Total Maximum Daily Loads of Nitrogen, Phosphorus and Biochemical Oxygen Demand for Breton Bay in St. Mary's County, Maryland

FINAL

Prepared by:

Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, MD 21230

Submitted to:

Watershed Protection Division
U.S. Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

June 2005

Submittal Date: June 8, 2005
Approval Date: December 19, 2005

Table of Contents

List of Figures

List of Tables

List of Abbreviations

7Q10	7-day consecutive lowest flow expected to occur every 10 years
BBEM	Breton Bay Eutrophication Model
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
CEAM	Center for Exposure Assessment Modeling
CHL *a*	Active Chlorophyll
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
CWAP	Clean Water Action Plan
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphorus
DO	Dissolved Oxygen
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
EUTRO5.1	Eutrophication Module of WASP5.1
FA	Future Allocation
LA	Load Allocation
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
MD	Maryland
MGD	Million Gallons per Day
MOS	Margin of Safety
NH_4^+	Ammonia
NO_{23}	Nitrate + Nitrite
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
ON	Organic Nitrogen
OP	Organic Phosphorus
PO_4	Ortho-Phosphate
SOD	Sediment Oxygen Demand
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WASP5.1	Water Quality Analysis Simulation Program 5.1
WLA	Waste Load Allocation
WWTP	Wastewater Treatment Plant
WQIA	Water Quality Improvement Act
WQLS	Water Quality Limited Segment

EXECUTIVE SUMMARY

This document proposes to establish Total Maximum Daily Loads (TMDLs) for nitrogen, phosphorus and biochemical oxygen demand (BOD) in Breton Bay (basin number 02-14-01-04). Breton Bay ultimately drains to the Chesapeake Bay, and is a part of the Lower Potomac Tributary Strategy Basin. Breton Bay is impaired by nutrients (nitrogen, phosphorus) and BOD, causing occasional algal blooms and low dissolved oxygen. Breton Bay was first identified in 1996 as impaired by nutrients due to signs of eutrophication (expressed as high chlorophyll *a* levels), suspended sediments, and evidence of impacts to biological communities. The suspended sediments and biological impairments will be addressed at a later date.

The water quality goal of these TMDLs is to reduce high chlorophyll *a* concentrations, and to maintain the dissolved oxygen criterion at a level whereby the designated uses for Breton Bay will be met. The TMDLs were determined using the Water Quality Analysis Simulation Program version 5.1 (WASP 5.1) water quality model. Loading caps for total nitrogen, total phosphorus and BOD entering Breton Bay are established for low flow and average annual flow conditions.

Growing Season Condition:

TMDLs for nitrogen, phosphorus and BOD, which address the growing season, are established for the period May 1 through October 31. These TMDLs are allocated between point sources and nonpoint sources as follows: The growing season TMDL for nitrogen is 4,746 lbs/growing season. The nonpoint sources are allocated 630 lbs/growing season of total nitrogen. The point sources are allocated 4,086 lbs/growing season of nitrogen. The growing season TMDL for phosphorus is 342 lbs/growing season. The nonpoint sources are allocated 30 lbs/growing season of phosphorus. The point sources are allocated 306 lbs/growing season of phosphorus. The growing season TMDL for biochemical oxygen demand (BOD) is 11,838 lbs/growing season. The nonpoint sources are allocated 1,548 lbs/growing season of BOD. The point sources are allocated 10,206 lbs/growing season of BOD. Explicit margins of safety make up the balance of the allocation.

Average Annual Flow Condition:

TMDLs for nitrogen, phosphorus and BOD, which address average annual conditions, are allocated between point sources and nonpoint sources. The average annual TMDL for nitrogen is 187,195 lbs/year. The nonpoint sources are allocated 119,902 lbs/year of total nitrogen. The point sources are allocated 62,580 lbs/year of nitrogen. The average annual TMDL for phosphorus is 11,627 lbs/year. The nonpoint sources are allocated 7,265 lbs/year of total phosphorus. The point sources are allocated 4,019 lbs/year of phosphorus. The average annual TMDL for biochemical oxygen demand (BOD) is 244,219 lbs/year. The nonpoint sources are allocated 202,520 lbs/year of BOD. The point sources are allocated 31,050 lbs/year of BOD. Explicit margins of safety make up the balance of the allocation.

Four factors provide assurance that these TMDLs will be implemented. First, National Pollutant Discharge Elimination System (NPDES) permits will play a role in assuring implementation for

point sources. Second, Maryland has several well-established programs that will be drawn upon, including Maryland's Tributary Strategies for Nutrient Reductions developed in accordance with the Chesapeake Bay Agreement. Third, Maryland's Water Quality Improvement Act of 1999 requires that nutrient management plans be implemented for all agricultural lands throughout Maryland. Finally, Maryland has adopted a watershed cycling strategy, which will assure that routine future monitoring and TMDL evaluations are conducted.

1.0 INTRODUCTION

Section 303(d)(1)(C) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (EPA) implementing regulations direct each State to develop a Total Maximum Daily Load (TMDL) for each impaired water quality limited segment (WQLS) on the Section 303(d) list, taking into account seasonal variations and a protective margin of safety (MOS) to account for uncertainty. A TMDL reflects the total pollutant loading of the impairing substance a water body can receive and still meet water quality standards.

TMDLs are established 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, 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.

Breton Bay (basin number 02-14-01-04) was first identified on the 1996 303(d) list submitted to EPA by the Maryland Department of the Environment (MDE). It was listed as being impaired by nutrients due to signs of eutrophication (expressed as high chlorophyll *a* levels), suspended sediments, and evidence of biological impacts. Eutrophication is the over-enrichment of aquatic systems by excessive inputs of nutrients (nitrogen and/or phosphorus). The nutrients act as a fertilizer leading to excessive growth of aquatic plants, which eventually die and decompose, leading to bacterial consumption of dissolved oxygen. For these reasons, this document proposes to establish TMDLs for nitrogen, phosphorus and biochemical oxygen demand (BOD) in Breton Bay. The suspended sediments and biological impairments will be addressed at a later date.

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1 General Setting and Source Assessment

The Breton Bay watershed encompasses over 55 square miles of land on Maryland's coastal plain between the Potomac and Patuxent Rivers (Figure 1). Breton Bay is 6.5 miles long and drains 35,418 acres. The land uses in the watershed consist of forest and other herbaceous vegetation (19,899 acres or 56%), mixed agriculture (8,293 acres or 23%), urban (6,600 acres or 19%) and water (626 acres or 2%) (Figures 2 and 3). The land use is based on 2002 Maryland Department of Planning (MDP) land cover data information. Figure 2 shows the geographic distribution of the different land uses. Figure 3 illustrates the relative amounts of the different land uses.

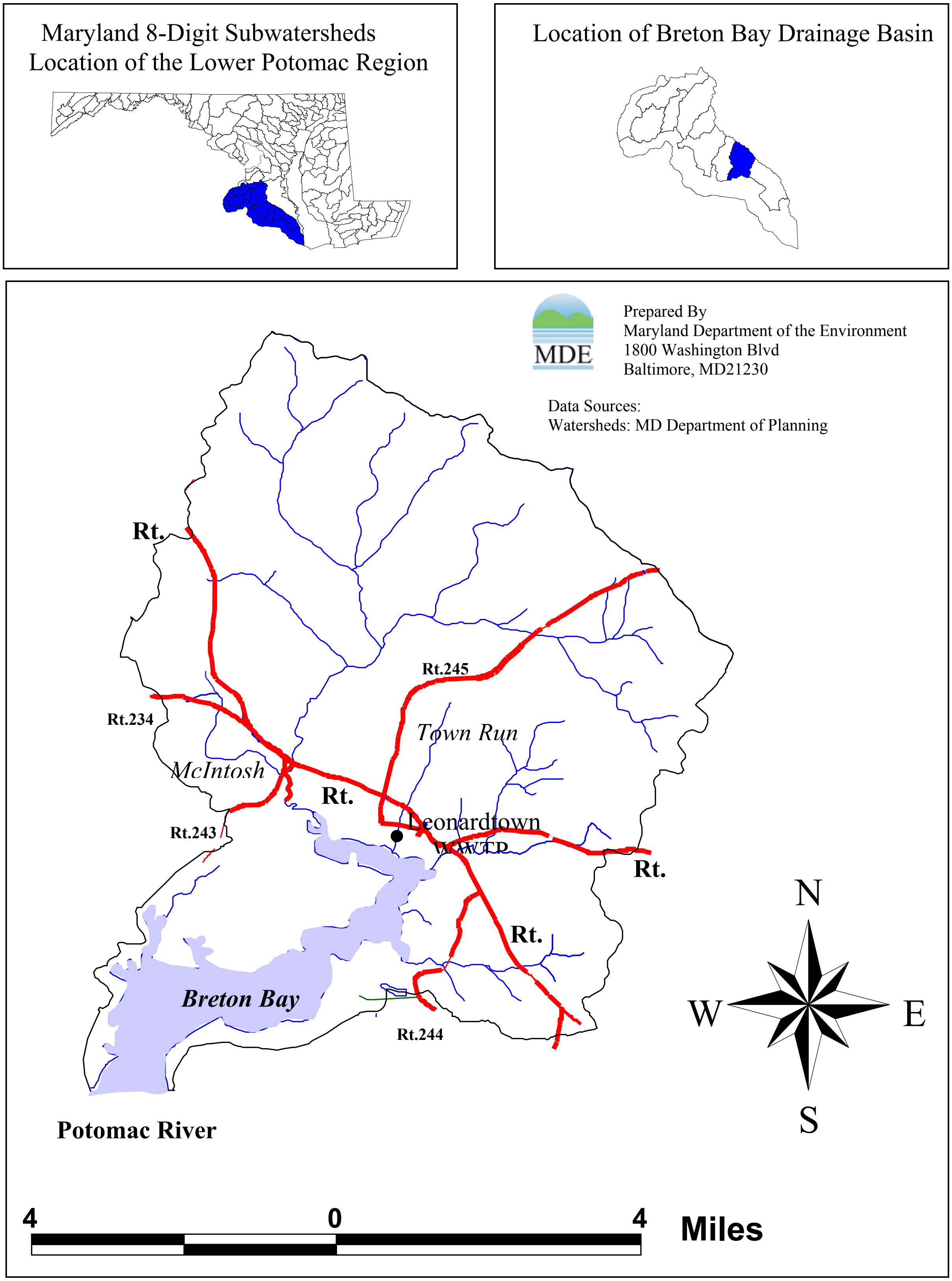


Figure 1: Location of the Breton Bay Drainage Basin and Breton Bay Eutrophication Model (BBEM) Study Area

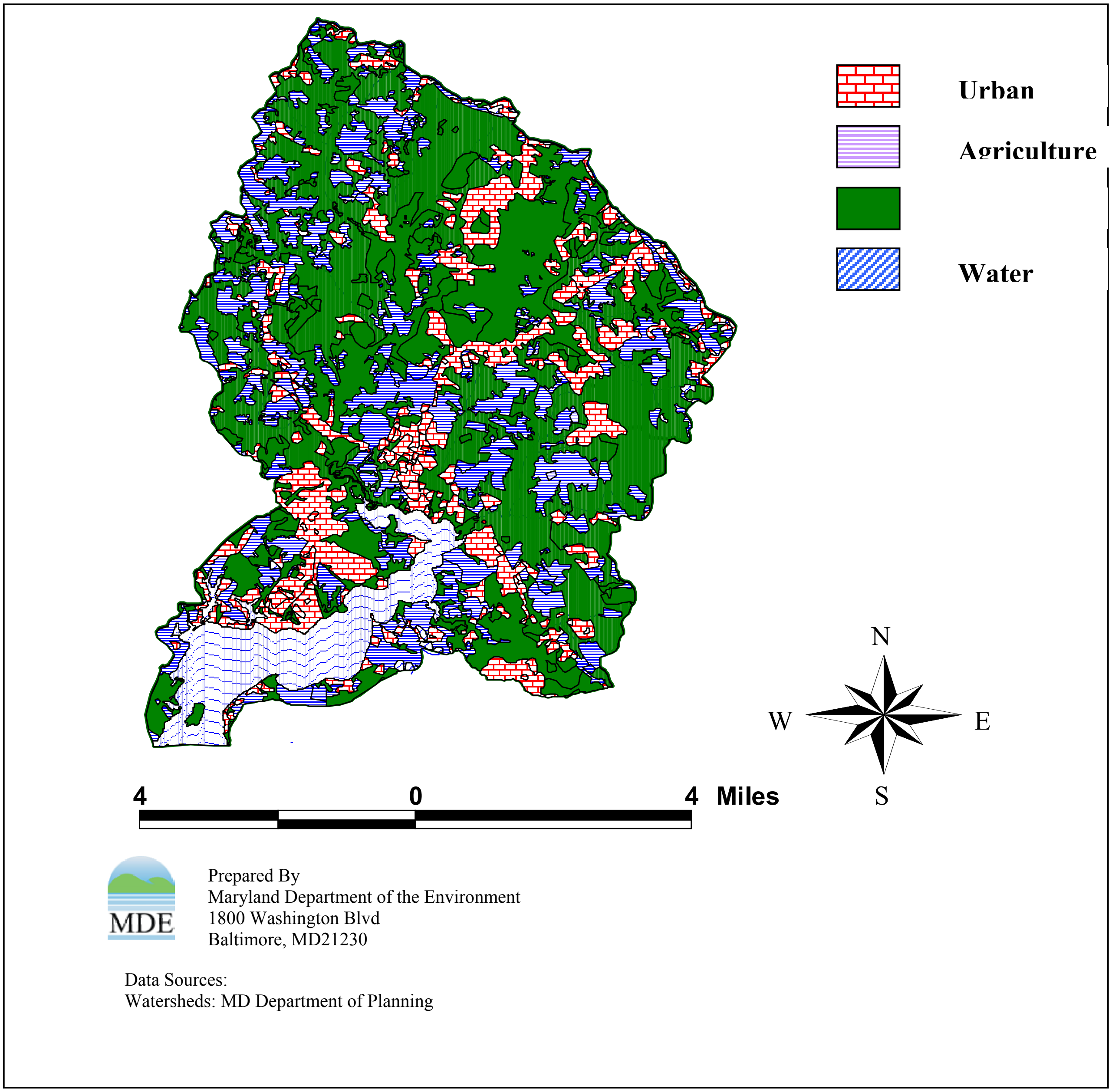


Figure 2: Predominant Land Use in the Breton Bay Drainage Basin

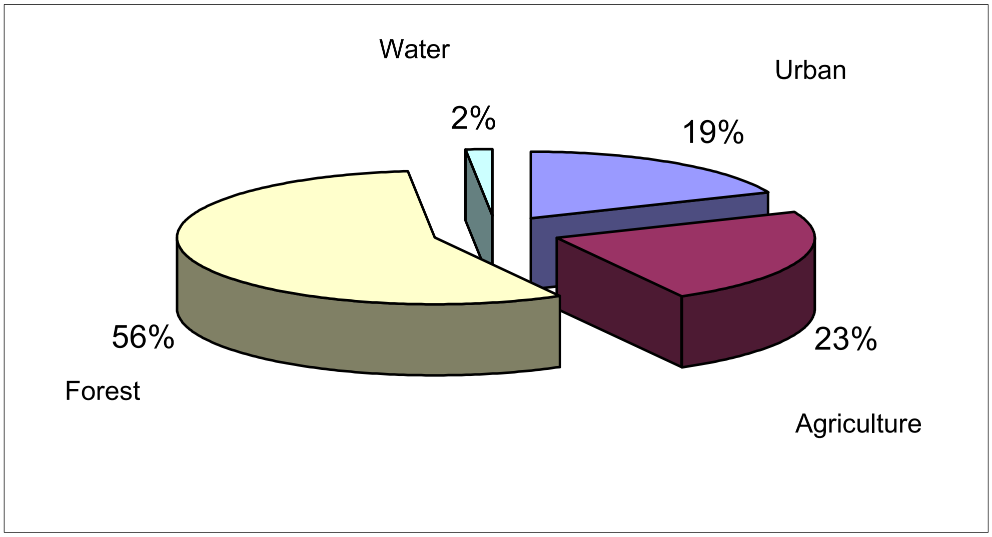
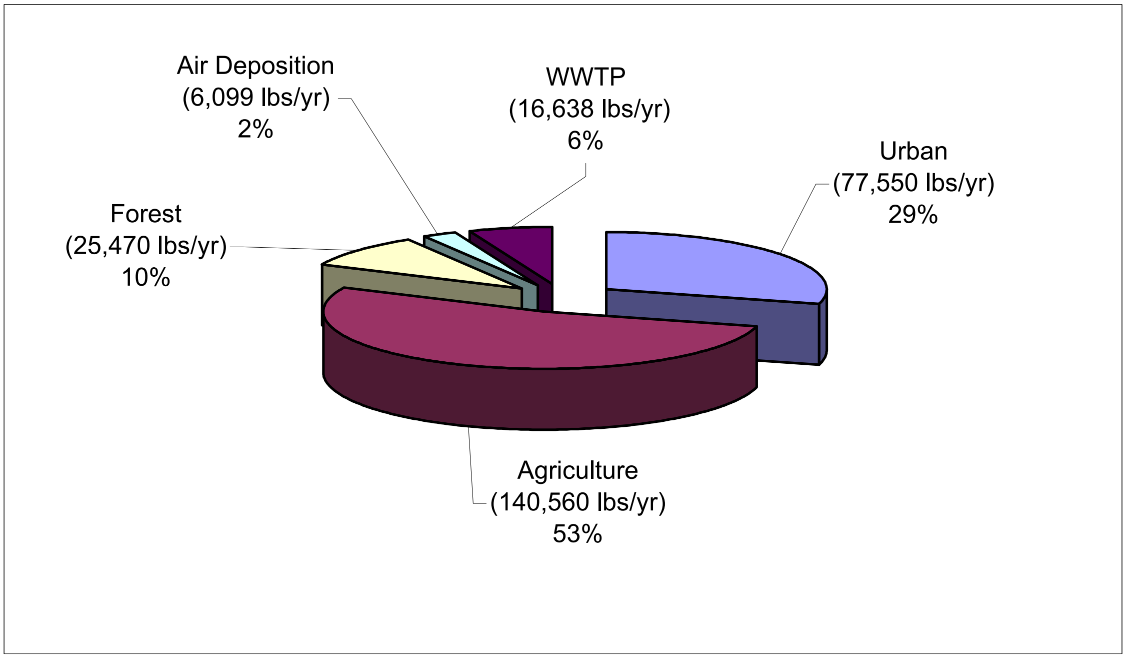


Figure 3: Proportions of Land Use in the Breton Bay Drainage Basin

The Leonardtown Wastewater Treatment Plant (WWTP), discharges into Town Run, a tributary of Breton Bay about 5.0 river miles from the mouth, with a permitted discharge capacity of 0.68 million gallons per day (MGD), and is the only significant point source on the Breton Bay Watershed. The estimated annual nutrient loadings for Breton Bay watershed are 266,317 lbs for total nitrogen and 19,866 lbs for total phosphorus. These loadings are generated from both point sources (including WWTP and urban stormwater) and nonpoint sources (including agriculture, forest and air deposition). The values of the loadings are estimated based on 2002 MDP land use data, EPA Chesapeake Bay Watershed Model loading coefficients (2002, Phase 4.3) and Leonardtown WWTP discharge monitoring data (DMR). A detailed breakdown for all the major contributors for nutrient loadings is illustrated in Figure 4. These long-term average values are presented to give the reader a reasonable estimate of the source contributions, and a sense of "current" conditions.

Leonardtown Wharf is a 5.5-acre waterfront development that will put offices, shops, a restaurant, loft apartments and a public park on Breton Bay. This mixed-use project is one of Maryland's designated Priority Places, a revitalization project located inside the Town of Leonardtown. For information on the Priority Places Strategy, go to http://www.priorityplaces.com/. State agencies will work with the town to assist in implementing the project in a manner that allows economic development and improves water quality, thus contributing to Chesapeake Bay Restoration initiatives. The Town has worked with MDE and several other agencies on the development of wetland restoration and buffers to streams, the bay and wetlands. Other environmental benefits include the cleanup of the site, which has been in a state of severe disrepair, improved stormwater management, and protection of the shoreline from erosion and pollution.

Total Nitrogen



Total Phosphorus

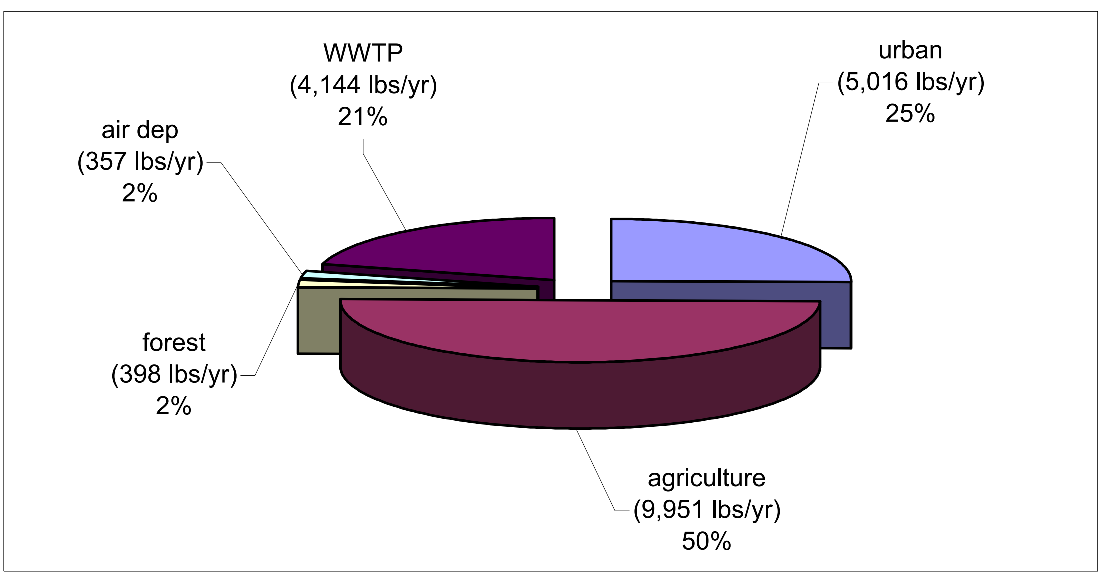


Figure 4: Estimated Annual Nitrogen and Phosphorus Loads

2.2 Water Quality Characterization

Water quality data has been collected and analyzed from stations throughout the length of Breton Bay (the locations of these stations are illustrated in Figure 5 and Table 1). Two water quality parameters associated with the observed impairment of Breton Bay, chlorophyll *a* and DO are presented below. Data from the water quality survey data on Breton Bay in 2001 and 2002 indicate that there have been water quality impairments at the upper portion of Breton Bay (Figure 6 and 7). Problems associated with eutrophication are most likely to occur during the growing season. During this season there is typically less stream flow available to flush the system, more sunlight to grow aquatic plants, and warmer temperatures, which are favorable conditions for biological processes of both plant growth and decay of dead plant matter. Because problems associated with eutrophication are usually most acute during this season, the temperature, flow, sunlight and other parameters associated with this period represent critical conditions for the TMDL analysis.

As a consequence of the generally level to moderate sloping topography and a soil texture consisting mostly by sandy soil in the drainage basin, low stream velocities are common in the growing season and indicators of water quality impairment are usually found in the upper portion of the Breton Bay. During the late spring/early summer, storm events bring heavy loads of nutrients and BOD through nonpoint source runoff, creating a favorable environment for aquatic plant growth. As the growing season progresses, an extended period of drought condition will lead to poor flushing and excess amounts of dead aquatic plants accumulated will create a DO deficit in that portion of Breton Bay. High chlorophyll *a* was observed in the early summer of 2001 (May) in the middle to upper portion of the Breton Bay. Low dissolved oxygen was also observed in Breton Bay in August and September of 2001 (Figure 6, 7) in the estuary between Town Run and McIntosh Run near Town of Leonardtown (Figure 8). These findings have confirmed that these areas experience eutrophication problems during the growing season.

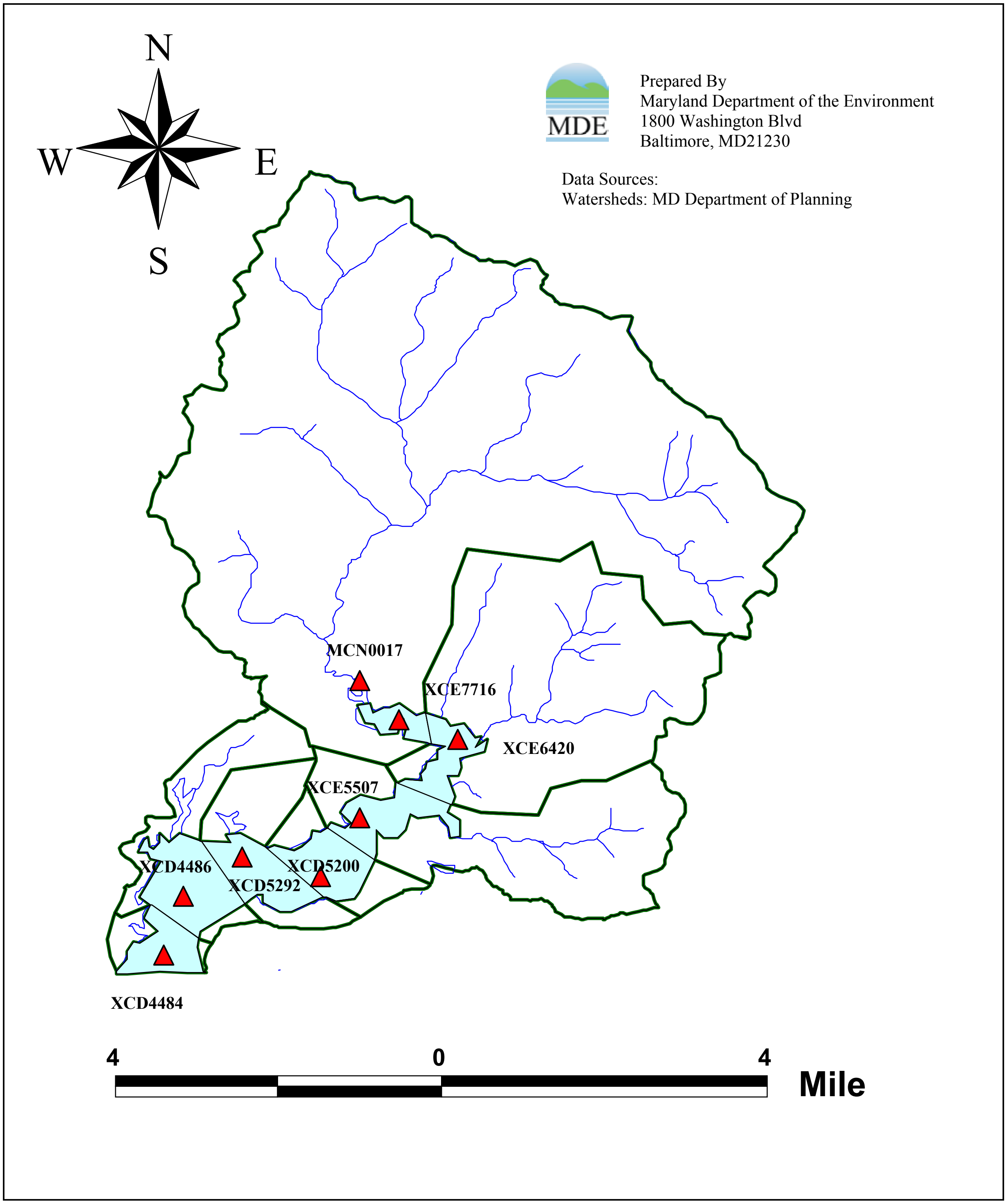


Figure 5: Locations of Water Quality Stations referenced in BBEM Segments

Table 1: Locations of Water Quality Stations referenced in BBEM

Water Quality Station	Location	Distance from the mouth (mile)
XCD 4484	38^o 14.392' N latitude 76^o 41.642' W longitude	0.5
XCD 4886	38^o 14.821' N latitude 76^o 41.452' W longitude	1.1
XCD 5292	38^o 15.242' N latitude 76^o 40.787' W longitude	2.0
XCD 5200	38^o 15.212' N latitude 76^o 39.996' W longitude	2.9
XCE 5507	38^o 15.495' N latitude 76^o 39.314' W longitude	3.8
XCE 6420	38^o 16.422' N latitude 76^o 38.055' W longitude	4.8
XCE 7716	38^o 17.151' N latitude 76^o 38.390' W longitude	6.1
MCN 0017*	38^o 18.248' N latitude 76^o 39.383' W longitude	6.7

*Located on McIntosh Run, data collected at this non-tidal station were used to estimate the pollutant loads from tributaries.

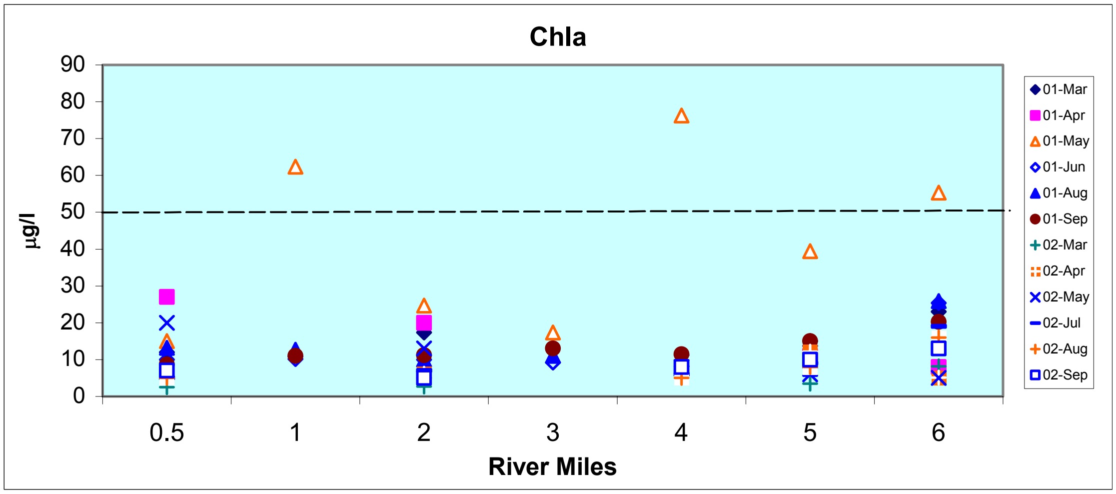


Figure 6: Longitudinal Profile of Chlorophyll *a* (Chla) Data

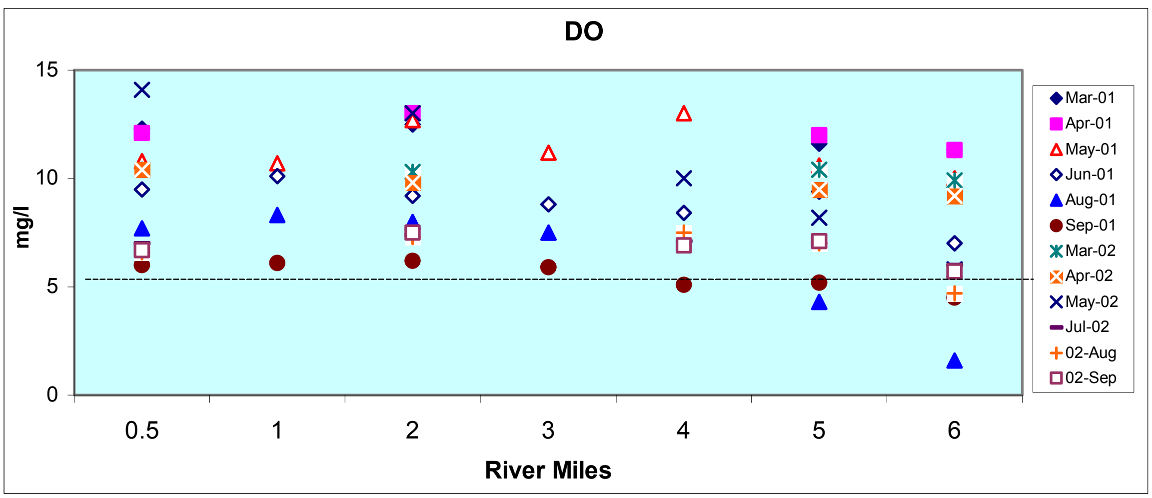


Figure 7: Longitudinal Profile of Dissolved Oxygen (DO) Data

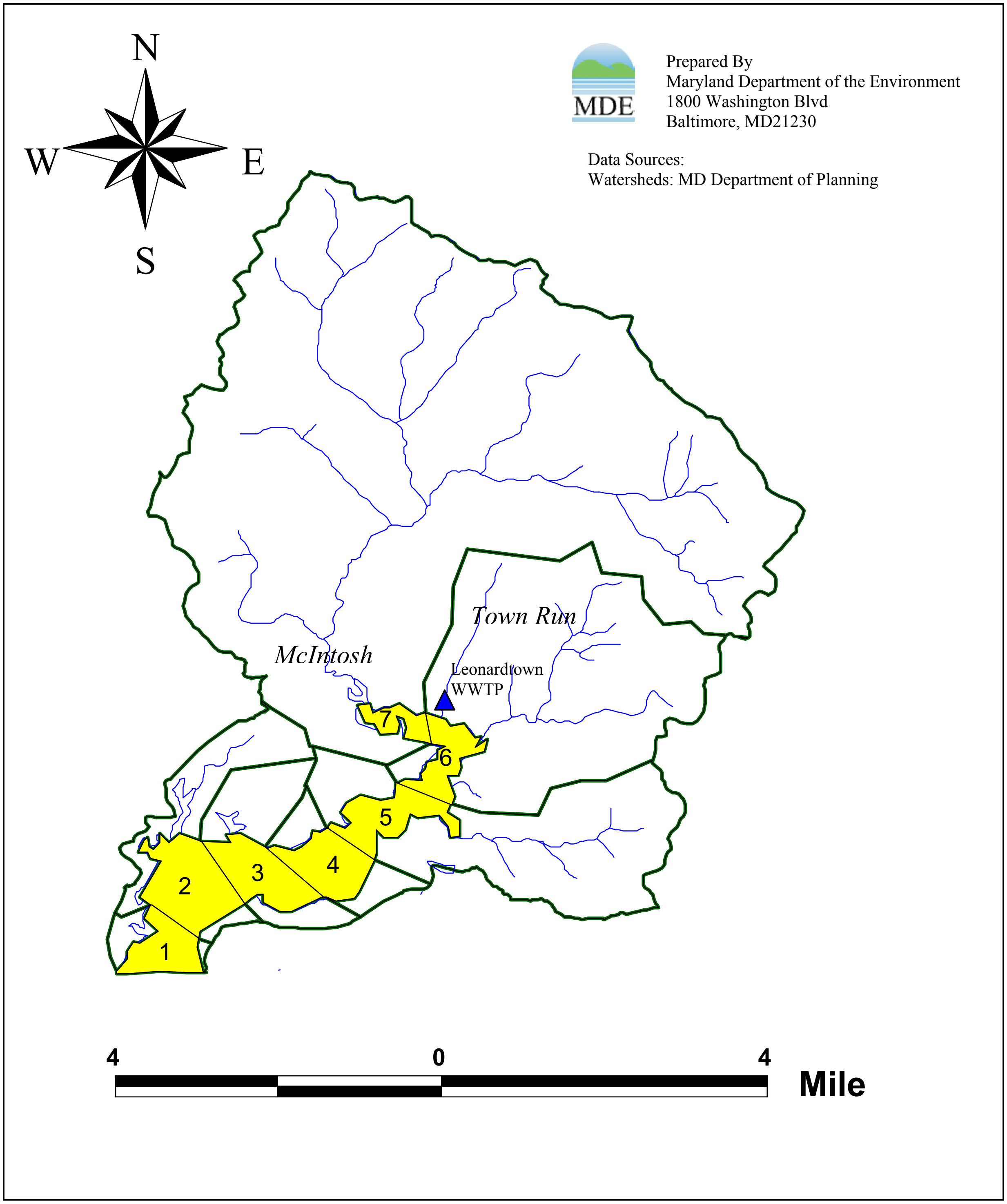


Figure 8: BBEM Segments and their associated subwatersheds

2.3 Water Quality Impairment

The Maryland water quality standards Surface Water Use Designation for Breton Bay is Use II – *shellfish harvesting, fishing, and protection of aquatic life and wildlife* (Code of Maryland Regulations (COMAR) 26.08.02.08M). The water quality impairment of Breton Bay system being addressed by this TMDL analysis consists of a higher than acceptable level of chlorophyll *a* and low dissolved oxygen level. The substances causing this water quality impairment are the nutrients nitrogen and phosphorus and BOD.

According to the numeric criteria for DO for Use II waters, concentrations may not be less than 5.0 mg/l at any time (COMAR 26.08.02.03-3C(3)). The achievement of 5.0 mg/l is expected in the well-mixed surface waters of the Breton Bay system.

Maryland's general water quality criteria prohibit pollution of waters of the State by any material in amounts sufficient to create nuisance or interfere with designated uses (COMAR 26.08.02.03B2). Additionally, certain surface waters are recognized as eutrophic, and all discharges to these surface waters are required to be treated as necessary to reduce eutrophic effects (COMAR 26.08.03.01.B3). Excessive eutrophication, indicated by elevated levels of chlorophyll *a*, can produce nuisance level of algae and interfere with desired uses such as fishing and swimming. The baseline scenario of TMDL analysis indicates that both nitrogen and phosphorus loadings from point and nonpoint sources have resulted in peak chlorophyll *a* concentrations occasionally exceeding the desired level of 50 μg/l in parts of the Breton Bay during both growing season and average annual flow conditions.

3.0 TARGETED WATER QUALITY GOAL

The objective of the nutrient and BOD TMDLs established in this document is to assure that the chlorophyll *a* and DO levels support the Use II designation for Breton Bay. Specifically, the TMDLs of nitrogen, phosphorus and BOD for Breton Bay are intended to:

1. Maintain a minimum DO level of 5.0 mg/l throughout the Breton Bay system, and
2. Reduced peak chlorophyll *a* levels (a surrogate for algal blooms) to below 50 μg/l throughout the Breton Bay system.

The DO level is based on specific numeric criteria for Use II waters set forth in the COMAR 28.08.02. The chlorophyll *a* water quality level is based on the guidelines set forth by Thomann and Mueller (1987) and by the EPA Technical Guidance Manual for Developing Total Maximum Daily Loads, Book 2, Part 1 (1997) that should support the designated uses of Breton Bay. These guidelines acknowledge it is acceptable to maintain chlorophyll *a* concentrations below a maximum 100 μg/l, with a goal less than 50 μg/l.

4.0 TOTAL MAXIMUM DAILY LOADS AND ALLOCATION

4.1 Overview

This section describes how the nutrient TMDLs and load allocations were developed for Breton Bay. The first section describes the modeling framework for simulating nutrient loads, hydrology, and water quality responses. The second and third sections summarize the scenarios that were explored using the model. The assessment investigates water quality responses assuming different stream flow and nutrient loading conditions. The fourth, fifth and sixth sections present the modeling results in terms of TMDLs and load allocations. The seventh section explains the rationale for the margin of safety (MOS). Finally, the pieces of the equation are combined in a summary accounting of the TMDLs for growing season and average annual flow conditions.

4.2 Analysis Framework

The computational framework chosen for the Breton Bay TMDLs was the Water Quality Analysis Simulation Program version 5.1 (WASP 5.1). This water quality simulation program provides a generalized framework for modeling contaminant fate and transport in surface waters and is based on the finite-segment approach (Di Toro *et al.*, 1983), dividing the water body into a series of segments and accounting for mass balance through various mass transportation and transformation equations. WASP 5.1 is supported and distributed by U.S. EPA's Center for Exposure Assessment Modeling (CEAM) in Athens, GA (Ambrose *et al.*, 1993). EUTRO 5.1 is the component of WASP 5.1 that simulates eutrophication, incorporating eight water quality constituents in the water column and the sediment bed.

The Breton Bay Eutrophication Model (BBEM) was implemented in a steady-state mode. This mode of using of WASP simulates constant flow and average water body volume over the tidal cycle. The tidal mixing is modeled using dispersion coefficients, which quantify the exchange of conservative substances between model segments. The model simulates an equilibrium state of the water body, which, in this case, considered low flow and average annual flow conditions. These conditions are described in more detail below.

The spatial domain of the BBEM extends from the mouth of Breton Bay for about 6.3 miles (10 km) towards the confluence of McIntosh Run. There are 7 model segments in this WASP modeling domain. A diagram of the WASP model segmentation is presented in Figure 8.

The nutrient TMDL analyses presented here consist of an assessment of growing season loading conditions and a projected loading for average annual flow condition. The TMDL analysis investigates the critical conditions under which symptoms of eutrophication are typically most acute, that is, in late growing season when flows are low, leading to poor flushing of the system, and when sunlight and temperatures are most conducive to excessive algal production.

The water quality model was calibrated to reproduce water quality characteristics for observed growing season conditions. Observed water quality data and stream conditions collected during the 2001 survey was used to support the calibration process, as explained further in Appendix A.

The estimation of stream flow used was based on the flows of two nearby U.S. Geological Survey (USGS) stations with continuous flow monitoring data. An average flow for each individual USGS gage was calculated by obtaining an average value over three growing season months (July, August, September) for the entire range of the flow data available. A ratio of flow to drainage area was calculated for each of the USGS gages and then an average of all the three flow to area ratios was determined. The flow for each sub-watershed was then determined by multiplying the flow to area ratio by its individual area. The estimation of stream flow used for the average annual flow condition was also calculated based on the data collected from same reference USGS gages. The locations for the reference USGS constant monitoring gaging stations can be found in Appendix A.

There is one municipal point source in the Breton Bay basin, the Leonardtown WWTP (design flow capacity 0.68 MGD). The methods of estimating loadings from tributary watersheds are described in Section 4.3. In brief, growing season tributary loads were derived from concentrations observed during growing season sampling in 2001 multiplied by the estimated flows. The average annual tributary loading estimation is calculated by multiplying the estimated annual regional nutrient load coefficients for each land use (obtained from EPA Chesapeake Bay Program) with the area of land use in each sub-watershed. The municipal point source load was based on the maximum permitted flow and the pollutant concentrations

The concentrations of nitrogen and phosphorus are modeled in their speciated forms. Nitrogen is simulated as ammonia (NH_4), nitrate and nitrite (NO_{23}), and organic nitrogen (ON). Phosphorus is simulated as ortho-phosphate (PO_4) and organic phosphorus (OP). NH_4 , NO_{23}, and PO_4 represent the dissolved forms of nitrogen and phosphorus. The dissolved forms of nutrients are more readily available for biological processes such as algae growth, which affect chlorophyll *a* levels and DO concentrations. The ratios of total nutrients to dissolved nutrients used in the model scenarios represent normalized values that have been measured in the field. These ratios are not expected to vary within a particular flow regime. Thus, a total nutrient value obtained from these model scenarios, under a particular flow regime, is expected to be protective of the water quality criteria in Breton Bay.

4.3 Scenario Descriptions

The BBEM model was applied to investigate different nutrient loading scenarios under growing season stream flow conditions. These analyses allow a comparison of conditions under which water quality problems exist, with future conditions that project the water quality response to various simulated load reductions of the impairing substances.

The analyses are grouped according to *baseline conditions*, and *TMDL conditions* associated with TMDLs. The baseline conditions are intended to provide a point of reference by which to compare the future scenario that simulates conditions of a TMDL. Defining this baseline for comparison is preferred to trying to establish a “current condition”. The baseline is defined in a consistent way among different TMDL projects, and does not vary in time. On the other hand, the alternative of using a “current condition” has the drawback of changing over time and leads to confusion. Since the development and review of a TMDL often take years, by the time it is completed, the "current" condition will be no longer valid. To avoid this confusion, the term "baseline condition" is used.

Baseline Condition (Growing Season): This first scenario represents the baseline condition of the waterbody at a simulated critical flow in Breton Bay. The method of estimating the critical flow is described in Appendix A. The scenario simulates a critical flow (7Q10) condition when the system is poorly flushed and sun light and warm water temperatures are most conducive to create the water quality problems associated with excessive nutrient enrichment.

The growing season loads from the tributaries were computed as the product of the observed concentrations and estimated critical flow. These loads integrate all natural and human induced sources, including agricultural practices, direct atmospheric deposition, and loads from septic tanks, which are associated with river base flow during growing season conditions. For the municipal point source load, the baseline conditions assume maximum allowable flow based on the NPDES (National Pollutant Discharge Elimination System) permit (Leonardtown WWTP, 0.68 MGD) with the estimated effluent condition (total nitrogen 8 mg/l, total phosphorus 2 mg/l, and current permitted biochemical oxygen demand 30 mg/l).

TMDL (Growing Season): The second scenario represents the future condition of maximum allowable loads during growing season. The flow is the same as that used in the first scenario. This scenario simulates an estimated 30% reduction in overall nitrogen, phosphorus and biochemical oxygen demand inputs from tributaries including agriculture, air deposition and forest as nonpoint source loads and urban stormwater runoffs classified as point source load. The point source load from Leonardtown WWTP assumes maximum permitted flow (0.68 MGD) with total nitrogen, total phosphorus and BOD maintained at 4 mg/l, 0.3 mg/l and 15 mg/l, respectively. In this scenario, reductions in nutrient sediment fluxes and sediment oxygen demand (SOD) were estimated based on the percentage reduction of organic matter settling on the bottom. Details of this modeling activity are described further in the technical memorandum entitled "*Nutrient Point Sources in the Breton Bay Watershed"* and Appendix A.

Baseline Condition (Average Annual): This third scenario represents the baseline condition of the waterbody at a simulated average annual condition in the Breton Bay. The model predicts the waterbody's response for nutrient input at average annual flow condition. The method of estimating the average annual flow is described in Appendix A.

For the point source load from the Leonardtown WWTP, this baseline condition assumes maximum permitted flow (0.68 MGD) with estimated current effluent condition (total nitrogen of 8 mg/l, total phosphorus of 2 mg/l and the current permitted BOD 30 mg/l).

The tributary loads contributed by all non-WWTP sources were calculated using loading rates for different land use from the EPA Chesapeake Bay Program Phase 4.3 watershed model and land use information from 2002 MDP data. The nutrient loads account for contributions from atmosphere deposition, agricultural, forest and urban lands.

TMDL (Average Annual): This fourth scenario represents the future condition of maximum allowable loads during average annual flow condition. The flow is the same as that used in the third scenario. This scenario simulates an estimated a comprehensive 30% reduction in nitrogen, phosphorus and BOD loads from all non-WWTP sources on the watershed (including agriculture, air deposition and forest from NPS and urban stormwater runoffs classified as point source). The loads from Leonardtown WWTP assume maximum allowable flow (0.68 MGD) with total nitrogen, total phosphorus and BOD maintained at 6 mg/l, 0.3 mg/l and 15 mg/l respectively. In this scenario, reductions in nutrient sediment fluxes and sediment oxygen demand (SOD) were estimated based on the percentage reduction of organic matter settling on the bottom Details of this modeling activity are described in Appendix A.

4.4 Scenario Results

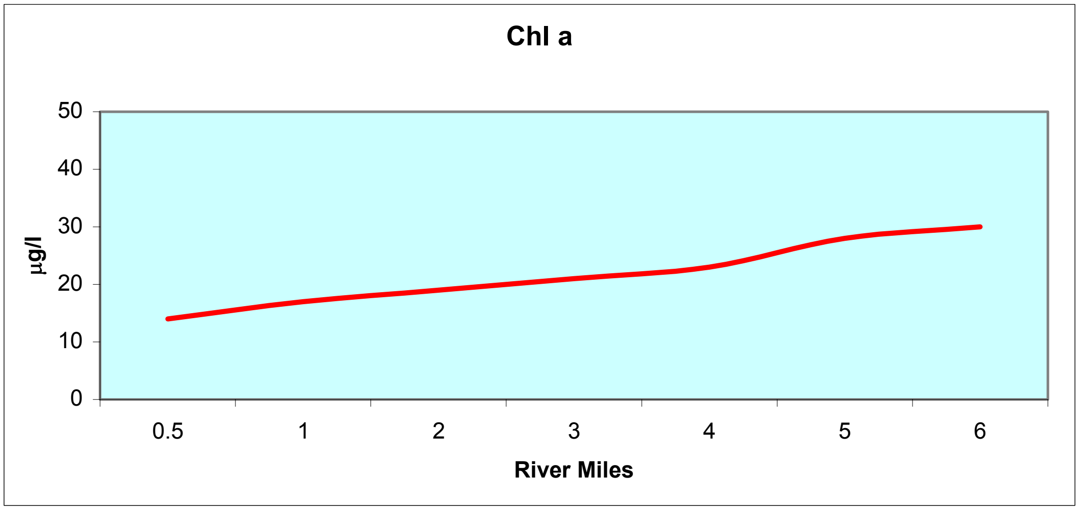
This section describes the results of the model scenarios described in the previous section. The BBEM results presented in this section are chlorophyll *a* level and daily minimum DO concentrations. These minimum DO concentrations account for diurnal fluctuations caused by photosynthesis and respiration of algae.

Baseline Condition (Growing Season) :

This scenario simulates critical low stream flow ($7Q_{10}$) conditions during the growing season. Municipal point source loads are assumed at the maximum, approved water and sewer plan flow and estimated effluent nutrient concentrations from the Leonardtown WWTP (0.68 MGD**)**. The loadings from the tributaries were estimated from the observed water quality parameters (e.g., nutrient concentrations) based on the water quality survey data in 2001 and 2002. Results for this scenario, representing the baseline condition for the growing season, are illustrated in Figure 9. The projected chlorophyll *a* level during the growing season is below 50 μg/l in all model segments. However, the DO concentrations in the upper estuary portion of Breton Bay fall below the 5 mg/l standard (Figure 9), indicating potential risks of a DO deficit. This scenario also suggests a necessary reduction of the BOD level from both the point and non point source entering the Breton Bay to prohibit the aggravation of DO deficit. The TMDL scenario, presented later, establishes maximum allowable loads that address these apparent problems.

Baseline (Growing Season)

(A)



(B)

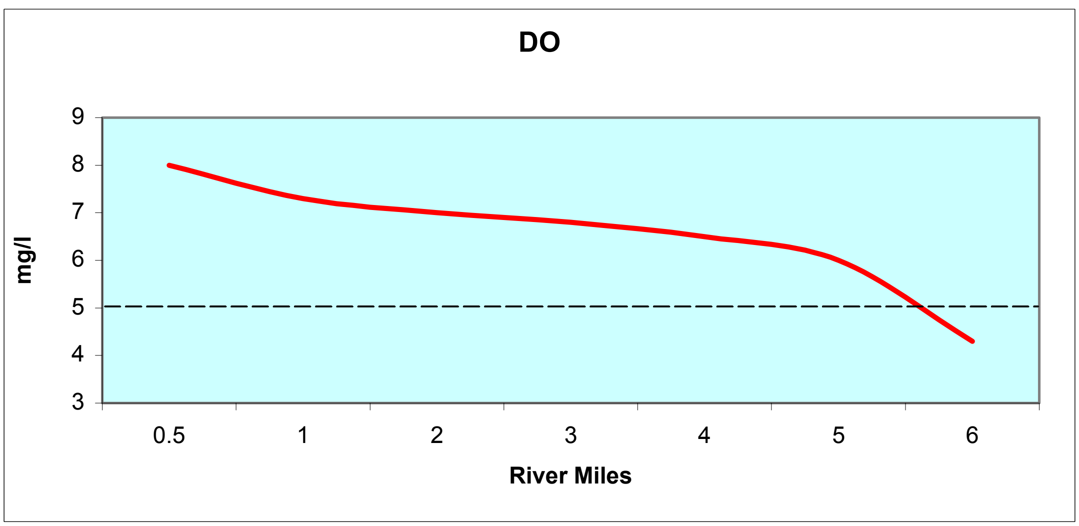


Figure 9: Results for the growing season Baseline scenario for (A) Chlorophyll *a* and (B) Dissolved Oxygen

TMDL (Growing Season):

The TMDL simulates the future condition of maximum allowable loads for critical flow ($7Q_{10}$) conditions during the growing season to meet the water quality standard for Breton Bay. Results for the TMDL are illustrated in comparison to the appropriate baseline conditions in Figure 10. Under the nutrient load reduction conditions described above for this scenario, the model results show that chlorophyll *a* concentrations are below the levels of 50 µg/l along the entire length of Breton Bay (Figure 10(A)). Results from Figure 10(B) also indicate that the minimum concentrations of dissolved oxygen in the upper segments have risen above the water quality criterion of 5.0 mg/l.

Baseline Condition (Average Annual):

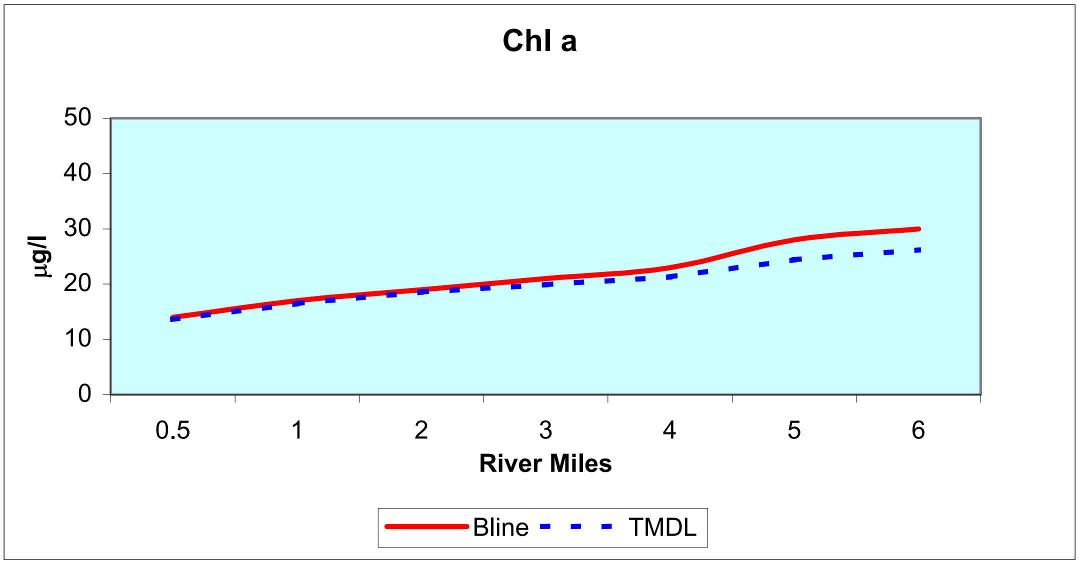
This scenario simulates average annual flow conditions. Nutrient tributary loads from all the non-WWTP sources (including agriculture, air deposition and forest as nonpoint source loads and urban stormwater runoffs classified as point source load) are based on loading rates for different land use from the EPA Chesapeake Bay Program Phase 4.3 (2002 Progress) watershed model and land use information from 2002 MDP data. Point source load from the wastewater treatment plant assumes maximum approved flow and observed effluent nutrient concentrations (0.68 MGD at Leonardtown WWTP). Results for this scenario, representing the average annual baseline condition, are illustrated in Figure 11. Figure 11A indicates that the average chlorophyll *a* level will exceed 50µg/l during average annual flow period in the upper segments. This prediction coincides with the growing season baseline result indicating that excess growth of aquatic plants in the upper region of Breton Bay during average flow season will set the stage for potential DO deficit during the growing season. The TMDL scenario, presented below, establishes maximum allowable loads that address these apparent problems.

TMDL (Average Annual):

This scenario simulates the future condition of maximum allowable loads for average annual flow conditions to meet the water quality in Breton Bay. Results for the TMDL are illustrated in comparison to the appropriate baseline condition (solid line) in Figure 12. Under the nutrient load reduction conditions described above, the results show that excessive chlorophyll *a* concentrations predicted in the upper estuary portion of Breton Bay in the baseline scenario has been reduced to below 50µg/l. Results from Figure 12(B) indicate that the minimum concentrations of dissolved oxygen along the length of the river are above the water quality standard of 5.0 mg/l.

TMDL (Growing Season)

(A)



(B)

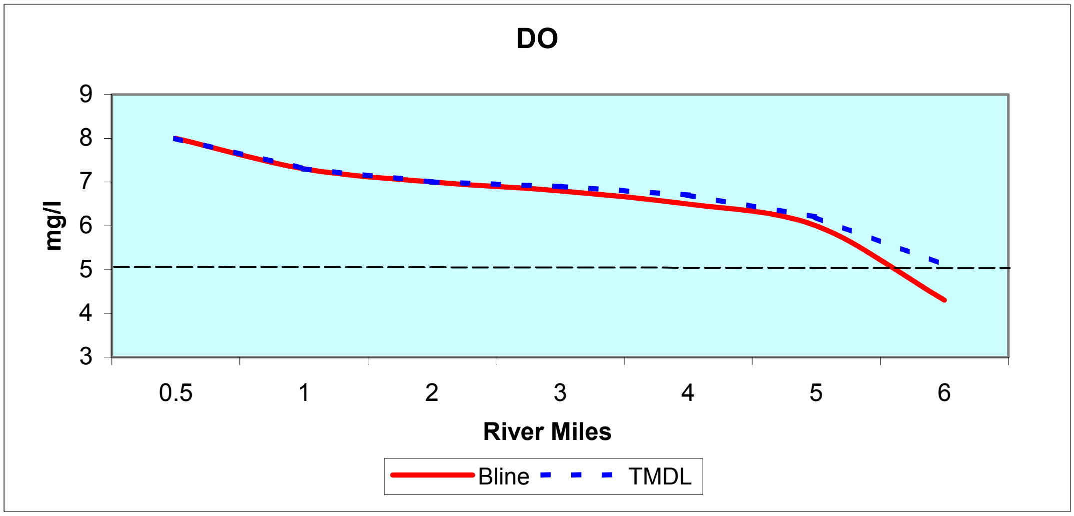
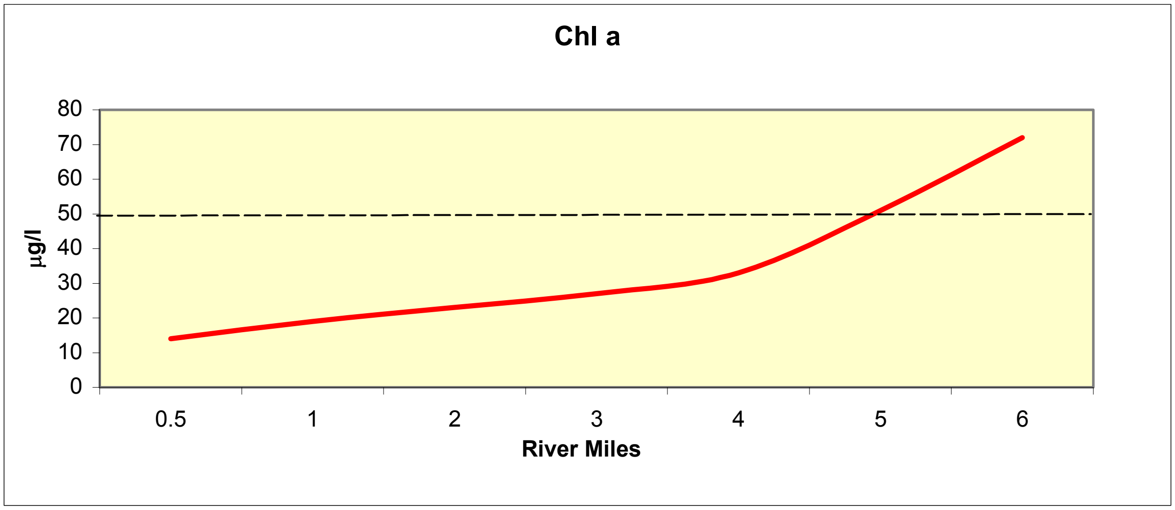


Figure 10: Results for the growing season TMDL scenario for (A) Chlorophyll *a* and (B) Dissolved Oxygen

Baseline (Average Annual)

(A)



(B)

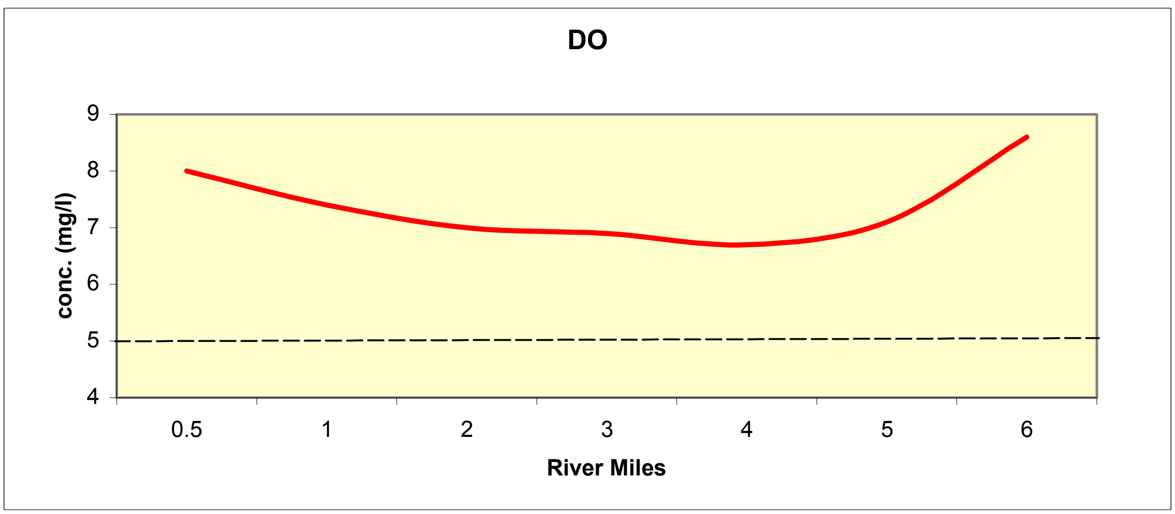
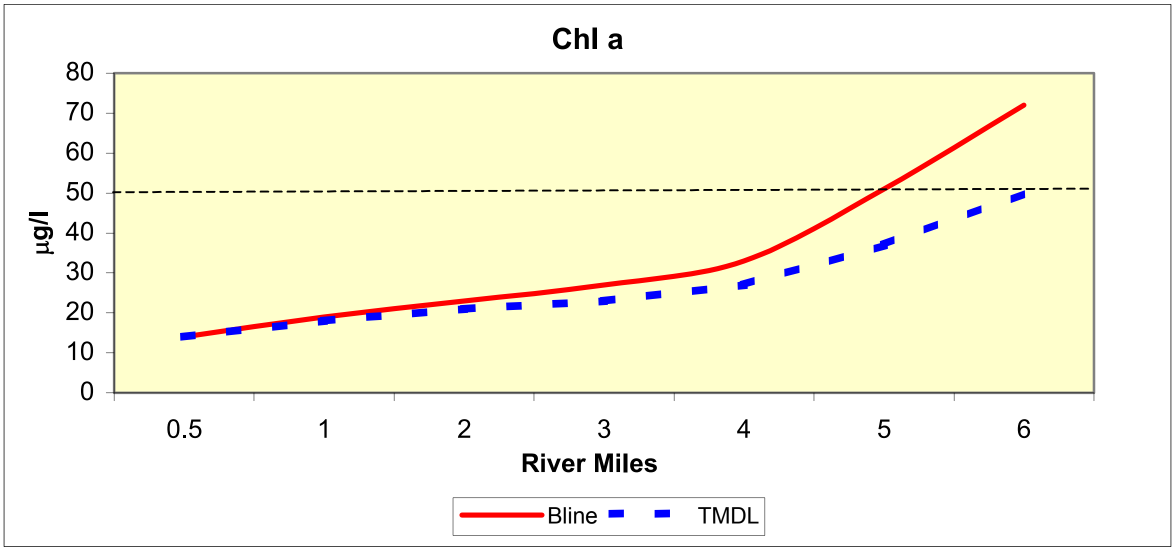


Figure 11: Results of Average Annual Baseline scenario for (A) Chlorophyll *a* and (B) Dissolved Oxygen

TMDL (Average Annual)

(A)



(B)

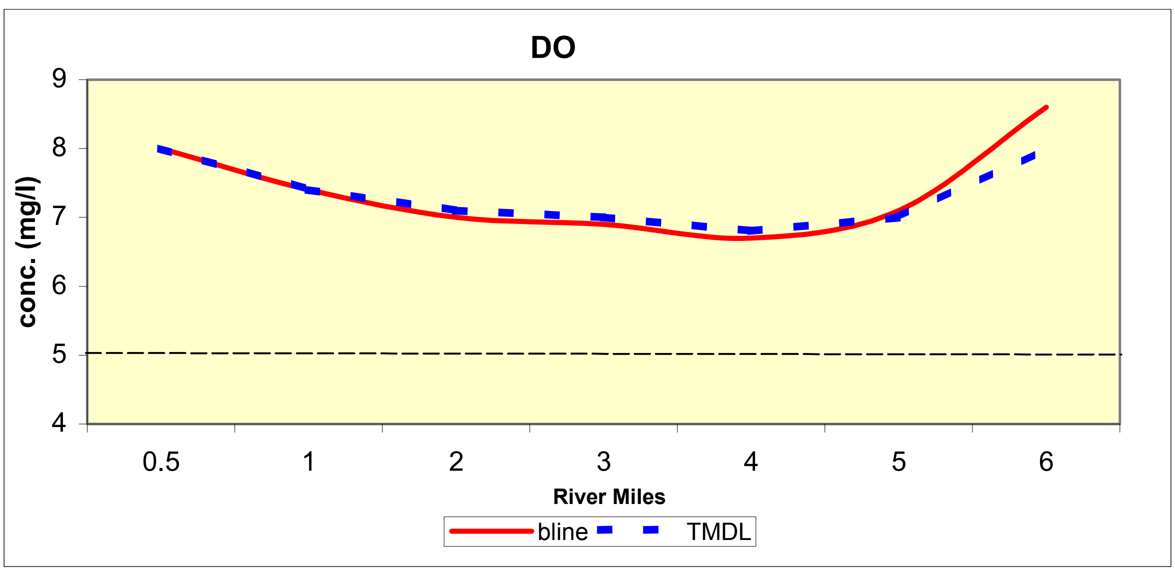


Figure 12: Results of Average Annual TMDL scenario for (A) Chlorophyll *a* and (B) Dissolved Oxygen

4.5 TMDL Loading Caps

This section presents the TMDLs of nitrogen, phosphorus and BOD. The outcomes of the TMDL analyses are presented in terms of a growing season TMDL and an average annual TMDL. The critical season for excessive algal growth in Breton Bay is during the growing season months, when at times the river system is poorly flushed. During this critical period, sunlight and warm water temperatures are most conducive to creating the water quality problems associated with excessive nutrient enrichment.

For May 1 through October 31, the following TMDLs apply:

Growing Season TMDL:

NITROGEN	**4,746** *lbs/growing season*
PHOSPHORUS	**342** *lbs/growing season*
BOD	**11,838** *lbs/growing season*

For the average annual flow, the following TMDLs apply:

Average Annual TMDL:

NITROGEN	**187,195** *lbs/year*
PHOSPHORUS	**11,627** *lbs/year*
BOD	**244,219** *lbs/year*

4.6 Load Allocations between Point Sources and Nonpoint Sources

The allocations described in this section demonstrate how the TMDL can be implemented to achieve water quality standards in Breton Bay. The allocations address geographic distributions of allowable nutrient loads, as well as the distribution between point sources and nonpoint sources. These allocations demonstrate how these TMDLs could be implemented to achieve water quality standards; however the State reserves the right to revise these allocations provided the allocations are consistent with the achievement of water quality standards.

Growing Season Allocations:

The tributary loads of nitrogen, phosphorus and BOD allocations for all non-WWTP sources (including Agriculture, air deposition and forest as nonpoint source loads and urban stormwater runoffs classified as point source load) simulated in both future scenarios represent 30% reductions from the baseline scenario. Recall that the baseline scenario loads were calculated through observed nutrient concentrations from the Breton Bay water quality survey conducted during the growing seasons of 2001 and 2002. These loads, based on observed concentrations, account for both "natural" and human-induced components. Allocations have been made to the Leonardtown WWTP based on its maximum permitted discharge flow and 4 mg/l nitrogen, 0.3 mg/l phosphorus and 15 mg/l BOD in the effluent. Point source allocation is described further in the technical memorandum entitled "*Nutrient Point Sources in the Breton Bay Watershed"* and Appendix A. To address the uncertainty during model development process and due to the difficulty of identifying the origin of pollutant among sources, 5% of the growing season loading for sources other than WWTP used in the BBEM growing season TMDL scenario is being allocated for margin of safety (MOS). The nitrogen, phosphorus and BOD allocations for the growing season are presented in Table 2.

Table 2: Growing Season Allocations

	Total Nitrogen *(lbs/growing season)*	**Total Phosphorus** *(lbs/growing season)*	**BOD** *(lbs/growing season)*
Nonpoint Source	630	30	1,548
Point Source[1]	4,086	306	10,206
MOS[2]	30	6	84
Total	4,746	342	11,838

1 Point source growing season allocation is designated for Leonardtown WWTP only.
2 5% of loads from all non-WWTP sources (including urban stormwater, agriculture, forest and air deposition).

<u>Average Annual Flow Allocations</u>:

This scenario was performed with a comprehensive 30% reduction of tributary loads from non-WWTP sources (for nitrogen reduction: 35% from urban stormwater, 36% from agriculture and 20% from air deposition, for phosphate: 32% from urban stormwater and 35% from agriculture, for BOD, a comprehensive 30% reduction from all sources). On the other hand, Leonardtown WWTP will maintain its effluent at the level of 6 mg/l nitrogen (excluding the growing season period), 0.3 mg/l phosphorus and 15 mg/l BOD. The tributary loads calculated in the annual flow condition was based on the nutrient loading rates provided by EPA Chesapeake Bay Program. Point source allocations are described further in the technical memorandum entitled "*Nutrient Point Sources in the Breton Bay Watershed"* and Appendix A. A portion (5%) of the annual agriculture loading used in the BBEM is being allocated for the margin of safety to address the many uncertainties in model simulations. The nitrogen and phosphorus allocations for average annual conditions are presented in Table 3.

Table 3: Average Annual Flow Allocations

	Total Nitrogen *(lbs/year)*	**Total Phosphorus** *(lbs/year)*	**BOD** * *(lbs/year)*
Nonpoint Source	119,902	7,265	202,520
Point Source	62,580 **	4,019 **	31,050
MOS	4,713 #	343 #	10,649 ##
Total	187,195	11,627	244,219

* Due to the difficulty of source separation the BOD allocation for urban stormwater in average annual TMDL is included in the nonpoint source allocation.
** The urban stormwater TN and TP allocation for average annual TMDL is included in point source allocation.
# 5% of annual agriculture load.
5% of loads from all non-WWTP sources.

4.7 Margins of Safety

The Clean Water Act requires a margin of safety (MOS) to be included as part of a TMDL in recognition of the many uncertainties in understanding and simulation of water quality in natural systems. For example, knowledge is incomplete regarding the exact nature and magnitude of pollutant loads from various sources and the specific impacts of these pollutants on the chemical and biochemical quality of complex, natural water bodies. The MOS is intended to account for such uncertainties in a manner that is conservative from the standpoint of environmental protection.

Based on EPA guidance, the MOS can be achieved through two approaches (EPA, April 1991). One approach is to reserve a portion of the loading capacity as a separate term in the TMDL (i.e., TMDL = Load Allocations + Waste Load Allocations + MOS). The second approach is to incorporate the MOS as conservative assumptions used in the TMDL analysis.

Maryland has adopted MOS for these TMDLs by using both a more conservative approach in the modeling process as well as a reserved portion from loading capacity. For instance, the average monthly flow from Leonardtown WWTP is 0.41 MGD (source: DMR 2002-2003), around 60 % of the design flow (0.68 MGD) utilized in baseline and scenario simulations in BBEM. In addition, safety factors are also built into the TMDL development process. In the absence of other factors, a generally acceptable range of peak chlorophyll *a* concentrations is between 50 and 100 μg/l. For the present TMDLs, MDE has elected to use the more conservative peak concentrations of 50 μg/l. In addition, MDE also includes an additional MOS allocation of 5% from all non-WWTP allocations in growing season condition (including urban stormwater, agriculture forest and air deposition) and 5% of agriculture allocation in average annual condition) to address the uncertainty of the modeling process. Table 3 includes the MOS incorporated in low flow and average flow TMDL.

4.8 Summary of Total Maximum Daily Loads

The growing season TMDLs, applicable from May 1 – Oct. 31 for Breton Bay:

For Nitrogen (*lbs/growing season*):

TMDL	=	LA[1]	+	WLA[1]	+	MOS[2]
4,746	=	**630**	+	**4,086**	+	**30**

For Phosphorus (*lbs/growing season*):

TMDL	=	LA[1]	+	WLA[1]	+	MOS[2]
342	=	**30**	+	**306**	+	**6**

For BOD (*lbs/growing season*):

TMDL	=	LA[1]	+	WLA[1]	+	MOS[2]
11,838	=	**1,548**	+	**10,206**	+	**84**

1. During the growing season, urban stormwater load is inclusive with LA
2. Representing 5 % of the growing season LA (including urban stormwater)

The Average Annual TMDLs, applicable for the annual flow condition for Breton Bay:

For Nitrogen (*lbs/year*):

TMDL	=	LA	+	WLA	+	MOS[1]
187,195	=	**119,902**	+	**62,580**	+	**4,713**

For Phosphorus (*lbs/year*):

TMDL	=	LA	+	WLA	+	MOS [1]
11,627	=	**7,265**	+	**4,019**	+	**343**

For BOD (*lbs/year*):

TMDL	=	LA	+	WLA	+	MOS[2]
244,219	=	**202,520**	+	**31,050**	+	**10,649**

1. Representing 5% of the agriculture allocation.
2. Representing 5% of the loads from all non-WWTP sources.

Where:

TMDL = Total Maximum Daily Load
LA = Load Allocation (Nonpoint Source)
WLA = Waste Load Allocation (Point Sources*)
MOS = Margin of Safety

*During average annual condition, point source load = WWTP + urban stormwater.

Average Daily Loads:

On average, the growing season TMDLs will result in loads of approximately 26 lbs/day of nitrogen, 2 lbs/day of phosphorus and 66 lbs/day of BOD. The average annual flow TMDLs will result in loads of approximately 513 lbs/day of nitrogen, 32 lbs/day of phosphorus and 669 lbs/day of BOD.

5.0 ASSURANCE OF IMPLEMENTATION

This section provides the basis for reasonable assurances that the nitrogen, phosphorus and BOD TMDLs will be achieved and maintained. For these TMDLs, Maryland has several well-established programs that will be drawn upon: the Water Quality Improvement Act of 1998 (WQIA); the Clean Water Action Plan (CWAP) framework; and the State's Chesapeake Bay Agreement's Tributary Strategies for Nutrient Reduction. Also, Maryland has adopted procedures to assure that future evaluations are conducted for all TMDLs that are established.

The implementation of point source nutrient controls will be executed through Enhanced Nutrient Reduction (ENR) strategy and NPDES permits. The ENR program provides cost-share grant funds to local governments to retrofit or upgrade wastewater treatment plants (WWTP) to remove a greater portion of nutrients from discharges. ENR technologies allow sewage treatment plants to provide a highly advanced level of nutrient removal. The ENR strategy builds on the success of the biochemical nutrient removal (BNR) program already in place. The NPDES permits for the Leonardtown WWTP will include nutrient load goals that have been established. Upon completion of the upgrade, the permits will require the permittee to make a best effort to meet the load goals providing reasonable assurance of implementation. The NPDES permits will also be consistent with the assumptions made in the TMDL (e.g., flow, nutrients effluent concentrations, CBOD, DO, etc.).

Maryland’s WQIA requires that comprehensive and enforceable nutrient management plans be developed, approved and implemented for all agricultural lands throughout Maryland. The WQIA specifically requires that nutrient management plans for nitrogen be developed and implemented by 2002, and plans for phosphorus to be done by 2005. Maryland’s CWAP has been developed in a coordinated manner with the State's 303(d) process. All Category I watersheds identified in Maryland's Unified Watershed Assessment process are consistent with the impaired waters list for 2002 approved by EPA. The State is giving a high-priority for funding assessment and restoration activities to these watersheds.

In 1983, the States of Maryland, Pennsylvania, and Virginia, the District of Columbia, the Chesapeake Bay Commission, and the U.S. EPA joined in a partnership to restore the Chesapeake Bay. In 1987, through the Chesapeake Bay Agreement, Maryland made a commitment to reduce nutrient loads to the Chesapeake Bay. In 1992, the Bay Agreement was amended to include the development and implementation of plans to achieve these nutrient reduction goals. Maryland’s resultant Tributary Strategies for Nutrient Reduction provide a framework that will support the implementation of NPS controls in the Lower Potomac Tributary Strategy Basin, which includes the Breton Bay watershed. Maryland is in the forefront of implementing quantifiable NPS controls through the Tributary Strategy efforts. This will help to assure that nutrient control activities are targeted to areas in which nutrient TMDLs have been established.

Also in 1983, the EPA Nationwide Urban Runoff Program determined that stormwater runoff from urban areas contains the same general types of pollutants found in wastewater, and that 30% of identified cases of water quality impairment were attributable to stormwater discharges. Pursuant to the Clean Water Act, MDE requires St. Mary’s County, the jurisdiction where the

Breton Bay watershed is located, to control stormwater discharges to the maximum extent practicable to comply with the nutrient loading goals from stormwater discharges established by the TMDL.

It is reasonable to expect that tributary loads can be reduced during the growing season period. While the growing season loads cannot be partitioned specifically into contributing sources, the sources themselves can be identified. These sources include dissolved forms of the impairing substances from groundwater, the effects of agricultural ditching and animals in the stream, and deposition of nutrients and organic matter to the stream bed from higher flow events. When these sources are controlled in combination, it is reasonable to achieve NPS reductions of the magnitude identified by this TMDL allocation.

In July 2003, the Center for Watershed Protection in cooperation with the Maryland Department of Natural Resources published a Watershed Restoration Action Strategy (WRAS) document for Breton Bay. The purpose of the document is to present a strategy to reduce NPS pollution that contribute to impairments in the watershed, while at the same time conserving the unique, high quality natural resources. The strategy was developed through the combined efforts of the general public, watershed stakeholders, local and county governments, non-profit organizations and State and Federal agencies. The document outlines the conditions in the watershed, the potential sources of pollution and impairments, and actions that can be taken to address these issues. It is anticipated that this strategy will assure TMDL implementation for nonpoint sources.

Finally, Maryland uses a five-year watershed cycling strategy to manage its waters. Pursuant to this strategy, the State is divided into five regions and management activities will cycle through those regions over a five-year period. The cycle begins with intensive monitoring, followed by computer modeling, TMDL development, implementation activities, and follow-up evaluation. The choice of a five-year cycle is motivated by the five-year federal NPDES permit cycle. This continuing cycle ensures that every five years intensive follow-up monitoring will be performed. Thus, the watershed cycling strategy establishes a TMDL evaluation process that assures accountability.

In addition, EPA Region 4 and EPA Region 6 have indicated that reductions in atmospheric contributions will be accomplished over time through existing and proposed Clean Air Act regulatory controls that will ensure significant reduction in airborne nutrient loading on a nationwide basis by reducing atmospheric emissions. Additionally, the following actions taken by EPA and the State of Maryland are also underway to assure the reduction of air deposition:

- To date, EPA has promulgated approximately 100 New Source Performance Standards under Section 111 of the Clean Air Act (CAA), of which about ten directly control nitrogen oxide (NOx) emissions;
- Because NOx is a precursor to ozone, Maryland and other states must apply similar requirements to major stationary sources of NOx emissions, including application of reasonably available control technology;
- The CAA Acid Rain Program specifies a two-part strategy to reduce NOx emissions from coal-fired electric power plants. EPA estimates that this program has resulted in

40% reductions in NOx emission rates from large utility boilers, and additional controls are expected over the next several years;

- In 1994, Maryland and other states signed a Memorandum of Understanding to achieve regional emission reductions of NOx (a.k.a. "OTC NOx Budget Program"). The agreement calls for the adoption of regulations to reduce NOx emissions in 1999 and further reduce emissions in 2003;
- In 1998, EPA issued the "NOx SIP Call" which assigns a cap on growing seasontime NOx emissions to be achieved by 2007;
- In 1999, EPA announced new limits for tailpipe emissions of NOx. These standards would require a 77% emissions reduction in cars over the next ten years;
- The proposed Clear Skies Act of 2003, aimed at power plants, estimates to reduce NOx emissions from Maryland sources by 70% by 2020, and 77% reductions in total NOx emissions in Maryland from 2000 levels. The estimated NOx deposition to the Chesapeake Bay watershed would be reduced up to 20%;
- Maryland and the other Chesapeake Bay states have agreed to incorporate nitrogen reductions resulting from the Clear Skies legislation as part of the overall plan to reduce nutrient loadings to the Bay.

The EPA expects to see reduced emissions as a number of regulations are implemented to control sulfur dioxide and nitrous oxides emissions. These controls for atmospheric emissions are expected to be implemented in phases.

REFERENCES

Ambrose, Robert B., Tim A. Wool, James A. Martin. "The Water Quality Analysis Simulation Program, Wasp5.1". Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency. 1993.

Code of Maryland Regulations, 26.08.02.08M, 26.08.02.03-3A(2), 26.08.02.03A(2), 26.08.02.03B(2), 26.08.03.01B(3)

Di Toro, D.M., J.J. Fitzpatrick, and R.V. Thomann "Documentation for Water Quality Analysis Simulation Program (WASP) and Model Verification Program (MVP)." EPA/600/3-81-044. 1983.

Maryland Department of Planning. 2002 Reference for Land Use.

Nitrogen: Multiple and Regional Impacts," EPA-430-R-01-06

Thomann, Robert V., John A. Mueller "Principles of Surface Water Quality Modeling and Control", HarperCollins Publisher Inc., New York, 1987.

U.S. EPA - Chesapeake Bay Program Watershed Model Scenario Output Database, Phase 4.3. Available at www.chesapeakebay.net.

U.S. EPA, "Guidance for water quality based decisions: The TMDL process," Office of Water, Washington D.C., 1991.

U.S. EPA Chesapeake Bay Program, "Chesapeake Bay Program: Watershed Model Application to Calculate Bay Nutrient Loadings: Final Findings and Recommendations," and Appendices, 1996.

U.S. EPA, "Technical Guidance Manual for Developing Total Maximum Daily Loads, Book 2: Streams and Rivers, Part 1: Biochemical Oxygen Demand/ Dissolved Oxygen and Nutrients/ Eutrophication," Office of Water, Washington D.C., March 1997.

U.S. EPA website : www.epa.gov/air/clearskies

U.S. EPA publication 3. 61 FR 67111-67164 (or www.epa.gov/airmarkt/arp/nox/phase2.html)