Total Maximum Daily Loads of Nitrogen and Phosphorus for the Still Pond Creek Kent County, Maryland

FINAL

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List of Abbreviations

BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CAFOs	Confined Animal Feeding Operations
CEAM	Center for Exposure Assessment Modeling
COMAR	Code of Maryland Regulation
CWAP	Clean Water Action Plan
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphorus
DO	Dissolved Oxygen
D_s	Secchi Depth
EPA	Environmental Protection Agency
EUTRO5.1	Eutrophication Module of WASP5.1
FNH_4	Ammonia Sediment Flux
FPO_4	Phosphate Sediment Flux
K_e	Extinction Coefficient
Km	Kilometers
LA	Load Allocation
Lb/month	Pounds Per Month
Lb/yr	Pounds Per Year
M	Meters
MACS	Maryland's Agricultural Cost Share Program
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
mg/l	Milligrams Per Liter
MOS	Margin of Safety
NBOD	Nitrogenous Biochemical Oxygen Demand
NH_3	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
SPCEM	Still Pond Creek Eutrophication Model
T	Temperature
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WASP5.1	Water Quality Analysis Simulation Program 5.1
WLA	Waste Load Allocation

WQLS	Water Quality Limited Segment
WQIA	Water Quality Improvement Act
7Q10	The 7-day consecutive lowest flow expected to occur every 10 years
g O_2/m^2	Grams of Oxygen Per Square Meter
*u*g/l	Micrograms Per Liter

EXECUTIVE SUMMARY

This document establishes Total Maximum Daily Loads (TMDLs) for nitrogen and phosphorus in Still Pond Creek. Still Pond Creek drains directly into the Chesapeake Bay and is part of the Upper Eastern Shore Tributary Strategy Basin. The creek is impaired by the nutrients nitrogen and phosphorus, which cause excessive algal blooms, and may contribute to hypoxia.

The water quality goal of these TMDLs is to reduce high chlorophyll *a* concentrations (a surrogate for algal blooms) and to maintain the dissolved oxygen criterion at a level whereby the designated uses for Still Pond Creek will be met. The TMDL was determined using the WASP5.1 water quality model. Maximum loads for total nitrogen and total phosphorus entering Still Pond Creek are established for both low flow and average annual flow conditions. As part of the TMDL analysis, the model was used to investigate seasonal variations and to establish margins of safety that are environmentally conservative.

The low flow TMDL for nitrogen is 349 lb/month, and the low flow TMDL for phosphorus is 31 lb/month. These TMDLs apply during the period May 1 through October 31. The low flow nonpoint source loads for the TMDLs are computed by multiplying the observed base flow concentrations by the estimated critical low flow. The maximum allowable loads have been allocated entirely to nonpoint sources, after allowing an appropriate margin of safety, because the watershed contains no permitted point sources to which allocations can be made.

The average annual TMDL for nitrogen is 34,918 lb/yr, and the average annual TMDL for phosphorus is 1,386 lb/yr. Baseline average annual nonpoint source loads, from which reductions are computed, are based on data collected by MDE in 1999. Again, because the watershed contains no permitted point sources to which allocations can be made, allowable average annual loads have been allocated to nonpoint sources only, with consideration given to an appropriate margin of safety.

Three factors provide assurance that these TMDLs will be implemented. First, 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. Second, Maryland's Water Quality Improvement Act of 1998 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 and the applicable federal 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.

Still Pond Creek was first identified on the 1996 303(d) list submitted to the Enviromental Protection Agency (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* concentration), and suspended sediments. Eutrophication is the over-enrichment of aquatic systems by excessive inputs of nutrients (nitrogen 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. This document proposes to establish TMDLs for the nutrients nitrogen and phosphorus in Still Pond Creek. The impairment for suspended sediments will be addressed separately.

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1 General Setting and Source Assessment

Still Pond Creek is located within Kent County, Maryland and is part of the Upper Eastern Shore Tributary Basin (Figure 1). Its headwaters originate near the intersection of Maryland’s routes 298, 561 and 292 (near Lynch). At its confluence with Churn Creek, Still Pond Creek itself finally drains to the Chesapeake Bay. The Still Pond Creek is approximately 5.2 miles (8.3 km) in length. The Still Pond Creek watershed has an area of approximately 15,018 acres (23.5 sq. miles). The land use in the watershed consist of forest and other herbaceous (4,067 acres or 27.1 %), mixed agriculture (8,418 acres or 56.0 %), water (1,376 acres or 9.2 %), and urban (1,156 acres or 7.7 %), based on 1997 Maryland Office of Planning land use data and 1997 Farm Service Agency data. Figure 2 shows the geographic distribution of the different land uses. Figure 3 shows the relative amounts of the different land uses.

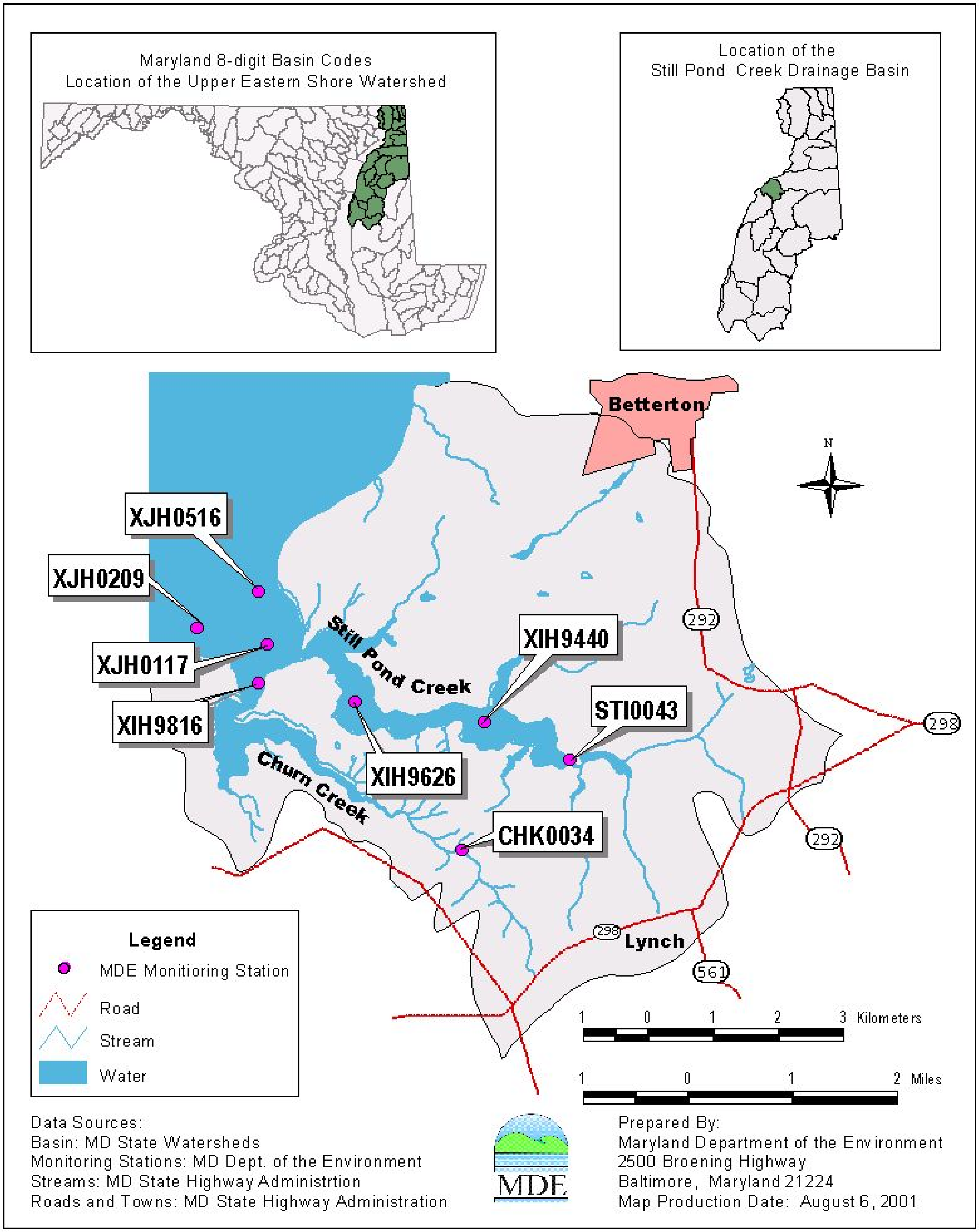

Figure 1: Location Map of the Still Pond Creek Drainage Basin within Maryland

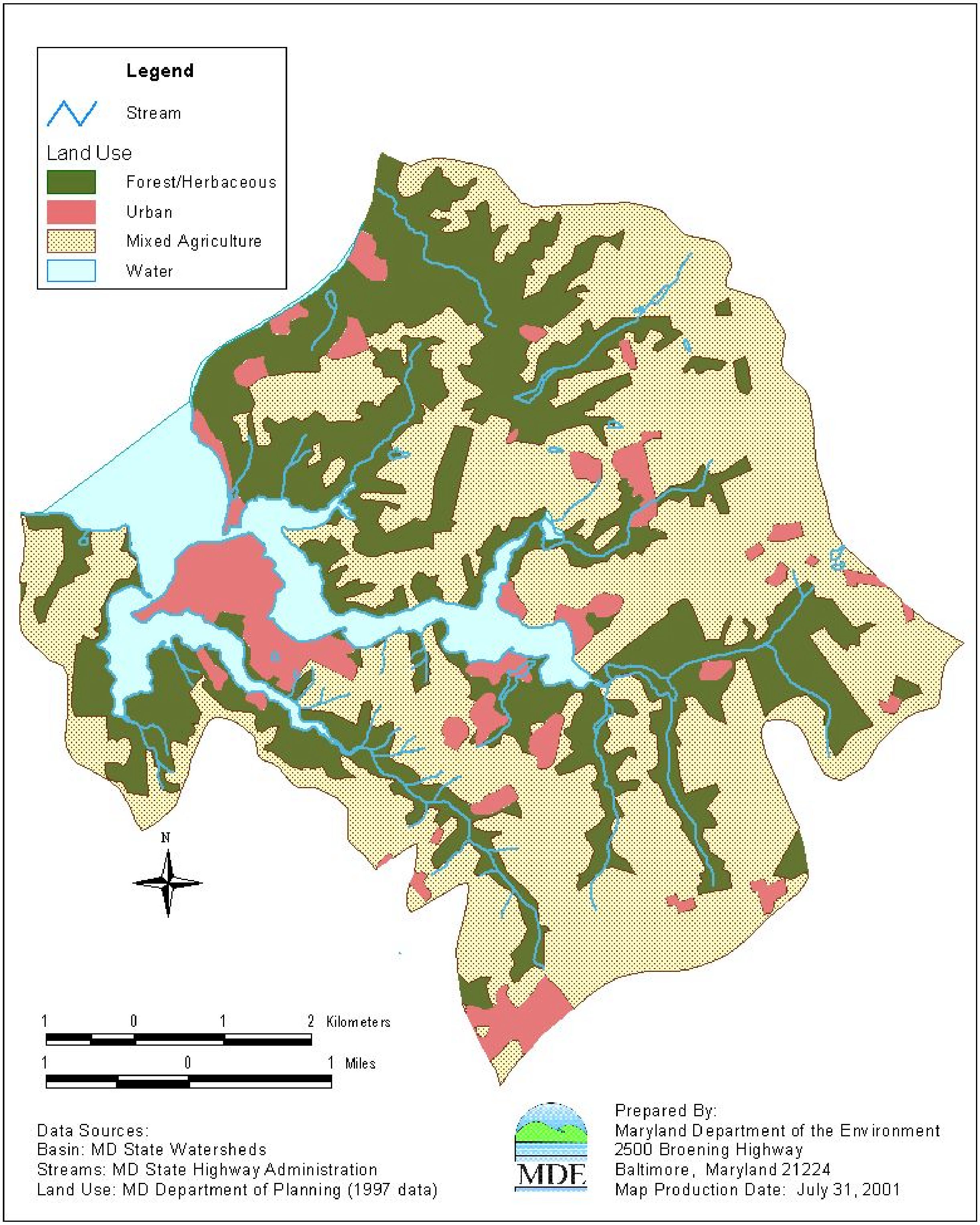

Figure 2: Predominant Land Use in the Still Pond Creek Drainage Basin

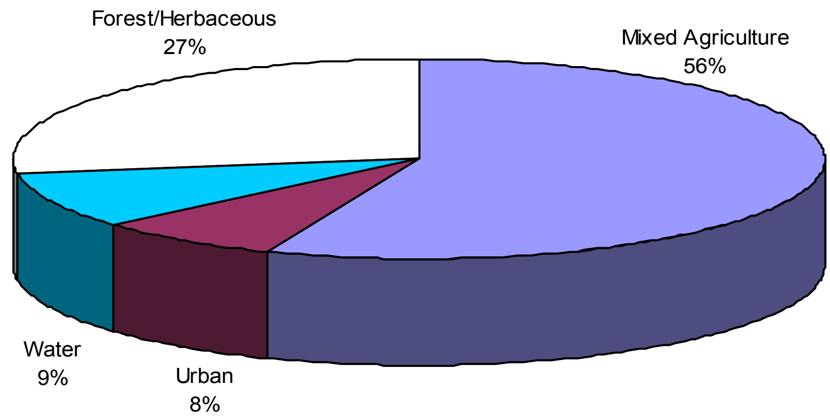

Figure 3: Proportions of Land Use in the Still Pond Creek Drainage Basin

Still Pond Creek is tidal throughout its navigable reach, which extends from the confluence with the Chesapeake Bay approximately 5.2 miles upstream to the headwaters. The creek presents a narrow constriction at about 0.8 miles upstream from the Chesapeake Bay, which results in very limited tidal exchange with the adjacent waters of the Chesapeake. This atypical tidal exchange produces unusual salinity distributions within Still Pond Creek, as well as other related hydrologic anomalies.

The narrow constriction in Still Pond Creek is at least partially responsible for elevated chlorophyll *a* concentrations observed in the upper sections of the creek. The headwaters of its tidal section are also characterized by weak currents, making the creek relatively stagnant. The narrow constriction is indicated by a broad depositional area in the headwaters, which at least partially relates to the area's distance from the origin of the tidal dependency. This limited tidal flushing causes high rates of sediment deposition that elevate bottom sediments in the creek and decrease its volume. The depth of the creek ranges from about 1 foot (0.3 m) at the headwaters to approximately 11 feet (3.4 m) at the mouth of the creek.

The watershed topography consists of well-drained soils with mild or minimal slopes and extensive agriculture with riparian forest along the edges of the river. Land use is predominantly row crop agriculture. Soybeans and corn crops are mostly grown for export from the county as grain. Use of chemical fertilizer predominates in this region (primarily anhydrous ammonia). No Confined Animal Feeding Operations (CAFOs) are found in the Still Pond Creek Watershed. Also a large seasonal migratory waterfowl population is present.

In the Still Pond Creek watershed, the estimated total nitrogen load is 51,486 lb/yr, and the total phosphorus load is 2,047 lb/yr. The percentages of the various land uses contributing to these loads are shown in Figure 4. These figures represent loads from nonpoint sources (NPS) only. There are no permitted point sources in the watershed that discharge nutrients. The average phosphorus and nitrogen loads were estimated from MDE observed data collected in 1999 and represent the best available estimate. The estimated NPS loads for baseline conditions (for low flow and average flow) serve only to provide the basis to compare the NPS reduction from current loads needed to reach the TMDL limit.

The data was collected in 1999, a fairly average year, in which the annual rainfall of 43.9 inches was slightly above the 10 year average of 37.5 inches over the period from 1991-2000. The range of annual rainfall for this period was 30 inches to 50 inches. MDE's estimate is supported by the results of water quality modeling, which indicated that loads higher than those estimated on the basis of observed data would result in unrealistically elevated nutrients and algal levels in the creek. The analysis used to estimate the maximum allowable load to the water body (i.e. TMDL) does not depend on the baseline estimate of NPS loads which are provided only for comparison to the loads allowed by the TMDL calculation. Thus, any uncertainty in the baseline NPS estimation does not affect the certainty of the estimated TMDL.

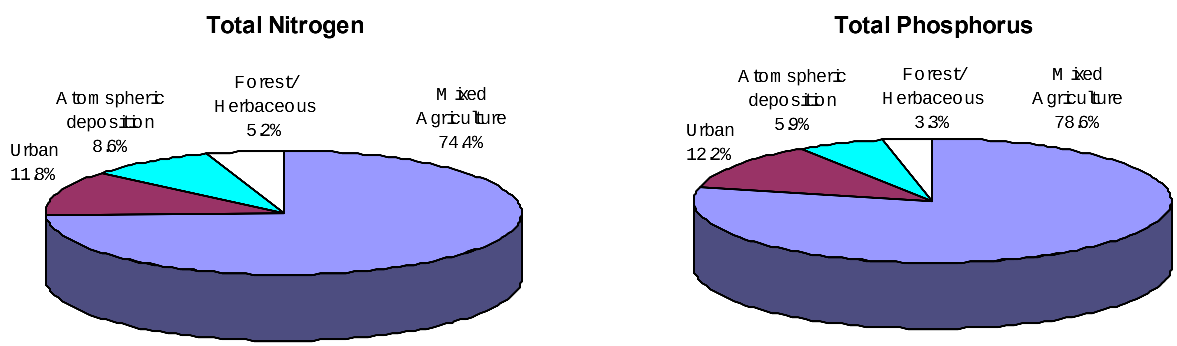

Figure 4: Percentages of Average Annual Flow Nitrogen and Phosphorus Nonpoint Source Loads

Finally, as part of the source assessment, we have considered that nutrient loads from the Chesapeake Bay might affect the Still Pond Creek. It is possible that, during high flow events from the Susquehanna River, fresh water intrusions cause algal growth or nutrient-laden sedimentation which could have secondary effects at later times (e.g., during low flow conditions). The fresh water intrusions from such high flow events are observed in the salinity profile data collected in 1999 (See Appendix A); however, determining the nutrient-related effects of these unpredictable events is an active area of research that is beyond the scope of this TMDL analysis. The potential implications of this phenomenon are acknowledged in the section entitled "Assurance of Implementation."

The NPS loads shown in Figure 4 were determined using land use loading coefficients. The land use information was based on 1997 Maryland Department of Planning data, with refinements of cropland acres based on 1997 Farm Service Agency data. The total nonpoint source load was calculated by summing all of the individual land use areas and multiplying by the corresponding land use loading coefficients. The loading coefficients were based on the results of the

Chesapeake Bay Watershed Model (U.S.EPA, 1996), a continuous simulation model. The Chesapeake Bay loading rates account for atmospheric deposition, and loads from septic tanks, urban development, agriculture, and forestland. This data was used only for an estimate of current NPS loadings and to calculate the percentages of the loads that could be controlled; it was not used in the development of the model used to calculate these TMDLs.

2.2 Water Quality Characterization

Four key water quality parameters associated with eutrophication, chlorophyll *a*, dissolved oxygen (DO), dissolved inorganic nitrogen (DIN), and dissolved inorganic phosphorus (DIP) are presented below (Figures 5 – 8). These data were collected by MDE during six water quality surveys conducted in Still Pond Creek during 1999. Three sets of samples were collected during seasonal low flow periods in summer (19-July-99, 16-Aug-99, 13-Sep-99), and three high flow periods in winter and spring (18-Mar-99, 12-April-99, 10-May-99). The reader is referred to Figure 1 for the locations of the water quality sampling stations. Table 1 presents the distance of each station from the mouth.

Problems associated with eutrophication are most likely to occur during the summer season (July, August, and September). During this season, there is typically less stream flow available to flush the system, more sunlight to grow aquatic plants, and warmer temperatures. These conditions are favorable 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.

Table 1: Location of Water Quality Stations

Water Quality Station	Miles from the Mouth of the Still Pond Creek
XJH0209	0.090
XJH0516	0.170
XJH0117	0.628
XIH9816	0.957
XIH9626	1.820
XIH9440	3.176
STI0043	4.213

As discussed below, the TMDL analysis also considers other seasons; however, the data collected during the high flow period (March, April and May 1999) does not show chlorophyll *a* or DO problems. The following graphs (Figures 5-8) present data from the low flow period. Additional data, including that for the high flow period, is presented in Appendix A.

As mentioned above in Section 2.1, the hydrologic characteristics of the Still Pond Creek render the system susceptible to algal blooms, especially at the upper reaches of the creek. In the upper reaches of the creek, the tidal dispersion is so poor that the water stagnates and any nutrients entering the stream from the watershed (including the marinas) or from the Chesapeake Bay stays, accumulates, and produces chlorophyll *a* growth, especially during the summer months. This chlorophyll *a* eventually dies, settles and is expected to cause higher sediment fluxes than the expected commonly seen in other systems.

Figure 5 presents a longitudinal profile of chlorophyll *a* data collected during Summer 1999, the low flow period which shows the higher chlorophyll *a* values in the upper section of the creek near the head of tide. The sampling region covers the entire tidal portion of Still Pond Creek from the station XJH0516, located approximately 0.17 miles above the mouth of the river, to the station STI0043 located 1.0 miles below the head of tide. Figure 5 shows that ambient chlorophyll *a* concentrations in the summer increase just below the head of tide. Concentrations reach their maximum (about 100 µg/l) at the 4.21 mile mark, and then taper off toward the mouth of the creek.

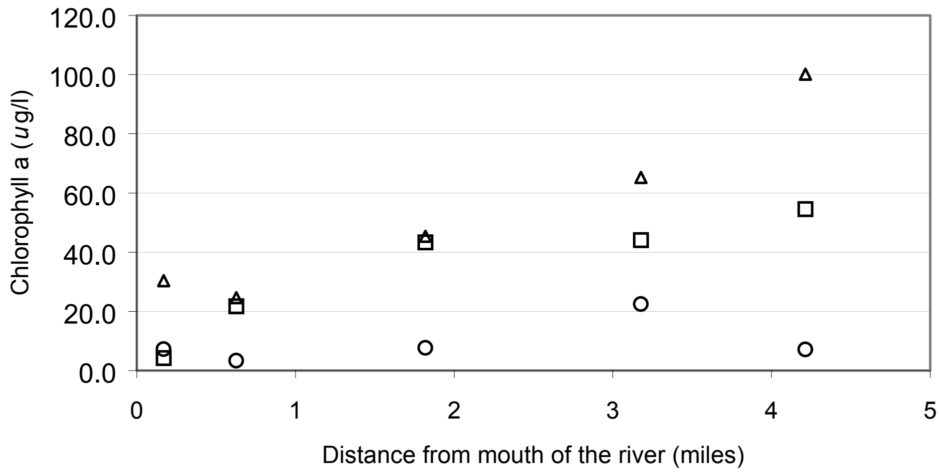

Figure 5: Longitudinal Profile of Chlorophyll *a* Data (Low Flow)

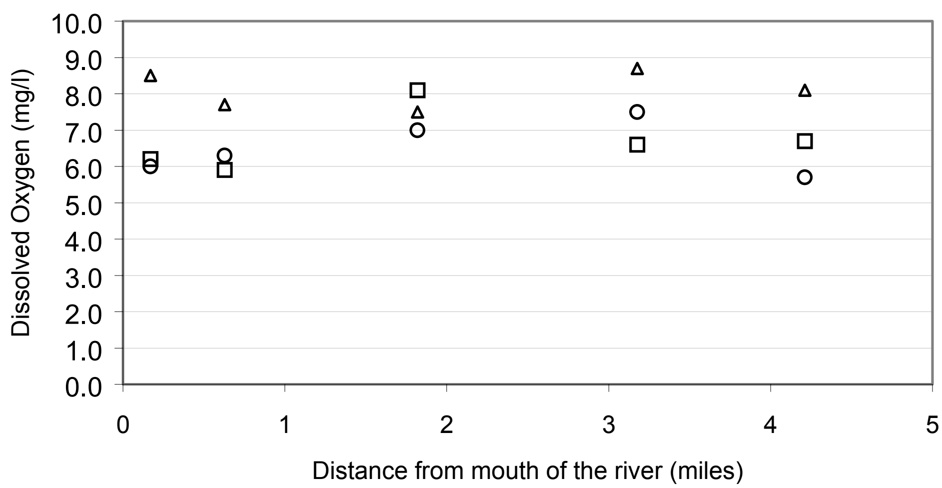

Figure 6: Longitudinal Profile of Dissolved Oxygen Data (Low Flow)

△ **July 1999** □ **August 1999** ○ **September 1999**

A similar longitudinal profile for DO concentrations is depicted in Figure 6. The data show a range between 5.7 and 9 mg/l along the length of the creek. Although observed DO concentrations are not below the minimum criteria of 5.0 mg/l in any of the samples taken during the 1999 survey, high concentrations of chlorophyll *a* suggest the possibility of low DO concentrations as a result of diurnal variations in oxygen due to algal respiration during non-daylight hours.

Figure 7 presents a longitudinal profile of DIN levels measured in the samples collected in 1999 during low flow conditions. The levels are generally below 0.60 mg/l throughout the stream system with several observations below 0.05 mg/l. The lower values are seen at the headwaters stations where chlorophyll *a* concentrations are very high. The DIN profile is consistent with the chlorophyll *a* profile, suggesting that the consumption of DIN support the growth of algae.

Figure 8 presents a longitudinal profile of DIP as indicated by ortho-phosphate levels measured in samples collected in 1999, during low flow conditions. All values fall in the range between 0.003 to 0.025 mg/l. Again, as in the DIN profile, the concentrations of DIP decreases upstream as we approach the head of tide. The profile is consistent with the chlorophyll *a* profile, suggesting that the consumption of DIP supports the growth of algae.

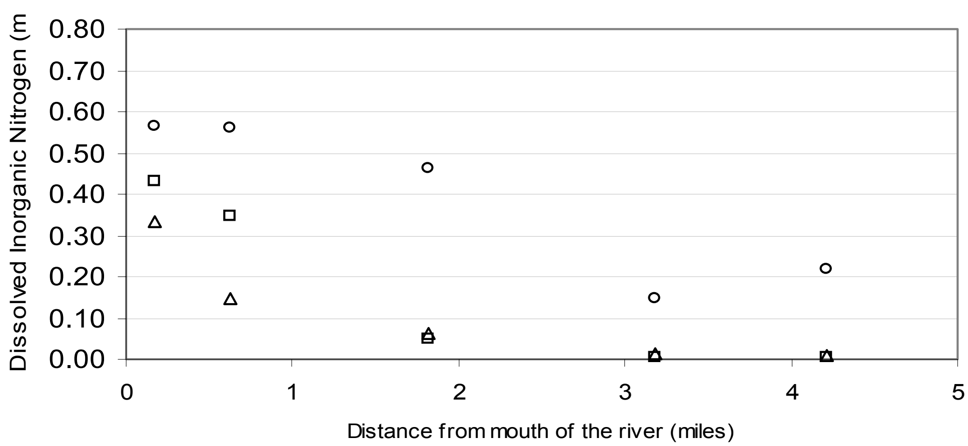

Figure 7: Longitudinal Profile of Dissolved Inorganic Nitrogen Data (Low Flow)

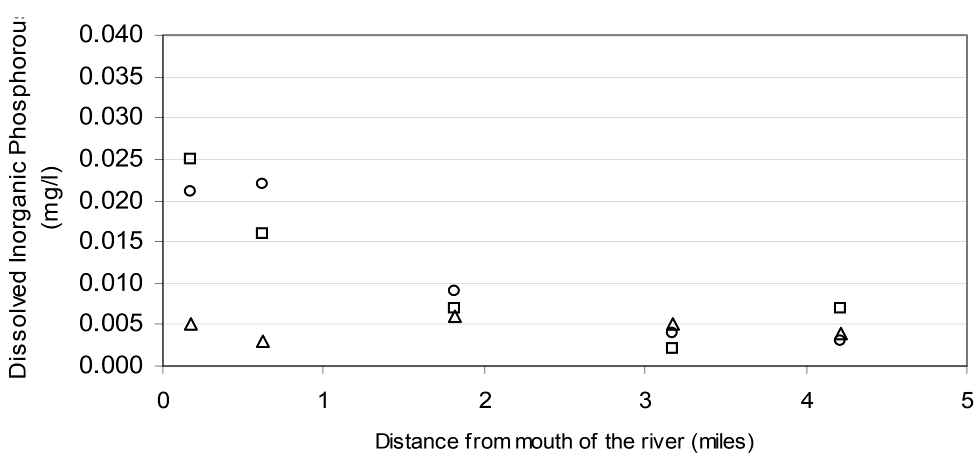

Figure 8: Longitudinal Profile of Dissolved Inorganic Phosphorus Data (Low Flow)

△ **July 1999** □ **August 1999** ○ **September 1999**

2.3 Water Quality Impairment

The Maryland water quality standards Surface Water Use Designation (Code of Maryland Regulations [COMAR] 26.08.02.07) for the Still Pond Creek is Use I – *water contact recreation, fishing, and protection of aquatic life and wildlife*. The water quality impairment of the Still Pond Creek system being addressed by this TMDL analysis is caused by an over enrichment of nutrients. Nutrient loadings from NPS have resulted in higher than acceptable chlorophyll *a* concentrations. Although observed DO concentrations are not below the minimum criteria of 5.0 mg/l in any of the samples taken during the 1999 survey, high concentrations of chlorophyll *a* suggest the possibility of low DO concentrations as a result of diurnal variations in oxygen due to algal respiration during non-daylight hours.

Maryland's General Water Quality Criteria prohibit pollution of waters of the State by any material in amounts sufficient to create a nuisance or interfere directly or indirectly with designated uses. See (COMAR 26.08.02.03B(2)). Excessive eutrophication, indicated by elevated levels of chlorophyll *a*, can produce nuisance levels of algae and interfere with designated uses such as fishing and swimming. The chlorophyll *a* concentrations in the upper reaches of Still Pond Creek has been observed to reach levels of 100 μg/l. These levels have been associated with excessive eutrophication.

3.0 TARGETED WATER QUALITY GOAL

The overall objective of the TMDLs established in this document is to reduce phosphorus and nitrogen loads to levels that are expected to result in meeting water quality criteria associated with eutrophication that support the Use I designation. Specifically, reduction in the phosphorus and nitrogen loads is intended to control excessive algae growth. Excessive algae growth can lead to violations of the numeric DO criteria, associated fish kills, and the violation of various narrative criteria associated with nuisances, such as odors, and impedance of direct contact use and the loss of habitat for the growth and propagation of aquatic life and wildlife.

In summary, the TMDLs for nitrogen and phosphorus are intended to:

1. Assure that a minimum dissolved oxygen concentration of 5.0 mg/l is maintained throughout the Still Pond Creek system; and

2. Resolve violations of narrative criteria associated with excess nutrient enrichment of the Still Pond Creek system, as reflected in chlorophyll *a* level greater than 50 μg/l in the poorly flushed tidal embayment.

The chlorophyll *a* water quality level is based on the designated uses of Still Pond Creek, guidelines set forth by Thomann and Mueller (1987) and by the EPA Technical Guidance Manual for Developing TMDLs, Book 2, Part 1 (1997). These guidelines acknowledge it is acceptable to maintain chlorophyll *a* concentrations below a maximum of 100 μg/l, with a target threshold of 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 Still Pond Creek. 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 and fifth sections present the modeling results in terms of TMDLs and load allocations. The sixth section explains the rationale for the margin of safety. Finally, the pieces of the equation are combined in a summary accounting of the TMDLs for seasonal low flow conditions and for annual loads.

4.2 Analysis Framework

The computational framework chosen for the Still Pond Creek TMDL was the Water Quality Analysis Simulation Program version 5.1 (WASP5.1). 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). WASP5.1 is supported and distributed by U.S. EPA's Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia (Ambrose *et al.,* 1993). EUTRO 5.1 is the component of WASP5.1 that simulates eutrophication, incorporating eight water quality constituents in the water column and the sediment bed.

The WASP5.1 model was implemented in a steady-state mode. This mode of using WASP5.1 simulates constant flow, and average water body volume over the tidal cycle. The tidal mixing is accounted for using dispersion coefficients, which quantify the exchange of conservative substances between WASP5.1 model segments. The model simulates an equilibrium state of the water body, which in this case, considered low flow and average flow conditions, described in more detail below.

The spatial domain of the Still Pond Creek Eutrophication Model (SPCEM) extends from the confluence of Still Pond Creek with the Chesapeake Bay for about 4 miles up to the head of tide. Twenty WASP5.1 model segments represent this modeling domain. Concentrations of relevant water quality parameters, observed in 1999 in the "free flowing" station of the river, serve as the model's upstream boundary. A diagram of the WASP5.1 model segmentation is presented in Appendix A. With the exception of subwatershed #13, which flows directly to the Chesapeake Bay, freshwater flows and NPS loadings from these subwatersheds are taken into consideration by dividing the drainage basin into 13 subwatersheds and assuming that flows and loadings are direct inputs to the SPCEM.

The nutrient TMDL analysis consists of two broad elements: an assessment of low flow loading conditions and an assessment of annual average loading. The low flow TMDL analysis investigates the critical conditions under which symptoms of eutrophication are typically most acute (i.e. in late summer 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 observed water quality characteristics for both observed low flow and observed high flow conditions. The calibration of the model for these two flow regimes establishes an analysis tool that may be used to assess a range of scenarios with differing flow and nutrient loading conditions. Observed water quality data collected during 1999 was used to support the calibration process, as explained further in the "Nonpoint Source Loadings" section of Appendix A.

The estimation of stream flow used in the critical low flow analyses was based on a regression analysis, which made use of the 1999 low flow months (July, August and September) data from the U.S. Geological Survey (USGS) flow gage station # 01493000 (Unicorn Branch located near Millington, MD); the station #01493112 (Chesterville Branch near Crumpton, MD); and the station #01493500 (Morgan Creek near Kennedyville, MD). The estimation of the annual average flow used the same method as the critical low flow calculation with the entire year 1999 data of the three USGS flow gage stations. This time period is consistent with the data used to calculate the boundary conditions for the model. The methods used to estimate stream flows are described further in the "Freshwater Flows" section of Appendix A.

The methods of estimating NPS loadings are described in Section 4.3. In brief, low flow NPS loads were derived from concentrations observed during low flow sampling in 1999 multiplied by the estimated critical low flows. Because the low flow loading estimations are based on observed data, they account for all human and natural sources. The annual average NPS loads were calculated using the same methods but using all the data available for the year 1999. These methods are elaborated upon in Section 4.3 and in the "Nonpoint Source Loadings" section of Appendix A.

The concentrations of the nutrients (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). Ammonia, nitrate and nitrite, and ortho-phosphate represent the dissolved forms of nitrogen and phosphorus. The dissolved forms of nutrients are more readily available for biological processes, such as algal growth, which affect chlorophyll *a* levels and dissolved oxygen concentrations. The ratios of total nutrients to dissolved nutrients used in the model scenarios represent 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 the Still Pond Creek.

4.3 Scenario Descriptions

The WASP5.1 model was applied to investigate different nutrient loading scenarios under various 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. By modeling both low flow and annual average loadings, the analyses account for seasonality, a necessary element of the TMDL development process. The analyses are grouped according to *baseline conditions* and *future* *conditions* associated with the TMDLs. Both groups include low flow and average annual loading scenarios, for a total of four scenarios.

The baseline conditions are intended to provide a point of reference by which to compare the future scenarios that simulate the conditions of the TMDL. Defining this baseline for comparison with the TMDL outcome is preferred to trying to establish a "current condition." The baseline is defined in a consistent way among different TMDLs, and does not vary in time; whereas, the alternative of using a "current condition" has the drawback of changing over time, which creates confusion. It is "current" at one point in time for a given TMDL, but development and review often take several years; by the time the TMDL is done, the "current" condition is no longer current. Also, what constitutes "current" for one TMDL is different for another TMDL developed at a later time. To avoid this confusion we use a "baseline" scenario.

The baseline conditions for NPS loads typically reflect an approximation of loads during the calibration-monitoring time frame, in this case 1999. There are no permitted point sources in the watershed that discharge nutrients. As such, the baseline conditions often reflect a fixed potential future critical condition, which approximates a maximum future loading assuming no control actions.

First Scenario: The first scenario represents the baseline conditions of the stream at a simulated critical low flow in the creek. The method of estimating the critical low flow is described in the "Freshwater Flows" section of Appendix A. The scenario simulates a critical condition when the creek system is poorly flushed, and sunlight and warm water temperatures are most conducive to creating the water quality problems associated with excessive nutrient enrichment.

The NPS nutrient concentrations for the first scenario were computed using the observed data collected during the low flow conditions of July and August of 1999, which were also used in the calibration of the model. Water quality data collected in September 1999 was available (see Figures 5-8 above,) but was not used in the calibration of the model due to the temperature difference between July–August and September 1999, which made the September data inappropriate to be included in the calibration of the model. The low flow NPS loads were computed as the product of the observed concentrations and estimated critical low flow. These low flow NPS and loads integrate all natural and human induced sources, including direct atmospheric deposition and loads from septic tanks.

Second Scenario: The second scenario represents baseline conditions of the stream at average flow and an average annual loading rate. Summer water temperatures and solar radiation values are used as conservative assumptions. The total NPS loads were calculated using an average of all the observed data MDE collected during 1999. These loads were computed as the product of the observed concentrations and estimated critical low flow. The nutrient loads account for contributions from atmospheric deposition, septic tanks, cropland, pasture, feedlots, forest, and urban land. A detailed description of this scenario can be found in Appendix A.

Third Scenario: The third scenario represents the future condition of maximum allowable loads during critical low stream flow. The stream flow is the same as that used in the first scenario.

This scenario simulates a reduction from the baseline conditions scenario controllable nonpoint source loads in the Still Pond Creek watershed. This reduction in nonpoint source loads includes a margin of safety computed as 5% of the NPS load allocation. In this future condition scenario, reductions in nutrient sediment fluxes and sediment oxygen demand (SOD) were estimated based on the percentage reduction of organic matter settling on to the bottom. Further discussion of this scenario is provided in Appendix A.

Fourth Scenario: The fourth scenario provides an estimate of future conditions of maximum allowable average annual loads. The scenario uses an average annual stream flow as in the second scenario. The scenario simulates a condition when the sunlight and warm water temperatures are most conducive to algal growth, which can lead to water quality problems associated with excessive nutrient enrichment. Because higher stream flows, like the average flow, typically occur during cooler seasons, the assumptions of high water temperature and solar radiation used in the analysis are conservative with respect to environmental protection.

This scenario simulates a reduction in controllable NPS loads of nitrogen and phosphorus in all subwatersheds of the Still Pond Creek watershed. A 3% margin of safety was also included for the NPS load calculation. Reductions in nutrient sediment fluxes and SOD were estimated based on the percentage reduction of organic matter settling to the bottom, computed as a function of the nutrient reduction. Further discussion of this scenario is provided in Appendix A.

4.4 Scenario Results

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

Baseline Condition Loading Scenarios:

- *First Scenario (Low Flow):* Simulates critical low stream flow conditions during summer season. Water quality parameters (e.g., nutrient concentrations) are based on 1999 observed data.

Results for the first scenario, representing the baseline condition for summer low flow, are summarized in Figure 9. Under these conditions, the peak chlorophyll *a* level is above the target threshold of 50 µg/l, reaching a peak value of about 74 µg/l. DO concentrations remain above 5.0 mg/l throughout the system of the creek.

- *Second Scenario (Average Annual Flow):* Simulates average annual stream flow conditions, with baseline annual nonpoint source loads computed on the basis of 1999 MDE observed data (see Appendix A).

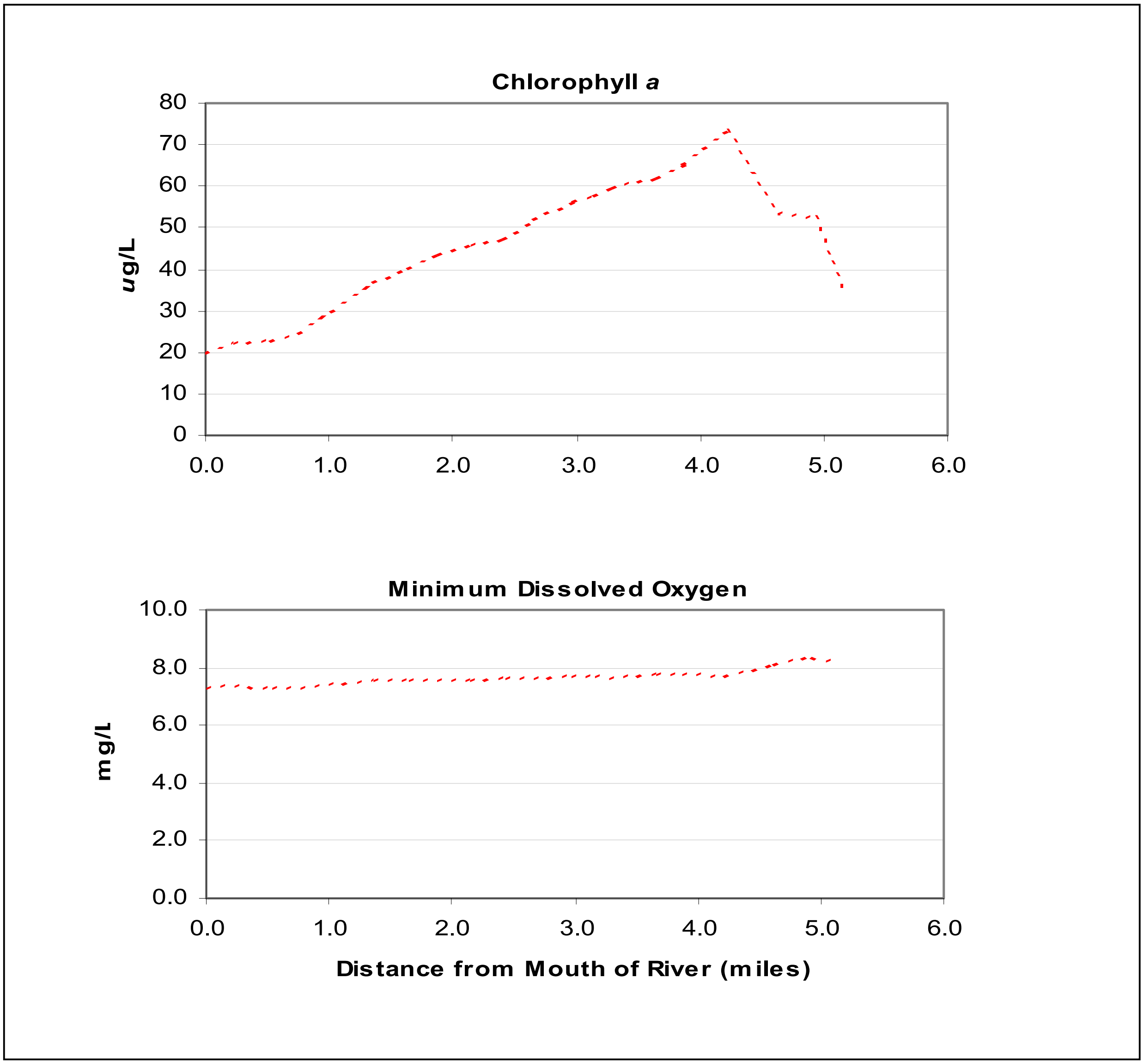

Figure 9: Model Results for the Low Flow Baseline Scenario for Chlorophyll *a* and Dissolved Oxygen (First Scenario)

Results for the second scenario, representing the baseline condition for the average stream flow and average loads, are summarized in Figure 10. Under these conditions, the chlorophyll *a* concentrations are also above the target threshold of 50 µg/l and DO concentrations remain above 5.0 mg/l throughout the length of the creek.

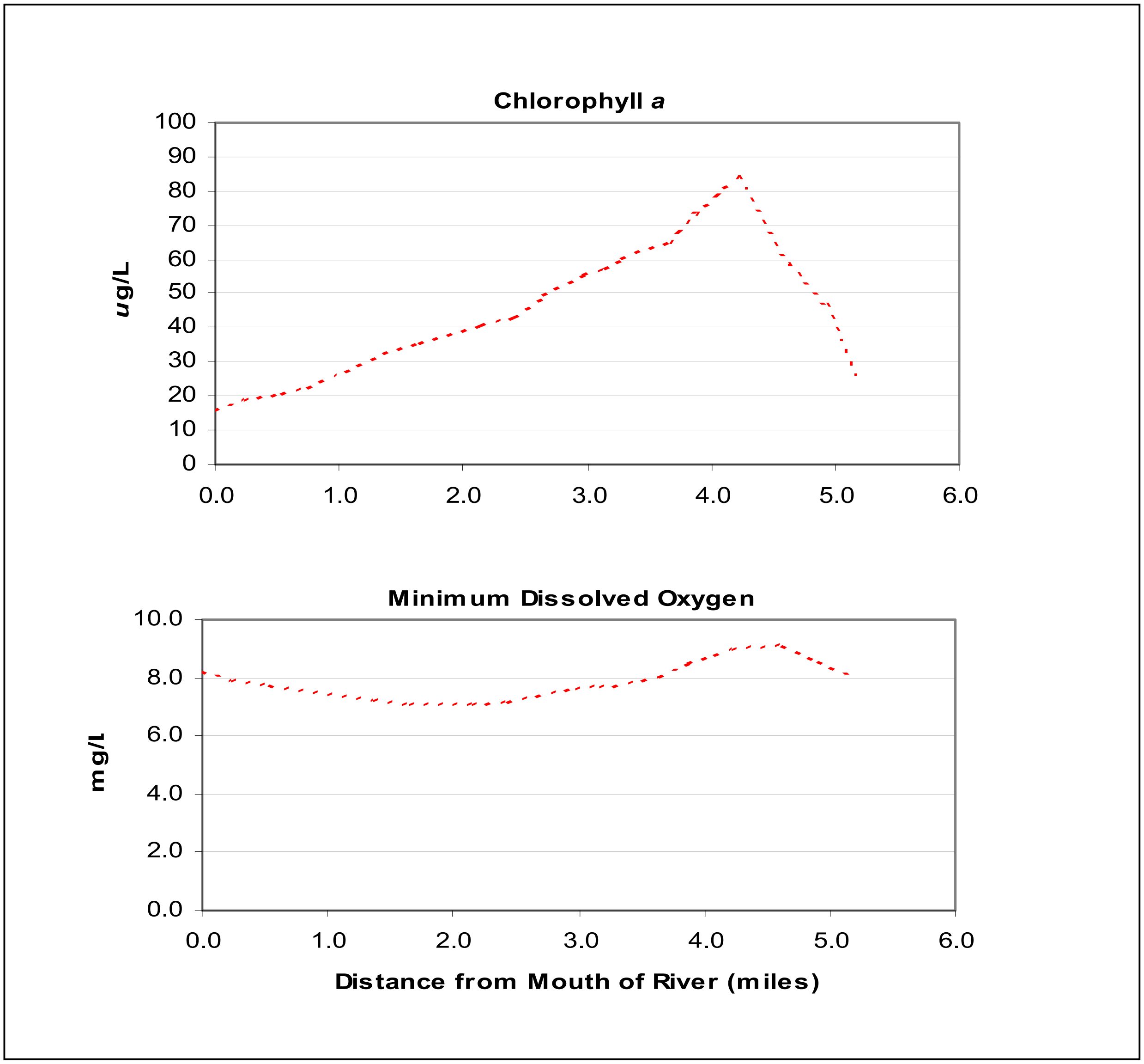

Figure 10: Model Results for the Average Flow Baseline Scenario for Chlorophyll *a* and Dissolved Oxygen (Second Scenario)

<u>Future Condition Scenarios:</u>

- *Third Scenario (Low Flow):* Simulates the future condition of maximum allowable loads for critical low stream flow conditions during summer season.

Results for the third scenario (dotted line), representing the maximum allowable loads for summer critical low flow, are summarized in comparison to the appropriate baseline scenario (solid line) in Figure 11. Under the nutrient load reduction conditions described above for this scenario, the results show that chlorophyll *a* concentrations remain below the target threshold of

50 µg/l along the entire system of Still Pond Creek. For DO, the comparison shows that the DO along the length of the creek remains above the water quality criterion of 5.0 mg/l for the future condition scenario.

- *Fourth Scenario (Average Annual Flow):* Simulates the future condition of maximum allowable annual loads under average annual stream flow and loading conditions.

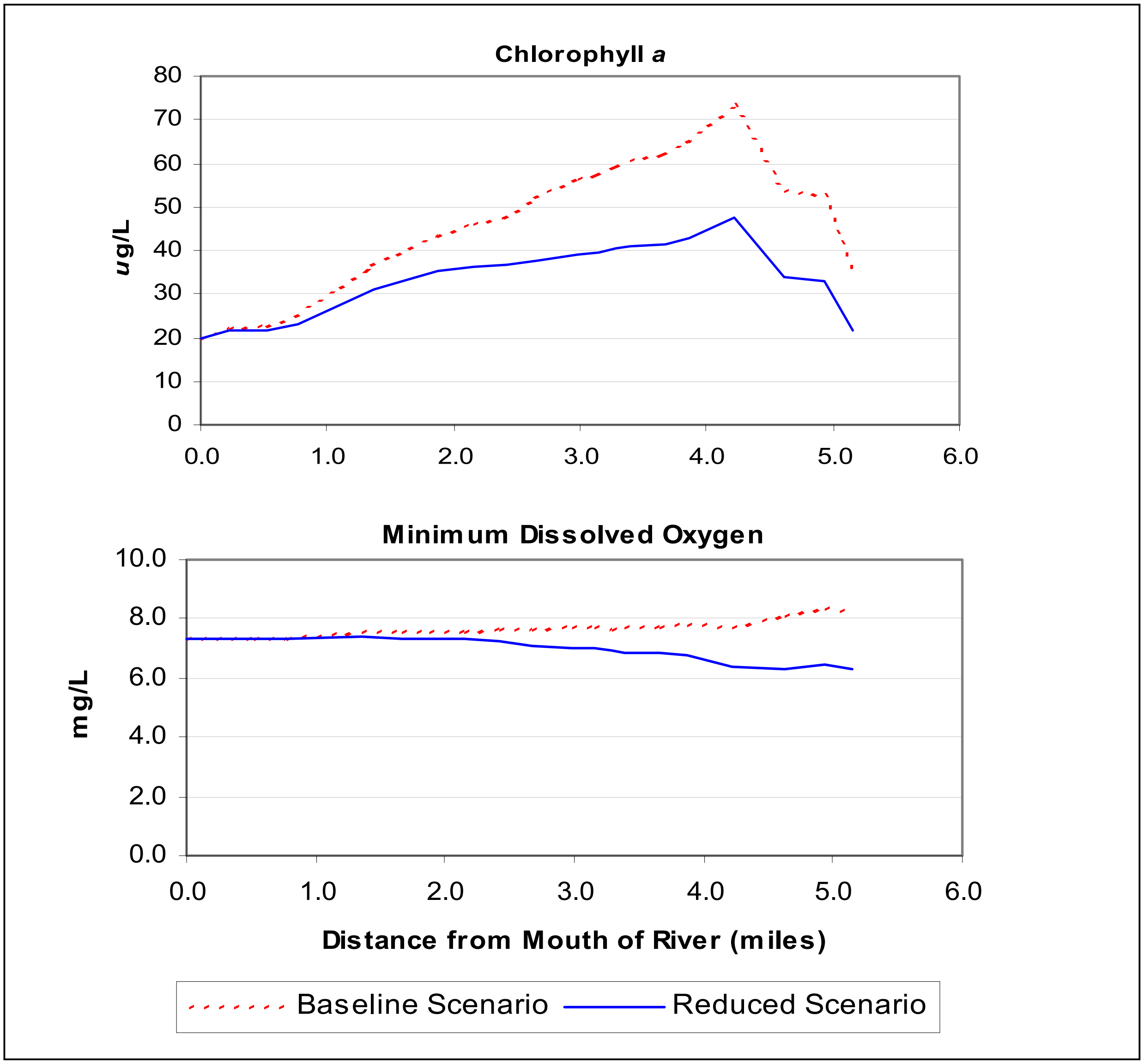

Figure 11: Model Results for the Low Flow Future Condition Scenario for Chlorophyll *a* and Dissolved Oxygen (Third Scenario)

Results for the fourth scenario (dotted line), representing the maximum allowable loads for average annual flow, are summarized in comparison to the appropriate baseline scenario (solid line) in Figure 12. Under the load reduction conditions described above for this scenario, the results show that chlorophyll *a* concentrations remain below the target threshold of 50 µg/l along the entire length of Still Pond Creek. For DO, the comparison shows that the DO along the creek remains above the water quality criterion of 5.0 mg/l for both scenarios.

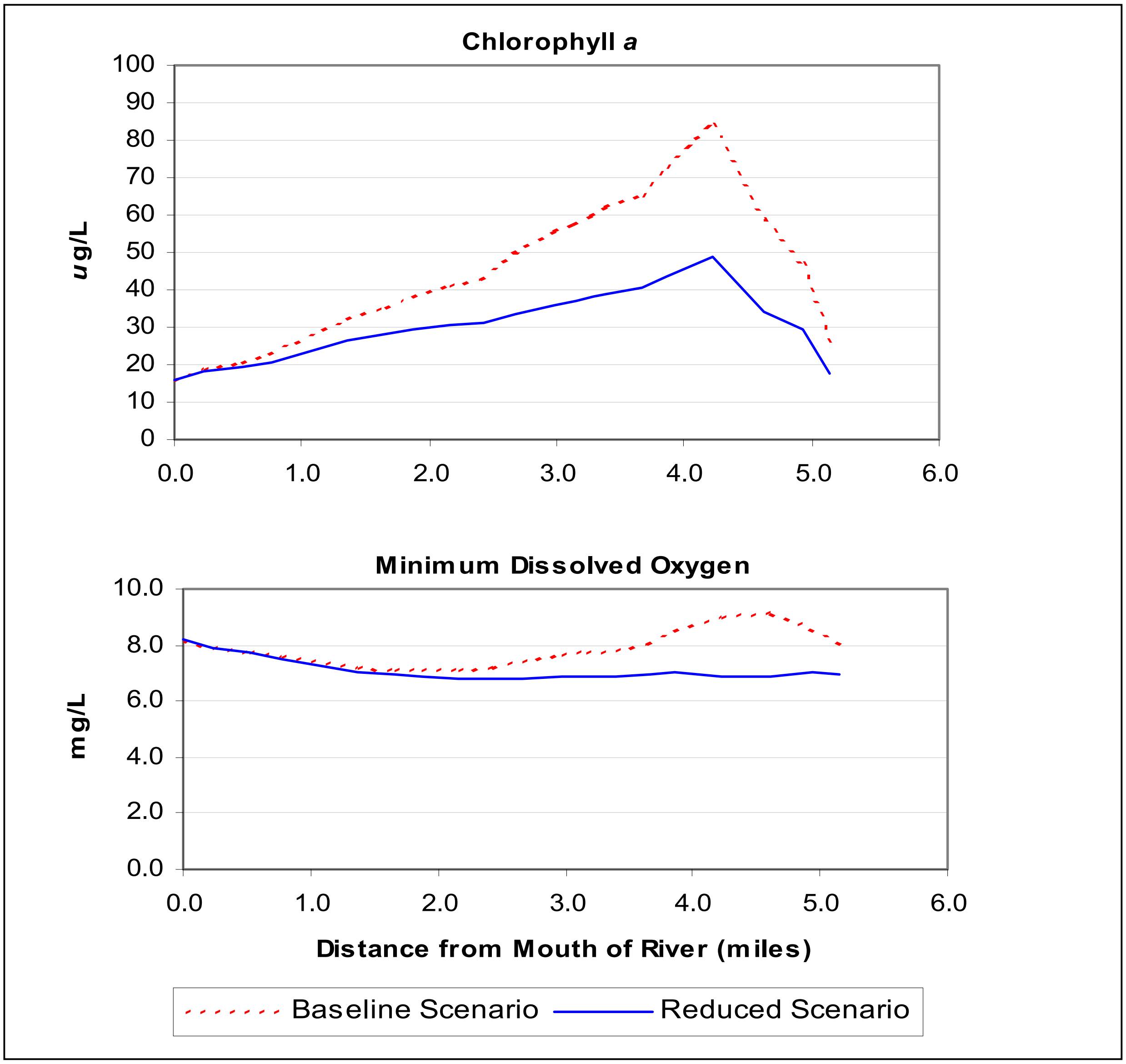

Figure 12: Model Results for the Average Annual Flow Future Condition Scenario for Chlorophyll *a* and Dissolved Oxygen (Fourth Scenario)

4.5 TMDL Loading Caps

This section presents TMDL for nitrogen and phosphorus. The outcomes are presented in terms of the low flow TMDL and average annual TMDL. The critical season for excessive algal growth in Still Pond Creek is during the summer months, when the creek is poorly flushed. During this critical time, sunlight and warm water temperatures are most conducive to creating the water quality problems associated with excessive nutrient enrichment. The low-flow TMDLs are stated in monthly terms, because this critical condition occurs for a limited period of time. It should be noted that limits placed on average annual loads are accounted for indirectly by adjusting bottom sediment nutrient sediment fluxes and SOD to be consistent with reductions in average annual loads (See Appendix A).

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

Low Flow TMDLs:

NITROGEN TMDL **349** ***lb/month***

PHOSPHORUS TMDL **31** ***lb/month***

The average annual TMDLs for nitrogen and phosphorous are:

Average Annual TMDLs:

NITROGEN TMDL **34,918** ***lb/year***

PHOSPHORUS TMDL **1,386** ***lb/year***

Because the TMDLs set limits on nitrogen, and because of the way the model simulates nitrogen, it is not necessary to include an explicit TMDL for nitrogenous biochemical oxygen demand (NBOD).

4.6 Load Allocations between Point Sources and Nonpoint Sources

The watershed that drains to Still Pond Creek has no permitted point source discharges of nutrients. Hence, for both the low flow and average annual TMDLs, the entire allocation, except for the margin of safety, is being made to nonpoint sources. The allocations presented in this section demonstrate how the nutrient TMDLs could be implemented to achieve water quality standards; however, the State reserves the right to modify these allocations as long as they remain consistent with the achievement of water quality standards.

<u>Low Flow Allocations</u>:

The NPS loads of nitrogen and phosphorus simulated in the third scenario represent reductions from the baseline scenario. Recall that the baseline scenario loads were based on nutrient concentrations observed in summer 1999. These nonpoint source loads, based on observed concentrations, account for both "natural" and human-induced components and cannot be separated into specific source categories.

There are no permitted point source discharges of nutrients in the watershed. Consequently, waste load allocations are set at zero. The nitrogen and phosphorus allocations for summer low flow conditions are presented in Table 2.

Table 2: Summer Low Flow Allocations

	Total Nitrogen *(lb/month)*	**Total Phosphorus *(lb/month)***
Nonpoint Source	349	31
Point Source	0	0

Average Annual Allocations:

The average annual NPS nitrogen and phosphorus allocations are represented as the average of the data collected in 1999, with a 40% reduction in controllable nitrogen and phosphorus NPS loads in all subwatersheds of the Still Pond Creek watershed. The NPS loads that were assumed in the model, account for both "natural" and human-induced components. As was discussed in the "Scenario Descriptions" section of this document, the loads were based on year 1999 MDE observed data.

There are no permitted point source discharges of nutrients in the watershed. Consequently, the waste load allocations are set to zero. The nitrogen and phosphorus allocations for the average annual TMDLs are shown in Table 3.

Table 3: Average Annual Allocations

	Total Nitrogen *(lb/yr)*	**Total Phosphorus *(lb/yr)***
Nonpoint Source	34,918	1,386
Point Source	0	0

4.7 Margins of Safety

A margin of safety (MOS) is required as part of a TMDL in recognition of many uncertainties in the 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 biological 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 = waste load allocation (WLA) + load allocation (LA) + MOS. The second approach is to incorporate the MOS as conservative assumptions used in the TMDL analysis.

Maryland has adopted margins of safety that combine these two approaches. Following the first approach, the load allocated to the MOS was computed as 5% of the nonpoint source loads for nitrogen and phosphorus for the low flow TMDL. Similarly, a 3% MOS was included in computing the average annual TMDLs. These explicit nitrogen and phosphorus margins of safety are summarized in Table 4.

Table 4: Summer Expected Low Flow and Annual Average Flow Margins of Safety (MOS)

	Nitrogen	Phosphorus
MOS Low Flow	17 lb/month	2 lb/month
MOS Average Flow	1,017 lb/yr	40 lb/yr

Another MOS is that the fourth model scenario, for average flow, was run under the assumption of summer temperature and summer solar radiation. When the water is warmer and more sunlight is present, there will be more algal growth and a higher potential for low dissolved oxygen concentrations. The model was also run under steady-state conditions for 200 days, assuming continuous average flows and loads. It is unlikely that these flows and loads will actually be seen for such an extended period of time during the summer. The higher temperatures and solar radiation are conservative assumptions that represent a significant margin of safety.

4.8 Summary of Total Maximum Daily Loads

The critical low flow TMDLs, applicable from May 1 – October 31, for Still Pond Creek are as follows:

For Nitrogen (*lb/month*):

TMDL	=	LA	+	WLA	+	MOS
349	=	332	+	0	+	17

For Phosphorus (*lb/month*):

TMDL	=	LA	+	WLA	+	MOS
31	=	29	+	0	+	2

The average annual TMDLs for Still Pond Creek are as follow:

For Nitrogen (*lb/yr*):

TMDL	=	LA	+	WLA	+	MOS
34,918	=	33,901	+	0	+	1,017

For Phosphorus (*lb/yr*):

TMDL	=	LA	+	WLA	+	MOS
1,386	=	1,346	+	0	+	40

Where:

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

5.0 ASSURANCE OF IMPLEMENTATION

This section provides the basis for reasonable assurances that the nitrogen and phosphorus TMDLs will be achieved and maintained. For both TMDLs, Maryland has several well-established programs that will be drawn upon: the Water Quality Improvement Act of 1998 (WQIA); the EPA-sponsored Clean Water Action Plan of 1998 (CWAP), 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.

Maryland's WQIA, of 1998, requires that comprehensive and enforceable nutrient management plans be developed, approved and implemented for all agricultural lands throughout Maryland. This act specifically requires that nutrient management plans be developed by December 2001 and be implemented by December 2002 if chemical fertilizer is used, and by 2004 - 5 for those who use manure or organic sources. In addition to nutrient management plans, Maryland's Agricultural Cost Share Program (MACS) has been developed to address potential pollution problems from agriculture and is available to fund Best Management Practices (BMPs) in this watershed. The Low Income Loans for Agricultural Conservation (LILAC) program is also available to provide loans.

Maryland's CWAP has been developed in a coordinated manner with the State's 303(d) process. All CWAP Category I watersheds identified in Maryland's Unified Watershed Assessment process are totally coincident with the impaired waters list for 1996 and 1998 approved by EPA. The State has given a higher 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 nonpoint source controls in the Eastern Shore Tributary Strategy Basin, which includes Still Pond Creek watershed. Maryland is in the forefront of implementing quantifiable nonpoint source 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.

It is reasonable to expect that nonpoint source loads can be reduced during low flow conditions. While the low flow loads cannot be partitioned specifically into contributing sources, the sources themselves can be identified. These sources include deposition of nutrients and organic matter to the stream bed from higher flow events, septic systems failure and wildlife animal contribution. When these sources are controlled in combination, it is reasonable to achieve nonpoint source reductions of the magnitude identified by this TMDL allocation.

Finally, Maryland has recently adopted 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 National Pollutant Discharge Elimination System (NPDES) permit cycle. This continuing cycle ensures that, within five years of establishing a TMDL, intensive follow-up monitoring will be performed. Thus, the watershed cycling strategy establishes a TMDL evaluation process that assures accountability.

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