Total Maximum Daily Loads of Nitrogen and Phosphorus for the Transquaking River Dorchester, Maryland

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List of Abbreviations

BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
CEAM	Center for Exposure Assessment Modeling
CHL*a*	Active Chlorophyll
CWA	Clean Water Act
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
EUTRO5	Eutrophication Module of WASP5
FA	Future Allocation
LA	Load Allocation
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MOS	Margin of Safety
NH_3	Ammonia
NO23	Nitrate + Nitrite
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
ON	Organic Nitrogen
OP	Organic Phosphorus
PO_4	Ortho-Phosphate
SOD	Sediment Oxygen Demand
TMDL	Total Maximum Daily Load
TREM	Transquaking River Eutrophication Model
USGS	United States Geological Survey
WASP5.1	Water Quality Analysis Simulation Program 5.1
WLA	Waste Load Allocation

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 waterbody can receive without violating water quality standards.

The Transquaking 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 Transquaking 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 Transquaking River.

EXECUTIVE SUMMARY

This document establishes Total Maximum Daily Loads (TMDLs) for nitrogen and phosphorus in the Transquaking River. Transquaking River drains to the Chesapeake Bay through the Fishing Bay, and is part of the Lower Eastern Shore Tributary Strategy Basin. The river is impaired by the nutrients nitrogen and phosphorus, which cause excessive algal blooms and exceedance 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 whereby the designated uses for the Transquaking River will be met. The TMDL was determined using the WASP5.1 water quality model. Total loading caps for nitrogen and phosphorus entering the Transquaking River are established for both low flow and average annual flow conditions. 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 11,046 lb/month, and the low flow TMDL for phosphorus is 1,686 lb/month. These TMDLs apply during the period May 1 through October 31. 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 loads make up the balance of the allocation.

The annual TMDL for nitrogen is 438,853 lb/yr, and the annual TMDL for phosphorus load is 31,746 lb/yr. Allowable loads have been allocated between point and nonpoint sources. The estimated average annual nonpoint source loads for the TMDLs are based on loading rates projected to the year 2000. The average annual point source loads make up the balance of the allocation.

Four factors provide assurance that these TMDLs will be implemented. First, NPDES permits will play a major role in assuring implementation. Second, Maryland has several well-established programs that will be drawn upon, including Maryland’s Tributary Strategies for Nutrient Reductions developed in accordance with the Chesapeake Bay Agreement. Third, Maryland’s Water Quality Improvement Act of 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.

The Transquaking 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 Transquaking River.

The Transquaking River was identified as being impaired by nutrients due to signs of eutrophication, and low dissolved oxygen. Eutrophication, the overenrichment of aquatic systems by excessive inputs of nitrogen and phosphorus**,** was evidenced in Transquaking River by seasonal algal blooms. For these reasons, this document establishes TMDLs for the nutrients – nitrogen and phosphorus in the Transquaking River.

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1 General Setting and Source Assessment

The Transquaking River is located in Dorchester County, Maryland (Figure 1). It originates south of East New Market Area and finally drains to the Chesapeake Bay through the Fishing Bay roughly seven miles due south of Bestpitch. The River is approximately 23.2 miles in length, from its confluence with the Fishing Bay to the head of the tide. The Transquaking River watershed has an area of approximately 70,922 acres or 110.8 square miles. The land uses in the watershed consist of forest and other herbaceous (44,426 acres or 62.6%), mixed agriculture (23,475 acres or 33.1%), water (1,811 acres or 2.6%), and urban (1,210 acres or 1.7%), based on 1997 Maryland Office of Planning land cover data, and 1997 Farm Service Agency (FSA) data). Figure 2 shows the geographic distribution of the different land uses. Figure 3 shows the relative amounts of the different land uses.

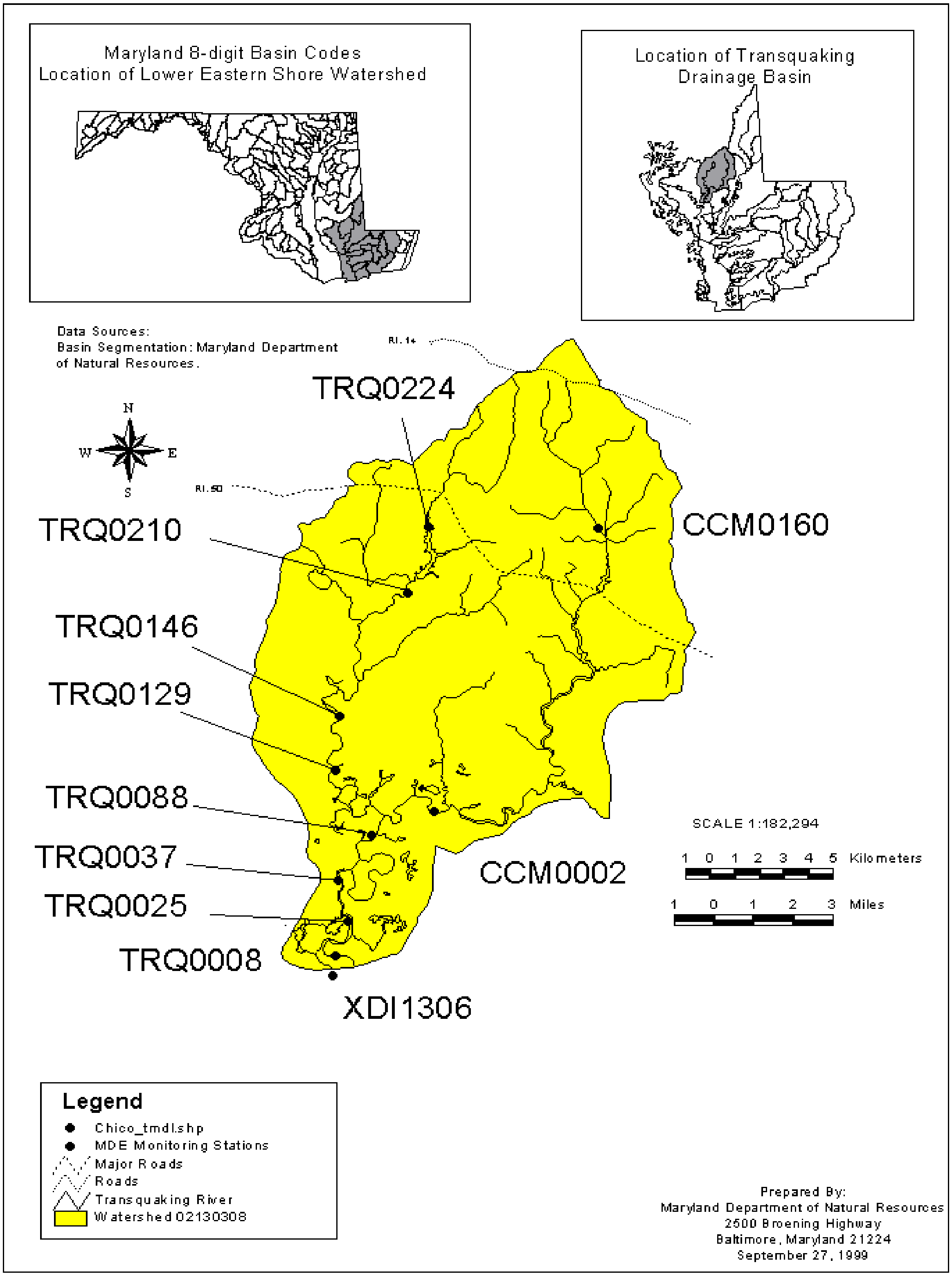

Figure 1: Location Map of the Transquaking River Drainage Basin within Maryland

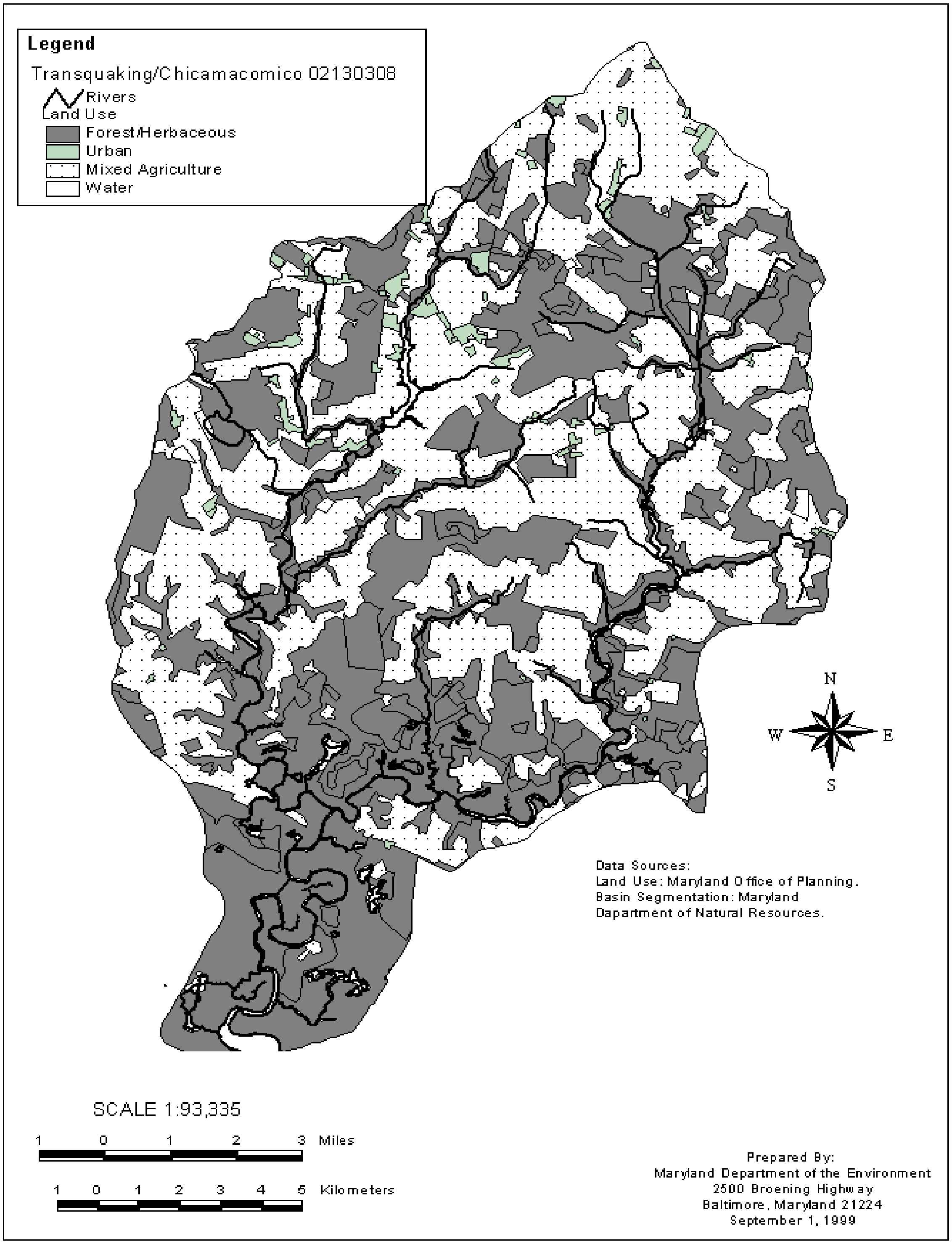

Figure 2: Predominant Land Use in the Transquaking River Drainage Basin

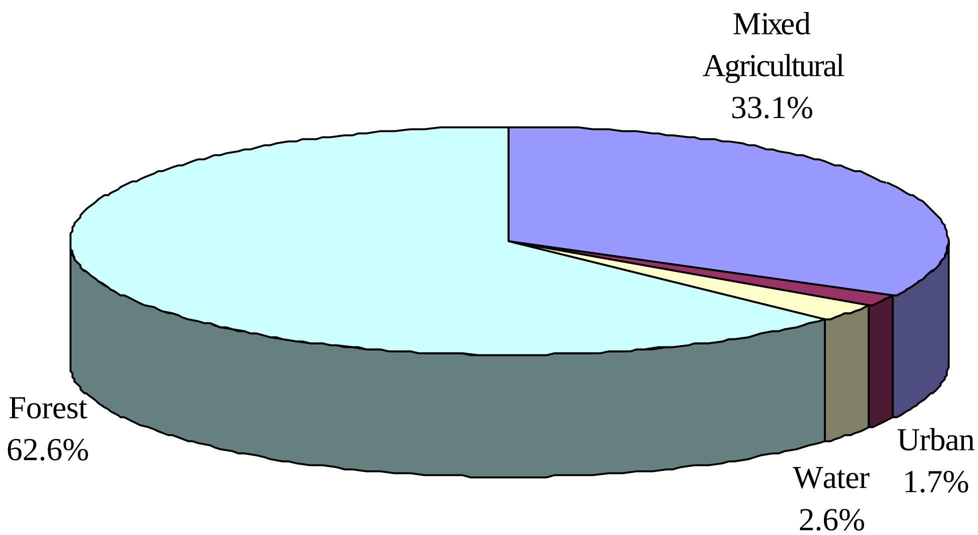

Figure 3: Estimated Land Use in the Transquaking River Drainage Basin

The Transquaking River is tidal throughout its navigable reach, which extends from the highly depositional delta area at its mouth for approximately 20.5 miles upstream to an area known as Higgins Mill Pond. Higgins Millpond was previously used as a source of water. A temporary dam was constructed on the upper section of river, but now only a remnant of it remains. Downstream of the Bestpitch area the River has an oxbow shape. A cut has been made through the bend to decrease the length of the stream for easier navigation. Currently the River flows predominantly through this cut. Depths of the River range from about 4 inches in the headwaters to greater than 11.5 feet at the confluence of Transquaking and Chicamacomico, and finally to about 6 feet where the Transquaking meets Fishing Bay.

In the Transquaking River watershed, the estimated total nitrogen load is 899,163 lb/yr, and the total phosphorus load is 43,812 lb/yr, for the year 2000 (Figure 4). The nonpoint source loads were determined using land use loading coefficients. The land use information was based on 1997 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, 1996), which was a continuous simulation model. The Chesapeake Bay Program nutrient loading rates account for atmospheric deposition, loads from septic tanks, and loads coming from urban development, agriculture, and forestland. The total nitrogen load coming from nonpoint sources is 545,113 lb/yr, and the total nonpoint source phosphorus load is 41,987 lb/yr.

There is one point source, Darling International Inc, contributing a major load to the watershed. Darling International Inc is a rendering facility and contributes 354,050 lb/yr of nitrogen and 1,825 lb/yr phosphorous to the basin.

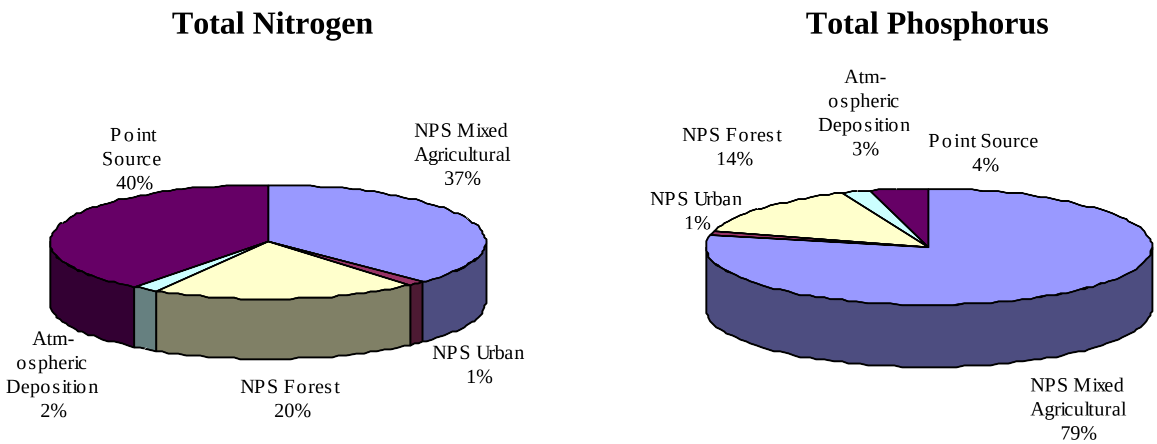

Figure 4: Estimated Nitrogen and Phosphorus Point and Nonpoint Source Loadings

2.2 Water Quality Characterization

Four water quality parameters: chlorophyll *a*, dissolved oxygen, dissolved inorganic nitrogen, and dissolved inorganic phosphorus were examined to determine the extent of the impairment in the Transquaking River. Six water quality surveys, three in winter (12-Feb-98, 16-Mar-98, 23-Mar-98) and three in summer (21-July-98, 18-Aug-98, 15-Sep-98) were conducted in the Transquaking River during 1998. Table 1 presents the distance of each station from the mouth. Figure 1 identifies the locations of the water chemistry sampled during each survey. The months of July, August, and September represent critical conditions for the Transquaking River. This is because during these months there is less water flowing in the channel, typically higher concentrations of nutrients, and the water temperatures are usually warmer creating good conditions for algal growth. The data collected in February and March does not show any chlorophyll *a* or DO problems. The following graphs present data from the critical low flow period.

Figure 5 presents a longitudinal profile of chlorophyll *a* data sampled during the 1998 field surveys. The sampling region covers the entire tidal portion of the Transquaking River from its confluence with the Fishing Bay (Station XDI1306) to above Higgins Millpond (Station TRQ0224). As the data indicates, ambient chlorophyll *a* concentrations in the summer for the first 9.3 miles are all below 50 μg/l. However, the levels are much greater above 9.3 miles, where mean values are about 80 μg/l, with a maximum concentration of over 143 μg/l.

Dissolved oxygen concentrations along the longitudinal profile are depicted in Figure 6. From the mouth up to a distance of about 12.4 miles the dissolved oxygen levels fall below the water quality standard of 5 mg/l, whereas above 12.4 miles, the concentrations are above the standard.

Table 1: Location of Water Quality Stations

Water Quality Station	Miles from Mouth of Transquaking River
XDI1306	-
TRQ0008	0.544
TRQ0025	1.796
TRQ0037	3.315
TRQ0088	8.809
TRQ0129	13.04
TRQ0146	15.147
TRQ0210	20.956
TRQ0224	23.081

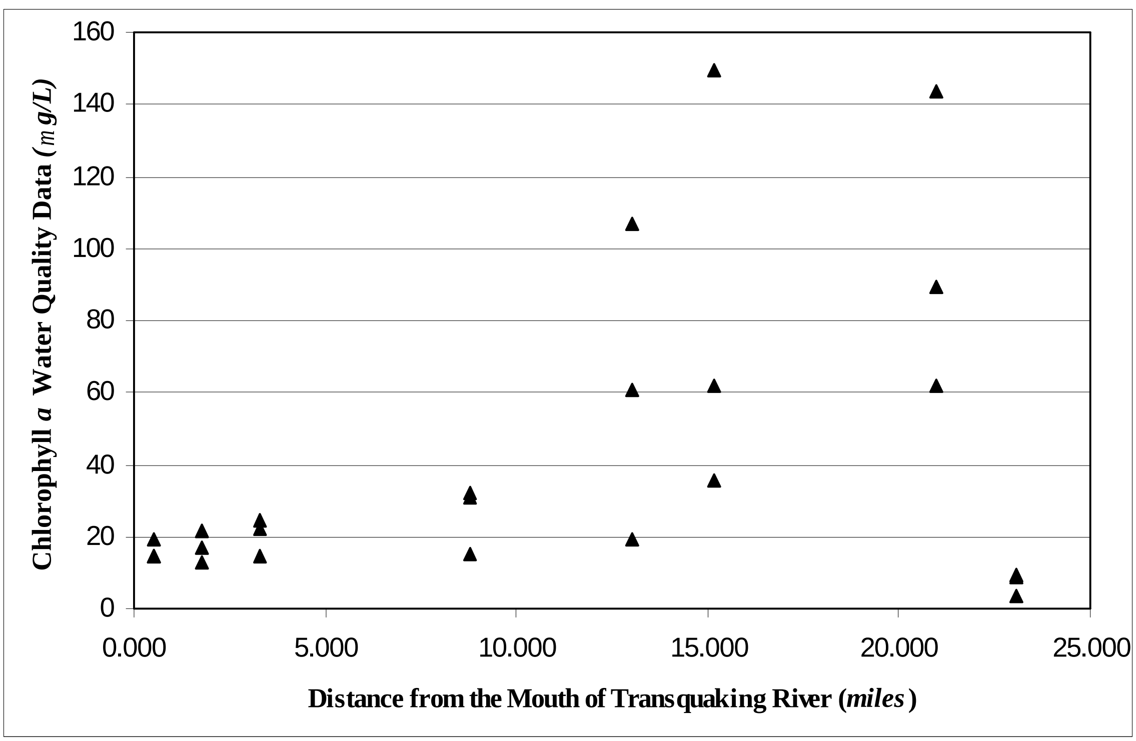

Figure 5: Longitudinal Profile of Chlorophyll *a* Data (Low flow)

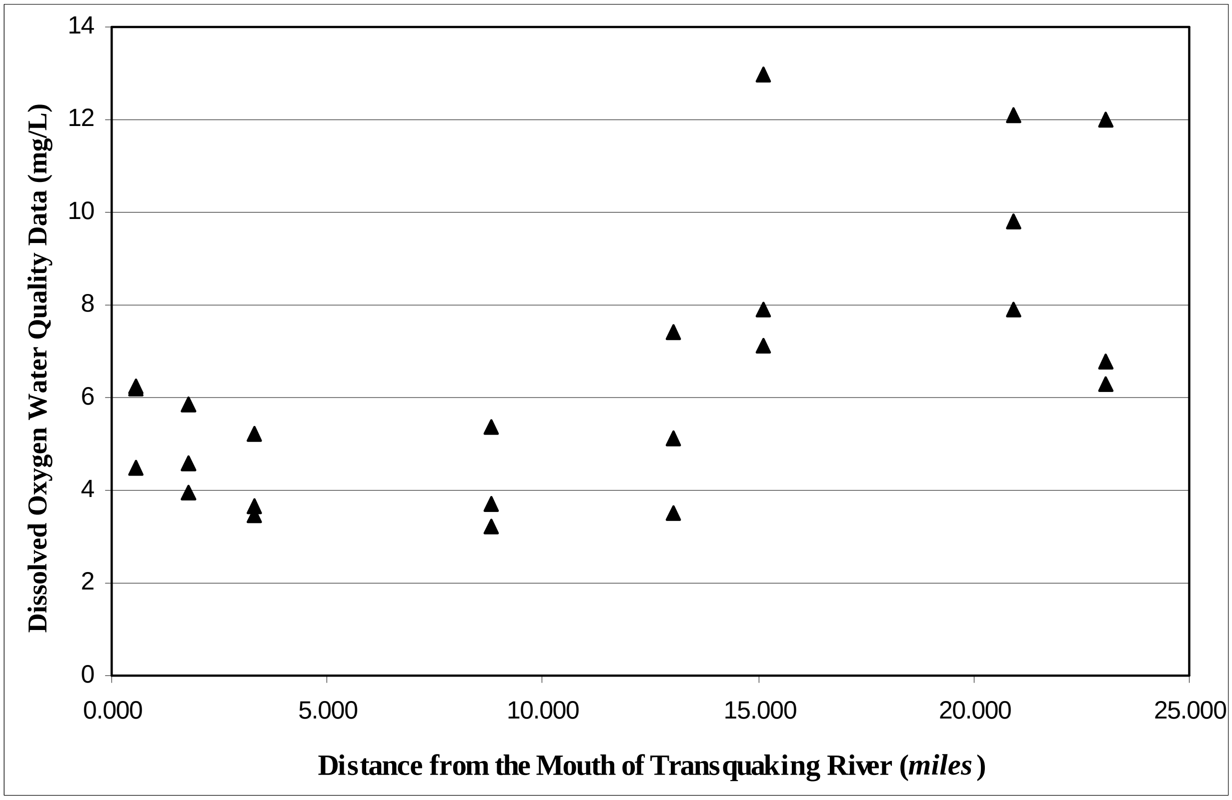

Figure 6: Longitudinal Profile of Dissolved Oxygen Data (Low flow)

The dissolved inorganic nitrogen levels along the longitudinal profile are depicted in Figure 7. For a distance of about 20 miles the levels are seen to be below 5 mg/l, whereas the concentrations above reach a value of 160 mg/L. During the winter season the concentration around the same station is about 0.28 mg/l.

Figure 8 presents a longitudinal profile of dissolved inorganic phosphorus as indicated by ortho-phosphate levels measured in samples collected in 1998. They are similar to that of ammonia, with concentrations in the tidal portion measured at or near the level of detection (0.01 mg/l), with elevated level inside the pond where it reaches a concentration of 1.1 mg/l. During winter the concentration at the same point is around 0.15 mg/l.

2.3 Water Quality Impairment

The Transquaking River system is impaired by an overenrichment of nutrients. Nitrogen and phosphorus loadings from both point and nonpoint sources have resulted in higher than acceptable chlorophyll *a* concentrations and dissolved oxygen concentrations below the standard of 5 mg/l. Mean summer concentrations of chlorophyll *a* in the upper reaches of the southeast branch of Transquaking River range between 50-80 μg/l, with nuisance algal bloom levels periodically reaching 140 μg/l. Mean summer concentrations of dissolved oxygen in the same region of Transquaking River range between 4-9 mg/l, with severe depletion resulting in concentrations as low as 3.2 mg/l.

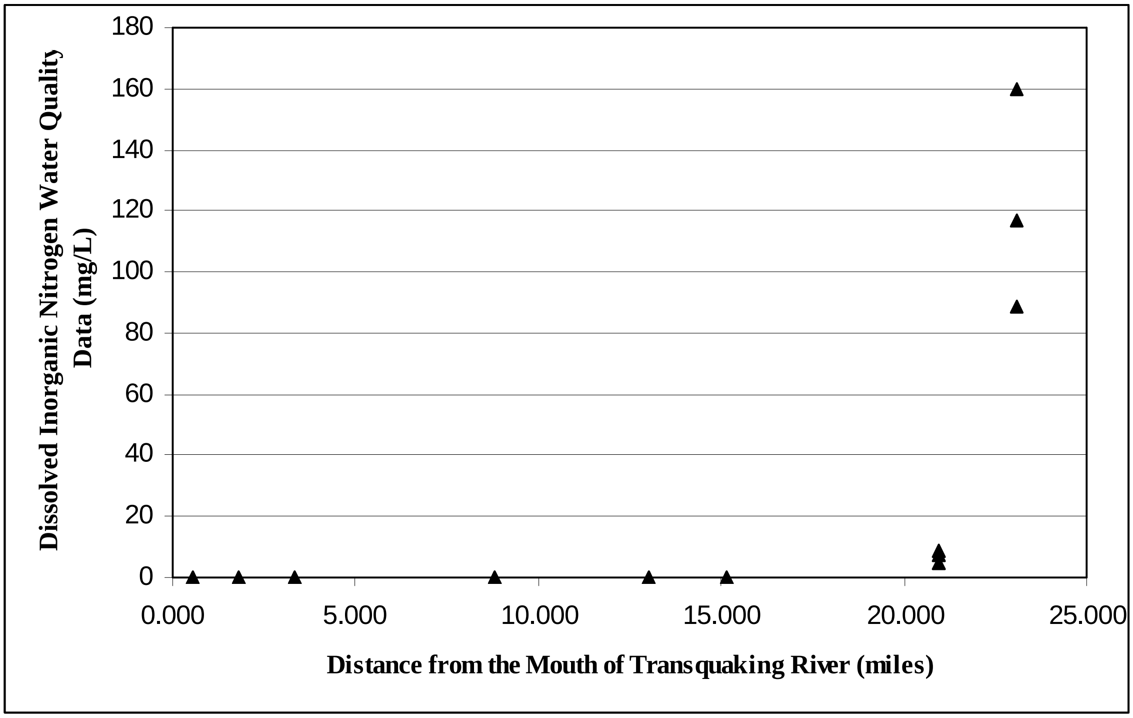

Figure 7: Longitudinal Profile of Dissolved Inorganic Nitrogen Data (Low flow)

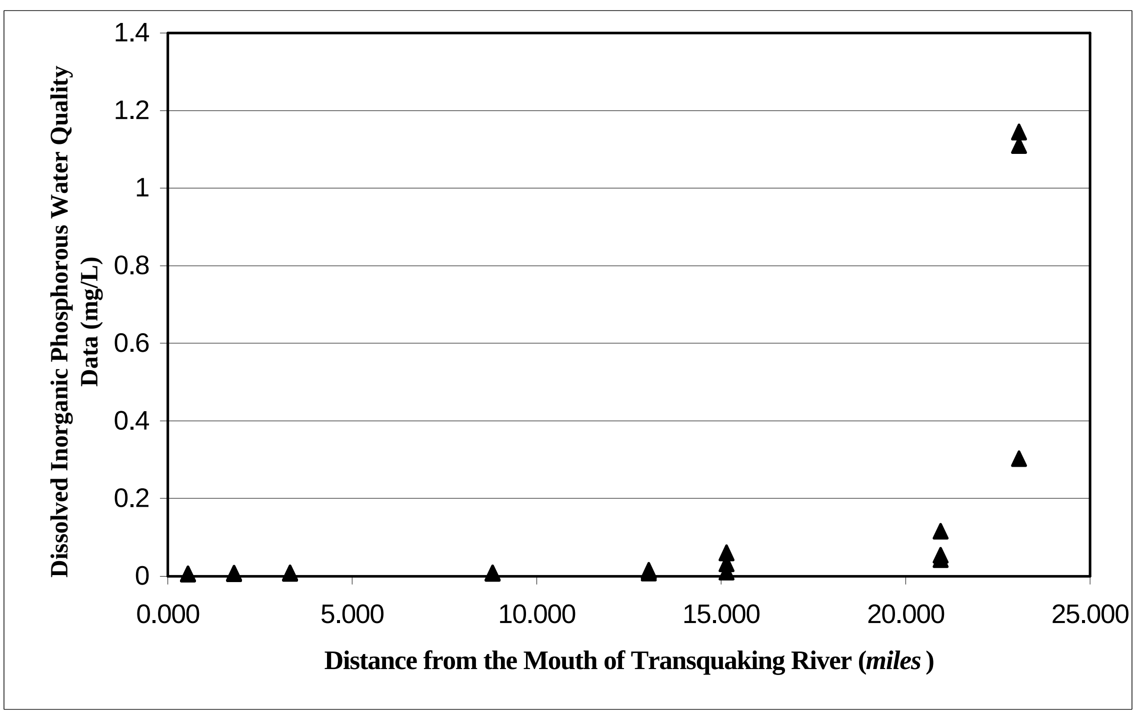

Figure 8: Longitudinal Profile of Dissolved Inorganic Phosphorus Data (Low flow)

3.0 TARGETED WATER QUALITY GOAL

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

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

2. Reduce peak chlorophyll *a* levels (a surrogate for algal blooms) to below 50 μg/l.[1]

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 Transquaking 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, Part1* (1997).

4.0 TOTAL MAXIMUM DAILY LOADS AND ALLOCATION

4.1 Overview

This section describes how the nutrient TMDLs and total loading allocations for point sources and nonpoint sources were developed for the Transquaking 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 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 Transquaking River TMDLs was 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, GA (Ambrose *et al.*, 1988). EUTRO5.1 is the component of WASP5.1 that simulates eutrophication, incorporating eight water quality constituents in the water column and the sediment bed.

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1 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.

The spatial domain of the Transquaking River Eutrophication Model (TREM) extends from the confluence of the Transquaking River and the Chesapeake Bay for about 26.2 miles along the mainstem of Transquaking River. One major branch, the Chicamacomico, drains into Transquaking River approximately 10 miles upstream of its mouth.

Freshwater flows and nonpoint source loadings are taken into consideration by dividing the drainage basin into 18 subwatersheds and assuming that these flows and loadings are direct inputs to the TREM. To estimate point source loads for the calibration, some point source discharge data was collected in 1999 for use with the primary calibration data set collected in 1998, described below. The reason for using some data measured in 1999 was to achieve an estimate of specific point source parameters that were not available for 1998. This was justified because plant operation did not change significantly between 1998 and 1999.

The TREM 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 TREM was calibrated for high flow and low flow conditions using the water quality monitoring data collected during February, March July, August, and September 1998. Results of the calibration for both high flow and low flow conditions are presented in Appendix A

4.3 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 of 5 mg/l and reducing chlorophyll *a* concentration to 50 µg/l.

The nutrient loading scenarios are grouped according to *expected conditions under current loads and future conditions*. The expected conditions represent the nutrient loads and water quality status in low flow and average flow conditions. The future conditions represent the system after there has been a reduction in nutrient loads to meet water quality standards. The future conditions also project the maximum allowable nutrient loads the system can incorporate without incurring an impairment. It also includes a margin of safety intended to account for estimation of 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 and nitrite (NO23), 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 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 Transquaking River.

The first scenario represents the expected conditions of the stream at low flow and warm water (above 70 ^{0}F) temperatures. There is one abandoned United States Geological Survey (USGS) flow gage (abandoned in 1980) in the Chicamacomico River, below Big Millpond. The flow for individual subwatershed was calculated using a regression equation based on 30 years of flow data, which encompasses the station in Transquaking along with all USGS gages on the entire Lower Delmarva Peninsula. During low flow condition, the following assumptions were made about the flows based on observations in the field: 100% of the regression flow coming from the mainstem, 50% of the regression flow coming from the subwatersheds with streams to carry the flow to the mainstem, and there was no flow from the other subwatersheds. The total nonpoint source (NPS) loads were computed using 1998 base-flow field data. The 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 taken to be the effluent concentrations measured during the 1999 plant monitoring survey at its designed permitted flow.

The second scenario represents the expected conditions of the stream at average flow. The total nonpoint source loads were calculated using the Chesapeake Bay Program loading rates, which represent edge-of-stream loads, for the year 2000 assuming Best Management Practice (BMP) implementation at levels consistent with current progress, and includes loads from atmospheric deposition, septic tanks, cropland, pasture, feedlots, forest, and urban land. Land use was calculated using 1997 MOP data, and adjusted using 1997 FSA crop acre data.

The third scenario represents the future conditions, for the case of low stream flow. The total nonpoint source flows were the same as for scenario 1. The nonpoint source loads were the same as scenario 1, plus a 5% margin of safety. The point source load was reduced to meet water quality standards. The details of the reduction for the point source is further described in the technical memorandum entitled *"Significant Nutrient Point and Nonpoint Sources in the Transquaking River Watershed"* and Appendix A.

The fourth scenario represents the future conditions, for the case of average stream flow. The flow was the same as scenario 2. The total nonpoint source (NPS) loads were based on the loadings calculated for scenario 2. The nitrogen and phosphorus loads were reduced to meet chlorophyll *a*, and dissolved oxygen standards in the water. A 3% margin of safety was also included for the nonpoint source load calculation**.** The point source was reduced to the same value as in scenario 3. Details of point and nonpoint source load reductions are described further in the technical memorandum entitled *"Significant Nutrient Point and Nonpoint Sources in the Transquaking River Watershed"* and Appendix A.

4.4 Scenario Results

The TREM 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 (See Appendix A for more details). The model can also output the minimum dissolved oxygen concentration, which will be used for all the model results in this section.

Expected Conditions under current loads Scenarios:

1. *Low Flow:* Assumes low stream flow conditions. Assumes the 1998 low-flow nonpoint source loads, and maximum point source design flow and load (1999 data).

2. *Average Annual Flow:* Assumes average stream flow conditions. Assumes the 2000 average annual nonpoint source loads, and maximum point source design flow and load (1999 data).

The first scenario represents the expected condition for summer low flow, when water quality is impaired by low dissolved oxygen concentrations. The second scenario represents the expected conditions during average stream flow. In both scenarios, the peak chlorophyll *a* levels are above the desired goal of 50 µg/l. The chlorophyll *a* and dissolved oxygen results for these conditions can be seen in Figure 9 and Figure 10. It can be seen that the dissolved oxygen level falls below the standard of 5 mg/l in both low flow and average flow conditions.

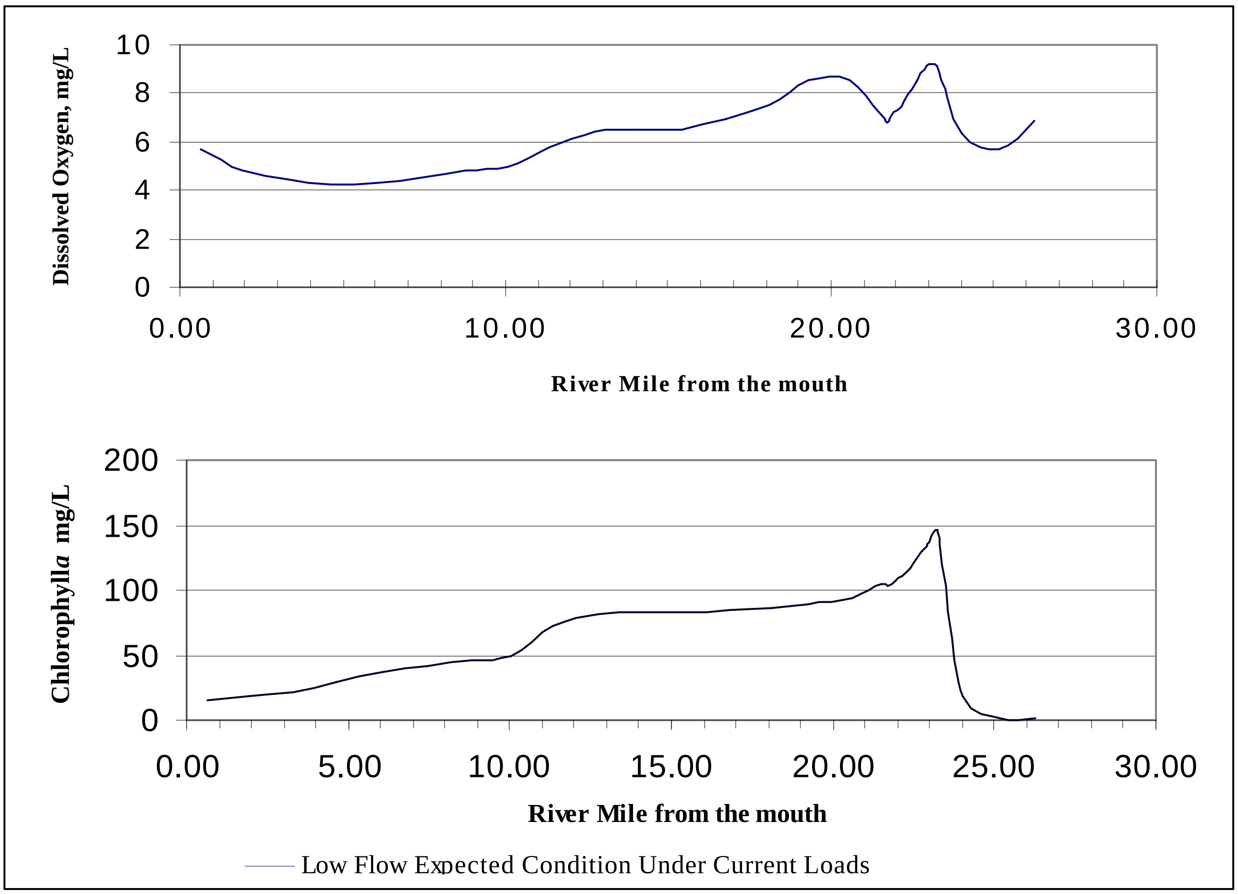

Figure 9: Model Results for the Low Flow Expected Conditions Under Current Loads Scenario for Chlorophyll *a* and Dissolved Oxygen (Scenario 1)

Future Condition Scenarios:

3. *Low Flow:* Assumes low stream flow conditions. Assumes 1998 summer low flow nonpoint source loads plus a 5% margin of safety. Assumes the reduced point source loads for the summer low flow expected conditions make up the balance of the total allowable load.

4. *Average Annual Flow:* Assumes average stream flow conditions. Assumes the year 2000 average annual nonpoint source loads reduced by 35% plus a 3% margin of safety. Assumes the reduced point source loads for the average annual condition make up the balance of the allowable load.

In both the future condition scenarios, a reasonable reduction in nutrient fluxes and sediment oxygen demand (SOD) was applied based on the percentage reduction of organic matter settling on to the bottom layer. The details of the methodology are presented in Appendix A.

The results of the future condition scenarios are presented in Figure 11 and Figure 12. Figure 11 presents future scenario with a reduced point source at low flow. The nonpoint source loads are

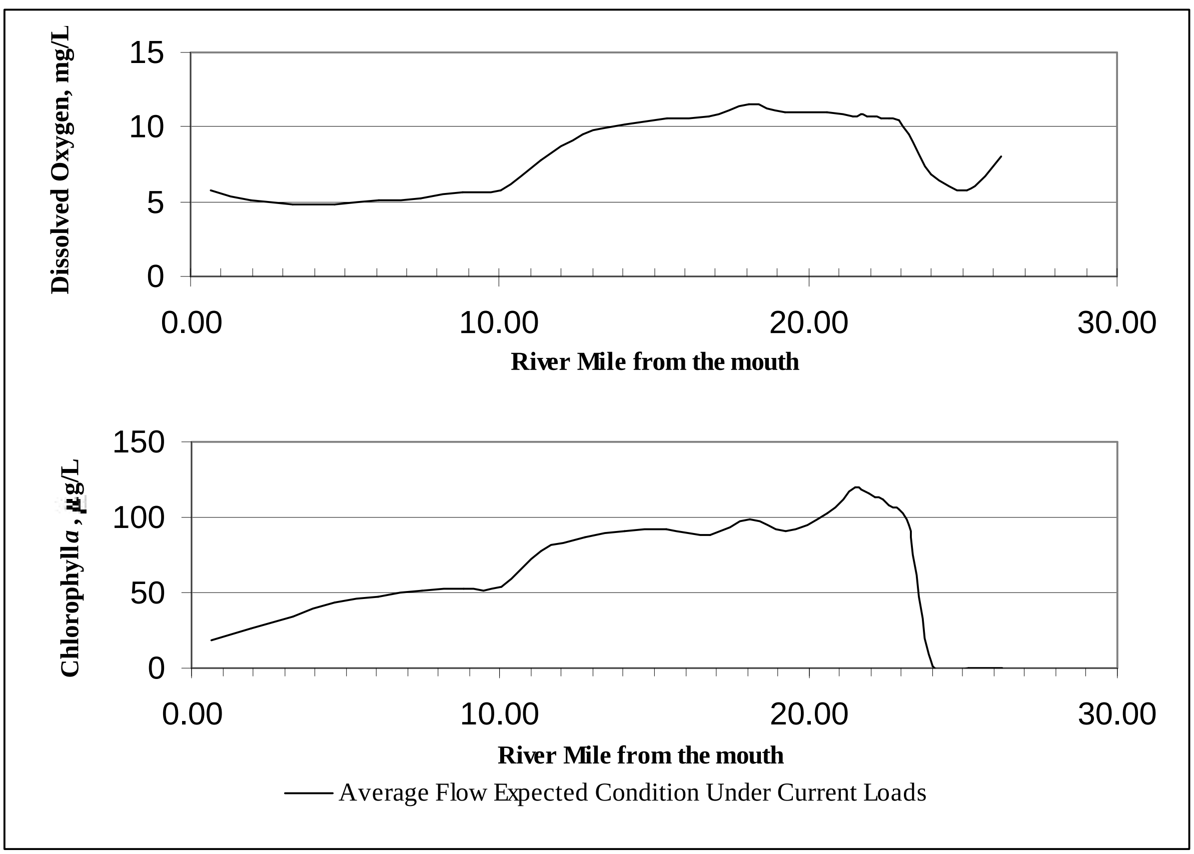

Figure 10: Model Results for the Average Flow Expected Condition Under Current Loads Scenario for Chlorophyll *a* and Dissolved Oxygen (Scenario 2)

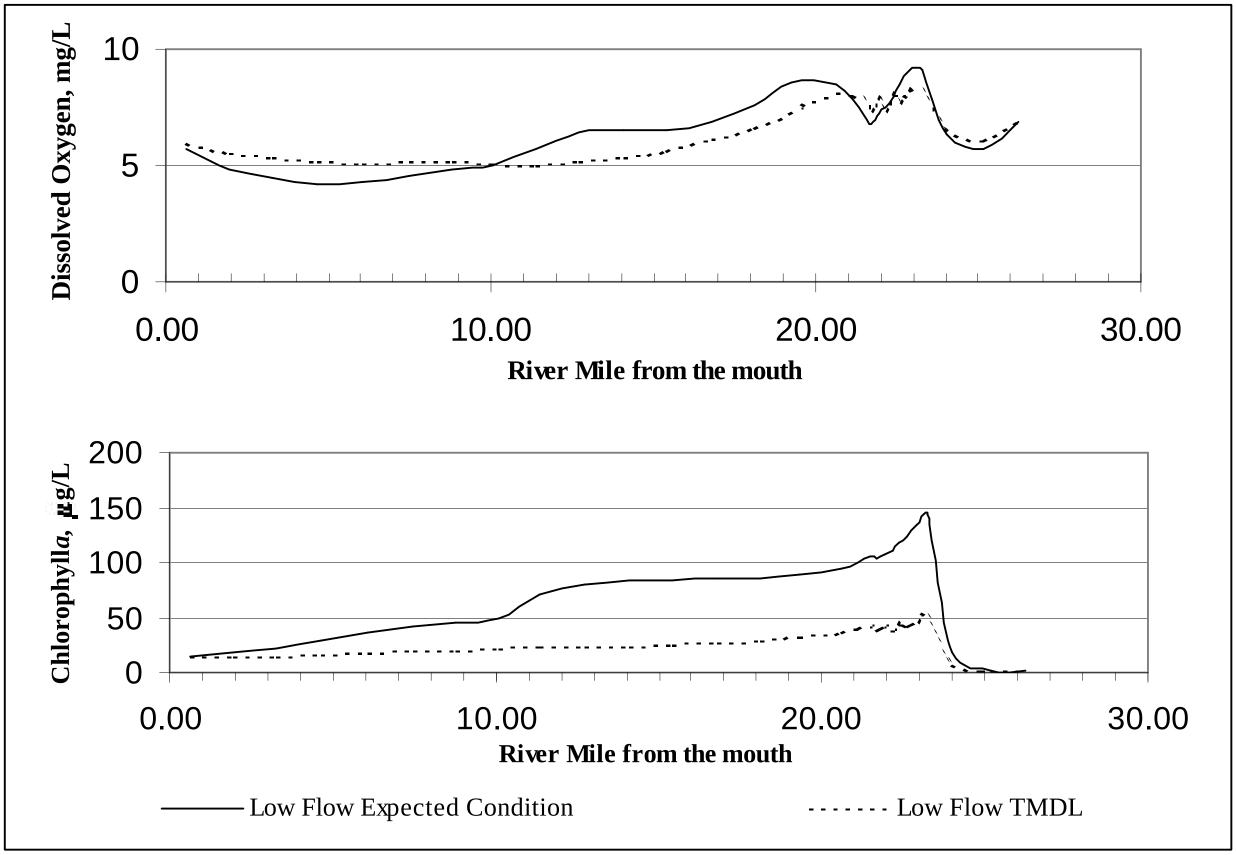

Figure 11: Model Results for the Low Flow Future Condition Scenario for Chlorophyll *a* and Dissolved Oxygen (Scenario 3)

the same as the low flow condition. With the reduction in point source loads, the model yields a maximum chlorophyll *a* concentration of about 50 µg/L just below Darling International, Inc. inside Higgins Millpond. It also shows the dissolved oxygen concentrations are above 5 mg/L all along the mainstem of the Transquaking River. Scenario 3 does not include a reduction in nonpoint source loads for the basin, and the water quality criteria are maintained at all points along the River. The results of future condition scenario for average flow are shown in Figure 12. A nonpoint load reduction of 35% has been applied to the nitrogen and phosphorus controllable loads. The results indicate that water quality is protected for the full length of the River. These two scenarios provide the justification for the TMDL presented below.

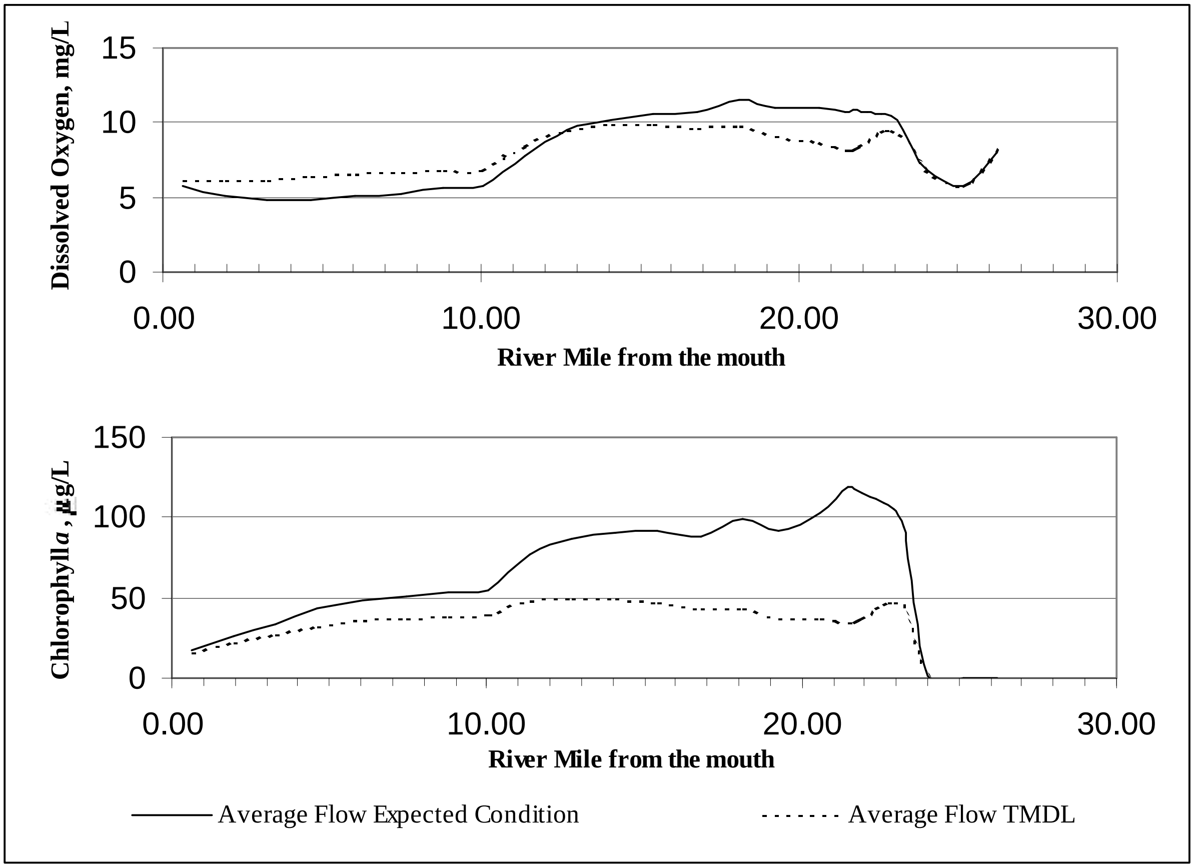

Figure 12: Model Results for the Average Flow Future Condition Scenario for Chlorophyll *a* and Dissolved Oxygen (Scenario 4)

4.5 TMDL Loading Caps

The critical season for excessive algal growth in the Transquaking River is during the summer months for low flow and average flow conditions. During low flow conditions the stream is poorly flushed, resulting in slow moving, warm water, which is susceptible to excessive algal growth. During average flow conditions, the increased nonpoint source nutrient loads can cause excessive algal growth. The model results for the third scenario indicate that, under expected low flow conditions, the desired water quality goals are achieved. The low flow TMDLs are stated in monthly terms because low flow conditions occur for shorter periods of time. For the summer months, May 1 through October 31, the following TMDLs apply:

NITROGEN TMDL **11,046 *lbs/month***

PHOSPHORUS TMDL **1,686 *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 scenario 2 have shown that during average flow conditions, high chlorophyll *a* concentrations are still likely to result in low dissolved oxygen. Model scenario 4 showed that with the nutrient reductions expected in the basin, the water quality standards would be maintained for dissolved oxygen. The resultant annual TMDLs for nitrogen and phosphorous are:

NITROGEN TMDL 438,853 *lbs/year*

PHOSPHORUS TMDL 31,746 *lbs/year*

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 biochemical oxygen demand (CBOD), because the NPDES permits reflect limits that are protective of dissolved oxygen standards in the river.

4.6 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 Transquaking River. Specifically, these allocations show that the sum of nutrient loadings to the Transquaking River from existing point and nonpoint sources or anticipated changed point sources and anticipated land uses can be maintained safely 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. MDE expressly reserves the right to allocate these TMDLs among different sources and land use categories in any manner that is reasonably calculated to achieve water quality standards.

Low Flow Allocations:

The nonpoint source load allocations (LA) for nitrogen and phosphorus for the summer low flow expected conditions are represented as the base-flow concentrations and flows as seen in summer 1998. 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 expected conditions made up the balance of the total allowable load. 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 and Nonpoint Sources in the Transquaking River Watershed*". The nonpoint source and point source nitrogen and phosphorus allocations for summer expected low flow conditions are shown in Table 3.

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

	Total Nitrogen *(lb/month)*	**Total Phosphorus *(lb/month)***
Nonpoint Source	9,263	1,479
Point Source	1,231	123

<u>Annual Allocations</u>:

The annual nonpoint source nitrogen and phosphorus load allocations are represented as estimated year 2000 loads, with a 35% reduction in total nitrogen and total phosphorus loads plus 3% margin of safety. 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. 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 and Nonpoint Sources in the Transquaking River Watershed*". Table 4 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	410,729	29,298
Point Source	14,954	1,496

4.7 Margins of Safety

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 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 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 flow TMDLs. These explicit nitrogen and phosphorus margins of safety are summarized in Table 5 and Table 6.

In addition to these explicit set-aside MOSs, additional safety factors are built-in into the TMDL development process. Note that the results of the model scenario for the expected low flow case indicate a chlorophyll *a* concentration that is around 50 µg/l. Further, the 50 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, MDE has elected to use the more conservative peak concentrations of 50 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.

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 sun light 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 150 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 significant margin of safety.

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

	Total Nitrogen	**Total Phosphorus**
MOS Low Flow	552 lb/month	84 lb/month
MOS Average Flow	13,170 lb/yr	952 lb/yr

4.8 Summary of Total Maximum Daily Loads

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

For Nitrogen (*lb/month*):

TMDL	=	LA	+	WLA	+	MOS
11,046	=	9,263	+	1,231	+	552

For Phosphorus (*lb/month*):

TMDL	=	LA	+	WLA	+	MOS
1,686	=	1,479	+	123	+	84

The annual TMDLs for Transquaking River, equated with illustrative allocations, are:

For Nitrogen (*lb/yr*):

TMDL	=	LA	+	WLA	+	MOS
438,853	=	410,729	+	14,954	+	13,170

For Phosphorus (*lb/yr*):

TMDL	=	LA	+	WLA	+	MOS
31,746	=	29,298	+	1,496	+	952

Where:

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

<u>Average Daily Loads:</u>

On average, the low flow TMDLs will result in loads of approximately 368 lb/day of nitrogen and 56 lb/day of phosphorus. And, on average the annual TMDLs will result in loads of approximately 1202 lb/day of nitrogen and 87 lb/day of phosphorus.

5.0 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 both TMDLs, Maryland has several well-established programs that will be drawn upon: the Water Quality Improvement Act of 1998 (WQIA), and 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.

The implementation of point source nutrient controls will be executed through the use of NPDES permits. The NPDES permit for the Darling International Rendering Plant will require stricter nitrogen limits. The NPDES permits in the Transquaking River will have compliance provisions, which provide a reasonable assurance of implementation.

Maryland’s WQIA requires that comprehensive and enforceable nutrient management plans be developed, approved and implemented for all agricultural lands throughout Maryland. This act specifically requires that these nutrient management plans be developed and implemented by 2004. Maryland’s CWAP has been developed in a coordinated manner with the State's 303(d) process. All Category I watersheds identified in Maryland's Unified Watershed Assessment process are totally coincident with the impaired waters list for 1996 and 1998 approved by EPA. The State has given a high-priority for funding assessment and restoration activities to these watersheds.

In 1983, the states of Maryland, Pennsylvania, and Virginia, the District of Columbia, the Chesapeake Bay commission, and the U.S. EPA joined in a partnership to restore the Chesapeake Bay. In 1987, through the Chesapeake Bay Agreement, Maryland made a commitment to reduce nutrient loads to the Chesapeake Bay. In 1992, the Bay Agreement was amended to include the development and implementation of plans to achieve these nutrient reduction goals. Maryland’s resultant Tributary Strategies for Nutrient Reduction provide a framework that will support the implementation of nonpoint source controls in the Lower Eastern Shore Tributary Strategy Basin, which includes Transquaking River 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.

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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