Total Maximum Daily Loads of Nitrogen and Phosphorus for the Port Tobacco River

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EPA Submittal: August 11, 1998
EPA Approval: March 18, 1999

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PREFACE

Section 303(d) of the federal Clean Water Act (the Act) directs States to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. For each WQLS, the State is to establish a Total Maximum Daily Load (TMDL) of the specified substance that the water can receive without violating water quality standards.

The Port Tobacco River was identified on the State's 1996 list of WQLSs as impaired by nutrients (nitrogen and phosphorus). This report proposes the establishment of two TMDLs for the Port Tobacco River: one for nitrogen and one for phosphorus.

Once the TMDLs are approved by the United States Environmental Protection Agency (EPA) they will be incorporated into the State's Continuing Planning Process pursuant to Section 303(e) of the Act. In the future, the established TMDLs will support point and nonpoint source measures needed to restore water quality in the Port Tobacco River.

EXECUTIVE SUMMARY

This document establishes Total Maximum Daily Loads (TMDLs) for nitrogen and phosphorus in the Port Tobacco River. The Port Tobacco River is a tributary of the Potomac River, and is part of the Lower Potomac Tributary Strategy Basin. The river is impaired by the nutrients nitrogen and phosphorus, which cause excessive algal blooms and can cause exceedances of the dissolved oxygen standard.

The water quality goal of these TMDLs is to reduce high chlorophyll *a* concentrations (a surrogate for algal blooms), and maintain dissolved oxygen standards at levels where the designated uses for the Port Tobacco River will be met. The TMDLs were determined using the WASP5 water quality model. Total loading caps for nitrogen and phosphorus entering the Port Tobacco River are established for both low flow conditions and for annual loads. As part of the TMDL process, 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 8,710 lbs/month, and the low flow TMDL for phosphorus is 871 lbs/month. These TMDLs apply during the period May 1 – October 31. The annual TMDL for nitrogen is 243,310 lb/yr, and the annual TMDL for phosphorus load is 15,570 lb/yr. Allowable loads have been allocated between point and nonpoint sources. The estimated annual nonpoint loads for the TMDL are based on land uses projected to the year 2000. The annual point source loads make up the balance of the allocation. The low flow nonpoint source loads for the TMDLs are established as the estimated base flow concentration times the base flow. The low flow point source load makes up the balance of the allocation. The point source loads may be met, in part, by the use of biological nitrogen removal and chemical phosphorus removal at the major point sources. Individual waste load allocations for point sources will be established through NPDES permits.

Three factors provide assurance that these TMDLs will be implemented. First, for the low flow TMDL, which is driven primarily by point source loads, NPDES permits will play a major role in assuring implementation. Second, for the average annual TMDLs, which involve more significant nonpoint source considerations, Maryland has several well-established programs that will be drawn upon, including the Tributary Strategies developed in accordance with the Chesapeake Bay Agreement. Finally, Maryland has adopted a watershed cycling strategy, which will assure that routine future monitoring and TMDL evaluations are conducted.

INTRODUCTION

Purpose and Background

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 margin of safety (MOS) for uncertainty. A TMDL reflects the total pollutant loading of the impairing substance a WQLS can receive and still meet water quality standards. The Port Tobacco River was first identified on the 1996 303(d) list submitted to EPA by the Maryland Department of the Environment**.** It was listed as being impaired by nutrients. This document establishes TMDLs for the nutrients nitrogen and phosphorus in the Port Tobacco River.

The Port Tobacco River was identified as being impaired by nutrients due to signs of eutrophication. Eutrophication, the overenrichment of aquatic systems by excessive inputs of nitrogen and phosphorus**,** was evidenced in the Port Tobacco River by recurrent seasonal algal blooms. Land development as well as the addition of point source discharges can increase the rate of eutrophication to problematic levels. Highly eutrophic waters will characteristically have fewer species present, and high concentrations of algae. Due to the algae, dissolved oxygen levels are likely to fluctuate between day and night, which can cause fish kills. The estuarine portion of the Port Tobacco River is classified as a Use II water and all free flowing portions are classified as Use I waters. Code of Maryland Regulations (COMAR) 26.08.02. High concentrations of algae and wide fluctuations in dissolved oxygen can interfere with the designated uses for Port Tobacco, and therefore cause a violation of the water quality standards of the State. For these reasons, this document will address high levels of nitrogen and phosphorus to control chlorophyll *a* concentrations (a surrogate for algal blooms) and to maintain dissolved oxygen standards.

DESCRIPTION AND SETTING

The Port Tobacco River, a tributary of the Potomac River, is located in Charles County, Maryland (Figure 1). The River is approximately 8.5 miles in length. The watershed of the Port Tobacco has an area of approximately 28,000 acres or 44 square miles. The predominant land use in the watershed, based on 1994 Maryland Office of Planning information, (Figures 2 and 3) is forest (16,830 acres or 60%), with other areas being under mixed agricultural (5,860 acres or 21%) and urban (5,370 acres or 19%) use. The upper free-flowing portion of the Port Tobacco traverses forest and agricultural lands. The lower, tidal portion enters the Potomac River near Windmill Point in the oligohaline salinity zone. Much of the shoreline of the Port Tobacco River's tidal portion is classified as coastal shallow fresh marsh. Depths of the river range from about 1.6 feet in the headwaters to greater than 36 feet in the tidal zone prior to the river's confluence with the Potomac River (PPSP, DNR).

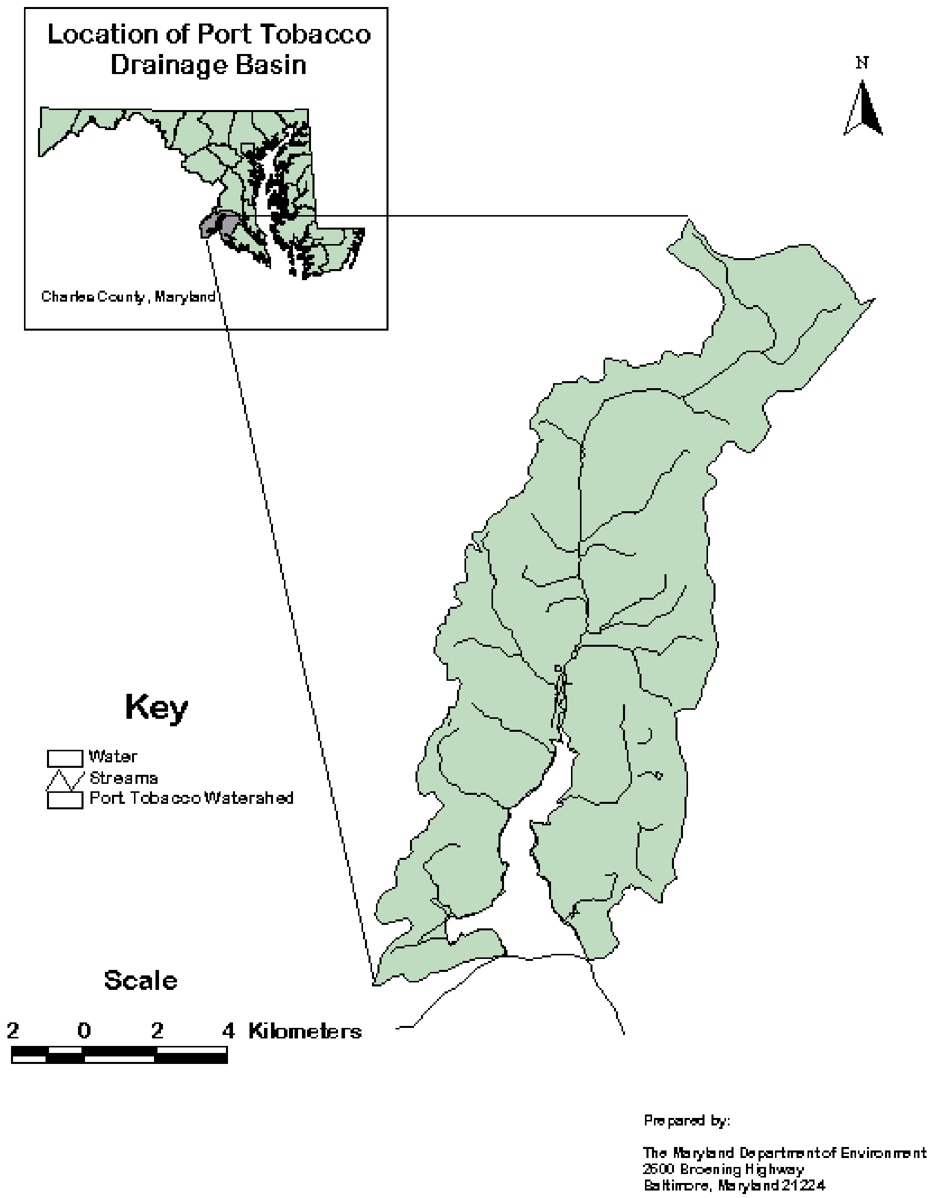

Figure 1: Location Map of the Port Tobacco Drainage Basin within Maryland

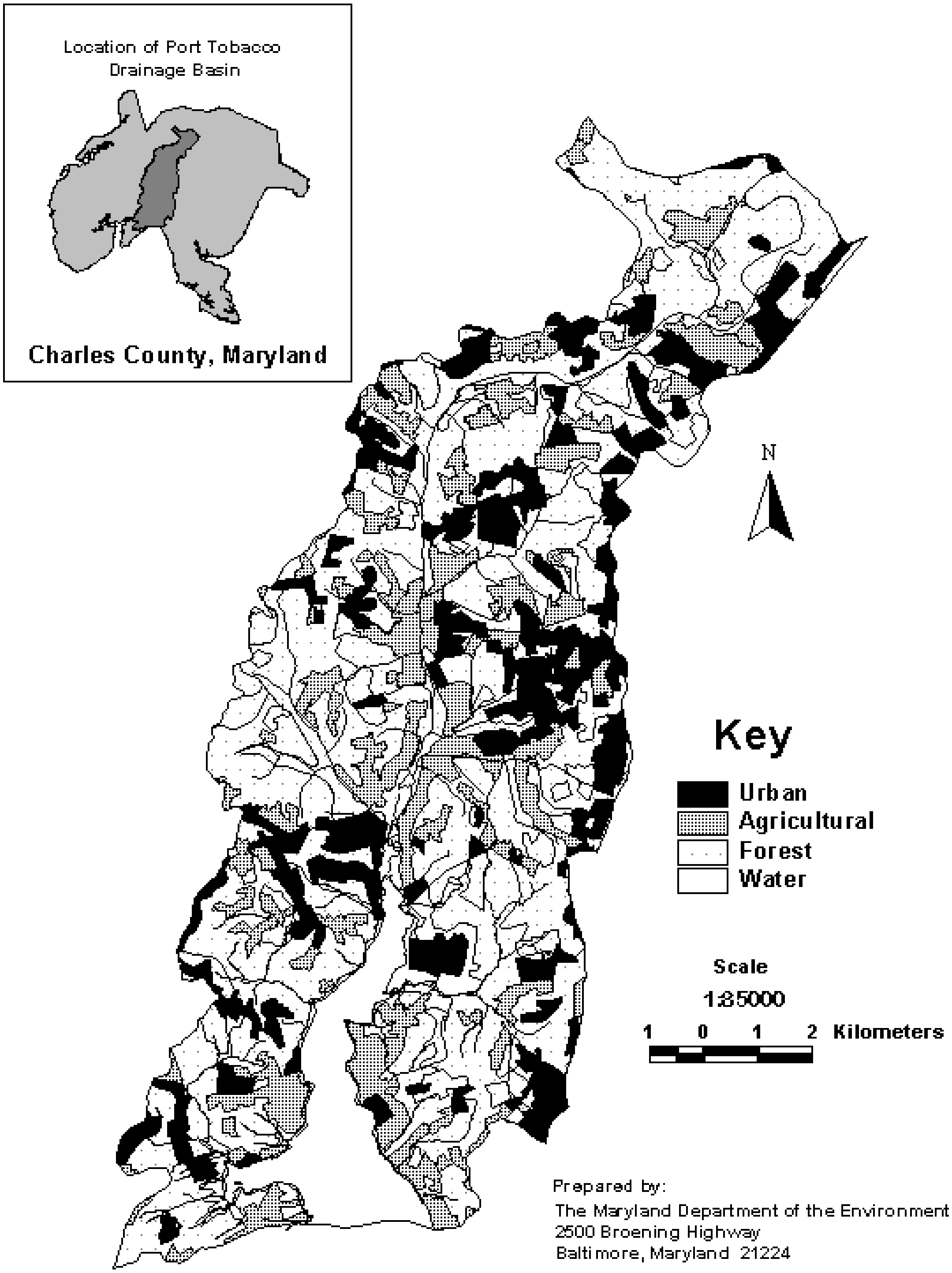

Figure 2: Predominant Land use in the Port Tobacco Drainage Basin

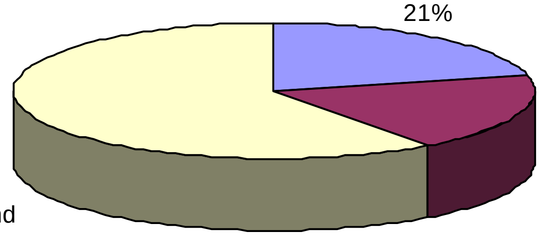

Figure 3: Estimated 1996 Land use in the Port Tobacco Drainage Basin

The tidal portion of the Port Tobacco is a slow flowing system located in the Coastal Plain Province. The drainage basin is generally flat, and the soils are typically classified as sandy or loamy. As a consequence of the generally flat topography and the sandy soils, stream velocities throughout the tidal portion of the river are minimal. Tidal currents in the lower river are extremely weak and variable. Bottom sediments in the river are typically found to be firm muds and clays of moderate to high compaction, locally mixed with sand and other deposits.

In the Port Tobacco watershed, the estimated total nitrogen load is 218,651 lb/yr, and the total phosphorus load is 14,862 lb/yr, for the year 1996 (Figure 4). The existing nonpoint source loads were determined using land use loading coefficients. The land use information was based on 1994 Maryland Office of Planning 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 Model (U.S. EPA, 1991), which was a continuous simulation model. The Chesapeake Bay Program nutrient loading rates account for atmospheric deposition[1], loads from septic tanks, and loads coming from urban development, agriculture, and forest land. The total nitrogen load coming from nonpoint sources is 190,470 lb/yr, and the total nonpoint source phosphorus load is 12,500 lb/yr.

The point source loads came from the discharge monitoring reports stored in MDE's point source database. The year 1996 was used because this is the most recent year for which point source data is presently available. For both nutrients, nonpoint sources are the single greatest load, with agriculture being the dominant source for both nitrogen (42% of the total load and 48% of the nonpoint source) and phosphorus (49% of the total load and 58% of the nonpoint source load). The La Plata Sewage Treatment Plant (STP), with an annual average flow of 0.902 million gallons per day (mgd) in 1996, is the only major point source (defined under the applicable law

1 Atmospheric deposition directly to the water's surface was not taken into account. The surface area of the water in the Port Tobacco Basin only accounts for 6% of the total surface area in the watershed. And, the majority of the water surface, the estuary, is located downstream from the impairment. Thus, the contribution from atmospheric deposition directly to the water's surface was considered insignificant.

as providing discharges with a flow greater than 0.5 mgd) in the watershed. Additionally, there are three other point sources of nutrients in the watershed with a combined flow of 0.054 mgd. The combined total point source contribution in 1996 is 13% for nitrogen and 16% for phosphorus.

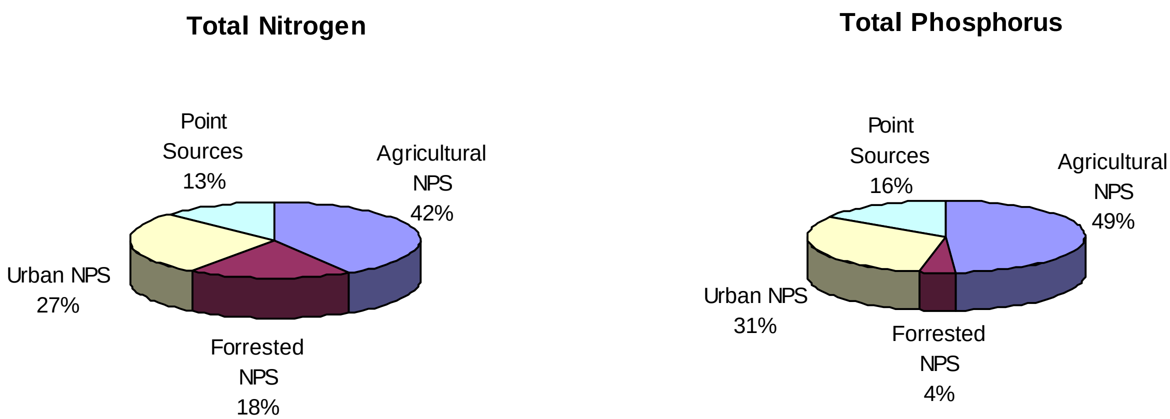

Figure 4: 1996 Nitrogen and Phosphorus Point and Nonpoint Source Loadings

WATER QUALITY CHARACTERIZATION

The water quality of four physical parameters, chlorophyll *a*, inorganic phosphorus, nitrate, and dissolved oxygen, were examined to determine the extent of the impairment in the Port Tobacco. Four water quality surveys were conducted in the Port Tobacco watershed in August of 1984. Figure 5 identifies the locations of the water chemistry sampled during each survey. The month of August represents critical conditions for the Port Tobacco. This is because in August there is less water flowing in the channel, higher concentrations of nutrients, and the water temperatures are usually warmer creating good conditions for algal growth. The water quality data from 1984 was used because it was comprehensive and readily available. Since that time, summer algal blooms in the Port Tobacco have been observed almost yearly by MDE's Water Management Administration, Municipal Permits Division, and documented by photographs. Also, MDE's Field Operations Program staff also completed several site visits during August of 1997 to confirm bathymetric data and ground truth land use information. Based upon the information obtained from these two sources, MDE believes that the water quality impairments that were observed in 1984 are representative of current conditions in the Port Tobacco.

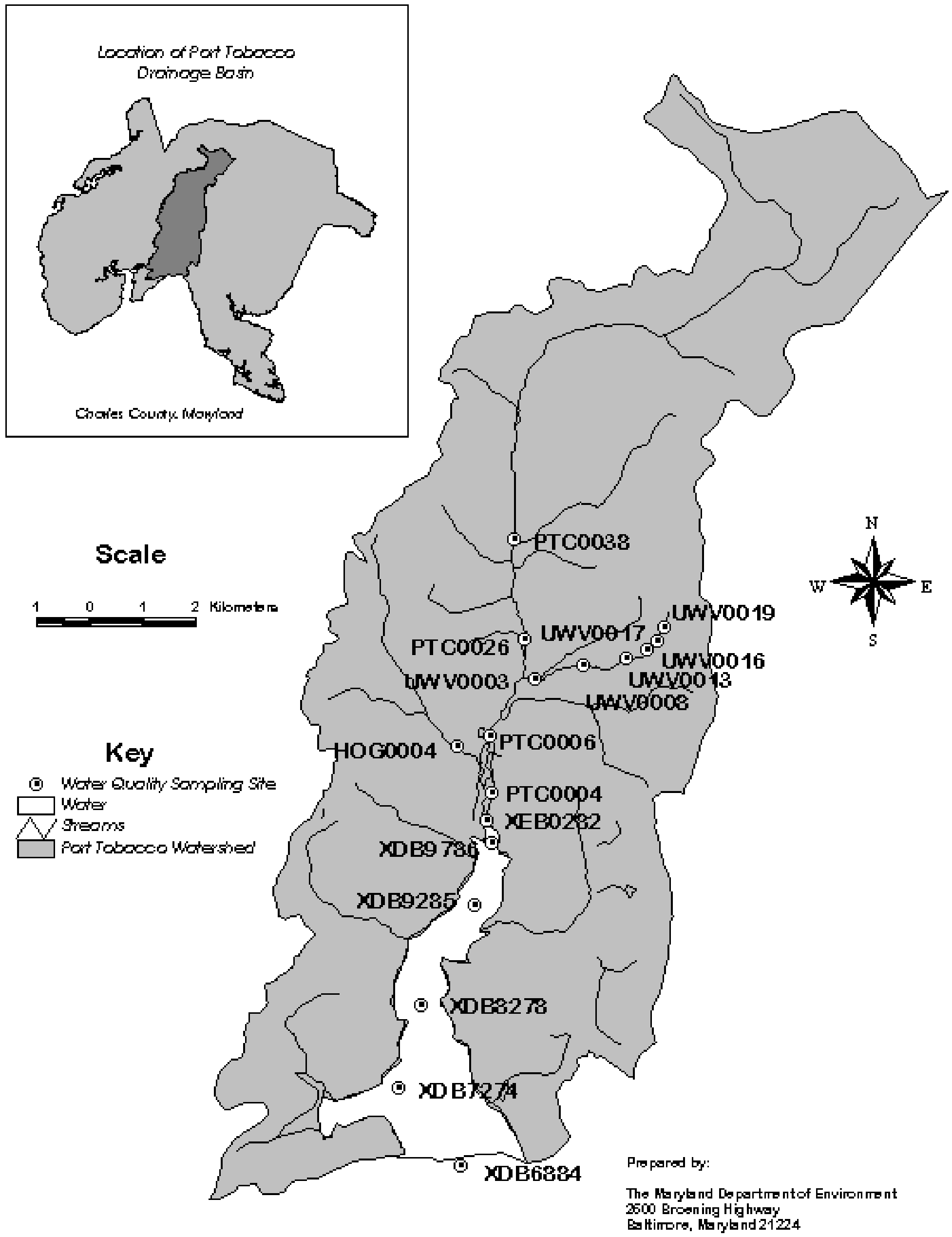

Figure 5: Locations of the Water Chemistry Sites Sampled

Figure 6 presents an average August longitudinal profile of chlorophyll *a* data sampled during the 1984 field surveys. The sampling region covers the entire tidal portion of the Port Tobacco from its confluence with the Potomac mainstem (Station XDB6884), and includes free-flowing stations in an unnamed tributary leading up to and above the La Plata STP. As the data indicates, ambient chlorophyll *a* concentrations for the first four stations are generally about 12 µg/l. However, the levels are much greater at and above Station XDB9786, where mean values are about 30 µg/l, with a maximum concentration of 70 µg/l. Nuisance bloom levels are sometimes observed in the range of 150-200 µg/l in the reach near monitoring Station PTC004.

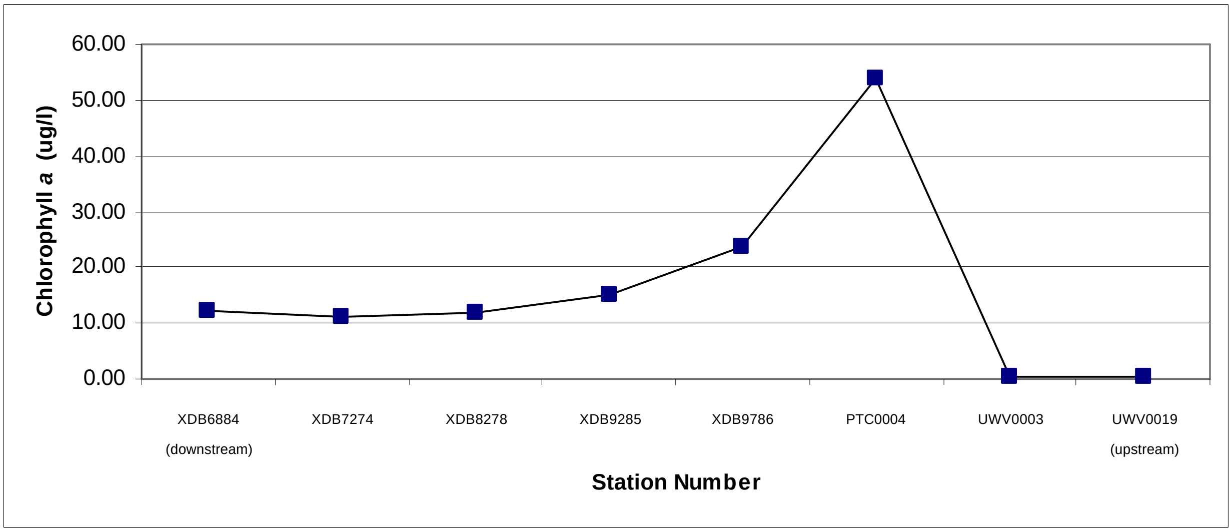

Figure 6: Average August Longitudinal Profile of Chlorophyll *a* Data

Figure 7 presents a longitudinal profile of inorganic phosphorus as indicated by PO4 levels measured in samples collected in1984. In the tidal portion of the Port Tobacco River (below Station PTC0004), PO4 levels are generally less than 0.2 mg/l. However, the concentration of PO4 increases rapidly in the free-flowing unnamed tributary, with peak values in the immediate vicinity of the La Plata STP outfall exceeding 2.5 mg/l at station UWV0003.

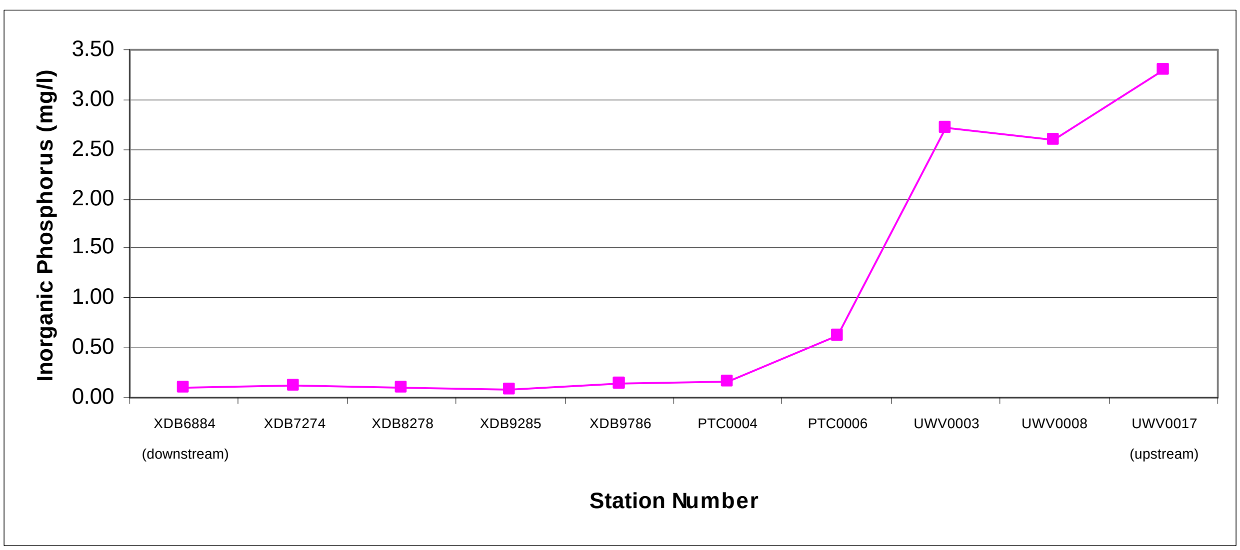

Figure 7: Average August Longitudinal Profile of Inorganic Phosphorus Data

The Nitrate (NO3) levels along the longitudinal profile are depicted in Figure 8. They are similar to that of PO4, with concentrations in the tidal portion measured at or near the level of detection (0.02 mg/l), with elevated levels at station UWV0003 near the outfall of the La Plata STP with a maximum concentration of greater than 11.0 mg/l.

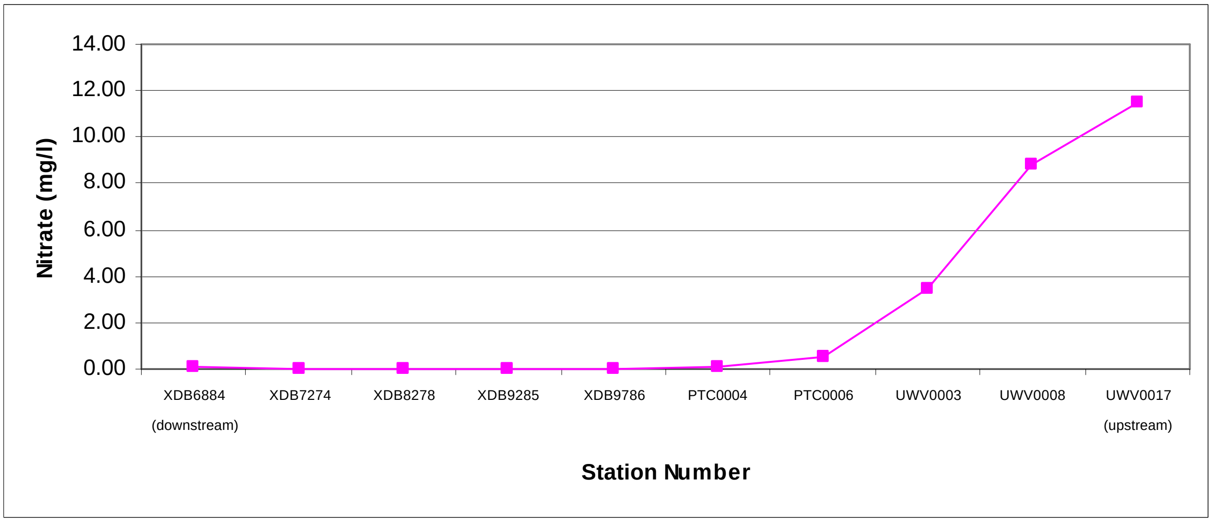

Figure 8: Average August Longitudinal Profile of Nitrate Data

Dissolved oxygen concentrations along the longitudinal profile are depicted in Figure 9. Values rarely fall below 8 mg/l, and are typically very close to saturation levels at the measured temperature and salinity ranges.

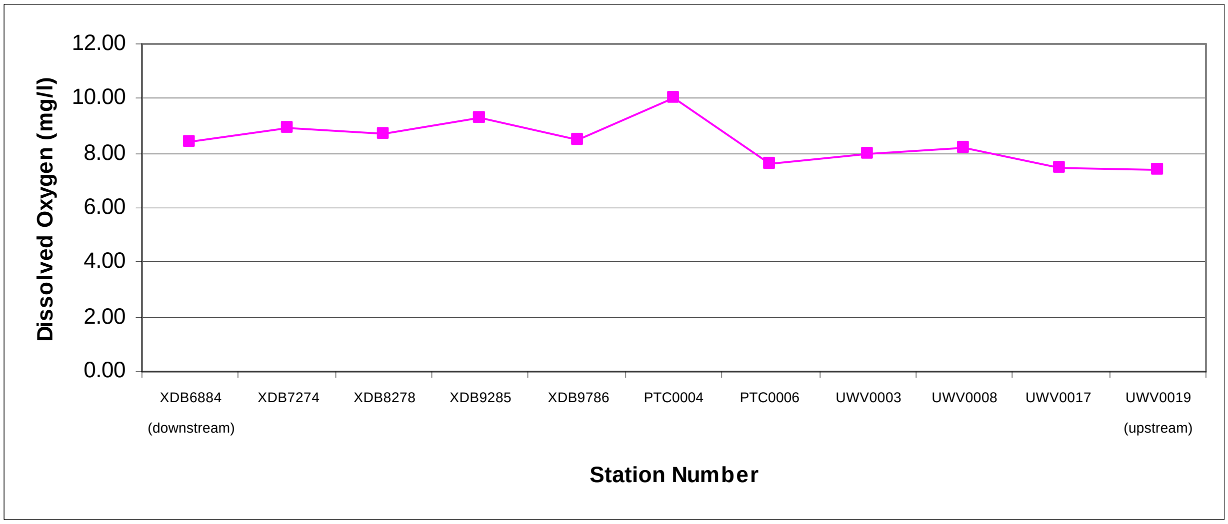

Figure 9: Average August Longitudinal Profile of Dissolved Oxygen Data

WATER QUALITY IMPAIRMENT

The Port Tobacco system is impaired by an overenrichment of nutrients. Nitrogen and phosphorus loadings from both point and nonpoint sources have resulted in persistent seasonal algal blooms, observed and documented by MDE, in the reach near the Route 6 crossing (Station PTC0004), as indicated in Figure 6. Mean summer concentrations of chlorophyll *a* in that region typically fall in the 45-65 µg/l range, with nuisance algal bloom levels periodically reaching 150 to 200 µg/l.

TARGETED WATER QUALITY GOAL

The objective of the TMDLs for nitrogen and phosphorus for the Port Tobacco River is to reduce nutrient inputs to a level that will ensure the maintenance of the dissolved oxygen standards and reduce frequency and magnitude of algal blooms. Specifically, the TMDLs for nitrogen and phosphorus for the Port Tobacco River are intended to:

1. Assure that a minimum dissolved oxygen level of 5 mg/l is maintained throughout the Port Tobacco system, and,

2. Reduce peak chlorophyll *a* levels (a surrogate for algal blooms) to below 52 µg/l.[2]

The dissolved oxygen level is based on specific numeric criteria for Use I & II waters set forth in the Code of Maryland Regulations 28.08.02. The chlorophyll *a* water quality level is based on the designated use of the Port Tobacco River, and 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).

TOTAL MAXIMUM DAILY LOADS AND ALLOCATION

Overview

This section describes how the nutrient TMDLs and total loading allocations for point sources and nonpoint sources were developed for the Port Tobacco River. 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 allocate the TMDLs between point sources and nonpoint sources. The sixth section explains the rationale for the margin of safety and a remaining future allocation. Finally, the

2 MDE establishes permit limits based on maintaining chlorophyll *a* concentrations below a maximum level of 100µg/l, with an ideal goal of less than 50µg/l.

pieces of the equation are combined in a summary accounting of the TMDLs for seasonal low flow conditions and for annual loads.

Analysis Framework

The computational framework chosen for the Port Tobacco TMDLs was WASP5. 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 is supported and distributed by U.S. EPA's Center for Exposure Assessment Modeling (CEAM) in Athens, GA (Ambrose *et al.*, 1988). EUTRO5 is the component of WASP5 that simulates eutrophication, incorporating eight water quality constituents in the water column and the sediment bed.

The spatial domain of the Port Tobacco Eutrophication Model (PTEM) extends from the confluence of the Port Tobacco River and the Potomac River for about 8.5 miles along the mainstem of the Port Tobacco River. To account for the point source discharges in the basin, three tributaries, which receive the effluents from three of the four municipal sewage treatment plants that discharge within the Port Tobacco drainage basin, are also included in the modeling domain. The fourth sewage treatment plant discharges directly into the mainstem. Freshwater flows and nonpoint source loadings are taken into consideration by dividing the drainage basin into 16 subwatersheds (Figure 10) and assuming that these flows and loadings are direct inputs to the PTEM. The watersheds surrounding the three tributaries that receive STP discharges, are also subdivided, and the loads are input directly into the tributaries.

The PTEM inputs, including nonpoint source loads, were derived from existing data and results from previous modeling of water bodies within the Chesapeake Bay system. These are documented in Appendix A. The PTEM was calibrated using the water quality monitoring data collected during August, 1984. The results of this calibration are shown in Figure 11, and the complete details are presented in Appendix A. As can be seen, the calibration of the model captured the peak chlorophyll *a* concentrations, and did well in capturing the trend in the dissolved oxygen concentrations. Although the data used to calibrate the model is from 1984, the parameters identified for the calibration of the model reflect fundamental system characteristics that do not change significantly over time.

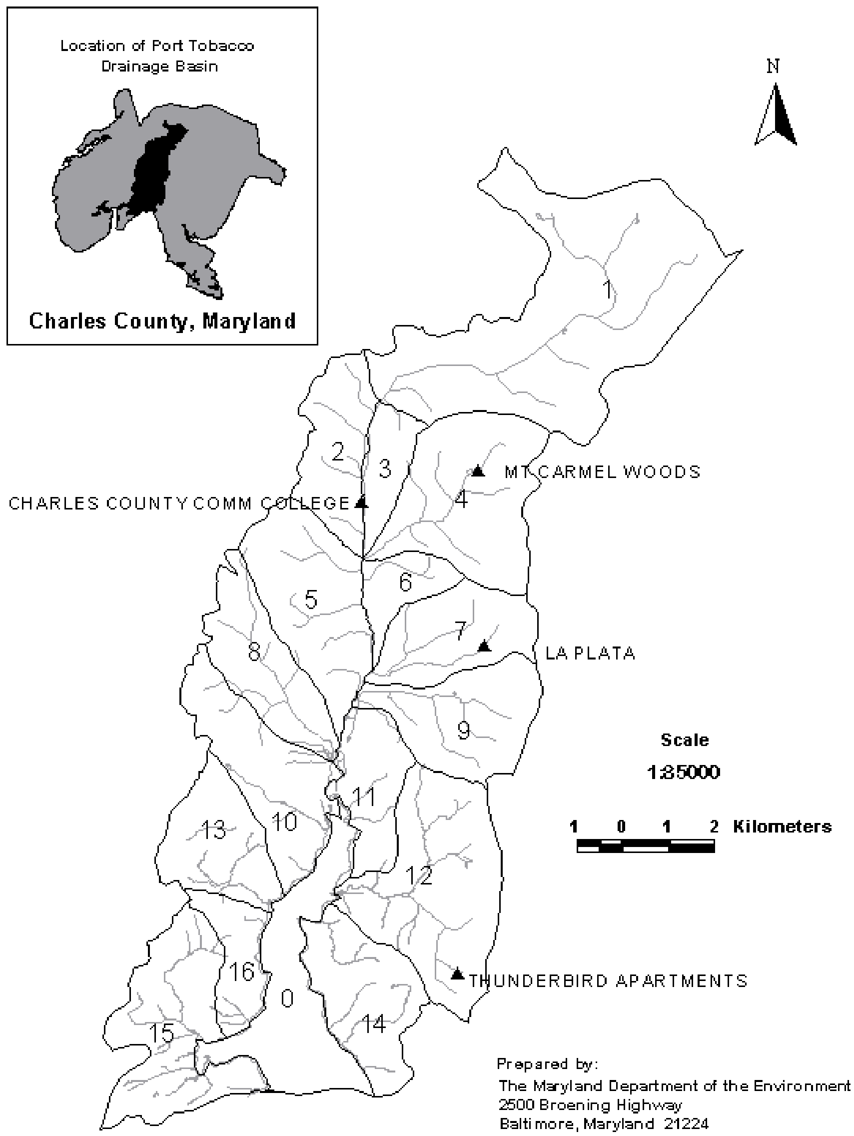

Figure 10: The 16 Subwatersheds of the Port Tobacco Drainage Basin

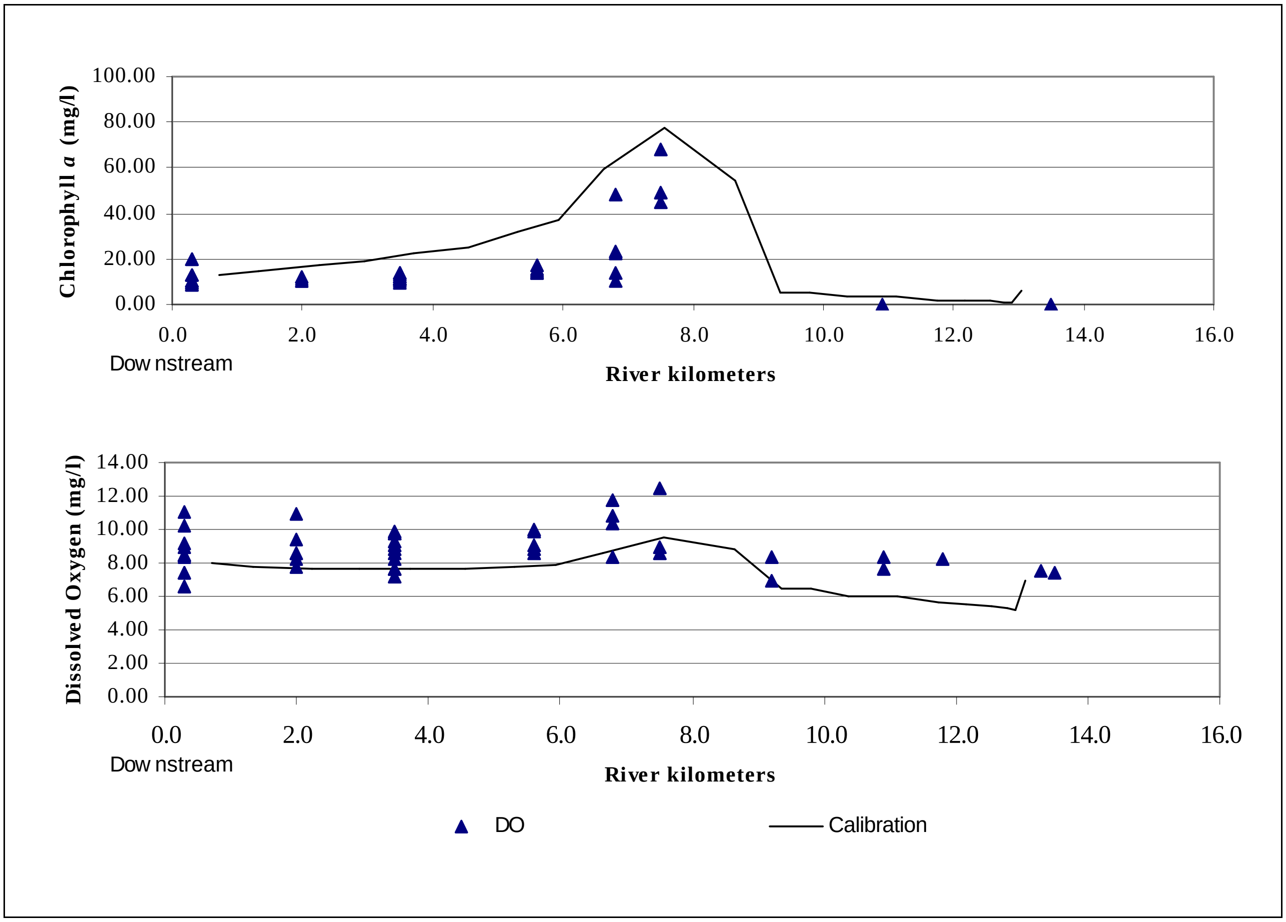

Figure 11: Results of the Calibration of the Model for Chlorophyll *a* and Dissolved Oxygen

Scenario Descriptions

The model was applied to several different nutrient loading scenarios under various stream flow conditions to project the water quality response of the system. By modeling various stream flows, the scenarios simulate seasonality, which is a necessary element of the TMDL development process. The total point and nonpoint source nutrient loads were established to achieve the water quality goal of maintaining a dissolved oxygen concentration standard of 5 mg/l and reducing chlorophyll *a* concentration to 52 µg/l.

The nutrient loading scenarios are grouped according to *base case* and *final conditions*. The base case conditions represent the nutrient loads and water quality status in 1984-85. The existing loads stated on page 4 from the 1996 data were not used in any of the modeling scenarios. The base case conditions of the system represent 1984 and 1985 loading conditions. Additionally these years were used because 1985 is the common base line year used in the Chesapeake Bay Agreement, and the calibration of the model used 1984 loads which were in the same time frame. This choice of base line year does not effect the outcome of the TMDL, which depends on projections calculated by the model**.** The final conditions represent the projected maximum allowable nutrient loads the system can incorporate without incurring an impairment. The final conditions include a margin of safety intended to account for estimation uncertainties in a manner that is environmentally conservative.

For both point and nonpoint sources, the concentrations of the nutrients nitrogen and phosphorus are modeled in their speciated forms. Nitrogen is simulated as ammonia (NH_3), nitrate (NO23) and organic nitrogen (ON). Phosphorus is simulated as ortho-phosphate (PO_4) and organic phosphorus (OP). Ammonia, nitrate, and ortho-phosphate represent the dissolved forms of nitrogen and phosphorus. The dissolved forms of nutrients are more readily available for chemical processes such as algae growth, that can 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 protective of the water quality criteria in the river.

The first scenario[3] represents the base case conditions of the stream at low flow, 15 mgd total flow in the basin, and warm water temperatures (above 70 ^{0}F**).** This flow represents actual field values measured in the Port Tobacco Basin during August, 1984. It was determined that August represents a low flow month, and extensive field expertise was used to conclude that the August, 1984 low flow values measured in the field represent what is actually seen during critical low flow periods. The total nonpoint source (NPS) loads were computed using 1984 base-flow field data. The total nonpoint source loads reflect atmospheric deposition, loads from septic tanks, and other nonpoint sources loads coming off the land. The total point source loads were average loading values taken from 1984 discharge monitoring reports (DMRs) (See Appendix A, Table A-5).

The second scenario represents the base case conditions of the stream at average flow, 29 mgd total flow in the basin. The total nonpoint source loads were calculated using the same methodology described in the beginning of the document for the 1996 loads**.** They were based on average loading rates that are consistent with the Chesapeake Bay Program loading rates (U.S. EPA, 1991), and account for both atmospheric deposition and loads from septic tanks. The total point source loads were average loading values taken from 1985 DMRs.

The third scenario represented final conditions for the case of low stream flow. Total nonpoint source loads were simulated as 1984 summer base flow nutrient concentrations plus a 3% margin of safety (MOS). The 1984 base flow nonpoint source loading was selected because it was the most reliable field data which was readily available. It represents a conservative estimate given that the 1984 loads predate the implementation of nonpoint source nutrient reduction controls for the Lower Potomac Tributary Strategy Basin which began in 1985. Total point source loads for the summer low flow critical conditions made up the balance of the total allowable load. Modeling input assumed that BNR and CPR would be implemented at major point sources under anticipated summer operating conditions. The minor point sources were assumed to operate

3 This model run is not technically a *scenario* because it served as a model calibration run.

without BNR or CPR during the same conditions. Details of this modeling activity are described further in the technical memorandum entitled *Significant Nutrient Point Sources in the Port Tobacco Watershed.*

The fourth scenario represented final conditions for the case of average stream flow. The total nonpoint source loads reflect estimated year 2000 loads for both nitrogen and phosphorus. The year 2000 nonpoint source loads were calculated using the same methodology described in the beginning of the document for establishing the 1996 loads. The year 2000 loading rates were based on the results of the Chesapeake Bay Model (U.S. EPA, 1991), and accounted for loads from both atmospheric deposition and septic tanks. The year 2000 nonpoint source loads do not assume any additional best management practice (BMP) implementation than provided for in the 1996 loads. They do assume land use changes in accordance with the land use changes expected for the entire Lower Potomac Watershed. In addition, a 3% MOS was applied to the NPS load. Point source loads for the average annual conditions made up the balance of the total allowable load. The basic assumptions were the same as those used in scenario 3 with the exception that nitrogen concentrations associated with BNR operation at major point sources were set at the anticipated average annual concentration. Details of this modeling activity are described further in the technical memorandum entitled *Significant Nutrient Point Sources in the Port Tobacco Watershed.* The loads used in all the model scenario runs can be seen in Table 1.

Table 1: Point and Nonpoint Source Loads used in the model Scenario Runs

Run	**Point Source**			**Nonpoint Source**			**MOS**	
#	Flow	Nitrogen	Phosphorus	Flow	Nitrogen	Phosphorus	Nitrogen	Phosphorus
	mgd	*lb/day*	*lb/day*	*cfs*	*lb/day*	*lb/day*	*lb/day*	*lb/day*
1	0.713	91.2	26.2	23.9	192.5	23.2	0	0
2	0.853	125.7	18.2	45.2	445.1	27.1	0	0
3	1.613	92.0	5.14	23.9	192.5	23.2	5.78	0.70
4	1.613	117.0	5.14	45.2	533.6	36.4	16.01	1.09

Scenario Results

<u>Base Case Scenarios</u>:

1. *Low Flow:* Assumes low stream flow conditions. Assumes the 1984 low flow nonpoint source loads, and 1984 average August point source loads for the point sources.

2. *Average Annual Flow:* Assumes average stream flow conditions. Assumes the 1985 average annual nonpoint source loads, and 1985 average annual point source loads for the point sources.

The first scenario represents the base case for summer low flow conditions when water quality is impaired by high chlorophyll levels. Peak chlorophyll *a* levels are above the desired goal of 52 µg/l. The second scenario shows that the system is flushed out by average flows even with relatively high nutrient loads. Peak chlorophyll *a* levels are about 20 µg/l. This is well below the desired goal of 52 µg/l, suggesting that summer low flow conditions represent the critical condition to consider for TMDL development. The chlorophyll *a* results for scenarios one and two can be seen in Figure 12. Figure 12 also shows the dissolved oxygen levels for these scenarios. It can be seen that the dissolved oxygen level does not fall below the standard of 5 mg/l in either of the scenarios.

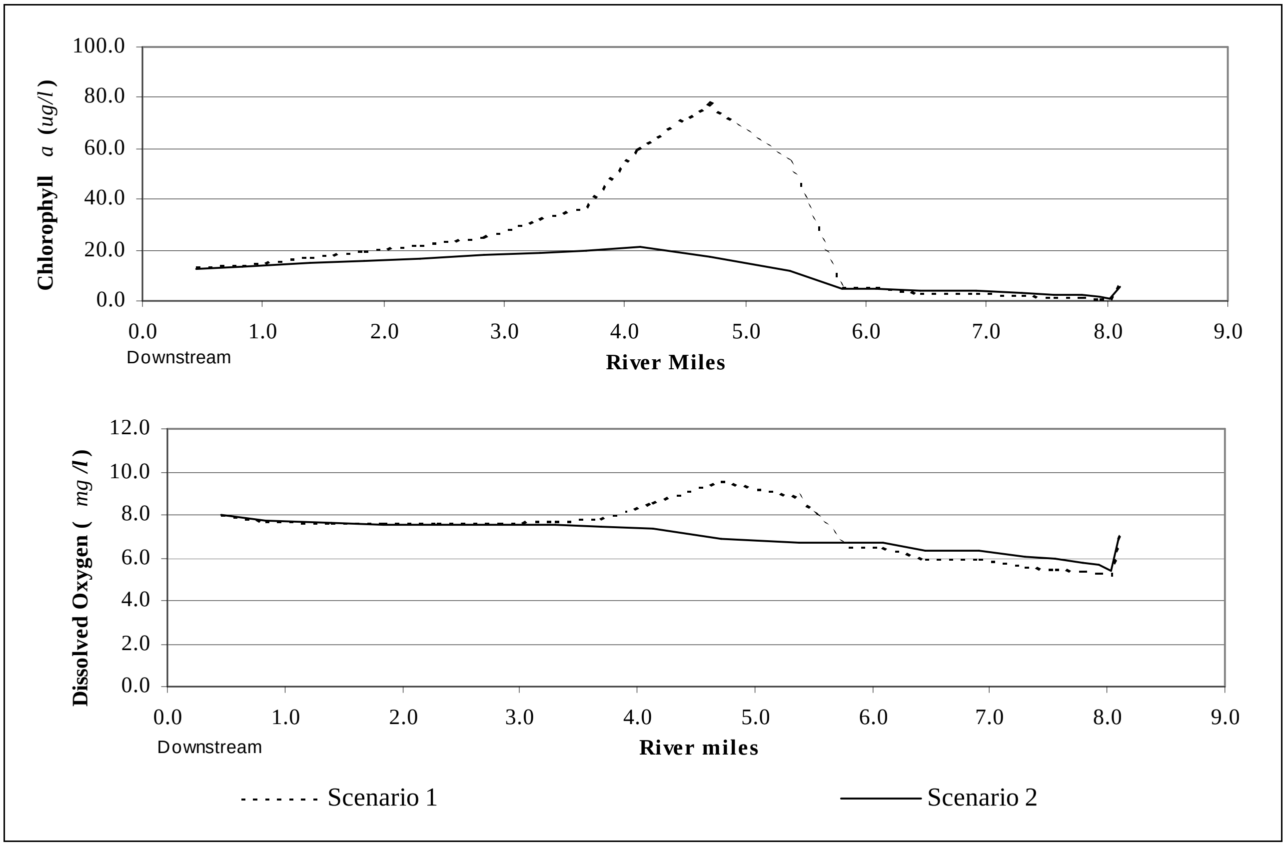

Figure 12: Model Results for the Base Case Scenarios for Chlorophyll *a* and Dissolved Oxygen

<u>Final Condition Scenarios</u>:

3. *Low Flow:* Assumes low stream flow conditions. Assumes 1984 summer low flow nonpoint source loads plus a 3% margin of safety. Assumes point source loads for the summer low flow critical conditions make up the balance of the total allowable load. Assumes that BNR and CPR will be implemented at the major point sources under anticipated summer operating conditions.

4. *Average Annual Flow:* Assumes average stream flow conditions. Assumes year 2000 nonpoint source loads, plus a 3% margin of safety added to the computed loads. Assumes that point source loads for the average annual conditions make up the balance of the total

allowable load. Assumes that BNR and CPR will be implemented at the major point sources under anticipated average annual concentrations.

The results of the third scenario indicate that, under summer low flow conditions, the water quality target for dissolved oxygen and chlorophyll *a* is satisfied at all locations along the mainstem of the Port Tobacco River. This scenario represents the critical condition for which the TMDL must satisfy water quality standards. The fourth scenario, shows that water quality standards are achieved along the entire length of the river during average flow conditions. This was anticipated given that average flow conditions in the base case scenario provided adequate flushing to maintain water quality standards. The results from scenarios 3 and 4 also showed that water quality is protected for the full length of the Port Tobacco River and the three tributaries that were modeled. The results from these two scenarios can be seen in Figure 13. These two scenarios provide the justification for the TMDL presented below.

The PTEM calculates the daily average dissolved oxygen concentrations in the stream. This is not necessarily protective of water quality when one considers the effects of diurnal dissolved oxygen variation due to photosynthesis and respiration of algae. The photosynthetic process centers about the chlorophyll containing algae, which utilize radiant energy from the sun to convert water and carbon dioxide into glucose, and release oxygen. Because the photosynthetic process is dependent on solar radiant energy, the production of oxygen proceeds only during daylight hours. Concurrently with this production, however, the algae require oxygen for respiration, which can be considered to proceed continuously. Minimum values of dissolved oxygen usually occur in the early morning predawn hours when the algae have been without light for the longest period of time. Maximum values of dissolved oxygen usually occur in the early afternoon. The diurnal range of dissolved oxygen (maximum minus minimum) may be large when excessive algae is present and if the daily mean level of dissolved oxygen is low, minimum values of dissolved oxygen during a day may approach zero.

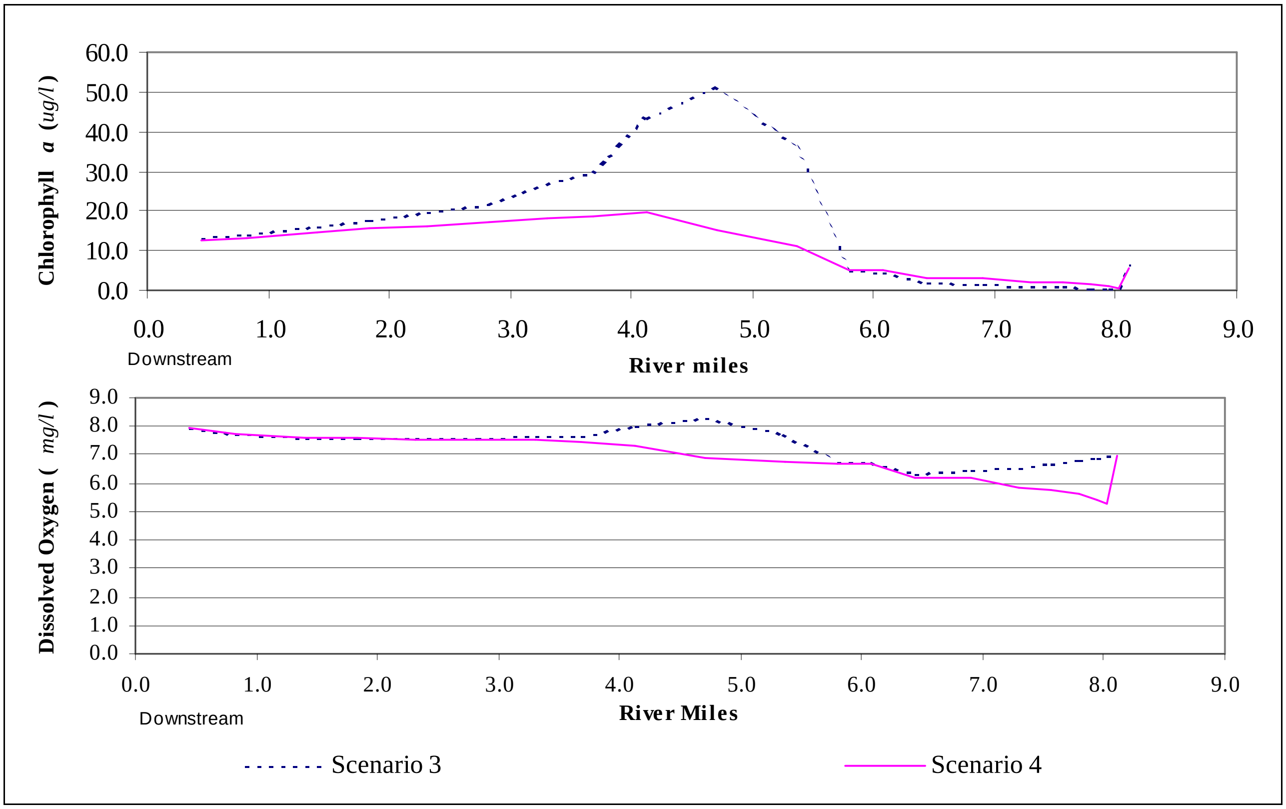

Figure 13: Model Results for Final Condition Scenarios for Chlorophyll *a* and Dissolved Oxygen

The diurnal dissolved oxygen variation due to photosynthesis and respiration can be estimated based on the amount of chlorophyll *a* in the water. For model scenario 3, where there is the greatest potential for a diurnal dissolved oxygen problem, the variation due to photosynthesis and respiration was calculated and subtracted from the average dissolved oxygen values produced by the model (Thomman and Mueller, 1987). For a more detailed explanation see Appendix A. The results did not produce a dissolved oxygen concentration below 6 mg/l, which is well above the standard of 5 mg/l. Therefore, the nutrient loads used for model scenario 3 are protective of both the chlorophyll *a* standard and the dissolved oxygen standard.

TMDL Loading Caps

The critical season for excessive algal growth in the Port Tobacco River is during low flow conditions in the summer. During this period the stream is poorly flushed, resulting in slow moving, warm water, which is susceptible to excessive algal growth. The model results for the third scenario indicate that, under critical summer conditions, the desired water quality goals are achieved. The summer critical condition TMDLs are stated in monthly terms to be consistent with the monthly concentration limits to eventually be required by NPDES permits. For the summer months, May 1 through October 31, the following TMDLs apply:

NITROGEN TMDL **8,710 *lbs/month***

PHOSPHORUS TMDL **871 *lbs/month***

While the low flow TMDLs presented above are designed to protect water quality during low flow conditions, the Department recognizes that nutrients may reach the River in significant quantities during higher flow periods. The results of model scenarios 2 and 4 have shown that the increased flushing of higher flows prevents immediate water quality problems. However, there is a concern that nutrient laden sediment, delivered and transported during higher flows, is suspected of causing excessive sediment oxygen demand, nutrient accumulation, and siltation when it deposits in the area of the marina at the head of the estuary. In response to this concern, the Department is also establishing annual TMDLs, based on average rather than low flow conditions. The resultant annual TMDLs for nitrogen and phosphorous are:

NITROGEN TMDL **243,310 lb/yr**

PHOSPHORUS TMDL **15,570 lb/yr**

It may be noted that these annual loads are higher than the total estimated loads for 1996, presented at the beginning of the document. In order to understand that the TMDLs protect water quality given this apparent regress, one must consider the conditions under which the loads are delivered to the stream. If the 1996 load was delivered steadily to the river, flowing at average streamflow, there would be no immediate water quality problems. As discussed earlier, the flushing effect of the average streamflow (compared to low flow) prevents water quality problems. Indeed, even annual loads greater than those in 1996, like those used in scenario 4 (on which the annual TMDL is based), delivered steadily to the river at average flow, will not cause problems. The problems occur only during low flow conditions—which are now protected by the low flow TMDLs presented above. The annual TMDLs, which apply during average flow conditions, are intended to prevent backsliding on current nonpoint source loads, thereby making an initial effort to address possible sedimentation problems while the situation is further evaluated. These annual TMDLs will be revised when refined data and analytical tools are developed.

Because the TMDLs set limits on nitrogen, and because of the way the model simulated nitrogen, it is not necessary to also include a TMDL for Nitrogenous Biochemical Oxygen Demand

(NBOD), to protect the dissolved oxygen standards in the river. It was also deemed unnecessary to include TMDLs for Carbonaceous Oxygen Demand (CBOD), because the NPDES permits reflect limits that are protective of dissolved oxygen standards on the river.

Load Allocations Between Point Sources and Nonpoint Sources

The allocations described in this section demonstrate how the subject TMDLs can be implemented to achieve water quality standards in the Port Tobacco River. Specifically, these allocations show that the sum of nutrient loadings to the Port Tobacco from existing and anticipated point sources and nonpoint sources or anticipated land uses can be maintained within the TMDLs established here.

The Clean Water Act and EPA regulations provide for flexibility in implementation of TMDLs, as long as the overall load is not exceeded. In the present case, individual waste load allocations ("WLAs"), i.e., effluent limitations for point sources, will be established through NPDES permits, which will be issued, reissued, or modified as appropriate on a watershed-wide basis. Load allocations ("LAs") to nonpoint sources set forth in this section represent best estimates of what loading rates will be in the year 2000 in light of existing land use and land use trends. They are not intended to impose restrictions on land use or require a reduction in loading from nonpoint sources below actual year 2000 loading rates. Maryland expressly reserves the right to allocate these TMDLs among different sources and in any manner that is reasonably calculated to achieve water quality standards.

This section describes possible allocations for both the low flow and average annual cases. Note that the overall point source allocations set forth in Table 2 (summer low flow) and Table 3 (average annual) combine current loads and future allocations ("FAs"). All significant sources have been addressed as described in technical memoranda entitled *Significant Nutrient Point Sources in the Port Tobacco Watershed*.

<u>Low Flow Allocations:</u>

The nonpoint source load allocations (LA) for nitrogen and phosphorus for the summer low flow critical conditions are represented as the base flow loads and flows as seen in 1984. This represents a conservative estimate given that the 1984 loads predate the implementation of nonpoint source nutrient reduction controls for the lower Potomac Tributary Strategy Basin. The low flow nonpoint source loads are attributable to base flow contributions. The nonpoint source loads that were assumed in the model account for both "natural" and human-induced components. Ideally one would separate the two, but in these cases adequate data was not available to do so.

Point source load allocations for the summer low flow critical conditions made up the balance of the total allowable load. Modeling inputs assumed that BNR and CPR would be implemented at the major point sources under anticipated summer operating conditions. The minor point sources were assumed to operate without BNR or CPR. This point source load allocation was adopted from results of model scenario 3. All significant point sources are addressed by this allocation and are described further in the technical memorandum entitled *Significant Nutrient Point Sources in the Port Tobacco Watershed.* The nonpoint source and point source nitrogen and phosphorus allocations for summer critical low flow conditions are shown in Table 2.

Table 2: Point Source and Nonpoint Source Summer Low Flow Load Allocations

	Total Nitrogen *(lb/month)*	**Total Phosphorus *(lb/month)***
Nonpoint Source	5,776	696
Point Source	2,761	154

Annual Allocations:

The annual nonpoint source nitrogen and phosphorus load allocations are represented as estimated year 2000 loads, assuming no additional best management practices (BMPs) implemented on any of the land uses. The background concentrations are included in the nonpoint source loads. As was discussed in the "Scenario Descriptions" section of this document the year 2000 loads were based on loading rates from the Chesapeake Bay Model (U.S. EPA, 1991).

Point source load allocations for the annual flow conditions made up the balance of the total allowable load. Modeling input assumed that BNR and CPR would be implemented at the major point sources under anticipated average annual operating conditions. The minor point sources were assumed to operate without BNR or CPR. This point source load allocation was adopted from results of model scenario 4. All significant point sources are addressed by this allocation and are described further in the technical memorandum entitled *Significant Nutrient Point Sources in the Port Tobacco Watershed.* Table 3 shows the load allocations to point and nonpoint sources respectively, for nitrogen and phosphorus for the annual TMDL.

Table 3: Point Source and Nonpoint Source Annual Load Allocations

	Total Nitrogen *(lb/yr)*	**Total Phosphorus *(lb/yr)***
Nonpoint Source	194,750	13,300
Point Source	42,720	1,870

Future Allocations and Margins of Safety

Future allocations represent surplus assimilative loading capacity that is either currently available, or projected to be available due to planned implementation of environmental controls. The future allocations for point sources for nitrogen and phosphorus have been computed as the difference between the estimated loads from the existing point sources at their current flow and the maximum allowable load, taking into account nonpoint sources as described below. The current loads at the point sources were calculated by multiplying 1996 monthly average flow by the anticipated future concentrations.

The annual future allocations for nonpoint source loads were computed as the difference between the 1996 nonpoint source loads stated in the beginning of the document and the year 2000 nonpoint source loads used in the final loading scenario. The future summer low flow nitrogen and phosphorus Future Allocations are given in Table 4. The annual nitrogen and phosphorus Future Allocations are given in Table 5.

A margin of safety (MOS) is required as part of a TMDL in recognition of the fact that there are many uncertainties in scientific and technical understanding of water quality in natural systems. Specifically, knowledge is incomplete regarding the exact nature and magnitude of pollutant loads from various sources and the specific impacts of those 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 one of 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 = WLA + LA + MOS). The second approach is to incorporate the MOS as conservative assumptions within the design conditions for the WLA and the LA.

Maryland has adopted margins of safety that combine these two approaches. Following the first approach, the load allocated to the MOS was computed as 3% of the year 2000 average annual nonpoint source loads for nitrogen and phosphorus for the annual TMDL. Similarly, a 3% MOS was included in computing the low flow TMDLs. These explicit nitrogen and phosphorus margins of safety are summarized in Table 4 and Table 5.

In addition to these explicit set-aside MOSs, additional safety factors are built into the TMDL development process. Note that the results of the model scenario for the critical low flow case indicate a chlorophyll *a* concentration that is slightly below 52 µg/l. Further, the 52 µg/l chlorophyll *a* target is itself somewhat conservative. 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, Maryland has elected to use the more conservative peak concentrations of 52 µg/l. Finally, under low stream flow conditions, the nonpoint source contribution is a fairly stable concentration associated with the stream's base flow. Thus, the margin of safety depends most on the point source contribution, the control of it is much more certain than nonpoint sources. Hence, another implicit safety factor will be provided by the NPDES permits, which are typically over-designed to account for the low flow conditions.

Table 4: Summer Critical Low Flow Margins of Safety and Future Allocations

	Total Nitrogen *(lb/month)*	**Total Phosphorus *(lb/month)***
Margins of Safety	173	21
Future Allocations	1,164	66

Table 5: Annual Margins of Safety and Future Allocations

	Total Nitrogen *(lb/yr)*	Total Phosphorus *(lb/yr)*
Margins of Safety	5,840	400
Future Allocations	22,080	1,610

Summary of Total Maximum Daily Loads

The critical low flow TMDLs, applicable from May 1 – Oct. 31 for the Port Tobacco River, equated with illustrative allocations, are:

For Nitrogen (*lb/month*):

TMDL	=	LA	+	WLA	+	MOS	+	FA
8,710	=	**5,776**	+	**1,597**	+	**173**	+	**1,164**

For Phosphorus (*lb/month*):

TMDL	=	LA	+	WLA	+	MOS	+	FA
871	=	**696**	+	**88**	+	**21**	+	**66**

The annual TMDLs for the Port Tobacco River, equated with illustrative allocations, are:

For Nitrogen (*lb/yr*):

TMDL	=	LA	+	WLA	+	MOS	+	FA
243,310	=	**190,470**	+	**24,920**	+	**5,840**	+	**22,080**

For Phosphorus (*lb/yr*):

TMDL	=	LA	+	WLA	+	MOS	+	FA
15,570	=	**12,500**	+	**1,060**	+	**400**	+	**1,610**

Where:

TMDL = Total Maximum Daily Load
LA = Nonpoint Source
WLA = Point Source
MOS = Margin of Safety
FA = Future Allocation

Average Daily Loads:

On average, the annual TMDLs will result in loads of approximately 667 lb/day of nitrogen and 43 lb/day of phosphorus. And, on average the summer critical low flow TMDLs will result in loads of approximately 290 lb/day of nitrogen and 29 lb/day of phosphorus.

ASSURANCE OF IMPLEMENTATION

This section provides the basis for reasonable assurances that the nitrogen and phosphorus TMDLs will be achieved and maintained. First, for the low flow TMDL, which is driven primarily by point source loads, NPDES permits will play a major role in assuring implementation. Second, for the average annual TMDLs, which involve more significant nonpoint source considerations, Maryland has several well-established programs that will be drawn upon. Finally, 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 the use of NPDES permits. The NPDES permit for the La Plata STP, which is by far the largest plant discharging to the Port Tobacco River, will require implementation of Biological Nutrient Removal (BNR) and Chemical Phosphorus Removal (CPR). CPR has already been implemented at the STP. The BNR facilities are currently in the design phase and will go into operation once they are finished being built. The NPDES permits for La Plata and the other point sources in the Port Tobacco River will have compliance provisions, which provide a reasonable assurance of implementation.

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 Lower Potomac Tributary Strategy Basin, which includes the Port Tobacco watershed. Maryland is in the forefront of implementing quantifiable nonpoint source controls through the Tributary Strategy efforts. In addition, Maryland is refining its State Nonpoint Source Management Plan, required under Section 319 of the Clean Water Act, through which the Tributary Strategy and other nonpoint source control efforts can be integrated. This will help to assure that nutrient control activities are targeted to areas in which nutrient TMDLs have been established.

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 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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APPENDIX A