediment loads based on Maryland watershed area only (consistent with MBSS random monitoring data).

APPENDIX B – MDE Permit Information

Table B-1: Permit Summary

NPDES Permit #	MDE Permit #	Facility	County	City	Type	TMDL[1]
MD0003484	00DP0626	R. C. WILLSON WATER FILTRATION PLANT	WASHINGTON	WILLIAMSPORT	WMA2	Process Water WLA
MD0067784	02DP1361	SHARPSBURG WTP[2]	WASHINGTON	SHARPSBURG	WMA2	Process Water WLA
MD0069132	03DP3446	CLEAR SPRING WTP	WASHINGTON	CLEAR SPRING	WMA2	Process Water WLA
MDG491405	00MM1405	MARTIN MARIETTA - PINESBURG QUARRY	WASHINGTON	WILLIAMSPORT	WMA5	Process Water WLA
MDG499832	00MM9832	C. WILLIAM HETZER, INC - SHALE PIT	WASHINGTON	WILLIAMSPORT	WMA5	Process Water WLA
MD0000582	03DP0026A	R. PAUL SMITH POWER STATION	WASHINGTON	WILLIAMSPORT	WMA1M	Process Water WLA
MS4-WA-003	03-IM-5500-046	WASHINGTON COUNTY MS4	WASHINGTON	COUNTY-WIDE	WMA6G	Stormwater WLA
		MDE GENERAL PERMIT TO CONSTRUCT	ALL	ALL		Stormwater WLA

Notes: [1]TMDL column identifies how the permit was considered in the TMDL allocation.
[2]WTP = Water Treatment Plant
[3]WWTP = Wastewater Treatment Plant

Table B-2: Industrial and Municipal Permit Data

TMDL Segment	Facility Name	NPDES Permit #	MDE Permit #	Type	Flow (MGD[1])	Permit Avg. Monthly Conc. (mg/l[2])	Permit Daily Max. Conc (mg/l)
Mainstem	R. PAUL SMITH POWER STATION	MD0000582	03DP0026A	WMA1M	1.2	30	100
1	R. C. WILLSON WATER FILTRATION PLANT	MD0003484	00DP0626	WMA2	0.66	20	30
Mainstem	SHARPSBURG WTP	MD0067784	02DP1361	WMA2	0.026	20	30
1	CLEAR SPRING WTP	MD0069132	03DP3446	WMA2	0.01	20	30

Notes: [1] MGD = Millions of gallons per day
[2] mg/l = Milligram per liter

Table B-3: General Mine Permit Data

TMDL Segment	Facility Name	NPDES Permit #	MDE Permit #	Flow (MGD)	Permit Avg. Quarterly Conc. (mg/l)	Permit Daily Max. Conc. (mg/l)
1	MARTIN MARIETTA - PINESBURG QUARRY	MDG491405	00MM1405	0.001	15	31
1	C. WILLIAM HETZER, INC - SHALE PIT	MDG499832	00MM9832	0.001	30	60

Table B-4: Stormwater Permits[1]

Permit #	Facility Name	NPDES Group
MS4-WA-0003	WASHINGTON COUNTY MS4	Phase II
03-IM-5500-046	MD GENERAL PERMIT TO CONSTRUCT	Phase I/II
	OTHER REGULATED STORMWATER	

Note:[1] Although not listed in this table, some individual process water permits incorporate stormwater requirements and are accounted for within the NPDES stormwater WLA (specifically the "Other" Regulated Stormwater Allocation in the Technical Memorandum *Significant Sediment Point Sources in the Potomac River Washington County* accompanying this TMDL report) as well as additional Phase II permitted MS4s, such as military bases, hospitals, etc.

APPENDIX C – Technical Approach Used to Generate Maximum Daily Loads

Summary

This appendix documents the technical approach used to define MDLs of sediment consistent with the average annual TMDL in the Potomac River Washington County watershed, which is considered the maximum allowable load the watershed can sustain and support aquatic life. The approach builds upon the modeling analysis that was conducted to determine the sediment loadings and can be summarized as follows.

- The approach defines MDLs for each of the source categories.
- The approach builds upon the TMDL modeling analysis that was conducted to ensure that average annual loading targets are at a level that support aquatic life.
- The approach converts daily time-series loadings into TMDL values in a manner that is consistent with available EPA guidance on generating daily loads for TMDLs (US EPA 2007).
- The approach considers a daily load level of a resolution based on the specific data that exists for each source category.

Introduction

This appendix documents the development and application of the approach used to define MDL values. It is divided into sections discussing:

- Basis for approach
- Options considered
- Selected approach
- Results of approach

Basis for approach

The overall approach for the development of daily loads was based upon the following factors:

- **Average Annual TMDL:** The basis of the average annual sediment TMDL is that cumulative high sediment loading rates have negative impacts on the biological community. Thus, the average annual sediment load was calculated so as to ensure the support of aquatic life.
- **CBP P5.2 Watershed Model Sediment Loads:** There are two spatial calibration points for sediment within the CBP P5.2 watershed model framework. First, EOS loads are calibrated to long term EOS target loads. These target loads are the loads used to determine an average annual TMDL, as actual CBP P5.2 calibration and scenario runs were not available upon development of the nontidal sediment TMDL methodology (Currey et al. 2006). Since the EOS target loads applied in the TMDL remain relatively unchanged during the final calibration stages of the

CBP P5.2 model, they are consistent with the final CBP P5.2 sediment loading estimates. The CBP P5.2 model river segments were calibrated to daily monitoring information for watersheds with a flow greater that 100 cubic feet per second (cfs), or an approximate area of 100 square miles.

- **Draft EPA guidance document entitled "Developing Daily Loads for Load-based TMDLs":** This guidance document provides options for defining MDLs when using TMDL approaches that generate daily output (US EPA 2007).

The rationale for developing TMDLs expressed as *daily* loads was to accept the existing average annual TMDL, but then develop a method for converting this number to a MDL – in a manner consistent with EPA guidance and available information.

Options considered

The draft EPA guidance document for developing daily loads does not specify a single approach that must be adhered to, but rather it contains a range of acceptable options (US EPA 2007). The selection of a specific method for translating a time-series of allowable loads into the expression of a TMDL requires decisions regarding both the level of resolution (e.g., single daily load for all conditions vs. loads that vary with environmental conditions) and level of probability associated with the TMDL.

This section describes the range of options that were considered when developing methods to calculate Potomac River Washington County MDLs.

<u>Level of Resolution</u>

The level of resolution pertains to the amount of detail used in specifying the MDL. The draft EPA guidance document on daily loads provides three categories of options for level of resolution, all of which are potentially applicable for the Potomac River Washington County watershed:

1. **Representative daily load:** In this option, a single daily load (or multiple representative daily loads) is specified that covers all time periods and environmental conditions.
2. **Flow-variable daily load:** This option allows the MDL to vary based upon the observed flow condition.
3. **Temporally-variable daily load:** This option allows the MDL to vary based upon seasons or times of varying source or water body behavior (US EPA 2007).

<u>Probability Level</u>

All TMDLs have some probability of being exceeded, with the specific probability being either explicitly specified or implicitly assumed. This level of probability directly or indirectly reflects two separate phenomena:

1. Water quality criteria consist of components describing acceptable magnitude, duration, and frequency. The frequency component addresses how often

conditions can allowably surpass the combined magnitude and duration components.

2. Pollutant loads, especially from wet weather sources, typically exhibit a large degree of variability over time. It is rarely practical to specify a "never to be exceeded value" for a daily load, as essentially any loading value has some finite probability of being exceeded.

The draft daily load guidance document states that the probability component of the MDL should be "based on a representative statistical measure" that is dependent upon the specific TMDL and the best professional judgment of the developers (US EPA 2007). This statistical measure represents how often the MDL is expected/allowed to be exceeded. The primary options for selecting this level of protection would be:

1. **The maximum daily load reflects some central tendency:** In this option, the MDL is based upon the mean or median value of the range of loads expected to occur. The variability in the actual loads is not addressed.
2. **The maximum daily load reflects a level of protection implicitly provided by the selection of some "critical" period**: In this option, the MDL is based upon the allowable load that is predicted to occur during some critical period examined during the analysis. The developer does not explicitly specify the probability of occurrence.
3. **The maximum daily load is a value that will be exceeded with a pre-defined probability:** In this option, a "reasonable" upper bound percentile is selected for the MDL based upon a characterization of the variability of daily loads. For example, selection of the 95^{th} percentile value would result in a MDL that would be exceeded 5% of the time.

Selected Approach

The approach selected for defining a Potomac River Washington County MDL was based upon the specific data that exists for each source category. The approach consists of unique methods for each of the following categories of sources:

- Approach for Nonpoint Sources and Stormwater Point Sources within the Potomac River Washington County watershed
- Approach for Process Water Point Sources within the Potomac River Washington County watershed

Approach for Nonpoint Sources and Stormwater Point Sources within the Potomac River Washington County Watershed

The level of resolution selected for the Potomac River Washington County MDL was a representative daily load, expressed as a single daily load for each loading source. This approach was chosen based upon the specific data that exists for nonpoint sources and stormwater point sources within the Potomac River Washington County watershed. Currently, the best available data is the CBP P5.2 model daily time series calibrated to long-term average annual loads (per land use). The CBP reach simulation results are calibrated to daily monitoring information for watershed segments with a flow typically greater that 100 cfs, but these model calibration runs were not available upon the development of the average annual nontidal sediment TMDL methodology (Currey et al. 2006). Therefore, to be consistent with the average annual TMDL, it was concluded that it would not be appropriate to apply the absolute values of the reach simulation model, daily time series results to calculate the MDL. Thus, the annual loads were used instead. However, it was assumed that the distribution of the daily values was correct, in order to calculate a normalized statistical parameter to estimate the MDLs.

In the case of the Potomac River Washington County, however, there is no P5.2 reach which represents the watershed *per se*: EOS loads from Potomac River Washington County are input into reaches representing the mainstem Potomac River, and sediment loads in these reaches are dominated by upstream contributions. To develop a times series of daily loads representative of the impaired watershed, a synthetic watershed was constructed using (1) EOS loads from Potomac River Washington County, (2) Maryland point sources sediment loads discharging directly to the mainstem Potomac River, and (3) river reach geometry and parameters from a neighboring watershed, Antietam Creek, which is approximately the same size as the Potomac River Washington County watershed. Using the P5.2 Model, a synthetic time series of daily sediment loads was simulated by routing the Potomac River Washington County sediment loads through the reach.

The MDL was estimated based on three factors: a specified probability level, the average annual sediment TMDL, and the coefficient of variation (CV) of the CBP P5.2 Potomac River Washington County synthetic reach simulation of daily loads. The probability level (or exceedance frequency) is based upon guidance from EPA (US EPA 1991) where examples suggest that when converting from a long-term average to a daily value, the z-score corresponding to the 99^{th} percentile of the log-normal probability distribution should be used. The average annual sediment TMDL is estimated from the CBP P5.2 EOS target loads. The calculation of the CV is described below.

The CBP P5.2 Potomac River Washington County reach simulation consisted of a daily time series beginning in 1985 and extending to the year 2005. The CV was estimated by first converting the daily sediment load values to a log distribution and then verifying that the results approximated the normal distribution (see Figure C-1). Next, the CV was calculated using the arithmetic mean and standard deviation results from the log transformation. The log-transformed values were used to reduce the possible influence of outliers. The resulting CV of 0.070 was calculated using the following equation:

$$CV = \frac{\beta}{\alpha} \quad \text{(Equation C.1)}$$

where:

CV = coefficient of variation

$\beta = \alpha\sqrt{e^{\sigma^2} - 1}$

$\alpha = e^{(\mu + 0.5*\sigma^2)}$

α = mean (arithmetic)

β = standard deviation (arithmetic)

μ = mean of logarithms

σ =standard deviation of logarithms

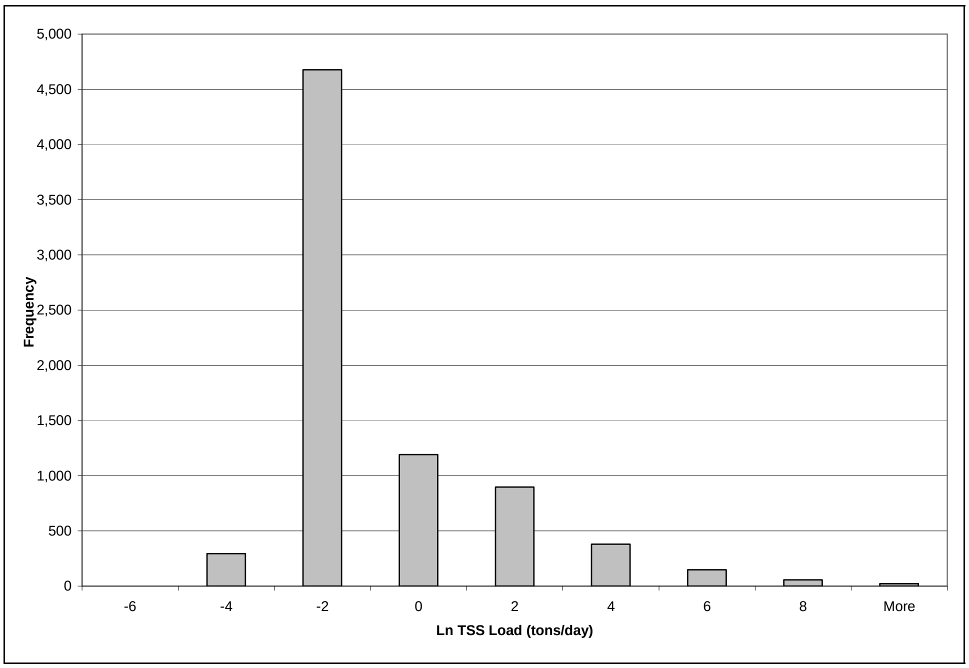

Figure C-1: Histogram of CBP River Segment Daily Simulation Results for the Potomac River Washington County Watershed

The maximum "daily" load for each contributing source is estimated as the long-term average annual load multiplied by a factor that accounts for expected variability of daily loading values. The equation is as follows:

$$MDL = LTA * e^{(z\sigma - 0.5\sigma^2)}$$ (Equation C.2)

where:
MDL = Maximum daily load
LTA = Long term average (average annual load)
Z = z-score associated with target probability level
$\sigma^2 = \ln(CV^2+1)$
CV = Coefficient of variation based on arithmetic mean and standard deviation

Using a z-score associated with the 99th percent probability, a CV of 0.070 and consistent units, the resulting dimensionless conversion factor from long term average annual loads to a MDL is 1.175. The average annual Potomac River Washington County TMDL of sediment/TSS is reported in ton/yr, and the conversion from ton/yr to a MDL in ton/day is 0.0032 (e.g. 1.175/365).

<u>Approach for Process Water Point Sources within the Potomac River Washington County Watershed</u>

The TMDL also considers contributions from other point sources (i.e., sources other than stormwater point sources) in the watershed that have NPDES permits with sediment limits. As these sources are generally minor contributors to the overall sediment load, the TMDL analysis that defined the average annual TMDL did not propose any reductions for these sources and held each of them constant at their existing technology-based NPDES permit monthly (or daily if monthly was not specified) limit for the entire year.

The approach used to determine MDLs for these sources was dependent upon whether a maximum daily limit was specified within the permit. If a maximum daily limit was specified, then the reported average flow was multiplied by the daily maximum limit to obtain a MDL. If a maximum daily limit was not specified, the MDLs were calculated based on the guidance provided in the Technical Support Document (TSD) for Water Quality-based Toxics Control (US EPA 1991). The long-term average annual TMDL was converted to maximum daily limits using Table 5-2 of the TSD assuming a coefficient of variation of 0.6 and a 99th percentile probability. This results in a dimensionless multiplication factor of 3.11. The average annual Potomac River Washington County TMDL of sediment/TSS is reported in ton/yr, and the conversion from ton/yr to a MDL in ton/day is 0.0085 (e.g. 3.11/365).

Results of approach

This section lists the results of the selected approach to define the Potomac River Washington County MDLs.

- Calculation Approach for Nonpoint Sources and Stormwater Point Sources within the Potomac River Washington County Watershed

LA_{PR} (ton/day) = Average Annual TMDL LA_{PR} (ton/yr) * 0.0032

Stormwater WLA_{PR} (ton/day) = Average Annual TMDL Stormwater WLA_{PR} (ton/yr) * 0.0032

- Calculation Approach for Process Water Point Sources within the Potomac River Washington County Watershed
    - For permits with a daily maximum limit:

Process Water WLA_{PR} (ton/day) = Permit flow (mgd) * Daily maximum permit limit (mg/l) * 0.0042, where 0.0042 is a combined factor required to convert units to ton/day

-
    - For permits without a daily maximum limit:

Process Water WLA_{PR} (ton/day) = Average Annual TMDL WLA_{PR} Other (ton/yr)* 0.0085, where 0.0085 is the factor required to covert units to ton/day

Table C-1: Potomac River Washington County Maximum Daily Loads of Sediment/TSS (lbs/day)

MDL (lbs/day)	=	LA_{PR}	+	WLA			+	MOS
				NPDES Stormwater WLA_{PR}	+	Process Water WLA_{PR}		
46.0	=	42.0	+	3.4	+	0.6	+	Implicit