FINAL

Water Quality Analysis of Total Phosphorus for the Lower Gunpowder Falls Watershed, Baltimore County, Maryland

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Submitted to:

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December 2011

EPA Submittal Date: 12/16/2011
EPA Approval Date: 5/18/2012

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Table of Contents

List of Figures

List of Tables

List of Abbreviations

BIBI	Benthic Index of Biotic Integrity
BSID	Biological Stressor Identification
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
DEPRM	Baltimore County Department of Environmental Protection & Resource Management
DO	Dissolved Oxygen
EPA	United States Environmental Protection Agency
EPT	*Ephemeroptera*, *Plecoptera*, and *Trichoptera*
FIBI	Fish Index of Biologic Integrity
MBSS	Maryland Biological Stream Survey
MDDNR	Maryland Department of Natural Resources
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
MGS	Maryland Geological Survey
mg/l	Milligrams Per Liter
NPDES	National Pollution Discharge Elimination System
NRCS	National Resources Conservation Service
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
USGS	United States Geological Survey
WWTP	Waste Water Treatment Plant
WQA	Water Quality Analysis
WQLS	Water Quality Limited Segment
µg/l	Micrograms Per Liter

EXECUTIVE SUMMARY

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes a Water Quality Analysis (WQA) for total phosphorus in the Lower Gunpowder Falls. Section 303(d) of the federal Clean Water Act (CWA) and the U. S. Environmental Protection Agency's (EPA) implementing regulations direct each state 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 listed on the *Integrated Report of Surface Water Quality in Maryland* (Integrated Report) (MDE 2010), the State is to either establish a Total Maximum Daily Load (TMDL) of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate via a Water Quality Analysis (WQA) that water quality standards are being met (CFR 2010).

The Maryland Surface Water Use Designation in the Code of Maryland Regulations (COMAR) states that all surface waters of Maryland shall be protected for Use I (*Water Contact Recreation, Fishing and Protection of Nontidal Warmwater Aquatic Life).* In addition, within the Lower Gunpowder Falls Watershed, Long Green Run [Creek] and Sweathouse Branch, and their respective tributaries are also designated as Use III (*Nontidal Coldwater Aquatic Life)* (COMAR 2010a,b,c,d); and the mainstem of Gunpowder Falls (U. S. Route 95 upstream to Cromwell Bridge Road) is designated as Use IV (*Recreational Trout Waters*) (COMAR 2010a, b, c).

The Lower Gunpowder Falls Watershed (basin code 02130802), located in Baltimore County, was identified on the 2010 Integrated Report as impaired by nutrients (1996 listings); and impacts to biological communities—1st through 4th order streams (2006 listing) (MDE 2010). Because phosphorus is generally the limiting nutrient in freshwater aquatic systems, the 1996 nutrients listing was refined in the 2010 Integrated Report, and phosphorus (total) was identified as the specific impairing substance. Consequently, for the purpose of this report, the terms "nutrients" and "phosphorus" will be used interchangeably. This WQA addresses the total phosphorus listing. The listing for impacts to biological communities will be addressed separately at a future date.

A data solicitation for information pertaining to pollutants, including nutrients, in the Lower Gunpowder Falls Watershed was conducted by MDE in 2009, and all readily available data from the period of 1996 through 2010 have been considered.

Currently, there are no numeric criteria for nutrients in Maryland's water quality standards. Nutrients typically do not have a direct impact on aquatic life; rather, they mediate impacts through eutrophication, or excessive algal growth, leading to low dissolved oxygen (DO), poor habitat, or shifts in the trophic relations in aquatic communities. Recently, MDE developed a biological stressor identification (BSID) methodology to identify the most probable cause(s) of the existing biological impairments in 1st through 4th order streams in Maryland 8-digit watersheds based on the suite of available physical, chemical, and land use data (MDE 2009a). The BSID analysis for the Lower Gunpowder Falls Watershed identifies sediment, in-stream habitat, and water chemistry (e. g. high chlorides, sulfates, conductivity) as potential biological

stressors. However, the BSID identified neither nitrogen nor phosphorus as potential biological stressors. Therefore, because the BSID determined that biological impairments in 1st through 4th order streams in the Lower Gunpowder Falls Watershed are not associated with nutrients, it is concluded that total phosphorus is not a cause of the biological impairments in the 1st through 4th order streams of the watershed.

The BSID methodology only applies to 1st through 4th order streams. Additional analysis was completed for the mainstem Gunpowder Falls within the Lower Gunpowder Falls Watershed, using Maryland Department of Natural Resources (MDDNR) Core/Trend data. Analysis of the Core/Trend biological monitoring data confirms that the Gunpowder Falls is supporting its aquatic life uses.

In addition, because Maryland has specific numeric criteria for DO, additional analysis of available DO data in the 1st through 4th order streams and the mainstem of the Lower Gunpowder Falls shows no violation of the DO criterion established for its designated uses. This analysis supports the conclusion that nutrients in general and phosphorus in particular are not impairing the aquatic life designated uses in the Lower Gunpowder Falls.

The results of the BSID study, combined with the analysis of dissolved oxygen monitoring data presented in this report, indicate that the Lower Gunpowder Falls Watershed is not being impaired by nutrients. This WQA supports the conclusion that a TMDL for total phosphorus is not necessary to achieve water quality standards in the Lower Gunpowder Falls Watershed.

Barring the receipt of contradictory data, this report will be used to support a revision of the phosphorus listing for the Lower Gunpowder Falls Watershed, from Category 5 ("waterbody is impaired, does not attain the water quality standard, and a TMDL is required") to Category 2 ("waterbodies meeting some [in this case nutrients-related] water quality standards, but with insufficient data to assess all impairments") when MDE proposes the revision of the Integrated Report.

Although the waters of the Lower Gunpowder Falls Watershed do not display signs of eutrophication, the State reserves the right to require future controls if evidence suggests that nutrients from the watershed are contributing to downstream water quality problems. For instance, reductions will be required to meet allocations assigned to the Gunpowder River Oligohaline Bay Water Quality Segment by the Chesapeake Bay TMDL, established by EPA on December 29, 2010.

1.0 INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) and the U. S. Environmental Protection Agency's (EPA) implementing regulations direct each state 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 listed on the *Integrated Report of Surface Water Quality in Maryland* (Integrated Report) (MDE 2010), the State is to either establish a Total Maximum Daily Load (TMDL) of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate via a Water Quality Analysis (WQA) that water quality standards are being met (CFR 2010).

A segment identified as a WQLS may not require the development and implementation of a TMDL if more recent information invalidates previous findings. The most common scenarios that would eliminate the need for a TMDL are: 1) analysis of more recent data indicating that the impairment no longer exists (*i. e.* , water quality standards are being met); 2) results of a more recent and updated water quality modeling which demonstrates that the segment is attaining standards; 3) refinements to water quality standards or to the interpretation of those standards accompanied by analysis demonstrating that the standards are being met; or 4) identification and correction of errors made in the initial listing. This document presents a WQA that eliminates the need for a TMDL for phosphorus in the Lower Gunpowder Falls using the first scenario described above.

The Maryland Surface Water Use Designation in the Code of Maryland Regulations (COMAR) states that all surface waters of Maryland shall be protected for Use I (*Water Contact Recreation, Fishing and Protection of Nontidal Warmwater Aquatic Life).* In addition, within the Lower Gunpowder Falls Watershed, Long Green Run [Creek] and Sweathouse Branch, and their respective tributaries are also designated as Use III (*Nontidal Coldwater Aquatic Life)* (COMAR 2010a,b,c,d); and the mainstem of Gunpowder Falls (U. S. Route 95 upstream to Cromwell Bridge Road) is designated as Use IV (*Recreational Trout Waters*) (COMAR 2010a, b, c.).

The Lower Gunpowder Falls Watershed (basin code 02130802), located in Baltimore County, was identified on the 2010 Integrated Report as impaired by nutrients (1996 listings); and impacts to biological communities—1st through 4th order streams (2006 listing) (MDE 2010). Because phosphorus is generally the limiting nutrient in freshwater aquatic systems, the 1996 nutrients listing was refined in the 2010 Integrated Report, and phosphorus (total) was identified as the specific impairing substance. Consequently, for the purpose of this report the terms "nutrients" and "phosphorus" will be used interchangeably. This WQA addresses the total phosphorus listing. The listing for impacts to biological communities will be addressed separately at a future date.

This report provides an analysis of recent data that supports the removal of the nutrients (total phosphorus) listing for the Lower Gunpowder Falls Watershed when MDE proposes the revision of the State's Integrated Report. The remainder of this report lays out the general setting of the Lower Gunpowder Falls Watershed area, and presents a discussion of the water quality characteristics in the basin in terms of the existing nutrients and nutrients-related (*i.e.* DO) water quality standards.

Currently in Maryland, there are no specific numeric criteria that quantify the impact of nutrients on the aquatic life of nontidal stream systems. However, MDE has developed a biological stressor identification (BSID) methodology to identify the most probable cause(s) of the existing biological impairments in 1st through 4th order streams in Maryland 8-digit watersheds based on the suite of available physical, chemical, and land use data (MDE 2009a). Additional analysis was completed for the mainstem Gunpowder Falls within the Lower Gunpowder Falls Watershed, using Maryland Department of Natural Resources (MDDNR) Core/Trend biological monitoring data. These are the two main analyses used for this WQA. In addition, the WQA also includes an analysis of dissolved oxygen (DO) monitoring data. Because low levels of DO are sometimes associated with the decay of excess primary production and therefore nutrient over-enrichment, the WQA must demonstrate that either DO standards are met or that nutrients are not the cause of any violation of DO standards.

2.0 GENERAL SETTING

Location

The Lower Gunpowder Falls Watershed is located in the central eastern portion of Baltimore County, Maryland (see Figure 1). The Loch Raven Dam divides the Loch Raven Watershed from the Lower Gunpowder Falls Watershed. The watershed begins at the Loch Raven Reservoir Dam and flows generally towards the east. Where it meets the tidal portions of Gunpowder River, it becomes the Gunpowder River watershed. Major tributaries in the watershed include Minebank Run, Long Green Creek, Sweathouse Run, Haystack Branch, Jennifer Branch, and Bean Run. The watershed is approximately 46 square miles. (DEPRM 2009) There are no "high quality," or Tier II, stream segments (Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI) aquatic life assessment scores > 4 (scale 1-5)) located within the watershed requiring the implementation of Maryland's anti-degradation policy (COMAR 2010f; MDE 2010b).

Geology/Soils

The Lower Gunpowder Falls watershed lies within the Piedmont and Coastal Plain provinces of Central Maryland. The Piedmont province is characterized by gentle to steep rolling topography, low hills and ridges. Crystalline rocks of volcanic origin consisting primarily of schist and gneiss characterize the surficial geology. These formations are resistant to short-term erosion and often determine the limits of stream bank and streambed. These crystalline formations decrease in elevation from northwest to southeast and eventually extend beneath the younger sediments of the Coastal Plain. The fall line represents the transition between the Atlantic Coastal Plain Province and the Piedmont Province. Thick, unconsolidated marine sediments deposited over the crystalline rock of the piedmont province characterize the Atlantic Coastal Plain surficial geology. The deposits include clays, silts, sands and gravels (CES 1995).

Soils in the western part of the Lower Gunpowder Falls Watershed belong to the Glenning-Gaila-Occoquan series, whereas in the eastern part they belong primarily to the Penn-Brentsville-Readington series and some small portion to the Urban land – Wheaton –Glenelg association (USDA 1995). All three soil associations are loamy and occur on broad ridge tops and side slopes. Glenning-Gaila-Occoquan soils occur in uplands. These well drained, deep to very deep soils are well suited for cultivated crops, pasture, or hay production (USDA 1995). Penn-Brentsville-Readington soils are moderately to well drained and tend to be moderately deep to deep. Soils in this series are suitable for woodland and pasture. Both the Glenning-Gaila-Occoquan and Penn-Brentsville-Readington soil units are somewhat limited for urban development because onsite sewage disposal is affected by restricted permeability, depth to bedrock, and sometimes slope (USDA 1995). Of the three major soil associations in the Lower Gunpowder Falls Watershed, the soils in the Urban land – Wheaton –Glenelg unit are the best suited for urban development-the major limitation is restricted permeability. These soils are well drained and deep (USDA 1995).

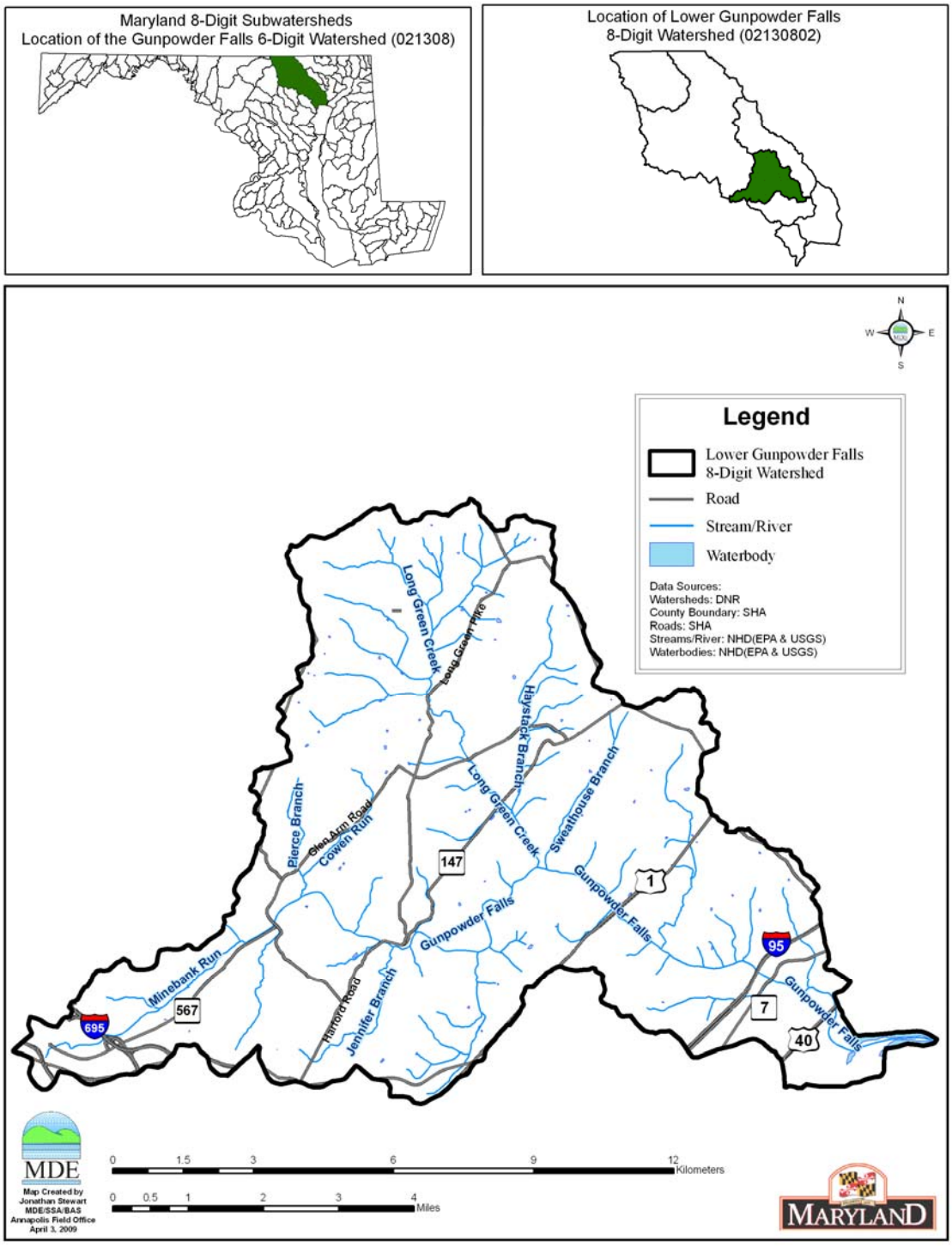

Figure 1. Location Map of the Lower Gunpowder Falls Watershed

Land Use

The Lower Gunpowder Falls Watershed comprises 29,240 acres of drainage area in Baltimore County, Maryland. The land use of the watershed is mostly urban and forested lands, with a smaller portion of agricultural lands. The Gunpowder Falls mainstem provides a natural divide of the land use types. Land to the north of the river is highly rural and agricultural. Land to the south of the river consists mainly of older residential and commercial areas, with smaller amounts of newly developed urban area. The valley forming the Lower Gunpowder Falls mainstem consists of heavily forested lands that are part of the Gunpowder Falls State Park (DEPRM 2009). Based on the Chesapeake Bay Phase 5.2 watershed model, urban land occupies approximately 42% of the watershed (6% impervious surfaces), with 43% of the watershed forested, 9% agricultural, and 5% pasture (USEPA 2009). Open water accounts for approximately 0.1% percent of the watershed (USEPA 2009). Figure 2 provides a land use map of the watershed.

Table 1: Land Use Percentage Distribution for the Lower Gunpowder Falls Watershed

General Land Use	Detailed Land Use	Area (Acres)	Percent	Grouped Percent of Total
Crop	Animal Feeding Operations	7.0	0.0	9.1
	Hay	1,282.1	4.4	
	High Till	320.4	1.1	
	Low Till	1,045.8	3.6	
	Nursery	2.5	0.0	
Extractive	Extractive	7.1	0.0	0.0
Forest	Forest	12,465.2	42.7	43.1
	Harvested Forest	125.9	0.4	
Pasture	Pasture	1,508.5	5.2	5.4
	Trampled Pasture	0.0	0.0	
Urban	Barren	78.0	0.3	42.4
	Impervious	1,765.5	6.0	
	Pervious	10,609.0	36.3	
Total		29,217.1	100.0	100.0

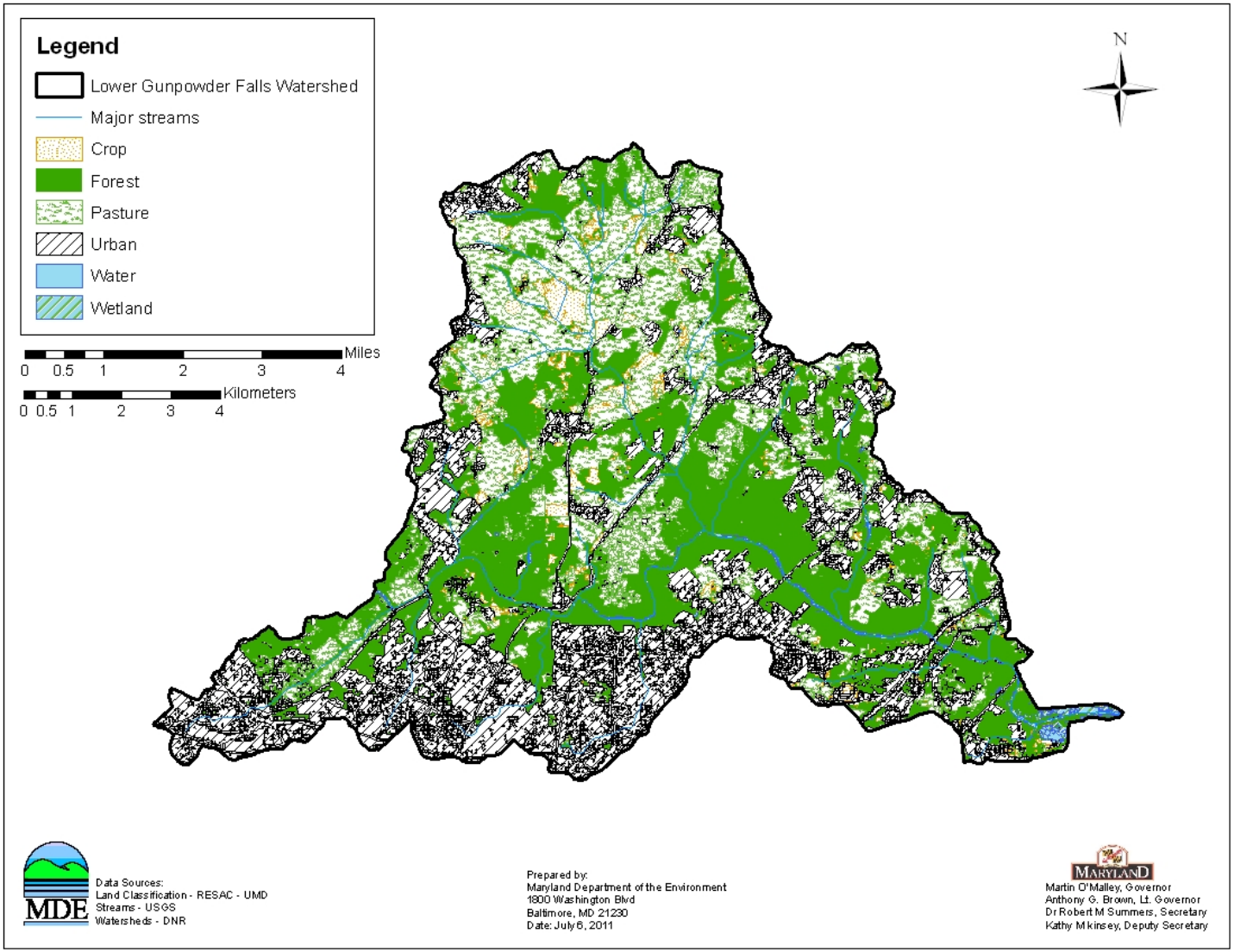

Figure 2. Land Use Map of the Lower Gunpowder Falls Watershed

Point Sources

According to the National Pollutant Discharge Elimination System (NPDES) data, there are four point source facilities with permits regulating their discharges in the Lower Gunpowder Falls Watershed. All four are municipal facilities that have NPDES permits regulating the discharge of nutrients (Table 2).

Table 2: Point Source Facilities in the Lower Gunpowder Falls Watershed

Facility	NPDES Number	MDE Number	Latitude (dec degree)	Longitude (dec degree)
GLEN ARM WWTP & WTP	MD0067903	06DP3235	39.2735	76.2945
GLEN MEADOWS RETIREMENT COMMUNITY	MD0022951	00DP0792	39.2641	76.3055
MARQUIPWARDUNITED, INC.	MD0024635	06DP0346	39.2717	76.2943
RICHLYN MANOR WWTP	MD0022713	00DP0778	39.2524	76.2619

3.0 WATER QUALITY CHARACTERIZATION

The Maryland Surface Water Use Designation in the Code of Maryland Regulations (COMAR) states that all surface waters of Maryland shall be protected for Use I (*Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life).* In addition, within the Lower Gunpowder Falls Watershed, Long Green Run [Creek] and Sweathouse Branch, and their respective tributaries are also designated as Use III – *Nontidal Coldwater* and the mainstem of Gunpowder Falls (U. S. Route 95 upstream to Cromwell Bridge Road) is designated as Use IV - (*Recreational Trout Waters*) (COMAR 2010a, b, c).

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 support of aquatic life, primary or secondary contact recreation, drinking water supply, and shellfish propagation and harvest. Water quality criteria consist of narrative statements and numeric values designed to protect the designated uses. The criteria developed to protect the designated use may differ and are dependent on the specific designated use(s) of a waterbody.

The 2010 Integrated Report specified that the designated use impaired by nutrients is the Aquatic Life Use. Currently, there are no numeric criteria for nutrients in Maryland's water quality standards for the protection of aquatic life in free-flowing non-tidal waters. MDE has developed a biological stressor identification (BSID) analysis to identify potential stressor of aquatic life, including nutrients, in 1st through 4th order streams assessed by the Maryland Biological Stream Survey (MBSS). The impact of nutrients (total phosphorus) on smaller-order streams in the watershed will be evaluated on the basis of the BSID analysis, which provides necessary and sufficient conditions for determining whether phosphorus is a potential stressor of the biological community in smaller-order streams.

Low levels of dissolved oxygen are sometimes associated with the decay of excess primary production and therefore nutrient over-enrichment. The dissolved oxygen (DO) concentration to protect Use I waters "may not be less than 5 milligrams per liter (mg/l) at any time". For Use III, the dissolved oxygen concentration "may not be less than 5 milligrams/liter at any time, with a minimum daily average of not less than 6 milligrams/liter". Additionally, the dissolved oxygen (DO) concentration to protect Use IV waters "may not be less than 5 milligrams per liter (mg/l) at any time" (COMAR 2010d). The water quality analysis must demonstrate that either the water quality standards for dissolved oxygen are met or that nutrients are not the cause of the violation of the standards.

A data solicitation was conducted by MDE in 2009, and all readily available water quality data from the time period of 1996 through 2010 were considered for this analysis. MDDNR collected water quality data from two stations on the mainstem Gunpowder Falls for its Core/Trend program between February 1998 and October 2010 and from 13 stations located on tributaries for its MBSS program in the spring and summer of 1996, 2002, and 2003. MDE also sampled at the two Core/Trend stations and at 4 other stations in the watershed between October 1999 and August 2000 and January 2007 to December 2007. USGS sampled at two stations in the Minebank Run tributary between 2004 and 2008.

3.1 Lower Gunpowder Falls Watershed Monitoring Stations

A total of 22 water quality monitoring stations were used to characterize the Lower Gunpowder Falls Watershed. The locations of the water quality monitoring stations are shown in Figure 3, and their geographical coordinates are listed in Table 3. Figures 4 through 6 provide graphical representation of the collected data for the parameters discussed below.

Water quality data for the 1st through 4th order streams will be analyzed separately from data for the mainstem Gunpowder Falls. Thirteen biological/physical habitat monitoring stations from Rounds 1 and 2 of the MBSS program were used to characterize the Lower Gunpowder Falls Watershed in Maryland's 2010 Integrated Report as well as for the BSID analysis (Round 2 only). Biological data were also collected at two stations for the MDDNR Core/Trend program on the Gunpowder Falls (see Figure 3 and Table 1).

Dissolved oxygen data was collected at all 22 stations. The potential impact of eutrophication on water quality is best measured during the growing season; therefore DO data from May through October will be analyzed.

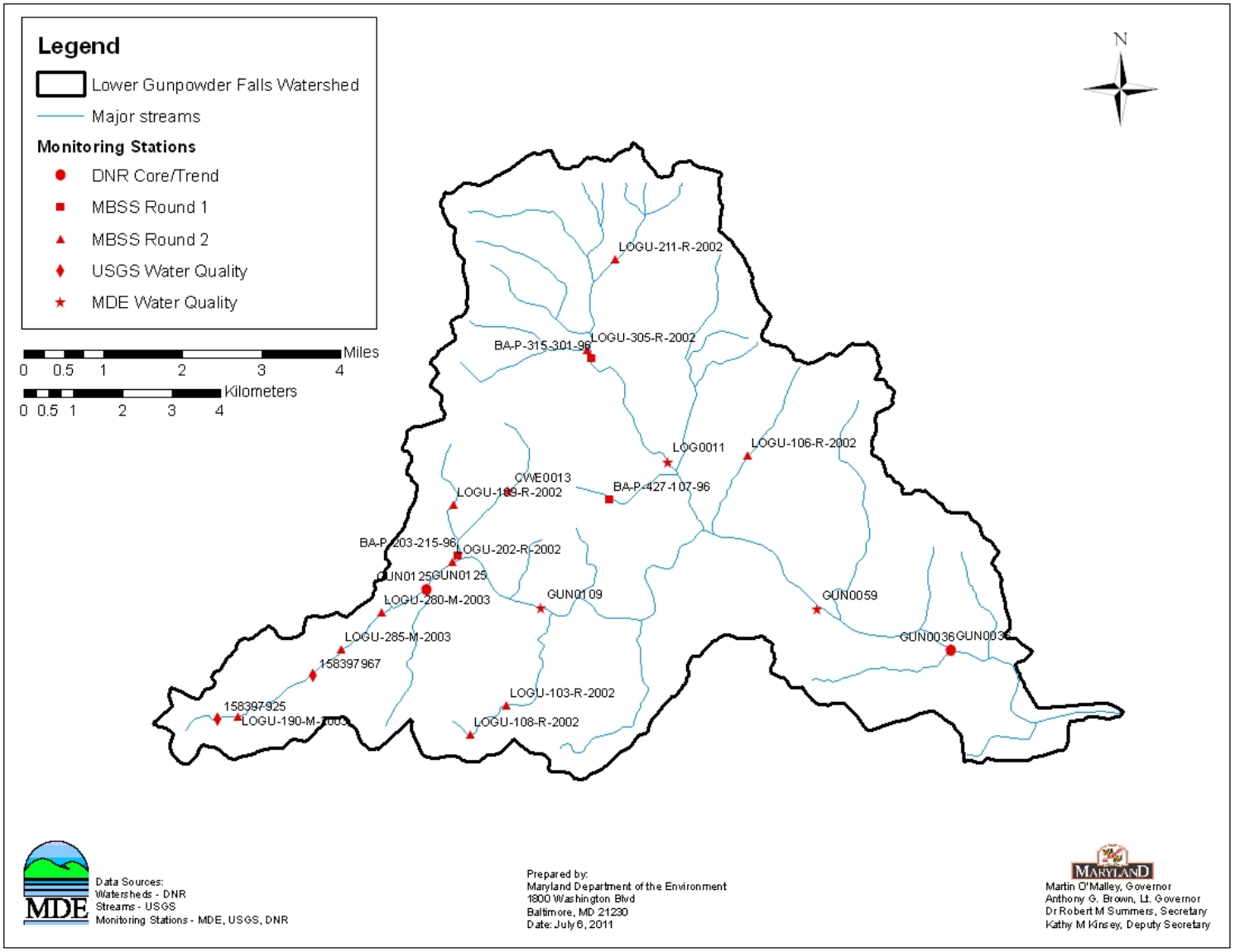

Figure 3. Water Quality Stations in Lower Gunpowder Falls Watershed Monitored During 1996-2010

Table 3: Water Quality Stations in the Lower Gunpowder Falls Watershed Monitored During 1996-2010

Station Number	Sponsor	Site Type	Location	Latitude (dec. deg)	Longitude (dec. deg)
BA-P-203-215-96	DNR	MBSS Round 1	Cowen Run	39.4320	-76.5220
BA-P-315-301-96	DNR	MBSS Round 1	Long Green Creek	39.4680	-76.4900
BA-P-427-107-96	DNR	MBSS Round 1	Long Green Creek	39.4420	-76.4860
LOGU-103-R-2002	DNR	MBSS Round 2	Jennifer Branch	39.4043	-76.5107
LOGU-106-R-2002	DNR	MBSS Round 2	Sweathouse Branch	39.4499	-76.4533
LOGU-108-R-2002	DNR	MBSS Round 2	Jennifer Branch	39.3989	-76.5193
LOGU-109-R-2002	DNR	MBSS Round 2	Cowen Run UT1	39.4412	-76.5230
LOGU-190-M-2003	DNR	MBSS Round 2	Minebank Run	39.4024	-76.5741
LOGU-202-R-2002	DNR	MBSS Round 2	Cowen Run	39.4307	-76.5232
LOGU-211-R-2002	DNR	MBSS Round 2	Long Green Creek UT2	39.4861	-76.4843
LOGU-280-M-2003	DNR	MBSS Round 2	Minebank Run	39.4214	-76.5401
LOGU-285-M-2003	DNR	MBSS Round 2	Minebank Run	39.4148	-76.5495
LOGU-305-R-2002	DNR	MBSS Round 2	Long Green Creek	39.4695	-76.4910
GUN0036	DNR	Core/Trend	Route 7	39.4139	-76.4056
GUN0125	DNR	Core/Trend	Cromwell Bridge Road	39.4257	-76.5294
CWE0013	MDE	Water Quality	Cowen Run	39.4435	-76.5099
GUN0036	MDE	Water Quality	Gunpowder Falls	39.4139	-76.4056
GUN0059	MDE	Water Quality	Gunpowder Falls	39.4216	-76.4371
GUN0109	MDE	Water Quality	Gunpowder Falls	39.4221	-76.5022
GUN0125	MDE	Water Quality	Gunpowder Falls	39.4257	-76.5294
LOG0011	MDE	Water Quality	Long Green Creek	39.4488	-76.4721
0158397925	USGS	Water Quality	Minebank Run	39.4021	-76.5790
0158397967	USGS	Water Quality	Minebank Run	39.4100	-76.5564

UT = Unnamed Tributary

3.2 Biological Stressor Identification Analysis

In the process of evaluating the existing biological impairments in 1st through 4th order streams, MDE developed a biological stressor identification (BSID) methodology (MDE 2009a). The BSID methodology uses data available from the statewide MDDNR MBSS. Data used in the development of the BSID report for the Lower Gunpowder Falls watershed are presented in Appendix A.

The current MDE biological assessment methodology is a three-step process: (1) a data quality review, (2) a systematic vetting of the dataset, and (3) a watershed assessment that presents the results as a final causal model, identifying impacts to aquatic life (MDE 2009a).

The BSID analysis for the Lower Gunpowder Falls Watershed found that 85% of stream miles with poor to very poor biological conditions are impacted by sediment, in-stream habitat, and water chemistry (e. g., high chlorides, sulfates, conductivity). The analysis further suggests that 95% of stream miles with poor to very poor biological conditions are influenced by various types

of urban land uses and a low percentage of forest cover, which in turn lead to altered hydrology, elevated levels of inorganic pollutants from impervious surface runoff, and increased sedimentation (MDE 2011).

The BSID analysis for the Lower Gunpowder Falls Watershed did not identify nutrients as potential stressors or indicate any significant association between current nutrient levels and the degraded biological conditions . According to this report, nutrients are not associated with any impairment to aquatic life or biological communities in the watershed (MDE 2011).

Additionally, the BSID analysis did not identify low DO concentrations as a potential stressor, which agrees with the data analysis in Section 3.3 below. Therefore, low DO concentrations are not associated with biological impairments in the smaller order streams in the Lower Gunpowder Falls Watershed (MDE 2011).

3.3 Dissolved Oxygen

MDE collected 60 water quality samples during the growing season (May through October) from the 1st to 4th order tributaries of the Lower Gunpowder Falls during 2000 and 2007. These DO concentrations ranged from 7.7 to 10.9 mg/l with an average of 8.9 mg/l. The United States Geological Survey (USGS) collected 246 samples in the tributaries from 2002 to 2008, with DO concentrations ranging from 4.8 to 19.5 mg/l and an average of 9.0 mg/l. Only one of these samples fell below the Use I and Use IV applicable DO criterion of 5 mg/l criterion. The MBSS program also collected field DO samples in tributaries during the summers of 1996, 2002, and 2003. The concentrations range from 5.8 to 11.0 mg/l with an average concentration of 8.1 mg/l. DO samples collected in Long Green Creek and Sweathouse Branch range from 6.1 to 10.9 mg/l, all above the Use III applicable DO criterion of 6 mg/l daily average. Given that only one of a total of 272 samples is below the applicable DO criterion, MDE deems that the water quality standard for DO is being met in the 1st through 4th order streams in the Lower Gunpowder Falls Watershed.

MDDNR collected samples for its Core/Trend program in the Lower Gunpowder Falls from 1998 to 2010, and MDE collected samples in the Gunpowder Falls in 1999, 2000, and 2007. Samples taken during the growing season (May through October) show DO concentrations ranging from 4.9 to 12.9 mg/l. Given that only one of 123 samples has a DO concentration below the Use I criterion of 5 mg/l, MDE considers that the water quality standard for DO is being met in the mainstem Lower Gunpowder Falls.

The DO data are presented graphically in Figure 4 and in tabular form in Appendix A.

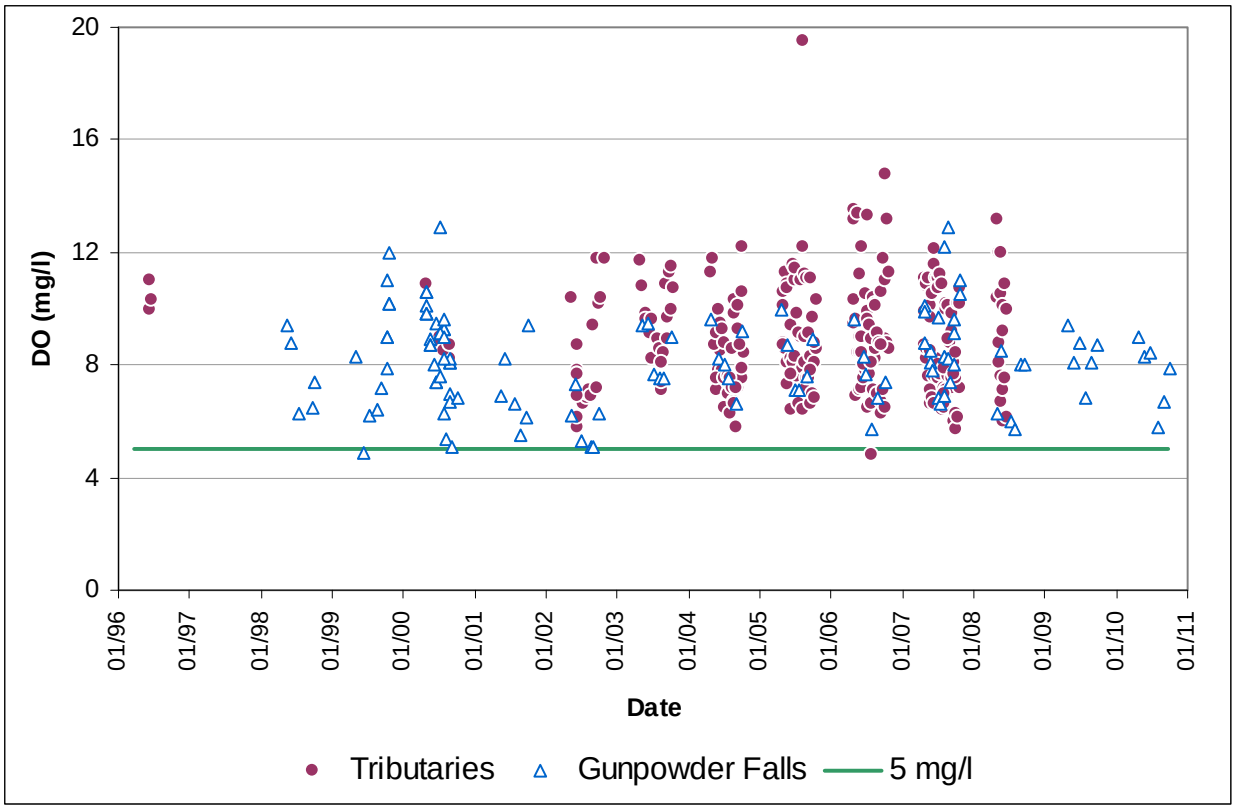

Figure 4: Lower Gunpowder Falls Watershed Dissolved Oxygen Data for Growing Season Periods May 1996 through October 2010

3.4 Nutrients

Evaluation of potentially eutrophic conditions is based on the BSID analysis and analysis of dissolved oxygen levels. Consequently, the nutrients data presented in this section are for informational purposes only.

Total nitrogen (TN) and total phosphorus (TP) data for the Lower Gunpowder Falls Watershed have been analyzed as part of this study. The results are presented here graphically in Figures 5 and 6, and in tabular form in Appendix A.

In the Lower Gunpowder Falls, MDDNR and MDE data show TN concentrations during the growing season (May through October) ranging from 0.58 to 3.41 mg/l and TP concentrations ranging from 0.01 to 0.43 mg/l. MDE and USGS also sampled several tributaries. These data shows TN concentrations ranging from 1.97 to 4.47 mg/l and TP concentrations ranging from 0.02 to 0.12 mg/l.

Nitrogen and phosphorus are essential nutrients for algae growth. If one nutrient is available in greater abundance relative to algal needs, then the nutrient that is less available limits the amount of plant matter that can be produced; this is known as the "limiting nutrient." The amount of the abundant nutrient does not matter because both nutrients are needed for algae growth. In general, a Nitrogen:Phosphorus (TN:TP) ratio in the range of 5:1 to 10:1 by mass is associated with plant growth being limited by neither phosphorus nor nitrogen. If the TN:TP ratio is greater than 10:1, phosphorus tends to be limiting; if the TN:TP ratio is less than 5:1, nitrogen tends to be limiting (Chiandani and Vighi 1974).

Both MDE and MDDNR sampled nutrients in the Lower Gunpowder Falls. Across the two surveys, the average TN:TP ratio during the growing season is 71.6 and the median 59.4. All of the samples have TN:TP ratios greater than ten. The observed data suggest that the Gunpowder Falls is phosphorus limited.

All of the samples taken in the lower-order streams during the growing season have TN:TP ratios greater than ten. The average ratio is 91.7 and the median 88.7. This implies that the smaller-order streams in the Lower Gunpowder Falls are also phosphorus limited.

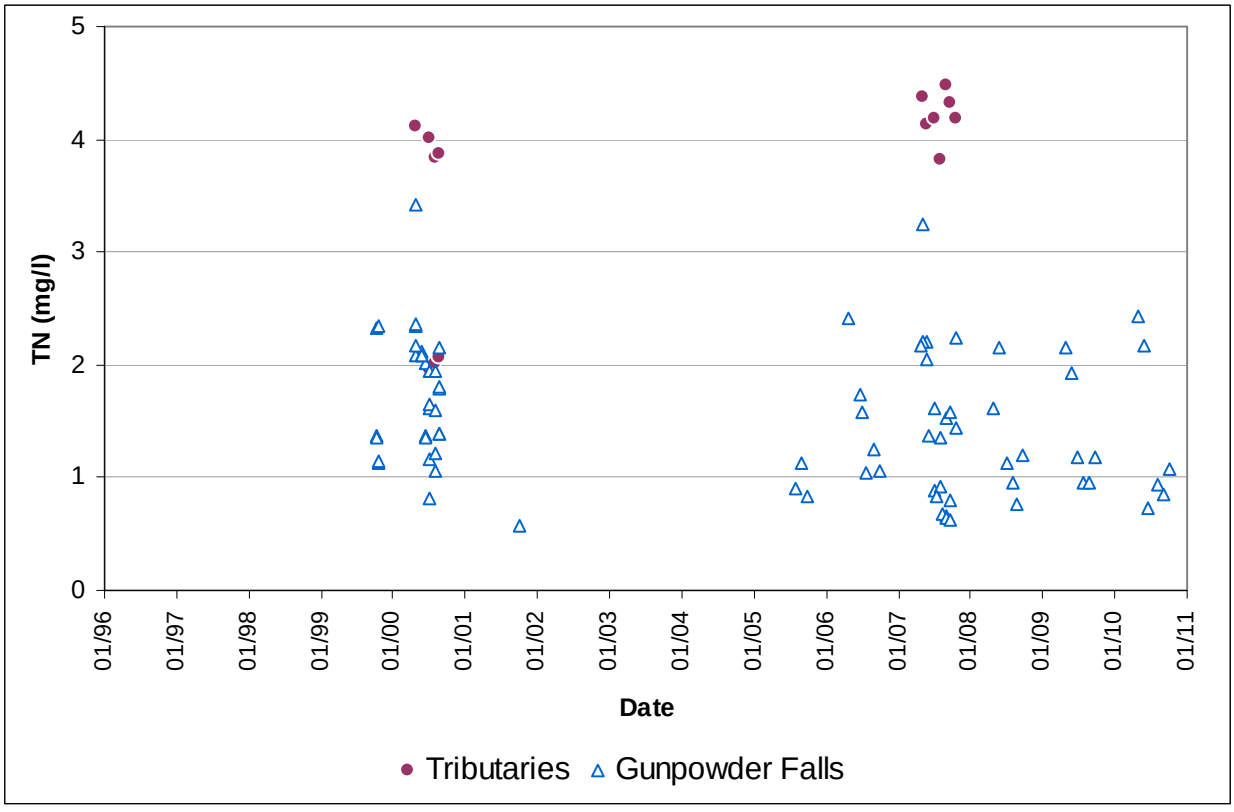

Figure 5: Lower Gunpowder Falls Watershed Total Nitrogen Data for Growing Season Periods May 1996 through October 2010

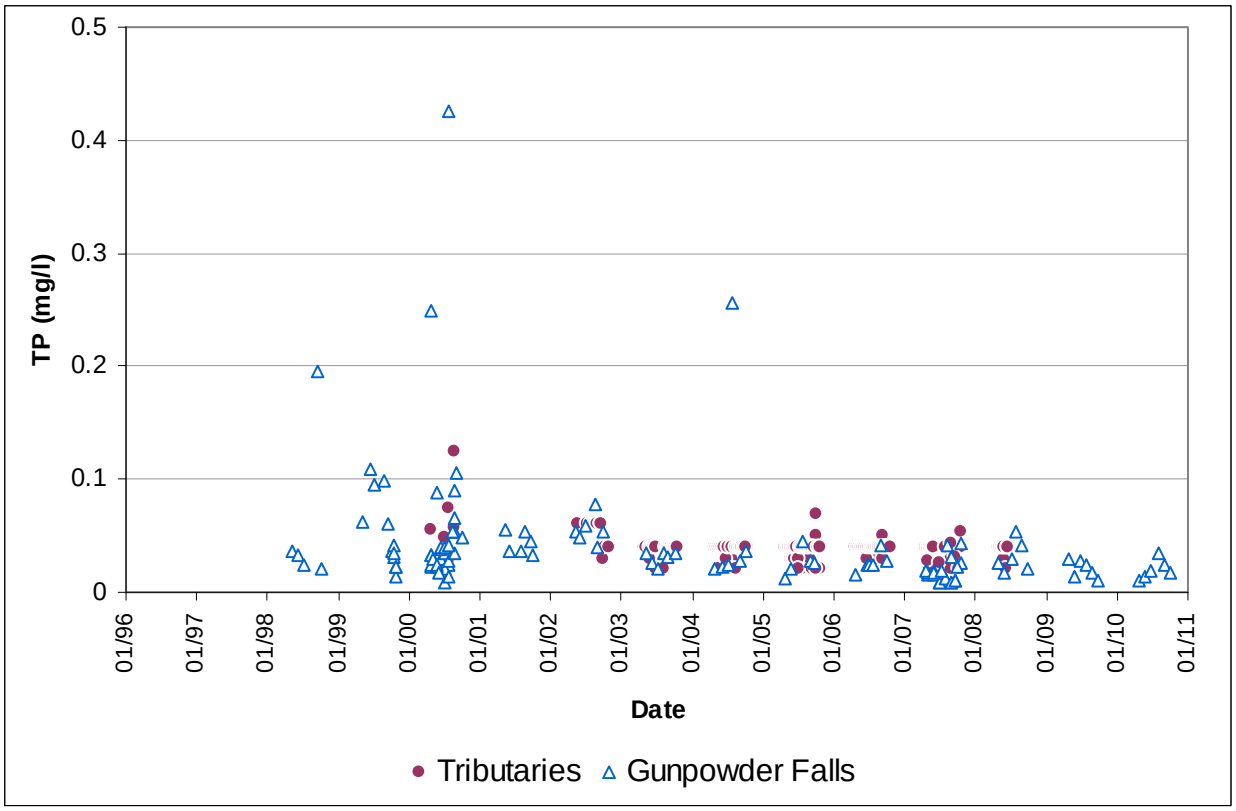

Figure 6: Lower Gunpowder Falls Watershed Total Phosphorus Data for Growing Season Periods May 1996 through October 2010

3.5 Mainstem Lower Gunpowder Core/Trend Biological Monitoring Stations

Additional biological data for the mainstem Lower Gunpowder Falls watershed were obtained from the MDDNR Core/Trend program. The program collected benthic macroinvertebrate data between 1976 and 2006. The data were used to calculate four benthic community measures used to determine the stream's water quality status: total number of taxa, Shannon-Weiner diversity index, modified Hilsenhoff biotic index, and percent *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT). MDDNR has extensive monitoring data for one station (GUN0125), and limited monitoring data for a second station (GUN0036) on the mainstem Lower Gunpowder Falls through the Core/Trend program. These stations have between 12 and 28 years of benthic macroinvertebrate data (MDDNR 2009). A summary of the results for the two stations is presented in Table 4.

Table 4: Lower Gunpowder Falls (MD 8-digit) Core/Trend Data

Site Number	Location	Current Water Quality Status	Trend Since 1970's	Years Sampled
GUN0036	Route 7	Fair/Good	No change	1976 – 1991, 1996
GUN0125	Cromwell Bridge Road	Good	Moderate improvement	1976 –2006

Generally, a CORE/TREND assessment of "GOOD" or better indicates that the waterbody is supporting its aquatic life use. Station GUN0036, off Route 7, achieved only FAIR/GOOD status, indicating a borderline water quality condition. Station GUN0036 was sampled regularly between 1976 and 1991, and then again in 1996. Sampling was discontinued at this station because the site was deemed to be inappropriate (i.e. too wide and deep) to apply the established CORE/TREND sampling protocols.

GUN0125, which currently has a GOOD status, was sampled regularly from 1976 – 2006. Additionally, there are two other CORE/TREND stations on the mainstem of the Gunpowder Falls which were sampled regularly between 1976 and 2006. One station is located in the Prettyboy Reservoir Watershed and the other in the Loch Raven Watershed. Both of these stations have a GOOD status. See Table 4 for a comparison of the four stations, including current status, long-term trend, and number of samples. See Figure 7 for a map of the station locations.

Table 5: Gunpowder River (MD 6-digit) mainstem Core/Trend Data

Site Number	Location	Current Water Quality Status	Trend Since 1970's	Years Sampled	# of samples
GUN0036	Route 7	Fair/Good	No change	1976 – 1991, 1996	12
GUN0125	Cromwell Bridge Road	Good	Moderate improvement	1976 – 2006	28
GUN0258	Lower Glencoe Road	Good	Slight improvement	1976 – 2006	28
GUN0476	Gunpowder Road	Good	No change	1976 – 2006	30

Due to the disparity in the data from GUN0036 (i.e. number of samples, timeline of samples) and the other three CORE/TREND stations on the mainstem Gunpowder Falls, and the fact that these other stations have a 'good" water quality status and two of them have shown "improvement" water quality trends, MDE has determined that data from GUN0036 are not representative of the station's current water quality conditions. Therefore, only GUN0125 will be considered in the assessment of the biological conditions in the mainstem (Gunpowder Falls) portion of Lower

Gunpowder Falls Watershed. Accordingly, the benthic macroinvertebrate data collected under the CORE/TREND program supports the conclusion that the mainstem of the Lower Gunpowder Falls is supporting its Aquatic Life Designated Use.

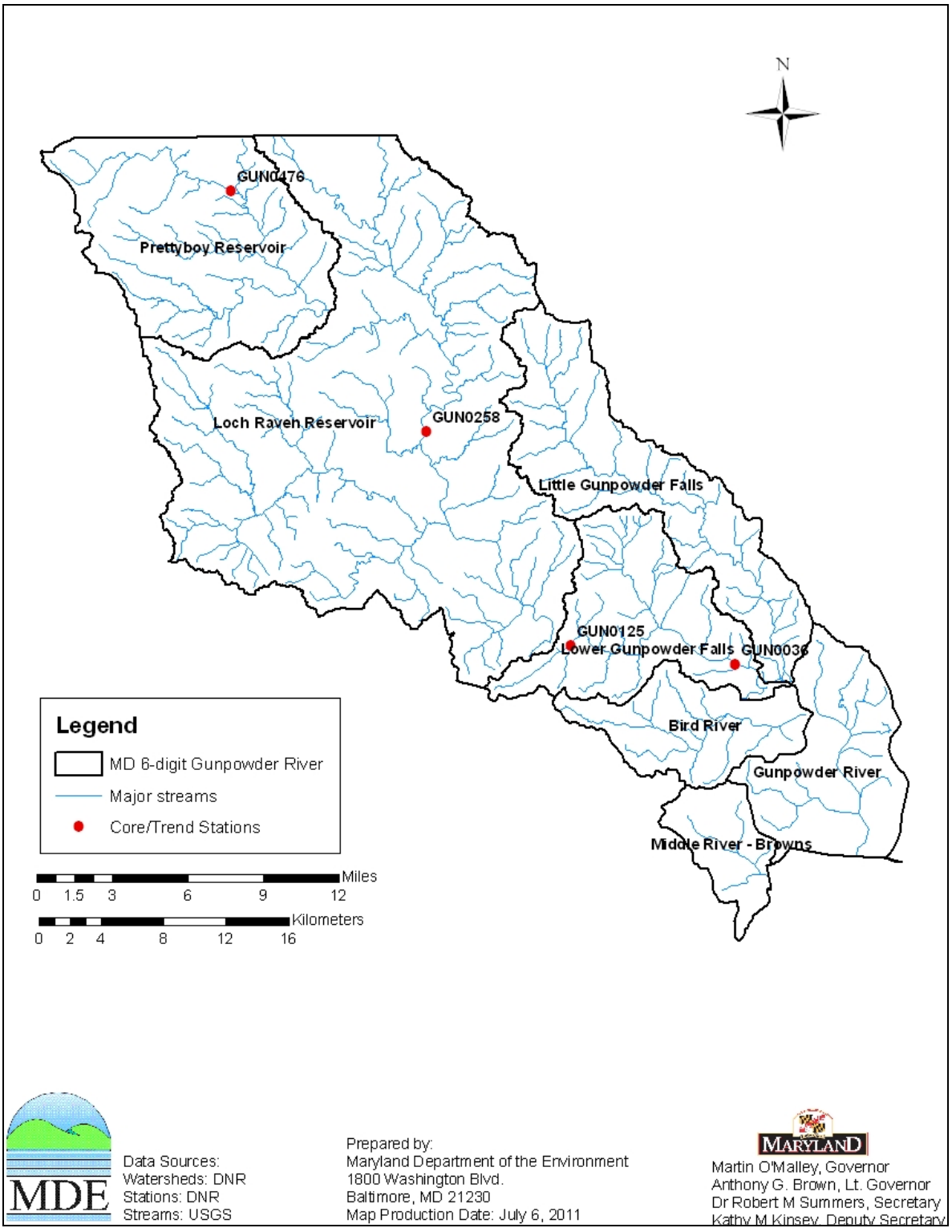

Figure 7. MDDNR Core/Trend Stations on the mainstem Gunpowder Falls within the MD 6-digit Gunpowder River Watershed

4.0 CONCLUSION

The BSID analysis of the Lower Gunpowder Falls Watershed does not identify phosphorus or nitrogen as a potential stressor of aquatic life in the watershed. Phosphorus and consequently, excess eutrophication is therefore not a cause of the biological impairments in the 1st through 4th order streams in the watershed. In addition, the BSID analysis does not associate low DO with biological impairments in the watershed. An analysis of available DO data from the 1st through 4th order streams in Lower Gunpowder Falls Watershed show that only one of 272 samples collected from smaller-order streams in the watershed has a DO concentration below the applicable DO criterion. Therefore, the DO criteria are also met in the smaller-order streams of the Lower Gunpowder Falls watershed.

An analysis of benthic monitoring data from MDDNR's Core/Trend program indicates that the Aquatic Life Designated Use is also met in the mainstem Lower Gunpowder Falls. An analysis of available DO concentrations from the mainstem Lower Gunpowder Falls also shows that the DO criterion is being met. Therefore, there is no evidence to support a conclusion that nutrients are interfering with the protection of aquatic life and water contact recreation designated uses of the mainstem Lower Gunpowder Falls.

MDE therefore concludes that currently the Aquatic Life Use in the Lower Gunpowder Falls Watershed is not being impaired by nutrients in general and phosphorus in particular. Barring the receipt of contradictory data, this report will be used to support a revision of the phosphorus listing for the Lower Gunpowder Falls Watershed, from Category 5 ("waterbody is impaired, does not attain the water quality standard, and a TMDL is required") to Category 2 ("waterbodies meeting some [in this case nutrients-related] water quality standards, but with insufficient data to assess all impairments"), when MDE proposes the revision of Maryland's Integrated Report.

Although the waters of the Lower Gunpowder Falls watershed do not display signs of impacts to the aquatic life, the State reserves the right to require future controls if evidence suggests that nutrients from the basin are contributing to downstream water quality problems. For instance, reductions in nutrients and sediments will be required to meet allocations assigned to the Gunpowder River Oligohaline Bay Water Quality Segment by the Chesapeake Bay TMDL, established by EPA on December 29, 2010**.**

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Appendix A – Tabular Water Quality Data

Table A-1: MDDNR Core/Trend Water Quality Data

Station	Sampling Date	DO (mg/l)	TN (mg/l)	TP (mg/l)
GUN0125	2/23/1998	11.8		0.094
GUN0125	3/16/1998	12.0		0.029
GUN0125	4/14/1998	10.6		0.016
GUN0125	5/12/1998	9.4		0.037
GUN0125	6/9/1998	8.8		0.033
GUN0125	7/14/1998	6.3		0.024
GUN0125	9/22/1998	6.5		0.196
GUN0125	10/6/1998	7.4		0.020
GUN0125	11/4/1998	8.7		0.020
GUN0125	12/1/1998	9.3		0.033
GUN0125	1/5/1999	10.8		0.067
GUN0125	2/2/1999	11.6		0.062
GUN0125	3/9/1999	12.9		0.032
GUN0125	4/6/1999	10.6		0.029
GUN0125	5/5/1999	8.3		0.063
GUN0125	6/16/1999	4.9		0.109
GUN0125	7/12/1999	6.2		0.096
GUN0125	8/25/1999	6.4		0.099
GUN0125	9/15/1999	7.2		0.060
GUN0125	10/12/1999	7.9		0.036
GUN0125	11/16/1999	10.2		0.021
GUN0125	12/14/1999	10.9		0.223
GUN0125	1/11/2000	10.2		0.040
GUN0125	2/8/2000	11.0		0.014
GUN0125	3/6/2000	9.5		0.054
GUN0125	4/5/2000	9.1		0.042
GUN0125	5/3/2000	9.8		0.029
GUN0125	6/7/2000	8.0		0.018
GUN0125	7/26/2000	8.2		0.425
GUN0125	8/14/2000	5.4		0.054
GUN0125	9/6/2000	5.1		0.106
GUN0125	10/4/2000	6.8		0.049
GUN0125	11/1/2000	9.3		0.041
GUN0125	12/5/2000	12.6		0.015
GUN0125	1/23/2001	11.8		0.023
GUN0125	2/20/2001	11.4		0.025
GUN0125	3/26/2001	10.4		0.038
GUN0125	4/30/2001	8.8		0.052
GUN0125	5/15/2001	6.9		0.056
GUN0125	6/6/2001	8.2		0.037

Station	Sampling Date	DO (mg/l)	TN (mg/l)	TP (mg/l)
GUN0125	7/31/2001	6.6		0.036
GUN0125	8/28/2001	5.5		0.053
GUN0125	9/24/2001	6.1		0.045
GUN0125	10/9/2001	9.4	0.58	0.033
GUN0125	11/6/2001	9.6		0.018
GUN0125	12/4/2001	8.6		0.022
GUN0125	1/14/2002	10.9		0.010
GUN0125	2/5/2002	12.3		0.014
GUN0125	3/5/2002	11.7		0.020
GUN0125	4/2/2002	8.4		0.022
GUN0125	5/13/2002	6.2		0.053
GUN0125	6/5/2002	7.3		0.049
GUN0125	7/1/2002	5.3		0.058
GUN0125	8/21/2002	5.1		0.077
GUN0125	9/3/2002	5.1		0.040
GUN0125	10/1/2002	6.3		0.053
GUN0125	11/6/2002	9.3		0.063
GUN0125	12/2/2002	11.0		0.024
GUN0125	1/7/2003	12.4		0.123
GUN0125	2/3/2003	11.0		0.014
GUN0125	3/3/2003	13.5		0.046
GUN0125	4/1/2003	11.4		0.042
GUN0125	5/13/2003	9.4		0.034
GUN0125	6/10/2003	9.5		0.026
GUN0125	7/15/2003	7.7		0.021
GUN0125	8/11/2003	7.5		0.034
GUN0125	9/3/2003	7.5		0.032
GUN0125	10/15/2003	9.0		0.035
GUN0125	11/3/2003	10.0		0.034
GUN0125	12/8/2003	11.5		0.022
GUN0125	1/6/2004	12.8		0.033
GUN0125	2/10/2004	13.6		0.019
GUN0125	3/9/2004	12.3		0.027
GUN0125	4/6/2004	11.5		0.013
GUN0125	5/3/2004	9.6		0.020
GUN0125	6/14/2004	8.2		0.023
GUN0125	7/12/2004	8.0		0.024
GUN0125	8/3/2004	7.5		0.256
GUN0125	9/8/2004	6.6		0.028
GUN0125	10/5/2004	9.2		0.037
GUN0125	11/4/2004	9.3		0.061
GUN0125	12/2/2004	11.5		0.028
GUN0125	1/19/2005	13.3		0.055
GUN0125	2/7/2005	13.5		0.020
GUN0125	3/7/2005	13.0		0.019
GUN0125	4/4/2005	12.3		0.027

Station	Sampling Date	DO (mg/l)	TN (mg/l)	TP (mg/l)
GUN0125	5/2/2005	10.0		0.012
GUN0125	6/1/2005	8.7		0.020
GUN0125	7/5/2005	7.1		
GUN0125	8/1/2005	7.1	0.90	0.045
GUN0125	9/8/2005	7.6	1.13	0.027
GUN0125	10/3/2005	8.9	0.83	0.026
GUN0125	11/1/2005	9.6	1.52	0.035
GUN0125	12/6/2005	11.6	1.41	0.021
GUN0125	1/3/2006	12.5	1.78	0.027
GUN0125	2/2/2006	12.7	2.09	0.013
GUN0125	3/1/2006	12.9	2.36	0.016
GUN0125	4/11/2006	10.9	2.78	0.015
GUN0125	5/1/2006	9.6	2.42	0.015
GUN0125	6/29/2006	8.3	1.74	0.025
GUN0125	7/6/2006	7.7	1.58	0.024
GUN0125	8/2/2006	5.7	1.04	0.025
GUN0125	9/6/2006	6.8	1.26	0.041
GUN0125	10/11/2006	7.4	1.06	0.028
GUN0125	11/2/2006	8.4	1.44	0.027
GUN0125	12/5/2006	11.6	1.42	0.014
GUN0125	1/4/2007	12.0	1.78	0.012
GUN0125	2/6/2007	13.6	1.89	0.012
GUN0125	3/5/2007	12.6	2.43	0.018
GUN0125	4/3/2007	11.0	2.33	0.018
GUN0125	5/3/2007	9.9	2.18	0.019
GUN0125	6/12/2007	7.8	1.37	0.018
GUN0125	7/19/2007	6.6	0.83	0.019
GUN0125	8/16/2007	6.9	0.68	0.041
GUN0125	9/10/2007	7.4	0.64	0.031
GUN0125	10/2/2007	9.1	0.62	0.023
GUN0125	11/14/2007	9.3	0.99	0.029
GUN0125	12/3/2007	11.4	1.12	0.086
GUN0125	1/7/2008	11.2	1.12	0.017
GUN0125	2/5/2008	10.4	1.34	0.027
GUN0125	3/6/2008	9.3	1.33	
GUN0125	4/2/2008	9.5	1.32	0.031
GUN0125	5/8/2008	6.3	1.62	0.026
GUN0125	6/3/2008	8.5	2.16	0.018
GUN0125	7/16/2008	6.0	1.13	0.029
GUN0125	8/7/2008	5.7	0.96	0.053
GUN0125	9/4/2008	8.0	0.76	0.041
GUN0125	10/1/2008	8.0	1.20	0.021
GUN0125	11/6/2008	7.8	0.99	0.021
GUN0125	12/1/2008	9.4	1.09	0.018
GUN0125	1/5/2009	12.2	1.49	0.012
GUN0125	2/2/2009	11.2	1.53	0.044

Station	Sampling Date	DO (mg/l)	TN (mg/l)	TP (mg/l)
GUN0125	3/3/2009	12.5	1.57	0.012
GUN0125	4/6/2009	10.4	2.21	0.038
GUN0125	5/4/2009	9.4	2.15	0.030
GUN0125	6/2/2009	8.1	1.92	0.014
GUN0125	7/7/2009	8.8	1.18	0.028
GUN0125	8/4/2009	6.8	0.95	0.025
GUN0125	9/2/2009	8.1	0.96	0.018
GUN0125	10/5/2009	8.7	1.19	0.010
GUN0125	11/2/2009	10.2	1.55	0.022
GUN0125	12/1/2009	11.0	2.22	0.013
GUN0125	1/5/2010	14.2	2.18	0.013
GUN0125	2/1/2010	13.8	2.38	0.018
GUN0125	3/1/2010	13.2	2.66	0.018
GUN0125	4/6/2010	9.9	2.72	0.020
GUN0125	5/4/2010	9.0	2.44	0.010
GUN0125	6/8/2010	8.3	2.17	0.014
GUN0125	7/1/2010	8.4	0.73	0.019
GUN0125	8/17/2010	5.8	0.94	0.035
GUN0125	9/13/2010	6.7	0.85	0.024
GUN0125	10/12/2010	7.9	1.07	0.018

Table A-2: MBSS Water Quality Data

Station	Sampling Date	DO (mg/l)	TN (mg/l)	TP (mg/l)
BA-P-203-215-96	4/9/1996			
BA-P-203-215-96	6/6/1996	11.0		
BA-P-315-301-96	4/3/1996			
BA-P-315-301-96	6/6/1996	10.0		
BA-P-427-107-96	4/2/1996			
BA-P-427-107-96	6/25/1996	10.3		
LOGU-103-R-2002	3/7/2002		2.03	0.010
LOGU-103-R-2002	6/12/2002	5.8		
LOGU-106-R-2002	3/7/2002		2.48	0.013
LOGU-106-R-2002	6/12/2002	7.8		
LOGU-108-R-2002	3/6/2002		1.73	0.013
LOGU-108-R-2002	6/12/2002	6.9		
LOGU-109-R-2002	3/26/2002		1.53	0.013
LOGU-109-R-2002	6/11/2002	7.7		
LOGU-190-M-2003	4/8/2003		1.45	0.064
LOGU-190-M-2003	8/20/2003	7.4		
LOGU-202-R-2002	3/26/2002		2.00	0.050
LOGU-202-R-2002	6/11/2002	8.7		
LOGU-211-R-2002	3/7/2002		4.43	0.025
LOGU-211-R-2002	6/13/2002	6.1		
LOGU-280-M-2003	4/8/2003		1.54	0.008
LOGU-280-M-2003	8/20/2003	8.1		
LOGU-285-M-2003	4/8/2003		1.76	0.010
LOGU-305-R-2002	3/7/2002		4.84	0.050
LOGU-305-R-2002	6/17/2002	7.7		

Table A-3: MDE Water Quality Data

Station	Sampling Date	DO (mg/l)	TN (mg/l)	TP (mg/l)
CWE0013	7/10/2000	9.0	1.97	0.021
CWE0013	7/31/2000	8.4	2.01	0.028
CWE0013	8/29/2000	8.2	2.06	0.058
GUN0036	10/13/1999	11.0	2.32	0.030
GUN0036	10/26/1999	12.0	2.34	0.015
GUN0036	11/16/1999	14.2	2.19	0.009
GUN0036	11/30/1999	14.3	2.23	0.019
GUN0036	12/14/1999	11.8	2.26	0.179
GUN0036	1/11/2000	12.2	2.22	0.084
GUN0036	1/24/2000	14.9	2.98	0.008
GUN0036	2/23/2000	13.7	2.38	0.020
GUN0036	2/29/2000	13.9	2.27	0.032
GUN0036	3/6/2000	12.7	2.45	0.012
GUN0036	3/6/2000	12.7	2.47	0.013
GUN0036	4/3/2000	10.5	2.11	0.012
GUN0036	4/3/2000	10.5	2.11	0.016
GUN0036	5/1/2000	10.6	2.34	0.034
GUN0036	5/1/2000	10.6	2.37	0.032
GUN0036	5/24/2000	8.9	2.11	0.089
GUN0036	6/20/2000	9.5	2.01	0.029
GUN0036	7/10/2000	9.1	1.62	0.020
GUN0036	7/10/2000	9.1	1.64	0.034
GUN0036	7/31/2000	9.3	1.59	0.025
GUN0036	7/31/2000	9.3		
GUN0036	8/29/2000	8.1	1.78	0.054
GUN0036	8/29/2000	8.1	1.81	0.053
GUN0036	1/9/2007	12.1	2.09	0.019
GUN0036	2/6/2007	15.5	2.99	0.008
GUN0036	3/6/2007	13.3	2.74	0.022
GUN0036	4/3/2007	10.9	2.60	0.017
GUN0036	5/8/2007	10.1	3.25	0.016
GUN0036	6/5/2007	8.5	2.21	0.018
GUN0036	7/10/2007	6.8	1.61	0.009
GUN0036	8/7/2007	8.3	1.36	0.011
GUN0036	9/5/2007	8.2	1.54	0.009
GUN0036	10/1/2007	8.0	1.59	0.010
GUN0036	10/29/2007	11.0	2.24	0.043
GUN0036	12/4/2007	13.7	2.03	0.032
GUN0059	3/7/2000	11.6	2.78	0.046
GUN0059	4/3/2000	9.9	2.49	0.058
GUN0059	5/1/2000	9.8	3.41	0.249
GUN0059	7/10/2000	9.1	1.94	0.020
GUN0059	7/31/2000	9.0	1.94	0.027
GUN0059	8/29/2000	7.0	2.15	0.089
GUN0109	3/6/2000	13.9	1.58	0.014

Station	Sampling Date	DO (mg/l)	TN (mg/l)	TP (mg/l)
GUN0109	4/3/2000	14.2	1.26	0.008
GUN0109	5/1/2000	10.1	2.08	0.022
GUN0109	7/10/2000	12.9	0.81	0.009
GUN0109	7/31/2000	9.6	1.07	0.015
GUN0109	8/29/2000	8.2	1.40	0.035
GUN0109	1/9/2007	11.5	1.89	0.013
GUN0109	2/6/2007	14.4	2.25	0.012
GUN0109	3/6/2007	12.6	2.60	0.017
GUN0109	4/3/2007	11.4	2.50	0.017
GUN0109	5/8/2007	8.8	2.20	0.017
GUN0109	6/5/2007	8.1	2.05	0.015
GUN0109	7/10/2007	9.7	0.89	0.008
GUN0109	8/7/2007	12.2	0.93	0.012
GUN0109	9/5/2007	12.9	0.66	0.008
GUN0109	10/1/2007	9.6	0.80	0.011
GUN0109	10/29/2007	10.5	1.44	0.025
GUN0109	12/4/2007	12.8	1.26	0.021
GUN0125	10/13/1999	9.0	1.38	0.041
GUN0125	10/13/1999	9.0	1.36	0.034
GUN0125	10/26/1999	10.2	1.13	0.022
GUN0125	10/26/1999	10.2	1.14	0.022
GUN0125	11/16/1999	11.2	1.34	0.018
GUN0125	11/16/1999	11.2	1.35	0.017
GUN0125	11/30/1999	11.2	1.14	0.017
GUN0125	11/30/1999	11.2	1.16	0.016
GUN0125	12/14/1999	11.2	1.34	0.185
GUN0125	12/14/1999	11.2	1.32	0.312
GUN0125	1/11/2000	10.6	1.40	0.040
GUN0125	1/11/2000	10.6	1.41	0.042
GUN0125	1/24/2000	12.6	1.74	0.011
GUN0125	1/24/2000	12.6	1.73	0.012
GUN0125	2/23/2000	11.3	1.59	0.017
GUN0125	2/23/2000	11.3	1.50	0.017
GUN0125	2/29/2000	10.7	1.54	0.029
GUN0125	2/29/2000	10.7	1.53	0.029
GUN0125	3/6/2000	13.0	2.22	0.005
GUN0125	4/3/2000	10.0	1.45	0.062
GUN0125	5/1/2000	9.8	2.18	0.025
GUN0125	5/24/2000	8.7	2.08	0.023
GUN0125	5/24/2000	8.7	2.08	0.024
GUN0125	6/20/2000	7.4	1.37	0.039
GUN0125	6/20/2000	7.4	1.35	0.040
GUN0125	7/10/2000	7.6	1.17	0.040
GUN0125	7/31/2000	6.3	1.22	0.042
GUN0125	8/29/2000	6.7	1.39	0.065
LOG0011	3/6/2000	12.3	4.75	0.041

Station	Sampling Date	DO (mg/l)	TN (mg/l)	TP (mg/l)
LOG0011	4/3/2000	10.7	3.95	0.034
LOG0011	5/1/2000	10.9	4.11	0.055
LOG0011	7/10/2000	8.8	4.02	0.048
LOG0011	7/31/2000	8.5	3.84	0.074
LOG0011	8/29/2000	8.7	3.88	0.125
LOG0011	1/9/2007	12.1	3.97	0.038
LOG0011	2/6/2007	14.9	5.15	0.009
LOG0011	3/6/2007	12.8	4.82	0.025
LOG0011	4/3/2007	10.8	4.20	0.017
LOG0011	5/8/2007	9.9	4.37	0.027
LOG0011	6/5/2007	8.5	4.14	0.041
LOG0011	7/10/2007	8.0	4.19	0.025
LOG0011	8/7/2007	7.9	3.82	0.039
LOG0011	9/5/2007	8.9	4.47	0.044
LOG0011	10/1/2007	7.7	4.33	0.032
LOG0011	10/29/2007	10.7	4.18	0.054
LOG0011	12/4/2007	12.0	4.20	0.036

Table A-4: USGS Water Quality Data

Station	Sampling Date	DO (mg/l)	TP (mg/l)
0158397925	6/3/2004	7.1	0.020
0158397925	6/10/2004	7.8	0.040
0158397925	6/21/2004	8.5	0.040
0158397925	6/28/2004	7.8	0.040
0158397925	7/6/2004	6.5	0.040
0158397925	7/12/2004	7.6	0.020
0158397925	7/29/2004	7.0	0.040
0158397925	8/5/2004	6.3	0.030
0158397925	8/17/2004	7.2	0.040
0158397925	8/25/2004	6.7	0.040
0158397925	9/1/2004	6.6	0.040
0158397925	9/9/2004	5.8	0.040
0158397925	9/16/2004	7.2	0.040
0158397925	9/23/2004	7.4	0.040
0158397925	9/30/2004	7.5	0.040
0158397925	10/5/2004	7.5	0.040
0158397925	10/12/2004	7.9	0.040
0158397925	10/21/2004	8.4	0.040
0158397925	11/1/2004	6.9	0.040
0158397925	11/18/2004	10.0	0.040
0158397925	11/29/2004	9.8	0.020
0158397925	12/6/2004	11.0	0.040
0158397925	12/13/2004	10.2	0.040
0158397925	12/21/2004	10.8	0.040
0158397925	1/3/2005	9.6	0.040
0158397925	1/18/2005	11.1	0.040
0158397925	1/31/2005	10.7	0.030
0158397925	2/15/2005	11.8	0.040
0158397925	3/2/2005	12.4	0.040
0158397925	3/5/2005	11.1	
0158397925	3/15/2005	11.7	0.040
0158397925	3/29/2005	10.9	0.030
0158397925	4/6/2005	11.7	0.040
0158397925	4/13/2005	12.2	0.010
0158397925	4/19/2005	11.8	0.040
0158397925	4/26/2005	11.9	0.040
0158397925	5/3/2005	10.6	0.040
0158397925	5/10/2005	8.8	0.040
0158397925	5/17/2005	8.6	0.040
0158397925	5/23/2005	8.1	0.040
0158397925	6/1/2005	7.3	0.030
0158397925	6/14/2005	6.4	0.030
0158397925	6/21/2005	8.2	0.030
0158397925	6/28/2005	8.1	0.040
0158397925	7/5/2005	7.7	0.020

Station	Sampling Date	DO (mg/l)	TP (mg/l)
0158397925	7/12/2005	8.3	0.020
0158397925	7/19/2005	7.6	0.020
0158397925	7/26/2005	6.6	0.040
0158397925	8/4/2005	9.0	0.020
0158397925	8/12/2005	6.4	0.040
0158397925	8/18/2005	7.9	0.040
0158397925	8/25/2005	8.1	0.040
0158397925	8/30/2005	7.1	0.040
0158397925	9/6/2005	7.5	0.030
0158397925	9/14/2005	7.5	0.020
0158397925	9/22/2005	8.3	0.040
0158397925	9/29/2005	6.6	0.040
0158397925	10/6/2005	7.0	0.040
0158397925	10/13/2005	8.1	0.050
0158397925	10/20/2005	6.8	0.020
0158397925	10/27/2005	8.6	0.020
0158397925	11/2/2005	8.4	0.030
0158397925	11/8/2005	7.8	0.030
0158397925	11/15/2005	8.2	0.030
0158397925	11/21/2005	8.5	0.040
0158397925	11/30/2005	9.3	0.100
0158397925	12/8/2005	10.6	0.030
0158397925	12/16/2005	13.1	0.160
0158397925	12/22/2005	11.4	0.040
0158397925	12/28/2005	10.8	0.020
0158397925	1/4/2006	11.0	0.040
0158397925	1/10/2006	10.6	0.040
0158397925	1/17/2006	10.2	0.040
0158397925	1/25/2006	10.5	0.040
0158397925	2/1/2006	10.3	0.040
0158397925	2/7/2006	11.2	0.020
0158397925	2/14/2006	11.3	0.040
0158397925	2/23/2006	12.8	0.040
0158397925	3/1/2006	12.4	0.040
0158397925	3/7/2006	12.5	0.040
0158397925	3/13/2006	11.9	0.040
0158397925	3/20/2006	11.6	0.040
0158397925	3/29/2006	11.7	0.040
0158397925	4/4/2006	8.4	0.040
0158397925	4/10/2006	10.1	0.040
0158397925	4/18/2006	10.6	0.040
0158397925	4/26/2006	9.3	0.040
0158397925	5/2/2006	10.3	0.040
0158397925	5/9/2006	9.5	0.040
0158397925	5/16/2006	6.9	0.040
0158397925	5/24/2006	8.4	0.040

Station	Sampling Date	DO (mg/l)	TP (mg/l)
0158397925	5/31/2006	8.4	0.040
0158397925	6/6/2006	7.1	0.040
0158397925	6/12/2006	7.2	0.040
0158397925	6/19/2006	8.4	0.040
0158397925	6/28/2006	7.5	0.040
0158397925	7/3/2006	7.8	
0158397925	7/14/2006	9.9	0.040
0158397925	7/19/2006	6.5	0.040
0158397925	7/25/2006	7.7	0.040
0158397925	7/31/2006	6.6	0.040
0158397925	8/8/2006	4.8	0.040
0158397925	8/11/2006	7.1	0.040
0158397925	8/23/2006	8.2	0.030
0158397925	8/28/2006	8.6	0.040
0158397925	9/6/2006	7.0	0.040
0158397925	9/14/2006	8.8	0.050
0158397925	9/20/2006	6.7	0.040
0158397925	9/25/2006	6.3	0.040
0158397925	10/2/2006	7.1	0.040
0158397925	10/11/2006	6.5	0.040
0158397925	10/16/2006	8.9	0.040
0158397925	10/23/2006	8.8	0.040
0158397925	10/30/2006	8.6	0.040
0158397925	11/6/2006	9.6	0.040
0158397925	11/14/2006	8.3	0.040
0158397925	11/20/2006	9.1	0.040
0158397925	11/27/2006	9.6	0.020
0158397925	12/4/2006	9.8	0.040
0158397925	12/7/2006	10.1	0.040
0158397925	12/18/2006	11.8	0.040
0158397925	12/22/2006	8.9	0.040
0158397925	1/3/2007	10.7	0.040
0158397925	1/17/2007	11.7	0.040
0158397925	1/23/2007	10.7	0.050
0158397925	1/31/2007	12.4	0.040
0158397925	2/5/2007	11.8	0.040
0158397925	2/12/2007	11.0	0.040
0158397925	2/20/2007	10.6	0.040
0158397925	2/27/2007	12.3	0.040
0158397925	3/5/2007	11.1	0.040
0158397925	3/13/2007	12.5	0.020
0158397925	3/19/2007	12.0	0.040
0158397925	3/27/2007	13.1	0.040
0158397925	4/2/2007	11.6	0.040
0158397925	4/9/2007	10.7	0.040
0158397925	4/16/2007	10.3	0.040

Station	Sampling Date	DO (mg/l)	TP (mg/l)
0158397925	4/25/2007	10.1	0.040
0158397925	5/2/2007	8.7	0.040
0158397925	5/9/2007	8.2	0.040
0158397925	5/16/2007	8.6	0.020
0158397925	5/21/2007	7.6	0.040
0158397925	5/31/2007	7.1	0.040
0158397925	6/6/2007	6.6	0.040
0158397925	6/11/2007	6.8	0.040
0158397925	6/18/2007	6.6	0.040
0158397925	6/25/2007	7.6	0.040
0158397925	7/2/2007	8.2	
0158397925	7/9/2007	7.7	0.040
0158397925	7/16/2007	7.5	0.020
0158397925	7/19/2007	7.7	0.020
0158397925	8/1/2007	6.4	0.040
0158397925	8/9/2007	6.5	0.040
0158397925	8/16/2007	7.2	0.040
0158397925	8/23/2007	7.0	0.040
0158397925	8/27/2007	7.1	0.040
0158397925	9/4/2007	7.6	0.030
0158397925	9/10/2007	8.8	0.020
0158397925	9/17/2007	7.5	0.040
0158397925	9/24/2007	7.2	0.040
0158397925	10/1/2007	6.0	0.040
0158397925	10/9/2007	5.7	0.040
0158397925	10/15/2007	6.3	0.040
0158397925	10/22/2007	6.1	0.020
0158397925	10/29/2007	7.2	0.040
0158397925	11/5/2007	7.2	0.040
0158397925	11/13/2007	10.2	0.120
0158397925	11/19/2007	9.8	0.040
0158397925	11/26/2007	6.2	0.040
0158397925	12/3/2007	8.6	0.040
0158397925	12/11/2007	7.8	0.020
0158397925	12/17/2007	10.2	0.030
0158397925	12/26/2007	7.4	0.040
0158397925	1/2/2008	9.3	0.040
0158397925	1/7/2008	9.4	0.040
0158397925	1/14/2008	8.8	0.030
0158397925	1/22/2008	9.4	0.040
0158397925	1/28/2008	10.5	0.040
0158397925	2/5/2008	10.3	0.040
0158397925	2/14/2008	11.5	0.030
0158397925	2/19/2008	10.2	0.040
0158397925	2/25/2008	12.5	0.040
0158397925	3/3/2008	9.6	0.040

Station	Sampling Date	DO (mg/l)	TP (mg/l)
0158397925	3/11/2008	11.3	0.040
0158397925	3/17/2008	11.2	0.040
0158397925	3/24/2008	10.4	0.040
0158397925	3/31/2008	9.1	0.040
0158397925	4/7/2008	9.8	0.020
0158397925	4/14/2008	9.9	0.020
0158397925	4/21/2008	9.7	0.120
0158397925	4/30/2008	9.5	0.040
0158397925	5/5/2008	10.4	0.040
0158397925	5/15/2008	8.8	0.040
0158397925	5/19/2008	8.1	0.040
0158397925	5/28/2008	7.6	0.040
0158397925	6/2/2008	6.7	0.030
0158397925	6/9/2008	6.0	0.040
0158397925	6/13/2008	7.1	0.040
0158397925	6/23/2008	7.5	0.040
0158397925	6/30/2008	6.1	0.040
0158397967	3/5/2002	12.4	0.060
0158397967	5/20/2002	10.4	0.060
0158397967	7/15/2002	6.6	0.060
0158397967	7/31/2002	6.8	0.060
0158397967	8/8/2002	7.0	0.060
0158397967	8/15/2002	7.1	0.060
0158397967	8/27/2002	6.9	0.060
0158397967	9/3/2002	9.4	0.060
0158397967	9/19/2002	11.8	0.060
0158397967	9/26/2002	7.2	0.060
0158397967	10/2/2002	10.2	0.030
0158397967	10/15/2002	10.4	0.040
0158397967	10/31/2002	11.8	0.040
0158397967	11/7/2002	11.8	0.040
0158397967	11/26/2002	12.8	0.040
0158397967	12/4/2002	15.4	0.040
0158397967	12/13/2002		0.040
0158397967	12/23/2002	12.8	0.020
0158397967	1/7/2003	12.7	0.040
0158397967	1/13/2003	13.7	0.040
0158397967	1/22/2003	15.2	0.040
0158397967	1/30/2003	15.5	0.040
0158397967	2/5/2003	14.3	0.040
0158397967	2/11/2003	14.8	0.040
0158397967	2/27/2003	12.8	0.030
0158397967	3/10/2003	13.3	0.040
0158397967	3/25/2003	14.2	0.040
0158397967	4/2/2003	14.4	0.040
0158397967	4/10/2003	13.9	0.040

Station	Sampling Date	DO (mg/l)	TP (mg/l)
0158397967	4/16/2003	13.1	0.040
0158397967	4/23/2003	15.3	0.040
0158397967	5/5/2003	11.7	0.040
0158397967	5/12/2003	10.8	0.040
0158397967	5/29/2003	9.8	0.040
0158397967	6/5/2003	9.6	0.030
0158397967	6/11/2003	9.2	0.040
0158397967	6/25/2003	9.1	0.040
0158397967	7/1/2003	9.6	0.040
0158397967	7/7/2003	8.2	0.020
0158397967	7/31/2003	8.9	0.020
0158397967	8/8/2003	8.6	0.020
0158397967	8/20/2003	7.1	0.040
0158397967	9/2/2003	8.4	0.040
0158397967	9/11/2003	10.9	0.040
0158397967	9/17/2003	9.7	0.040
0158397967	9/25/2003	8.9	0.040
0158397967	10/2/2003	11.3	0.040
0158397967	10/8/2003	11.5	0.040
0158397967	10/16/2003	10.0	0.040
0158397967	10/23/2003	10.7	0.040
0158397967	11/3/2003	9.6	0.040
0158397967	11/13/2003	9.9	0.040
0158397967	11/20/2003	9.1	0.030
0158397967	12/1/2003	11.5	0.040
0158397967	12/9/2003	13.6	0.040
0158397967	12/18/2003	12.8	0.020
0158397967	12/29/2003	13.2	0.040
0158397967	1/6/2004	13.2	0.040
0158397967	1/12/2004	14.6	0.040
0158397967	1/22/2004	15.3	0.040
0158397967	2/2/2004	16.3	0.040
0158397967	2/11/2004	14.1	0.040
0158397967	2/19/2004	16.0	0.040
0158397967	2/26/2004	16.6	0.040
0158397967	3/4/2004	13.8	0.040
0158397967	3/10/2004	13.8	0.040
0158397967	3/18/2004		0.040
0158397967	3/25/2004	13.9	0.040
0158397967	4/8/2004	9.7	0.040
0158397967	4/15/2004	11.7	0.040
0158397967	4/22/2004	11.6	0.040
0158397967	4/29/2004	10.8	0.040
0158397967	5/5/2004	11.3	0.040
0158397967	5/13/2004	11.8	0.040
0158397967	5/20/2004	8.7	0.040

Station	Sampling Date	DO (mg/l)	TP (mg/l)
0158397967	5/26/2004	7.5	0.020
0158397967	6/3/2004	9.1	0.040
0158397967	6/10/2004	10.0	0.040
0158397967	6/21/2004	9.5	0.040
0158397967	6/28/2004	9.3	0.030
0158397967	7/6/2004	7.5	0.040
0158397967	7/12/2004	8.8	0.040
0158397967	7/29/2004	7.6	0.040
0158397967	8/5/2004	7.5	0.020
0158397967	8/17/2004	8.6	0.020
0158397967	8/25/2004	10.3	0.040
0158397967	9/1/2004	9.8	0.040
0158397967	9/9/2004	7.2	0.040
0158397967	9/16/2004	9.3	0.040
0158397967	9/23/2004	10.1	0.040
0158397967	9/30/2004	8.7	0.040
0158397967	10/5/2004	10.6	0.040
0158397967	10/12/2004	12.2	0.040
0158397967	11/1/2004	12.0	0.040
0158397967	11/9/2004	12.6	0.040
0158397967	11/29/2004	10.5	0.040
0158397967	12/6/2004	13.3	0.040
0158397967	12/13/2004	13.3	0.040
0158397967	12/21/2004	15.6	0.040
0158397967	1/3/2005	12.9	0.040
0158397967	1/18/2005	14.1	0.040
0158397967	1/31/2005	14.3	0.040
0158397967	2/15/2005	13.3	0.040
0158397967	3/2/2005	13.5	0.040
0158397967	3/5/2005	12.4	
0158397967	3/15/2005	12.5	0.040
0158397967	3/29/2005	10.5	0.040
0158397967	4/6/2005	11.3	0.040
0158397967	4/13/2005	12.5	0.010
0158397967	4/19/2005	12.0	0.040
0158397967	4/26/2005	11.6	0.040
0158397967	5/3/2005	10.1	0.040
0158397967	5/10/2005	8.7	0.040
0158397967	5/17/2005	11.3	0.040
0158397967	5/23/2005	10.9	0.040
0158397967	6/1/2005	10.7	0.040
0158397967	6/14/2005	7.7	0.040
0158397967	6/21/2005	9.4	0.040
0158397967	6/28/2005	11.6	0.040
0158397967	7/5/2005	11.0	0.030
0158397967	7/11/2005	11.4	0.020

Station	Sampling Date	DO (mg/l)	TP (mg/l)
0158397967	7/19/2005	9.8	0.040
0158397967	7/26/2005	9.1	0.040
0158397967	8/4/2005	11.0	0.040
0158397967	8/12/2005	12.2	0.040
0158397967	8/18/2005	19.5	0.040
0158397967	8/25/2005	11.2	0.040
0158397967	8/30/2005	9.0	0.040
0158397967	9/6/2005	11.1	0.040
0158397967	9/14/2005	9.1	0.040
0158397967	9/22/2005	11.1	0.040
0158397967	9/29/2005	7.8	0.040
0158397967	10/6/2005	9.7	0.070
0158397967	10/13/2005	8.8	0.020
0158397967	10/20/2005	8.8	0.040
0158397967	10/27/2005	10.3	0.040
0158397967	11/2/2005	11.4	0.040
0158397967	11/8/2005	11.1	0.040
0158397967	11/15/2005	11.0	0.040
0158397967	11/21/2005	11.6	0.040
0158397967	11/30/2005	9.4	0.040
0158397967	12/8/2005	14.3	0.040
0158397967	12/16/2005	13.1	0.050
0158397967	12/22/2005	13.7	0.040
0158397967	12/28/2005	12.6	0.040
0158397967	1/4/2006	13.3	0.040
0158397967	1/10/2006	14.0	0.040
0158397967	1/17/2006	14.3	0.040
0158397967	1/25/2006	12.8	0.040
0158397967	2/1/2006		0.040
0158397967	2/7/2006	13.2	0.040
0158397967	2/14/2006	13.8	0.040
0158397967	2/23/2006	14.8	0.040
0158397967	3/1/2006	14.6	0.040
0158397967	3/7/2006	15.1	0.040
0158397967	3/13/2006	13.4	0.040
0158397967	3/20/2006	13.3	0.040
0158397967	3/29/2006	13.1	0.040
0158397967	4/4/2006	11.5	0.040
0158397967	4/10/2006	12.7	0.040
0158397967	4/18/2006	13.2	0.040
0158397967	4/26/2006	12.5	0.040
0158397967	5/2/2006	13.5	0.040
0158397967	5/9/2006	13.2	0.040
0158397967	5/16/2006	9.6	0.040
0158397967	5/24/2006	13.4	0.040
0158397967	5/31/2006	11.2	0.040

Station	Sampling Date	DO (mg/l)	TP (mg/l)
0158397967	6/6/2006	9.0	0.040
0158397967	6/12/2006	9.0	0.040
0158397967	6/19/2006	12.2	0.040
0158397967	6/28/2006	8.0	0.030
0158397967	7/3/2006	10.5	0.040
0158397967	7/14/2006	13.3	0.040
0158397967	7/19/2006	9.6	0.040
0158397967	7/25/2006	9.4	0.040
0158397967	7/31/2006	8.9	0.040
0158397967	8/8/2006	8.1	0.040
0158397967	8/11/2006	10.4	0.040
0158397967	8/23/2006	10.2	0.040
0158397967	8/28/2006	10.1	0.040
0158397967	9/6/2006	9.1	0.040
0158397967	9/14/2006	8.8	0.030
0158397967	9/20/2006	10.6	0.040
0158397967	9/25/2006	8.7	0.040
0158397967	10/2/2006	11.8	0.040
0158397967	10/11/2006	11.0	0.040
0158397967	10/16/2006	14.8	0.040
0158397967	10/23/2006	13.2	0.040
0158397967	10/30/2006	11.3	0.040
0158397967	11/6/2006	13.6	0.040
0158397967	11/14/2006	12.5	0.040
0158397967	11/20/2006	11.0	0.040
0158397967	11/27/2006	11.8	0.040
0158397967	12/4/2006	13.5	0.040
0158397967	12/7/2006	13.7	0.040
0158397967	12/18/2006	15.0	0.040
0158397967	12/22/2006	11.8	0.040
0158397967	1/3/2007	12.3	0.040
0158397967	1/17/2007	14.4	0.040
0158397967	1/23/2007	14.0	0.030
0158397967	1/31/2007	15.3	0.040
0158397967	2/5/2007	16.6	0.040
0158397967	2/12/2007	15.5	0.040
0158397967	2/20/2007	13.9	0.030
0158397967	2/27/2007	13.0	0.030
0158397967	3/5/2007	12.4	0.040
0158397967	3/13/2007	13.5	0.010
0158397967	3/19/2007	12.2	0.040
0158397967	3/27/2007	14.0	0.040
0158397967	4/2/2007	12.8	0.040
0158397967	4/9/2007	11.9	0.040
0158397967	4/16/2007	10.9	0.040
0158397967	4/25/2007	12.2	0.040

Station	Sampling Date	DO (mg/l)	TP (mg/l)
0158397967	5/2/2007	11.1	0.040
0158397967	5/9/2007	10.8	0.040
0158397967	5/16/2007	10.9	0.040
0158397967	5/21/2007	11.1	0.020
0158397967	5/31/2007	10.1	0.040
0158397967	6/6/2007	9.7	0.040
0158397967	6/11/2007	10.5	0.040
0158397967	6/18/2007	11.6	0.040
0158397967	6/25/2007	12.1	0.040
0158397967	7/2/2007	11.1	
0158397967	7/9/2007	11.1	0.040
0158397967	7/16/2007	10.7	0.040
0158397967	7/19/2007	11.2	0.040
0158397967	8/1/2007	10.9	0.040
0158397967	8/9/2007	6.6	0.040
0158397967	8/16/2007	7.0	0.040
0158397967	8/23/2007	10.2	0.040
0158397967	8/27/2007	10.0	0.040
0158397967	9/4/2007	10.1	0.020
0158397967	9/10/2007	8.2	0.040
0158397967	9/17/2007	9.8	0.040
0158397967	9/24/2007	9.2	0.040
0158397967	10/1/2007	8.1	0.040
0158397967	10/9/2007	7.5	0.040
0158397967	10/15/2007	8.4	0.040
0158397967	10/22/2007	10.2	0.020
0158397967	10/29/2007	10.2	0.040
0158397967	11/5/2007	11.8	0.020
0158397967	11/13/2007	10.1	0.040
0158397967	11/19/2007	11.1	0.040
0158397967	11/26/2007	12.1	0.040
0158397967	12/3/2007	11.6	0.030
0158397967	12/11/2007	12.0	0.040
0158397967	12/17/2007	12.8	0.040
0158397967	12/26/2007	13.1	0.040
0158397967	1/2/2008	15.4	0.040
0158397967	1/7/2008	17.2	0.040
0158397967	1/14/2008	17.0	0.040
0158397967	1/22/2008	16.1	0.040
0158397967	1/28/2008	16.6	0.040
0158397967	2/5/2008	12.9	0.040
0158397967	2/14/2008	13.2	0.040
0158397967	2/19/2008	14.1	0.040
0158397967	2/25/2008	14.7	0.040
0158397967	3/3/2008	14.3	0.040
0158397967	3/11/2008	8.8	0.040

Station	Sampling Date	DO (mg/l)	TP (mg/l)
0158397967	3/17/2008	13.8	0.040
0158397967	3/24/2008	13.2	0.040
0158397967	3/31/2008	12.3	0.040
0158397967	4/7/2008	14.0	0.040
0158397967	4/14/2008	13.8	0.040
0158397967	4/21/2008	9.8	0.100
0158397967	4/30/2008	11.5	0.040
0158397967	5/5/2008	13.2	0.040
0158397967	5/15/2008	12.0	0.040
0158397967	5/19/2008	12.0	0.040
0158397967	5/28/2008	12.0	0.040
0158397967	6/2/2008	10.5	0.040
0158397967	6/9/2008	9.2	0.040
0158397967	6/13/2008	10.1	0.020
0158397967	6/23/2008	10.9	0.040
0158397967	6/30/2008	10.0	0.040