Total Maximum Daily Loads of Carbonaceous Biochemical Oxygen Demand (CBOD) and Nitrogenous Biochemical Oxygen Demand (NBOD) for Georges Creek in Allegany and Garrett Counties, Maryland

FINAL

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LIST OF ABBREVIATIONS

7Q10	7-day consecutive lowest flow expected to occur every 10 years
BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
CFR	Code of Federal Regulations
cfs	Cubic feet per second
COMAR	Code of Maryland Regulations
CSO	Combined Sewer Overflow
CWA	Clean Water Act
CWAP	Clean Water Action Plan of 1998
DNR	Department of Natural Resources
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
FA	Future Allocation
INPRG	An abbreviation for "Input Program" for a steady state mathematical model developed by Maryland Department of the Environment
LA	Load Allocation
lb/month	Pound per month
MDE	Maryland Department of the Environment
mgd	million gallons per day
mg/L	milligrams per Liter
MOS	Margin of Safety
NBOD	Nitrogenous Biochemical Oxygen Demand
NPDES	National Pollutant Discharge Elimination System
SOD	Sediment Oxygen Demand
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
µg/L	micrograms per Liter
USGS	United States Geological Survey
WLA	Waste Load Allocation
WQIA	Water Quality Improvement Act of 1998
WQLS	Water Quality Limited Segment
WWTP	Waste Water Treatment Plant

EXECUTIVE SUMMARY

This document establishes Total Maximum Daily Loads (TMDLs) that address the control of pollutants affecting dissolved oxygen levels in Georges Creek (02-14-10-04). Georges Creek is a free-flowing freshwater stream. It is a tributary of the North Branch Potomac River.

The water quality goal of the TMDLs is to establish allowable Carbonaceous Biochemical Oxygen Demand (CBOD) and Nitrogenous Biochemical Oxygen Demand (NBOD) inputs at levels that will ensure the ambient dissolved oxygen standard is maintained in Georges Creek. The TMDLs were developed using a mathematical model for free-flowing streams. The model was used to determine allowable CBOD and NBOD loading resulting in the maintenance of the high receiving stream dissolved oxygen concentrations. The model was also used to investigate seasonal variations in stream conditions and to establish margins of safety that are environmentally conservative. Load allocations were determined for distributing allowable loads between point and nonpoint sources.

The allocation of CBOD and NBOD for nonpoint sources was based on observed field values and the projected/estimated implementation of nutrient management plans, which will also achieve a reduction in CBOD and NBOD loads. The point source allocation was based on the current and future projected maximum National Pollutant Discharge Elimination System (NPDES) permit at the Georges Creek Wastewater Treatment Plant. The overall objective of the TMDLs established in this document is to determine allowable CBOD and NBOD loads that are expected to result in meeting all water quality standards, including the requirements of Maryland's Antidegradation Policy regulation (COMAR §26.08.02.04). The TMDLs for 7Q10 low-flow conditions in Georges Creek is 12,355 lb/month for CBOD and 28,259 lb/month for NBOD. These TMDLs are seasonal and apply during the period from June 1 to October 31.

Several factors provide assurance that these TMDLs will be implemented. First, NPDES permits will be written to be consistent with the load allocations in the TMDLs. Second, Maryland has adopted a watershed cycling strategy, which will ensure that future water quality monitoring and TMDL evaluations are routinely conducted. In addition, implementation of the nonpoint source CBOD and NBOD reductions in this watershed will be assured by two specific programs, the Water Quality Improvement Act of 1998 (WQIA) and the EPA-sponsored Clean Water Action Plan of 1998 (CWAP).

1.0 INTRODUCTION

The Clean Water Act (CWA) Section 303(d)(1)(C) and federal regulations at 40 CFR §130.7(c)(1) direct each State to develop Total Maximum Daily Loads (TMDLs) for all impaired waters (water quality limited segments (WQLS)) on the Section 303(d) list in which currently required pollution controls are inadequate to achieve water quality standards. States must consider seasonal variations and must include a margin of safety to account for uncertainty in the monitoring and modeling processes. A TMDL reflects the total pollutant loading of an impairing substance a waterbody can receive and still meet water quality standards.

Georges Creek was identified on Maryland's 1996 list of WQLSs due to excess nutrients and suspended sediment, and on the 1998 Additions to the 303(d) list for low pH. The sediment and pH impairments will be addressed in separate TMDL documents. Water quality data used for the initial impairment decision included a single sample with a high level of chlorophyll-a in the downstream segment, below the Georges Creek wastewater treatment plant discharge point. The 1999 water quality survey data showed the chlorophyll-a concentrations ranged between 0.3 to 30.2 μg/L and dissolved oxygen concentrations ranged from 7.8 to 13.2 mg/L. In recent water quality surveys on July 11 and 17, 2001, the average chlorophyll-a concentrations ranged from 3.0 to 6.8 μg/l. The earlier nutrient impairment conclusion cannot be supported on the basis of a single high chlorophyll a sample, and is not confirmed in water quality data collected from Georges Creek for the period between July 11 and 17, 2001 as described in more detail below. These recent data showed neither a nutrient nor dissolved oxygen impairment. Despite the presence of other impairing substances, this data indicates that the dissolved oxygen characteristics of Georges Creek are significantly better than the water quality standards established for this water body and these characteristics should be maintained under Code of Maryland Regulations (COMAR) §26.08.02.04. The Department is considering whether Georges Creek will be designated as a Tier II waterbody for dissolved oxygen pursuant to Maryland's Antidegradation Policy (COMAR §26.08.02.04). If Tier II designation is pursued, a more stringent review will be required before biochemical oxygen demand (BOD) loadings are allowed to increase. Reductions in ambient dissolved oxygen (DO) could occur in the future with increases in carbonaceous biological oxygen demand (CBOD) and nitrogenous biochemical oxygen demand (NBOD).

Based on the available data, Maryland Department of the Environment (MDE) concluded that CBOD and NBOD are the principal threat to water quality in Georges Creek. This report documents the proposed establishment of TMDLs for Georges Creek to maintain present and future dissolved oxygen concentrations. MDE believes that these CBOD and NBOD TMDLs will completely address the original 303(d) listing for nutrients.

Upon approval by the United States Environmental Protection Agency (EPA), these TMDLs will be reflected in the State's Continuing Planning Process. In the future, the established TMDLs will support regulatory and voluntary measures needed to protect water quality in Georges Creek.

TMDLs are established to achieve and maintain water quality standards. Water quality standards consist of a designated use for a particular body of water, the water quality criteria designed to protect that use, and implementation of the State's Antidegradation Policy. 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 State's Antidegradation Policy requires that high quality waters must be maintained unless certain exceptions apply.

Georges Creek is presently designated as a Use I-P according to COMAR 26.08.02. The in-stream dissolved oxygen standard for a Use I-P water is 5.0 mg/l at any time. Georges Creek was first identified on the 1996 303(d) list submitted to EPA by MDE. It was listed as being impaired by nutrients and suspended sediment. The in-stream chlorophyll-a concentrations in recent water quality data collected from Georges Creek are low (average of 3.0 ug/l) in the upstream segments and (average of 6.0 ug/l) downstream from the wastewater treatment plant point of discharge. The data does not indicate low dissolved oxygen impairment.

The water quality in Georges Creek appears to be better than the minimum required under Use I-P, and it is expected that the stream may receive consideration for Tier II water quality protection under the Department's existing Antidegradation Policy. Tier II waters require that currently high water quality, in this case dissolved oxygen, be maintained. Based on MDE's analysis, it is anticipated that future degradation of dissolved oxygen could occur if Georges Creek CBOD or NBOD are allowed to increase beyond the amount specified in the TMDLs. The Department's analysis demonstrates that the BOD loading in the stream affects the dissolved oxygen, and describes the development of TMDLs for CBOD and NBOD levels in Georges Creek.

2.0 DESCRIPTION OF THE WATERSHED

Georges Creek is a tributary of the North Branch Potomac River, located in Allegany County, Maryland (Figure 1). The North Branch Potomac River joins the South Branch forming the Potomac River. The mainstem of Georges Creek is approximately 15 miles long. The watershed of Georges Creek has an area of approximately 47,693 acres. As shown in Figure 2, the predominant land uses in the watershed, based on 1997 Maryland Office of Planning land cover data, are forest comprising 34,046 acres or 71% of the total area, with urban at 4,532 acres or 10%, surface mining at 3,259 acres or 7%, and agricultural land uses at 5,856 acres or 12%.

The Georges Creek watershed lies in the Allegheny Plateau. The geological strata include shale and sandstone of the Devonian Chemung and Hampshire formations (Maryland Geological Survey, Geologic Map of Maryland, 1968). Soils in the watershed are primarily Calvin-Gilpin association, gently sloping to steep, moderately deep, well-drained soils; formed over acid, red to gray shale and sandstone (U.S. Department of Agriculture, Soil Survey of Garrett/Allegany Counties, 1977).

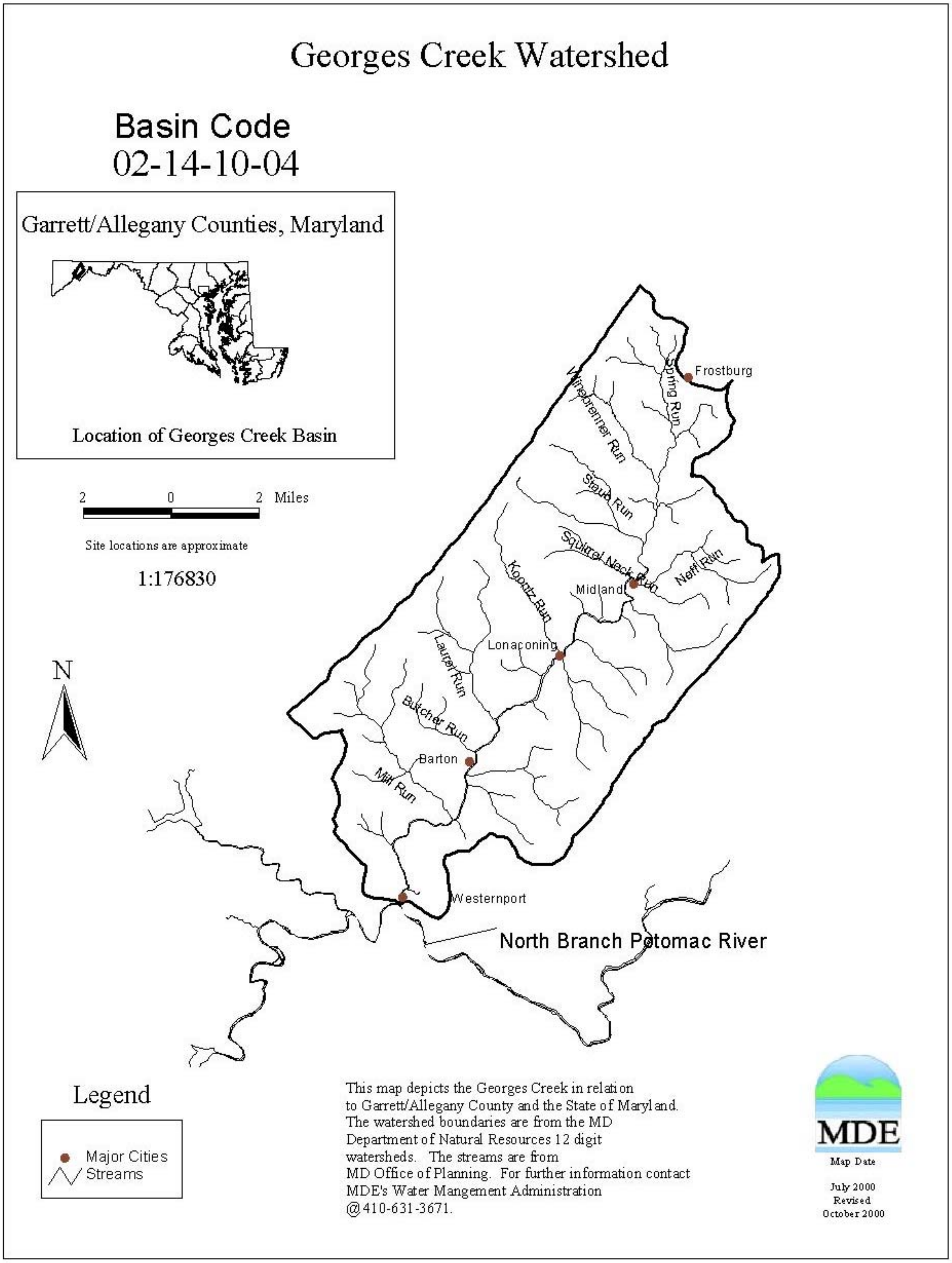

Figure 1: Location of Georges Creek Drainage Basin within Garrett and Allegany Counties, Maryland

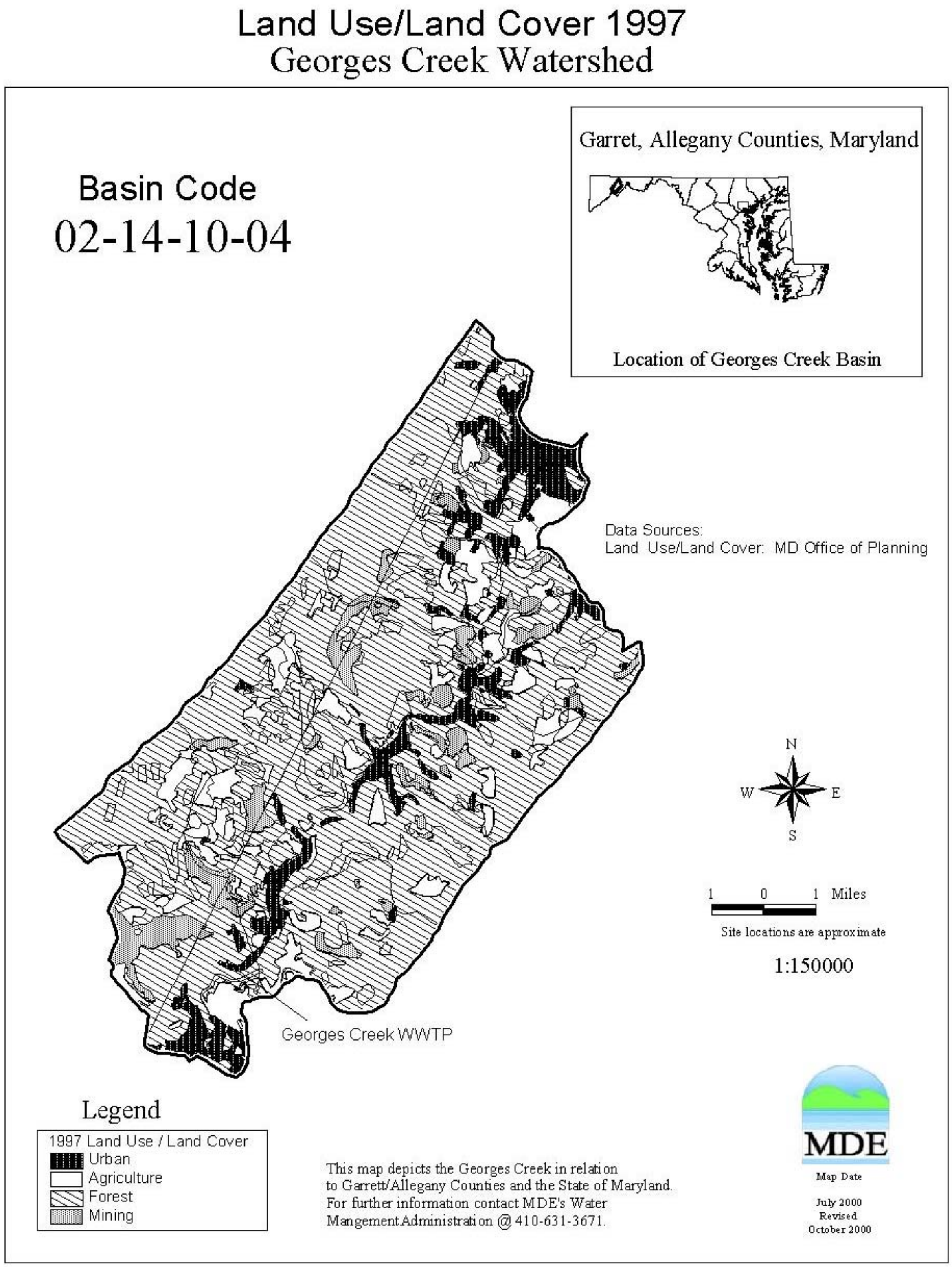

Figure 2: Land use in Georges Creek Drainage Basin, Garrett and Allegany Counties, Maryland

3.0 WATER QUALITY CHARACTERIZATION

3.1 Georges Creek Water Quality

Five long-term water quality-sampling stations located in Georges Creek were used to characterize the present water quality. Figure 3 shows the location of water quality sampling sites, a United States Geological Survey (USGS) flow gage, and other geographic points of interest. Since 1970, Maryland Department of Natural Resources (DNR) and MDE have collected water chemistry data at these stations. Four water quality parameters: dissolved oxygen, total nitrogen, total phosphorus, and chlorophyll-a, collected at these stations were examined for the period between March and
October 1999.

3.2 Water Quality Impairment

Maryland's 1996 303(d) list indicated that the cause of impairment to Georges Creek was nutrients. Observed 1999 summer total nitrogen, total phosphorus and chlorophyll-a respectively are (at *GEO0010 location*) 1.872, 0.034 and 0.0193 mg/l; (at *GEO0031*) 0.462, 0.008 and 0.0003 mg/l; (at *GEO0065*) 0.633, 0.004 and 0.00075 mg/l; and (at *GEO00150*) 1.443, 0.246 and 0.0009 mg/l as shown in Figures 5, 6, 8, 9, 11, 12, 14, 15 and Table 1.

In recent water quality data collected July 11 and 17, 2001 the total nitrogen, total phosphorus and chlorophyll-a respectively average values are (at *GEO0000*) 0.833, 0.0037 and 0068 mg/l; (at *GEO0010*) 0.808, 0.0037 and 0.006 mg/l; (at *GEO0020*) 0.814, 0.0043 and 0.004 mg/l; and (at *GEO0031*) 0.583, 0.0034 and 0.003 mg/l as shown in Table 2. Generally, nutrient levels are of concern in slow moving water bodies such as lakes and estuaries having low velocities and long travel times. Low velocities and excess nutrients can encourage the growth of undesirable levels of algae. Algal growth can be a significant factor affecting dissolved oxygen levels due to photosynthetic oxygen production and oxygen consumption through respiration. Evidence of undesirable levels of algae is normally supported by large diurnal variations in dissolved oxygen concentrations. Subsequent modeling, along with a careful examination of the chlorophyll-a and dissolved oxygen data, has determined that BOD, and not nutrients is the dominant substance that may cause future low dissolved oxygen conditions in Georges Creek. Chlorophyll-a concentrations in Georges Creek downstream of the WWTP averaged 19.3 ug/l in 1999 water quality data. Follow-up samples collected in July 2001 averaged only 6.4 ug/l. The limited data on chlorophyll-a shown in Tables 1 and 2 do not support a conclusion that algae is a significant factor influencing dissolved oxygen concentrations or cause an eutrophication problem in Georges Creek.

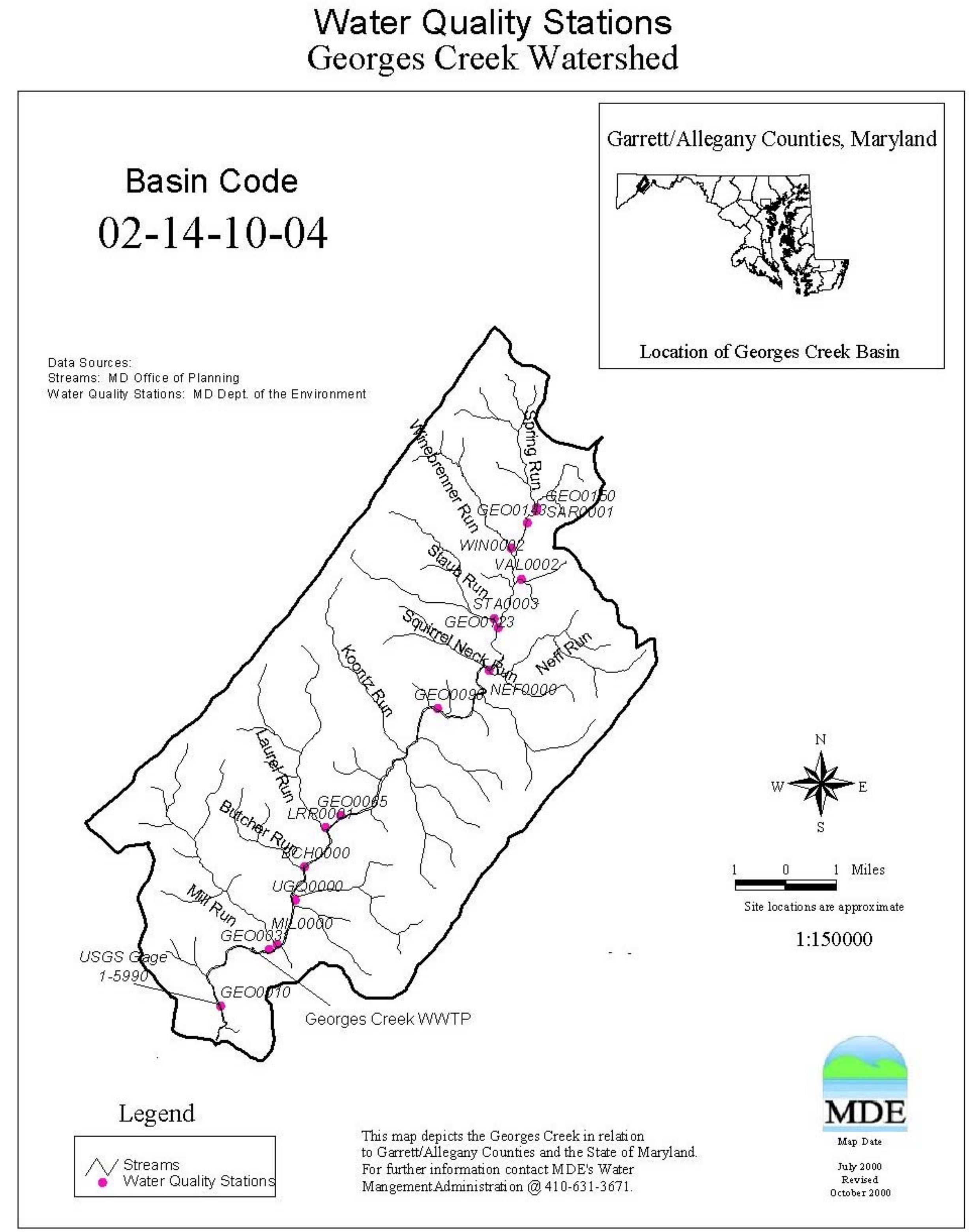

Figure 3: Location of Water Quality Monitoring Stations and other point of interest

Chlorophyll-a Concentrations									
	Georges Creek Sampling Locations								
	GEO0010		GEO0031		GEO0065		GEO0143		GEO0150
Minimum Value (ug/l)	8.373		0.299		0.5981		0.299		0.598
Maximum Value (ug/l)	30.203		0.299		0.897		0.299		0.748
Average Value (ug/l)	19.3		0.30		0.75		0.30		0.67

Table 1: Georges Creek average chlorophyll-a Concentration for March, April, July, August and October 1999

Chlorophyll-a Concentrations							
	Georges Creek Sampling Locations						
	GEO0000		GEO0010		GEO0020		GEO0031
Minimum Value (ug/l)	5.1		4.6		2.5		1.0
Maximum Value (ug/l)	8.4		7.3		5.5		4.9
Average Value (ug/l)	6.8		6.0		4.0		3.0

Table 2: Georges Creek average chlorophyll-a Concentration for July 11 and 17, 2001

The important issues for these TMDLs in Georges Creek are the amount of BOD entering the system and the resulting dissolved oxygen concentrations. These parameters were measured in the 1999 Water Quality Survey at stations GEO0010, GEO0031, GEO0065 and GEO0150. Figures 4, 7, 10 and 13 show the dissolved oxygen concentrations with an average concentration of 10.4 mg/l and a peak concentration of 13.2 mg/l. Figures 5, 8, 11, and 14 show the total nitrogen concentrations with 0.92 mg/l average and 2.48 mg/l peak. Figures 6, 9, 12 and 15 show the total phosphorus concentrations averaged 0.015 mg/l and peaked at 0.098 mg/l. These data demonstrate that Georges Creek is meeting the numeric criteria for dissolved oxygen. As a result, the Department determined that the nutrient concentrations necessary to support its designated use are adequate and is not impaired for nutrients.

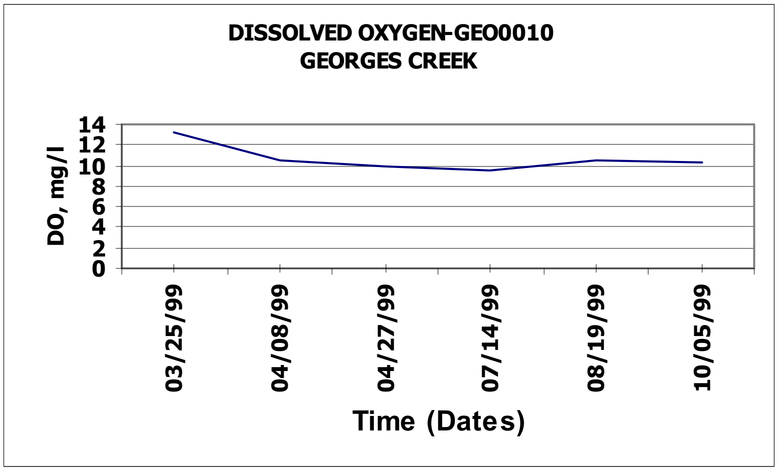

Figure 4: Dissolved Oxygen Concentration at GEO0010

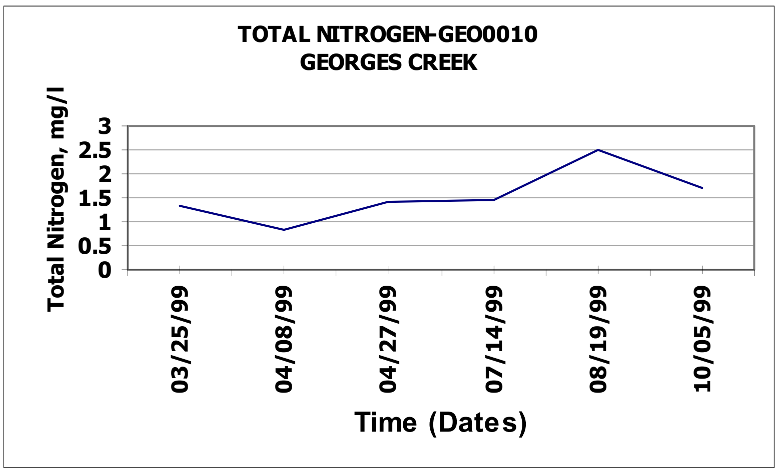

Figure 5: Total Nitrogen Concentration at GEO0010

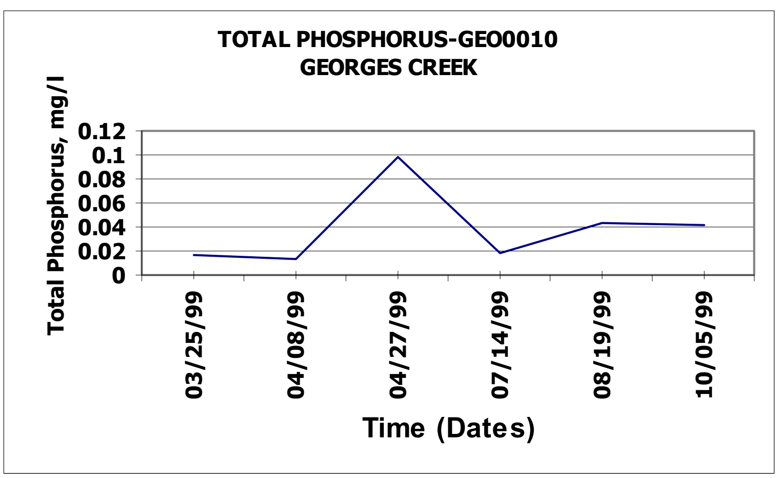

Figure 6: Total Phosphorus Concentration at GEO0010

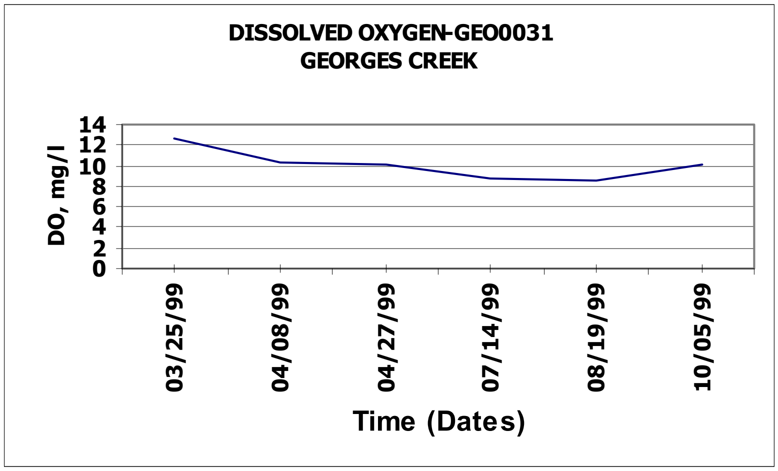

Figure 7: Dissolved Oxygen Concentration at GEO0031

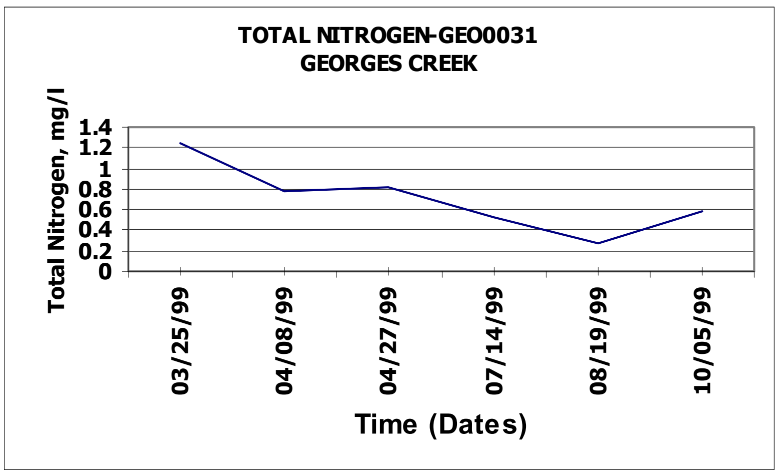

Figure 8: Total Nitrogen Concentration at GEO0031

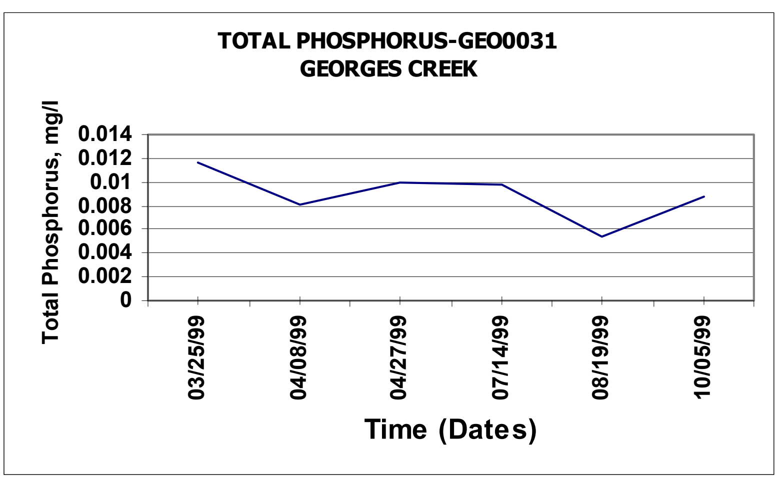

Figure 9: Total Phosphorus Concentration at GEO0031

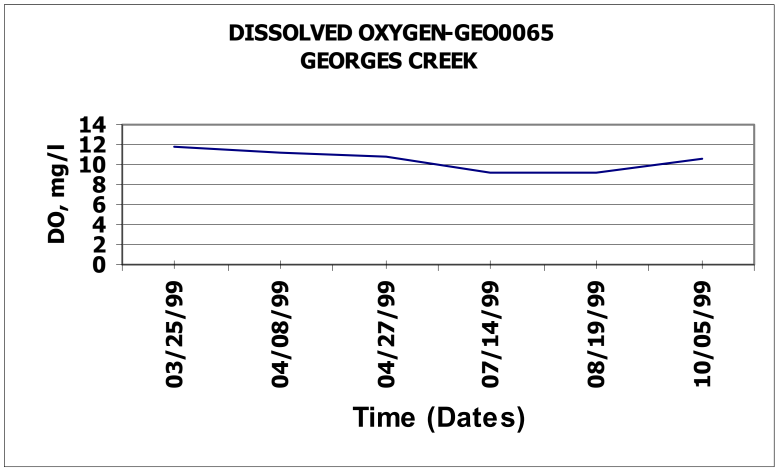

Figure 10: Dissolved Oxygen Concentration at GEO0065

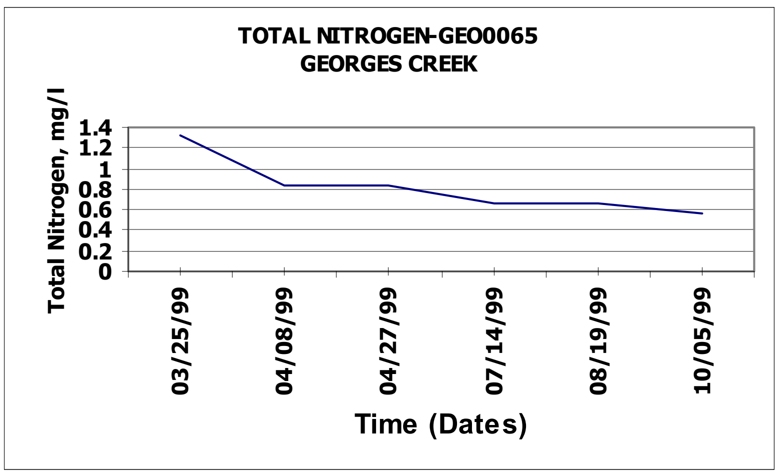

Figure 11: Total Nitrogen Concentration at GEO0065

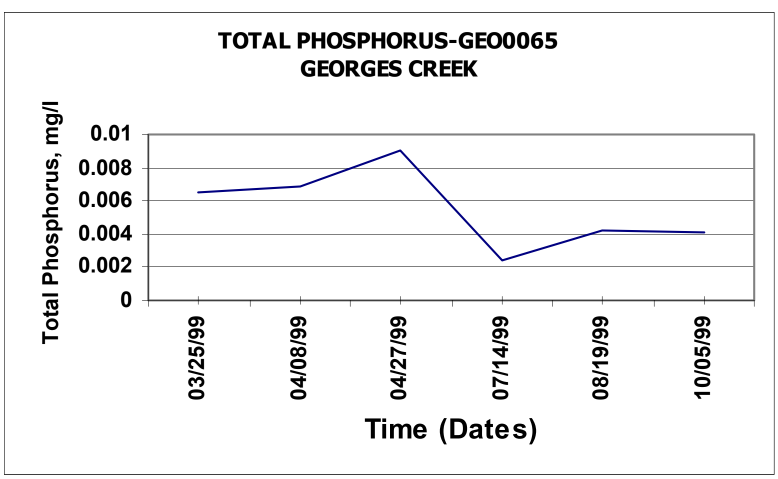

Figure 12: Total Phosphorus Concentration at GEO0065

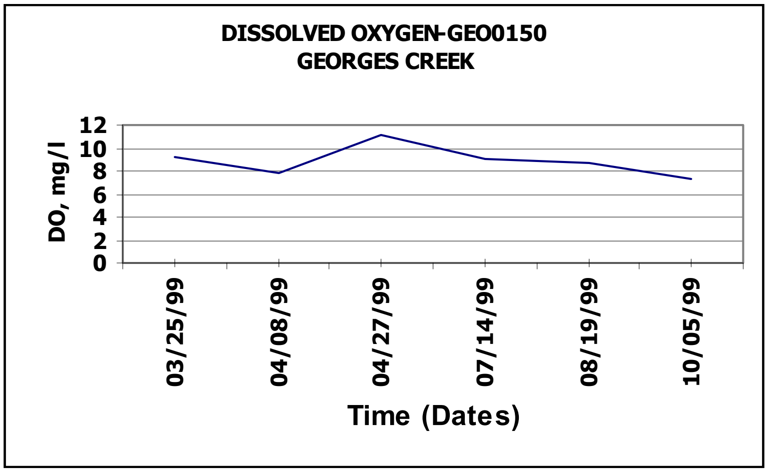

Figure 13: Dissolved Oxygen Concentration at GEO0096

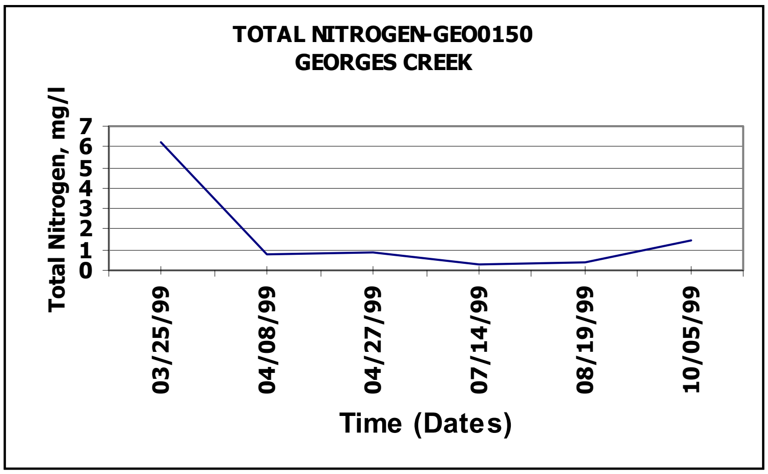

Figure 14: Total Nitrogen Concentration at GEO0096

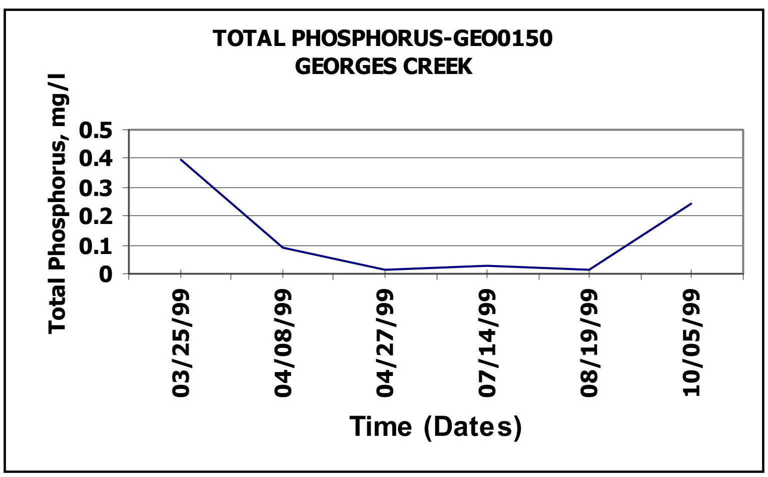

Figure 15: Total Phosphorus Concentration at GEO0096

3.3 Sources of the Impairing Substance

The primary substance of concern to be addressed in these TMDLs for the Georges Creek watershed is BOD. BOD is a composite term that describes the consumption of oxygen through the oxidation of carbon and nitrogen by bacteria in the water. The sources of BOD include both point and nonpoint source loads. The Georges Creek Wastewater Treatment Plant and fifteen combined sewer overflows (CSOs) are the only point sources in Georges Creek watershed. Based on reporting by the local jurisdiction, the CSOs occur mostly during the wet weather conditions when the in-stream dissolved oxygen is expected to be high and there is great dilution available. These CSOs are regulated under NPDES Permit No. 95-DP-3146 for the Frostburg CSOs, Permit No. 95-DP-3144 for the Allegany County Sanitary District CSOs, and 95-DP-3136 for the Westernport CSOs. These permits require implementation of the nine minimum controls plus development of a long-term control plan. During low flow and average high flow conditions, both point and nonpoint sources contribute significant nutrient and BOD loads to the system. The point source values for BOD in the effluent used in this document come from the NPDES discharge permit for the Georges Creek WWTP and the EPA's Combined Sewer Overflows (CSOs) Guidance For Monitoring and Modeling (EPA 832-B-99-002 January, 1999).

The nonpoint source loads of BOD enter the system at the upstream boundary located at water quality modeling segment 1 and downstream tributaries of Winebrenner Run, Staub Run, Neck Run, Koontz Run, Neff Run, Laurel Run, Butcher Run, and Mill Run. The nonpoint source loads are based on the in-stream water quality monitoring data. Because the low flow loading estimations are based on observed data, they account for both human and natural sources.

In addition to accounting for sources of BOD, the processes that deplete dissolved oxygen were also considered. These processes include those that consume oxygen (sinks) as well as those that generate oxygen (sources). These processes and some additional factors are presented in Figure 16. As mentioned before, BOD reflects the amount of oxygen consumed through two processes: CBOD and NBOD. CBOD is the reduction of organic carbon material to its lowest energy state, carbon dioxide (CO_2), through the metabolic action of microorganisms (principally bacteria). NBOD is the term for the oxygen required for nitrification, which is the biological oxidation of ammonia to nitrate. The BOD values seen throughout this document represent the amount of oxygen consumed by the oxidation of carbonaceous and nitrogenous waste materials over a 5-day period at 20^oC. This is referred to as a 5-day, 20^oC BOD and is the standard reference value utilized internationally by design engineers and regulatory agencies. The 5-day BOD represents primarily consumption of carbonaceous material and minimal nitrogenous material. The ultimate BOD represents the total oxygen consumed by carbonaceous and nitrogenous material over an unlimited length of time.

Another factor influencing dissolved oxygen concentrations is sediment oxygen demand (SOD). As with BOD, SOD is a combination of several processes. Primarily, it is the aerobic decay of organic materials that settle to the bottom of the stream. However, SOD is usually considered negligible in free flowing streams like Georges Creek because frequent scouring during storm events usually prevents long-term accumulation of organic material. All of the dissolved oxygen sources and sinks make up a dissolved oxygen balance. For more information, see Appendix A.

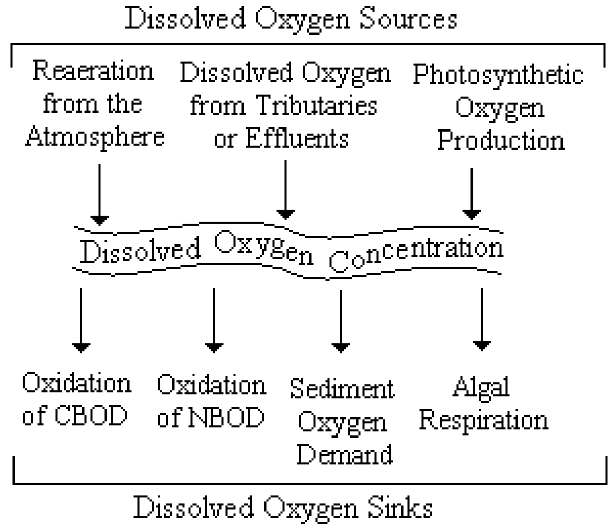

Figure 16: Sources and Sinks for Dissolved Oxygen in a River

4.0 TARGETED WATER QUALITY GOAL

Georges Creek is a Use I-P designated water body according to the Code of Maryland Regulations (COMAR) 26.08.02. The dissolved oxygen standard for a Use I-P water is 5.0 mg/l at any time. The minimum dissolved oxygen (DO) concentration observed in all segments of Georges Creek during the summer stream surveys of 1999 was 7.8 mg/L. Since the observed dissolved oxygen values in Georges Creek consistently exceed the water quality minimum standard of 5.0 mg/L, it is better than the minimum required standards and needs to be maintained. The in-stream DO minimum concentration of 7.5 mg/L will assure that observed dissolved oxygen concentrations are maintained in Georges Creek. The overall objective of the TMDLs for Georges Creek is to determine the maximum allowable BOD inputs from point and nonpoint sources that will allow for maintenance of the existing, higher than the minimum standard dissolved oxygen levels. See Appendix A for a detailed computation of the DO target.

5.0 TOTAL MAXIMUM DAILY LOADS AND ALLOCATIONS

This section describes how the TMDLs and load allocations for point and nonpoint sources were developed for Georges Creek. The first section describes the modeling framework used to simulate water quality constituent interactions and hydrology. The second and third sections summarize the WQ management scenarios that were explored using the model. These scenarios investigate water quality responses assuming different stream flow conditions and load allocations. 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. The final section presents a summary accounting of the TMDLs.

5.1 Analysis Framework

Analysis Framework for CBOD and NBOD

The computational framework, or model, chosen for determining the Georges Creek TMDLs was the INPRG water quality model. INPRG is a steady state mathematical model, developed within MDE for the assessment of point and nonpoint source discharges of material that exert an oxygen demand in free-flowing streams. The model requires an input of CBOD and NBOD to incorporate the total BOD loads. The CBOD and NBOD values were calculated by multiplying BOD_5 by 1.5 and TKN by 4.6 respectively. The model prepares input data and runs a free-flowing stream model based upon the Streeter Phelp's equation. The model calculates the daily average dissolved oxygen concentrations in the stream by considering the oxidation of CBOD and NBOD and reaeration only, predicting the receiving stream's CBOD, NBOD, and dissolved oxygen concentrations for selected stream input conditions. For more information on INPRG, see Appendix A.

The spatial domain represents the watershed that is included in the model. The Georges Creek INPRG water quality model spatial domain extends approximately 15 miles from its headwaters to the confluence with the North Branch Potomac River (see Figure 17). Nine modeling points were selected with Station 1 in the upper boundary of the model's spatial domain and Station 9 at the confluence with the North Branch Potomac River in the lower boundary. Figure 17 also includes the location of other key inputs to the model as well as the model segmentation.
Each model station identified in Figure 17 is located at the confluence of a tributary of Georges Creek with the mainstem. Each tributary station and the drainage area below station 1 have an associated nonpoint source load entering the system. The majority of the nonpoint source loads enter the system from the tributary boundaries at Winebrenner Run (station 2), Staub Run and Neff Run (station 3), Laurel Run and Butcher Run (station 6), and Mill Run (station 8). The nonpoint source loads are based on in-stream water quality monitoring data. The in-stream data accounts for atmospheric deposition to the land, nonpoint source runoff from urban development, agriculture, forestland, and infiltration from septic tanks. The freshwater flows used in the model were obtained from the USGS gage 01599000 located on Georges Creek near Franklin, Maryland. Seven-day, 10-year, low-flow conditions were incorporated into all model runs.

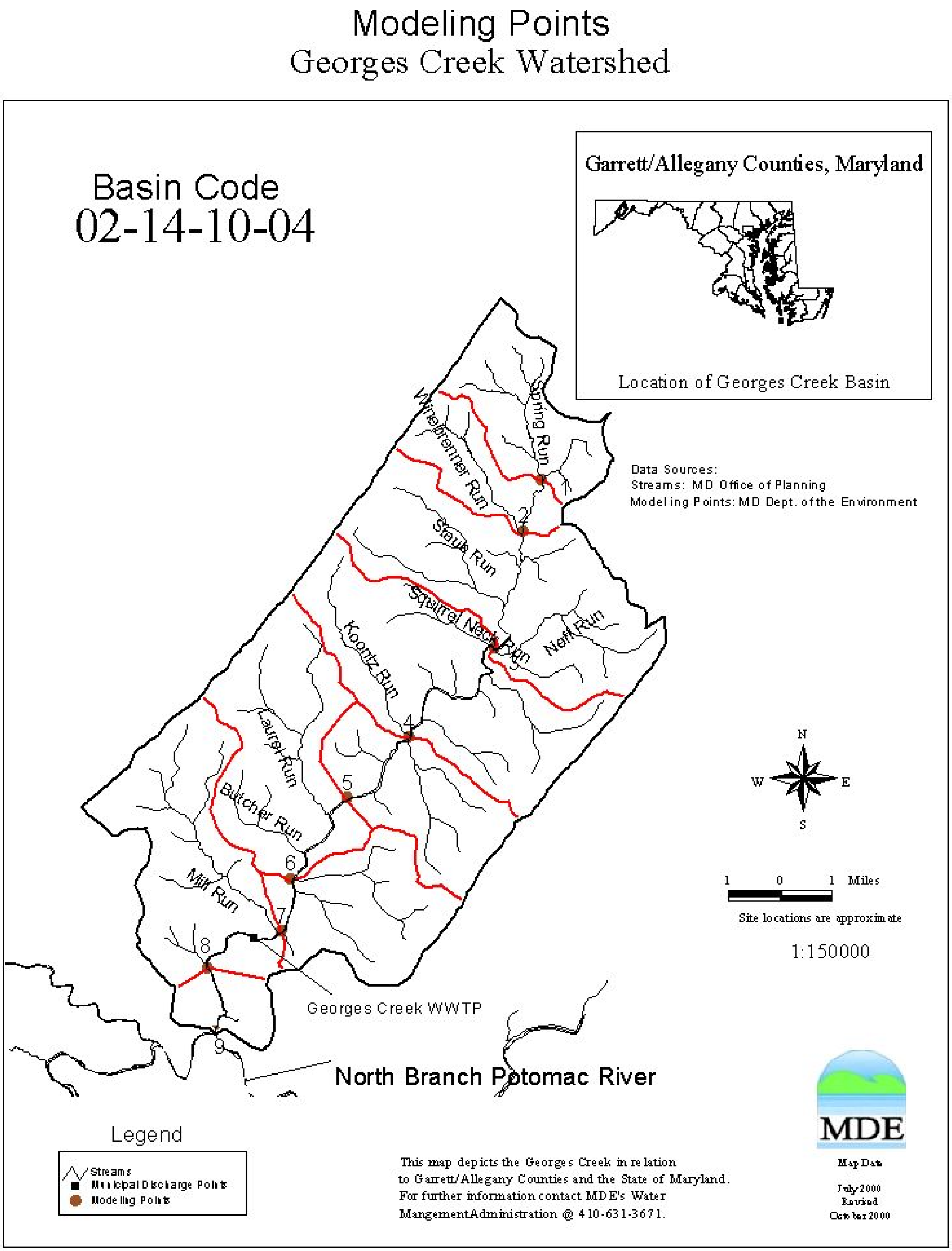

Figure 17: Representation of Modeling Domain, Segmentation, Point and Nonpoint Source location

The Georges Creek Wastewater Treatment Plant (WWTP) is the primary NPDES permitted point source in the Georges Creek watershed. The Georges Creek WWTP is an oxidation ditch treatment system with an ultraviolet disinfecting process. In addition to the Georges Creek WWTP, there are fifteen combined sewer overflow points that discharge from storm drains into Georges Creek during major rain events. The INPRG model was calibrated using the July, August and October 1999 data collected by MDE.

5.2 Scenario Descriptions

To project the water quality response of the system, the calibrated model was subjected to several different scenarios under selected stream flow conditions. By modeling several stream flow conditions, the scenarios simulate seasonality, which is a necessary element of the TMDL development process. The scenarios were grouped into three categories: existing conditions, intermediate conditions, and final condition scenarios. In the existing conditions scenario*,* the system was examined for in-stream dissolved oxygen response when subjected to present point and nonpoint source loads. The intermediate conditions scenario represented the future conditions of the system when subjected to wet winter high-flow and CSO event conditions. The final condition scenarios represented the system when subjected to projected maximum future point and nonpoint source loads without violating the target dissolved oxygen standard.

Existing Condition Scenario

The first run scenario represented the system during summer low-flow critical conditions. A flow of 4.68 cfs at USGS gage 01599000 located on Georges Creek near Franklin was used, which represents the 7-day consecutive lowest flow expected to occur every 10 years, known as the 7Q10 flow. The flows entering at the upstream boundary and from tributaries were estimated based on proportional drainage areas and gage data from the USGS gage 01599000. The nonpoint source loads reflect observed water quality concentrations in the Georges Creek watershed during the summer stream surveys of 1999. The point source loads were computed under an assumption that the Georges Creek WWTP would be discharging at its current permitted monthly maximum NPDES permit limits. Because this scenario represents summer conditions, summer limits were used where applicable.

Intermediate Condition Scenario

The second scenario represented the system during high flow winter/spring and CSO discharge event conditions. Low dissolved oxygen concentrations were not expected to occur during the winter. However, to rule out winter/spring and CSO events as critical periods, average high-flow data were used in this scenario. Average CSO flow of 0.25 mgd from data collected during 01/01/01 to 08/28/01 period, and average stream discharge of 81.2 cfs from a USGS gaging station were used. The nonpoint source loads reflected observed water quality concentrations in the Georges Creek watershed during the March and April stream surveys of 1999. The point source loads from the Georges Creek WWTP were computed under the same assumptions as scenario one. The assumed Scenario 2 point source and nonpoint source conditions are conservative, since they do not consider the implementation of future TMDL control strategies developed to achieve

7Q10 low-flow water quality requirements. The results of the second scenario, as can be seen in Figure 18, show the in-stream dissolved oxygen well above 7.5 mg/l during the average high-flow and CSO discharge event conditions. Therefore, further examination of the average high-flow and CSO events condition were not necessary.

Final Condition Scenario

In the third scenario, the system was subjected to estimated maximum point and nonpoint source loads. This scenario was intended to determine the proposed TMDLs, including MOS and future allocations. The nonpoint source loads were increased from scenario one by 50% to include a future allocation and margin of safety. The point source loads were increased by the same proportion as the nonpoint source (from 0.6 to 0.9 mgd plant flow). This third scenario achieved the desired goal of maintaining the daily average target dissolved oxygen standard of 7.5 mg/l, since the model predicted the lowest dissolved oxygen sag of 7.46 mg/l at model station 8. The point and nonpoint source loads for all scenarios are shown in Table 3.

Scenarios		1	2	3	(3-1) Future Less Current Allocation
Nonpoint Source Loads					
CBOD	*lb/day*	38.69	1087.35	58.04	19.35
NBOD	*lb/day*	27.45	751.71	41.42	13.97
Flow	*cfs*	4.78	36.66	4.78	-
Point Source Loads					
CBOD	*lb/day*	225.18	225.18	337.77	112.59
NBOD	*lb/day*	575.46	575.46	863.19	287.73
Flow	*mgd*	0.60	0.60	0.90	0.30
CBOD MOS	*lb/day*	0.00	00.00	14.07	14.07
NBOD MOS	*lb/day*	0.00	00.00	35.97	35.97

Table 3: Point and Nonpoint Source Flows and Loads used in the Model Scenario Runs

5.3 Model Results

Existing Condition Scenarios

1. **Low Flow:** Assumes 7-day consecutive lowest flow expected to occur once every 10 years. Assumes average summer nonpoint source concentrations. Assumes current monthly summertime NPDES permitted flows and concentrations at the Georges Creek WWTP. A wastewater flow of 0.6 million gallons per day was assumed for the facility with CBOD and NBOD loads based on BOD_5 = 30 mg/L and Total Kjeldahl Nitrogen (TKN) = 25 mg/L.

Intermediate Condition Scenario

2. **Average High Flow:** Assumes stream flow conditions during average winter/spring and CSO events. Assumes average winter/spring nonpoint source concentrations. Assumes current monthly summer NPDES permitted limits. A practical maximum summer wastewater flow of 0.6 million gallons per day was assumed for Georges Creek WWTP.

The first scenario represents the critical conditions of the system during summer low stream flow. As seen in Figure 18, the projected dissolved oxygen level does not go below the target water quality standard of 7.5 mg/l.

The results of the second scenario, also seen in Figure 18, show the stream system to have dissolved oxygen concentrations well above 7.5 mg/l during the average high flow and CSO event conditions. The plotted dissolved oxygen concentrations for all scenarios are the average daily dissolved oxygen concentrations, as calculated by the model.

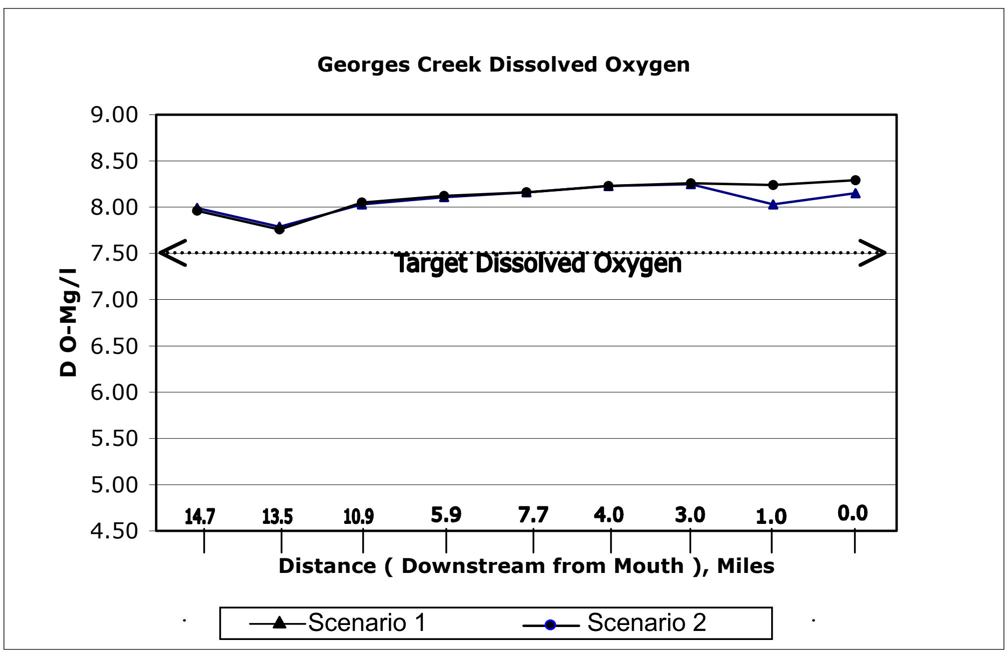

Figure 18: Results of Model Scenario Runs 1 and 2 for Dissolved Oxygen

Final Condition Scenario

3. **Future Projected WWTP flow:** Assumes 7-day consecutive lowest flow expected to occur once every 10 years. Assumes Georges Creek WWTP wastewater flow increased by 50% (0.6 to 0.9 mgd), secondary limitation of 30 mg/L BOD_5 and 25 mg/L TKN. Assumes increased nonpoint source load by 50% and additional 25% load of difference between weekly and monthly discharge limits for margin of safety.

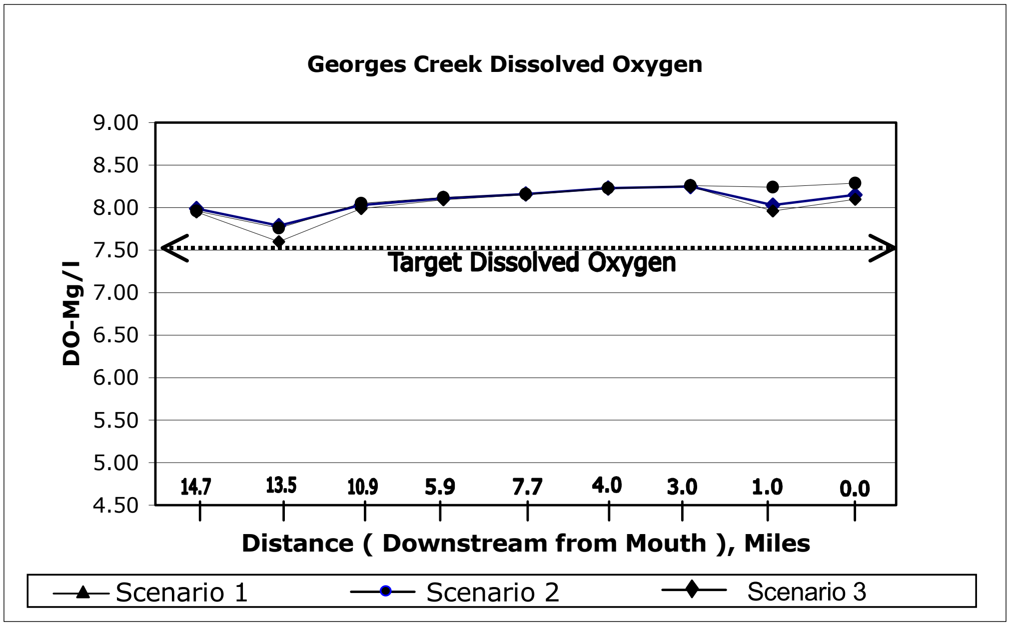

Figure 19: Results of Model Scenarios 1, 2 and 3 for Dissolved Oxygen

As shown in Figure 19, the results of Scenario 3 indicate a critical dissolved oxygen sag close to 7.5 mg/L when the Georges Creek WWTP and the nonpoint source loads are increased by 50% of their values as in Scenario one. Scenario 3, therefore, provides the waste load allocations, future growth, and a margin of safety for the TMDLs. For a detailed analysis of the model scenario runs, see Appendix A.

5.4 TMDL Loading Caps

The first model scenario shows that the dissolved oxygen standard in Georges Creek is not violated during low stream flow conditions in the summer. The critical stream conditions for dissolved oxygen occur when the water temperatures are warmer and there is less water flowing in the system. The second model run indicates that no dissolved oxygen violations are expected during average high-flow conditions. The third model scenario shows that the dissolved oxygen standard is met with future allocation and a margin of safety. Thus, the modeling analyses indicate that, under future projected conditions with the proposed CBOD and NBOD TMDLs, water quality standards would be maintained for all flow conditions. The TMDLs were calculated for only 7Q10 conditions. Because 7Q10 and other critical conditions are only likely to occur during summer months, these TMDLs only apply from June 1 to October 31. Model scenario three represents the final TMDL loading scenario.

The resultant TMDLs loading for CBOD and NBOD as represented in Figure 20 is:

CBOD TMDL (June 1 to October 31)	**12,355 *lb/month***
NBOD TMDL (June 1 to October 31)	**28,259 *lb/month***

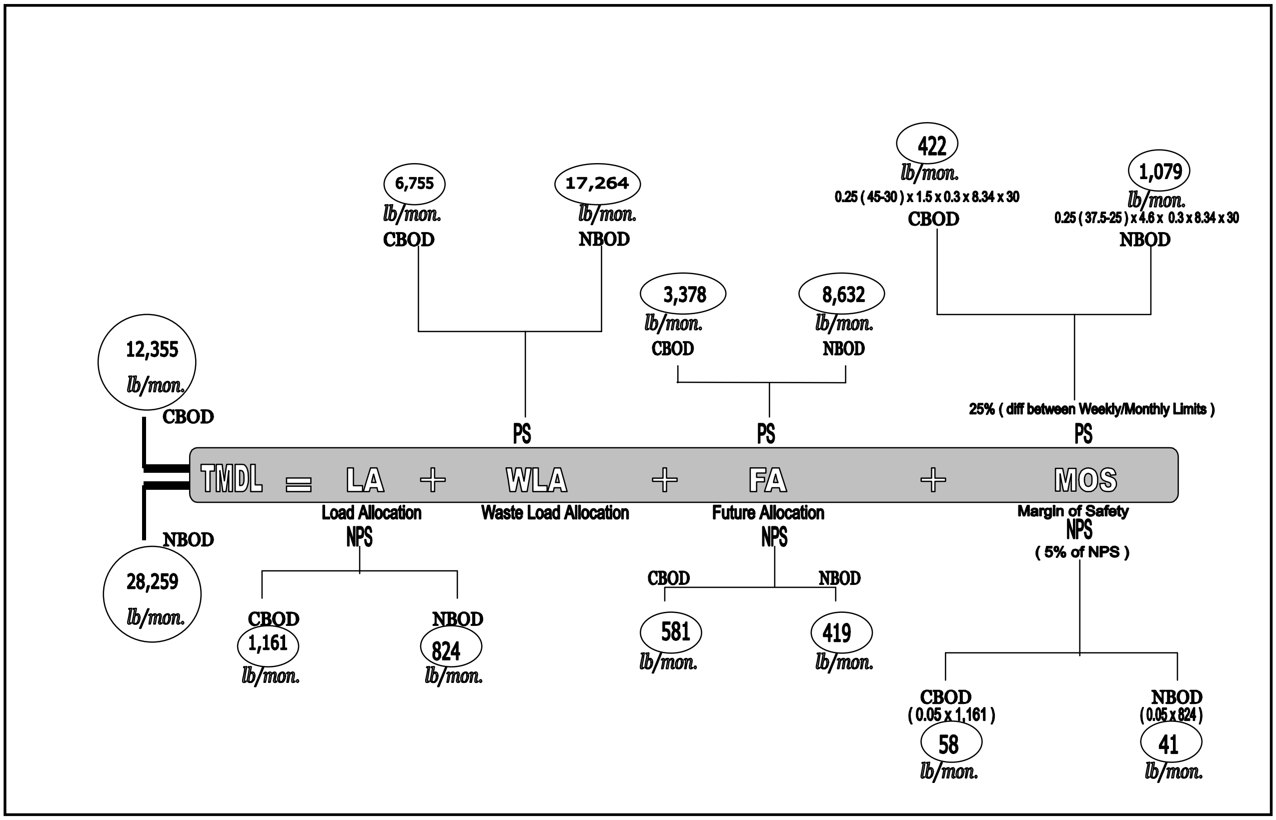

Figure 20: Georges Creek TMDL Loading Cap Schematic

5.5 Load Allocations Between Point Sources and Nonpoint Sources

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 BOD Point and Nonpoint Sources in Georges Creek Watershed." Table 4 shows the load allocations to point and nonpoint sources respectively, for CBOD and NBOD for the average annual TMDLs.

The point source load allocations for CBOD and NBOD are represented as future monthly summer loads (based on future NPDES permits) from the Georges Creek WWTP. The total monthly load allocations were calculated directly from future monthly average permit limits multiplied by 30 days. To implement the point source allocations, permit limits will continue to be expressed as monthly average limits and will be calculated by dividing the allocated TMDL monthly load by 30.

To ensure that sampling variability issues are addressed, the limits will also require, as a minimum, the same minimum sampling frequencies that are associated with current permit limits. These load allocations are also based on the understanding that the Georges Creek WWTP will continue to discharge at a minimum daily average dissolved oxygen concentration of no less than 6.0 mg/l. NPDES permit limits for BOD_5 and TKN at the facility were developed to be protective of dissolved oxygen standards in Georges Creek.

The current in-stream concentrations of CBOD from nonpoint sources were estimated to range from 1.0 to 15 mg/L and NBOD from 0.13 to 4.4 mg/L. These are representative values obtained from summer sampling and data analysis in the Georges Creek watershed during the months of July, August and October 1999. The average observed CBOD and NBOD concentrations were used for the final TMDL loading scenario and then multiplied by the 7Q10 flow (0.25 cfs) at Station 1, the upper boundary of the model's spatial domain, and by each tributary's 7Q10 flow and associated CBOD and NBOD to produce the nonpoint source load allocations for the TMDLs. The nonpoint source loads that were assumed in the model account for both natural and human-induced components. The total load allocation for nonpoint source CBOD is 1,161 lb/month and 824 lb/month for NBOD. Of this total load, 93 lb/month CBOD and 174 lb/month NBOD come from Station 1, and 1,068 lb/month CBOD and 650 lb/month NBOD come from tributaries. The point source and nonpoint source allocations for CBOD and NBOD are summarized in Table 4. Figure 20 provides more detailed schematic computations of these loads. The loading, concentrations, and flow in column six of Table 3 represents future assimilative surplus for Georges Creek. The actual effluent limits and related permit conditions for the George Creek WWTP will be established at the time of permit issuance or renewal. These limits will be based upon conditions present at that time, as reflected in population projections, infrastructure needs, and appropriate concentrations and loadings needed to assure the maintenance of applicable water quality standards.

	Nonpoint Source	**Point Source**		**Total**
CBOD	**1,161**	**6,755**		**7,916**
NBOD	**824**	**17,264**		**18,088**

Table 4: Point Source and Nonpoint Source Load Allocations (lb/month)

The nonpoint source load allocations were calculated for 7Q10 flow. This produced a very small load allocation for nonpoint sources. It must be made clear that the above load allocations assume no runoff loads due to rainfall. Scenario 2 showed that when the flows in the river were increased and the Georges Creek WWTP was discharging a practical maximum wastewater design flow during the summer period, there were no water quality violations within the modeling domain. Figure 19, showed that when the river flows were increased in Scenario 2 and the point and nonpoint source concentrations remained unchanged, the water quality in the river was maintained. The assumption of constant concentrations was an approximation made to insure that the 7Q10 allocations would not violate water quality standards at higher flows. To allocate loads at higher flows, a more detailed analysis of in-stream water quality constituents would have to be performed. This document only allocates loads during 7Q10 conditions. The nonpoint source load allocations may increase above those stated in this document for flows higher than the 7Q10 flow.

5.6 Future Allocation and Margin of Safety

Future allocations represent surplus assimilative capacity that is either presently available, or projected to become available due to planned implementation of environmental controls or other changes. The present CBOD and NBOD concentrations at the upper boundary of the Georges Creek modeling domain are 1.5 and 2.8 mg/L. It was estimated that an additional 0.75 mg/L CBOD and 1.4 mg/L NBOD could be introduced at the upper boundary of the model, and the in-stream water quality would still be met at all downstream locations. It was also determined that, in addition to the current WWTP's 0.6 mgd flow, 0.3 mgd could be introduced from the Georges Creek WWTP without violating the in-stream dissolved oxygen standard.

TMDLs must include a margin of safety (MOS) in recognition of the uncertainties in scientific and technical understanding of water quality in natural systems. Specifically, 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 are not known. 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: (1) reserve a portion of the loading capacity as a separate term in the TMDL, or (2) incorporate the MOS as part of the design conditions for the waste load allocations (WLA) and the load allocations (LA) computations (EPA, April 1991).

The CBOD and NBOD TMDLs for Georges Creek employ both of these approaches. In the TMDLs, 480 and 1,120 lb/month of loading capacity were set aside for a margin of safety for CBOD and NBOD, respectively. The third model scenario incorporated the MOS for CBOD and NBOD at the tributary boundaries of the model and at the Georges Creek WWTP. The MOS at the tributary boundaries of the model was 5% of the total nonpoint future load allocation. The MOS at the Georges Creek WWTP was calculated as 25% of the difference between the weekly and monthly effluent permit limits. This is considered an appropriate MOS because it is unlikely that the Georges Creek WWTP will go above its monthly limit more than a quarter of the time during a month.

In addition to the set-aside CBOD and NBOD MOS, the design conditions for the WLA, LA and the future allocation (FA) computations include two implicit MOSs. First, the critical condition of the consecutive 7-day low-flow expected to occur once every 10 years was used to determine the final TMDL load allocations. Because the 7Q10 flow constitutes a worst case scenario, its use builds a conservative assumption into the TMDLs. Second, all of the modeling was done using the NPDES monthly permit limits for effluent concentrations. The monthly limits are conservative because they represent an upper limit that the WWTP will strive not to exceed. Also, the very large future allocations implicitly include a margin of safety for both the point and non-point sources. The point source loadings could allow an increased flow of 50%, while the service area for the Georges Creek WWTP has shown little, if any, population growth. The non-point sources have an allowable increase of 50% while new nutrient management plans should reduce non-point source loadings. The future allocation and margin of safety can be seen in Table 5.

	Future Allocation	Margin of Safety
CBOD	3,959	480
NBOD	9,051	1,120

Table 5: Future Allocation and Margin of Safety (lb/month)

5.7 Summary of Total Maximum Daily Load

The low-flow TMDLs, applicable from June 1 – October 31, for Georges Creek, equated with illustrative allocations are:

For CBOD (lb/month)

TMDL	=	LA	+	WLA	+	FA	+	MOS
12,355	=	1,161	+	6,755	+	3,959		480

For NBOD (lb/month)

TMDL	=	LA	+	WLA	+	FA	+	MOS
28,259	=	824	+	17,264	+	9,051		1,120

Where:

TMDL = Total Maximum Daily Load
LA = Load Allocation
WLA = Waste Load Allocation
FA = Future Allocation
MOS = Margin of Safety

6.0 ASSURANCE OF IMPLEMENTATION

This section provides a basis for reasonable assurances that the Georges Creek CBOD and NBOD TMDLs will be achieved and maintained. The certainty of implementation of the CBOD and NBOD TMDLs in this watershed will be enhanced by four specific programs: enforceable NPDES permits for the wastewater dischargers in the basin, the Water Quality Improvement Act of 1998 (WQIA), the EPA-sponsored Clean Water Action Plan of 1998 (CWAP) and Maryland's five year watershed cycling strategy

Enforceable NPDES permits that will be written for the wastewater dischargers in this basin also provide confidence in assuring the implementation of these TMDLs. The implementation of point source CBOD and NBOD controls will be executed through the use of NPDES permit for the

Georges Creek WWTP and for the CSOs in the Georges Creek watershed, through the implementation of EPA's 1994 CSO Control Policy. The CSO Control Policy is a national framework for control of CSOs through the National Pollutant Discharge Elimination System (NPDES) permit program. Maryland requires communities with combined sewer systems to implement the CSO Policy's Nine Minimum Controls (NMCs), and is working with permittees in their development of CSO Long Term Control Plans (LTCPs) that will eventually provide for full compliance with the Clean Water Act.

Maryland's WQIA requires that comprehensive and enforceable nutrient management plans be developed, approved and implemented for all commercial agricultural lands throughout Maryland. This act specifically requires that nutrient management plans be developed and implemented by 2004. Implementation of nutrient management plans should also result in a reduction of nonpoint CBOD and NBOD loads.

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 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.

Also, 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 these 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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