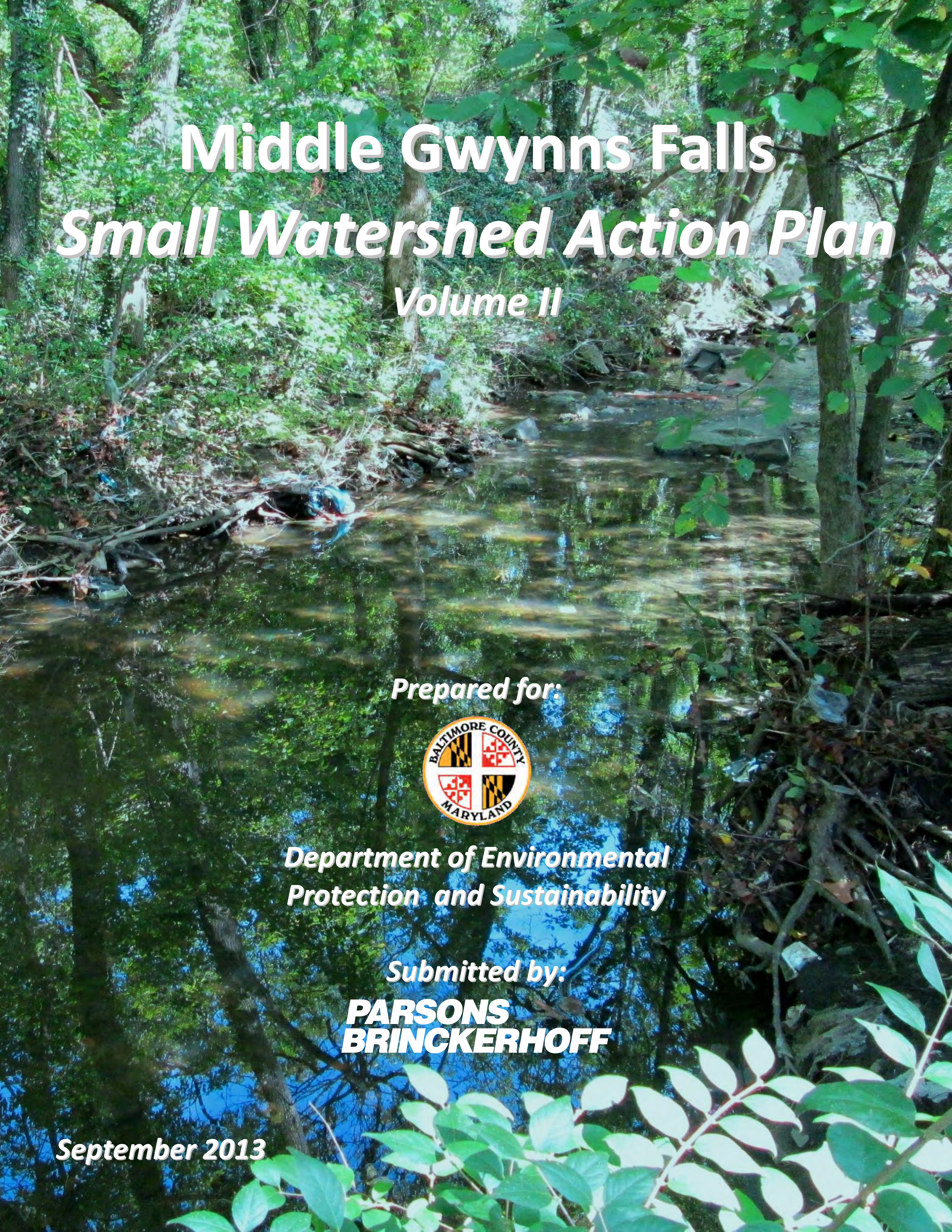


Middle Gwynns Falls
Small Watershed Action Plan
Volume II

Prepared for:

BALTIMORE COUNTY
MARYLAND

Department of Environmental Protection and Sustainability

Submitted by:

PARSONS BRINCKERHOFF

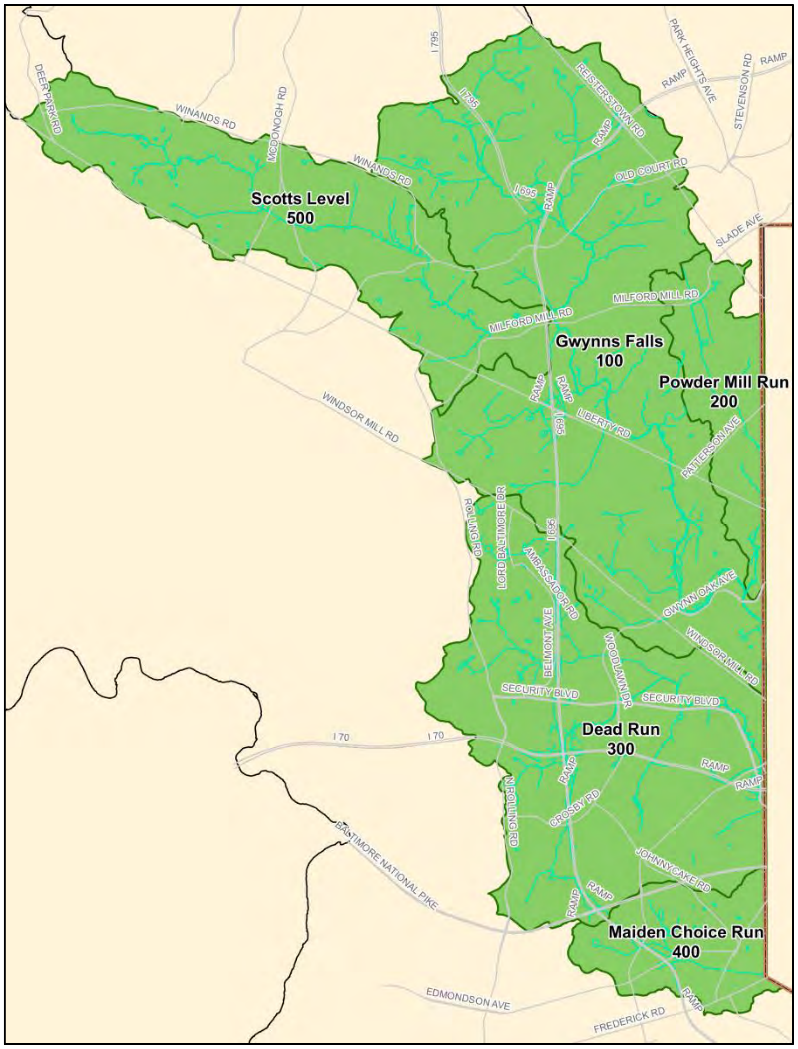
September 2013

APPENDIX E:

Middle Gwynns Falls Watershed Characterization Report

(PB 2013)

Middle Gwynns Falls
Watershed Characterization Report



Prepared for:

Department of Environmental Protection & Sustainability

Prepared by:

PARSONS BRINCKERHOFF

September 2013

FINAL

Table of Contents

Appendix A: SWM Facility Assessment Data

Appendix B: Uplands Survey Data

Appendix C: Supporting Calculations for NSA Analysis

List of Figures

List of Tables

CHAPTER 1: INTRODUCTION

1.1 Purpose

The purpose of the Middle Gwynns Falls Watershed Characterization Report is to:

1. Summarize the factors that may affect the water quality of the Middle Gwynns Falls watershed such as landscape, geomorphology, hydrology, and biological characteristics;
2. Explain the current conditions of the Middle Gwynns Falls watershed and its natural resources;
3. Describe human impacts on the watershed such as development and land use; and
4. Identify restoration and preservation strategies appropriate for accomplishing watershed goals.
5. Consider Environmental Justice concerns while working to improve water quality.

The observations and conclusions presented in this watershed characterization report will be used to develop a Small Watershed Action Plan (SWAP) for the Middle Gwynns Falls watershed planning area.

1.2 Watershed Location and Scale

The Gwynns Falls watershed is located in the Piedmont physiographic province of Maryland and encompasses portions of Baltimore County and Baltimore City. Only the portion of the watershed that resides within Baltimore County that is south of the confluence of Horsehead Branch and the main stem of the Gwynns Falls is addressed in this SWAP and herein will be simply referred to as the Middle Gwynns Falls watershed (see Figure 1-1). The Middle Gwynns Falls watershed planning area has an extent of approximately 14,881 acres (23.3 square miles). The watershed drains to the Patapsco River and the Chesapeake Bay. It is bordered to the East by Baltimore City and to the South and West by the Patapsco River watershed. The northern boundary of the Middle Gwynns Falls watershed is bordered by the Liberty Reservoir, Upper Gwynns Falls, and Jones Falls watersheds.

The Middle Gwynns Falls watershed was subdivided into smaller drainage areas or subwatersheds, which are listed in Table 1-1 along with respective acreages. In addition to characterizing the entire planning area, analyses were conducted on a subwatershed scale to provide detailed information for smaller areas and to focus restoration and preservation efforts. Also, success of restoration efforts can be more easily monitored and measured on this smaller scale. Figure 1-2 shows the 5 subwatersheds comprising the Middle Gwynns Falls watershed. Methods for the delineation of the watersheds and subwatersheds are described in further detail in Chapter 2.

Table 1-1: Middle Gwynns Falls Subwatershed Areas

Subwatershed	Area (Acres)	Area (Sq Miles)
Gwynns Falls	6,165	9.63
Powder Mill Run	958	1.50
Dead Run	4,177	6.53
Maiden Choice Run	928	1.45
Scotts Level	2,653	4.15
Total	***14,881***	***23.25***

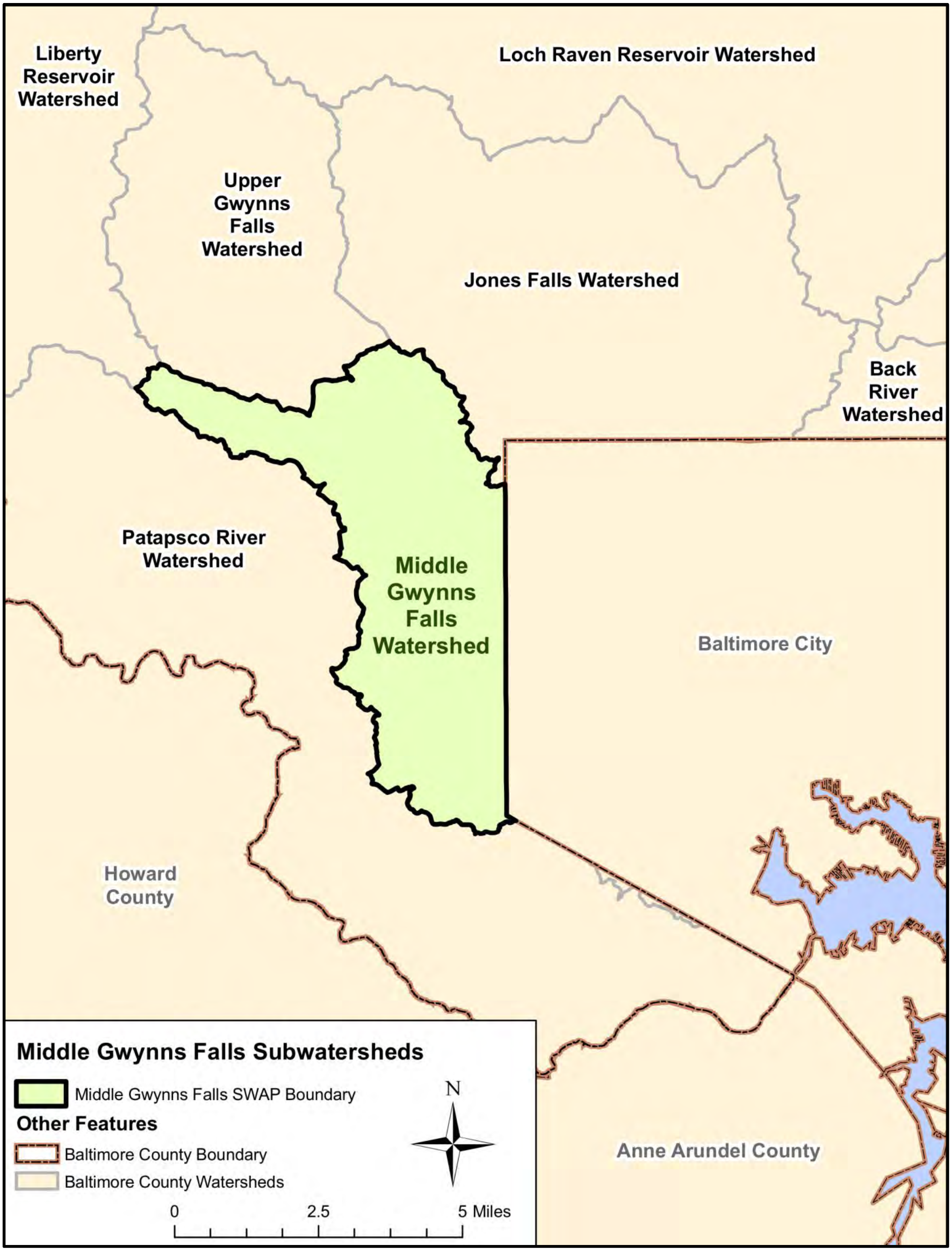


Figure 1-1: Location of Middle Gwynns Falls Watershed

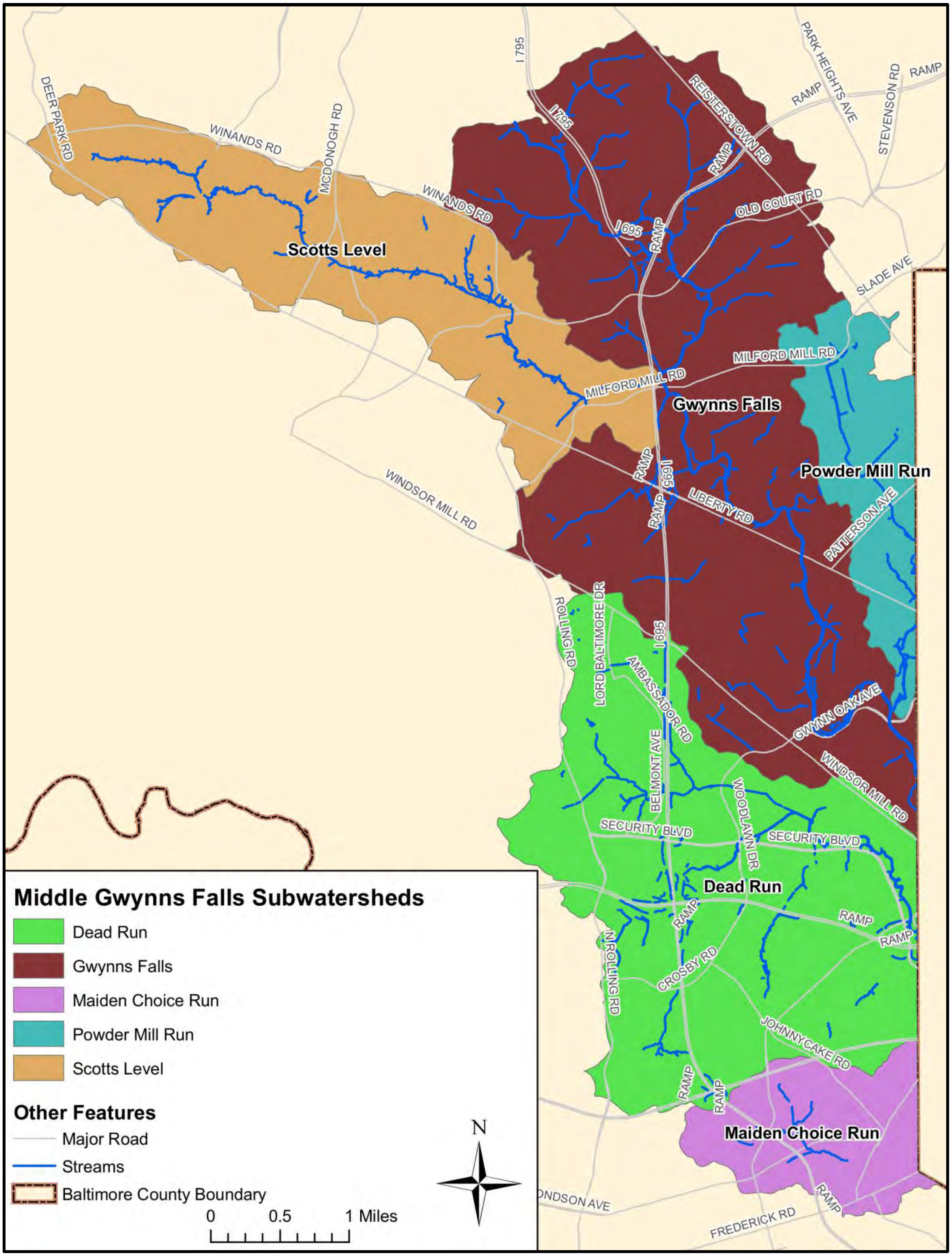


Figure 1-2: Middle Gwynns Falls Subwatersheds

1.3 Report Organization

The Middle Gwynns Falls Watershed Characterization report is organized into the following six chapters:

Chapter 1 – Explains the purpose of the report and the location and scope of the watershed characterization.

Chapter 2 – Summarizes characteristics related to landscape and land use that may affect natural resources and water quality in the Middle Gwynns Falls watershed. This chapter contains landscape information related to natural features such as geology, topography, soils, forest cover, and streams. Information pertaining to human influence on landscape is also discussed, including land use, population, impervious cover amount, water distribution and stormwater infrastructure.

Chapter 3 – Discusses water quality and quantity conditions in the watershed based on available monitoring data.

Chapter 4 – Describes the upland assessments conducted to identify pollutant sources and restoration opportunities for three assessment categories: neighborhoods, institutions, and hotspots. This section also includes a summary of the stream stability, forest, and stormwater management assessments conducted as part of the *Gwynns Falls Water Quality Management Plan*.

Chapter 5 – Presents restoration and preservation strategies appropriate for accomplishing watershed goals developed by the community and the Middle Gwynns Falls Steering Committee.

Chapter 6 – Lists the references consulted during the development of this report.

CHAPTER 2: LANDSCAPE AND LAND USE

2.1 Introduction

This chapter discusses land cover and land use in the Middle Gwynns Falls watershed, describing characteristics of both the natural land surface as well as development activities taking place within the watersheds. Natural characteristics, such as soil type, and development related features, such as impervious cover, strongly influence the quantity and quality of watershed runoff. For example, the infiltration capacity of soils on pervious ground affects the amount and rate at which precipitation will be absorbed into the ground surface; impervious surfaces such as buildings and paved areas impede rainfall infiltration, which can lead to flooding, erosion, and eventually decrease in groundwater supply. In addition, the type and extent of pollutants carried by stormwater is affected by land use characteristics. Residential or agricultural areas may contribute fertilizers and pesticides to stormwater runoff. Depending on the land use activities taking place, developed areas may transmit pollutants such as trash, bacteria from livestock and pet waste, and chemicals directly to receiving water bodies because there is often inadequate vegetative buffer to filter out the pollutants before the runoff reaches the water. The information presented in this chapter provides the physical setting and background necessary to evaluate other watershed elements including water quality, natural resources, restoration and management.

2.2 Natural Landscape

Natural land surface characteristics relevant to watershed properties and processes are described in the following sections. These topics include climate, watershed delineation, topography, geology, soil properties, forest cover, and streams.

2.2.1 Climate

Climate is an important consideration because it can influence soil and erosion processes, stream flow patterns, and topography. Climate also affects vegetative growth and determines the species composition of terrestrial and aquatic life of a region. In addition, rainfall patterns are an important component of the hydrology of a watershed and can affect watershed management strategies.

The Middle Gwynns Falls region can be described as a humid continental climate with four distinct seasons. It has a relatively temperate climate due to the combined effects of the Appalachian Mountains to the West and the Chesapeake Bay and Atlantic Ocean to the East. According to the National Climatic Data Center (NCDC), the region is also in the path of low pressure systems that move across the country resulting in frequent changes in wind direction and weather (NOAA). Average annual rainfall in Baltimore, Maryland is 41.88 inches based on 141 years of data (1871-2011) (NOAA, 2012). Rainfall is uniformly distributed throughout the year, with monthly averages ranging from 3.05 inches for January to 4.03 inches for September. Most snowfall occurs in December, January, February and March, with an average annual snowfall of 20.1 inches based on 128 years of data (1883-2011) (NOAA, 2011).

2.2.2 Watershed Delineation

A watershed-based approach for evaluating water quality conditions and improvement potential involves determining the drainage areas that contribute runoff and groundwater to a specific water body. Drainage areas vary greatly in size depending on the scale of the stream system of interest. Drainage areas for large river, estuary, and lake systems are typically on the order of several thousand square miles and are often referred to as basins. For example, the Chesapeake Bay basin covers over 64,000 square miles, including over 100,000 rivers and streams and portions of six different states(CBP, 2008). Basins consist of sub-basins which refer to drainage areas on the order of several hundred square miles and may consist of one or more major stream networks. Maryland has 13 sub-basins including the Patapsco/Back River sub-basin. Sub-basins are further subdivided into watersheds and then subwatersheds which are the most commonly used and practical hydrologic units for management and restoration purposes. There are 138 state-defined watersheds (called 8-digit watersheds) in Maryland, ranging in size from 20 to 100 square miles, and these are comprised of over 1,100 subwatersheds (called 12-digit watersheds) identified by Maryland Department of Natural Resources (DNR); a subwatershed refers to the drainage area of a specific stream and typically covers 10 square miles or less (DNR, 2005).

There are 14 state-defined, 8-digit watersheds in Baltimore County. The 8-digit Gwynns Falls watershed (02-13-09-05) is approximately 66 square miles and encompasses portions of Baltimore County and Baltimore City. The portion of the Gwynns Falls 8-digit watershed located in the County comprising the Middle Gwynns Falls watershed is approximately 23 square miles (14,881 acres). For planning and management purposes, the Middle Gwynns Falls watershed has been further subdivided into 5 subwatersheds by Baltimore County, as illustrated in Figure 1-2. Watershed delineations were provided by the Baltimore County Office of Information Technology (OIT) via spatial data based on 1998 Maryland state-defined 8-digit and 12-digit watershed information. A study for the upper portion of the Gwynns Falls watershed was completed by Baltimore County in 2011.

2.2.3 Topography

The topography of a region describes the shape of the land including locations and elevations of surface features such as ridges and valleys. Land shape characteristics such as steepness affect the direction and magnitude of surface water flows, degree of soil erosion, and suitability for development. Land surface topography has importance in water quality because steeper slopes are more prone to overland flow and soil erosion, which means that these areas have a greater potential to generate pollutants in runoff. Soil slope data for the Middle Gwynns Falls watershed was obtained from the Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database (USDA, 2010) and divided into the following four slope ranges which were derived from slope classification definitions in the U.S Department of Agriculture (USDA) *Soil Survey Manual* (USDA, 1993).

- Nearly Level (0 to 5% slopes)
- Gently sloping, undulating (2 to 10% slopes)
- Strongly sloping, rolling (4 to 16% slopes)

- Moderately steep, hilly (10 to 45% slopes)

Table 2-1 provides a summary of the percent breakdown of soil slopes by watershed. The majority of Middle Gwynns Falls watershed is relatively flat, with over 79% being nearly level and 8.8% gently sloping. Less than 3% of the entire area has moderately steep slopes. Based on the soil slope alone, the Middle Gwynns Falls planning area is not very prone to erosion by overland flow; however, degree of erosion is also dependent on soil type and land use/land cover. The subwatershed with the flattest topography is Scotts Level, with 88% nearly level land. The Gwynns Falls and Maiden Choice Run subwatersheds are the only areas with a significant amount of strongly sloping topography at 13.7% and 21.1%, respectively. Gwynns Falls subwatershed has the largest percentage of moderately steep, hilly topography with 4.8%. Figure 2-1 illustrates the distribution of the slope ranges within the Middle Gwynns Falls watershed.

Table 2-1: Middle Gwynns Falls Slope Classification by Subwatershed

	SLOPE CATEGORY %			
Subwatershed	**Nearly Level* (0-5%)**	**Gently sloping, undulating (2-10%)**	**Strongly sloping, rolling (4-16%)**	**Moderately steep, hilly (10-45%)**
Gwynns Falls	73.0	8.5	13.7	4.8
Powder Mill Run	85.6	7.0	5.6	1.8
Dead Run	86.8	5.5	6.6	1.1
Maiden Choice Run	53.4	25.5	21.1	0.0
Scotts Level	87.6	9.6	2.6	0.2
Total	***79.1***	***8.8***	***9.7***	***2.4***

* Includes Water features shown in Figure 2-1.

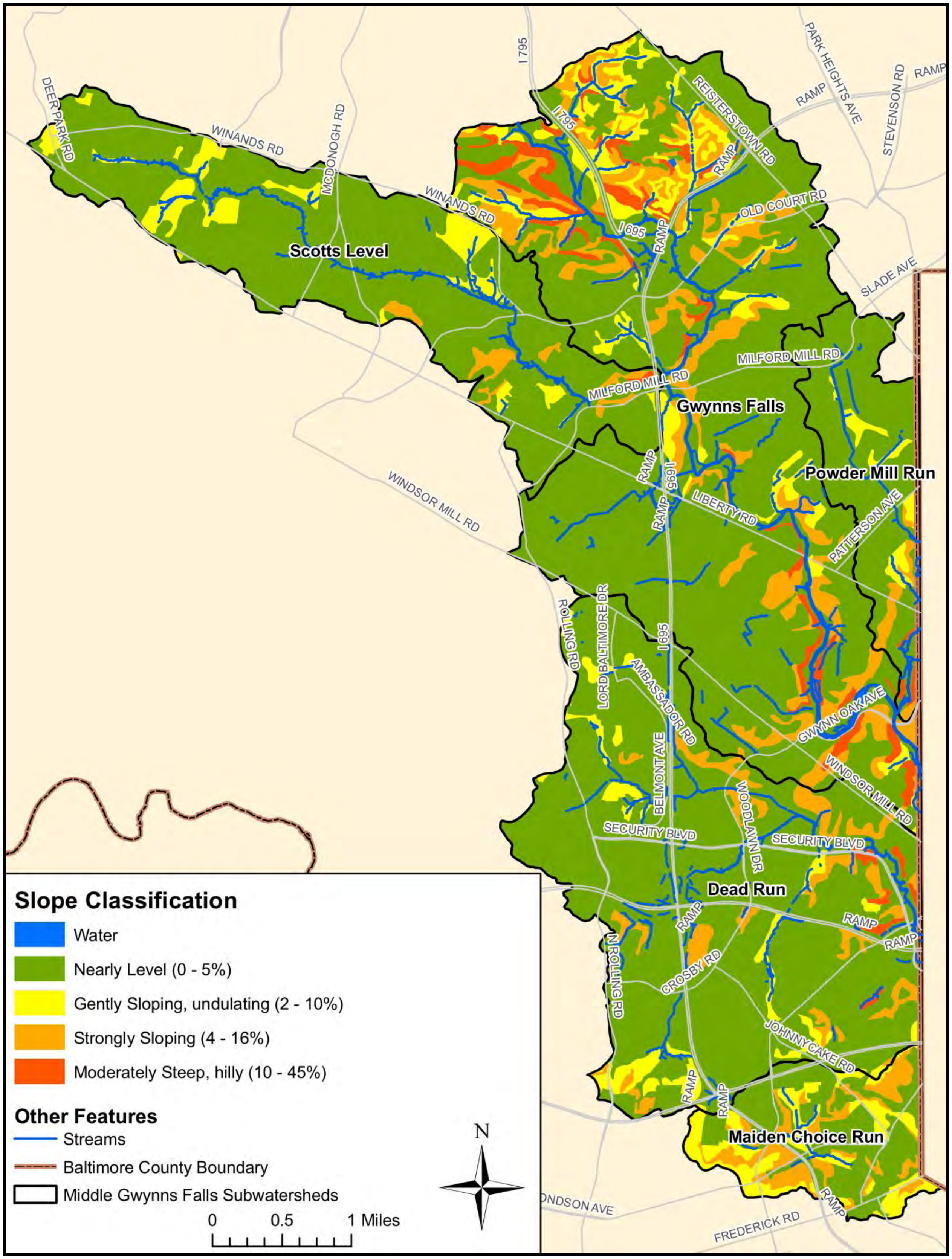


Figure 2-1: Middle Gwynns Falls Topography based on Soil Slopes

2.2.4 Geology

The geology of an area affects the chemical composition of surface water and groundwater, as well as groundwater and well recharge rates. It is also relevant to soil formation and influences the buffering of pollutants to water bodies in developed areas. Consequently, geology often has a close correlation to water quality.

The Middle Gwynns Falls watershed is located in the Uplands Section of the Piedmont Plateau Province of Maryland. Soils in this region consists of very deep, moderately sloping, well drained upland soils.The dominant piedmont soils in the Baltimore area consist of Ultic Hapludalfs. Highly disturbed soils make up more than 60 percent of the land area of urbanized areas of the watershed (MGS, 2009). Nearly 95% of the surficial geology in the study area is comprised primarily of old metamorphic rock such as Mt. Washington Amphibolite, Hollofield Layered Ultramafite, and the Oella Formation (MGS, 2009).

The Legore-Montalto and the Mount Lucas soil associations dominate the watershed, commonly in the Urban Land Complex form. These natural soils in the area range from well drained to poorly drained in the Urban Land Complex form. The “Urban Land Complex” designates areas consisting of soils that have mostly been cut, filled or graded for land development. Therefore, groundwater recharge rates are generally poorer in developed areas where the natural infiltration rates of the soils have been decreased through urban fill and compaction. As such, the geology is closely correlated with water quality, and affects the buffering of pollution to stream systems in developed areas.

2.2.5 Soils

Soil characteristics are an important consideration when evaluating water quantity and quality in streams and rivers. Soil type and moisture content, for example, impact how land may be used and its potential for vegetation and habitat. Soil conditions are also evaluated for projects aimed at improving water quality and/or habitat.

Soils data including hydrologic soil groups and soil erodibility for the Middle Gwynns Falls watershed was obtained from spatial data provided by the NRCS SSURGO database (USDA, 2010).

2.2.5.1 Hydrologic Soil Groups

The NRCS classifies soils into four hydrologic soil groups (HSG) based on their runoff potential and infiltration rates. Infiltration rate can be described as the ability of a soil to absorb precipitation. Runoff potential can be described as just the opposite of infiltration rate. Soils with high runoff potential have low infiltration capacity and tend to cause overland flow instead of allowing runoff to infiltrate. Infiltration rates are highly variable among soil types and are also influenced by disturbances to the soil profile such as land development activities. For example, urbanization on land composed of high infiltration soils (such as sands and gravels) will greatly increase runoff; whereas development on land composed of low infiltration soils such as silts and clays will have less of an impact on runoff.

The four hydrologic soil groups range from A to D, from lowest runoff potential to highest, respectively. Brief descriptions of each hydrologic soil group are provided below. Further explanation can be found in the USDA/NRCS publication, *Urban Hydrology for Small Watersheds, Technical Release 55*(USDA, 1986).

- **Group A** soils include sand, loamy sand, or sandy loam types. These soils have a high infiltration rate and low runoff potential even when thoroughly wet. This type of soil consists mainly of deep, well to excessively drained sands and gravels. These soils have a high rate of water transmission.
- **Group B** soils include silt loam and loam types. They have a moderate infiltration rate when thoroughly wet. These soils mainly consist of somewhat deep to deep, moderately well to well drained soils with moderately fine texture to moderately coarse texture. This type of soil has a moderate rate of water transmission.
- **Group C** soils are sandy clay loam. These soils have a low infiltration rate when thoroughly wet. These types of soils typically have a layer that hinders downward movement of water. This type of soil is moderately fine texture or fine texture, and has a low rate of water transmission.
- **Group D** soils include clay loam, silt clay loam, sandy clay, silty clay, or clay types. These soils have a very low infiltration rate and high runoff potential when thoroughly wet. These consist mainly of clays with high swell potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission.

As shown in Table 2-2 and Figure 2-2, over 71% of soils in the Middle Gwynns Falls planning area fall into hydrologic soil groups C and D, which have low to very low infiltration rates and therefore, relatively high runoff potential. Scotts Level and Maiden Choice Run subwatersheds have more soil in hydrologic soil groups A and B, which have higher infiltration rates and therefore, relatively low runoff potential.

Table 2-2: Middle Gwynns Falls Hydrologic Soil Groups

Subwatershed	Hydrologic Soil Group (%)				Water (%)
	A	B	C	D	
Gwynns Falls	6.3	25.9	48.7	18.9	0.2
Powder Mill Run	0.0	9.8	58.2	32.0	0.0
Dead Run	4.3	9.7	38.5	47.6	0.0
Maiden Choice Run	9.7	28.9	18.3	43.1	0.0
Scotts Level	5.4	38.1	30.0	26.5	0.0
Total	***5.4***	***22.7***	***41.2***	***30.6***	***0.1***

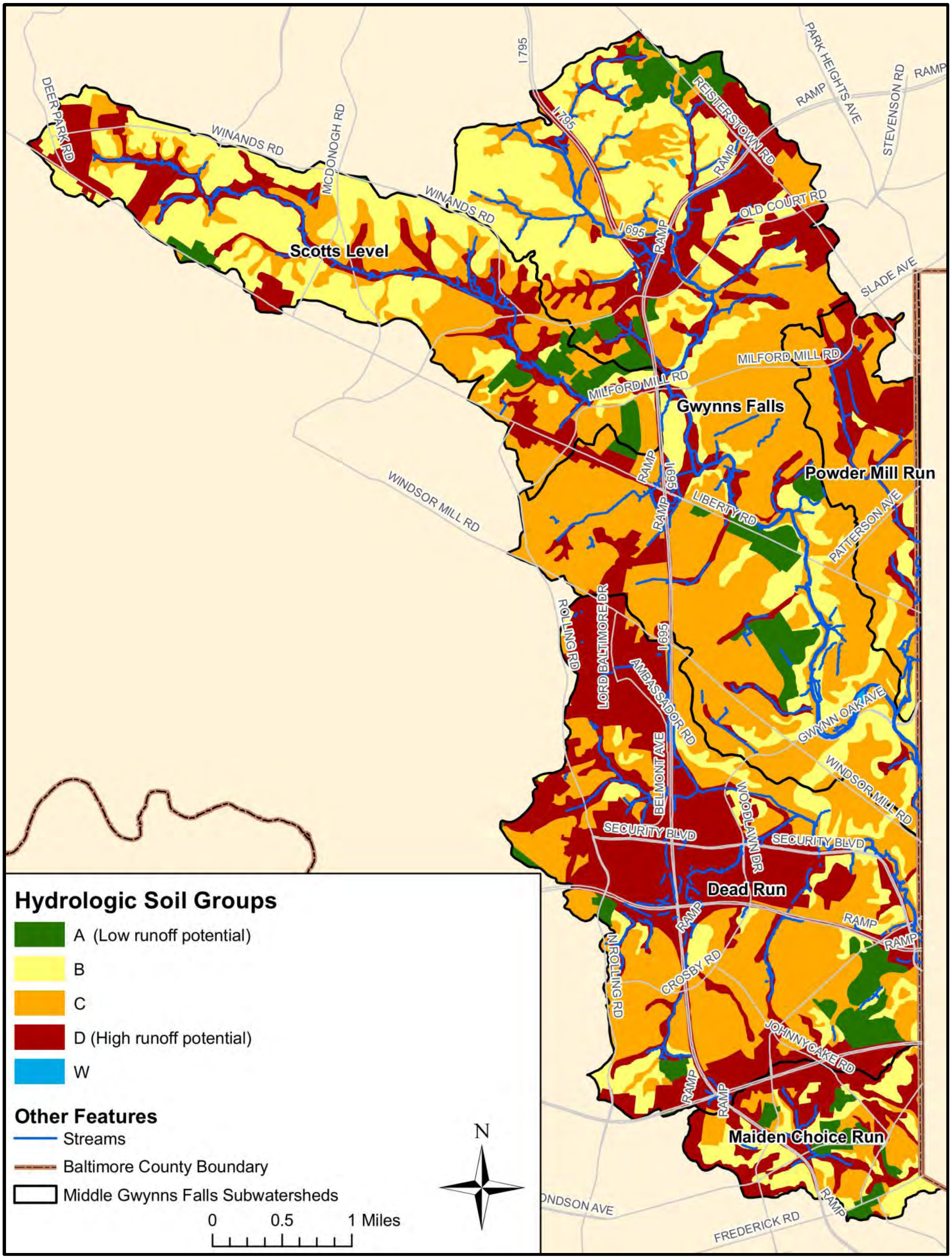


Figure 2-2: Middle Gwynns Falls Hydrologic Soil Groups

2.2.5.2 Erodibility

Erodibility is the susceptibility of soil to erosion. It is quantified by the K factor, which is used in the Universal Soil Loss Equation (USLE) developed by USDA's Agricultural Research Service to estimate rate of erosion and soil loss for a particular site. Soil erodibility is determined based on the physical and chemical properties of the soil, which represent how strongly soil particles cohere to one another. Soils with low K factors indicate low erodibility or high resistance to detachment, and soils with high K factors indicate high erodibility potential. For example, soils high in clay content are the least erodible with K values of about 0.05 to 0.15, and soils with high silt content are the most erodible with K values often greater than 0.4 (Ouyang, 2002).

Table 2-4 summarizes soil erodibility values in the Middle Gwynns Falls watershed by subwatershed. Erodibility K factors range from 0 to 0.49 and were grouped into three categories as follows:

- Low Erodibility (0 ≤ K factor ≤ 0.2);
- Medium Erodibility (0.24 ≤ K factor ≤ 0.32); and
- High Erodibility (0.37 ≤ K factor ≤ 0.49)

Table 2-3: Middle Gwynns Falls Soil Erodibility Categorization Based on K factor

	Soil Erodibility Category (%)		
Subwatershed	**Low***	**Medium**	**High**
Gwynns Falls	20.3	51.6	28.1
Powder Mill Run	27.8	49.4	22.8
Dead Run	46.6	27.9	25.5
Maiden Choice Run	36.0	32.4	31.5
Scotts Level	13.4	52.7	33.9
Total	***27.9***	***43.8***	***28.3***

* Includes Water features shown in Figure 2-4.

As shown in Table 2-3 and Figure 2-3, there is a significant presence of all three soil erodibility categories in the Middle Gwynns Falls planning area. Moderately erodible soils are more evident in Gwynns Falls, Powder Mill Run, and Scotts Level, which all have over 49% moderately erodible soils. Highly erodible soils are the least evident in Gwynns Falls, Powder Mill Run, and Dead Run (<30%). Soils within Dead Run and Maiden Choice Run have the highest percentage within the low erodibility category. Soils with low erodibility, correspond to soils with very low infiltration rates (pertaining to hydrologic soil group D). This is because most of these soils are classified as Urban Land, which over time have been graded and compacted for urban development. Areas that are relatively underdeveloped, on the other hand, are suitable for preservation of forested area especially in locations with high soil erodibility but low slopes.

Subwatersheds with larger percentages of highly erodible soils present the greatest potential for addressing soil conservation issues via best management practices (BMPs), such as minimizing bare soil and keeping topsoil in place. Soil erodibility data are also useful in combination with other information such as location of cropland, slope steepness, and distance from streams to determine where other

BMPs, such as retirement of highly erodible land, are appropriate. High K factor values also serve as a warning for planning of urban activities near streams such as road construction and utility placements.

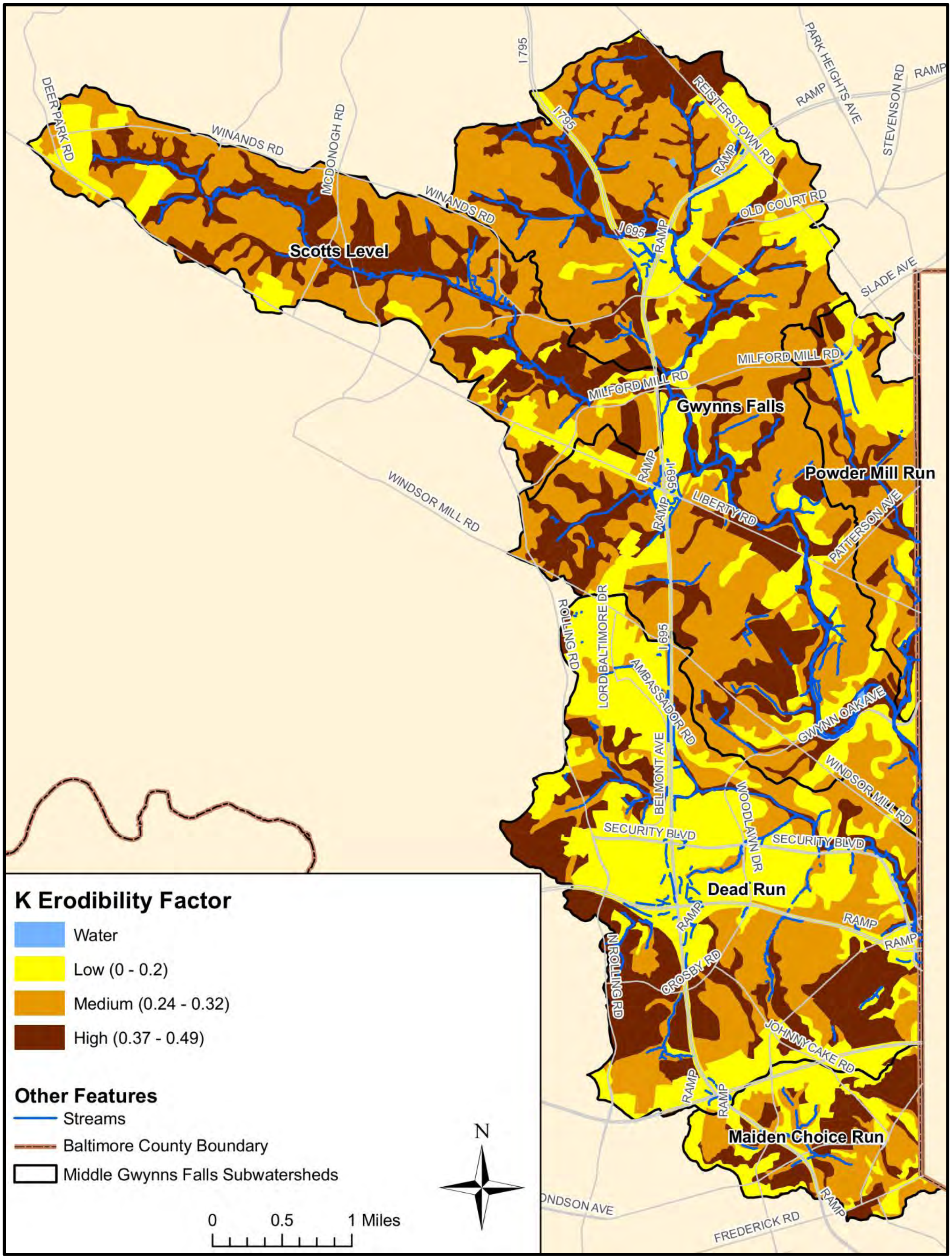


Figure 2-3: Middle Gwynns Falls Soil Erodibility Based on K factor

2.2.6 Forest Cover

Forests provide the greatest protection among land cover types for water and soil quality. In pristine systems, forest and soils co-evolve, shaping the hydrologic cycle; these systems operate within a natural range of variability, assuring healthy habitat and water quality. The Middle Gwynns Falls watershed consisted mainly of old-growth forest prior to colonial settlement, as is true for the entire Chesapeake Bay basin. Much deforestation has occurred since then; however, even in developed systems, forest cover can still provide many benefits such as reducing erosion potential and protecting water quality if carefully planned and conserved.

Forest cover data for the Middle Gwynns Falls watershed were obtained from various sources. Spatial data from Baltimore County OIT showing wooded areas delineated before 1998 were used as a base. As some of the planning area has undergone further deforestation over the years, this data was then edited based on aerial imagery provided by Baltimore County OIT as well as 2007 Urban Tree Canopy Land Cover spatial data for Baltimore County. The latter was created based on 2007 infrared aerial imagery and 2005 LiDAR data by the University of Vermont Spatial Analysis Laboratory.

Table 2-4 lists the number of acres of forest cover for each subwatershed in the Middle Gwynns Falls planning area, along with percent of the subwatershed that is forested. Figure 2-4 shows the distribution of forest cover within the planning area. The Middle Gwynns Falls watershed contains approximately 5,738 acres of forest cover, or slightly less than 40% of the planning area. This is not consistent with Maryland Department of Planning (MDP) 2010 land use/land cover classification scheme, which estimates that 12.5% of forest cover remains in the planning area. Although the parks in the Middle Gwynns Falls watershed are small, forest cover has been retained in many residential areas. These areas present a potential for forest preservation. The lowest forest cover percentage is found in Dead Run subwatershed with approximately 29.7%. This area offers a potential opportunity for reforestation.

Table 2-4: Middle Gwynns Falls Forested Area by Subwatershed

Subwatershed	Total Acres	Forested Acres	% Forested
Gwynns Falls	6,165	2679	43.4%
Powder Mill Run	958	449	46.9%
Dead Run	4,177	1240	29.7%
Maiden Choice Run	928	343	36.9%
Scotts Level	2,653	1027	38.7%
Total	***14,881***	***5,738***	***38.6%***

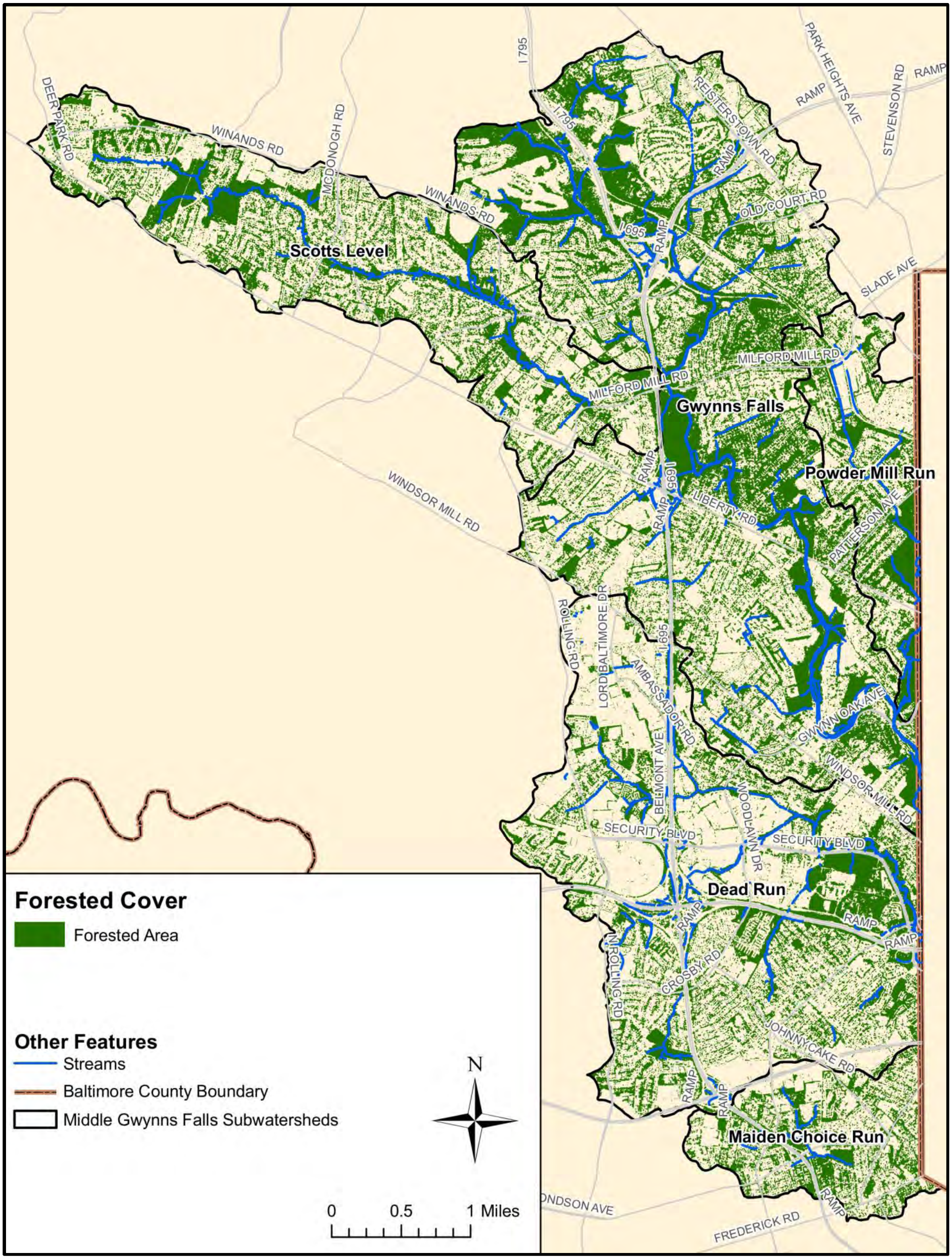


Figure 2-4: Middle Gwynns Falls Forest Cover

2.2.7 Stream Systems

All of the streams in a watershed make up its stream system. Streams are the most visible part of the hydrologic cycle. Streams are the flowing surface waters; and while they are distinct from groundwater and standing surface water such as lakes, they are closely connected to both. The stream system is an intrinsic part of the landscape and closely reflects conditions on the land. Streams are a fundamental natural resource with numerous benefits for plants, animals, and humans. Maintaining a healthy stream system is a priority for many individuals and organizations, and requires ensuring that stream flows and water quality closely mimic the conditions found in un-impacted watersheds.

2.2.7.1 Stream System Characteristics

The subwatersheds with the most stream miles include Gwynns Falls and Dead Run. These two subwatersheds compromise nearly 74% of all stream miles in the planning area. Gwynns Falls alone contains over 39 miles of stream, constituting over half of all stream miles in the planning area. The above subwatersheds may represent a priority for stream preservation, whereas streams in more urbanized areas may present a priority for stream restoration opportunities.

The Middle Gwynns Falls watershed was divided into smaller series of subwatersheds. Subwatersheds were based on the drainage areas contributing to major creeks and rivers as well as geographic/property considerations within the watershed. Baltimore County delineated five subwatersheds for Middle Gwynns Falls. Figure 2-5 shows the system of streams and subwatersheds comprising the Middle Gwynns Falls watershed. Table 2-5 summarizes number of stream miles in each subwatershed along with stream density, defined as miles of stream per square mile of subwatershed area. Comparing the stream density of each subwatershed gives an indication of how much the streams have been altered, especially headwater streams. Headwater streams are the smaller tributaries that carry water from the upper reaches of the watershed to the main channel. As an area becomes urbanized, headwater streams are oftern filled in or incorporated into storm sewer systems (i.e. piped). This alters the hydrologic connectivity and physical habitat of the the headwater streams and consequently, the watershed as a whole. Comparing the stream densities of each watershed in Table 2-5 with the land uses in Table 2-7 shows a close correlation between stream density and percent cover of forest, high density residential, commercial, and industrial land use.

There are nearly 78 miles of stream in the planning area, all of which eventually drain to the Chesapeake Bay. Stream data for the planning area are provided by Baltimore County Office OIT based on the hydrology lines captured from 3D compilation processes using imagery captured in 2005.

Table 2-5: Middle Gwynns Falls Stream Mileage and Density

Subwatershed	Area (Sq Miles)	Stream Miles	Stream Density (mi./sq. mi.)
Gwynns Falls	9.63	39.74	4.13
Powder Mill Run	1.50	6.04	4.04
Dead Run	6.53	18.18	2.78
Maiden Choice Run	1.45	1.68	1.16
Scotts Level	4.15	12.27	2.96
Total	***23.3***	***77.9***	***3.4***

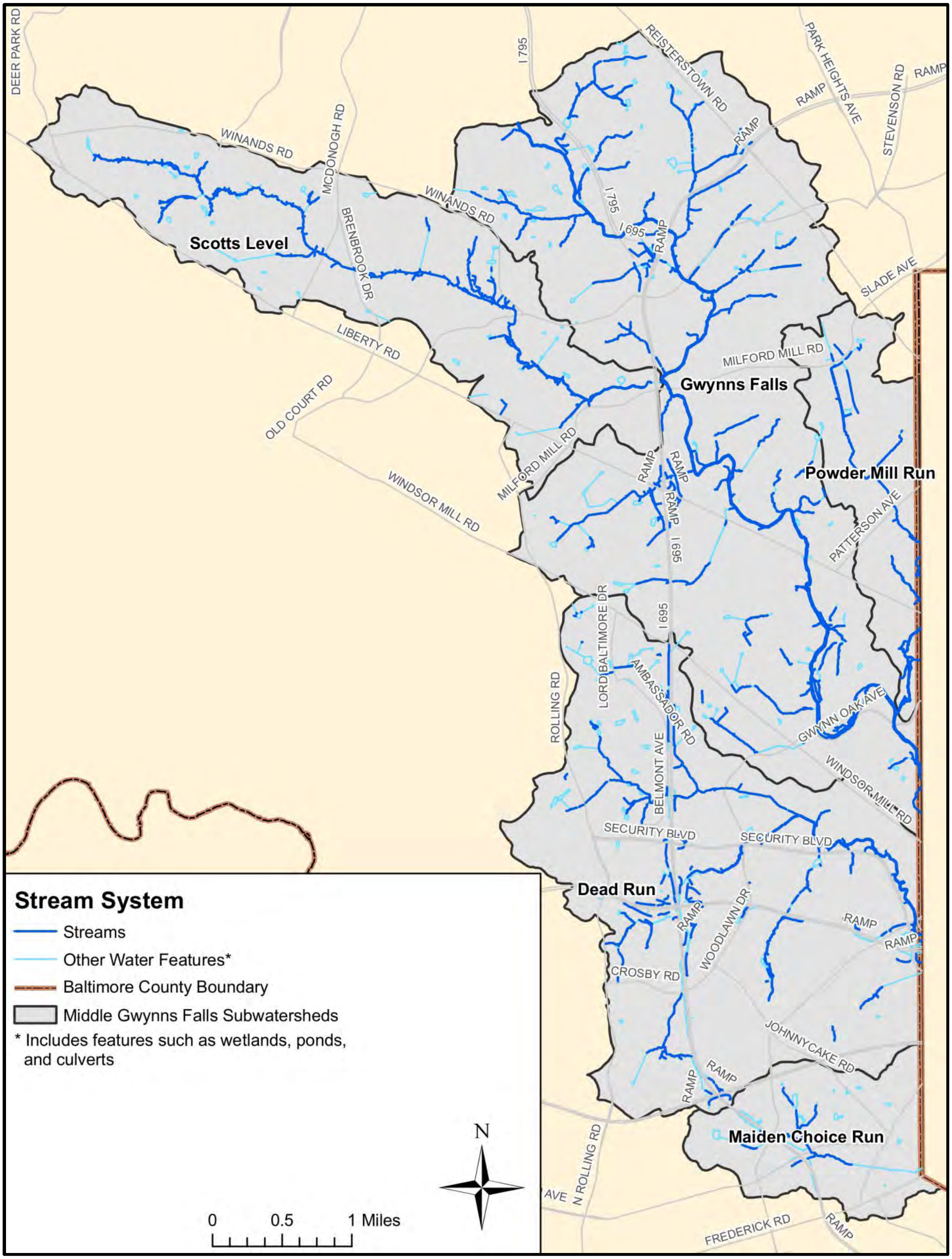


Figure 2-5: Middle Gwynns Falls Stream System

2.2.7.2 Stream Riparian Buffers

Riparian buffers refer to the vegetated areas adjacent to streams and other water bodies that protect them from pollutant loads while also providing bank stabilization and habitat. Forested buffer areas along streams play a crucial role in improving water quality and flood mitigation since they can intercept and reduce surface runoff, stabilize stream banks, trap sediment, and provide habitat for various types of terrestrial and aquatic life. For example, tree roots capture and remove pollutants including excess nutrients such as nitrogen from shallow flowing water; the tree root structure also holds soil together to reduce erosion potential, and slows water flow which reduces sediment load and risk of flooding. Tree canopies provide shading that helps to keep cooler water temperatures preferred by many aquatic organisms, particularly cold-water species like trout. In smaller streams, terrestrial plant material falling into the stream is the primary source of food for stream life. While leaves provide seasonal food for stream life at the base of the food chain, fallen tree branches and trunks provide a more consistent, slow-release food source throughout the year. Tree roots and snags also offer habitat and spawning areas for fish and other aquatic species.

Maintaining healthy streams and forest buffers are important for reducing nutrient and sediment loads to the Middle Gwynns Falls watershed, and thus to the Chesapeake Bay. When stream riparian buffers are converted from forest to agriculture or urban development, many of these benefits are lost and stream health declines. Riparian buffer zones can be re-established or preserved as a BMP to reduce land use impacts by intercepting and controlling pollutants entering a water body.

The condition of stream riparian buffers in the Middle Gwynns Falls watershed was analyzed based on a 100-foot buffer on both sides of all streams. It should be noted that this 100-foot buffer is different that the regulated “forest buffer” mentioned in Article 33, Title 3 of the the Baltimore County Code. The regulated forest buffer is used primarily as a setback when delelopment is to occur near a stream.The condition of the riparian buffer was classified using three categories: impervious, open pervious, or forest. The stream data described in the previous section were used as a base to create the 100-foot buffer. First, road and building data and the urban tree canopy data were overlaid on the 100-foot buffer area to obtain the impervious and forested area lying within the buffer zone. Remaining areas that were not impervious or forested were classified as open pervious. Table 2-6 summarizes stream riparian buffer conditions by subwatershed, and the distribution is shown in Figure 2-6.

Table 2-6: Middle Gwynns Falls Land Cover in the 100-ft Stream Buffer

	IMPERVIOUS		OPEN PERVIOUS		FOREST			
Subwatershed	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Total Acres**	**Total % of Watershed**
Gwynns Falls	71.3	8.8%	201.8	25.0%	533.4	66.1%	806.4	49.4%
Powder Mill Run	9.6	8.3%	25.4	21.9%	80.8	69.7%	115.9	7.1%
Dead Run	100.7	23.9%	105.6	25.0%	215.6	51.1%	421.9	25.9%
Maiden Choice Run	8.0	17.6%	9.5	20.9%	28.0	61.5%	45.5	2.8%
Scotts Level	14.8	6.1%	41.4	17.2%	185.0	76.7%	241.1	14.8%
Total	***204.4***	***12.5%***	***383.7***	***23.5%***	***1042.7***	***63.9%***	***1630.9***	***100.0%***

The largest percentage of the riparian buffer falls under forest (approximately 63.9%), which is an important area to protect and maintain. In comparison, Total impervious areas within the stream riparian buffer zones are relatively low at approximately 12.5% for the planning area. Dead Run subwatershed has the highest percentage and acreage of impervious area in the buffer zone, at approximately 23.9% and 100.7 acres, respectively. This area may present potential opportunities for impervious cover removal or buffer establishment. The subwatershed with the highest open pervious acreage in the buffer zone is Gwynns Falls and may have potential for reforestation.

The subwatershed with the highest acreage of forested riparian buffer is Gwynns Falls with approximately 533 acres. This area may present potential preservation opportunities. It is also noteworthy that Maiden Choice Run and Scotts Level have significant residential development and high percentages of forested buffer, ranging from approximately 61% to 76%. It appears that stream riparian buffers are relatively well maintained in these areas despite the urbanization, which also offers preservation and public education opportunities.

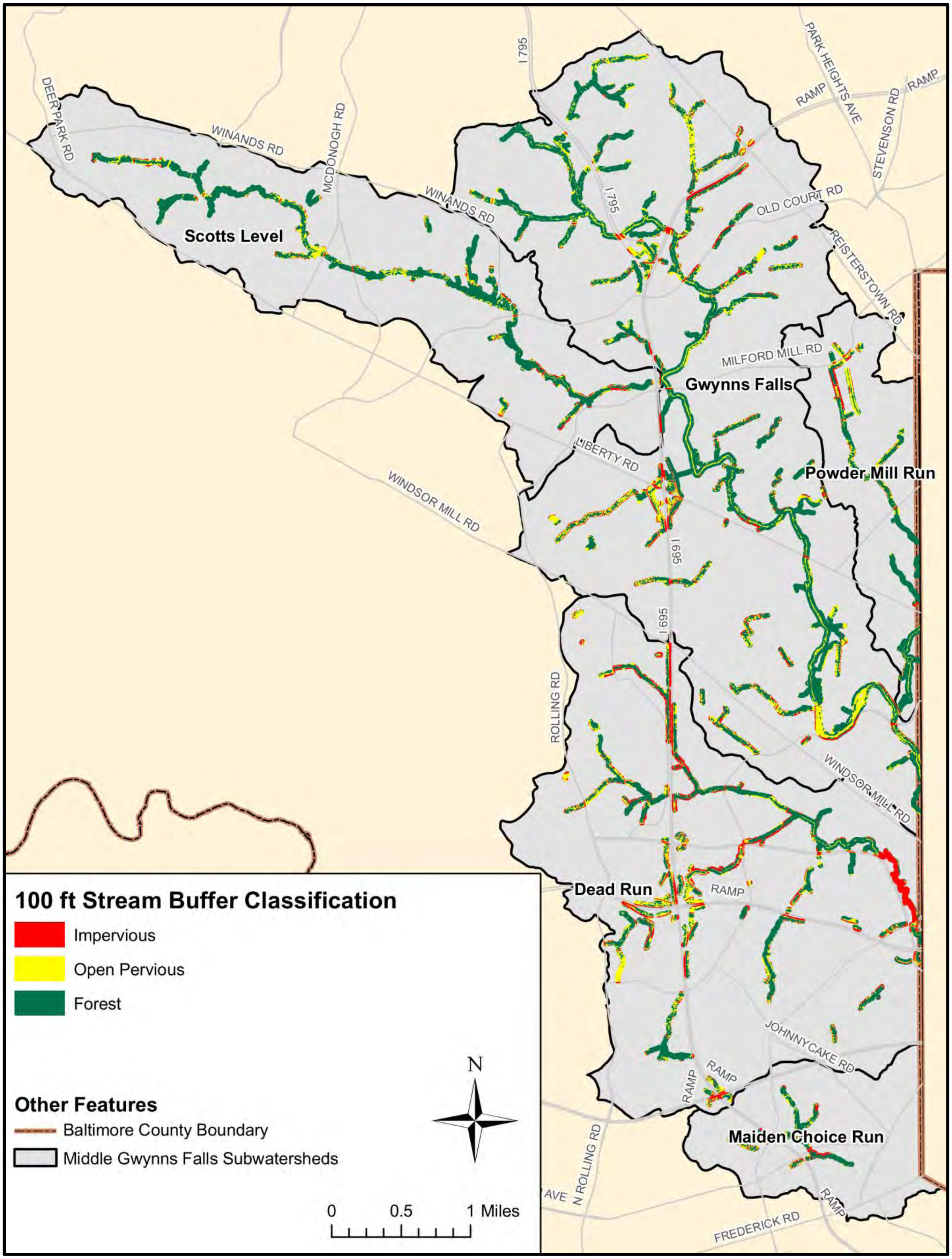


Figure 2-6: Middle Gwynns Falls 100-ft Stream Buffer Condition

2.3 The Human Modified Landscape

Human activities have altered the natural landscape over time through the use of land and water resources. The intensity of development activities has increased since the colonization of Maryland in the 1600s, which has resulted in environmental impacts to both terrestrial and aquatic ecosystems. This section describes the characteristics of the human modified landscape and how it is associated with impacts to the natural ecosystem of the Middle Gwynns Falls watershed. This includes a description of land use and land cover, population, impervious cover, drinking water and wastewater, stormwater systems, discharge permits, and zoning.

2.3.1 Land Use and Land Cover

Land use represents the types of human activities taking place within a watershed and has pronounced impacts on water quality and habitat. The extent of these impacts, including types and amounts of pollutants generated, varies depending on the types of land uses that are present in the watershed. As discussed previously, a forested watershed has the ability to absorb pollutants such as sediment and nutrients and reduce the flow rate of runoff into streams. Developed areas have impervious surfaces that block the natural seepage of precipitation into the ground. These impervious surfaces include roads, parking lots, roofs and other human constructions. Unlike most natural surfaces, impervious surfaces tend to concentrate stormwater runoff, accelerate flow rates, and direct stormwater to the nearest stream. This behavior can cause bank erosion and destruction of in-stream and riparian habitat of the receiving water body. Undeveloped watersheds and those with smaller amounts of impervious surfaces tend to have better water quality in local streams than developed watersheds with larger amounts of impervious surfaces. In addition, agricultural land can contribute to increases in nutrients and coliform bacteria in streams if not properly managed.

MDP develops statewide land use/land cover spatial data to provide a general overview of predominant land cover and usage, and to monitor development activities throughout the state. The land use/land cover delineations are based on high altitude aerial photography and satellite imagery. In this report, land use analyses were performed using 2010 MDP land use spatial data provided by Baltimore County OIT. This data was originally based on the 2007 National Agriculture Imagry Program (NAIP) aerial imagery and parcel information from Maryland Property View 2008. Table 2-7 summarizes land use categories in the Middle Gwynns Falls watershed and their percent composition in each subwatershed. Figure 2-7 illustrates the land use/land cover distribution in the planning area.

Predominate land use types present within the Middle Gwynns Falls planning area are medium and high density residential (approximately 8,595 acres or 57% of total area). As per 2010 MDP, forested areas cover approximately 12.5% of the Middle Gwynns Falls watershed. It should be noted that the 2010 MDP land use/land cover classification scheme has a mimimum mapping area of 5 acres. Due to the fact that there are many forested areas less than 5 acres, a much smaller estimate of total forest cover versus estimates using a smaller scale occurs. As per the 2010 MDP, over 87% of the Middle Gwynns Falls watershed is developed by residential, commercial, industrial, institutional, or transportation land uses. Residential areas were subdivided into four subcategories based on density; very low density (5 to 20-acre lots); low density (1/2 to 5-acre lots); medium density (1/8 to 1/2-acre lots); and high density (less than 1/8-acre lots). Medium and high density residential subcategories make up the majority of residential areas within the planning area (approximately 95%). Subwatersheds with the highest percentages of residential areas include Maiden Choice Run and Scotts Level. Residential areas present an opportunity for community involvement in restoration efforts, neighborhood pollutant source control, and environmental stewardship.

Other urban land uses including commercial, institutional, industrial, open urban land, and transportation also make up a significant portion of the planning area (approximately 3927 acres or 26% of total area). The majority of commercial land use is in the Dead Run subwatershed. Institutional areas such as community centers, schools, churches, medical facilities, and government offices comprise about 6% of the total area and may present opportunities to initiate environmentally sensitive management of the property and to promote environmental awareness education. Other land use include agricultural, which comprises approximately 0.2% of the planning area, and may indicate likely sources of nutrient loading into the river.

Table 2-7: Middle Gwynns Falls Land Use/Land Cover Classification (%)

Land Use Type	Gwynns Falls	Powder Mill Run	Dead Run	Maiden Choice Run	Scotts Level	*Total % of SWAP AREA*
Very Low Density Residential	1.3	0.0	0.0	0.3	0.2	0.6%
Low Density Residential	3.7	2.3	2.0	3.2	0.8	2.6%
Medium Density Residential	44.9	52.5	23.8	50.7	60.0	42.5%
High Density Residential	12.8	13.3	20.4	20.5	11.7	15.2%
Commercial	5.3	3.5	14.0	12.0	6.5	8.3%
Industrial	0.5	2.9	11.1	0.4	0.0	3.5%
Institutional	5.0	5.3	9.9	3.6	5.6	6.4%
Open Urban Land	6.9	1.4	5.5	3.1	2.9	5.2%
Agriculture - Cropland	0.0	0.0	0.0	0.0	0.0*	0.0%
Agriculture - Pasture	0.4	0.0	0.0	0.0	0.0	0.2%
Deciduous Forest	14.6	14.3	7.3	3.1	11.5	11.3%
Mixed Forest	0.2	0.7	0.0	0.0	0.4	0.2%
Brush	1.9	0.8	0.8	0.0	0.0	1.0%
Transportation	2.5	3.1	5.1	3.2	0.4	2.9%

*Scotts Level contains 0.24 acreas of Agricultural Cropland or 0.01% of subwatershed area

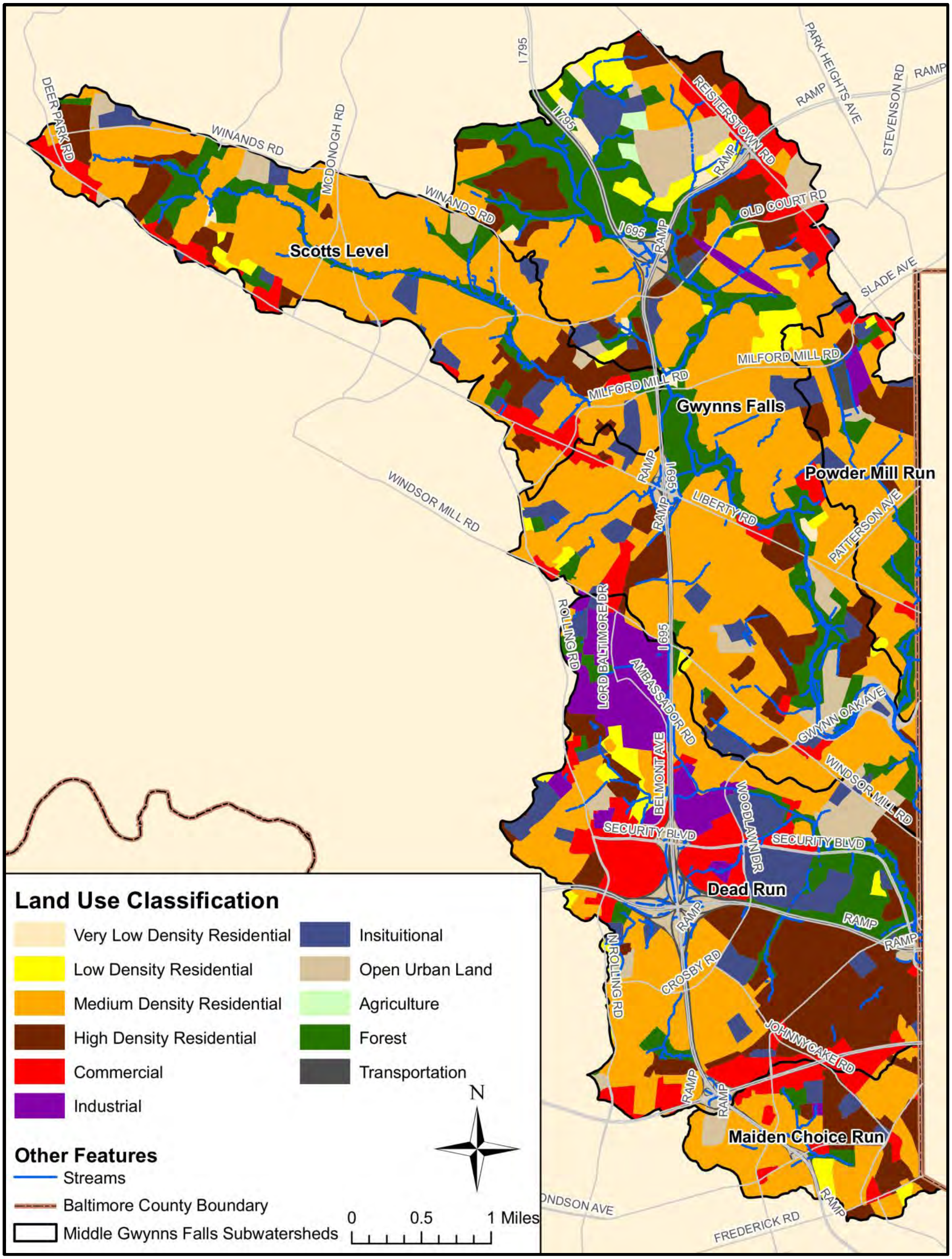


Figure 2-7: Middle Gwynns Falls Land Use/Land Cover

2.3.2 Population

Population data provides another method of evaluating the intensity of land use. Areas of concentrated population normally represent more intense use of the land and potential for environmental degradation. Much of the degradation from these locations (likely found in urban and suburban areas) is related to the extent of impervious cover and depletion of land covers such as forests that help to protect water resources. Smart growth principles are aimed at directing future growth to areas of existing services and locations where development has already begun. This strategy will result in less conversion into residential and commercial land uses, and therefore promote conservation of land uses with less environmental impact such as forest and agriculture.

Population data presented in this section are based on 2010 Census blocks and population data from the U.S. Census Bureau. Table 2-8 summarizes population and population densities with respect to total area and total impervious area for each subwatershed. Figure 2-8 shows the distribution of population density throughout the Middle Gwynns Falls planning area. Not surprisingly, population is generally most dense in areas occupied by medium to high density residential land uses. The subwatersheds with the highest population densities are Maiden Choice Run and Scotts Level. The total population of the Middle Gwynns Falls planning area is 106,839 with a population density of 7.2 people/acre.

Table 2-8: Middle Gwynns Falls Population Data

Subwatershed	Total Population (2010 census)	Total Area (Acres)	Population Density (per acre)	Impervious Area (Acres)	Impervious Acres per person	Population Density (per impervious acre)
Gwynns Falls	40,577	6,165	6.58	1435	0.04	28.27
Powder Mill Run	7,651	958	7.99	239	0.03	32.04
Dead Run	24,770	4,177	5.93	1632	0.07	15.18
Maiden Choice Run	9,989	928	10.76	305	0.03	32.79
Scotts Level	23,852	2,653	8.99	684	0.03	34.90
Middle Gwynns Falls Total	***106,839***	***14,881***	***7.18***	***4294***	***0.04***	***24.9***

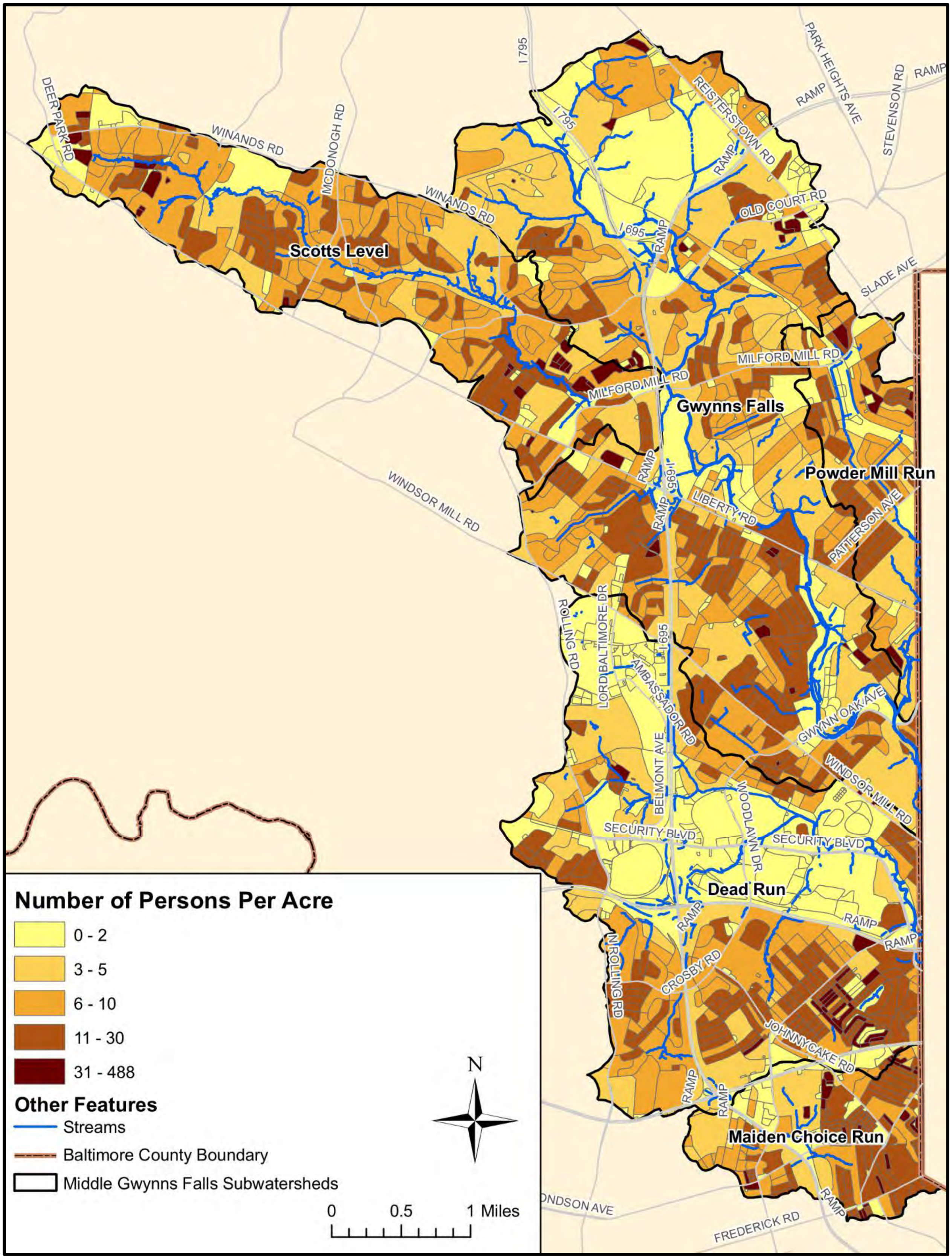


Figure 2-8: Middle Gwynns Falls Population Distribution

2.3.3 Impervious Surfaces

Impervious surfaces such as roads, parking lots, roofs, and other paved areas prevent precipitation from naturally infiltrating into the ground. Stormwater runoff from these areas becomes overland flow and is typically concentrated, accelerated, and conveyed directly to the nearest stream. Consequently, the high energy flows of stormwater runoff from impervious surfaces can cause stream erosion and habitat destruction. This runoff is also likely to be more polluted than runoff from previous areas. In general, undeveloped watersheds with small amounts of impervious cover are more likely to have better water quality in local streams than urbanized watersheds with greater amounts of impervious cover.

Impervious cover is a primary factor when determining pollutant characteristics and quantities in stormwater runoff. Research has been conducted to link the degree of urbanization (typically measured by amount of impervious cover) with various watershed-based indicators of water quality such as diversity and abundance of aquatic and terrestrial life. The Center for Watershed Protection (CWP) compiled stream research conducted in various parts of the country and developed a simple model that relates stream quality to percentage of impervious cover in a watershed. Studies used to develop the impervious cover model measured stream quality based on a variety of indicators such as number of aquatic insect species, stream temperature, channel stability, aquatic habitat, wetland plant diversity, and fish communities present. CWP's impervious cover model is shown in Figure 2-9.

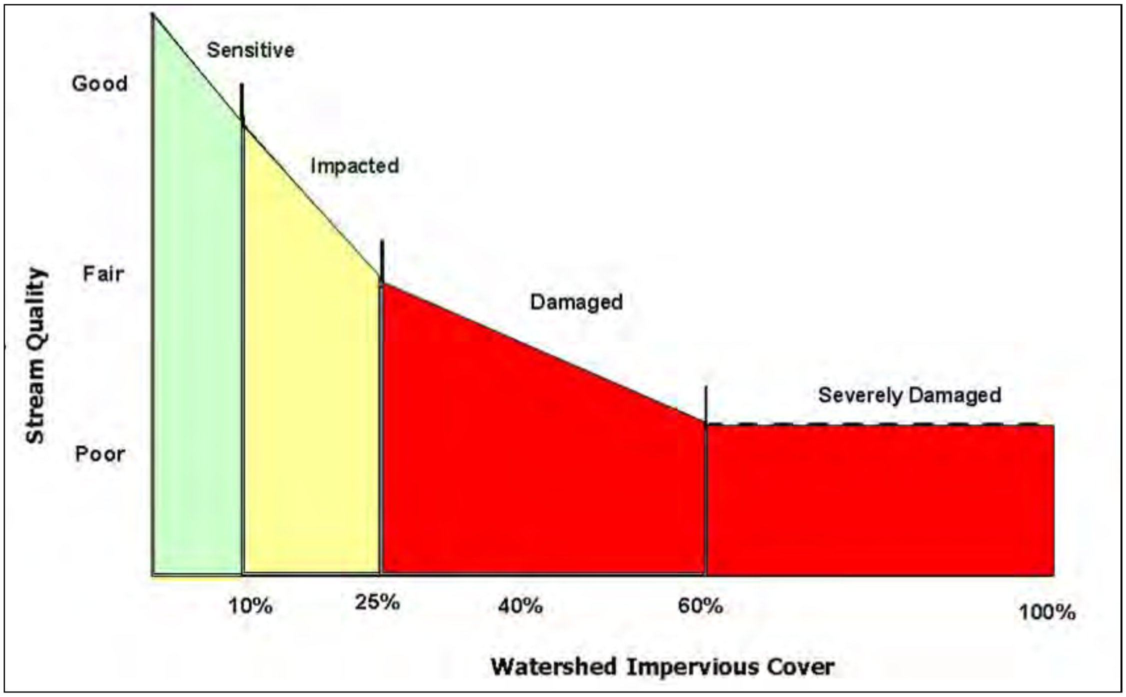


Figure 2-9: Impervious Cover Model (adapted from CWP, 2003)

Based on the compiled research, CWP determined four classifications to predict stream quality based on watershed imperviousness: sensitive; impacted; damaged; or severely damaged. Watersheds with less than 10% impervious cover are referred to as sensitive and typically have high quality streams with stable channels, good habitat conditions, and good to high water quality. These watersheds are considered sensitive because they are susceptible to environmental degradation with increased urbanization and impervious cover. The model predicts that between 10 and 25 percent impervious cover, watersheds become impacted and would show clear signs of degradation such as erosion, channel widening, and a decline in stream habitat. There is a possibility to restore streams to a somewhat natural functioning system within this category. When a watershed has more than 25 percent impervious cover, streams are classified as damaged and characterized by fair to poor water quality, unstable channels, severe erosion, and inability to support aquatic life and provide habitat; many streams in this category are typically piped or channelized. Figure 2-9 shows that when impervious cover exceeds 60 percent, a watershed is classified as severely damaged and means that most of the natural stream system is gone. Management of damaged and severely damaged streams may focus on decreasing pollutant loads to downstream receiving waters (e.g., installing BMPs) but the ability to restore natural functions, such as habitat, is unlikely. Restoration efforts may also focus on making the remaining stream systems stable, aesthetically pleasing and an amenity to the community. It should be noted that the impervious cover model is a simplified approach for classifying the quality of urban systems. Although it is based on research, there are inherent model assumptions and limitations that should be considered such as regional variations and scale effects. In addition, while impervious cover is a relevant and significant indicator for watershed health, it is only one of many different factors affecting stream health and contributing to the cumulative impacts of development on water quality. For example, agricultural land uses may also contribute sediment and nutrient loads to receiving waters. Furthermore, the ability of BMPs to offset adverse impacts from urbanized areas is not specifically accounted for in the model(CWP, 2003).

Impervious cover data were obtained from 2008 roads and buildings spatial data provided by Baltimore County OIT. Impervious area quantities shown in Table 2-9 are the sum of road and building areas. The table also shows the percentage of impervious cover within each subwatershed. It should be noted that parking lots are included in the roads column of ble 2-9, whereas sidewalks are not included. Figure 2-10 illustrates the location of impervious surfaces within the Middle Gwynns Falls watershed. The total impervious area calculated is approximately 4,294 acres, over 28% of the watershed. Subwatersheds with the highest percentage of impervious cover include Dead Run and Maiden Choice Run.

Table 2-9: Middle Gwynns Falls Impervious Area Estimates

Subwatershed	Total Area (Acres)	Roads (Acres)	Buildings (Acres)	Impervious Area (Acres)	% Impervious	CWP Impervious Rating
Gwynns Falls	6,165	892	543	1,435	23.3%	Impacted
Powder Mill Run	958	141	98	239	24.9%	Impacted
Dead Run	4,177	1,138	494	1,632	39.1%	Damaged
Maiden Choice Run	928	188	117	305	32.8%	Damaged
Scotts Level	2,653	401	283	684	25.8%	Damaged
Total	***14,881***	***2,759***	***1,536***	***4,294***	***28.9%***	***Damaged***

Figure 2-11 shows impervious cover ratings for the subwatersheds in the Middle Gwynns Falls planning area based on the CWP model. As expected from the extent of urbanization and impervious cover percentages, the Middle Gwynns Falls watershed does not contain any sensitive subwatersheds. Gwynns Falls and Powder Mill Run are considered impacted subwatersheds, whereas Scotts Level, Dead Run, and Maiden Choice Run are damaged subwatersheds, according to the CWP model. “Impacted” subwatersheds mainly correspond to those with high amounts of residential development; and “damaged” subwatersheds have more commercial development, which is associated with more impervious cover density. There are no subwatersheds in the Middle Gwynns Falls planning area classified as “sensitive” or “severely damaged” under the CWP impervious cover model.

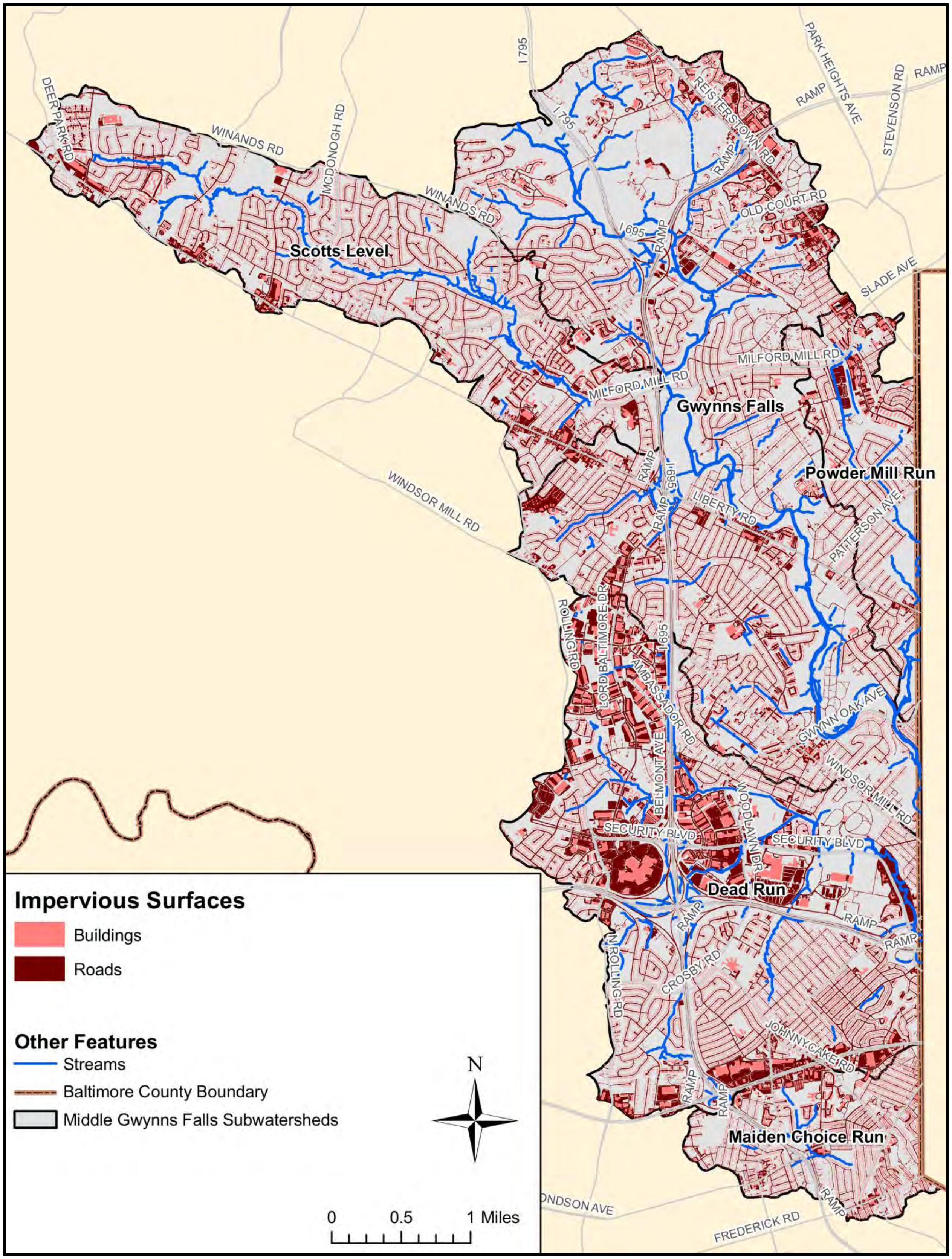


Figure 2-10: Middle Gwynns Falls Impervious Surfaces

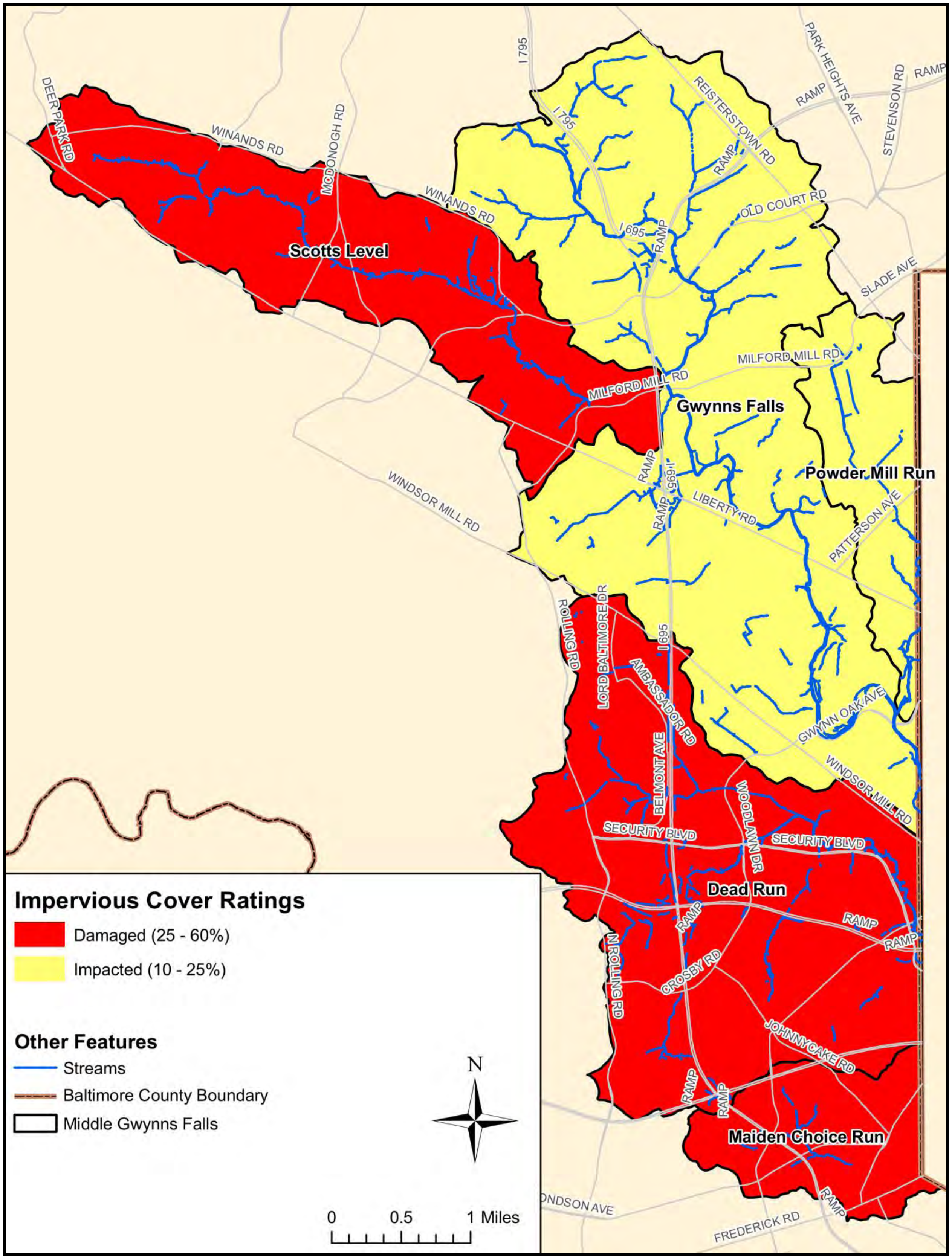


Figure 2-11: Middle Gwynns Falls Impervious Cover Ratings

2.3.4 Directly Connected Impervious Area

The amount of Directly Connected Impervious Area (DCIA) is a key parameter that controls the amount of runoff generated. Precipitation that falls onto areas that are considered "directly connected impervious areas" is assumed to immediately run off and not infiltrate. It is important to note that the DCIA refers to impervious areas that are directly connected to the watershed's drainage network. The total impervious area in the watershed can be significantly higher than the DCIA. DCIA is related to the type of land use in a catchment. Catchment refers to the "drainage area" of the strom drain system. Heavily developed areas with storm drains and many paved streets and roads possess large areas of imperviousness directly connected to streams. Residential areas, which have large areas covered by houses, can possess relatively low DCIA if roof drainage is not directly connected to storm drains or street drainage. Rural, agricultural areas, and forests have very little DCIA except for rock channels near streams. Water falling on the DCIA is assumed to contribute almost instantaneously to the overflow hydrograph.

Table 2-10 shows the DCIA for existing land use conditions for each subwatershed in the Middle Gwynns Falls planning area. The *Gwynns Falls Water Quality Management Plan*(DPW & DEPRM, 2004) estimated values for DCIA for each land use within a catchment using hydrologic judgment, guidance from the storm water management manual (EPA, 1992), and the results of previous watershed studies. Dead Run and Maiden Choice Run have the highest percentages of DCIA in the Middle Gwynns Falls watershed, which concurs with the impervious cover ratings and impervious areas analysis in the previous section. In the previous section; Scotts Level, Dead Run, and Maiden Choice Run are considered damaged subwatersheds due to the high percentage of impervious cover. Figure 2-12 illustrates the DCIA for existing land use conditions for the Middle Gwynns Falls planning area. It should be noted that impervious areas may slightly differ from the values in Section 2.3.3. The values in Table 2-10 were taken directly from the 2004 Gwynns Falls Water Quality Management Plan, and were not part of the impervious area analysis for this report.

Table 2-10: Directly connected impervious Area (DCIA) – Existing Land Use

Subwatershed	Subwatershed Area (Acres)	Total Area of DCIA (Acres)	% Directly Connected (Existing Land Use)
Gwynns Falls	6,165	1,343	21.8%
Powder Mill Run	958	245	25.6%
Dead Run	4,177	1,650	39.5%
Maiden Choice Run	928	261	28.1%
Scotts Level	2,653	618	23.3%
Total in Middle Gwynns Falls	***14,881***	***4,117***	***27.7%***

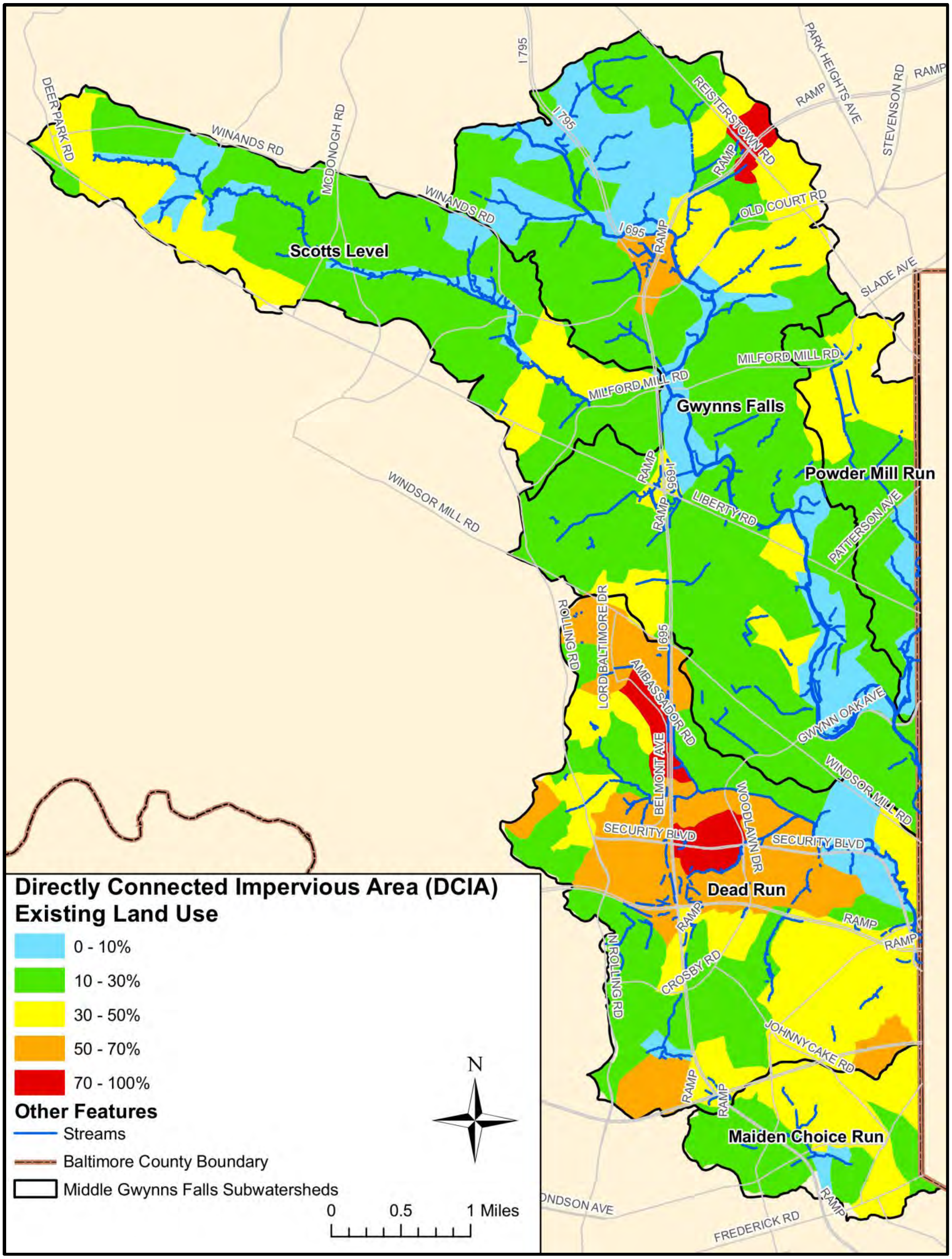


Figure 2-12: Middle Gwynns Falls Directly Connected Impervious Area (DCIA) – Existing Land Use

2.3.5 Erosion Ratio Classification

The erosion ratio method is based on relationships that reflect changes in channel width caused by changes in the 2-year peak flow, which corresponds to top-of-bank flow depth conditions. The relationship between stream width and 2-year peak flow was used as a guideline in assessing the impacts of urbanization on streambank erosion. The erosion ratio can be evaluated based on the 2-year post-development peak flow (Q2) and 2-year peak flow (Q1) for natural (undeveloped) conditions. The equation for the erosion ratio is $(Q2/Q1)^{0.5}$. This ratio is used to categorize increases in stream channel erosion potential as follows:

- "Minimal" erosion potential: Erosion ratio is less than 1.25 (i.e., less than a 25% increase in stream width compared to natural stream channel conditions).
- "Moderate" erosion potential: Erosion ratio is between 1.25 and 1.50 (i.e., a 25% to 50% increase in stream width compared to natural stream channel conditions).
- "Excessive" erosion potential: Erosion ratio is greater than 1.50 (i.e., more than a 50% increase in stream width compared to natural stream channel conditions).

The erosion ratio is computed for a channel segment and reflects cumulative effects; therefore values for the Gwynn Falls mainstem subwatersheds reflect the impact on all upstream subwatersheds. The erosion ratio analysis is intended to identify areas based on existing conditions that are susceptible to degradation in stream stability as urbanization occurs. The *Gwynns Falls Water Quality Management Plan*(DPW & DEPRM, 2004) estimated erosion ratio values within each catchment of the Gwynns Falls Watershed. Table 2-11 shows the overall erosion ratio classification based on existing land use conditions for each subwatershed in the Middle Gwynns Falls planning area. Figure 2-13 illustrates the erosion ratio classification for each catchment within the Middle Gwynns Falls planning area.

Table 2-11: Middle Gwynns Falls Erosion Ratio Classification – Existing Conditions

Subwatershed	Minimal	Moderate	Excessive
Gwynns Falls	11.5%	11.7%	76.8%
Powder Mill Run	13.1%	0.8%	86.1%
Dead Run	3.0%	9.8%	87.2%
Maiden Choice Run	3.4%	0.0%	96.6%
Scotts Level	8.6%	2.7%	88.7%
Total in Middle Gwynns Falls	***8.2%***	***8.2%***	***83.6%***

Maiden Choice Run and Scotts Level have the highest percentages of catchments classified as having "excessive" erosion potential. This is not surprising given the high imperviousness of those subwatersheds. The catchments classified as "minimal" and "moderate" makeup 16.4% of the Middle Gwynns Falls planning area. Overall, the rating tends toward "excessive" erosion ratios throughout the Middle Gwynns Falls watershed.

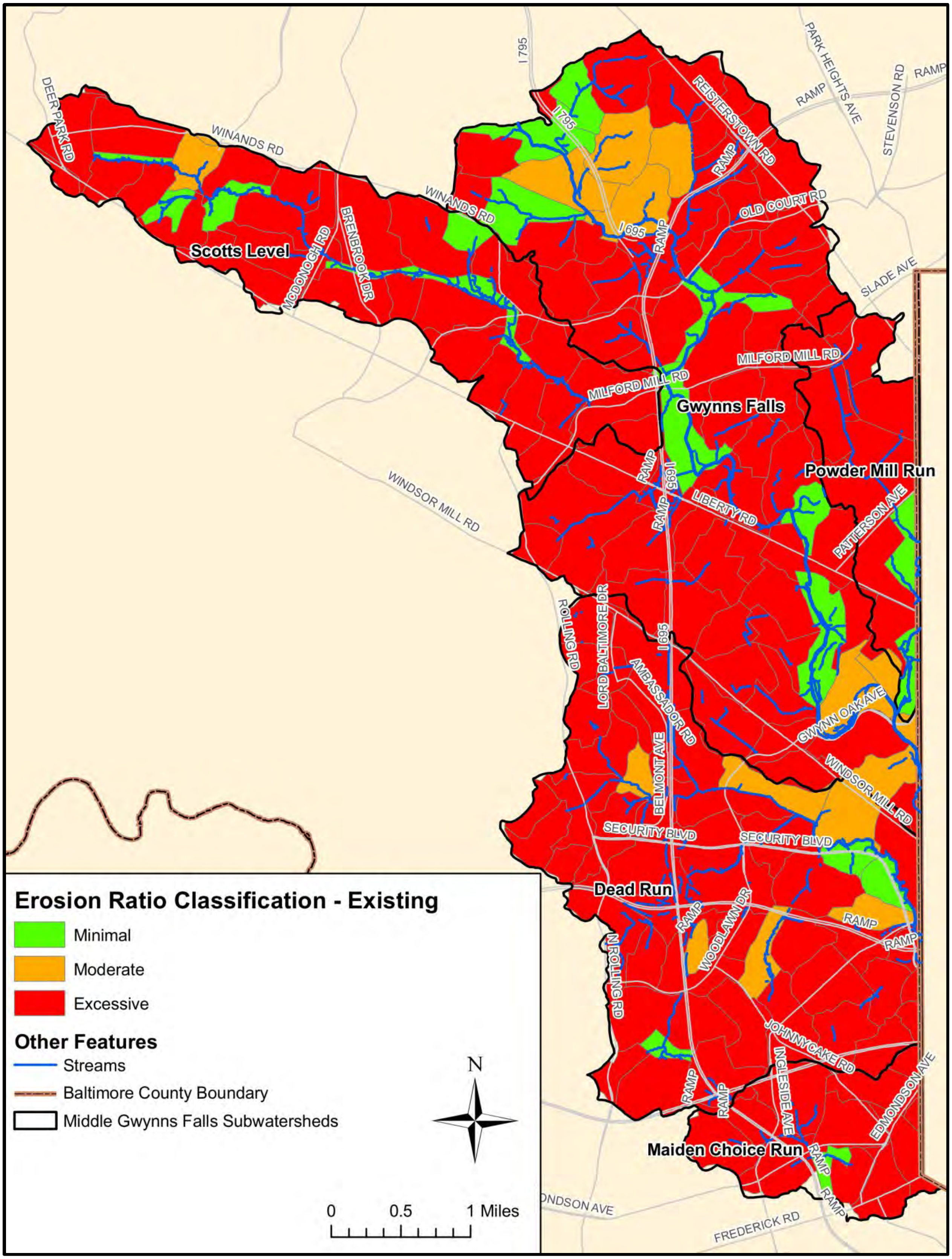


Figure 2-13: Middle Gwynns Falls Erosion Ratio Classification

2.3.6 Drinking Water

Drinking water is a fundamental need for human development. It can be supplied either by public distribution systems or by wells associated with individual developed properties. Having an adequate supply of drinking water and a method for its conveyance is essential to the human population.

2.3.6.1 Public Water Supply

Environmental impacts associated with public supply of water include the potential for increased residential development with the associated effects of increased impervious cover as discussed in the previous section, as well as the potential for leaks from the system. Leaks from public water supply systems introduce chlorine into the aquatic system which can result in the death of aquatic organisms. In addition, major leaks can cause erosion which contributes to the sediment load in the stream channels; this can bury aquatic benthic communities and degrade habitat.

2.3.7 Wastewater

Wastewater produced by human processes must be treated and disposed properly. This is accomplished either through public conveyance to a treatment facility or through on-site disposal systems such as septic systems. Residential wastewater consists of all water typically used by residents including wash water, bathroom water, and any other rinse water such as paint brush, floor washing, and etc. industrial wastewater could contain various contaminants such as metals, organic compounds, detergents, or synthetic compounds depending on the operation. All of these types of wastewater have the potential to adversely impact the natural environment.

2.3.7.1 Septic Systems

Properly functioning septic systems provide treatment for nearly all the phosphorous present in wastewater, but can leak nitrogen in the form of nitrates. Depending on the location of the system, nitrates may be reduced or eliminated through de-nitrification as the treated water passes through riparian buffers, particularly forested buffers. Failing systems can release nitrogen, phosphorous, and other chemicals, and in turn, contaminate the aquatic environment. They can also result in increased bacterial contamination of nearby streams and therefore increased potential for human health concerns. Table 2-12 summarizes the approximate number of septic systems present in the Middle Gwynns Falls planning area by subwatershed. Septic systems data are based on the 2011 septic and public sewer spatial data from Baltimore County EPS. Based on this data, the Gwynns Falls subwatershed contains the most septic systems of all subwatersheds, over 89% of which are residential. Figure 2-14 shows the distribution if residential and non-residential septic systems in the Middle Gwynns Falls watershed.

Table 2-12: Middle Gwynns Falls Septic Systems by Subwatershed

Subwatershed	Residential	Non-Residential	Total # of Septic Systems
Gwynns Falls	171	20	191
Powder Mill Run	7	5	12
Dead Run	43	15	58
Maiden Choice Run	17	12	29
Scotts Level	83	8	91
Total	***321***	***60***	***381***

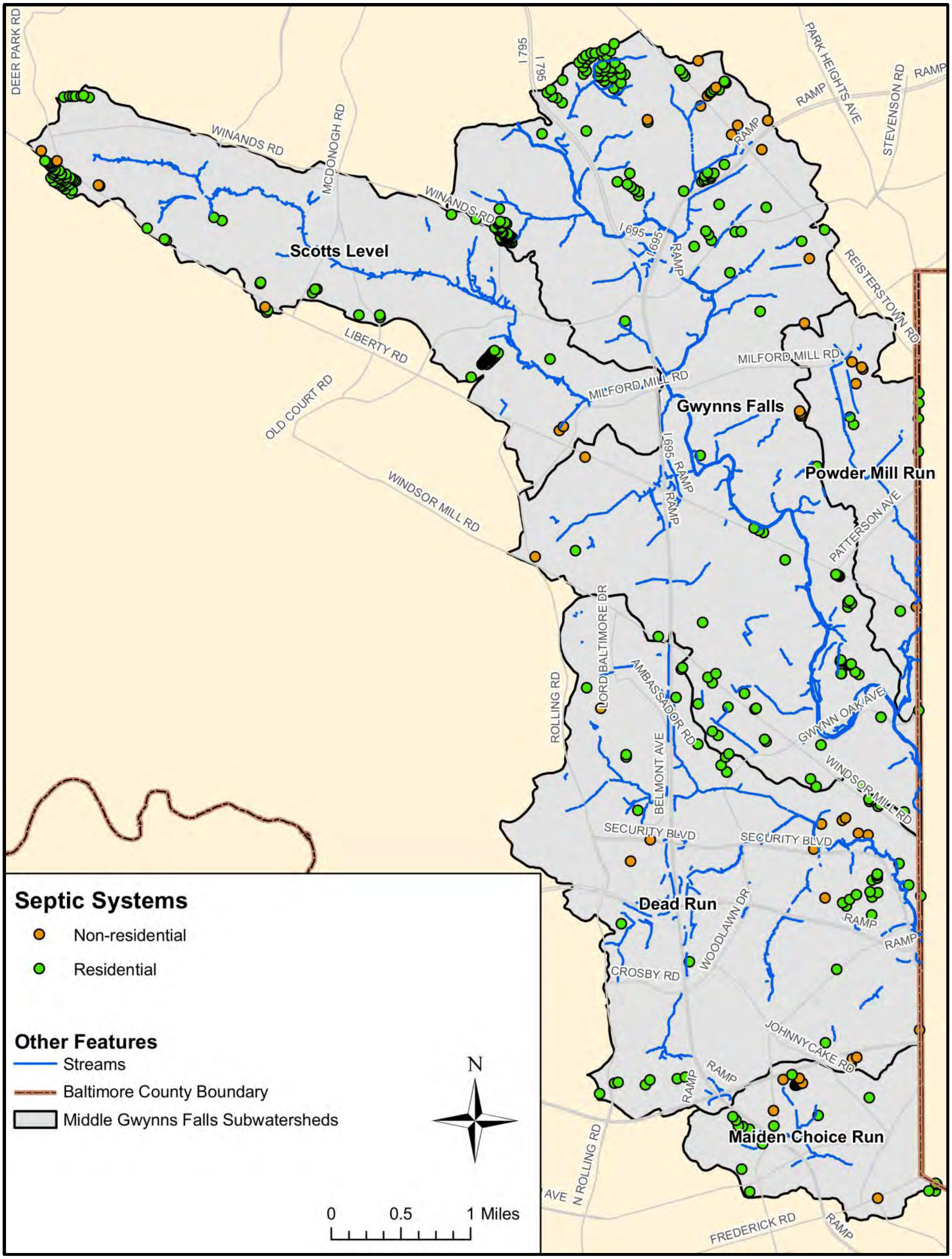


Figure 2-14: Location of Septic Systems in Middle Gwynns Falls Watershed

2.3.7.2 Public Sewer

The public sewer system conveys wastewater from individual households or businesses to a facility that treats the wastewater prior to discharge. It consists of the piping system within the public right-of-way and cleanouts on individual properties. Property owners are responsible for the maintenance of their individual cleanouts. The portion of the system within the public right-of-way is owned and maintained by the local government, including the gravity piping system, access manholes, pumping stations, and force mains. Table 2-13 below summarizes the lengths of public sewer piping in the Middle Gwynns Falls planning area by type (gravity main or pressurized main) and by subwatershed. This data was compiled from gravity main, manhole, and force main spatial data provided by Baltimore County OIT. Table 2-14 summarizes public sewer piping density (length of sewer main per square mile of subwatershed area) for each subwatershed. Gwynns Falls subwatershed contains the most sanitary sewer piping including both pressurized main and gravity mains. Powder Mill Run and Maiden Choice Run subwatersheds have the most sanitary sewer piping, gravity and pressurized combine, per subwatershed area.

Table 2-13: Public Sewer Piping Length in Middle Gwynns Falls Watershed

Subwatershed	Pressurized Main (ft)	Gravity Main (ft)	Gravity Main Abandoned (ft)	Total (ft)
Gwynns Falls	4,019	664,183	15,938	684,140
Powder Mill Run	1,818	127,408	4,078	133,305
Dead Run	203	397,753	384	398,340
Maiden Choice Run	0	125,993	1,402	127,395
Scotts Level	1,387	347,088	2,967	351,442
Total	***7,427***	***1,662,425***	***24,769***	***1,694,621***

Table 2-14: Public Sewer Piping Density in Middle Gwynns Falls Watershed

Subwatershed	Area (Sq Miles)	Pressurized Main (ft/sq mi)	Gravity Main (ft/sq mi)
Gwynns Falls	9.63	417	68,952
Powder Mill Run	1.50	1,215	85,116
Dead Run	6.53	31	60,941
Maiden Choice Run	1.45	0	86,894
Scotts Level	4.15	335	83,724
Total	***23.3***	***319***	***71,496***

Environmental impacts associated with the public sewers are usually the results of sewage overflows. Sanitary sewer overflows (SSOs) typically result from blockages in the sewage system, pumping station failure, or rainwater inflows exceeding pipe capacity. Contamination can also occur during dry weather due to leaks in the sewer system. Water quality concerns related to sewer overflows and leaks include high bacteria concentrations, release of nutrients, increased turbidity (cloudiness), and low dissolved oxygen concentrations.

2.3.7.3 Wastewater Treatment Facilities

There are no wastewater treatment facilities in the Middle Gwynns Falls planning area. Wastewater from the Middle Gwynns Falls watershed is conveyed to either the Patapsco Wastewater Treatment Plant located in the Baltimore Harbor or the Back River Treatment Plant. Both of these facilities are scheduled for an enhanced nutrient removal upgrade to be completed by 2017, which will aid in nitrogen removal for the watershed.

2.3.8 Stormwater

Stormwater is generated during and immediately after storm events. Precipitation that does not seep into the ground becomes stormwater runoff and flows directly to receiving water bodies. The quantity and characteristics of stormwater runoff is affected by rainfall amount and intensity, soil properties, land slope, and land use/land cover type. Concerns associated with stormwater include 1) volume and rate of runoff and 2) water pollution.

As previously discussed, larger volumes of stormwater runoff are generated from areas with impervious cover than from undeveloped land; impervious surfaces prevent infiltration of runoff into the ground, conveying it to stream systems more swiftly and in larger quantities. The increase in runoff rate and volume can cause flooding and stream erosion, which results in destruction of habitat and natural stream functions such as nutrient reduction. In addition, there is less potential for groundwater recharge when there is little or no infiltration of stormwater.

Stormwater runoff also contains various contaminants depending on land use characteristics and human activities that take place within a watershed. The contaminants that are carried by stormwater to the stream systems include pollutants deposited on impervious surfaces and other developed lands from daily human activity. Common pollutants found in impervious surface runoff (such as from highways and parking lots) are sediment, metals, bacteria, nutrients, and petroleum; pollutants such as these accumulate over time from sources such as road maintenance activities (de-icing and roadside fertilizer use), vehicles (exhaust and leaks), and accidents or spills and are washed off during storm events. While the runoff from other developed lands, for example agriculture and residential areas, may be moderate compared to highly impervious areas, it can still carry pollutants such as nutrients, bacteria, and chemicals to receiving water bodies.

2.3.8.1 Storm Drainage System

The storm drainage system consists of either drainage swales (roadside ditches) or a curb and gutter system including inlets, piping, and outfalls. Both methods are intended to prevent flooding and potentially hazardous situations by removing water quickly from roadways. However, the efficiency and watershed impacts associated with each method differ significantly. The curb and gutter system drains stormwater more quickly from impervious surfaces and typically conveys water directly into the stream system. In doing so, however, it delivers increased runoff volumes and more untreated pollutants to receiving water bodies. Currently, Baltimore County's storm drainage system is comprised of approximately 1,760 miles of storm drain pipe, over 72,000 inlet structures, and over 41,000 storm manhole structures.

Drainage swales typically convey stormwater at a slower velocity than the curb and gutter system, but the stormwater volume is somewhat reduced before entering the stream system. Drainage swales also allow some infiltration into the ground unlike the curb and gutter system, thereby reducing the amount of water delivered to the streams and providing some filtering of pollutants.

Table 2-15 summarizes the curb and gutter system components in the Middle Gwynns Falls planning area by subwatershed. The summary includes estimates of major outfalls (greater than 3 feet in diameter) and minor outfalls (less than 3 feet in diameter), along with corresponding number of inlets and pipe length draining to those outfalls. Storm drain system data used to compile this information were created by Baltimore County EPS based on storm drain plans and topographic data. This data provides a reasonable approximation of storm drain pipe lengths which were rounded to the nearest tens of feet. Table 2-16 provides a summary of the percentage of each subwatershed that is covered by the storm drain system, or in other words, the drainage areas of the storm drain system in a subwatershed divided by the total subwatershed area. It also shows the inlet density (number of inlets per square mile) of each subwatershed. Figure 2-15 shows the location of major and minor outfalls within the Middle Gwynns Falls watershed.

Table 2-15: Stormwater System Components in Middle Gwynns Falls Watershed

	MAJOR (> 3ft)			MINOR (< 3ft)			ALL OUTFALLS		
Subwatershed	**Outfalls (#)**	**Inlets (#)**	**Pipe (ft)**	**Outfalls (#)**	**Inlets (#)**	**Pipe (ft)**	**Total Outfalls (#)**	**Total Inlets (#)**	**Total Piping (ft)**
Gwynns Falls	44	273	40,723	168	603	74,154	212	876	114,877
Powder Mill Run	10	73	11,300	18	60	6,890	28	133	18,190
Dead Run	47	311	38,601	56	194	29,896	103	505	68,497
Maiden Choice Run	6	26	3,985	8	31	3,041	14	57	7,026
Scotts Level	27	205	25,150	108	383	55,470	135	588	80,620
Total	***134***	***888***	***119,760***	***358***	***1,271***	***169,450***	***492***	***2,159***	***289,210***

Table 2-16: Stormwater System Coverage in Middle Gwynns Falls Watershed

Subwatershed	Subwatershed Area (Acres)	Stormwater System Drainage Area (Acres)	Area Covered by Stormwater System (%)	No. of Inlets (#)	Inlet Density (#/sq mi)
Gwynns Falls	6,165	2,734	44%	876	90.9
Powder Mill Run	958	488	51%	133	88.9
Dead Run	4,177	2,149	51%	505	77.4
Maiden Choice Run	928	184	20%	57	39.3
Scotts Level	2,653	1,847	70%	588	141.8
Total	***14,881***	***7,402***	***50%***	***2,159***	***92.9***

The subwatershed with the highest number of total outfalls is Gwynns Falls. The subwatershed with the largest percentage of storm drain coverage and highest inlet density is Scotts Level. The majority of the Middle Gwynns Falls watershed is residential and commercial and explains the significant number of inlets and area covered by the storm drainage system. Approximately 50% of Middle Gwynns Falls watershed is covered by the storm drainage system with an inlet density of approximately 92.9 inlets per square mile. Locations with higher inlet densities represent potential locations for management of pollution sources and community education measures such as storm drain marking.

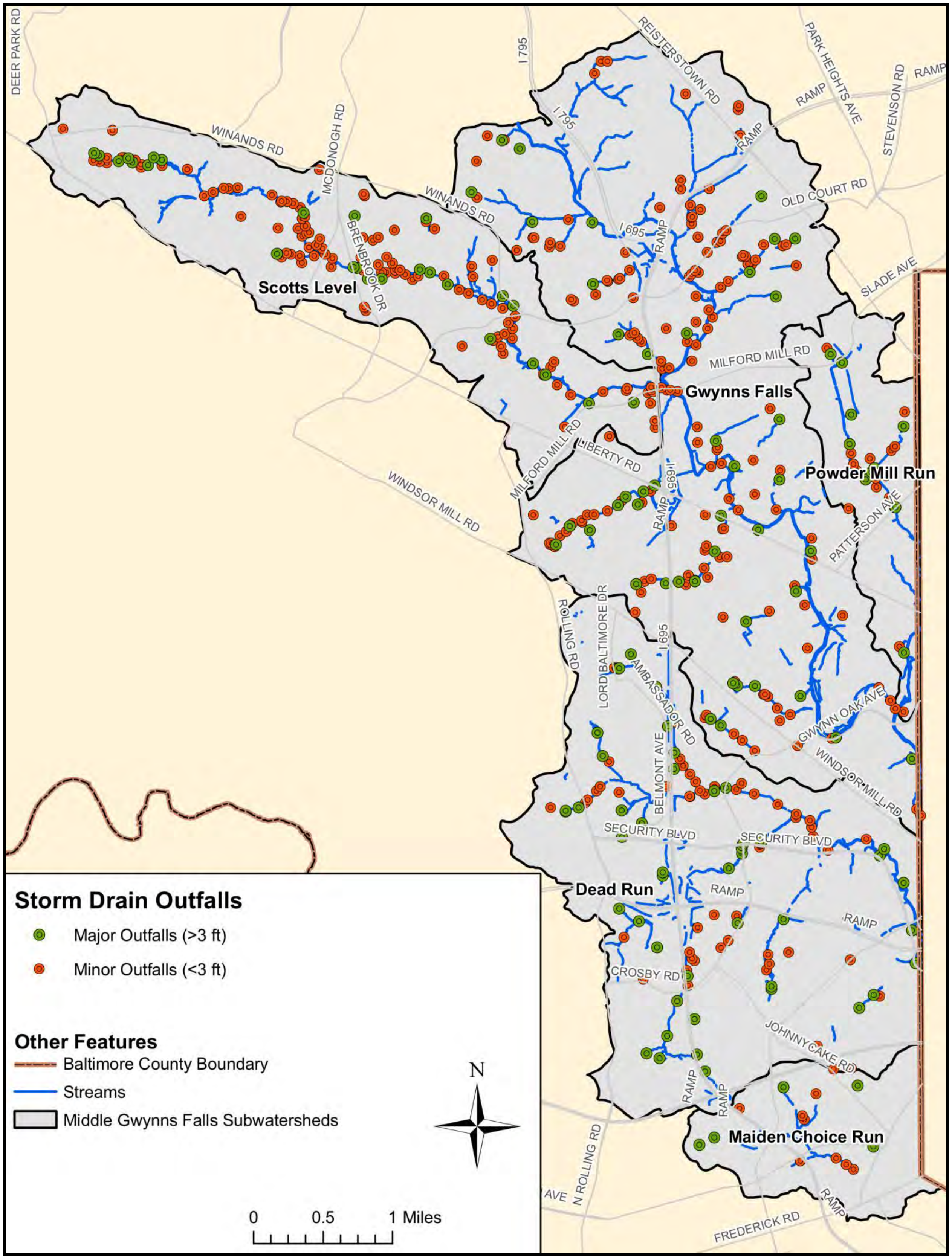


Figure 2-15: Middle Gwynns Falls Storm Drain Outfalls

2.3.8.2 Stormwater Management Facilities

The Maryland Department of the Environment (MDE) developed stormwater management (SWM) regulations over 25 years ago to control the quantity of runoff. SWM practices have evolved since then, and will continue to grow as new technology and research are developed. SWM is a significant consideration for new development and redevelopment within the state. Per Title 4, Subtitle 2, of the Environment Article of Annotated Code of Maryland, management of stormwater runoff is required to reduce erosion, sedimentation, pollution, and flooding. Increased importance of water quality and water resource protection has led to the development of the Maryland Stormwater Design Manual in 2000 to provide Best Management Practice (BMP) design standards and environmental incentives, and promoting a general shift toward low-impact SWM practices that mimic natural hydrologic processes and achieve pre-development conditions. The latter is evident by the Maryland Stormwater Management Act of 2007 which requires that Environmental Site Design (ESD) be implemented to the maximum extent practicable via nonstructural BMPs and/or other innovative design techniques.

There are many types of BMP options for managing stormwater runoff and providing stormwater quality treatment. SWM facilities can target specific objectives depending on the BMP type such as stormwater quality, soil stabilization, stormwater flow control, and stream restoration. In addition, different SWM facilities have different pollutant removal capabilities. For example, early pond designs for SWM have low pollutant removal efficiency compared to practices that filter stormwater or allow it to infiltrate into the ground or through plant roots. Considerations such as space requirements, maintenance needs, cost, and community acceptance are taken into account when selecting the appropriate stormwater treatment measures.

Table 2-17 summarizes the number of various types of SWM facilities in the Middle Gwynns Falls planning area including the sum of their drainage areas per subwatershed. The SWM facilities are categorized into detention ponds, wet ponds, wetlands, infiltration practices, filtration practices, extended detention, proprietary BMPs, grassed swales and channels, and others. Figure 2-16 shows the distribution of these SWM facilities within the planning area. Data for SWM facilities and their drainage areas were obtained from Baltimore County EPS.

Table 2-17: Stormwater Management Facilities in Middle Gwynns Falls Watershed

SWM Facility Type	Gwynns Falls	Powder Mill run	Dead Run	Maiden Choice Run	Scotts Level	Middle Gwynns Falls Subtotals
Dry Pond (#)	29	0	36	7	13	***85***
Drainage Area (acres)	649.9	0.0	885.5	202.4	138.3	***1,876.1***
Wet Pond (#)	4	0	1	0	0	***5***
Drainage Area (acres)	61.2	0.0	26.3	0.0	0.0	***87.4***
Underground Detention (#)	9	0	9	1	5	***24***
Drainage Area (acres)	56.3	0.0	33.0	2.2	10.3	***101.9***
Wetland (#)	0	1	1	0	0	***2***
Drainage Area (acres)	0.0	7.1	23.0	0.0	0.0	***30.1***
Infiltration (#)	10	1	12	1	7	***31***
Drainage Area (acres)	32.3	0.6	47.6	1.0	5.5	***87.0***
Filtration (#)	17	3	11	2	10	***43***
Drainage Area (acres)	37.3	17.2	29.1	7.1	18.8	***109.5***
Extended Detention (#)	46	1	20	6	16	***89***
Drainage Area (acres)	392.5	6.2	170.4	16.5	144.2	***729.8***
Proprietary BMP (#)	8	1	7	1	3	***20***
Drainage Area (acres)	8.5	0.4	25.7	0.2	3.1	***37.8***
Grassed Swale/Channel (#)	1	2	1	1	1	***6***
Drainage Area (acres)	4.9	5.9	0.1	0.8	0.1	***11.7***
Other (#)	1	3	3	1	4	***12***
Drainage Area (acres)	1.7	6.2	2.8	0.9	4.2	***15.8***
Total SWM Facilities (#)	***125***	***12***	***101***	***20***	***59***	***317***
Total Drainage Area Acres to SWM	***1,244.5***	***43.6***	***1,243.5***	***231.2***	***324.5***	***3,087.2***

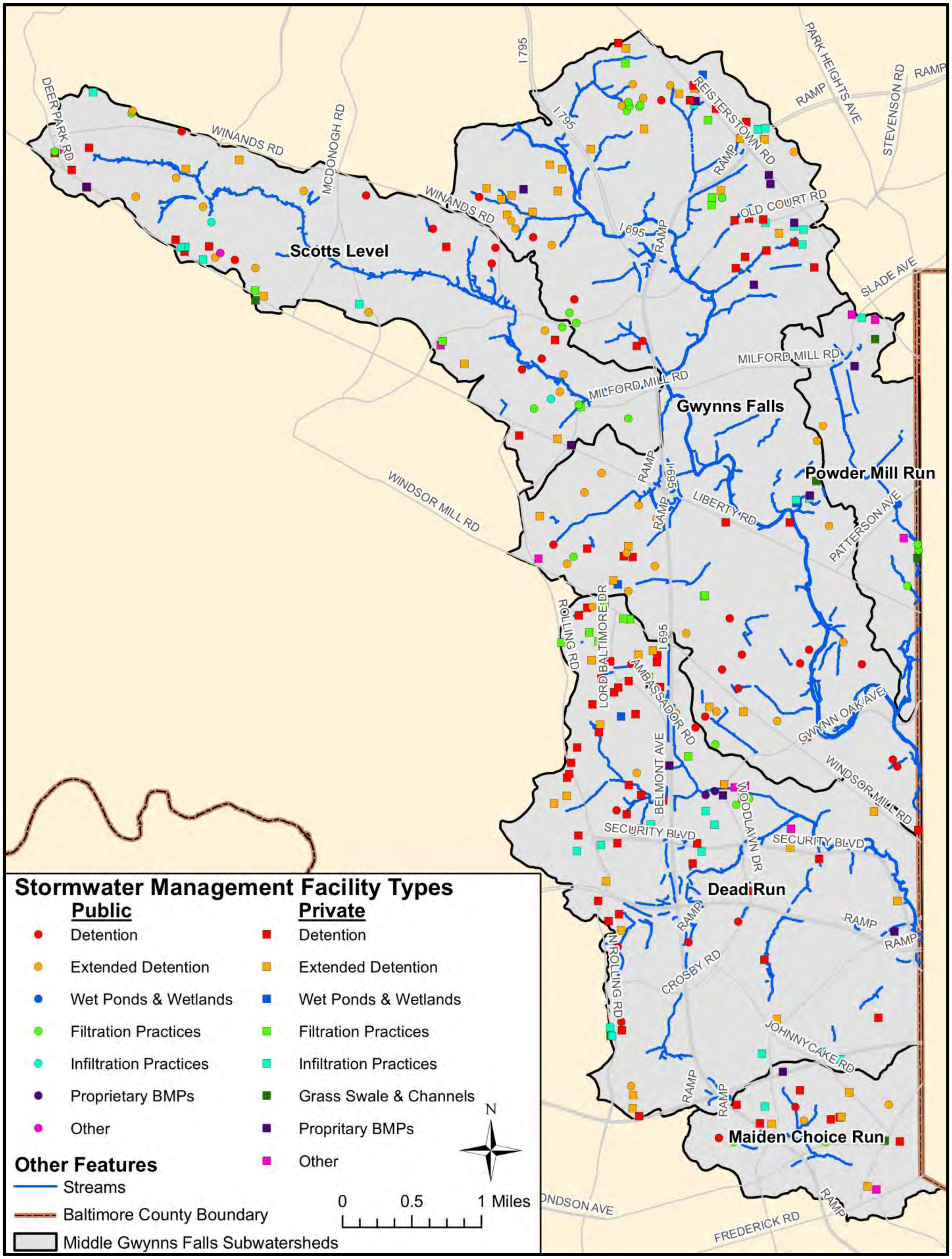


Figure 2-16: Distribution of Stormwater Management Facilities in Middle Gwynns Falls Watershed

SWM facilities are present in all of the subwatersheds of the Middle Gwynns Falls planning area. The most common SWM facility type is extended detention facilities followed closely by dry detention facilities. Subwatersheds with the most SWM facilities tend to be those with more commercial and industrial activity. In addition to extended detention facilities, the Middle Gwynns Falls also has a high number of dry ponds and filtration devices. Filtration devices that are listed include bioretention, sand filter, gabion sand, and check dams. Dry pond facilities represent the best opportunity for conversion to BMPs with higher pollutant removal capabilities, such as extended detention ponds. The proprietary BMPs that are listed include oil & grit separators, Bay Separator, and Stormceptor devices which remove sediment, oil and grease through a hydrodynamic separation process where they settle out as the stormwater flows in a circular path. Floatables and debris that are collected in the treatment chamber are typically removed by a vacuum truck at regular intervals. SWM facilities that are classified under “other” include porous pavement.

Table 2-18 shows the total drainage area and the percentage of urban land treated by SWM facilities in each subwatershed. Urban land in this case refers to low, medium, and high density residential, commercial, industrial, institutional, open urban, and transportation land uses. This is important to evaluate because subwatersheds with high amounts of urban land but low SWM coverage percentages present opportunities for BMP implementation. BMPs can be implemented in existing developed areas with no current SWM practices or to retrofit facilities that are not providing adequate stormwater treatment. Approximately 87% of the planning area is classified as urban land, and 24% of this area is treated by SWM facilities. Chapter 3 provides more details on assessed SWM facilities within the Middle Gwynns Falls planning area.

Table 2-18: Area Treated by Stormwater Management Facilities in Middle Gwynns Falls Watershed

Subwatershed	Area (Acres)	Urban Land Use (Acres)	Area Treated by SWM (Acres)	Urban Land Use Treated by SWM (%)
Gwynns Falls	6,165	5,109	1,244	24%
Powder Mill Run	958	807	44	5%
Dead Run	4,177	3,840	1,243	32%
Maiden Choice Run	928	899	231	26%
Scotts Level	2,653	2,338	324	14%
Middle Gwynns Falls Total	***14,881***	***12,993***	***3,087***	***24%***

2.3.9 NPDES Discharge Permits

Businesses and other facilities that discharge municipal or industrial wastewater or conduct activities that can contribute pollutants to a waterway are required to obtain a National Pollutant Discharge Elimination System (NPDES) Permit. The type of NPDES permit required depends on the nature of the activities conducted by the facility. Table 2-19 summarizes the number of facilities holding NPDES permits in the Middle Gwynns Falls watershed, by subwatershed and permit type. While some facilities hold multiple permits, only one per facility is reflected in the table.

Table 2-19: NPDES-Permitted Facilities in Middle Gwynns Falls Watershed

Subwatershed	# General Industrial Stormwater Permits	# General Oil Contamination Groundwater Remediation Permits	# General Permits	Total # of Permits in Subwatershed
Gwynns Falls	4	0	11	15
Powder Mill Run	0	1	3	4
Dead Run	2	0	5	7
Maiden Choice Run	1	0	0	1
Scotts Level	0	0	4	4
Total	***7***	***1***	***23***	***31***

The federal NPDES permits listed above also function as MDE water management permits. Descriptions of each type of NPDES permit are provided as follows by MDE:

- **General Industrial Stormwater Permits** are required for industrial facilities discharging stormwater to storm drains or surface waters.
- **General Oil Contamination Groundwater Remediation Permits** are required for discharges of treated groundwater from petroleum contaminated groundwater sources to surface or groundwater of the State.
- **General Permits** are required for facilities discharging wastewater or stormwater to any place other than a sanitary sewer, or for any manufacturing, fleet vehicle, or recycling facility.

NPDES permit data for the Middle Gwynns Falls watershed was estimated from spatial data provided by Baltimore County EPS, based on 2008 MDE records; this data was cross-referenced with more recent data obtained from MDE in 2011. As of 2008, there are a total of 31 facilities holding NPDES permits in the Middle Gwynns Falls planning area. Almost all General Permit holders are apartment complexes. General Industrial Stormwater Permits have been issued to a variety of industrial facilities including chemical and machine manufacturers, and transportation facilities such as MTA – Old Court Metro Maintenance Facility. Amoco Service Station in the Powder Mill Run subwatershed holds the only General Oil Contamination Groundwater Remediation Permit. The subwatershed with the most NPDES permitted facilities is Gwynns Falls. Gwynns Falls also has the most General Permits. Figure 2-17 shows the locations of NPDES-permitted facilities in the Middle Gwynns Falls watershed.

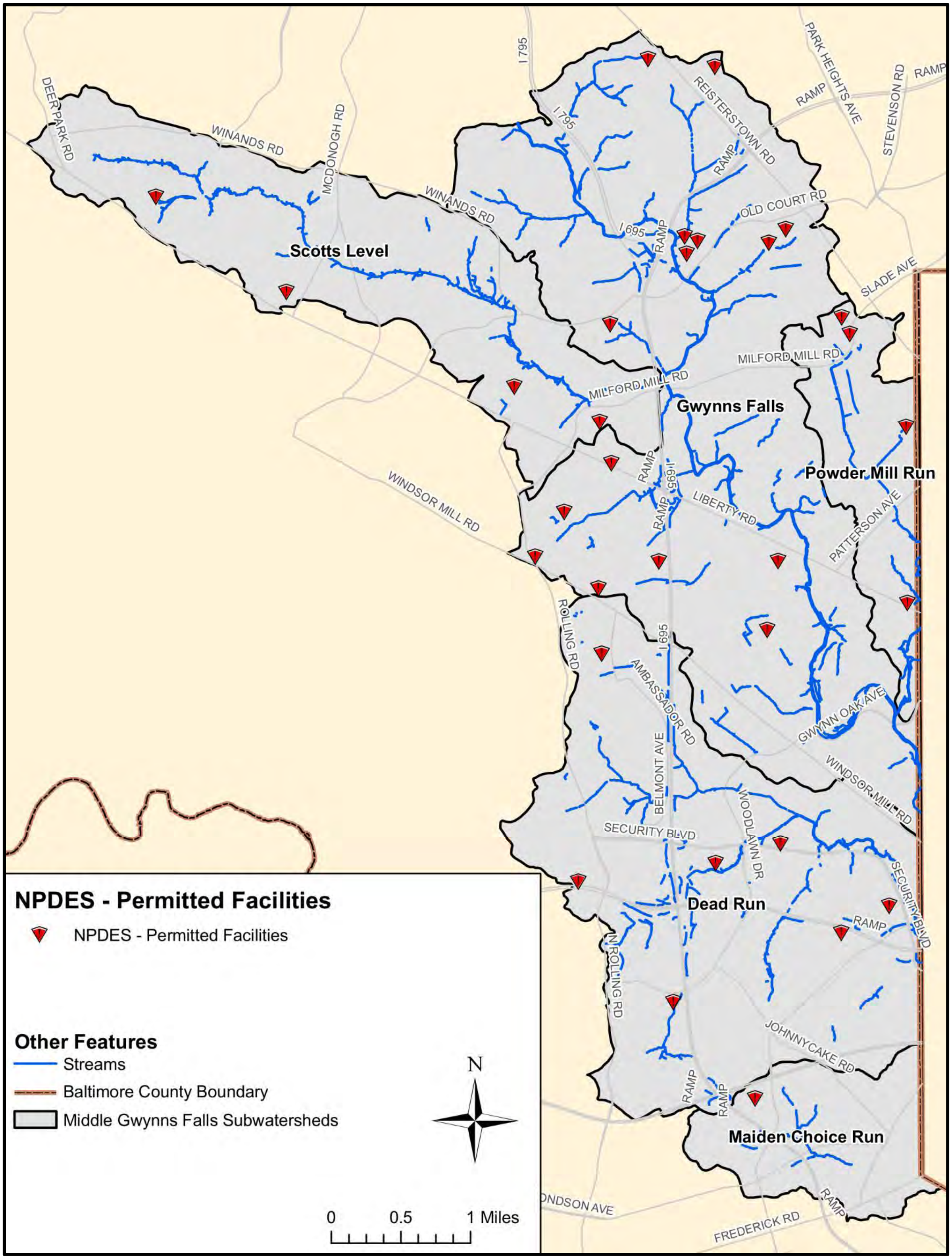


Figure 2-17: Location of NPDES-Permitted Facilities in Middle Gwynns Falls Watershed

2.3.10 Zoning

According to the Baltimore County Office of Planning (2012), zoning is defined as “a system of land use regulation that controls the physical development of land and a legal mechanism by which local government is able to regulate an owner’s right to use privately owned land for the sake of protecting the public health, safety, and/or general welfare.” In other words, zoning manages development patterns over time throughout the County. Table 2-20 shows the various zoning categories present in the Middle Gwynns Falls watershed.

As shown in Figure 2-18, a significant portion of Middle Gwynns Falls watershed is dense residential development and commercial. Residential and commercial areas are located in the same general locations because they are considered compatible land uses as population is typically concentrated in these areas. A large section of Dead Run is zoned for industrial use.

Table 2-20: Baltimore County Zoning in Middle Gwynns Falls Watershed

Zoning Code	Zoning Description	Total Acres	% of Watershed Area
DR 1	Density Residential - 1 unit/acre	766	5.2%
DR 2	Density Residential - 2 units/acre	330	2.2%
DR 3.5	Density Residential - 3.5 units/acre	2,325	15.6%
DR 5.5	Density Residential - 5.5 units/acre	7,878	52.9%
DR 10.5	Density Residential - 10.5 units/acre	512	3.4%
DR 16	Density Residential - 16 units/acre	925	6.2%
RAE 1	Residence, Apartment - 40 units/acre	8	0.1%
RAE 2	Residence, Apartment - 80 units/acre	7	0.0%
Commercial	Office/Business	1,366	9.2%
Industrial	Manufacturing	751	5.0%
RC 5	Rural Residential	12	0.1%
Total		***14,881***	***100.0%***

As presented in Table 2-20, approximately 86% of the Middle Gwynns Falls watershed is zoned for residential land use, the most common being categories DR 3.5 and DR 5.5. DR 3.5 and DR 5.5 generally correspond to the MDP-classified medium density land use category. Industrial use is permitted in approximately 5% of the Middle Gwynns Falls watershed. Commercial use is permitted in approximately 9.2% of the Middle Gwynns Falls watershed.

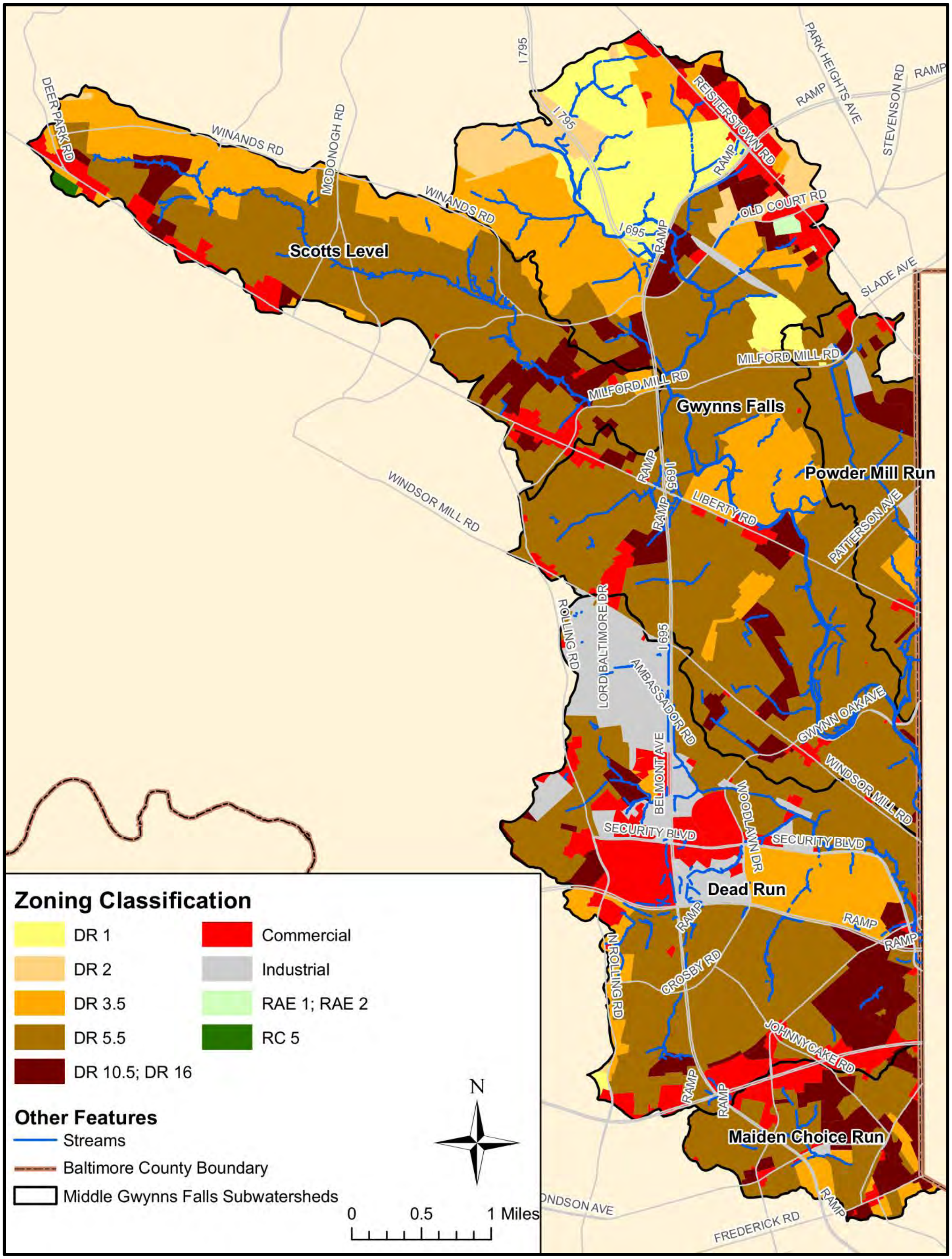


Figure 2-18: Middle Gwynns Falls Zoning

2.3.11 Environmental Justice

Environmental Justice (EJ) is defined as the "equal distribution of environmental benefits and harms regardless of race, income, or socioeconomic status" (EPS, 2011). Addressing EJ concerns acts to minimize the disproportionate burden of environmental concerns that are placed on disadvantaged and vulnerable segments of the population. A white paper and memo of findings on water quality issues and EJ indicators was produced for Baltimore County in 2011 by Biohabitats. Informed by that research, a GIS mapping model was developed to identify priority at-risk environmental justice communities in the County. After collecting available GIS data layers, relevant indicators were grouped into social and demographic indicators, major human health indicators, major watershed health indicators, and minor watershed health indicators (EPS, 2011).

Figure 2-19 displays the weighting of the twelve indicators used to quantify EJ concerns. Social and demographic layers (in red) have the highest weighting factors for a combined total of 50%. Major human health indicator layers (in orange) including bacteria and toxics TMDL and 303d stream impairments have the second highest weighting factors at a combined total of 28% due to their direct impact on public health, another key component in EJ. Major watershed health layers (in blue) including SSOs, impervious cover, storm drain outfalls, and hot spots are ranked in the third level of indicators as a total of 20% of the composite. Tree canopy (in purple) is weighted as a minor watershed health indicator at 2% of the total composite (EPS, 2011). These indicators were analyzed using subwatersheds and census block groups to divide the County into smaller blocks.

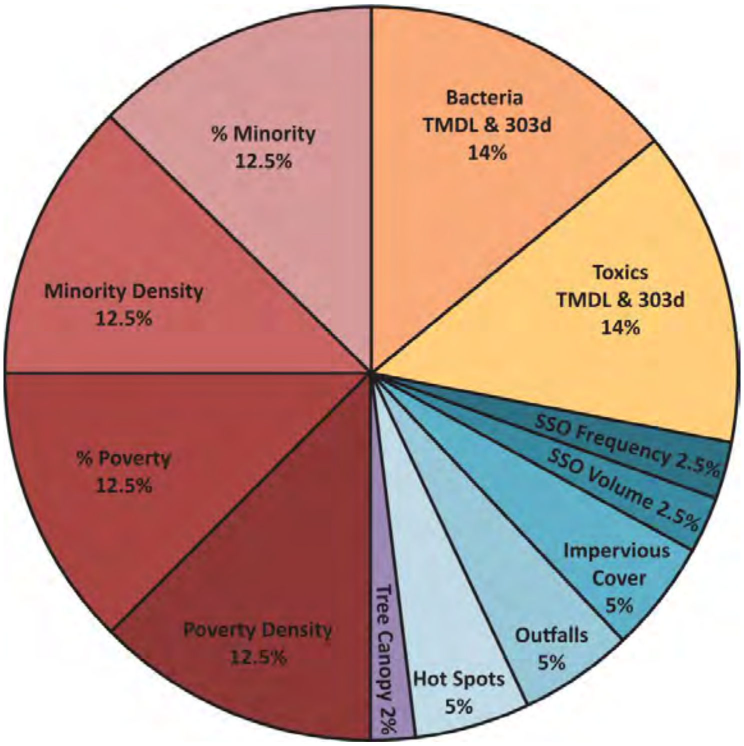


Figure 2-19: Weighting of Environmental Justice Indicator Categories (EPS, 2011)

After the analysis, a composite score was developed for each census block group based on the indicators in Figure 2-19 and graded as high, medium, or low in regards to potential EJ concerns. Within the Middle Gwynns Falls watershed, 90 distinct block groups were analyzed of which 39 were categorized as high, 38 as medium, and 13 as low for Environmental Justice. Table 2-21 summarizes the amount of high EJ risk areas within the Middle Gwynns Falls subwatersheds.

Table 2-21: High Environmental Justice Risk Areas in Middle Gwynns Falls Watershed

Subwatershed	Area (Acres)	Area of High EJ Risk (Acres)	% of Area with High EJ Risk (Acres)
Gwynns Falls	6,165	3,109	50.4%
Powder Mill Run	958	699	72.9%
Dead Run	4,177	2,606	62.4%
Maiden Choice Run	928	0	0.0%
Scotts Level	2,653	1,863	70.2%
Total	***14,881***	***8,277***	***55.6%***

The 39 census blocks categorized as high were contained within or intersected 4 subwatersheds in the study area, Gwynns Falls, Powder Mill Run, Scotts Level, and Dead Run, as seen in Figure 2-20. Powder Mill Run, Scotts Level and Dead Run are ranked second, third, and fifth, respectively among subwatersheds within the entire County with the greatest percentage of area classified as high EJ risk. The high EJ risk areas within the Middle Gwynns Falls watershed encompass 70 neighborhoods, 25 institutions and 12 hotspots assessed in the Uplands Assessment. These assessment sites constitute locales where restoration activities should be given a higher priority due to their presence in an EJ risk area. More information on the neighborhoods, institutions, and hotspots located in this area can be found in Chapter 4 and Appendix B of this report.

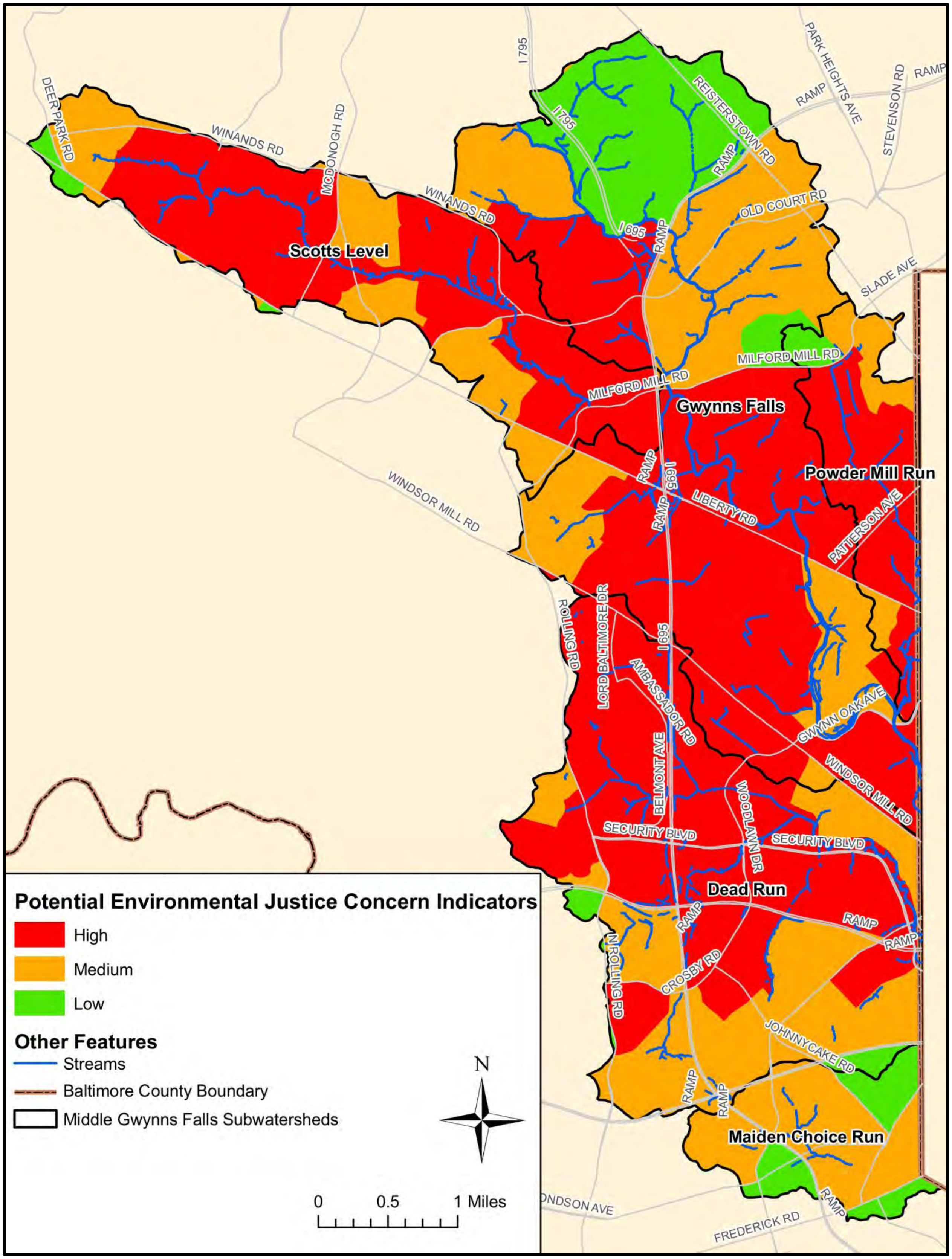


Figure 2-20: Potential Environmental Justice Concern Indicators in Middle Gwynns Falls

CHAPTER 3: WATER QUALITY AND LIVING RESOURCES

3.1 Introduction

Water is an integral part of the habitat of all species. The SWAP goals for maintaining and improving water quality also aim to provide for plants, animals, and their habitat. Because habitat conditions affect the ability of natural communities to find food and shelter and carry on natural processes, it is necessary to evaluate the state of existing land, water, and biological elements that provide for their needs. This chapter describes the water quality, living resources, and habitat for the Middle Gwynns Falls watershed based on existing conditions.

Living resources including all animals and plants require water to survive; they and their habitats are intimately connected to and respond sensitively to water quality and habitat conditions. Their dependence on water quality provides a gauge with which to measure and evaluate the status of water bodies and the effects that watershed characteristics and activities have on these water bodies. For example, in some cases water quality is measured in terms of its ability to support living resources such as trout or shellfish. Information on living resources is presented in this chapter to indicate water quality status and to evaluate habitat conditions in the Middle Gwynns Falls watershed. This information can help to determine if current watershed management practices are adequately providing for the needs of natural communities.

The following sections include descriptions of the following with respect to the Middle Gwynns Falls watershed: impairments per Maryland state water quality standards, pollutant loading analysis for total nitrogen and total phosphorus, water quality monitoring data available to date, sewer overflow occurrences and impacts, and stormwater management facility assessments.

3.2 303(d) Listings and Total Maximum Daily Loads (TMDLs)

The Clean Water Act (CWA) requires states, territories and authorized tribes to: develop water quality standards for all jurisdictional surface waters; monitor these surface waters; and identify and list impaired waters. More specifically, Section 305(b) of the CWA requires annual water quality assessments to determine the status of jurisdictional waters. Section 303(d) requires states to identify and periodically update a list of impaired waters that fail to meet applicable state water quality standards. States must also establish priority rankings and develop Total Maximum Daily Loads (TMDLs) for waters on the 303(d) list, which generally target pollutants including sediment, metals, bacteria, nutrients, and pesticides. According to USEPA, a TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet state water quality standards.

Water quality standards are developed from a combination of the designated use for a given water body and the water quality criteria designed to protect that use. Surface waters (e.g., streams) within the Middle Gwynns Falls watershed south of Reisterstown Road including the main stem and its tributaries are designated as Use I – water contact recreation, fishing, and protection of aquatic life and wildlife. The Gwynns Falls main stem and its tributaries located north of Reisterstown Road are designated as Use III – support of estuarine and marine aquatic life and shell fish harvesting. In addition, Dead Run and its tributaries are considered Use IV – recreational trout waters. Further downstream from the planning area, the receiving tidal water segment of the Gwynns Falls, the Patapsco River Mesohaline (MD-PATMH), is designated as Use II (DSD, 2010).

Based on the water quality criteria associated with the above designated uses, the Middle Gwynns Falls watershed are listed in *Maryland's Final 2012 Integrated Report of Surface Water Quality* for various pollutants of concern. Each listing is applicable to the non-tidal areas of the Gwynn Falls the (basin 02130905). In addition, because the Gwynns Falls eventually drains to the Baltimore Harbor and the Chesapeake Bay, listings in these waters must be addressed in the Gwynns Falls as well. Each listing within the Integrated Report is sorted by attainment status or category upon which a water body is placed. Table 3-1 provides the definition for each attainment status or listing category within the report (MDE, 2012).

Table 3-1: Maryland Integrated Report Listing Categories (MDE, 2012)

Listing Category	Definition
2	Waters meeting the standards for which they have been assessed.
3	Waters that have insufficient data or information to determine whether any water quality standard is being attained
4a	Waters that are still impaired but have a TMDL developed that establishes pollutant loading limits designed to bring the waterbody back in to compliance
4b	Waters that are impaired but for which a technological remedy should correct the impairment
4c	Waters that are impaired but not for a conventional pollutant. This includes pollution caused by habitat alteration or flow limitations.
5	Water bodies that may require a TMDL

The water quality segments in Middle Gwynns Falls that are applicable to the current SWAP area contain the following listings in the 2012 Integrated Report: nutrients (phosphorus), polychlorinated biphenyls (PCBs) in fish tissue, sediments (total suspended solids), fecal coliform, channelization, and chlorides. Impairment listings within categories 4a, 4b, 4c, or 5 reflect an inability to meet water quality standards. When a water quality segment is listed as impaired, action can be taken by developing and/or adhering to a TMDL or by submitting a Water Quality Analysis (WQA) to remove a specific pollutant from the impairment listing. TMDLs can be developed for a single pollutant or group of pollutants of concern. Impairment in the tidal receiving waters is related to pollutants coming from the entire watershed; therefore, TMDLs developed for the tidal segment MD-PATMH and its subsegments will require watershed pollutant load reductions. WQAs are performed to determine if the pollutant of concern is actually impairing the waters. If it is determined that the pollutant of concern is not contributing to water impairment, a report documenting the findings is submitted to USEPA for concurrence. Maryland's 2012 Integrated Report (IR) of Surface Water Quality represents a fully combined 303(d) and 305(b) report approved by USEPA(MDE, 2012).

Table 3-2 summarizes the status of the current listings for portions of the Middle Gwynns Falls watershed that are applicable to the current SWAP area.

Table 3-2: Middle Gwynns Falls Water Quality Impairment Listings and Status

Listing	Applicable Segment	Listing Category	Status	Approval Date
Phosphorus (Total)	MD-02130905	2	Water Quality Assessment	3/15/2010
PCB in Fish Tissue	MD-02130905	3	Indeterminant	N/A
Total Suspended Solids (TSS)	MD-02130905	4a	TMDL Complete	03/10/2010
Fecal Coliform	MD-02130905	4a	TMDL Complete	12/4/2007
Channelization	MD-02130905	4c	BSID Completed	02/09/2012
Chlorides	MD-02130905	5	BSID Completed	02/09/2012

As shown in Table 3-2, the Middle Gwynns Falls watershed has six listings applicable to the current SWAP area. Total phosphorus was listed under Category 2, meaning surface waters in the Gwynns Falls meet the total phosphorus standard. The *Water Quality Analysis of Eutrophication for the Gwynns Falls Watershed in Baltimore County and Baltimore City, Maryland* states that "although the amount of nutrients entering the Gwynns Falls is not causing localized impairments, it is contributing to the eutrophication of the downstream tidal waters of the Harbor. Therefore, the TMDL for the Baltimore Harbor requires nutrient reductions in the Gwynns Falls necessary to meet water quality standards in the Harbor" (MDE, 2009). PCBs were listed under category 3 meaning that insufficient data was available to make a determination on its impairment status in the watershed. Two listings in the Gwynns Falls, total suspended solids and fecal coliform, were placed under category 4a, meaning a TMDL has been completed for each.

A biological stressor identification (BSID) analysis was developed to determine the cause of biological impairments in 2009 and revised in 2012. The BSID analysis determined the cause of degraded biological communities to be inorganic pollutants (chlorides and conductivity), flow/sediment related stressors, anthropogenic channelization, and ammonia. Inorganic pollutants (chlorides) were found in 76% of stream miles with very poor to poor biological conditions. A TMDL has been completed for total suspended sediments that are a result of flow/sediment related stressors. Channelization in the Gwynns Falls was listed under Category 4c of the 2012 Integrated Report. Additionally, the BSID recommends a more intensive analysis of ammonia toxicity to determine if impairment truly exists (MDE, 2012).

Additional impairments within the tidal segment MD-PATMH that would apply to the Gwynns Falls include total nitrogen and trash. The Chesapeake Bay TMDL, which was completed in December, 2010, supercedes the nutrient and sediment reductions mandated for the Gwynns Falls and its receiving tidal water (MD-PATMH). The trash impairment listing for MD-PATMH is listed under category 5, meaning a TMDL may be required in the future. When a TMDL is produced, it will also apply to the Middle Gwynns Falls study area.

Impairments for chlorides and bacteria, along with the Chesapeake Bay TMDL are discussed in further detail in the following sections.

3.2.1 Chesapeake Bay Nutrient and Sediment Impairment

The Chesapeake Bay Program (CBP) has developed the Phase 5 Watershed Model. This model, in conjunction with the Estuary Model, is used to determine the sources and reductions of nitrogen, phosphorus, and sediment needed to meet Chesapeake Bay tidal water quality standards. The Phase 5 model was used to develop a Chesapeake Bay-wide TMDL and to assign nutrient and sediment load reductions to individual states and ultimately local jurisdictions based on the segment loads. In Maryland, nutrient and sediment load reductions were assigned on a County basis for achievement by a 2025 timeframe. 2017 was established as an intermediary milestone with specific targeted load reductions to be achieved. Table 3-3 lists the pollutant load reduction requirements for Baltimore County, and in turn the Middle Gwynns Falls watershed, under the Chesapeake Bay TMDL.

Table 3-3: Baltimore County Stormwater Sector Pollutant Load Reductions

TMDL Pollutant	% Pollutant Load Reduction Requirements for Baltimore County	
	2017	2025
Nitrogen	20.3%	29.0%
Phosphorous	31.6%	45.1%

3.2.2 Bacteria (Fecal Coliform)

Sampling from four representative stations in the Gwynns Falls watershed was used to estimate a baseline load for fecal coliform. High flows and low flows for annual and seasonal conditions were then used to determine the TMDL load which is reported in the units of Most Probable Number (MPN) per day. The fecal bacteri TMDL for the entire Gwynns Falls watershed is 917.4 billion *E.coli* MPN/day. This TMDL is split between load allocations (LA) for nonpoint sources and waste load allocations (WLA) for point sources including wastewater treatment plants (WWTPs), municipal separate storm sewers (MS4s), and combined sewer overflows (CSOs). There are no WWTPs in the Gwynns Falls watershed and the WLA from CSOs is 0. The final TMDL is split between LA (176.0 billion *E. coli* MPN/day) and WLA from MS4s (741.4 billion *E. coli* MPN/day). In Baltimore County, the TMDL calls for implementation of the elimination of sanitary sewer overflows (SSOs) ordered under the consent decree between Baltimore County, MDE, and EPA. In addition, other BMPs will be needed to meet reduction requirements including public education on pet waste and management of overpopulation of wildlife.

3.2.3 Chlorides

High concentrations of chlorides are toxic to aquatic organisms and can result from industrial discharges, metals contamination, and application of road salts in urban landscapes. The BSID analysis did not find a high concentration of metals in the watershed so high chlorides and consequently high conductivity can most likely be attributed to application of road salts. Because there is no specific criteria related to the impact of chlorides, MDE was not able to identify and impose limits on a specific chloride pollutant in the watershed.

3.3 Pollutant Loading Analysis

Pollutant loading analyses are intended to assess the impacts of current and future development on water quality. For the Middle Gwynns Falls watershed, a pollutant loading analysis was completed based on land-uses in the watershed along with the presence of septic systems and point sources within the watershed.

3.3.1 Land-Use Pollutant Loading

Land use analyses have been performed for each of the Maryland designated 8-digit watersheds located entirely or in part within Baltimore County. As part of these analyses, Baltimore County derived watershed-specific pollutant loading rates for nitrogen, phosphorus, and sediment based on the Chesapeake Bay Program (CBP) July 2011 Watershed Model. The model derived segment-specific loading rates for urban and non-urban land uses. Pollutant loading rates corresponding to different land use types in the Middle Gwynns Falls watershed are summarized in Table 3-4.

Table 3-4: Annual Pollutant Loading Rates for Water Resources Element (WRE) Land Use Classifications (lbs/acre/yr)

WRE Land Cover	Nitrogen Per Acre	Phosphorus Per Acre	Sediment Per Acre
Impervious Urban	17.34	1.51	2056.95
Pervious Urban	11.55	0.30	280.43
Cropland	23.07	1.32	1422.32
Pasture	7.97	0.74	307.45
Forest	2.78	0.04	82.17

As presented in Chapter 2, land use information for the Middle Gwynns Falls watershed was obtained from Baltimore County and is based on MDP’s 2010 land use/land cover (LU/LC) GIS spatial data. For purposes of the watershed pollutant loading analysis, Baltimore County uses a consolidated version of MDP’s LU/LC classifications because loading rates do not differ significantly between certain land use classes (e.g., various forest types). The MDP LU/LC categories present in the Middle Gwynns Falls watershed and the corresponding WRE land use classes used for the pollutant loading analysis are summarized in Table 3-5. It should be noted that the total forest area in Table 3-5, 1,934 acres, does not match the values in the 2010 Maryland Department of Planning spatial data. This is due to the fact that The MDP LU/LC classification of “Large Lot Agriculture” and “Large Lot Forest” Listed in Table 3-4 was split between cropland, pasture, and forest for the WRE Land Cover. This adds 74 more acres of forest to the WRE land use classification.

Table 3-5: Reclassification of MDP LU/LC to Water Resources Element (WRE) Land Use for Middle Gwynns Falls

MDP LU/LC Classification	WRE Land Cover
11 Low Density Residential	Urban*
12 Medium Density Residential	Urban*
13 High Density Residential	Urban*
14 Commercial	Urban*
15 Industrial	Urban*
16 Institutional	Urban*
18 Open Urban Land	Urban*
21 Cropland	Cropland
41 Deciduous Forest	Forest and Wetlands
43 Mixed Forest	Forest and Wetlands
44 Brush	Forest and Wetlands
50 Water	Water
60 Wetlands	Forest and Wetlands
80 Transportation	Urban*
191 Large Lot Agriculture	Divided between Cropland, Pasture, and Forest
192 Large Lot Forest	Divided between Cropland, Pasture, and Forest

Total acreages of each WRE land use category were calculated for the Middle Gwynns Falls watershed. These were multiplied by the corresponding loading rates presented in Table 3-4, yielding annual pollutant loads for total nitrogen, total phosphorus, and total sediment from the watershed. The total annual land use pollutant loadings calculated for the Middle Gwynns Falls watershed are summarized in Table 3-6.

Table 3-6: Total Annual Pollutant Loads for Nitrogen, Phosphorus and Sediment for Middle Gwynns Falls Watershed

		NITROGEN		PHOSPHORUS		SEDIMENT	
WRE Land Use	Area (acres)	Loading Rate (lbs/ac)	Load (lbs)	Loading Rate (lbs/ac)	Load (lbs)	Loading Rate (lbs/ac)	Load (lbs)
Impervious Urban	4,294	17.34	74,468	1.51	6,502	2056.95	8,833,323
Pervious Urban	8,619	11.55	99,547	0.30	2,559	280.43	2,416,886
Cropland	5	23.07	117	1.32	7	1422.32	7,220
Pasture	29	7.97	232	0.74	21	307.45	8,938
Forest	1,934	2.78	5,378	0.04	76	82.17	158,925
Total	***14,881***		***179,742***		***9,165***		***11,425,292***

Total annual nitrogen and phosphorus loads estimated for the Middle Gwynns Falls watershed are 179,742 lbs TN/year and 9,165 lbs TP/year, respectively. Total annual sediment loading from land use sources into the Middle Gwynns Falls watershed is 11,425,292 lbs Sediment/year. Pollutant loadings were also calculated on a subwatershed basis using the same loading rates and land use classification. These estimates will provide baseline pollutant loads before implementation of restoration projects and will allow a better assessment of both progress made to date and further progress needed to meet watershed goals or anticipated TMDLs for urban nonpoint source reduction.

Table 3-7 summarizes the acreages of WRE land use categories by subwatershed in the Middle Gwynns Falls watershed. The resulting nitrogen, phosphorus, and sediment loads for the 5 subwatersheds are presented in Table 3-8, Table 3-9, and Table 3-10, respectively. These three tables also include annual nitrogen, phosphorus, and sediment loading rates per acre (lbs/ac/yr) calculated for each subwatershed. The tables show that the subwatersheds generating the greatest pollutant loads are Gwynns Falls and Dead Run. It is important to note that these subwatersheds also have larger surface areas compared to the remaining subwatersheds. Dead Run and Maiden Choice Run are predicted to generate the highest amount of annual pollutant loading per acre out of all subwatersheds. These two subwatersheds also contain the highest percentage of impervious coverage in the watershed. In general, the subwatersheds in the Middle Gwynns Falls are highly urbanized compared to other areas in the County and pollutant loadings into surface waters are consequently high. Subwatershed pollutant loadings and rates will be used to prioritize restoration efforts. Total planning level pollutant load estimates will be used to determine necessary reductions to meet watershed goals and any future TMDL reductions.

Table 3-7: Middle Gwynns Falls Water Resources Element (WRE) Land Use Acreages by Subwatershed

SUBWATERSHED	WRE LAND COVER				
	Impervious Urban	Pervious Urban	Cropland	Pasture	Forest
Gwynns Falls	1,435	3,601	4	28	1,096
Powder Mill Run	239	568	0	0	151
Dead Run	1,632	2,208	0	0	337
Maiden Choice Run	305	592	0	0	31
Scotts Level	684	1,649	1	0	320
Total	***4,294***	***8,619***	***5***	***29***	***1,934***

Table 3-8: Middle Gwynns Falls Annual Nitrogen Loads by Subwatershed Based on WRE Land Use (lbs/yr)

SUBWATERSHED	Total Area (acres)	WRE LAND COVER					Total Nitrogen Load (lbs/yr)	Nitrogen Loading Rate (lbs/acre/yr)
		Impervious Urban	Pervious Urban	Cropland	Pasture	Forest		
Gwynns Falls	6,165	24,888	41,595	100	226	3,047	69,856	11.3
Powder Mill Run	958	4,141	6,563	0	0	420	11,123	11.6
Dead Run	4,177	28,304	25,501	1	1	937	54,744	13.1
Maiden Choice Run	928	5,282	6,841	3	1	85	12,214	13.2
Scotts Level	2,653	11,852	19,047	13	3	889	31,804	12.0
Total	***14,881***	***74,468***	***99,547***	***117***	***232***	***5,378***	***179,742***	***12.1***

Table 3-9: Middle Gwynns Falls Annual Phosphorus Loads by Subwatershed Based on WRE Land Use (lbs/yr)

SUBWATERSHED	Total Area (acres)	WRE LAND COVER					Total Phosphorus Load (lbs/yr)	Phosphorus Loading Rate (lbs/acre/yr)
		Impervious Urban	Pervious Urban	Cropland	Pasture	Forest		
Gwynns Falls	6,165	2,173	1,069	6	21	43	3,312	0.54
Powder Mill Run	958	362	169	0	0	6	536	0.56
Dead Run	4,177	2,471	655	0	0	13	3,140	0.75
Maiden Choice Run	928	461	176	0	0	1	639	0.69
Scotts Level	2,653	1,035	490	1	0	13	1,538	0.58
Total	***14,881***	***6,502***	***2,559***	***7***	***21***	***76***	***9,165***	***0.62***

Table 3-10: Middle Gwynns Falls Annual Sediment Loads by Subwatershed Based on WRE Land Use (lbs/yr)

SUBWATERSHED	Total Area (acres)	WRE LAND COVER					Total Sediment Load (lbs/yr)	Sediment Loading Rate (lbs/acre/yr)
		Impervious Urban	Pervious Urban	Cropland	Pasture	Forest		
Gwynns Falls	6,165	2,952,240	1,009,878	6,161	8,722	90,032	4,067,033	659.7
Powder Mill Run	958	491,150	159,334	0	0	12,411	662,894	691.9
Dead Run	4,177	3,357,454	619,127	73	47	27,686	4,004,386	958.6
Maiden Choice Run	928	626,544	166,103	213	56	2,524	795,440	857.2
Scotts Level	2,653	1,405,936	462,445	774	113	26,271	1,895,538	714.4
Total	***14,881***	***8,833,323***	***2,416,886***	***7,220***	***8,938***	***158,925***	***11,425,292***	***767.8***

3.3.2 Septic and Point Source Pollutant Loading

An analysis was completed by Baltimore County based on the presence of septic systems and point source pollution contributions within the Middle Gwynns Falls watershed. Septic systems are classified based on their location in the watershed and their proximity to streams. For septic systems located in the Chesapeake Bay Critical Area, a loading rate of 16.44 lbs Nitrogen/year is used. For systems outside the critical area, rates of 10.28 lbs Nitrogen /year if the system is located within 1,000 feet of a stream and 6.17 lbs Nitrogen/year if the system is located further than 1,000 feet of a stream are used. Septic systems do not provide phosphorus to the nutrient loading of the watersheds. In the Middle Gwynns Falls watershed, there are no septic systems located within the Chesapeake Bay Critical Area. Table 3-11 presents the yearly load for septic systems in the Middle Gwynns Falls watershed.

Table 3-11: Annual Nitrogen Loads from Septic (lbs/year)

	# of Septic Systems			Nitrogen Load		
	< 1000' from Stream	> 1000' from stream	Total # of Septic Systems	< 1000' from Stream	< 1000' from Stream	Total Nitrogen Load
Gwynns Falls	26	165	191	267	1,018	1,285
Powder Mill	8	4	12	82	25	107
Dead Run	28	30	58	288	185	473
Maiden Choice	0	29	29	0	179	179
Scott's Level	19	72	91	195	444	640
Total	***81***	***300***	***381***	***833***	***1,851***	***2,684***

Point sources are made up of pollutant loads accounted for by NPDES permit holders within the watershed. In the Middle Gwynns Falls watershed, these consist of two (2) swimming pool facilities. Table 3-12 presents the annual nutrient loads attributable to point sources within the study area.

Table 3-12: Annual Nitrogen, Phosphorus, and Sediment Loads from Point Sources (lbs/year)

	TN(lbs)	TP(lbs)	TSS(lbs)
Swimming Pool #1	1.2	0.1	18.2
Swimming Pool #2	1.2	0.1	18.2
Total	***2.4***	***0.2***	***36.4***

3.4 Water Quality Monitoring Data

Baltimore County and Maryland DNR have conducted chemical, physical, and biological monitoring for the Middle Gwynns Falls watershed through various programs. Section 3.4.1 presents results from the Scotts Level long-term monitoring program and Section 3.4.1.4 presents the countywide monitoring programs. Section 3.4.3 provides a summary of data obtained from the Baltimore Ecosystem Study, and the County's Illicit Discharge Detection and Elimination Data are also presented in Section 3.4.4.

3.4.1 Scotts Level Branch Long-Term Monitoring

As part of Baltimore County's NPDES Municipal Discharge Permit, the County is required to monitor the effectiveness of restoration efforts. In the past, monitoring has taken place in the Spring Branch area of the County. Using that past experience, the County has designed a more effective monitoring program for the Scotts Level subwatershed (EPS, 2013). The Scotts Level Long-Term Monitoring Program is intended to monitor all restoration projects in Scotts Level Branch above the in-stream monitoring site. Each restoration project will have an EPA Quality Assurance Project Plan associated with it to plan, implement, and assess the quality of the environmental data that is obtained.

While the Spring Branch study monitored the effectiveness of one large restoration project, the Scotts Level Branch monitoring is designed on the basis that a number of restoration projects will be implemented within the subwatershed over a period of time. The ability to detect effects of individual restoration projects will be dependent on the size of the restoration project in relation to the total subwatershed size. Therefore each restoration project will be monitored for project effectiveness, dependent on staff availability. The cumulative effects of restoration will be measured at the long-term in-stream monitoring site. In order to assess restoration progress in the Scotts Level Branch subwatershed, a paired watershed, before-after design concept will be used. Two additional subwatersheds within Gwynns Falls, Powder Mill Run (within the planning area) and Upper Gwynns Falls (above Gwynnbrook Road) have been selected as the "paired" subwatersheds (Figure 3-1) (EPS, 2013).

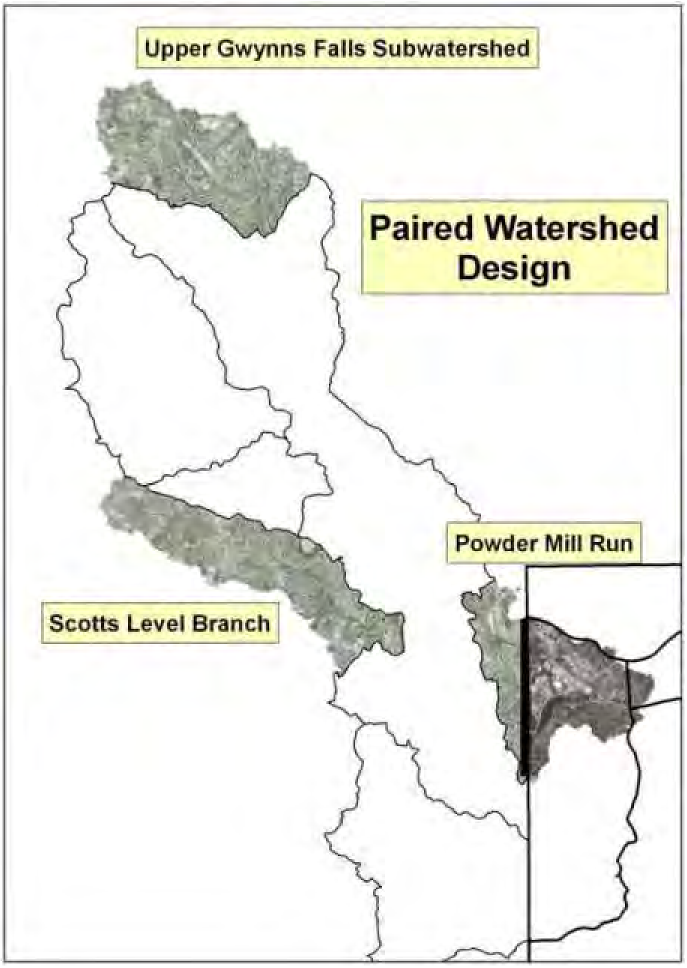


Figure 3-1: Subwatersheds to be used in the Paired Watershed Monitoring Design

3.4.1.1 Flow Monitoring

Both Scotts Level and Powder Mill Run have a gage installed and operated by the USGS to provide rating curves and annual data. The USGS gage in Scotts Level is located on the southern end of the subwatershed and is labeled as site SL-1. In addition, a 36" storm drain outfall near the headwaters of Scotts Level Branch is being monitored for discharge and chemistry (SL-9). The Baltimore County NPDES - Municipal Stormwater Discharge Permit 2012 Annual Report provides detailed results for the flow monitoring at each of the Scotts Level gages.

Precipitation Data

Precipitation stations near the gages provide precipitation data. Table 3-13 and Table 3-14 provide data on rainfall accumulation, intensity, and duration for SL-01 and SL-09, respectively.

Table 3-13: 2011 Precipitation Amount, Intensity, and Duration by Category for SL-01 (EPS, 2013)

Precipitation Category (Inches)	Accumulation Amount				Intensity (inches/hour)			Duration (hours)		
	# Storms	% Storms	Total Acc.	% Acc.	Intensity Category	# Storm	% storms	Duration Category	# storms	% storms
< .1	16	21.9	1.1	0.6	< .1	61	83.6	<1	14	19.2
.1 - <.25	11	15.1	3.0	1.6	.1 - <.25	4	5.5	1 – <3	5	6.8
.25 - <.50	13	17.8	8.2	4.5	.25 - <.50	5	6.8	3 – <6	6	8.2
.50 - <.75	12	16.4	12.8	7.1	.50 - <.75	1	1.4	6 – <9	3	4.1
.75 – <1.00	5	6.8	8.1	4.4	.75 – <1.00	1	1.4	9 – <12	3	4.1
1.00 – <1.50	8	11.0	18.5	10.1	1.00 – <1.50	1	1.4	12 – <15	2	2.7
1.50 – <2.00	1	1.4	2.7	1.5	1.50 – <2.00	0	0.0	15 – <18	4	5.5
2.00 – <3.00	5	6.8	22.4	12.3	2.00 – <3.00	0	0.0	18 – <21	5	6.8
3.00 – 4.00	1	1.4	6.3	3.0	3.00 – 4.00	0	0.0	21 – 24	6	8.2
>4.00	1	1.4	16.8	9.3	>4.00	0	0.0	>24	25	34.2
Total	**73**		**54.94**			**73**			**73**	

Table 3-14: 2011 Precipitation Amount, Intensity, and Duration by Category for SL-09 (EPS, 2013)

Precipitation Category (Inches)	Accumulation Amount				Intensity (inches/hour)			Duration (hours)		
	# Storms	% Storms	Total Acc.	% Acc.	Intensity Category	# Storm	% storms	Duration Category	# storms	% storms
< .1	4	5.3	0.04	0.1	< .1	62	82.7	<1	13	17.3
.1 - <.25	22	29.3	2.07	3.5	.1 - <.25	6	8.0	1 – <3	8	10.7
.25 - <.50	14	18.7	5.24	8.8	.25 - <.50	7	9.3	3 – <6	3	4.0
.50 - <.75	13	17.3	7.65	12.8	.50 - <.75	0	0.0	6 – <9	2	2.7
.75 – <1.00	6	8.0	5.33	8.9	.75 – <1.00	0	0.0	9 – <12	4	5.3
1.00 – <1.50	6	8.0	7.40	12.4	1.00 – <1.50	0	0.0	12 – <15	3	4.0
1.50 – <2.00	3	4.0	4.86	8.1	1.50 – <2.00	0	0.0	15 – <18	3	4.0
2.00 – <3.00	5	6.7	12.36	20.7	2.00 – <3.00	0	0.0	18 – <21	5	6.7
3.00 – <4.00	1	1.3	3.45	5.8	3.00 – <4.00	0	0.0	21 – <24	8	10.7
>4.00	1	1.3	11.37	19	>4.00	0	0.0	>24	26	34.7
Total	**75**		**59.77**			**75**			**75**	

Storms less than 0.25" accounted for slightly over a third of the total number or rainfall events at each station but accounted for less than 4% of the total rainfall accumulation. In contrast, storms over 1" of rainfall accounted for 22% of that total number of storms at SL-01 and 36.2" of rainfall accumulation. At SL-09, this was more pronounced as storms over 1" of rainfall accounted for 21.3% of the total number of storms and 66% of the rainfall volume (EPS, 2013).

Flow Data

15-minute discharge readings were taken at SL-01 (near headwaters) between October 1, 2005 and June 31, 2012, and at SL-09 (outfall) between January 1, 2010 and June 31, 2012. Each corresponding dataset was analyzed to determine the number of storm events that took place during that period. Figure 3-2 and Figure 3-3 provides a graph of the daily discharge and precipitation for calendar year 2011 at SL-01 and SL-09, respectively (EPS, 2013).

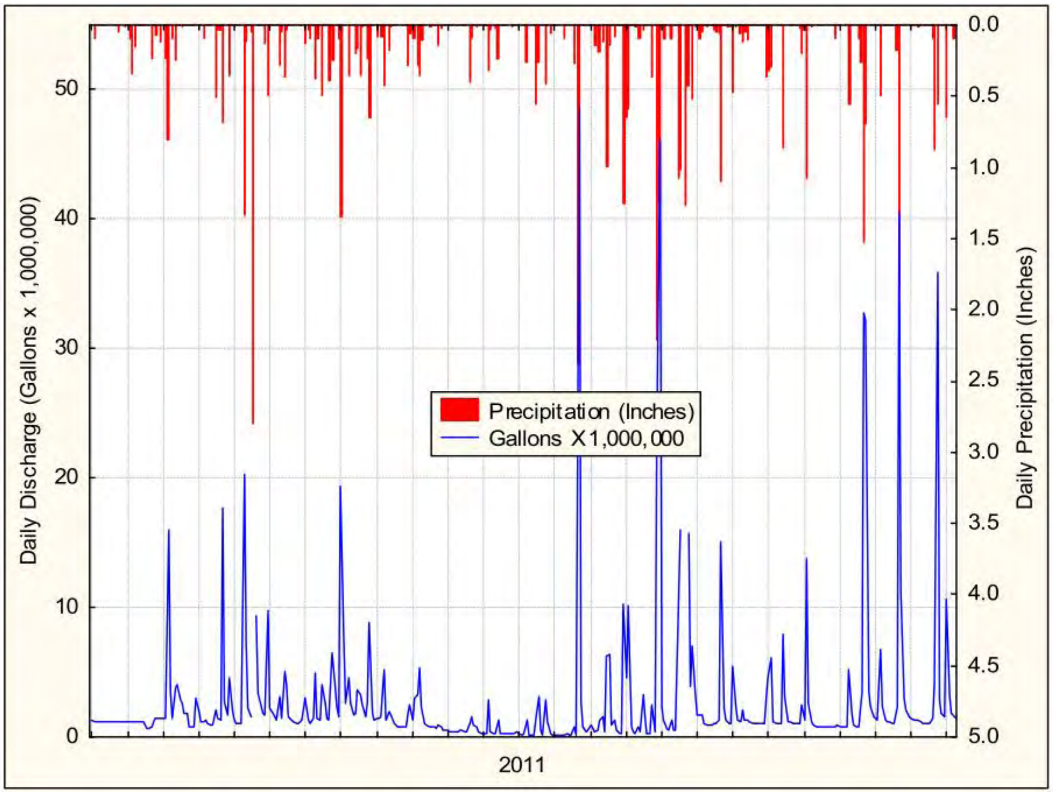


Figure 3-2: Calendar year 2011 Daily Precipitation and Discharge at SL-01 (EPS, 2013)

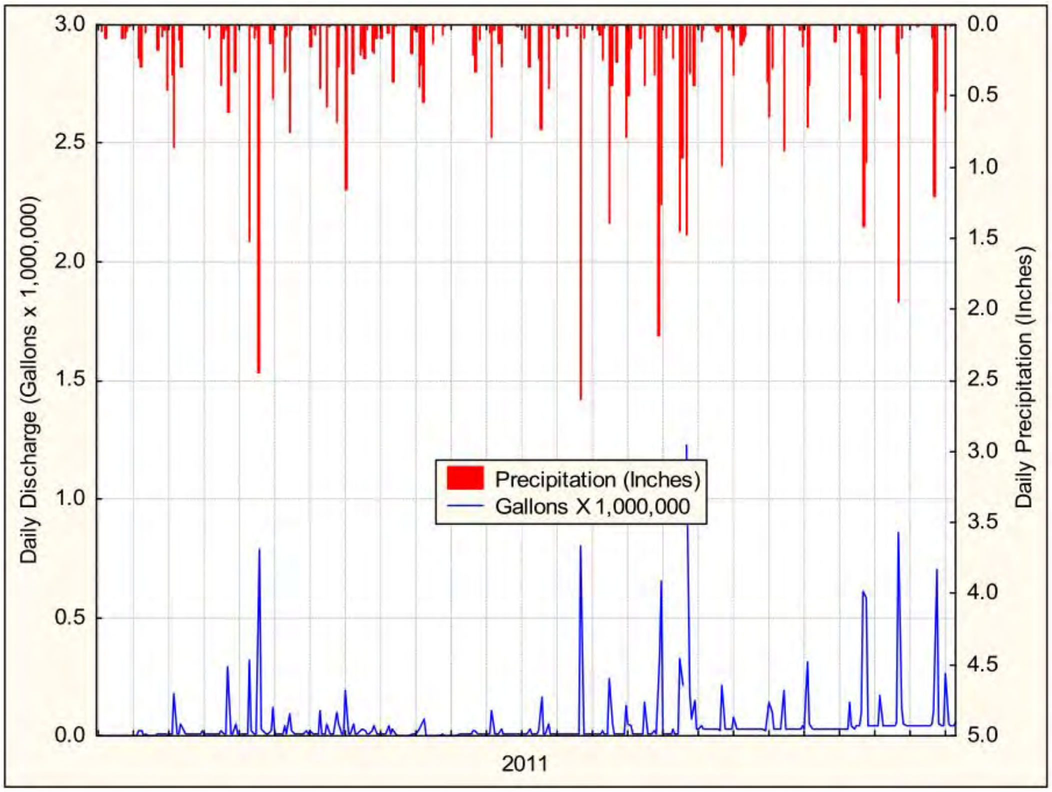


Figure 3-3: Calendar year 2011 Daily Precipitation and Discharge at SL-09 (EPS, 2013)

3.4.1.2 Chemical Monitoring

The chemical monitoring portion of the Scotts Level Branch Long-Term Monitoring Program consists of three components, storm event monitoring, baseflow monitoring, and pollutant load calculations.

Storm Event Modeling

Storm event modeling is conducted at two sites (SL-01 and SL-09) in the Scotts Level subwatershed and the USGS gage in the Upper Gwynns Falls. Data from Powder Mill is to be provided by Baltimore City. The data from all four sites is analyzed using regression analysis to determine the relationship between discharge and pollutant concentration. These relationships are then correlated with the flow data collected from the USGS operated gages and the water level sensor operated by EPS. The results and subsequent analysis following restoration are used to determine annual loads and any load reductions due to restoration activities. Baltimore County's 2012 Annual NPDES Report provided the results to date of the storm event modeling at the Scotts Level monitoring sites SL-01 and SL-09 seen in Figure 3-6. Table 3-15 and Table 3-16 provide the regression equations showing the relationship between discharge and pollutant concentrations for SL-01 and SL-09, respectively.

Table 3-15: SL-01 Regression Equations Relationship between Discharge (CFS) and Pollutant Concentrations

Parameter	Regression Equation
Total Suspended Solids	1.2947+0.2297*(log cfs)
Total Kjeldahl Nitrogen	0.0031-0.0217*(log cfs)
Nitrate/Nitrite	-0.3657-0.0526*(log cfs)
Total Nitrogen	0.1383-0.0161*(log cfs)
Total Phosphorus	-0.9015+0.0418*(log cfs)
Total Copper	-2.1628-0.0078*(log cfs)
Total Lead	-2.5939+0.02*(log cfs)
Total Zinc	-1.7436+0.0498*(log cfs)
Chloride	1.3514+0.0498*(log cfs)
Sodium	1.2928-0.0508*(log cfs)

Table 3-16: SL-09 Regression Equations Relationship between Discharge (CFS) and Pollutant Concentrations

Parameter	Regression Equation
Total Suspended Solids	1.395+0.2195*(log cfs)
Total Kjeldahl Nitrogen	-0.0054-0.0061*(log cfs)
Nitrate/Nitrite	-0.4899-0.1261*(log cfs)
Total Nitrogen	0.1608-0.0486*(log cfs)
Total Phosphorus	-0.8117+0.0046*(log cfs)
Total Copper	-2.0598+0.0632*(log cfs)
Total Lead	-2.5301+0.014*(log cfs)
Total Zinc	-1.5407+0.1226*(log cfs)
Chloride	1.0113-0.1304*(log cfs)
Sodium	1.0126-0.2516*(log cfs)

“For SL-01, total suspended solids and total zinc exhibited strong positive relationships with discharge, while nitrate/nitrite and sodium displayed a strong negative relationship with discharge. The TKN, TP, chloride and total lead relationship with discharge was relatively weak and positive. TN (TKN+Nitrate/Nitrite Nitrogen) displayed a weak and negative relationship” (EPS, 2013).

“For SL-09, the total suspended solids, total copper and total zinc exhibited a strong positive relationship with discharge, while nitrate/nitrite, TN, chloride and sodium displayed a strong negative relationship. The total phosphorus and total lead relationship with discharge was relatively weak and positive. TKN displayed a weak and negative relationship. The data will be analyzed through regression on a seasonal basis for next years report.” (EPS, 2013).

Baseflow Monitoring

Baseflow samples were taken at 10 monitoring sites within Scotts Level (see Figure 3-4) and three locations in Powder Mill Run. Baseflow monitoring in the Upper Gwynns Falls in only conducted at the USGS gage site. Baseflow sampling is done to determine the portions of discharge and pollutant loading found in dry weather and storm event flow conditions.

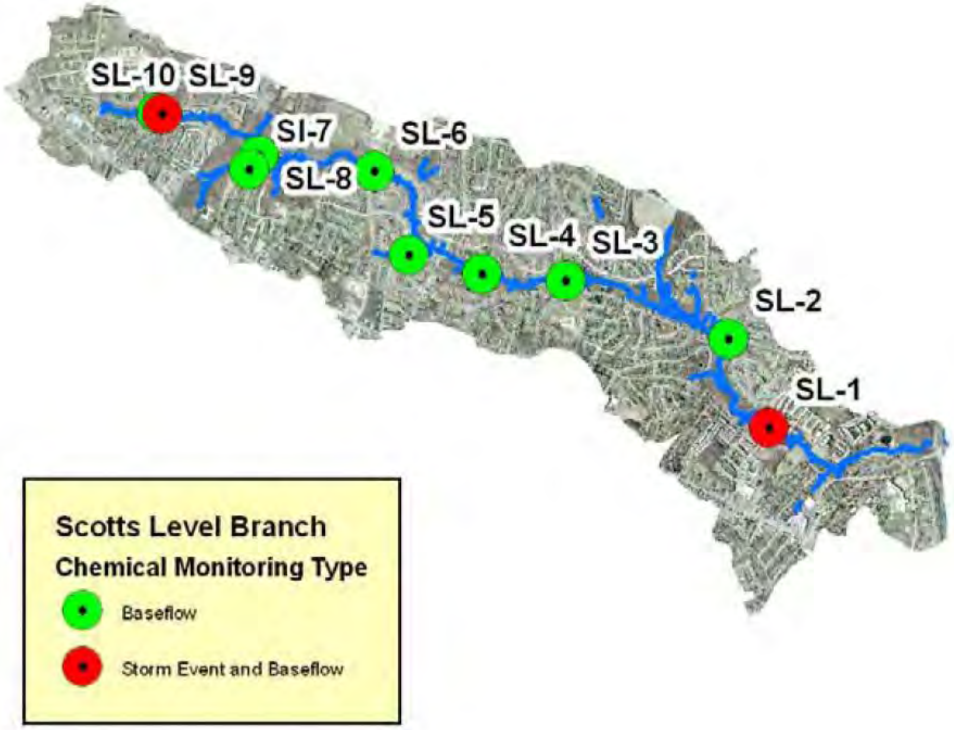


Figure 3-4: Scotts Level Branch Chemical Monitoring Locations (EPS, 2013)

Pollutant loads obtained from 4 baseflow samples (one per season) during the year 2011 are shown in Table 3-17 as a concentration as well as standardized to a daily pollutant load for the drainage area and daily pollutant load per acre.

Table 3-17: 2011 Mean Daily Baseflow Pollutant Loads for Scott's Level Branch Sites (EPS, 2013)

Site	Acres	TKN (mg/L)	TKN Daily Load (lbs)	TKN Daily Load (#s per acre)	NO_2/NO_3 (mg/L)	NO_2/NO_3 Daily Load (lbs)	NO_2/NO_3 Daily Load (lbs per acre)
SL-01	2,186	0.3	1.714	0.0008	1.23	9.394	0.0043
SL-02	1,908	0.31	1.18	0.0006	1.18	6.213	0.0033
SL-03	1,434	0.28	0.422	0.0003	1.23	3.602	0.0025
SL-04	1,167	0.63	1.932	0.0017	1.12	2.594	0.0022
SL-05-Trib	202	0.35	0.11	0.0005	3.01	0.057	0.0003
SL-06	742	0.68	0.144	0.0002	0.99	0.94	0.0013
SL-07-Trib	62	0.83	0.025	0.0004	1.13	0.29	0.0047
SL-08	451	0.15	0.151	0.0003	1.13	1.93	0.0043
SL-09-outfall	15	0.25	0.017	0.0011	3.93	0.103	0.0069
SL-10	265	0.39	0.55	0.0021	1.62	3.559	0.0134
Site	**Acres**	**TN (mg/L)**	**TN Daily Load (lbs)**	**TN Daily Load (lbs per acre)**	**TP (mg/L)**	**TP Daily Load (lbs)**	**TP Daily Load (lbs per acre)**
SL-01	2,186	1.51	11.176	0.0051	0.03	0.171	0.00008
SL-02	1,908	1.48	7.853	0.0041	0.03	0.099	0.00005
SL-03	1,434	1.52	4.36	0.003	0.03	0.04	0.00003
SL-04	1,167	1.96	3.726	0.0032	0.03	0.167	0.00014
SL-05-Trib	202	3.26	0.063	0.0003	0.03	0.006	0.00003
SL-06	742	1.88	1.045	0.0014	0.03	0.017	0.00002
SL-07-Trib	62	1.35	0.316	0.0051	0.16	0.006	0.0001
SL-08	451	1.23	2.102	0.0047	0.03	0.032	0.00007
SL-09-outfall	15	4.11	0.11	0.0073	0.03	0.001	0.00007
SL-10	265	1.98	4.534	0.0171	0.03	0.031	0.00012

Pollutant Load Calculations

The regression equations derived during storm event modeling along with results of the baseflow monitoring, are used to develop pollutant concentrations and ultimately pollutant loads for each 15-minute interval during the sampling period. Table 3-18 and Table 3-19 provide the results of this analysis at SL-01 and SL-09 for the calendar year 2011 for the annual load rate and a standardized load rate for an average rainfall year. In addition, the table also shows how the pollutant loads are divided between seasons and dry weather/storm event conditions.

Table 3-18: Pollutant Load Characteristics for USGS gaged in-stream site (SL-01) calendar year 2011 (EPS, 2013)

Parameter	Pounds/ Year	Pounds/Year Standardized by average rainfall	Pound/Acre Standardized by average rainfall	% by Season	Storm Event Pounds	% Load as Storm Flow	Baseflow Pounds	% Load as Baseflow
TSS								
Fall	98,920	75,513	34.54	15.0%	88,907	89.9%	10,013	10.1%
Winter	125,080	95,484	43.68	19.0%	117,478	93.9%	7,602	6.1%
Spring	49,728	37,961	17.37	7.5%	44,985	90.5%	4,743	9.5%
Summer	385,518	294,296	134.63	58.5%	379,909	98.5%	5,609	1.5%
Total	659,246	503,254	230.22		631,279	95.8%	27,967	4.2%
TKN								
Fall	2,279	1,739	0.80	20.3%	1,827	80.2%	452	19.8%
Winter	2,654	2,026	0.93	23.7%	2,318	87.3%	336	12.7%
Spring	1,539	1,175	0.54	13.7%	1,316	85.5%	223	14.5%
Summer	4,733	3,613	1.65	42.2%	4,503	95.1%	230	4.9%
Total	11,204	8,553	3.91		9,964	88.9%	1,240	11.1%
NO_2/NO_3								
Fall	896	684	0.31	20.9%	706	78.8%	190	21.2%
Winter	1,035	790	0.36	24.2%	894	86.3%	141	13.7%
Spring	624	476	0.22	14.6%	529	84.8%	95	15.2%
Summer	1,730	1,320	0.60	40.4%	1,633	94.4%	97	5.6%
Total	4,285	3,271	1.50		3,762	87.8%	523	12.2%
TN								
Fall	3,159	2,412	1.10	20.2%	2,542	80.5%	617	19.5%
Winter	3,685	2,813	1.29	23.6%	3,225	87.5%	460	12.5%
Spring	2,122	1,620	0.74	13.6%	1,817	85.6%	305	14.4%
Summer	6,651	5,077	2.32	42.6%	6,336	95.3%	315	4.7%
Total	15,618	11,922	5.45		13,920	89.1%	1,698	10.9%
TP								
Fall	340	260	0.12	19.1%	282	83.1%	58	16.9%
Winter	404	309	0.14	22.7%	361	89.3%	43	10.7%
Spring	215	164	0.08	12.0%	187	87.0%	28	13.0%
Summer	826	631	0.29	46.3%	796	96.4%	30	3.6%
Total	1,786	1,363	0.62		1,626	91.1%	160	8.9%
Total Copper								
Fall	16.2	12.3	0.0056	20.0%	13.1	80.6%	3.1	19.4%
Winter	18.9	14.4	0.0066	23.4%	16.6	87.8%	2.3	12.2%
Spring	10.8	8.2	0.0038	13.3%	9.2	85.6%	1.6	14.4%
Summer	34.7	26.5	0.0121	43.1%	33.1	95.5%	1.6	4.5%
Total	80.6	61.5	0.0281		72.0	89.4%	8.6	10.6%

Parameter	Pounds/ Year	Pounds/Year Standardized by average rainfall	Pound/Acre Standardized by average rainfall	% by Season	Storm Event Pounds	% Load as Storm Flow	Baseflow Pounds	% Load as Baseflow
Total Lead								
Fall	6.5	5.0	0.0023	19.7%	5.3	81.8%	1.2	18.2%
Winter	7.6	5.8	0.0027	22.8%	6.8	89.2%	0.8	10.8%
Spring	4.2	3.2	0.0015	12.6%	3.6	86.3%	0.6	13.7%
Summer	14.9	11.4	0.0052	44.9%	14.3	96.0%	0.6	4.0%
Total	33.2	25.4	0.0116		30.0	90.5%	3.2	9.5%
Total Zinc								
Fall	50.2	38.3	0.0175	18.9%	41.8	83.2%	8.4	16.8%
Winter	59.7	45.6	0.0209	22.5%	53.4	89.5%	6.3	10.5%
Spring	31.4	24.0	0.0110	11.8%	27.4	87.1%	4.0	12.9%
Summer	124.1	94.8	0.0434	46.8%	119.8	96.5%	4.3	3.5%
Total	265.4	202.6	0.0927		242.4	91.3%	23.0	8.7%
Sodium								
Fall	41,028	31,320	14.33	20.9%	32,359	78.9%	8,669	21.1%
Winter	47,384	36,172	16.55	24.1%	40,951	86.4%	6,433	13.6%
Spring	28,497	21,754	9.95	14.5%	24,197	84.9%	4,300	15.1%
Summer	79,506	60,693	27.76	40.5%	75,105	94.5%	4,401	5.5%
Total	196,415	149,939	68.59		172,612	87.9%	23,803	12.1%
Chloride								
Fall	62,426	47,655	21.80	18.9%	51,999	83.3%	10,427	16.7%
Winter	74,281	56,705	25.94	22.5%	66,480	89.5%	7,801	10.5%
Spring	39,119	29,863	13.66	11.8%	34,043	87.0%	5,076	13.0%
Summer	154,503	117,945	53.95	46.8%	149,106	96.5%	5,397	3.5%
Total	330,331	252,167	115.36		301,628	91.3%	28,703	8.7%

Table 3-19: Pollutant Load Characteristics for USGS gaged in-stream site (SL-09) calendar year 2011 (EPS, 2013)

Parameter	Pounds/ Year	Pounds/Year Standardized by average rainfall	Pound/Acre Standardized by average rainfall	% by Season	Storm Event Pounds	% Load as Storm Flow	Baseflow Pounds	% Load as Baseflow
TSS								
Fall	1,114	782	52.13	21.5%	884	79.4%	230	20.6%
Winter	792	556	37.07	15.3%	730	92.2%	62	7.8%
Spring	283	198	13.20	5.4%	255	90.0%	28	10.0%
Summer	3,001	2,106	140.40	57.8%	2,929	97.6%	72	2.4%
Total	5,190	3,642	242.80		4,798	92.4%	392	7.6%
TKN								
Fall	51	36	2.40	29.8%	33	65.0%	18	35.0%
Winter	31	22	1.47	18.2%	26	84.0%	5	16.0%
Spring	14	10	0.67	8.3%	11	77.8%	3	22.2%
Summer	76	54	3.60	44.6%	70	91.7%	6	8.3%
Total	173	121	8.07		140	80.8%	33	19.2%
NO_2/NO_3								
Fall	20	14	0.93	34.1%	11	55.3%	9	44.7%
Winter	11	8	0.53	19.5%	9	78.4%	2	21.6%
Spring	6	4	0.27	9.8%	4	67.8%	2	32.2%
Summer	22	15	1.00	36.6%	18	83.9%	4	16.1%
Total	59	41	2.73		42	71.6%	17	28.4%
TN								
Fall	79	55	3.67	30.9%	49	61.7%	30	38.3%
Winter	47	33	2.20	18.5%	38	81.1%	9	18.9%
Spring	22	16	1.07	9.0%	17	75.5%	5	24.5%
Summer	106	74	4.93	41.6%	94	88.9%	12	11.1%
Total	254	178	11.87		198	77.8%	56	22.2%
TP								
Fall	8	6	0.40	31.6%	5	64.7%	3	35.3%
Winter	5	3	0.20	15.8%	4	81.5%	1	18.5%
Spring	2	2	0.13	10.5%	2	84.4%	0	15.6%
Summer	12	8	0.53	42.1%	11	92.7%	1	7.3%
Total	27	19	1.27		22	81.7%	5	18.3%
Total Copper								
Fall	0.42	0.30	0.0200	27.3%	0.29	70.1%	0.13	29.9%
Winter	0.27	0.19	0.0127	17.3%	0.23	86.6%	0.04	13.4%
Spring	0.11	0.08	0.0053	7.3%	0.09	83.5%	0.02	16.5%
Summer	0.76	0.53	0.0353	48.2%	0.71	93.5%	0.05	6.5%
Total	1.56	1.10	0.0733		1.33	85.3%	0.23	14.7%

Parameter	Pounds/ Year	Pounds/Year Standardized by average rainfall	Pound/Acre Standardized by average rainfall	% by Season	Storm Event Pounds	% Load as Storm Flow	Baseflow Pounds	% Load as Baseflow
Total Lead								
Fall	0.15	0.10	0.0067	27.8%	0.10	66.1%	0.05	33.9%
Winter	0.09	0.07	0.0047	19.4%	0.08	86.8%	0.01	13.2%
Spring	0.04	0.03	0.0020	8.3%	0.03	80.1%	0.01	19.9%
Summer	0.24	0.16	0.0107	44.4%	0.22	90.3%	0.02	9.7%
Total	0.52	0.36	0.0240		0.43	81.9%	0.09	18.1%
Total Zinc								
Fall	1.34	0.94	0.0627	24.9%	0.99	73.6%	0.35	26.4%
Winter	0.89	0.63	0.0420	16.7%	0.79	89.2%	0.10	10.8%
Spring	0.35	0.24	0.0160	6.3%	0.30	84.9%	0.05	15.1%
Summer	2.80	1.97	0.1313	52.1%	2.68	95.8%	0.12	4.2%
Total	5.39	3.78	0.2520		4.76	88.3%	0.63	11.7%
Sodium								
Fall	766	538	35.87	35.9%	374	48.8%	392	51.2%
Winter	432	303	20.20	20.2%	295	68.2%	137	31.8%
Spring	261	183	12.20	12.2%	160	61.2%	101	38.8%
Summer	678	476	31.73	31.7%	501	73.9%	177	26.1%
Total	2,137	1,500	100.00		1,330	62.2%	807	37.8%
Chloride								
Fall	623	437	29.13	33.4%	351	56.4%	272	43.6%
Winter	361	253	16.87	19.4%	274	75.9%	87	24.1%
Spring	188	132	8.80	10.1%	130	69.0%	58	31.0%
Summer	692	485	32.33	37.1%	582	84.0%	110	16.0%
Total	1,863	1,307	87.13		1,337	71.7%	526	28.3%

3.4.1.3 *Geomorphologic Monitoring*

The geomorphologic monitoring is intended to provide an estimate of stream erosion and deposition rates, and an estimate of the pollutant load derived from stream channel erosion. In addition, it is intended over time to provide an estimate of the effects of restoration on stream stability on both a project basis and over the entire subwatershed. 20 cross-section locations in Scotts Level and 10 in Powder Mill are monitored annually to provide an assessment on the amount of channel differentiation that is occurring. Streambank soil samples are also taken at locations near the cross sections to hep calculate loading estimates for sediment, total nitrogen, and total phosphorus for comparison with in-stream monitoring results.

Table 3-20 and Table 3-21 provide a summary of the standardized aggradation and degradation estimates for Scotts Level and Powder Mill, respectively.

As stated in the 2012 Annual NPDES Report, "impervious land cover influences the majority of the Scotts Level hydrology. Therefore the sediment fluxes within the Scotts Level stream channel are most likely part of the process of the stream reworking its surrounding legacy flood plain sediments and ultimately transporting them into the Gwynns Falls main stem and beyond" (EPS, 2013). "The Powder Mill Run channel remained active, especially at the lower (CX 1) and upper (CX 10) limits of the study area. A head cut began during late spring or summer 2009, just upstream of CX 1, which resulted in a large amount of channel material filling the cross section. Heavy rainfall (approximately 14 inches above average, as measured at BWI) and scouring stream flows were the likely cause of the head cut at CX 1, as well as the bedload movement at the other cross sections. The head cut continued through 2010 and exposed a concrete sewer line casing early in 2011. All monitoring reaches except for PM-4 gained channel material between 2011 and 2012. The imperviousness of the upstream channel likely concentrates high flows and causes downstream channel instability" (EPS, 2013).

Table 3-20: Scotts Level Branch Stream Channel Changes Over Time

SL #	CX 2011-2012	CX 2006-2012
20	sa	sa
19	d	sa
18	a	a
17 (Trib.)	*	*
16	a	a
15	sa	sa
14	d	sd
13	sa	sd
12	a	sa
11	d	d
10	a	sa
9	d	d
8	a	nc
7	sd	sa
6	a	sd
5	**	**
4	**	**
3	d	sd
2	a	sd
1	d	sa

Table 3-21: Powder Mill Run, 2008-2009 and 2005-2009 Stream Channel Changes

PM #	CX 2011-2012	CX 2006-2012
10	A	sa
9	Sa	sa
8	A	Sa
7	Sa	sa
6	Sa	sa
5	A	sd
4	d	sd
3	a	sd
2	A	sd
1	***	***

Symbols: a: aggradation, d: degradation, sa: slight aggradation, sd: slight degradation

* The left pin monument for SL 17 was removed by vandals. Annual comparisons could not be made. A new pin was set, and comparisons will continue in the 2013 report.

** Permission from private property owners for sampling SL 5 and SL 4 has not yet been obtained, therefore there are no results.

*** A severe sewage leak just upstream of the cross-section did not allow measurement during the monitoring year.

3.4.1.4 Biological Monitoring

Using Maryland Biological Stream Survey (MBSS) methods, benthic macroinvertebrate and fish sampling is conducted annually at five fixed stations on Scotts Level Branch and three fixed stations on Powder Mill Run, during the appropriate index periods (March-April for macroinvertebrates, June-September for fish). At the time of sample collection, the appropriate MBSS stream habitat assessment is conducted.

The biological monitoring data are integrated with the cross sectional and habitat data to produce an overall assessment of conditions in the subwatersheds. In addition, the results will be compared between the two subwatersheds and to reference sites within Baltimore County. Inter-annual comparisons and changes in the biological community will be related to restoration progress within Scotts Level Branch (EPS, 2013).

During 2011, benthic macroinvertebrates were sampled between March 7 and April 2, and fish were sampled beween August 22 and September 30. Using the MBSS for Piedmont streams, the Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI) were calculated based on the following criteria: 1.00-1.99 (Very Poor), 2.00-2.99 (Poor), 3.00-3.99 (Fair), and 4.00-5.00 (Good). In addition, during sample collection, the physical habitat of the streams was assessed using the MBSS Phyical Habitat Index (PHI). The FIBI and BIBI scores at each sampling location were all categorized as poor or very poor with the BIBI score scoring lower than the FIBI score at each location. In addition, the PHI scores were all calculated as Severely Degraded or Degraded.

3.4.2 Baltimore Countywide Monitoring

Baltimore County conducts several water quality monitoring programs across the County. The following subsections provide details on monitoring that is currently in place or had been in place in the past.

3.4.2.1 Baltimore County Trend Chemical Monitoring Program

Baltimore County's Trend Chemical Monitoring Program observes ambient chemical conditions and determines trends in chemical concentrations and pollutant loads over time. This data is used to determine areas to target restoration, assess the impact of implemented restoration activities, and determine the amount of progress made towards meeting TMDLs and other restoration goals. The program was initiated in January 2011 and replaced Baltimore County's previous Baseflow Monitoring program. 40 monitoring sites are visited on the same day, once per month, and monitored for TSS, TS, TKN, Nitrate/Nitrite, Total Phosphorus, Ortho-phosphorus, Cadmium, Copper, Lead, Zinc, BOD, COD, Chlorides, Sodium, Hardness, Magnesium and Calcium as well as temperature and pH. Two of the monitoring sites are located in the Middle Gwynns Falls planning area. GW-12 is located on the main stem of the Gwynns Falls where it crosses Essex Road just north of Liberty Road. GW-10 is located in the Dead Run subwatershed along the interchange of Ingleside Avenue and Security Boulevard. Total pollutant loads calculated for the year 2011 at these monitoring stations can be found in Table 3-22.

Table 3-22: Pollutant Load Analysis (lbs) 2011

Site	TSS	TKN	Nitrate/ Nitrite	TN	TP	Total Copper	Total Lead	Total Zinc	Chloride	Sodium
GW10	3,343,280	29,712	11,271	43,913	3,680	1,484	156	2,685	7,320,518	3,047,005
GW12	6,880,612	47,588	21,691	52,868	*	629	368	6,143	8,061,724	7,109,398

TN concentrations within both of the monitoring areas were categorized as low while TP concentrations were categorized as elevated at GW-12 and Very High at GW-10. Because trend chemical monitoring began in 2011, trends in concentration over time have not been developed to date.

3.4.2.2 Bacteria Monitoring

Bacteria monitoring is conducted at 32 monitoring locations in Baltimore County including 4 in the Gwynns Falls watershed. Only one of the monitoring sites within the Gwynns Falls watershed lies within the Middle Gwynns Falls planning area. Beginning in June 2010, samples were collected on the first Thursday of every month and were analyzed for E. coli. Results were reported in units of Most Probable Number (MPN), an estimate based on the number of organisms present per sample (EPS, 2013). According to the EPA, an average of the samples taken from recreational waters of less than 176 MPN is acceptable for swimming. The results of the bacteria monitoring within the Gwynns Falls watershed can be found in Table 3-23.

Table 3-23: Bacteria Sampling in the Gwynns Falls Watershed (EPS, 2013)

Station	Location	Total # Samples	Geometric Mean	# Samples Exceeded Limit (126 MPN)	% Samples Exceeded Limit	Rating
GWY-1	Lower Gwynns	7	2,149	6	86%	Very Poor
GWY-2	Middle Gwynns	12	258	4	33%	Fair
GWY-5	Lower Gwynns	12	647	7	58%	Poor
GWY-6	Upper Gwynns	12	226	1	8%	Good

Station GWY-2, is the only bacteria monitoring station located within the study area and was given a fair rating. Its average sample reading exceeded the 126 MPN limit and approximately one-third of its individual samples exceeded the limit. The two stations located within Baltimore City (GWY-1 and GWY-5) were found to be poor or very poor with averages well over the 126 MPN limit. Station GWY-6, located in the Upper Gwynns Falls had the lowest average (although still higher than the 126 MPN limit) and was given a rating of good.

3.4.2.3 Biological Monitoring

Baltimore County has four biological monitoring programs, in addition to the program for Scotts Level: Probabilistic Monitoring, Capital Improvement Project Monitoring, Reference Site Monitoring, and Submerged Aquatic Vegetation Monitoring. Only the Probabilistic Monitoring program contains any sites within the study area outside of the realm of the Scotts Level Branch Long-Term Monitoring Program.

Probabilistic Monitoring

Baltimore County has followed the Maryland Bioogical Stream Survey (MBSS) probabilistic monitoring methods since 2003 to assess ecological health in local streams. In odd-numbered years, macroinvertebrate samples are taken in the Gwynns Falls during the spring index period and a Benthic Index of Biotic Integrity (BIBI) score is calculated. The BIBI scores are grouped and given a condition rating: "Very Poor" (1.00 – 1.99), "Poor" (2.00 – 2.99), "Fair" (3.00 – 3.99), and "Good" (4.00 – 5.00) (EPS, 2013). Table 3-24 provides the distribution of BIBI scores calculated for the entire Gwynns Falls watershed between 2003 and 2011. Figure 3-5 provides a visual reference of the distribution of the BIBI scores during this time period.

Table 3-24: Historical BIBI Scores in the Gwynns Falls Watershed (EPS, 2013)

Year	# of Samples	1.00-1.99 Very Poor	2.00-2.99 Poor	3.00-3.99 Fair	4.00-4.99 Good
2003	30	43%	53%	3%	0%
2005	22	18%	68%	14%	0%
2007	26	12%	54%	19%	15%
2009	26	35%	42%	23%	0%
2011	23	35%	30%	30%	4%

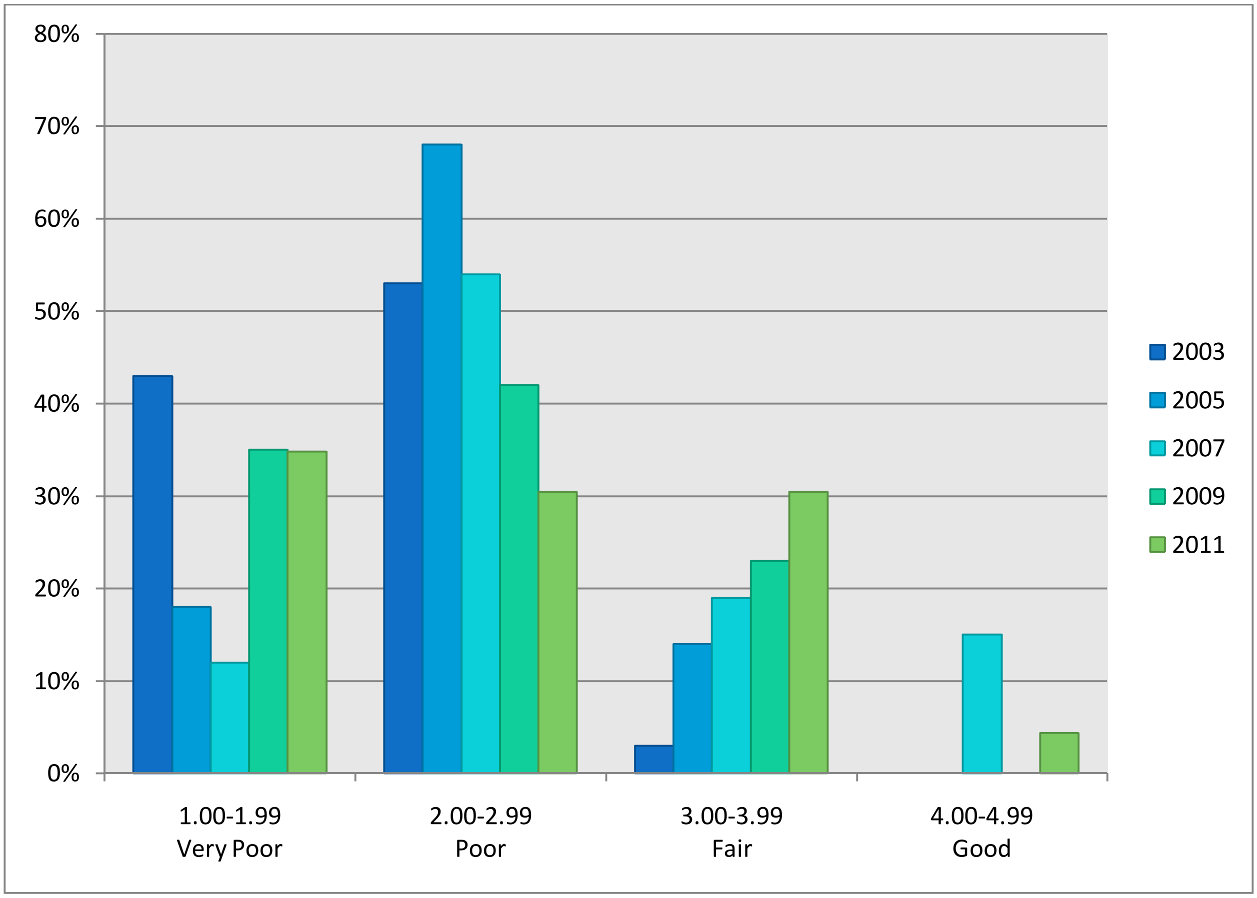


Figure 3-5: Bar Graph of BIBI Scores in the Gwynns Falls Watershed over Time

Since 2003, a higher percentage of BIBI scores have shifted into the “Poor” or “Fair” ratings. Only 2 of the 5 sampling periods contained any ratings of “Good” and these were both below 20%.

In addition, Baltimore County used a procedure developed by MDE and DNR to determine the biological impairment of fresh water streams and watershed condition during all 5 sampling years. This method assesses watersheds at the 8-digit scale and uses statistical measures to calculate the portion of degraded stream miles across an entire watershed. Each watershed is ranked as either “Attaining,” “Impaired,” or “Inconclusive” (EPS, 2013). Table 3-25 provides the results of the impairment analysis for the Gwynns Falls watershed.

Table 3-25: Gwynns Falls Watershed Biological Condition Using Percent Stream Mile Method (EPS, 2013)

Year	Sites Degraded	# of Sites	% Stream Miles with Possible Degradation	CL_{Lower} (%)	CL_{Upper} (%)	Category
2003	29	30	97%	88%	99%	Impaired
2005	19	22	86%	72%	95%	Impaired
2007	17	26	65%	51%	78%	Impaired
2009	18	26	69%	55%	81%	Impaired
2011	15	23	65%	50%	79%	Impaired

Each year, Gwynns Falls has fallen under the impair category although the percentage of stream miles with possible degradation has decreased from 97% in 2003 to 65% in 2011.

3.4.2.4 Baseflow Monitoring

The Baltimore County baseflow monitoring program was initiated in 1999 and targeted areas requiring Water Quality Management Plans. The initial watersheds targeted for baseflow monitoring included the Lower Gunpowder, the Little Gunpowder, Middle River, and Baltimore Harbor. In 2000, baseflow monitoring was conducted in the Back River, Jones Falls, and Gwynns Falls to address the lack of chemical monitoring information available in these locations. The program was halted until 2003 when baseflows were again monitored in the Patapsco/Back River Basin in odd-numbered years and the Gunpowder/Deer Creek basins in even-numbered years. In 2007, baseflow monitoring sites were prioritized into 2 tiers due to staff constraints. Tier 1 sites were regularly sampled while Tier 2 sites were only sampled to support any SWAP studies for the area (EPS, 2011). The baseflow monitoring program was superseded by the Trend Chemical Monitoring Program in 2011.

In the Middle Gwynns falls, 19 sites were monitored for baseflows. Table 3-26 provides a summary of the location of the baseflow monitoring sites which can also be seen in Figure 3-6.

Table 3-26: Baseflow Monitoring Sites in Middle Gwynns Falls

Subwatershed	Water Quality Sites	Subwatershed Abbreviation
Gwynns Falls	GW06	GF
Dead Run	GW08, GW09, GW10	DR
Scotts Level	SL00, SL01, SL02, SL03, SL04, SL05, SL06, SL07, SL08, SL09, SL10	SL
Powder Mill Run	GW07, PM01, PM02, PM03	PM
Maiden Choice Run	NONE	MC

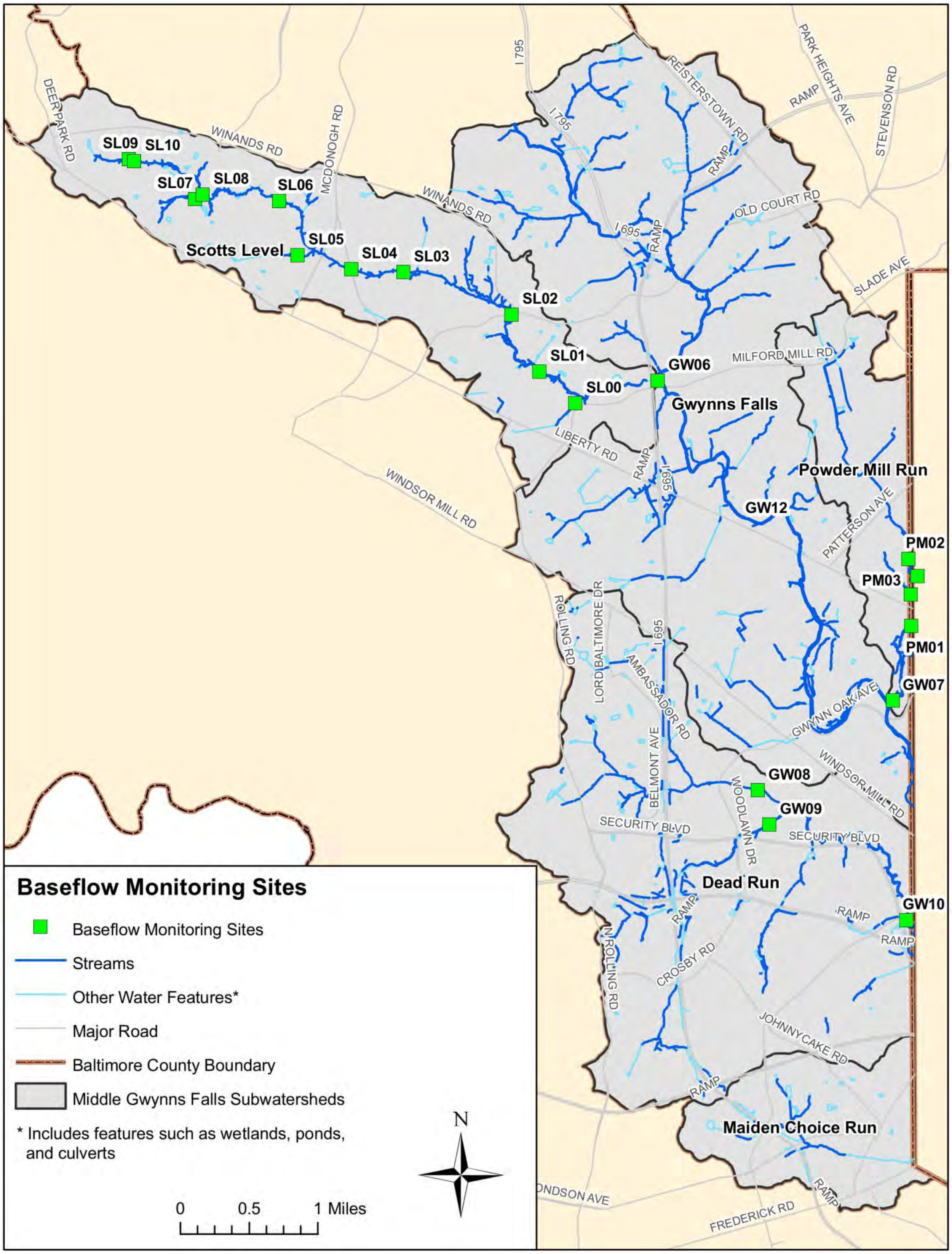


Figure 3-6: Baseflow Monitoring Sites in Middle Gwynns Falls

Numerous water quality parameters were measured in the Middle Gwynns Falls. Of particular importance were measurements for total suspended solids (TSS), nutrients, and chloride due to 303(d) listings and TMDL

- Suspended Solids: Excessive suspended solids can adversely impact aquatic life as it affects the light available for photosynthesis by plants and visual capability of aquatic life. Decreased light can lead to a decrease in algae communities that may limit food supplies and reduce growth rates of invertebrate and fish communities. Suspended solids can inhibit the hunting capability of visual fish predators and cause gill damage. Excessive sediment can also negatively affect habitat structure, through the burial of space between the gravel in the stream bottom (called embeddedness). Embeddedness can kill incubating fish eggs/larvae and benthic macroinvertebrates and can trap bacteria and organics on the stream bottom causing oxygen depletion.
- Nutrients: Over-enrichment of water bodies by excessive nutrient input can cause excessive growth of aquatic plants (algal blooms) and bacterial consumption of dissolved oxygen when the plants decompose. This can lead to significant reductions in water quality as well as abundance and diversity of aquatic life communities.
- Chloride: Chlorides come from various sources such as road salting, waste water, and agricultural runoff. High levels of chlorides can be toxic to aquatic communities including fish. The Maryland Biological Stressor Identification Process (MDE, 2009) has identified a level of 50 mg/L chloride as impacting aquatic life.

Total nitrogen, total phosphorus, chloride and sediment were evaluated because the watershed is 303(d) listed for nutrient and sediment impairment and these are key Chesapeake Bay Program parameters. Table 3-12 shows stream ratings based on total nitrogen concentration data adapted from the Maryland Department of Natural Resources, using loading coefficients reported by Frink (Frink, 1991). Total phosphorus ratings in Table 3-12 were developed by evaluating non-tidal phosphorus data from the Chesapeake Bay Program (Belval & Sprague, 1999). Sediment moves primarily during storm events and thus elevated concentrations of sediment were not found in these baseflow samples (EPS, May, 2011).

Table 3-27: Stream Ratings by Nutrient Concentrations

Rating	Total Nitrogen (TN)	Total Phosphorus (TP)
Baseline	0.0 – 1.0	<0.05
Slightly elevated	1.0 – 2.0	0.05 - 0.075
Moderate	2.0 – 3.0	0.075 – 0.10
High	3.0 – 5.0	0.10 – 0.20
Excessive	>5.0	>0.20

The USEPA National Recommended Water Quality Criteria (EPA, 2012) lists the chronic life criterion for chloride as 230 mg/L and the acute toxicity limit for chloride as 860 mg/L. Table 3-28 provides a summary of the baseflow monitoring data for the Middle Gwynns Falls planning area by subwatershed. Suspended solids concentrations found during baseflow monitoring do not reflect elevated concentrations which are much higher during larger storm events.

Table 3-28: Middle Gwynns Falls Baseflow Monitoring Summary by Subwatershed

Parameter (mg/L)		GF	DR	SL	PM
		(mg/L)	(mg/L)	(mg/L)	(mg/L)
Suspended Solids	Max	4.00	6.00	236.00	22.00
	Min	0.50	0.50	0.50	0.50
	Median	0.50	0.50	0.50	0.50
	Mean	1.29	1.07	7.20	3.49
	Std. Dev.	1.32	1.42	22.34	5.28
Total Nitrogen	Max	1.70	1.87	10.42	2.62
	Min	1.24	0.59	0.16	0.38
	Median	1.38	1.24	1.22	1.39
	Mean	1.44	1.27	1.60	1.40
	Std. Dev.	0.16	0.34	1.13	0.46
Total Phosphorus	Max	0.05	0.08	5.98	1.66
	Min	0.02	0.01	0.01	0.02
	Median	0.05	0.04	0.03	0.03
	Mean	0.04	0.04	0.09	0.07
	Std. Dev.	0.01	0.02	0.52	0.24
Chloride	Max	62.26	1333.28	1226.72	948.22
	Min	43.93	109.75	0.25	35.82
	Median	46.68	178.88	65.20	117.17
	Mean	50.05	281.02	99.24	161.69
	Std. Dev.	6.62	315.08	154.07	177.22

Average Total Nitrogen concentrations were rated as Slightly Elevated for all of the subshedwaters with baseflow monitoring sites with Scotts Level having the highest average and maximum event. Total Phosphorus averages were rated as baseline for all of the subwatersheds except for Scotts Level which was rated as Slightly Elevated. The acute toxicity limit for chlorides was reached during the maximum events in the Dead Run, Scotts Level, and Powder Mill Run subwatersheds. Dead Run had the highest average chloride concentrations.

3.4.3 Baltimore Ecosystem Study

The Baltimore Ecosystem study is intended to research the long-term ecological characteristics of the Gwynns Falls ecosystem as part of the National Science Foundation's Long-Term Ecological Research Program. As part of the wider scope of the study which includes research on topics like biodiversity, meteorology, public health, social issues, soils, and urban design, water quality sample sites were established at several sites along the main stem of the Gwynns Falls and it subwatersheds (Cary Institute of Ecosystem Studies, 2012). Two of these sampling locations fall within subwatersheds of the Middle Gwynns Falls planning area:

1. The Gwynns Falls main stem on the right bank 300 ft downstream from the bridge on Essex Road and 300 ft north of State Highway 26 (Liberty Road).
2. Dead Run on the right bank at the downstream side of the bridge on Colonial Road at its intersection with Security Boulevard.

Figure 3-7 provides a map of the sampling sites in the Middle Gwynns Falls watershed from the Baltimore Ecosystem Study.

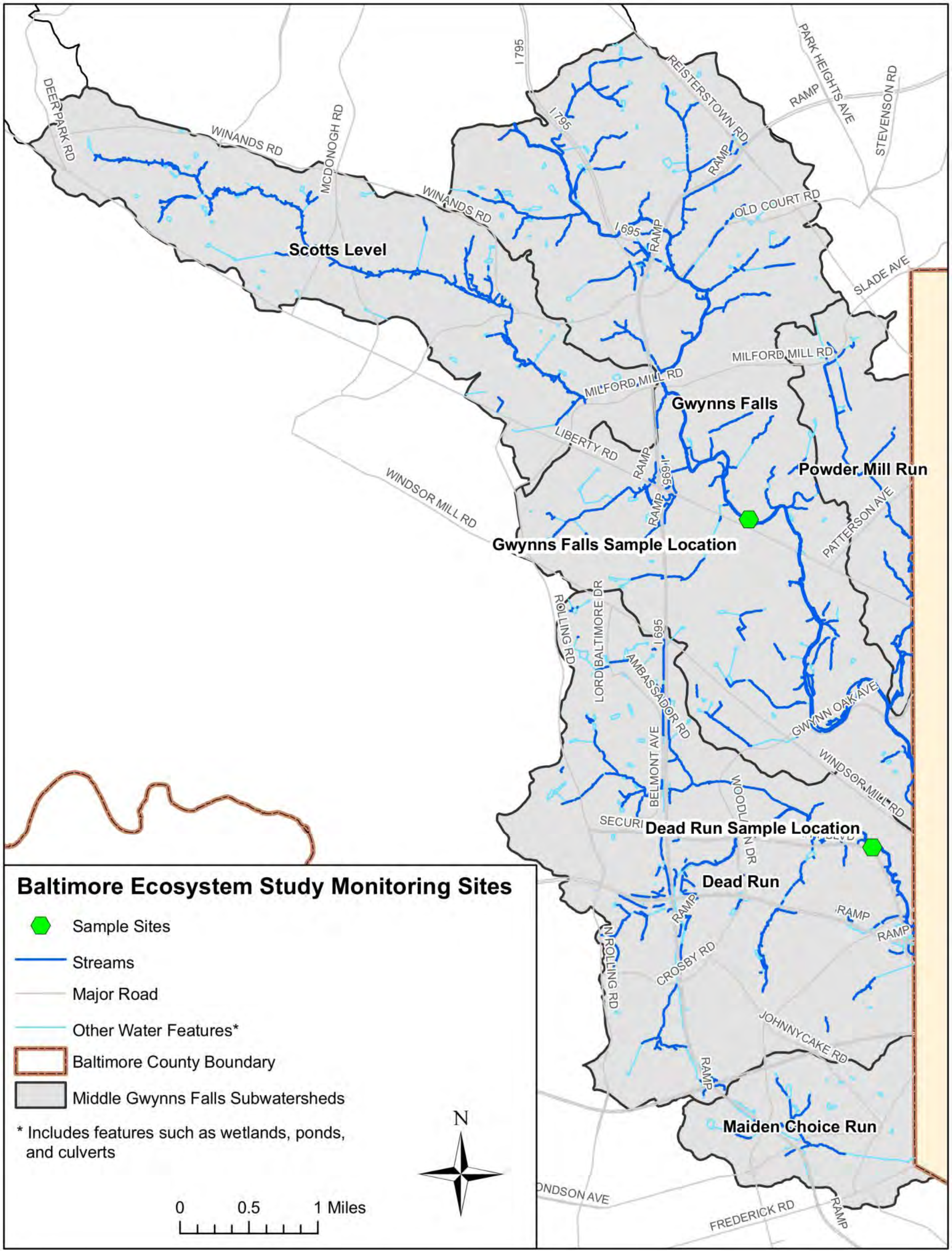


Figure 3-7: Location of Sampling Sites of the Baltimore Ecosystem Study in the Middle Gwynns Falls Watershed

Each of the sites is sampled weekly for chemistry data and continuously monitored for discharge. At the two sampling sites in the Middle Gwynns study area, chemistry data includes analysis of TN, TP, and chloride concentrations over time. TN and TP data from the Baltimore Ecosystem Study website was available from November 15, 1999 through June 2, 2010 while chloride data was available from November 24, 1998 through June 2, 2010. Table 3-29 provides a summary of the data obtained from the study while Table 3-30 provides a percentage distribution of the samples in relation to the nutrient concentration stream ratings from Table 3-27 and the USEPA National Recommended Water Quality Criteria for chloride discussed in Section 0.

Table 3-29: Summary of TN, TP, and Chloride Sampling Data from Baltimore Ecosystem Study in the Middle Gwynns Falls Watershed

Parameter		Dead Run	Gwynns Falls
		(mg/L)	(mg/L)
Total Nitrogen	**Max**	11.68	6.60
	Min	0.21	0.61
	Median	1.12	1.54
	Mean	1.20	1.58
	Std. Dev.	0.77	0.50
Total Phosphorus	**Max**	0.22	0.20
	Min	0.00	0.00
	Median	0.02	0.01
	Mean	0.03	0.01
	Std. Dev.	0.02	0.02
Chloride	**Max**	11600.00	2520.00
	Min	0.02	4.89
	Median	190.00	66.50
	Mean	454.25	110.67
	Std. Dev.	1061.17	198.63

Table 3-30: Exceedance Values for TN, TP, and Chloride Sampling Data from Baltimore Ecosystem Study in the Middle Gwynns Falls Watershed

Parameter		Dead Run (mg/L)	Gwynns Falls (mg/L)
Total Nitrogen	# of Samples	518	528
	% Baseline	39%	5%
	% Slightly elevated	56%	84%
	% Moderate	4%	9%
	% High	0%	1%
	% Excessive	1%	0%
Total Phosphorus	# of Samples	516	525
	% Baseline	91%	95%
	% Slightly elevated	6%	3%
	% Moderate	2%	0%
	% High	1%	2%
	% Excessive	0%	0%
Chloride	# of Samples	559	598
	% Above Chronic Life Criterion	38%	8%
	% Above Acute Toxicity Limit	10%	2%

Over 95% of the stream samples from Dead Run were classified as either baseline or only slightly elevated for nutrient concentrations. Dead Run did contain the highest readings for TN and TP concentrations in the study but average TN concentrations were lower than readings in Gwynns Falls. At the Gwynns Falls sampling location 89% of TN concentration readings registered as baseline or slightly elevated compared to 98% for TP concentration readings. Dead Run contained the highest maximum and average concentrations for chloride while also having the highest percentage of samples above the USEPA National Recommended Water Quality Criteria. Figure 3-8, Figure 3-9, and Figure 3-10 provide graphs displaying the concentrations of TN, TP, and chloride, respectively, over the time of the study.

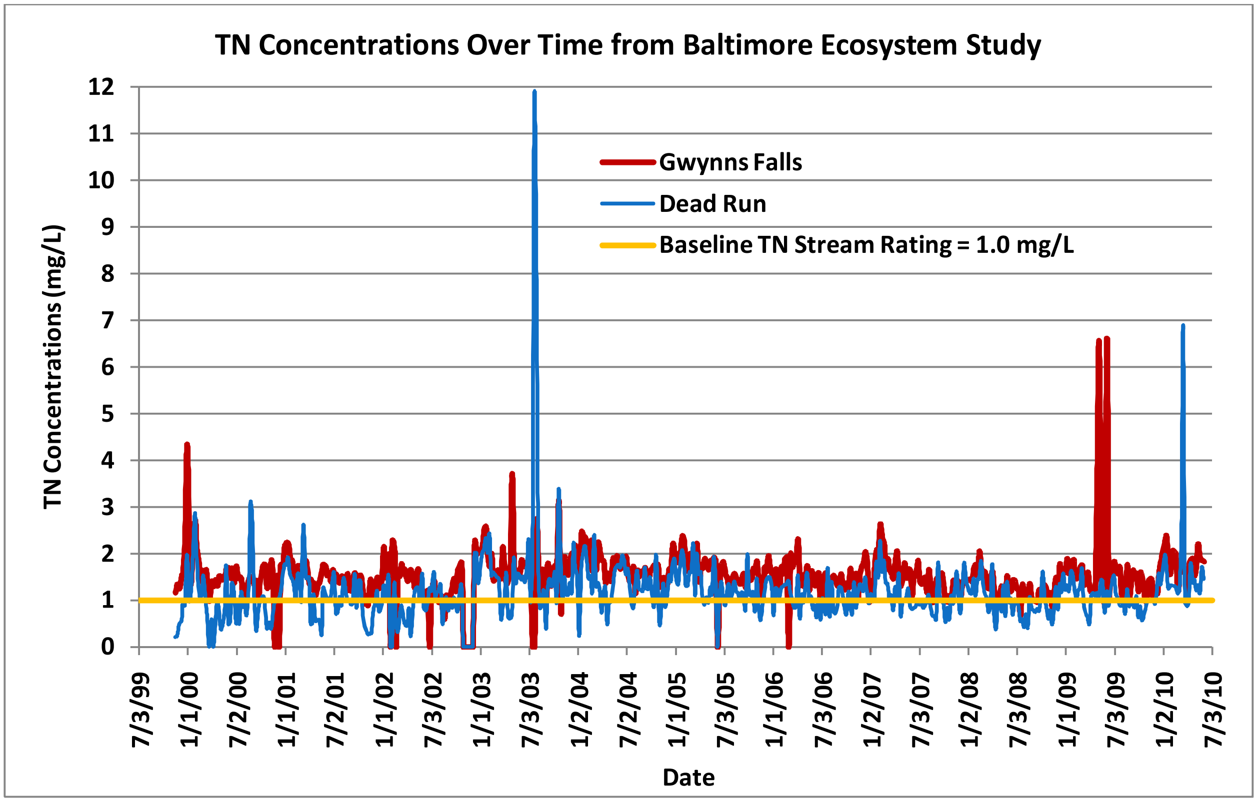


Figure 3-8: TN Concentrations from Sampling Sites in the Baltimore Ecosystem Study

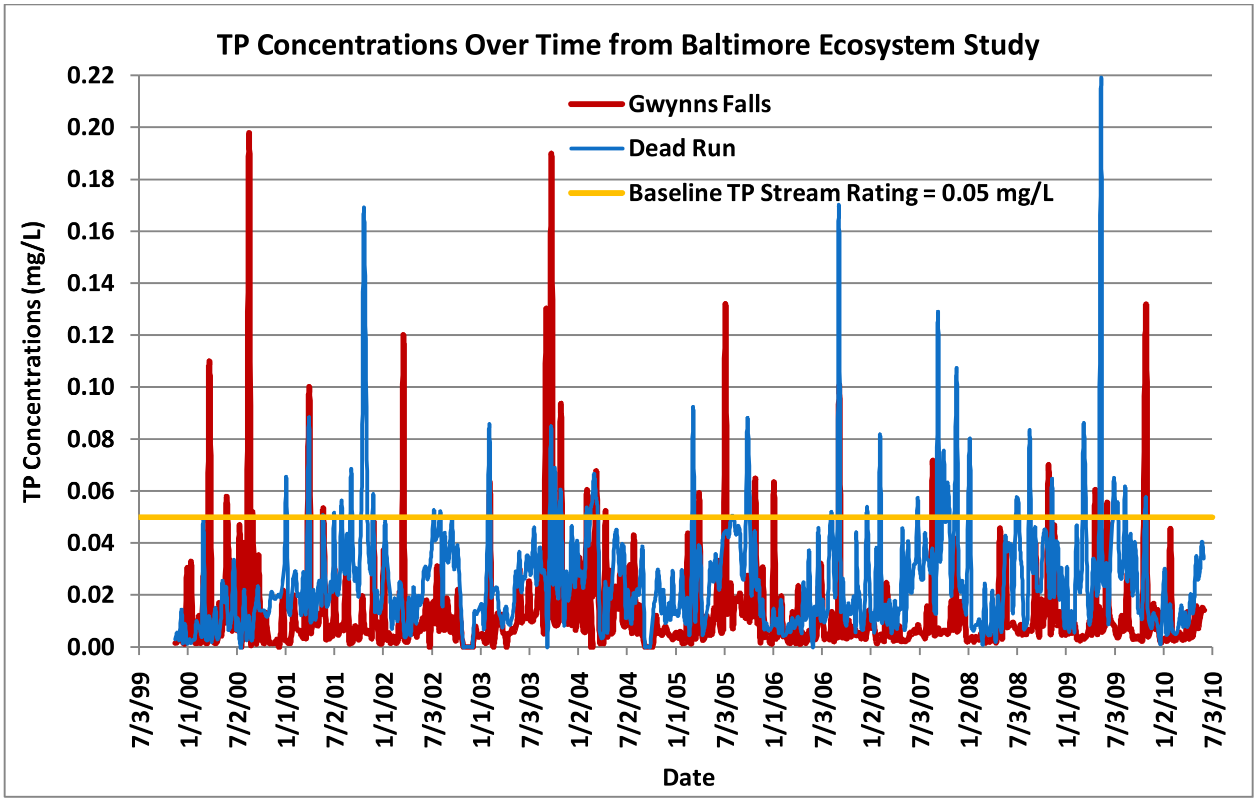


Figure 3-9: TP Concentrations from Sampling Sites in the Baltimore Ecosystem Study

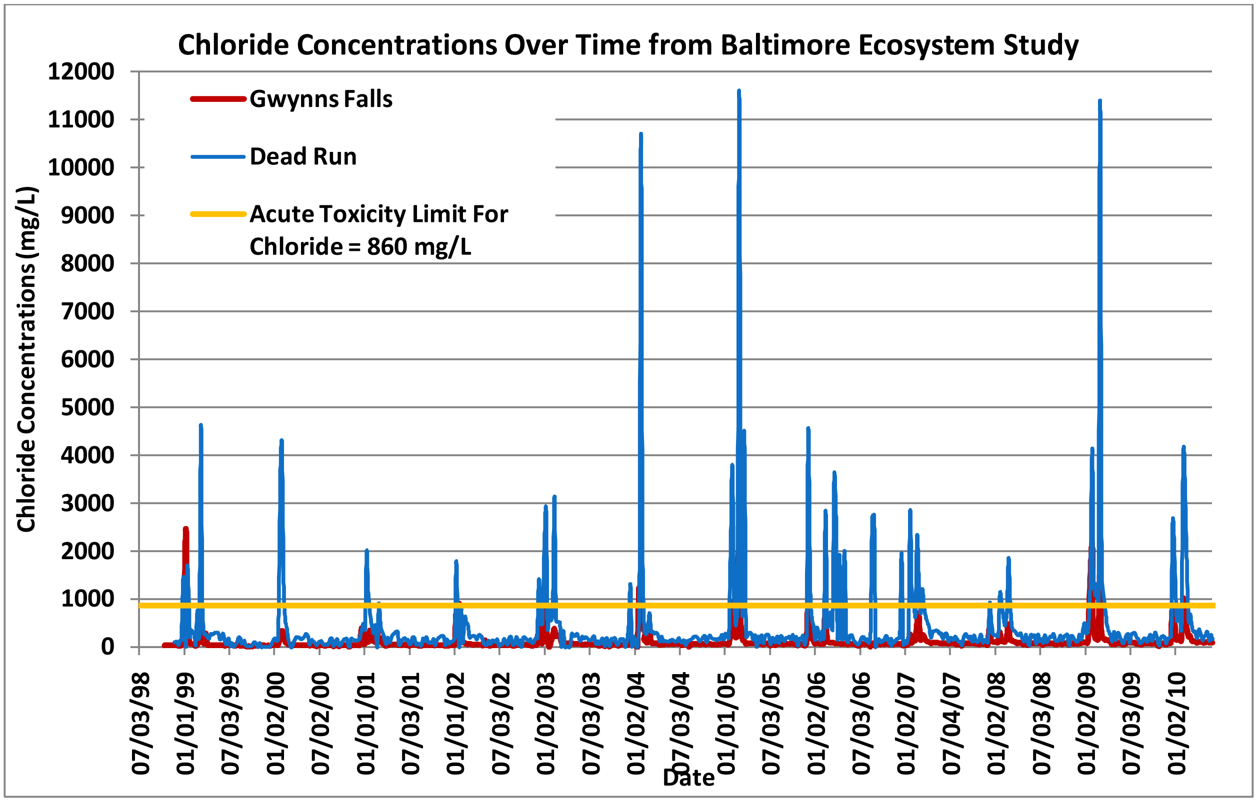


Figure 3-10: Chloride Concentrations from Sampling Sites in the Baltimore Ecosystem Study

3.4.4 Illicit Discharge and Elimination Data

Baltimore County monitors illicit discharges from its storm sewer system through a program of routine outfall screening. The program consists of three parts:

1. A quantitative analysis of the effluent that includes measuring the effluent flow rate, temperature and pH, and field testing for parts per million (ppm) of chlorine, phenols, and copper using a specially configured LaMotte NPDES test kit;
2. A qualitative assessment of the effluent, outfall structure, and receiving channel noting conditions such as water color, odor, vegetative condition, sedimentation, erosion, damage, etc.; and
3. A visual inspection of each outfall that identifies any structural damage.

The County has an outfall prioritization system based on data from the outfall screening. There are approximately 3,628 outfalls based on storm drain spatial data provided by Baltimore County EPS. About 80 percent of these (2,912) are minor outfalls (less than 3 feet in diameter) which are not prioritized. Of the remaining 716 major outfalls (greater than 3 feet in diameter), 593 of them have a prioritization rating. The prioritization system allows for a more streamlined approach in selecting outfalls to screen and provides a more efficient use of manpower. Also under this system, outfalls that have been screened only once or have not been screened at all can be screened sufficiently and properly prioritized. The list of outfalls to be screened is generated by a Microsoft Access query based on the prioritization.

Under the outfall prioritization system, outfalls that have not been screened at least twice are not prioritized. Prioritized outfalls, those screened two or more times, are assigned one of the following priority ratings:

- ***Priority 1 (Critical):*** Outfalls with major problems that require immediate correction and/or close monitoring, or outfalls with recurring problems. These outfalls are sampled four times each year.
- ***Priority 2 (High):*** Outfalls with moderate to minor problems that have the potential to become severe. These outfalls are sampled once a year.
- ***Priority 3 (Low):*** Outfalls with minor or no problems that do not require close monitoring. These outfalls are sampled on a 10-year cycle.
- ***Priority 0 (Not prioritized)*****:** Outfalls with insufficient data to determine a priority rating. This may be due to inaccessibility or if there has been only a single screening.

A second screening is conducted if nearly a decade has passed since the previous screening. If no pollution problems were indicated, then the outfall is considered a low priority. This allows more focus on outfalls with more potential of an illicit connection. A second screening is also performed at an outfall when prior screening indicates that one or more of the water quality criteria were exceeded. The second screening helps determine whether the pollutant is a persistent constituent of the effluent or simply an anomaly. No remedial action is taken if the second screening indicates that the pollutant is within acceptable levels; however, the outfall is considered to have a potential illicit connection and is automatically queued for re-screening within one year. If the problem is severe enough to warrant immediate correction, an investigation begins immediately. Some sites are determined to have problems severe enough to warrant immediate investigation and/or corrective action only after one screening.

There are 134 major outfalls in the Middle Gwynns Falls watershed (see Figure 2-15). Table 3-31 summarizes the priority ratings for these outfalls by subwatershed.

Table 3-31: Baltimore County Storm Drain Outfall Prioritization Results for Middle Gwynns Falls

Subwatershed	OUTFALL PRIORITY RATING				Total
	Priority 1	Priority 2	Priority 3	Priority 0	
Gwynns Falls	3	7	26	8	44
Powder Mill Run	2	3	3	2	10
Dead Run	2	11	24	10	47
Maiden Choice Run	0	2	2	2	6
Scotts Level	7	9	8	3	27
Total	***14***	***32***	***63***	***25***	***134***

As shown in Table 3-31, Dead Run has the largest number of major outfalls with 47 followed closely by Gwynns Falls which has 44. Scotts Level has the largest number of Priority 1 outfalls with 7. Over two thirds of the major outfalls in the Middle Gwynns Falls watershed are categorized as Priority 2 or 3. 25 major outfalls have not been prioritized.

3.5 Stream Corridor Assessments

As part of the *Gwynns Falls Water Quality Management Plan* (DPW & DEPRM, 2004), a detailed stream assessment was conducted along the vast majority of stream miles in the Middle Gwynns Falls watershed. This section presents the results of the analysis conducted for the 2004 report.

3.5.1 Stream Classification Type (Rosgen)

Streams can be classified using the Rosgen classification approach, which is based on the morphology of the channel. Rosgen stream classification types range from A through G and are based on the following channel attributes: mean bankfull depth; maximum bankfull depth; bankfull width; flood-prone area width; channel sinuosity; mean channel slope; and median channel material size. Cruised reach assessments were conducted on over 70 miles of first, second, and third order stream reaches in the entire Gwynns Falls watershed of Baltimore County that were not previously assessed by the U.S. Army Corps of Engineers. Field teams walked the entire length of each reach and performed rapid field assessments, which included assessing channel morphology, channel disturbances, channel habitat, and restoration opportunities. The stream reaches for the entire Gwynns Falls were visually assessed and classified according to Rosgen's stream classification system during the *Gwynns Falls Water Quality Management Plan* (DPW & DEPRM, 2004). This information can also be found on the Baltimore County web site.

The majority of the watershed's streams can be classified as B, E, or F. Table 3-32 shows the distribution of stream types within the Middle Gwynns Falls watershed. Figure 3-11 shows the Rosgen stream classification for both the cruised and corps reaches.

Table 3-32: Middle Gwynns Falls Rosgen Stream Classification

Subwatershed	A	B	C	D	E	F	G
Gwynns Falls	0.0%	25.5%	10.0%	0.0%	12.3%	43.5%	8.6%
Powder Mill Run	0.0%	0.0%	23.8%	0.0%	43.5%	16.9%	15.8%
Dead Run	0.0%	29.6%	0.0%	0.0%	25.6%	37.8%	6.9%
Maiden Choice Run	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Scotts Level	0.0%	28.0%	13.4%	0.0%	46.7%	5.0%	7.0%
Total in Middle Gwynns Falls	***0.0%***	***24.4%***	***9.1%***	***0.0%***	***24.4%***	***32.4%***	***9.6%***

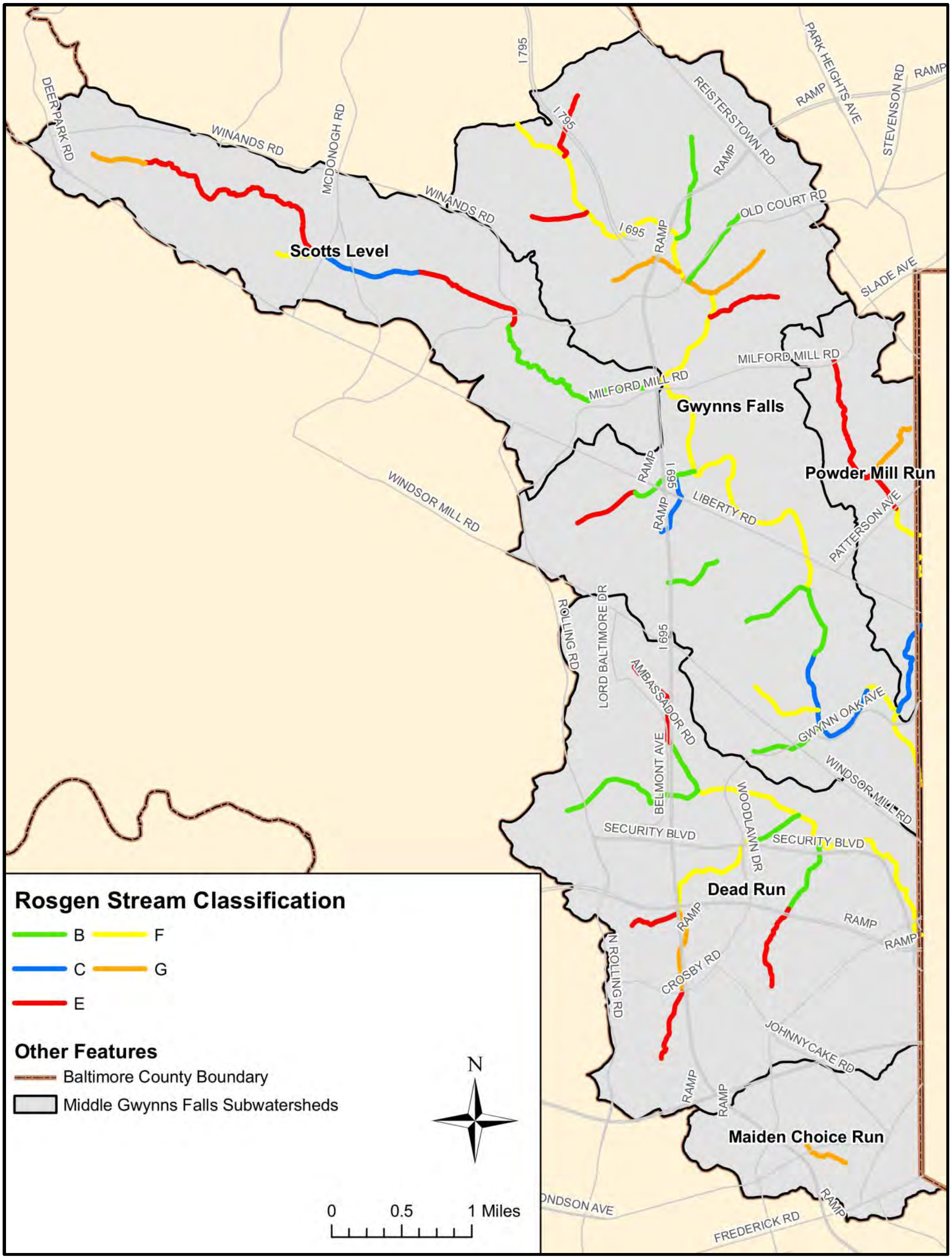


Figure 3-11: Rosgen Stream Classification Type in Middle Gwynns Falls Watershed

3.5.2 Stream Order

The Middle Gwynns Falls watershed is a complicated stream network that contains first through fifth order streams. Stream order outlines the order of streams as a way to define the size of perennial streams. A first order stream is the smallest type of stream and consists of small tributaries. First order streams flow into larger streams. First through third order streams are also called headwater streams and make up upper reaches of the watershed. Fourth through fifth order streams are medium streams. When two first order streams combine, they form a second order stream. From this point on, when two second order streams join, they form a third order stream, and so forth.

Streams for the entire Gwynns Falls watershed were assessed and classified according to the stream order classification system. Figure 3-12 shows the stream order of the Middle Gwynns Falls streams. Table 3-33 summarizes the percentages of stream order within each subwatershed. The majority of the streams in the Middle Gwynns Falls planning area are first and second order streams.

Table 3-33: Stream Order by Subwatershed

Subwatershed	Total Stream Length (Miles)	Percentage of 1st Order Streams	Percentage of 2nd Order Streams	Percentage of 3rd Order Streams	Percentage of 4th Order Streams	Percentage of 5th Order Streams
Gwynns Falls	39.7	51.6%	15.0%	0.0%	0.0%	33.4%
Powder Mill Run	6.0	28.5%	49.9%	20.7%	0.0%	0.9%
Dead Run	18.2	47.9%	26.5%	14.6%	11.0%	0.0%
Maiden Choice Run	1.7	49.8%	30.6%	19.6%	0.0%	0.0%
Scotts Level	12.3	36.6%	63.4%	0.0%	0.0%	0.0%
Total	***77.9***	***46.6%***	***28.8%***	***6.1%***	***3.0%***	***15.5%***

As seen in Figure 3-12, the main stem of the Gwynns Falls matures to a 5th order stream in the Upper Gwynns Falls Watershed, prior to entering the planning area of this study. Besides the main stem, streams in the Gwynns Falls and Scotts Level subwatershed are comprised of entirely 1st and 2nd order streams. Powder Mill Run contains approximately 1.2 miles of 3rd order stream prior to converging with the Gwynns Fall main stem. Dead Run contains the only 4th order streams in the study area, but like Maiden Choice Run, streams in that subwatershed do not converge with the Gwynns Falls main stem until it flows into Baltimore City. Maiden Choice Run is comprised completely of 1st through 3rd order streams or headwater streams.

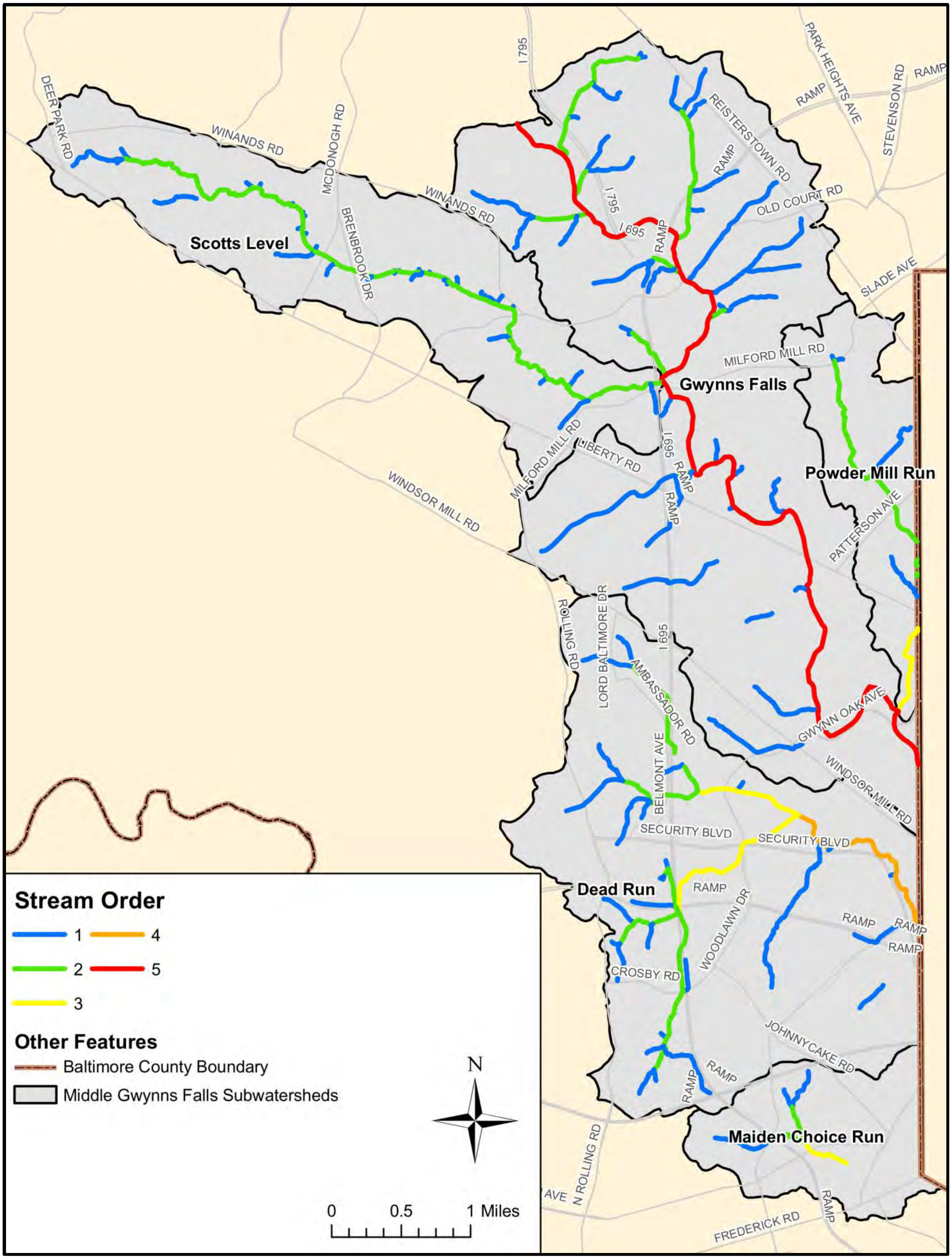


Figure 3-12: Middle Gwynns Falls Stream Order

3.5.3 Unstable Stable Stream Ratio

Unstable stable stream ratio is the relation of unstable stream length to total stream length. During development of the *Gwynns Falls Water Quality Management Plan* (DPW & DEPRM, 2004), reach assessments were conducted on over 70 miles of first, second, and third order stream reaches in the entire Gwynns Falls watershed of Baltimore County that were not previously assessed by the U.S. Army Corps of Engineers. Field teams walked the entire length of each reach and performed rapid field assessments, which included assessing channel morphology, channel disturbances, channel habitat, and restoration opportunities. Low erosion potential was given to reaches with an unstable to stable length ratio of less than 25 percent. Medium erosion potential was given to reaches with an unstable to stable stream ratio between 25 and 50 percent. High erosion potential was given to any reaches that had more than 50% unstable to stable lengths.

Unstable channel conditions represent good opportunities to implement stream restoration projects along individual stream reaches. With increased urbanization and the addition of impervious areas near streams, large quantities of water is flowing quickly through streams, causing stream banks to erode. Eroding stream banks add sediment to streams causing habitat loss, and increase the risk of flooding. Table 3-34 summarizes the unstable to stable stream ratio percentages by subwatershed.

Table 3-34: Middle Gwynns Falls Unstable Stable Stream Ratio

Subwatershed	Low (<25%)	Medium (25% to 50%)	High (>50%)
Gwynns Falls	24.9%	49.3%	25.9%
Powder Mill Run	0.0%	0.0%	0.0%
Dead Run	33.0%	40.0%	26.9%
Maiden Choice Run	47.4%	23.6%	29.0%
Scotts Level	49.1%	22.4%	28.5%
Total in Middle Gwynns Falls	***29.4%***	***44.2%***	***26.5%***

Approximately 73% of streams assessed in the Middle Gwynns Falls planning area have unstable stable stream ratios less than 50%. About 26% of the Gwynns Falls subwatershed's streams have high erosion potential and considered highly unstable. Reach assessments were not completed for the Powder Mill Run subwatershed. Figure 3-13 shows the unstable to stable ratios for the reach assessments evaluated during the *Gwynns Falls Water Quality Management Plan*.

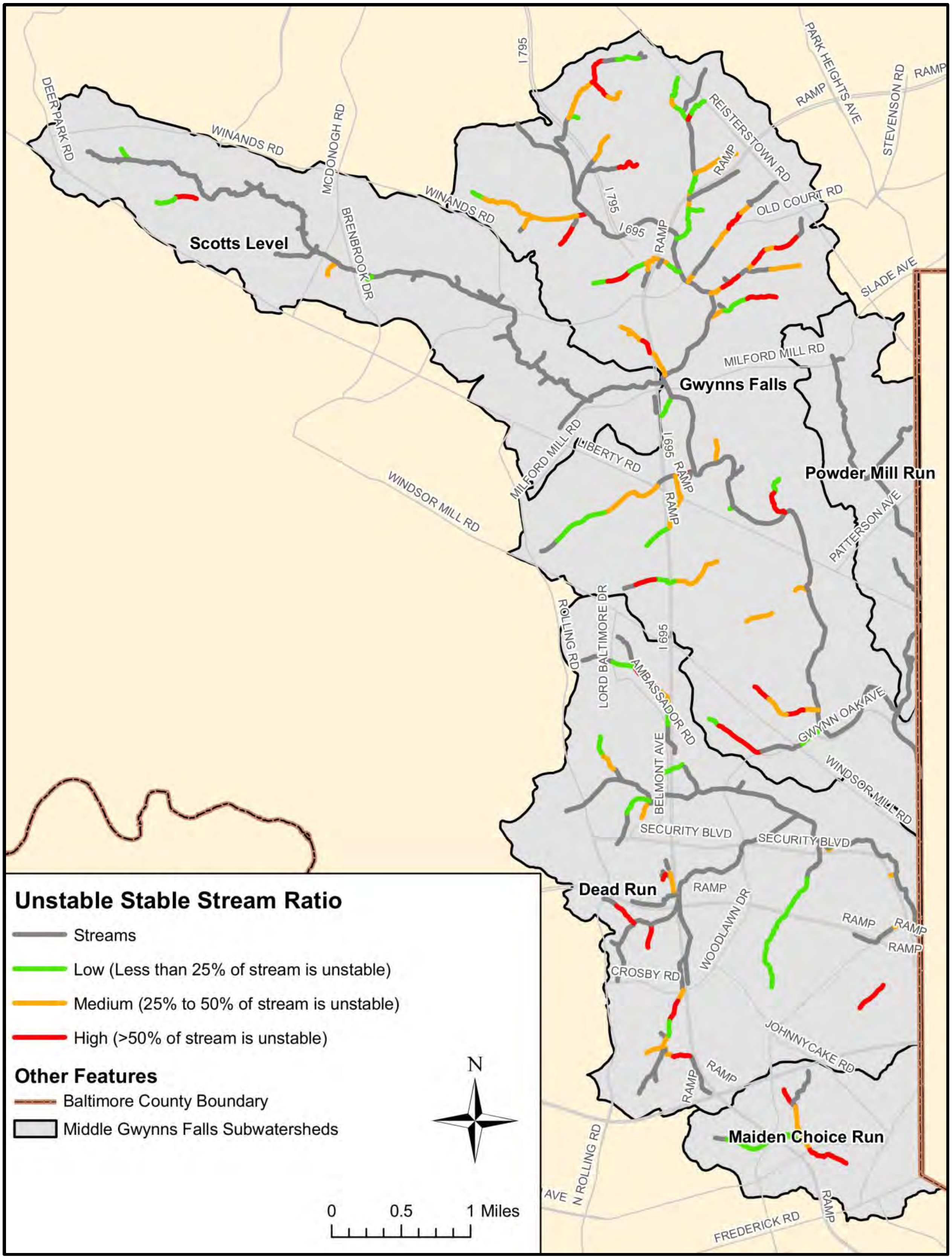


Figure 3-13: Middle Gwynns Falls Unstable to Stable Stream Ratio

3.6 Sewer Overflow Impacts

Sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs) are often unavoidable byproducts of our expanding population and aging sewer systems. Sewer overflows can be caused by various factors such as severe weather, insufficient maintenance, pumping station equipment malfunction, electrical outage, sewer line breaks, improper disposal of oil and grease, and vandalism. Raw sewage can enter nearby streams when flows exceed the sanitary sewer system's capacity or if the infrastructure fails. USEPA reports that there are at least 40,000 of these incidents per year nationwide. Environmental and human health consequences of these overflows can be serious. For example, *E. coli* bacteria and other pathogens are typically present in raw sewage and can pose health risks to individuals who may come into contact with contaminated water. Sewer overflows can also contain high levels of nutrients such as nitrogen and phosphorus which are toxic to aquatic life and can lead to depletion of oxygen in waterways. High levels of sediment are also present in sewer overflows which can clog streams and block sunlight from reaching essential aquatic plants.

In September 2005, USEPA and MDE issued a consent decree to Baltimore County with deadlines to reduce and eliminate sanitary sewer overflows. Implementation of work in compliance with the consent decree, such as capital projects, equipment upgrades, and operations improvements, will reduce nutrients and bacteria entering streams in the Middle Gwynns Falls watershed. However, this may not address all impacts associated with the sanitary sewer system since the consent decree only targets overflows and does not include sewer main leaks. Depending on the location of the leaks, which are typically at pipe joints, the sanitary sewer system may still have adverse impacts to the stream system.

Table 3-35 summarizes the number of SSO events documented and approximate volume discharged between 2000 and 2011, based on Baltimore County's SSO spatial data. Table 3-36 summarizes the estimated volume of overflow and associated pollutant loads during this period by subwatershed.

Table 3-35: Sanitary Sewer Overflow Volumes in Middle Gwynns Falls (2000-2011)

Year	# of SSO Events	Volume of Overflow (gal)
2000	4	8,500
2001	8	16,670
2002	12	4,905
2003	25	21,050
2004	36	1,655,475
2005	58	5,642,482
2006	43	1,220,294
2007	25	1,857,656
2008	22	1,527,211
2009	13	228,866
2010	17	5,116,323
2011	18	3,982,951
Total	***281***	***21,282,383***

From 2000 to 2003, the number of SSO events increased but the overflow volumes were relatively small compared to later years. Beginning in 2004, the number and volume of SSO events began to dramatically increase along with the volume of sewage overflowing. These numbers can be attributed to better tracking of SSO events in anticipation of the consent decree in 2005. Since the consent decree was released in 2005, the number of SSO events has trended downward although volumes remained high. Of the top ten SSO events in terms of volume in the Middle Gwynns Falls watershed (491,920 gallons and higher), eight have occurred after 2005, and the other two events took place in 2005.

Table 3-36: Sanitary Sewer Overflow Volumes and Pollutant Loads by Subwatershed

Subwatershed	# of SSO Events	Volume of Overflow (gal)	TP (lbs)	TN (lbs)	FC (MPN)
Gwynns Falls	102	6,167,485	513.1	1541.9	1.5E+15
Powder Mill Run	65	3,428,702	285.3	857.2	8.2E+14
Dead Run	37	531,391	44.2	132.8	1.3E+14
Maiden Choice Run	71	11,152,830	927.9	2788.2	2.7E+15
Scotts Level	6	1,975	0.2	0.5	4.7E+11
Total	***281***	***21,282,383***	***1,770.7***	***5,320.6***	***5.1E+15***

Pollutant load estimates were calculated based on the following assumptions:

- **Total Phosphorus (TP):** A conversion factor of 8.3×10^{-5} was used to convert gallons of overflow to pounds of pollutant. This is based on a 10 mg/L TP concentration for raw sewage and a multiplier of 8.3×10^{-6} lb·L/mg·gal.
- **Total Nitrogen (TN):** A conversion factor of 2.5×10^{-4} was used to convert gallons of overflow to pounds of pollutant. This is based on a 30 mg/L TN concentration for raw sewage and a multiplier of 8.3×10^{-6} lb·L/mg·gal.
- **Fecal Coliform (FC):** A conversion factor of 2.4×10^{8} was used to convert gallons of overflow to MPN fecal coliform. This is based on a multiplier of 6.4×10^{6} MPN/100 mL.

Figure 3-14 shows the location of SSO events reported during 2000 to 2011 in the Middle Gwynns watershed. The largest ten overflow events during this period occurred in the Maiden Choice Run and Gwynns Falls subwatersheds. Four events totaled an overflow volume greater than 1,000,000 gallons (3 in Maiden Choice Run and one in Gwynns Falls). The greatest number of SSO incidents has been reported in the Gwynns Falls subwatershed, while the largest overflow volume has occurred in Maiden Choice Run. All of these areas have the potential for follow-up inspection to address SSO problems.

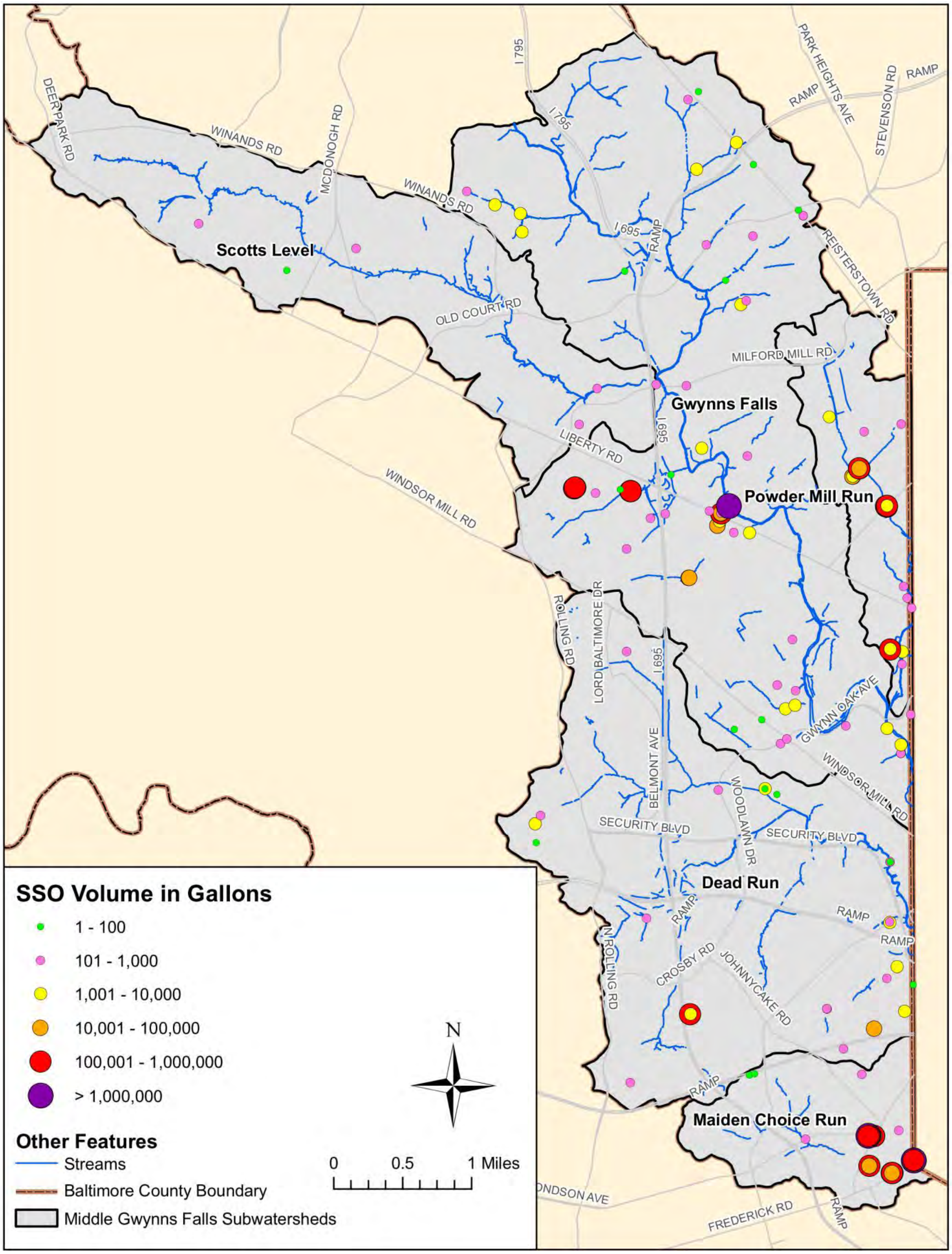


Figure 3-14: Sanitary Sewer Overflow Locations in Middle Gwynns Falls Watershed (2000-2011)

3.7 Stormwater Management Facilities

Existing SWM facilities within the Middle Gwynns Falls watershed were investigated for potential conversion to water quality management facilities. As discussed in Chapter 2, there are a total of 317 SWM facilities that have been built within the planning area according to Baltimore County EPS's database. These include dry and wet ponds, underground detention facilities, wetlands, filtration practices, infiltration practices, extended detention, proprietary BMPs, grassed swales and channels. Approximately 51% of these SWM facilities are filtration practices, infiltration practices, or extended detention facilities. These practices are considered to have higher pollutant removal capabilities, since stormwater has a chance to infiltrate into the ground or through plant roots, compared to conventional SWM techniques which are designed for quantity control without water quality improvements features.

Of the 317 existing facilities, 85 are dry detention ponds which are typically designed to address water quantity only (flood control), providing almost no pollutant removal. Dry ponds have the greatest potential for conversion to a type of facility that provides water quality benefits in addition to quantity control. 15 of the 85 dry detention facilities were assessed for potential conversion to an extended detention facility.

Dry extended detention ponds are designed to capture and retain stormwater runoff for a minimum duration (e.g., 24 hours) to allow pollutants to settle out while also being able to provide flood control if additional storage is incorporated into the design. The locations of the 15 assessed detention ponds in the Middle Gwynns Falls watershed are shown in Figure 3-15. Information was collected in the field to assess the existing conditions and conversion potential of each dry detention pond in the Middle Gwynns Falls watershed. SWM assessment criteria are listed in Table 3-37. Each of the detention ponds are described briefly below including key findings, pond maintenance and retrofit recommendations, and site photos.

Table 3-38 summarizes the available information obtained from Baltimore County EPS's database including structure location, ownership, design capacity (drainage area, storm event), and as-built date (if available). Note that Site ID numbers correspond to structure numbers in the County database. Field data findings are summarized in Table 3-39. 10 of the 15 detention ponds have potential for water quality improvements such as conversion to an extended detention facility or incorporation of filtration or infiltration practices.

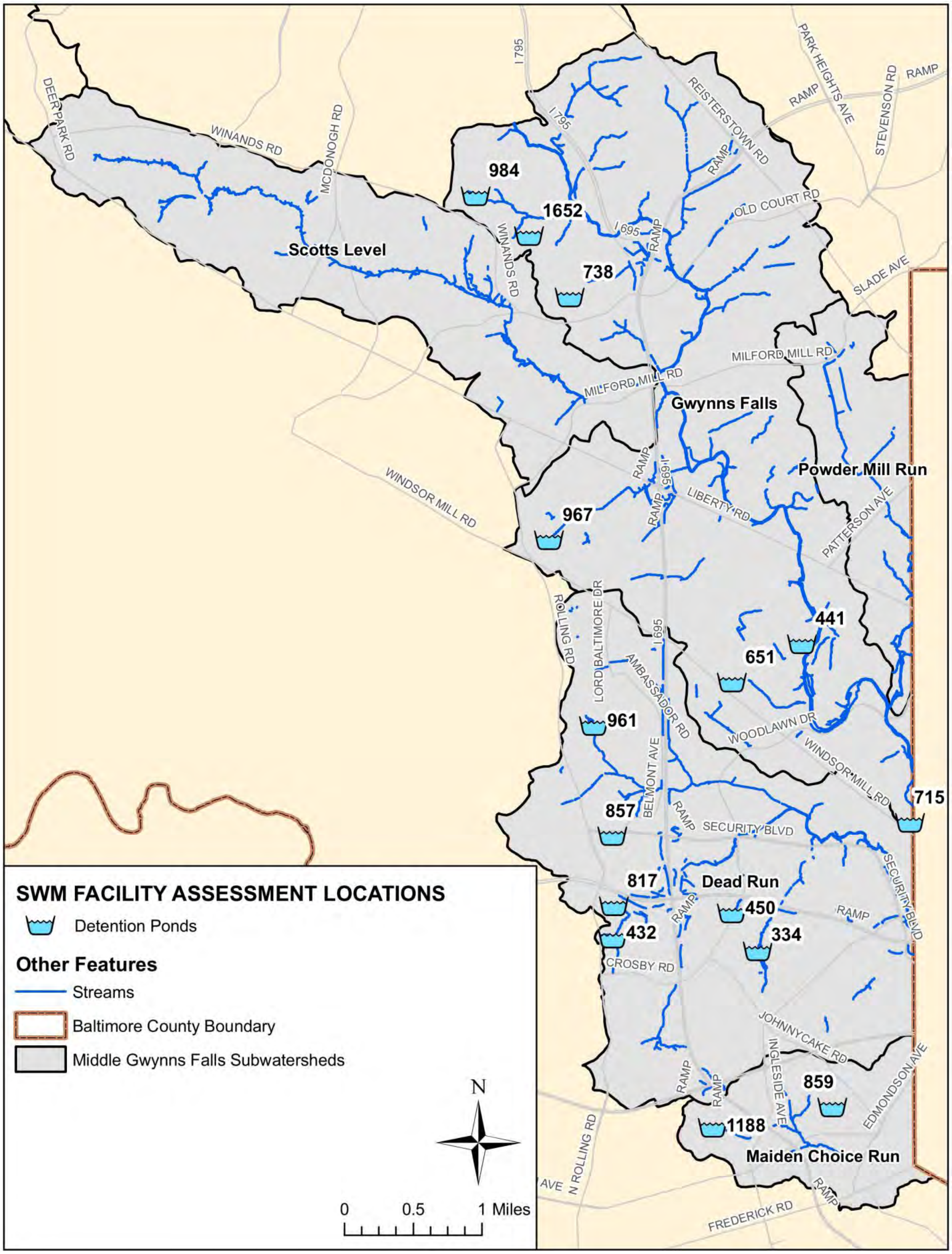
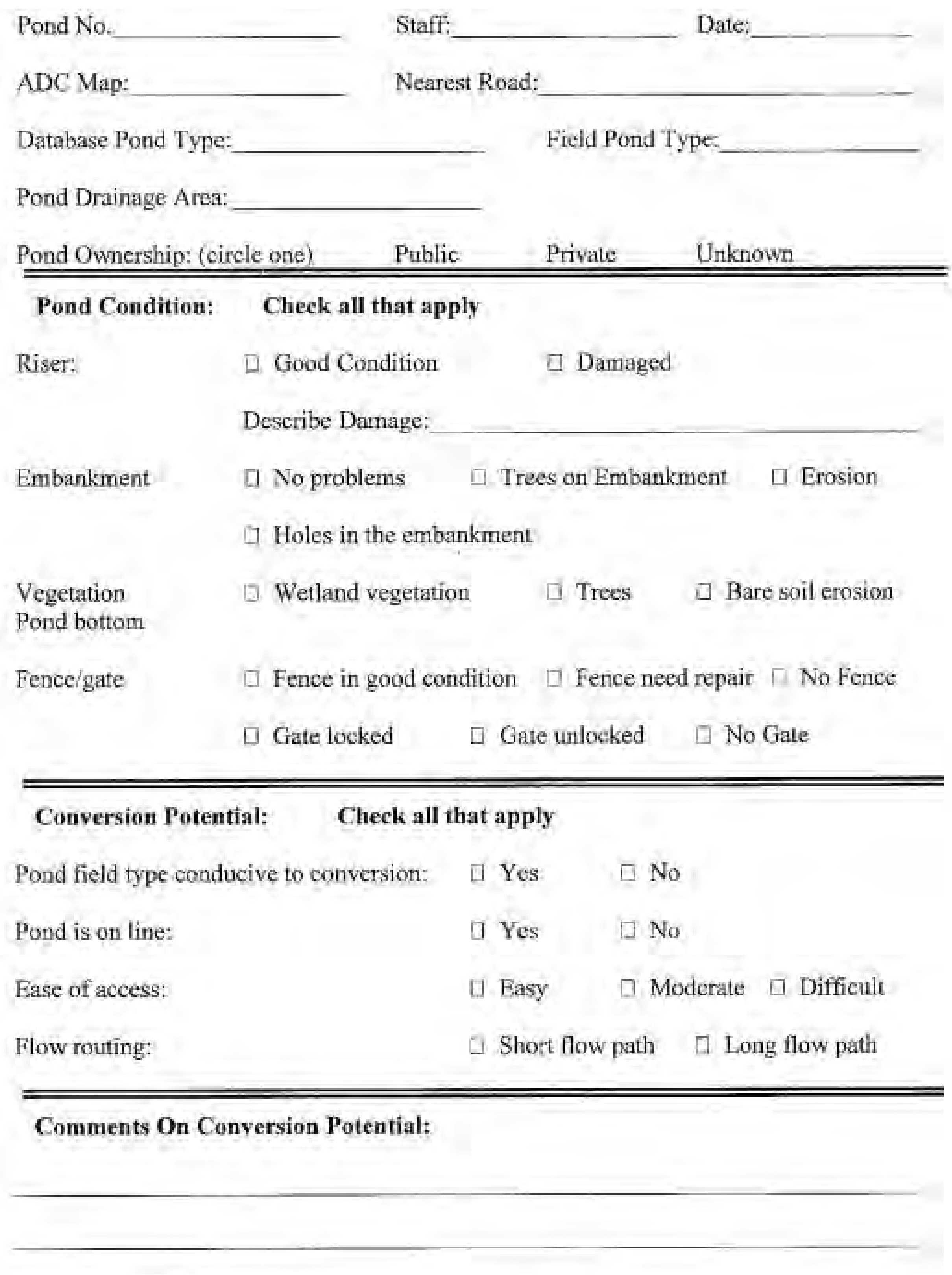


Figure 3-15: Detention Ponds Assessed for Conversion Potential in Middle Gwynns Falls

Table 3-37: SWM Facility Assessment Criteria



Pond No.____________________ Staff:____________________ Date:______________

ADC Map:__________________ Nearest Road:________________________________

Database Pond Type:______________________ Field Pond Type:_________________

Pond Drainage Area:______________________

Pond Ownership: (circle one) Public Private Unknown

Pond Condition: **Check all that apply**

Riser: ☐ Good Condition ☐ Damaged

Describe Damage:____

Embankment ☐ No problems ☐ Trees on Embankment ☐ Erosion

☐ Holes in the embankment

Vegetation Pond bottom ☐ Wetland vegetation ☐ Trees ☐ Bare soil erosion

Fence/gate ☐ Fence in good condition ☐ Fence need repair ☐ No Fence

☐ Gate locked ☐ Gate unlocked ☐ No Gate

Conversion Potential: **Check all that apply**

Pond field type conducive to conversion: ☐ Yes ☐ No

Pond is on line: ☐ Yes ☐ No

Ease of access: ☐ Easy ☐ Moderate ☐ Difficult

Flow routing: ☐ Short flow path ☐ Long flow path

Comments On Conversion Potential:

____

____

Table 3-38: Detention Pond Information from Baltimore County Database

Site ID	Subwatershed	Structure Name	Nearest Road	Ownership	DA_Acres	Pond Design	Pond As-Built
SWM_C_334	Dead Run	Brigadoon	Brigadoon Trail	Private	17.97	2, 10, 100	9/29/1992
SWM_C_432	Dead Run	Crosby Meadow	Halfpenny Lane	Public	33.00	2, 10, 100	1/13/1993
SWM_C_441	Gwynns Falls	Deerfield Addition Pond 1	Spring Mill Circ	Public	13.30	2, 50	1/1/2000
SWM_C_450	Dead Run	Discovery Acres 1	Johnnycake Rd	Public	23.00	5, 50	1/1/2000
SWM_C_651	Gwynns Falls	Lawnwood	Lawnwood Circle	Public	47.10	2, 10, 100	7/8/1994
SWM_C_715	Gwynns Falls	Mosby Mill Apartments	Janper Ct	Private	18.96	2, 10, 100	3/8/1999
SWM_C_738	Gwynns Falls	Old Court Grove	Panacea/Bonnie Brae	Public	16.62	2, 10, 100	10/18/1990
SWM_C_817	Dead Run	Rolling Crossroads Professional Center	Johnnycake/Rolling Crossroads	Private	13.34	2, 10, 100	
SWM_C_857	Dead Run	Security Square Shop Center Addition	Security/Lord Baltimore	Private	11.71	2, 25	
SWM_C_859	Maiden Choice Run	Shade Tree Apts	Northdale	Private	20.35	2, 10, 100	7/19/1988
SWM_C_961	Dead Run	Waterford Place	Kevsway Ct.	Private	64.88	2, 10, 100	9/28/1994
SWM_C_967	Gwynns Falls	Windsor Gardens	Northmont	Public	52.80	2, 10, 100	6/19/1995
SWM_C_984	Gwynns Falls	Owings Overlook (aka Winands Valley Estate)	Dutch Mill/Windmill	Public	41.61	2, 10, 100	3/2/1995
SWM_C_1188	Maiden Choice Run	Banneker Regional Pond	Maryland Ave	Public	60.20	5, 100	1/1/2000
SWM_C_1652	Gwynns Falls	Julian Woods Pond 1	Metree Way	Public	10.00	2, 10, 100	1/1/2000

Table 3-39: Detention Pond Field Assessment Summary

Site ID	Riser	Embankment	Bottom	Fence	Gate	Water Quality Potential	Connection	Access	Flow Path
SWM_C_334	Good	No Problems	Turf Grass	Repair Needed	Unlocked	Y	Offline	Easy	Long
SWM_C_432	Damage	Trees	Wetland	Repair Needed	Unlocked	Y	Online	Difficult	Short
SWM_C_441	Minor Maintenance	Trees	Trees	Good	Locked	Y	Offline	Easy	Short
SWM_C_450	Minor Maintenance	Trees	Wetland	No Fence	No Gate	N	Offline	Difficult	Long
SWM_C_651	Good	Trees	Wetland	Good	Unlocked	N	Offline	Easy	Long
SWM_C_715	Good	Trees	Turf Grass	No Fence	No Gate	Y	Offline	Easy	Short
SWM_C_738	Good	Trees	Wetland	Repair Needed	No Gate	N	Offline	Moderate	Short
SWM_C_817	Good	Trees	Wetland	Repair Needed	No Gate	N	Offline	Difficult	Short
SWM_C_857	Good	No Problems	Wetland	Good	Locked	Y	Offline	Easy	Long
SWM_C_859	Damage	No Problems	Trees	No Fence	No Gate	Y	Offline	Easy	Short
SWM_C_961	Good	No Problems	Wetland	Good	Unlocked	Y	Offline	Easy	Long
SWM_C_967	Minor Maintenance	Holes	Wetland	Good	Locked	Y	Online	Easy	Long
SWM_C_984	Good	Erosion	Wetland	Repair Needed	Unlocked	Y	Online	Easy	Long
SWM_C_1188	Good	No Problems	Wetland	No Fence	No Gate	Y	Offline	Easy	Long
SWM_C_1652	Good	Trees	Wetland	No Fence	No Gate	N	Offline	Easy	Short

SWM_C_334

Detention Pond, SWM_C_334, is a privately-owned facility, located in the Dead Run subwatershed at the end of Brigadoon Trail. This pond is designed to handle runoff from the 2-, 10-, and 100-year events from 17.97 acres of residential development. This pond was recommended to be upgraded to provide additional water quality treatment. Key findings, pond maintenance and retrofit recommendations are listed below.

Key findings

- The pond is easily accessible from Brigadoon Trail.
- The pond bottom is well maintained and comprised of turf grass.
- A portion of the fence at the pond inflow is severely damaged from leaves causing an obstruction of flow. Consequently, there is an accumulation of sediment and debris at this location.
- Low flows into the pond have created a distinct channel from the inflow to the riser structure.

Maintenance Recommendation

- Remove sediment, debris from the pond inflow near the broken fence area.
- Repair fence at the pond inflow to allow flow to pass through without creating an obstruction.

Pond Retrofit Recommendation

- Replace the existing, inflowing V-ditch with trapezoidal grass channel that could serve as a bioswale.
- Construct pretreatment forebays at the existing pipe outfalls draining to pond.
- The existing low-flow channel in the pond could be converted into a grass swale to provide water quality treatment for smaller storms which contain the majority of pollutants from the drainage area.

Figure 3-16: Channelized Grass Inflow (left) and Damaged Fence (right) at SWM_C_334

SWM_C_432

Detention Pond, SWM_C_432, is a public-owned facility, located in the Dead Run subwatershed at the end of Halfpenny Lane. This pond is designed to handle runoff from the 2-, 10-, and 100-year events from 33 acres of residential development. This pond was recommended to be upgraded to provide additional water quality treatment. Key findings, pond maintenance and retrofit recommendations are listed below.

Key findings

- The pond is accessible from Halfpenny Lane. The only part of the pond that has easy access is at the pipe/channel inflow into the pond. The remainder of the pond is difficult to access because the surrounding pond fence/ adjacent property are approximately 8 feet from the pond top of cut (too narrow for equipment).
- The outfall pipe is blocked with sediment, debris and therefore the pond has permanent pool.
- There is potential for horizontal expansion at northwest corner of the facility.
- The pond bottom has invasive species (Phragmites). It also contains a large amount of wetland vegetation and trees.

Pond Maintenance Recommendation

- Clean sediment, debris from the pond outfall pipe.
- Invasive species management.
- Remove small trees and dense vegetation around outlet.

Pond Retrofit Recommendation

- Construct pretreatment forebay at the pond inflow channel.
- Construct maintenance access road to the riser.
- Extend the flow path from the inflow to the outfall by constructing concrete baffle wall and/or berms on the pond bottom.
- The large area of the pond provides potential retrofit possibilities including installation of pretreatment forebay at pond inflow channel that could flow into shallow wetlands and then into a deep micropool in front of riser with submerged reverse slope low flow pipe. Because of the current blockage at the pipe outfall, the pond is performing similarly to a stormwater wetland facility. If flooding during larger events has not been an issue, there is the potential for the pond to be permanently converted to a stormwater wetland facility.

Figure-3-17: Invasive Species, Ponding (left) and Sediment Blocking the Downstream Outfall (right) at SWM_C_432

SWM_C_441

Detention Pond, SWM_C_441, is a public-owned facility, located in the Gwynns Falls subwatershed at the intersection of Spring Mill Circle and Woodgreen Circle. This pond is designed to handle runoff from the 2- and 50-year events from 13.3 acres of residential development. This pond was recommended to be upgraded to provide additional water quality treatment. Key findings, pond maintenance and retrofit recommendations are listed below.

Key findings

- The pond is easily accessible from Spring Mill Circle.
- The low flow pipe at CMP riser is clogged with sediment.
- There are some vegetation and vines growing on fence and trees on the pond embankment.
- The pond bottom has some trees and areas of bare soil debris along with the presence of trash at the pond inflow as well as the pond bottom.
- There is room for horizontal expansion on the south side of pond. This area is currently bare soil with some grassed and forested area.

Pond Maintenance Recommendation

- Remove trees and stabilize the bare soil on pond embankment and bottom.
- Remove trash from the pond.
- Investigate impact of trees on the underground barrel from the riser structure.
- Remove impervious access road and replace with a pervious, cellular confinement load support system.

Pond Retrofit Recommendation

- Construct a micropool at pond inflow.
- Investigate the existing capacity of the pond and the need for horizontal expansion to support conversion to an extended detention facility.

- Investigate the potential for installation of trash and debris collection measures.

Figure-3-18: Impervious Access Road (left) and Trees, Trash near Riser (right) at SWM_C_441

SWM_C_450

Detention Pond, SWM_C_450, is listed as a public-owned facility, located in the Dead Run subwatershed at the intersection of Woodlawn Drive and Jonas Way. This pond is designed to handle runoff from the 5- and 50-year events from 23 acres of residential development. Due to site constraints and limited or no room for expansion, this pond was not recommended for a water quality retrofit, however significant pond maintenance is needed. Key findings and pond maintenance recommendations are listed below.

Key findings

- The only part of the pond that has easy access is at the pond outfall. The remainder is difficult to access because of heavy vegetation, trees, and steep slopes.
- There are trees on pond embankment and bottom.
- The pond bottom is mostly comprised of dense vegetation with some invasive species (Phragmites) and wetland vegetation present.
- There is a significant amount of trash, woody debris, and sediment accumulation in and around the pond.
- Massive active slope erosion was observed at the gabion structure intended to provide protection to the pond inlet causing a large undercut along pond side slope.
- There is minor channel bank erosion at the downstream of the pond outfall and minor undercutting at CMP pipe outfall.
- The CMP riser shows minor rusting and minor erosion around its base.

Pond Maintenance Recommendation

- Remove trees from pond embankment and pond bottom.
- Invasive species management.
- Clean up trash and sediment in and around the pond.

- Stabilize the pond side slopes to prevent the erosion.
- Repair erosion around the riser.
- Stabilize the gabion structure at pond inflow.
- Construct the riprap outlet protection to prevent the erosion at downstream channel.
- Construct maintenance access roads to the riser and pond inflow.

Figure-3-19: Side Slope Failure (left) and Erosion & Undercutting at Outfall (right) at SWM_C_450

SWM_C_651

Detention Pond, SWM_C_651, is a public-owned facility, located in the Gwynns Falls subwatershed at the end of Lawnwood Circle. This pond is designed to handle runoff from the 2-, 10-, and 100-year events from 47.1-acres of residential development. Due to site constraints and limited or no room for expansion, this pond was not recommended for a water quality retrofit. Key findings and pond maintenance recommendations are listed below.

Key findings

- The pond is easily accessible from Lawnwood Circle.
- A large accumulation of sediment was observed at the pie inflow into the pond.
- There are trees on pond embankment and bottom.
- The pond bottom contains invasive species (Phragmites), wetland vegetation, and trees.
- There is lot of vegetation obstructing the low flow pipe to the riser.

Pond Maintenance Recommendation

- Remove trees from the pond embankment and bottom.
- Invasive species management
- Unclog existing inflow filled with sediment from the inlet at Lawnwood Circle draining to the pond.
- Construct the riprap outlet protection at the pipe outfall draining into pond.

Figure -3-20: Outlet Structure (left) and Sediment at Inflow (right) at SWM_C_651

SWM_C_715

Detention Pond, SWM_C_715, is a privately-owned facility, located in the Gwynns Falls subwatershed at the end of Janper Court. This pond is designed to handle runoff from the 2-, 10-, and 100-year events from 18.96 acres of apartment development. This pond was recommended to be upgraded to provide additional water quality treatment. Key findings, pond maintenance and retrofit recommendations are listed below.

Key findings

- The facility is easily accessible from the Janper Court.
- Trees were found on the pond embankment.
- The pond bottom consists of mowed turf grass with channelized areas leading from the inflows directly to the outlet structure, lessening detention time and evapotranspiration during smaller storm events.
- The low flow pipe is missing a trash rack.

Pond Maintenance Recommendation

- Clean out sediment around pipe inflow.
- Add trash rack to low flow pipe at riser.
- Remove trees from pond embankment.

Pond Retrofit Recommendation

- Construct a micropool at pond inflow channel.
- If the pond has adequate capacity, the 18” low flow orifice of the riser structure should be altered in order to detain water for a 24 hour detention time, which is the current standards for extended detention ponds in Use I waters.

Figure-3-21: Riser with 18" Low Flow Pipe (left) and Grass Swale Leading to Riser (right) at SWM_C_715

SWM_C_738

Detention Ponds, SWM_C_738, is a public-owned facility, located in the Gwynns Falls subwatershed at the intersection of Panacea Road and Bonnie Brae Road. This pond is designed to handle runoff from the 2-, 10-, and 100-year events from 16.62 acres of residential development. Due to site constraints and limited or no room for expansion, this pond was not recommended for a water quality retrofit. Key findings and pond maintenance recommendations are listed below.

Key findings

- The pond is accessible from Bonnie Brae Road. The only part of the pond that has easy access is at the pipe/channel inflow into the pond. The remainder of the pond is difficult to access because the surrounding pond fence and heavy vegetation.
- There are trees on pond embankment and bottom.
- The fence was not extended to the ground at the riser structure, and vines and vegetation have grown on fence.
- The outfall pipe was not found and the riser structure was believed to outlet to underground piping for a long distance.
- The facility is constrained horizontally on all sides, so there is no potential for horizontal expansion.
- The facility is constrained vertically by the steep side slopes, so there is no potential for excavation for water quality treatment.

Pond Maintenance Recommendation

- The fence should be repaired to prevent access to the riser structure as well as being cleared of vegetation and vines.
- Remove trees threatening the stability of the pond embankment and at pond bottom.
- The pond bottom can be cleaned and the inflow channel upgraded to provide long detention times and potential evapotranspiration to low flows.

Figure-3-22: Fence Not Extended to Ground (left) and Vegetation Around Riser (right) at SWM_C_738

SWM_C_817

Detention Pond, SWM_C_817, is a privately-owned facility, located in the Dead Run subwatershed at the intersection of Johnny Cake Road and Rolling Cross Roads. This pond is designed to handle runoff from the 2-, 10-, and 100-year events from 13.34 acres of residential development. Due to site constraints and limited or no room for expansion, this pond was not recommended for a water quality retrofit. Furthermore, a parcel at Rolling Crossroads Road (Parcel "D") was bought by the State of Maryland for a State Court Annex building. Key findings and pond maintenance recommendations are listed below.

<u>Key findings</u>

- The pond has difficult access due to dense vegetation on and around the fencing.
- Pond functions have been replaced by an underground facility and oil and grit separator located under the parking lot of an existing shoping center on the west side of Rolling Crossroads Road.
- There are trees on pond embankment and a lot of vines and vegetation growing on the fence.
- A large soil stockpile area for the new construction was observed along Rolling Crossroads. Erosion and sediment control practices seemed to be poorly maintained causing an accumulation of sediment against the silt fence. Sediment has overtopped the silt fence at numerous locations and was susceptible to being washed into the stormwater facility during a rain event.
- The pond bottom has invasive species (Phragmites).
- The existing pond is constrained horizontally on all sides, so there is no potential for horizontal expansion.
- The existing pond is constrained vertically by the steep side slopes, so there is no potential for excavation for water quality treatment.
- The State of Maryland must address storm water managemt for development of "Parcel D".

-

Pond Maintenance Recommendation

- Invasive species management.
- Clear vegetation and vines at fence.
- Remove trees threatening the stability of the pond embankment.
- Construct maintenance access road to the riser, pond inflow.
- At the time of the assessment, observations on the poor erosion and sediment control practices were provided to representatives at EPS. It is recommended that the site be inspected regularly to ensure that sediment from the adjacent property does not wash into the pond.

Figure-3-23: Sediment from Adjacent Stockpile Overtopping Silt Fence (left) and Dense Vegetation around Riser (right) at SWM_C_817

SWM_C_857

Detention Pond, SWM_C_857, is a privately-owned facility, located in the Dead Run subwatershed at the intersection of Security Boulevard and Lord Baltimore Drive. This pond is designed to handle runoff from the 2- and 25-year events from 11.71 acres of commercial development and parking lot. This pond was recommended to be upgraded to provide additional water quality treatment. Key findings, pond maintenance and retrofit recommendations are listed below.

Key findings

- The pond is easily accessible from the parking lot at the intersection.
- Trees and wetland vegetation were observed at the pond bottom.
- The pond was completely surrounded by a perimeter fence with a locked access gate.
- The facility can be expanded horizontally by steepening the side slopes to the fence.
- The pond bottom has invasive species (Phragmites).

Pond Maintenance Recommendation

- Clean up debris and sediment at pond inflow.
- Remove small trees from the pond bottom.
- Invasive species management.

Pond Retrofit Recommendation

- Construct pretreatment forebay at existing pipe outfall into the pond.
- Extend the pond horizontally to provide additional capacity for conversion to an extended detention facility.

Figure-3-24: Dense Invasive Vegetation Around the Outlet Structure (left) and Curb Cut Inlet Configuration (right) Draining to SWM_C_857

SWM_C_859

Detention Pond, SWM_C_859, is a privately-owned facility, located in the Maiden Choice Run subwatershed at private road off of Northdale Road. This pond is designed to handle runoff from the 2-, 10-, and 100-year events from 20.35 acres of institutional development. This pond was recommended to be upgraded to provide additional water quality treatment. Key findings, pond maintenance and retrofit recommendations are listed below.

Key findings

- The pond is accessible from the private road off of the Northdale Road. There is an access gate at the private road.
- The pond bottom consists of mowed turf grass and some trees.
- Equipment was observed in the pond bottom providing evidence of use as a recreation area.
- The riser lid is missing.
- There is potential for horizontal expansion in a grassed area on the north side of the pond.

Pond Maintenance Recommendation

- Install riser lid.
- Remove trees and extraneous from the pond bottom.

Pond Retrofit Recommendation

- Construct a micropool at pond inflow.
- Extend the pond horizontally to provide additional capacity for conversion to an extended detention facility.

Figure-3-25: Pond Embankment (left) and Control Structure with Missing Lid (right) at Detention Pond SWM_C_859

SWM_C_961

Detention Pond, SWM_C_961, is a privately-owned facility, located in the Dead Run subwatershed at the end of Kevsway Court. This pond is designed to handle runoff from the 2-, 10-, and 100-year events from 64.88 acres of residential development. This pond was recommended to be upgraded to provide additional water quality treatment. Key findings, pond maintenance and retrofit recommendations are listed below.

Key findings

- The pond is easily accessible from Kevsway Court. There was an access gate and the gate was unlocked.
- The pond bottom consists of wetland vegetation, trees and bare soil in some locations.
- The end section at the pipe inflow to the pond has a minor undercut, and the surrounding area showed evidence of erosion.
- There were two underdrains connected to the riser, which could be disconnected and directed to the pond. The underdrains could have the potential for conveying illicit discharges.
- The pond bottom has invasive species (Phragmites).
- There is potential for horizontal expansion around the western and northern areas of the pond for potential conversion to an extended detention facility.

Pond Maintenance Recommendation

- Clean up debris and sediment at pond the inflow and riser.
- Stabilize the eroded area at the pond inflow, and repair the undercut at the pond inflow end section.
- Remove small trees from the pond bottom.
- Invasive species management.
- Investigate the source of the two underdrains connected to the riser.

Pond Retrofit Recommendation

- Construct a micropool at pond inflow.
- Extend the pond horizontally to provide additional capacity for conversion to an extended detention facility.

Figure-3-26: Undercutting and Erosion at Inflow Endsection (left) and Control Structure with Flowing Underdrains (right) at SWM_C_961

SWM_C_967

Detention Pond, SWM_C_967, is a public-owned facility, located in the Gwynns Falls subwatershed off of Northmont Road. This pond is designed to handle runoff from the 2-, 10-, and 100-year events from 52.80 acres of residential development. This pond was recommended to be upgraded to provide additional water quality treatment. Key findings, pond maintenance and retrofit recommendations are listed below.

Key findings

- The pond is easily accessible from Northmont Road. The access gate was locked, and one of the residents has a key and granted access for the assessment.
- The pond bottom was densely vegetated with trees and wetland vegetation.
- There are trees on pond embankment and some animal burrows, which has created holes in the embankment.

- The pond bottom has invasive species (Phragmites).
- The drainage area should be verified to check whether large pond size is needed or not.
- The local resident indicated that the pond has a stream that is flowing almost all of the time through the pond.

Pond Maintenance Recommendation

- Remove small trees from the pond bottom.
- Remove trees and fill animal burrows threatening the stability of the pond embankment.
- Invasive species management.

Pond Retrofit Recommendation

- The large area of the pond provides potential retrofit possibilities including installation of pretreatment forebay at pond inflow channel that could flow into shallow wetlands and then into a deep micropool in front of riser with submerged reverse slope low flow pipe.
- The low flow channel could be upgraded to remove the invasive species.

Figure-3-27: Invasive Species (left) and Control Structure (right) at SWM_C_967

SWM_C_984

Detention Pond, SWM_C_984, is a public-owned facility, located in the Gwynns Falls subwatershed off of Windmill Circle. This pond is designed to handle runoff from the 2-, 10-, and 100-year events from 41.61 acres of residential development. This pond was recommended to be upgraded to provide additional water quality treatment. Key findings, pond maintenance and retrofit recommendations are listed below.

Key findings

- The pond is easily accessible from Windmill Circle.
- The pond bottom consists of trees and wetland vegetation with bare soil in some locations.
- There are trees on pond embankment.

- The fence was found to be broken at several locations and the access gate was unlocked.
- An abundance of sediment and trash was observed around the riser. Additionally, the low flow pipe was not visible due to sediment.
- There is long flow path between inflow and the riser.
- Evidence of a bleach smell was noted at the pond inflow (gabion inflow structure).
- Downed tree branches were present which potentially obstruct flow at the pond outfall.

Pond Maintenance Recommendation

- Remove small trees from the pond bottom and trees threatening the stability of the pond embankment.
- Clean sediment and trash around the riser.
- Remove downed tree branches blocking the pond outfall.

Pond Retrofit Recommendation

- The flow path could be lengthened by constructing a meandering channel.
- Construct maintenance access road to the riser.
- The large area of the pond provides potential retrofit possibilities including installation of pretreatment forebay at pond inflow channel that could flow into shallow wetlands or wet detention pond and then into a deep micropool in front of riser with submerged reverse slope low flow pipe.
- The capacity of the pond should be determined to verify if there is potential for conversion to an extended detention facility.

Figure-3-28: Down Tree Branches at Pond Outfall (left) and Low Flow Channel (right) at SWM_C_984

SWM_C_1188

Detention Pond, SWM_C_1188, is a public-owned facility, located in the Maiden Choice Run subwatershed off of Maryland Avenue. This pond is designed to handle runoff from the 5- and 100-year events from 60.2 acres of residential and park development. This pond was recommended to be upgraded to provide additional water quality treatment. Key findings, pond maintenance and retrofit recommendations are listed below.

Key findings

- The pond is easily accessible from Maryland Avenue.
- The pond bottom consists of trees and wetland vegetation.
- The CMP riser has minor rusting.
- The pond inflow pipe is located above the existing grade, which has a shorter flow path to riser. All three swales inflows have a longer flow path.
- The pond has a large drainage area, which is mostly pervious. There is potential for extra capacity, although the treatment potential is questionable.

Pond Maintenance Recommendation

- Remove small trees from the pond bottom.

Pond Retrofit Recommendation

- Construct a micropool at pipe inflow and inflow channels.
- Convert the 3 grassed swales flowing into the pond into bioswales to treat runoff.

Figure-3-29: Pipe Invert at Inflow Endwall above Grade (left) and Wide Grass Swale Draining to Pond (right) at SWM_C_1188

SWM_C_1652

Detention Pond, SWM_C_1652, is a public owned facility, located in the Gwynns Falls subwatershed at the end of Metree Way. This pond is designed to handle runoff from the 2-, 10-, and 100-year events from 10 acres of residential development. This pond was not recommended for a water quality retrofit. Key findings and pond maintenance recommendations are listed below.

Key findings

- The pond is easily accessible from Metree Way.

- The pond bottom contains small trees and wetland vegetation with bare soil in some locations.
- There are trees on pond embankment and some animal burrows, which has created holes in the embankment.
- The pond outfall was unable to be located as it appeared to be carried in underground piping for a large distance.
- The existing pond is constrained horizontally on all sides, so there is no potential for horizontal expansion.
- The existing pond is constrained vertically by the steep side slopes, so there is no potential for excavation for water quality treatment.

Pond Maintenance Recommendation

- Remove small trees from the pond bottom.
- Remove trees and fill animal burrows threatening the stability of the pond embankment.

Figure-3-30: Animal Burrow (left) and Trees (right) on the Embankment at SWM_C_1652

CHAPTER 4: UPLANDS ASSESSMENT

4.1 Introduction

Upland areas were assessed according to the Unified Subwatershed and Site Reconnaissance (USSR) Manual developed by CWP (2004) to identify potential pollution sources influencing water quality and to evaluate restoration project opportunities. The USSR manual is the last manual in a series of 11 regarding techniques for restoring urban watersheds. It provides detailed guidance for field survey techniques and was developed to help watershed groups, municipal staff, and consultants to quickly identify major stormwater pollution sources and assess subwatershed restoration potential for source controls, pervious area management, and improved municipal maintenance such as education, retrofits, street sweeping, inlet cleaning, and open space management.

The field survey of upland areas in the Middle Gwynns Falls watersheds included three major components:

- Neighborhood Source Assessment (NSA)
- Hotspot Site Investigation (HSI)
- Institutional Site Investigation (ISI)

Each of the above components is described in detail in the following sections.

4.2 Neighborhood Source Assessment (NSA)

NSAs describe pollution source areas, stewardship behaviors, and restoration opportunities within individual neighborhoods. Each neighborhood has unique characteristics which determine the ability to implement restoration projects, source controls, and stewardship practices. The sections below describe the methods used to delineate and assess individual neighborhoods in the Middle Gwynns Falls watershed.

4.2.1 Assessment Protocol

Prior to conducting NSAs in the field, neighborhoods were delineated in the office using ADC street maps and GIS data such as tax parcels, historical development information and aerial photography provided by Baltimore County OIT. A neighborhood was delineated based on a group of homes with similar characteristics including lot sizes, road widths, setbacks, year houses were built, and house types (apartment complex, row homes, single family detached, etc.) NSAs were identified using the classification scheme “NSA_C_001”, where ‘C’ denotes the Middle Gwynns Falls planning area, and neighborhoods were then numbered sequentially as delineated. Neighborhoods defined in the office using available information were verified in the field. Adjustments were made as necessary in the field to group similar neighborhoods or separate dissimilar neighborhoods.

The field team drove through every street in a defined neighborhood to identify potential pollution sources and restoration opportunities. To standardize the NSA process and be able to prioritize potential restoration efforts, data was collected in each neighborhood for four main source areas: yards and lawns; driveways, parking lots, sidewalks, and curbs; rooftop runoff; and common areas. These are each described briefly below.

Yards and Lawns

Yards and lawns typically represent a significant portion of the pervious cover in an urban subwatershed and therefore can be a major source of nutrients, pesticides, sediment, and runoff. Maintenance behaviors tend to be similar within individual neighborhoods and certain activities can impact subwatershed quality such as fertilization, pesticide use, watering, landscaping, and waste management. Potential pollution sources evaluated under the yards and lawns category include grass cover and management status (fertilization and irrigation methods), bare soil, and junk or trash. The field team also identified the proportions of impervious cover, grass cover, landscaping, and bare soil within each neighborhood. The amount of existing tree cover and landscaping was then compared to the other cover types to evaluate potential for increasing these features and providing water quality benefits through interception and filtration of stormwater runoff.

Driveways, Parking Lots, Sidewalks, and Curbs

Driveways, sidewalks, and curbs are common in many urban subwatersheds and convey neighborhood runoff to the storm drain system. Activities such as car washing, deicing, and improper chemical storage can contribute pollutants such as nutrients, oil, sediment, and chlorides, into the storm drain system. While driving through neighborhoods, data was collected for potential pollution sources including: stained/dirty driveways; sidewalks covered with lawn clippings/leaves or receiving non-target irrigation (source of nutrients and sediment); pet waste (source of bacteria); long-term car parking (unused old cars with potential to leak chemicals, oil, and/or grease); and amount of sediment, organic matter, and/or trash present along curbs. Potential for street tree planting and street sweeping was also evaluated based on some of these factors.

Rooftops

Rooftop runoff is another contributor to stormwater runoff and pollutants in neighborhoods. Downspout retrofits can help reduce runoff and pollutants introduced to local streams. The field team identified whether downspouts discharged rooftop runoff to pervious areas, rain barrel, impervious surfaces (driveways, street), and/or directly to the storm drain system and the proportion of each within a neighborhood. The potential for disconnecting and redirecting downspouts from impervious surface or storm drain system was also evaluated.

Common Areas

Common areas such as community parks (homeowners open space and/or local open space), parking lots, and alleys are good opportunities to observe community behaviors such as pet waste disposal, stormwater management, storm drain marking, and how natural areas or buffers are managed. Good maintenance of these areas indicated that residents or a homeowner’s association are active in caring for the neighborhood and may represent opportunities for restoration projects. Data was collected on the condition of storm drain inlets (whether they were clean or filled with debris) and presence of pet waste or dumping in common areas to identify potential pollution sources in a neighborhood. The potential for storm drain marking, stormwater management practices, and stream buffer planting was also evaluated.

Other NSA Information

In addition to these four source areas, basic information was collected in individual neighborhoods to help rate restoration potential. This information included lot size, house types and whether a homeowners' association exists for the community. Presence of sewer service and amount of remodeling or redevelopment activities were also identified for additional potential pollution sources. After surveying the entire neighborhood and completing the basic information and four major source area sections, any major pollutants that are potentially being generated by the neighborhood are indicated on the field form in the following categories; nutrients; oil and grease; trash/litter; bacteria; and sediment. For example, if a neighborhood had several long-term parked vehicles, oil and grease would be flagged as a potential major pollutant being generated in that neighborhood. The presence of trash in yards, dumping in common areas, or overflowing/uncovered dumpsters would be a significant indicator for trash/litter generated in a neighborhood. Sediment was flagged as a major pollutant source if erosion or bare soil was observed, and/or a considerable portion of the curb and gutters were covered with sediment.

Recommended Actions

After evaluation of an entire neighborhood, specific actions were recommended for neighborhood restoration or retrofits based on initial field observations. Recommended actions included in the Middle Gwynns Falls watershed NSAs included:

- Downspout disconnection
- Fertilizer reduction
- Bayscaping
- Storm drain marking
- Street tree and shade tree planting
- Street sweeping
- Trash management
- Multi-family parking lot or alley retrofit

The last step of the NSA involved rating the overall neighborhood pollution severity and restoration potential. The severity of pollution generated by a neighborhood is denoted by the Pollution Severity Index (PSI) based on benchmarks and scoring system in the USSR manual. An NSA PSI is rated as severe, high, moderate, or none. A neighborhood's potential for residential restoration projects is rated as high, moderate, or low according to the Restoration Opportunity Index (ROI). The USSR also provides benchmarks and guidelines to establish NSA ROI ratings.

4.2.2 Summary of Sites Investigated

A total of 153 neighborhoods were assessed throughout the Middle Gwynns Falls watershed (see Figure 4-1). The number of neighborhoods within each subwatershed is summarized in Table 4-1. Note that a neighborhood may overlap multiple watersheds; in this case, the neighborhood is counted once for each subwatershed in which it falls. Analyses of acres of land or miles of road addressed by recommended actions, however, are based on the actual proportion of the neighborhood that falls within each subwatershed. This is explained further in the subsequent sections. Neighborhoods within the Gwynns Falls, Powder Mill Run, Dead Run, and Maiden Choice Run subwatersheds were assessed by consultants from Parsons Brinckerhoff, Inc. and NMP Engineering, Inc. while neighborhoods within Scotts Level were assessed by County staff.

Table 4-1: Neighborhoods Surveyed per Subwatershed

Subwatershed	# of NSAs
Gwynns Falls	71
Powder Mill Run	14
Dead Run	33
Maiden Choice Run	15
Scotts Level	39

About 10% of the assessed neighborhoods, 15 out of 153, were rated as having both high PSI and high ROI. Overall, 27 neighborhoods were rated as having high PSI; and 95 neighborhoods were considered to have moderate PSI. 45 neighborhoods were considered as having high ROI; and 84 neighborhoods were rated as having moderate PSI. The remaining neighborhoods had either a low PSI or ROI rating. The 15 neighborhoods with high PSI and high ROI ratings represent the best areas to target for restoration initially. The distribution of PSI and ROI ratings among the NSAs are shown in Figure 4-2.

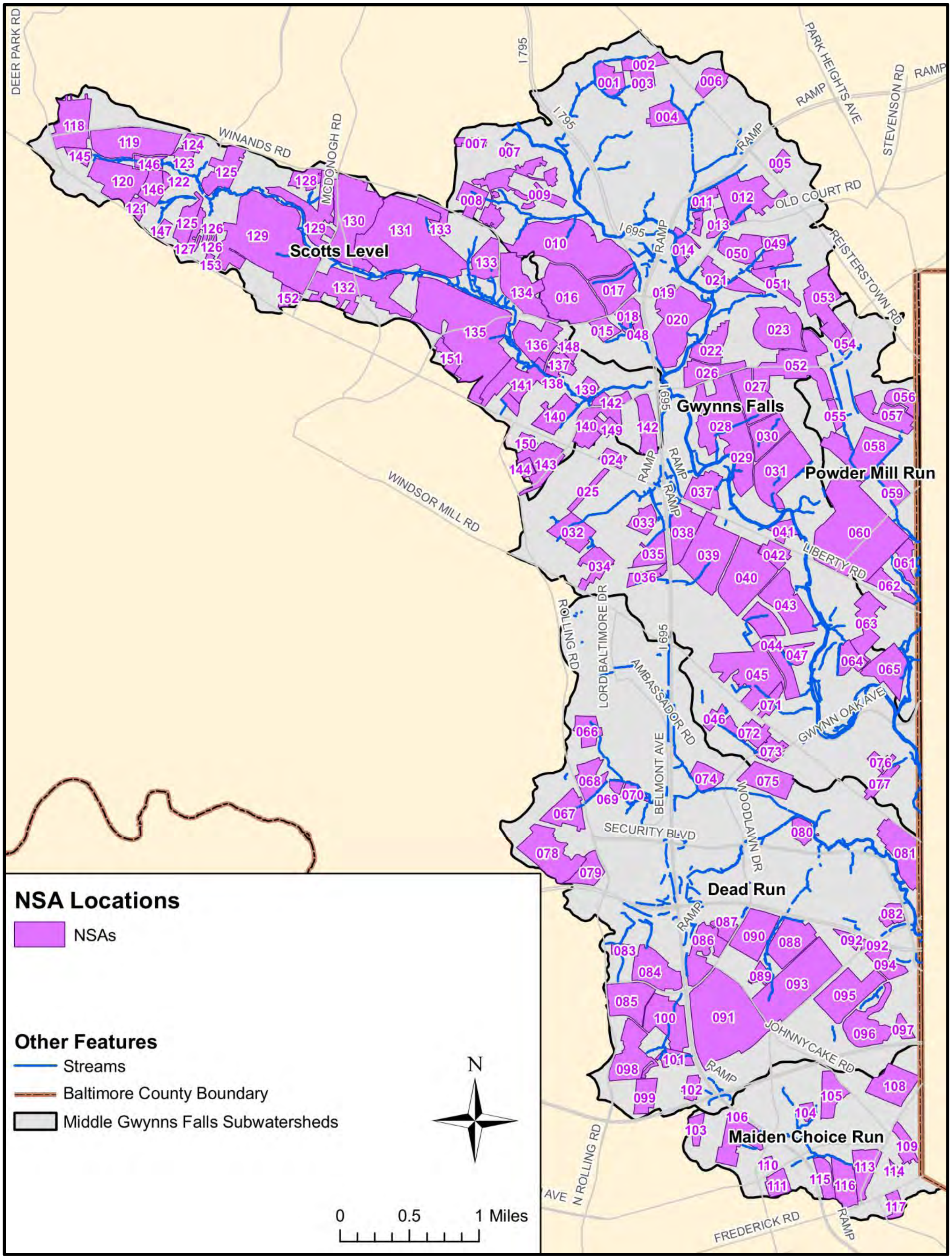


Figure 4-1: Location of NSAs in Middle Gwynns Falls Watersheds

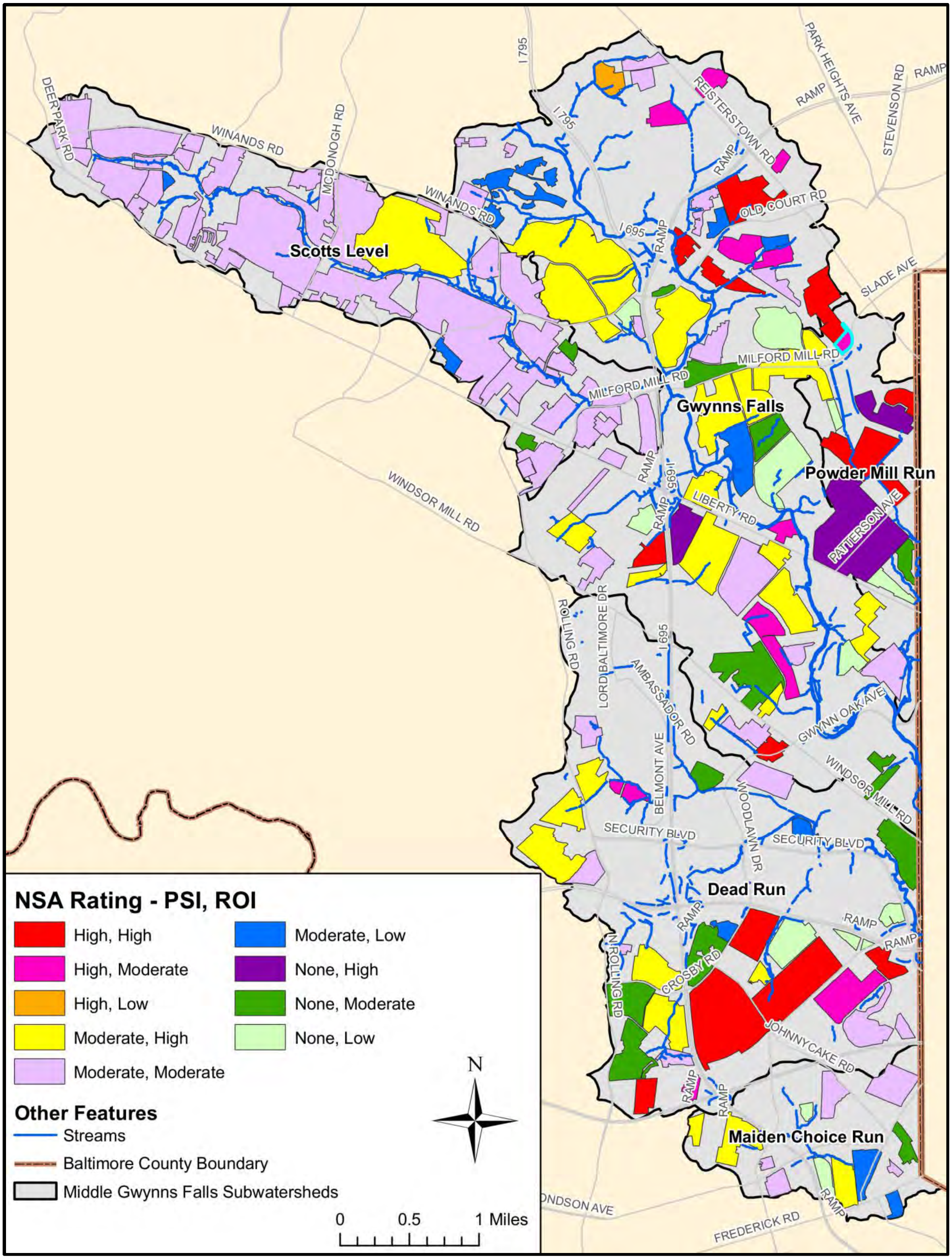


Figure 4-2: NSA Pollution Severity and Restoration Opportunity Indices in the Middle Gwynns Falls Watershed

4.2.3 General Findings

The following subsections describe the actions recommended based on evaluation of the NSAs. This includes an explanation of the methodologies and criteria used to evaluate the potential for recommended actions, as well as results expected if these actions were applied. Figures showing general locations of NSAs recommended for certain actions are included in each subsection. Appendix B includes a summary of NSA data collected and recommended actions by individual neighborhoods. Calculations supporting estimates of results for recommended actions are included in Appendix C.

4.2.3.1 Downspout Disconnection

Rooftop runoff is managed via downspouts which are classified as either connected or disconnected. Directly connected downspouts extend underground, discharging runoff directly to the storm drain system without treatment. Indirectly connected downspouts drain to impervious surfaces such as paved driveways, sidewalk, or curb and gutter system with little or no treatment. Disconnected downspouts allow rooftop runoff to infiltrate into the ground and enter streams through the groundwater system in a slower more natural fashion. Downspout disconnection is desirable because it decreases flow to local streams during storm events; helping prevent erosion and reducing pollutant loads to streams. Disconnection may involve redirecting connected downspouts from impervious areas or the storm drain system onto pervious area such as yards or lawns. This requires at least 15 feet of pervious area down gradient from the downspout for filtration to occur. Rain barrels and rain gardens are other disconnection options that can be recommended in lieu of redirection if certain conditions exist. Rain barrels, for example, may be used to store rooftop runoff for irrigation if there is limited pervious area available for downspout redirection and if the typical neighborhood has several hundred square feet of lawn area available down gradient from the downspout.

Downspout redirection is recommended for neighborhoods where at least 25% of the downspouts are indirectly connected to impervious area or directly connected to the storm drain system and where the average lot has at least 15 feet of pervious area available down gradient from the connected downspout for redirection. Table 4-2 includes a summary of the number of neighborhoods recommended for downspout redirection and the acres of rooftop addressed if downspout redirection were implemented by subwatershed. Table 4-2 also lists the percent of total impervious rooftop area in each subwatershed that would be addressed if downspout redirection were implemented; total impervious rooftop area per subwatershed was calculated using 2008 buildings spatial data provided by Baltimore County OIT.

Table 4-2: Rooftop Acres Addressed by Downspout Redirection

Subwatershed	# of NSAs Recommended for Downspout Redirection*	Rooftop Acres Addressed	% of Subwatershed Rooftop Area Addressed
Gwynns Falls	48	108.7	38.6%
Powder Mill Run	7	16.7	30.6%
Dead Run	23	56.2	34.4%
Maiden Choice Run	11	18.9	46.0%
Scotts Level	7	5.4	2.5%
Middle Gwynns Falls Total	***87***	***205.8***	***27.0%***

*If a neighborhood overlaps multiple subsheds, it is counted for each subwatershed it encompasses.

Figure 4-3 illustrates the location of neighborhoods recommended for downspout redirection. Out of the 153 neighborhoods assessed, 87 have the potential for downspout disconnection through redirection. If implemented, this could address approximately 27% of the total impervious rooftop area in the Middle Gwynns Falls watersheds.

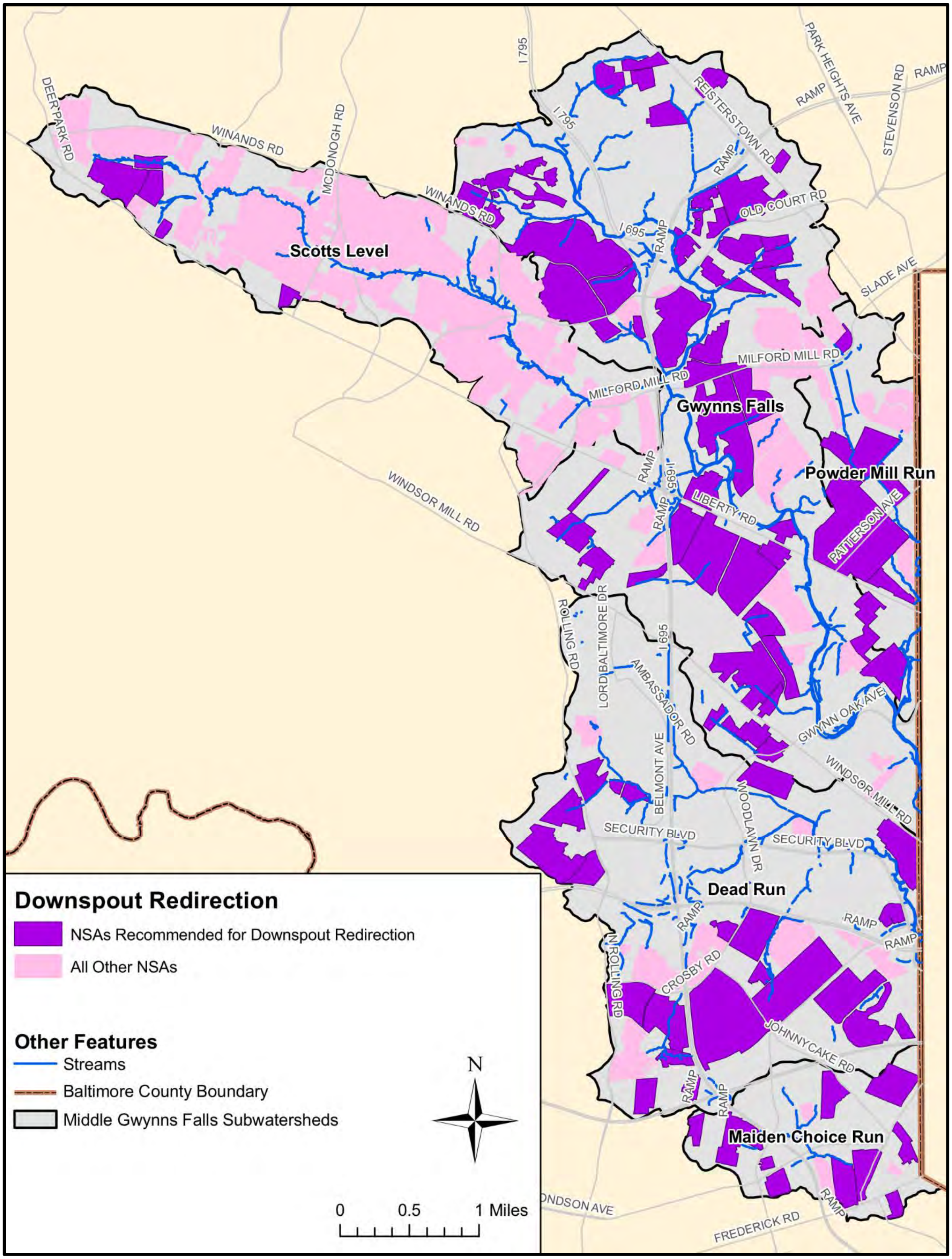


Figure 4-3: Neighborhoods Recommended for Downspout Disconnection

4.2.3.2 Bayscaping

Bayscaping refers to the use of plants native to the Chesapeake Bay watershed for landscaping. Because they are native to the region, these plants require less irrigation, fertilizers, and pesticides to maintain as compared to non-native or exotic plants. This means fewer chemical pollutants and lawn maintenance requirements. Bayscaping is also beneficial to wildlife.

All neighborhoods could use more bayscaping; however, the benefits and feasibility of this action are limited by the space available for landscaping. Several neighborhoods are characterized by smaller lot sizes and/or significant impervious cover, where bayscaping might be difficult. In addition, neighborhoods already containing a significant amount of landscaping were not considered a priority. Therefore, bayscaping was recommended in neighborhoods where the typical lot was at least ¼ acre in size, was less than 10% landscaped, and where there was sufficient grass area available (greater than 50%). Bayscaping for apartment complexes were recommended if there was greater than 25% grass cover. Table 4-3 includes a summary of the number of neighborhoods recommended for bayscaping based on these criteria and the area of available lawn addressed if this action were initiated by subwatershed. Table 4-3 also lists the percent of the total subwatershed area that would be addressed by implementing bayscaping in the recommended neighborhoods.

Table 4-3: Acres of Land Addressed by Bayscaping

Subwatershed	# of NSAs Recommended for Bayscaping*	Acres of Land Addressed	% of Subwatershed Area Addressed
Gwynns Falls	20	130.4	2.1%
Powder Mill Run	4	44.3	4.6%
Dead Run	5	86.0	2.1%
Maiden Choice Run	5	10.5	1.1%
Scotts Level	11	121.0	4.6%
Middle Gwynns Falls Total	***42***	***392.1***	***2.6%***

*If a neighborhood overlaps multiple subsheds, it is counted for each subwatershed it encompasses.

Figure 4-4 illustrates the location of neighborhoods recommended for bayscaping. Out of the 153 neighborhoods assessed, 42 (27%) met the criteria and were recommended for bayscaping. Table 4-3 shows that only approximately 2.6% of the Middle Gwynns Falls planning area would be addressed by this action; this is because many of the neighborhoods have a limited amount of area available for bayscaping due to small lot sizes and/or significant impervious cover.

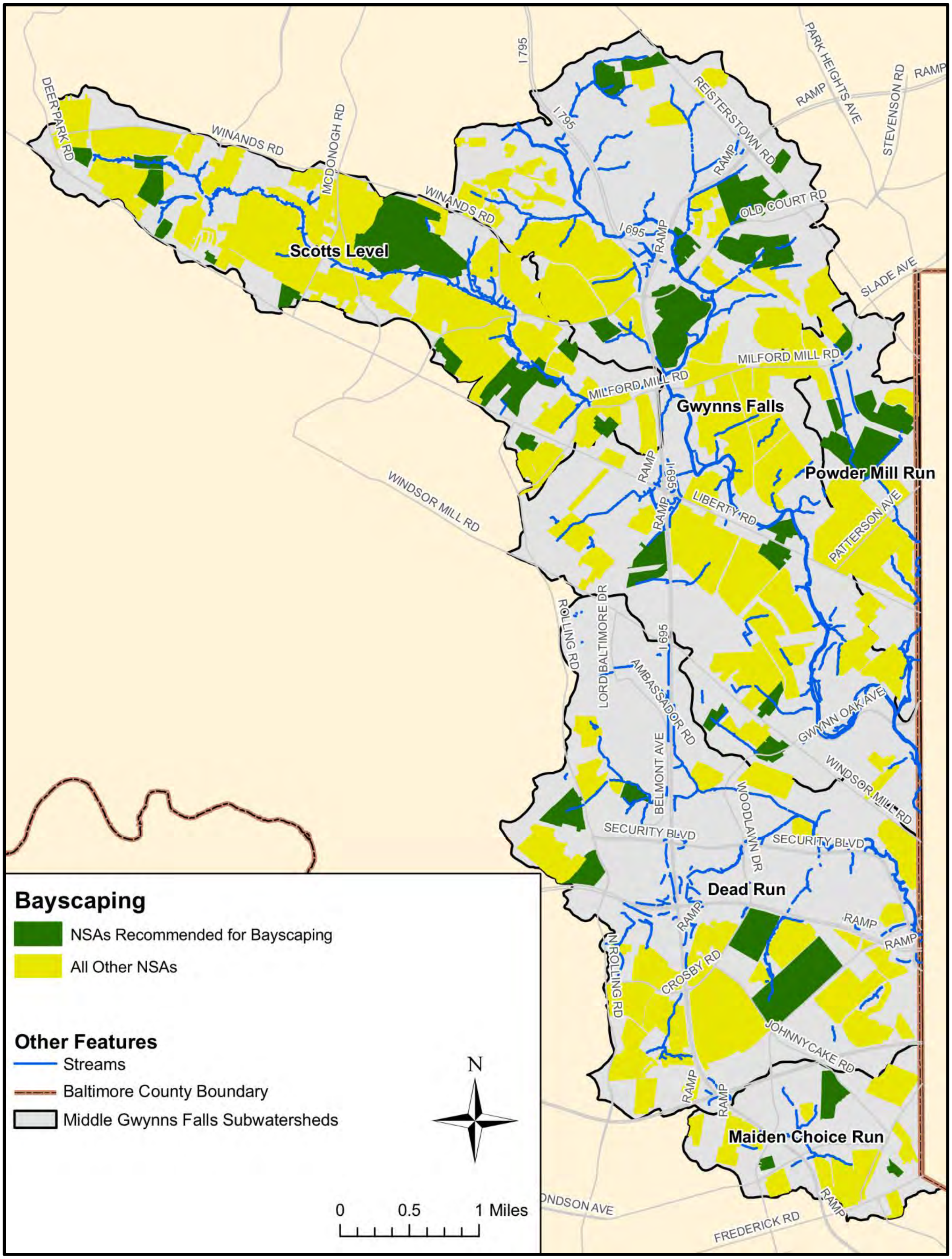


Figure 4-4: Neighborhoods Recommended for Bayscaping

4.2.3.3 Storm Drain Marking

Most of the neighborhoods in the Middle Gwynns Falls watershed consist of curb and gutter systems with storm drain inlets that convey stormwater runoff quickly and directly to the stream system and ultimately to the Chesapeake Bay. Most neighborhoods do not have storm drain markings or indicators that the inlets eventually drain to the Chesapeake Bay. Since there is little or no infiltration of stormwater in a curb and gutter system, there is more potential for pollutants to be carried to the stream system. Storm drain markings indicate that inlets drain to the Gwynns Falls or Chesapeake Bay; this is a way to educate residents that any trash, lawn clippings (potential for nutrient pollution), or other debris accumulating along the curbs and gutters will be washed away during a storm event and end up in the Chesapeake Bay.

Neighborhoods recommended for storm drain marking have curb and gutter systems with inlets appropriate for marking and where less than 10% of the existing inlets were already marked and legible. Table 4-4 includes a summary of the number of neighborhoods recommended for storm drain marking and the number of inlets addressed if this action were initiated by subwatershed. The number of inlets addressed is estimated based on the inlet densities calculated by subwatershed in Section 2.3.8. Table 4-4 also lists the percent of the total inlets in each subwatershed that would be addressed if storm drain marking was implemented in the recommended neighborhoods.

Table 4-4: Number of Inlets Addressed by Storm Drain Marking

Subwatershed	# of NSAs Recommended for Storm Drain Marking*	Approximate # of Inlets Addressed	% of Inlets in Subwatershed Addressed
Gwynns Falls	64	268	30.6%
Powder Mill Run	12	55	41.4%
Dead Run	30	126	25.0%
Maiden Choice Run	12	15	26.3%
Scotts Level	39	356	60.5%
Middle Gwynns Falls Total	***138***	***820***	***38.0%***

*If a neighborhood overlaps multiple subsheds, it is counted for each subwatershed it encompasses.

Figure 4-5 illustrates the location of neighborhoods recommended for storm drain marking. Out of the 153 neighborhoods assessed, 138 (90%) met the criteria and were recommended for storm drain marking. Table 4-4 also shows that about 38% of the inlets in the watershed could be addressed by this action just in the neighborhoods alone.

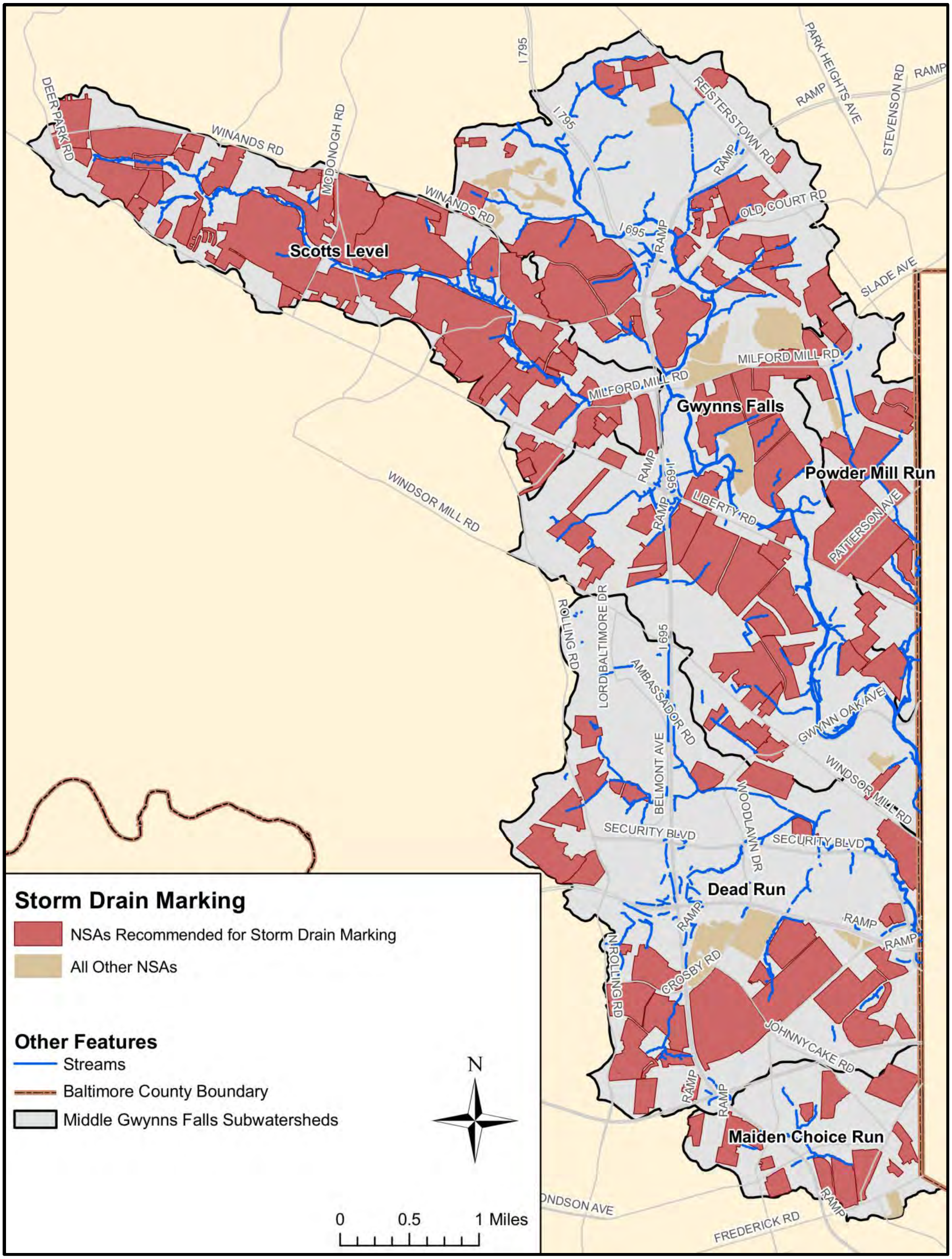


Figure 4-5: Neighborhoods Recommended for Storm Drain Marking

4.2.3.4 Street Trees and Shade Trees

Street trees and shade trees are not only an asset to a neighborhood aesthetically but also provide air and water quality improvement since they intercept precipitation with their leaves and absorb precipitation and nutrients through their root systems. This infiltration of precipitation through leaves or the root systems slows flow input and provides some treatment before stormwater runoff reaches the stream system.

Street trees were recommended for neighborhoods with a minimum of 6 feet of green space between the sidewalk and curb and less than 75% of these areas had trees planted. The number of trees was estimated based on a spacing of one tree per 30 feet. Open space shade trees were recommended for open pervious areas in neighborhoods where the space had no apparent current use. The number of shade trees was estimated based on a spacing of approximately 135 trees per acre for larger areas, based on the Baltimore County Policy and Guidelines for Community Tree Planting Projects. This assures a survival rate of 100 trees per acre after 25 years. Table 4-5 includes a summary of the number of neighborhoods recommended for street tree planting and the number of street trees proposed per subwatershed.

Table 4-6 shows a summary of the number of neighborhoods recommended for shade tree planting and the number of shade trees proposed per subwatershed.

Table 4-5: Street Tree Potential by Subwatershed

Subwatershed	# of NSAs Recommended for Street Trees*	# of Street Trees that Could be Planted
Gwynns Falls	17	1,786
Powder Mill Run	6	287
Dead Run	14	2,984
Maiden Choice Run	4	491
Scotts Level	6	54
Middle Gwynns Falls Total	***41***	***5,602***

*If a neighborhood overlaps multiple subsheds, it is counted for each subwatershed it encompasses.

Table 4-6: Shade Tree Potential by Subwatershed

Subwatershed	# of NSAs Recommended for Shade Trees*	# of Shade Trees that Could be Planted
Gwynns Falls	29	1,671
Powder Mill Run	3	205
Dead Run	12	943
Maiden Choice Run	5	100
Scotts Level	10	520
Middle Gwynns Falls Total	***55***	***3,439***

*If a neighborhood overlaps multiple subsheds, it is counted for each subwatershed it encompasses.

Figure 4-6 illustrates the location of neighborhoods where street trees could be planted. Out of the 153 neighborhoods assessed, 41 (27%) met the criteria and were recommended for street trees. For the most part, neighborhoods not recommended for street trees either did not have sidewalks and a curb and gutter system or there was insufficient green space between the sidewalk and curb. There is potential for planting over 5,602 street trees throughout the watershed.

Figure 4-7 shows the location of neighborhoods where shade trees are recommended. Out of the 153 neighborhoods assessed, 55 (36%) met the criteria for potential shade tree planting. 3,439 shade trees are estimated for the Middle Gwynns Falls watersheds.

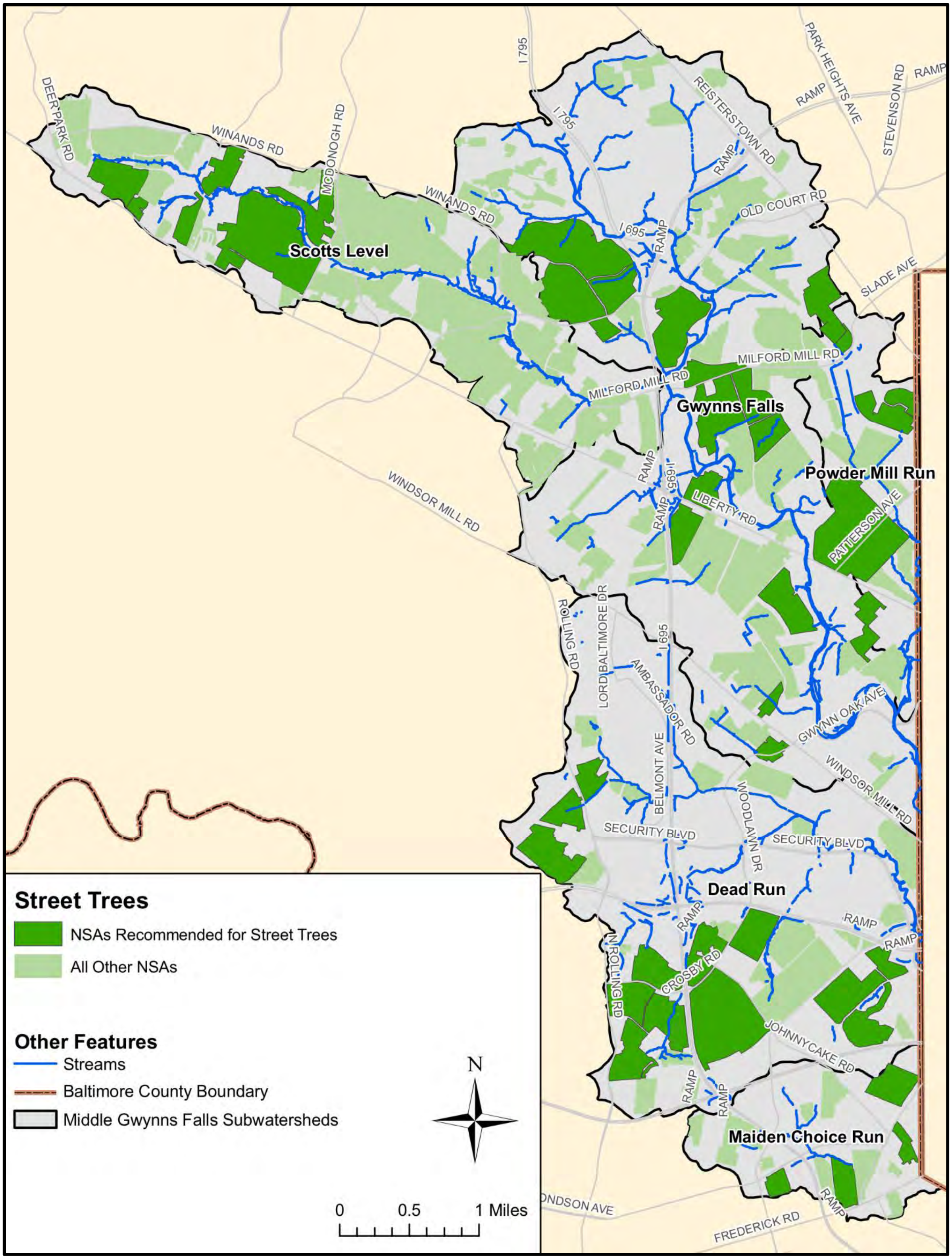


Figure 4-6: Neighborhoods Recommended for Street Tree Planting

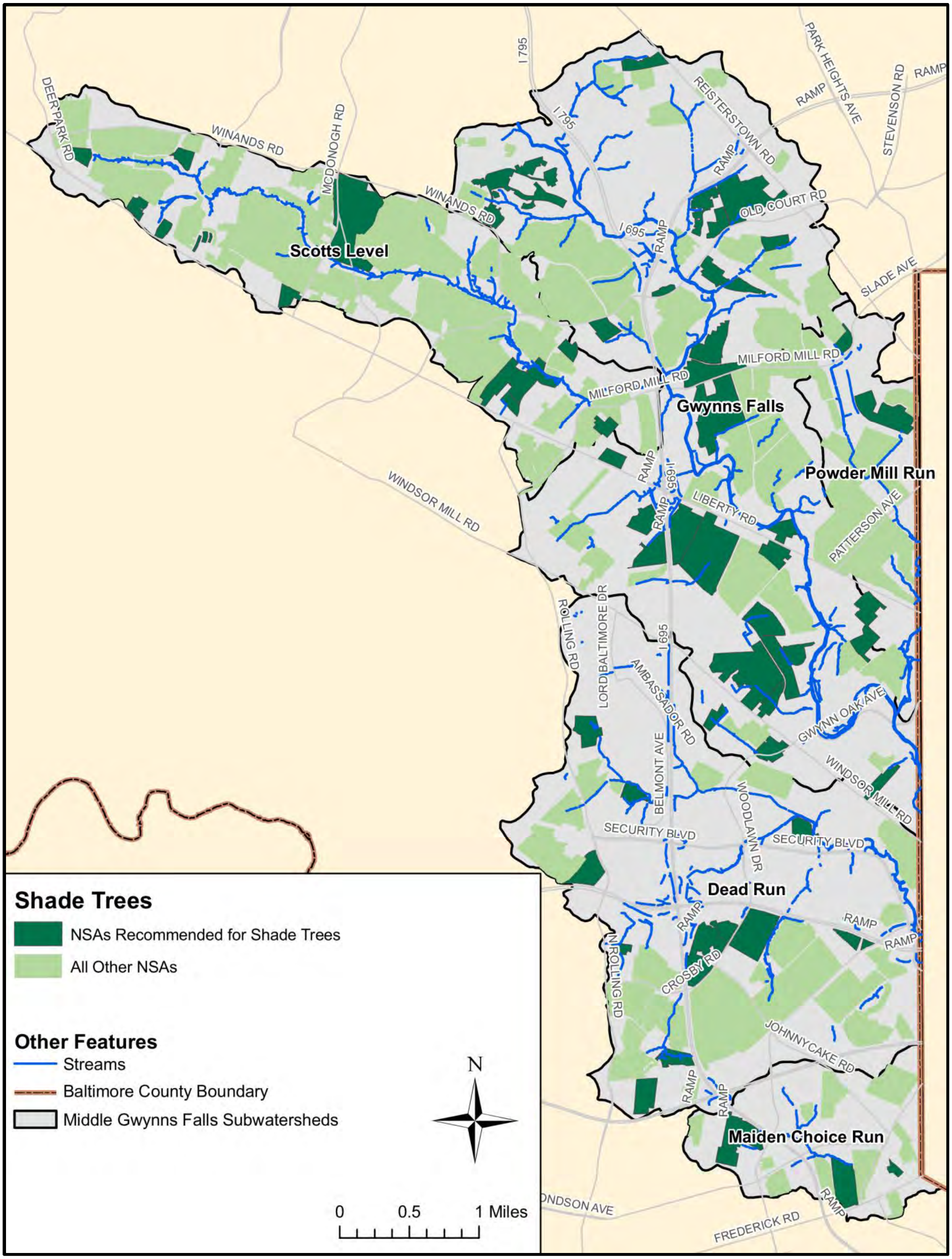


Figure 4-7: Neighborhoods Recommended for Shade Tree Planting

4.2.3.5 Street Sweeping

Street sweeping helps remove trash, sediment and other organic matter such as leaves and grass clippings from the curb and gutter system and prevents them from entering the storm drains and nearby streams. Street sweeping also reduces sediment and other pollutant loads such as oil and metals to the stream system. Excessive organic matter, sediment, and trash can clog streams and the storm drain system resulting in costly maintenance and stream health impairment. Also, the decay of an unbalanced amount of organic matter in a stream depletes the supply of dissolved oxygen, depriving other aquatic life including fish of their oxygen demand. An aggressive street sweeping initiative can ease the effects of a curb and gutter storm drain system on receiving streams.

Neighborhoods where 22% or more of the curbs and gutters were covered with excessive trash, sediment, and/or organic matter were recommended for street sweeping. Table 4-7 includes a summary of the number of neighborhoods recommended for street sweeping and the miles of street addressed if implemented by subwatershed. Miles addressed by street sweeping were estimated by determining the miles of roads within each neighborhood recommended for street sweeping using Baltimore County's 2008 roads spatial data. For neighborhoods intersecting two or more subsheds, the miles addressed are only displayed for the subsheds where they are present.

Table 4-7: Miles Addressed by Street Sweeping

Subwatershed	# of NSAs Recommended for Street Sweeping*	Miles Addressed by Street Sweeping
Gwynns Falls	19	37.0
Powder Mill Run	6	9.3
Dead Run	10	20.7
Maiden Choice Run	4	6.8
Scotts Level	2	2.3
Middle Gwynns Falls Total	***34***	***76.1***

*If a neighborhood overlaps multiple subwatersheds, it is counted in "# of NSAs" for each subwatershed it encompasses. Miles of sweeping are counted only for the subshed where they are proposed.

Figure 4-8 illustrates the location of neighborhoods recommended for street sweeping. Out of the 153 neighborhoods assessed, 34 (22%) met the criteria for street sweeping, 7 of which overlap multiple subwatersheds. If initiated, this could address 72 miles of road within neighborhoods recommended in the watershed.

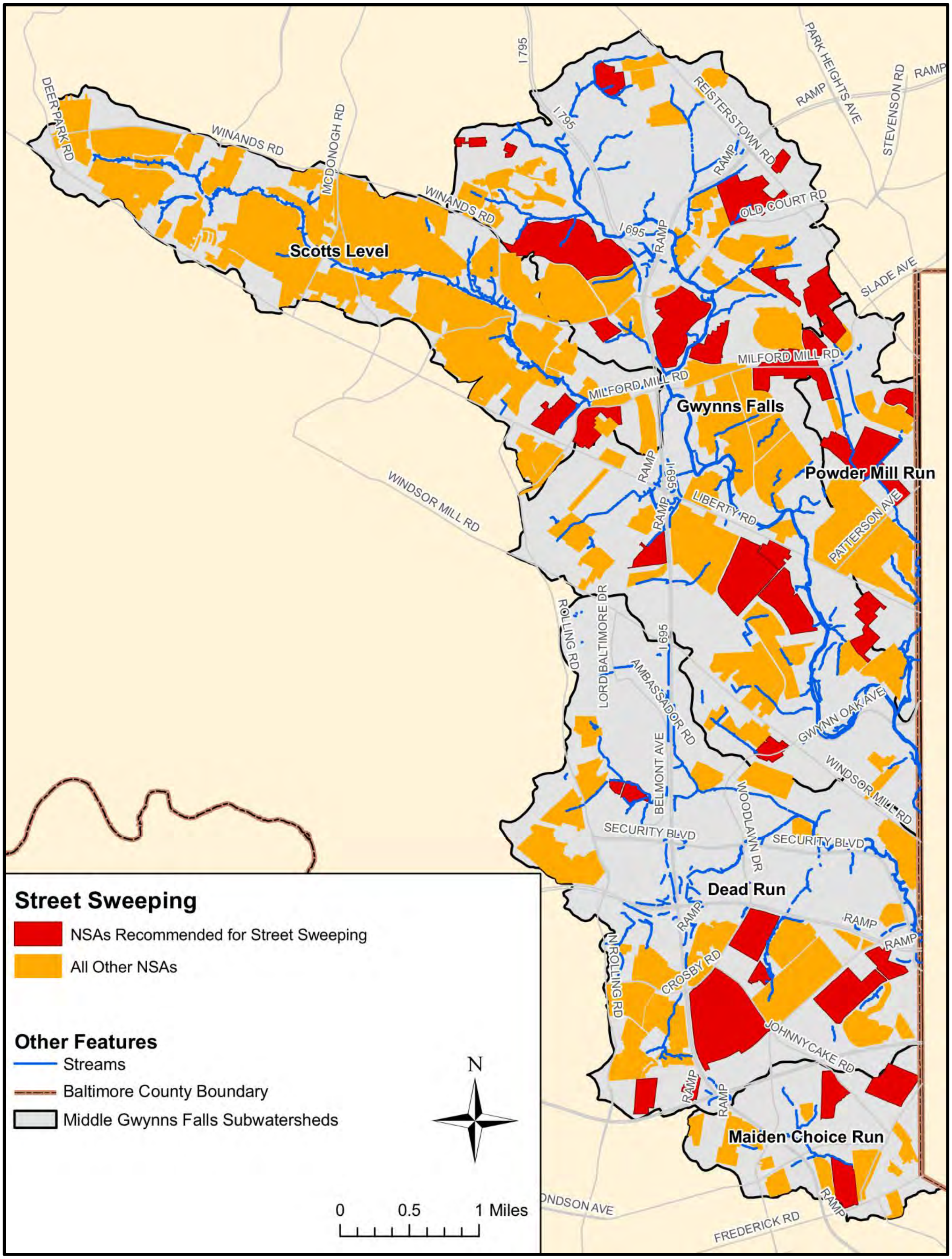


Figure 4-8: Neighborhoods Recommended for Street Sweeping

4.2.3.6 Neighborhood Trash Management

Trash can be a major pollutant of concern in neighborhoods. The uplands survey revealed that the study area may benefit from trash management initiatives such as community cleanups, trash management education, and working with the Department of Public Works (DPW) to implement a bulk trash pick-up program.

Neighborhoods where junk or trash was observed in 10% or more of yards were recommended for trash management initiatives. Neighborhoods with less than 10% of yards with junk/trash but with other warning signs such as overflowing dumpsters or dumping in alleys or other common areas were also included. Table 4-8 includes a summary of the number of neighborhoods recommended for trash management initiatives and the acres of land addressed if it was implemented by subwatershed. Table 4-8 also includes a summary of the percent of the total subwatershed area addressed by initiating trash management.

Table 4-8: Acres of Land Addressed by Trash Management

Subwatershed	# of NSAs Recommended for Trash Management*	Acres of Land Addressed	% of Subwatershed Area Addressed
Gwynns Falls	4	70.7	1.1%
Powder Mill Run	2	28.3	2.9%
Dead Run	6	127.0	3.0%
Maiden Choice Run	0	0.0	0.0%
Scotts Level	1	60.0	2.3%
Middle Gwynns Falls Total	***13***	***286.0***	***1.9%***

*If a neighborhood overlaps multiple subsheds, it is counted for each subwatershed it encompasses.

Figure 4-9 illustrates the location of neighborhoods recommended for trash management initiatives. Out of the 153 neighborhoods assessed, 13 (8%) were recommended for trash management. If initiated, this could address approximately 2% of the total Middle Gwynns Falls planning area. Overall, the Middle Gwynns Falls planning area was relatively clear of trash.

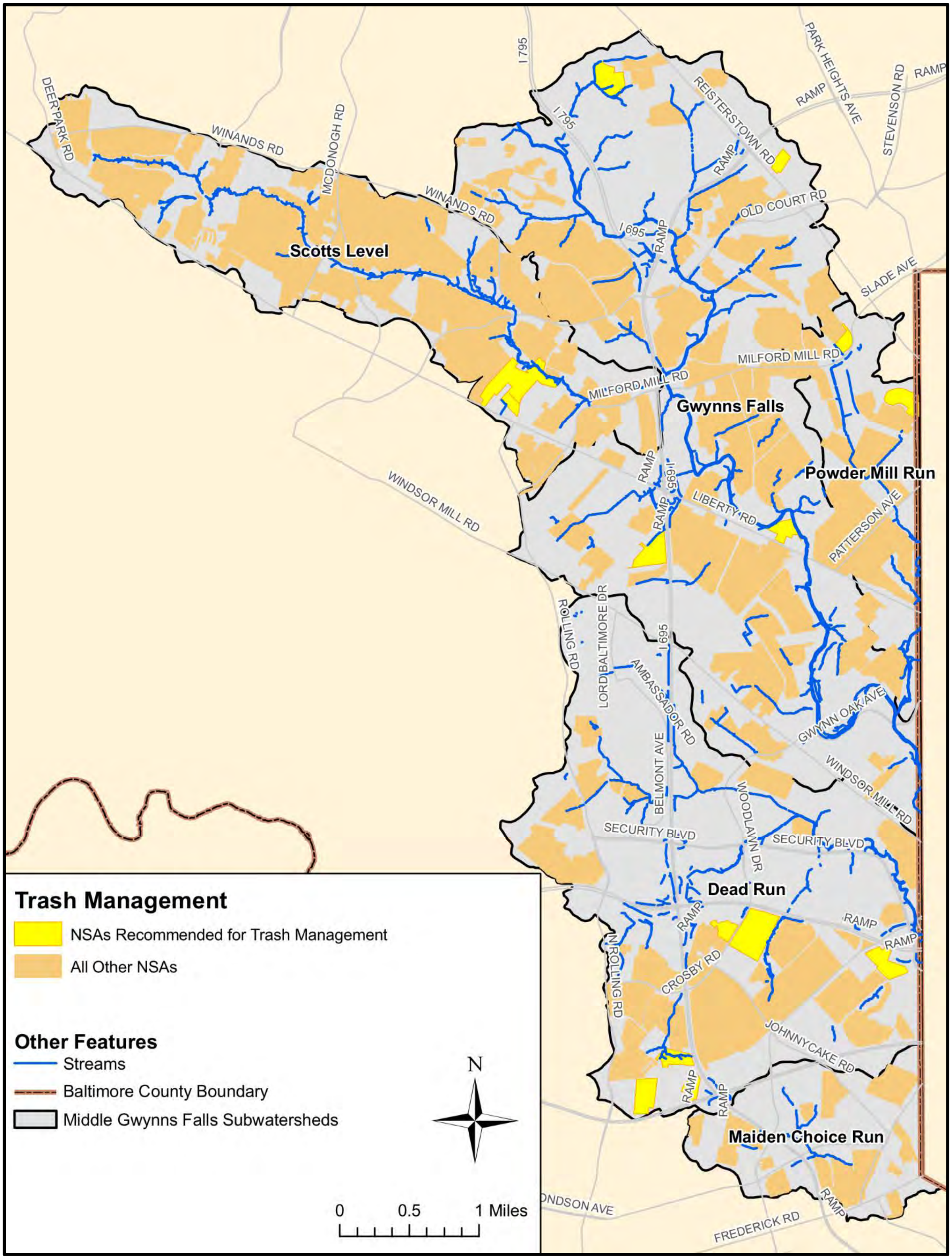


Figure 4-9: Neighborhoods Recommended for Trash Management

4.2.3.7 *Parking Lot or Alley Retrofit*

There are several apartment, townhouse, and condo complexes in the study area. Multi-family parking lots in these types of neighborhoods can be an opportunity for a stormwater retrofit to address stormwater runoff from impervious surfaces. In addition, neighborhoods with paved alleys could also be an opportunity for a stormwater retrofit if sufficient pervious area is available. As discussed previously in Chapter 2, filtration practices such as bioretention areas with native plantings could be used to capture and treat stormwater runoff from impervious parking lots and alleys while requiring minimal maintenance.

Neighborhoods where sufficient green space was available down gradient of a multi-family parking lot or alley were recommended for stormwater retrofit practice. Table 4-9 includes a summary by subwatershed of the number of neighborhoods recommended for stormwater retrofits and the approximate acres of impervious cover addressed if implemented.

Table 4-9: Acres of Impervious Cover Addressed by Stormwater Retrofit

Subwatershed	# of NSAs Recommended for Stormwater Retrofit*	Acres of Impervious Cover Addressed
Gwynns Falls	11	9.6
Powder Mill Run	2	4.2
Dead Run	5	2.2
Maiden Choice Run	2	0.4
Scotts Level	3	1.0
Middle Gwynns Falls Total	***23***	***17.5***

*If a neighborhood overlaps multiple subsheds, it is counted for each subwatershed it encompasses.

Figure 4-10 illustrates the location of neighborhoods recommended for multi-family parking lot or alley stormwater retrofits. Out of the 153 neighborhoods assessed, 23 (15%) have sufficient green space available for multi-family parking lot or alley stormwater retrofits. Note that the 17.5 acres of impervious cover addressed is an approximation based on potential sites identified in the field and area calculations using GIS and visual inspection of aerial images. Actual area addressed will depend on a closer inspection of site conditions conducive to a stormwater retrofit application (e.g., grading requirements, cost, etc.)

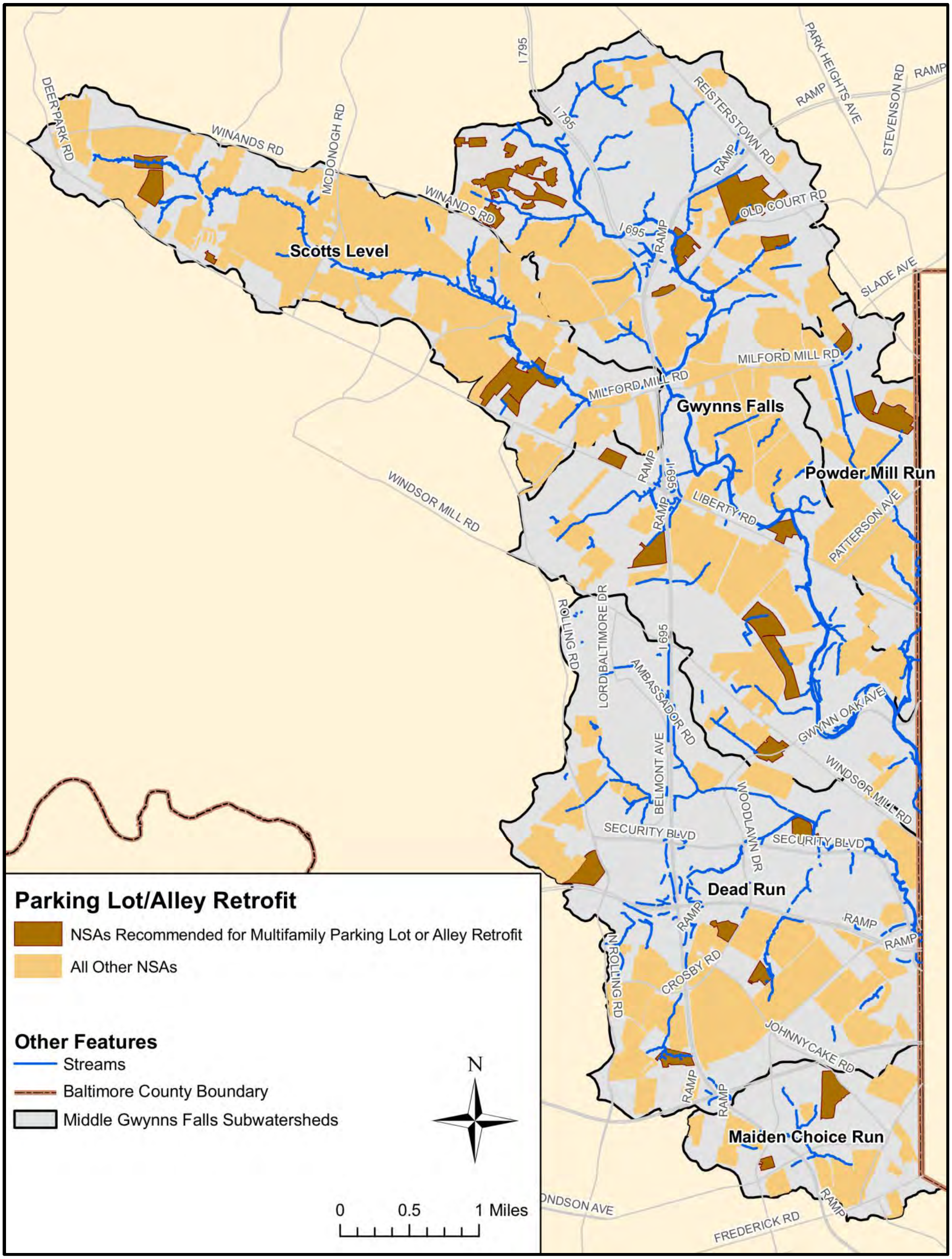


Figure 4-10: Neighborhoods Recommended for Parking Lot/Alley Retrofit

4.3 Hotspot Site Investigation (HSI)

Stormwater hotspots are areas that have potential to generate higher concentrations of stormwater pollutants than typically found in urban runoff and/or have a higher risk of spills, leaks, or illicit discharges due to the nature of their operations (CWP, 2004). These generally include commercial, industrial, municipal, or transport-related operations. Hotspots are either regulated or unregulated. Regulated hotspots are known sources of pollution that abide by applicable federal or state laws (e.g., NPDES permits). The nature of unregulated operations makes them likely to be potential pollutant sources. Stormwater pollutants generated as a result of hotspot operations depend on the specific activities taking place but typically include nutrients, hydrocarbons, metals, chloride, pesticides, bacteria, and trash.

Commercial hotspots include a range of businesses and activities but are normally grouped together in subwatersheds. Operations characteristic of commercial hotspots include waste or wash water generation, outdoor material storage, fuel handling, or auto/boat repair. Common commercial hotspots include auto repair shops, car dealers, car washes, parking facilities, gas stations, marinas, garden centers, construction equipment and building material lots, swimming pools, and restaurants. Industrial operations utilize, generate, handle, and/or store pollutants that can be washed off with stormwater, spilled, or mistakenly discharged into the storm drain. Many industrial hotspots are regulated under NPDES industrial discharge permits and include various manufacturing operations such as metal production, chemical manufacturing, and food processing. Municipal hotspots typically refer to local government operations such as solid waste, wastewater, road and vehicle maintenance, and yard waste. Like industrial operations, many municipal hotspots are subject to NPDES stormwater permits. Transport-related hotspots normally include areas of significant impervious cover and extensive private storm drain systems. Many are regulated and include uses such as airports, ports, highway construction, and trucking centers.

The purpose of HSIs is to evaluate pollution potential from hotspot operations and identify potential restoration practices that may be necessary. The following subsections describe the methods used to identify and assess a sample of hotspots in the Middle Gwynns Falls watershed.

4.3.1 Assessment Protocol

Because there are numerous operations in the study area that qualify as stormwater hotspots, individual sites were preselected in the office. Commercial/industrial areas within the watershed were identified using GIS tax parcel information, land use data, NPDES locations and aerial photographs in the office. Commercial/industrial areas were depicted on base maps for field use and included clustered urban areas and distinct or larger hotspot type operations. During the uplands survey, these commercial/industrial areas were briefly explored for hotspot potential. Sites were selected for formal investigation based on several factors. One objective of the HSIs was to examine a variety of hotspot operations and select sites to represent common types of hotspots found in the planning area. HSIs were also focused on unregulated hotspots since access to regulated hotspots is often limited and because regulated hotspots are previously documented/known pollutant sources. Regulated hotspots are already subject to NPDES permit regulations which normally require strict effluent concentration limits and periodic monitoring. Obvious sources of pollution observed during the upland assessment were revisited for hotspot potential. Problem areas identified by community members during the upland assessment were also scouted for hotspot potential.

Unique ID numbers were assigned to HSIs using the classification scheme "HSI_C_100", where 'C' denotes the Middle Gwynns Falls planning area and the first number correspond to a specific subwatershed. Subwatersheds were assigned unique numbers summarized in Table 4-10 for the purposes of HSIs and ISIs.

Table 4-10: Subwatershed ID Numbers

ID	Subwatershed
1	Gwynns Falls
2	Powder Mill Run
3	Dead Run
4	Maiden Choice Run
5	Scotts Level

Hotspot sites were numbered sequentially in the order they were surveyed within a particular subwatershed. For example, HSIs in Dead Run would be identified as 301, 302, 303, etc.

While hotspots have unique operations, drainage systems, and pollutant-related risks, stormwater quality problems can be characterized and evaluated by operations and activities common to most hotspots. Per the USSR manual, the HSI involved an evaluation of six common operations at each potential hotspot: vehicle operations, outdoor materials, waste management, physical plant, turf/landscaping, and stormwater infrastructure. The field team surveyed the entire property of each potential hotspot selected for an HSI to determine water quality impacts and restoration opportunities.

These six categories were used to standardize the HSI process and prioritize potential restoration efforts. Parameters evaluated within each operation category are described briefly below.

Vehicle Operations

Vehicle operations include maintenance, repair, recycling, fueling, washing or long-term parking. The presence of any of these activities was noted for each site since they can be a major source of metals, oil and grease, and hydrocarbons. Outdoor activities including vehicle storage, repair, fueling, and washing were also noted as potential pollution sources. Connections between vehicle operations and the storm drain system are the main focus of this category. The following were noted during the HSI as potential pollution sources: vehicle spills/leakage, lack of runoff diversion methods from storage/repair areas, directly connected fueling areas, and direct discharges to the storm drain from vehicle washing.

Outdoor Materials

Stormwater quality issues result from improper handling or storage of outdoor materials at hotspots. Locations where materials were loaded or unloaded were examined to see if materials were uncovered and draining to a storm drain inlet. Storage areas were also evaluated for types of materials stored outdoors and their potential for entering the storm drain system. Uncovered materials and stained storage areas were used as indicators of poor outdoor storage practices and potential pollution sources.

The field team also looked for improperly labeled storage containers, lack of secondary containment for liquids, and whether the storage area was directly or indirectly connected to the storm drain system. If any of these were observed, they were marked as potential pollution sources.

Waste Management

Every hotspot generates waste as a result of daily operations which can be potentially hazardous or a source of stormwater pollution depending on the type of waste and how it is stored. The field team noted the type of waste generated (e.g., hazardous, garbage, etc.) and the condition of dumpsters. Dumpsters with no cover or open lids, with leaks, damaged/in poor condition, and/or overflowing were noted as potential pollution sources. Dumpsters located near storm drain inlets or lacking runoff diversion methods were also recorded as potential pollution sources.

Physical Plant

Common physical plant practices include cleaning, maintaining, or repairing the building, outdoor work areas, and parking lots. These activities can be a source of sediment, nutrients, paints, and solvents in stormwater runoff. For each hotspot, the condition of the building itself was evaluated. Stained, dirty, or damaged buildings were noted as potential pollution sources as well as staining or discoloration around the building which is evidence that maintenance activities (e.g., painting, power-washing, resealing, etc.) discharge to storm drains. Similarly, parking lots that were stained, dirty, breaking up, and/or impervious were recorded as potential pollution sources. Downspouts connected to impervious surfaces or directly to the storm drain system were also recorded as pollution sources at a hotspot site. A stain leading to storm drains denoted poor cleaning practices (e.g., for construction activities).

Turf/Landscaping

Ground maintenance activities for turf/landscaped areas were also evaluated at hotspot sites. High turf management and improper irrigation practices were noted since they are potential sources of nutrient, fertilizer, and pesticide pollution. The field team also determined whether landscaped areas drained directly to storm drains or if organics (leaves, grass) accumulated on impervious surfaces. More than 20% of bare soil in turf/landscaped areas was flagged as a sediment pollution source.

Stormwater Infrastructure

If stormwater treatment practices were not present, this was flagged as a potential pollution source. Private storm drains were also evaluated for pollution and illicit connection potential. Storm drains with considerable amounts of sediment, organics, and/or trash were identified as potential pollution sources.

Recommended Actions

For each operation on the HSI field form, there is an observed pollution source box which was checked when there was clear evidence of pollution problems at the time of the investigation. After surveying the entire property and evaluating hotspot operations, one or more of the follow-up actions listed below may be recommended based on initial field observations:

- Refer for immediate enforcement
- Follow-up on-site inspection
- Test for illicit discharge

- Future education effort
- Check to see it hotspot is an NPDES non-filer
- On-site non-residential retrofit
- Pervious area restoration
- Schedule a review of stormwater pollution prevention plan

4.3.2 Summary of Sites Investigated

A total of 40 hotspot candidates were investigated in the Middle Gwynns Falls watershed. Most of the sites (30 out of 40) were commercial establishments. Four (4) industrial facilities, three (3) transport-related sites, two (2) municipal facilities, and one (1) animal facility were also investigated. Hotspots within the Gwynns Falls, Powder Mill Run, Dead Run, and Maidens Choice Run subwatersheds were assessed by Parsons Brinckerhoff, Inc. and NMP Engineering, Inc. Hotspots within the Scotts Level subwatershed were assessed by County staff. The hotspot candidates included as part of the uplands survey are listed in Table 4-11 including site ID, type, and subwatershed. All assessed hotspots were given an initial hotspot designation based on the severity of pollution potential observed in the field. Hotspots were categorized as either severe, confirmed, potential, or not a hotspot. Locations and initial hotspot status designations are shown in Figure 4-11.

As mentioned previously, hotspot candidates represent areas where urban development/commercial uses are concentrated and are intended to represent common types of hotspot operations located throughout the watershed. While based on this sample assessment, the overall watershed strategy should also encompass all hotspot operations occurring in the watershed.

Table 4-11: Summary of Hotspot Sites Investigated in Middle Gwynns Falls

Site ID	Subwatershed	Type
HSI_C_101	Gwynns Falls	Commercial (Gas Station)
HSI_C_102	Gwynns Falls	Transport (Metro Stop)
HSI_C_103	Gwynns Falls	Commercial (Gas Station)
HSI_C_104	Gwynns Falls	Commercial (Gas Station)
HSI_C_105	Gwynns Falls	Commercial (Auto Repair/ Gas Station)
HSI_C_106	Gwynns Falls	Commercial (Auto Repair/ Gas Station)
HSI_C_107	Gwynns Falls	Animal Facility (Vet)
HSI_C_108	Gwynns Falls	Commercial (Car Wash)
HSI_C_109	Gwynns Falls	Commercial (Gas Station)
HSI_C_201	Powder Mill	Commercial (Auto Repair)
HSI_C_202	Powder Mill	Transport (Metro Stop)
HSI_C_203	Powder Mill	Commercial (Car Dealership)
HSI_C_301	Dead Run	Transport-Related (School Bus Storage)
HSI_C_302	Dead Run	Municipal (BGE Business Center)
HSI_C_303	Dead Run	Commercial (Car Dealership and Auto Repair)
HSI_C_304	Dead Run	Commercial (Shopping Center/ Mall)
HSI_C_305	Dead Run	Commercial (Hardware Store/ Garden Center)
HSI_C_306	Dead Run	Commercial (Car Wash)
HSI_C_307	Dead Run	Municipal (Maintenance Shop)
HSI_C_308	Dead Run	Commercial (Gas Station)
HSI_C_309	Dead Run	Industrial (Construction company yard))
HSI_C_310	Dead Run	Industrial (Construction Education)
HSI_C_311	Dead Run	Industrial (Construction Materials)
HSI_C_312	Dead Run	Commercial (Shopping Center)
HSI_C_313	Dead Run	Commercial (Hardware Store/ Garden Center)
HSI_C_401	Maidens Choice	Commercial (Car Dealership)
HSI_C_402	Maidens Choice	Commercial (Car Wash/ Auto Repair\ Gas Station)
HSI_C_501	Scotts Level	Commercial (Auto Dealership)
HSI_C_502	Scotts Level	Commercial (Bowling Alley)
HSI_C_503	Scotts Level	Commercial (Shopping Center)
HSI_C_504	Scotts Level	Commercial (Shopping Center)
HSI_C_505	Scotts Level	Commercial (Auto Dealership)
HSI_C_506	Scotts Level	Commercial (Building Supply/Equipment Rental)
HSI_C_507	Scotts Level	Commercial (Shopping Center)
HSI_C_508	Scotts Level	Commercial (Shopping Center)
HSI_C_509	Scotts Level	Commercial (Restaurant)
HSI_C_510	Scotts Level	Commercial (Shopping Center)
HSI_C_511	Scotts Level	Commercial (Shopping Center)
HSI_C_512	Scotts Level	Commercial (Auto Dealership)
HSI_C_513	Scotts Level	Industrial (Heating Oil Distribution Site)

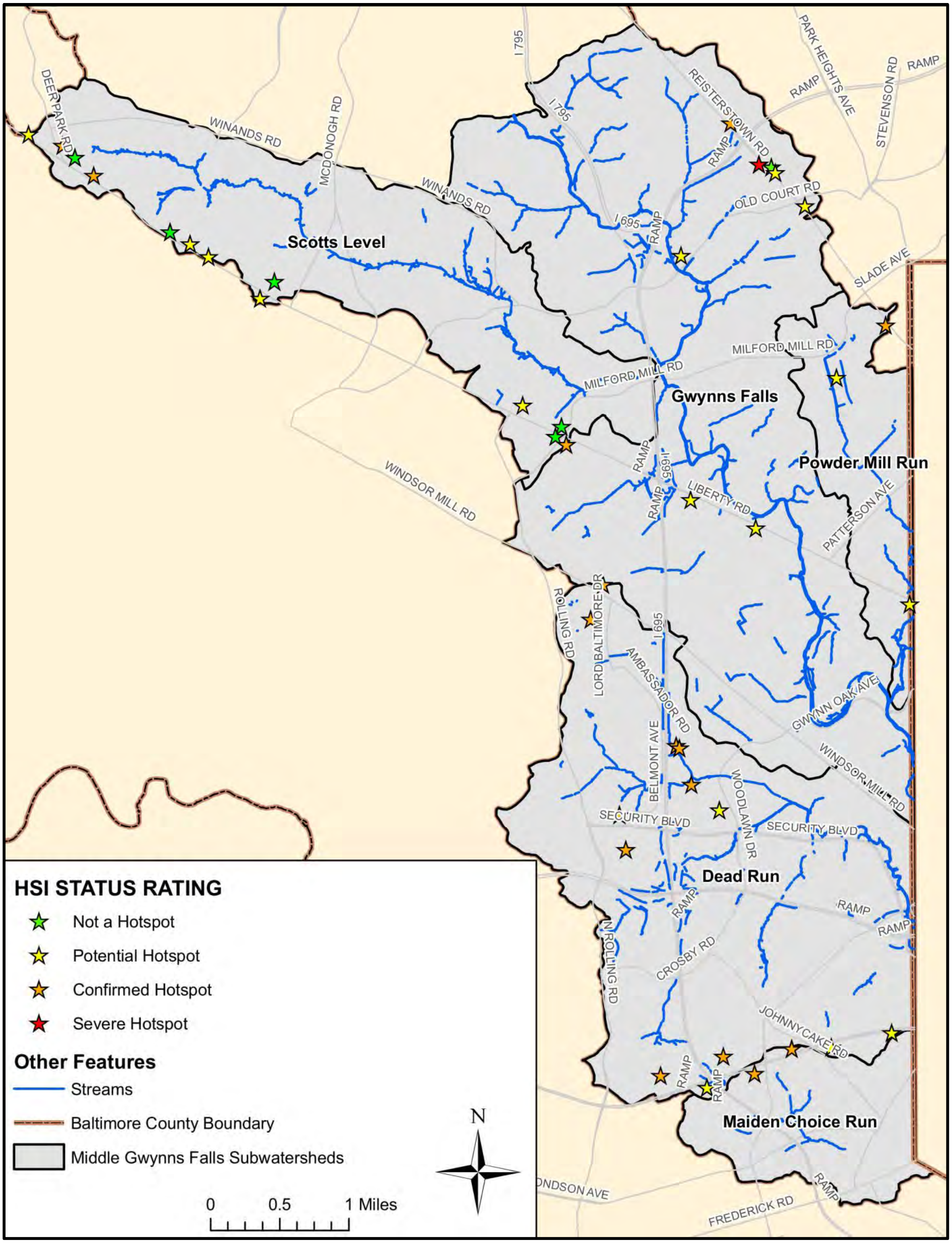


Figure 4-11: HSI Locations in Middle Gwynns Falls

4.3.3 General Findings

A summary of HSI results is presented in Appendix B including hotspot status, category, pollution sources, and comments regarding hotspot observations. Vehicle operations and waste management were the most common operations contributing to hotspot stormwater pollution among this sample of hotspot candidates. Outdoor materials storage, stormwater infrastructure (i.e., lack of stormwater management and/or condition of storm drains) and physical plant conditions (e.g., stained/breaking up parking lot, evidence of stains leading to storm drain) were also common pollutant sources at investigated hotspots. Turf/landscaping operations were identified as potential pollution sources for sixteen (16) sites due to most of the landscape areas draining to inlets. A brief description of the various hotspot categories assessed and general findings are provided in the subsequent subsections. This includes a description of how the pollution potential for specific sites can be ranked within a specific category.

4.3.3.1 Commercial

There are several commercial areas within the watershed, each with unique operations and pollution sources. Commercial hotspots were divided into categories based on characteristic operations and pollution sources: auto-related, shopping centers/hardware stores/garden centers, and active construction, restaurant.

Auto-related

There are several auto-related commercial establishments throughout the Middle Gwynns Falls watershed area including auto repair shops, sales (e.g., car parts, accessories), tire service centers, gas stations, and car washes. The typical sources of stormwater pollution from this category of hotspots include vehicle operations, outdoor materials, physical plant, and waste management operations. Vehicle operations generally include repair, fueling, washing, and storing. Any of these activities can contribute potentially hazardous pollution to the storm drain system if proper housekeeping is not performed or if impervious surfaces lack diversions or treatment for stormwater runoff. In some cases, materials such as tires or engine parts were being stored outdoors. If materials are uncovered or lack secondary containment for liquids and stored on an impervious surface, there is potential for any vehicle-related pollutants attached to the materials to be washed off during a storm event into the stream or storm drain system (see Figure 4-12). It is also common for impervious surfaces (parking lots) at these types of hotspots to be stained as a result of vehicle operations or outdoor material storage which can also result in pollutants being transported by stormwater runoff (see Figure 4-13). The main recommended action for these types of operations is to include in future education efforts explaining proper storage of outdoor materials (covered, stored on pallets not directly on pavement), ensure adequate buffer or diversion methods for stream/storm drain systems, and incorporate treatment of stormwater runoff where possible.

Figure 4-12: Potential Pollution Sources from Outdoor Material Storage at Auto-related Hotspots including uncovered materials stored outside (left) and storage containers without secondary containment (right).

Figure 4-13: Asphalt staining from Outdoor Vehicle Operations at Auto-related Hotspots.

All commercial operations generate waste and auto-related enterprises have the potential to generate hazardous pollutants that can enter the stream or storm drain system. For example, many sites had leaking dumpsters with overflowing or spilled trash (see Figure 4-14). This included an assortment of trash such as paper and tires. Again, future education could help address waste management related efforts. This may include proper waste management operations such as closing dumpster lids, creating runoff diversion between dumpsters and stream/storm drains, proper disposal of hazardous materials, and providing more trash receptacles in the parking area for clients. It may also involve educating clients about the hotspot and harmful effects of trash getting into the stream or storm drain system.

Figure 4-14: Leaking (left) and Overflowing Dumpsters (right) from Waste Management Operations at Auto-related Hotspots

Shopping Centers/ Hardware Stores/ Garden Centers

There are several commercial shopping center areas within the planning area, each with unique operations and pollution sources. Common sources of pollutants from the commercial shopping centers assessed include those from waste management operations. Dumpsters are often located on impervious surfaces at shopping centers and if in poor condition, staining or leaks can contribute pollutants directly into the storm drain system or nearby stream. There is also potential for wind or rain to carry trash from uncovered or overflowing dumpsters to the storm drain or stream system (see Figure 4-15).

Figure 4-15: Leaking (left) and Overflowing Dumpsters (right) from Waste Management Operations at Commercial Hotspots

Commercial areas sometimes have outdoor shopping or stockpile areas where materials are stored outside. Similar to the discussion above, if materials are uncovered and on impervious surfaces, runoff from these areas can go directly into the storm drain system along with certain pollutants depending on the type of materials. For example, Figure 4-16 shows an outdoor stockpile of sod that is stored on a shopping center parking lot directly adjacent to an inlet. There is potential for soil, organic matter, and nutrients from the sod and the other garden plants in the lot to be washed away during a rainfall or snow event and enter the storm drain system. In addition, storage of solid supplies can lead to gross solids washing into surface waters and storm sewers in the vicinity of the hotspot.

Figure 4-16: Outdoor Material Storage at a Garden Center (left) and a Hardware Store (right).

Both of the hardware store sites visited within the planning area had outdoor storage areas. Most of the material storage at these areas is contained within a fenced area which appears to contain any trash; however runoff was observed from one of the areas which were draining to a storm drain system (See Figure 4-17).

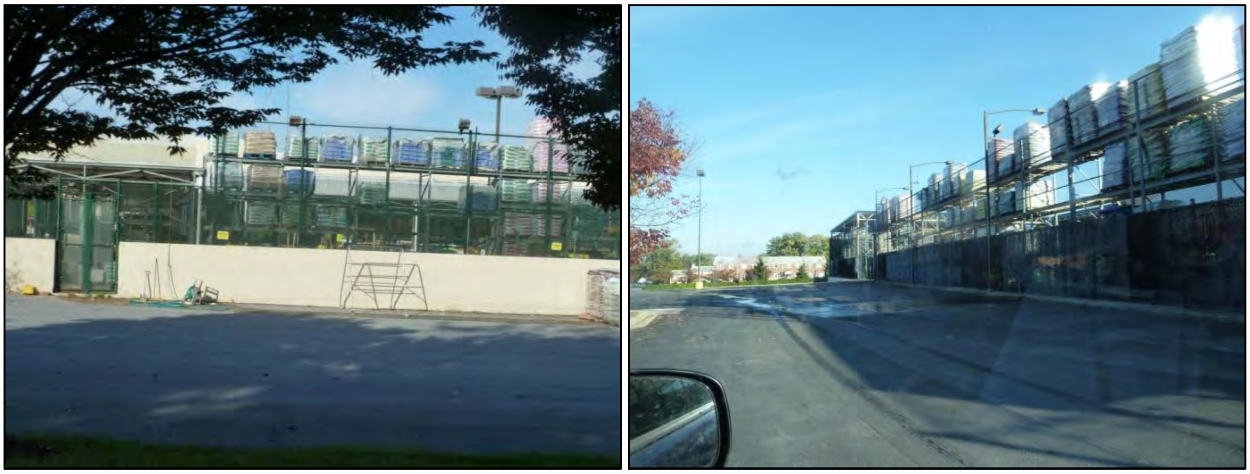


Figure 4-17: Outdoor Materials Storage from Hardware Stores

At all four of the shopping centers/ hardware store/ garden centers assessed in the Middle Gwynns Falls watershed, the physical plant was noted as a potential pollution source, specifically the condition the parking surface. In shopping centers with multiple retail stores, large amounts of impervious surfaces are present to accommodate parking needs of these businesses. Impervious surfaces create increased runoff into storm systems and local surface waters, creating erosion problems and carrying nutrients and oil-based pollutants. When impervious surfaces break up, additional pollutants in the form of sediments are added to the runoff, further degrading downstream waters. Figure 4-18 shows examples of pollution sources from impervious surfaces at shopping center hotspots in the Middle Gwynns Falls watershed area.

Figure 4-18: Degraded Impervious Surfaces at Commercial Hotspots

Active Construction

At one (1) of the shopping centers, active construction was observed (see Figure 4-19). Construction activities, although temporary, result in earth disturbing activities which can create large areas of bare soil that have the potential to erode and wash sediment into local streams during rain events. In addition, construction sites can have large stockpiles of materials such as rock or sand that should be covered or contained to divert runoff to approved sediment control devices. At the construction site assessed during the upland assessments, inadequate erosion and sediment control measures were in place which created a potential for sediment washing into storm drains and wetlands adjacent to the site. It is recommended that Baltimore County continue to work with MDE to enforce regulations at these sites dictating proper erosion and sediment control practices. In Figure 4-19, the left picture shows a large stockpile area with silt fence surrounding it. MDE requires stockpile areas to stabilized as soon as possible and as dictated by their approved plan Erosion and Sediment Control Plan. According to the *2011 Maryland Standards and Specifications for Soil Erosion and Sediment Control*, "at a minimum, all perimeter controls (e.g., earth berms, sediment traps) and slopes steeper than 3:1 require stabilization within three calendar days and all other disturbed areas within seven calendar days. Super silt fence is recommended, although not required to protect large stockpiles. The right picture, although covered, is leaking liquids, which should be contained.

Figure 4-19: Soil Stockpile (left) and Leaking Stockpile Area (right) at Construction Hotspots

Restaurant

Commercial restaurant sites generally consist of parking area outside the restaurant facility with waste management practices located on site. Like shopping centers, impervious cover at restaurants can become deteriorated or stained, leading to sediment or nutrient-laden runoff entering local storm drain systems. Several restaurants were subsampled due to their association with the shopping centers that were sampled. The primary concern for the “shopping center” restaurants observed in the Gwynns Falls planning area was how the waste from the site was handled, specifically used cooking grease and oils. Nearly every grease bin that was observed during the sampling had staining around the bin (Figure 4-20). Other common problems were uncovered or leaking dumpsters with adjacent trash that was being stored next to the dumpster or had been spilled. These sites are recommended for future education efforts related to waste management.

Figure 4-20: Leaking Grease Bins from Waste Management Operations at Restaurant Hotspots

Commercial Hotspot Summary

Pollution potential from commercial hotspots including auto-related facilities, shopping centers, active construction sites, and restaurants can be ranked as high, medium or low based on the following example criteria:

- *High pollution potential*: Staining of impervious surfaces leading to storm drain inlets or stream; dumpsters in poor condition (leaking, overflowing, uncovered, next to storm drain or stream without diversion); improper disposal of hazardous materials or wash water; uncovered or lack of runoff diversion methods for repair/fueling areas or outdoor materials storage
- *Low pollution potential:* Proper disposal methods; good housekeeping (well maintained parking lot, waste management); stormwater management practices.

4.3.3.2 Transport-related

Transport-related hotpots generally include large impervious areas and a significant amount of vehicle operations. They can also include waste management operations. These areas can be sources of potentially hazardous pollutants such as oil and grease from leaking vehicles and stained parking lot surfaces. Some can also be potential sources of trash/dumping and stormwater pollution from outdoor materials storage. These types of sites may be good candidates for future education efforts related to vehicle operations, outdoor materials storage, and waste management.

Three (3) transport-related sites were assessed in the Middle Gwynns Falls planning area, two (2) of which involved metro stop stations, and the other site being a school bus storage area. Although the three (3) sites had staining and cracking of impervious surfaces, each site had specific problems pertaining only to the site (see Figure 4-21). For instance, an existing SWM facility was present at one of the metro stops; however there appeared to be an excessive amount of impervious area that was blocked from vehicles and not being used for parking. The other metro stop was located directly adjacent next to the main stem of the Gwynns Falls, and did not appear to have any SWM facilities. Furthermore, an excessive amount of trash and impervious staining from the dumpster was observed. The school bus storage site had a maintenance shop with 55-gallon drums and other chemicals stored improperly; furthermore, the site had an uncovered fueling station. Recommendations on transport-related sites depend on whether they are public or private properties. If the site is public, then it is recommended to coordinate with the appropriate government agency and determine the best way to reduce pollutants. If the site is privately owned, then the site is recommended for future education efforts related to proper vehicle operations and waste management.

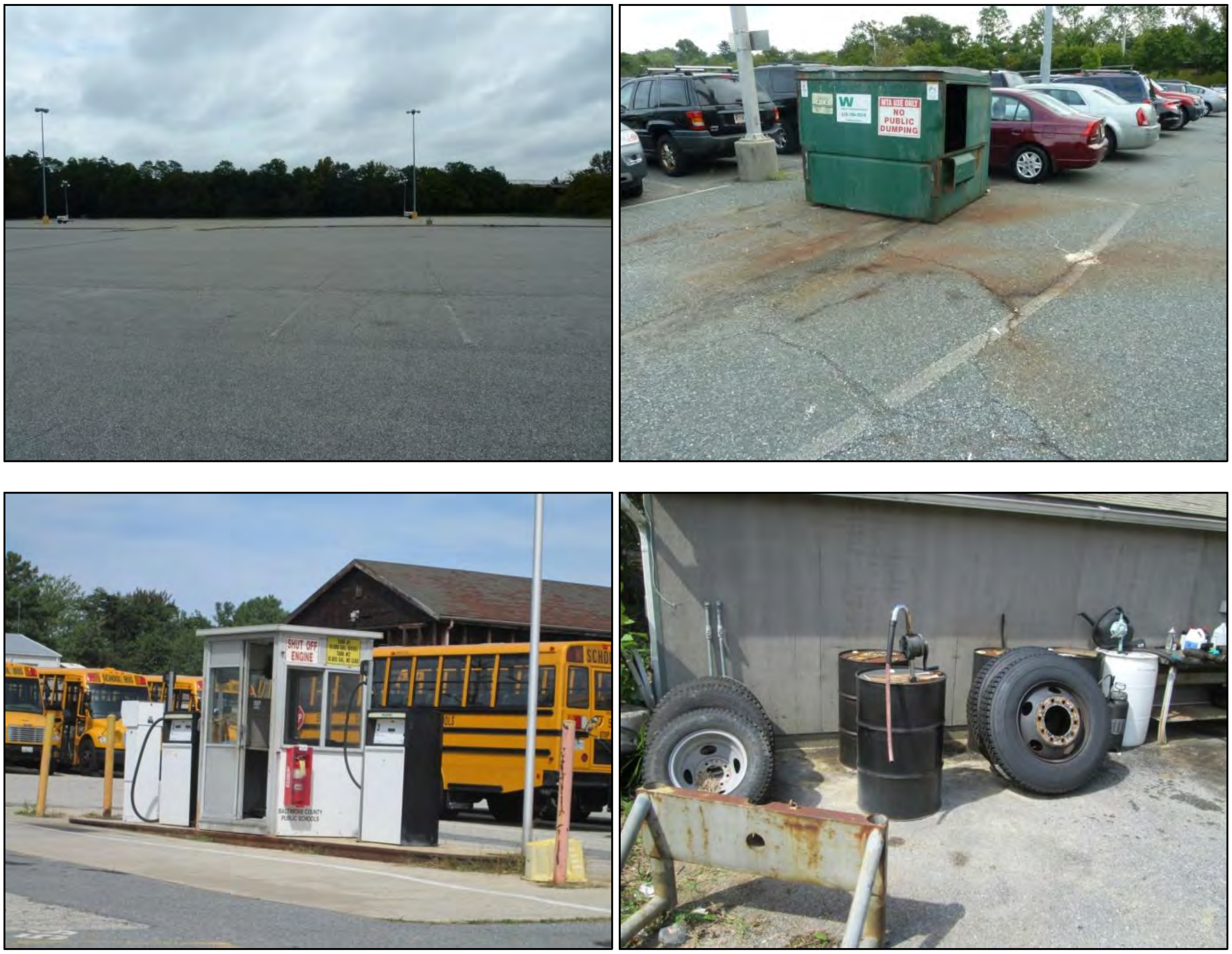


Figure 4-21: Excess Impervious Area (top left), Staining from Dumpsters (top right), Uncovered Fueling Area (bottom left), and Outdoor Storage of Drums (bottom right) at Transport-Related Hotspots

Pollution potential from transport-related hotspots can be ranked as high, medium or low based on the following example criteria:

- High pollution potential: Staining of impervious surfaces leading to storm drain inlets or stream; dumpsters in poor condition (leaking, overflowing, uncovered, next to storm drain or stream without diversion); uncovered or lack of runoff diversion methods for repair/fueling areas or outdoor materials storage

- Low pollution potential: Proper disposal methods; good housekeeping (well maintained parking lot, waste management); stormwater management practices

4.3.3.3 Industrial

Industrial sites generally include manufacturing sites, maintenance yards for construction companies, and distribution centers. As discussed in Section 2.3.10, only 5.0 % of the watershed is zoned industrial. Despite the small percentage of cover, industrial areas have the potential to contribute a significant release of illicit pollutants into nearby storm sewers and surface waters. Four (4) industrial operations were assessed within the planning area. The first was a distribution center for construction materials.

The second was a maintenance yard for a masonry construction company which stored construction materials, equipment, and 55-gallon drums. The third was an industrial education facility which had construction materials stored outside. The fourth was a heating oil distribution center. All four sites had storage areas located on pervious and impervious ground and three of these were located within the stream buffer. The sites within the stream buffer had materials which lacked covers and diversion methods to prevent potential pollutants from entering the stream. These industrial sites are recommended for future education efforts related to proper outdoor materials storage. Also, due to the nature of industrial sites, it is recommended that it be verified that these sites have NPDES permits. See Figure 4-22 for examples of outdoor materials storage observed at industrial hotspots.

Figure 4-22: Improper Outdoor Materials Storage at Industrial Hotspots

Industrial Hotspot Summary

Pollution potential from industrial hotspots including construction companies, material distribution centers, and equipment storage can be ranked as high, medium or low based on the following example criteria:

- *High pollution potential*: Staining of impervious surfaces leading to storm drain inlets or stream; dumpsters in poor condition (leaking, overflowing, uncovered, next to storm drain or stream without diversion); improper disposal of hazardous materials or wash water; uncovered or lack of runoff diversion methods for repair/fueling areas or outdoor materials storage

- *Low pollution potential:* Proper disposal methods; good housekeeping (well maintained parking lot, waste management); stormwater management practices

4.3.3.4 Municipal Operations

Municipal properties tend to consist of storage yards, maintenance yards and fueling center and these sites usually have large impervious areas. Storage of heavy equipment and the maintenance of vehicles can contribute a significant amount of pollutants. It should be noted that municipal sewage treatment facilities are not included in this category. No municipal sewage treatment facilities were identified in the Middle Gwynns Falls Planning area.

Two (2) municipal operations were assessed within the planning area (see Figure 4-23). The first was the BGE Rutherford Business Center. The second was the SHA Radio Shop at MD 40 and I-695. Both sites contained outdoor storage; however, both had indoor maintenance shops. The SHA site had equipment stored on pervious ground whereas the BGE site had a large impervious lot with electrical equipment stored uncovered. Runoff from each site has the potential for pollutants to enter either groundwater or streams. No SWM facilities were identified at the SHA site, and only one small SWM facility was identified at the BGE site. These municipal operations sites are recommended for future education efforts on modifying municipal infrastructure and maintenance policies. Also, due to the size and nature of municipal sites, it is recommended that it be verified that these sites have NPDES permits.

Figure 4-23: Equipment Storage on Pervious Areas (left) and an Electric Vehicle Charging Station (right) at Municipal Hotspots

Municipal Hotspot Summary

Pollution potential from municipal hotspots include public works maintenance yards, storage yards, and equipment storage and can be ranked as high, medium or low based on the following example criteria:

- *High pollution potential*: Staining of impervious surfaces leading to storm drain inlets or stream;; improper disposal of hazardous materials or wash water; uncovered or lack of runoff diversion methods for repair/fueling areas or outdoor materials storage

- *Low pollution potential:* Proper disposal methods; good housekeeping (well maintained parking lot, waste management); stormwater management practices

4.4 Institutional Site Investigation (ISI)

The USSR manual does not treat institutional sites as a separate component of the uplands survey; instead, institutions can be assessed using HSI protocols. Consistent with recently completed County watershed studies, a modified version of the HSI field form was used to assess institutional sites since HSI protocols do not exactly match conditions encountered on institutional properties and because institutional areas make up 5 percent of the watershed area. The ISI method was first developed and implemented for the Upper Back River watershed study and was also used for the Tidal Back River, Middle River/Tidal Gunpowder, and the Bear Creek/Old Road Bay watershed studies. Institutions surveyed as part of this study include the following types of community-based facilities: schools, faith-based facilities, community centers, fire and rescue stations, and care facilities (e.g., senior living). The following subsections describe the methods used to identify and evaluate pollution sources and restoration potential at institutional facilities.

4.4.1 Assessment Protocol

Institutional properties were identified in the office prior to conducting the field assessment using GIS tax parcel information, land use data, aerial photographs, and an ADC map. These were shown and labeled on field maps created for the upland assessments and on larger base maps showing the entire watershed. Institutions were surveyed as encountered in the field using these maps and a list of institutions as guidance. Unique ID numbers were assigned to ISIs using the classification scheme "ISI_C_101", where 'C' denotes the Middle Gwynns Falls planning area and the first number corresponds to a specific subwatershed. As previously described, subwatersheds were assigned the unique numbers summarized in Table 4-10 for the purposes of HSIs and ISIs. Institutional sites were numbered sequentially in the order they were surveyed within a particular subwatershed. For example, ISIs in Maidens Choice would be identified as 0401, 0402, 0403, etc.

The entire property of an institutional site was walked by the field team to collect necessary data and take photographs. Basic information was filled out first including type of institution, address and ownership (public or private). Ownership is important because different approaches may be used to contact private versus public institutions. For example, a message may be received differently coming from the government as opposed to a non-profit group. Strategies for individual institutions will incorporate these different approaches. The ISI field form includes many of the pollution source categories used on the HSI form. Some of the restoration opportunities and recommended actions from the NSAs are also incorporated into the ISI. The focus of ISIs is to identify potential restoration opportunities, educate the community and provide water quality benefits. Institutions within the Gwynns Falls, Powder Mill Run, Dead Run, and Maidens Choice Run subwatersheds were assessed by Parsons Brinckerhoff, Inc. and NMP Engineering, Inc. Institutions within the Scotts Level subwatershed were assessed by County staff. The information collected for each of the pollution source and restoration categories are briefly described below.

Tree Planting

Potential tree planting locations at an ISI site were marked on aerial photographs while walking the property. After walking the entire site, the total number of trees that could be planted at the site was estimated based on 30-foot spacing between trees for narrow sites or based on an estimate of 135 trees per acre for larger open areas. More accurate numbers can be determined during the post-fieldwork desktop analysis after restoration opportunities have been selected and prioritized.

Exterior

The exterior category is similar to the physical plant category in the HSI, except it also includes restoration opportunities. The condition of the building(s) and parking lot(s) were noted. Stained, dirty, damaged/breaking up surfaces were noted as potential pollution sources for both of these components. If no stormwater management was provided for impervious parking areas, this was also considered as a potential pollution source. Exterior storm drain inlets were inspected for evidence of maintenance or wash water dumping and poor erosion/sediment control, cleaning, or material storage practices for construction activities. Any observations of staining, discoloration, or mop threads around a storm drain inlet indicated a potential pollution source as a result of these activities. Building downspouts that were directly connected to the storm drain system or indirectly connected to impervious surfaces were also recorded as potential pollution sources.

Potential restoration opportunities evaluated in the exterior category included impervious cover removal and downspout disconnection. Locations where excess impervious cover could be removed were marked on aerial field maps. Examples include unused or underutilized parking areas and abandoned athletic courts/foot paths.

Waste Management

Every institution generates waste as a result of daily operations, but unlike hotspots, it is typically just garbage. One exception to this could be health care facilities that have the potential to generate medical waste. The field team noted the type of waste generated (e.g., hazardous, garbage, medical, etc.) and the condition of dumpsters. Dumpsters with no cover or open lids, with leaks, damaged/in poor condition, and/or overflowing were noted as potential pollution sources. The field team also observed whether trash was present that could leave the site with wind or rain. Dumpsters located near storm drain inlets or lacking runoff diversion methods were also recorded as potential pollution sources.

Vehicle Operations

Most institutions did not have vehicle operations but a few (including faith-based, care facilities and fire & rescue stations) did have fleet vehicles such as buses and trucks on-site. Vehicle operations include maintenance, repair, recycling, fueling, washing or long-term parking. The presence of any of these activities was noted for each site since they can be a source of metals, oil and grease, and hydrocarbons. For the most part, it appeared that institutions likely only stored and washed vehicles on-site. Outdoor activities including vehicle storage, repair, fueling, and washing were also noted as potential pollution sources.

Outdoor Materials

Materials such as mulch piles, storage drums, and de-icing salt are sometimes stored on institution grounds. Locations where materials were loaded or unloaded were examined to see if materials were uncovered and draining to a storm drain inlet. Storage areas were also evaluated for types of materials stored outdoors and their potential for entering the storm drain system. Uncovered materials and stained storage areas were used as indicators of poor outdoor storage practices and potential pollution sources.

Turf/Landscaping

The percentage of forest canopy, turf grass, landscaping, and bare soil covering the pervious area of a site was recorded on the field form. Sites with more than 20 percent of bare soil were noted as a potential source of sediment pollution. Ground maintenance activities for turf/landscaped areas were also evaluated. High turf management and improper irrigation practices (non-target/over-watering) were noted since they are potential pollution sources of nutrients, fertilizer, and pesticides. The field team also determined whether landscaped areas drained directly to storm drains or if organics (leaves, grass) accumulated on impervious surfaces. Evidence of buffer encroachment and whether buffers were adequately planted was also recorded for evaluating restoration potential.

Stormwater Infrastructure

The field team checked whether storm drains were marked and whether stormwater treatment practices were present. These were evaluated for potential pollution sources and restoration potential. In addition, field teams also noted opportunities for the installation of stormwater retrofits to treat existing impervious areas.

Recommended Actions

After walking the entire property and evaluating the categories discussed above, one or more of the follow-up actions listed below were recommended based on initial field observations:

- Tree planting
- Stormwater retrofit
- Downspout disconnection
- Impervious cover removal
- Trash management
- Storm drain marking
- Stream buffer improvement
- Education (e.g., lawn care, outdoor materials storage)

4.4.2 Summary of Sites Investigated

A total of 51 institutions were assessed throughout the Middle Gwynns Falls watershed. The number and type of institutions assessed within each subwatershed is summarized in Table 4-12. Several of the institutions overlapped multiple subwatersheds. For this analysis, institutions which overlap watershed boundaries counted toward the subwatershed in which the majority of the area falls within. For example, Bedford Elementary and Sudbrook Magnet Middle School encompasses portions of the Gwynns Falls and Powder Mill Run subwatersheds. Since the majority of the ISI area falls within the Gwynns Falls, it was counted toward this subwatershed for analysis purposes. Figure 4-24 shows the distribution of the various types of institutions assessed throughout the planning area.

Table 4-12: Types of Institutions Assessed

Subwatershed	Community Centers	Public Schools	Private Schools	Police, Fire & Rescue	Care Facilities	Faith-Based	Cemetery	Golf/ Swim
Gwynns Falls	2	6	2	1	4	8	1	1
Powder Mill Run	-	1	-	1	-	-	-	-
Dead Run	-	4	1	1	-	2	-	-
Maiden Choice Run	-	1	1	1	-	2	-	-
Scotts Level	-	6	0	1	1	2	-	1
Total	***2***	***18***	***4***	***5***	***5***	***14***	***1***	***2***

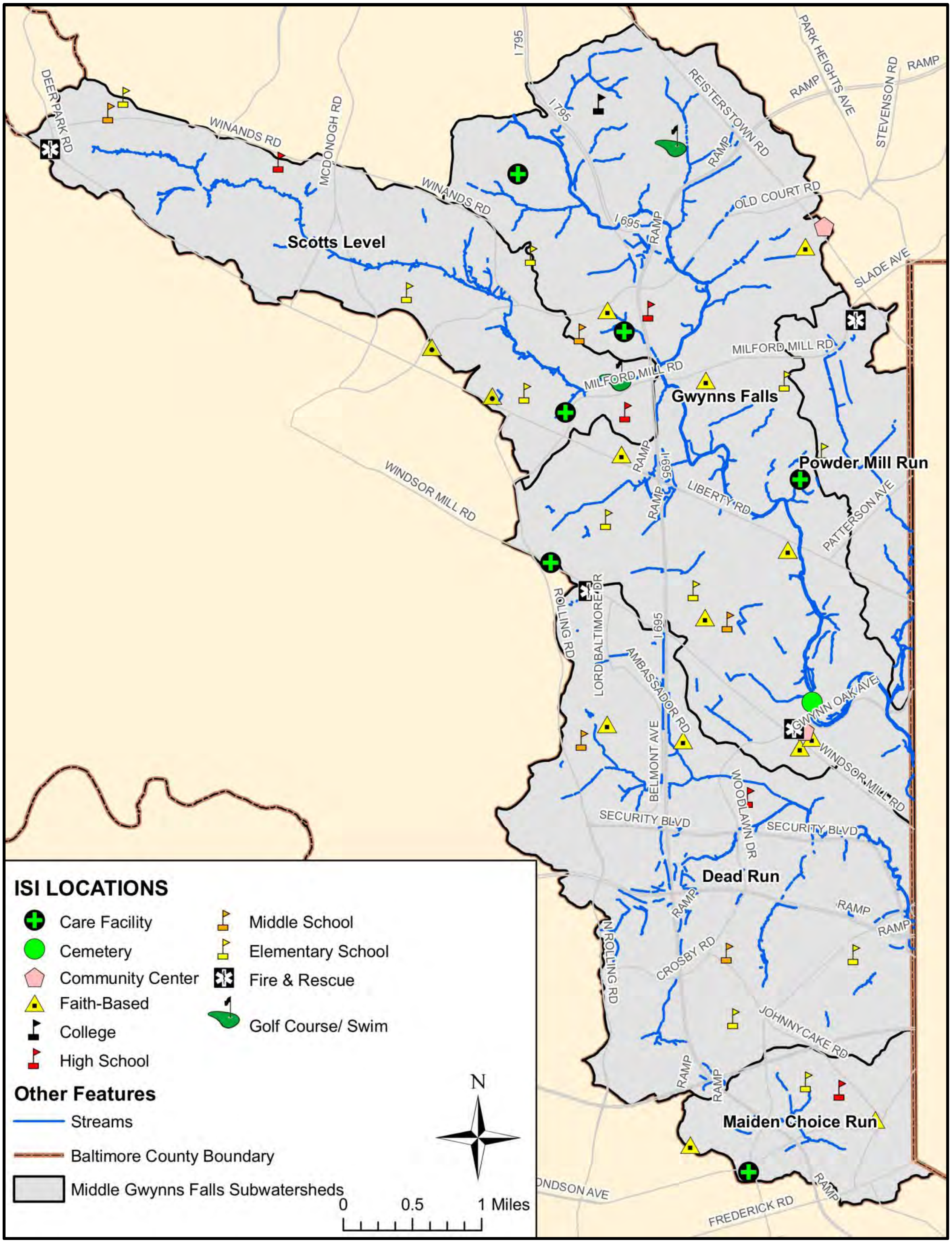


Figure 4-24: ISI Locations in Middle Gwynns Falls

4.4.3 General Findings

The number of the different types of recommended actions for ISIs is summarized in Table 4-13 by subwatershed.

Table 4-13: ISI Recommended Actions by Subwatershed

Subwatershed	# of Trees	SW Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management	Storm Drain Marking	Buffer Improvement	Education
Gwynns Falls	4,503	7	8	4	18	18	5	25
Powder Mill Run	280	1	0	1	2	2	0	2
Dead Run	2,315	4	3	0	5	7	2	8
Maiden Choice Run	204	1	4	0	3	4	0	5
Scotts Level	2,391	3	0	3	7	6	2	11
Total	***9,693***	***16***	***15***	***8***	***35***	***37***	***9***	***51***

4.4.3.1 Tree Planting

It was estimated that a total of 9,693 trees could be planted at institutions located within all five subwatersheds comprising the Middle Gwynns Falls planning area. Trees were recommended for 41 out of the 51 institutions assessed. Tree planting sites were identified in the field and noted on field maps. The number of trees was estimated based on 30-foot spacing between trees for narrow sites or based on an estimate of 135 trees per acre for larger open areas. The table above represents planning level estimates which would be refined through follow-up site investigations if a site is selected for a restoration/improvement project(s). Like street trees, open space shade trees are not only an asset aesthetically but they also provide air and water quality improvement since they intercept precipitation with their leaves and can absorb precipitation and nutrients through their root systems. This infiltration of precipitation through leaves or the root systems slows flow input and provides some treatment before stormwater runoff reaches the stream system.

4.4.3.2 Stormwater Retrofits

As shown in Table 4-13, stormwater retrofits were recommended at 16 sites. Storm drain marking was also a common recommendation (37 sites). Downspout disconnection was recommended for 2 public institutions and 13 private institution site (2 schools, 1 care facility and 11 churches) where sufficient pervious area was available to redirect rooftop runoff. All of these actions present an opportunity to educate the community about the connection between the storm drain system, Middle Gwynns Falls, and how their actions can impact or improve water quality.

Stormwater retrofits were recommended at 11 public institutions (11 schools) and 5 private facilities (2 schools, 2 faith-based, and 1 fire and rescue). Stormwater retrofit opportunities included treating runoff from parking lots, inlet retrofits, and conversion/inspection of existing SWM facilities. Sites where sufficient pervious area was available to treat a portion of the runoff from an impervious parking lot could implement infiltration or filtration practices such as trenches, basins, or bio-retention that incorporate vegetation and filter media through which stormwater infiltrates for pollutant removal prior to groundwater recharge or entering the stream system.

The typical stormwater retrofit recommended at institutions is the bioswale. Bioswales are linear infiltration facilities which incorporate landscaping plants that are planted in a special soil mixture. This promotes the removal of pollutants through filtration and the uptake of excess nutrients by the plants. As runoff filters through the soil mixture it infiltrates into the ground. The soil mixture is kept dry with an under drain system. The under drain either discharges into an existing stormdrain system or daylights to a vegetated area.

All four sites shown in Figure 4-25 are areas where the bioswale stormwater retrofit is recommended. Each of these sites has a large pervious area located adjacent to impervious parking lots. These areas provide good opportunities to address runoff from the parking lots and potential ponding or sediment build-up issues, and also treat runoff before it enters on-site inlets or streams. Sites ISI_C_117 and ISI_C_401 have impervious areas from an entrance circle in which runoff could be directed to a bioswale. The bioswale could run parallel with the existing curbline. By removing the curb at the location of the bioswale runoff can sheetflow directly into the facility. Sites ISI_C_202 and ISI_C_306 have impervious areas from a parking lot in which runoff could be directed to a bioswale. As with Sites ISI_C_117 and ISI_C_401 the bioswales could run parallel with the existing curbline. By removing the curb at the location of the bioswale, runoff can sheetflow directly into the facility. If runoff enters the facility as concentrated flow, a forebay could be constructed to intercept sediment so as to not clog the filter media. Under drains for each site could be connected directly to the existing storm drain system. Overflows would discharge directly into the inlet. At all four of these sites, minimal modifications to existing curbs and storm drain systems need to occur in order to construct the bioswales. Few if any trees would need to be removed.

Figure 4-25: Parking Lot Retrofit Opportunities at ISI_C_117 (top left), ISI_C_202 (top right), ISI_C_306 (bottom left) and ISI_C_401 (bottom right)

Other facilities recommended for stormwater retrofits are shown in Figure 4-26. At site ISI_C_104 there is an opportunity to treat a tennis court with only minimal modifications to a storm drain system. The area drains into an inlet which discharges to a field as concentrated flow from a culvert. Due to the flow being concentrated, it does not receive any stormwater treatment. If a level spreader is constructed downstream of the culvert, the concentrated flow can be converted to sheet flow which will allow the area to be treated with a “sheet flow to buffer” credit.

ISI_C_108 and ISI_C_117 are sites where impervious can potentially be removed and a microbiotretention facility constructed to treat the remaining impervious areas. Microbioretention facilities are similar to bioswales in that stormwater treatment is provided with plantings in a special soil mixture. Microbioretention facilities, however, are nonlinear and usually receive concentrated flows. Microbioretention as with bioswales have an under drain. The under drain discharges directly to a storm drain system.

Site ISI_C_208 is an area where a wet swale can be constructed. This site has a small parking lot in which concentrated flow discharges through a gravel area before entering a wooded area. This gravel area can be replaced with a wet swale. Wet swales are ideal for sites which are wet in existing conditions. Wet swales are not filtering facilities and do not having an under drain. Treatment is provided through the collection of sediment and pollutants in the wet area. Nutrients are taken up by plantings. This site was observed to be wet; however, it is recommended that a soil boring be done in the area to confirm if the wet conditions are ideal for a wet swale facility.

Figure 4-26: Various Retrofit Opportunities such as a level spreader at ISI_C_104 (top left), a microbioretention at ISI_C_108 (top right), a microbioretention at ISI_C_117 (bottom left) and wet swale at ISI_C_201 (bottom right)

4.4.3.3 Impervious Cover Removal

As discussed previously, impervious surfaces prevent precipitation from naturally infiltrating into the ground. Because runoff from impervious surfaces is often accelerated and concentrated when it reaches the storm drain and stream systems, it can lead to stream erosion, habitat destruction, and water pollution. Removing unused or underutilized impervious surfaces will help increase pervious area and the watershed's capacity for infiltrating and treating stormwater runoff.

Impervious cover removal was a recommended action for 8 out of the 51 institutions investigated. It was a recommended action for sites where a considerable impervious area appeared to be abandoned or underutilized such as parking lots and athletic courts. It also included areas where impervious cover was not absolutely necessary and appeared to be damaged (patched, breaking up) such as areas on the side or behind buildings, areas between buildings and parking lots, or areas between walkways/sidewalks.

As discussed in the previous section, at several of the areas where impervious can be removed, a SWM retrofit can be constructed in the area of impervious removal to treat the remaining impervious. ISI_C_108 and ISI_C_117 are shown in Figure 4-26.

Figure 4-28 shows examples at various sites in which extraneous asphalt can be removed. At ISI_C_117, there exists an unused, dilapidated runway for track and field. This runway could be removed and replaced with grass. It should be noted that although this area constitutes a small amount of impervious, these unused runways were observed at many of the middle school sites visited. Since removing these runways is inexpensive, the cumulative effect of removing all unused runways may comprise a significant amount of impervious area. ISI_C_105 and ISI_C_306 are other middle school sites with unused track and field runways.

Other examples where impervious cover can be removed are large unused impervious areas behind schools. At sites ISI_C_117, ISI_C_202 and ISI_C_306, wide impervious walkways were observed on the properties. Much of the impervious area at the locations could be removed and replaced with grass leaving a standard 5’ walkway for pedestrians. These sites are illustrated in Figure 4-27.

There are a few other examples where excess impervious can be removed. At site ISI_C_304 there was excess asphalt adjacent to a path. At ISI_C_306 the parking lot islands were paved with asphalt. These two sites are illustrated in Figure 4-28. Although these two sites contain very little impervious area that can be removed, the removal of the impervious area will greatly improve the visual quality at these sites.

Figure 4-27: Extraneous Asphalt Cover Removal Opportunities at ISI_C_117 (top left and top right), ISI_C_202 (bottom left), and ISI_C_304 (bottom right)

Figure 4-28: Extraneous Asphalt Cover Removal Opportunities at ISI_C_306

4.4.3.4 Buffer Improvement

Forested buffer areas along streams are important for improving water quality and flood mitigation since they can reduce surface runoff, stabilize stream banks (root systems), shade streams, remove pollutants such as nutrients and sediment from runoff and provide habitat for various types of terrestrial and aquatic life including fish. Several institutions have streams that run through the property which is a potential opportunity for improving an inadequate stream buffer by introducing native vegetation and trees. Buffer improvement options, however, must be sensitive to property uses while striking a balance with protecting water resources. For example, a narrow buffer consisting of native vegetation might be an alternative to 50-foot wide, wooded buffers on either side.

Buffer improvement was identified as a recommended action for 9 out of the 51 institutions assessed. These 9 sites constituted a variety of sites including the following: golf course, cemetery, police precinct, swim club, care center, senior center, and three schools. School properties typically represent a unique opportunity to combine restoration projects with education. The public schools recommended for buffer improvement are ISI_C_115, ISI_C_302, and ISI_C_304 (see Figure 4-29). At site ISI_C_302 the stream runs adjacent to the property. The stream appeared to be in good condition; however nearby development could add additional stress to the stream. Planting along the 100’ stream buffer will help reduce any incremental impacts from surrounding activities, and provide additional habitat for riparian plants and animal. At ISI_C_304, the stream was observed to be in very poor condition. Large amounts of trash and steep eroded banks were observed. Buffer planting could be performed at this site in conjunction with a stream cleaning and/or restoration project.

Figure 4-29: Buffer Improvement Opportunity at ISI_C_0302 (left) and ISI_C_0304 (right)

4.4.3.5 Trash Management

Trash management is an area in need of improvement throughout various areas of the watershed including institutions. A total of 35 institution sites (22 public, 13 private) were recommended for trash management action. Waste management education is recommended to address leaking dumpsters, open or uncovered dumpsters where trash can leave the site, and dumpster placement near storm drain inlets or streams. For example, at ISI_C_103 and ISI_C_105 there was evidence of leakage by stains on the ground. Dumpsters with evidence of leaking should be repaired or replaced. At ISI_C_103 a grease dumpster was overflowing into a grassed area which was resulting in the vegetation being killed. At site ISI_C_105 staining from the dumpster led to nearby storm drains. Runoff diversion methods should be used to contain leaks and prevent potential pollutants from being carried by stormwater runoff into the storm drains. At some sites, dumpsters were noted as overflowing and with potential for trash to be carried off-site by wind and/or rain. In these cases, it should be determined whether additional dumpsters or increased pick-up frequency is necessary. Dumping was also noted at multiple institutional areas including both litter and bulk items. One trash dumping problem was observed at ISI_C_102 where rubble and other materials were observed in the woods at the rear of the property (see Figure 4-30). At site ISI_C_113 a used 55-gallon oil drum was being stored on the grass. The surrounding dead vegetation indicated evidence of leakage (see Figure 4-30).

Figure 4-30: Trash Management Opportunities at ISI_C_103 (top left), ISI_C_105 (top right), ISI_C_102 (bottom left), ISI C_113 (bottom right).

4.5 Forest Patch Assessment

Maintaining and improving the quality of the forested portions of the Gwynns Falls watershed is critical for the protection of habitat, stream stability and water quality. As part of the *Gwynns Falls Water Quality Management Plan* (DPW & DEPRM, 2004), a forest patch assessment was conducted to investigate potential reforestation/conservation opportunities.

There are several challenges that must be overcome in order to protect the forested resources within the Middle Gwynns Falls.

- Historic land use practices
- Fragmentation of existing forested areas
- Invasive species
- Limited land availability

Much of the development in the Gwynns Falls watershed occurred prior to the introduction of regulatory programs intended to protect natural resources. Consequently, the resulting landscape contains patches of unevenly distributed forest stands mixed with other land uses. This forest fragmentation increases the length between forest patches and surrounding landscapes and reduces the amount of undisturbed interior forest area where greater diversity in native vegetative and wildlife species, structure, and habitats are usually present. Fragmentation alters the structure, composition and function of the forest.

Fragmentation also increases the invasive species problem due to the susceptibility of trees at the forest stand edge to wind, air pollution and increased temperatures (Saunders D. A., 1991). Invasive species that are being cultivated in nearby landscaped communities may out-compete native species in forests with increased edge and disturbance (Binelli, Gholz, & Duryea, 2001). While invasive species may be controlled, they represent a long term maintenance and management problem because of recolonization from readily available seed sources.

The final challenge is the limited availability of land for reforestation. Land within the watershed that could be used for reforestation often goes for premium rates because it is located within urban land. Intense development throughout the Middle Gwynns Falls has limited the amount of land available for reforestation. The goal of this study is to identify the best opportunities for enhancement within the Gwynns Falls.

Although there are many challenges to enhancing the forested areas within the Middle Gwynns Falls, the benefits of providing a more forested watershed are clear. An enhanced forest system will provide greater biodiversity, improved stream stability and water quality treatment of urban runoff prior to reaching the stream channel (DPW & DEPRM, 2004).

4.5.1 Assessment Protocol

The forest assessment that was completed for the Gwynns Falls study was based on the fourth phase of a previous analysis conducted by Baltimore County, *A GIS Analysis of Forest Cover in the Gwynns Falls Watershed* (1999). The 1999 Baltimore County GIS study in the Gwynns Falls was based on the assessment methodology used in a 1996 Baltimore County study called *A GIS-based Methodology for Establishing a Greenway Corridor System in a Fragmented Forest Landscape* (1996). The methodology of the 1996 study was designed to use a GIS based analysis to verify the location and extent of forest and stream resources, and to prioritize sites for conservation. The studies utilize a three phased desktop based GIS system to identify, analyze, assess, and prioritize forest patches and deforested low order tributaries for conservation and restoration. The primary goal of the GIS studies is to target forest parcels in low order tributaries with the greatest potential for restoration, enhancement, and conservation (DPW & DEPRM, 2004).

4.5.2 Summary of Sites Investigated

14 small forested patches on unforested, low order tributaries were assessed in the Middle Gwynns Falls watershed using Baltimore County's "Level IV" rapid assessment protocol. Ranging in size from 1.1 acres to 113.8 acres, the assessment scored the patches on six general attributes and twenty-four specific resource parameters (maximum possible conversion score is 717). The site attributes and specific resource parameter headings are identified in Table 4-14.

Table 4-14: Site Attributes and Specific Resource Parameters Assessed in the Field at Each Selected Forest Patch

Site Attributes	Resources Parameters
General Site Characteristics	***Maximum Conservation Score 33***
	Habitat heterogeneity
Forest Composition	***Maximum Conservation Score 82***
	Forest cover, food, and nest site value
	Number of dominant/co-dominant native canopy species
	Species richness of indigenous trees, shrubs, and vines
	Evenness of species diversity
Forest Structure	***Maximum Conservation Score 90***
	Crown closure
	Size class of canopy species
	Stand stratification
	Tree size-class distribution
Forest/Wildlife Habitat	***Maximum Conservation Score 127***
	Standing dead trees
	Trees with excavated cavities
	Downed logs and coarse woody debris
	Humus layer
	Leaf mold
Disturbances	***Maximum Conservation Score 165***
	Types of disturbance
	Intensity of disturbances
	Periods of disturbances discernable in the field
	Presence of exotic invasive species
	Distribution of exotic invasive species
	Extent of exotic invasives into edges
Riparian Corridor	***Maximum Conservation Score 220***
	Water availability
	Does parcel contain headwaters, seeps, or springs
	Presence /condition of riparian corridor
	Streambank soil erosion

Table 4-15 shows the results of the forest patch assessments. The average conservation score was 393 out of a possible maximum of 717. The scores ranged between 499 and 150 with a median score of 426. In general the patch scores were very close (in the 400 range). A small number of patches scored significantly lower because their connection to stream resources were either poor or severed and/or there was a significant invasive species presence. These two site attributes account for 54% of the total score.

Table 4-15: Forest Patch Score Results, Sorted by Sub-Watershed

Forest Patch ID	Score	Sub-Watershed	Area (Acres)
168-23	499	Dead Run	7.1
168-29	451	Dead Run	2.6
168-35	448	Dead Run	18.2
168-11	419	Dead Run	2.5
168-30	252	Dead Run	2.0
161-4	192	Maidens Choice	1.5
72-178	485	Mid Gwynns	32.9
72-147	469	Mid Gwynns	113.8
72-129	455	Mid Gwynns	4.2
72-135	433	Mid Gwynns	1.1
72-187	417	Mid Gwynns	2.5
72-127	372	Mid Gwynns	7.3
72-130	313	Mid Gwynns	2.2
72-141	150	Mid Gwynns	64.7

Eight forest patches were assessed in the Middle Gwynns Falls subwatershed. The patch sizes ranged between one and 114 acres with a mean patch size of 29 acres. The median patch size was six acres. The average score was 389 out of a possible maximum of 717, and the range of scores was between 485 and 150. The median score was 425. **Error! Reference source not found.** provides a map from the *2004 Gwynns Falls Water Quality Management Plan* of the forest patch assessment in the Middle Gwynns Falls subwatershed (DPW & DEPRM, 2004).

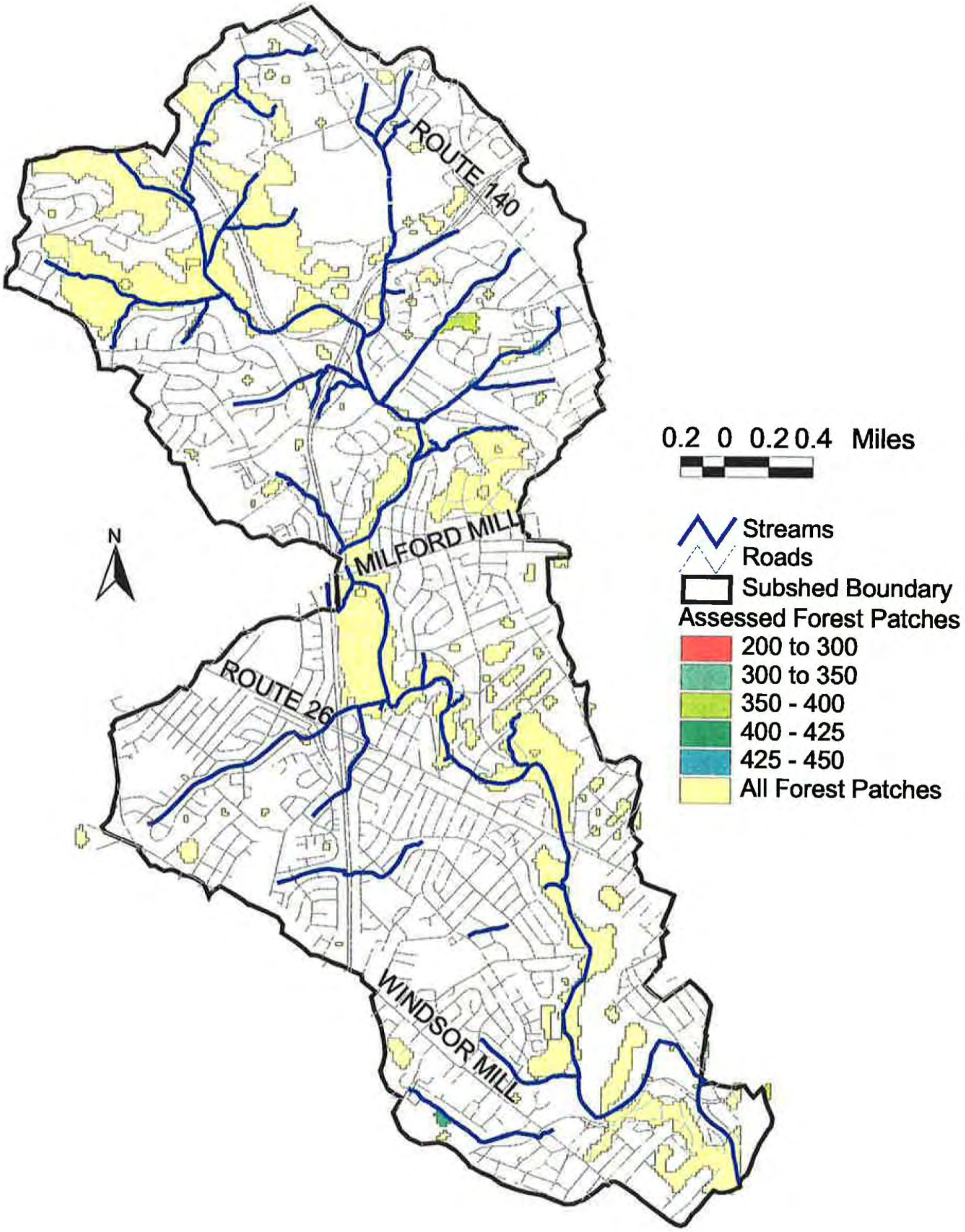


Figure 4-31: Middle Gwynns Falls Subwatershed Forest Patch Assessment Map

Five forest patches were assessed in the Dead Run subwatershed. The patch sizes ranged between two and 18 acres with a mean patch size of 6.5 acres. The median size was 6.5 acres. The average score was

413 out of a possible maximum of 717, and the range of scores was between 499 and 252. The median score was 448. Figure 4-32 provides a map from the *2004 Gwynns Falls Water Quality Management Plan* of the forest patch assessment in the Dead Run subwatershed (DPW & DEPRM, 2004).

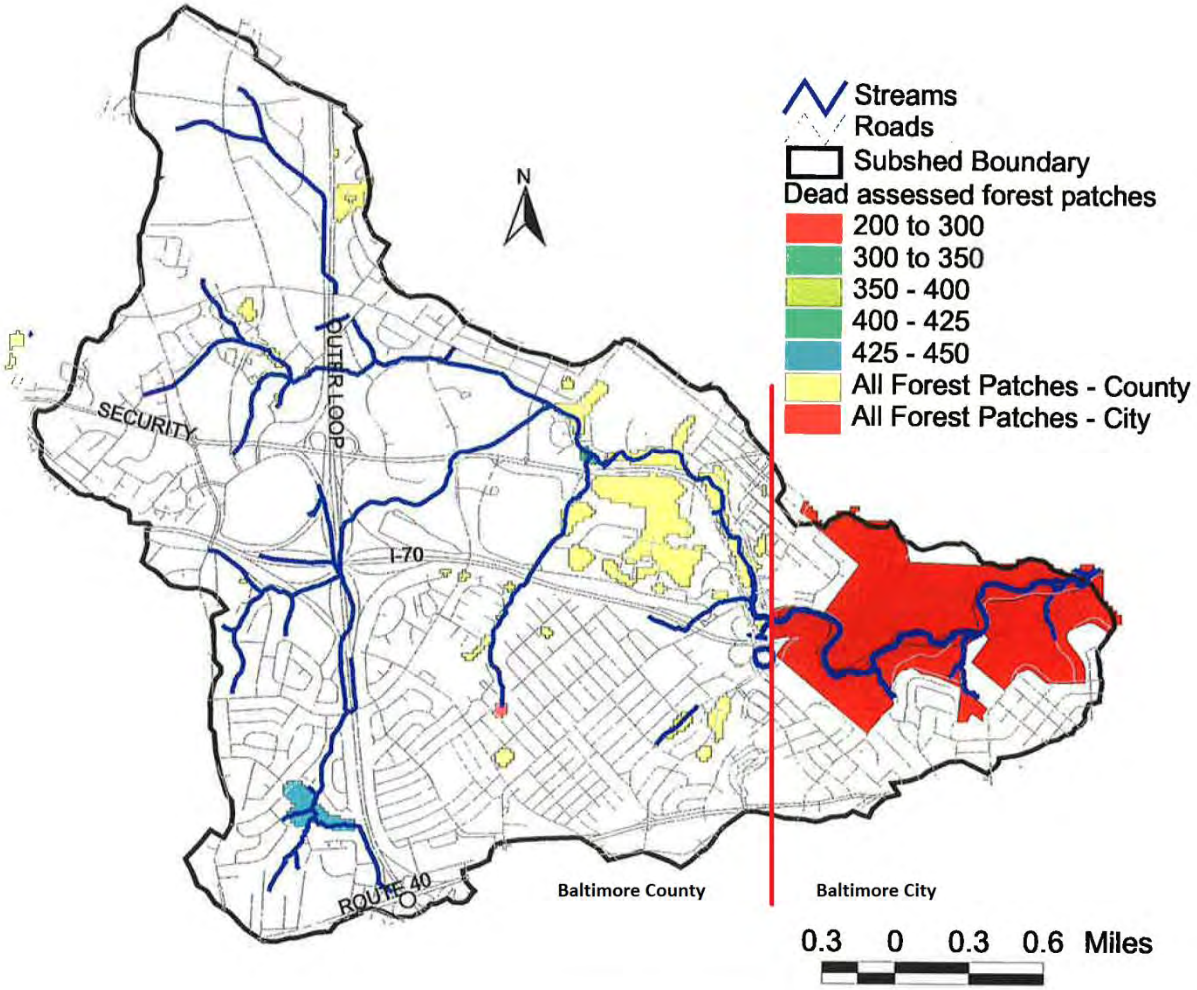


Figure 4-32: Dead Run Subwatershed Forest Patch Assessment Map

Only one forest patch was assessed in the County portion of the Maidens Choice subwatershed. The patch size was 1.5 acres. The score was 192 out of a possible maximum of 717. Figure 4-33 provides a map from the *2004 Gwynns Falls Water Quality Management Plan* of the forest patch assessment in the Maidens Choice subwatershed (DPW & DEPRM, 2004).

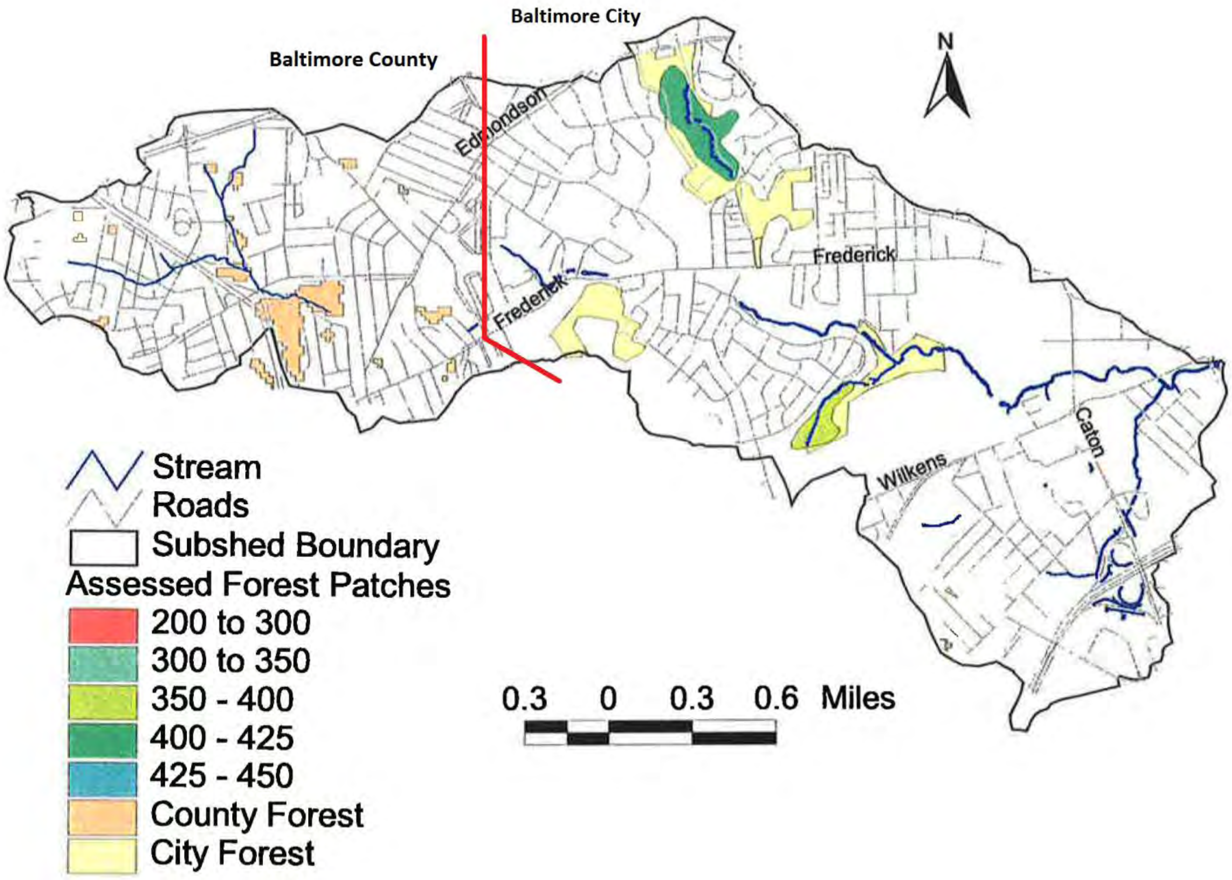


Figure 4-33: Maidens Choice Subwatershed Forest Patch Assessment Map

4.5.3 General Findings

The goal of the study is to identify opportunities to enlarge or enhance existing forest patches on lower order tributaries of Middle Gwynns Falls subwatersheds. To maximize the benefit to those subwatersheds, restoration should be directed to the highest quality sites; i.e., those sites that scored the highest in the forest assessment. Other factors may contribute to the decisions to provide restoration services at a given site. These may include the availability of undeveloped land adjacent to the forest patches, cost, the ability to incorporate the reforestation project into other watershed restoration projects at a given site, and the degree of connectedness of the assessed site to other high quality forest patches within the subwatershed. Therefore, these other criteria should be factored into the decision making when choosing reforestation projects rather than simply accepting the highest-ranking sites as having the best potential for reforestation.

More broad-based recommendations include, but are not limited to, establishing greenways ranging from narrow urban trails to winding river corridors to very wide, landscape level linkages designed to connect open spaces for ecological, cultural and recreational purposes. Some other typical ways to enhance biodiversity and maintain and/or restore the ecosystem's ecological processes within targeted forest patches include (DPW & DEPRM, 2004):

- Leaving stumps, leaves, snags and logs on-site to enhance the ecosystem's natural structure, maintain the nutrient cycle, and provide habitat for wildlife and other organisms;
- Controlling invasive plants and animals which may eliminate native species;
- Re-instating hydroperiods, i.e., flooding in drained wetlands;
- Mimicking successional stages of nearby similar ecosystems;
- Promotion and education about the need for retaining leaves, twigs, branches and logs on site to store and cycle nutrients; and
- Finding ways to aid the hydrological cycle by improving infiltration (Binelli, Gholz, & Duryea, 2001).

CHAPTER 5: RESTORATION AND PRESERVATION OPTIONS

5.1 Introduction

This chapter presents an overview of the key management practice recommendations for the Middle Gwynns Falls watershed based on the information collected during both the office/desktop analysis and field assessments. These practices are geared toward restoring degraded resources in urban/suburban watersheds. The chapter is divided into five sections: Municipal Capital Programs; Municipal Management Programs; Volunteer Restoration Programs; Neighborhood, Business and Institutional Initiatives; and Citizen Awareness Activities. The sections were delineated based on the entity controlling and performing the activities along with their funding and schedule requirements.

5.2 Municipal Capital Programs

Municipal capital programs are projects and purchases that the County can undertake in the short term to improve water quality in the Middle Gwynns Falls watershed.

5.2.1 Stormwater Management Upgrades

The application of stormwater management practices varies according to various physical characteristics such as impervious cover and land use makeup of the site or subwatershed. The most efficient method to augment stormwater treatment is to convert existing dry detention ponds to a design with greater pollutant removal capability. This is referred to as a stormwater pond conversion. If enough land is available, the greatest benefit would be to construct a new facility, designed with current state of the art technology, to reduce pollutants to the maximum extent practicable. However, a developed subwatershed seldom has sufficient open space. Instead there are options available to put treatment systems directly in the storm drain system. Many packaged systems are available through the retail market and are explained further below. Additional sites in alleys and adjacent to parking lots can offer treatment of large amounts of impervious surface. Also, new research in porous concrete and asphalt may offer the potential for additional reductions in impervious cover on public and private properties.

Most of the Middle Gwynns Falls planning area was developed prior to the passage of the Stormwater Act of 2007 in Maryland requiring more robust environmental site design. Stormwater retrofitting involves implementing stormwater BMPs and/or treatment devices in existing developed areas where previous practices did not exist or were ineffective to help improve water quality. Stormwater retrofits improve water quality by capturing and treating runoff before it reaches receiving water bodies. Retrofits target specific objectives depending on BMP type including stormwater quality, soil stabilization, stormwater flow control, and stream restoration. Several considerations must be taken into account to select appropriate stormwater treatment measures such as space requirements, cost, and community acceptance. Based on initial field and desktop evaluations, the following stormwater retrofit categories are recommended for addressing water quality issues in the Middle Gwynns Falls watershed through municipal capital programs: conversion of existing detention ponds, storm drain inlet and outfall retrofits, and public parking lot retrofits. Each of these categories is described briefly in the sections below.

5.2.1.1 Detention Pond Conversion

Dry detention ponds are typically designed for flood control and have little or no pollutant removal capacity. These facilities have the greatest potential for conversion to an extended detention pond which is designed to capture and retain stormwater runoff to allow sediments and pollutants to settle out while also providing flood control if necessary. Ten (10) out of the 15 existing detention ponds assessed during the SWM facility survey were determined to have potential for conversion to a wetland or extended detention facility. The facilities currently are vegetated with wetland vegetation, turf grass, or trees on the bottom with a riser structure or pipe acting as an outlet. Five (5) of the facilities had no fence at all, and five (5) needed repairs. While open pervious area provides more filtration of stormwater runoff than impervious surfaces, an extended detention pond or wetland with more dense vegetation such as trees, shrubs, and/or native plants would provide even more water quality benefits and would require less maintenance.

5.2.1.2 Storm Drain Inlet and Outfall Retrofits

Baltimore County's curb and gutter system consists of numerous inlets, pipes, and outfalls. While the curb and gutter system removes stormwater quickly from roadways, it often delivers increased runoff volumes and untreated pollutants to receiving water bodies. One way to address these potential water quality issues is to install proprietary BMPs at selected storm drain inlets. Various structural BMPs are commercially available and include catch basin inserts, water quality inlets, oil/grit separators, filtering devices and hydrodynamic devices. Proprietary BMPs are designed to address specific pollutants such as floatables and solid waste, nutrients, metals, sediment and oil/grease. Most are helpful for removing a portion of pollutants for pretreatment when used in conjunction with another BMP type such as an infiltration trench or a grassed swale for filtering pollutants upstream of an inlet.

While proprietary devices can be costly, they are water improvement alternatives for areas where there is inadequate space for other stormwater management options. Inlets selected for proprietary devices can be prioritized based on the County's outfall screening program.

Where space exists between and an outfall and the stream channel, other BMPs can be considered such as floodplain wetlands and energy dissipation devices. Floodplain wetlands can provide treatment of storm flows prior to entering the stream channel. Energy dissipation devices can reduce stream power and thus erosive forces of storm flows prior to entering the stream channel.

5.2.1.3 Public Parking Lot Retrofits

The potential for installing new stormwater retrofits for treating runoff from existing developed areas is often limited by space availability. However, BMPs that require less space for treating runoff from portions of impervious surfaces can be an alternative to larger storage facilities such as wetlands and extended detention ponds. In areas where insufficient space is available for basin-scale retrofits, other infiltration/filtration practices such as bioretention can be incorporated into the parking lot layout. Bioretention, for example, involves open space combined with vegetated areas where stormwater is temporarily stored and passed through vegetation and a filter bed of sand, organic matter, soil, or other suitable media. Filtered stormwater is collected and returned to the storm drain system or allowed to partially exfiltrate into soil. Many public facilities were identified as having sufficient open space for bioretention areas to treat runoff from parking lots or as having potential to incorporate retrofits of inlets on a smaller scale. Another retrofit option for treating runoff from large impervious surfaces with limited open space is underground stormwater retention/infiltration systems. Underground stormwater retrofits help address sediment and nutrient inputs to the stream system as well as standing water observed at several of these locations as a result of a lack of stormwater management measures.

5.2.2 Stream Corridor Restoration

Stream corridor restoration practices are used to enhance the appearance, stability, and aquatic function of urban stream corridors. These types of practices can range from simple stream clean-ups and localized bank stabilization to comprehensive repairs such as channel re-design and re-alignment. Stream restoration practices are often combined with stormwater retrofits and riparian management practices to meet subwatershed restoration objectives. Primary recommended practices for Middle Gwynns Falls stream corridors include buffer restoration, stream clean-ups, and stream repair.

5.2.2.1 Forest and Buffer Improvement

Forests are the best land use for the protection of water quality. The Middle Gwynns Falls watershed is covered with over 38% forest and may provide opportunities for planting. Forested buffers are linear wooded areas along rivers, streams and shorelines which help stabilize banks, prevent erosion, filter pollutants such as sediment and nutrients, and provide wildlife habitat. Several portions of the Middle Gwynns Falls stream system has inadequate buffers as a result of human development activities. A significant amount of the watershed has been urbanized and as a result, the original forested stream buffer has been replaced by mowed lawn areas or impervious cover.

The main restoration strategy proposed for the Middle Gwynns Falls watershed is to enhance forests and impacted stream buffers. This can be accomplished by a variety of methods including:

- Planting on residential and open space properties with native vegetation – Institutions and residential communities should reduce the amount of mowed grass and plant additional native trees.

- Land Preservation – Forest protection is one reason for pursuing a property as part of the county’s land preservation programs. Benefits to water quality are a part of the evaluation criteria in determining the most important parcels for protection. Smaller sites may be protected through NeighborSpace, a nonprofit organization that preserves small blocks of land within urban communities.

- Targeted education programs - Property owners, including private residences, businesses and institutions, need to learn the water quality benefits of buffers that are forested or planted with native vegetation. Stream buffer signs are one way to remind residents of the importance of stream buffers. Educational programs can teach residents that allowing their streams to have natural buffers can help preserve their property as well as provide water quality benefits. It also may help limit some of the trash dumping and yard waste observed in neighborhoods, along roadways, and in commercial areas.

- Invasive species control – Invasive and non-native plant species such as phragmites or multiflora rose were identified in various locations within the watershed. Invasive species concerns can be addressed through public education, training of County grounds maintenance staff, and developing a volunteer group dedicated to controlling invasive species in the planning area.

- Community Reforestation Program (CRP) – established by EPS to plant, monitor, and maintain forest mitigation projects. The program is funded through fees-in-lieu of mitigation for forests removed as a result of public and private land development, as required by the implementation of the county's Forest Conservation Act and Chesapeake Bay Critical Area Regulations. The CRP includes a four-person reforestation crew that carries out year-round reforestation operations. By utilizing the existing CRP, the county can achieve targeted reforestation along well-suited rivers and streams.

5.2.2.2 Stream Repair

Natural channel design techniques are utilized to stabilize eroded, degraded stream banks and to protect infrastructure such as private property, buildings and utilities. Stabilizing the stream channel improves water quality by preventing eroded soils, and the pollutants contained in them, from entering the stream. In addition, protecting infrastructure such as sewer and storm drain pipes reduces and/or eliminates water quality impacts associated with leaking sewer pipes and manholes. Where conditions allow, reconnecting the stream channel to its floodplain provides additional water quality benefits. When considering stream repair, it is important to take into account what is occurring upstream in the watershed. The hydrology and stormwater management practices upstream of a restoration site will dictate the quantity and speed runoff will reach a site. In addition, the sediment supply of the upstream channel is also an important consideration during the design of stream restoration repairs.

5.2.2.3 Wetland Restoration

Wetlands are highly valuable lands in terms of their abilities to both improve water quality and as important habitat for many species. Wetlands are defined as areas that are inundated or saturated by surface or groundwater at a frequency sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands are often called swamps, marshes, or bogs. This strategy entails the creation or enhancement of existing wetlands that have been lost or impaired in the past. The County often undertakes wetland restoration on public lands where wetlands have been destroyed or impaired as well as partnering with businesses and institutions where wetland restoration is a viable option.

5.2.3 Pervious Area Restoration

Pervious areas offer a good opportunity for restoration in subwatersheds since they can be used to restore natural infiltration properties, enhance stream buffers, and provide wildlife habitat. These areas also present an opportunity for reforestation in the watershed which is a high priority in terms of improving infiltration and recharge functions. Other techniques can also be used to improve natural functions including soil aeration, amendments, and establishing native plants and meadows. Sites prioritized for pervious area restoration should require minimal preparation for reforestation or regeneration with little evidence of soil compaction, invasive plant species, and trash/dumping. Most of the pervious areas assessed were publicly owned.

5.3 Municipal Management Programs

Municipal management programs are longer-term or continuous actions that Baltimore County can take to improve water quality in the Middle Gwynns Falls watershed.

5.3.1 Trash Management/Education

Dumping of bulk materials was noted as a problem in the watershed by field teams and residents. Ensuring the Department of Public Works provides a user-friendly and effective bulk trash pickup program would help prevent future dumping problems in the watershed. This may involve extending existing hours for bulk trash drop off at landfills or implementing a monthly bulk trash pick-up service at various locations in the watershed.

Existing trash initiative includes Baltimore County's Project Stream Clean (stream clean-ups throughout the region organized by the Alliance for the Chesapeake Bay). Implementing municipal practices and programs related to trash management/education in the Middle Gwynns Falls watershed would improve water quality and aesthetics of the watershed.

5.3.2 Street Sweeping

Baltimore County has an active street sweeping program to remove debris, dirt and pollutants from the storm drain system. Effective street sweeping usually involves using a vacuum assisted sweeper and a schedule that coincides with things like trash pick-up days or seasonal changes such as leaf litter in the fall and more frequent lawn care activities in spring and summer. The frequency and locations of this program in the study area should be evaluated and updated to include neighborhoods identified as having significant sediment, organic matter, and/or trash in the curb and gutter system. An evaluation of existing street sweeping programs is included as part of the Baltimore Watershed Agreement. Street sweeping is also related to the trash component of the agreement.

5.3.3 Tree Planting

Several opportunities for reforestation and buffer improvement were identified during the field assessments including street tree and open space shade tree plantings in various neighborhoods, open pervious areas and institutions throughout the watershed. This presents an opportunity to apply for municipal tree planting programs including SHA's "Partnership Program" and DNR's "Tree-mendous Maryland" program to help reforest areas of the watershed.

5.3.4 Inlet Cleaning

Over time, solids in stormwater runoff collect in storm drains and inlets. As solids accumulate in an inlet, they are susceptible to downstream transport during larger storm events, contributing to pollution in the Midlle Gwynns Falls watershed. A study conducted by the University of Maryland – Baltimore County (UMBC) and the Center for Watershed Protection as part of the U.S. EPA Chesapeake Bay Program concluded that annual or semi-annual cleaning of storm drain inlet can significantly increase solids removal rates (18-35%) while also contributing to nitrogen and phosphorus removal. The Department of Public Works employs three inlet cleaning trucks. Inlet cleaning at regular intervals can reduce pollutant loads in the watershed, reduce flooding and help locate illicit discharges into the storm sewer system.

5.3.5 Erosion and Sediment Control

Construction activities in or near streams were observed during the uplands assessment of the watershed. In these cases, erosion and sediment controls are vital to prevent soil and other pollutants from entering the storm drain system or nearby streams. Follow-up inspections and improvements to substandard erosion and sediment control practices at construction sites are implemented and enforced by the Baltimore County Department of Permits, Approvals, and Inspections to prevent sediment and other pollutant inputs from entering into the storm drain system and stream network.

5.3.6 Dry Weather Discharge Prevention

Baltimore County's illicit connection detection and elimination program targets dry weather flows that contain significant pollutant loads. Examples include illicit discharges, sewage overflows, or industrial and transportation spills. Dry weather discharges can be continuous, intermittent, or transitory. Resulting water quality problems can be extreme depending on the volume and type of discharge. For example, sewage discharges include bacteria and can directly affect public health while other discharges such as oil, chlorine, pesticides, and trace metals can be toxic to aquatic life. Dry weather discharge prevention focuses on four major sources that can occur in a subwatershed as described briefly below.

- Illicit Sewage Discharges: When septic systems fail or when sewer pipes are mistakenly or illegally connected to the storm drain pipe network, sewage can get into streams. Sometimes sewage is directly discharged to a stream or ditch without treatment or illegally dumped into the storm drain system from boats or RVs.

- Commercial and Industrial Illicit Discharges: Some businesses mistakenly or illegally dispose of liquid wastes that can adversely impact water quality into the storm drain system. Examples include hotspots where materials such as oil, paint, and solvents are improperly disposed, where businesses' drains are directly connected to the storm drain system, or where untreated wash water or process water is dumped into the storm drain system.

- Industrial and Transport Spills: Pollutants can enter the storm drain system as a result of ruptured tanks, pipeline breaks, accidents/spills, or illegal dumping. These events are more likely to occur in urban subwatersheds and may result in potentially hazardous materials reaching streams through the storm drain system.

- Failing Sewage Lines: Sewer lines often follow the stream corridor. If they leak, overflow, or break, sewage will be discharged directly into the stream. The frequency of failure depends on the age, condition, and capacity of the existing sanitary sewer system.

5.3.7 Land Preservation

Land preservation complements the implementation of BMP's by insuring that specific non-urban land uses remain intact over time on specific parcels. Land preservation includes areas such as parks and watershed protection zones where non-extractive uses predominate, as well as areas that are intensively managed for agriculture.

These parcels may be large, such as parks, or small, protecting a single farm. Land preservation reflects societal priorities and decisions to limit urban and residential development, and provides broad benefits. However, by themselves, they do not assure that certain environmental goals, such as good water quality, will be met.

"Protected land" includes any land with some form of long-term limitation on conversion to urban/developed land use. This protection may be in various forms: public ownership for natural resource or low impact recreational intent (i.e. park), private ownership where a third party acquired the development rights or otherwise acquired the right to limit use through the purchase of an easement (i.e. conservation easement), etc. The extent of "protection" varies greatly from one situation to the next. Therefore, for some protected land, it may be necessary to explore the details of land protection parcel-by-parcel through the local land records office to determine the true extent of protection.

For purposes of watershed management, an understanding of existing protected lands can provide a starting point in prioritizing potential protection and restoration activities. In some cases, protected lands may provide opportunities for restoration projects because owners of these lands may value natural resource protection or enhancement goals. A summary of current conservation easements is provided in Chapter 2.

5.3.7.1 Maryland and County Rural Legacy Program

Baltimore County participates in the State's Rural Legacy Program which was developed in 1997 to protect large, continuous tracts of valuable cultural and natural resource lands through grants made to local applicants. Baltimore County's Rural Legacy Plan aims to protect large blocks of forest, wetlands, farms, and other open spaces that are of significant ecological value as habitat for rare, threatened and endangered species and to preserve the environmental benefits that these areas provide to the Chesapeake Bay.

5.3.7.2 Maryland Environmental Trust and Local Land Trusts

Created by the Maryland General Assembly in 1967 to protect Maryland's natural environment, the Maryland Environmental Trust (MET) seeks donated easements on farms and forestlands, wildlife habitats, waterfront acreages, natural areas, historic sites, and other valuable and scenic features. In 1974, a landowner in Baltimore County was one of the first to protect their property through this program. Today, Baltimore County remains a leader in the state, with county landowners preserving over 12,000 acres through donations. Although both MET and local land trusts prefer to accept donations on lands greater than 50 acres, local land trusts are often willing to work with smaller property owners. Donations are accepted throughout the year. Landowners may qualify for a significant tax deduction and/or credit. MET also provides loans to qualified groups for the purchase of land for preservation.

5.4 Volunteer Restoration Programs

Volunteer restoration programs include activities or projects supported by the County but conducted by volunteers and volunteer organizations such as a watershed improvement group.

5.4.1 Stream Cleanups

Stream clean-ups are a simple practice used to enhance the appearance of the stream corridor by removing unsightly trash, litter, and debris. These are usually performed by volunteers and are one of the most effective methods for generating community awareness and involvement in watershed activities. Public outreach tools should be used to encourage and inform residents about organizing stream clean-ups and support available from the County.

5.4.2 Tree Planting

As noted previously, a number of open space and street tree planting opportunities are present in the Middle Gwynns Falls watershed, offering an opportunity to apply for municipal tree planting programs including SHA's "Partnership Program" and DNR's "Tree-mendous Maryland" program to help reforest areas of the watershed. These types of programs also provide an opportunity to involve volunteers from various neighborhoods, businesses and schools to help plant trees throughout the watershed while educating the community about the importance of trees for air and water quality benefits.

5.4.3 Pet Waste Stations

Unmanaged pet waste is a major contributor to bacteria, such as fecal coliform, in streams. Pet waste stations usually consist of a sign prompting pet owner's to discard of pet waste properly and a supply of convenient pet waste disposal bags for waste collection and disposal. Pet waste stations that are well-situated in parks or neighborhoods with high pet activity can help to reduce the bacteria flowing into streams along with maintaining an attractive area. Citizen volunteers can be asked to help install pet waste stations in high pet-traffic areas along with ensuring that stations are well-stocked with bags for collection and disposal.

5.4.4 Storm Drain Marking

Most of the developed areas in the Middle Gwynns Falls watershed consist of curb and gutter systems including storm drain inlets that convey stormwater runoff quickly and directly to the stream system and ultimately to the Chesapeake Bay. Some inlets had faded storm drain marking but for the most part, inlets did not have any indicators that they drain to Middle Gwynns Falls and eventually the Chesapeake Bay. Since there is little or no infiltration of stormwater in a curb and gutter system, there is more potential for pollutants to be carried to the stream system. Storm drain marking is a way to educate residents that anything building up along the curbs and gutters such as trash and lawn clippings will be washed away after a storm event and end up in the Chesapeake Bay.

5.5 Business and Institutional Initiatives

Business and institutional initiatives include activities that are available for commercial businesses and institutions to undertake in order to improve water quality in the area. These activities can be supported by the County.

5.5.1 Impervious Cover Removal

Impervious surfaces including roads, parking lots, roofs and other paved surfaces prevent precipitation from naturally seeping into the ground. Stormwater runoff from impervious surfaces is often concentrated, accelerated and discharged directly to the storm drain system or nearest stream. This can result in erosion, flooding, habitat destruction, and increased pollutant loads to receiving water bodies. Subwatersheds with high amounts of impervious cover are more likely to have degraded stream systems and be significant contributors to water quality problems in the watershed than those that are less developed.

Unused or unmaintained impervious surfaces with the potential for removal were identified at several institutions. At sites where parking lots may be larger than necessary, portions of the impervious cover could be removed and converted to bioretention areas for treating stormwater runoff from the remaining impervious surfaces. Some institutions may also have parking areas that are not frequently used (e.g., cemeteries) and could be suitable for conversion to permeable pavement which allows some infiltration of stormwater runoff while providing support for less frequent traffic/vehicle use. Several neighborhoods incorporated grass strips, gravel, or permeable pavers in private driveways which allow some infiltration of stormwater runoff. Completely paved driveways, however, were more common in the neighborhoods assessed during this study. Education and outreach tools could be used to inform residents of the water quality impacts associated with large impervious driveways or patios and options available for conversion to or incorporation of more permeable surfaces.

Channelized sections of stream corridors were identified during the uplands assessment and may be candidates for removal of existing concrete lining to restore streams to more natural systems. This would allow natural infiltration of stormwater and support pollutant removal prior to stormwater discharge into receiving waters.

5.5.2 Potential Redevelopment of Urban Areas

Natural areas that are developed into impervious urban landscapes result in an increase in runoff and pollutant loading. Redeveloping these urban areas back into a more natural setting can provide nutrient load reductions. In the Water Resources Element of its Master Plan 2020, Baltimore County has analyzed redevelopment scenarios and identified potential land for redevelopment in each of its watersheds.

Urban watersheds developed prior to modern stormwater regulations have fewer stormwater management facilities to capture and treat stormwater runoff. As businesses and property owners choose to redevelop properties that already have high amounts of impervious cover, they must meet redevelopment regulations in Baltimore County requiring a 50% reduction in impervious surface or inclusion of equivalent stormwater quality management facilities.

5.5.3 Pervious Area Restoration

Several institutions assessed had extensive opportunities for reforestation which would also require less ground maintenance and improve energy efficiency. Parcels meeting these criteria are good candidates for follow-up investigations and landowner contact.

5.5.4 Stormwater Retrofits

The following represent stormwater retrofits that can be undertaken by private entities to positively affect water quality.

5.5.4.1 Parking Lot

A few institutions were identified as having sufficient open space for bioretention areas to treat runoff from parking lots or as having potential to incorporate retrofits of inlets on a smaller scale. Another retrofit option for treating runoff from large impervious surfaces with limited open space is underground stormwater retention/infiltration systems. Stormwater retrofits would help address sediment and nutrient inputs to the stream system as well as standing water observed at several of these locations as a result of a lack of stormwater management measures.

5.5.4.2 Downspout Disconnection

Downspouts directly connected to the storm drain system or draining to impervious surfaces such as parking lots, sidewalks, or the curb and gutter system increase the volume and flow rate of pollutant-laden runoff reaching streams. Disconnected downspouts allow rooftop runoff to infiltrate into the ground and enter streams through the groundwater system in a slower more natural fashion. This decreases flow to local streams during storm events and helps prevent erosion and reduce pollutants loads to streams. Disconnecting downspouts in commercial corridors is an inexpensive way to improve water quality in the Middle Gwynns Falls watershed.

5.5.5 Open Space Planting

Several opportunities for reforestation and buffer improvement were identified during the field assessments including open space shade tree plantings in various open pervious areas and institutions throughout the watershed. This presents an opportunity to apply for municipal tree planting programs including SHA’s Partnership Program and DNR’s Tree-Mendous Maryland program to help reforest areas of the watershed.

Tree-Mendous Maryland coordinates the free delivery of trees to citizens and community groups, and provides an inexpensive way to obtain trees and shrubs for planting on public lands and within community open spaces. These types of programs also provide an opportunity to involve volunteers from various neighborhoods, businesses and schools to help plant trees throughout the watershed while also educating the community about the importance of trees for air and water quality benefits.

5.5.6 Pollution Source Control

Hotspots are commercial, industrial, municipal, or transport-related operations in the watershed that tend to generate higher concentrations of stormwater pollutants and/or have a higher risk of spills, leaks, or illicit discharges. Pollution prevention practices can significantly reduce hotspot pollution problems. Local government agencies must adopt pollution prevention practices for their operations and lead by example. This should be followed by inspection and incentive-based educational efforts for privately operated sites with enforcement measures as a backstop. The ability to conduct such inspections and enforcement actions should be clearly articulated in local codes and ordinances and through education programs. As previously noted, some industrial/commercial sites are required to have NPDES permits for stormwater and/or wastewater discharges. While the County assists with the identification of these sites, MDE is responsible for regulating industrial/commercial sites that are required to have NPDES permits. Another potential program is to host workshops for local businesses that detail the permit requirements and how to prepare pollution prevention plans.

5.6 Citizen Awareness Activities

Citizen awareness activities are actions that any resident or citizen in the Middle Gwynns Falls watershed can take that would provide a benefit to water quality.

5.6.1 Pollution Prevention/Source Control Education

Residents engage in behaviors that can adversely impact water quality. Some of these behaviors observed during the assessment of neighborhoods in the watershed include over-fertilizing lawns, excessive use of pesticides, improper disposal/storage of potentially hazardous materials (e.g., household cleaners, paints, automotive fluid, etc.), and dumping into storm drains (e.g., wash water). Pollution prevention/source control education efforts should also target waste management activities in the watershed to address dumpsters located near storm drain inlets or streams without diversion methods, poor dumpster conditions (leaking, overflowing, and uncovered), and the occurrence of trash dumping in the watershed. Positive behaviors were also observed such as tree planting, disconnected downspouts, and picking up pet waste which can help improve water quality. A pollution prevention program can be designed to discourage negative behaviors and/or encourage positive behaviors. Either way, the goal is to deliver a specific message through targeted education to promote behavior changes. Local watershed organizations can help influence these changes using pollution prevention education and outreach to teach citizens how to properly care for the watershed.

5.6.2 Trash and Recycling

Educating the public about the trash issues and impacts to water quality in the watershed through a trash campaign is one way to address trash and dumping problems. Baltimore County has implemented a Clean Green County initiative to boost recycling rates throughout the County. A targeted campaign could be launched in the Middle Gwynns Falls watershed with a slogan and messages tailored to the residents and issues in the study area. By adopting a slogan and campaign for the watershed, residents will be aware of the issues and encouraged to take responsibility for the health of the Middle Gwynns Falls in their communities. Public education and awareness can also be accomplished through community clean-ups in neighborhoods or schools with observed trash management issues.

5.6.3 Environmental Awareness and Education

Community-based facilities present good opportunities for educating the public about water quality issues and improvement methods for the watershed. This can be accomplished by implementing water quality BMPs such as rain gardens and bioretention areas at these sites. In addition to environmental education, these BMPs have water quality and aesthetic benefits for property users. There is also potential for involving the community through BMP installation and maintenance. Environmental education can also be accomplished through water quality sampling and monitoring of stormwater management measures such as wetlands and extended detention ponds at schools, for example. Buffer and tree planting activities also present an opportunity for combining community involvement and environmental education.

5.6.4 Bayscaping

A “Bayscape” is a landscape using native plants to provide habitat for local and migratory animals, improve water quality, and reduce the need for chemical pesticides and herbicides. Bayscaping plants, such as trees, shrubs and perennials, are able to make better use of rain water than typical lawn grasses, and so require less watering once established. They are also better at trapping and removing nitrogen and pollutants from rain water so that it is not released into nearby water bodies. A Bayscape is also valuable for the gardener or landowner because it offers greater visual interest than lawn, reduces the time and expense of mowing, watering, fertilizing and treating lawn and garden areas, and can address areas with problems such as erosion, poor soils, steep slopes or poor drainage.

5.6.5 MD Green School Awards Program

Baltimore County uses *The Maryland Green School Awards Program* to provide a framework for integrating environmental learning and community involvement in local schools. Baltimore County provides local and regional resources to enhance staff development opportunities and increase the environmental awareness and interest of local school principals, teachers, and facilities managers. Support includes assistance from Baltimore County Public School's Office of Science, free delivery of trees by EPS, and outdoor education and technical support at a number of Nature Centers. A requirement of each Green School is to demonstrate Best Management Practices at their site. These may include: water conservation, energy conservation, solid waste reduction, and habitat restoration using the school grounds.

5.6.6 Downspout Disconnection

Most of the neighborhoods assessed in the Middle Gwynns Falls watershed were recommended for downspout disconnection. This is because most downspouts were directly connected to the storm drain system or indirectly connected, draining to impervious surfaces such as driveways, sidewalks, or the curb and gutter system. Historically, flooding has been an issue with streams within the Middle Gwynns Falls planning area and that issue is magnified with the development of large amounts of impervious area. Disconnected downspouts allow rooftop runoff to infiltrate into the ground and enter streams through the groundwater system in a slower more natural fashion. By using pervious ground to intercept and infiltrate runoff prior to its entering a conveyance system (i.e. gutter, inlet, and pipe), neighborhoods can be altered to mimic the predevelopment hydrology of the area to a greater extent. This decreases flow to local streams during storm events and helps prevent erosion and reduce pollutants loads to streams. Many of the typical lots do not have sufficient room for rain gardens; however, redirecting downspouts to pervious areas such as yards or lawns or to rain barrels seems to be a viable option for most neighborhoods recommended for downspout disconnection.

Rain gardens are the most desirable option in terms of water quality because they consist of native plants that capture and treat runoff. This may be an option for multifamily neighborhoods like apartment complexes where there is several hundred square feet of open pervious area available down gradient from the downspout. Rain gardens may also be an option for disconnecting downspouts at institutional sites with sufficient space available. Redirecting downspouts to pervious areas or rain barrels is also an option for institutional sites as well as individual homeowners.

CHAPTER 6: REFERENCES

Baltimore County Office of Planning. (2012, August 7). *What is Zoning?* Retrieved November 27, 2012, from Baltimore County Md. Planning: http://www.baltimorecountymd.gov/Agencies/planning/zoning/index.html

Belval, D. L., & Sprague, L. A. (1999). *Monitoring Nutrients in the Major Rivers Draining to Chesapeake Bay.* Richmond, VA & Baltimore, MD: United States Geological Service.

Binelli, E. K., Gholz, H. L., & Duryea, M. L. (2001). *Plant Succession and Disturbances in the.* Florida Cooperative Extension Service, School of Forest Resources and Conservation Department. Gainesville, FL: University of Florida.

Cary Institute of Ecosystem Studies. (2012). *What is BES?* Retrieved November 29, 2012, from Baltimore Ecosystem Study: http://www.beslter.org

CBP. (2008). *The Chesapeake Bay Watershed*. Retrieved September 19, 2012, from Chesapeake Bay Program: http://www.chesapeakebay.net/discover/baywatershed

CWP. (2004). *Unified Subwatershed and Site Reconnaissance: A User's Manual.* Ellicott City, MD: Center for Watershed Protection.

CWP. (2003). *Impacts of Impervious Cover on Aquatic Systems.* Ellicott City, MD: Center for Watershed Protection.

DEPRM. (1999). *A GIS Analysis of Forest Cover in the Gwynns Falls Watershed.* Towson, MD: Baltimore County Department of Environmental Protection & Resource Management.

DEPRM. (1996). *A GIS-based Methodology for Establishing a Greenway Corridor System in a Fragmented Forest Landscape* . Towson, MD: Baltimore County Department of Environmental Protection & Resource Management.

DNR. (2005). *A User's Guide to Watershed Planning in Maryland.* Watershed Services. Ellicott City, MD: Center for Watershed Protection.

DPW & DEPRM. (2004). *Gwynns Falls Water Quality Management Plan.* Prepared by Parsons Brinckerhoff, Inc. in association with Coastal Resources, Inc. & Greenman Pedersen, Inc.: Baltimore City Department of Public Works and Baltimore County Department of Environmental Protection and Resource Management.

DSD. (2010, April 19). *08 Stream Segment Designations*. Retrieved February 4, 2013, from COMAR Online: http://www.dsd.state.md.us/comar/getfile.aspx?file=26.08.02.08.htm

EPA. (2012, November 7). *National Recommended Water Quality Criteria.* Retrieved November 26, 2012, from United States Environmental Protection Agency: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm

EPA. (1992). *Storm Water Management Model, Version 4: User's Manual.* Athens, GA: Environmental Protection Agency.

EPS. (2011). *Baltimore County NPDES - Municipal Stormwater Discharge Permit 2011 Annual Report.* Towson, MD: Baltimore County Department of Environmental Protection and Sustainability.

EPS. (2013). *Baltimore County NPDES - Municipal Stormwater Discharge Permit 2012 Annual Report.* Towson, MD: Baltimore County Department of Environmental Protection and Sustainability.

EPS. (2011). *Mapping Environmental Justice + Water Quality in Baltimore County.* Baltimore, MD: Biohabitats.

EPS. (May, 2011). *Upper Gwynns Falls Small Watershed Action Plan.* Baltimore, MD: A. Morton Thomas and Associates, Inc. Consulting Engineers.

Frink, C. (1991). Estimating Nutrient Exports to Estuaries. *Journal of Environmental Quality , 20* (4), 717-724.

MDE. (2009). *Maryland Biological Stressor Identification Process .* Baltimore, MD: Maryland Department of the Environment.

MDE. (2012). *The 2012 Integrated Report of Surface Water Quality in Maryland.* Baltimore, MD: Maryland Department of the Environment.

MDE. (2009). *Water Quality Analysis of Eutrophication for the Gwynns Falls Watershed in Baltimore County and Baltimore City, Maryland .* Baltimore, MD: Maryland Department of the Environment.

MDE. (2012). *Watershed Report for Biological Impairment of the Gwynns Falls Watershed in Baltimore City and Baltimore County, Maryland.* Baltimore, MD: Maryland Department of the Environment.

MGS. (2009, January). *Guide to Maryland Geology*. Retrieved October 2012, from MGS Online: http://www.mgs.md.gov/esic/brochures/mdgeology.html

NOAA. (2012, September). *Baltimore Monthly Precipitation (since 1871).* Retrieved September 19, 2012, from National Weather Service Forecast Office: http://www.erh.noaa.gov/lwx/climate/bwi/bwiprecip.txt

NOAA. (2011, December 31). *Baltimore Monthly Snowfall (since 1883).* Retrieved September 19, 2012, from National Weather Service Forecast Office: http://www.erh.noaa.gov/lwx/climate/bwi/bwisnow.txt

NOAA. (n.d.). *Station Locator: Baltimore Washington International Airport.* Retrieved July 10, 2009, from National Climatic Data Center: http://www.ncdc.noaa.gov/oa/climate/stationlocator.html

Ouyang, D. (2002). *RUSLE: On-Line Soil Erosion Assessment Tool*. (M. S. University, Producer) Retrieved from Institute of Water Research: http://www.iwr.nsu.edu/rusle

Saunders D. A., R. J. (1991). Biological Consequences of Ecosystem Fragmentation: A Review. *Conservation Biology , 5* (1), 18-32.

USDA. (1993). *Soil Survey Manual.* Washington D.C.: Soil Survey Division Staff.

USDA. (1986). *Technical Release 55: Urban Hydrology for Small Watersheds.* U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS), Conservation Engineering Division.

APPENDIX A:

SWM FACILITY ASSESSMENT DATA

Middle Gwynns Falls SWM Facility Assessment Data

Site ID	Subwatershed	Structure Name	Location (Nearest Road)	Ownership	Drainage Area (acres)	Riser	Embankment	Vegetation	Fence Condition	Gate Condition	Water Quality Potential	Access	Flow Path	Horizontal Expansion Potential	Vertical Expansion Potential	WQ Notes
SWM_C_961	DEAD RUN	WATERFORD PLACE	KEVSWAY CT.	Private	64.88	GOOD CONDITION	NO PROBLEMS	WETLAND VEGATATION	GOOD CONDITION	UNLOCKED	Y	EASY	LONG	Y	N	DISCONNECT UNDERDRAINS INTO RISER STRUCTURE; MICROPOOL AT INFLOW; UNDERCUT AT INFLOW HEADWALL
SWM_C_857	DEAD RUN	SECURITY SQUARE SHOP CENTER ADDITION	SECURITY/LORD BALTIMORE	Private	11.71	GOOD CONDITION	NO PROBLEMS	WETLAND VEGATATION	GOOD CONDITION	LOCKED	Y	EASY	LONG	Y	N	HORIZONTAL EXPANSION BY STEEPENING SLOPES; TREATMENT AT OUTFALL
SWM_C_817	DEAD RUN	ROLLING CROSSROADS PROFESSIONAL CENTER	JOHNNYCAKE/ROLLING CROSSROADS	Private	13.34	GOOD CONDITION	TREES ON EMBANKMENT	WETLAND VEGATATION	REPAIR NEEDED	NO GATE	N	DIFFICULT	SHORT	N	N	INVASIVES MANAGEMENT; ADJACENT STOCKPILE DRAINING TO POND
SWM_C_450	DEAD RUN	DISCOVERY ACRES 1 **BUILT**	JOHNNYCAKE RD	Public	23.00	MINOR MAINTANCE	TREES ON EMBANKMENT	WETLAND VEGATATION	NO FENCE	NO GATE	N	DIFFICULT	LONG	N	N	STABILIZE INFLOW/GABBION STRUCTURE THAT IS UNDERCUT, STABILIZE OUTFALL
SWM_C_432	DEAD RUN	CROSBY MEADOW **COUNTY AB APPROVAL ONLY**	HALFPENNY LANE	Public	33.00	DAMAGE	TREES ON EMBANKMENT	WETLAND VEGATATION	REPAIR NEEDED	UNLOCKED	Y	DIFFICULT	SHORT	Y	Y	CURRENTLY ACTING AS SW WETLAND. COULD CONVERT POND TO ENGINEERED WETLAND SINCE FLOODING IS APPARENTLY NOT AN ISSUE AS IS
SWM_C_334	DEAD RUN	BRIGADOON	BRIGADOON TRAIL	Private	17.97	GOOD CONDITION	NO PROBLEMS	TURF GRASS	REPAIR NEEDED	UNLOCKED	Y	EASY	LONG	N	N	POTENTIAL FOR INSTALLATION OF BIOSWALES ON UPSTREAM SIDE OF POND WITH FOREBAY. UPGRADE LOW FLOW CHANNEL. FIX FENCE
SWM_C_984	GWYNNS FALLS	OWINGS OVERLOOK (AKA WINANDS VALLEY ESTATE	DUTCH MILL/WINDMILL	Public	41.61	GOOD CONDITION	EROSION	WETLAND VEGATATION	REPAIR NEEDED	UNLOCKED	Y	EASY	LONG	Y	N	LARGE POND AREA COULD MEAN EXCESS CAPACITY; INSTALL MICROPOOL AND MEANDER FLOW PATH
SWM_C_967	GWYNNS FALLS	WINDSOR GARDENS	NORTHMONT	Public	52.80	MINOR MAINTANCE	HOLES IN EMBANKMENT	WETLAND VEGATATION	GOOD CONDITION	LOCKED	Y	EASY	LONG	NONE	N	CHECK DRAINAGE AREA TO VERIFY CAPACITY, POTENTIAL FOR MICROPOOL AND CONVERSION AS DRAINAGE AREA SEEMED TO BE MUCH LESS THAN GIVEN
SWM_C_738	GWYNNS FALLS	OLD COURT GROVE	PANACEA/BONNIE B	Public	16.62	GOOD CONDITION	TREES ON EMBANKMENT	WETLAND VEGATATION	REPAIR NEEDED	NO GATE	N	MODERATE	SHORT	N	N	CLEAN BOTTOM; UPGRADE LOW FLOW CHANNEL
SWM_C_715	GWYNNS FALLS	MOSBY MILL APARTMENTS	JANPER CT	Private	18.96	GOOD CONDITION	TREES ON EMBANKMENT	TURF GRASS	NO FENCE	NO GATE	Y	EASY	SHORT	N	N	MICROPOOL AT INFLOW DITCH; LOOK AT RESIZING LOW FLOW PIPE
SWM_C_651	GWYNNS FALLS	LAWNWOOD	LAWNWOOD CIRCLE	Public	47.10	GOOD CONDITION	TREES ON EMBANKMENT	WETLAND VEGATATION	GOOD CONDITION	UNLOCKED	N	EASY	LONG	N	N	
SWM_C_441	GWYNNS FALLS	DEERFIELD ADDITION POND 1 **BUILT**	SPRING MILL CIRC	Public	13.30	MINOR MAINTANCE	TREES ON EMBANKMENT	TREES	GOOD CONDITION	LOCKED	Y	EASY	SHORT	Y	N	POTENTIAL MICROPOOL AT INFLOW; H EXPANSION ON S SIDE; STABILIZE BARE EARTH; REMOVE IMPERVIOUS ACCESS
SWM_C_1652	GWYNNS FALLS	JULIAN WOODS POND 1**BUILT**	METREE WAY	Public	10.00	GOOD CONDITION	TREES ON EMBANKMENT	WETLAND VEGATATION	NO FENCE	NO GATE	N	EASY	SHORT	N	N	NO EXPANSION POTENTIAL
SWM_C_859	MAIDEN CHOICE RUN	SHADE TREE APTS	NORTHDALE	Private	20.35	DAMAGE	NO PROBLEMS	TREES	NO FENCE	NO GATE	Y	EASY	SHORT	Y	N	POTENTIAL FOR HORIZONTAL EXPANSION TO NORTH TO INCREASE CAPACITY FOR EXTENDED DETENTION CONVERSION
SWM_C_1188	MAIDEN CHOICE RUN	BANNEKER REGIONAL POND **BUILT**	MARYLAND AVE	Public	60.20	GOOD CONDITION	NO PROBLEMS	WETLAND VEGATATION	NO FENCE	NO GATE	Y	EASY	LONG	Y	N	MICROPOOL AT INFLOW ABOVE BOTTOM OF POND; 3 INFLOW SWALES COULD BE CONVERTED TO BIOSWALES; CHECK FOR EXCESS CAPACITY

APPENDIX B:

UPLANDS SURVEY DATA

Neighborhood Information and Recommended Actions																								
Neighborhood ID	Subwatershed	Neighborhood Name	Acres	PSI	ROI	Downspout Redirect	Rain Barrel	Rain Garden	Stencil	BayScape	Lot Canopy Improvement	Fertilizer Reduction	Percent Lawns High	Pet Waste	Trash Management	Yard Trash Percentage	Buffer Impact	Street Trees	Open Space Shade Trees	Park Creation	Parking Lot Retrofit	Alley Retrofit	Street Sweeping	Other Actions	Lot Size (Acres)
NSA_C_001	Gwynns Falls	BERKSHIRE HILLS	24.31	High	Low	Y	Y	Y	Y	Y	N	N	10	N	Y	10	N	0	0	N	N	N	0.44	N/A	>1
NSA_C_002	Gwynns Falls	ARCHIMEDES (APARTMENTS)	15.01	Moderate	Moderate	Y	Y	N	Y	Y	Y	N	0	N	N	0	N	0	232	N	N	N	0.00	Open space tress good for landscaping and planting trees	<1/8
NSA_C_003	Gwynns Falls	HOPKINS PROPERTY	13.23	Moderate	Moderate	Y	Y	N	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	1/8
NSA_C_004	Gwynns Falls	PIKESVILLE FARMS	24.17	High	Moderate	Y	Y	Y	N	Y	Y	N	0	N	N	0	Y	0	0	N	N	N	0.00	No storm drains, site draining directly towards stream	1/2
NSA_C_005	Gwynns Falls	PIKESVILLE VILLAGE	8.19	High	Moderate	Y	Y	N	Y	Y	Y	N	0	N	Y	10	N	0	0	N	N	N	0.30	Lots of sediment and nutrients draining from reservoir property	1/4
NSA_C_006	Gwynns Falls	GREY ROCK (CONDOMINIUMS)	19.25	High	Moderate	Y	Y	N	Y	Y	Y	Y	50	N	N	0	N	0	0	N	N	N	0.00		<1/8
NSA_C_007	Gwynns Falls	McDonogh Run	11.41	Moderate	Moderate	N	Y	Y	Y	Y	Y	N	5	N	N	0	N	0	0	N	Y	N	0.95	Land next to NSA is owned by Baltimore Co. and a good oppurtunity for a BMP.	<1/8
NSA_C_008	Gwynns Falls	OWINGS OVERLOOK	21.52	Moderate	Moderate	Y	Y	Y	Y	Y	Y	N	10	N	N	0	N	0	0	N	N	N	0.00	New houses being built in development	1/8
NSA_C_009	Gwynns Falls	VILLAGES AT WOODHOLME (CONDOMINIUM)	62.96	Moderate	Low	Y	Y	N	N	N	Y	N	0	N	N	0	N	0	215	N	Y	N	0.00	N/A	<1/8
NSA_C_010	Gwynns Falls	WILLOW GLEN NORTH ADD	139.19	Moderate	High	Y	Y	Y	Y	N	Y	N	15	N	N	0	N	72	0	N	N	N	5.59	Street tree planting on Scotts Level Rd.	<1/4
NSA_C_011	Gwynns Falls	ROSLAND (TOWN HOMES)	19.27	Moderate	Moderate	Y	Y	N	Y	Y	Y	N	5	N	N	0	Y	0	30	N	N	N	0.00	Minor dumping on weyanoke ct.; Minor debris/sediment at inlet/crub	<1/8
NSA_C_012	Gwynns Falls	POMONA (APARTMENTS)	60.41	High	High	Y	Y	Y	Y	Y	Y	N	0	N	N	0	N	0	570	N	Y	N	3.52	Many oppurtunities for tree planting and new BMP	<1/8
NSA_C_013	Gwynns Falls	WOODHOLME ESTATES	13.00	Moderate	Low	Y	Y	Y	Y	N	N	N	0	N	N	0	N	0	35	N	N	N	0.00	Bus stop near neighborhood that has the potential for tree planting	1/2
NSA_C_014	Gwynns Falls	BRITTANY APARTMENTS	17.00	High	High	Y	Y	Y	Y	Y	Y	N	5	N	N	0	Y	0	0	N	Y	N	0.00	Severe erosion occurring in stream buffer area. Apartment buildings encroaching on stream.	<1/8
NSA_C_015	Gwynns Falls	OWINGS CHASE APARTMENTS	13.62	Moderate	High	Y	Y	N	Y	N	N	N	0	N	N	0	N	8	41	N	N	N	1.23	Street tree planting along Molly Rd. (one side)	<1/8
NSA_C_016	Gwynns Falls	LAYDON PARK	89.62	Moderate	High	Y	Y	N	Y	Y	Y	Y	25	N	N	0	N	63	0	N	N	N	0.00	Street tree planting along end of Arrowhead Rd.	1/4
NSA_C_017	Gwynns Falls	OLD COURT ESTATES	41.63	Moderate	High	Y	Y	N	Y	Y	Y	N	5	N	N	0	N	44	0	N	N	N	0.00	Street tree planting along Scotts Level Rd.	1/4
NSA_C_018	Gwynns Falls	OLD COURT	16.72	None	Low	N	Y	Y	Y	N	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	1
NSA_C_019	Gwynns Falls	PRESCOTT SQUARE APARTMENTS	4.91	None	Moderate	N	Y	N	Y	Y	Y	N	0	N	N	0	N	0	49	N	Y	N	0.00	N/A	<1/8
NSA_C_020	Gwynns Falls	SCOTTS HILL SMOKE TREE	86.26	Moderate	High	Y	Y	Y	Y	Y	Y	N	15	N	N	0	N	618	0	N	N	N	3.80	N/A	1/4
NSA_C_021	Gwynns Falls	GWYNNVALE	25.27	High	High	Y	Y	Y	Y	Y	Y	N	15	N	N	0	Y	0	73	Y	N	N	0.00	Potential for open space tree planting or park creation at end of shamrock In., property owned by Baltimore Co.	<1/4
NSA_C_022	Gwynns Falls	SILVER CREEK	29.24	Moderate	Moderate	Y	Y	N	N	N	Y	Y	30	N	N	0	N	0	89	N	N	N	1.79	Street sweeping recommended.	1/8
NSA_C_023	Gwynns Falls	SUDBROOK PARK	58.55	None	Low	N	Y	N	N	N	N	N	10	N	N	0	N	0	0	N	N	N	0.00	Lots of landscaping and tress in community.	>1
NSA_C_024	Gwynns Falls	DUNHILL VILLAGE (APPARTMENTS)	10.45	Moderate	Moderate	N	Y	Y	Y	Y	Y	N	0	N	N	0	N	0	74	N	Y	N	0.00	Potential for Grass swale along Dunhill Village Cir., Minor dumping going on behind dumpsters	<1/8
NSA_C_025	Gwynns Falls	CEDAR RUN	9.69	Moderate	Moderate	Y	Y	Y	Y	N	Y	N	10	N	N	0	N	0	0	N	N	N	0.00	N/A	1/8
NSA_C_026	Gwynns Falls	SILVER CREEK	29.18	None	Moderate	Y	Y	N	N	N	N	N	0	N	N	0	N	82	16	N	N	N	0.00	Street tree planting on Millford Mill Rd.	1/8
NSA_C_027	Gwynns Falls	WILLIAMSBURG	43.19	Moderate	High	Y	Y	N	Y	Y	Y	N	0	N	N	0	N	85	0	N	N	N	0.00	Street tree planting along one-side of Campfield Rd. and Sudbrook Rd.	1/4
NSA_C_028	Gwynns Falls	WILLOW GLEN	77.49	Moderate	High	Y	Y	Y	Y	Y	Y	N	15	N	N	0	N	52	9	N	N	N	0.00	Planting oppurtunity in circle medians off of Ricksway Rd. Street tree planting on left-side of Leafydale Terr. up to Leafydale Ct. Both sides of Leafydale Terr. after Leafydale Ct.	1/3
NSA_C_029	Gwynns Falls	VILLA NOVA	49.58	Moderate	Low	Y	Y	Y	N	N	N	N	0	N	N	0	N	0	0	N	N	N	0.00	Only 2 inlets in the entire neighborhood.	1/2

Neighborhood Information and Recommended Actions

Neighborhood ID	Subwatershed	Neighborhood Name	Acres	PSI	ROI	Downspout Redirect	Rain Barrel	Rain Garden	Stencil	BayScape	Lot Canopy Improvement	Fertilizer Reduction	Percent Lawns High	Pet Waste	Trash Management	Yard Trash Percentage	Buffer Impact	Street Trees	Open Space Shade Trees	Park Creation	Parking Lot Retrofit	Alley Retrofit	Street Sweeping	Other Actions	Lot Size (Acres)
NSA_C_030	Gwynns Falls	VILLA NOVA BEDFORD	35.53	None	Moderate	N	Y	Y	Y	N	N	N	10	N	N	0	Y	26	0	N	N	N	0.00	Street tree planting along Campfield Pl. Houses encroaching on stream. Stream not completely forested.	1/2
NSA_C_031	Gwynns Falls	VILLA NOVA ESSEX	76.96	None	Low	N	Y	Y	Y	N	N	N	10	N	N	0	N	0	0	N	N	N	0.00	Very well maintained community.	1/2
NSA_C_032	Gwynns Falls	RIPPLEWOOD	32.39	Moderate	High	Y	Y	Y	Y	N	Y	N	5	N	N	0	Y	0	0	N	N	N	0.00	Long-term cars parked on 7403 Allmont Rd. and 3322 Ripple Rd.	1/4
NSA_C_033	Gwynns Falls	BARKLEY WOODS (TOWN HOMES)	17.55	None	Low	N	Y	N	Y	Y	Y	N	0	N	N	0	N	0	45	N	N	N	0.00	Some storm drains are stenciled, but not all of them.	<1/8
NSA_C_034	Gwynns Falls	LIBERTY GARDEN PARK	24.47	Moderate	Moderate	Y	Y	Y	Y	N	Y	Y	20	N	N	0	N	0	0	N	N	N	0.00	N/A	<1/4
NSA_C_035	Gwynns Falls	LIBERTY GARDEN APARTMENTS	23.64	High	High	N	Y	Y	Y	Y	Y	N	0	N	Y	10	Y	0	119	N	Y	N	1.67	Potential for micro-bioretention pond near playground (end of rudsill ct.)	<1/8
NSA_C_036	Gwynns Falls	MILFORD GARDENS (DUPLEXES)	12.46	Moderate	High	Y	Y	Y	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	1/4
NSA_C_037	Gwynns Falls	MILFORD	32.86	Moderate	High	Y	Y	Y	Y	N	N	N	5	N	N	0	Y	91	0	N	N	N	0.00	Street tree planting on Croydon Rd.	1/2
NSA_C_038	Gwynns Falls	LIBERTY CREST	38.15	None	High	Y	Y	Y	Y	Y	Y	N	10	N	N	0	N	72	26	N	N	N	0.00	Open space planting along Marston Rd. Street tree planting along Croydon Rd.	1/8
NSA_C_039	Gwynns Falls	KELLYBROOK	85.20	Moderate	High	Y	Y	N	Y	Y	Y	N	5	N	N	0	Y	0	126	N	N	N	0.00	Open space tree planting oppurtunity at Yataruba Dr. Stream buffer is not forested.	1/8
NSA_C_040	Gwynns Falls	WOODMOOR	82.61	Moderate	Moderate	Y	Y	N	Y	N	Y	N	5	N	N	0	N	0	0	N	N	N	4.34	Some inlets were stenciled with the new type of stencild.	<1/4
NSA_C_041	Gwynns Falls	CRESCENT POINTE (APARTMENTS)	14.58	High	Moderate	Y	Y	N	Y	Y	N	N	0	N	Y	15	N	0	14	N	Y	N	0.00	Potential for pavement removal. There is dumping in several areas.	<1/8
NSA_C_042	Gwynns Falls	LANTERN HILL APARTMENTS	16.86	Moderate	High	Y	Y	N	Y	N	Y	N	0	N	N	0	N	0	70	N	N	N	1.41	N/A	<1/8
NSA_C_043	Gwynns Falls	DEERFIELD	57.01	Moderate	High	N	Y	N	Y	Y	Y	N	0	N	N	0	N	56	0	N	N	N	3.86	Tree planting on one-side of Yararuba.	1/4
NSA_C_044	Gwynns Falls	Gwynn Oaks Landing	54.92	High	Moderate	Y	Y	N	Y	N	N	N	0	N	N	0	Y	0	68	N	Y	N	0.00	Bioretention potential at Townbrook dr. and Creastway Rd. Tree planting oppurtunity near pool at apartment complex.	<1/8
NSA_C_045	Gwynns Falls	LAWNWOOD	83.16	None	Moderate	Y	Y	Y	Y	N	N	N	15	N	N	0	N	0	107	N	N	N	0.00	Median along Windsor Blvd good for tree planting. Open space along Oakside Cir.	<1/4
NSA_C_046	Gwynns Falls	BELLMONT	9.06	Moderate	High	Y	Y	N	Y	Y	Y	N	0	N	N	0	Y	0	96	N	N	N	0.00	Apartments are encroaching on streat and the stream is not buffered.	<1/8
NSA_C_047	Gwynns Falls	DEERFIELD ADDITION (TOWN HOMES)	12.73	Moderate	Moderate	N	Y	N	Y	Y	N	N	0	N	N	0	N	0	19	N	N	N	0.00	N/A	<1/8
NSA_C_048	Gwynns Falls	COURTLAND WOODS	6.39	Moderate	Moderate	Y	Y	N	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	<1/8
NSA_C_049	Gwynns Falls	BEDFORD COMMONS (CONDOMINIUMS)	10.15	Moderate	Low	Y	Y	N	Y	Y	N	N	0	N	N	0	N	0	26	N	Y	N	0.00	N/A	<1/8
NSA_C_050	Gwynns Falls	CHURCH LANE	49.85	High	Moderate	Y	Y	Y	Y	Y	N	N	5	N	N	0	Y	0	0	Y	N	N	0.00	All around SWM facilities there is oppurtunities for tree planting	1/2
NSA_C_051	Gwynns Falls	SUDBROOK PARK	19.97	Moderate	Moderate	Y	Y	N	Y	N	Y	N	10	N	N	0	N	0	0	N	N	N	1.22	Some existing trees between sidewalk and roadway	1/2
NSA_C_052	Powder Mill Run	SUDBROOK PARK GREENWOOD	77.66	Moderate	High	N	Y	Y	Y	Y	Y	N	10	N	N	0	N	0	0	N	N	N	4.74	N/A	1/8
NSA_C_053	Gwynns Falls	EAST SUDBROOK PARK	54.65	High	High	N	Y	Y	Y	N	Y	Y	20	N	N	0	N	88	0	N	N	N	3.11	Potential for tree planting on Clarendon Str. inlets at p;der side of neighborhoof filled with sediment and organic matter	1/8
NSA_C_054	Powder Mill Run	MILFORD APARTMENTS	8.21	High	Moderate	Y	Y	N	Y	Y	Y	N	0	N	Y	10	N	102	26	N	Y	N	0.00	Oppurtunity for tree planting and SWM Facility.	<1/8
NSA_C_055	Powder Mill Run	MILLINEE	8.33	None	Low	N	Y	Y	N	Y	N	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	1/4

Neighborhood Information and Recommended Actions																									
Neighborhood ID	Subwatershed	Neighborhood Name	Acres	PSI	ROI	Downspout Redirect	Rain Barrel	Rain Garden	Stencil	BayScape	Lot Canopy Improvement	Fertilizer Reduction	Percent Lawns High	Pet Waste	Trash Management	Yard Trash Percentage	Buffer Impact	Street Trees	Open Space Shade Trees	Park Creation	Parking Lot Retrofit	Alley Retrofit	Street Sweeping	Other Actions	Lot Size (Acres)
NSA_C_056	Powder Mill Run	MILBROOK (ROW HOMES)	20.04	High	High	N	Y	N	Y	Y	Y	Y	20	N	Y	20	N	33	0	N	N	N	0.46	tree planting along Brookmill rd. Many backyards have debris and trash and homeowners are storing alot of misc. property outside.	1/8
NSA_C_057	Powder Mill Run	MILBROOK APARTMENTS	40.25	None	High	N	Y	Y	Y	Y	Y	N	10	N	N	0	N	33	238	N	Y	Y	0.00	Alley retrofit behind apts on Millbrook Dr., Parking lot reofit for cobblestone ct. with a good location for a BMP across from parking lots.	<1/8
NSA_C_058	Powder Mill Run	Campfield Gardens	65.84	High	High	Y	Y	Y	Y	Y	Y	Y	25	N	N	0	Y	0	0	N	N	N	3.65	N/A	1/4
NSA_C_059	Powder Mill Run	DALTON	21.29	High	High	Y	Y	Y	Y	Y	Y	Y	20	N	N	0	N	0	0	N	N	N	1.28	Remove sediment and debri from gutters.	1/8
NSA_C_060	Powder Mill Run	LOCH EARN	199.65	None	High	Y	Y	N	Y	Y	Y	N	15	Y	N	0	N	62	0	N	N	N	0.00	Some of the inlets ere stenciled, but worn off.	1/8
NSA_C_061	Powder Mill Run	SETON POINT	18.16	None	Moderate	N	Y	Y	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	Very new development and still under construction.	<1/4
NSA_C_062	Powder Mill Run	HAYWOOD HEIGHTS	18.80	None	Low	Y	Y	N	Y	N	Y	N	10	N	N	0	N	0	0	N	N	N	0.00	N/A	1/8
NSA_C_063	Gwynns Falls	POWHATAN	33.64	Moderate	High	Y	Y	N	Y	Y	Y	N	5	N	N	0	N	24	63	N	N	N	1.87	Open space tree planting at end of Robin Hill Rd. part of Robin Hill Rd. good for street tree planting.	<1/8
NSA_C_064	Gwynns Falls	KELOX WEST	19.51	None	Low	N	Y	N	Y	N	Y	N	10	N	N	0	N	0	0	N	N	N	0.00	Oppurtunity near school for SWM facility to treat the school parking lot.	1/8
NSA_C_065	Gwynns Falls	GWYNN OAK SUMMIT	42.56	Moderate	Moderate	Y	Y	N	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	1/8
NSA_C_066	Dead Run	WATERFORD PLACE (TOWN HOUSES)	20.82	Moderate	Moderate	N	Y	N	Y	Y	Y	N	5	N	N	0	Y	0	247	N	N	N	0.00	Stream buffer is not forested.	<1/8
NSA_C_067	Dead Run	CHADWICK MANOR	32.68	Moderate	High	Y	Y	N	Y	Y	Y	N	10	N	N	0	Y	242	0	N	N	N	0.00	Entire neighborhood good for tree planting. Stream buffer partly vegetated and houses encroaching.	1/4
NSA_C_068	Dead Run	ROLLING ROAD FARMS	26.39	Moderate	High	Y	Y	Y	Y	N	Y	Y	25	N	N	0	N	94	0	N	N	N	0.00	Street tree planting on Dogwood Rd. and Glen Spring Rd.	1/4
NSA_C_069	Dead Run	QUAIL MEADOWS (TOWN HOUSES)	4.45	High	Moderate	Y	Y	N	Y	N	Y	N	0	N	N	0	N	0	0	N	N	N	0.34	Street sweeping is highly recommended.	<1/8
NSa_C_070	Dead Run	CANDLEWOOD CONDOMINIUM	12.78	High	Moderate	Y	Y	N	Y	Y	N	N	0	N	N	0	N	0	57	N	N	N	0.79	Street sweeping highly recommended.	<1/8
NSA_C_071	Gwynns Falls	BROOKSTONE APARTMENTS	12.41	Moderate	High	Y	Y	N	Y	Y	Y	N	0	N	N	0	Y	94	11	N	N	N	0.00	N/A	<1/8
NSA_C_072	Gwynns Falls	WELLS MANOR	24.09	Moderate	Moderate	Y	Y	Y	Y	N	Y	N	15	N	N	0	N	0	0	N	N	N	0.00	N/A	1/8
NSA_C_073	Gwynns Falls	CLARKE MANOR APARTMENTS	16.68	High	High	Y	Y	N	Y	Y	N	N	0	N	N	0	Y	22	12	N	Y	N	0.89	Concrete-lines stream is not buffered.	<1/8
NSA_C_074	Dead Run	BROOKLAWN/ THE MEADOWS	19.98	None	Moderate	N	Y	Y	Y	N	Y	N	10	N	N	0	N	0	0	N	N	N	0.00	N/A	1/4
NSA_C_075	Dead Run	BROADACRES	38.94	Moderate	Moderate	Y	Y	N	Y	Y	Y	Y	25	N	N	0	N	0	0	N	N	N	0.00	N/A	<1/4
NSA_C_076	Gwynns Falls	STREAMWOOD II	8.98	None	Moderate	N	Y	N	N	Y	Y	N	5	N	N	0	N	0	0	N	N	N	0.00	Very new community!	1/8
NSA_C_077	Dead Run	STREAMWOOD	12.54	None	Moderate	N	Y	N	Y	Y	Y	N	10	N	N	0	N	0	35	N	N	N	0.00	N/A	1/8
NSA_C_078	Dead Run	CHADWICK MANOR	64.64	Moderate	High	Y	Y	Y	Y	Y	Y	Y	25	N	N	0	N	542	0	N	N	N	0.00	N/A	1/8
NSA_C_079	Dead Run	ROLLING ROAD APARTMENTS	23.09	Moderate	Moderate	Y	Y	N	Y	Y	Y	N	0	N	N	0	N	0	248	N	Y	N	0.00	Apartments can do some landscaping in front. Some areas of bare soil were noticed. Minor dumping near dumpsters.	<1/8
NSA_C_080	Dead Run	THE MEADOWS	14.20	Moderate	Low	N	Y	N	Y	N	N	Y	25	N	N	0	N	0	85	N	Y	N	0.00	Open space area for tree planting is owned by Baltimore Co. Potential for bio-retention at end of Sunny Ct.	1/4
NSA_C_081	Dead Run	WINDSOR TERRACE	56.36	None	Moderate	Y	Y	N	Y	N	N	N	5	N	N	0	N	0	0	N	N	N	0.00	Very old inlets.	1/8
NSA_C_082	Dead Run	HAMLET WEST APARTMENTS	13.92	None	Low	Y	Y	N	Y	N	N	N	5	N	N	0	N	0	0	N	N	N	0.00	Lids open at dumpsters. Community has very good tree planting and landscaping.	<1/8
NSA_C_083	Dead Run	CROSBY MEADOWS (TOWNHOMES)	5.10	Moderate	Moderate	N	Y	N	Y	Y	Y	N	0	N	N	0	N	0	68	N	N	N	0.00	Monor dumping in two areas.	<1/8
NSA_C_084	Dead Run	WESTVIEW PARK BY CROSBY	46.42	Moderate	High	N	Y	Y	Y	Y	Y	Y	20	N	N	0	N	157	0	N	N	N	0.00	N/A	<1/4

Neighborhood Information and Recommended Actions																									
Neighborhood ID	Subwatershed	Neighborhood Name	Acres	PSI	ROI	Downspout Redirect	Rain Barrel	Rain Garden	Stencil	BayScape	Lot Canopy Improvement	Fertilizer Reduction	Percent Lawns High	Pet Waste	Trash Management	Yard Trash Percentage	Buffer Impact	Street Trees	Open Space Shade Trees	Park Creation	Parking Lot Retrofit	Alley Retrofit	Street Sweeping	Other Actions	Lot Size (Acres)
NSA_C_085	Dead Run	WESTVIEW PARK GLENWILDE	46.23	None	Moderate	Y	Y	N	Y	N	N	N	15	N	N	0	N	150	0	N	N	N	0.00	N/A	1/8
NSA_C_086	Dead Run	DISCOVERY ACRES	44.37	None	Moderate	N	Y	Y	N	N	Y	Y	25	N	N	0	N	45	173	N	N	N	0.00	Open space for tree planting at Craigmont Rd. and Vida Dr. (owned by Baltimore Co.).	1/4
NSA_C_087	Dead Run	DISCOVERY ACRES APARTMENTS	10.49	Moderate	Low	Y	Y	N	N	N	Y	N	0	N	Y	10	N	0	24	N	Y	N	0.00	Oppurtunity for micro-bioretention near parking lot. Minor dumping/trash around dumpster.	<1/8
NSA_C_088	Dead Run	CATONSVILLE MANOR	47.63	None	Low	N	Y	N	Y	N	N	N	5	N	N	0	N	0	0	N	N	N	0.00	N/A	1/4
NSA_C_089	Dead Run	BRIGADOON (TOWN HOMES)	9.51	Moderate	High	Y	Y	N	Y	Y	Y	N	0	N	N	0	N	0	0	N	Y	N	0.73	N/A	<1/8
NSA_C_090	Dead RUn	WALDEN TOWNHOUSE APARTMENTS	47.59	High	High	Y	Y	N	N	Y	Y	N	0	N	Y	10	N	25	112	N	N	N	2.70	N/A	<1/8
NSA_C_091	Dead Run	WESTVIEW PARK	163.03	High	High	Y	Y	Y	Y	Y	N	Y	25	N	N	0	N	395	0	N	N	N	11.83	Tree planting on Kent Ave., Southridge Rd., and Craigmont Rd.	1/8
NSA_C_092	Dead Run	STRAWBERRY APARTMENTS	9.89	None	Low	N	Y	N	N	N	Y	N	0	N	N	0	N	0	61	N	N	N	0.00	There is trash around the dumpsters. Dumpsters have no lids.	<1/8
NSA_C_093	Dead Run	CATONSVILLE MANO BALTIMORE	113.89	High	High	Y	Y	N	Y	Y	Y	Y	25	N	N	0	Y	0	0	N	N	N	0.00	Inlets along Baltimore Street are stenciled (near Ingleside Ave.)	1/4
NSA_C_094	Dead Run	INGLESIDE PARK (ROW HOMES)	21.07	High	High	N	Y	N	Y	Y	Y	N	10	N	Y	10	N	72	0	N	N	N	1.00	Lots of trash and litter in Alley	<1/8
NSA_C_095	Dead Run	EDMONSON HEIGHTS ON FOREST PARK(ROW HOMES)	62.00	High	Moderate	Y	Y	N	Y	N	Y	Y	25	N	N	0	N	254	0	N	N	N	1.45	N/A	<1/8
NSA_C_096	Dead Run	EDMONSON HEIGHTS ON GRANVILLE (ROW HOMES)	47.57	Moderate	Moderate	Y	Y	N	Y	N	Y	Y	20	N	N	0	N	349	0	N	N	N	0.00	N/A	<1/8
NSA_C_097	Dead Run	WEST HILLS	8.97	Moderate	Moderate	Y	Y	N	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	1/8
NSA_C_098	Dead Run	WESTVIEW PARK SOUTH	52.18	None	Moderate	N	Y	Y	Y	Y	N	N	10	N	N	0	N	90	0	N	N	N	0.00	Street tree planting on Chesworth Rd.	1/4
NSA_C_099	Dead Run	DOUGLAS PARK	21.92	High	High	Y	Y	Y	Y	N	Y	N	10	N	Y	10	N	0	26	N	N	N	1.02	Some trash in yards.	1/4
NSA_C_100	Dead Run	WESTVIEW PARK NORTH	53.50	Moderate	High	Y	Y	Y	Y	N	Y	Y	25	N	N	0	N	68	0	N	N	N	0.00	Tree planting on Chesworth Rd.	1/4
NSA_C_101	Dead Run	VILLAGE OAKS (APARTMENTS)	15.11	Moderate	Moderate	Y	Y	Y	Y	N	N	N	0	N	Y	10	Y	0	169	N	Y	N	0.00	Community has vegetable garden. Maybe be able to do a micro-bioretention near parking lot close to stream.	<1/8
NSA_C_102	Dead Run	CATONSVILLE PINES	10.78	High	Moderate	Y	Y	N	Y	Y	N	N	5	N	Y	10	N	0	0	N	N	N	0.85	Trash on Wayman Str.	1/4
NSA_C_103	Maiden Choice Rur	WINTER HEIGHTS	11.54	Moderate	High	Y	Y	Y	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	1/8
NSA_C_104	Maiden Choice run	MAPLE WOODS	6.19	None	Low	N	Y	N	Y	N	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	<1/8
NSA_C_105	Maiden Choice Rur	THE TIMBERS	26.86	Moderate	Moderate	Y	Y	N	Y	Y	N	N	0	N	N	0	N	0	0	N	Y	N	2.02	Oppurtunity for bioretention near Cedar Run Pl.	<1/8
NSA_C_106	Maiden Choice Rur	CATONSVILLE HEIGHTS	41.83	Moderate	High	Y	Y	Y	Y	N	Y	N	0	N	N	0	Y	0	12	N	N	N	0.00	Houses encroaching on stream and stream not buffered.	1/8
NSA_C_107	Maiden Choice Rur	FERN PLACE APARTMENTS	2.20	High	High	Y	Y	N	N	Y	Y	N	0	N	N	0	Y	0	61	N	N	N	0.16	Removal of pavement at old parking lot and possibly replace with gravel lot.	<1/8
NSA_C_108	Maiden Choice Rur	MERIDALE LITTLE FARMS	42.81	Moderate	Moderate	Y	Y	N	Y	N	N	N	5	N	N	0	N	239	0	N	N	N	2.63	Street tree planting on Aldershot rd., North Bend Rd., and Plymouth Rd.	1/8
NSA_C_109	Maiden Choice Rur	OVERBROOK	15.33	None	Moderate	Y	Y	Y	Y	N	N	N	15	N	N	0	N	68	0	N	N	N	0.00	N/A	1/4
NSA_C_110	Maiden Choice Rur	CATON APARTMENTS	4.82	Moderate	Moderate	Y	Y	Y	Y	Y	Y	N	0	N	N	0	N	0	0	N	Y	N	0.00	Dumping in dumpster area. Potential for bioretention at end of first parking area.	<1/8
NSA_C_111	Maiden Choice Rur	INGLEWOOD	16.15	Moderate	Moderate	Y	Y	N	Y	Y	Y	N	10	N	N	0	N	18	0	N	N	N	0.00	Street tree planting along Edmondson Rd in the median	1/8
NSA_C_112	Maiden Choice Rur	HOLLY HOUSE APARTMENTS	2.44	None	Low	N	Y	N	N	Y	Y	N	0	N	N	0	N	0	14	N	N	N	0.00	Open space tree planting possible in front of some apartments.	<1/8
NSA_C_113	Maiden Choice Rur	NORTH PARADISE	29.49	Moderate	Low	Y	Y	N	Y	N	N	N	10	N	N	0	Y	0	0	N	N	N	0.00	N/A	<1/8
NSA_C_114	Maiden Choice Rur	MERRIL MANOR APARTMENTS	3.87	Moderate	Moderate	N	Y	N	Y	Y	Y	N	0	N	N	0	Y	0	30	N	N	N	0.00	Dumping near dumpster.	<1/8
NSA_C_115	Maiden Choice Rur	EDEN TERRACE	18.03	None	Low	N	Y	Y	Y	N	N	N	10	N	N	0	N	0	0	N	N	N	0.00	Some sediment in "v" ditch along roadway. Alot of trees in neighborhood!	1/2

Neighborhood Information and Recommended Actions																									
Neighborhood ID	Subwatershed	Neighborhood Name	Acres	PSI	ROI	Downspout Redirect	Rain Barrel	Rain Garden	Stencil	BayScape	Lot Canopy Improvement	Fertilizer Reduction	Percent Lawns High	Pet Waste	Trash Management	Yard Trash Percentage	Buffer Impact	Street Trees	Open Space Shade Trees	Park Creation	Parking Lot Retrofit	Alley Retrofit	Street Sweeping	Other Actions	Lot Size (Acres)
NSA_C_116	Maiden Choice Rur	DUNMORE	30.97	Moderate	High	Y	Y	Y	Y	N	N	Y	20	N	N	0	N	87	19	N	N	N	2.05	Open space tree planting oppurtunity at end of Dunmore rd. About 40% of driveways had grass strip going down them.	1/8
NSA_C_117	Maiden Choice Rur	MOUNT RIDGE	10.83	Moderate	Low	Y	Y	N	N	Y	N	N	0	N	N	0	N	0	0	N	N	N	0.00	Inlets stenciled on S. Symington Ave.	1/8
NSA_C_118	Scotts Level	The Village of Twelve Trees	58.77	Moderate	Moderate	N	N	N	Y	N	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	shade tree planting in open area around development	<1/8
NSA_C_119	Scotts Level	The Woodlands	74.63	Moderate	Moderate	N	N	Y	Y	N	N	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	<1/4
NSA_C_120	Scotts Level		55.99	Moderate	Moderate	Y	N	N	Y	N	Y	N	0	N	N	0	N	12	0	N	N	N	0.00	N/A	<1/4
NSA_C_121	Scotts Level	Village of Deer Park	9.49	Moderate	Moderate	N	N	N	Y	N	Y	N	0	N	N	0	N	12	280	N	N	N	0.00	shade tree planting area is east of development, owned by Baltimore Co., 1.4 acres	<1/8
NSA_C_122	Scotts Level		4.73	Moderate	Low	N	N	N	Y	N	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	potential for rain gardens on end units and either side of dead end road	<1/8
NSA_C_123	Scotts Level	Winands Village	9.60	Moderate	Moderate	N	N	N	Y	N	Y	N	0	N	N	0	N	0	12	N	N	N	0.00	shade trees in common area in middle of neighborhood	<1/8
NSA_C_124	Scotts Level	Winands Woods	10.11	Moderate	Moderate	N	N	N	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	<1/4
NSA_C_125	Scotts Level		59.17	Moderate	Moderate	N	N	Y	Y	Y	Y	N	0	N	N	0	N	20	0	N	N	N	0.00	N/A	<1/4
NSA_C_126	Scotts Level	Pikeswood Village	11.56	Moderate	Moderate	N	N	Y	Y	Y	Y	N	25	Y	N	0	N	0	0	N	N	N	0.00	N/A	<1/4
NSA_C_127	Scotts Level	Pikeswood Village	3.46	Moderate	Moderate	N	N	N	Y	N	Y	N	0	N	N	0	N	0	8	N	N	N	0.00	shade trees: Joleon and Painted Tree	<1/8
NSA_C_128	Scotts Level	Sunset Ridge Road	17.82	Moderate	Moderate	N	N	Y	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	<1/4
NSA_C_129	Scotts Level		254.29	Moderate	Moderate	N	N	N	Y	Y	Y	N	0	Y	N	0	Y	10	0	N	N	N	0.00	asphalt removal; create islands in culdesacs on: Cassandra Ct.&Collier, Eastman Rd., #3733 Trent Rd.: street trees: Offutt, Collier Rd., Cassen	<1/4
NSA_C_130	Scotts Level	Falcon Ridge	106.06	Moderate	Moderate	N	N	N	Y	Y	Y	N	0	N	N	0	N	0	40	N	N	N	0.00	Open space tree planting on Lumo Cir.	<1/4
NSA_C_131	Scotts Level		177.72	Moderate	High	N	N	Y	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	Asphalt removal: Brest Rd - end; Buffer encroachment: Wanda and Rouen (junk/debris)	1/4
NSA_C_132	Scotts Level		88.87	Moderate	Moderate	N	N	Y	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	LT cars reported	<1/4
NSA_C_133	Scotts Level		43.07	Moderate	Moderate	N	N	N	Y	Y	Y	N	10	N	N	0	N	0	0	N	N	N	0.00	LT cars reported	<1/4
NSA_C_134	Scotts Level	Belle Farms Estates	59.94	Moderate	Moderate	N	N	N	Y	Y	Y	N	5	N	N	0	N	0	0	N	N	N	0.00		<1/4
NSA_C_135	Scotts Level		215.10	Moderate	Moderate	N	N	N	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	LT cars reported; Downy Dale buffer encroachment	<1/4
NSA_C_136	Scotts Level		43.69	Moderate	Moderate	N	N	N	Y	Y	N	N	10	N	N	0	Y	0	0	N	N	N	0.00	LT cars reported. Street trees: Byron, Parkfield	<1/4
NSA_C_137	Scotts Level	Courtland Manor	13.92	Moderate	Moderate	N	N	N	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	<1/8
NSA_C_138	Scotts Level		3.05	Moderate	Moderate	N	N	N	Y	N	Y	Y	0	Y	N	0	N	0	0	N	N	N	0.00	N/A	<1/8
NSA_C_139	Scotts Level	Cedar Towers	8.42	Moderate	Moderate	N	N	N	Y	N	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	<1/8
NSA_C_140	Scotts Level		63.50	Moderate	Moderate	N	N	N	Y	Y	N	N	0	N	N	0	N	0	0	N	N	N	0.00	LT cars reported	<1/4
NSA_C_141	Scotts Level		60.05	Moderate	Moderate	N	N	N	Y	Y	Y	N	0	N	Y		Y	0	50	N	Y	N	0.00	Virunga Ct. inadequate buffer; nearly every dumpster uncovered	
NSA_C_142	Scotts Level		42.69	Moderate	Moderate	N	N	N	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	LT cars reported	<1/4
NSA_C_143	Scotts Level		42.85	Moderate	Moderate	N	N	Y	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	cars on grass on Millvale Rd. (no driveways); LT cars reported	<1/4
NSA_C_144	Scotts Level	Orchard Glen	12.18	Moderate	Moderate	N	N	N	Y	Y	Y	N	10	N	N	0	N	0	0	N	N	N	0.00		<1/4
NSA_C_145	Scotts Level	Deer Park Apartments	10.38	Moderate	Moderate	N	N	N	Y	Y	Y	N	0	N	N	0	N	0	30	N	N	N	0.00	Shade trees: corner of Marriotsville and Cervine Lane	
NSA_C_146	Scotts Level	Woodridge Apartments	31.48	Moderate	Moderate	Y	N	N	Y	Y	Y	N	0	N	N	0	Y	0	0	N	Y	N	0.00	Slated for stream restoration by EPS Capital	
NSA_C_147	Scotts Level	Pikeswood Park Apartments	6.30	Moderate	Moderate	N	N	Y	Y	Y	Y	N	0	N	N	0	N	0	50	N	N	N	0.00	Potential retrofit to keep roof water from flowing onto street	
NSA_C_148	Scotts Level	Marriot Square Apartments	8.06	None	Moderate	N	N	N	Y	Y	Y	N	0	N	N	0	N	0	20	N	N	N	0.00	Shade trees: in central courtyard and on east side	
NSA_C_149	Scotts Level	Woodholme Manor Apartments	9.89	Moderate	Moderate	N	N	N	Y	Y	Y	N	0	N	N	0	N	0	10	N	N	N	0.00	N/A	
NSA_C_150	Scotts Level	Liberty West Apartments	8.35	None	Moderate	N	N	Y	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	
NSA_C_151	Scotts Level	Randallstown Non-profit Housing Corporation	13.31	Moderate	Low	N	N	N	Y	Y	Y	N	0	N	N	0	N	0	0	N	N	N	0.00	N/A	

Neighborhood Information and Recommended Actions																									
Neighborhood ID	Subwatershed	Neighborhood Name	Acres	PSI	ROI	Downspout Redirect	Rain Barrel	Rain Garden	Stencil	BayScape	Lot Canopy Improvement	Fertilizer Reduction	Percent Lawns High	Pet Waste	Trash Management	Yard Trash Percentage	Buffer Impact	Street Trees	Open Space Shade Trees	Park Creation	Parking Lot Retrofit	Alley Retrofit	Street Sweeping	Other Actions	Lot Size (Acres)
NSA_C_152	Scotts Level	McDonogh Village	10.24	Moderate	Moderate	Y	N	N	Y	Y	Y	N	0	N	N	0	N	0	25	N	N	N	0.00	Tree planting on north side of Brice Run Rd. by pool	
NSA_C_153	Scotts Level	Lykens Court	2.57	Moderate	Moderate	N	N	N	Y	Y	Y	N	0	N	N	0	N	0	0	N	Y	N	0.00	Asphalt removal in center of p. lot - create a planted island	<1/8

Institution Information and Recommended Actions													
Site ID	Subwatershed	Name	Type	Public/ Private	Nutrient Manage- ment	# Trees for Planting	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Manage- ment	Storm Drain Marking	Buffer Improve- ment	Notes
ISI_C_101	Gwynns Falls	NER ISRAEL RABBINICAL COLLEGE	College	Private	N	476	N	N	N	Y	N	N	TP; Hazardous Mat.
ISI_C_102	Gwynns Falls	WOODHOME COUNTRY CLUB	Golf Course	Private	Y	796	N	N	N	Y	Y	Y	TP, Nutrient; unprot stockpiles by buff; Dumpster
ISI_C_103	Gwynns Falls	NORTH OAKS RETIREMENT COMMUNITY	Care Facility	Private	N	156	N	N	N	Y	Y	N	TP' "Grease" Dumpster Leaking
ISI_C_104	Gwynns Falls	WINAND ELEMENTARY SCHOOL	Elementary School	Public	N	245	Y	N	N	Y	Y	N	TP; SWM
ISI_C_105	Gwynns Falls	OLD COURT MIDDLE SCHOOL	Middle School	Public	N	128	Y	N	N	Y	Y	N	SWM; TP; Dumpster Leaking into inlet
ISI_C_106	Gwynns Falls	COURTLAND GARDENS NURSING CENTER	Care Facility	Private	N	0	N	N	N	N	Y	N	New Ex. SWM; Newly planted; SD Marking
ISI_C_107	Gwynns Falls	BLESSED TRINITY CHURCH OF DELIVERENCE	Faith-Based	Private	N	9	N	Y	N	N	N	N	TP, Disconnect
ISI_C_108	Gwynns Falls	TALMUDICAL ACADEMY OF BALTIMORE	High School	Private	N	43	Y	Y	Y	Y	Y	N	Trash, drains clogged, Disc.; imp rem; TP; SWM
ISI_C_109	Gwynns Falls	ST PAUL'S EVANGELICAL LUTHERAN CHURCH	Faith-Based	Private	N	29	N	Y	N	N	Y	N	Disco; TP; SD Marking
ISI_C_110	Gwynns Falls	MILFORD MILL UNITED METHODIST CHURCH	Faith-Based	Private	N	140	N	Y	N	N	N	N	TP; Disconnect
ISI_C_111	Gwynns Falls	BEDFORD ELEMENTARY & SUDBROOK MAGNET MIDDLE SCHOOL	Elementary School	Public	N	103	Y	N	N	Y	Y	N	TP; SWM; Inlets not marked
ISI_C_112	Gwynns Falls	HEBBVILLE ELEMENTARY SCHOOL	Elementary School	Public	N	297	Y	N	Y	Y	Y	N	TP; SWM Imp. Removal
ISI_C_113	Gwynns Falls	AUGSBURG LUTHERAN HOME AND VILLAGE	Care Facility	Private	N	248	N	N	N	Y	Y	N	TP; leaking dumpster; 55-gal on grass; const mat

Institution Information and Recommended Actions													
Site ID	Subwatershed	Name	Type	Public/ Private	Nutrient Manage-ment	# Trees for Planting	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Manage-ment	Storm Drain Marking	Buffer Improve-ment	Notes
ISI_C_114	Gwynns Falls	EPWORTH UNITED METHODIST CHAPEL	Faith-Based	Private	N	91	N	Y	N	N	Y	N	TP; SD Marking
ISI_C_115	Gwynns Falls	WOODMOOR ELEMENTARY SCHOOL	Elementary School	Public	N	230	N	N	N	Y	Y	Y	TP; Leaking Dumpster; EX. SWM; buff plant
ISI_C_116	Gwynns Falls	RISING SUN FIRST BAPTIST CHURCH	Faith-Based	Private	N	0	N	N	N	N	Y	N	Bare Soil; Inlets not Marked
ISI_C_117	Gwynns Falls	WOODLAWN MIDDLE SCHOOL	Middle School	Public	N	989	Y	N	Y	Y	N	N	much TP; imp rem; SWM; dumpster
ISI_C_118	Gwynns Falls	WOODLAWN MEMORIAL CEMETARY	Cemetary	Private	N	448	N	N	N	Y	Y	Y	TP at Buffer; Dumpster trash; SD; erosion; trash
ISI_C_119	Gwynns Falls	Pikesville Senior Center	Community Center	Public	N	4	N	Y	N	Y	N	N	Dumpster spilled; poor landscaping; TP; Discon.
ISI_C_120	Gwynns Falls	ST CHARLES BORROMEOS	Faith-Based	Private	N	0	Y	N	N	Y	Y	N	SWM; SD Marking
ISI_C_121	Gwynns Falls	WOODLAWN POLICE PRECINCT 2	Fire & Rescue	Public	N	19	N	N	N	Y	Y	Y	TP; Buff plant; concrete stream
ISI_C_122	Gwynns Falls	WOODLAWN SENIOR CENTER	Community Center	Public	N	39	N	N	Y	Y	Y	Y	Imp rem; buff plant; TP; concrete stream
ISI_C_123	Gwynns Falls	ST LUKES CHURCH	Faith-Based	Private	N	8	N	Y	N	N	Y	N	SD MArking; Small Area for TP
ISI_C_124	Gwynns Falls	ETHIOPIAN ORTHODOX TEWAHDO MEKANE	Faith-Based	Private	N	0	N	Y	N	Y	N	N	Heating Oil Tank in Grass; Disconnect
ISI_C_125	Gwynns Falls	SENIOR CENTER - WINDSOR MILL ROAD	Care Facility	Private	N	5	N	N	N	Y	N	N	Dumpster Overflowing' TP; Parking Lot breaking up
ISI_C_201	Powder Mill	MARYLAND STATE POLICE	Fire & Rescue	Public	N	97	N	N	N	Y	Y	N	TP; SD Marking
ISI_C_202	Powder Mill	CAMPFIELD EARLY CHILDHOOD LEARNING & DEVP CENTR	Elementary School	Public	N	183	Y	N	Y	Y	Y	N	Dumpster overflowing; imp. rem.; TP; SWM
ISI_C_301	Dead Run	BALTIMORE COUNTY FIRE STATION 3	Fire & Rescue	Public	N	0	N	N	N	Y	Y	N	Uncovered Fueling; Dumpster; EX. SWM

Institution Information and Recommended Actions

Site ID	Subwatershed	Name	Type	Public/ Private	Nutrient Manage-ment	# Trees for Planting	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Manage-ment	Storm Drain Marking	Buffer Improve-ment	Notes
ISI_C_302	Dead Run	JOHN PAUL REGIONAL CATHOLIC SCHOOL	Middle School	Private	N	132	Y	Y	N	N	Y	Y	TP by Stream; SWM; Disconnect; Dumpster Good
ISI_C_303	Dead Run	TEMPLE BAPTIST CHURCH OF BALTIMORE CITY	Faith-Based	Private	N	144	N	N	N	N	N	N	TP; dumpster good; parking lot braking up
ISI_C_304	Dead Run	WOODLAWN HIGH SCHOOL	High School	Public	N	1417	N	N	N	Y	Y	Y	Many TP some in Buffer; EX SWM; Uncovered Fueling
ISI_C_305	Dead Run	CHURCH OF CHRIST IN WOODLAWN	Faith-Based	Private	N	0	N	Y	N	N	Y	N	Ex. SWM diversion berm needs repair; bare soil
ISI_C_306	Dead Run	SOUTHWEST ACADEMY FOR ARTS & SCIENCES	Middle School	Public	N	450	Y	N	N	Y	Y	N	SWM; TP; Dumpster drains to inlet; SD
ISI_C_307	Dead Run	JOHNNYCAKE ELEMENTARY SCHOOL	Elementary School	Public	N	44	Y	Y	N	Y	Y	N	SWM; TP; Inlet clogged; Dumpster leaking
ISI_C_308	Dead Run	EDMONSON HEIGHTS ELEMENTARY SCHOOL	Elementary School	Public	N	128	Y	N	N	Y	Y	N	SWM; TP; dumpster ok; SD
ISI_C_401	Maidens Choice	WESTOWNE ELEMENTARY SCHOOL	Elementary School	Public	N	201	Y	N	N	Y	Y	N	Bare Soil; TP; SWM retro; dumpster to SD
ISI_C_402	Maidens Choice	MOUNT DE SALES ACADEMY	High School	Private	N	0	N	Y	N	Y	Y	N	trash Poor E&S from Construction practices
ISI_C_403	Maidens Choice	CHRISTIAN TEMPLE	Faith-Based	Private	N	0	N	Y	N	N	Y	N	Ex. SWM; Bare Earth; Disconnect
ISI_C_404	Maidens Choice	MORNING STAR BAPTIST CHURCH	Faith-Based	Private	N	3	N	Y	N	Y	Y	N	3 TP; dumpster to inlet; parking lot breaking
ISI_C_405	Maidens Choice	FOREST HAVEN NURSING HOME	Care Facility	Private	N	0	N	Y	N	N	N	N	Disconnect; Dumpster ok
ISI_C_501	Scotts Level	Deer Park ES	Elementary School	Public	Y	220	N	N	N	Y	N	N	N/A
ISI_C_502	Scotts Level	Deer Park MS	Middle School	Public	Y	340	N	N	N	Y	Y	N	N/A
ISI_C_503	Scotts Level	Liberty Road Volunteer Fire Dept.	Fire_Rescue	Private	N	156	Y	N	N	N	Y	N	N/A
ISI_C_504	Scotts Level	Church Lane ES	Elementary School	Public	Y	520	N	N	N	Y	Y	N	N/A

Institution Information and Recommended Actions													
Site ID	Subwatershed	Name	Type	Public/ Private	Nutrient Management	# Trees for Planting	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management	Storm Drain Marking	Buffer Improvement	Notes
ISI_C_505	Scotts Level	Randallstown HS	High School	Public	Y	400	Y	N	Y	N	Y	N	N/A
ISI_C_506	Scotts Level	Mount Olive United Methodist Church	Faith-Based	Private	N	15	N	N	Y	Y	N	N	N/A
ISI_C_507	Scotts Level	Greater Bethlehem Temple Church	Faith-Based	Private	N	420	Y	N	N	N	N	N	Remove added stone around p. lot
ISI_C_508	Scotts Level	Scotts Branch ES	Elementary School	Public	Y	80	N	N	N	Y	Y	N	N/A
ISI_C_509	Scotts Level	Chimes Inc.	Care Facility	Private	N	40	N	N	N	N	N	Y	Request Chimes to stop mowing SW pond
ISI_C_510	Scotts Level	Milford Mill Swim Club	Swim	Private	N	0	N	N	Y	Y	N	Y	Owner is trying to sell property (in disrepair)
ISI_C_511	Scotts Level	Milford Mill Academy HS	High School	Public	Y	200	N	N	N	Y	Y	N	Addition under construction

Hotspot Information and Recommended Actions																			
Subwatershed	Site_ID	Hot Spot Status	Refer for Enforce-ment	Follow Up Inspection	Test for IDDE	Education	Check NDPES Permit	On Site Retrofit	PAA	Review SW PPP	Business Type	Category	Vehicle Operations	Outdoor Materials	Waste Manage-ment	Physical Plant	Turf/ Land-scaping	Storm Water	Comments
Gwynns Falls	HSI_C_101	Confirmed Hot Spot	N	N	N	Y	Y	N	N	N	Gas Station	Commercial	Y	Y	Y	Y	Y	Y	55-gal on grass; dumpster leaking
Gwynns Falls	HSI_C_102	Potential Hot Spot	N	N	N	Y	Y	N	N	N	Metro Stop Parking Lot	Transport-Related	Y	N	Y	N	Y	N	dumpster staining; trash; staining at bus stop
Gwynns Falls	HSI_C_103	Potential Hot Spot	N	N	N	Y	Y	N	N	N	Gas Station	Commercial	Y	N	Y	Y	Y	N	Dumpster Trqash spilled
Gwynns Falls	HSI_C_104	Potential Hot Spot	N	N	N	Y	Y	N	N	N	Gas Station	Commercial	Y	N	Y	Y	Y	N	Fuel station uncovered; dumspter trash spilled
Gwynns Falls	HSI_C_105	Severe Hot Spot	Y	Y	Y	Y	Y	N	N	N	Gas Station and Car Care	Commercial	Y	Y	Y	Y	Y	N	55-gal drums on grass and leaking; haz mat; stores cars leaking
Gwynns Falls	HSI_C_106	Confirmed Hot Spot	N	N	N	Y	Y	N	N	N	Gas Station and Car Care	Commercial	Y	Y	Y	N	N	N	55-gal drums outside, car staining
Gwynns Falls	HSI_C_107	Not a Hot Spot	N	N	N	Y	N	N	N	N	Animal Hospital	Animal Facility	N	N	Y	N	N	N	Parking lot poor; exc. imp.; dumpster lid open
Gwynns Falls	HSI_C_108	Potential Hot Spot	N	Y	Y	Y	Y	N	N	Y	Car Wash	Commercial	Y	N	Y	N	Y	N	Parking lot full of stains; trash in gutters; dumpster to inlet; wash to drain
Gwynns Falls	HSI_C_109	Potential Hot Spot	N	N	N	Y	Y	N	N	N	Gas Station	Commercial	Y	Y	Y	N	N	N	Dumpster Trash; 55-gal; outdoor propane
Powder Mill Run	HSI_C_201	Confirmed Hot Spot	N	N	N	Y	Y	N	N	N	Car Repair	Commercial	Y	Y	Y	Y	N	N	Used Oil Container with stains on lot; lot breaking up
Powder Mill	HSI_C_202	Potential Hot Spot	N	N	N	Y	Y	N	Y	N	Metro Stop Parking Lot	Transport-Related	Y	N	Y	Y	Y	Y	imp. rem.; staining at bus stop; dumpster leaking
Powder Mill Run	HSI_C_203	Potential Hot Spot	N	N	N	Y	N	N	N	N	Car Dealership	Commercial	Y	Y	Y	Y	N	N	Uncovered Heating Oil; Materials Stored Outside
Dead Run	HSI_C_301	Confirmed Hot Spot	N	N	N	Y	Y	N	N	N	Bus Storage	Transport-Related	Y	Y	Y	N	N	N	uncovered fueling; mat. outside; staining
Dead Run	HSI_C_302	Confirmed Hot Spot	N	N	N	Y	Y	N	N	N	Gas and Electric	Municipal	Y	Y	Y	Y	Y	Y	outside material; ex. SWM; machine shop; leaking vehicles
Dead Run	HSI_C_303	Confirmed Hot Spot	N	N	N	Y	Y	N	N	N	Car Sales and Auto Repair	Commercial	Y	Y	Y	Y	N	Y	Ex.SWM; Unmarked Drums; Parking lot breaking up; car parts outside
Dead Run	HSI_C_304	Confirmed Hot Spot	N	Y	N	Y	Y	N	Y	N	Shopping Center/ Mall	Commercial	Y	Y	Y	Y	Y	Y	Grand Auto Body Shop Worst; Imp. Rem areas; trash
Dead Run	HSI_C_305	Confirmed Hot Spot	N	N	N	Y	Y	N	N	N	Hardware Store/ Garden Center	Commercial	Y	Y	Y	Y	N	N	Mulch on Parking Lot; Trash
Dead Run	HSI_C_306	Potential Hot Spot	N	N	N	Y	Y	N	N	N	Car Wash	Commercial	Y	N	Y	N	Y	N	Trash in inlet; runoff to private drain
Dead Run	HSI_C_307	Potential Hot Spot	N	N	N	Y	N	N	N	N	Maintenance Shop	Municipal	Y	Y	Y	N	Y	N	Equipment stored on grass; dumpster leaking
Dead Run	HSI_C_308	Potential Hot Spot	N	N	N	Y	Y	N	N	N	Gas Station	Commercial	Y	Y	Y	N	Y	N	Dumpster overflowing; staining on lot; trash stored on ground
Dead Run	HSI_C_309	Confirmed Hot Spot	N	Y	Y	Y	Y	N	N	N	Construction	Industrial	Y	Y	Y	N	N	N	stream borders property; mater. stored outside; messy lot
Dead Run	HSI_C_310	Confirmed Hot Spot	N	N	N	Y	Y	N	N	N	Construction - Education	Industrial	Y	Y	Y	N	N	N	lot sheetflows to stream; material stored in woods; org. on pavement
Dead Run	HSI_C_311	Confirmed Hot Spot	N	Y	N	Y	Y	N	N	N	Construction Materials	Industrial	N	Y	Y	Y	Y	N	Outdoor stored Materials; stream buffer; Trash
Dead Run	HSI_C_312	Potential Hot Spot	N	N	N	Y	Y	N	N	Y	Shopping Center	Commercial	N	Y	Y	Y	Y	Y	grease dumpster leaking; much trash
Dead Run	HSI_C_313	Confirmed Hot Spot	N	N	N	Y	Y	N	N	N	Hardware Store/ Garden Center	Commercial	Y	Y	Y	Y	Y	N	Garden area draining to inlet; trash; loading areas drain to inlet
Maidens Choice Run	HSI_C_401	Confirmed Hot Spot	N	N	N	Y	Y	N	N	N	Car Dealership	Commercial	Y	N	Y	N	Y	N	Unmarked containers; staining on lot; dumpster leaking

Hotspot Information and Recommended Actions

Subwatershed	Site_ID	Hot Spot Status	Refer for Enforce-ment	Follow Up Inspection	Test for IDDE	Education	Check NDPES Permit	On Site Retrofit	PAA	Review SW PPP	Business Type	Category	Vehicle Operations	Outdoor Materials	Waste Manage-ment	Physical Plant	Turf/ Land-scaping	Storm Water	Comments
Maiden Choice Run	HSI_C_402	Confirmed Hot Spot	N	N	N	Y	Y	N	N	N	Gas Station, Auto Repair and Car Wash	Commercial	Y	N	Y	Y	N	N	Dumpster and Car Wash Draining to Inlet, auto repair ok; inlet clogged
Scotts Level	HSI_C_501	Potential Hot Spot	N	N	N	N	N	N	N	N	RV sales/service	Commercial	Y	N	N	N	N	N	N/A
Scotts Level	HSI_C_502	Confirmed Hot Spot	Y	Y	N	N	N	N	N	N	Bowling alley	Commercial	N	N	Y	N	N	N	Trash by dumpster was cleaned up
Scotts Level	HSI_C_503	Not a Hot Spot	N	N	N	N	N	N	N	N	shopping center	Commercial	N	N	N	N	N	N	N/A
Scotts Level	HSI_C_504	Confirmed Hot Spot	N	Y	N	Y	N	Y	Y	N	shopping center	Commercial	N	Y	Y	Y	N	Y	trash on site; trash dumped by Uhaul parking; 7+ cats living behind the stores
Scotts Level	HSI_C_505	Potential Hot Spot	Y	N	N	N	Y	N	N	N	car dealer	Commercial	Y	Y	Y	Y	N	Y	potential IC removal (area along Burmont is failing); IC seems excessive
Scotts Level	HSI_C_506	Potential Hot Spot	N	N	N	N	Y	N	N	N	Building supply/equipment rental	Commercial	Y	Y	Y	N	N	N	lots of equipment on the ground uncovered
Scotts Level	HSI_C_507	Not a Hot Spot	N	N	N	N	N	N	N	N	shopping center	Commercial	N	N	Y	N	N	N	N/A
Scotts Level	HSI_C_508	Potential Hot Spot	N	N	N	N	N	N	N	N	shopping center	Commercial	N	N	Y	N	N	N	IC removal at Tawnmore/Rolling
Scotts Level	HSI_C_509	Not a Hot Spot	N	N	N	N	N	N	N	N	Chinese restaurant	Commercial	N	N	Y	N	N	N	potential IC removal
Scotts Level	HSI_C_510	Confirmed Hot Spot	Y	N	N	N	N	N	N	N	shopping center	Commercial	N	N	Y	N	N	N	IC removal of back parking lot
Scotts Level	HSI_C_511	Not a Hot Spot	N	N	N	N	N	N	N	N	shopping center	Commercial	N	N	Y	N	N	N	N/A
Scotts Level	HSI_C_512	Potential Hot Spot	N	N	N	N	Y	N	N	N	car dealer (new and used)	Commercial	Y	Y	Y	Y	N	Y	N/A
Scotts Level	HSI_C_513	Not a Hot Spot	N	N	N	N	Y	N	N	Y	heating oil distribution site	Industrial	N	N	Y	N	N	N	a model site

APPENDIX C:

SUPPORTING CALCULATIONS FOR NSA ANALYSIS

Supporting Calculations for NSA Analysis

Downspout Disconnection

Table 4-2 in the Middle Gwynns Falls Watershed Characterization Report summarizes rooftop acres and % of subwatershed rooftop area addressed by downspout redirection for the recommended neighborhoods. The method in which these two columns were calculated is described below.

Rooftop Acres Addressed

Only NSAs recommended for downspout redirection contribute to this analysis. Rooftop acres addressed by redirecting downspouts in a recommended neighborhood were calculated as follows:

Acres of Buildings x %Connected Downspouts

For example, NSA_C_002 was recommended for downspout redirect and has a total of 3.12 acres of buildings (i.e., rooftop) based on Baltimore County's GIS buildings layer. During the uplands survey, it was estimated that 60% of the downspouts in NSA_C_002 were directed onto impervious surfaces. Therefore, the total rooftop acres addressed by redirecting downspouts in this neighborhood would be 3.12 acres x 0.60 = 1.87 acres.

In some cases, NSAs encompass more than one subwatershed. The rooftop acres addressed for a given subwatershed is calculated as the total rooftop acres in the NSA multiplied by the proportion of the NSA area within that subwatershed. NSA_C_063, for example, overlaps Gwynns Falls and Powder Mill Run where 78.4% of its area is within Gwynns Falls and 21.6% is within Powder Mill Run. During the uplands survey, it was estimated that 30% of the downspouts in NSA_C_063 were directed onto impervious surfaces. The rooftop acres addressed by redirecting downspouts in NSA_C_063 in Gwynns Falls were calculated as 6.17 acres x 0.784 x 0.3 = 1.5 acres. The rooftop acres addressed through redirecting downspouts in Powder Mill Run would be 6.17 acres x 0.216 x 0.3 = 0.4 acres.

% of Subwatershed Rooftop Area Addressed

For a given subwatershed, the % of subwatershed rooftop area addressed by downspout redirection was calculated as:

Σ Individual NSA Rooftop Acres Addressed / Total Subwatershed Rooftop Acres

The total acres of rooftop within a subwatershed were determined using Baltimore County's GIS buildings layer.

Bayscaping

Table 4-3 in the Middle Gwynns Falls Watershed Characterization Report summarizes the acres of land and % of subwatershed area addressed by bayscaping for the recommended neighborhoods. The method in which these two columns were calculated is described below.

Acres of Land Addressed

Only NSAs recommended for bayscaping contributed to this analysis. Acres of land addressed by bayscaping in a recommended neighborhood were calculated as follows:

(NSA Total Acres - NSA Road Acres) x %Lot Available for Bayscaping

The first expression in parentheses in the equation above represents the total acres of individual lots in an NSA. According to CWP, the minimum recommended proportion of bayscaping is 10% of an individual lot. Therefore, the %Lot Available for Bayscaping was calculated as 10% minus the fraction of existing landscaping of a typical lot in a recommended NSA. Multiplying these two factors yields the total acres of land in an NSA recommended/available for bayscaping. For example, NSA_C_001 was recommended for bayscaping and has a total area of 24.31 acres. Based on Baltimore County's GIS layers, there are approximately 1.25 acres of roads and 1.03 acres of buildings in this NSA. This means NSA_ C_001 consists of approximately 24.31 – 1.25 – 1.03 = 22.03 acres of total lots. During the uplands survey, it was estimated that the average lot in NSA_ C_001 already consisted of 75% grass cover and 5% landscaping. This means 10% – 5% = 5% would be recommended for additional bayscaping. At max, this equates to 22.03 acres x 0.75 = 16.5 acres of land could be addressed by bayscaping in this NSA.

As mentioned above, some NSAs encompass more than one subwatershed. The acres of land addressed for a given subwatershed is calculated as the total acres of land recommended for bayscaping in the NSA multiplied by the proportion of the NSA area within that subwatershed. NSA_ C_58, for example, overlaps Gwynns Falls and Powder Mill Run where 0.3% of its area is within Gwynns Falls and 99.7% is within Powder Mill Run. The acres of land addressed by bayscaping in NSA_ C_58 in Gwynns Falls were calculated as 28.26 acres x 0.003 = 0.08 acres. The acres of land addressed through bayscaping in Powder Mill Run would be 28.26 acres x 0.997 = 28.27 acres.

% of Subwatershed Area Addressed

For a given subwatershed, the % of the total subwatershed area addressed by bayscaping was calculated as:

Σ Individual NSA Land Acres Addressed / Total Subwatershed Acres

Storm Drain Marking

Table 4-4 in the Middle Gwynns Falls Characterization Report summarizes the number of inlets and % of subwatershed inlets addressed by storm drain marking for the recommended neighborhoods. The method in which these two columns were calculated is described below.

Approximate No. of Inlets Addressed

Only NSAs recommended for storm drain marking contributed to this analysis. The approximate number of inlets addressed in a neighborhood recommended for storm drain marking was calculated as follows:

NSA Area [sq miles] x Subwatershed Inlet Density [#inlets/sq mile]

The approximate number of inlets was determined for all five subwatersheds in Middle Gwynns Falls using Baltimore County's storm drain system database. Inlet density for each subwatershed was calculated as the number of inlets divided by the total subwatershed area (see Section 2.3.8.1).

As mentioned previously, some NSAs encompass more than one subwatershed. For these cases, the number of inlets addressed for a given subwatershed was calculated using the results from the equation above multiplied by the proportion of the NSA area within that subwatershed. For example, NSA_C_052 was recommended for storm drain marking and has a total area of 77.44 acres or 0.121 square miles. NSA_ C_052 overlaps Gwynns Falls and Powder Mill Run where 46.2% of its area is within Gwynns Falls and 53.8% is within Powder Mill Run. The number of inlets addressed by storm drain marking for this NSA in Gwynns Falls would be 0.121 sq miles x 90.9 inlets/sq mile x 0.462 = 5.1 (~5 inlets). The number of inlets addressed by storm drain marking for this NSA in Powder Mill Run would be 0.121 sq miles x 88.9 inlets/sq mile x 0.538 = 5.8 inlets (~6 inlets). The total number of inlets addressed within a subwatershed was rounded to the nearest whole number.

% of Subwatershed Inlets Addressed

For a given subwatershed, the % of the total subwatershed inlets addressed for storm drain marking was calculated as:

Σ Individual NSA Inlets Addressed / Total Subwatershed Inlets

Street Trees and Shade Trees

Table 4-5 in the Middle Gwynns Falls Watershed Characterization Report summarizes the number of street trees that could be planted in each subwatershed if this action were addressed for the recommended neighborhoods. Similarly, Table 4-6 of the report summarizes the number of open space shade trees that could be planted if this action were addressed for the recommended neighborhoods. The number of street trees recommended for each neighborhood was estimated during the uplands survey based on available space as described in Section 4.2.3.4.

For NSAs encompassing more than one subwatershed, the total number of recommended street trees was multiplied by the proportion of the NSA area within each subwatershed. NSA_C_60, for example, overlaps Gwynns Falls and Powder Mill Run where 37.7% of its area is within Gwynns Falls and 62.3% is within Powder Mill Run. The total number of street trees recommended for NSA_ C_60 was 75. The number of street trees recommended for NSA_ C_60 in Gwynns Fall was calculated as 75 x 0.377 = 28 trees. The number of street trees recommended for NSA_C_60 in Powder Mill Run would be 75 x 0.623 = 47 trees.

A similar example can be made for the calculation of shade trees in NSA_C_77, which overlaps Gwynns Falls by 89% and Dead Run by 11%. A total of 26 shade trees were recommended for this neighborhood during the uplands survey. The number of shade trees recommended for NSA_ C_77 in Gwynns Falls was calculated as 26 x 0.89 = 23 trees. The number of shade trees recommended for NSA_ C_77 in Dead Run would be 26 x 0.11 = 3 trees.

Street Sweeping

Table 4-7 in the Middle Gwynns Falls Watershed Characterization Report summarizes the miles of road recommended for street sweeping in each subwatershed. If a neighborhood was recommended for street sweeping, all roads in the neighborhood counted toward the total miles that would be addressed by this action. Miles of road in each neighborhood were determined based on Baltimore County’s GIS roads layer. For NSAs encompassing more than one subwatershed, the total miles addressed by street sweeping was multiplied by the proportion of the NSA area within each subwatershed.

Trash Management

Table 4-8 in the Middle Gwynns Falls Watershed Characterization Report summarizes the acres of land and % of subwatershed area addressed by trash management for the recommended neighborhoods. The method in which these two columns were calculated is described below.

Acres of Land Addressed

Neighborhoods were recommended for trash management during the uplands survey if 10% or more of homes in the neighborhood contained trash or other indications of trash. Acres of land addressed by trash management in a recommended neighborhood were simply taken as the total area of the NSA. Only NSAs recommended for trash management contributed to the total acres of land addressed by this action in each subwatershed.

% of Subwatershed Area Addressed

For a given subwatershed, the % of the total subwatershed area addressed by trash management was calculated as:

$$\Sigma \textit{ Individual NSA Acres Addressed / Total Subwatershed Acres}$$

APPENDIX F:

Chesapeake Bay TMDL Executive Summary

CHESAPEAKE BAY TMDL EXECUTIVE SUMMARY

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has established the Chesapeake Bay Total Maximum Daily Load (TMDL), a historic and comprehensive “pollution diet” with rigorous accountability measures to initiate sweeping actions to restore clean water in the Chesapeake Bay and the region’s streams, creeks and rivers.

Despite extensive restoration efforts during the past 25 years, the TMDL was prompted by insufficient progress and continued poor water quality in the Chesapeake Bay and its tidal tributaries. The TMDL is required under the federal Clean Water Act and responds to consent decrees in Virginia and the District of Columbia from the late 1990s. It is also a keystone commitment of a federal strategy to meet President Barack Obama’s Executive Order to restore and protect the Bay.

The TMDL – the largest ever developed by EPA – identifies the necessary pollution reductions of nitrogen, phosphorus and sediment across Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia and the District of Columbia and sets pollution limits necessary to meet applicable water quality standards in the Bay and its tidal rivers and embayments. Specifically, the TMDL sets Bay watershed limits of 185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus and 6.45 billion pounds of sediment per year – a 25 percent reduction in nitrogen, 24 percent reduction in phosphorus and 20 percent reduction in sediment. These pollution limits are further divided by jurisdiction and major river basin based on state-of-the-art modeling tools, extensive monitoring data, peer-reviewed science and close interaction with jurisdiction partners.

The TMDL is designed to ensure that all pollution control measures needed to fully restore the Bay and its tidal rivers are in place by 2025, with at least 60 percent of the actions completed by 2017. The TMDL is supported by rigorous accountability measures to ensure cleanup commitments are met, including short-and long-term benchmarks, a tracking and accountability system for jurisdiction activities, and federal contingency actions that can be employed if necessary to spur progress.

Watershed Implementation Plans (WIPs), which detail how and when the six Bay states and the District of Columbia will meet pollution allocations, played a central role in shaping the TMDL. Most of the draft WIPs submitted by the jurisdictions in September 2010 did not sufficiently identify programs needed to reduce pollution or provide assurance the programs could be implemented. As a result, the draft TMDL issued September 24, 2010 contained moderate- to high-level backstop measures to tighten controls on federally permitted point sources of pollution.

A 45-day public comment period on the draft TMDL was held from September 24 to November 8, 2010. During that time, EPA held 18 public meetings in all seven Bay watershed jurisdictions, which were attended by about 2,500 citizens. EPA received more than 14,000 public comments and, where appropriate, incorporated responses to those comments in developing the final TMDL.

After states submitted the draft WIPs, EPA worked closely with each jurisdiction to revise and strengthen its plan. Because of this cooperative work and state leadership, the final WIPs were significantly improved. Examples of specific improvements include:

- Regulated point sources and non-regulated nonpoint sources of nitrogen, phosphorus, and sediment are fully considered and evaluated separately in terms of their relative contributions to water quality impairment of the Chesapeake Bay's tidal waters.
- Committing to more stringent nitrogen and phosphorus limits at wastewater treatment plants, including on the James River in Virginia. (Virginia, New York, Delaware)
- Pursuing state legislation to fund wastewater treatment plant upgrades, urban stormwater management and agricultural programs. (Maryland, Virginia, West Virginia)
- Implementing a progressive stormwater permit to reduce pollution. (District of Columbia)
- Dramatically increasing enforcement and compliance of state requirements for agriculture. (Pennsylvania)
- Committing state funding to develop and implement state-of-the-art-technologies for converting animal manure to energy for farms. (Pennsylvania)
- Considering implementation of mandatory programs for agriculture by 2013 if pollution reductions fall behind schedule. (Delaware, Maryland, Virginia)

These improvements enabled EPA to reduce and remove most federal backstops, leaving a few targeted backstops and a plan for enhanced oversight and contingency actions to ensure progress. As a result, the final TMDL is shaped in large part by the jurisdictions' plans to reduce pollution, which was a long-standing priority for EPA and why the agency always provided the jurisdictions with flexibility to determine how to reduce pollution in the most efficient, cost-effective and acceptable manner.

Now the focus shifts to the jurisdictions' implementation of the WIP policies and programs that will reduce pollution on-the-ground and in-the-water. EPA will conduct oversight of WIP implementation and jurisdictions' progress toward meeting two-year milestones. If progress is insufficient, EPA is committed to take appropriate contingency actions including targeted compliance and enforcement activities, expansion of requirements to obtain NPDES permit coverage for currently unregulated sources, revision of the TMDL allocations and additional controls on federally permitted sources of pollution, such as wastewater treatment plants, large animal agriculture operations and municipal stormwater systems.

In 2011, while the jurisdictions continue to implement their WIPs, they will begin development of Phase II WIPs, designed to engage local governments, watershed organizations, conservation districts, citizens and other key stakeholders in reducing water pollution.

TMDL BACKGROUND

The Clean Water Act (CWA) sets an overarching environmental goal that all waters of the United States be "fishable" and "swimmable." More specifically it requires states and the District of Columbia to establish appropriate uses for their waters and adopt water quality standards that are protective of those uses. The CWA also requires that every two years jurisdictions develop – with EPA approval – a list of waterways that are impaired by pollutants and do not meet water quality standards. For those waterways identified on the impaired list, a TMDL must be developed. A TMDL is essentially a “pollution diet” that identifies the maximum amount of a pollutant the waterway can receive and still meet water quality standards.

Most of the Chesapeake Bay and its tidal waters are listed as impaired because of excess nitrogen, phosphorus and sediment. These pollutants cause algae blooms that consume oxygen and create “dead zones” where fish and shellfish cannot survive, block sunlight that is needed for underwater Bay grasses, and smother aquatic life on the bottom. The high levels of nitrogen, phosphorus and sediment enter the water from agricultural operations, urban and suburban stormwater runoff, wastewater facilities, air pollution and other sources, including onsite septic systems. Despite some reductions in pollution during the past 25 years of restoration due to efforts by federal, state and local governments; non-governmental organizations; and stakeholders in the agriculture, urban/suburban stormwater, and wastewater sectors, there has been insufficient progress toward meeting the water quality goals for the Chesapeake Bay and its tidal waters.

More than 40,000 TMDLs have been completed across the United States, but the Chesapeake Bay TMDL will be the largest and most complex thus far – it is designed to achieve significant reductions in nitrogen, phosphorus and sediment pollution throughout a 64,000-square-mile watershed that includes the District of Columbia and large sections of six states. The TMDL is actually a combination of 92 smaller TMDLs for individual Chesapeake Bay tidal segments and includes pollution limits that are sufficient to meet state water quality standards for dissolved oxygen, water clarity, underwater Bay grasses and chlorophyll-*a*, an indicator of algae levels (Figure ES-1). It is important to note that the pollution controls employed to meet the TMDL will also have significant benefits for water quality in tens of thousands of streams, creeks, lakes and rivers throughout the region.

Since 2000, the seven jurisdictions in the Chesapeake Bay watershed (Delaware, District of Columbia, Maryland, New York, Pennsylvania, Virginia, and West Virginia), EPA and the Chesapeake Bay Commission, which are partners in the Chesapeake Bay Program, have been planning for a Chesapeake Bay TMDL.

Since September 2005, the seven jurisdictions have been actively involved in decision-making to develop the TMDL. During the October 2007 meeting of the Chesapeake Bay Program’s Principals’ Staff Committee, the Bay watershed jurisdictions and EPA agreed that EPA would establish the multi-state TMDL. Since 2008, EPA has sent official letters to the jurisdictions detailing all facets of the TMDL, including: nitrogen, phosphorus and sediment allocations; schedules for developing the TMDL and pollution reduction plans; EPA’s expectations and evaluation criteria for jurisdiction plans to meet the TMDL pollution limits; reasonable assurance for controlling nonpoint source pollution; and backstop actions that EPA could take to ensure progress.

The TMDL also resolves commitments made in a number of consent decrees, Memos of Understanding, the Chesapeake Bay Foundation settlement agreement of 2010, and settlement agreements dating back to the late 1990s that address certain tidal waters identified as impaired in the District of Columbia, Delaware, Maryland and Virginia.

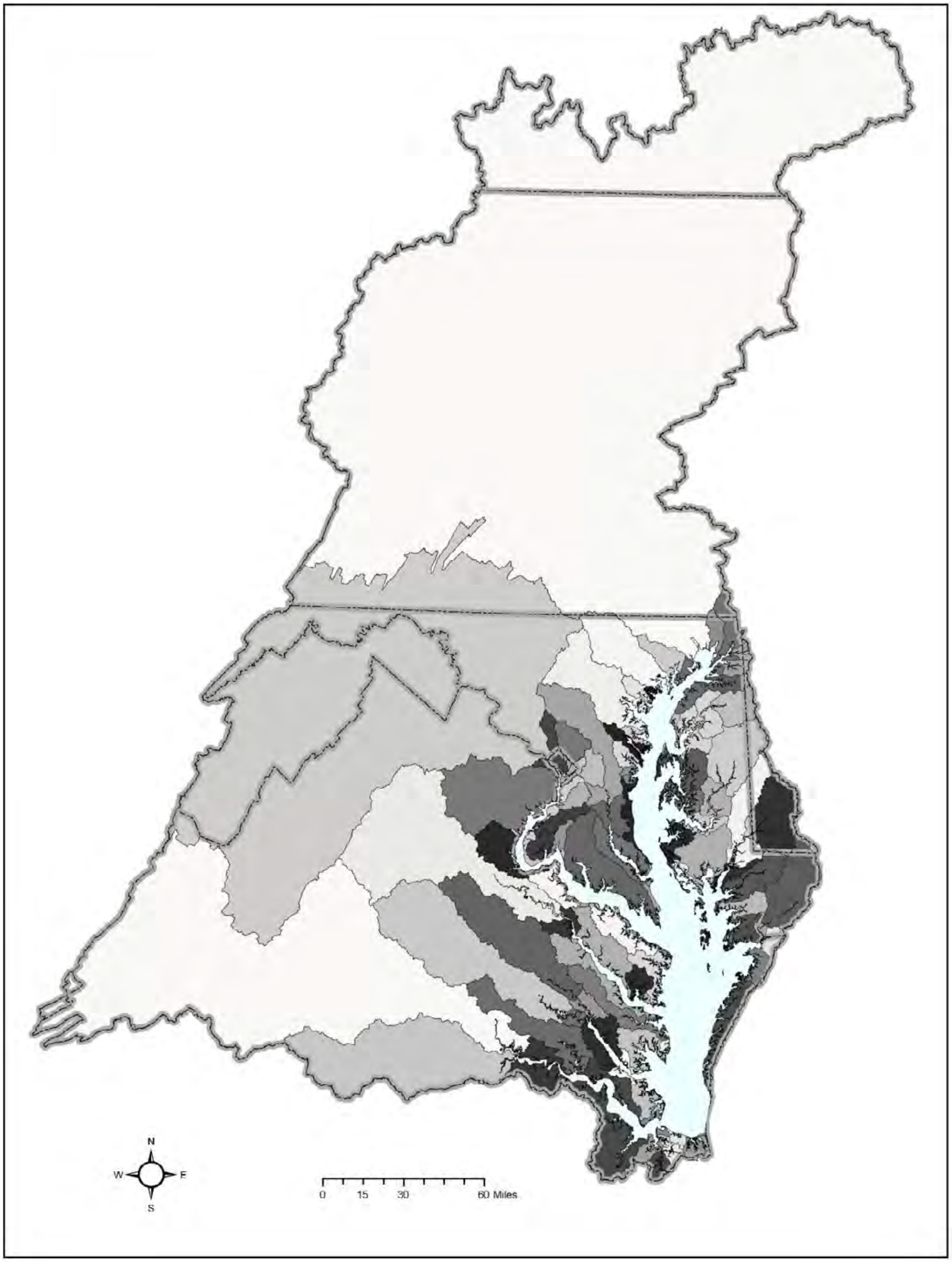


Figure ES-1. A nitrogen, phosphorus and sediment TMDL has been developed for each of the 92 Chesapeake Bay segment watersheds.

Additionally, President Obama issued Executive Order 13508 on May 12, 2009, which directed the federal government to lead a renewed effort to restore and protect the Chesapeake Bay and its watershed. The Chesapeake Bay TMDL is a keystone commitment in the strategy developed by 11 federal agencies to meet the President's Executive Order.

DEVELOPING THE CHESAPEAKE BAY TMDL

Development of the Chesapeake Bay TMDL required extensive knowledge of the stream flow characteristics of the watershed, sources of pollution, distribution and acreage of the various land uses, appropriate best management practices, the transport and fate of pollutants, precipitation data and many other factors. The TMDL is informed by a series of models, calibrated to decades of water quality and other data, and refined based on input from dozens of Chesapeake Bay scientists. Modeling is an approach that uses observed and simulated data to replicate what is occurring in the environment to make future predictions, and was a critical and valuable tool to develop the Chesapeake Bay TMDL.

The development of the TMDL consisted of several steps:

1. EPA provided the jurisdictions with loading allocations for nitrogen, phosphorus and sediment for the major river basins by jurisdiction.
2. Jurisdictions developed draft Phase I WIPs to achieve those basin-jurisdiction allocations. In those draft WIPs, jurisdictions made decisions on how to further sub-allocate the basin-jurisdiction loadings to various individual point sources and a number of point and nonpoint source pollution sectors.
3. EPA evaluated the draft WIPs and, where deficiencies existed, EPA provided backstop allocations in the draft TMDL that consisted of a hybrid of the jurisdiction WIP allocations modified by EPA allocations for some source sectors to fill gaps in the WIPs.
4. The draft TMDL was published for a 45-day public comment period and EPA held 18 public meetings in all six states and the District of Columbia. Public comments were received, reviewed and considered for the final TMDL.
5. Jurisdictions, working closely with EPA, revised and strengthened Phase I WIPs and submitted final versions to EPA.
6. EPA evaluated the final WIPs and used them along with public comments to develop the final TMDL.

Since nitrogen and phosphorus loadings from all parts of the Bay watershed have an impact on the impaired tidal segments of the Bay and its rivers, it was necessary for EPA to allocate the nitrogen and phosphorus loadings in an equitable manner to the states and basins. EPA used three basic guides to divide these loads.

- Allocated loads should protect living resources of the Bay and its tidal tributaries and should result in all segments of the Bay mainstem, tidal tributaries and embayments meeting water quality standards for dissolved oxygen, chlorophyll *a*, water clarity and underwater Bay grasses.
- Tributary basins that contribute the most to the Bay water quality problems must do the most to resolve those problems (on a pound-per-pound basis) (Figure ES-2).
- All tracked and reported reductions in nitrogen, phosphorus and sediment loads are credited toward achieving final assigned loads.

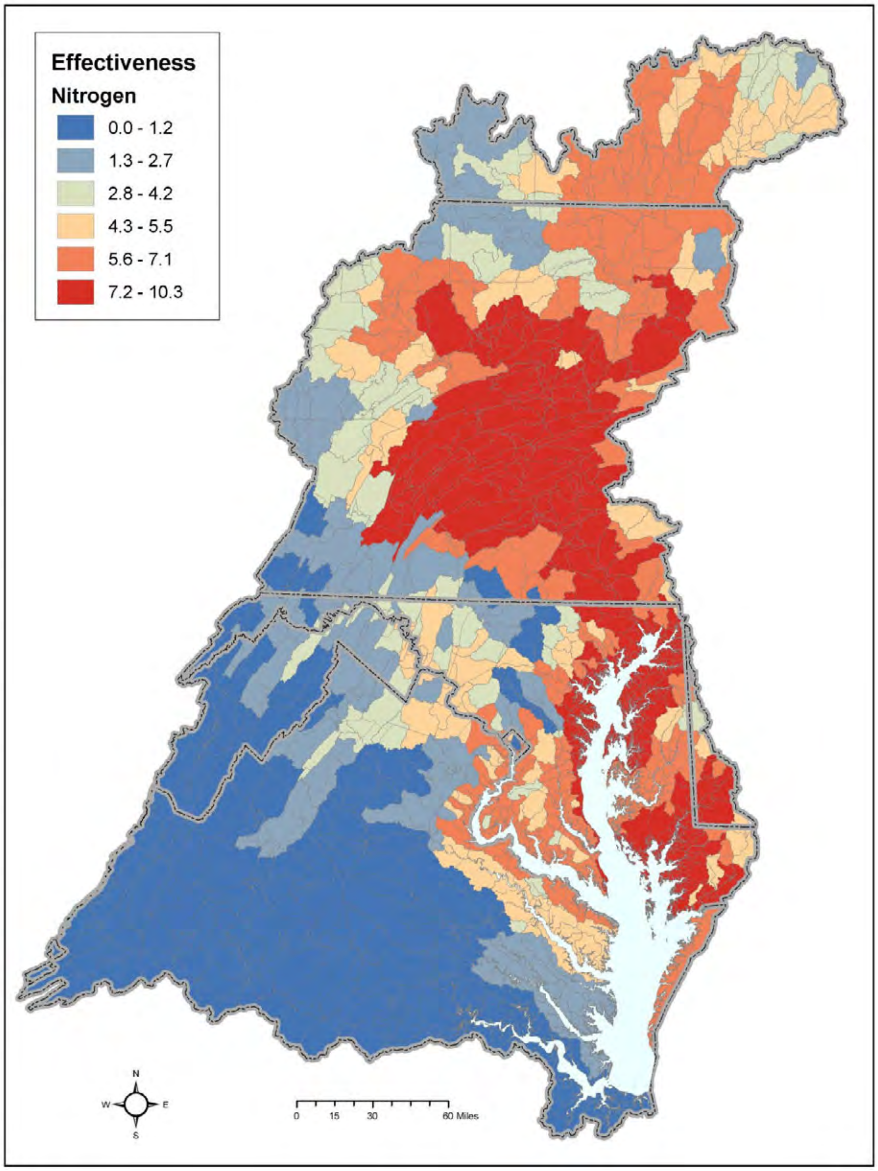


Figure ES-2. Sub-basins across the Chesapeake Bay watershed with the highest (red) to lowest (blue) pound for pound nitrogen pollutant loading effect on Chesapeake Bay water quality.

In addition, EPA has committed to reducing air deposition of nitrogen to the tidal waters of the Chesapeake Bay from 17.9 to 15.7 million pounds per year. The reductions will be achieved through implementation of federal air regulations during the coming years.

To ensure that these pollutant loadings will attain and maintain applicable water quality standards, the TMDL calculations were developed to account for critical environmental conditions a waterway would face and seasonal variation. An implicit margin of safety for nitrogen and phosphorus, and an explicit margin of safety for sediment, also are included in the TMDL.

Ultimately, the TMDL is designed to ensure that by 2025 all practices necessary to fully restore the Bay and its tidal waters are in place, with at least 60 percent of the actions taken by 2017.

The TMDL loadings to the basin-jurisdictions are provided in Table ES-1. These loadings were determined using the best peer-reviewed science and through extensive collaboration with the jurisdictions and are informed by the jurisdictions' Phase I WIPs.

Table ES-1. Chesapeake Bay TMDL watershed nitrogen, phosphorus and sediment final allocations by jurisdiction and by major river basin.

Jurisdiction	Basin	Nitrogen allocations (million lbs/year)	Phosphorus allocations (million lbs/year)	Sediment allocations (million lbs/year)
Pennsylvania	Susquehanna	68.90	2.49	1,741.17
	Potomac	4.72	0.42	221.11
	Eastern Shore	0.28	0.01	21.14
	Western Shore	0.02	0.00	0.37
	PA Total	**73.93**	**2.93**	**1,983.78**
Maryland	Susquehanna	1.09	0.05	62.84
	Eastern Shore	9.71	1.02	168.85
	Western Shore	9.04	0.51	199.82
	Patuxent	2.86	0.24	106.30
	Potomac	16.38	0.90	680.29
	MD Total	**39.09**	**2.72**	**1,218.10**
Virginia	Eastern Shore	1.31	0.14	11.31
	Potomac	17.77	1.41	829.53
	Rappahannock	5.84	0.90	700.04
	York	5.41	0.54	117.80
	James	23.09	2.37	920.23
	VA Total	**53.42**	**5.36**	**2,578.90**
District of Columbia	Potomac	2.32	0.12	11.16
	DC Total	**2.32**	**0.12**	**11.16**
New York	Susquehanna	8.77	0.57	292.96
	NY Total	**8.77**	**0.57**	**292.96**
Delaware	Eastern Shore	2.95	0.26	57.82
	DE Total	**2.95**	**0.26**	**57.82**
West Virginia	Potomac	5.43	0.58	294.24
	James	0.02	0.01	16.65
	WV Total	**5.45**	**0.59**	**310.88**
Total Basin/Jurisdiction Draft Allocation		**185.93**	**12.54**	**6,453.61**
Atmospheric Deposition Draft Allocation[a]		**15.7**	**N/A**	**N/A**
Total Basinwide Draft Allocation		**201.63**	**12.54**	**6,453.61**

[a] Cap on atmospheric deposition loads direct to Chesapeake Bay and tidal tributary surface waters to be achieved by federal air regulations through 2020.

ACCOUNTABILITY AND GOALS

The Chesapeake Bay TMDL is unique because of the extensive measures EPA and the jurisdictions have adopted to ensure accountability for reducing pollution and meeting deadlines for progress. The TMDL will be implemented using an accountability framework that includes WIPs, two-year milestones, EPA's tracking and assessment of restoration progress and, as necessary, specific federal contingency actions if the jurisdictions do not meet their commitments. This accountability framework is being established in part to provide demonstration of the reasonable assurance provisions of the Chesapeake Bay TMDL pursuant to both the Clean Water Act (CWA) and the Chesapeake Bay Executive Order, but is not part of the TMDL itself.

When EPA establishes or approves a TMDL that allocates pollutant loads to both point and nonpoint sources, it determines whether there is a "reasonable assurance" that the point and nonpoint source loadings will be achieved and applicable water quality standards will be attained. Reasonable assurance for the Chesapeake Bay TMDL is provided by the numerous federal, state and local regulatory and non-regulatory programs identified in the accountability framework that EPA believes will result in the necessary point and nonpoint source controls and pollutant reduction programs. The most prominent program is the CWA's National Pollutant Discharge Elimination System (NPDES) permit program that regulates point sources throughout the nation. Many nonpoint sources are not covered by a similar federal permit program; as a result, financial incentives, other voluntary programs and state-specific regulatory programs are used to achieve nonpoint source reductions. These federal tools are supplemented by a variety of state and local regulatory and voluntary programs and other commitments of the federal government set forth in the Executive Order strategy and identified in the accountability framework.

Beginning in 2012, jurisdictions (including the federal government) are expected to follow two-year milestones to track progress toward reaching the TMDL's goals. In addition, the milestones will demonstrate the effectiveness of the jurisdictions' WIPs by identifying specific near-term pollutant reduction controls and a schedule for implementation (see next section for further description of WIPs). EPA will review these two-year milestones and evaluate whether they are sufficient to achieve necessary pollution reductions and, through the use of a Bay TMDL Tracking and Accountability System, determine if milestones are met.

If a jurisdiction's plans are inadequate or its progress is insufficient, EPA is committed to take the appropriate contingency actions to ensure pollution reductions. These include expanding coverage of NPDES permits to sources that are currently unregulated, increasing oversight of state-issued NPDES permits, requiring additional pollution reductions from point sources such as wastewater treatment plants, increasing federal enforcement and compliance in the watershed, prohibiting new or expanded pollution discharges, redirecting EPA grants, and revising water quality standards to better protect local and downstream waters.

Watershed Implementation Plans

The cornerstone of the accountability framework is the jurisdictions' development of WIPs, which serve as roadmaps for how and when a jurisdiction plans to meet its pollutant allocations under the TMDL. In their Phase I WIPs, the jurisdictions were expected to subdivide the Bay TMDL allocations among pollutant sources; evaluate their current legal, regulatory, programmatic and financial tools available to implement the allocations; identify and rectify potential shortfalls in attaining the allocations; describe mechanisms to track and report implementation activities; provide alternative approaches; and outline a schedule for implementation.

EPA provided the jurisdictions with detailed expectations for WIPs in November 2009 and evaluation criteria in April 2010. To assist with WIP preparation, EPA provided considerable technical and financial assistance. EPA worked with the jurisdictions to evaluate various “what if” scenarios – combinations of practices and programs that could achieve their pollution allocations.

The two most important criteria for a WIP is that it achieves the basin-jurisdiction pollution allocations and meets EPA’s expectations for providing reasonable assurance that reductions will be achieved and maintained, particularly for non-permitted sources like runoff from agricultural lands and currently unregulated stormwater from urban and suburban lands.

After the draft Phase I WIP submittals in September 2010, a team of EPA sector experts conducted an intense evaluation process, comparing the submissions with EPA expectations. The EPA evaluation concluded that the pollution controls identified in two of the seven jurisdictions’ draft WIPs could meet nitrogen and phosphorus allocations and five of the seven jurisdictions’ draft WIPs could meet sediment allocations. The EPA evaluation also concluded that none of the seven draft Phase I WIPs provided sufficient reasonable assurance that pollution controls identified could actually be implemented to achieve the nitrogen, phosphorus and sediment reduction targets by 2017 or 2025.

In response to its findings, EPA developed a draft TMDL that established allocations based on using the adequate portions of the jurisdictions’ draft WIP allocations along with varying degrees of federal backstop allocations in all seven jurisdictions. Backstop allocations focused on areas where EPA has the federal authority to control pollution allocations through NPDES permits, including wastewater treatment plants, stormwater permits, and animal feeding operations.

Public Participation

The draft Chesapeake Bay TMDL was developed through a highly transparent and engaging process during the past two years. The outreach effort included hundreds of meetings with interested groups; two rounds of public meetings, stakeholder sessions and media interviews in all six states and the District of Columbia in fall of 2009 and 2010; a dedicated EPA website; a series of monthly interactive webinars; notices published in the Federal Register; and a close working relationship with Chesapeake Bay Program committees representing citizens, local governments and the scientific community.

The release of the draft Chesapeake Bay TMDL on September 24, 2010 began a 45-day public comment period that concluded on November 8, 2010. During the comment period EPA conducted 18 public meetings in all six states and the District of Columbia. More than 2,500 people participated in the public meetings. Seven of these meetings were also broadcast live online. During the six weeks that EPA officials traveled around the watershed, they also held dozens of meetings with stakeholders, including local governments, agriculture groups, homebuilder and developer associations, wastewater industry representatives and environmental organizations. EPA received more than 14,000 comments – most of which supported the TMDL – and the Agency's response to those comments is included as an appendix to the TMDL.

Final Watershed Implementation Plans and TMDL

Since submittal of the draft WIPs and release of the draft TMDL in September 2010, EPA worked closely with each jurisdiction to revise and strengthen its plan. Because of this cooperative work and state leadership, the final WIPs were significantly improved. Examples of specific improvements include:

- Committing to more stringent nitrogen and phosphorus limits at wastewater treatment plants, including on the James River in Virginia. (Virginia, New York, Delaware)
- Pursuing state legislation to fund wastewater treatment plant upgrades, urban stormwater management and agricultural programs. (Maryland, Virginia, West Virginia)
- Implementing a progressive stormwater permit to reduce pollution. (District of Columbia)
- Dramatically increasing enforcement and compliance of state requirements for agriculture. (Pennsylvania)
- Committing state funding to develop and implement state-of-the-art-technologies for converting animal manure to energy for farms. (Pennsylvania)
- Considering implementation of mandatory programs for agriculture by 2013 if pollution reductions fall behind schedule. (Delaware, Maryland, Virginia)

These improvements enabled EPA to reduce and remove most federal backstops, leaving a few targeted backstops and a plan for enhanced oversight and contingency actions to ensure progress.

Backstop Allocations, Adjustments, and Actions

Despite the significant improvement in the final WIPs, one of the jurisdictions did not meet all of its target allocations and two of the jurisdictions did not fully meet EPA's expectations for reasonable assurance for specific pollution sectors. To address these few remaining issues, EPA included in the final TMDL several targeted backstop allocations, adjustments and actions. As a result of the jurisdictions' significant improvements combined with EPA's backstops, EPA believes the jurisdictions are in a position to implement their WIPs and achieve the needed pollution reductions. This approach endorses jurisdictions' pollution reduction commitments, gives them the flexibility to do it their way first, and signals EPA's commitment to fully use its authorities as necessary to reduce pollution.

New York Wastewater – Backstop Allocation

- EPA closed the numeric gap between New York's WIP and its modified allocations by establishing a backstop that further reduces New York's wasteload allocation for wastewater. EPA is establishing an aggregate wasteload allocation for wastewater treatment plants.
- EPA calculated this backstop WLA using the nitrogen and phosphorus performance levels that New York committed to, but assumes that significant wastewater treatment plants (WWTPs) are at current flow rather than design flow.

- EPA understands that New York plans to renew and/or modify WWTP permits upon completion of its Phase II WIP, consistent with the applicable TMDL allocations at that time. New York is reviewing engineering reports from WWTPs and, in its Phase II WIP, will provide information to support individual WLAs for these plants.

Pennsylvania Urban Stormwater – Backstop Adjustment

- EPA transferred 50 percent of the stormwater load that is not currently subject to NPDES permits from the load allocation to the wasteload allocation. The TMDL allocation adjustment increases reasonable assurance that pollution allocations from urban stormwater discharges will be achieved and maintained by signaling that EPA is prepared to designate any of these discharges as requiring NPDES permits. Urban areas would only be subject to NPDES permit conditions protective of water quality as issued by Pennsylvania upon designation. EPA will consider this step if Pennsylvania does not demonstrate progress toward reductions in urban loads identified in the WIP. EPA may also pursue designation activities based on considerations other than TMDL and WIP implementation.
- EPA will maintain close oversight of general permits for the Pennsylvania stormwater sector (PAG-13 and PAG-2) and may object if permits are not protective of water quality standards and regulations. Upon review of Pennsylvania's Phase II WIP, EPA will revisit the wasteload allocations for wastewater treatment plants, including more stringent phosphorus limits, in the event that Pennsylvania does not reissue PAG-13 and PAG-2 general permits for Phase II MS4s and construction that are protective of water quality by achieving the load reductions called for in Pennsylvania's Phase I WIP.

West Virginia Agriculture – Backstop Adjustment

- EPA shifted 75 percent of West Virginia's animal feeding operation (AFO) load into the wasteload allocation and assumed full implementation of barnyard runoff control, waste management and mortality composting practices required under a CAFO permit on these AFOs. The shift signals that any of these operations could potentially be subject to state or federal permits as necessary to protect water quality. AFOs would only be subject to NPDES permit conditions as issued by West Virginia upon designation. EPA will consider this step if West Virginia does not achieve reductions in agricultural loads as identified in the WIP. EPA may also pursue designation activities based upon considerations other than TMDL and WIP implementation.
- Based upon West Virginia's ability to demonstrate near-term progress implementing the agricultural section of its WIP, including CAFO Program authorization and permit applications and issuance, EPA will assess in the Phase II WIP whether additional federal actions, such as establishing more stringent wasteload allocations for wastewater treatment plants, are necessary to ensure that TMDL allocations are achieved.

Enhanced Oversight and Contingencies

While final WIPs were significantly improved and the jurisdictions deserve credit for the efforts, EPA also has minor concerns with the assurance that pollution reductions can be achieved in certain pollution sectors in Pennsylvania, Virginia and West Virginia. EPA has informed these jurisdictions that it will consider future backstops if specific near-term progress is not demonstrated in the Phase II WIP.

Pennsylvania Agriculture

- Based on Pennsylvania's ability to demonstrate near-term progress implementing the agricultural section of its WIP, including EPA approval for its CAFO program and enhanced compliance assurance with state regulatory programs, EPA will assess in the Phase II WIP whether additional federal actions, such as shifting AFO loads from the load allocation to the wasteload allocation or establishing more stringent wasteload allocations for WWTPs, are necessary to ensure that TMDL allocations are achieved.

Pennsylvania Wastewater

- EPA established individual wasteload allocations for wastewater treatment plants in the TMDL to ensure that sufficient detail is provided to inform individual permits for sources within the wasteload allocation. Individual allocations do not commit wastewater plants to greater reductions than what the state has proposed in its WIP. Provisions of the TMDL allow, under certain circumstances, for modifications of allocations within a basin to support offsets and trading opportunities.
- EPA will assess Pennsylvania’s near-term urban stormwater and agriculture program progress and determine whether EPA should modify TMDL allocations to assume additional reductions from wastewater treatment plants.

Virginia Urban Stormwater

- If the statewide rule and/or the Phase II WIP do not provide additional assurance regarding how stormwater discharges outside of MS4 jurisdictions will achieve nitrogen, phosphorus, and sediment reductions proposed in the final Phase I WIP and assumed within the TMDL allocations, EPA may shift a greater portion of Virginia’s urban stormwater load from the load allocation to the wasteload allocation. This shift would signal that substantially more stormwater could potentially be subject to NPDES permits issued by the Commonwealth as necessary to protect water quality.

West Virginia Urban Stormwater

- If stormwater rules and/or the Phase II WIP do not provide additional assurance regarding how urban stormwater discharges outside of MS4 jurisdictions will achieve nitrogen, phosphorus, and sediment allocations proposed in the final Phase I WIP and assumed within the TMDL load allocations, EPA may shift a greater portion of West Virginia’s urban stormwater load from the load allocation to the wasteload allocation. The shift would signal that substantially more urban stormwater could potentially be subject to state permit coverage and/or federal Clean Water Act permit coverage as necessary to protect water quality.

West Virginia Wastewater

- EPA established individual wasteload allocations for significant wastewater treatment plants in the TMDL to ensure that sufficient detail is provided to inform individual permits for sources within the wastewater wasteload allocation. Individual allocations do not commit wastewater plants to greater reductions than what the state has proposed in its WIP. Provisions of this TMDL allow, under certain circumstances, for modifications of allocations within a basin to support offsets and trading opportunities.

- EPA will assess West Virginia's near-term agriculture program progress and determine whether additional federal actions consistent with EPA's December 29, 2009 letter, such as modifying TMDL allocations to assume additional reductions from wastewater treatment plants, are necessary to ensure that TMDL allocations are achieved.

Ongoing oversight of Chesapeake Bay jurisdictions

EPA will carefully review programs and permits in all jurisdictions. EPA's goal is for jurisdictions to successfully implement their WIPs, but EPA is prepared to take necessary actions in all jurisdictions for insufficient WIP implementation or pollution reductions. Federal actions can be taken at any time, although EPA will engage particularly during two-year milestones and refining the TMDL in 2012 and 2017. Actions include:

- Expanding coverage of NPDES permits to sources that are currently unregulated
- Increasing oversight of state-issued NPDES permits
- Requiring additional pollution reductions from federally regulated sources
- Increasing federal enforcement and compliance
- Prohibiting new or expanded pollution discharges
- Conditioning or redirecting EPA grants
- Revising water quality standards to better protect local and downstream waters
- Discounting nutrient and sediment reduction progress if jurisdiction cannot verify proper installation and management of controls

FINAL TMDL

As a result of the significantly improved WIPs and the removal and reduction of federal backstops, the final TMDL is shaped in large part by the jurisdictions' plans to reduce pollution. Jurisdiction-based solutions for reducing pollution was a long-standing priority for EPA and why the agency always provided the jurisdictions with flexibility to determine how to reduce pollution in the most efficient, cost-effective and acceptable manner.

Now, the focus shifts to jurisdictions' implementation of the WIP policies and programs designed to reduce pollution on-the-ground and in-the-water. EPA will conduct oversight of WIP implementation and jurisdictions' progress toward meeting two-year milestones. If progress is insufficient, EPA will utilize contingencies to place additional controls on federally permitted sources of pollution, such as wastewater treatment plants, large animal agriculture operations and municipal stormwater systems, as well as target compliance and enforcement activities.

Federal agencies will greatly contribute to restoration of the Chesapeake Bay watershed, particularly through implementation of the new federal strategy created under President Obama's Executive Order. Eleven federal agencies have committed to a comprehensive suite of actions and pursuit of critical environmental goals on the same 2025 timeline as the TMDL. Additionally, federal agencies will be establishing and meeting two-year milestones, with the specific charge of taking actions that directly support the jurisdictions in reducing pollution and restoring water quality.

The jurisdictions are expected to submit Phase II WIPs that provide local area pollution targets for implementation on a smaller scale; the timeframe for these Phase II WIPs will be determined in early 2011. Phase III WIPs in 2017 are expected to be designed to provide additional detail of restoration actions beyond 2017 and ensure that the 2025 goals are met.

APPENDIX G:

Total Maximum Daily Loads of Fecal Bacteria for the Non-Tidal Gwynns Falls Basin in Baltimore City and Baltimore County, Maryland

Total Maximum Daily Loads of Fecal Bacteria for the Non-Tidal Gwynns Falls Basin in Baltimore City and Baltimore County, Maryland

FINAL

MARYLAND
DEPARTMENT OF THE ENVIRONMENT
1800 Washington Boulevard, Suite 540
Baltimore MD 21230-1718

Submitted to:

Watershed Protection Division
U.S. Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

September 2006

EPA Submittal Date: Sept. 9, 2006
EPA Approval Date: Dec. 4, 2007

Table of Contents

List of Figures

List of Tables

List of Abbreviations

APHA	American Public Health Association
ARCC	Average rates of correct classification
ARA	Antibiotic Resistance Analysis
BMP	Best Management Practice
BST	Bacteria Source Tracking
cfs	Cubic Feet per Second
CFR	Code of Federal Regulations
CFU	Colony Forming Units
COMAR	Code of Maryland Regulations
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
CWA	Clean Water Act
DNR	Department of Natural Resources
EPA	Environmental Protection Agency
GIS	Geographic Information System
LA	Load Allocation
LTCP	Long Term Control Plan
MACS	Maryland Agricultural Cost Share Program
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
ml	Milliliter(s)
MOS	Margin of Safety
MPN	Most Probable Number
MPR	Maximum Practicable Reduction
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
NPDES	National Pollutant Discharge Elimination System
RCC	Rates of Correct Classification
SSO	Sanitary Sewer Overflows
STATSGO	State Soil Geographic
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WQIA	Water Quality Improvement Act
WLA	Wasteload Allocation
WQLS	Water Quality Limited Segment
WWTP	Wastewater Treatment Plan

EXECUTIVE SUMMARY

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes a Total Maximum Daily Load (TMDL) for fecal bacteria in the non-tidal portion of Gwynns Falls (basin number 02130905). Section 303(d) of the federal Clean Water Act (CWA) and the 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, states are required 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 that water quality standards are being met.

The Maryland Department of the Environment (MDE) has identified Gwynns Falls in the State of Maryland's 303(d) List as impaired by nutrients (1996), sediments (1996), bacteria (fecal coliform) (2002), and impacts to biological communities (2002). The designated uses for Gwynns Falls are as follows: Gwynns Falls and tributaries above Reisterstown Road – Use III (Nontidal Cold Water); Dead Run and tributaries – Use IV (Recreational Trout Waters); and all remaining waters – Use I (Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life). See Code of Maryland Regulations (COMAR) 26.08.02.08K(3)(e) & (5)(e). This document proposes to establish a TMDL for fecal bacteria in Gwynns Falls and its tributaries that will allow for the attainment of the designated use of primary contact recreation. The listings for sediments, nutrients, and impacts to biological communities will be addressed separately at a future date. A data solicitation for fecal bacteria was conducted by MDE in 2003, and all readily available data from the past five years were considered.

To establish baseline and allowable pollutant loads for this TMDL, a flow duration curve approach was employed, using flow strata estimated from United States Geological Survey (USGS) daily flow monitoring data and bacteria monitoring data. The sources of fecal bacteria are estimated at four representative stations in the Gwynns Falls watershed where samples were collected for one year. Multiple antibiotic resistance analysis (ARA) source tracking was used to determine the relative proportion of domestic (pets and human associated animals), human (human waste), livestock (agricultural related animals), and wildlife (mammals and waterfowl) source categories.

The allowable load is determined by estimating a baseline load from current monitoring data. The baseline load is estimated using a long-term geometric mean and weighting factors from the flow duration curve. The TMDL load for fecal bacteria entering Gwynns Falls is established after considering four different hydrological conditions: high flow and low flow annual conditions; and high flow and low flow seasonal conditions (the period between May 1st and September 30th where water contact recreation is more prevalent). This allowable load is reported in the units of Most Probable Number (MPN)/day and represents a long-term load estimated over a variety of hydrological conditions.

Two scenarios were developed; the first assessing whether attainment of current water quality standards could be achieved with maximum practicable reductions (MPRs) applied, and the second requiring higher maximum reductions. Scenario solutions were based on an optimization method where the objective was to minimize the overall risk to human health, assuming that the risk varies over the four bacteria source categories. In the four subwatersheds of Gwynns Falls, it was estimated that water quality standards could not be attained with the MPRs. Thus, a second scenario allowing greater reductions, which may not be feasible, was applied.

The fecal bacteria TMDL developed for the Gwynns Falls watershed is 917.4 billion *E. coli* MPN/day. The TMDL is distributed between load allocation (LA) for nonpoint sources and waste load allocations (WLA) for point sources, including National Pollutant Discharge Elimination System (NPDES) wastewater treatment plants (WWTPs), municipal separate storm sewer systems (MS4), and NPDES combined sewer overflows (CSOs). There are no WWTPs located in the Gwynns Falls watershed. The LA is 176.0 billion *E. coli* MPN/day. The MS4 WLA is 741.4 billion *E. coli* MPN/day and the CSO WLA is 0.0 billion *E. coli* MPN/day. The margin of safety (MOS) is explicit and has been incorporated by estimating the loading capacity of the stream based on a more stringent water quality endpoint concentration. The *E. coli* water quality criterion concentration was reduced by 5%, from 126 MPN/100ml to 119.7 MPN/100ml.

Once the EPA has approved a TMDL, and it is known what measures must be taken to reduce pollution levels, implementation of best management practices (BMPs) is expected to take place. MDE intends for the required reduction to be implemented in an iterative process that first addresses those sources with the largest impacts to water quality and creating the greatest risks to human health, with consideration given to ease and cost of implementation. In addition, follow-up monitoring plans will be established to track progress and to assess the implementation efforts. As previously stated, water quality standards cannot be attained in the Gwynns Falls subwatersheds using the MPR scenario. This may occur in subwatersheds where wildlife is a significant component or in subwatersheds that require very high reductions of fecal bacteria loads to meet water quality standards. Therefore, MDE proposes a staged approach to implementation of the required reductions, beginning with the MPR scenario, as an iterative process that first addresses those sources making the largest impacts on water quality and creating the greatest risks to human health, with consideration given to ease and cost of implementation. In addition, follow-up monitoring plans will be established to track progress and to assess the effectiveness of implementation efforts.

1.0 INTRODUCTION

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes a Total Maximum Daily Load (TMDL) for fecal bacteria in the non-tidal portion of Gwynns Falls (basin number 02130905). Section 303(d)(1)(C) of the federal Clean Water Act (CWA) and the EPA implementing regulations direct each state to develop a TMDL for each impaired water quality limited segment (WQLS) on the Section 303(d) List, taking into account seasonal variations and a protective margin of safety (MOS) to account for uncertainty. A TMDL reflects the total pollutant loading of the impairing substance a waterbody can receive and still meet water quality standards.

TMDLs are established to achieve and maintain water quality standards. A water quality standard is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Designated uses include activities such as swimming, drinking water supply, and shellfish propagation and harvest. Water quality criteria consist of narrative statements and numeric values designed to protect the designated uses. Criteria may differ among waters with different designated uses.

The Maryland Department of the Environment (MDE) has identified Gwynns Falls in the State's 303(d) List as impaired by nutrients (1996), sediments (1996), bacteria (fecal coliform) (2002), and impacts to biological communities (2002). The designated uses for Gwynns Falls are as follows: Gwynns Falls and tributaries above Reisterstown Road – Use III (Nontidal Cold Water); Dead Run and tributaries – Use IV (Recreational Trout Waters); and all remaining waters – Use I (Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life). See Code of Maryland Regulations (COMAR) 26.08.02.08K(3)(e) & (5)(e). This document proposes to establish a TMDL for fecal bacteria in Gwynns Falls and its tributaries that will allow for the attainment of the designated use primary contact recreation. The listings for sediments, nutrients, and impacts to biological communities will be addressed separately at a future date. A data solicitation for fecal bacteria was conducted by MDE in 2003, and all readily available data from the past five years were considered.

Fecal bacteria are microscopic single-celled organisms (primarily fecal coliform and fecal streptococci) found in the wastes of warm-blooded animals. Their presence in water is used to assess the sanitary quality of water for body-contact recreation, for consumption of molluscan bivalves (shellfish), and for drinking water. Excessive amounts of fecal bacteria in surface water used for recreation are known to indicate an increased risk of pathogen-induced illness to humans. Infections due to pathogen-contaminated recreation waters include gastrointestinal, respiratory, eye, ear, nose, throat, and skin diseases (EPA, 1986).

In 1986, EPA published "Ambient Water Quality Criteria for Bacteria" in which three indicator organisms were assessed to determine their correlation with swimming-associated illnesses. Fecal coliform, *E. coli* and enterococci were the indicators used in the analysis. Fecal coliform are a subgroup of total coliform bacteria and *E. coli* are a subgroup of fecal coliform. Although most *E. coli* are harmless and are found in great quantities in the intestines of people and warm-blooded animals, certain pathogenic strains may cause illness. Enterococci are a subgroup of bacteria in the fecal streptococcus group. Fecal coliform, *E. coli* and enterococci can all be classified as fecal bacteria. The results of the EPA study (EPA, 1986) demonstrated that fecal coliform showed less correlation to swimming-associated gastroenteritis than did either *E. coli* or enterococci.

The Gwynns Falls watershed was listed on the Maryland 303(d) List using fecal coliform as the indicator organism. Based on EPA's guidance (EPA, 1986), adopted by Maryland in 2004, the State has revised the bacteria water quality criteria and it is now based on water column limits for either *E. coli* or enterococci. Because multiple monitoring datasets are available within this watershed for various pathogen indicators, the general term fecal bacteria will be used to refer to the impairing substance throughout this document. The TMDL will be based on the pathogen indicator organisms specified in Maryland's current bacteria water quality criteria, either *E. coli* or enterococci. The indicator organism used in the Gwynns Falls TMDL analysis was *E. coli*.

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1 General Setting

Location

The Gwynns Falls watershed is located in the Patapsco River Basin within Maryland (see Figure 2.1.1). The watershed encompasses 41,710 acres (61 square miles) in Baltimore City and Baltimore County, Maryland. The headwaters of the Gwynns Falls begin in Glyndon, Maryland and flows southeast until its confluence with the Middle Branch of the Patapsco River near downtown Baltimore. Five major tributaries of the Gwynns Falls, listed north to south, include: Red Run, Horsehead Branch, Scotts Level Branch, Dead Run, and Maidens Choice Creek.

Geology/Soils

The Gwynns Falls watershed lies within the Piedmont and Atlantic Coastal Plain Provinces of Central Maryland. The Piedmont Province is characterized by gentle to steep rolling topography, low hills and ridges. The surface geology is characterized by crystalline rocks of volcanic origin consisting primarily of schist and gneiss. 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. The Atlantic Coastal Plain surface geology is characterized by thick, unconsolidated marine sediments deposited over the crystalline rock of the piedmont province. The deposits include clays, silts, sands and gravels. In the areas around the head of tide, the topography is flat, with elevations below 100 feet. The elevations steadily increase going north to approximately 600 feet in the headwaters. Streambeds throughout the basin are comprised of rock and rubble with gradually sloped stream banks.

The Gwynns Falls watershed lies predominantly in the Baile and Lehigh soil series. The Lehigh soil series consists of somewhat poorly drained to moderately well-drained, rather shallow soils. The Baile soil series consists of deep, poorly drained, nearly level to gently sloping, dominantly gray soils of the Piedmont Plateau. Baile soils have a high available moisture capacity and a water table that is seasonally at or near the surface (U.S. Department of Agriculture (USDA), 1977). The spatial distributions for each soil series are shown in Figure 2.1.2.

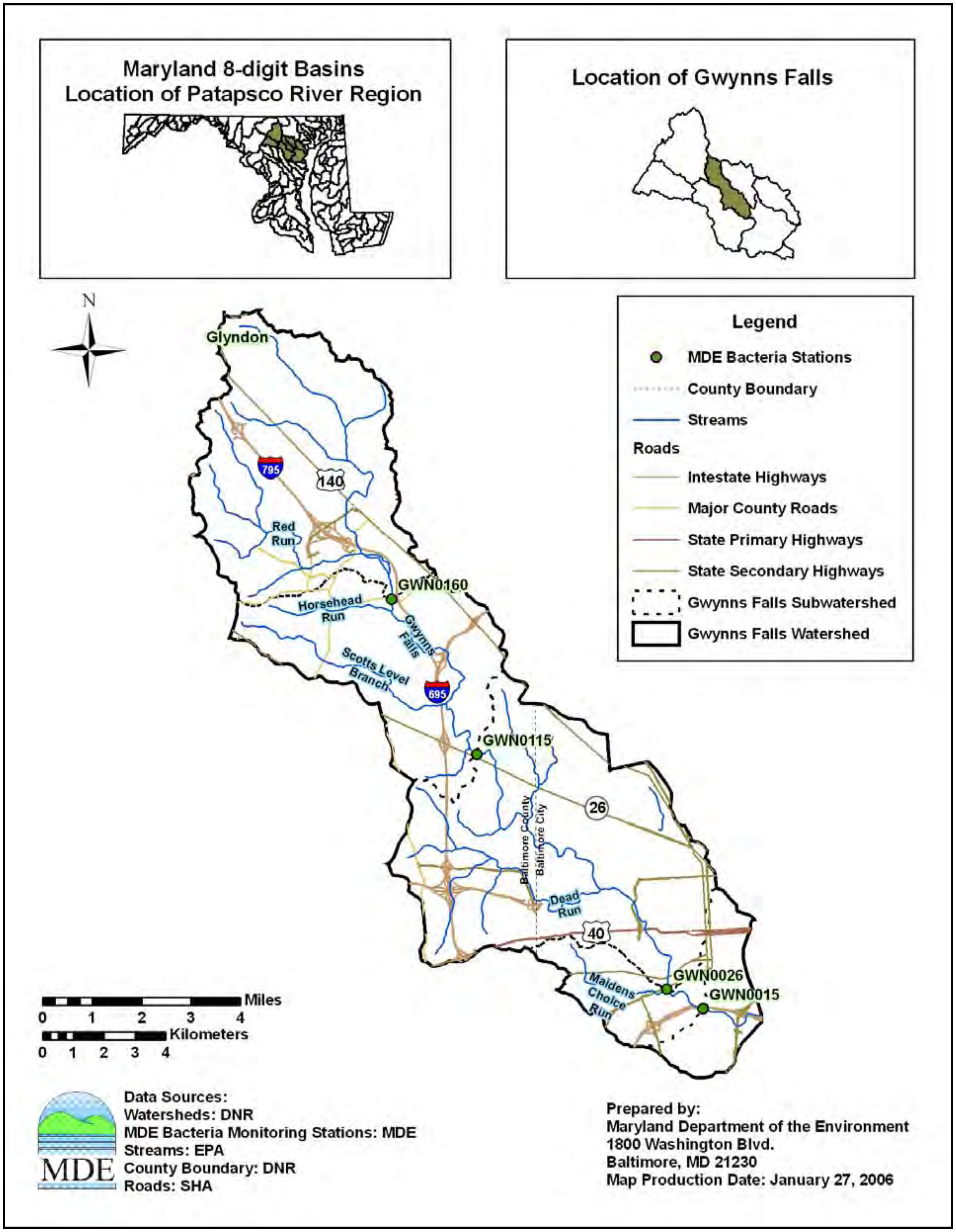


Figure 2.1.1: Location Map of the Gwynns Falls Watershed

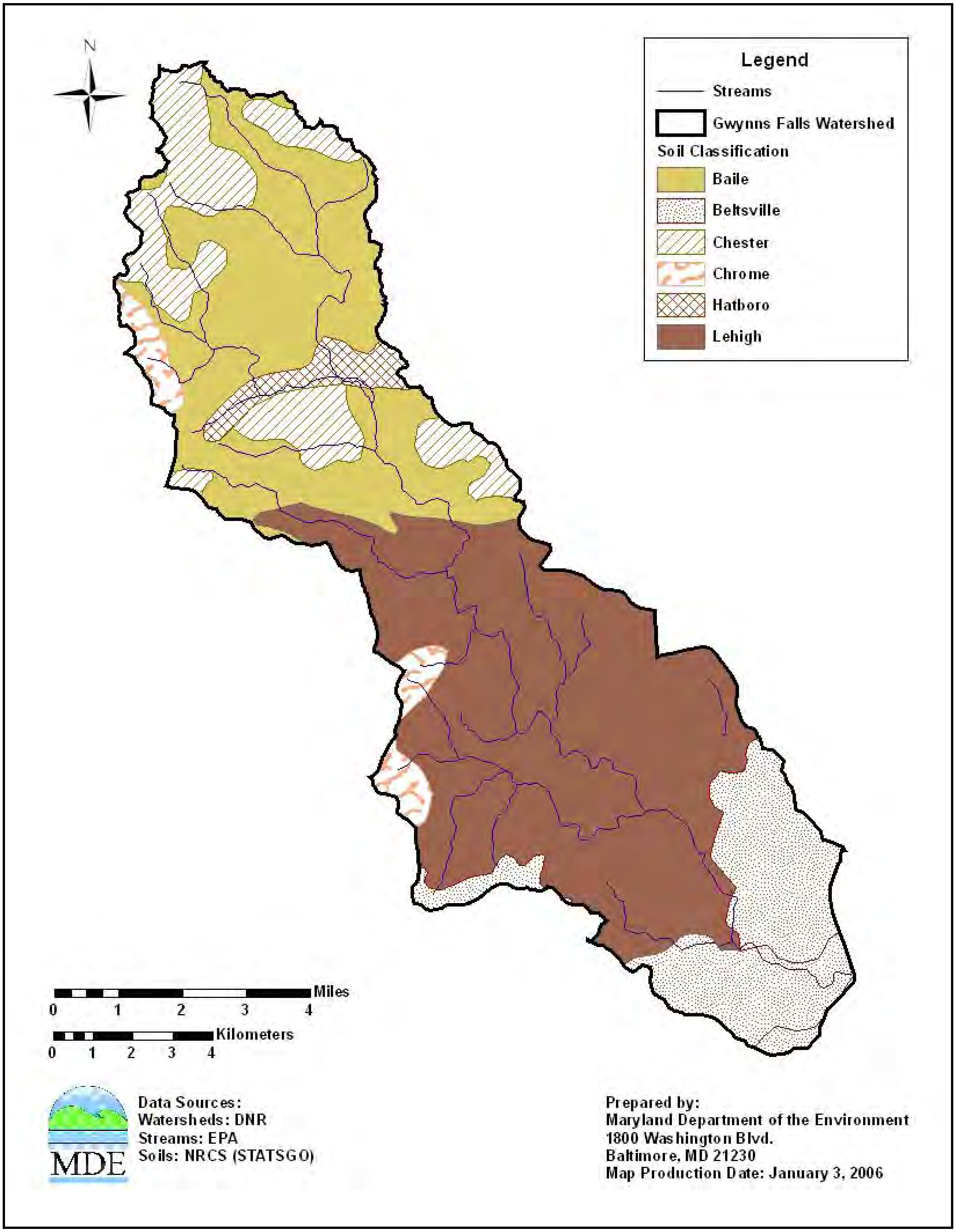


Figure 2.1.2: General Soil Series in the Gwynns Falls Watershed

Land Use

The 2002 Maryland Department of Planning (MDP) land use/land cover data show that the Gwynns Falls watershed is primarily a residential and commercial region. The watershed contains 23,860 acres (37.3 square miles) of residential land use and 9,367 acres (14.6 square miles) of commercial land use. Forest lands account for 7,068 acres (11 square miles) of the watershed, found primarily along the mainstem and tributaries of Gwynns Falls. A small portion of the watershed consists of crops and pasture lands at 921 (1.4 square miles) and 333 acres (0.5 square miles), respectively. The land use percentage distribution for the Gwynns Falls watershed is displayed in Table 2.1.1, and spatial distributions for each land use are presented in Figure 2.1.3.

Table 2.1.1: Land Use Percentage Distribution for Gwynns Falls Watershed

Land Type	Acreage	Percentage
Forest	7,068	16.9%
Residential	23,860	57.2%
Commercial	9,367	22.5%
Crops	921	2.2%
Pasture	333	0.8%
Water	161	0.4%
Totals	**41,710**	**100%**

Population

The total population in the Gwynns Falls watershed is estimated to be 315,828. Figure 2.1.4 displays the population density in the watershed. The human population and the number of households were estimated based on a weighted average from the Geographic Information System (GIS) 2000 Census Block and the 2002 MDP land use cover. Since the Gwynns Falls watershed is a sub-area of the Census Block, the GIS tool was used to extract the areas from the 2000 Census Block within the watershed. Based on the land use for residential density (low, medium, high) from the MDP land use cover, the number of dwellings per acre was calculated using Table 2.1.2 in the Gwynns Falls watershed.

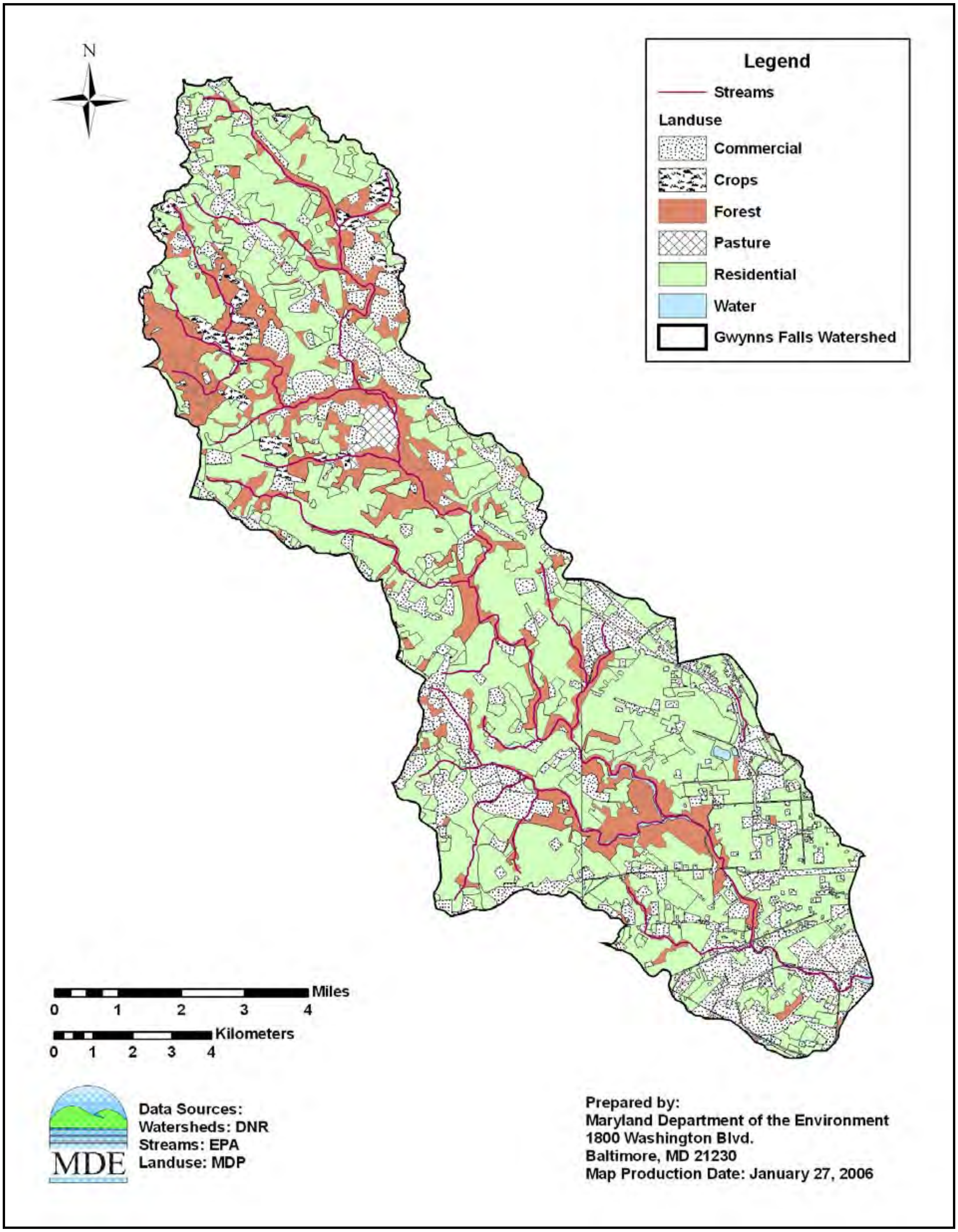
Table 2.1.2: Number of Dwellings Per Acre

Land use Code	Dwellings Per Acre
11 Low Density Residential	1
12 Medium Density Residential	5
13 High Density Residential	8

Based on the number of households from the total population from the Census Block and the number of dwellings per acre from the MDP land use cover, population per subwatershed was calculated. These results are presented in Table 2.1.3.

Table 2.1.3: Total Population Per Subwatershed in Gwynns Falls Watershed

Subwatershed	Population	Dwellings
GWN0015	23,498	6,785
GWN0026	177,152	54,725
GWN0115	56,752	26,625
GWN0160	58,426	26,309
Total	315,828	114,444



Data Sources:
Watersheds: DNR
Streams: EPA
Landuse: MDP

Prepared by:
Maryland Department of the Environment
1800 Washington Blvd.
Baltimore, MD 21230
Map Production Date: January 27, 2006

Figure 2.1.3: Land Use of the Gwynns Falls Watershed

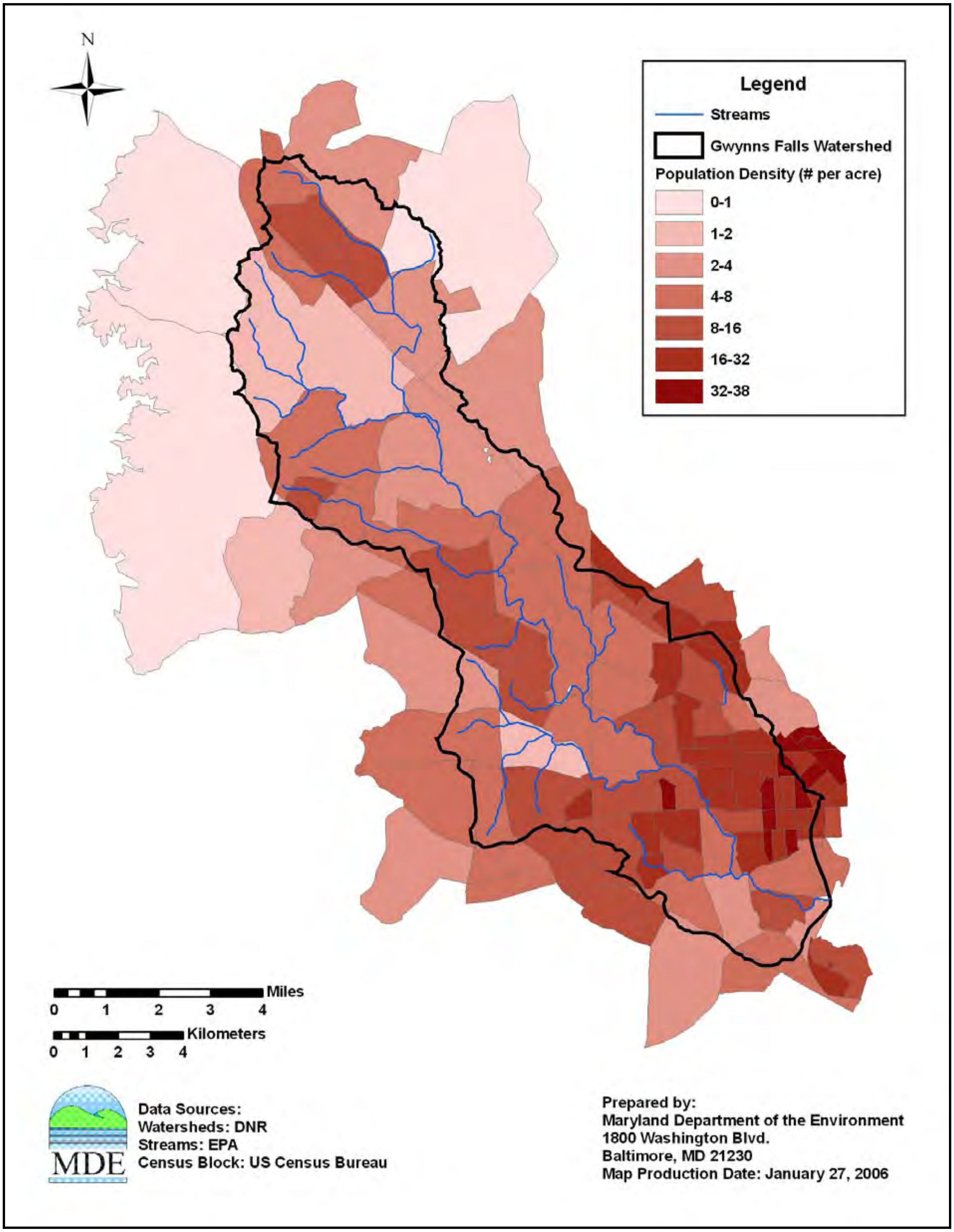


Figure 2.1.4: Population Density in Gwynns Falls Watershed

2.2 Water Quality Characterization

EPA's guidance document, "Ambient Water Quality Criteria for Bacteria" (1986), recommended that states use *E. coli* (for fresh water) or enterococci (for fresh or salt water) as pathogen indicators. Fecal bacteria, *E. coli*, and enterococci were assessed as indicator organisms for predicting human health impacts. A statistical analysis found that the highest correlation to gastrointestinal illness was linked to elevated levels of *E. coli* and enterococci in fresh water (enterococci in salt water).

As per EPA's guidance, Maryland has adopted the new indicator organisms, *E. coli* and enterococci, for the protection of public health in Use I, II, and IV waters. These 303(d) bacteria listings were originally assessed using fecal coliform bacteria in 2002. The assessment was based on a geometric mean of the monitoring data, where the result could not exceed a geometric mean of 200 MPN/100ml. From EPA's analysis (EPA, 1986), this fecal coliform geometric mean target equates to an approximate risk of 8 illnesses per 1,000 swimmers at fresh water beaches and 19 illnesses per 1,000 swimmers at marine beaches (enterococci only), which is consistent with MDE's revised Use I bacteria criteria. Therefore, the original 303(d) List fecal coliform listings can be addressed using the refined bacteria indicator organisms to ensure that risk levels are acceptable.

Bacteria Monitoring

Table 2.2.1 lists the historical monitoring data for the Gwynns Falls watershed. Bacterial data collected at Maryland Department of Natural Resources (DNR) CORE monitoring station GWN0115 were used by MDE to identify the bacterial impairment. MDE conducted additional bacteria monitoring at four stations throughout Gwynns Falls from October 2002 through October 2003. USGS gage station 01589300, located in the Gwynns Falls watershed at Villa Nova, MD, was used in the estimation of the surface flow. The gage flow data was incomplete for this station; therefore, the flow for unobserved periods (01/01/1992 to 10/01/1996) was estimated using MDE's Patapsco/Back River Watershed Stormwater Management Model (SWMM) calibrated to USGS gage station 01589300. The locations of these stations are shown in Tables 2.2.2 – 2.2.4 and in Figure 2.2.1. Observations recorded from MDE's monitoring station are displayed in Appendix A.

Bacteria counts are highly variable in Gwynns Falls. This is typical for all streams due to the nature of bacteria and their relationship to flow. Bacteria counts ranged between 20 and 86,600 MPN/100 ml.

Table 2.2.1: Historical Monitoring Data in the Gwynns Falls Watershed

Organization	Date	Parameter	Summary
DNR CORE Monitoring	01/95 to 12/03	Fecal Coliform*	GWN0115: Gwynns Falls near intersection of Liberty Road and Essex Road (Milford, MD)
MDE	10/02 to 10/03	*E. coli*	2 station Enumeration 2x per month
MDE	10/02 to 10/03	BST (*E. coli*)	2 station ARA Bacterial Source Tracking (BST) 1x per month

*Only *E. coli* was used for this analysis.

Table 2.2.2: Locations of DNR (CORE) Monitoring Station in the Gwynns Falls Watershed

Monitoring Station	Observation Period	Total Observations	LATITUDE Decimal Degrees	LONGITUDE Decimal Degrees
GWN0115	1/4/95 - 12/8/03	104	39.346	-76.734

Table 2.2.3: Locations of MDE Monitoring Stations in the Gwynns Falls Watershed

Monitoring Station	Observation Period	Total Observations	LATITUDE Decimal Degrees	LONGITUDE Decimal Degrees
GWN0015	2002-2003	26	39.271	-76.648
GWN0026	2002-2003	23	39.277	-76.662
GWN0115	2002-2003	26	39.346	-76.734
GWN0160	2002-2003	23	39.392	-76.765

Table 2.2.4: Locations of USGS Gauging Stations in Gwynns Falls Watershed

Gage Station	Observation Period	Total Observations	LATITUDE Decimal Degrees	LONGITUDE Decimal Degrees
1589300	1992-2006	5126	39.346	-76.734

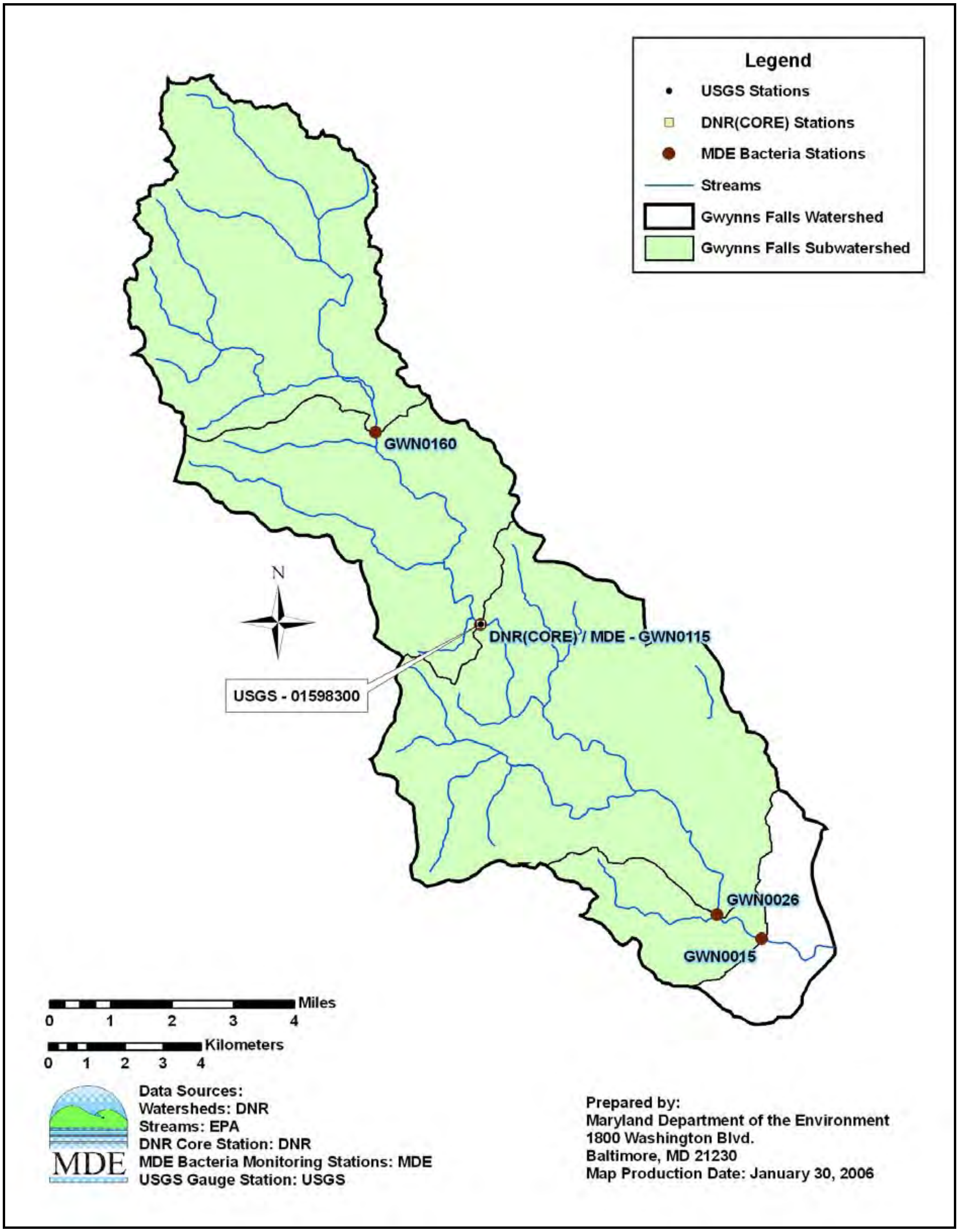


Figure 2.2.1: Monitoring Stations in the Gwynns Falls Watershed

2.3 Water Quality Impairment

Designated Uses and Water Quality Standard

The Maryland water quality standards Surface Water Use Designations for Gwynns Falls are as follows: Gwynns Falls and tributaries above Reisterstown Road – Use III (Non-tidal Cold Water); Dead Run and tributaries – Use IV (Recreational Trout Waters); and all remaining waters – Use I (Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life) (COMAR 26.08.02.08R(3)(e) & (4)(e)). Gwynns Falls has been included on the final 2004 Integrated 303(d) List as impaired by fecal coliform bacteria.

Water Quality Criteria

The State water quality standard for bacteria (*E. coli*) used in this study is as follows (COMAR Section 26.08.02.03-3):

Table 2.3.1: Bacteria Criteria Values (COMAR 26.08.02.03-3 Water Quality Criteria Specific to Designated Uses; Table 1)

Indicator	Steady State Geometric Mean Indicator Density
Freshwater	
E. coli	126 MPN/100ml

Interpretation of Bacteria Data for General Recreational Use

The relevant portion (for freshwater) of the listing methodology pursuant to the 2006 integrated 303(d) List for all Use Waters - Water Contact Recreation and Protection of Aquatic Life is as follows (MDE, January 2006):

Recreational Waters

A steady-state geometric mean will be calculated with available data where there are at least five representative sampling events. The data shall be from samples collected during steady-state conditions and during the beach season (Memorial Day through Labor Day) to be representative of the critical condition. If the resulting steady-state geometric mean is greater than 126 cfu/100 ml *E. coli* in freshwater, the waterbody will be listed as impaired. If fewer than five representative sampling events for an area being assessed are available, data from the previous two years will be evaluated in the same way. The single sample maximum criterion applies only to beaches and is to be used for closure and advisory decisions based on short term exceedances of the geometric mean portion of the standard.

Water Quality Assessment

Bacteria water quality impairment in Gwynns Falls was assessed by comparing both the annual and the seasonal (May 1st – September 30th) steady-state geometric means of *E. coli* concentrations with the water quality criterion. The steady-state condition is defined by unbiased sampling targeting average flow conditions and/or equally sampling or providing for unbiased sampling of high and low flows. The 1986 EPA criteria document assumed steady-state flow in determining the risk at various bacterial concentrations, and therefore the chosen criterion value also reflects steady-state conditions (EPA, 1986). The steady-state geometric mean condition can be estimated either by monitoring design or more practically by statistical analysis as follows:

1. A stratified monitoring design is used where the number of samples collected is proportional to the duration of high flows, mid flows and low flows within the watershed. This sample design allows a geometric mean to be calculated directly from the monitoring data.

2. Routine monitoring typically results in samples from varying hydrologic conditions (*i.e.*, high flows, mid flows and low flows) where the numbers of samples are not proportional to the duration of those conditions. Averaging these results without consideration of the sampling conditions results in a biased estimate of the steady state geometric mean. The potential bias of the steady state geometric means can be reduced by weighting the samples results collected during high flow, mid flow and low flow regimes by the proportion of time each flow regime is expected to occur. This ensures that the high flow and low flow conditions are proportionally balanced on an annual and seasonal basis.

3. If (1) the monitoring design was not stratified based on flow regime or (2) flow information is not available to weight the samples accordingly, then a geometric mean of sequential monitoring data can be used as an estimate of the steady state geometric mean condition for the specified period.

A routine monitoring design was used to collect bacteria data in the Gwynns Falls watershed. To estimate the steady state geometric means, the monitoring data were first reviewed by plotting the sample results versus their corresponding daily flow duration percentile. Graphs illustrating these results can be found in Appendix B.

To calculate the steady state geometric means with routine monitoring data, a conceptual model was developed by dividing the daily flow frequency for the stream segment into strata that are representative of hydrologic conditions. A conceptual continuum of flows is illustrated in Figure 2.3.1.

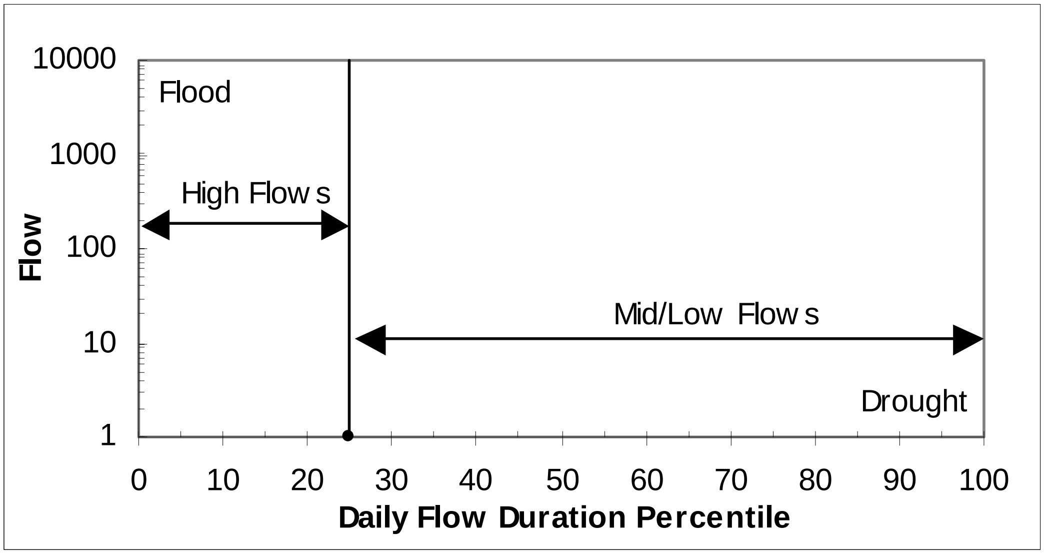


Figure 2.3.1: Conceptual Diagram of Flow Duration Zones

During high flows a significant portion of the total stream flow is from surface flow contributions. Low flow conditions represent periods with minimal rainfall and surface runoff. There is typically a transitional period (mid flows) between the high and low flow durations that is representative of varying contributions of surface flow inputs that result from differing rainfall volumes and antecedent soil moisture conditions. The division of the entire flow regime into strata enables the estimation of a less biased geometric mean from routine monitoring data that more closely approaches steady state. Based on a flow analysis of several watersheds throughout Maryland, it was determined that flows within the 20th to 28th daily flow duration percentiles were representative of average daily flows. It is assumed for this analysis that flows above the 25th percentile represent high flows and flows below the 25th percentile represent mid/low flows. A detailed method of how the flow strata were defined is presented in Appendix B.

Factors for estimating a steady state geometric mean are based on the frequency of each flow stratum. The weighting factor accounts for the proportion of time that each flow stratum represents. The weighting factors for an average hydrological year used in the Gwynns Falls TMDL analysis are presented in the following table (Table 2.3.2).

Table 2.3.2: Weighting factors for Average Hydrology Year Used for Estimation of Geometric Means in the Gwynns Falls Watershed (Average Hydrology Year)

Flow Duration Zone	Duration Interval	Weighting Factor
High Flows	0 – 25%	0.25
Mid/Low Flows	25 – 100%	0.75

Bacteria enumeration results for samples within a specified flow stratum will receive their corresponding weighting factor. The steady state geometric mean is calculated as follows:

$$M = \sum_{i=1}^{2} M_i * W_i \qquad (1)$$

where

$$M_i = \frac{\sum_{j=1}^{n_i} \log_{10}(C_{i,j})}{n_i} \qquad (2)$$

M = log weighted mean
M_i = log mean concentration for stratum i
W_i = Proportion of stratum i
$C_{i,j}$ = Concentration for sample j in stratum i
n_i = number of samples in stratum i

Finally the steady state geometric mean concentration is estimated using the following equation:

$$C_{gm} = 10^M \qquad (3)$$

C_{gm} = Steady state geometric mean concentration

Tables 2.3.3 and 2.3.4 present the maximum and minimum concentrations by stratum, geometric means by stratum and the overall steady state geometric mean for the Gwynns Falls subwatersheds for the annual and the seasonal (May 1st –September 30th) periods.

Table 2.3.3: Gwynns Falls Annual Steady State Geometric Mean by Stratum per Subwatersheds

Station	Flow Stratum	Samples (#)	*E. coli* Minimum Concentration (MPN/100ml)	*E. coli* Maximum Concentration (MPN/100ml)	Annual Steady State Geometric Mean (MPN/100ml)	Annual Weighted Geometric Mean (MPN/100ml)
GWN0015	**High**	7	15,530	86,600	40,086	32,470
	Low	19	5,800	77,000	30,267	
GWN0026	**High**	6	280	38,700	3,633	753
	Low	17	60	4,350	446	
GWN0115	**High**	7	320	16,700	1,009	321
	Low	19	20	5,790	219	
GWN0160	**High**	6	110	23,800	1,611	508
	Low	17	60	2,050	345	

Table 2.3.4: Gwynns Falls Seasonal (May 1st-September 30th) Period Steady State Geometric Mean by Stratum per Subwatersheds

Station	Flow Stratum	Samples (#)	*E. coli* Minimum Concentration (MPN/100ml)	*E. coli* Maximum Concentration (MPN/100ml)	Seasonal Steady State Geometric Mean (MPN/100ml)	Seasonal Weighted Geometric Mean (MPN/100ml)
GWN0015	**High**	3	43,500	86,600	62,529	40,716
	Low	9	5,800	77,000	35,290	
GWN0026	**High**	3	280	38,700	1,498	528
	Low	9	60	2,600	373	
GWN0115	**High**	3	620	16,700	1,954	842
	Low	9	310	5,790	636	
GWN0160	**High**	3	820	23,800	3,102	1,062
	Low	9	360	2,050	743	

2.4 Source Assessment

Nonpoint Source Assessment

Nonpoint sources of fecal bacteria do not have one discharge point but occur over the entire length of a stream or waterbody. During rain events, surface runoff transports water and fecal bacteria over the land surface and discharges to the stream system. This transport is dictated by rainfall, soil type, land use, and topography of the watershed. sMany types of nonpoint sources introduce fecal bacteria to the land surface including the manure spreading process, direct deposition from livestock during the grazing season, and excretions from pets and wildlife. The deposition of non-human fecal bacteria directly to the stream occurs when livestock or wildlife have direct access to the waterbody. Nonpoint source contributions from human activities generally arise from failing septic systems and their associated drain fields or from leaking infrastructure (*i.e*., sewer systems). Land use in the Gwynns Falls watershed consists primarily of forested and developed land uses; therefore, sources associated with agricultural land use (*i.e.*, livestock) are not a consideration in this analysis. The entire watershed is covered by two National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) individual permits; thus, contributions from domestic animal and human sources will be categorized under point sources or Waste Load Allocations (WLA). Wildlife contributions will be distributed between WLAs and Load Allocations (LA) due to the presence of wildlife in both developed and undeveloped areas of the watershed.

Sewer Systems

The Gwynns Falls sewage collection system conveys wastewater from municipalities in Baltimore County and Baltimore City. The wastewater is then treated by two municipal wastewater treatment plants (WWTPs), the Patapsco and Back River WWTPs. Two sections of the sewage collection system, located in the Forest Park and Walbrook regions of Baltimore City, are combined sewer systems (CSSs) receiving stormwater as well as wastewater. In addition, stormwater in the watershed is conveyed through storm sewers covered by NPDES MS4 permits. Because the bacteria sources associated with these sewer systems are thus derived from point sources, they are addressed in the Point Source Assessment section below.

Septic Systems

Several septic systems are located in the northwestern region of the watershed in areas where no sewer service exists (See Figure 2.4.1). Table 2.4.1 displays the number of septic systems and households per subwatershed.

Table 2.4.1: Septic Systems and Households per Subwatershed in Gwynns Falls Watershed

Subwatershed Station	Septics Systems (units)	Households per Subwatershed
GWN0015	0	4,521
GWN0026	193	47,729
GWN0115	3021	26,495
GWN0160	8073	26,260
Total	**11,287**	**105,005**

Point Source Assessment

There are two broad types of National Pollutant Discharge Elimination System (NPDES) permits considered in this analysis, individual and general. Both types of permits include industrial and municipal categories. Individual permits can include industrial and municipal WWTPs and Phase I municipal separate storm sewer systems (MS4s). MDE general permits have been established for surface water discharges that include: Phase II and other MS4 permits, surface coal mines, mineral mines, quarries, borrow pits, ready-mix concrete, asphalt plants, seafood processors, hydrostatic testing of tanks and pipelines, marinas, concentrated animal feeding operations, and stormwater associated with industrial activities.

Municipal Separate Stormwater Systems (MS4)

The Gwynns Falls watershed is located in Baltimore City and Baltimore County; both are Phase I NPDES MS4 permit jurisdictions. The MS4 permit covers stormwater discharges from the municipal separate stormwater sewer system in the City and County.

Baltimore City has conducted stormwater monitoring for 15 years in the area, both at the outfalls and in-stream. The City has monitored for fecal bacteria during base flow and storm events. Broken sanitary pipes laid in the streambed are a major source of fecal bacteria. As a result, fecal concentrations are much higher in Gwynns Falls during dry weather than during wet weather, because the sanitary system is exfiltrating (seeping) into the stream.

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) occur when the capacity of a sanitary sewer is exceeded. There are several factors that may contribute to SSOs from a sewer system, including pipe capacity, operations and maintenance effectiveness, sewer design, age of system, pipe materials, geology and building codes. SSOs are prohibited by the Clean Water Act and, where applicable, by the jurisdiction’s wastewater treatment plant discharge permits. SSOs must be reported to MDE’s Water Management Administration in accordance with COMAR 26.08.10, to be addressed under the State’s compliance and enforcement program.

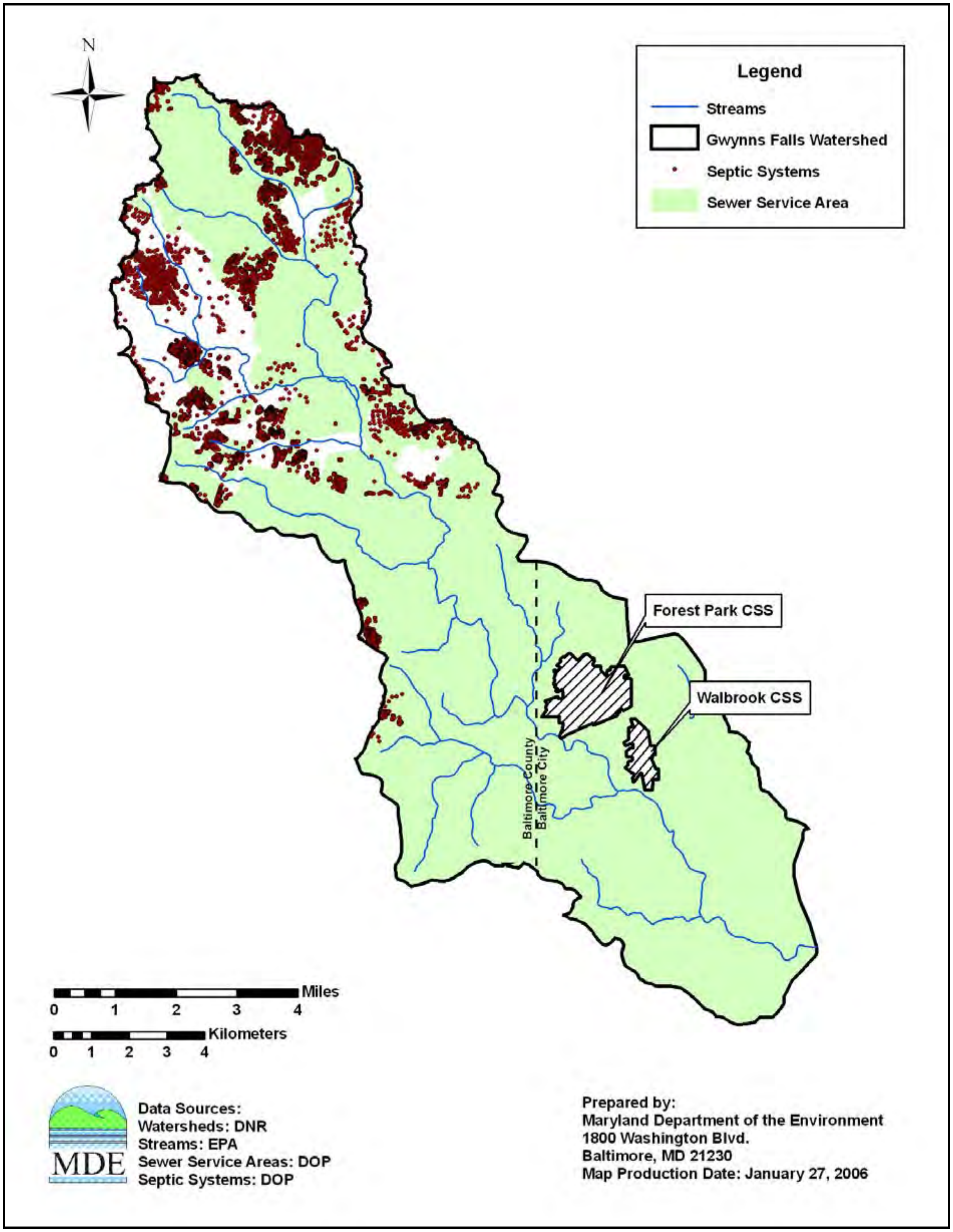


Figure 2.4.1: Sanitary Sewer Service Area and Septics in the Gwynns Falls Watershed

In 2002, Baltimore City, MDE, and EPA entered into a civil consent decree to address SSOs and combined sewer overflows (CSOs)[1] within its jurisdictional boundaries. See U.S., *et al.*, *v.* Mayor and City Council of Baltimore, JFM-02-12524, Consent Decree (Sept. 30, 2002). Similarly, in 2005, Baltimore County, MDE and EPA entered into a civil consent decree to address SSOs in the County. See U.S., *et al. v.* Baltimore County, AMD-05-2028, Consent Decree (Sept. 20, 2006). The consent decrees require the City and the County to evaluate their sanitary sewer systems and to repair, replace, or rehabilitate the system as indicated by the results of those evaluations, with all work to be completed by January 2016 for Baltimore City and by March 2020 for Baltimore County.

There were a total of 188 SSO events reported between October 2002 and October 2003. Approximately 1.4 million gallons of SSO discharge were released through various waterways (surface water, groundwater, sanitary sewers, etc.) in the Gwynns Falls mainstem and tributaries (MDE, Water Management Administration). Figure 2.4.2 depicts the location of the SSO events.

SSO and CSO Structures

CSO and SSO structures, which are a part of the sewage collection system infrastructure, are designed to release sewage when the capacity of a combined or separate sewer system is exceeded, in order to prevent backups within the collection system. Like non-structural SSOs, there are several factors that may contribute to structural CSOs and SSOs from a sewage collection system, including pipe capacity, operations and maintenance effectiveness, sewer design, age of system, pipe materials, geology and building codes. Structural CSOs and SSOs are designed to discharge; therefore, they are subject to NPDES permit requirements. As explained in the preceding section, all overflow structures will be eliminated from the sanitary sewer system by January 2016 for Baltimore City and by March 2020 for Baltimore County.

In the Gwynns Falls watershed, the Patapsco and Back River WWTP are responsible for all CSO and SSO structural releases under their associated NPDES permits. The watershed contains a total of 38 sewer overflow structures. Table 2.4.2 and Figure 2.4.3 display the location of CSO and SSO structures which discharge into the Gwynns Falls and its tributaries.

---

[1] A "combined sewer system" is a sewer system in which stormwater and sanitary sewerage are conveyed through a common set of pipes for treatment at a wastewater treatment plant. A CSO is an overflow from such a combined system. Baltimore City agreed in the Consent Decree to separate the sanitary and stormwater lines in the small areas served by a combined system and has completed that separation.

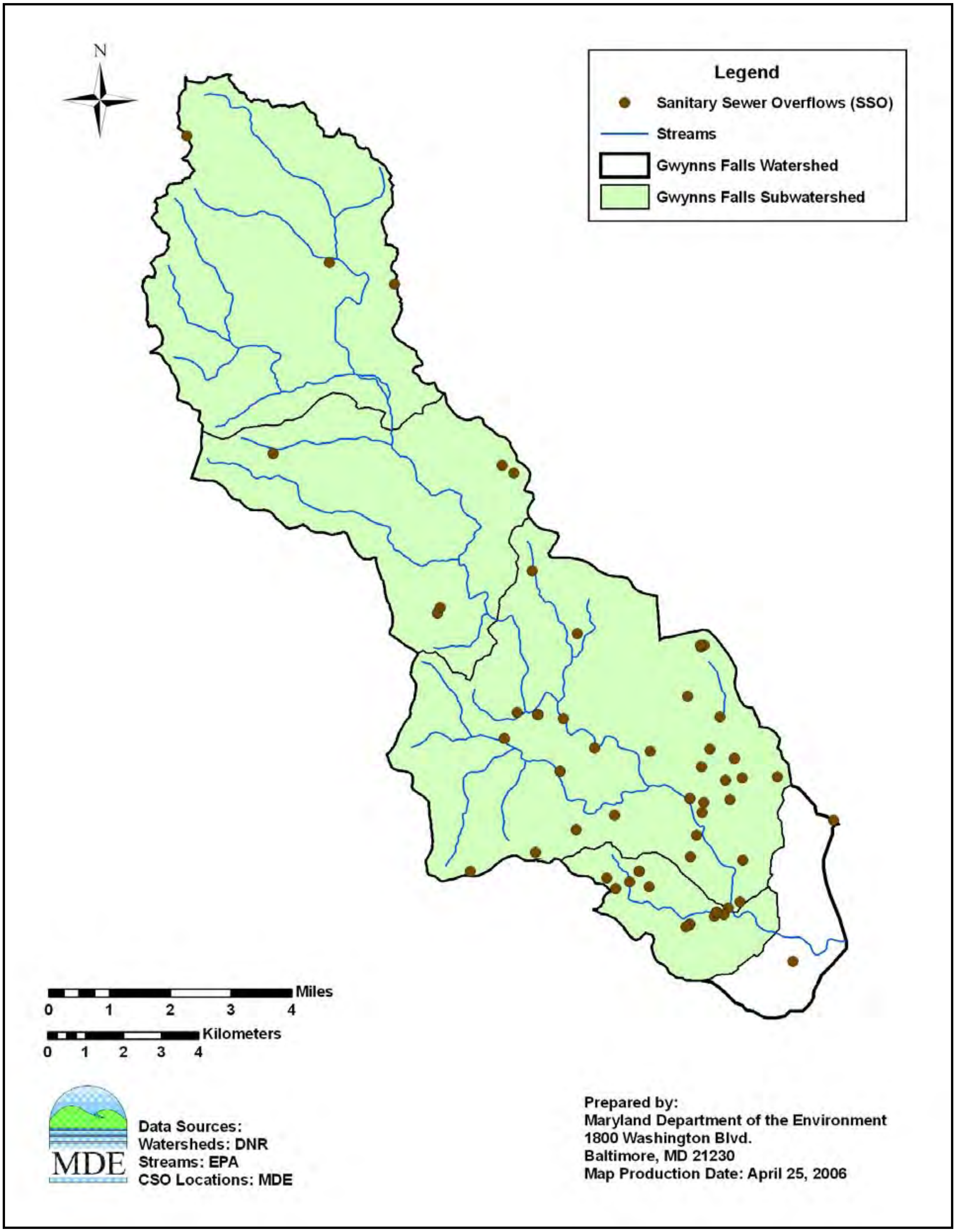


Figure 2.4.2: Sanitary Sewer Overflow Locations in the Gwynns Falls Watershed

Table 2.4.2: Sanitary Sewer Overflow Structures in the Gwynns Falls Watershed

Treatment Plant	NPDES ID	CSO/SSO Structure ID	Type	Latitude	Longitude	Receiving Water
Back River WWTP	MD0021555	79	SSO	39.277	-76.663	Gwynns Falls
		81	SSO	39.277	-76.662	Gwynns Falls
		55	SSO	39.345	-76.672	Gwynns Run
		56	SSO	39.339	-76.671	Gwynns Run
		57	SSO	39.340	-76.671	Gwynns Run
		60	SSO	39.325	-76.674	Gwynns Run
		63	SSO	39.323	-76.666	Gwynns Run
		103	SSO	39.327	-76.675	Gwynns Run
		106	SSO	39.306	-76.664	Gwynns Run
		107	SSO	39.307	-76.663	Gwynns Run
		126	SSO	39.332	-76.675	Gwynns Run
		127	SSO	39.331	-76.675	Gwynns Run
		128	SSO	39.333	-76.676	Gwynns Run
		130	SSO	39.328	-76.664	Gwynns Run
		131	SSO	39.340	-76.670	Gwynns Run
Patapsco WWTP	MD0021601	10P	CSO	39.326	-76.695	Gwynns Falls
		11P	CSO	39.323	-76.700	Gwynns Falls
		13P	CSO	39.319	-76.704	Gwynns Falls
		18P	CSO	39.329	-76.686	Gwynns Falls
		19P	CSO	39.327	-76.688	Gwynns Falls
		21P	CSO	39.308	-76.680	Gwynns Falls
		31P	CSO	39.326	-76.692	Gwynns Falls
		16P	SSO	39.295	-76.709	Dead Run
		17P	SSO	39.297	-76.702	Dead Run
		84	SSO	39.267	-76.632	Gwynns Falls
		12P	SSO	39.320	-76.700	Gwynns Falls
		22P	SSO	39.306	-76.679	Gwynns Falls
		25P	SSO	39.325	-76.700	Gwynns Falls
		26P	SSO	39.324	-76.701	Gwynns Falls
		27P	SSO	39.325	-76.687	Gwynns Falls
		6	SSO	39.274	-76.666	Maidens Choice Run
		23P	SSO	39.286	-76.713	Maidens Choice Run
		24P	SSO	39.279	-76.709	Maidens Choice Run
		32P	SSO	39.274	-76.675	Maidens Choice Run
		28P	SSO	39.342	-76.694	Powder Mill
		29P	SSO	39.342	-76.692	Powder Mill
		30P	SSO	39.342	-76.692	Powder Mill
		33P	SSO	39.343	-76.702	Powder Mill

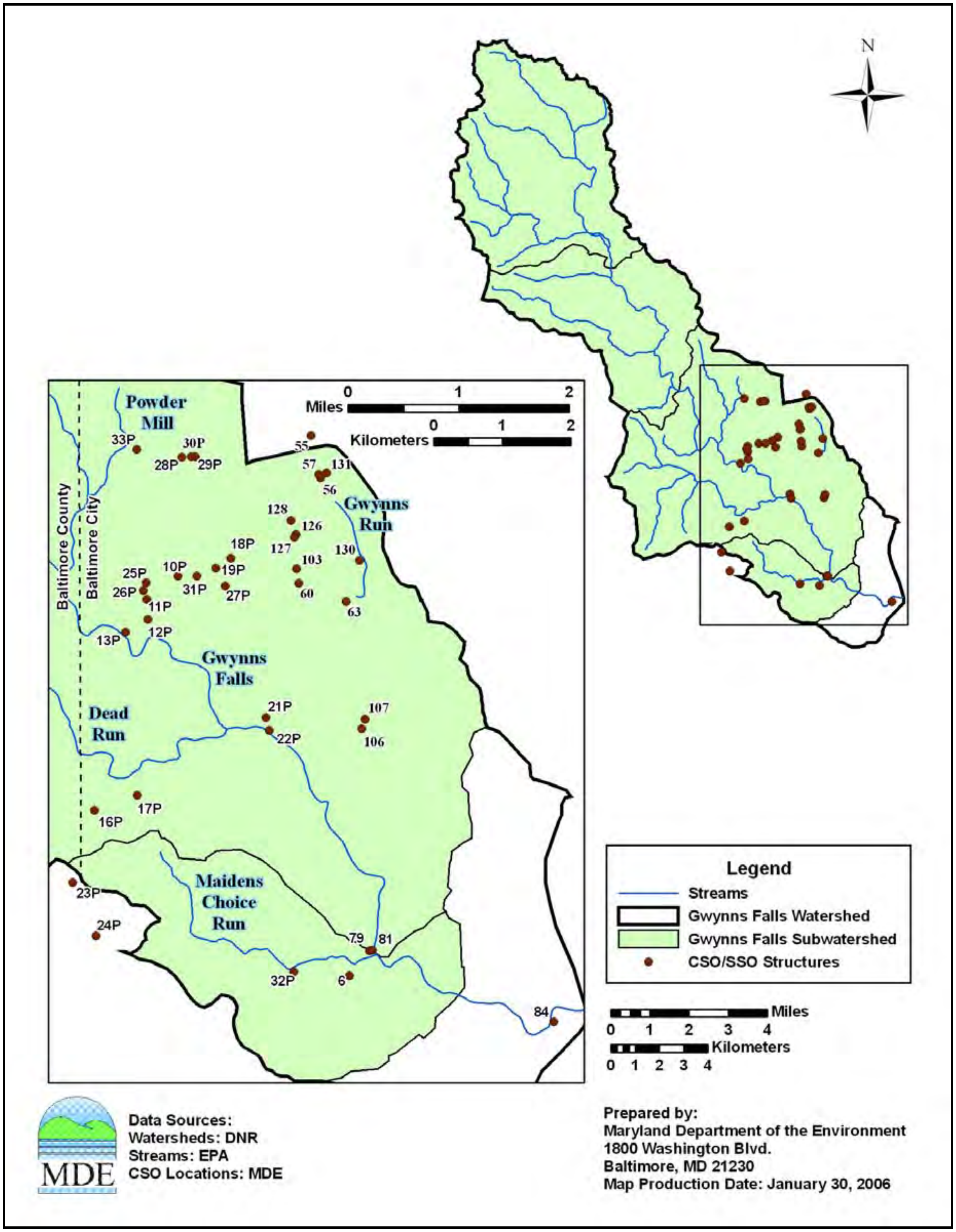


Figure 2.4.3: Sanitary Sewer Overflow Structure Locations in the Gwynns Falls Watershed

There were a total of 31 CSO events reported between October 2002 and October 2003. Approximately 3.8 million gallons of CSO discharge were released in the Gwynns Falls mainstem and tributaries (MDE, Water Management Administration).

Bacteria Source Tracking

Bacteria source tracking (BST) was used to identify the relative contribution of bacteria from different sources in in-stream water samples. BST monitoring was conducted at four stations throughout the Gwynns Falls watershed with 12 samples (one per month) collected for a one-year duration. Sources are defined as domestic (pets and human associated animals), human (human waste), livestock (agricultural animals), and wildlife (mammals and waterfowl). To identify sources, samples are collected within the watershed from known fecal sources, and the patterns of antibiotic resistance of these known sources are compared to isolates of unknown bacteria from ambient samples. Details of the BST methodology and data can be found in Appendix C.

An accurate representation of the expected contribution from each source is estimated by using a stratified weighted mean of the identified sample results over the specified period. The weighting factors are based on the log10 of the bacteria concentration and the percent of time that represents the high stream flow or low stream flow (see Appendix B). The procedure for calculating the stratified weighted mean of the sources per monitoring station is as follows:

1. Calculate the percentage of isolates per source per each sample date (S).
2. Calculate the weighted percentage (MS) of each source per flow strata (high/low) (see Section 4). The weighting is based on the log10 bacteria concentration for the water sample.
3. The final weighted mean source percentage, for each source category, is based on the proportion of time in each flow duration zone (see Appendix C).

The weighted mean for each source category is calculated using the following equations:

$$M_k = \sum_{i=1}^{2} MS_{i,k} * W_i \qquad (4)$$

where

$$MS_{i,k} = \frac{\sum_{j=1}^{n_i} \log_{10}(C_{i,j}) * S_{i,j,k}}{n_i} \qquad (5)$$

M_k = weighted mean proportion of isolates of source k
$MS_{i,k}$ = Weighted mean proportion of isolates for source k in stratum i
W_i = Proportion covered by stratum i
i = stratum

j = sample
k = Source category (1 = human, 2 = domestic, 3 = livestock, 4 = wildlife, 5 = unknown)
$C_{i,j}$ = Concentration for sample j in stratum i
$S_{i,j,k}$ = Proportion of isolates for sample j, of source k in stratum i
n_i = number of samples in stratum i

The complete distributions of the annual and seasonal periods source loads are listed in Table 2.4.3 and 2.4.4. Details of the BST data can be found in Appendix C.

Table 2.4.3: Distribution of Fecal Bacteria Source Loads in the Gwynns Falls Watershed for the Average Annual Period

STATION	Flow Stratum	% Domestic Animals	% Human	% Livestock	% Wildlife	% Unknown
GWN0015	**High Flow**	10	73	0	4	13
	Low Flow	21	66	0	2	11
	Weighted	18	68	0	2	12
GWN0026	**High Flow**	14	66	0	12	8
	Low Flow	27	47	0	10	16
	Weighted	24	52	0	10	14
GWN0115	**High Flow**	11	48	0	16	25
	Low Flow	14	44	0	31	11
	Weighted	14	45	0	27	14
GWN0160	**High Flow**	10	65	0	15	10
	Low Flow	8	59	0	21	12
	Weighted	8	60	0	20	12

Table 2.4.4: Distribution of Fecal Bacteria Source Loads in the Gwynns Falls Watershed for the Seasonal Period (May 1st – September 30th)

STATION	Flow Stratum	% Domestic Animals	% Human	% Livestock	% Wildlife	% Unknown
GWN0015	**High Flow**	10	61	0	4	25
	Low Flow	17	65	0	2	16
	Weighted	16	63	0	3	18
GWN0026	**High Flow**	3	55	0	26	16
	Low Flow	23	43	0	16	18
	Weighted	18	45	0	19	18
GWN0115	**High Flow**	2	45	0	14	39
	Low Flow	9	53	0	27	11
	Weighted	7	51	0	24	18
GWN0160	**High Flow**	12	54	0	22	12
	Low Flow	7	60	0	22	11
	Weighted	8	58	0	22	12

3.0 TARGETED WATER QUALITY GOAL

The overall objective of the fecal bacteria TMDL set forth in this document is to establish the loading caps needed to ensure attainment of water quality standards in the Gwynns Falls watershed. These standards are described fully in Section 2.3, “Water Quality Impairment.”

4.0 TOTAL MAXIMUM DAILY LOADS AND SOURCE ALLOCATION

4.1 Overview

This section provides an overview of the non-tidal fecal bacteria TMDL development, with a discussion on the many complexities involved in estimating bacteria concentrations, loads and sources. The second section presents the analysis framework and how the hydrological, water quality and BST data are linked together in the TMDL process. The third section describes the analysis for estimating a representative geometric mean fecal bacteria concentration and baseline loads. The analysis methodology is based on available monitoring data and is specific to a free-flowing stream system. The fourth section addresses the critical condition and seasonality. The fifth section presents the margin of safety. The sixth section discusses TMDL loading caps. The seventh section presents TMDL scenario descriptions. The eighth section presents the load allocations. Finally, in section nine, the TMDL equation is summarized.

To be most effective, the TMDL provides a basis for allocating loads among the known pollutant sources in the watershed so that appropriate control measures can be implemented and water quality standards achieved. By definition, the TMDL is the sum of the individual waste load allocations (WLA) for point sources, load allocations (LA) for nonpoint sources and natural background sources. A margin of safety (MOS) is also included and accounts for the uncertainty in the analytical procedures used for water quality modeling, and the limits in scientific and technical understanding of water quality in natural systems. Although this formulation suggests that the TMDL be expressed as a load, federal regulations (40 CFR 130.2(i)) provide that the TMDL can be expressed in terms of “mass per time, toxicity or other appropriate measure.”

For many reasons, bacteria are difficult to simulate in water quality models. They reproduce and die off in a non-linear fashion as a function of many environmental factors, including temperature, pH, turbidity (UV light penetration), and settling. They occur in concentrations that vary widely (*i.e.*, over orders of magnitude) and an accurate estimation of source inputs is difficult to develop. Finally, limited data are available to characterize the effectiveness of any program or practice at reducing bacteria loads (Schueler, 1999).

Bacteria concentrations, determined through laboratory analysis of in-stream water samples for bacteria indicators (*e.g.*, *E. coli*), are expressed in either colony forming units (CFU) or most probable number (MPN) of colonies. The first method (Method 1600) is a direct estimate of the bacteria colonies (EPA, 1985), and the second (Method 9223B) is a statistical estimate of the number of colonies (American Public Health Association (APHA), 1998). Enumeration results demonstrate the extreme variability in the total bacteria counts. The distribution of the enumeration results from water samples tends to be lognormal, with a strong positive skew of the data. Estimating loads of constituents that vary by orders of magnitude can introduce much uncertainty and result in large confidence intervals around the final results.

Estimating bacteria sources can be problematic due to the many assumptions required and the limited available data. For example, when considering septic systems, information is required on the spatial location of failing septic systems, consideration of transport to in-stream assessment location and estimation of the load from the septic system (degree of failure). Secondary sources, such as illicit discharges, also add to the uncertainty in a bacteria water quality model.

Estimating domestic animal sources requires information regarding the pet population in a watershed, how often the owners clean up after them, and the spatial location of the pet waste relative to the stream (near-field for upland transport). Livestock sources are limited by spatial resolution of Agricultural Census information (available at the county level), site-specific issues relating to animals' confinement, and confidentiality of data related to the development of Nutrient Management Plans. The most uncertain source category is wildlife. In an urban environment, this can result from the increased deer populations near streams to rat populations in storm sewers. In rural areas, estimation of wildlife populations and habitat locations in a watershed is required.

MDE appreciates the inherent uncertainty in developing traditional water quality models for the calculation of bacteria TMDLs. Traditional water quality modeling is very expensive and time-consuming and, as identified, contains many potential uncertainties. MDE believes it should be reserved for specific constituents and complex situations. In this TMDL, MDE applies an analytical method which, when combined with BST analysis, provides reasonable results (Cleland, 2003). Using this approach, MDE can address more impaired streams in the same time period than using the traditional water quality modeling methods.

4.2 Analytical Framework

This TMDL analysis uses flow duration curves to identify flow intervals that are indicators of hydrological conditions (*i.e.*, annual average, critical conditions). As explained previously, this analytical method, combined with water quality monitoring data and BST, provides a better description of water quality and meets TMDL requirements.

Figure 4.2.1 illustrates how the hydrological (flow duration curve), water quality and BST data are linked together for the TMDL development.

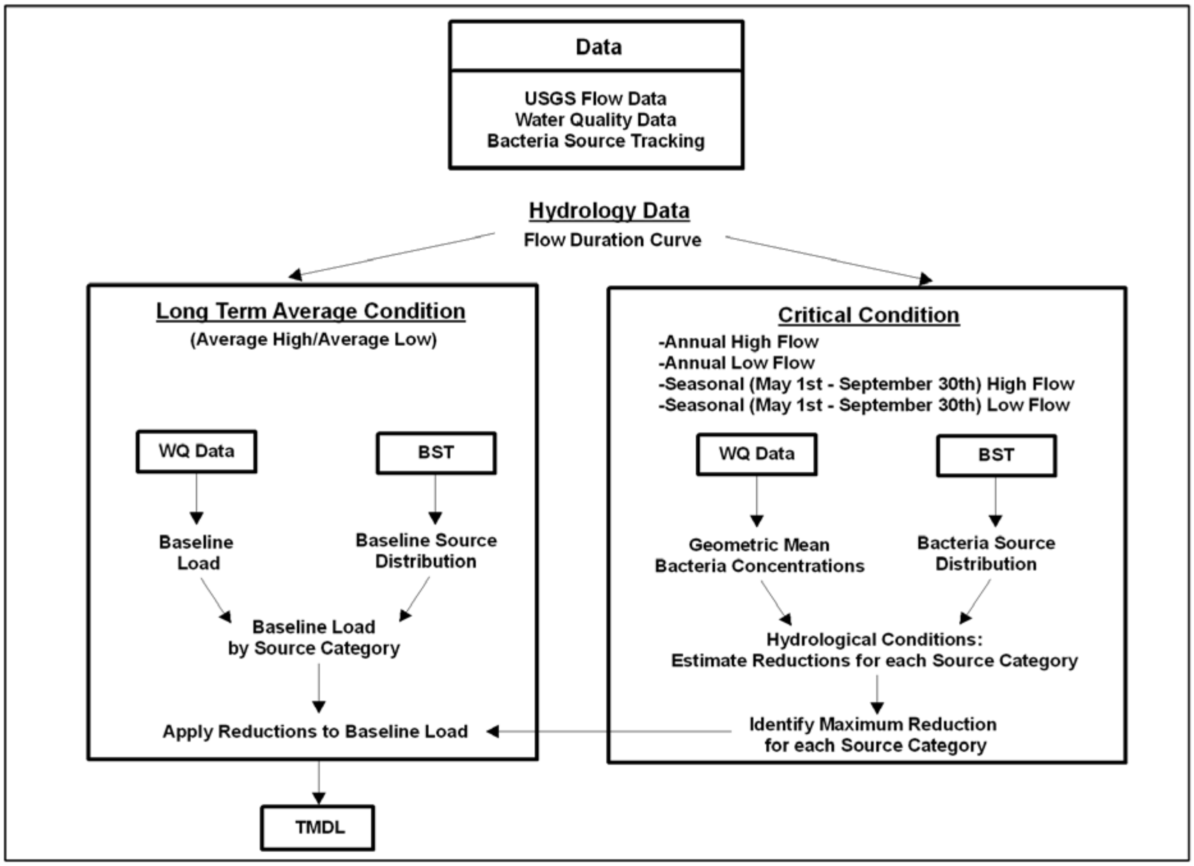


Figure 4.2.1: Diagram of Non-tidal Bacteria TMDL Analytical Framework

4.3 Estimating Baseline Loads

Baseline loads estimated in this TMDL analysis are reported as long-term average loads. The geometric mean concentration is calculated from the log transformation of the raw data. Statistical theory tells us that when back-transformed values are used to calculate average daily loads or total annual loads, the loads will be biased low (Richards, 1998). To avoid this bias, a factor should be added to the log-concentration before it is back-transformed. There are several methods of determining this bias correction factor, ranging from parametric estimates resulting from the theory of the log-normal distribution to non-parametric estimates using a smearing factor [Ferguson, 1986; Cohn *et al*., 1989; Duan, 1983]. There is much literature on the applicability and results from these various methods with a summary provided in Richards (1998). Each has advantages and conditions of applicability. A non-parametric estimate of the bias correction factor (Duan, 1983) was used in this TMDL analysis.

The bias correction factor is estimated as follows:

$$F_1 = A_i / C_i \qquad (6)$$

F_1 = Bias correction factor
A_i = Long term annual arithmetic mean for stratum i
C_i = Long term annual geometric mean for stratum i

Daily average flows are estimated for each flow stratum using the watershed area ratio approach, since nearby long-term flow monitoring data are available.

The loads for each stratum are estimated as follows:

$$L_i = Q_i * C_i * F_1 * F_2 \qquad (7)$$

where

L_i = Daily average load (MPN/day) at each station for stratum i
Q_i = Daily average flow (cfs) for stratum i
C_i = long term annual geometric mean for stratum i
F_1= Bias correction factor
F_2= Unit conversion factor from cfs*MPN/100ml to MPN/day (2.4466x107)

For each subwatershed, the total baseline load is estimated as follows:

$$L_t = \sum_{i=1}^{2} L_i * W_i \qquad (8)$$

L_t = Daily average load at station (MPN/day)
W_i= Proportion or weighting factor of stratum i

In the Gwynns Falls watershed, a weighting factor of 0.25 for high flow and 0.75 for low flow were used to estimate the average annual baseline load expressed as billion *E. coli* MPN/day. Results are found in Table 4.3.1.

Table 4.3.1: Baseline Load Calculations

Station		**GWN0160**	**GWN0115sub**	**GWN0026sub**	**GWN0015sub**
Area (mi^2)		19.2	13.4	24.8	4.0
High Flow	**Daily Average Flow (cfs)**	74.9	52.3	96.7	15.5
	***E. coli* Concentration (MPN/100ml)**	1611.3	302.3	8109.8	740277.0
	Bias Correction Factor	3.2	2.9	3.6	1.2
Low Flow	**Daily Average Flow (cfs)**	14.0	9.8	18.1	2.9
	***E. coli* Concentration (MPN/100ml)**	345.4	65.2	1271.1	156243.6
	Bias Correction Factor	1.6	2.6	1.7	1.2
Baseline Load (Billion *E. coli* MPN/day)		2539.6	314.8	17990.7	90620.3

The Gwynns Falls watershed was delineated into four subwatershed segments based on the location of each monitoring station. Baseline loads were estimated for each station. For subwatersheds with upstream monitoring stations, the total baseline load from upstream stations was multiplied by a transport factor derived from first order decay and subtracted from the downstream cumulative load to estimate the adjacent subwatershed baseline load. The decay factor for *E. coli* used in the analysis was obtained from the study “Pathogen Decay in Urban Waters” by Easton *et al.* (2001), and was estimated by linear regression of counts of microorganisms versus time (die-off plots). For stations GWN0115, GWN0026 and GWN0015 there is an upstream monitoring station. These subwatersheds were defined with the extension sub to the station name (*e.g.*, GWN0115sub). Refer back to Figure 2.2.1 for subwatershed locations. Refer back to Figure 2.2.1 for subwatershed locations.

The general equation for the flow mass balance is:

$$\sum Q_{us} + Q_{sub} = Q_{ds} \tag{9}$$

where

Q_{us} = Upstream flow
Q_{sub} = Subwatershed flow
Q_{ds} = Downstream flow

and the general equations for bacteria loading mass balance:

$$\sum (e^{kt} * Q_{us} * C_{us}) + Q_{sub} * C_{sub} = Q_{ds} * C_{ds} \tag{10}$$

where

C_{us} = Upstream bacteria concentration
k = Bacteria (*E. coli)* decay coefficient (1/day) = 0.762 day^{-1}
t = travel time from upstream watershed to outlet
C_{sub} = Subwatershed bacteria concentration
C_{ds} = Downstream bacteria concentration

The concentrations in the subwatersheds were estimated by considering the ratio of high flow concentration to low flow concentrations in the upstream watersheds. If the total load and average flow were used to estimate the geometric mean concentration, this estimated concentration would be biased if there was a correlation with flow and concentration. For example, in two strata, the steady state geometric mean is estimated as follows:

$$L = (Q_{high} * W_{high} * C_{high}) + (Q_{low} * W_{low} * C_{low}) \tag{10}$$

L = Average Load
Q_i = Average flow for stratum i
W_i= Proportion of stratum i
C_i = Concentration for stratum i
n_i = number of samples in stratum i

The load in equation (10) is based on two concentrations and therefore when using the mass balance approach and the total load, this results in two unknowns, C_{high} and C_{low}, in the same equation. Thus a relationship between C_{high} and C_{low} must be estimated to solve for the concentration in both strata. This relationship is estimated using the average of the ratios estimated from the monitoring data in the upstream watersheds. Using this relationship, the following two equations result:

$$C_{low} = \frac{L}{Q_{high} * R * W_{high} + Q_{low} * W_{low}} \qquad (11)$$

where

$$R = \frac{C_{high}}{C_{low}} \qquad (12)$$

and the final geometric mean concentration is estimated as follows:

$$GM = 10^{W_{high} \log_{10}(C_{high}) + W_{low} \log_{10}(C_{low})} \qquad (13)$$

Source estimates from the bacteria source tracking analysis are completed for each station and are based on the contribution from the upstream watershed, if applicable. Given the uncertainty of in-stream bacteria processes and the complexity involved in back-calculating an accurate source transport factor, the sources for GWN0115sub, GWN0026sub, and GWN0015sub were assigned from the analysis for GWN0115, GWN0026, and GWN0015, respectively.

4.4 Critical Condition and Seasonality

Federal regulations (40 CFR 130.7(c)(1)) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of the waterbody is protected during times when it is most vulnerable.

For this TMDL the critical condition is determined by assessing annual and seasonal hydrological conditions for high flow and low flow periods. Seasonality is captured by assessing the time period when water contact recreation is expected (May 1st - September 30th). The average hydrological condition over a 15-year period is approximately 25% high flow and 75% low flow as defined in Appendix B. Using the definition of a high flow condition as occurring when the daily flow duration interval is less than 25% and a low flow condition as occurring when the daily flow duration interval is greater than 25%, the critical hydrological condition can be estimated by the percent of high or low flows during a specific period and hydrological condition.

As stated above, Maryland’s proposed fecal bacteria TMDL for Gwynns Falls has been determined by assessing various hydrological conditions to account for seasonal and annual averaging periods. The following four conditions shown in Table 4.4.1 were used to account for the critical condition: annual high flow, annual low flow, seasonal high flow and seasonal low flow.

Table 4.4.1: Hydrological Conditions Used to Account for Critical Condition and Seasonality

Hydrological Condition		Averaging Period	Water Quality Data Used	Fraction High Flow	Fraction Low Flow	Condition Period
Annual	Average	365 days	All	0.25	0.75	Long Term Average
	Wet	365 days	All	0.56	0.44	Jan 1997 - Jan 1998
	Dry	365 days	All	0.06	0.94	May 1994 - May 1995
Seasonal	Wet	May 1st – Sept 30th	May 1st – Sept 30th	0.46	0.54	May 1996 - Sep 1996
	Dry	May 1st – Sept 30th	May 1st – Sept 30th	0.00	1.00	May 1993 - Sep 1993

The critical condition is determined by the maximum reduction per source that satisfies all four conditions, and is required to meet the water quality standard while minimizing the risk to water contact recreation. It is assumed that the reduction that can be implemented to a bacteria source category will be constant through all conditions (*e.g.*, pet waste can be reduced by 75%).

The monitoring data for all stations located in the Gwynns Falls watershed cover a sufficient temporal span (at least one year) to estimate annual and seasonal conditions. The required reductions of fecal bacteria to meet water quality standards at each station for each hydrological condition are presented in Table 4.4.2.

Table 4.4.2: Required Reductions of Fecal Bacteria to Meet Water Quality Standards

Station	Time Period	Hydrological Condition	Domestic %	Human %	Livestock %	Wildlife %
GWN0160	Annual	Wet	98%	98%	0%	33%
		Dry	28%	98%	0%	0%
	Seasonal	Wet	98%	98%	0%	76%
		Dry	98%	98%	0%	47%
	Maximum Source Reduction		**98%**	**98%**	**0%**	**76%**
GWN0115sub	Annual	Wet	0%	32%	0%	0%
		Dry	0%	0%	0%	0%
	Seasonal	Wet	96%	98%	0%	2%
		Dry	0%	82%	0%	0%
	Maximum Source Reduction		**96%**	**98%**	**0%**	**2%**
GWN0026sub	Annual	Wet	98%	98%	0%	85%
		Dry	98%	98%	0%	45%
	Seasonal	Wet	98%	98%	0%	78%
		Dry	98%	98%	0%	45%
	Maximum Source Reduction		**98%**	**98%**	**0%**	**85%**
GWN0015sub	Annual	Wet	99.998%	99.9996%	0%	99.096%
		Dry	99.997%	99.9991%	0%	97.037%
	Seasonal	Wet	99.999%	99.9998%	0%	99.562%
		Dry	99.998%	99.9996%	0%	98.890%
	Maximum Source Reduction		**99.999%**	**99.9998%**	**0%**	**99.562%**

4.5 Margin of Safety

A Margin of Safety (MOS) is required as part of this TMDL in recognition of the many uncertainties in the understanding and simulation of bacteriological water quality in natural systems and in statistical estimates of indicators. As mentioned in Section 4.1, it is difficult to estimate stream loadings for fecal bacteria due to the variation in loadings across sample locations and time. Load estimation methods should be both precise and accurate to obtain the true estimate of the mean load. Refined precision in the load estimation is due to using a stratified approach along the flow duration intervals, thus reducing the variation in the estimates. Moreover, Richards (1998) reports that averaging methods are generally biased, and the bias increases as the size of the averaging window increases. Finally, accuracy in the load estimation is based on minimal bias in the final result when compared to the true value.

Based on EPA guidance, the MOS can be achieved through two approaches (EPA, April 1991). One approach is to reserve a portion of the loading capacity as a separate term in the TMDL (*i.e.*, TMDL = LA + WLA + MOS). The second approach is to incorporate the MOS as conservative assumptions used in the TMDL analysis. For this TMDL, the second approach was used by estimating the loading capacity of the stream based on a more stringent water quality criterion concentration. The *E. coli* water quality criterion concentration was reduced by 5%, from 126 *E. coli* MPN/100ml to 119.7 *E. coli* MPN/100ml.

4.6 TMDL Loading Caps

The TMDL loading cap is an estimate of the assimilative capacity of the monitored watershed and is provided in MPN/day. The loading caps presented in this section are for the watersheds located upstream of monitoring stations GWN0160, GWN0115, GWN0026, and GWN0015.

The TMDL is based on a long-term average hydrological condition. Estimation of the TMDL requires knowledge of how the bacteria concentrations vary with flow rate or the flow duration interval. This concentration versus flow relationship is accounted for by using the strata defined on the flow duration curve.

The TMDL loading caps are estimated by first determining the baseline or current condition loads for each subwatershed and the associated geometric mean from the available monitoring data. The baseline load is estimated using the geometric mean concentration and average daily flow for each flow stratum. The loads from these two strata are then weighted to represent average conditions (see Table 4.3.1), based on the proportion of each stratum, to estimate the total long-term loading rate.

Next, the percent reduction required to meet the water quality criterion is estimated from the observed bacteria concentrations accounting for the critical conditions (See Section 4.4). A reduction in concentration is proportional to a reduction in load; thus, the TMDL is equal to the current baseline load multiplied by one minus the required reduction.

$$TMDL = L_b * (1 - R) \tag{12}$$

where

Lb = Current or baseline load estimated from monitoring data
R = Reduction required from baseline to meet water quality criterion

The bacteria TMDLs for the subwatersheds are shown in Table 4.6.1.

Table 4.6.1: Gwynns Falls Watershed TMDL Summary

Station	Baseline Load (Billion *E. coli* MPN/day)	TMDL Load (Billion *E. coli* MPN/day)	% Target Reduction
GWN0160	2539.6	172.5	93.2%
GWN0115sub	314.8	103.4	67.2%
GWN0026sub	17990.7	629.9	96.5%
GWN0015sub	90620.3	11.5	99.99%
Total	111465.5	917.4	

4.7 Scenario Descriptions

Source Distribution

The final source distribution is derived from the source proportions listed in Table 2.4.3. For the purposes of the TMDL analysis and allocations, the percentage of sources identified as "unknown" were removed and the known sources were then scaled up proportionally so that they totaled 100%. The source distribution used in this scenario is presented in Table 4.7.1.

Table 4.7.1: Baseline Source Distributions

Station	Domestic		Human		Livestock		Wildlife	
	%	Load (Billion *E. coli* MPN/day)	%	Load (Billion *E. coli* MPN/day)	%	Load (Billion *E. coli* MPN/day)	%	Load (Billion *E. coli* MPN/day)
GWN0160	9.2%	233.7	68.5%	1740.4	0.0%	0.0	22.3%	565.5
GWN0115sub	15.6%	49.1	52.5%	165.3	0.0%	0.0	31.9%	100.4
GWN0026sub	27.8%	5009.4	60.1%	10821.2	0.0%	0.0	12.0%	2160.1
GWN0015sub	20.6%	18667.8	76.6%	69410.0	0.0%	0.0	2.8%	2542.6

Practicable Reduction Targets

The maximum practicable reduction (MPR) for each of the four source categories is listed in Table 4.7.2. These values are based on best professional judgment and a review of the available literature. It is assumed that human sources would potentially confer the highest risk of gastrointestinal illness and therefore should have the highest reduction. If a domestic WWTP is located in the upstream watershed, this is considered in the MPR in order to not violate the permitted loads. The domestic animal category includes sources from pets (*e.g.*, dogs) and the MPR is based on an estimated success of education and outreach programs.

Table 4.7.2: Maximum Practicable Reduction Targets

	Human	**Domestic**	**Livestock**	**Wildlife**
Max Practical Reduction per Source	95%*	75%	75%	0%
Rationale	(a) Direct source inputs (b) Human pathogens more prevalent in humans than animals. (c) Enteric viral diseases spread from human to human[1]	Target goal reflects uncertainty in effectiveness of urban BMPs[2] and is also based on best professional judgment	Target goal based on sediment reductions from BMPs[3] and best professional judgment	No programmatic approaches for wildlife reduction to meet water quality standards Waters contaminated by wild animal waste offer a public health risk that is orders of magnitude less than that associated with human waste.[4]

*Since much of the human sources in this watershed are due to infrastructure failure, correction of exfiltration required by a consent decree may result in greater reductions than in other watersheds.

[1] USEPA. 1984. Health Effects Criteria for Fresh Recreational Waters. EPA-600/1-84-004. U.S. Environmental Protection Agency, Washington, DC.
[2] USEPA. 1999. Preliminary Data Summary of Urban Storm Water Best Management Practices. EPA-821-R-99-012. U.S. Environmental Protection Agency, Washington, DC.
[3] USEPA. 2004. Agricultural BMP Descriptions as Defined for The Chesapeake Bay Program Watershed Model. Nutrient Subcommittee Agricultural Nutrient Reduction Workshop.
[4] Environmental Indicators and Shellfish Safety. 1994. Edited by Cameron, R., Mackeney and Merle D. Pierson, Chapman & Hall.

As previously stated, these practicable reduction targets are based on the available literature and best professional judgment. There is much uncertainty with estimated reductions from best management practices (BMPs). The BMP efficiency for bacteria reduction ranged from -6% to +99% based on a total of 10 observations (EPA, 1999). The MPR to agricultural lands was based on sediment reductions identified by the EPA (EPA, 2004).

The practicable reduction scenario was developed based on an optimization analysis whereby a subjective estimate of risk was minimized, and constraints were set on maximum reduction and allowable background conditions. Risk was defined on a scale of one to five, where it was assumed that human sources had the highest risk (5), domestic animal and livestock next (3) and wildlife the lowest (1) (see Table 4.7.2). The objective is to minimize the sum of the risk for all conditions while meeting the maximum practicable reduction constraints. The model was defined as follows:

$$\text{Min} \sum_{i=1}^{4} (Ph*5 + Pd*3 + Pl*3 + Pw*1) \qquad i = \text{hydrological condition}$$

Subject to

C = Ccr
0 <= Rh <= 95%
0 <= Rl <= 75%
0 <= Rd <= 75%
Rw = 0
Ph, Pl, Pd, Pw >= 1%

Where

Ph = % human source in final allocation
Pd = % domestic animal source in final allocation
Pl = % livestock source in final allocation
Pw = % wildlife source in final allocation
C = In-stream concentration
Ccr = Water quality criterion
Rh = Reduction applied to human sources
Rl = Reduction applied to livestock sources
Rd = Reduction applied to domestic animal sources
Rw = Reduction applied to wildlife sources

In all four subwatersheds, the constraints of this scenario could not be satisfied, indicating there was not a practicable solution. A summary of the analysis is presented in Table 4.7.3

Table 4.7.3: Practicable Reduction Results

Station	**Applied Reductions**				**WQS Achievable**
	Domestic %	**Human %**	**Livestock %**	**Wildlife %**	
GWN0160	75.0%	95.0%	75.0%	0.0%	No
GWN0115sub	75.0%	95.0%	75.0%	0.0%	No
GWN0026sub	75.0%	95.0%	75.0%	0.0%	No
GWN0015sub	75.0%	95.0%	75.0%	0.0%	No

The TMDL must specify load allocations that will meet the water quality standards. In the practicable reduction targets scenario, none of the four subwatersheds could meet water quality standards based on MPRs.

To further develop the TMDL, the constraints on the MPRs were relaxed in all four subwatersheds where the water quality attainment was not achievable with the MPRs. In these subwatersheds, the maximum allowable reductions were increased to 98% for all sources, including wildlife. A similar optimization procedure was used to minimize risk. Again, the objective is to minimize the sum of the risk for all conditions while meeting the maximum practicable reduction constraints. The model was defined as follows:

$$\text{Min} \sum_{i=1}^{7} (Ph*5 + Pd*3 + Pl*3 + Pw*1) \qquad i = \text{hydrological condition}$$

Subject to

$C = Ccr$
$0 <= Rh <= 98\%$
$0 <= Rl <= 98\%$
$0 <= Rd <= 98\%$
$0 <= Rw <= 98\%$
$Ph, Pl, Pd, Pw >= 1\%$

Where

Ph = % human source in final allocation
Pd = % domestic animal source in final allocation
Pl = % livestock source in final allocation
Pw = % wildlife source in final allocation
C = In-stream concentration
Ccr = Water quality criterion
Rh = Reduction applied to human sources
Rl = Reduction applied to livestock sources
Rd = Reduction applied to domestic animal sources
Rw = Reduction applied to wildlife sources

The required reductions and TMDL allocations by source category for each subwatershed are presented in Table 4.7.4 and Table 4.7.5, respectively. For subwatershed GWN0015sub a maximum reduction constraint of 98% for all bacterial sources was insufficient in order to meet the target reduction, therefore the constraint was further relaxed to a maximum reduction of 100%.

Table 4.7.4: TMDL Reduction Results: Optimization Model Up to 98% Reduction

Station	Domestic %	Human %	Livestock %	Wildlife %	Target Reduction
GWN0160	98.0%	98.0%	0.0%	76.5%	93.2%
GWN0115sub	96.0%	98.0%	0.0%	2.3%	67.2%
GWN0026sub	98.0%	98.0%	0.0%	85.5%	96.5%
GWN0015sub	99.9989%	99.9998%	0.0%	99.6%	99.987%

Table 4.7.5: TMDL Reduction Results: Reduced Loads by Source

Station	Domestic (Billion *E. coli* MPN/day)	Human (Billion *E. coli* MPN/day)	Livestock (Billion *E.coli* MPN/day)	Wildlife (Billion *E. coli* MPN/day)	Total (Billion *E. coli* MPN/day)
GWN0160	4.7	34.8	0.0	133.1	172.5
GWN0115sub	1.9	3.3	0.0	98.2	103.4
GWN0026sub	100.2	216.4	0.0	313.3	629.9
GWN0015sub	0.2	0.2	0.0	11.1	11.5

4.8 TMDL Allocation

The TMDL allocation includes load allocations (LA) for nonpoint sources and waste load allocations (WLA) for point sources and for stormwater (where MS4 permits are required). The margin of safety is explicit and has been incorporated in the analysis by estimating the loading capacity of the stream based on a more stringent water quality endpoint concentration. It is expressed as a 5% reduction of the *E. coli* water quality criterion concentration, from 126 MPN/100ml to 119.7 MPN/100ml. The final loads are based on average hydrological conditions but take into account critical conditions. The load reduction scenario results in allocations that will achieve water quality standards. The State reserves the right to revise these allocations provided such revisions are consistent with the achievement of water quality standards.

The bacteria sources are grouped into four categories that are also consistent with divisions for various management strategies. The categories are human, domestic animal, livestock and wildlife. TMDL allocation rules are presented in Table 4.8.1. This table identifies how the TMDL will be allocated among MS4 permits and the LA.

Table 4.8.1: Potential Source Contributions for TMDL Allocations

Allocation Category	**LA**	**WLA**		
		WWTP	**MS4**	**CSOs**
Human			X	
Domestic			X	
Livestock				
Wildlife	X		X	

The entire Gwynns Falls watershed is covered by MS4 permits; therefore, with no wastewater treatment plants (WWTPs) permitted to discharge fecal bacteria in the watershed, the final human load is allocated entirely to WLA-MS4. Domestic pets are also allocated entirely to WLA-MS4. There are no livestock contributions in the Gwynns Falls watershed. Note that only the final WLA is reported in this TMDL. Wildlife is distributed between the LA and WLA-MS4, based on a ratio of the amount of urban land compared to pasture and forest land in the watershed.

Baltimore County and Baltimore City have developed Long Term Control Plans (LTCPs) based on consent decrees between the jurisdictions and MDE, which require the elimination of all CSOs by March 2020 and January 2016, respectively; therefore, a zero allocation will be assigned to WLA-CSOs.

MS4 Stormwater Allocations

Both individual and general NPDES MS4 Phase I and Phase II permits are point sources subject to WLA assignment in the TMDL. Quantification of rainfall-driven nonpoint source loads is uncertain. EPA recognized this in its guidance document entitled "Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs" (November 2002), which states that available data and information usually are not detailed enough to determine WLAs for NPDES-regulated stormwater discharges on an outfall-specific basis. Therefore, in watersheds with an existing MS4 permit, domestic animal bacteria loads will be lumped into a single WLA-MS4 load. In watersheds with no existing individual MS4 permits, these loads will be included in the LA.

The jurisdictions within the Gwynns Falls watershed, Baltimore County and Baltimore City, are covered by individual Phase I MS4 program regulations. Based on EPA’s guidance, the MS4 WLA is presented as one combined load for the entire land area of each county. In the future, when more detailed data and information become available, it is anticipated that MDE will revise the WLA into appropriate WLAs and LAs, and may also revise the LAs accordingly. Note that the overall reductions in the TMDL will not change. The WLA-MS4 distribution between Baltimore City and Baltimore County is presented in Table 4.8.2.

Table 4.8.2: MS4 Stormwater Allocations

Station	**WLA – MS4 Loads (Billion *E. coli* MPN/day)**		
	Baltimore City	Baltimore County	Total
GWN0160	N/A	110.0	110.0
GWN0115sub	N/A	69.6	69.6
GWN0026sub	311.7	239.7	551.3
GWN0015sub	10.2	0.3	10.5

N/A – not applicable – subwatershed within Baltimore County only

4.9 Summary

The TMDLs for the Gwynns Falls subwatersheds are presented in Table 4.9.1.

Table 4.9.1: Gwynns Falls Watershed TMDL

Station	**TMDL Load (Billion *E. coli* MPN/day)**	**LA Load (Billion *E. coli* MPN/day)**	**WLA – MS-4 Load (Billion *E. coli* MPN/day)**	**WLA-CSO Load (Billion *E. coli* MPN/day)**
GWN0160	172.5	62.6	110.0	0
GWN0115sub	103.4	33.8	69.6	0
GWN0026sub	629.9	78.6	551.3	0
GWN0015sub	11.5	1.0	10.5	0
Total	**917.4**	**176.0**	**741.4**	**0.0**

In all four subwatersheds, based on the practicable reduction rates specified, water quality standards could not be achieved. This may occur in watersheds where wildlife is a significant component or watersheds that require very high reductions to meet water quality standards. However, if there is no feasible TMDL scenario, then MPRs are increased to provide estimates of the reductions required to meet water quality standards. For these watersheds, it is noted that the reductions may be beyond practical limits. In this case, it is expected that the first stage of implementation will be to implement the MPR scenario.

5.0 ASSURANCE OF IMPLEMENTATION

Section 303(d) of the Clean Water Act and current EPA regulations require reasonable assurance that the TMDL load and wasteload allocations can and will be implemented. In the Gwynns Falls watershed, the TMDL analysis indicates that reduction of fecal bacteria loads from all sources including wildlife are beyond the maximum practicable reduction (MPR) targets. Gwynns Falls and its tributaries may not be able to attain water quality standards. The extent of the fecal bacteria load reductions required to meet water quality criteria in the watershed of Gwynns Falls are not feasible by effluent limitations or by implementing cost-effective and reasonable best management practices. Therefore, MDE proposes a staged approach to implementation beginning with the MPR scenario, with regularly scheduled follow-up monitoring to assess the effectiveness of the implementation plan.

The most significant planned implementation measures in the Gwynns Falls watershed involve the separation of combined sewer systems in Baltimore City and the elimination of sanitary sewer overflows in Baltimore City and Baltimore County. Each of these jurisdictions is obligated under a judicial consent decree and judgment to adopt and implement a Long Term Control Plan ("LTCP") to eliminate sewer overflows. <u>See</u> Consent Decree and Judgments, Consolidated Case Number: JFM-02-12524, Baltimore City Consent Decree (entered Sept. 30, 2002); and Consolidated Case Number: AMD-05-2028, Baltimore County Consent Decree (entered Sept. 20, 2006). The judicial decrees and judgments require the jurisdictions to implement these LTCPs by January 2016 for Baltimore City and by March 2020 for Baltimore County. Deadlines for LTCP implementation will be incorporated into NPDES permits and, if shorter than the court ordered deadline, permits will reflect what can be feasibly accomplished with consideration to the complexity of the engineering, the availability of resources, and the need for inter-jurisdictional coordination.

Additional reductions will be achieved through the implementation of BMPs; however, the literature reports considerable uncertainty concerning the effectiveness of BMPs in treating bacteria. As an example, pet waste education programs have varying results based on stakeholder involvement. Additionally, the extent of wildlife reduction associated with various BMP methods (*e.g.*, structural, non-structural, *etc.*) is uncertain. Therefore, MDE intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality and human health risk, with consideration given to ease of implementation and cost. The iterative implementation of BMPs in the watershed has several benefits: tracking of water quality improvements following BMP implementation through follow-up stream monitoring; providing a mechanism for developing public support through periodic updates on BMP implementation; and helping to ensure that the most cost-effective practices are implemented first.

In 1983, the EPA Nationwide Urban Runoff Program found that stormwater runoff from urban areas contains the same general types of pollutants found in wastewater, and that 30% of identified cases of water quality impairment were attributable to stormwater discharges. In November 1990, EPA required jurisdictions with a population greater than 100,000 to apply for NPDES permits for stormwater discharges. The jurisdictions where the Gwynns Falls watershed is located, Baltimore County and Baltimore City, are required to participate in the stormwater

NPDES program, and must comply with the NPDES permit regulations for stormwater discharges. The permit-required management programs are being implemented in the County and City to meet locally established watershed protection and restoration goals and to control stormwater discharges to the maximum extent practicable. These jurisdiction-wide programs are designed to control stormwater discharges to the maximum extent practical. Funding sources for implementation include the State Water Quality Revolving Loan Fund and the Stormwater Pollution Cost Share Program. Details of this program and additional funding sources can be found at http://www.dnr.state.md.us/bay/services/summaries.html.

Additionally, MDE's "Managing Maryland for Results" (MDE, 2005) states the following related to separate sewer system overflows and combined sewer system overflows:

> Objective 4.5: Reduce the quantity in gallons of sewage overflows [total for Combined Sewer System Overflows (CSO) and Separate Sewer System Overflows (SSO)] equivalent to a 50% reduction of 2001 amounts (50, 821,102 gallons) by the year 2010 through implementation of EPA's minimum control strategies, LTCPs, and collection system improvements in capacity, inflow and infiltration reduction, operation and maintenance.
>
> Strategy 4.5.1: MDE adopted new regulations effective March 28, 2005 to detail procedures that must be followed regarding reporting overflows or treatment plant bypasses and also to require public notification of certain sewage overflows.
>
> Strategy 4.5.2: MDE will inspect and take enforcement actions against those CSO jurisdictions that have not developed LTCPs by dates set within current consent or judicial orders.
>
> Strategy 4.5.3: MDE will take enforcement actions to require that jurisdictions experiencing significant or repeated SSOs take appropriate steps to eliminate overflows, and will fulfill the commitment in the EPA 106 grant for NPDES enforcement regarding the initiation of formal enforcement actions against 20% of jurisdictions in Maryland with CSOs and significant SSO problems annually. Under Section 106 of the Clean Water Act, EPA is authorized to issue grants to states for the purpose of assisting in establishing and carrying out pollution control programs.

Implementation and Wildlife Sources

It is expected that in some waters for which TMDLs will be developed, the bacteria source analysis may indicate that after controls are in place for all anthropogenic sources, the waterbody will not meet water quality standards. Neither MD nor EPA is proposing the elimination of wildlife to allow for the attainment of water quality standards, although managing the overpopulation of wildlife is an option for state and local stakeholders.

After developing and implementing to the maximum extent possible a reduction goal based on the anthropogenic sources identified in the TMDL, MD anticipates that implementation to reduce the controllable nonpoint sources may also reduce some wildlife inputs to the waters.

REFERENCES

American Public Health Association, American Water Works Association, and Water Environment Federation, 1998, Standard methods for the examination of water and wastewater (20th ed.): Washington, D.C., American Public Health Association

Cleland, Bruce. 2003. TMDL Development from the "Bottom Up" – Part III: Duration Curves and Wet-weather Assessments. America's Clean Water Foundation. Washington D.C.

Code of Federal Regulations, 40 CFR 130.2(h), 40 CFR 130.7(c)(1). Website http://www.access.gpo.gov/nara/cfr/waisidx_04/40cfr130_04.html, last visited 06/24/05.

Code of Maryland Regulations (COMAR), 26.08.02.03-3A(1). Bacteriological Criteria for Use I, III, IV-P Waters, Website http://www.dsd.state.md.us/comar/26/26.08.02.03-3.htm., last visited 4/15/06.

Code of Maryland Regulations (COMAR), 26.08.02.08 K(3)(e) & (5)(e). Stream Segment Designations, Website http://www.dsd.state.md.us/comar/26/26.08.02.08.htm, last visited 4/15/06.

Code of Maryland Regulations (COMAR), 26.08.10. Overflows or Bypasses, Website http://www.dsd.state.md.us/comar/26/26.08.02.08.htm, last visited 4/15/06.

Cohn, T.A., L.L. DeLong, E.J. Gilroy, and R.M. Hirsch, and D.K. Wells. 1989. Estimating Constituent Loads. Water Resources Research 25: 937-942.

Duan, N. (1983). Smearing Estimate: A Nonparametric Retransformation method. Journal of the American Statistical Association 78:605-610.

Ferguson, R.I. 1986. River Loads Underestimated by Rating Curves. Water Resources Research 22: 74-76.

Maryland Department of the Environment, 2002 List of Impaired Surface Waters [303(d) List] and Integrated Assessment of Water Quality in Maryland.

Maryland Department of the Environment, 2004 FINAL List of Impaired Surface Waters [303(d) List] and Integrated Assessment of Water Quality in Maryland.

Maryland Department of the Environment, Draft 2006 List of Impaired Surface Waters [303(d) List] and Integrated Assessment of Water Quality in Maryland. January 2006.

Maryland Department of the Environment. Patapsco/Back River Watershed SWMM Model Report. June 2002.

Maryland Department of the Environment. Managing Maryland for Results. July 2005.

Maryland Department of Planning, 2002, 2002 Land Use, Land Cover Map Series.

Maryland Department of Planning. Estimates of Septic Systems (2003). Baltimore: Maryland Department of Planning, Comprehensive Planning Unit.

Richards, R.P. 1998. Estimation of pollutant loads in rivers and streams: A guidance document for NPS programs. Project report prepared under Grant X998397-01-0, U.S. Environmental Protection Agency, Region VIII, Denver. 108 p.

Schueler, T. 1999. “Microbes and Urban Watersheds”. Watershed Protection Techniques. 3(1): 551-596.

U.S. Department of Agriculture (USDA), Soil Conservation Service (SCS). Soil Survey of Baltimore County, MD, 1977.

U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS). State Soil Geographic (STATSGO) DataBase. 1995.

U.S. Department of Commerce. United States Census Bureau’s GIS Coverage (2000). Washington DC: US Bureau of the Census.

U.S. Environmental Protection Agency and Maryland Department of the Environment *v*. Mayor and City Council of Baltimore, Consolidated Case Number: JFM-02-12524, Consent Decree (entered Sept. 30, 2002).

U.S. Environmental Protection Agency and Maryland Department of the Environment *v*. Baltimore County, Consolidated Case Number: AMD-05-2028, Consent Decree (entered Sept. 20, 2006).

U.S. Environmental Protection Agency. Test Methods for Eschericichia coli and Enterococci in Water by the Membrane Filter Procedure. EPA600/4-85-076. Washington, DC. NTIS PB86-158052, 1985.

U.S. Environmental Protection Agency. Ambient Water Quality Criteria for Bacteria-1986, EPA-440/5-84-002. 1986.

U.S. Environmental Protection Agency. Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs. Washington, DC. November 2002.

U.S. Environmental Protection Agency. Guidance for water quality-based decisions: The TMDL Process, EPA 440/4-91-001. Washington, DC. 1991.

U.S. Environmental Protection Agency, Office of Water. Bacteria Indicator Tool User's Guide. EPA-823-B-01-003. 2000.

U.S. Environmental Protection Agency. Protocol for developing Pathogen TMDLs, EPA 841-R-00-002, Office of Water (4503F). Washington, DC. 134pp. 2001.

U.S. Environmental Protection Agency. National Recommended Water Quality Criteria: 2002. EPA-822-R-02-047. November 2002.

U.S. Environmental Protection Agency, Office of Water. Implementation Guidance for Ambient Water Quality Criteria for Bacteria. EPA-823-B-02-003. Washington, D.C. 2003.

Appendix A – MDE Monitoring Station Bacteria Data

Table A-1: Bacteria Concentration Raw Data per Sampling Date with Corresponding Daily Flow Frequency

Station	Date	Daily Flow Frequency	*E. coli* Concentration (MPN/100ml)
GWN0015	10/08/02	98.87	24190
GWN0015	10/22/02	89.45	19860
GWN0015	11/13/02	17.81	15530
GWN0015	11/25/02	68.93	24190
GWN0015	12/03/02	77.57	24190
GWN0015	12/17/02	46.28	18400
GWN0015	01/07/03	28.96	24190
GWN0015	01/22/03	61.54	72700
GWN0015	02/04/03	17.81	26000
GWN0015	03/04/03	17.81	29100
GWN0015	03/18/03	20.56	57900
GWN0015	04/22/03	38.29	38700
GWN0015	05/06/03	40.08	36500
GWN0015	05/20/03	30.25	36500
GWN0015	06/03/03	16.62	86600
GWN0015	06/17/03	21.73	64900
GWN0015	06/24/03	27.85	24190
GWN0015	07/08/03	48.80	57900
GWN0015	07/22/03	42.27	24190
GWN0015	08/05/03	32.77	77000
GWN0015	08/19/03	51.26	5800
GWN0015	08/26/03	32.77	61300
GWN0015	09/09/03	58.40	68700
GWN0015	09/23/03	0.14	43500
GWN0015	10/07/03	61.54	41100

Station	**Date**	**Daily Flow Frequency**	***E. coli*** **Concentration (MPN/100ml)**
GWN0015	10/21/03	58.40	11200
GWN0026	11/25/02	68.93	210
GWN0026	12/03/02	77.57	630
GWN0026	12/17/02	46.28	270
GWN0026	01/07/03	28.96	4350
GWN0026	01/22/03	61.54	820
GWN0026	02/04/03	17.81	17330
GWN0026	03/04/03	17.81	19860
GWN0026	03/18/03	20.56	1990
GWN0026	04/22/03	38.29	370
GWN0026	05/06/03	40.08	670
GWN0026	05/20/03	30.25	600
GWN0026	06/03/03	16.62	280
GWN0026	06/17/03	21.73	310
GWN0026	06/24/03	27.85	210
GWN0026	07/08/03	48.80	820
GWN0026	07/22/03	42.27	60
GWN0026	08/05/03	32.77	2600
GWN0026	08/19/03	51.26	370
GWN0026	08/26/03	32.77	160
GWN0026	09/09/03	58.40	220
GWN0026	09/23/03	0.14	38700
GWN0026	10/07/03	61.54	480
GWN0026	10/21/03	58.40	340
GWN0115	10/08/02	98.87	190
GWN0115	10/22/02	89.45	120
GWN0115	11/13/02	17.81	660
GWN0115	11/25/02	68.93	30

Station	**Date**	**Daily Flow Frequency**	***E. coli* Concentration (MPN/100ml)**
GWN0115	12/03/02	77.57	70
GWN0115	12/17/02	46.28	120
GWN0115	01/07/03	28.96	160
GWN0115	01/22/03	61.54	20
GWN0115	02/04/03	17.81	1210
GWN0115	03/04/03	17.81	560
GWN0115	03/18/03	20.56	320
GWN0115	04/22/03	38.29	60
GWN0115	05/06/03	40.08	750
GWN0115	05/20/03	30.25	460
GWN0115	06/03/03	16.62	720
GWN0115	06/17/03	21.73	620
GWN0115	06/24/03	27.85	730
GWN0115	07/08/03	48.80	540
GWN0115	07/22/03	42.27	380
GWN0115	08/05/03	32.77	5790
GWN0115	08/19/03	51.26	460
GWN0115	08/26/03	32.77	310
GWN0115	09/09/03	58.40	400
GWN0115	09/23/03	0.14	16700
GWN0115	10/07/03	61.54	120
GWN0115	10/21/03	58.40	130
GWN0160	11/25/02	68.93	60
GWN0160	12/03/02	77.57	200
GWN0160	12/17/02	46.28	120
GWN0160	01/07/03	28.96	110
GWN0160	01/22/03	61.54	150
GWN0160	02/04/03	17.81	110

Station	**Date**	**Daily Flow Frequency**	***E. coli* Concentration (MPN/100ml)**
GWN0160	03/04/03	17.81	3650
GWN0160	03/18/03	20.56	1460
GWN0160	04/22/03	38.29	350
GWN0160	05/06/03	40.08	1020
GWN0160	05/20/03	30.25	360
GWN0160	06/03/03	16.62	820
GWN0160	06/17/03	21.73	1530
GWN0160	06/24/03	27.85	2010
GWN0160	07/08/03	48.80	880
GWN0160	07/22/03	42.27	550
GWN0160	08/05/03	32.77	2050
GWN0160	08/19/03	51.26	470
GWN0160	08/26/03	32.77	490
GWN0160	09/09/03	58.40	410
GWN0160	09/23/03	0.14	23800
GWN0160	10/07/03	61.54	130
GWN0160	10/21/03	58.40	190

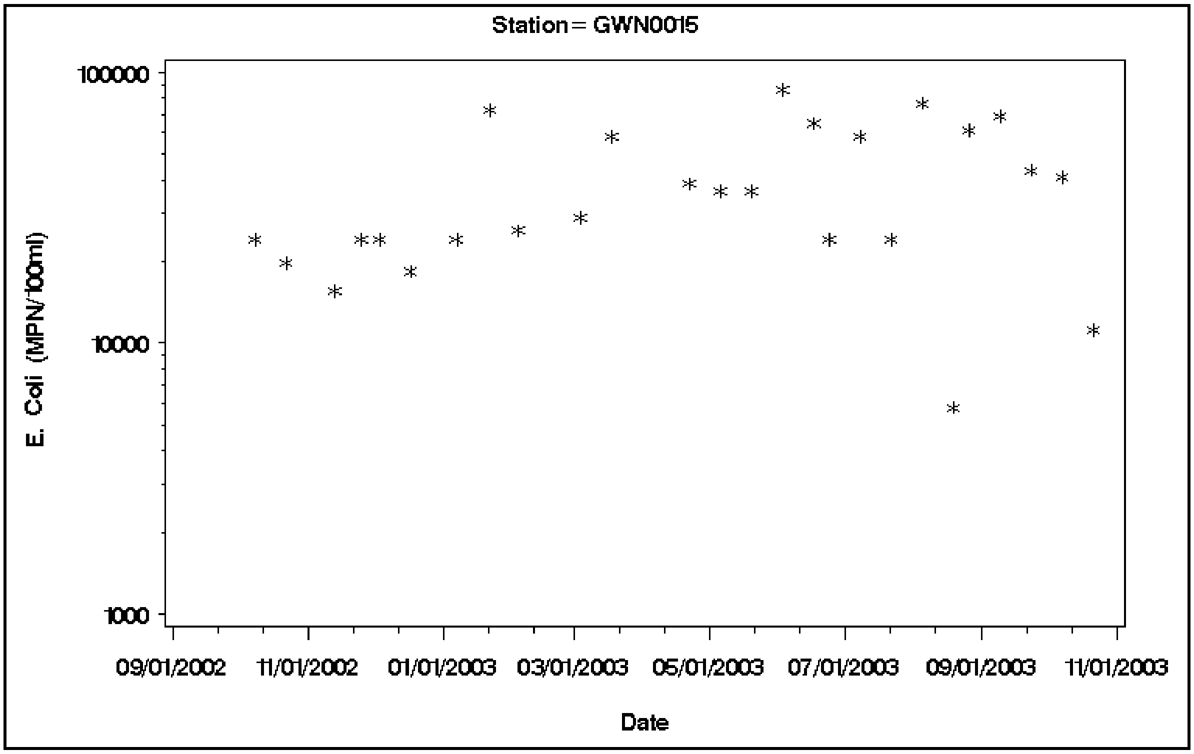


Figure A-1: *E. coli* Concentration vs. Time for MDE Monitoring Station GWN0015

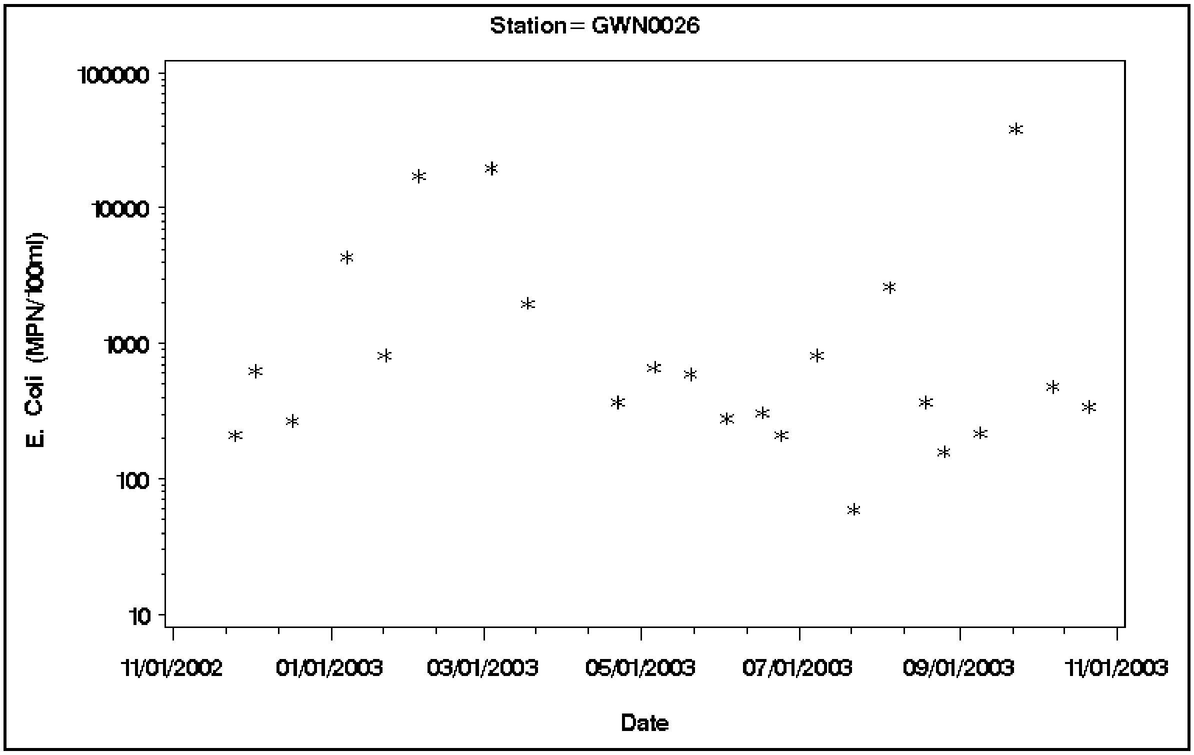


Figure A-2: *E. coli* Concentration vs. Time for MDE Monitoring Station GWN0026

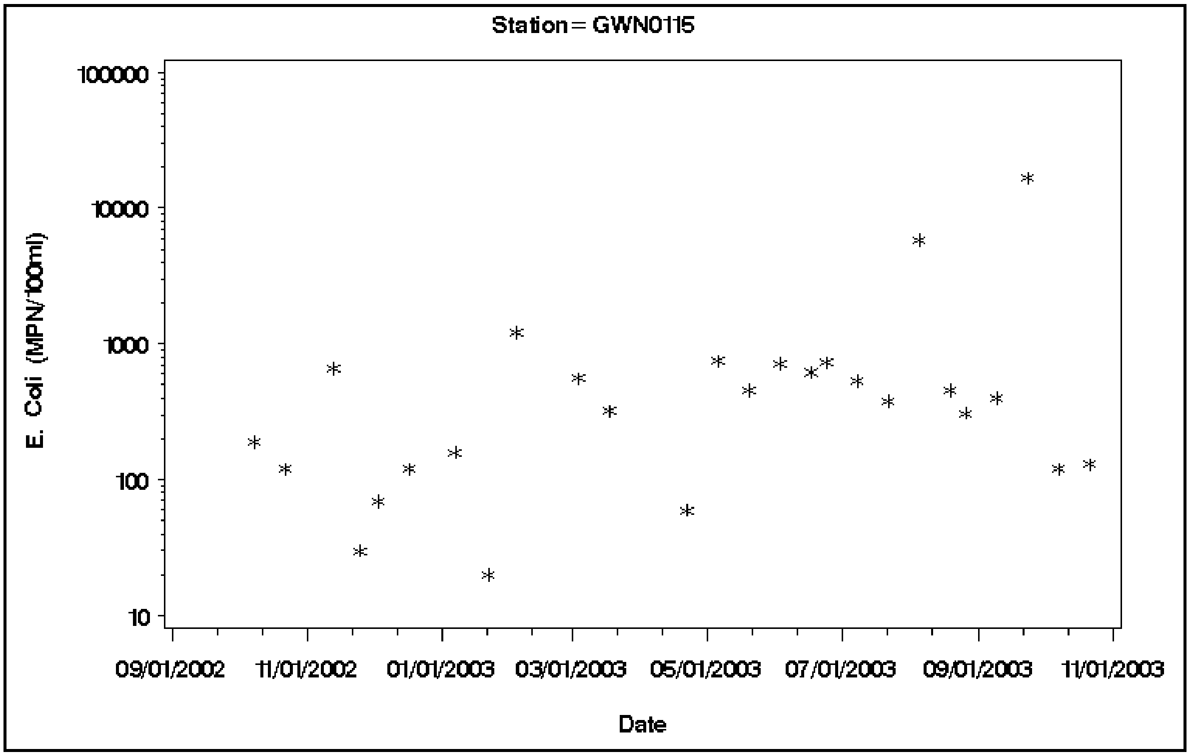


Figure A-3: ***E. coli*** **Concentration vs. Time for MDE Monitoring Station GWN0115**

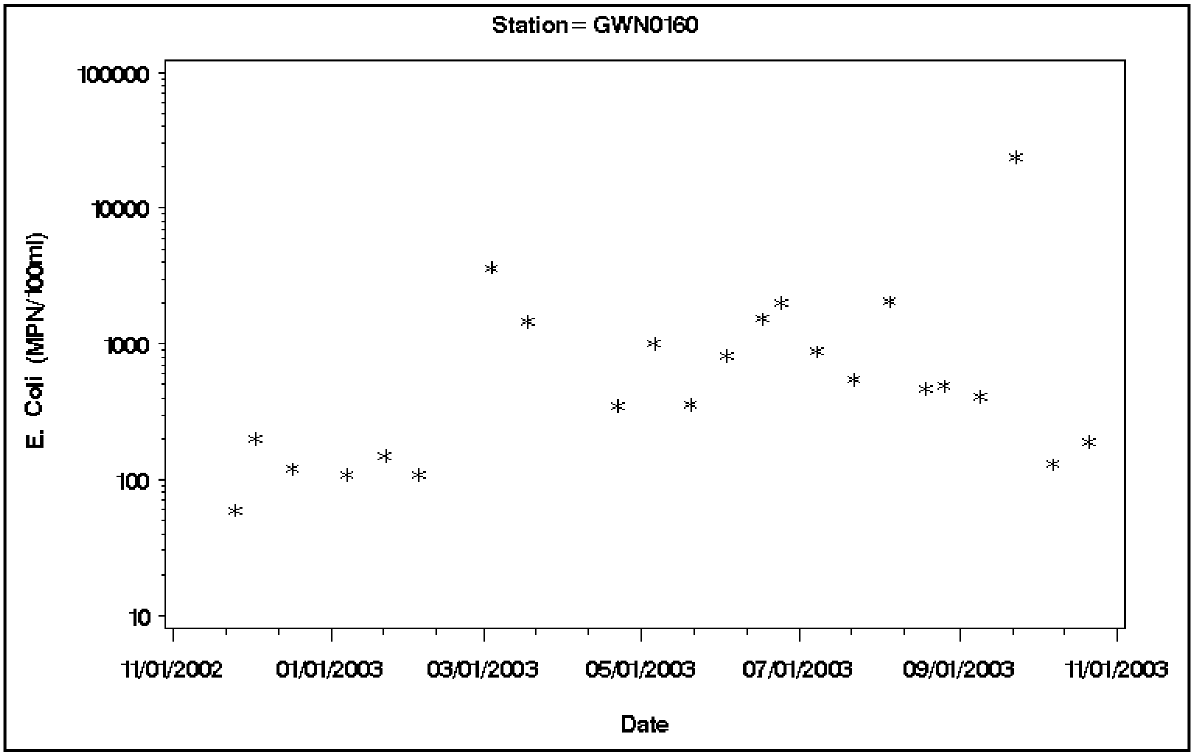


Figure A-4: ***E. coli*** **Concentration vs. Time for MDE Monitoring Station GWN0160**

Appendix B - Flow Duration Curve Analysis to Define Strata

The Gwynns Falls watershed was assessed to determine hydrologically significant strata. The purpose of these strata is to apply weights to monitoring data and thus (1) reduce bias associated with the monitoring design and (2) approximate a critical condition for TMDL development. The strata group hydrologically similar water quality samples and provide a better estimate of the mean concentration at the monitoring station.

The flow duration curve for a watershed is a plot of all possible daily flows, ranked from highest to lowest, versus their probability of exceedance. In general, the higher flows will tend to be dominated by excess runoff from rain events and the lower flows will result from drought type conditions. The mid-range flows are a combination of high base flow with limited runoff and lower base flow with excess runoff. The range of these mid-level flows will vary with soil antecedent conditions. The purpose of the following analysis is to identify hydrologically significant groups, based on the previously described flow regimes, within the flow duration curve.

Flow Analysis

There is a United States Geological Survey (USGS) gage station in the Gwynns Falls watershed. The gage flow data are incomplete for this station, therefore the flow for unobserved periods (1/01/1992 to 10/01/1996) was estimated using MDE’s Patapsco/Back River watershed SWMM model calibrated to USGS gage station (01589300). The gage and dates of information used are as follows:

Table B-1: USGS Gages used in the Gwynns Falls Watershed

USGS Gage #	Dates used	Description
01589300	October 1, 1996 to January 17, 2006	USGS Active Gage 01589300 on Gwynns Falls at Villa Nova
01589300 (estimate)	Jan 1, 1992 to Dec 31, 1996	Estimated flow based on SWMM calibrated to USGS Gage 01589300 (MDE, 2002)

The flow duration curve for the estimated gage is presented in figure B-1.

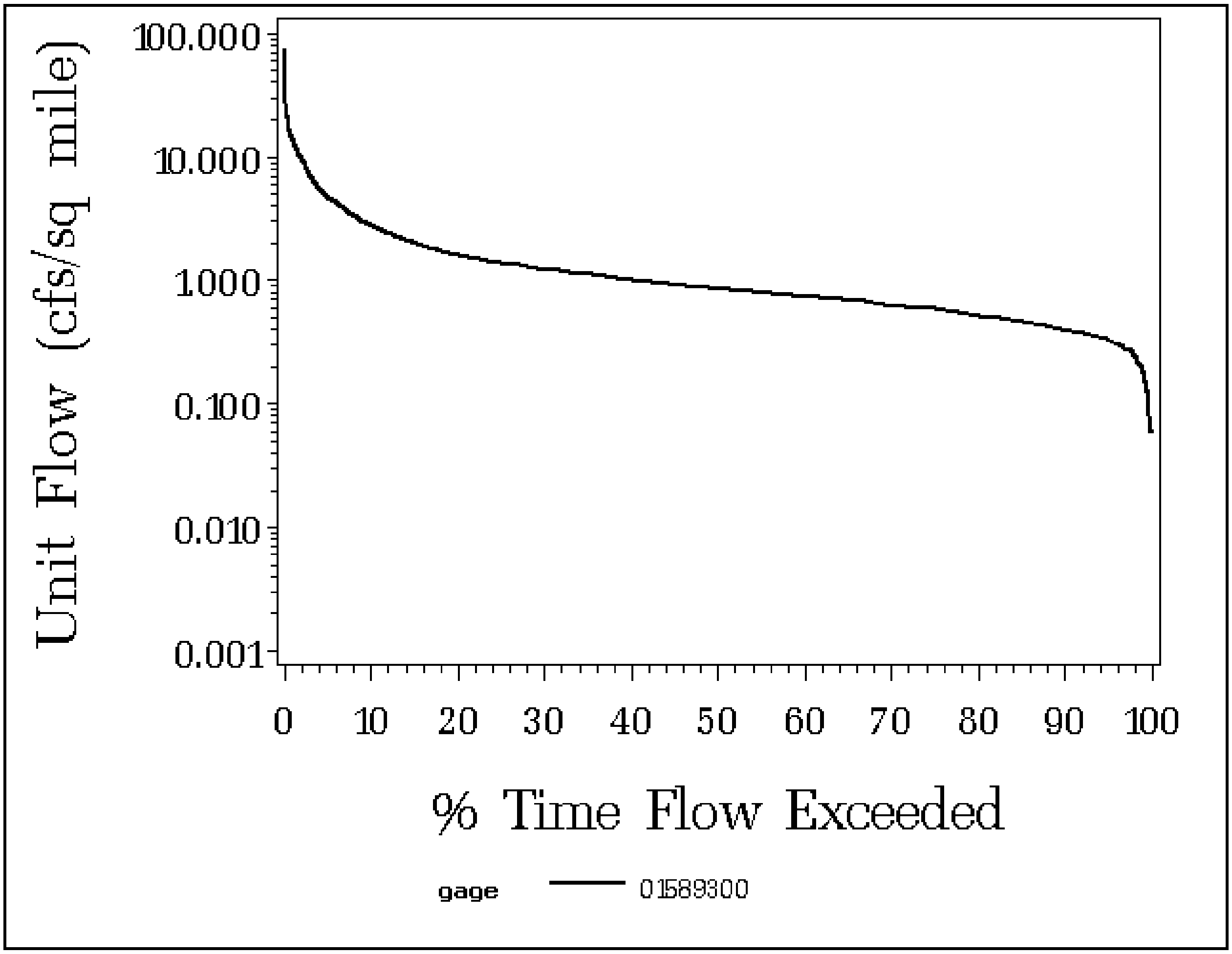


Figure B-1: Gwynns Falls Flow Duration Curves

Based on the long-term flow data for the Gwynns Falls watershed and other watersheds in the area (*i. e*., Jones Falls, Herring Run), the long term average daily unit flows range between 1.2 to 1.6 cfs/sq. mile, which corresponds to a range of 20th to 28th flow frequency based on the flow duration curves of these watersheds. Using the definition of a high flow condition as occurring when flows are higher than the long-term average flow and a low flow condition as occurring when flows are lower than the long-term average flow, the 25th percentile threshold was selected to define the limits between high flow and mid/low flows. Therefore, a high flow condition will be defined as occurring when the daily flow duration percentile is less than 25% and a low flow condition will be defined as occurring when the daily flow duration percentile is greater than 25%. Definitions of high, mid, and low range flows are presented in Table B-2.

Table B-2: Definition of Flow Regimes

High flow	Represents conditions where stream flow tends to be dominated by surface runoff.
Low flow	Represents conditions where stream flow tends to be more dominated by groundwater flow.

Flow-Data Analysis

The final analysis to define the daily flow duration intervals (flow regions, strata) includes the bacteria monitoring data. Bacteria (enterococci or *E. coli*) monitoring data are "placed" within the regions (stratum) based on the daily flow duration percentile of the date of sampling. Figures B-2 to B-5 show the Gwynns Falls *E. coli* monitoring data with corresponding flow frequency for the annual average and the seasonal conditions.

Maryland's water quality standards for bacteria state that a steady-state geometric mean will be calculated with available data where there are at least five representative sampling events. The data shall be from samples collected during steady-state conditions and during the beach season (Memorial Day through Labor Day) to be representative of the critical condition. If fewer than five representative sampling events are available, the previous two years will be evaluated. In Gwynns Falls, there are sufficient samples in the high flow strata to estimate the geometric mean. For the low flow strata less than five samples exist; therefore, the mid and low flow strata will be combined to calculate the geometric mean.

Weighting factors for estimating a weighted geometric mean are based on the frequency of each flow stratum during the averaging period. The weighting factors for the averaging periods and hydrological conditions are presented in Table B-3. Averaging periods are defined in this report as:

(1) Annual Average Hydrological Condition
(2) Annual High Flow Condition
(3) Annual Low Flow Condition
(4) Seasonal (May 1st – September 30th) High Flow Condition
(5) Seasonal (May 1st – September 30th) Low Flow Condition

Weighted geometric means for the average annual and the seasonal conditions are plotted with the monitoring data on Figures B-2 to B-5.

Table B-3: Weighting Factors for Estimation of Geometric Mean

Hydrological Condition		Averaging Period	Water Quality Data Used	Fraction High Flow	Fraction Low Flow
Annual	Average	365 days	All	0.25	0.75
	Wet	365 days	All	0.56	0.44
	Dry	365 days	All	0.06	0.94
Seasonal	Wet	May 1st – Sept 30th	May 1st – Sept 30th	0.46	0.54

	Dry	May 1st – Sept 30th	May 1st – Sept 30th	0.00	1.00

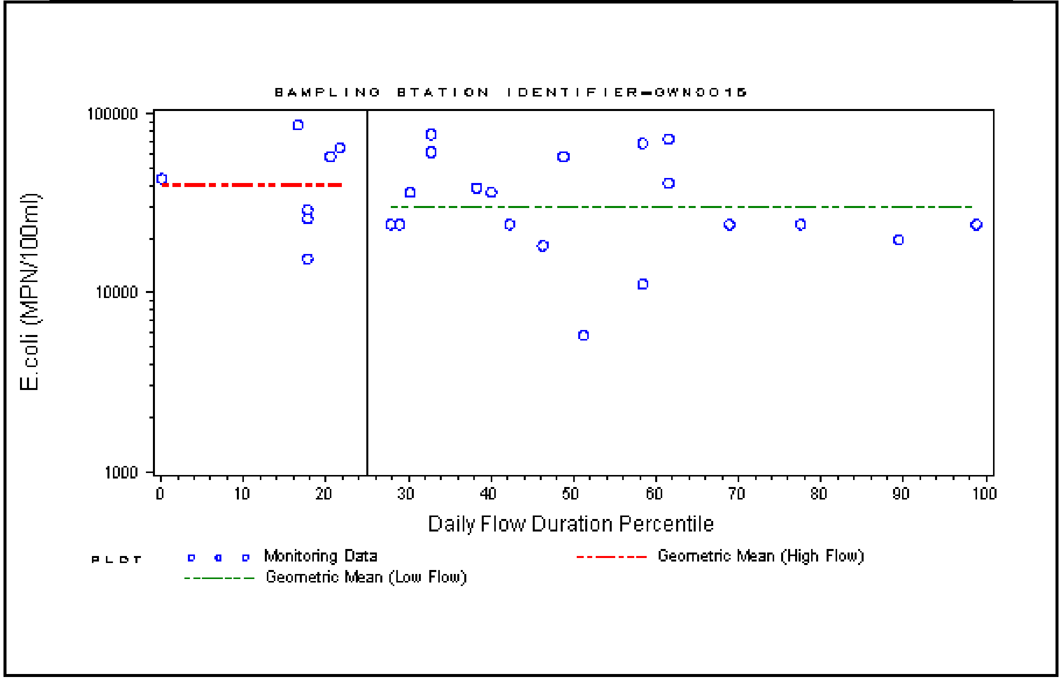


Figure B-2: *E. coli* Concentration vs. Flow Duration for Gwynns Falls Monitoring Station GWN0015 (Average Annual Condition)

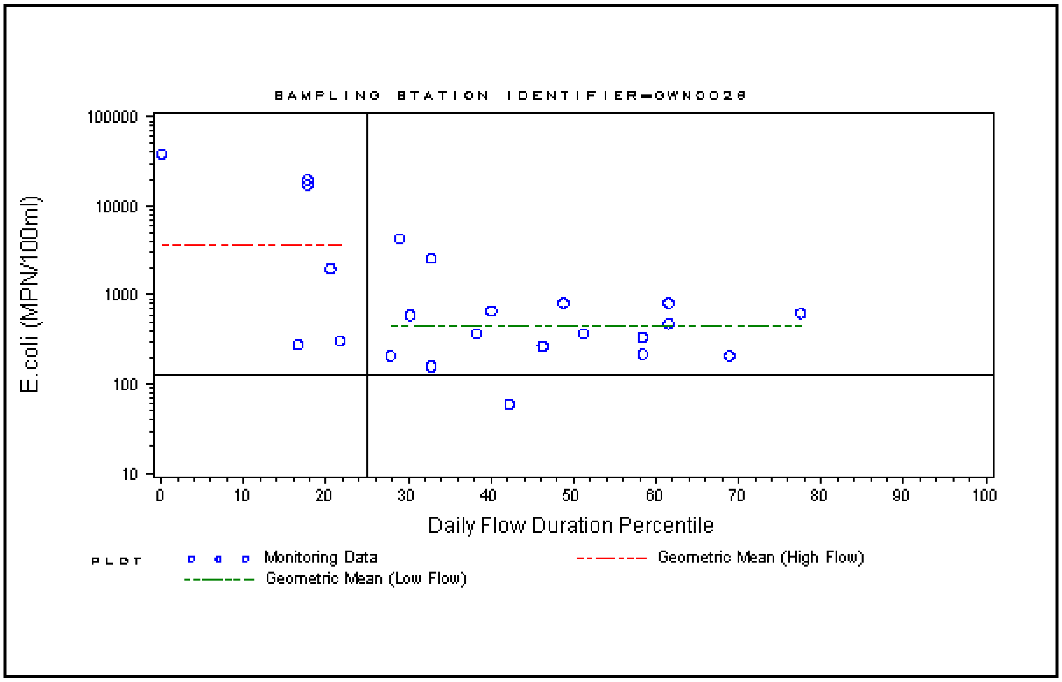


Figure B-3: *E. coli* Concentration vs. Flow Duration for Gwynns Falls Monitoring Station GWN0026 (Average Annual Condition)

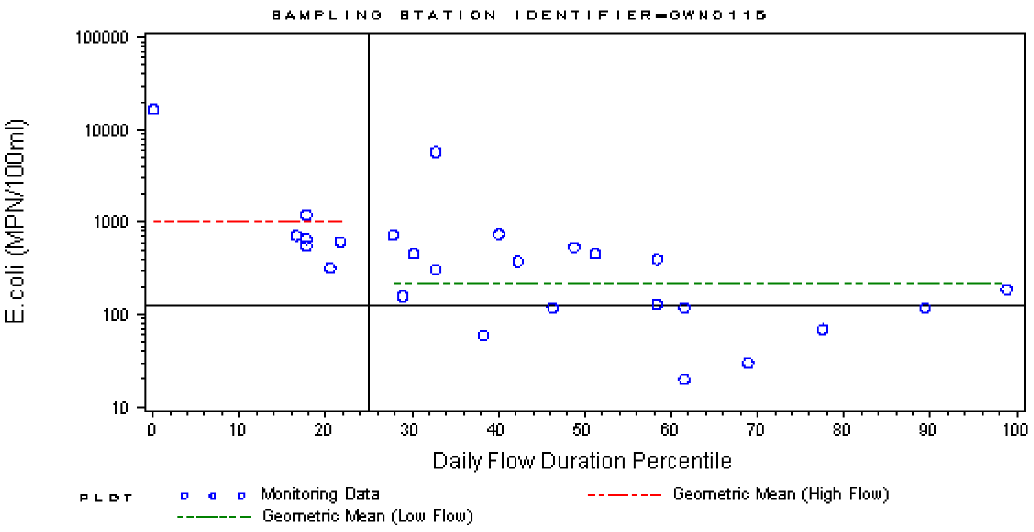


Figure B-4: *E. coli* Concentration vs. Flow Duration for Gwynns Falls Monitoring Station GWN0115 (Average Annual Condition)

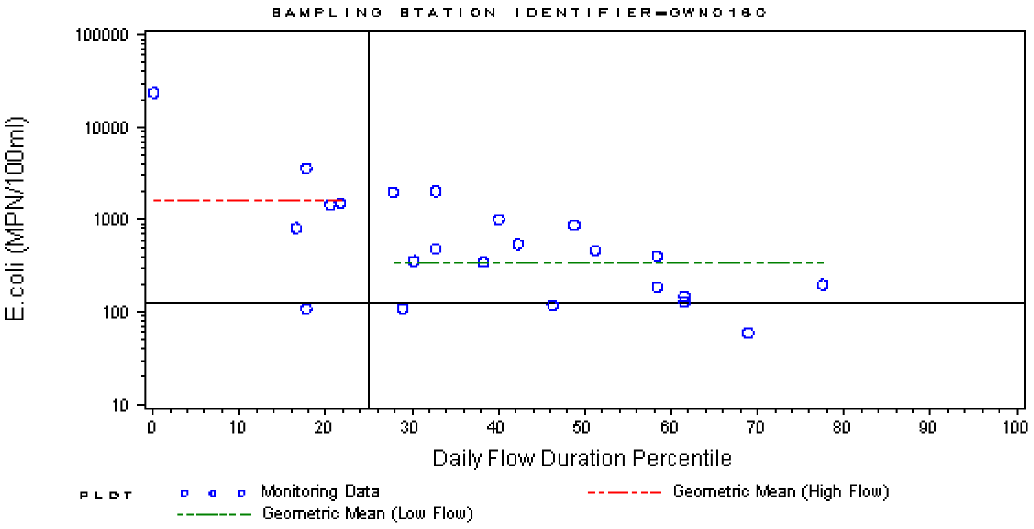


Figure B-5: *E. coli* Concentration vs. Flow Duration for Gwynns Falls Monitoring Station GWN0160 (Average Annual Condition)

Appendix C – Gwynns Falls BST Report

Maryland Department of the Environment

Identifying Sources of Fecal Pollution in Shellfish and Nontidal Waters in Maryland Watersheds

November 1, 2003 – October 31, 2005

Final Report
January 31, 2006

Revised 02.03.2006

Mark F. Frana, Ph.D. and Elichia A. Venso, Ph.D.
Co-Principal Investigators
Department of Biological Sciences and
Environmental Health Science
Salisbury University, Salisbury, MD

Table of Contents

INTRODUCTION

Microbial Source Tracking. Microbial Source Tracking (MST) is a relatively recent scientific and technological innovation designed to distinguish the origins of enteric microorganisms found in environmental waters. Several different methods and a variety of different indicator organisms (both bacteria and viruses) have successfully been used for MST, as described in recent reviews (Scott *et al.*, 2002; Simpson *et al.*, 2002). When the indicator organism is bacteria, the term Bacterial Source Tracking (BST) is often used. Some common bacterial indicators for BST analysis include: *E. coli, Enterococcus* spp., *Bacteroides-Prevotella,* and *Bifidobacterium* spp.

Techniques for MST can be grouped into one of the following three categories: molecular (genotypic) methods, biochemical (phenotypic) methods, or chemical methods. Ribotyping, Pulsed-Field Gel Electrophoresis (PFGE), and Randomly-Amplified Polymorphic DNA (RAPD) are examples of molecular techniques. Biochemical methods include Antibiotic Resistance Analysis (ARA), F-specific coliphage typing, and Carbon Source Utilization (CSU) analysis. Chemical techniques detect chemical compounds associated with human activities, but do not provide any information regarding nonhuman sources. Examples of this type of technology include detection of optical brighteners from laundry detergents or caffeine (Simpson *et al*., 2002).

Many of the molecular and biochemical methods of MST are “library-based,” requiring the collection of a database of fingerprints or patterns obtained from indicator organisms isolated from known sources. Statistical analysis determines fingerprints/patterns of known sources species or categories of species (*i.e.*, human, livestock, pets, wildlife). Indicator isolates collected from water samples are analyzed using the same MST method to obtain their fingerprints or patterns, which are then statistically compared to those in the library. Based upon this comparison, the final results are expressed in terms of the “statistical probability” that the water isolates came from a given source (Simpson *et al*. 2002).

In this BST project, we studied the following Maryland nontidal watershed: Gwynns Falls, Jones Falls, and Herring Run. The methodology used was the ARA with *Enterococcus* spp. as the indicator organism. Previous BST publications have demonstrated the predictive value of using this particular technique and indicator organism (Hagedorn, 1999; Wiggins, 1999).

Antibiotic Resistance Analysis. A variety of different host species can potentially contribute to the fecal contamination found in natural waters. Many years ago, scientists speculated on the possibility of using resistance to antibiotics as a way of determining the sources of this fecal contamination (Bell *et al.*, 1983; Krumperman, 1983). In ARA, the premise is that bacteria isolated from different hosts can be discriminated based upon differences in the selective pressure of microbial populations found in the gastrointestinal tract of those hosts (humans, livestock, pets, wildlife) (Wiggins, 1996). Microorganisms isolated from the fecal material of wildlife would be expected to have a much lower level of resistance to antibiotics than isolates collected from the fecal material of humans, livestock and pets. In addition, depending upon the specific antibiotics used in the analysis, isolates from humans, livestock and pets could be differentiated from each other.

In ARA, isolates from known sources are tested for resistance or sensitivity against a panel of antibiotics and antibiotic concentrations. This information is then used to construct a library of antibiotic resistance patterns from known-source bacterial isolates. Microbial isolates collected from water samples are then tested and their resistance results are recorded. Based upon a comparison of resistance patterns of water and library isolates, a statistical analysis can predict the likely host source of the water isolates. (Hagedorn 1999; Wiggins 1999).

LABORATORY METHODS

Isolation of *Enterococcus* from Known-Source Samples. Fecal samples, identified to source, were delivered to the Salisbury University (SU) BST lab by Maryland Department of the Environment (MDE) personnel. Fecal material suspended in phosphate buffered saline was plated onto selective m-Enterococcus agar. After incubation at 37^{o} C, up to 10 *Enterococcus* isolates were randomly selected from each fecal sample for ARA testing.

Isolation of Enterococcus from Water Samples. Water samples were collected by MDE staff and shipped overnight to MapTech Inc, Blacksburg, Va. Bacterial isolates were collected by membrane filtration. Up to 24 randomly selected *Enterococcus* isolates were collected from each water sample and all isolates were then shipped to the SU BST lab.

Antibiotic Resistance Analysis. Each bacterial isolate from both water and scat were grown in Enterococcosel® broth (Becton Dickinson, Sparks, MD) prior to ARA testing. *Enterococcus* are capable of hydrolyzing esculin, turning this broth black. Only esculin-positive isolates were tested for antibiotic resistance.

Bacterial isolates were plated onto tryptic soy agar plates, each containing a different concentration of a given antibiotic. Plates were incubated overnight at 37^{o} C and isolates then scored for growth (resistance) or no growth (sensitivity). Data consisting of a “1” for resistance or “0” for sensitivity for each isolate at each concentration of each antibiotic was then entered into a spread-sheet for statistical analysis.

The following table includes the antibiotics and concentrations used for isolates in analyses for all the study watersheds.

Table C-1: Antibiotics and concentrations used for ARA

Antibiotic	Concentration (µg/ml)
Amoxicillin	0.625
Cephalothin	10, 15, 30, 50
Chloramphenicol	10
Chlortetracycline	60, 80, 100
Erythromycin	10
Gentamycin	5, 10, 15
Neomycin	40, 60, 80
Oxytetracycline	20, 40, 60, 80, 100
Salinomycin	10
Streptomycin	40, 60, 80, 100
Tetracycline	10, 30, 50, 100
Vancomycin	2.5

KNOWN-SOURCE LIBRARY

Construction and Use. Fecal samples (scat) from known sources in each watershed were collected during the study period by MDE personnel and delivered to the BST Laboratory at SU. *Enterococcus* isolates were obtained from known sources (e.g., human, dog, cow, beaver, coyote, deer, fox, rabbit, and goose). For each watershed, a library of patterns of *Enterococcus* isolate responses to the panel of antibiotics was analyzed using the statistical software CART® (Salford Systems, San Diego, CA). *Enterococcus* isolate response patterns were also obtained from bacteria in water samples collected at the monitoring stations in each basin. Using statistical techniques, these patterns were then compared to those in the appropriate library to identify the probable source of each water isolate. A combined library of known sources was used for Georges Creek and Wills Creek Watersheds using patterns from scat obtained from both watersheds, and the water isolate patterns of each were compared to the combined library.

STATISTICAL ANALYSIS

We applied a tree classification method, [1]CART®, to build a model that classifies isolates into source categories based on ARA data. CART® builds a classification tree by recursively splitting the library of isolates into two nodes. Each split is determined by the antibiotic variables (antibiotic resistance measured for a collection of antibiotics at varying concentrations). The first step in the tree-building process splits the library into two nodes by considering every binary split associated with every variable. The split is chosen that maximizes a specified index of homogeneity for isolate sources within each of the nodes. In subsequent steps, the same process is applied to each resulting node until a *stopping* criterion is satisfied. Nodes where an additional split would lead to only an insignificant increase in the *homogeneity index* relative to the *stopping* criterion are referred to as *terminal* nodes.[2] The collection of *terminal* nodes defines the classification model. Each *terminal* node is associated with one source, the source that is most populous among the library isolates in the node. Each water sample isolate (*i.e.*, an isolate with an unknown source), based on its antibiotic resistance pattern, is identified with one specific *terminal* node and is assigned the source of the majority of library isolates in that *terminal* node.[3]

We imposed an additional requirement in our classification method for determining the sources of water sample isolates. We interpreted the proportion of the majority source among the library isolates in a *terminal* node as a probability. This proportion is an estimate of the probability that an isolate with unknown source, but with the same antibiotic resistance pattern as the library isolates in the *terminal* node, came from the source of the majority of the library isolates in the *terminal* node. If that probability was less than a specified *acceptable source identification probability*, we did not assign a source to the water sample isolates identified with that *terminal* node. Instead we assigned "Unknown" as the source for that node and "Unknown" for the source of all water sample isolates identified with that node. The *acceptable source identification probability* for the tree-classification model for an individual watershed is shown in the Results section for that watershed.

---

[1] The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Hastie T, Tibshirani R, and Friedman J. Springer 2001.

[2] An ideal split, i.e., a split that achieves the theoretical maximum for homogeneity, would produce two nodes each containing library isolates from only one source.

[3] The CART® tree-classification method we employed includes various features to ensure the development of an optimal classification model. For brevity in exposition, we have chosen not to present details of those features, but suggest the following sources: Breiman L, et al. *Classification and Regression Trees*. Pacific Grove: Wadsworth, 1984; and Steinberg D and Colla P. *CART—Classification and Regression Trees.* San Diego, CA: Salford Systems, 1997.

ARA RESULTS

Gwynns Falls Watershed

Known-Source Library. The 710 known-source isolates in the library were grouped into three categories: domestic (pets, specifically dogs), human, and wildlife (deer, goose) (Tables C-2). The library was analyzed for its ability to take a subset of the library isolates and correctly predict the identity of their host sources when they were treated as unknowns. Average rates of correct classification (ARCC) for the library were found by repeating this analysis using several probability cutoff points, as described above. The number-not-classified for each probability was determined. From these results, the percent unknown and percent correct classification (RCCs) was calculated (Table C-3).

Table C-2: Gwynns Falls. Category, total number, and number of unique patterns in the known-source library

Category	Potential Source	Total Isolates	Unique Patterns
Pet	dog	97	48
Human	human	347	240
Wildlife	deer, goose	266	65
Total		**710**	**353**

Table C-3: Gwynns Falls. Number of isolates not classified, percent unknown, and percent correct for six (6) cutoff probabilities

Cutoff Probability	Number Not Classified	Percent Unknown	Percent Correct
.25	0	0%	82%
.375	0	0%	82%
.50	36	5%	83%
.60	85	12%	86%
.70	146	20.5%	88%
.80	199	28%	91%
.90	348	49%	97%

A cutoff probability of 0.80 (80%) was shown to yield a high ARCC of 91%. An increase to a 0.90 (90%) cutoff did not increase the rate of correct classification as much as it increased the percent unknown (Figure C-1). Therefore, using a cutoff probability of 0.80 (80%), the 199 isolates that were not useful in the prediction of probable sources were removed, leaving 511 isolates remaining in the library. This library was then used in the statistical prediction of probable sources of bacteria in water samples collected from Gwynns Falls. The rates of correct classification for the three categories of sources in the library, with a 0.80 (80%) probability cutoff, are shown in Table C-4 below.

Figure C-1: Gwynns Falls. Classification Model: Percent Correct versus Percent Unknown

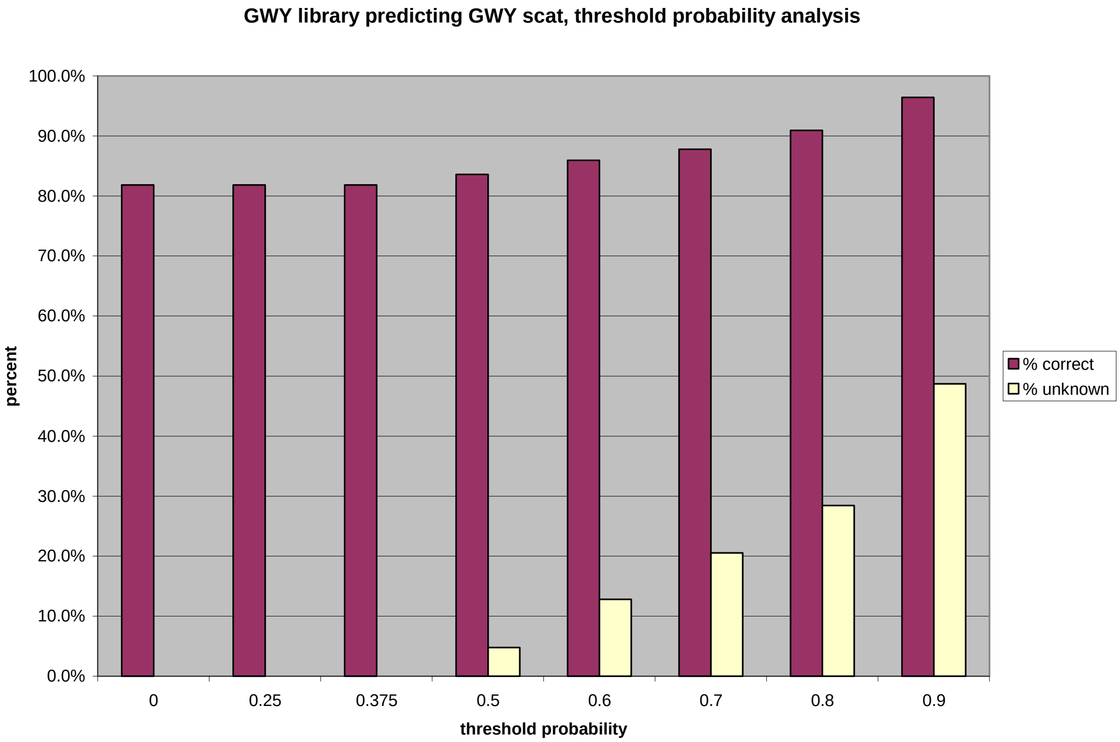


Table C-4: Gwynns Falls. Actual species categories versus predicted categories, at 80% cutoff, with rates of correct classification (RCC) for each category

Actual ↓	Predicted → HUMAN	PET	WILDLIFE	TOTAL	RCC[1]
HUMAN	**250**	11	21	282	89%
PET	1	**48**	3	52	92%
WILDLIFE	7	3	**164**	174	94%
Total	**258**	**62**	**188**	**508**	**91%**

[1] RCC = Actual number of predicted species category / Total number predicted. Example: One hundred sixty-three (163) domestic correctly predicted / 175 total number predicted for domestic = 163/175 = 93%.

Gwynns Falls Water Samples. Monthly monitoring from six (6) stations on Gwynns Falls was the source of water samples. The maximum number of *Enterococcus* isolates per water sample was 24, although the number of isolates that actually grew was sometimes fewer than 24. A total of 1231 *Enterococcus* isolates were analyzed by statistical analysis. The BST results by species category, shown in Table C-5, indicates that 87% of the water isolates were classified after excluding unknowns when using an 0.80 (80%) probability cutoff.

Table C-5: Gwynns Falls. Potential host sources of water isolates by species category, number of isolates, percent isolates classified at cutoff probability of 80%

Category	Number	% Isolates Classified 80% Prob.	% Isolates Classified (excluding unknowns)
DOMESTIC	190	15%	18%
HUMAN	691	56%	64%
WILDLIFE	196	16%	18%
UNKNOWN	154	13%	
Missing Data	0		
Total	1231		
% Classified	**87%**		

The seasonal distribution of water isolates from samples collected at each sampling station is shown below in Table C-6.

Table C-6: Gwynns Falls. *Enterococcus* isolates obtained from water collected during the fall, winter, spring, and summer seasons for each of the six (6) monitoring stations

Station	Spring	Summer	Fall	Winter	Total
GWN0015	71	72	92	72	**307**
GWN0026	71	91	47	72	**281**
GWN0115	71	70	91	72	**304**
GWN0160	72	88	63	68	**291**
GWN0186	0	0	24	0	**24**
RDR0001	0	0	24	0	**24**
Total	**285**	**321**	**341**	**284**	**1231**

Tables C-7 through C-11 on the following pages show the results of BST analysis from the estimation of number of isolates per station per date to the final estimation of the overall percentage of bacteria sources by subwatershed.

Table C-7: BST Analysis - Number of Isolates per Station per Date

Station	Date	Domestic %	Human %	Livestock %	Wildlife %	Unknown %
GWN0015	11/13/2002	3	14	0	3	1
GWN0015	12/3/2002	7	15	0	1	0
GWN0015	1/7/2003	12	12	0	0	0
GWN0015	2/4/2003	2	21	0	0	1
GWN0015	3/4/2003	1	22	0	0	1
GWN0015	4/22/2003	0	20	0	0	3
GWN0015	5/6/2003	8	15	0	0	1
GWN0015	6/3/2003	2	18	0	1	3
GWN0015	7/8/2003	5	17	0	0	2

Station	Date	Domestic %	Human %	Livestock %	Wildlife %	Unknown %
GWN0015	8/5/2003	0	17	0	1	6
GWN0015	9/9/2003	4	13	0	1	6
GWN0015	9/23/2003	3	11	0	1	9
GWN0015	10/8/2003	6	13	0	1	4
GWN0026	12/3/2002	19	5	0	0	0
GWN0026	1/7/2003	10	12	0	0	2
GWN0026	2/4/2003	0	23	0	0	1
GWN0026	3/4/2003	11	13	0	0	0
GWN0026	4/22/2003	0	18	0	3	3
GWN0026	5/6/2003	1	19	0	2	2
GWN0026	6/3/2003	0	19	0	2	2
GWN0026	7/8/2003	6	9	0	4	4
GWN0026	7/22/2003	8	4	0	5	7
GWN0026	8/5/2003	8	9	0	4	3
GWN0026	9/9/2003	4	6	0	4	6
GWN0026	9/23/2003	1	8	0	7	4
GWN0026	10/7/2003	0	2	0	0	1
GWN0115	11/13/2002	0	13	0	9	1
GWN0115	12/3/2002	2	5	0	14	2
GWN0115	1/7/2003	9	15	0	0	0
GWN0115	2/4/2003	11	8	0	0	5
GWN0115	3/4/2003	1	16	0	3	4
GWN0115	4/22/2003	10	8	0	4	2

Station	Date	Domestic %	Human %	Livestock %	Wildlife %	Unknown %
GWN0115	5/6/2003	2	12	0	9	1
GWN0115	6/3/2003	0	10	0	8	5
GWN0115	7/8/2003	4	9	0	6	4
GWN0115	8/5/2003	1	15	0	4	4
GWN0115	9/9/2003	2	13	0	7	1
GWN0115	9/23/2003	1	11	0	0	12
GWN0115	10/7/2003	0	0	0	16	5
GWN0160	12/3/2002	0	23	0	0	0
GWN0160	1/7/2003	5	10	0	7	0
GWN0160	2/4/2003	1	17	0	4	2
GWN0160	3/4/2003	2	18	0	0	2
GWN0160	4/22/2003	2	16	0	3	3
GWN0160	5/6/2003	3	16	0	4	1
GWN0160	6/3/2003	7	13	0	3	1
GWN0160	7/8/2003	0	14	0	9	0
GWN0160	7/22/2003	4	8	0	6	6
GWN0160	8/5/2003	1	19	0	0	3
GWN0160	9/9/2003	0	9	0	6	3
GWN0160	9/23/2003	0	13	0	7	4
GWN0160	10/7/2003	1	2	0	6	7

Table C-8: Percentage of Sources per Station per Date

Station	Date	Domestic %	Human %	Livestock %	Wildlife %	Unknown %
GWN0015	11/13/2002	14.29	66.67	0.00	14.29	4.76
GWN0015	12/3/2002	30.43	65.22	0.00	4.35	0.00
GWN0015	1/7/2003	50.00	50.00	0.00	0.00	0.00
GWN0015	2/4/2003	8.33	87.50	0.00	0.00	4.17
GWN0015	3/4/2003	4.17	91.67	0.00	0.00	4.17
GWN0015	4/22/2003	0.00	86.96	0.00	0.00	13.04
GWN0015	5/6/2003	33.33	62.50	0.00	0.00	4.17
GWN0015	6/3/2003	8.33	75.00	0.00	4.17	12.50
GWN0015	7/8/2003	20.83	70.83	0.00	0.00	8.33
GWN0015	8/5/2003	0.00	70.83	0.00	4.17	25.00
GWN0015	9/9/2003	16.67	54.17	0.00	4.17	25.00
GWN0015	9/23/2003	12.50	45.83	0.00	4.17	37.50
GWN0015	10/8/2003	25.00	54.17	0.00	4.17	16.67
GWN0026	12/3/2002	79.17	20.83	0.00	0.00	0.00
GWN0026	1/7/2003	41.67	50.00	0.00	0.00	8.33
GWN0026	2/4/2003	0.00	95.83	0.00	0.00	4.17
GWN0026	3/4/2003	45.83	54.17	0.00	0.00	0.00
GWN0026	4/22/2003	0.00	75.00	0.00	12.50	12.50
GWN0026	5/6/2003	4.17	79.17	0.00	8.33	8.33
GWN0026	6/3/2003	0.00	82.61	0.00	8.70	8.70
GWN0026	7/8/2003	26.09	39.13	0.00	17.39	17.39
GWN0026	7/22/2003	33.33	16.67	0.00	20.83	29.17

Station	Date	Domestic %	Human %	Livestock %	Wildlife %	Unknown %
GWN0026	8/5/2003	33.33	37.50	0.00	16.67	12.50
GWN0026	9/9/2003	20.00	30.00	0.00	20.00	30.00
GWN0026	9/23/2003	5.00	40.00	0.00	35.00	20.00
GWN0026	10/7/2003	0.00	66.67	0.00	0.00	33.33
GWN0115	11/13/2002	0.00	56.52	0.00	39.13	4.35
GWN0115	12/3/2002	8.70	21.74	0.00	60.87	8.70
GWN0115	1/7/2003	37.50	62.50	0.00	0.00	0.00
GWN0115	2/4/2003	45.83	33.33	0.00	0.00	20.83
GWN0115	3/4/2003	4.17	66.67	0.00	12.50	16.67
GWN0115	4/22/2003	41.67	33.33	0.00	16.67	8.33
GWN0115	5/6/2003	8.33	50.00	0.00	37.50	4.17
GWN0115	6/3/2003	0.00	43.48	0.00	34.78	21.74
GWN0115	7/8/2003	17.39	39.13	0.00	26.09	17.39
GWN0115	8/5/2003	4.17	62.50	0.00	16.67	16.67
GWN0115	9/9/2003	8.70	56.52	0.00	30.43	4.35
GWN0115	9/23/2003	4.17	45.83	0.00	0.00	50.00
GWN0115	10/7/2003	0.00	0.00	0.00	76.19	23.81
GWN0160	12/3/2002	0.00	100.00	0.00	0.00	0.00
GWN0160	1/7/2003	22.73	45.46	0.00	31.82	0.00
GWN0160	2/4/2003	4.17	70.83	0.00	16.67	8.33
GWN0160	3/4/2003	9.09	81.82	0.00	0.00	9.09
GWN0160	4/22/2003	8.33	66.67	0.00	12.50	12.50
GWN0160	5/6/2003	12.50	66.67	0.00	16.67	4.17

Station	Date	Domestic %	Human %	Livestock %	Wildlife %	Unknown %
GWN0160	6/3/2003	29.17	54.17	0.00	12.50	4.17
GWN0160	7/8/2003	0.00	60.87	0.00	39.13	0.00
GWN0160	7/22/2003	16.67	33.33	0.00	25.00	25.00
GWN0160	8/5/2003	4.35	82.61	0.00	0.00	13.04
GWN0160	9/9/2003	0.00	50.00	0.00	33.33	16.67
GWN0160	9/23/2003	0.00	54.17	0.00	29.17	16.67
GWN0160	10/7/2003	6.25	12.50	0.00	37.50	43.75

Table C-9: *E. coli* Concentration and Percentage of Sources by Stratum (Annual Period)

Station	Date	Flow Regime	*E. coli* Concentration (MPN/100ml)	Domestic %	Human %	Livestock %	Wildlife %	Unknown %
GWN0015	11/13/02	High	15530	14.29	66.67	0.00	14.29	4.76
GWN0015	02/04/03	High	26000	8.33	87.50	0.00	0.00	4.17
GWN0015	03/04/03	High	29100	4.17	91.67	0.00	0.00	4.17
GWN0015	03/18/03	High	57900	.	.	.	.	.
GWN0015	06/03/03	High	86600	8.33	75.00	0.00	4.17	12.50
GWN0015	06/17/03	High	64900	.	.	.	.	.
GWN0015	09/23/03	High	43500	12.50	45.83	0.00	4.17	37.50
GWN0026	02/04/03	High	17330	0.00	95.83	0.00	0.00	4.17
GWN0026	03/04/03	High	19860	45.83	54.17	0.00	0.00	0.00
GWN0026	03/18/03	High	1990	.	.	.	.	.
GWN0026	06/03/03	High	280	0.00	82.61	0.00	8.70	8.70
GWN0026	06/17/03	High	310	.	.	.	.	.
GWN0026	09/23/03	High	38700	5.00	40.00	0.00	35.00	20.00
GWN0115	11/13/02	High	660	0.00	56.52	0.00	39.13	4.35
GWN0115	02/04/03	High	1210	45.83	33.33	0.00	0.00	20.83
GWN0115	03/04/03	High	560	4.17	66.67	0.00	12.50	16.67
GWN0115	03/18/03	High	320	.	.	.	.	.
GWN0115	06/03/03	High	720	0.00	43.48	0.00	34.78	21.74
GWN0115	06/17/03	High	620	.	.	.	.	.
GWN0115	09/23/03	High	16700	4.17	45.83	0.00	0.00	50.00
GWN0160	02/04/03	High	110	4.17	70.83	0.00	16.67	8.33
GWN0160	03/04/03	High	3650	9.09	81.82	0.00	0.00	9.09

Station	**Date**	**Flow Regime**	***E. coli* Concentration (MPN/100ml)**	**Domestic %**	**Human %**	**Livestock %**	**Wildlife %**	**Unknown %**
GWN0160	03/18/03	High	1460	.	.	.	.	.
GWN0160	06/03/03	High	820	29.17	54.17	0.00	12.50	4.17
GWN0160	06/17/03	High	1530	.	.	.	.	.
GWN0160	09/23/03	High	23800	0.00	54.17	0.00	29.17	16.67
GWN0015	10/08/02	Low	24190	.	.	.	.	.
GWN0015	10/22/02	Low	19860	.	.	.	.	.
GWN0015	11/25/02	Low	24190	.	.	.	.	.
GWN0015	12/03/02	Low	24190	30.43	65.22	0.00	4.35	0.00
GWN0015	12/17/02	Low	18400	.	.	.	.	.
GWN0015	01/07/03	Low	24190	50.00	50.00	0.00	0.00	0.00
GWN0015	01/22/03	Low	72700	.	.	.	.	.
GWN0015	04/22/03	Low	38700	0.00	86.96	0.00	0.00	13.04
GWN0015	05/06/03	Low	36500	33.33	62.50	0.00	0.00	4.17
GWN0015	05/20/03	Low	36500	.	.	.	.	.
GWN0015	06/24/03	Low	24190	.	.	.	.	.
GWN0015	07/08/03	Low	57900	20.83	70.83	0.00	0.00	8.33
GWN0015	07/22/03	Low	24190	.	.	.	.	.
GWN0015	08/05/03	Low	77000	0.00	70.83	0.00	4.17	25.00
GWN0015	08/19/03	Low	5800	.	.	.	.	.
GWN0015	08/26/03	Low	61300	.	.	.	.	.
GWN0015	09/09/03	Low	68700	16.67	54.17	0.00	4.17	25.00
GWN0015	10/07/03	Low	41100	.	.	.	.	.
GWN0015	10/21/03	Low	11200	.	.	.	.	.

Station	Date	Flow Regime	*E. coli* Concentration (MPN/100ml)	Domestic %	Human %	Livestock %	Wildlife %	Unknown %
GWN0026	11/25/02	Low	210	.	.	.	.	.
GWN0026	12/03/02	Low	630	79.17	20.83	0.00	0.00	0.00
GWN0026	12/17/02	Low	270	.	.	.	.	.
GWN0026	01/07/03	Low	4350	41.67	50.00	0.00	0.00	8.33
GWN0026	01/22/03	Low	820	.	.	.	.	.
GWN0026	04/22/03	Low	370	0.00	75.00	0.00	12.50	12.50
GWN0026	05/06/03	Low	670	4.17	79.17	0.00	8.33	8.33
GWN0026	05/20/03	Low	600	.	.	.	.	.
GWN0026	06/24/03	Low	210	.	.	.	.	.
GWN0026	07/08/03	Low	820	26.09	39.13	0.00	17.39	17.39
GWN0026	07/22/03	Low	60	33.33	16.67	0.00	20.83	29.17
GWN0026	08/05/03	Low	2600	33.33	37.50	0.00	16.67	12.50
GWN0026	08/19/03	Low	370	.	.	.	.	.
GWN0026	08/26/03	Low	160	.	.	.	.	.
GWN0026	09/09/03	Low	220	20.00	30.00	0.00	20.00	30.00
GWN0026	10/07/03	Low	480	0.00	66.67	0.00	0.00	33.33
GWN0026	10/21/03	Low	340	.	.	.	.	.
GWN0115	10/08/02	Low	190	.	.	.	.	.
GWN0115	10/22/02	Low	120	.	.	.	.	.
GWN0115	11/25/02	Low	30	.	.	.	.	.
GWN0115	12/03/02	Low	70	8.70	21.74	0.00	60.87	8.70
GWN0115	12/17/02	Low	120	.	.	.	.	.
GWN0115	01/07/03	Low	160	37.50	62.50	0.00	0.00	0.00

Station	**Date**	**Flow Regime**	***E. coli* Concentration (MPN/100ml)**	**Domestic %**	**Human %**	**Livestock %**	**Wildlife %**	**Unknown %**
GWN0115	01/22/03	Low	20	.	.	.	.	.
GWN0115	04/22/03	Low	60	41.67	33.33	0.00	16.67	8.33
GWN0115	05/06/03	Low	750	8.33	50.00	0.00	37.50	4.17
GWN0115	05/20/03	Low	460	.	.	.	.	.
GWN0115	06/24/03	Low	730	.	.	.	.	.
GWN0115	07/08/03	Low	540	17.39	39.13	0.00	26.09	17.39
GWN0115	07/22/03	Low	380	.	.	.	.	.
GWN0115	08/05/03	Low	5790	4.17	62.50	0.00	16.67	16.67
GWN0115	08/19/03	Low	460	.	.	.	.	.
GWN0115	08/26/03	Low	310	.	.	.	.	.
GWN0115	09/09/03	Low	400	8.70	56.52	0.00	30.43	4.35
GWN0115	10/07/03	Low	120	0.00	0.00	0.00	76.19	23.81
GWN0115	10/21/03	Low	130	.	.	.	.	.
GWN0160	11/25/02	Low	60	.	.	.	.	.
GWN0160	12/03/02	Low	200	0.00	100.00	0.00	0.00	0.00
GWN0160	12/17/02	Low	120	.	.	.	.	.
GWN0160	01/07/03	Low	110	22.73	45.46	0.00	31.82	0.00
GWN0160	01/22/03	Low	150	.	.	.	.	.
GWN0160	04/22/03	Low	350	8.33	66.67	0.00	12.50	12.50
GWN0160	05/06/03	Low	1020	12.50	66.67	0.00	16.67	4.17
GWN0160	05/20/03	Low	360	.	.	.	.	.
GWN0160	06/24/03	Low	2010	.	.	.	.	.
GWN0160	07/08/03	Low	880	0.00	60.87	0.00	39.13	0.00

Station	**Date**	**Flow Regime**	***E. coli* Concentration (MPN/100ml)**	**Domestic %**	**Human %**	**Livestock %**	**Wildlife %**	**Unknown %**
GWN0160	07/22/03	Low	550	16.67	33.33	0.00	25.00	25.00
GWN0160	08/05/03	Low	2050	4.35	82.61	0.00	0.00	13.04
GWN0160	08/19/03	Low	470	.	.	.	.	.
GWN0160	08/26/03	Low	490	.	.	.	.	.
GWN0160	09/09/03	Low	410	0.00	50.00	0.00	33.33	16.67
GWN0160	10/07/03	Low	130	6.25	12.50	0.00	37.50	43.75
GWN0160	10/21/03	Low	190	.	.	.	.	.
GWN0015	10/08/03	.	.	25.00	54.17	0.00	4.17	16.67

Table C-10: Percentage of Sources per Station by Stratum (Annual Period)

Station	**Flow Regime**	**Domestic %**	**Human %**	**Livestock %**	**Wildlife %**	**Unknown %**
GWN0015	High	9.47	73.21	0.00	4.41	12.92
GWN0015	Low	21.12	65.88	0.00	1.84	11.16
GWN0026	High	14.12	65.80	0.00	11.68	8.39
GWN0026	Low	27.28	47.16	0.00	9.90	15.66
GWN0115	High	10.83	48.51	0.00	15.52	25.14
GWN0115	Low	14.21	43.77	0.00	31.26	10.76
GWN0160	High	9.76	64.44	0.00	15.36	10.43
GWN0160	Low	7.56	59.03	0.00	21.04	12.37

Table C-11: Overall Percentage of Sources per Station (Annual Period)

Station	Domestic %	Human %	Livestock %	Wildlife %	Unknown %	Total
GWN0015	18.21	67.71	0.00	2.48	11.60	100
GWN0026	23.99	51.82	0.00	10.34	13.84	100
GWN0115	13.37	44.95	0.00	27.32	14.36	100
GWN0160	8.11	60.39	0.00	19.62	11.88	100

Gwynns Falls Summary

The use of ARA was successful for identification of bacterial sources in the Gwynns Falls Watershed as evidenced by the high ARCC (91%) for the library. The lowest RCC (for human) is very acceptable 89%. When water isolates were compared to the library and potential sources predicted, 87% of the isolates were classified by statistical analysis. The largest category of potential sources in the watershed as a whole was human (64%), followed by domestic and wildlife, (both 18% of the classified isolates, respectively).

REFERENCES

Bell, J.B., Elliott, G.E. & Smith, D.W. (1983). Influence of Sewage Treatment an Urbanization on Selection of Multiple Resistance in Fecal Coliform Populations. *Appl. Environ. Microbiol.* 46, 227-32.

Department of Health and Human Services. Centers for Disease Control and Prevention. Pulsenet. "National Molecular Subtyping Network for Foodborne Disease Surveillance" http://www.cdc.gov/pulsenet [Available 01.26.06].

Hagedorn, C., Robinson, S.L., Filtz, J.R., Grubbs, S.M., Angier, T.A. & Beneau, R.B. (1999) Determining Sources of Fecal Pollution in a Rural Virginia Watershed with Antibiotic Resistance Patterns in Fecal Streptococci. *Appl. Environ. Microbiol.* 65, 5522-5531.

Krumperman, P.H. (1983) Multiple Antibiotic Resistance Indexing of *Escherichia coli* to Identify High-Risk Sources of Fecal Contamination of Foods. *Appl. Environ. Microbiol.* 46, 165-70.

Scott, T.M., Rose, J.B., Jenkins, T.M., Farrah, S.R. & Lukasik, J. 2002 Microbial Source Tracking: Current Methodology and Future Directions. *Appl. Environ. Microbiol.* 68(12), 3373-3385.

Simpson, J.M., Santo Domingo, J.W. & Reasoner, D.J. 2002 Microbial Source Tracking: State of the Science. *Environ. Sci. Technol.* 36(24), 5279-5288.

Wiggins, B.A. (1996) Discriminant Analysis of Antibiotic Resistance Patterns in Fecal Streptococci, a Method to Differentiate Human and Animal Sources of Fecal Pollution in Natural Waters. *Appl. Environ. Microbiol.* 62, 3997-4002.

Wiggins, B.A., Andrews, R.W., Conway, R.A., Corr, C.L., Dobratz, E. J., Dougherty, D.P., Eppard, J.R., Knupp, S.R., Limjoco, M.C., Mettenburg, J.M., Rinehardt, J.M., Sonsino, J., Torrijos, R.L. & Zimmerman, M.E. (1999) Use of Antibiotic Resistance Analysis to Identify Nonpoint Sources of Fecal Pollution. *Appl. Environ. Microbiol.* 65, 3483-3486.

ACKNOWLEDGEMENTS

We wish to thank the Richard A. Henson School of Science and Technology of Salisbury University, Salisbury, MD for its support. We also want to acknowledge Dr. Bertram Price and Joshua Greenberg of Price Associates, Inc., for their contributions to the statistical analysis in this project.

APPENDIX H:

Total Maximum Daily Load of Sediment in the Gwynns Falls Watershed, Baltimore City and Baltimore County, Maryland

Total Maximum Daily Load of Sediment in the Gwynns Falls Watershed, Baltimore City and Baltimore County, Maryland

FINAL

DEPARTMENT OF THE ENVIRONMENT
1800 Washington Boulevard, Suite 540
Baltimore, Maryland 21230-1718

Submitted to:

Watershed Protection Division
U.S. Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

September 2009

EPA Submittal Date: September 28, 2009
EPA Approval Date: March 10, 2010

Table of Contents

List of Figures

List of Tables

List of Abbreviations

BIBI	Benthic Index of Biotic Integrity
BIP	Buffer Incentive Program
BMP	Best Management Practices
BSID	Biological Stressor Identification
CBP P5	Chesapeake Bay Program Phase 5
CV	Coefficient of Variation
CWA	Clean Water Act
DNR	Maryland Department of Natural Resources
EOF	Edge-of-Field
EOS	Edge-of-Stream
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
EPSC	Environmental Permit Service Center
ESD	Environmental Site Design
ETM	Enhanced Thematic Mapper
FDC	Flow Duration Curve
FIBI	Fish Index of Biologic Integrity
GIS	Geographic Information System
HSPF	Hydrological Simulation Program – FORTRAN
IBI	Index of Biotic Integrity
LA	Load Allocation
MAL	Minimum Allowable IBI Limit
MBSS	Maryland Biological Stream Survey
MD 8-Digit	Maryland 8-digit Watershed
MDE	Maryland Department of the Environment
MDL	Maximum Daily Load
MGD	Millions of Gallons per Day
mg/l	Milligrams per liter
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System

NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NRI	Natural Resources Inventory
PCBs	Polychlorinated Biphenyls
PSU	Primary Sampling Unit
RESAC	Regional Earth Science Applications Center
TMDL	Total Maximum Daily Load
Ton/yr	Tons per Year
TSD	Technical Support Document
TSS	Total Suspended Solids
TM	Thematic Mapper
USGS	United Stated Geological Survey
WLA	Waste Load Allocation
WTP	Water Treatment Plant
WQA	Water Quality Analysis
WQIA	Water Quality Improvement Act
WQLS	Water Quality Limited Segment
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes a Total Maximum Daily Load (TMDL) for sediment in the Gwynns Falls watershed (basin number 02130905) (2008 *Integrated Report of Surface Water Quality in Maryland Assessment Unit ID*: MD-02130905). Section 303(d) of the federal Clean Water Act (CWA) and the EPA's 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, the State is required to either establish a TMDL of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met (CFR 2008b).

The Maryland Department of the Environment (MDE) has identified the waters of the Gwynns Falls watershed on the State's 2008 Integrated Report as impaired by sediments (1996), nutrients – phosphorus (1996), bacteria (2002), and impacts to biological communities (2002) (MDE 2008). The designated uses of the Gwynns Falls mainstem and its tributaries is Use I (Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life), except for the Gwynns Falls mainstem and its tributaries above Reisterstown Road and Red Run and its tributaries, which are designated as Use III (Nontidal Cold Water), and Dead Run and its tributaries, which are classified as Use IV (Recreational Trout Waters) (COMAR 2008a,b,c,d,e).

The TMDL established herein by MDE will address the 1996 sediments listing, for which a data solicitation was conducted, and all readily available data from the past five years have been considered. A TMDL for fecal bacteria was approved by the EPA in 2007, and a Water Quality Analysis (WQA) for nutrients to address the phosphorus listing is scheduled to be submitted to the EPA in 2009. The listing for impacts to biological communities will be refined in the 2010 Integrated Report's list of impaired waterbodies as a result of a stressor identification analysis.

The Gwynns Falls watershed aquatic health scores, consisting of the Benthic Index of Biotic Integrity (BIBI) and Fish Index of Biotic Integrity (FIBI), indicate that the biological metrics for the watershed exhibit a significant negative deviation from reference conditions based on Maryland's biocriteria listing methodology. The biocriteria listing methodology assesses the overall condition of Maryland's 8-digit (MD 8-digit) watersheds that have multiple sites with failing biological metrics by measuring the percentage of stream miles that are degraded, based on the BIBI and FIBI scores at these sites, and then calculating whether the percentage of degraded stream miles differs significantly from reference conditions (i.e., unimpaired watershed <10% stream miles degraded) (Roth et al. 2005; MDE 2008). The objective of the TMDL established herein is to ensure that there will be no sediment impacts affecting aquatic health, thereby establishing a sediment load that supports the Use I/III/IV designations for the Gwynns Falls watershed.

Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic health of nontidal stream systems. Therefore, to determine whether aquatic health is impacted by elevated sediment loads, MDE's recently developed *Biological Stressor Identification* (BSID) methodology was applied. The BSID identifies the most probable cause(s) for observed biological impairments throughout MD's 8-digit watersheds by ranking the likely stressors affecting a watershed using a suite of available physical, chemical, and land use data. The ranking of stressors was conducted via a risk-based, systematic, weight-of-evidence approach. The risk-based approach estimates the strength of association between various stressors and a degraded biological community. The BSID analysis then identifies individual stressors (pollutants) as probable or unlikely causes of the poor biological conditions within a given MD 8-digit watershed and subsequently concludes whether or not these individual stressors or groups of stressors are contributing to the impairment (MDE 2009a).

The BSID analysis for the Gwynns Falls watershed concludes that biological communities are likely impaired due to flow/sediment related stressors. Three individual stressors (channelization, channel alteration, and bar formation) that are associated with sediment related impacts and an altered hydrologic regime were identified as being probable causes of the biological impairment. Furthermore, the degradation of biological communities in the watershed is strongly associated with urban land use and its concomitant effects: altered hydrology, sediment related impacts, and elevated levels of sulfate, chlorides, and conductivity (a measure of the presence of dissolved substances) (MDE 2009b).

In order to quantify the impact of sediment on the aquatic health of non-tidal stream systems, a reference watershed TMDL approach was used and resulted in the establishment of a *sediment loading threshold* (Currey et al. 2006). This threshold is based on a detailed analysis of sediment loads from watersheds that are identified as supporting aquatic life (i.e., reference watersheds) based on Maryland's biocriteria (Roth et al. 1998, 2000; Stribling et al. 1998; MDE 2008). This threshold is then used to determine a watershed specific sediment TMDL.

The computational framework chosen for the Gwynns Falls watershed TMDL was the Chesapeake Bay Program Phase 5 (CBP P5) watershed model target *edge-of-field* (EOF) land use sediment loading rate calculations combined with a *sediment delivery ratio*. The *edge-of-stream* (EOS) sediment load is calculated per land use as a product of the land use area, land use target loading rate, and loss from the EOF to the main channel. The spatial domain of the CBP P5 watershed model segmentation aggregates to the MD 8-digit watersheds, which is consistent with the impairment listing.

EPA's regulations require TMDLs to take into account seasonality and critical conditions for stream flow, loading, and water quality parameters (CFR 2008b). The intent of this requirement is to ensure that the water quality of the waterbody is protected during times when it is most vulnerable. The biological monitoring data used to determine the reference watersheds integrates the stress effects over the course of time and thus inherently addresses critical conditions. Seasonality is captured in two components. First, it is implicitly included in biological sampling. Second, the Maryland Biological Stream

Survey (MBSS) dataset included benthic sampling in the spring and fish sampling in the summer.

All TMDLs need to be presented as a sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources generated within the assessment unit, natural background, tributary, and adjacent segment loads. Furthermore, all TMDLs must include a margin of safety (MOS) to account for any lack of knowledge and uncertainty concerning the relationship between loads and water quality (CFR 2008a,b). It is proposed that the estimated variability around the reference watershed group used in this analysis already accounts for such uncertainty, and therefore the MOS is implicitly included.

The Gwynns Falls Total Baseline Sediment Load is 22,048.5 tons per year (ton/yr), which can be further subdivided into a nonpoint source baseline load (Nonpoint Source BL_{GF}) and two types of point source baseline loads: National Pollutant Discharge Elimination System (NPDES) regulated stormwater (NPDES Stormwater BL_{GF}) and regulated process water (Process Water BL_{GF}) (see Table ES-1).

Table ES-1: Gwynns Falls Baseline Sediment Loads (ton/yr)

Total Baseline Load (ton/yr)	=	Nonpoint Source BL_{GF}	+	NPDES Stormwater BL_{GF}	+	Process Water BL_{GF}
22,048.5	=	1,759.3	+	20,076.0	+	213.2

The Gwynns Falls Average Annual TMDL of Sediment/Total Suspended Solids (TSS) is 13,996.2 tons per year. The Load Allocation (LA_{GF}) is 1,759.3 tons per year, the NPDES Stormwater Waste Load Allocation (NPDES Stormwater WLA_{GF}) is 12,023.7 tons per year, and the Process Water Waste Load Allocation (Process Water WLA_{GF}) is 213.2 tons per year (see Table ES-2). This TMDL will ensure that the sediment loads and resulting effects are at a level to support the Use I/III/IV designations for the Gwynns Falls watershed, and more specifically, at a level the watershed can sustain without causing any sediment related impacts to aquatic health. The TMDL, however, will not completely resolve the impairment to biological communities within the watershed. Since the BSID watershed analysis identifies other possible stressors (i.e., chlorides, sulfate, conductivity) as impacting the biological conditions, this impairment remains to be fully addressed through the Integrated Report listing process and the TMDL development process, such that all impairing substances identified as impacting biological communities in the watershed are reduced to levels that will meet water quality standards, as established in future TMDLs for those substances (MDE 2009a).

Table ES-2 Gwynns Falls Average Annual TMDL of Sediment/Total Suspended Solids (ton/yr)

TMDL (ton/yr)	=	LA_{GF}	+	NPDES Stormwater WLA_{GF}	+	Process Water WLA_{GF}	+	MOS
13,996.2	=	1,759.3	+	12,023.7	+	213.2	+	Implicit

Table ES-3: Gwynns Falls Baseline Load, TMDL, and Total Reduction Percentage

Baseline Load (ton/yr)	TMDL (ton/yr)	Total Reduction (%)
22,048.5	13,996.2	36.5

In addition to the TMDL value, a Maximum Daily Load (MDL) is also presented in this document. The calculation of the MDL, which is derived from the TMDL average annual loads, is explained in Appendix C and presented in Table C-1.

Once the EPA has approved this TMDL, and it is known what measures must be taken to reduce pollution levels, implementation of best management practices (BMPs) is expected to take place primarily via the municipal separate storm sewer system (MS4) permitting process for medium and large municipalities. MDE intends for the required reduction to be implemented in an iterative process that first addresses those sources with the largest impact to water quality, with consideration given to ease and cost of implementation.

Maryland has several well-established programs to draw upon, including the Water Quality Improvement Act of 1998 (WQIA) and the Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act). Several potential funding sources available for local governments for implementation are available, such as the Buffer Incentive Program (BIP), the State Water Quality Revolving Loan Fund, and the Stormwater Pollution Cost Share Program.

1.0 INTRODUCTION

This document, upon approval by the U.S. Environmental Protection Agency (EPA), establishes a Total Maximum Daily Load (TMDL) for sediment in the Gwynns Falls watershed (basin number 02130905) (2008 *Integrated Report of Surface Water Quality in Maryland* Assessment Unit ID: MD-02130905). Section 303(d)(1)(C) of the federal Clean Water Act (CWA) and the EPA's implementing regulations direct each state to develop a TMDL for each impaired water quality limited segment (WQLS) on the State's Integrated Report, taking into account seasonal variations, critical conditions, and a protective margin of safety (MOS) to account for uncertainty (CFR 2008b). A TMDL reflects the total pollutant loading of the impairing substance a waterbody can receive and still meet water quality standards.

TMDLs are established to determine the pollutant load reductions needed to achieve and maintain water quality standards. A water quality standard is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Designated uses include activities such as swimming, drinking water supply, protection of aquatic life, 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 Maryland Department of the Environment (MDE) has identified the waters of the Gwynns Falls watershed on the 2008 Integrated Report as impaired by sediments (1996), nutrients – phosphorus (1996), bacteria (2002), and impacts to biological communities (2002) (MDE 2008). The designated uses of the Gwynns Falls mainstem and its tributaries is Use I (Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life), except for the Gwynns Falls mainstem and its tributaries above Reisterstown Road and Red Run and its tributaries, which are designated as Use III (Nontidal Cold Water), and Dead Run and its tributaries, which are classified as Use IV (Recreational Trout Waters) (COMAR 2008a,b,c,d,e).

The TMDL established herein by MDE will address the 1996 sediments listing, for which a data solicitation was conducted, and all readily available data from the past five years have been considered. A TMDL for fecal bacteria was approved by the EPA in 2007, and a Water Quality Analysis (WQA) for nutrients to address the phosphorus listing is scheduled to be submitted to the EPA in 2009. The listing for impacts to biological communities will be refined in the 2010 Integrated Report's list of impaired waterbodies as a result of a stressor identification analysis

The objective of the TMDL established herein is to ensure that there will be no sediment impacts affecting aquatic health, thereby establishing a sediment load that supports the Use I/III/IV designations for the Gwynns Falls watershed. Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic health of nontidal stream systems. Therefore, to determine whether aquatic health is impacted by elevated sediment loads, MDE's recently developed *Biological Stressor Identification* (BSID) methodology was applied.

The BSID identifies the most probable cause(s) for observed biological impairments throughout Maryland's 8-digit (MD 8-digit) watersheds by ranking the likely stressors affecting a watershed using a suite of available physical, chemical, and land use data. The ranking of stressors was conducted via a risk-based, systematic, weight-of-evidence approach. The risk-based approach estimates the strength of association between various stressors and a degraded biological community. The BSID analysis then identifies individual stressors (pollutants) as probable or unlikely causes of the poor biological conditions within a given MD 8-digit watershed and subsequently concludes whether or not these individual stressors or groups of stressors are contributing to the impairment (MDE 2009a).

In order to quantify the impact of sediment on the aquatic health of non-tidal stream systems, a reference watershed TMDL approach was used and resulted in the establishment of a *sediment loading threshold* (Currey et al. 2006). This threshold is based on a detailed analysis of sediment loads from watersheds that are identified as supporting aquatic life (i.e., reference watersheds) based on Maryland's biocriteria (Roth et al. 1998, 2000; Stribling et al. 1998; MDE 2008). This threshold is then used to determine a watershed specific sediment TMDL.

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1 General Setting

Location

The Gwynns Falls is a free flowing stream that originates in Baltimore County, Maryland and flows 25 miles in a southeasterly direction until it empties into the tidal Patapsco River. The watershed is located in the Patapsco River sub-basin of the Chesapeake Bay watershed within Baltimore County and Baltimore City, Maryland and covers approximately 65 square miles (see Figure 1). Five major tributaries of the Gwynns Falls, listed north to south, include: Red Run, Horsehead Branch, Scotts Level Branch, Dead Run, and Maidens Choice Creek. There is one “high quality”, or Tier II, stream segment (Benthic Index of Biotic Integrity (BIBI)/Fish Index of Biotic Integrity (FIBI) aquatic health scores > 4 (scale 1-5)), Red Run between the confluences of the stream’s 1st and 3rd unnamed tributaries, located within the watershed requiring the implementation of Maryland’s antidegradation policy. Also, approximately 0.4% of the watershed is covered by water (i.e., streams, ponds, etc.). The total population in the Gwynns Falls watershed is approximately 315,828 (MDE 2007b).

Geology/Soils

The Gwynns Falls watershed lies within the Piedmont and Atlantic Coastal Plain Geologic Provinces of Central Maryland. The Piedmont Province is characterized by a gentle to steep rolling topography, low hills, and ridges (DNR 2008; MGS 2008; MDE 2000). The surface geology is characterized by crystalline rocks, originally of sedimentary origin that were later transformed via heating into metamorphic rocks, consisting primarily of schist and gneiss. These formations are resistant to short term erosion and often determine the limits of the stream bank and streambed. The 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. The Atlantic Coastal Plain surface geology is characterized by thick, unconsolidated marine sediments deposited over the crystalline rock of the piedmont province. The deposits include clays, silts, sands, and gravels. In the areas around the head of tide, the topography is flat, with elevations below 100 feet. The elevations steadily increase going north to approximately 600 feet in the headwaters. Streambeds throughout the basin are comprised of rock and rubble with gradually sloped stream banks (CES 1995). The Gwynns Falls watershed lies predominantly in the Manor-Glenelg soil association in the upper Baltimore County portion of the watershed and the Legore-Aldino-Neshaminy soil association in the lower Baltimore County portion of the watershed (USDA 1977, 1998).

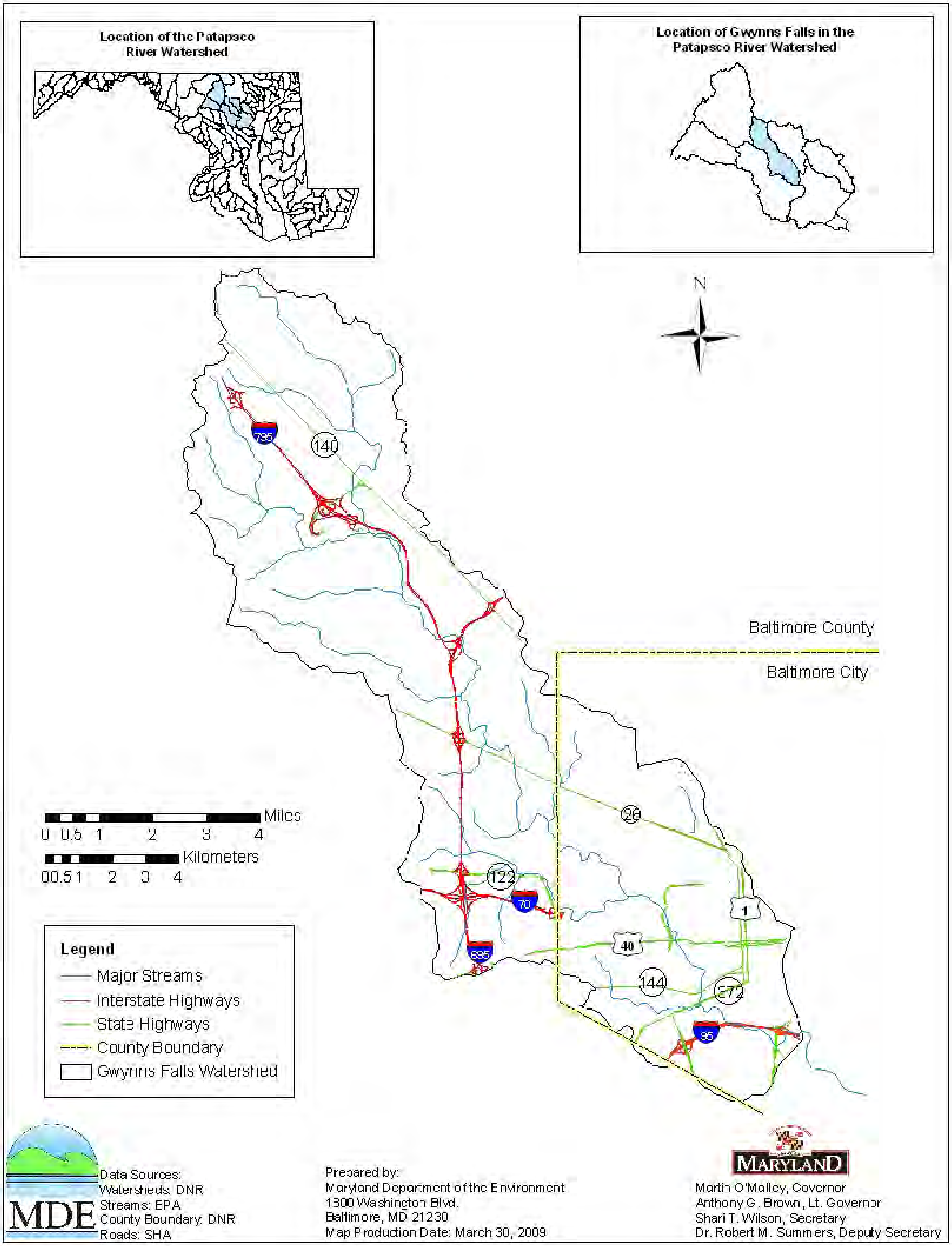


Figure 1: Location Map of the Gwynns Falls Watershed in Baltimore City and Baltimore County, Maryland

2.1.1. Land Use

Land Use Methodology

The land use framework used to develop this TMDL was originally developed for the Chesapeake Bay Program Phase 5 (CBP P5) watershed model.[1] The CBP P5 land use Geographic Information System (GIS) framework was based on two distinct layers of development. The first GIS layer was developed by the Regional Earth Science Applications Center (RESAC) at the University of Maryland and was based on satellite imagery (Landsat 7-Enhanced Thematic Mapper (ETM) and 5-Thematic Mapper (TM)) (Goetz et al. 2004). This layer did not provide the required level of accuracy that is especially important when developing agricultural land uses. In order to develop accurate agricultural land use calculations, the CBP P5 used county level U.S. Agricultural Census data as a second layer (USDA 1982, 1987, 1992, 1997, 2002).

Given that land cover classifications based on satellite imagery are likely to be least accurate at edges (i.e., boundaries between covers), the RESAC land uses bordering agricultural areas were analyzed separately. If the agricultural census data accounted for more agricultural use than the RESAC's data, appropriate acres were added to agricultural land uses from non-agricultural land uses. Similarly, if census agricultural land estimates were smaller than RESAC's, appropriate acres were added to non-agricultural land uses.

Adjustments were also made to the RESAC land cover to determine developed land uses. RESAC land cover was originally based on the United States Geological Survey (USGS) protocols used to develop the 2000 National Land Cover Database. The only difference between the RESAC and USGS approaches was RESAC's use of town boundaries and road densities to determine urban land covered by trees or grasses. This approach greatly improved the accuracy of the identified urban land uses, but led to the misclassification of some land adjacent to roads and highways as developed land. This was corrected by subsequent analysis. To ensure that the model accurately represented development over the simulation period, post-processing techniques that reflected changes in urban land use have been applied.

The result of this approach is that CBP P5 land use does not exist in a single GIS coverage; instead it is only available in a tabular format. The CBP P5 watershed model is comprised of 25 land uses. Most of these land uses are differentiated only by their nitrogen and phosphorus loading rates. The land uses are divided into 13 classes with distinct sediment erosion rates. Table 1 lists the CBP P5 generalized land uses, detailed land uses, which are classified by their erosion rates, and the acres of each land use in the Gwynns Falls watershed. Details of the land use development methodology have been summarized in the report entitled *Chesapeake Bay Phase 5 Community Watershed Model* (US EPA 2008).

---

[1] The EPA Chesapeake Bay Program developed the first watershed model in 1982. There have been many upgrades since the first phase of this model. The CBP P5 was developed to estimate flow, nutrient, and sediment loads to the Bay.

Gwynns Falls Watershed Land Use Distribution

The Gwynns Falls watershed consists primarily of urban land use (87.5%), with a small amount of forest land use (10.5%). There are also small amounts of crop (1.7%) and pasture (0.2%). A detailed summary of the watershed land use areas is presented in Table 1, and a land use map is provided in Figure 2.

Table 1: Land Use Percentage Distribution for the Gwynns Falls Watershed

General Land Use	Detailed Land Use	Area (Acres)	Percent	Grouped Percent of Total
Crop	Animal Feeding Operations	13.1	0.0	1.7
	Hay	73.6	0.2	
	High Till	144.3	0.3	
	Low Till	470.9	1.1	
	Nursery	1.1	0.0	
Extractive	Extractive	15.9	0.0	0.0
Forest	Forest	4,328.9	10.4	10.5
	Harvested Forest	43.7	0.1	
Pasture	Pasture	86.6	0.2	0.2
	Trampled Pasture	0.2	0.0	
Urban	Urban: Barren (Construction)	357.7	0.9	87.5
	Urban: Impervious	13,582.9	32.7	
	Urban: Pervious	22,436.8	54.0	
Total		41,555.8	100.0	100.0

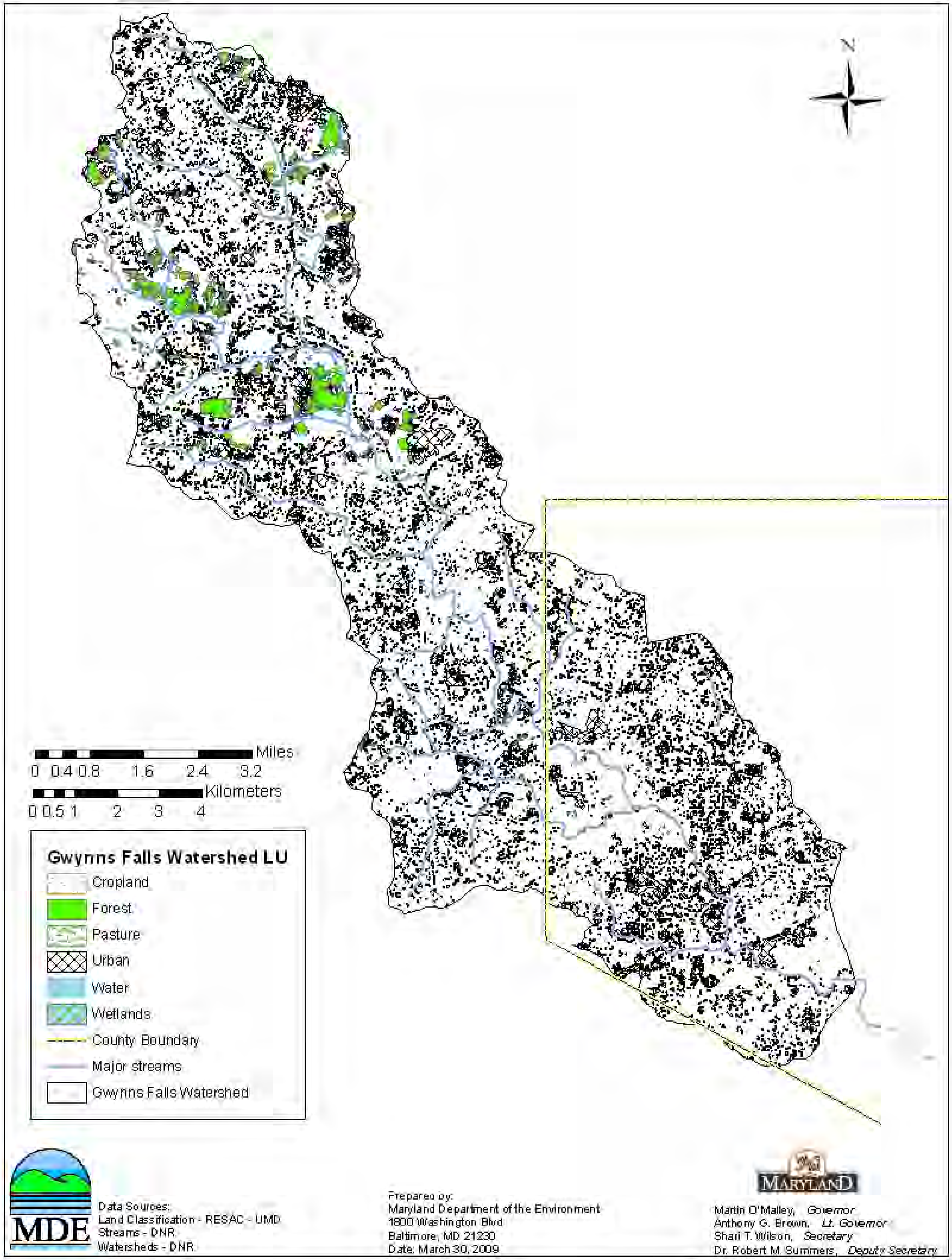


Figure 2: Land Use of the Gwynns Falls Watershed

2.2 Source Assessment

The Gwynns Falls Watershed Total Baseline Sediment Load can be subdivided into nonpoint and point source loads. This section summarizes the methods used to derive each of these distinct source categories.

2.2.1 Nonpoint Source Assessment

In this document, the nonpoint source loads account for sediment loads from unregulated stormwater runoff within the Gwynns Falls watershed. This section provides the background and methods for determining the nonpoint source baseline loads generated within the Gwynns Falls watershed (Nonpoint Source BL_{GF}).

General load estimation methodology

Nonpoint source sediment loads generated within the Gwynns Falls watershed are estimated based on the *edge-of-stream (EOS) calibration target loading rates* from the CBP P5 model. This approach is based on the fact that not all of the *edge-of-field* (EOF) sediment load is delivered to the stream or river (some of it is stored on fields down slope, at the foot of hillsides, or in smaller rivers or streams that are not represented in the model). To calculate the actual EOS loads, a *sediment delivery ratio* (the ratio of sediment reaching a basin outlet compared to the total erosion within the basin) is used. Details of the methods used to calculate sediment load have been summarized in the report entitled *Chesapeake Bay Phase 5 Community Watershed Model* (US EPA 2008).

Edge-of-Field Target Erosion Rate Methodology

EOF target erosion rates for agricultural land uses and forested land use were based on erosion rates determined by the Natural Resource Inventory (NRI). NRI is a statistical survey of land use and natural resource conditions conducted by the Natural Resources Conservation Service (NRCS) (USDA 2006). Sampling methodology is explained by Nusser and Goebel (1997).

Estimates of average annual erosion rates for pasture and cropland are available on a county basis at five-year intervals, starting in 1982. Erosion rates for forested land uses are not available on a county basis from NRI; however, for the purpose of the CBP Phase 2 watershed model, NRI calculated average annual erosion rates for forested land use on a watershed basis. These rates are still being used as targets in the CBP P5 model.

The average value of the 1982 and 1987 surveys was used as the basis for EOF target loads. The erosion rates from this period do not reflect best management practices (BMPs) or other soil conservation policies introduced in the wake of the effort to restore the Chesapeake Bay. To compensate for this, a BMP factor was included in the loading estimates using best available “draft” information from the CBP P5. Rates for urban pervious, urban impervious, and barren land were based on a combination of best professional judgment, literature analysis, and regression analysis. Table 2 lists erosion rates specific to the Gwynns Falls watershed.

Table 2: Summary of EOF Erosion Rate Calculations

Land Use	Data Source	Baltimore County (tons/acre/year)	Baltimore City (tons/acre/year)
Forest	Phase 2 NRI	0.46	0.47
Harvested Forest[1]	Average Phase 2 NRI (x 10)	3	3
Nursery	Pasture NRI (x 9.5)	12.26	2.57
Pasture	Pasture NRI (1982-1987)	1.29	0.27
Trampled pasture[2]	Pasture NRI (x 9.5)	12.26	2.57
Animal Feeding Operations[2]	Pasture NRI (x 9.5)	12.26	2.57
Hay[2]	Crop NRI (1982-1987) (x 0.32)	3.18	0.8
High Till	Crop NRI (1982-1987) (x 1.25)	12.42	3.14
Low till With Manure[2]	Crop NRI (1982-1987) (x 0.75)	7.45	1.89
Pervious Urban	Intercept Regression Analysis	0.74	0.74
Extractive	Best professional judgment	10	10
Barren	Literature survey	20	20
Impervious	100% Impervious Regression Analysis	5.18	5.18

Notes: [1] Based on an average of NRI values for the Chesapeake Bay Phase 5 segments.
[2] NRI score data adjusted based on land use.

Sediment Delivery Ratio: The base formula for calculating *sediment delivery ratio*s in the CBP P5 model is the same as the formula used by the NRCS (USDA 1983).

$$DF = 0.417762 * A^{-0.134958} - 0.127097 \qquad \text{(Equation 2.1)}$$

where
DF (delivery factor) = the sediment delivery ratio
A = drainage area in square miles

In order to account for the changes in sediment loads due to distance traveled to the stream, the CBP P5 model uses the *sediment delivery ratio*. Land use specific *sediment delivery ratios* were calculated for each river segment using the following procedure:

(1) mean distance of each land use from the river reach was calculated;

(2) *sediment delivery ratio*s for each land use were calculated (drainage area in Equation 2.1 was assumed to be equal to the area of a circle with radius equal to the mean distance between the land use and the river reach).

Edge-of-Stream Loads

Edge-of-stream loads are the loads that actually enter the river reaches (i.e., the mainstem of a watershed). Such loads represent not only the erosion from the land but all of the intervening processes of deposition on hillsides and sediment transport through smaller rivers and streams.

Streambank Erosion

Many studies have documented the relationship between high amounts of connected impervious surfaces, increases in storm flows, and stream degradation in the form of streambank erosion (Schueler 1994; Arnold and Gibbons 1996). In many urbanized watersheds, small stream channels have been replaced by sewer pipes. As a result, impervious surfaces such as rooftops, parking lots, and road surfaces are now directly connected to the main stream channel via the storm sewer system. During a storm event, this causes a greater amount of precipitation to flow more rapidly into a given stream channel once it reaches the surface. Furthermore, less water infiltrates into the ground both during and after a storm event, thereby limiting the amount of groundwater recharge to a stream. This altered urban hydrology typically causes abnormally high flows in streams during storms and abnormally low flows during dry periods. The high flows occurring during storm events increase sheer stress and cause excessive erosion of streambanks and streambeds, which leads to degraded stream channel conditions for biological communities (MDE 2007a).

Two methods of estimating streambank erosion were presented in the *Total Maximum Daily Loads of Sediment/Total Suspended Solids for the Anacostia River Basin, Montgomery and Prince George's Counties, Maryland and The District of Columbia*. The first estimate uses the Anacostia Hydrological Simulation Program – FORTRAN (HSPF) watershed model in conjunction with the Penn State University streambank erosion equation (Evans et al. 2003). The analysis estimated that approximately 73% of the total annual sediment load within the Anacostia River watershed could be attributed to streambank erosion (MDE 2007a).

The second method analyzes the long term relationship between flow and total suspended solids (TSS) concentrations to quantify the effects of an altered urban hydrology on watershed sediment loads. Changes in hydrology in the Anacostia River watershed were characterized using daily flow data from the USGS gage stations. The long-term changes over time in the flow duration curves (FDCs) for each of these stations was quantified using a type of statistical analysis known as "quantile regression." The portion of the FDC representing the highest flows was determined to have increased significantly over time, consistent with hydrologic alteration from increased impervious surfaces. Also, a "sediment rating curve" (i.e., the relationship between suspended sediment concentration and flow) was computed and combined with the FDCs to estimate annual sediment loads before and after increased development (i.e., altered hydrology). The results of the analysis indicate that approximately 75% of the total annual sediment load in the Anacostia River watershed is due to alterations in hydrology (MDE 2007a).

Using CBP P5 urban sediment EOF target values, MDE developed a formula for estimating the percent of erosional sediment resultant from streambank erosion (i.e., that portion of the total urban sediment load attributed to stream bank erosion) based on the amount of impervious land within a watershed. The equation uses the urban sediment loading factors to estimate the proportion of the urban sediment load from stream bank erosion. The assumption is that as impervious surfaces increase, the upland sources decrease, flow increases, and the change in sediment load results from increased streambank erosion. While this formula only represents an empirical approximation, it is consistent with results from the Anacostia River Sediment TMDL and recognizes that stream bank erosion can be a significant portion of the total sediment load. The formula is as follows:

$$\%E = \frac{I * L_I}{I * L_I + (1 - I)L_P} \qquad \text{(Equation 2.2)}$$

where:
% E = percent erosional sediment resultant from streambank erosion
I = percent impervious
L_I = Impervious urban land use EOF load
L_P = Pervious urban land use EOF load

The relationship demonstrated in equation 2.2 is expressed graphically in Figure 3. Using the equation, the Anacostia River watershed (23% impervious) would equate to approximately a 68% erosional sediment load resultant from streambank erosion. Per Table 1, approximately 33% of the Gwynns Falls watershed is covered by impervious surfaces. This would equate to approximately a 77% erosional sediment load resultant from streambank erosion.

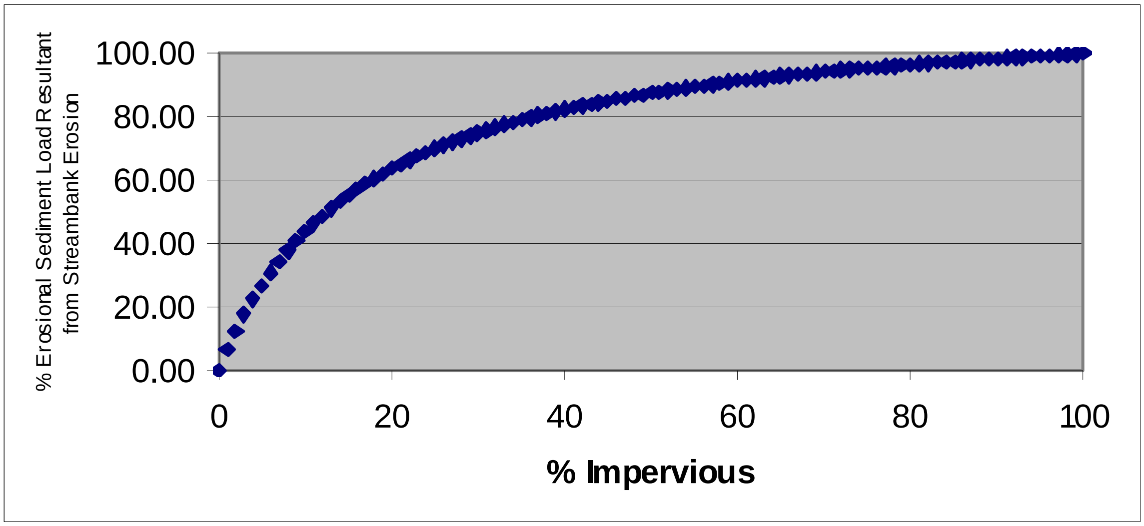


Figure 3: Percent Impervious vs. Percent Erosional Sediment Load Resultant from Streambank Erosion

For this TMDL, erosional sediment resultant from streambank erosion represents an aggregate load within the total urban impervious EOF loads as described in the report *Chesapeake Bay Phase V Community Watershed Model* (US EPA 2008) and is not explicitly reported.

2.2.2 Point Source Assessment

A list of 57 active permitted point sources that contribute to the sediment load in the Gwynns Falls watershed was compiled using MDE's Environmental Permit Service Center (EPSC) database. The types of permits identified include individual municipal, individual municipal separate storm sewer systems (MS4s), general mineral mining, general industrial stormwater, and general MS4s. The permits can be grouped into two categories, process water and stormwater. The process water category includes those loads generated by continuous discharge sources whose permits have TSS limits. The stormwater category includes all National Pollutant Discharge Elimination System (NPDES) regulated stormwater discharges. Other permits that do not meet these conditions are considered *de minimis* in terms of the total sediment load.

The sediment loads for the 5 process water permits (Process Water BL_{GF}) are calculated based on their TSS limits and corresponding flow information. The 52 NPDES Phase I or Phase II stormwater permits identified throughout the Gwynns Falls watershed are regulated based on BMPs and do not include TSS limits. In the absence of TSS limits, the NPDES regulated stormwater baseline load (NPDES Stormwater BL_{GF}) is calculated using methods described in Section 2.2.1 and watershed specific urban land use sediment delivery factors. A detailed list of the permits appears in Appendix B.

2.2.3 Summary of Baseline Loads

Table 3 summarizes the Gwynns Falls Baseline Sediment Load, reported in tons per year (ton/yr) and presented in terms of nonpoint and point source loadings.

Table 3: Gwynns Falls Baseline Sediment Loads (ton/yr)

Total Baseline Load (ton/yr)	=	**Nonpoint Source BL_{GF}**	+	**NPDES Stormwater BL_{GF}**	+	**Process Water BL_{GF}**
22,048.5	=	1,759.3	+	20,076.0	+	213.2

Table 4 presents a breakdown of the Gwynns Falls Total Baseline Sediment Load, detailing loads per land use. The largest portion of the sediment load is from urban land (92%). The remainder of the sediment load is from crop land (5%) and forest (2%), with small amounts from other land uses.

Table 4: Detailed Baseline Sediment Budget Loads Within the Gwynns Falls Watershed

General Land Use	Detailed Land Use	Load (Ton/Yr)	Percent	Grouped Percent of Total
Crop	Animal Feeding Operations	34.9	0.2	5.4
	Hay	49.9	0.2	
	High Till	361.3	1.6	
	Low Till	740.1	3.4	
	Nursery	2.9	0.0	
Extractive	Extractive	34.3	0.2	0.2
Forest	Forest	482.0	2.2	2.3
	Harvested Forest	31.7	0.1	
Pasture	Pasture	21.6	0.1	0.1
	Trampled Pasture	0.7	0.0	
Urban[1]	Urban: Barren (Construction)	1069.8	4.9	91.1
	Urban: Impervious	15,507.8	70.3	
	Urban: Pervious	3,498.4	15.9	
	Process Water	213.2	1.0	1.0
Total		22,048.5	100.0	100.0

Note: [1] The urban land use load represents the permitted stormwater load.

2.3 Water Quality Characterization

The Gwynns Falls watershed was originally listed on Maryland's 1996 303(d) List as impaired by elevated sediments from nonpoint sources, with supporting evidence cited in Maryland's 1996 305(b) report. The 1996 305(b) report did not directly state that elevated sediments were a concern, and it has been determined that the sediment listing was based on best professional judgment (MDE 2004; DNR 1996).

Currently in Maryland, there are no specific numeric criteria for suspended sediments. Therefore, to determine whether aquatic health is impacted by elevated sediment loads, MDE's recently developed biological stressor identification methodology was applied. The primary goal of the BSID analysis is to identify the most probable cause(s) for observed biological impairments throughout MD's 8-digit watersheds (MDE 2009a).

The BSID analysis applies a case-control, risk-based, weight-of-evidence approach to identify potential causes of biological impairment. The risk-based approach estimates the strength of association between various stressors and a degraded biological community. The BSID analysis then identifies individual stressors (pollutants) as probable or unlikely causes of the poor biological conditions within a given MD 8-digit watershed and subsequently reviews ecological plausibility/concludes whether or not these individual stressors or groups of stressors are contributing to the impairment (MDE 2009a).

The primary dataset for BSID analysis is round two Maryland Department of Natural Resources (DNR) Maryland Biological Stream Survey (MBSS) data (collected between 2000-2004) because it provides a broad spectrum of paired data variables, which allow for a more comprehensive stressor analysis. The MBSS is a robust statewide probability-based sampling survey for assessing the biological conditions of wadeable, non-tidal streams (Klauda et al. 1998; Roth et al. 2005). It uses a fixed length (75 m) randomly selected stream segment for collecting site level information within a primary sampling unit (PSU), also defined as a watershed. The randomly selected stream segments, from which field data are collected, are selected using either stratified random sampling with proportional allocation, or simple random sampling (Cochran 1977). The random sample design allows for unbiased estimates of overall watershed conditions. Thus, the dataset facilitated case-control analyses because 1) in-stream biological data are paired with chemical, physical, and land use data variables that could be identified as possible stressors and 2) it uses a probabilistic statewide monitoring design.

The BSID analysis groups the individual stressors (physical and chemical variables) into three generalized parameters in order to assess how the resulting impacts of these stressors can alter the biological community and structure. The three generalized parameters include: sediment, habitat, and water chemistry. Identification of a sediment/flow stressor as contributing to the biological impairment is based on the results of the individual stressor associations within both the sediment and habitat parameters that reveal the effects of sediment related impacts or an altered hydrologic regime (MDE 2009a).

In addition to the MBSS round two data applied within the BSID analysis, data from the Maryland DNR Core/Trend Program was also used for water quality characterization in the TMDL. The program collected benthic macroivertebrate data between 1976 and 2006. This data was used to calculate four benthic community measures: total number of taxa, the Shannon Weiner diversity index, the modified Hilsenhoff biotic integrity index, and percent Ephemeroptera, Plecoptera, and Trichoptera (EPT). DNR has extensive monitoring data for two stations on the mainstem of the Gwynns Falls through the Core/Trend program. One station is located at Liberty Road and the other at Route 1. (See Figure 4 and table 5) (DNR 2007).

Gwynns Falls Watershed Monitoring Stations

A total of 30 water quality monitoring stations were used to characterize the Gwynns Falls Watershed. Twenty-eight biological/physical habitat monitoring stations from the MBSS program round one and two data collection were used to characterize the Gwynns Falls Watershed in Maryland's 2008 Integrated Report. The BSID analysis used the 12 biological/physical habitat monitoring stations from the MBSS program round two data collection. Additionally, two biological monitoring stations from the Maryland Core/Trend monitoring network were applied within the TMDL analysis. All stations are presented in Figure 4 and listed in Table 5.

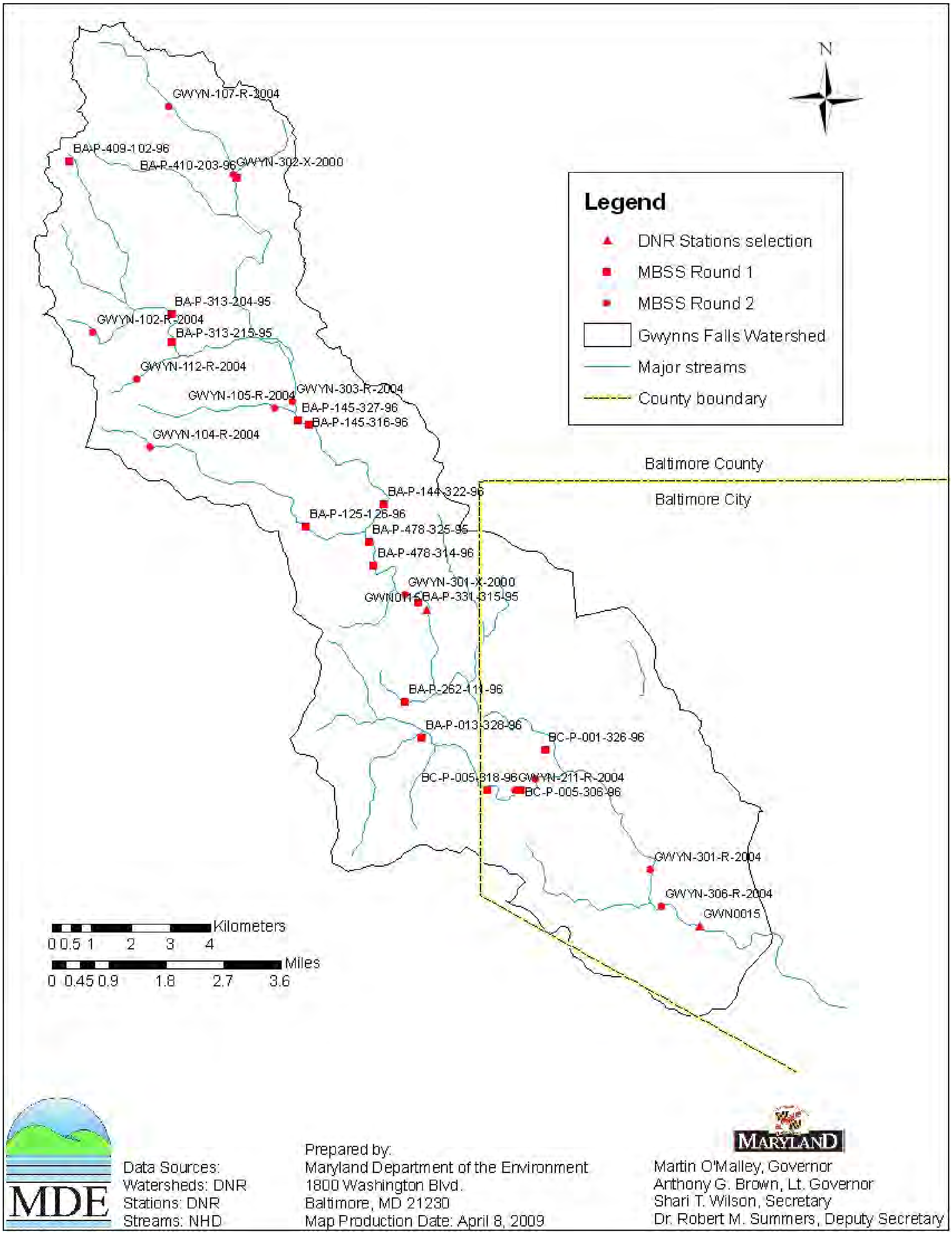


Figure 4: Monitoring Stations in the Gwynns Falls Watershed

Table 5: Monitoring Stations in the Gwynns Falls Watershed

Site Number	Sponsor	Site Type	Site Name	Latitude (dec degrees)	Longitude (dec degrees)
BA-P-013-328-96	MD DNR	MBSS, Round 1	DEAD RUN	39.3140	-76.7280
BA-P-125-126-96	MD DNR	MBSS, Round 1	SCOTTS LEVEL BR	39.3620	-76.7620
BA-P-144-322-96	MD DNR	MBSS, Round 1	GWYNNS FALLS	39.3670	-76.7390
BA-P-145-316-96	MD DNR	MBSS, Round 1	GWYNNS FALLS	39.3850	-76.7610
BA-P-145-327-96	MD DNR	MBSS, Round 1	GWYNNS FALLS	39.3860	-76.7640
BA-P-262-111-96	MD DNR	MBSS, Round 1	GWYNNS FALLS UT1	39.3220	-76.7330
BA-P-313-204-95	MD DNR	MBSS, Round 1	RED RUN	39.4102	-76.8012
BA-P-313-215-95	MD DNR	MBSS, Round 1	RED RUN	39.4040	-76.8009
BA-P-331-315-95	MD DNR	MBSS, Round 1	GWYNNS FALLS	39.3446	-76.7289
BA-P-409-102-96	MD DNR	MBSS, Round 1	RED RUN	39.4450	-76.8310
BA-P-410-203-96	MD DNR	MBSS, Round 1	GWYNNS FALLS	39.4410	-76.7820
BA-P-478-314-96	MD DNR	MBSS, Round 1	GWYNNS FALLS	39.3530	-76.7420
BA-P-478-325-95	MD DNR	MBSS, Round 1	GWYNNS FALLS	39.3583	-76.7434
BC-P-001-326-96	MD DNR	MBSS, Round 1	GWYNNS FALLS	39.3110	-76.6920
BC-P-005-306-96	MD DNR	MBSS, Round 1	DEAD RUN	39.3020	-76.6990
BC-P-005-318-96	MD DNR	MBSS, Round 1	DEAD RUN	39.3020	-76.7090
GWYN-102-R-2004	MD DNR	MBSS, Round 2	RED RUN UT 2	39.4062	-76.8241
GWYN-104-R-2004	MD DNR	MBSS, Round 2	SCOTTS LEVEL BR	39.3801	-76.8078
GWYN-105-R-2004	MD DNR	MBSS, Round 2	HORSEHEAD BR	39.3888	-76.7709
GWYN-107-R-2004	MD DNR	MBSS, Round 2	GWYNNS FALLS	39.4572	-76.8018
GWYN-112-R-2004	MD DNR	MBSS, Round 2	RED RUN UT 1	39.3955	-76.8114
GWYN-210-R-2004	MD DNR	MBSS, Round 2	DEAD RUN	39.3044	-76.6949
GWYN-211-R-2004	MD DNR	MBSS, Round 2	DEAD RUN	39.3019	-76.7008
GWYN-301-R-2004	MD DNR	MBSS, Round 2	GWYNNS FALLS	39.2838	-76.6614
GWYN-301-X-2000	MD DNR	MBSS, Round 2	GWYNNS FALLS	39.3464	-76.7331
GWYN-302-X-2000	MD DNR	MBSS, Round 2	GWYNNS FALLS	39.4419	-76.7831
GWYN-303-R-2004	MD DNR	MBSS, Round 2	GWYNNS FALLS	39.3904	-76.7656
GWYN-306-R-2004	MD DNR	MBSS, Round 2	GWYNNS FALLS	39.2755	-76.6582
GWN0015	MD DNR	Trend	Route 1	39.3140	-76.7280
GWN0115	MD DNR	Core	Liberty road	39.3620	-76.7620

2.4 Water Quality Impairment

The Maryland water quality standards surface water use designations for the Gwynns Falls mainstem and its tributaries is Use I (Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life), except for the Gwynns Falls mainstem and its tributaries above Reisterstown Road and Red Run and its tributaries, which are designated as Use III (Nontidal Cold Water), and Dead Run and its tributaries, which are classified as Use IV (Recreational Trout Waters) (COMAR 2008a,b,c,d,e). The water quality impairment of the Gwynns Falls watershed addressed by this TMDL is caused by an elevated sediment load beyond a level that the watershed can sustain without causing any sediment related impacts to aquatic health, where aquatic health is based on benthic and fish Index of Biotic Integrity (IBI) scores, as demonstrated via the BSID analysis for the watershed.

The Gwynns Falls watershed is listed on Maryland's 2008 Integrated Report as impaired for impacts to biological communities. Greater than 79% of the stream miles in the Gwynns Falls watershed are assessed as having degraded biological conditions (when compared to regional reference indices). The biological impairment listing is based on the combined results of MBSS round one (1995-1997) and round two (2000-2004) data, which includes twenty-eight stations. Twenty-two of the twenty-eight stations have degraded BIBI/FIBI scores significantly lower than 3.0 (MDE 2008). As mentioned in Section 2.3, however, only MBSS round 2 data were used in the BSID analysis. See Figure 4 and Table 5 for station locations and information.

The results of the BSID analysis for the Gwynns Falls watershed are presented in a report entitled *Watershed Report for Biological Impairment of the Gwynns Falls Watershed in Baltimore City and Baltimore County, Maryland Biological Stressor Identification Analysis Results and Interpretation* (MDE 2009b). The report states that the degradation of biological communities in the Gwynns Falls watershed is strongly associated with urban land use and its concomitant effects: altered hydrology, sediment related impacts, and elevated levels of sulfate, chlorides, and conductivity (a measure of the presence of dissolved substances).

The BSID analysis has determined that the biological impairment in the Gwynns Falls watershed is due in part to flow/sediment related stressors. Specifically, the analysis confirmed that individual stressors within the sediment and habitat parameter groupings were contributing to the biological impairment in the watershed. Also, the analysis identified the following stressors within the sediment and habitat parameter groupings as having a statistically significant association with impaired biological communities at the respective percentage of degraded sites: channelization (34%), channel alteration (poor: 24%), and bar formation (extensive: 23%). Overall, sediment and flow stressors within the sediment and habitat parameter groupings were identified at approximately 24% and 40%, respectively, of the degraded sites throughout the watershed (MDE 2009b). Therefore, since sediment is identified as a stressor to the biological communities in the Gwynns Falls watershed, a TMDL is required.

As a supplement to the MBSS round two data used in the BSID analysis, the biological monitoring results from the two Maryland DNR Core/trend stations along the mainstem of the Gwynns Falls indicate that mainstem water quality can be classified as poor to fair/good based on percent EPT, taxa number, biotic index, and diversity index (see Table 6). Statistical analysis of the long term Core/Trend data indicates since 1977, that one station has shown improvement and one station has shown no change (DNR 2007). The poor water quality status for Station GWN0015 is consistent with the results of the MBSS data at the nearby upstream station, GWYN-306-R-2004.

Table 6: Gwynns Falls Core/Trend Data

Site Number	Current Water Quality Status	Trend Since 1970's
GWN0015	POOR	NO CHANGE
GWN0115	FAIR/GOOD	SLIGHT IMPROVEMENT

3.0 TARGETED WATER QUALITY GOAL

The objective of the sediment TMDL established herein is to reduce sediment loads, and subsequent effects on aquatic health, in the Gwynns Falls watershed to levels that support the Use I/III/IV designations (Water contact recreation, and protection of Nontidal Warmwater Aquatic Life) (Nontidal Coldwater) (Recreational Trout Waters) (COMAR 2008a,b,c,d,e). Assessment of aquatic health is based on Maryland's biocriteria protocol, which evaluates both the amount and diversity of the benthic and fish community through the use of the IBI (Roth et al. 1998, 2000; Stribling et al. 1998; MDE 2008).

Reductions in sediment loads are expected to result from decreased watershed and streambed erosion, which will then lead to improved benthic and fish habitat conditions. Specifically, sediment load reductions are expected to result in an increase in the number of benthic sensitive species present, an increase in the available and suitable habitat for a benthic community, a possible decrease in fine sediment (fines), and improved stream habitat diversity, all of which will result in improved water quality.

The TMDL, however, will not completely resolve the impairment to biological communities within the watershed. Since the BSID watershed analysis identifies other possible stressors (i.e., chlorides, sulfate, conductivity) as impacting the biological conditions, this impairment remains to be fully addressed through the Integrated Report listing process and the TMDL development process, such that all impairing substances identified as impacting biological communities in the watershed are reduced to levels that will meet water quality standards, as established in future TMDLs for those substances (MDE 2009a).

4.0 TOTAL MAXIMUM DAILY LOADS AND SOURCE ALLOCATION

4.1 Overview

This section describes how the sediment TMDL and the corresponding allocations were developed for the Gwynns Falls watershed. Section 4.2 describes the analysis framework for estimating sediment loading rates and the assimilative capacity of the watershed stream system. Section 4.3 summarizes the scenarios that were used in the analysis and presents results. Section 4.4 discusses critical conditions and seasonality. Section 4.5 explains the calculations of TMDL loading caps. Section 4.6 details the load allocations, and Section 4.7 explains the rationale for the margin of safety. Finally, Section 4.8 summarizes the TMDL.

4.2 Analysis Framework

Since there are no specific numeric criteria that quantify the impact of sediment on the aquatic health of nontidal stream systems, a reference watershed approach will be used to establish the TMDL. Furthermore, as the BSID analysis established a link between biological impairment and sediment related stressors, the reference watershed approach will utilize a biological endpoint.

Watershed Model

The watershed model framework chosen for the Gwynns Falls watershed TMDL was the CBP P5 long-term average annual watershed model EOS loading rates. The spatial domain of the CBP P5 watershed model segmentation aggregates to the MD 8-digit watersheds, which is consistent with the impairment listing. The EOS loading rates were used because actual time variable CBP P5 calibration and scenario runs are currently being developed and are not yet available. These target-loading rates are used to calibrate the land use EOS loads within the CBP P5 model and thus should be consistent with future CBP modeling efforts.

The nonpoint source and NPDES stormwater baseline sediment loads generated within the Gwynns Falls watershed are calculated as the sum of corresponding land use EOS loads within the watershed and represent a long-term average loading rate. Individual land use EOS loads are calculated as a product of the land use area, land use target loading rate, and loss from the EOF to the main channel. The loss from the EOF to the main channel is the *sediment delivery ratio* and is defined as the ratio of the sediment load reaching a basin outlet to the total erosion within the basin. A *sediment delivery ratio* is estimated for each land use type based on the proximity of the land use to the main channel. Thus, as the distance to the main channel increases, more sediment is stored within the channels (i.e., *sediment delivery ratio* decreases). Details of the data sources for the unit loading rates can be found in Section 2.2 of this report.

The Gwynns Falls watershed was evaluated using two watershed TMDL segments (see Figure 5). TMDL Segment 1 represents the sediment loads generated in the northwestern portion of the watershed. TMDL Segment 2 represents the sediment loads generated in the southeastern portion of the watershed.

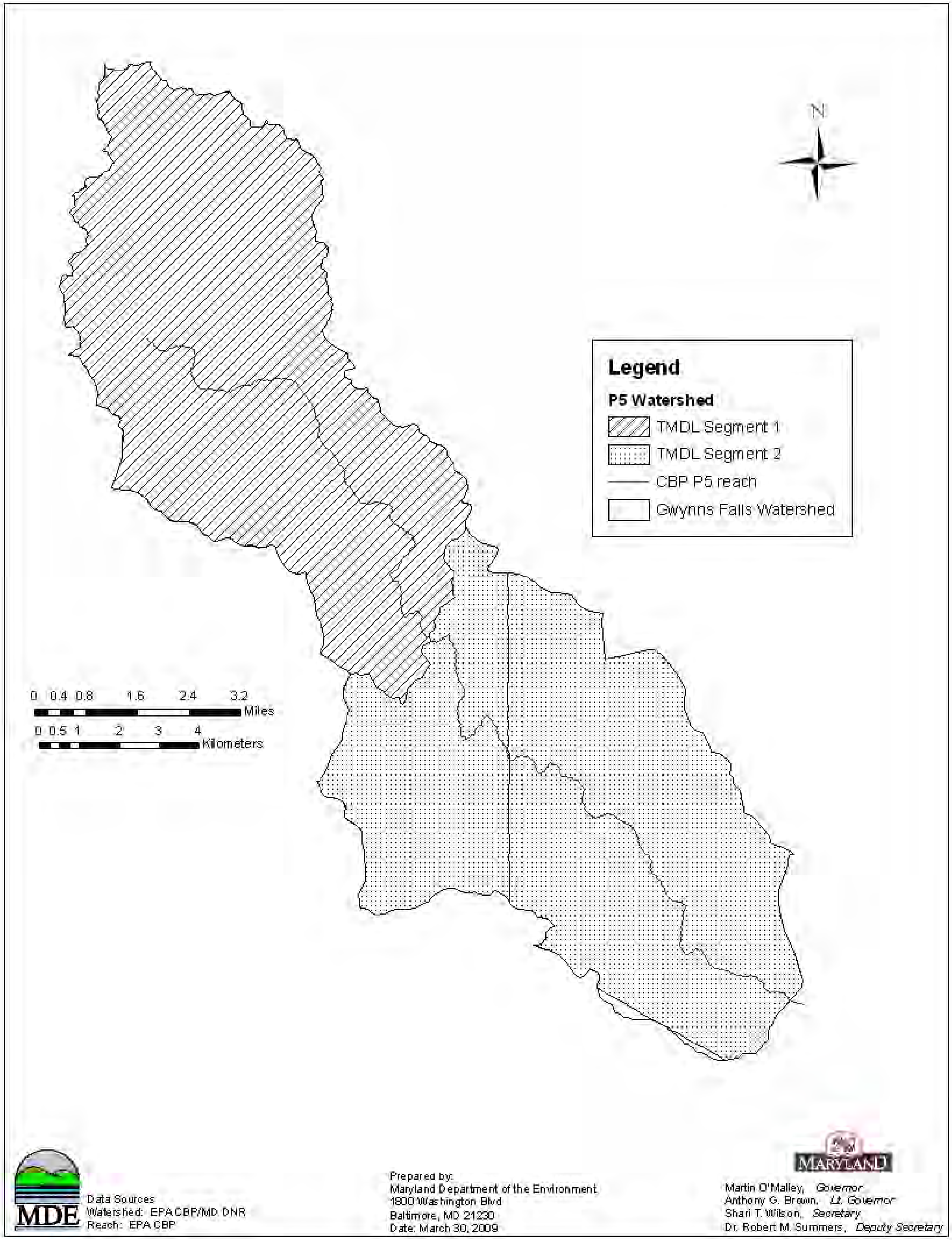


Figure 5: Gwynns Falls Watershed TMDL Segmentation

Reference Watershed Approach

Currently in Maryland, there are no specific numeric criteria that quantify the impact of sediment on the aquatic health of non-tidal stream systems. Therefore, in order to quantify the impact of sediment on the aquatic health of non-tidal stream systems, a reference watershed TMDL approach was used and resulted in the establishment of a *sediment loading threshold* for watersheds within the Highland and Piedmont physiographic regions (Currey et al. 2006). Reference watersheds were determined based on Maryland's biocriteria methodology. The biocriteria methodology assesses biological impairment at the 8-digit watershed scale based on the percentage of MBSS monitoring stations, translated into watershed stream miles, that are degraded. Individual monitoring station impairment is determined based on BIBI/FIBI scores lower than the Minimum Allowable IBI Limit (MAL), which is calculated based on the average annual allowable IBI value of 3.0 (on a scale of 1 to 5). Applying the MAL threshold helps avoid classification errors when assessing biological impairment (Roth et al. 1998, 2000; Stribling et al. 1998; MDE 2008).

Comparison of watershed sediment loads to loads from reference watersheds requires that the watersheds be similar in physical and hydrological characteristics. To satisfy this requirement, Currey et al. (2006) selected reference watersheds only from the Highland and Piedmont physiographic regions (see appendix A for the list of reference watersheds). This region is consistent with the non-coastal region that was identified in the 1998 development of FIBI and subsequently used in the development of BIBI (Roth et al. 1998; Stribling et al. 1998).

To reduce the effect of the variability within the Highland and Piedmont physiographic regions, the watershed sediment loads were then normalized by a constant background condition, the all forested watershed condition. This new normalized term, defined as the *forest normalized sediment load* (Y_n), represents how many times greater the current watershed sediment load is than the *all forested sediment load*. A similar approach was used by EPA Region 9 for sediment TMDLs in California (e.g., Navarro River or Trinity River TMDLs), where the loading capacity was based on an analysis of the amount of human-caused sediment delivery that can occur in addition to natural sediment delivery, without causing adverse impacts to aquatic life. The *forest normalized sediment load* for this TMDL is calculated as the current watershed sediment load divided by the *all forested sediment load*. The equation for the *forest normalized sediment load* is as follows:

$$Y_n = \frac{y_{ws}}{y_{for}} \qquad \text{(Equation 4.1)}$$

where:

Y_n = forest normalized sediment load
y_{ws} = current watershed sediment load (ton/yr)
y_{for} = all forested sediment load (ton/yr)

Nine reference watersheds were selected from the Highland/Piedmont region. Reference watershed *forest normalized sediment loads* were calculated using CBP P5 2000 land use in order to maintain consistency with MBSS sampling years. The median and 75th percentile of the reference watershed *forest normalized sediment loads* were calculated and found to be 3.3 and 4.2 respectively. These values are in close agreement with more complex methods used to determine the *sediment loading threshold* in previous nontidal sediment TMDLs. Therefore, the median value of 3.3 was established as the *sediment loading threshold* as an environmentally conservative approach to develop this TMDL (see Appendix A for more details).

The *forest normalized sediment loads* for the Gwynns Falls watershed (estimated as 4.3 and 5.9 for TMDL Segments 1 and 2 respectively) were calculated using CBP P5 2005 landuse, to best represent current conditions. A comparison of the Gwynns Falls watershed *forest normalized sediment loads* to the *forest normalized reference sediment load* (also referred to as the *sediment loading threshold*) demonstrates that both TMDL segments exceed the *sediment loading threshold*, indicating that they are receiving loads that are above the maximum allowable load that the watershed can sustain and still meet water quality standards.

4.3 Scenario Descriptions and Results

The following analyses allow a comparison of baseline conditions (under which water quality problems exist) with future conditions, which project the water quality response to various simulated sediment load reductions. The analyses are grouped according to baseline conditions and future conditions associated with TMDLs.

Baseline Conditions

The baseline conditions are intended to provide a point of reference by which to compare the future scenario that simulates conditions of a TMDL. The baseline conditions typically reflect an approximation of nonpoint source loads during the monitoring time frame, as well as estimated point source loads based on discharge data for the same period.

The Gwynns Falls watershed baseline sediment loads are estimated using the CBP P5 target EOS land use sediment loading rates with 2005 land use. Watershed loading calculations, based on the CBP P5 segmentation scheme, are represented by multiple CBP P5 model segments within each TMDL segment. The sediment loads from these segments are combined to represent the baseline condition. The point source sediment loads are estimated based on the existing permit information. Details of these loading source estimates can be found in Section 2.2 and Appendix B of this report.

Future (TMDL) Conditions

This scenario represents the future conditions of maximum allowable sediment loads whereby there will be no sediment related impacts to aquatic health. In the TMDL calculation, the allowable load for the impaired watershed is calculated as the product of the *sediment loading threshold* (determined from watersheds with a healthy biological community) and the Gwynns Falls *all forested sediment load* (see Section 4.2). The resulting load is considered the maximum allowable load the watershed can sustain without causing any sediment related impacts to aquatic health.

The TMDL loading and associated reductions are averaged at the MD 8-digit watershed scale, which is consistent with the original listing scale. It is important to recognize that some subwatersheds may require higher reductions than others, depending on the distribution of the land use.

The formula for estimating the TMDL is as follows:

$$TMDL = \sum_{i=1}^{n} Yn_{ref} \cdot y_{forest\,i} \qquad \text{(Equation 4.2)}$$

where
TMDL = allowable load for impaired watershed (ton/yr)
Yn_{ref} = sediment loading threshold = forest normalized reference sediment load (3.3)
$y_{forest\,i}$ = all forested sediment load for segment *i* (ton /yr)
i = CBP P5 model segment
n = number of CBP P5 model segments in watershed

The Gwynns Falls watershed allowable sediment load is estimated using equation 4.2.

4.4 Critical Condition and Seasonality

EPA’s regulations require TMDLs to take into account seasonality and critical conditions for stream flow, loading, and water quality parameters (CFR 2008b). The intent of this requirement is to ensure that the water quality of the waterbody is protected during times when it is most vulnerable. The biological monitoring data used to determine the reference watersheds integrates the stress effects over the course of time and thus inherently addresses critical conditions. Seasonality is captured in two components. First, it is implicitly included through the use of the biological monitoring data. Second, the MBSS dataset included benthic sampling in the spring and fish sampling in the summer.

4.5 TMDL Loading Caps

This section presents the Gwynns Falls watershed average annual sediment TMDL. This load is considered the maximum allowable long-term average annual load the watershed can sustain without causing any sediment related impacts to aquatic health.

The long-term average annual TMDL was calculated for both TMDL Segment 1 and Segment 2 (see Figure 5) independently, based on Equation 4.2 and set at a load 3.3 times the all forested condition. In order to attain the TMDL loading cap calculated for the segments, reductions will be applied to the predominant controllable sources. If only these predominant (generally the largest) sources are controlled, water quality standards can be achieved in the most effective, efficient, and equitable manner. Urban land was identified as the most extensive predominant controllable source in both of the TMDL segments.

Currently, MDE requires that large and medium MS4s retrofit 10% of existing urban land area where there is failing or no stormwater management every permit cycle (5 years). This level of restoration has been determined to be the current maximum feasible, regulated stormwater reduction scenario. Therefore, the reductions applied within this TMDL analysis are consistent with this 10% retrofit goal to existing urban land every 5 years with an estimated 65% TSS reduction efficiency from future stormwater BMPs (Claytor and Schueler 1997; Baldwin et al. 2007; Baish and Caliri 2009).

If the TMDL still is not achieved after applying the current maximum feasible urban stormwater reductions, then constant reductions will be applied to the remaining predominant controllable sources (i.e., significant contributors of sediment to the stream system), independent of jurisdiction. In addition to urban land, predominant sources typically include high till crops, low till crops, hay, pasture, and harvested forest, but additional sources might need to be controlled in order to ensure that the TMDL is attained.

The Gwynns Falls Baseline Load and TMDL are presented in Table 7.

Table 7: Gwynns Falls Baseline Load and TMDL

	Baseline Load (ton/yr)	**TMDL** (ton/yr)	**Reduction** (%)
TMDL Segment 1	8,474.7	6,481.3	23.5
TMDL Segment 2	13,573.6	7,514.9	44.6
Total	22,048.5	13,996.2	36.5

4.6 Load Allocations Between Point and Nonpoint Sources

Per EPA regulation, all TMDLs need to be presented as a sum of waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint source loads generated within the assessment unit, as well as natural background, tributary, and adjacent segment loads (CFR 2008a). Consequently, the Gwynns Falls watershed TMDL allocations are presented in terms of WLAs (i.e., point source loads identified within the watershed) and LAs (i.e., the nonpoint source loads within the watershed). The State reserves the right to allocate the TMDL among different sources in any manner that is reasonably calculated to protect aquatic life from sediment related impacts.

As described in Section 4.5, reductions were only applied to the regulated urban stormwater sources. Furthermore, reductions were only applied to urban areas developed prior to 1985 (i.e., approximate areas with no stormwater management). This is consistent with MS4 permit requirements for retrofitting existing urban areas at a rate of 10% every 5 years. The reduction in sediment loads associated with retrofitting 10% of existing urban areas every 5 years, with an estimated 65% TSS reduction efficiency, represents the current maximum feasible reduction scenario from the urban land use within the watershed.

In this watershed, in addition to urban land, crop and pasture were identified as the predominant controllable sources; however, no reductions were applied to these sources, since the TMDL is achieved when the current maximum feasible reductions are applied to the regulated urban stormwater sources in the watershed. Forest is the only non-controllable source, as it represents the most natural condition in the watershed, and no reductions were applied to permitted process water sources because at 1.0% of the total load, such controls would produce no discernable water quality benefit.

Table 8 summarizes the TMDL results for the Gwynns Falls watershed, derived by applying the current maximum feasible reductions to the applicable urban sediment sources. Tables 9 and 10 summarize the TMDL scenarios for TMDL Segments 1 and 2 individually. The reductions associated with the current maximum feasible scenario result in sediment loading reductions greater than those needed to achieve the TMDL. Thus, the TMDL results in Tables 8, 9, and 10 represent a feasible reduction scenario from the applicable urban sediment sources, determined using the current maximum feasible reduction scenario as a basis. The TMDL results in an overall reduction of 36% for the Gwynns Falls watershed. For more detailed information regarding the Gwynns Falls Watershed TMDL nonpoint source LA, please see the technical memorandum to this document entitled "*Significant Sediment Nonpoint Sources in the Gwynns Falls Watershed*".

Table 8: Gwynns Falls TMDL Reductions by Source Category

Baseline Load Source Categories		**Baseline Load** (ton/yr)	**TMDL Components**	**TMDL** (ton/yr)	**Reduction** (%)
Nonpoint Source		1,759.3	**LA**	1,759.3	0.0%
Point Source	Urban	20,076.0	**WLA**	12,023.7	40.1%
	Permits	213.2		213.2	0.0%
TOTAL		**22,048.5**		**13,996.2**	**36.5%**

Table 9: Gwynns Falls TMDL Segment 1 Reductions by Source Category

Baseline Load Source Categories		**Baseline Load** (ton/yr)	**TMDL Components**	**TMDL** (ton/yr)	**Reduction** (%)
Nonpoint Source		1,507.0	**LA**	1,507.0	0.0
Point Source	Urban	6,967.7	**WLA**	4,974.2	28.6
	Permits	0.1		0.1	0.0
TOTAL		**8,474.7**		**6,481.3**	**23.5**

Table 10: Gwynns Falls TMDL Segment 2 Reductions by Source Category

Baseline Load Source Categories		**Baseline Load** (ton/yr)	**TMDL Components**	**TMDL** (ton/yr)	**Reduction** (%)
Nonpoint Source		252.3	**LA**	252.3	0.0
Point Source	Urban	13,108.2	**WLA**	7,049.5	46.2
	Permits	213.1		213.1	0.0
TOTAL		**13,573.6**		**7,514.9**	**44.6**

The WLA of the Gwynns Falls watershed is allocated to two permitted source categories, Process Water WLA and Stormwater WLA. The categories are described below.

Process Water WLA

Process Water permits with specific TSS limits and corresponding flow information are assigned to the WLA. In this case, detailed information is available to accurately estimate the WLA. If specific TSS limits are not explicitly stated in the process water permit, then TSS loads are expected to be *de minimis*. If loads are *de minimis*, then they pose little or no risk to the aquatic environment and are not a significant source.

Process Water permits with specific TSS limits include:
- Individual industrial facilities
- Individual municipal facilities
- General mineral mining facilities

There are 5 process water sources with explicit TSS limits, which include 1municipal sources, and 4 mineral mines. The total estimated TSS load from all of the process water sources is based on current permit limits and is equal to 213.2 ton/yr. As mentioned above, no reductions were applied to this source because at 1.0% of the total load, such controls would produce no discernable water quality benefit. For a detailed list of the 5 process water sources including information on their permit limits, please see Appendix B. For information regarding the allocations to individual process water point sources, please see the technical memoranda to this document entitled "*Significant Sediment Point Sources in the Gwynns Falls Watershed*".

Stormwater WLA

Per EPA requirements, "stormwater discharges that are regulated under Phase I or Phase II of the NPDES stormwater program are point sources that must be included in the WLA portion of a TMDL" (US EPA 2002). Phase I and II permits can include the following types of discharges:

- Small, medium, and large MS4s – these can be owned by local jurisdictions, municipalities, and state and federal entities (e.g., departments of transportation, hospitals, military bases),

- Industrial facilities permitted for stormwater discharges, and
- Small and large construction sites.

EPA recognizes that available data and information are usually not detailed enough to determine WLAs for NPDES regulated stormwater discharges on an outfall-specific basis (US EPA 2002). Therefore, NPDES regulated stormwater loads within the Gwynns Falls watershed will be expressed as a single NPDES stormwater WLA. Upon approval of the TMDL, “NPDES-regulated municipal stormwater and small construction storm water discharges effluent limits should be expressed as BMPs or other similar requirements, rather than as numeric effluent limits” (US EPA 2002).

The Gwynns Falls NPDES stormwater WLA is based on reductions applied to the sediment load from the urban land use of the watershed derived from the current maximum feasible stormwater reduction scenario and may include legacy or other sediment sources. Some of these sources may also be subject to controls from other management programs. The Gwynns Falls NPDES stormwater WLA requires an overall reduction of 40.1% (see Table 8).

As stormwater assessment and/or other program monitoring efforts result in a more refined source assessment, MDE reserves the right to revise the current NPDES stormwater WLA provided the revisions are reasonably calculated to protect aquatic life from sediment related impacts.

For more information on the methods used to calculate the baseline urban sediment load, see Section 2.2.2. For a detailed list of all of the NPDES regulated stormwater discharges within the watershed, please see Appendix B, and for information regarding the NPDES stormwater WLA distribution amongst these discharges, please see the technical memorandum to this document entitled “*Significant Sediment Point Sources in the Gwynns Falls Watershed*”.

4.7 Margin of Safety

All TMDLs must include a margin of safety to account for any lack of knowledge and uncertainty concerning the relationship between loads and water quality (CFR 2008b). It is proposed that the estimated variability around the reference watershed group used in this analysis already accounts for such uncertainty. Analysis of the reference group *forest normalized sediment loads* indicates that approximately 75% of the reference watersheds have a value of less than 4.2. Also, 50% of the reference watersheds have a value less than 3.3. Based on this analysis the *forest normalized reference sediment load* (also referred to as the *sediment loading threshold*) was set at the median value of 3.3 (Currey et al. 2006). This is considered an environmentally conservative estimate, since 50% of the reference watersheds have a load above this value, which when compared to the 75% value, results in an implicit margin of safety of approximately 18%.

4.8 Summary of Total Maximum Daily Loads

The average annual Gwynns Falls watershed TMDL is summarized in Table 11. The TMDL is the sum of the LA, NPDES Stormwater WLA, Process Water WLA, and MOS. The Maximum Daily Load (MDL) is summarized in Table 12 (See Appendix C for more details).

Table 11: Gwynns Falls Watershed Average Annual TMDL of Sediment/TSS (ton/yr)

TMDL (ton/yr)	=	LA_{GF}	+	NPDES Stormwater WLA_{GF}	+	Process Water WLA_{GF}	+	MOS
13,996.2	=	1,759.3	+	12,023.7	+	213.2	+	Implicit

Table 12: Gwynns Falls Maximum Daily Loads of Sediment/TSS (ton/day)

MDL (ton/day)	=	LA_{GF}	+	NPDES Stormwater WLA_{GF}	+	Process Water WLA_{GF}	+	MOS
558.7	=	70.4	+	486.5	+	1.82	+	Implicit

5.0 ASSURANCE OF IMPLEMENTATION

This section provides the basis for reasonable assurances that the sediment TMDL will be achieved and maintained. Section 303(d) of the Clean Water Act and current EPA regulations require reasonable assurance that the TMDL load and wasteload allocations can and will be implemented (CFR 2008b). Maryland has several well-established programs to draw upon, including the Water Quality Improvement Act of 1998 (WQIA) and the Federal Nonpoint Source Management Program (§ 319 of the Clean Water Act).

Potential funding sources available for local governments for implementation include the Buffer Incentive Program (BIP), the State Water Quality Revolving Loan Fund, and the Stormwater Pollution Cost Share Program. Details of these programs and additional funding sources can be found at http://www.dnr.state.md.us/bay/services/summaries.html.

Potential BMPs for reducing sediment loads and resulting impacts can be grouped into three general categories. The first is directed toward agricultural lands, the second towards urban (developed) land, and the third applies to all land uses. Since urban land was identified as the most extensive primary, predominant controllable source of sediment within the watershed (i.e., 92% of the total Gwynns Falls Baseline Sediment Load), and based on current maximum feasible reductions to regulated urban stormwater, the entirety of the required sediment reductions within the Gwynns Falls watershed are attributed to urban (developed) land use. The various BMPs applicable to reducing urban sediment loads are discussed below.

Sediment from urban areas can be reduced by stormwater retrofits, impervious surface reduction, street sweeping, inlet cleaning, increases in urban tree canopy cover, and stream restoration. Stormwater retrofits include modification of existing stormwater structural practices to address both water quality and flow control. The majority of the sediment reductions required from the urban areas within the Gwynns Falls watershed are attributed to streambank erosion (see section 2.2.1). Therefore, flow controls must be installed to reduce sheer stress and limit bank erosion in order to address this portion of the urban sediment load. Additionally, impervious surface reduction results in a change in hydrology that could also reduce streambank erosion. In terms of upland urban sediment loads, stormwater retrofit reductions range from as low as 10% for dry detention to approximately 80% for wet ponds, wetlands, infiltration practices, and filtering practices (US EPA 2003). It is anticipated that the implementation of the TMDL will include the array of urban BMPs and practices outlined above. Implementation is expected to occur primarily via the MS4 permitting process for medium and large municipalities, which requires that these jurisdictions retrofit 10% of the existing urban land area every permit cycle, or 5 years.

It has been estimated that the average TSS removal efficiencies for BMPs installed between the years of 1985-2002 and post 2002, which are reflective of the stormwater management regulations in place during these time periods, is 50% and 80%, respectively (Claytor and Schueler 1997; Baldwin et al. 2007; Baish and Caliri 2009). Based on these average TSS reduction efficiencies, BMP specific reduction efficiencies as estimated by

CBP, and best professional judgment, MDE estimates that future stormwater retrofits, which are expected to be implemented as part of the 10% retrofit goal to existing urban land every 5 years, will have approximately a 65% reduction efficiency for TSS, which is subject to change over time. Additionally, any new development in the watershed will be subject to the Stormwater Management Act of 2007 and will be required to use environmental site design (ESD) to the maximum extent practicable.

All non-forested land uses can benefit from improved riparian buffer systems. A riparian buffer reduces the effects of upland sediment sources through trapping and filtering. Riparian buffer efficiencies vary depending on type (grass or forested), land use (urban or agriculture), and physiographic region. The CBP estimates riparian buffer sediment reduction efficiencies in the Gwynns Falls region to be approximately 50% (US EPA 2006). Additionally, reforestation, whether adjacent to part of the watershed stream system or in a watershed's interior, can decrease upland sediment sources as well.

In summary, through the use of the aforementioned funding mechanisms and best management practices, there is reasonable assurance that this TMDL can be implemented.

REFERENCES

Arnold, C. L., and C. J. Gibbons. 1996. Impervious Surface Coverage: The Emergence of a Key Environmental Indicator. *Journal of the American Planning Association 62(2): 243-258.*

Baish, A. S., and M. J. Caliri. 2009. *Overall Average Stormwater Effluent Removal Efficiencies for TN, TP, and TSS in Maryland from 1984-2002*. Baltimore, MD: Johns Hopkins University.

Baldwin, A. H., S. E. Weammert, and T. W. Simpson. 2007. *Pollutant Load Reductions from 1985-2002*. College Park, MD: Mid Atlantic Water Program.

Claytor, R., and T. R. Schueler. 1997. *Technical Support Document for the State of Maryland Stormwater Design Manual Project*. Baltimore, MD: Maryland Department of the Environment.

CES (Coastal Environmental Service, Inc.). 1995. *Patapsco/Back River Watershed Study*. Baltimore, MD: Maryland Department of the Environment.

CFR (Code of Federal Regulations). 2008a. *40 CFR* 130.2(i). http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=43ac087684bf922499af8ffed066cb09;rgn=div5;view=text;node=40%3A21.0.1.1.17;idno=40;cc=ecfr#40:21.0.1.1.17.0.16.3 (Accessed December, 2008).

___________. 2008b. *40 CFR 130.7.* http://a257.g.akamaitech.net/7/257/2422/22jul20061500/edocket.access.gpo.gov/cfr_2006/julqtr/40cfr130.7.htm (Accessed December, 2008).

Cochran, W. G. 1977. *Sampling Techniques*. New York: John Wiley and Sons.

COMAR (Code of Maryland Regulations). 2008a. *26.08.02.02.* http://www.dsd.state.md.us/comar/26/26.08.02.02.htm (Accessed December, 2008).

____________. 2008b. *26.08.02.07 (F)5.* http://www.dsd.state.md.us/comar/26/26.08.02.07.htm (Accessed December, 2008).

____________. 2008c. *26.08.02.08 K(3)(d).* http://www.dsd.state.md.us/comar/26/26.08.02.08.htm (Accessed December, 2008).

____________. 2008d. *26.08.02.08 K(3)(c).* http://www.dsd.state.md.us/comar/26/26.08.02.08.htm (Accessed December, 2008).

____________. 2008e. *26.08.02.08 K(5)(e).* http://www.dsd.state.md.us/comar/26/26.08.02.08.htm (Accessed December, 2008).

Currey, D. L., A. A. Kasko, R. Mandel, and M. J. Brush. 2006. *A Methodology for Addressing Sediment Impairments in Maryland's Non-tidal Watersheds*. Baltimore, MD: Maryland Department of the Environment. Also Available at http://www.mde.state.md.us/assets/document/Sediment%20TMDL%20Method%20Report_20070728.pdf.

DNR (Maryland Department of Natural Resources). 1996. *Maryland Water Quality Inventory, 1993-1995: A report on The Status of Natural Waters in Maryland Required by Section 305(b) of the Federal Water Pollution Control Act and Reported to the US Environmental Protection Agency and Citizens of the State of Maryland*. Annapolis, MD: Department of Natural Resources.

___________. 2007. *Personal fax communication with Ellen Friedman.* Annapolis, MD: Department of Natural Resources, Monitoring and Non-Tidal Assessment Program.

___________. 2008. *Physiography of Maryland*. http://www.dnr.state.md.us/forests/healthreport/mdmap.html (Accessed December, 2008).

Evans, B. M., S. A. Sheeder, and D. W. Lehning. 2003. A Spatial Technique for Estimating Streambank Erosion Based on Watershed Characteristics. *Journal of Spatial Hydrology* 3(1).

Goetz, S. J., C. A. Jantz, S. D. Prince, A. J. Smith, R. Wright, and D. Varlyguin. 2004. Integrated Analysis of Ecosystem Interactions with Land Use Change: the Chesapeake Bay Watershed. In *Ecosystems and Land Use Change*, edited by R. S. DeFries, G. P. Asner, and R. A. Houghton. Washington, DC: American Geophysical Union.

Klauda, R., P. Kazyak, S. Stranko, M. Southerland, N. Roth, and J. Chaillou. 1998. The Maryland Biological Stream Survey: A State Agency Program to Assess the Impact of Anthropogenic Stresses on Stream Habitat Quality and Biota. *Environmental Monitoring and Assessment 51*: 299-316.

MGS (Maryland Geological Survey). 2008. *A Brief Description of the Geology of Maryland*. http://www.mgs.md.gov/esic/brochures/mdgeology.html (Accessed December, 2008).

MDE (Maryland Department of the Environment). 2000. *An Overview of Wetlands and Water Resources of Maryland*. Baltimore, MD: Maryland Department of the Environment.

____________. 2004. *2004 List of Impaired Surface Waters [303(d) List] and Integrated Assessment of Water Quality in Maryland Submitted in Accordance with Sections 303(d) and 305(b) of the Clean Water Act*. Baltimore, MD: Maryland Department of the Environment. Also Available at http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/Maryland%20303%20dlist/final_2004_303dlist.asp.

____________. 2007a. *Total Maximum Daily Loads of Sediment/Total Suspended Solids for the Anacostia River Basin, Montgomery and Prince George's Counties, Maryland and the District of Columbia*. Baltimore, MD: Maryland Department of the Environment. Also Available at http://www.mde.state.md.us/assets/document/AnacostiaSed_MD-DC_TMDL_061407_final.pdf.

____________. 2007b. *Total Maximum Daily Loads of Fecal Bacteria for the Non-Tidal Gwynns Falls Basin in Baltimore City and Baltimore County, Maryland*. Baltimore, MD: Maryland Department of the Environment. Also Available at http://www.mde.state.md.us/assets/document/GwynnsFalls_TMDL_092106_final.pdf

____________. 2008. *The 2008 Integrated Report of Surface Water Quality in Maryland*. Baltimore, MD: Maryland Department of the Environment. Also Available at http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/Maryland%20303%20dlist/2008_Final_303d_list.asp.

____________. 2009a. *Maryland Biological Stressor Identification Process*. Baltimore, MD: Maryland Department of the Environment.

____________. 2009b. *Watershed Report for Biological Impairment of the Gwynns Falls Watershed in Baltimore City and Baltimore County, Maryland: Biological Stressor Identification Analysis Results and Interpretation*. Baltimore, MD: Maryland Department of the Environment.

Nusser, S. M., and J. J. Goebel. 1997. The National Resources Inventory: A Long-Term Multi-Resource Monitoring Program. *Environmental and Ecological Statistics* 4: 181-204.

Roth, N., M. T. Southerland, J. C. Chaillou, R. Klauda, P. F. Kazyak, S. A. Stranko, S. Weisberg, L. Hall Jr., and R. Morgan II. 1998. Maryland Biological Stream Survey: Development of a Fish Index of Biotic Integrity. *Environmental Management and Assessment* 51: 89-106.

Roth, N. E., M. T. Southerland, J. C. Chaillou, P. F. Kazyak, and S. A. Stranko. 2000. *Refinement and Validation of a Fish Index of Biotic Integrity for Maryland Streams*. Columbia, MD: Versar, Inc. with Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division.

Roth, N. E., M. T. Southerland, J. C. Chaillou, G. M. Rogers, and J. H. Volstad. 2005. *Maryland Biological Stream Survey 2000-2004: Volume IV: Ecological Assessment of Watersheds Sampled in 2003*. Columbia, MD: Versar, Inc. with Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division.

Schueler, T. 1994. The *Importance of Imperviousness. Subwatershed Protection Techniques 1*. Ellicott City, MD: Center for Watershed Protection.

Stribling, J. B., B. K. Jessup, J. S. White, D. Boward, and M. Hurd. 1998. *Development of a Benthic Index of Biotic Integrity for Maryland Streams*. Owings Mills, MD: Tetra Tech, Inc. with Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Program.

USDA (United States Department of Agriculture). 1977. *Soil Survey of Baltimore County*. Washington, DC: United States Department of Agriculture.

_____________. 1982. *1982 Census of Agriculture*. Washington, DC: United States Department of Agriculture.

_____________. 1983. Sediment Sources, Yields, and Delivery Ratios. In *National Engineering Handbook, Section 3, Sedimentation*. Washington, D.C: United States Department of Agriculture, Natural Resources Conservation Service.

_____________. 1987. *1987 Census of Agriculture*. Washington, DC: United States Department of Agriculture.

_____________. 1992. *1992 Census of Agriculture*. Washington, DC: United States Department of Agriculture.

_____________. 1997. *1997 Census of Agriculture*. Washington, DC: United States Department of Agriculture.

_____________. 1998. *Soil Survey of Baltimore City*. Washington, DC: United States Department of Agriculture.

_____________. 2002. *2002 Census of Agriculture*. Washington, DC: United States Department of Agriculture.

_____________. 2006. *State Soil Geographic (STATSGO) Database for Maryland*. Washington, DC: United States Department of Agriculture, Natural Resources Conservation Service. Also Available at http://www.ncgc.nrcs.usda.gov/products/datasets/statsgo/index.html.

US EPA (U.S. Environmental Protection Agency). 1991. *Technical Support Document (TSD) for Water Quality-based Toxics Control*. Washington, DC: U.S. Environmental Protection Agency. Also Available at http://www.epa.gov/npdes/pubs/owm0264.pdf.

_____________. 2002. *Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs*. Washington, DC: U.S. Environmental Protection Agency.

_____________. 2003. *Stormwater Best Management Practice Categories and Pollutant Removal Efficiencies*. Annapolis, MD: U.S. Environmental Protection Agency with Chesapeake Bay Program.

_____________. 2006. *Sediment Best Management Practice Summaries*. Annapolis, MD: U.S. Environmental Protection Agency with Chesapeake Bay Program.

_____________. 2007. *Options for the Expression of Daily Loads in TMDLs* (DRAFT 6/22/07). Washington, D.C: U.S. Environmental Protection Agency, Office of Wetlands, Oceans & Watersheds. Also Available at www.epa.gov/owow/tmdl/draft_daily_loads_tech.pdf.

_____________. 2008. In Preparation. *Chesapeake Bay Phase V Community Watershed Model*. Annapolis, MD: U.S. Environmental Protection Agency with Chesapeake Bay Program.

APPENDIX A – Watershed Characterization Data

Table A-1: Reference Watersheds

MD 8-digit Name	MD 8-digit	Percent stream mile degraded (%)[1,2]	Forest Normalized Sediment Load[3]
Deer Creek	02120202	11	3.9
Broad Creek	02120205	12	4.5
Little Gunpowder Falls	02130804	15	3.3
Prettyboy Reservoir	02130806	16	3.7
Middle Patuxent River	02131106	20	3.2
Brighton Dam	02131108	11	4.2
Sideling Creek	02140510	20	1.9
Fifteen Mile Creek	02140511	4	1.6
Savage River	02141006	7	2.5
Median			**3.3**
75th			**4.2**

Notes:

[1] Percent stream miles degraded within an 8-digit watershed is based on the percentage of impaired MBSS stations within the watershed (MDE 2008).

[2] The percent stream miles degraded threshold to determine if an 8-digit watershed is impaired for impacts to biological communities is based on a comparison to reference conditions (MDE 2008).

[3] Forest normalized sediment loads based on Maryland watershed area only (consistent with MBSS random monitoring data).

APPENDIX B – MDE Permit Information

Table B-1: Permit Summary

Permit #	NPDES	Facility	County	City	Type	TMDL
04DP0681	MD0003034	ASHBURTON WATER FILTRATION PLANT	BALTIMORE CITY	BALTIMORE	WMA2M	Process Water WLA
00MM0975	MDG490975	ARUNDEL CORPORATION - DELIGHT QUARRY	BALTIMORE COUNTY	REISTERSTOWN	WMA5	Process Water WLA
00MM9722	MDG499722	LARRY E. KNIGHT, INC.	BALTIMORE COUNTY	GLYNDON	WMA5	Process Water WLA
00MM9831	MDG499831	S & G CONCRETE - GRANTLEY	BALTIMORE CITY	BALTIMORE	WMA5	Process Water WLA
00MM9866	MDG499866	AJO CONCRETE CONTRACTING, INC	BALTIMORE CITY	BALTIMORE	WMA5	Process Water WLA
02SW0025		SOLO CUP OPERATING CORPORATION (SCOC)	BALTIMORE COUNTY	OWINGS MILLS	WMA5SW	Stormwater WLA
02SW0034		FOUNDRY SERVICE & SUPPLY CO., INC.	BALTIMORE COUNTY	PIKESVILLE	WMA5SW	Stormwater WLA
02SW0155		NURAD TECHNOLOGIES, INC.	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW0306		QUEST INTERNATIONAL FLAVORS & FOOD INGREDIENTS	BALTIMORE COUNTY	OWINGS MILLS	WMA5SW	Stormwater WLA
02SW0659		PITT OHIO EXPRESS, INC. - BALTIMORE	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW0703		BALTIMORE CITY DPW - WESTERN SUBSTATION	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW0705		BALTIMORE CITY DPW - NORTHWESTERN SUBSTATION	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW0712		NEW ENGLAND MOTOR FREIGHT	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW0739		RUBBER MILLERS, INC.	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW0777		EMANUEL TIRE COMPANY-MORELAND	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW0779		SAFETY-KLEEN SYSTEMS, INC. - BALTIMORE	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW0805		GEORGE G. RUPPERSBERGER & SONS, INC.	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA

Permit #	NPDES	Facility	County	City	Type	TMDL
02SW0848		UNITED PARCEL SERVICE - VERO ROAD	BALTIMORE COUNTY	BALTIMORE	WMA5SW	Stormwater WLA
02SW0864		P. FLANIGAN & SONS INC. - WESTPORT	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW0868		BALTIMORE CONCRETE PRODUCTS, INC.	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW0930		ESTES EXPRESS LINES	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1014		P. FLANIGAN & SONS, INC.	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1016		CAPITOL CAKE COMPANY	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1027		NATIONAL INSTRUMENT COMPANY, INC.	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1053		LIGON AND LIGON, INC.	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1137		WOODLAWN MOTOR COACH, INC.	BALTIMORE COUNTY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1138		ALL SUPPLIES & PARTS, INC. - ASAP COMPRESSORS	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1206		TRIFINITY MANUFACTURING BALTIMORE, LLC	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1216		UNITED IRON AND METAL, LLC	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1248		POTTS & CALLAHAN, INC. - GWYNNS FALLS	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1272		UNILEVER BESTFOODS NORTH AMERICA	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1297		WINCHESTER HOMES, INC.	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1307		NORTHWEST TRANSFER STATION	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1375		MR. MARTIN L. REESE	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1398		DANIEL G. SCHUSTER, LLC. - OWINGS MILLS	BALTIMORE COUNTY	OWINGS MILLS	WMA5SW	Stormwater WLA
02SW1492		CRUSADER CHEMICAL COMPANY, INC.	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA

Permit #	NPDES	Facility	County	City	Type	TMDL
02SW1495		CARROLL AWNING COMPANY, INC.	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1563		CHEMLIME N.J., INC.	BALTIMORE COUNTY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1656		JOE CORBI'S WHOLESALE PIZZA	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1657		ALPHARMA USHP - BALTIMORE	BALTIMORE COUNTY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1673		MTA - NORTHEAST MAINTENANCE SHOP	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1677		MTA - NORTHWEST BUS DIVISION	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1716		SHIRE U.S. MANUFACTURING, INC.	BALTIMORE COUNTY	OWINGS MILLS	WMA5SW	Stormwater WLA
02SW1778		TRIAD INCORPORATED	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1836		PATUXENT MATERIALS, INC. - BALTIMORE	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1884		CRISPY BAGEL COMPANY	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1912		DECKER'S SALVAGE COMPANY, INC	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1964		BALTIMORE COUNTY BUREAU OF HIGHWAYS - SHOP 2	BALTIMORE COUNTY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1978		P & J CONTRACTING COMPANY, INC.	BALTIMORE CITY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1992		BEVERAGE CAPITAL CORPORATION	BALTIMORE COUNTY	BALTIMORE	WMA5SW	Stormwater WLA
02SW1996		MTA - OLD COURT METRO MAINTENANCE FACILITY	BALTIMORE COUNTY	PIKESVILLE	WMA5SW	Stormwater WLA
02SW2009		SHA - OWINGS MILLS SHOP	BALTIMORE COUNTY	OWINGS MILLS	WMA5SW	Stormwater WLA
02SW3031		RALOID CORPORATION	BALTIMORE COUNTY	REISTERSTOWN	WMA5SW	Stormwater WLA
05DP3317	MD0068314	BALTIMORE COUNTY MS4	BALTIMORE	COUNTY-WIDE	WMA6	Stormwater WLA
99DP3315	MD0068292	BALTIMORE CITY MS4	BALTIMORE CITY	CITY-WIDE	WMA6	Stormwater WLA
99DP3313	MD0068276	STATE HIGHWAY ADMINSTRATION MS4	ALL PHASE I	STATE-WIDE	WMA6	Stormwater WLA

Permit #	NPDES	Facility	County	City	Type	TMDL
		MDE GENERAL PERMIT TO CONSTRUCT	ALL	ALL		Stormwater WLA

Notes: [1] TMDL column identifies how the permit was considered in the TMDL allocation.
[2] WTP = Water Treatment Plant
[3] WWTP = Wastewater Treatment Plant

Table B-2: Municipal Permit Data

Facility name	**NPDES #**	**MDE Permit #**	**Flow** (MGD[1])	**Permit Avg Monthly Conc.** (mg/l[2])	**Permit Avg. Weekly Conc.** (mg/l)
ASHBURTON WATER FILTRATION PLANT	MD0003034	04DP0681	7.0	20	30

Table B-3: General Mine Permit Data

Facility name	**NPDES #**	**MDE Permit #**	**Flow** (MGD)	**Permit Avg Quarterly Conc.** (mg/l)	**Permit Daily Max Conc.** (mg/l)
ARUNDEL CORPORATION - DELIGHT QUARRY	MDG490975	00MM0975	0.001	30	66
LARRY E. KNIGHT, INC.	MDG499722	00MM9722	0.001	30	60
S & G CONCRETE - GRANTLEY	MDG499831	00MM9831	0.005	30	60
AJO CONCRETE CONTRACTING, INC	MDG499866	00MM9866	0.001	30	60

Table B-4: Stormwater Permits[1]

Permit #	**Facility**	**NPDES Group**
02SW0025	SOLO CUP OPERATING CORPORATION (SCOC)	Phase I
02SW0034	FOUNDRY SERVICE & SUPPLY CO., INC.	Phase I
02SW0155	NURAD TECHNOLOGIES, INC.	Phase I
02SW0306	QUEST INTERNATIONAL FLAVORS & FOOD INGREDIENTS	Phase I
02SW0659	PITT OHIO EXPRESS, INC. - BALTIMORE	Phase I
02SW0703	BALTIMORE CITY DPW - WESTERN SUBSTATION	Phase I
02SW0705	BALTIMORE CITY DPW - NORTHWESTERN SUBSTATION	Phase I
02SW0712	NEW ENGLAND MOTOR FREIGHT	Phase I
02SW0739	RUBBER MILLERS, INC.	Phase I
02SW0777	EMANUEL TIRE COMPANY-MORELAND	Phase I
02SW0779	SAFETY-KLEEN SYSTEMS, INC. - BALTIMORE	Phase I
02SW0805	GEORGE G. RUPPERSBERGER & SONS, INC.	Phase I
02SW0848	UNITED PARCEL SERVICE - VERO ROAD	Phase I
02SW0864	P. FLANIGAN & SONS INC. - WESTPORT	Phase I
02SW0868	BALTIMORE CONCRETE PRODUCTS, INC.	Phase I
02SW0930	ESTES EXPRESS LINES	Phase I
02SW1014	P. FLANIGAN & SONS, INC.	Phase I
02SW1016	CAPITOL CAKE COMPANY	Phase I
02SW1027	NATIONAL INSTRUMENT COMPANY, INC.	Phase I
02SW1053	LIGON AND LIGON, INC.	Phase I
02SW1137	WOODLAWN MOTOR COACH, INC.	Phase I
02SW1138	ALL SUPPLIES & PARTS, INC. - ASAP COMPRESSORS	Phase I
02SW1206	TRIFINITY MANUFACTURING BALTIMORE, LLC	Phase I
02SW1216	UNITED IRON AND METAL, LLC	Phase I
02SW1248	POTTS & CALLAHAN, INC. - GWYNNS FALLS	Phase I
02SW1272	UNILEVER BESTFOODS NORTH AMERICA	Phase I
02SW1297	WINCHESTER HOMES, INC.	Phase I
02SW1307	NORTHWEST TRANSFER STATION	Phase I
02SW1375	MR. MARTIN L. REESE	Phase I

Permit #	**Facility**	**NPDES Group**
02SW1398	DANIEL G. SCHUSTER, LLC. - OWINGS MILLS	Phase I
02SW1492	CRUSADER CHEMICAL COMPANY, INC.	Phase I
02SW1495	CARROLL AWNING COMPANY, INC.	Phase I
02SW1563	CHEMLIME N.J., INC.	Phase I
02SW1656	JOE CORBI'S WHOLESALE PIZZA	Phase I
02SW1657	ALPHARMA USHP - BALTIMORE	Phase I
02SW1673	MTA - NORTHEAST MAINTENANCE SHOP	Phase I
02SW1677	MTA - NORTHWEST BUS DIVISION	Phase I
02SW1716	SHIRE U.S. MANUFACTURING, INC.	Phase I
02SW1778	TRIAD INCORPORATED	Phase I
02SW1836	PATUXENT MATERIALS, INC. - BALTIMORE	Phase I
02SW1884	CRISPY BAGEL COMPANY	Phase I
02SW1912	DECKER'S SALVAGE COMPANY, INC	Phase I
02SW1964	BALTIMORE COUNTY BUREAU OF HIGHWAYS - SHOP 2	Phase I
02SW1978	P & J CONTRACTING COMPANY, INC.	Phase I
02SW1992	BEVERAGE CAPITAL CORPORATION	Phase I
02SW1996	MTA - OLD COURT METRO MAINTENANCE FACILITY	Phase I
02SW2009	SHA - OWINGS MILLS SHOP	Phase I
02SW3031	RALOID CORPORATION	Phase I
05DP3317	BALTIMORE COUNTY MUNICIPAL SEPARATE STORM SEWER	Phase I
99DP3315	BALTIMORE CITY MS4	Phase I
99DP3313	STATE HIGHWAY ADMINSTRATION MS4	Phase I
	MDE GENERAL PERMIT TO CONSTRUCT	Phase I/II

Notes: [1] Although not listed in this table, some individual permits from Tables B-2 and B-3 incorporate stormwater requirements and are accounted for within the NPDES stormwater WLA (specifically the “Other” Regulated Stormwater Allocation in the Technical Memorandum *Significant Sediment Point Sources in the Gwynns Falls Watershed* accompanying this TMDL report) as well additional Phase II permitted MS4s, such as military bases, hospitals, etc.

APPENDIX C – Technical Approach Used to Generate Maximum Daily Loads

Summary

This appendix documents the technical approach used to define maximum daily loads of sediment consistent with the average annual TMDL in the Gwynns Falls watershed, which is considered the maximum allowable load the watershed can sustain without causing any sediment related impacts to aquatic health. The approach builds upon the modeling analysis that was conducted to determine the sediment loadings and can be summarized as follows.

- The approach defines maximum daily loads for each of the source categories.
- The approach builds upon the TMDL modeling analysis that was conducted to ensure that average annual loading targets do not cause any sediment related impacts to aquatic health.
- The approach converts daily time-series loadings into TMDL values in a manner that is consistent with available EPA guidance on generating daily loads for TMDLs (US EPA 2007).
- The approach considers a daily load level of a resolution based on the specific data that exists for each source category.

Introduction

This appendix documents the development and application of the approach used to define maximum daily load values. It is divided into sections discussing:

- Basis for approach
- Options considered
- Selected approach
- Results of approach

Basis for approach

The overall approach for the development of daily loads was based upon the following factors:

- **Average Annual TMDL:** The basis of the average annual sediment TMDL is that cumulative high sediment loading rates have negative impacts on the biological community. Thus, the average annual sediment load was calculated so as to not cause any sediment related impacts to aquatic health.
- **CBP P5 Watershed Model Sediment Loads:** There are two spatial calibration points for sediment within the CBP P5 watershed model framework. First, EOS loads are calibrated to long term EOS target loads. These target loads are the loads used to determine an average annual TMDL. Furthermore, the target loads were used in the TMDL because, as calibration targets, they are expected to

remain relatively unchanged during the final calibration stages of the CBP P5 model, and therefore will be the most consistent with the final CBP P5 watershed model sediment loading estimates. Currently, the CBP P5 model river segments are being calibrated to daily monitoring information for watersheds with a flow greater that 100 cfs, or an approximate area of 100 square miles.

- **Draft EPA guidance document entitled "Developing Daily Loads for Load-based TMDLs":** This guidance document provides options for defining maximum daily loads when using TMDL approaches that generate daily output (US EPA 2007).

The rationale for developing TMDLs expressed as *daily* loads was to accept the existing average annual TMDL, but then develop a method for converting this number to a maximum *daily* load – in a manner consistent with EPA guidance and available information.

Options considered

The draft EPA guidance document for developing daily loads does not specify a single approach that must be adhered to, but rather it contains a range of acceptable options (US EPA 2007). The selection of a specific method for translating a time-series of allowable loads into the expression of a TMDL requires decisions regarding both the level of resolution (e.g., single daily load for all conditions vs. loads that vary with environmental conditions) and level of probability associated with the TMDL.

This section describes the range of options that were considered when developing methods to calculate Gwynns Falls Maximum Daily Loads.

Level of Resolution

The level of resolution pertains to the amount of detail used in specifying the maximum daily load. The draft EPA guidance document on daily loads provides three categories of options for level of resolution, all of which are potentially applicable for the Gwynns Falls watershed:

1. **Representative daily load:** In this option, a single daily load (or multiple representative daily loads) is specified that covers all time periods and environmental conditions.
2. **Flow-variable daily load:** This option allows the maximum daily load to vary based upon the observed flow condition.
3. **Temporally-variable daily load:** This option allows the maximum daily load to vary based upon seasons or times of varying source or water body behavior (US EPA 2007).

Probability Level

All TMDLs have some probability of being exceeded, with the specific probability being either explicitly specified or implicitly assumed. This level of probability directly or indirectly reflects two separate phenomena:

1. Water quality criteria consist of components describing acceptable magnitude, duration, and frequency. The frequency component addresses how often conditions can allowably surpass the combined magnitude and duration components.
2. Pollutant loads, especially from wet weather sources, typically exhibit a large degree of variability over time. It is rarely practical to specify a "never to be exceeded value" for a daily load, as essentially any loading value has some finite probability of being exceeded.

The draft daily load guidance document states that the probability component of the maximum daily load should be "based on a representative statistical measure" that is dependent upon the specific TMDL and the best professional judgment of the developers (US EPA 2007). This statistical measure represents how often the maximum daily load is expected/allowed to be exceeded. The primary options for selecting this level of protection would be:

1. **The maximum daily load reflects some central tendency:** In this option, the maximum daily load is based upon the mean or median value of the range of loads expected to occur. The variability in the actual loads is not addressed.
2. **The maximum daily load reflects a level of protection implicitly provided by the selection of some "critical" period**: In this option, the maximum daily load is based upon the allowable load that is predicted to occur during some critical period examined during the analysis. The developer does not explicitly specify the probability of occurrence.
3. **The maximum daily load is a value that will be exceeded with a pre-defined probability:** In this option, a "reasonable" upper bound percentile is selected for the maximum daily load based upon a characterization of the variability of daily loads. For example, selection of the 95th percentile value would result in a maximum daily load that would be exceeded 5% of the time.

Selected Approach

The approach selected for defining a Gwynns Falls Maximum Daily Load was based upon the specific data that exists for each source category. The approach consists of unique methods for each of the following categories of sources:

- Approach for Nonpoint Sources and Stormwater Point Sources within the Gwynns Falls watershed
- Approach for Process Water Point Sources within the Gwynns Falls watershed

Approach for Nonpoint Sources and Stormwater Point Sources within the Gwynns Falls watershed

The level of resolution selected for the Gwynns Falls Maximum Daily Load was a representative daily load, expressed as a single daily load for each loading source. This approach was chosen based upon the specific data that exists for nonpoint sources and stormwater point sources within the Gwynns Falls watershed. Currently, the best available data is the CBP P5 model daily time series calibrated to long-term average annual loads (per landuse). The CBP reach simulation results are calibrated to daily monitoring information for watershed segments with a flow typically greater that 100 cfs, but they have not been through appropriate peer review. Therefore, it was concluded that it would not be appropriate to apply the absolute values of the reach simulation model results to the TMDL, and the annual loads were used instead. However, it was assumed that the distribution of the daily values was correct, in order to calculate a normalized statistical parameter to estimate the maximum daily loads.

The maximum daily load was estimated based on three factors: a specified probability level, the average annual sediment TMDL, and the coefficient of variation (CV) of the CBP P5 Gwynns Falls reach simulation daily loads. The probability level (or exceedance frequency) is based upon guidance from EPA (US EPA 1991) where examples suggest that when converting from a long-term average to a daily value, the z-score corresponding to the 99th percentile of the log-normal probability distribution should be used. The average annual sediment TMDL is estimated from the CBP P5 EOS target loads. The calculation of the CV is described below.

The CBP P5 Gwynns Falls reach simulation consisted of a daily time series beginning in 1985 and extending to the year 2005. The CV was estimated by first converting the daily sediment load values to a log distribution and then verifying that the results approximated the normal distribution (see Figure C-1). Next, the CV was calculated using the arithmetic mean and standard deviation results from the log transformation. The log-transformed values were used to reduce the possible influence of outliers. The resulting CV of 15.4 was calculated using the following equation:

$$CV = \frac{\beta}{\alpha} \qquad \text{(Equation C.1)}$$

where:
CV = coefficient of variation
$\beta = \alpha\sqrt{e^{\sigma^2} - 1}$
$\alpha = e^{(\mu + 0.5*\sigma^2)}$
α = mean (arithmetic)
β = standard deviation (arithmetic)
μ = mean of logarithms
σ =standard deviation of logarithms

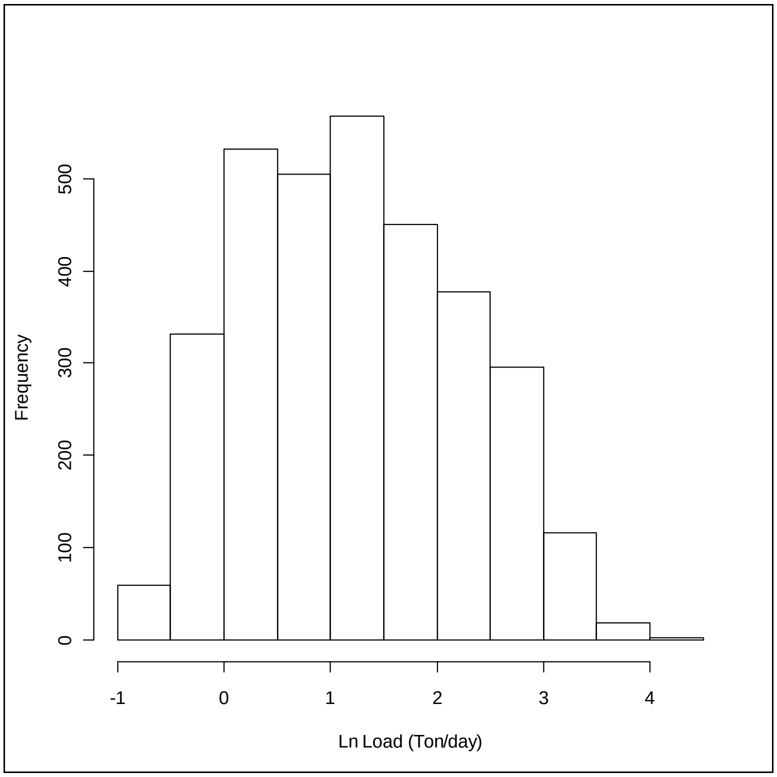


Figure C-1: Histogram of CBP River Segment Daily Simulation Results for the Gwynns Falls Watershed

The maximum “daily” load for each contributing source is estimated as the long-term average annual load multiplied by a factor that accounts for expected variability of daily loading values. The equation is as follows:

$$MDL = LTA * e^{(z\sigma - 0.5\sigma^2)} \qquad \text{(Equation C.2)}$$

where:
MDL = Maximum daily load
LTA = Long term average (average annual load)
Z = z-score associated with target probability level
$\sigma = \ln(CV^2+1)$
CV = Coefficient of variation based on arithmetic mean and standard deviation

Using a z-score associated with the 99th percent probability, a CV of 15.4, and consistent units, the resulting dimensionless conversion factor from long term average annual loads to a maximum daily load is 14.96. The average annual Gwynns Falls TMDL of sediment/TSS is reported in ton/year, and the conversion from ton/year to a maximum daily load in ton/day is 0.04 (e.g. 14.96/365)

Approach for Process Water Point Sources within the Gwynns Falls watershed

The TMDL also considers contributions from other point sources (i.e., sources other than stormwater point sources) in the watershed that have NPDES permits with sediment limits. As these sources are generally minor contributors to the overall sediment load, the TMDL analysis that defined the average annual TMDL did not propose any reductions for these sources and held each of them constant at their existing technology-based NPDES permit monthly (or daily if monthly was not specified) limit for the entire year.

The approach used to determine maximum daily loads for these sources was dependent upon whether a maximum daily load was specified within the permit. If a maximum daily limit was specified, then the reported average flow was multiplied by the daily maximum limit to obtain a maximum daily load. If a maximum daily limit was not specified, the maximum daily loads were calculated based on the guidance provided in the Technical Support Document (TSD) for Water Quality-based Toxics Control (US EPA 1991). The long-term average annual TMDL was converted to maximum daily limits using Table 5-2 of the TSD assuming a coefficient of variation of 0.6 and a 99th percentile probability. This results in a dimensionless multiplication factor of 3.11. The average annual Gwynns Falls TMDL of sediment/TSS is reported in ton/yr, and the conversion from ton/yr to a maximum daily load in ton/day is 0.0085 (e.g. 3.11/365)

Results of approach

This section lists the results of the selected approach to define the Gwynns Falls Maximum Daily Loads.

- Calculation Approach for Nonpoint Sources and Stormwater Point Sources within the Gwynns Falls watershed

LA_{GF} (Ton/day) = Average Annual TMDL LA_{GF} (ton/yr) * .04

Stormwater WLA_{GF} (Ton/day) = Average Annual TMDL Stormwater WLA_{GF} (ton/yr) * .04

- Calculation Approach for Process Water Point Sources within the Gwynns Falls watershed
    - For permits with a daily maximum limit:

Process Water WLA_{GF} (ton/day) = Permit flow (mgd) * Daily maximum permit limit(mg/l) * 0.0042

-
    - For permits without a daily maximum limit:

Process Water WLA_{GF} (Ton/day) = Average Annual TMDL WLA_{GF} Other (ton/yr)* 0.0085

Table C-1: Gwynns Falls Maximum Daily Loads of Sediment/TSS (ton/day)

MDL (ton/day)	=	LA_{GF}	+	NPDES Stormwater WLA_{GF}	+	Process Water WLA_{GF}	+	MOS
558.7	=	70.4	+	486.5	+	1.82	+	Implicit

APPENDIX I:

Water Quality Analysis of Eutrophication for the Gwynns Falls Watershed in Baltimore County and Baltimore City, Maryland

Water Quality Analysis of Eutrophication for the Gwynns Falls Watershed in Baltimore County and Baltimore City, Maryland

FINAL

DEPARTMENT OF THE ENVIRONMENT
1800 Washington Boulevard, Suite 540
Baltimore MD 21230-1718

Submitted to:

Water Protection Division
U.S. Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

September 2009

EPA Submittal Date: September 15, 2010
EPA Approval Date: March 15, 2010

This page deliberately left blank.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

BOD	Biochemical Oxygen Demand
BSID	Biological Stressor Identification
CES	Coastal Environmental Services
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
DNR	Department of Natural Resources
DO	Dissolved Oxygen
EPA	United States Environmental Protection Agency
MBSS	Maryland Biological Stream Survey
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
mg/l	Milligrams Per Liter
mi^2	Square Miles
NPDES	National Pollution Discharge Elimination System
NRCS	National Resources Conservation Service
SCS	Soil Conservation Service
SSURGO	Soil Survey Geography
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSI	Trophic State Index
USGS	United States Geological Survey
WQLS	Water Quality Limited Segment
µg/l	Micrograms Per Liter

EXECUTIVE SUMMARY

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)*, 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 that water quality standards are being met (CFR 2007).

Gwynns Falls (assessment unit ID: MD-02130905) was identified on the State of Maryland's *Integrated Report* as impaired by nutrients, sediments (1996 listings), bacteria (fecal coliform), and impacts to biological communities (2002 listings). The designated uses for Gwynns Falls are as follows: Gwynns Falls and tributaries above Reisterstown Road, and Red Run and its tributaries – Use III (Nontidal Cold Water); Dead Run and tributaries – Use IV (Recreational Trout Waters); and all remaining waters – Use I (Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life). See Code of Maryland Regulations (COMAR) 26.08.02.08K(3)(e) & (5)(e). A TMDL was completed in 2006 to address the bacteria listing. The 1996 nutrients listing was refined in the 2008 Integrated Report and phosphorus was identified as the specific impairing substance. Consequently, for the purpose of this report the terms nutrients and phosphorus will be used interchangeably. A TMDL for sediment is scheduled to be submitted to the EPA in 2009, and 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 Gwynns Falls basin (as part of a data solicitation for the Patapsco River basin) was conducted by MDE in November 2007, and all readily available data from the past five years have been considered. Currently, there are no specific 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 excessive algal growth leading to low dissolved oxygen. Therefore, the evaluation of potentially eutrophic conditions due to nutrient over-enrichment will be based on whether nutrient-related parameters (i.e., dissolved oxygen levels and chlorophyll *a* concentrations) are found to impair designated uses in the Gwynns Falls (in this case, protection of aquatic life and wildlife, fishing, and swimming).

Recently, MDE developed a biological stressor identification (BSID) methodology to identify the most probable cause(s) of the existing biological impairments in Maryland 8-digit watersheds based on the suite of available physical, chemical, and land use data (MDE 2009a). The BSID analysis for the Gwynns Falls indicates inorganic pollutants, ammonia toxicity, and flow/sediment stressors are associated with impacts to biological communities; these findings will be addressed separately. The BSID analysis did not identify any nutrient stressors present and/or nutrient stressors showing a significant association with degraded biological conditions (MDE 2009b). The results of the BSID study, combined with the analysis of recent water quality data presented in this report, indicate that the Gwynns Falls is not being impaired by nutrients.

This WQA supports the conclusion that a TMDL for nutrients is not necessary to achieve water quality standards in the Gwynns Falls.

Although the waters of the Gwynns Falls do not display signs of eutrophication, the State reserves the right to require future controls if evidence suggests that nutrients from the basin are contributing to downstream water quality problems. In December 2007, EPA approved TMDLs of nitrogen and phosphorus for the Baltimore Harbor. The Gwynns Falls watershed is located upstream of the Baltimore Harbor and drains into the Harbor's tidal waters. Although the amount of nutrients entering the Gwynns Falls is not causing localized impairments, it is contributing to the eutrophication of the downstream tidal waters of the Harbor. Therefore, the TMDL for the Baltimore Harbor requires nutrient reductions in the Gwynns Falls necessary to meet water quality standards in the Harbor. On the same principle, additional reductions may also be required by the forthcoming Chesapeake Bay TMDL, currently under development and due to be established by EPA by the end of 2010.

Barring the receipt of contradictory data, this report will be used to support a revision of the phosphorus listing for the Gwynns 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*.

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)*, 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 that water quality standards are being met (CFR 2007).

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 factual scenarios obviating 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.

Gwynns Falls (Assessment Unit ID: MD-02130905) was identified in the *Integrated Report* as impaired by nutrients, sediments (1996 listings), bacteria (fecal coliform), and impacts to biological communities (2002 listings) (MDE, 2008a). The designated uses for Gwynns Falls are as follows: Gwynns Falls and tributaries above Reisterstown Road, and Red Run and its tributaries – Use III (Nontidal Cold Water); Dead Run and tributaries – Use IV (Recreational Trout Waters); and all remaining waters – Use I (Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life). See Code of Maryland Regulations (COMAR) 26.08.02.08K(3)(e) & (5)(e). A TMDL was completed in 2006 to address the bacteria listing. The 1996 nutrients listing was refined in the 2008 *Integrated Report* and phosphorus was identified as the specific impairing substance. Consequently, for the purpose of this report the terms nutrients and phosphorus will be used interchangeably. A TMDL for sediment is scheduled to be submitted to the EPA in 2009, and 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 (phosphorus) listing for the Gwynns 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 Gwynns Falls watershed area and presents a discussion of the water quality characteristics in the basin in terms of the existing water quality standards relating to nutrients. This analysis supports the conclusion that the waters of the Gwynns Falls watershed do not display signs of eutrophication or nutrient over-enrichment.

2.0 GENERAL SETTING

Location

The Gwynns Falls watershed is located in the Patapsco River Basin within Maryland (see Figure 1). The watershed encompasses 41,710 acres (61 square miles) in Baltimore City and Baltimore County, Maryland. The headwaters of the Gwynns Falls begin in Glyndon, Maryland and flows southeast until its confluence with the Middle Branch of the Patapsco River near downtown Baltimore. Five major tributaries of the Gwynns Falls, listed north to south, include: Red Run, Horsehead Branch, Scotts Level Branch, Dead Run, and Maidens Choice Creek.

Geology/Soils

The Gwynns Falls watershed lies within the Piedmont and Atlantic Coastal Plain Provinces of Central Maryland. The Piedmont Province is characterized by gentle to steep rolling topography, low hills and ridges. The surface geology is characterized by metamorphic crystalline rocks consisting primarily of schist and gneiss. 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. The Atlantic Coastal Plain surface geology is characterized by thick, unconsolidated marine sediments deposited over the crystalline rock of the piedmont province. The deposits include clays, silts, sands and gravels. In the areas around the head of tide, the topography is flat, with elevations below 100 feet. The elevations steadily increase going north to approximately 600 feet in the headwaters. Streambeds throughout the basin are comprised of rock and rubble with gradually sloped stream banks.

The Gwynns Falls watershed lies predominantly in the Baile and Lehigh soil series. The Lehigh soil series consists of somewhat poorly drained to moderately well-drained, rather shallow soils. The Baile soil series consists of deep, poorly drained, nearly level to gently sloping, dominantly gray soils of the Piedmont Plateau. Baile soils have a high available moisture capacity and a water table that is seasonally at or near the surface (U.S. Department of Agriculture (USDA), 1995).

Land Use

The 2002 Maryland Department of Planning (MDP) land use/land cover data show that the Gwynns Falls watershed is primarily a residential and commercial region. The watershed contains 33,100 acres of residential land use and commercial land use. Forest lands account for 7,068 acres of the watershed, found primarily along the mainstem and tributaries of Gwynns Falls. A small portion of the watershed, 1,738 acres, consists of crops and pasture lands. The land use spatial distributions for each land use are presented in Figure 2.

Point Sources

There are no municipal or industrial point source facilities with permits regulating their discharges in the Gwynns Falls watershed.

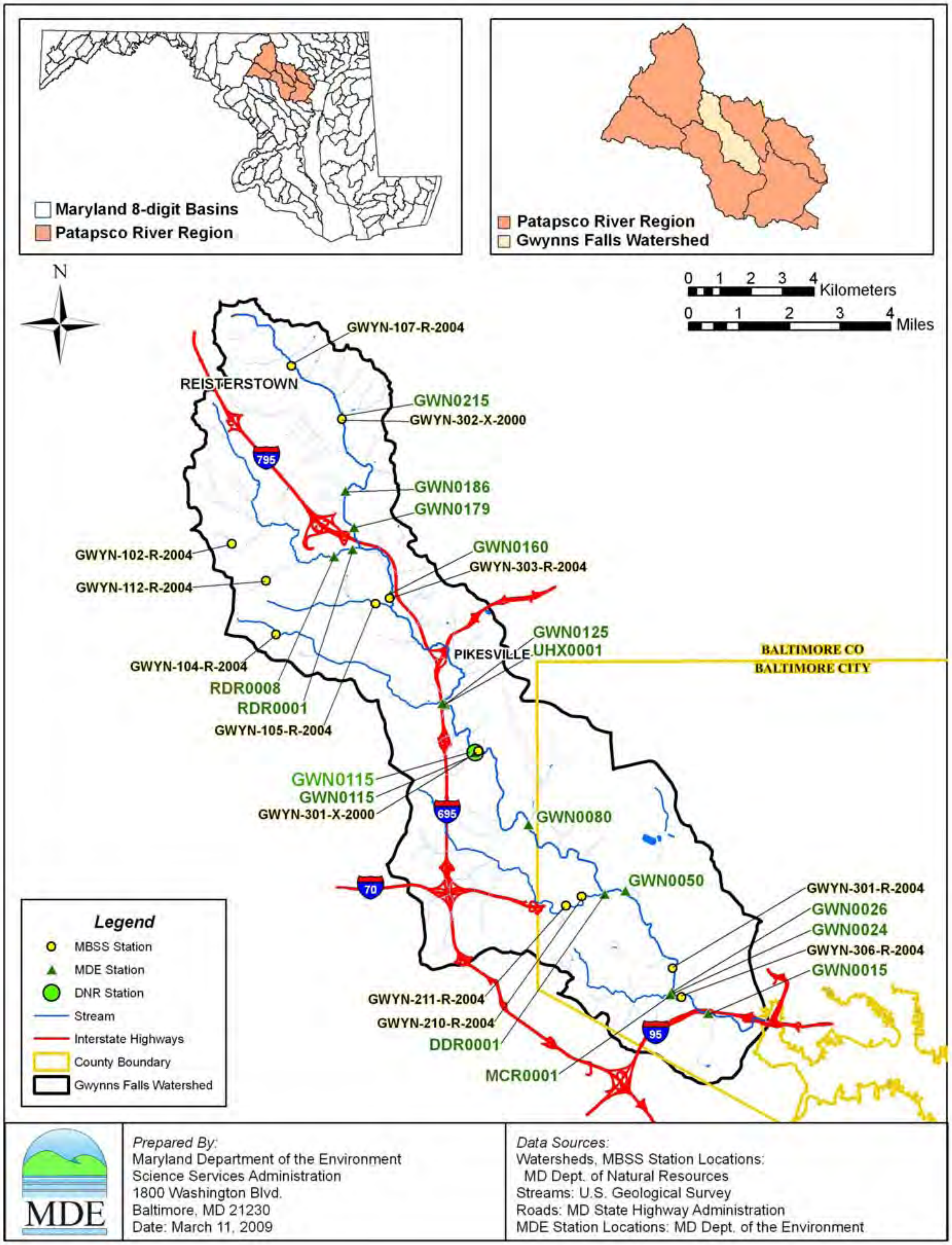


Figure 1: Location Map and Monitoring Stations of the Gwynns Falls Watershed

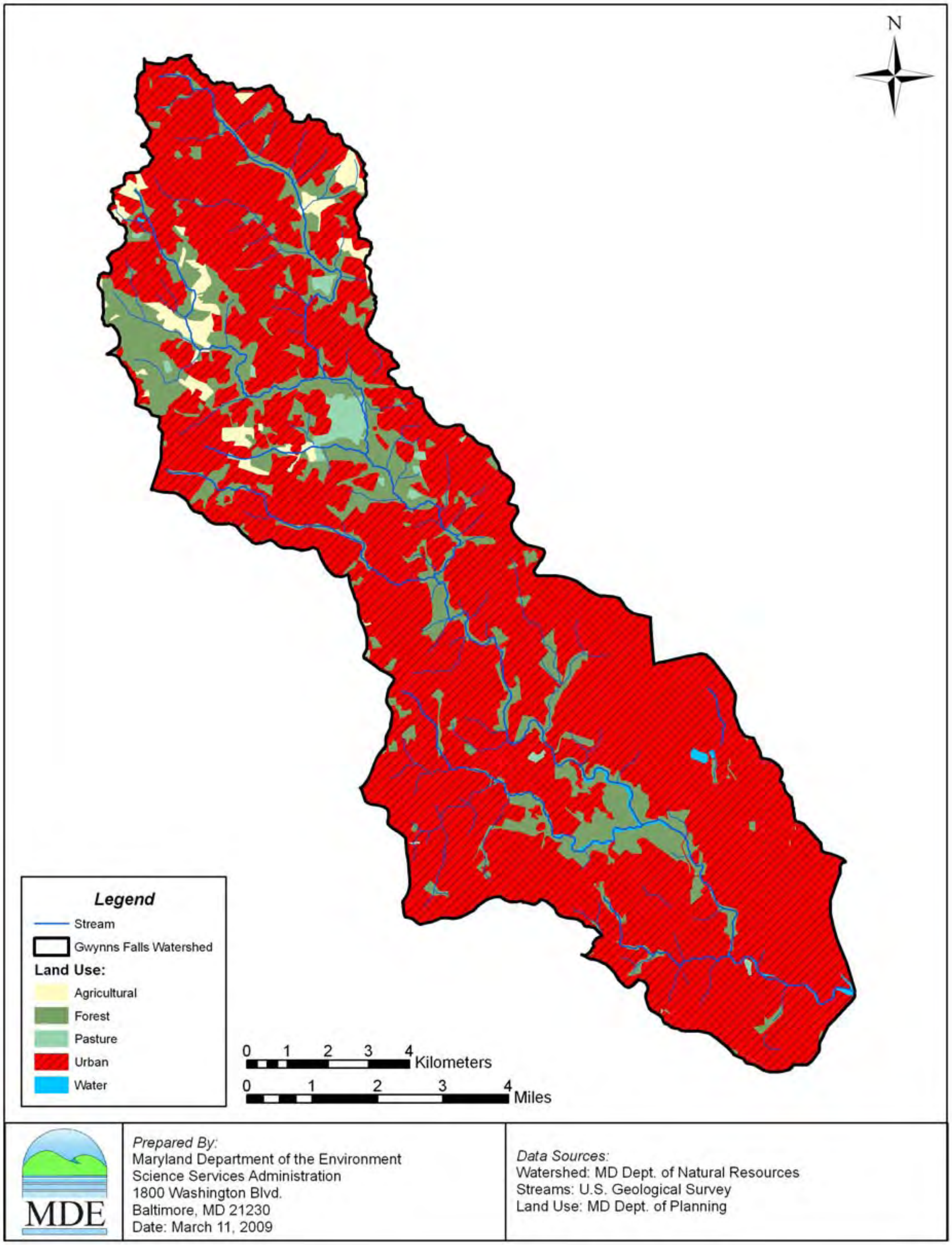


Figure 2: Land Use of the Gwynns Falls Watershed

3.0 WATER QUALITY CHARACTERIZATION

The Maryland Surface Water Use Designation for Gwynns Falls are as follows: Gwynns Falls and tributaries above Reisterstown Road, and Red Run and its tributaries – Use III (Non-tidal Cold Water); Dead Run and tributaries – Use IV (Recreational Trout Waters); and all remaining waters – Use I (Water Contact Recreation, and Protection of Nontidal Warmwater Aquatic Life) (COMAR 26.08.02.08K(3)(e) & (5)(e)). 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.

Currently, there are no specific numeric criteria for nutrients in Maryland's water quality standards. Therefore, the evaluation of potentially eutrophic conditions due to nutrient over-enrichment will be based on whether nutrient-related parameters (i.e., dissolved oxygen levels and chlorophyll *a* concentrations) are found to impair designated uses in the Gwynns Falls. The dissolved oxygen (DO) concentration to protect Use I and Use IV waters "may not be less than 5 milligrams per liter (mg/l) at any time" (COMAR 26.08.02.03-3A(2)). The DO concentration to protect Use III waters may not be less than 5 milligrams/liter at any time, with a minimum daily average of not less than 6 milligrams/liter " (COMAR 26.08.02.03-3D(2)). The water quality data presented in this section will show that DO concentrations in the Gwynns Falls and its tributaries meet these criteria, and that Maryland's narrative criteria for chlorophyll *a* are also met.

In addition to the DO and chlorophyll *a* data analysis, the results of a new biological stressor identification (BSID) analysis demonstrate that any biological impairment in the watershed is not caused by nutrient enrichment. Instead, the analysis suggests that the degradation to biological communities in the Gwynns Falls is strongly associated with the extensive urban nature of the watershed, which results in altered hydrology and elevated levels of ammonia[1], chlorides, and conductivity (a measure of the presence of dissolved substances) (MDE 2009b).

A data solicitation was conducted in 2007. All readily available water quality data from the past five years have been considered for this analysis. Water quality data from MDE surveys conducted along the Gwynns Falls from October 1999 through August 2000, October 2002 through December 2005, and January 2007 through December 2007, were used. Maryland Department of Natural Resources (DNR) data used in the analysis were from January 1998 through June 2007. Data from Maryland Biological Stream Survey (MBSS) sampling conducted in April 2000, and March 2004, were also used. Table 2 lists the water quality monitoring stations in the Gwynns Falls watershed with their geographical coordinates. Figures 3 through 6 provide graphical representation of the collected data for the parameters discussed below.

---

[1] Ammonia is a nitrogen nutrient species which, in excessive amounts has potential toxic effects on aquatic life. Maryland has numeric toxic substance criteria for ammonia for the protection of fresh water aquatic life (COMAR 26.08.02.03-2(H).

Table 3.1: Water Quality Stations in Gwynns Falls Watershed Monitored During 1998-2007

Station ID	Agency/Program	Latitude (Decimal-Degrees)	Longitude (Decimal-Degrees)
GWN0015	MDE	39.271	-76.648
GWN0215	MDE	39.443	-76.783
DDR0001	MDE	39.305	-76.686
GWN0024	MDE	39.269	-76.662
GWN0026	MDE	39.277	-76.662
GWN0050	MDE	39.306	-76.679
GWN0080	MDE	39.325	-76.715
GWN0125	MDE	39.360	-76.745
GWN0160	MDE	39.392	-76.765
GWN0179	MDE	39.411	-76.779
GWN0186	MDE	39.421	-76.782
MCR0001	MDE	39.276	-76.662
RDR0001	MDE	39.405	-76.779
RDR0008	MDE	39.402	-76.786
UHX0001	MDE	39.360	-76.746
GWN0115	DNR/MDE	39.343	-76.726
GWYN-102-R-2004	DNR/MBSS	39.400	-76.820
GWYN-104-R-2004	DNR/MBSS	39.380	-76.800
GWYN-105-R-2004	DNR/MBSS	39.380	-76.770
GWYN-107-R-2004	DNR/MBSS	39.450	-76.800
GWYN-112-R-2004	DNR/MBSS	39.390	-76.810
GWYN-210-R-2004	DNR/MBSS	39.300	-76.690
GWYN-211-R-2004	DNR/MBSS	39.300	-76.700
GWYN-301-R-2004	DNR/MBSS	39.280	-76.660
GWYN-301-X-2000	DNR/MBSS	39.340	-76.730
GWYN-302-X-2000	DNR/MBSS	39.440	-76.780
GWYN-303-R-2004	DNR/MBSS	39.390	-76.760
GWYN-306-R-2004	DNR/MBSS	39.270	-76.650

Antidegradation Policy and Tier II Waters

Antidegradation is one of three key components required by the Clean Water Act. These three components are: designated uses, water quality criteria, and antidegradation policy. The Clean Water Act's (CWA) Tier II antidegradation policy is found in section 303(d) and its goals are to 1) ensure that no activity will lower water quality to support existing uses, and 2) maintain and protect high quality waters.

Waters of the Gwynns Falls watershed designated as Tier II are listed in Table 2.1.

Table 2.1: High Quality (Tier II) Waters in the Loch Raven Reservoir Watershed

Tier II Segment	County	Segment Length (miles)
Red Run 1	Baltimore	1.63

3.1 Dissolved Oxygen

DNR samples were taken in the Gwynns Falls from January 1998 through June 2007. MDE samples were taken from October 1999 through August 2000, October 2002 through December 2005, and January 2007 through December 2007, and MBSS samples were taken in April 2000, and March 2004. Samples taken during the growing season (May through October) show DO concentrations ranging from 5.4 to 11.8 mg/l, all above the DO criterion for Use I waters of 5 mg/l. There is one monitoring station located in Dead Run (DDR0001), a tributary of the Gwynns Falls designated as Use IV. All four samples at this station have DO concentrations above the Use IV criterion of 5 mg/l, with a lowest value of 5.4 mg/l. Gwynns Falls and its tributaries above Reisterstown Road are designated as Use III. Monitoring Stations located above Reisterstown Road are: GWN0179, GWN0186, GWN0215, GWYN107-X and GWYN302-R. In addition, Red Run and its tributaries are designated as Use III. Stations located in Red Run are: RDR0001 and RDR0008. All samples at these seven monitoring stations have DO concentrations above the Use III daily average criterion of 6 mg/l. DO concentrations at these stations located above Reisterstown Road are between 6.6 and 10.9 mg/l. DO data are presented graphically in Figure 3 and in tabular form in Appendix A. The water quality standard for DO is being met in the Gwynns Falls watershed.

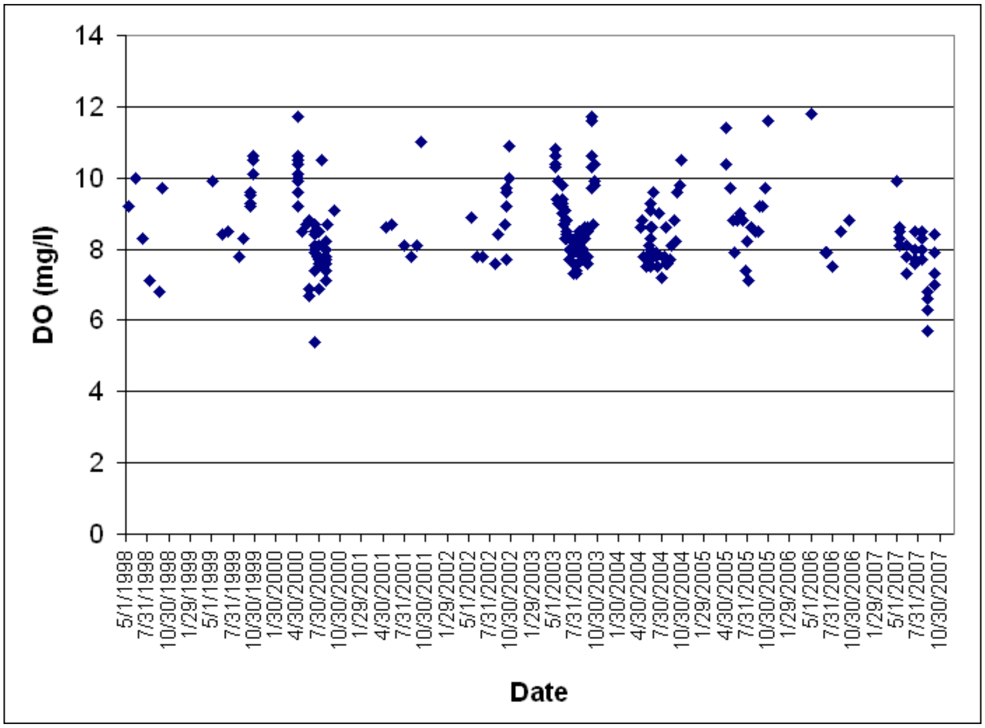


Figure 3: Gwynns Falls Dissolved Oxygen Data for Growing Season Periods May 1999 through October 2007

3.2 Chlorophyll *a*

Currently, Maryland water quality standards do not specify numeric criteria for chlorophyll *a*. However, pollution of waters of the State by any material in amounts sufficient to create a nuisance or interfere with designated uses is prohibited (COMAR 26.08.02.03B(2)). Elevated chlorophyll *a* concentrations, a measure of algal growth, may indicate poor water quality that cannot support a waterbody's designated uses and may constitute a nuisance condition. Nuisance levels of algae can interfere with uses related to recreational activities such as fishing, boating, and aesthetic appreciation. High chlorophyll *a* levels can also present taste, odor, and treatment problems in water supply systems.

Narrative water quality criteria are an important component of the State's water quality standards, but are difficult to incorporate into quantitative water quality or TMDL analyses. In the case of free-flowing non-tidal waters, there is an insufficient understanding of the relationship between chlorophyll *a* concentrations and the waterbody's designated use impairment. However, COMAR includes narrative criteria for acceptable chlorophyll *a* levels in tidal waters. Maryland's numeric interpretation of these criteria for application in estuarine waters, adapted from previously approved nutrient TMDLs, is as follows:

> The chlorophyll *a* concentration goal used by the State in estuarine TMDL analyses is based on guidelines set forth by Thomann and Mueller (1987) and by the EPA Technical

> Guidance Manual for Developing Total Maximum Daily Loads, Book 2, Part 1 (1997). The chlorophyll *a* narrative criterion (COMAR 26.08.02.03-3C(10)) states: "Chlorophyll *a* - Concentrations of chlorophyll *a* in free-floating microscopic aquatic plants (algae) shall not exceed levels that result in ecologically undesirable consequences that would render tidal waters unsuitable for designated uses." The Thomann and Mueller guidelines acknowledge that "'Undesirable levels of phytoplankton [chlorophyll *a*] vary considerably depending on water body." MDE has determined, per Thomann and Mueller, that it is acceptable to maintain chlorophyll *a* concentrations below a maximum of 100 µg/L, and to target, with some flexibility depending on waterbody characteristics, a 30-day rolling average of approximately 50 µg/L (with some flexibility depending on waterbody characteristics). (MDE 2006)

Maryland has also developed guidelines for application of the narrative criteria in drinking water reservoirs. The guidelines, adapted from previously approved TMDLs, are as follows:

> The chlorophyll *a* endpoints selected for public water supply reservoirs are (a) a ninetieth-percentile instantaneous concentration not to exceed 30 µg/l in the surface layers, and (b) a 30-day moving average concentration not to exceed 10 µg/l in the surface layers. The concentration of 10 µg/l corresponds to a score of approximately 53 on the Carlson's Trophic State Index (TSI). This is at the boundary of mesotrophic and eutrophic conditions, which is an appropriate trophic state at which to manage these reservoirs. Mean chlorophyll *a* concentrations exceeding 10 µg/l are associated with peaks exceeding 30 µg/l, which in turn are associated with a shift to blue-green assemblages, which present taste, odor and treatment problems (Walker 1984). Achieving these chlorophyll *a* endpoints should thus safeguard such reservoirs from nuisance algal blooms. (MDE 2008b)

Using the chlorophyll *a* targets for tidal waters and public water supply reservoirs described above as screening values for non-tidal waters, the following data analysis reflects an absence of excessive algal growth in the Gwynns Falls, as indicated by low chlorophyll *a* concentrations in comparison with those values.

DNR and MDE monitoring data in the Gwynns Falls show growing season (May through October) averages, by station, between 1.03 and 2.88 µg/l. These samples show observed chlorophyll *a* concentrations ranging from 0.21 and 14.95 µg/l, with only 2 samples (out of 182) above 10 µg/l. These monitoring data values suggest that chlorophyll *a* concentrations any nuisance issues due to nutrients in the Gwynns Falls or interfering with its designated uses.

The chlorophyll *a* data are presented graphically in Figure 4 and in tabular form in Appendix A.

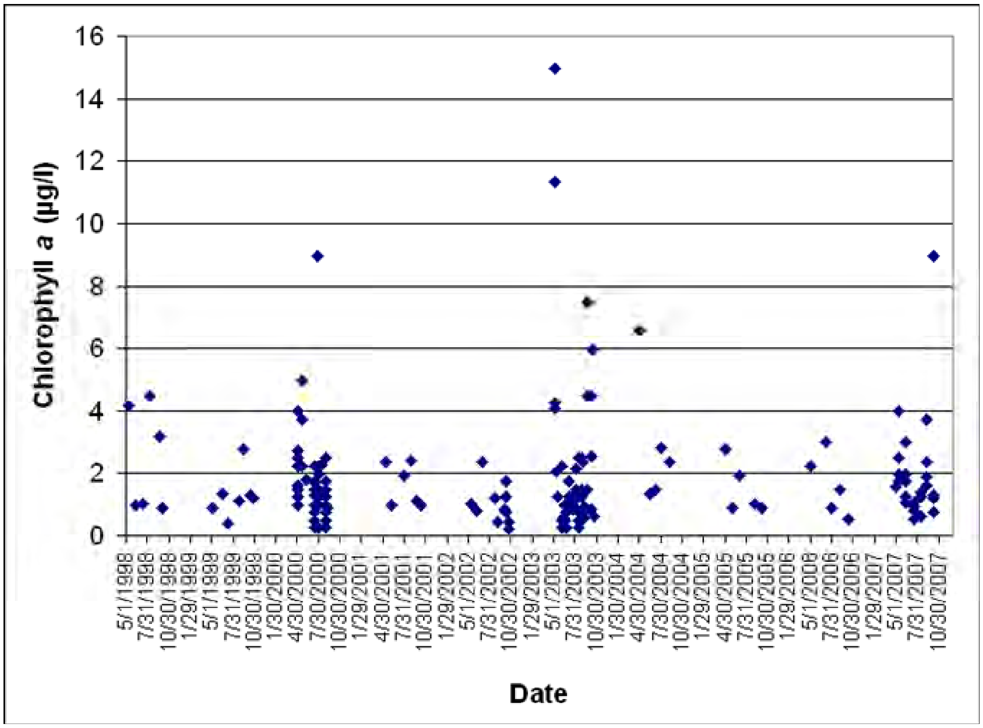


Figure 4: Gwynns Falls Chlorophyll *a* Data for Growing Season Periods May 1999 through October 2007

3.3 Nutrients

In the absence of State water quality standards with specific numeric limits for nutrients, evaluation of potentially eutrophic conditions is based on whether nutrient-related parameters (i.e., dissolved oxygen levels and chlorophyll *a* concentrations) are found to impair the designated uses in the Gwynns Falls (in this case protection of aquatic life and wildlife, fishing, and swimming). Consequently, the nutrients data presented in this section are for informational purposes only.

Total nitrogen (TN) and total phosphorus (TP) data for the Gwynns Falls have been collected as part of this study and the results are presented here for informational purposes, graphically in Figures 5 and 6, and in tabular form in Appendix A. In general, DNR, MDE, and MBSS data show TN concentrations during the growing season (May through October) ranging from 0.89 to 4.39 mg/l and TP concentrations ranging from 0.006 to 0.36 mg/l.

In the absence of specific numeric criteria to assess the TP and TN monitoring data results, MDE evaluated these results using its BSID methodology, which compared Gwynns Falls parameters to the results from similar control sites (i.e., watersheds with no biological impairments) and concluded that nutrients are not likely stressors associated with the degraded biological conditions (MDE 2009b). Current DO conditions in the Gwynns Falls further support this conclusion.

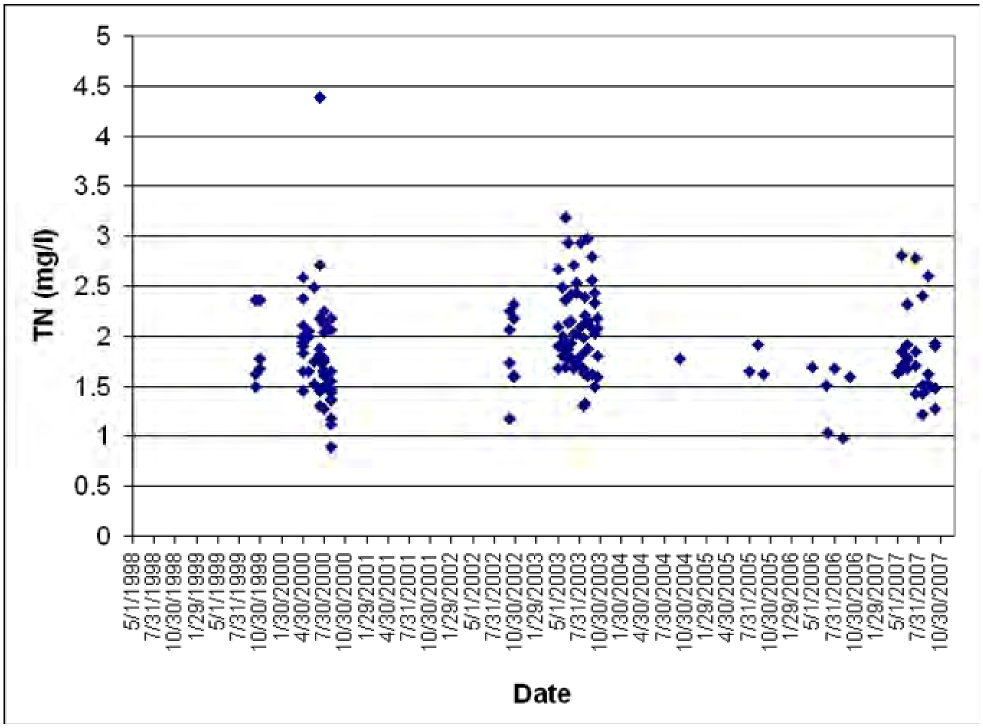


Figure 5: Gwynns Falls Total Nitrogen Data from May 1999 through October 2007

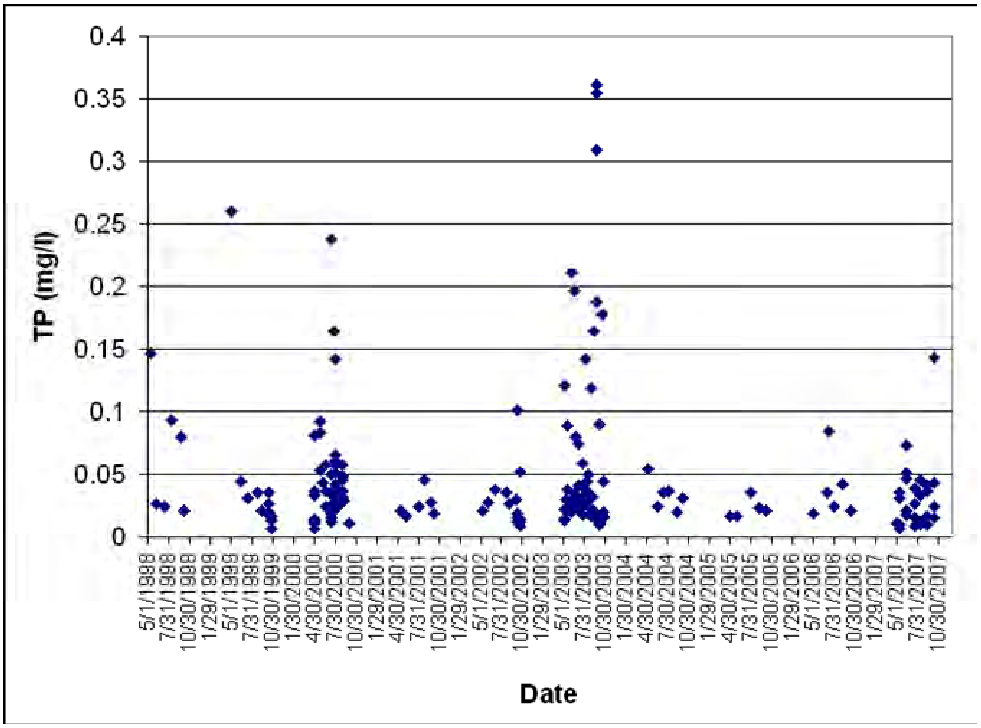


Figure 6: Gwynns Falls Total Phosphorus Data from May 1999 through October 2007

3.4 Biological Stressor Identification Analysis

In the process of evaluating the existing biological impairments, MDE developed a BSID methodology (MDE 2009a). The BSID methodology uses data available from the statewide DNR MBSS. These data 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 of this assignment in terms of currently used *Integrated Report* listing categories.

The BSID analysis for the Gwynns Falls watershed did not identify nutrients (as indicated by DO, total nitrogen, total phosphorus, etc.) as potential stressors or indicate any significant association between current nutrient levels and the degraded biological conditions (MDE 2009b). According to this report, nutrients are not causing any impairment to aquatic life or biological communities in the Gwynns Falls.

The BSID analysis results suggest rather that the degradation of biological communities in the Gwynns Falls watershed is strongly associated with the urban nature of the watershed, which has resulted in altered hydrology and elevated levels of ammonia, chlorides, and conductivity (a measure of the presence of dissolved substances). As explained in the BSID report, the urbanization of landscapes creates broad and interrelated forms of degradation (i.e., hydrological, morphological, and water chemistry) that can affect stream ecology and biological composition. Peer-reviewed scientific literature establishes a link between highly urbanized landscapes and degradation in the aquatic health of non-tidal stream ecosystems.

4.0 CONCLUSION

Based on the analysis of data presented in the preceding section of this report, indicating that DO and chlorophyll *a* concentrations are meeting water quality criteria, and on the results of the Gwynns Falls BSID analysis, MDE concludes that currently the Gwynns Falls watershed is not being impaired by nutrients. (The BSID analysis indicates inorganic pollutants, ammonia toxicity, and flow/sediment stressors are associated with impacts to biological communities; these findings will be addressed separately.) Barring the receipt of contradictory data, this report will be used to support a revision of the phosphorus listing for the Gwynns 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 Gwynns Falls do not display signs of eutrophication, the State reserves the right to require future controls if evidence suggests that nutrients from the basin are contributing to downstream water quality problems. In December 2007, EPA approved TMDLs of nitrogen and phosphorus for the Baltimore Harbor. The Gwynns Falls watershed is located upstream of the Baltimore Harbor and drains into the Harbor’s tidal waters. Although the amount of nutrients entering the Gwynns Falls is not causing localized impairments, it is contributing to the eutrophication of the downstream tidal waters of the Harbor. Therefore, the TMDL for the Baltimore Harbor requires nutrient reductions in the Gwynns Falls necessary to meet water quality standards in the Harbor. On the same principle, additional reductions may also be required by the forthcoming Chesapeake Bay TMDL, currently under development and due to be established by EPA by the end of 2010.

REFERENCES

CES (Coastal Environmental Service, Inc.). 1995. *Patapsco/Back River Watershed Study*, prepared for MDE.

CFR (Code of Federal Regulations). 2007. *40 CFR 130.7*. http://a257.g.akamaitech.net/7/257/2422/22jul20061500/edocket.access.gpo.gov/cfr_2006/julqtr/40cfr130.7.htm (Accessed March, 2007).

COMAR (Code of Maryland Regulations). *COMAR 26.08.02.03, 26.08.02.03-3, 26.08.02.08 and 26.08.02.03-2*. http://www.dsd.state.md.us/comar (Accessed December 2008).

MDE (Maryland Department of the Environment). 2006. Total Maximum Daily Loads of Nitrogen and Phosphorus for the Upper and Middle Chester Rivers in Kent and Queen Anne's Counties, Maryland.

————. 2008a. The 2008 Integrated Report of Surface Water Quality in Maryland. Baltimore, MD: Maryland Department of the Environment. http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/Maryland%20303%20dlist/2008_Final_303d_list.asp (Accessed December, 2008).

————. 2008b. Total Maximum Daily Loads of Phosphorus and Sediments for Triadelphia Reservoir and Total Maximum Daily Loads of Phosphorus for Rocky Gorge Reservoir, Howard, Montgomery and Prince George's Counties, Maryland. Baltimore, MD: Maryland Department of the Environment.

————. 2009a. Maryland Biological Stressor Identification Process. Baltimore, MD: Maryland Department of the Environment.

————. 2009b. Watershed Report for Biological Impairment of the Gwynns Falls Basin in Anne Arundel, Baltimore, Carroll, and Howard Counties and Baltimore City, Maryland - Biological Stressor Identification Analysis Results and Interpretation. Baltimore, MD: Maryland Department of the Environment.

MDP (Maryland Department of Planning). 2002. 2002 Land Use, Land Cover Map Series.

Thomann, Robert V., John A. Mueller. 1987. “Principles of Surface Water Quality Modeling and Control.” HarperCollins Publisher Inc., New York.

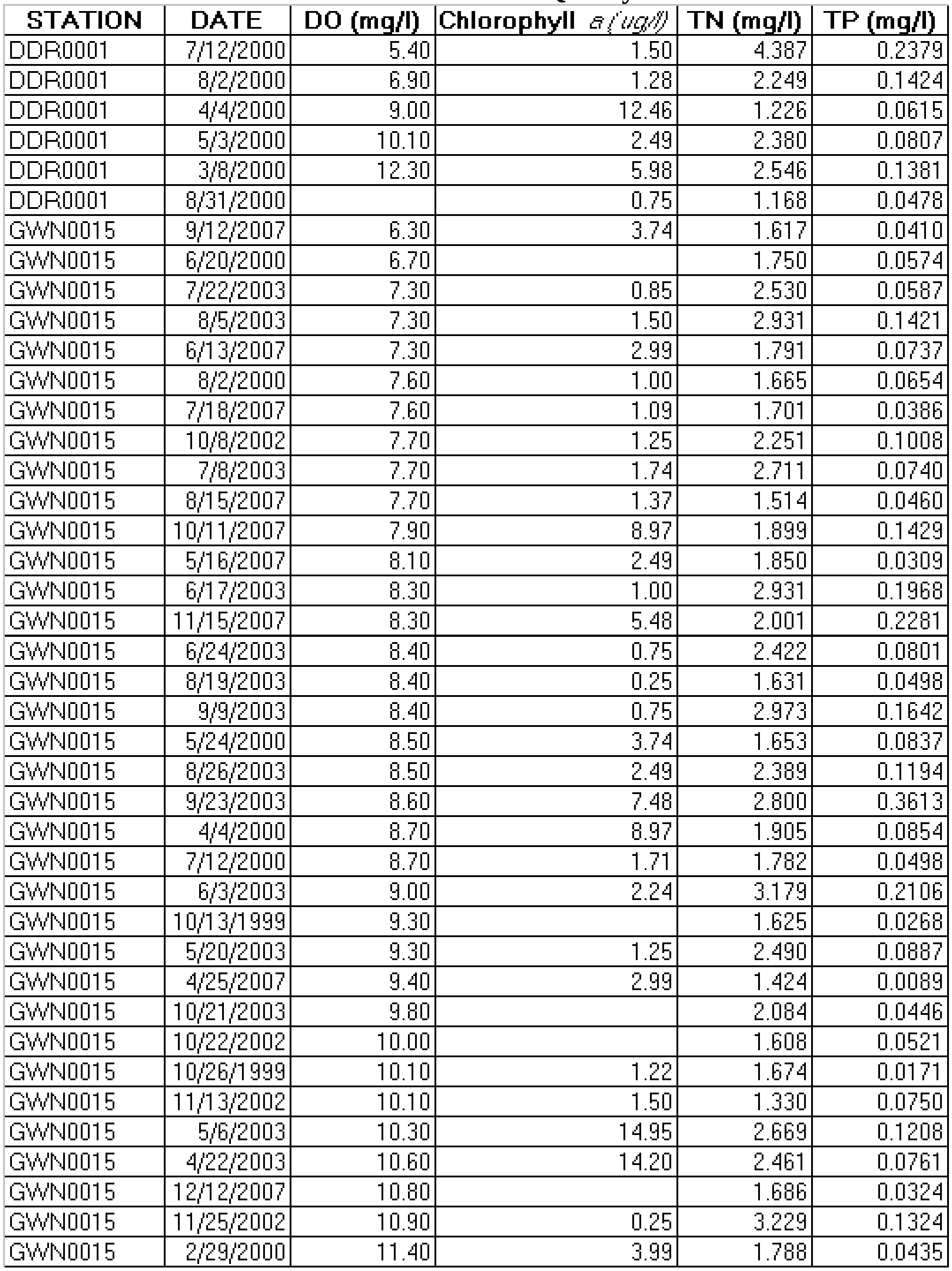
USDA (U.S. Department of Agriculture). 1995. Natural Resources Conservation Service (NRCS). State Soil Geographic (STATSGO) DataBase.

U.S. EPA, “Technical Guidance Manual for Developing Total Maximum Daily Loads, Book2: Streams and Rivers, Part 1: Biochemical Oxygen Demand/ Dissolved Oxygen and Nutrients/Eutrophication,” Office of Water, Washington D.C., March 1997.

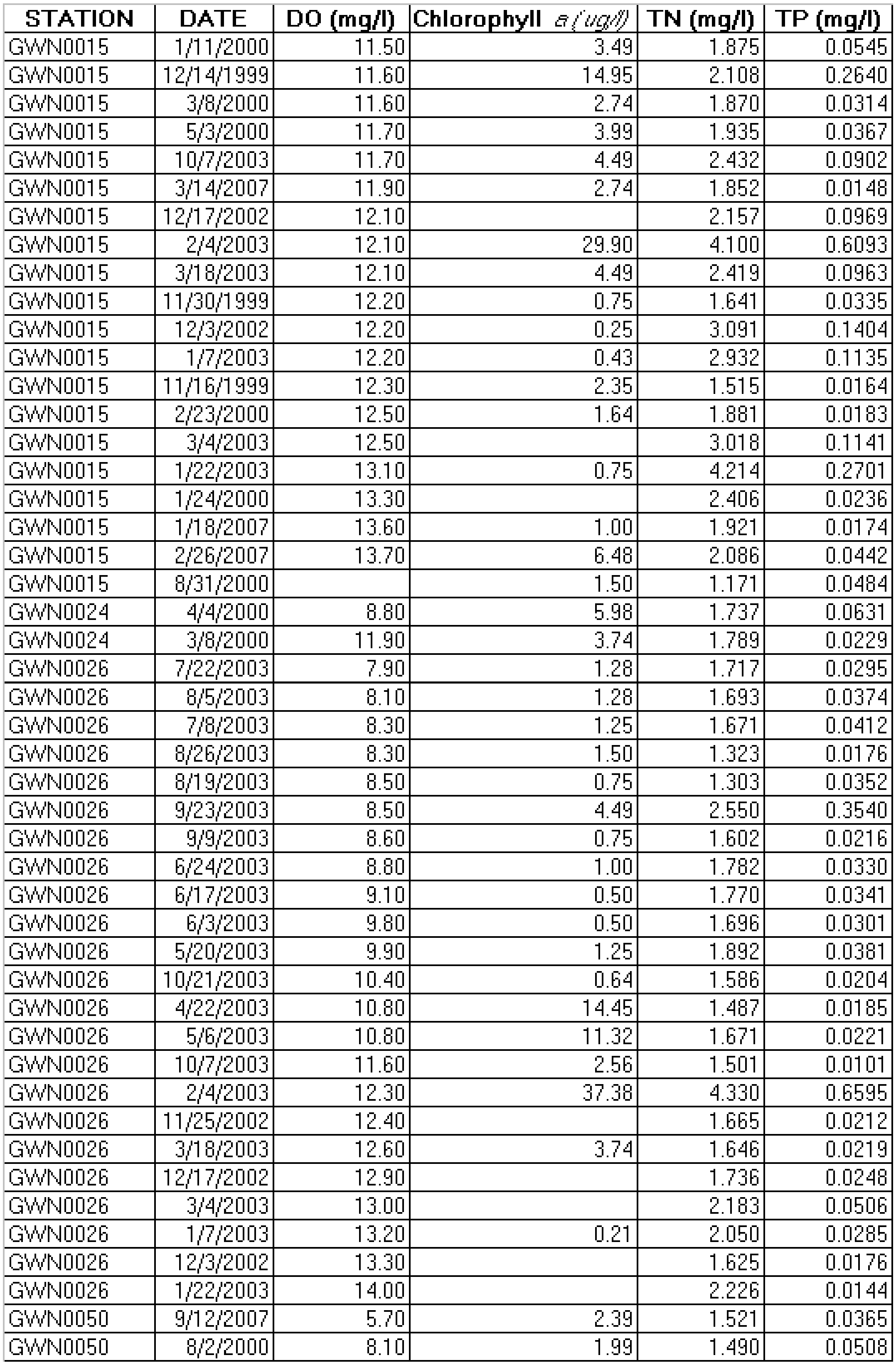
Walker, W.W., Jr. 1984. Statistical Bases for Mean Chlorophyll *a* Criteria. *Lake and Reservoir Management: Proceedings of Fourth Annual Conference*. North American Lake Management Society, pp. 57 – 62.

Appendix A – Tabular Water Quality Data

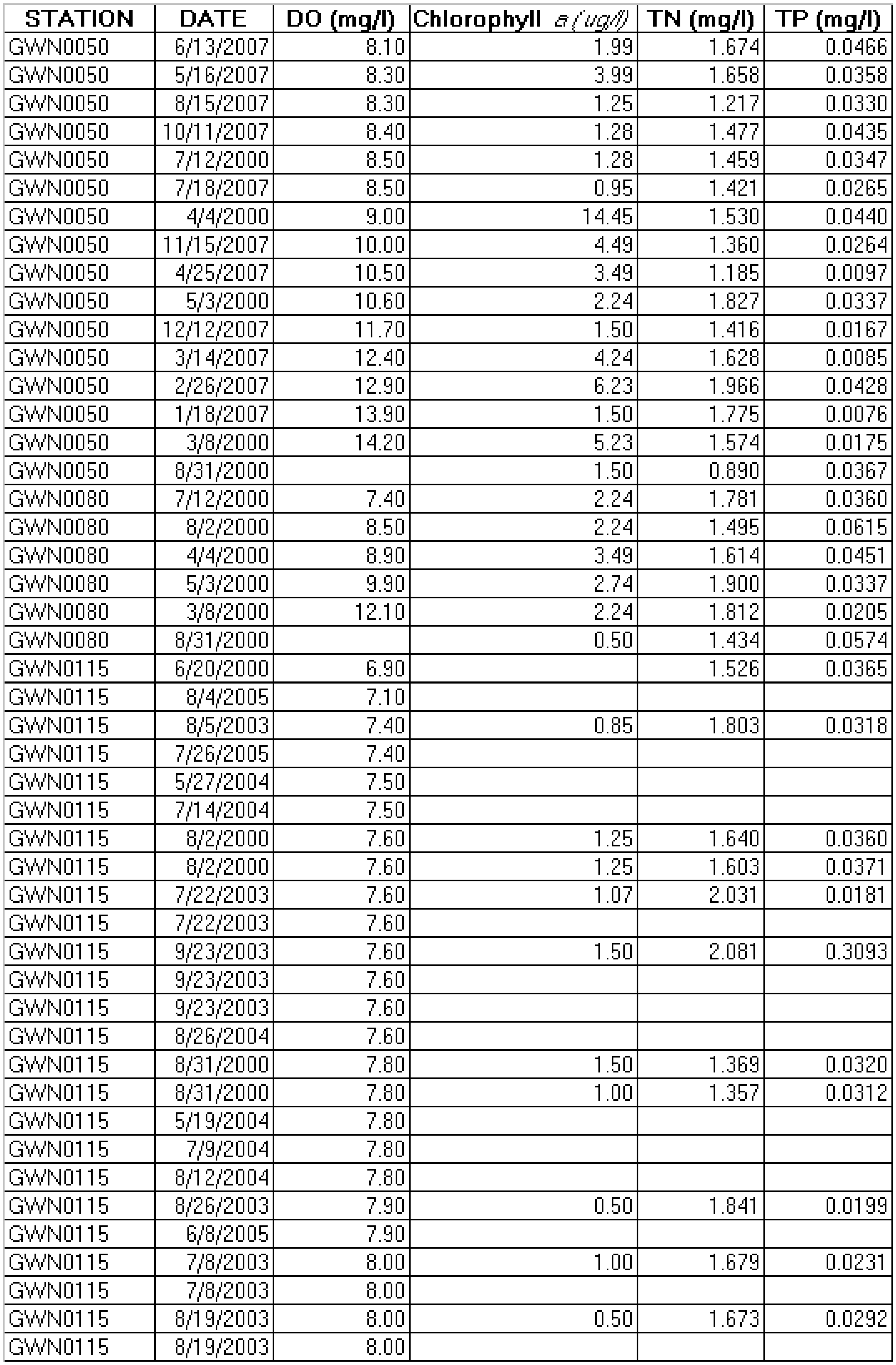
Table A-1: MDE Water Quality Data



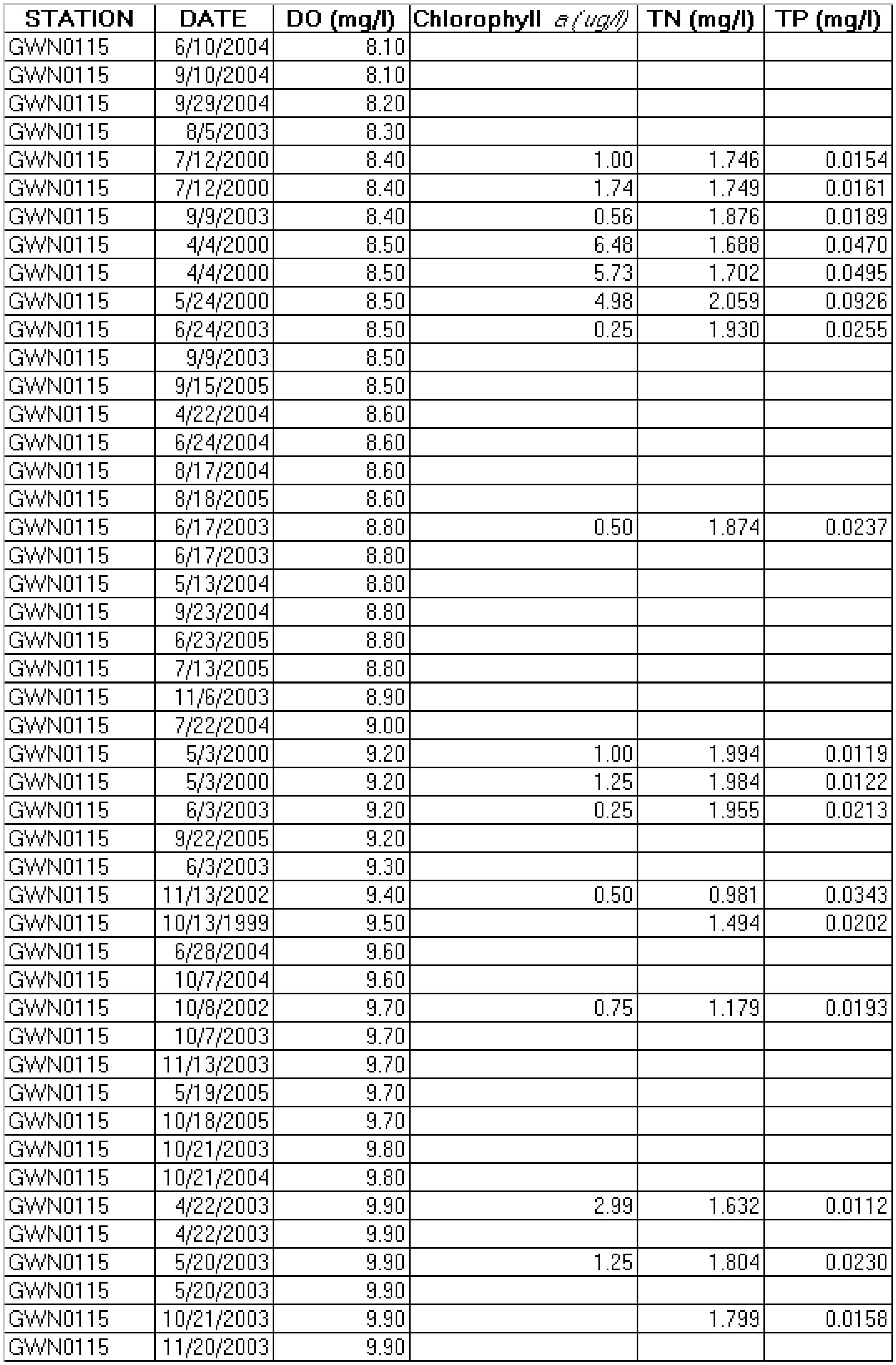
STATION	DATE	DO (mg/l)	Chlorophyll *a (ug/l)*	TN (mg/l)	TP (mg/l)
DDR0001	7/12/2000	5.40	1.50	4.387	0.2379
DDR0001	8/2/2000	6.90	1.28	2.249	0.1424
DDR0001	4/4/2000	9.00	12.46	1.226	0.0615
DDR0001	5/3/2000	10.10	2.49	2.380	0.0807
DDR0001	3/8/2000	12.30	5.98	2.546	0.1381
DDR0001	8/31/2000		0.75	1.168	0.0478
GWN0015	9/12/2007	6.30	3.74	1.617	0.0410
GWN0015	6/20/2000	6.70		1.750	0.0574
GWN0015	7/22/2003	7.30	0.85	2.530	0.0587
GWN0015	8/5/2003	7.30	1.50	2.931	0.1421
GWN0015	6/13/2007	7.30	2.99	1.791	0.0737
GWN0015	8/2/2000	7.60	1.00	1.665	0.0654
GWN0015	7/18/2007	7.60	1.09	1.701	0.0386
GWN0015	10/8/2002	7.70	1.25	2.251	0.1008
GWN0015	7/8/2003	7.70	1.74	2.711	0.0740
GWN0015	8/15/2007	7.70	1.37	1.514	0.0460
GWN0015	10/11/2007	7.90	8.97	1.899	0.1429
GWN0015	5/16/2007	8.10	2.49	1.850	0.0309
GWN0015	6/17/2003	8.30	1.00	2.931	0.1968
GWN0015	11/15/2007	8.30	5.48	2.001	0.2281
GWN0015	6/24/2003	8.40	0.75	2.422	0.0801
GWN0015	8/19/2003	8.40	0.25	1.631	0.0498
GWN0015	9/9/2003	8.40	0.75	2.973	0.1642
GWN0015	5/24/2000	8.50	3.74	1.653	0.0837
GWN0015	8/26/2003	8.50	2.49	2.389	0.1194
GWN0015	9/23/2003	8.60	7.48	2.800	0.3613
GWN0015	4/4/2000	8.70	8.97	1.905	0.0854
GWN0015	7/12/2000	8.70	1.71	1.782	0.0498
GWN0015	6/3/2003	9.00	2.24	3.179	0.2106
GWN0015	10/13/1999	9.30		1.625	0.0268
GWN0015	5/20/2003	9.30	1.25	2.490	0.0887
GWN0015	4/25/2007	9.40	2.99	1.424	0.0089
GWN0015	10/21/2003	9.80		2.084	0.0446
GWN0015	10/22/2002	10.00		1.608	0.0521
GWN0015	10/26/1999	10.10	1.22	1.674	0.0171
GWN0015	11/13/2002	10.10	1.50	1.330	0.0750
GWN0015	5/6/2003	10.30	14.95	2.669	0.1208
GWN0015	4/22/2003	10.60	14.20	2.461	0.0761
GWN0015	12/12/2007	10.80		1.686	0.0324
GWN0015	11/25/2002	10.90	0.25	3.229	0.1324
GWN0015	2/29/2000	11.40	3.99	1.788	0.0435



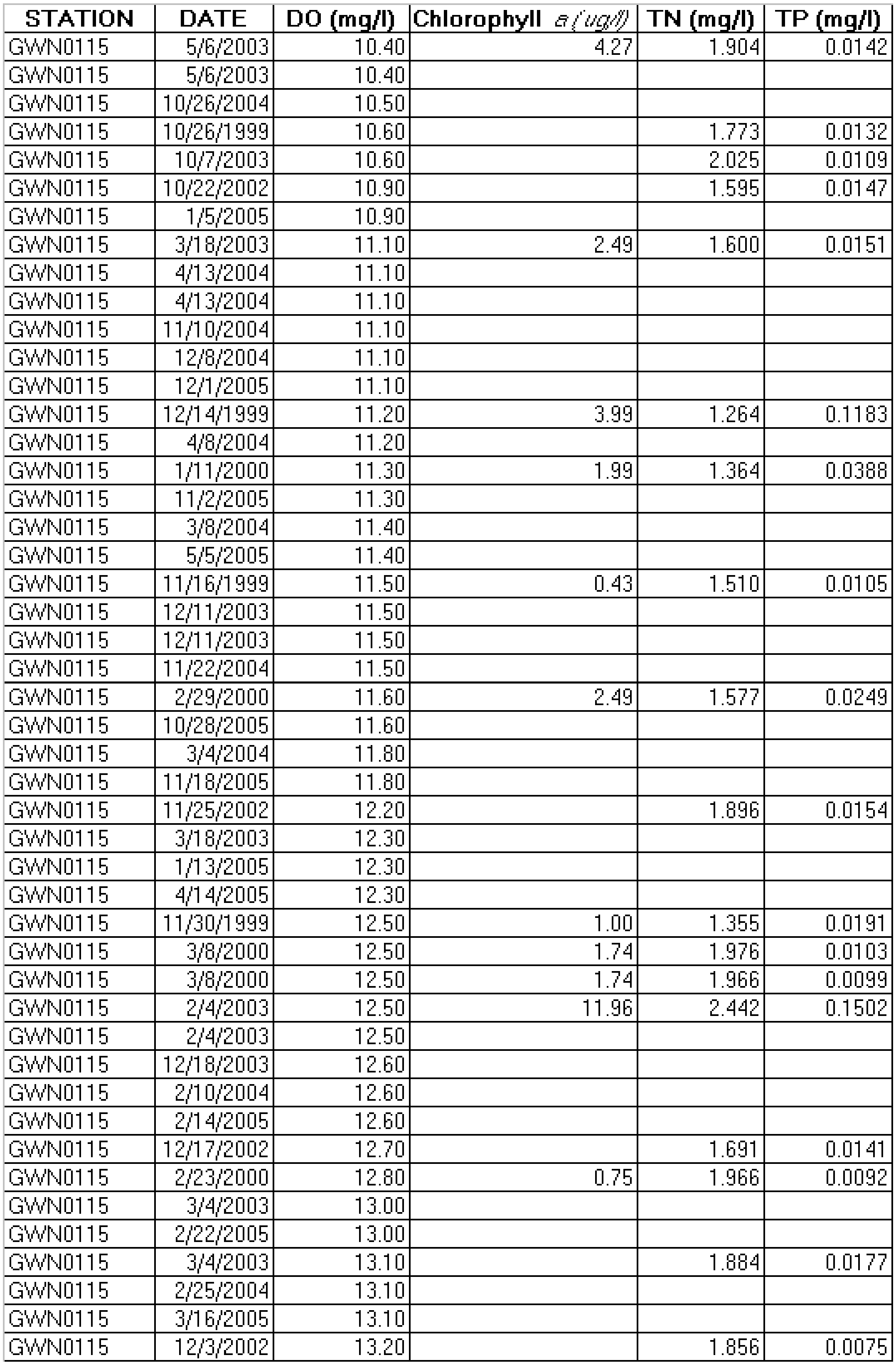
STATION	DATE	DO (mg/l)	Chlorophyll *a* (ug/l)	TN (mg/l)	TP (mg/l)
GWN0015	1/11/2000	11.50	3.49	1.875	0.0545
GWN0015	12/14/1999	11.60	14.95	2.108	0.2640
GWN0015	3/8/2000	11.60	2.74	1.870	0.0314
GWN0015	5/3/2000	11.70	3.99	1.935	0.0367
GWN0015	10/7/2003	11.70	4.49	2.432	0.0902
GWN0015	3/14/2007	11.90	2.74	1.852	0.0148
GWN0015	12/17/2002	12.10		2.157	0.0969
GWN0015	2/4/2003	12.10	29.90	4.100	0.6093
GWN0015	3/18/2003	12.10	4.49	2.419	0.0963
GWN0015	11/30/1999	12.20	0.75	1.641	0.0335
GWN0015	12/3/2002	12.20	0.25	3.091	0.1404
GWN0015	1/7/2003	12.20	0.43	2.932	0.1135
GWN0015	11/16/1999	12.30	2.35	1.515	0.0164
GWN0015	2/23/2000	12.50	1.64	1.881	0.0183
GWN0015	3/4/2003	12.50		3.018	0.1141
GWN0015	1/22/2003	13.10	0.75	4.214	0.2701
GWN0015	1/24/2000	13.30		2.406	0.0236
GWN0015	1/18/2007	13.60	1.00	1.921	0.0174
GWN0015	2/26/2007	13.70	6.48	2.086	0.0442
GWN0015	8/31/2000		1.50	1.171	0.0484
GWN0024	4/4/2000	8.80	5.98	1.737	0.0631
GWN0024	3/8/2000	11.90	3.74	1.789	0.0229
GWN0026	7/22/2003	7.90	1.28	1.717	0.0295
GWN0026	8/5/2003	8.10	1.28	1.693	0.0374
GWN0026	7/8/2003	8.30	1.25	1.671	0.0412
GWN0026	8/26/2003	8.30	1.50	1.323	0.0176
GWN0026	8/19/2003	8.50	0.75	1.303	0.0352
GWN0026	9/23/2003	8.50	4.49	2.550	0.3540
GWN0026	9/9/2003	8.60	0.75	1.602	0.0216
GWN0026	6/24/2003	8.80	1.00	1.782	0.0330
GWN0026	6/17/2003	9.10	0.50	1.770	0.0341
GWN0026	6/3/2003	9.80	0.50	1.696	0.0301
GWN0026	5/20/2003	9.90	1.25	1.892	0.0381
GWN0026	10/21/2003	10.40	0.64	1.586	0.0204
GWN0026	4/22/2003	10.80	14.45	1.487	0.0185
GWN0026	5/6/2003	10.80	11.32	1.671	0.0221
GWN0026	10/7/2003	11.60	2.56	1.501	0.0101
GWN0026	2/4/2003	12.30	37.38	4.330	0.6595
GWN0026	11/25/2002	12.40		1.665	0.0212
GWN0026	3/18/2003	12.60	3.74	1.646	0.0219
GWN0026	12/17/2002	12.90		1.736	0.0248
GWN0026	3/4/2003	13.00		2.183	0.0506
GWN0026	1/7/2003	13.20	0.21	2.050	0.0285
GWN0026	12/3/2002	13.30		1.625	0.0176
GWN0026	1/22/2003	14.00		2.226	0.0144
GWN0050	9/12/2007	5.70	2.39	1.521	0.0365
GWN0050	8/2/2000	8.10	1.99	1.490	0.0508



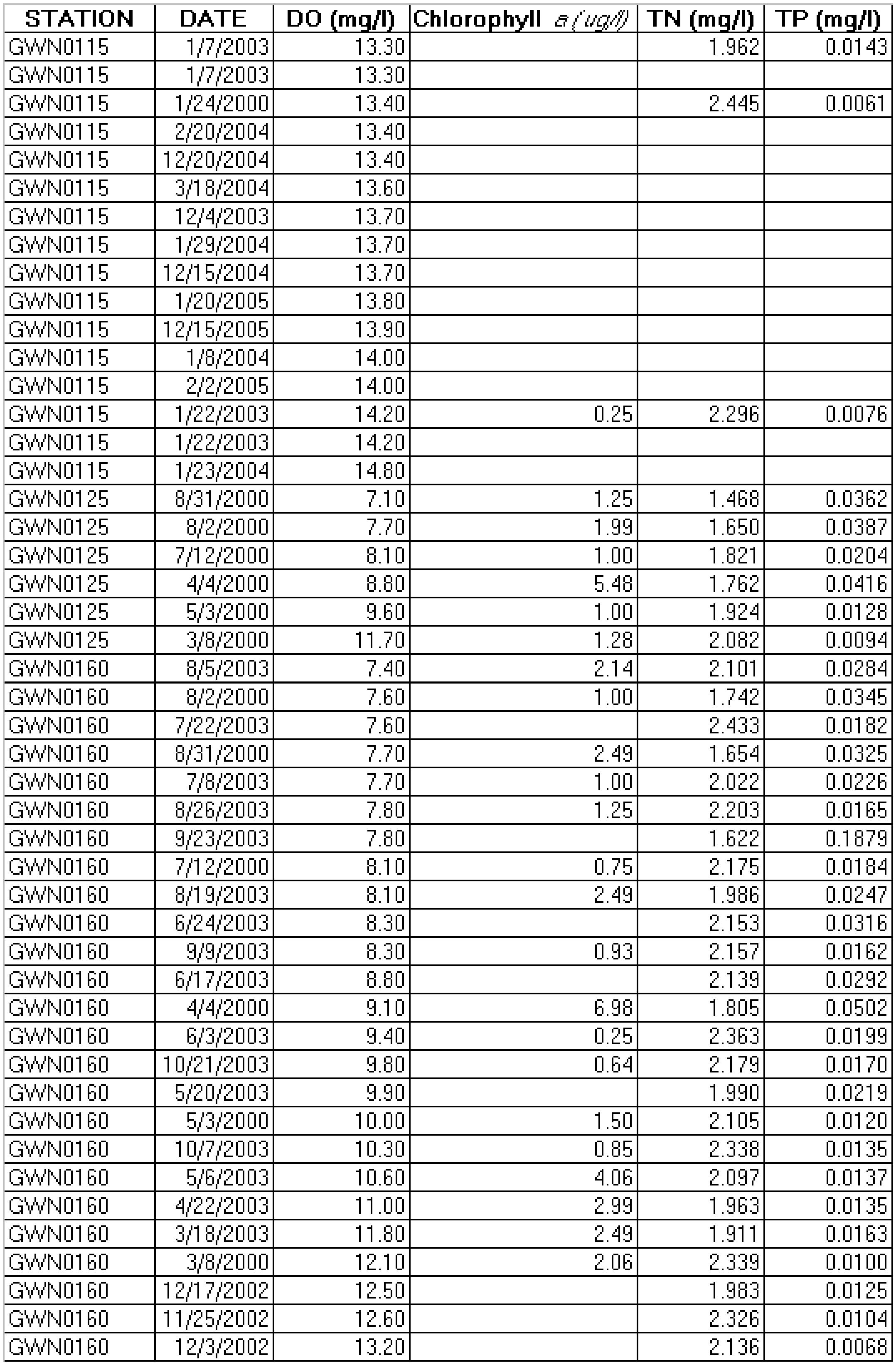
STATION	DATE	DO (mg/l)	Chlorophyll *a* (ug/l)	TN (mg/l)	TP (mg/l)
GWN0050	6/13/2007	8.10	1.99	1.674	0.0466
GWN0050	5/16/2007	8.30	3.99	1.658	0.0358
GWN0050	8/15/2007	8.30	1.25	1.217	0.0330
GWN0050	10/11/2007	8.40	1.28	1.477	0.0435
GWN0050	7/12/2000	8.50	1.28	1.459	0.0347
GWN0050	7/18/2007	8.50	0.95	1.421	0.0265
GWN0050	4/4/2000	9.00	14.45	1.530	0.0440
GWN0050	11/15/2007	10.00	4.49	1.360	0.0264
GWN0050	4/25/2007	10.50	3.49	1.185	0.0097
GWN0050	5/3/2000	10.60	2.24	1.827	0.0337
GWN0050	12/12/2007	11.70	1.50	1.416	0.0167
GWN0050	3/14/2007	12.40	4.24	1.628	0.0085
GWN0050	2/26/2007	12.90	6.23	1.966	0.0428
GWN0050	1/18/2007	13.90	1.50	1.775	0.0076
GWN0050	3/8/2000	14.20	5.23	1.574	0.0175
GWN0050	8/31/2000		1.50	0.890	0.0367
GWN0080	7/12/2000	7.40	2.24	1.781	0.0360
GWN0080	8/2/2000	8.50	2.24	1.495	0.0615
GWN0080	4/4/2000	8.90	3.49	1.614	0.0451
GWN0080	5/3/2000	9.90	2.74	1.900	0.0337
GWN0080	3/8/2000	12.10	2.24	1.812	0.0205
GWN0080	8/31/2000		0.50	1.434	0.0574
GWN0115	6/20/2000	6.90		1.526	0.0365
GWN0115	8/4/2005	7.10			
GWN0115	8/5/2003	7.40	0.85	1.803	0.0318
GWN0115	7/26/2005	7.40			
GWN0115	5/27/2004	7.50			
GWN0115	7/14/2004	7.50			
GWN0115	8/2/2000	7.60	1.25	1.640	0.0360
GWN0115	8/2/2000	7.60	1.25	1.603	0.0371
GWN0115	7/22/2003	7.60	1.07	2.031	0.0181
GWN0115	7/22/2003	7.60			
GWN0115	9/23/2003	7.60	1.50	2.081	0.3093
GWN0115	9/23/2003	7.60			
GWN0115	9/23/2003	7.60			
GWN0115	8/26/2004	7.60			
GWN0115	8/31/2000	7.80	1.50	1.369	0.0320
GWN0115	8/31/2000	7.80	1.00	1.357	0.0312
GWN0115	5/19/2004	7.80			
GWN0115	7/9/2004	7.80			
GWN0115	8/12/2004	7.80			
GWN0115	8/26/2003	7.90	0.50	1.841	0.0199
GWN0115	6/8/2005	7.90			
GWN0115	7/8/2003	8.00	1.00	1.679	0.0231
GWN0115	7/8/2003	8.00			
GWN0115	8/19/2003	8.00	0.50	1.673	0.0292
GWN0115	8/19/2003	8.00			



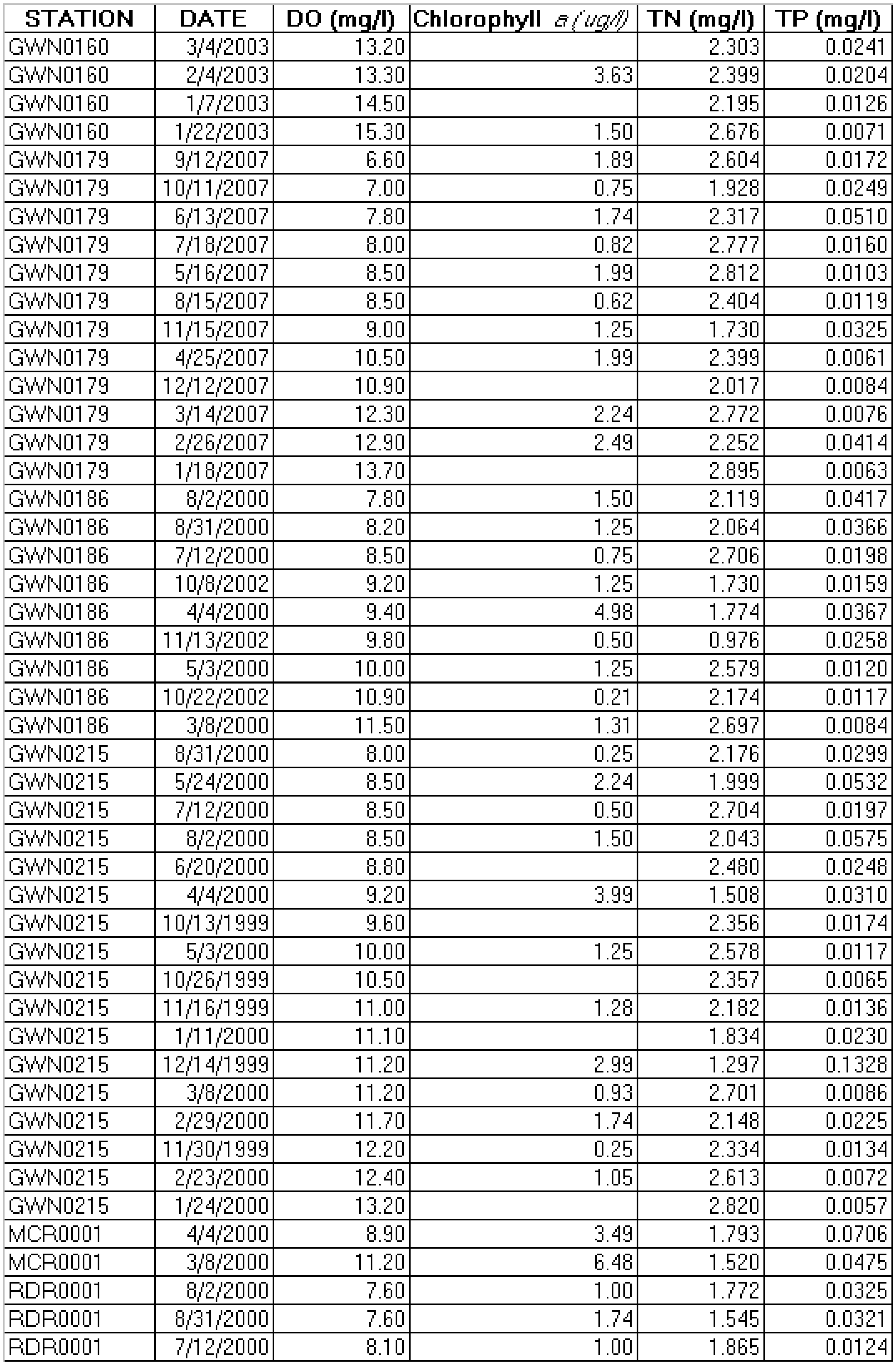
STATION	DATE	DO (mg/l)	Chlorophyll *a (ug/l)*	TN (mg/l)	TP (mg/l)
GWN0115	6/10/2004	8.10			
GWN0115	9/10/2004	8.10			
GWN0115	9/29/2004	8.20			
GWN0115	8/5/2003	8.30			
GWN0115	7/12/2000	8.40	1.00	1.746	0.0154
GWN0115	7/12/2000	8.40	1.74	1.749	0.0161
GWN0115	9/9/2003	8.40	0.56	1.876	0.0189
GWN0115	4/4/2000	8.50	6.48	1.688	0.0470
GWN0115	4/4/2000	8.50	5.73	1.702	0.0495
GWN0115	5/24/2000	8.50	4.98	2.059	0.0926
GWN0115	6/24/2003	8.50	0.25	1.930	0.0255
GWN0115	9/9/2003	8.50			
GWN0115	9/15/2005	8.50			
GWN0115	4/22/2004	8.60			
GWN0115	6/24/2004	8.60			
GWN0115	8/17/2004	8.60			
GWN0115	8/18/2005	8.60			
GWN0115	6/17/2003	8.80	0.50	1.874	0.0237
GWN0115	6/17/2003	8.80			
GWN0115	5/13/2004	8.80			
GWN0115	9/23/2004	8.80			
GWN0115	6/23/2005	8.80			
GWN0115	7/13/2005	8.80			
GWN0115	11/6/2003	8.90			
GWN0115	7/22/2004	9.00			
GWN0115	5/3/2000	9.20	1.00	1.994	0.0119
GWN0115	5/3/2000	9.20	1.25	1.984	0.0122
GWN0115	6/3/2003	9.20	0.25	1.955	0.0213
GWN0115	9/22/2005	9.20			
GWN0115	6/3/2003	9.30			
GWN0115	11/13/2002	9.40	0.50	0.981	0.0343
GWN0115	10/13/1999	9.50		1.494	0.0202
GWN0115	6/28/2004	9.60			
GWN0115	10/7/2004	9.60			
GWN0115	10/8/2002	9.70	0.75	1.179	0.0193
GWN0115	10/7/2003	9.70			
GWN0115	11/13/2003	9.70			
GWN0115	5/19/2005	9.70			
GWN0115	10/18/2005	9.70			
GWN0115	10/21/2003	9.80			
GWN0115	10/21/2004	9.80			
GWN0115	4/22/2003	9.90	2.99	1.632	0.0112
GWN0115	4/22/2003	9.90			
GWN0115	5/20/2003	9.90	1.25	1.804	0.0230
GWN0115	5/20/2003	9.90			
GWN0115	10/21/2003	9.90		1.799	0.0158
GWN0115	11/20/2003	9.90			



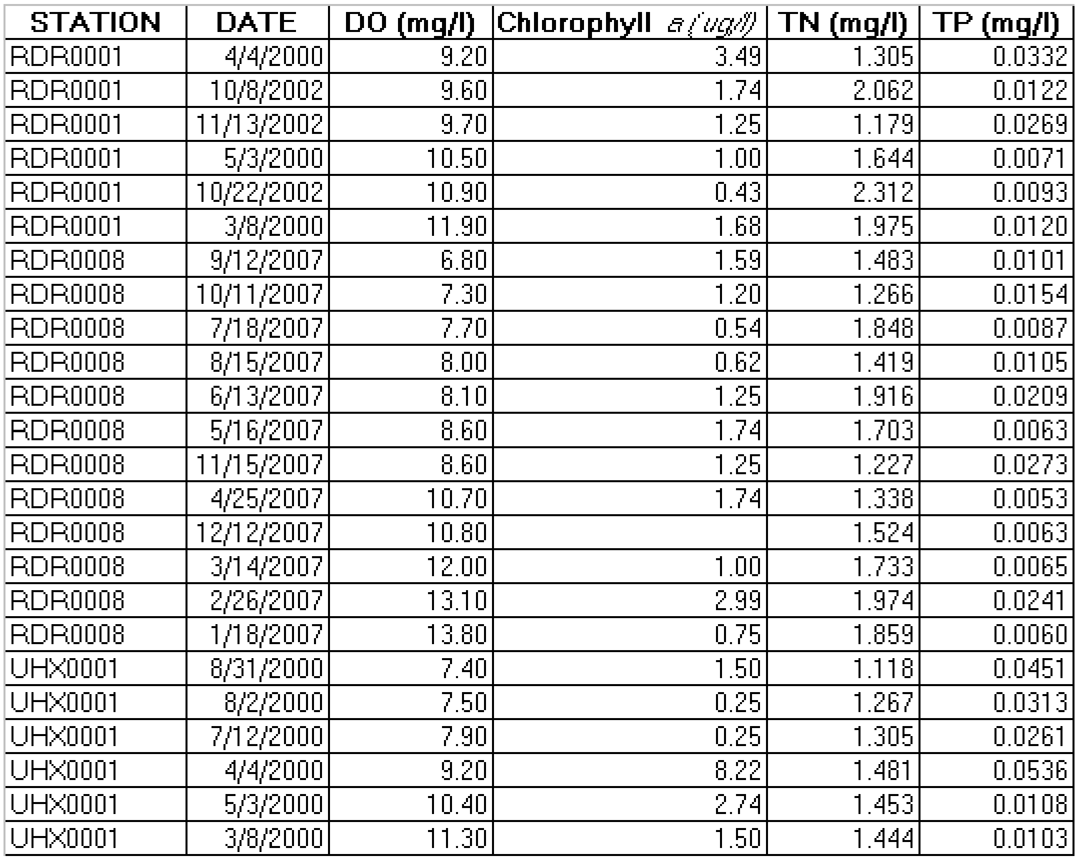
STATION	DATE	DO (mg/l)	Chlorophyll *a* (ug/l)	TN (mg/l)	TP (mg/l)
GWN0115	5/6/2003	10.40	4.27	1.904	0.0142
GWN0115	5/6/2003	10.40			
GWN0115	10/26/2004	10.50			
GWN0115	10/26/1999	10.60		1.773	0.0132
GWN0115	10/7/2003	10.60		2.025	0.0109
GWN0115	10/22/2002	10.90		1.595	0.0147
GWN0115	1/5/2005	10.90			
GWN0115	3/18/2003	11.10	2.49	1.600	0.0151
GWN0115	4/13/2004	11.10			
GWN0115	4/13/2004	11.10			
GWN0115	11/10/2004	11.10			
GWN0115	12/8/2004	11.10			
GWN0115	12/1/2005	11.10			
GWN0115	12/14/1999	11.20	3.99	1.264	0.1183
GWN0115	4/8/2004	11.20			
GWN0115	1/11/2000	11.30	1.99	1.364	0.0388
GWN0115	11/2/2005	11.30			
GWN0115	3/8/2004	11.40			
GWN0115	5/5/2005	11.40			
GWN0115	11/16/1999	11.50	0.43	1.510	0.0105
GWN0115	12/11/2003	11.50			
GWN0115	12/11/2003	11.50			
GWN0115	11/22/2004	11.50			
GWN0115	2/29/2000	11.60	2.49	1.577	0.0249
GWN0115	10/28/2005	11.60			
GWN0115	3/4/2004	11.80			
GWN0115	11/18/2005	11.80			
GWN0115	11/25/2002	12.20		1.896	0.0154
GWN0115	3/18/2003	12.30			
GWN0115	1/13/2005	12.30			
GWN0115	4/14/2005	12.30			
GWN0115	11/30/1999	12.50	1.00	1.355	0.0191
GWN0115	3/8/2000	12.50	1.74	1.976	0.0103
GWN0115	3/8/2000	12.50	1.74	1.966	0.0099
GWN0115	2/4/2003	12.50	11.96	2.442	0.1502
GWN0115	2/4/2003	12.50			
GWN0115	12/18/2003	12.60			
GWN0115	2/10/2004	12.60			
GWN0115	2/14/2005	12.60			
GWN0115	12/17/2002	12.70		1.691	0.0141
GWN0115	2/23/2000	12.80	0.75	1.966	0.0092
GWN0115	3/4/2003	13.00			
GWN0115	2/22/2005	13.00			
GWN0115	3/4/2003	13.10		1.884	0.0177
GWN0115	2/25/2004	13.10			
GWN0115	3/16/2005	13.10			
GWN0115	12/3/2002	13.20		1.856	0.0075



STATION	DATE	DO (mg/l)	Chlorophyll *a* (ug/l)	TN (mg/l)	TP (mg/l)
GWN0115	1/7/2003	13.30		1.962	0.0143
GWN0115	1/7/2003	13.30			
GWN0115	1/24/2000	13.40		2.445	0.0061
GWN0115	2/20/2004	13.40			
GWN0115	12/20/2004	13.40			
GWN0115	3/18/2004	13.60			
GWN0115	12/4/2003	13.70			
GWN0115	1/29/2004	13.70			
GWN0115	12/15/2004	13.70			
GWN0115	1/20/2005	13.80			
GWN0115	12/15/2005	13.90			
GWN0115	1/8/2004	14.00			
GWN0115	2/2/2005	14.00			
GWN0115	1/22/2003	14.20	0.25	2.296	0.0076
GWN0115	1/22/2003	14.20			
GWN0115	1/23/2004	14.80			
GWN0125	8/31/2000	7.10	1.25	1.468	0.0362
GWN0125	8/2/2000	7.70	1.99	1.650	0.0387
GWN0125	7/12/2000	8.10	1.00	1.821	0.0204
GWN0125	4/4/2000	8.80	5.48	1.762	0.0416
GWN0125	5/3/2000	9.60	1.00	1.924	0.0128
GWN0125	3/8/2000	11.70	1.28	2.082	0.0094
GWN0160	8/5/2003	7.40	2.14	2.101	0.0284
GWN0160	8/2/2000	7.60	1.00	1.742	0.0345
GWN0160	7/22/2003	7.60		2.433	0.0182
GWN0160	8/31/2000	7.70	2.49	1.654	0.0325
GWN0160	7/8/2003	7.70	1.00	2.022	0.0226
GWN0160	8/26/2003	7.80	1.25	2.203	0.0165
GWN0160	9/23/2003	7.80		1.622	0.1879
GWN0160	7/12/2000	8.10	0.75	2.175	0.0184
GWN0160	8/19/2003	8.10	2.49	1.986	0.0247
GWN0160	6/24/2003	8.30		2.153	0.0316
GWN0160	9/9/2003	8.30	0.93	2.157	0.0162
GWN0160	6/17/2003	8.80		2.139	0.0292
GWN0160	4/4/2000	9.10	6.98	1.805	0.0502
GWN0160	6/3/2003	9.40	0.25	2.363	0.0199
GWN0160	10/21/2003	9.80	0.64	2.179	0.0170
GWN0160	5/20/2003	9.90		1.990	0.0219
GWN0160	5/3/2000	10.00	1.50	2.105	0.0120
GWN0160	10/7/2003	10.30	0.85	2.338	0.0135
GWN0160	5/6/2003	10.60	4.06	2.097	0.0137
GWN0160	4/22/2003	11.00	2.99	1.963	0.0135
GWN0160	3/18/2003	11.80	2.49	1.911	0.0163
GWN0160	3/8/2000	12.10	2.06	2.339	0.0100
GWN0160	12/17/2002	12.50		1.983	0.0125
GWN0160	11/25/2002	12.60		2.326	0.0104
GWN0160	12/3/2002	13.20		2.136	0.0068

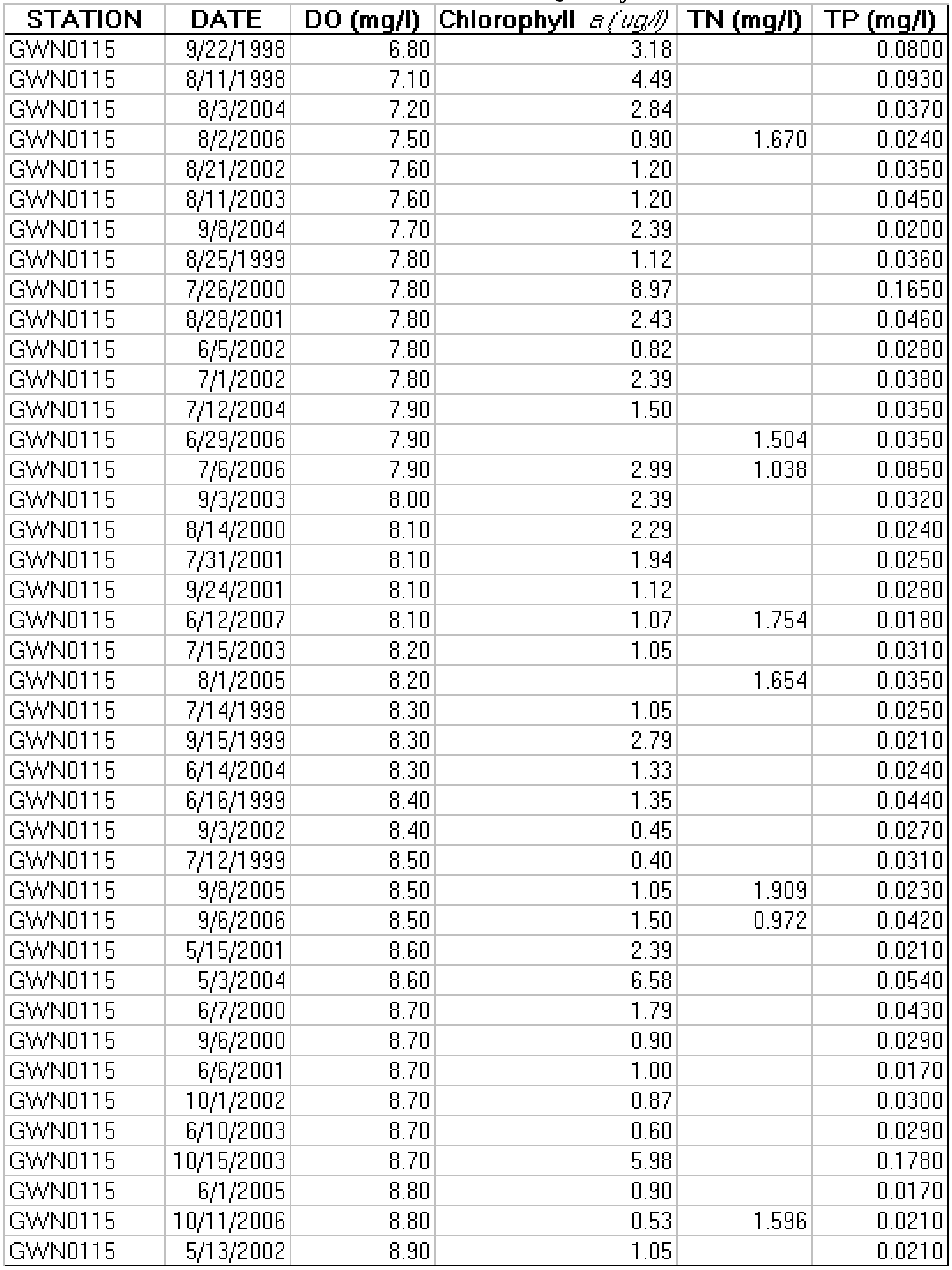


STATION	DATE	DO (mg/l)	Chlorophyll *a* (ug/l)	TN (mg/l)	TP (mg/l)
GWN0160	3/4/2003	13.20		2.303	0.0241
GWN0160	2/4/2003	13.30	3.63	2.399	0.0204
GWN0160	1/7/2003	14.50		2.195	0.0126
GWN0160	1/22/2003	15.30	1.50	2.676	0.0071
GWN0179	9/12/2007	6.60	1.89	2.604	0.0172
GWN0179	10/11/2007	7.00	0.75	1.928	0.0249
GWN0179	6/13/2007	7.80	1.74	2.317	0.0510
GWN0179	7/18/2007	8.00	0.82	2.777	0.0160
GWN0179	5/16/2007	8.50	1.99	2.812	0.0103
GWN0179	8/15/2007	8.50	0.62	2.404	0.0119
GWN0179	11/15/2007	9.00	1.25	1.730	0.0325
GWN0179	4/25/2007	10.50	1.99	2.399	0.0061
GWN0179	12/12/2007	10.90		2.017	0.0084
GWN0179	3/14/2007	12.30	2.24	2.772	0.0076
GWN0179	2/26/2007	12.90	2.49	2.252	0.0414
GWN0179	1/18/2007	13.70		2.895	0.0063
GWN0186	8/2/2000	7.80	1.50	2.119	0.0417
GWN0186	8/31/2000	8.20	1.25	2.064	0.0366
GWN0186	7/12/2000	8.50	0.75	2.706	0.0198
GWN0186	10/8/2002	9.20	1.25	1.730	0.0159
GWN0186	4/4/2000	9.40	4.98	1.774	0.0367
GWN0186	11/13/2002	9.80	0.50	0.976	0.0258
GWN0186	5/3/2000	10.00	1.25	2.579	0.0120
GWN0186	10/22/2002	10.90	0.21	2.174	0.0117
GWN0186	3/8/2000	11.50	1.31	2.697	0.0084
GWN0215	8/31/2000	8.00	0.25	2.176	0.0299
GWN0215	5/24/2000	8.50	2.24	1.999	0.0532
GWN0215	7/12/2000	8.50	0.50	2.704	0.0197
GWN0215	8/2/2000	8.50	1.50	2.043	0.0575
GWN0215	6/20/2000	8.80		2.480	0.0248
GWN0215	4/4/2000	9.20	3.99	1.508	0.0310
GWN0215	10/13/1999	9.60		2.356	0.0174
GWN0215	5/3/2000	10.00	1.25	2.578	0.0117
GWN0215	10/26/1999	10.50		2.357	0.0065
GWN0215	11/16/1999	11.00	1.28	2.182	0.0136
GWN0215	1/11/2000	11.10		1.834	0.0230
GWN0215	12/14/1999	11.20	2.99	1.297	0.1328
GWN0215	3/8/2000	11.20	0.93	2.701	0.0086
GWN0215	2/29/2000	11.70	1.74	2.148	0.0225
GWN0215	11/30/1999	12.20	0.25	2.334	0.0134
GWN0215	2/23/2000	12.40	1.05	2.613	0.0072
GWN0215	1/24/2000	13.20		2.820	0.0057
MCR0001	4/4/2000	8.90	3.49	1.793	0.0706
MCR0001	3/8/2000	11.20	6.48	1.520	0.0475
RDR0001	8/2/2000	7.60	1.00	1.772	0.0325
RDR0001	8/31/2000	7.60	1.74	1.545	0.0321
RDR0001	7/12/2000	8.10	1.00	1.865	0.0124

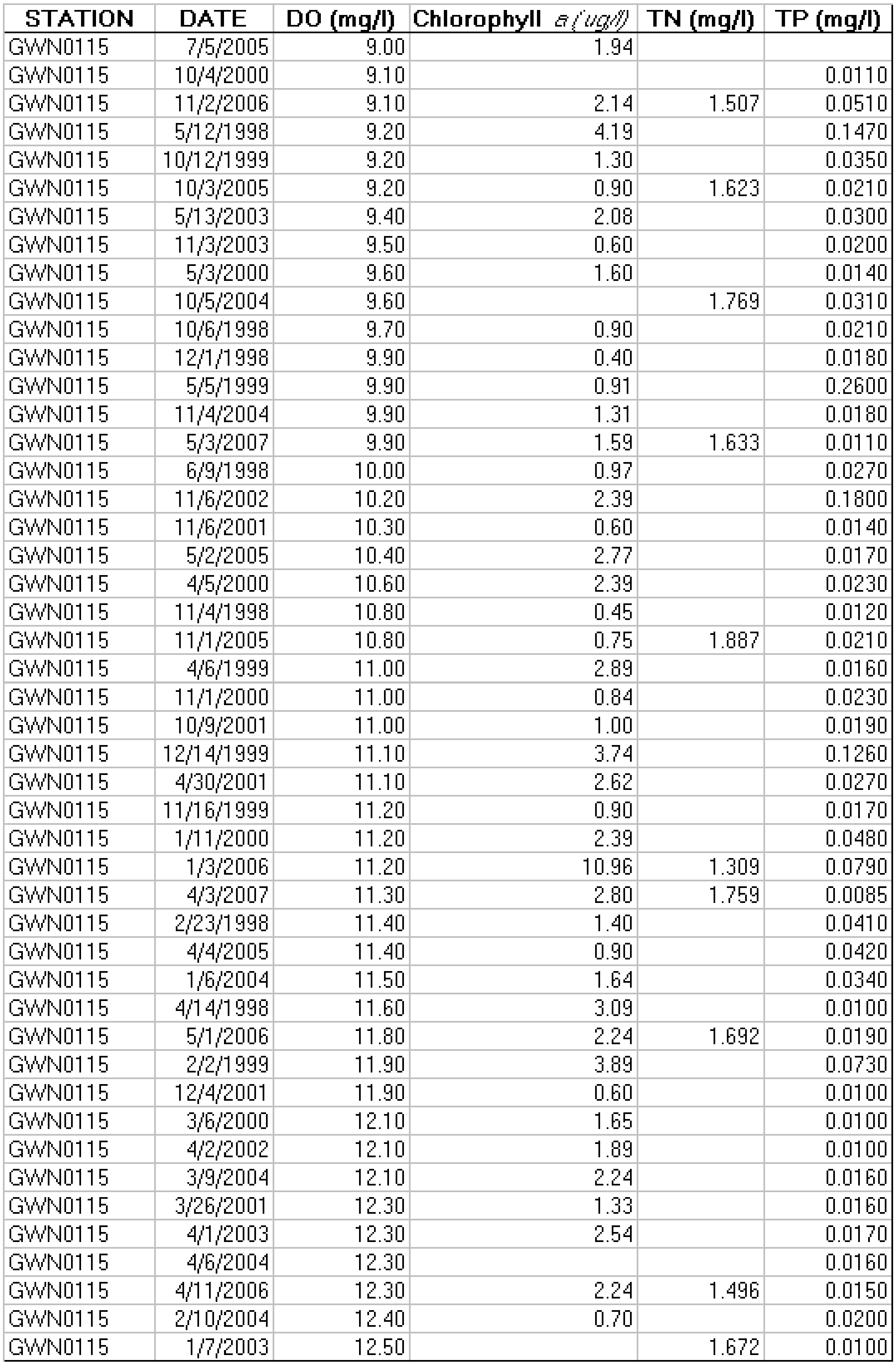


STATION	DATE	DO (mg/l)	Chlorophyll *a* (ug/l)	TN (mg/l)	TP (mg/l)
RDR0001	4/4/2000	9.20	3.49	1.305	0.0332
RDR0001	10/8/2002	9.60	1.74	2.062	0.0122
RDR0001	11/13/2002	9.70	1.25	1.179	0.0269
RDR0001	5/3/2000	10.50	1.00	1.644	0.0071
RDR0001	10/22/2002	10.90	0.43	2.312	0.0093
RDR0001	3/8/2000	11.90	1.68	1.975	0.0120
RDR0008	9/12/2007	6.80	1.59	1.483	0.0101
RDR0008	10/11/2007	7.30	1.20	1.266	0.0154
RDR0008	7/18/2007	7.70	0.54	1.848	0.0087
RDR0008	8/15/2007	8.00	0.62	1.419	0.0105
RDR0008	6/13/2007	8.10	1.25	1.916	0.0209
RDR0008	5/16/2007	8.60	1.74	1.703	0.0063
RDR0008	11/15/2007	8.60	1.25	1.227	0.0273
RDR0008	4/25/2007	10.70	1.74	1.338	0.0053
RDR0008	12/12/2007	10.80		1.524	0.0063
RDR0008	3/14/2007	12.00	1.00	1.733	0.0065
RDR0008	2/26/2007	13.10	2.99	1.974	0.0241
RDR0008	1/18/2007	13.80	0.75	1.859	0.0060
UHX0001	8/31/2000	7.40	1.50	1.118	0.0451
UHX0001	8/2/2000	7.50	0.25	1.267	0.0313
UHX0001	7/12/2000	7.90	0.25	1.305	0.0261
UHX0001	4/4/2000	9.20	8.22	1.481	0.0536
UHX0001	5/3/2000	10.40	2.74	1.453	0.0108
UHX0001	3/8/2000	11.30	1.50	1.444	0.0103

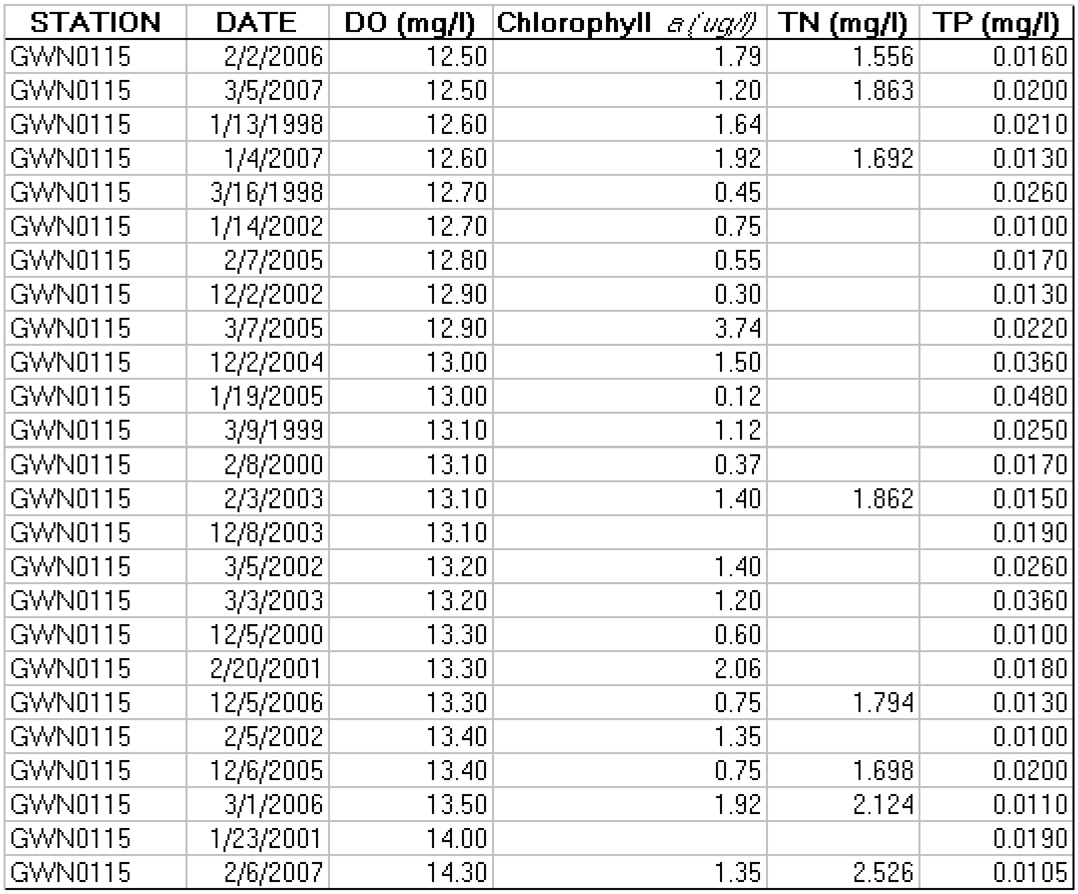
Table A-2: DNR Water Quality Data



STATION	DATE	DO (mg/l)	Chlorophyll *a (ug/l)*	TN (mg/l)	TP (mg/l)
GWN0115	9/22/1998	6.80	3.18		0.0800
GWN0115	8/11/1998	7.10	4.49		0.0930
GWN0115	8/3/2004	7.20	2.84		0.0370
GWN0115	8/2/2006	7.50	0.90	1.670	0.0240
GWN0115	8/21/2002	7.60	1.20		0.0350
GWN0115	8/11/2003	7.60	1.20		0.0450
GWN0115	9/8/2004	7.70	2.39		0.0200
GWN0115	8/25/1999	7.80	1.12		0.0360
GWN0115	7/26/2000	7.80	8.97		0.1650
GWN0115	8/28/2001	7.80	2.43		0.0460
GWN0115	6/5/2002	7.80	0.82		0.0280
GWN0115	7/1/2002	7.80	2.39		0.0380
GWN0115	7/12/2004	7.90	1.50		0.0350
GWN0115	6/29/2006	7.90		1.504	0.0350
GWN0115	7/6/2006	7.90	2.99	1.038	0.0850
GWN0115	9/3/2003	8.00	2.39		0.0320
GWN0115	8/14/2000	8.10	2.29		0.0240
GWN0115	7/31/2001	8.10	1.94		0.0250
GWN0115	9/24/2001	8.10	1.12		0.0280
GWN0115	6/12/2007	8.10	1.07	1.754	0.0180
GWN0115	7/15/2003	8.20	1.05		0.0310
GWN0115	8/1/2005	8.20		1.654	0.0350
GWN0115	7/14/1998	8.30	1.05		0.0250
GWN0115	9/15/1999	8.30	2.79		0.0210
GWN0115	6/14/2004	8.30	1.33		0.0240
GWN0115	6/16/1999	8.40	1.35		0.0440
GWN0115	9/3/2002	8.40	0.45		0.0270
GWN0115	7/12/1999	8.50	0.40		0.0310
GWN0115	9/8/2005	8.50	1.05	1.909	0.0230
GWN0115	9/6/2006	8.50	1.50	0.972	0.0420
GWN0115	5/15/2001	8.60	2.39		0.0210
GWN0115	5/3/2004	8.60	6.58		0.0540
GWN0115	6/7/2000	8.70	1.79		0.0430
GWN0115	9/6/2000	8.70	0.90		0.0290
GWN0115	6/6/2001	8.70	1.00		0.0170
GWN0115	10/1/2002	8.70	0.87		0.0300
GWN0115	6/10/2003	8.70	0.60		0.0290
GWN0115	10/15/2003	8.70	5.98		0.1780
GWN0115	6/1/2005	8.80	0.90		0.0170
GWN0115	10/11/2006	8.80	0.53	1.596	0.0210
GWN0115	5/13/2002	8.90	1.05		0.0210

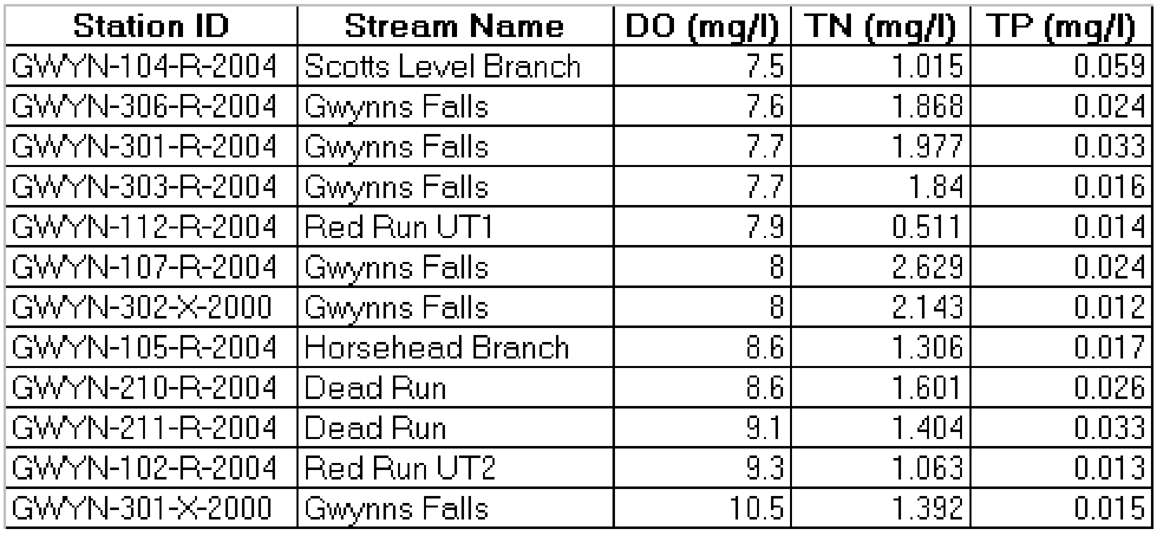


STATION	DATE	DO (mg/l)	Chlorophyll *a (ug/l)*	TN (mg/l)	TP (mg/l)
GWN0115	7/5/2005	9.00	1.94		
GWN0115	10/4/2000	9.10			0.0110
GWN0115	11/2/2006	9.10	2.14	1.507	0.0510
GWN0115	5/12/1998	9.20	4.19		0.1470
GWN0115	10/12/1999	9.20	1.30		0.0350
GWN0115	10/3/2005	9.20	0.90	1.623	0.0210
GWN0115	5/13/2003	9.40	2.08		0.0300
GWN0115	11/3/2003	9.50	0.60		0.0200
GWN0115	5/3/2000	9.60	1.60		0.0140
GWN0115	10/5/2004	9.60		1.769	0.0310
GWN0115	10/6/1998	9.70	0.90		0.0210
GWN0115	12/1/1998	9.90	0.40		0.0180
GWN0115	5/5/1999	9.90	0.91		0.2600
GWN0115	11/4/2004	9.90	1.31		0.0180
GWN0115	5/3/2007	9.90	1.59	1.633	0.0110
GWN0115	6/9/1998	10.00	0.97		0.0270
GWN0115	11/6/2002	10.20	2.39		0.1800
GWN0115	11/6/2001	10.30	0.60		0.0140
GWN0115	5/2/2005	10.40	2.77		0.0170
GWN0115	4/5/2000	10.60	2.39		0.0230
GWN0115	11/4/1998	10.80	0.45		0.0120
GWN0115	11/1/2005	10.80	0.75	1.887	0.0210
GWN0115	4/6/1999	11.00	2.89		0.0160
GWN0115	11/1/2000	11.00	0.84		0.0230
GWN0115	10/9/2001	11.00	1.00		0.0190
GWN0115	12/14/1999	11.10	3.74		0.1260
GWN0115	4/30/2001	11.10	2.62		0.0270
GWN0115	11/16/1999	11.20	0.90		0.0170
GWN0115	1/11/2000	11.20	2.39		0.0480
GWN0115	1/3/2006	11.20	10.96	1.309	0.0790
GWN0115	4/3/2007	11.30	2.80	1.759	0.0085
GWN0115	2/23/1998	11.40	1.40		0.0410
GWN0115	4/4/2005	11.40	0.90		0.0420
GWN0115	1/6/2004	11.50	1.64		0.0340
GWN0115	4/14/1998	11.60	3.09		0.0100
GWN0115	5/1/2006	11.80	2.24	1.692	0.0190
GWN0115	2/2/1999	11.90	3.89		0.0730
GWN0115	12/4/2001	11.90	0.60		0.0100
GWN0115	3/6/2000	12.10	1.65		0.0100
GWN0115	4/2/2002	12.10	1.89		0.0100
GWN0115	3/9/2004	12.10	2.24		0.0160
GWN0115	3/26/2001	12.30	1.33		0.0160
GWN0115	4/1/2003	12.30	2.54		0.0170
GWN0115	4/6/2004	12.30			0.0160
GWN0115	4/11/2006	12.30	2.24	1.496	0.0150
GWN0115	2/10/2004	12.40	0.70		0.0200
GWN0115	1/7/2003	12.50		1.672	0.0100



STATION	DATE	DO (mg/l)	Chlorophyll a (ug/l)	TN (mg/l)	TP (mg/l)
GWN0115	2/2/2006	12.50	1.79	1.556	0.0160
GWN0115	3/5/2007	12.50	1.20	1.863	0.0200
GWN0115	1/13/1998	12.60	1.64		0.0210
GWN0115	1/4/2007	12.60	1.92	1.692	0.0130
GWN0115	3/16/1998	12.70	0.45		0.0260
GWN0115	1/14/2002	12.70	0.75		0.0100
GWN0115	2/7/2005	12.80	0.55		0.0170
GWN0115	12/2/2002	12.90	0.30		0.0130
GWN0115	3/7/2005	12.90	3.74		0.0220
GWN0115	12/2/2004	13.00	1.50		0.0360
GWN0115	1/19/2005	13.00	0.12		0.0480
GWN0115	3/9/1999	13.10	1.12		0.0250
GWN0115	2/8/2000	13.10	0.37		0.0170
GWN0115	2/3/2003	13.10	1.40	1.862	0.0150
GWN0115	12/8/2003	13.10			0.0190
GWN0115	3/5/2002	13.20	1.40		0.0260
GWN0115	3/3/2003	13.20	1.20		0.0360
GWN0115	12/5/2000	13.30	0.60		0.0100
GWN0115	2/20/2001	13.30	2.06		0.0180
GWN0115	12/5/2006	13.30	0.75	1.794	0.0130
GWN0115	2/5/2002	13.40	1.35		0.0100
GWN0115	12/6/2005	13.40	0.75	1.698	0.0200
GWN0115	3/1/2006	13.50	1.92	2.124	0.0110
GWN0115	1/23/2001	14.00			0.0190
GWN0115	2/6/2007	14.30	1.35	2.526	0.0105

Table A-3: MBSS Water Quality Data



Station ID	Stream Name	DO (mg/l)	TN (mg/l)	TP (mg/l)
GWYN-104-R-2004	Scotts Level Branch	7.5	1.015	0.059
GWYN-306-R-2004	Gwynns Falls	7.6	1.868	0.024
GWYN-301-R-2004	Gwynns Falls	7.7	1.977	0.033
GWYN-303-R-2004	Gwynns Falls	7.7	1.84	0.016
GWYN-112-R-2004	Red Run UT1	7.9	0.511	0.014
GWYN-107-R-2004	Gwynns Falls	8	2.629	0.024
GWYN-302-X-2000	Gwynns Falls	8	2.143	0.012
GWYN-105-R-2004	Horsehead Branch	8.6	1.306	0.017
GWYN-210-R-2004	Dead Run	8.6	1.601	0.026
GWYN-211-R-2004	Dead Run	9.1	1.404	0.033
GWYN-102-R-2004	Red Run UT2	9.3	1.063	0.013
GWYN-301-X-2000	Gwynns Falls	10.5	1.392	0.015

APPENDIX J:

Watershed Report for Biological Impairment of the Gwynns Falls Watershed in Baltimore City and Baltimore County, Maryland Biological Stressor Identification Analysis Results and Interpretation

Watershed Report for Biological Impairment of the Gwynns Falls Watershed in Baltimore City and Baltimore County, Maryland
Biological Stressor Identification Analysis Results and Interpretation

REVISED FINAL

MARYLAND
DEPARTMENT OF THE ENVIRONMENT
1800 Washington Boulevard, Suite 540
Baltimore, Maryland 21230-1718

Submitted to:

Water Protection Division
U.S. Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

June 2009
Revised: February 2012

Table of Contents

List of Figures

List of Tables

List of Abbreviations

AR	Attributable Risk
BIBI	Benthic Index of Biotic Integrity
BSID	Biological Stressor Identification
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
DO	Dissolved Oxygen
FIBI	Fish Index of Biologic Integrity
IBI	Index of Biotic Integrity
MDDNR	Maryland Department of Natural Resources
MDE	Maryland Department of the Environment
MBSS	Maryland Biological Stream Survey
mg/L	Milligrams per liter
NPDES	National Pollutant Discharge Elimination System
SSA	Science Services Administration
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
WQA	Water Quality Analysis
WQLS	Water Quality Limited Segment

Executive Summary

Section 303(d) of the federal Clean Water Act (CWA) and the United States Environmental Protection Agency's (USEPA) 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), 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.

Gwynns Falls, located in Baltimore County and Baltimore City was identified in Maryland's Integrated Report as impaired by nutrients, sediments (1996 listings), bacteria (fecal coliform) , and combination benthic/fishes bio-assessment (2002 listings) (MDE 2008). All impairments are listed for non-tidal streams. The 1996 nutrient listing was refined in the 2008 Integrated Report and phosphorus was identified as the specific impairing substance. Similarly, the 1996 sediments listing was refined in the 2008 Integrated Report to a listing for total suspended solids. A TMDL addressing the 2002 bacteria impairment was approved by the USEPA in 2008.

In 2002, the State began listing biological impairments on the Integrated Report. The current Maryland Department of Environment (MDE) biological assessment methodology assesses and lists only at the Maryland 8-digit watershed scale, which maintains consistency with how other listings on the Integrated Report are made, how TMDLs are developed, and how implementation is targeted. The listing methodology assesses the condition of Maryland 8-digit watersheds with multiple impacted sites by measuring the percentage of stream miles that have an Index of Biotic Integrity (IBI) score less than 3, and calculating whether this is significant from a reference condition watershed (i.e., healthy stream, <10% stream miles degraded).

The Maryland Surface Water Use Designation in the Code of Maryland Regulations (COMAR) for Gwynns Falls are as follows: Gwynns Falls and tributaries above Reisterstown Road – Use III - *Nontidal Cold Water*; Dead Run and tributaries – Use IV - *Recreational Trout Waters* (COMAR 2009 a,b,c,d) . In addition, COMAR requires these waterbodies to support at a minimum the Use I designation - *water contact recreation, and protection of nontidal warmwater aquatic life*. The Gwynns Falls watershed is not attaining its designated use of supporting aquatic life because of biological impairments. As an indicator of designated use attainment, MDE uses Benthic and Fish Indices of Biotic Integrity (BIBI/FIBI) developed by the Maryland Department of Natural Resources Maryland Biological Stream Survey (MDDNR MBSS).

The current listings for biological impairments represent degraded biological conditions for which the stressors, or causes, are unknown. The MDE Science Services Administration (SSA) has developed a biological stressor identification (BSID) analysis that uses a case-control, risk-based approach to systematically and objectively determine the predominant cause of reduced biological conditions, thus enabling the Department to most effectively direct corrective management action(s). The risk-based approach, adapted from the field of epidemiology,

estimates the strength of association between various stressors, sources of stressors and the biological community, and the likely impact these stressor have on the degraded sites in the watershed.

The BSID analysis uses data available from the statewide MDDNR MBSS. Once the BSID analysis is completed, a number of stressors (pollutants) may be identified as probable or unlikely causes of poor biological conditions within the Maryland 8-digit watershed study. BSID analysis results can be used as guidance to refine biological impairment listings in the Integrated Report by specifying the probable stressors and sources linked to biological degradation.

This Gwynns Falls watershed report presents a brief discussion of the BSID process on which the watershed analysis is based, and may be reviewed in more detail in the report entitled *Maryland Biological Stressor Identification Process* (MDE 2009). Data suggest that the degradation of biological communities in the Gwynns Falls is strongly associated with urban land use and its concomitant effects: altered hydrology and elevated levels of ammonia, chlorides, and conductivity (a measure of the presence of dissolved substances). The urbanization of landscapes creates broad and interrelated forms of degradation (i.e., hydrological, morphological, and water chemistry) that can affect stream ecology and biological composition. Peer-reviewed scientific literature establishes a link between highly urbanized landscapes and degradation in the aquatic health of non-tidal stream ecosystems.

The results of the BSID analysis, and the probable causes and sources of the biological impairments in the Gwynns Falls, can be summarized as follows:

- The BSID analysis has determined that the biological communities are likely degraded due to inorganic pollutants (i.e., chlorides and conductivity). Inorganic pollutants levels are significantly associated with degraded biological conditions and found in approximately 76% of the stream miles with very poor to poor biological conditions in the Gywnns Falls watershed. Impacts on water quality due to conductivity and chlorides are dependent on prolonged exposure; future monitoring of these inorganic pollutants will help in determining the spatial and temporal extent of this impairment in the watershed. Impervious surfaces and urban runoff cause an increase in contaminant loads from point and nonpoint sources by delivering an array of inorganic pollutants to surface waters. Currently, there is a lack of monitoring data for many of these substances; therefore, additional monitoring of priority inorganic pollutants is needed to more precisely determine the specific cause(s) of impairment.
- The BSID analysis has determined that the biological communities in Gwynns Falls are also likely degraded due to flow/sediment related stressors. Specifically, altered hydrology and increased runoff from urban impervious surfaces have resulted in channel erosion and subsequent elevated suspended sediment transport through the watershed, which are in turn the probable causes of impacts to biological communities. The BSID results thus confirm the 1996 Category 5 listing for total suspended solids as an

impairing substance in Gwynns Falls, and link this pollutant to biological conditions in these waters.

- The BSID process has also determined that biological communities in the Gwynns Falls watershed are likely degraded due to anthropogenic channelization of stream segments. MDE considers channelization to be a form of pollution not a pollutant; therefore, a Category 5 listing for this stressor is inappropriate. However, Category 4c is for waterbody segments where the State can demonstrate that the failure to meet applicable water quality standards is a result of pollution. Category 4c listings include segments impaired due to stream channelization or the lack of adequate flow. MDE recommends a Category 4c listing for the Gwynns Falls watershed based on channelization being present in approximately 34% of degraded stream miles.
- The BSID analysis has identified one water chemistry stressor present (ammonia) at two sites showing a possible association with degraded biological conditions. A more intensive analysis of all available data is recommended to determine if there is an ammonia toxicity impairment in the Gwynns Falls watershed.
- Although there is presently a Category 5 listing for phosphorus in Maryland’s 2008 Integrated Report, the BSID analysis did not identify any nutrient stressors (i.e., total nitrogen, total phosphorus, dissolved oxygen, etc.) present and/or nutrient stressors showing a significant association with degraded biological conditions.

1.0 Introduction

Section 303(d) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (USEPA) 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), 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. In 2002, the State began listing biological impairments on the Integrated Report. Maryland Department of the Environment (MDE) has developed a biological assessment methodology to support the determination of proper category placement for 8-digit watershed listings.

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 guides the assignment of biological condition to Integrated Report categories. In the data quality review step, available relevant data are reviewed to ensure they meet the biological listing methodology criteria of the Integrated Report (MDE 2008). In the vetting process, an established set of rules is used to guide the removal of sites that are not applicable for listing decisions (e.g., tidal or black water streams). The final principal database contains all biological sites considered valid for use in the listing process. In the watershed assessment step, a watershed is evaluated based on a comparison to a reference condition (i.e., healthy stream, <10% degraded) that accounts for spatial and temporal variability, and establishes a target value for "aquatic life support." During this step of the assessment, a watershed that differs significantly from the reference condition is listed as impaired (Category 5) on the Integrated Report. If a watershed is not determined to differ significantly from the reference condition, the assessment must have an acceptable precision (i.e., margin of error) before the watershed is listed as meeting water quality standards (Category 1 or 2). If the level of precision is not acceptable, the status of the watershed is listed as inconclusive and subsequent monitoring options are considered (Category 3). If a watershed is classified as impaired (Category 5), then a stressor identification analysis is completed to determine if a TMDL is necessary.

The MDE biological stressor identification (BSID) analysis applies a case-control, risk-based approach that uses the principal dataset, with considerations for ancillary data, to identify potential causes of the biological impairment. Identification of stressors responsible for biological impairments was limited to the round two Maryland Department of Natural Resources (MDDNR) Maryland Biological Stream Survey (MBSS) dataset (2000 – 2004) because it provides a broad spectrum of paired data variables (i.e., biological monitoring and stressor information) to best enable a complete stressor analysis. The BSID analysis then links potential causes/stressors with general causal scenarios and concludes with a review for ecological plausibility by State scientists. Once the BSID analysis is completed, one or several stressors (pollutants) may be identified as probable or unlikely causes of the poor biological conditions within the Maryland 8-digit watershed. BSID analysis results can be used together with a variety of water quality analyses to update and/or support the probable causes and sources of biological impairment in the Integrated Report.

The remainder of this report provides a characterization of the Gwynns Falls watershed, and presents the results and conclusions of a BSID analysis of the watershed.

2.0 Gwynns Falls Watershed Characterization

2.1 Location

The Gwynns Falls originates in Glyndon, Baltimore County just south of where Highway 795 ends and turns into Route 128. The River flows southeast through the heavily suburbanized area of Reisterstown and Owings Mills crossing under Rt. 140 and Hwy. 795 in the Owings Mills Industrial Park and Corporate Campus areas. Gwynns Falls continues southeast with Red Run and Horsehead Run tributaries entering the main stem, which roughly flows parallel to Hwy. 795. Gwynns Falls again crosses under Hwy. 795 and then Hwy. 695 roughly flowing southeast and paralleling Hwy. 695. The tributary Scotts Level Branch flows into the main stem, which then crosses under Rt. 26 (Liberty Road) before crossing over the Baltimore County/City line. Gwynns Falls flows through Gwynns Falls Park where the tributary Dead Run joins into the main stem where the river, still flowing in a roughly southeasterly direction, crosses under Rt. 40, Rt. 144, Rt. 1, and Hwy. 95 where the tributary Maidens Choice Run joins it. Gwynns Falls then flows past the Carroll Camden Industrial Area and empties into the Middle Branch of the Patapsco River immediately after crossing under the Hwy. 295 and 95 interchange. The drainage area of the Gwynns Falls watershed is 41,700 acres. The location of the watershed is depicted in Figure 1. The watershed area is located in two of three distinct eco-regions identified in the MBSS Index of Biotic Integrity (IBI) metrics (Southerland et al. 2005) (see Figure 2).

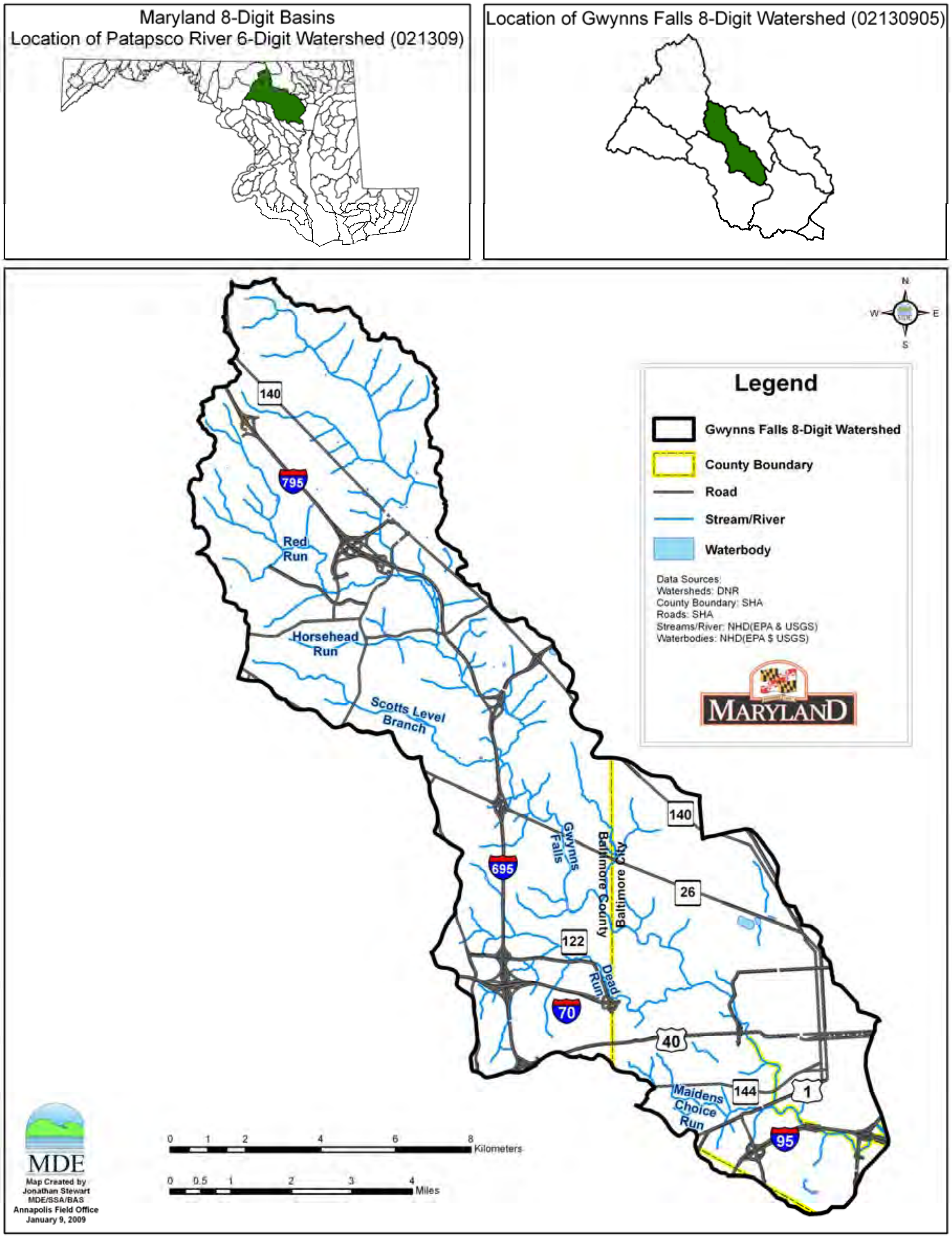


Figure 1. Location Map of the Gwynns Falls Watershed

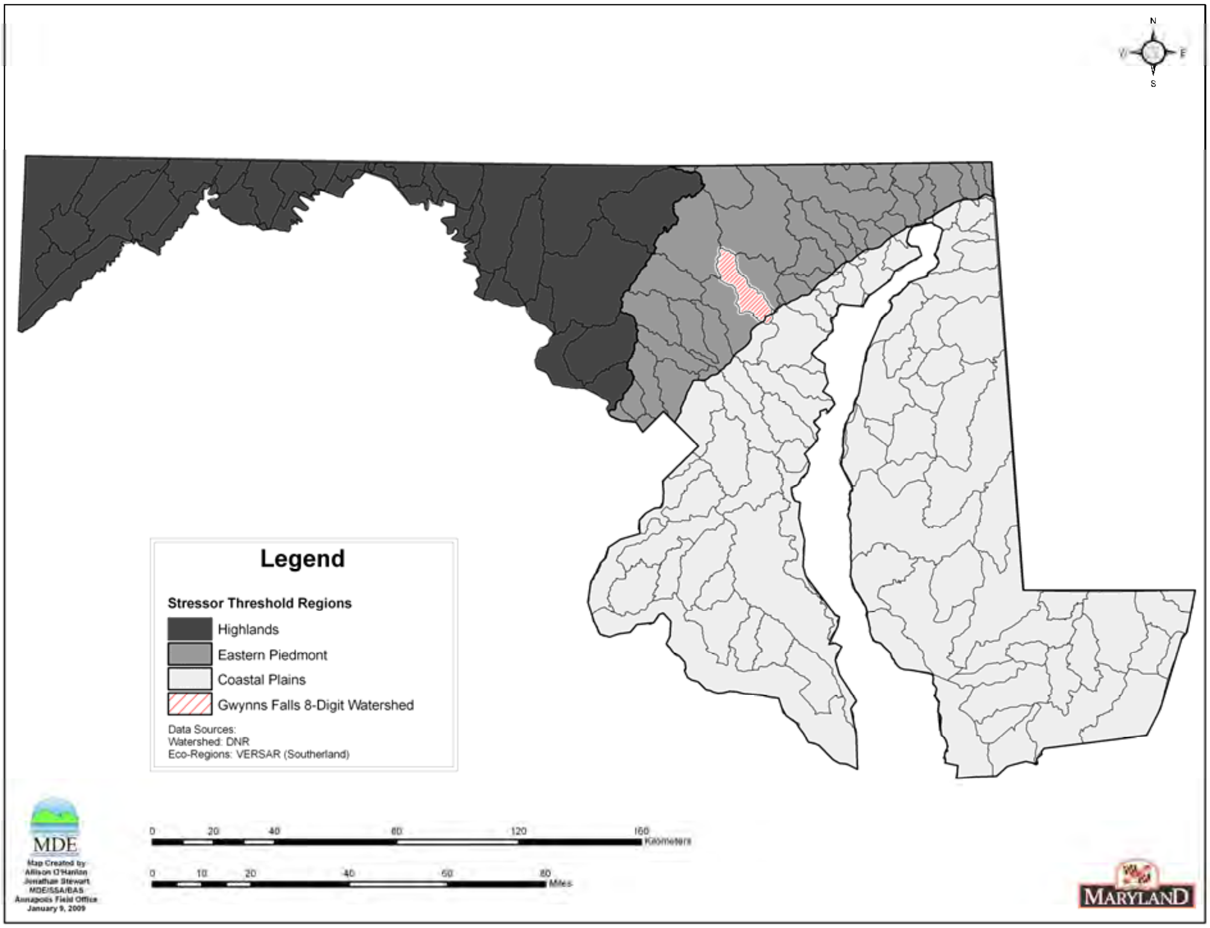


Figure 2. Eco-Region Location Map of Gwynns Falls Watershed

2.2 Land Use

The Gwynns Falls watershed is approximately 41,700 acres in size. The land use in the Gwynns Falls watershed is primarily urban. The watershed contains approximately 33,000 acres (79%)of urban land use. The watershed consists of agricultural land use at 1,400 acres (3%) and 7,000 acres (17%)of forest lands, with the forest found primarily along the main stem and tributaries of Gwynns Falls. Approximately 195 acres of the watershed consist of water. The land use distribution is based on land use/land cover data from the Maryland Department of Planning (MDP 2002). The spatial distributions for each land use are presented in Figure 3 and the land use percentage distribution for the Gwynns Falls watershed is displayed in Figure 4.

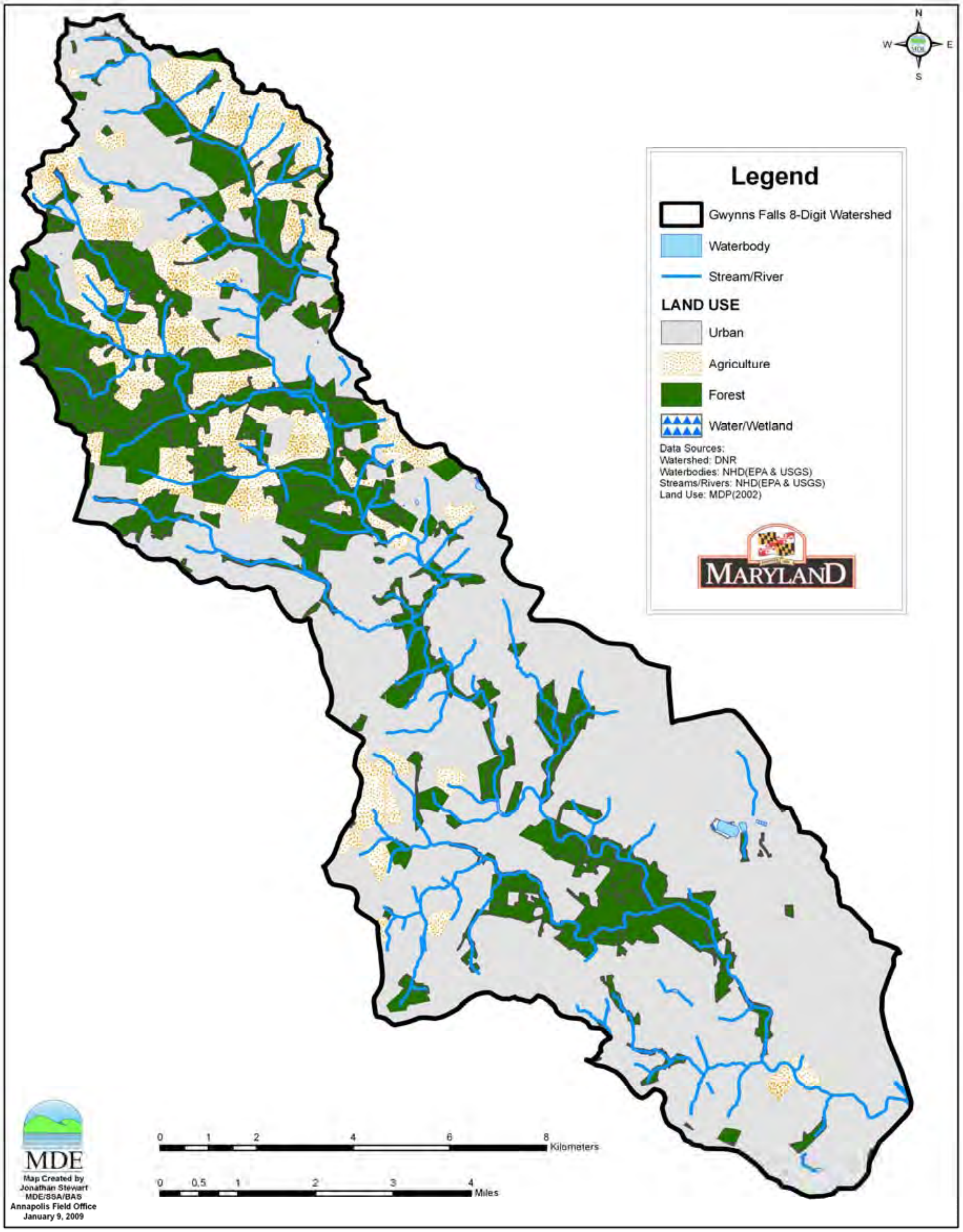


Figure 3. Land Use Map of the Gwynns Falls Watershed

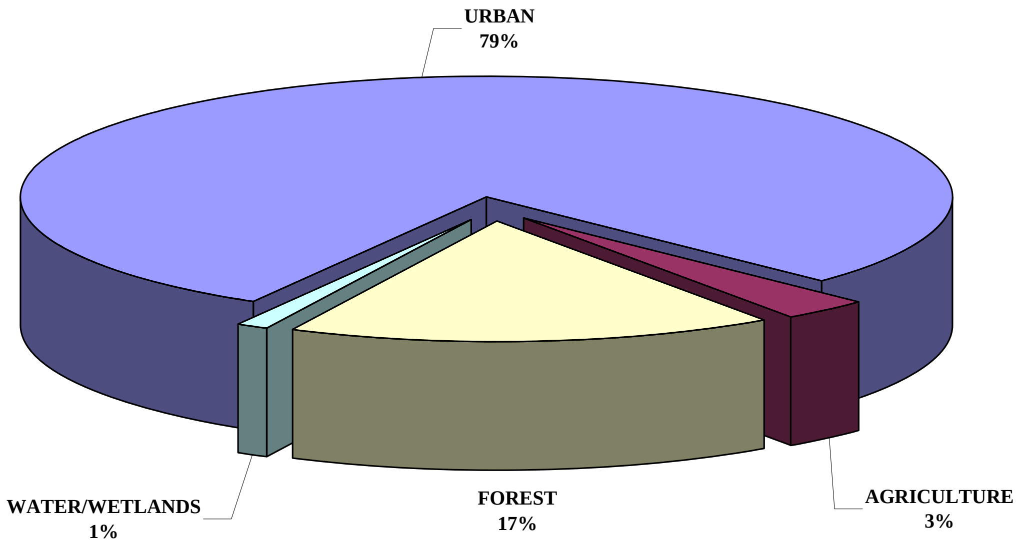


Figure 4. Proportions of Land Use in the Gwynns Falls Watershed

2.3 Soils/hydrology

The Gwynns Falls watershed lies within the Piedmont and Atlantic 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 surface 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 surface geology. The deposits include clays, silts, sands and gravels. In the areas around the head of tide, the topography is flat, with elevations below 100 feet. The elevations steadily increase going north to approximately 600 feet in the headwaters. Streambeds throughout the basin are comprised of rock and rubble with gradually sloped stream banks.

The Gwynns Falls watershed lies predominantly in the Baile and Lehigh soil series. The Lehigh soil series consists of somewhat poorly drained to moderately well drained, rather shallow soils. The Baile soil series consists of deep, poorly drained, nearly level to gently sloping, dominantly gray soils of the Piedmont Plateau (USDA SCS 1977).

3.0 Gwynns Falls Water Quality Characterization

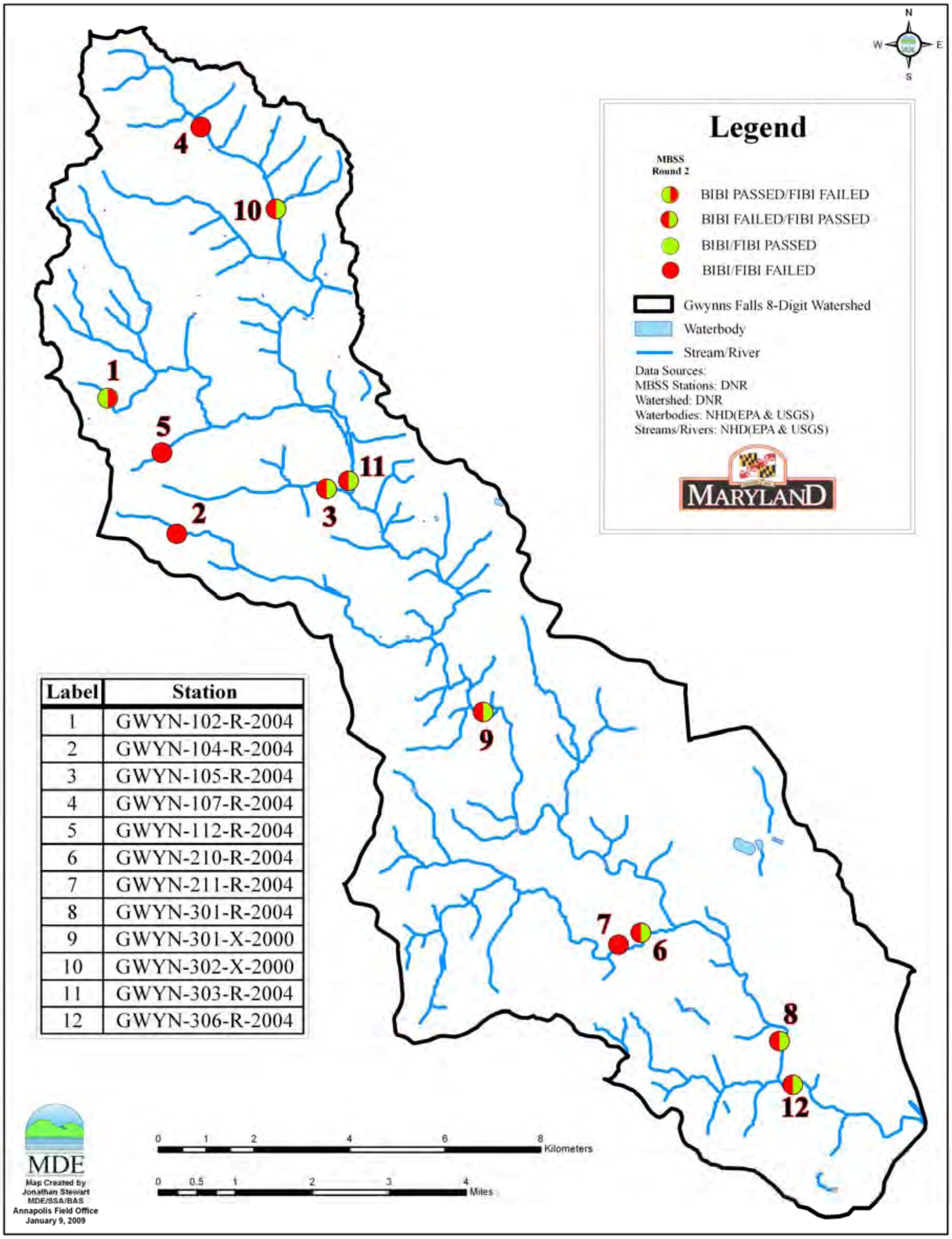
3.1 Integrated Report Impairment Listings

Gwynns Falls was identified in Maryland's Integrated Report as impaired by nutrients, sediments (1996 listings), bacteria (fecal coliform) , and combination benthic/fishes bio-assessment (2002 listings) (MDE 2008). All impairments are listed for non-tidal streams. The 1996 nutrient listing was refined in the 2008 Integrated Report and phosphorus was identified as the specific impairing substance. Similarly, the 1996 sediments listing was refined in the 2008 Integrated Report to a listing for total suspended solids. A TMDL addressing the 2002 bacteria impairment was approved by the USEPA in 2008.

3.2 Biological impairment

The Maryland Surface Water Use Designation in the Code of Maryland Regulations (COMAR) for Gwynns Falls are as follows: Gwynns Falls and tributaries above Reisterstown Road – Use III - *Nontidal Cold Water*; Dead Run and tributaries – Use IV *Recreational Trout Waters* (COMAR 2009 a,b,c,d). In addition, COMAR requires these waterbodies to support at a minimum the Use I designation - *water contact recreation, and protection of nontidal warmwater aquatic life*. 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 Gwynns Falls watershed is listed under Category 5 of the 2008 Integrated Report as impaired for evidence of biological impacts. Approximately 79% of stream miles in the Gwynns Falls watershed are estimated as having benthic and/or fish indices of biological integrity (BIBI/FIBI) in the very poor to poor category. The biological impairment listing is based on the combined results of MDDNR MBSS round one (1995-1997) and round two (2000-2004) data that include twenty-eight stream sites. Twenty-two of the twenty-eight sites have BIBI and or FIBI scores significantly lower than 3.0. The BSID analysis uses the principal data set, containing MBSS Round 2 data only, which includes fifteen sites in the Gwynns Falls watershed. Eleven of the twelve sites have BIBI/FIBI scores significantly lower than 3.0. Figure 5 illustrates the location of principal dataset sites within the Gwynns Falls Watershed.



Label	Station
1	GWYN-102-R-2004
2	GWYN-104-R-2004
3	GWYN-105-R-2004
4	GWYN-107-R-2004
5	GWYN-112-R-2004
6	GWYN-210-R-2004
7	GWYN-211-R-2004
8	GWYN-301-R-2004
9	GWYN-301-X-2000
10	GWYN-302-X-2000
11	GWYN-303-R-2004
12	GWYN-306-R-2004

Figure 5: Gwynns Falls Watershed Primary Dataset Site Locations

4.0 Stressor Identification Results

The BSID process uses results from the BSID data analysis to evaluate each biologically impaired watershed and determine potential stressors and sources. Interpretation of the BSID analysis results is based upon components of Hill's Postulates (Hill 1965), which propose a set of standards that could be used to judge when an association might be causal. The components applied are: 1) the strength of association which is assessed using the odds ratio; 2) the specificity of the association for a specific stressor (risk among controls); 3) the presence of a biological gradient; 4) ecological plausibility which is illustrated through final causal models; and 5) experimental evidence gathered through literature reviews to help support the causal linkage.

The BSID data analysis tests for the strength of association between stressors and degraded biological conditions by determining if there is an increased risk associated with the stressor being present. More specifically, the assessment compares the likelihood that a stressor is present, given that there is a degraded biological condition, by using the ratio of the incidence within the case group as compared to the incidence in the control group (odds ratio). The case group is defined as the sites within the assessment unit with BIBI/FIBI scores significantly lower than 3.0 (i.e., poor to very poor) The controls are sites with similar physiographic characteristics (Highland, Eastern Piedmont, and Coastal region), and stream order for habitat parameters (two groups – 1st and 2nd-4th order), that have good biological conditions.

The common odds ratio confidence interval was calculated to determine if the odds ratio was significantly greater than one. The confidence interval was estimated using the Mantel-Haenzel (MH)(1959) approach and is based on the exact method due to the small sample size for cases. A common odds ratio significantly greater than one indicates that there is a statistically significant higher likelihood that the stressor is present when there are very poor to poor biological conditions (cases) than when there are fair to good biological conditions (controls). This result suggests a statistically significant positive association between the stressor and very poor to poor biological conditions and is used to identify potential stressors.

Once potential stressors are identified (i.e., odds ratio significantly greater than one), the risk attributable to each stressor is quantified for all sites with very poor to poor biological conditions within the watershed (i.e., cases). The attributable risk (AR) defined herein is the portion of the cases with very poor to poor biological conditions that are associated with the stressor. The AR is calculated as the difference between the proportion of case sites with the stressor present and the proportion of control sites with the stressor present.

Once the AR is calculated for each possible stressor, the AR for groups of stressors is calculated. Similar to the AR calculation for each stressor, the AR calculation for a group of stressors is also summed over the case sites using the individual site characteristics (i.e., stressors present at that site). The only difference is that the absolute risk for the controls at each site is estimated based on the stressor present at the site that has the lowest absolute risk among the controls.

After determining the AR for each stressor and the AR for groups of stressors, the AR for all potential stressors is calculated. This value represents the proportion of cases, sites in the watershed with poor to very poor biological conditions, which would be improved if the potential stressors were eliminated (Van Sickle and Paulsen 2008). The purpose of this metric is to determine if stressors have been identified for an acceptable proportion of cases (MDE 2009).

Through the BSID data analysis, MDE identified habitat parameters, water chemistry parameters, and potential sources significantly associated with poor to very poor fish and/or benthic biological conditions. As shown in Table 1 through Table 3, parameters from the sediment, habitat, and water chemistry groups are identified as possible biological stressors in Gwynns Falls. Parameters identified as representing possible sources are listed in Table 4 and include various urban land use types. Table 5 shows the summary of combined AR values for the stressor groups in the Gwynns Falls watershed. Table 6 shows the summary of combined AR values for the source groups in the Gwynns Falls watershed.

Table 1. Sediment Biological Stressor Identification Analysis Results for the Gwynns Falls

Parameter Group	Stressor	Total number of sampling sites in watershed with stressor and biological data	Cases (number of sites in watershed with poor to very poor Fish or Benthic IBI)	Controls (Average number of reference sites per strata with fair to good Fish and Benthic	% of case sites with stressor present	% of control sites per strata with stressor present	Possible stressor (Odds of stressor in cases significantly higher than odds of stressors in controls using p<0.1)	Percent of stream miles in watershed with poor to very poor Fish or Benthic IBI impacted by
Sediment	extensive bar formation present	12	11	78	36%	13%	Yes	23%
	moderate bar formation present	12	11	78	64%	43%	No	----
	bar formation present	12	11	78	100%	91%	No	----
	channel alteration marginal to poor	12	11	78	64%	43%	No	----
	channel alteration poor	12	11	78	36%	12%	Yes	24%
	high embeddedness	12	11	78	0%	9%	No	----
	epifaunal substrate marginal to poor	12	11	78	0%	9%	No	----
	epifaunal substrate poor	12	11	78	0%	1%	No	----
	moderate to severe erosion present	12	11	78	18%	60%	No	----
	severe erosion present	12	11	78	0%	13%	No	----
	poor bank stability index	12	11	78	0%	4%	No	----
	silt clay present	12	11	78	100%	100%	No	----

Table 2. Habitat Biological Stressor Identification Analysis Results for the Gwynns Falls

Parameter Group	Stressor	Total number of sampling sites in watershed with stressor and biological data	Cases (number of sites in watershed with poor to very poor Fish or Benthic IBI)	Controls (Average number of reference sites per strata with fair to good Fish and Benthic IBI)	% of case sites with stressor present	% of control sites per strata with stressor present	Possible stressor (Odds of stressor in cases significantly higher than odds of stressors in controls using p<0.1)	Percent of stream miles in watershed with poor to very poor Fish or Benthic IBI impacted by Stressor
In-Stream Habitat	channelization present	12	11	79	45%	11%	Yes	34%
	instream habitat structure marginal to poor	12	11	78	0%	8%	No	----
	instream habitat structure poor	12	11	78	0%	0%	No	----
	pool/glide/eddy quality marginal to poor	12	11	78	18%	32%	No	----
	pool/glide/eddy quality poor	12	11	78	0%	0%	No	----
	riffle/run quality marginal to poor	12	11	78	27%	12%	No	----
	riffle/run quality poor	12	11	78	9%	1%	No	----
	velocity/depth diversity marginal to poor	12	11	78	36%	33%	No	----
	velocity/depth diversity poor	12	11	78	0%	0%	No	----
	concrete/gabion present	12	11	79	18%	2%	Yes	15%
	beaver pond present	12	11	78	0%	3%	No	----
Riparian Habitat	no riparian buffer	12	11	79	36%	21%	No	----
	low shading	12	11	78	0%	8%	No	----

Table 3. Water Chemistry Biological Stressor Identification Analysis Results for the Gwynns Falls

Parameter Group	Stressor	Total number of sampling sites in watershed with stressor and biological data	Cases (number of sites in watershed with poor to very poor Fish or Benthic IBI)	Controls (Average number of reference sites per strata with fair to good Fish and Benthic IBI)	% of case sites with stressor present	% of control sites per strata with stressor present	Possible stressor (Odds of stressor in cases significantly higher than odds of stressors in controls using p<0.1)	Percent of stream miles in watershed with poor to very poor Fish or Benthic IBI impacted by Stressor
Water Chemistry	high total nitrogen	12	11	165	0%	47%	No	----
	high total dissolved nitrogen	2	2	56	0%	45%	No	----
	ammonia acute with salmonid present	12	11	165	18%	5%	No	----
	ammonia acute with salmonid absent	12	11	165	18%	3%	Yes	15%
	ammonia chronic with salmonid present	12	11	165	18%	15%	No	----
	ammonia chronic with salmonid absent	12	11	165	18%	4%	No	----
	low lab pH	12	11	165	0%	2%	No	----
	high lab pH	12	11	165	0%	2%	No	----
	low field pH	12	11	164	0%	4%	No	----
	high field pH	12	11	164	0%	2%	No	----
	high total phosphorus	12	11	165	0%	6%	No	----
	high orthophosphate	12	11	165	0%	8%	No	----
	dissolved oxygen < 5mg/l	12	11	164	0%	1%	No	----
	dissolved oxygen < 6mg/l	12	11	164	0%	2%	No	----
	low dissolved oxygen saturation	12	11	152	0%	1%	No	----
	high dissolved oxygen saturation	12	11	152	0%	0%	No	----
	acid neutralizing capacity below chronic level	12	11	165	0%	1%	No	----
	acid neutralizing capacity below episodic level	12	11	165	0%	7%	No	----
	high chlorides	12	11	165	82%	5%	Yes	76%
	high conductivity	12	11	165	82%	6%	Yes	76%
	high sulfates	12	11	165	18%	4%	No	----

Table 4. Stressor Source Identification Analysis Results for the Gwynns Falls

Parameter Group	Source	Total number of sampling sites in watershed with stressor and biological data	Cases (number of sites in watershed with poor to very poor Fish or Benthic IBI)	Controls (Average number of reference sites per strata with fair to good Fish and Benthic IBI)	% of case sites with source present	% of control sites per strata with source present	Possible stressor (Odds of stressor in cases significantly higher than odds of sources in controls using p<0.1)	Percent of stream miles in watershed with poor to very poor Fish or Benthic IBI impacted by Source
Sources Urban	high impervious surface in watershed	12	11	164	82%	3%	Yes	79%
	high % of high intensity urban in watershed	12	11	165	100%	16%	Yes	79%
	high % of low intensity urban in watershed	12	11	165	82%	5%	Yes	76%
	high % of transportation in watershed	12	11	165	100%	9%	Yes	91%
	high % of high intensity urban in 60m buffer	12	11	164	82%	4%	Yes	78%
	high % of low intensity urban in 60m buffer	12	11	164	91%	6%	Yes	85%
	high % of transportation in 60m buffer	12	11	164	45%	6%	Yes	39%
Sources Agriculture	high % of agriculture in watershed	12	11	165	0%	22%	No	----
	high % of cropland in watershed	12	11	165	0%	3%	No	----
	high % of pasture/hay in watershed	12	11	165	0%	29%	No	----
	high % of agriculture in 60m buffer	12	11	164	0%	13%	No	----
	high % of cropland in 60m buffer	12	11	164	0%	3%	No	----
	high % of pasture/hay in 60m buffer	12	11	164	0%	23%	No	----
Sources Barren	high % of barren land in watershed	12	11	165	0%	10%	No	----
	high % of barren land in 60m buffer	12	11	164	0%	10%	No	----
Sources Anthropogenic	low % of forest in watershed	12	11	165	73%	8%	Yes	65%
	low % of forest in 60m buffer	12	11	164	82%	9%	Yes	73%

Table 4. Stressor Source Identification Analysis Results for the Gwynns Falls (Cont.)

Parameter Group	Source	Total number of sampling sites in watershed with stressor and biological data	Cases (number of sites in watershed with poor to very poor Fish or Benthic IBI)	Controls (Average number of reference sites per strata with fair to good Fish and Benthic IBI)	% of case sites with source present	% of control sites per strata with source present	Possible stressor (Odds of stressor in cases significantly higher than odds of sources in controls using p<0.1)	Percent of stream miles in watershed with poor to very poor Fish or Benthic IBI impacted by Source
Sources Acidity	atmospheric deposition present	12	11	165	0%	5%	No	----
	AMD acid source present	12	11	165	0%	0%	No	----
	organic acid source present	12	11	165	0%	0%	No	----
	agricultural acid source present	12	11	165	0%	2%	No	----

Table 5. Summary of Combined AR Values for Stressor Groups for the Gwynns Falls Watershed

Parameter Group	Percent of stream miles in watershed with poor to very poor Fish or Benthic IBI impacted by Parameter Group(s) (AR)	
Sediment	24%	94%
In-Stream Habitat	40%	
Riparian Habitat	----	
Water Chemistry	77%	

Table 6. Summary of Combined AR Values for Source Groups for the Gwynns Falls Watershed

Source Group	Percent of stream miles in watershed with poor to very poor Fish or Benthic IBI impacted by Parameter Group(s) (AR)	
Urban	96%	96%
Agriculture		
Barren Land		
Lack of Forest	74%	
Acidity		

Sediment Conditions

BSID analysis results for the Gwynns Falls identified two sediment parameters that have a statistically significant association with poor to very poor stream biological condition: *channel alteration poor, and extensive bar formation present.*

Channel alteration poor was identified as significantly associated with degraded biological conditions in the Gwynns Falls, and found to impact approximately 24% of the stream miles with poor to very poor biological conditions. *Channel alteration poor* measures large-scale modifications in the shape of the stream channel due to the presence of artificial structures (channelization) and/or bar formations. Marginal to poor and poor ratings are expected in unstable stream channels that experience frequent high flows.

Extensive Bar formation present was identified as significantly associated with degraded biological conditions and found in 23% of the stream miles with very poor to poor biological conditions in the Gwynns Falls. This stressor measures the movement of sediment in a stream system, and typically results from significant deposition of gravel and fine sediments and its presence is a metric for the channel alteration rating. Although some bar formation is natural, extensive bar formation indicates channel instability related to frequent and intense high flows that quickly dissipate and rapidly lose the capacity to transport the sediment loads downstream. Excessive sediment loading is expected to reduce and homogenize available feeding and reproductive habitat, degrading biological conditions.

Seventy- nine percent of the Gwynns Falls watershed is comprised of urban land uses. As development and urbanization increased in the Gwynns Falls watershed so did the morphological changes that affect a stream's habitat. The most critical of these environmental changes are those that alter the watershed's hydrologic regime. Increases in impervious surface cover that accompanies urbanization alters stream hydrology, forcing runoff to occur more readily and quickly during rainfall events, thus decreasing the amount of time it takes water to reach streams causing urban streams to be more "flashy" (Walsh et al. 2005). When stormwater flows through stream channels faster, more often, and with more force, the results are stream channel alteration and streambed scouring. The scouring associated with these increased flows leads to accelerated channel erosion, thereby increasing sediment deposition throughout the streambed either through the formation of bars or settling of sediment in the stream substrate.

Some of the impacts associated with erosion and sedimentation smothering the benthic communities, reduced survival rate of fish eggs, and reduced habitat quality from embedding of the stream bottom (Hoffman et al. 2003). All of these processes result in an unstable stream ecosystem that impacts habitat and the dynamics (structure and abundance) of stream benthic organisms (Allan 2004). An unstable stream ecosystem often results in a loss of available habitat from sedimentation, continuous displacement of biological communities from scouring that require frequent re-colonization and the loss of sensitive taxa, with a shift in biological communities to more tolerant species.

The combined AR is used to measure the extent of stressor impact of degraded stream miles, very poor to poor biological conditions, if the sediment stressor were removed. The combined AR for the sediment stressor group is approximately 24 % suggesting these stressors results in moderate impacts to the degraded stream miles in the Gwynns Falls (Table 5).

In-stream Habitat Conditions

BSID analysis results for the Gwynns Falls identified two in-stream habitat parameters that have a statistically significant association with poor to very poor stream biological condition: *channelization present* and *concrete/gabion present.*

Channelization present was identified as significantly associated with degraded biological conditions and found in 34% of the degraded stream miles in the Gwynns Falls. This stressor measures the presence/absence of channelization in stream banks and its presence is a metric for the channel alteration rating. It describes both the straightening of channels and their fortification with concrete or other hard materials. Channelization inhibits the natural flow regime of a stream resulting in increased flows during storm events that can lead to scouring and, consequently, displacement of biological communities. The resulting bank/channel erosion creates unstable channels and excess sediment deposits downstream.

Concrete/gabion present was identified as significantly associated with degraded biological conditions in the Gwynns Falls, and found to impact approximately 15% of the stream miles with poor to very poor biological conditions. *Concrete/gabion present*, like ‘channelized,’ inhibits the heterogeneity of stream morphology needed for colonization, abundance, and diversity of fish and benthic communities. Concrete channelization increases flow and provides a homogeneous substrate, conditions which are detrimental to diverse and abundant colonization.

The stressors identified for the in-stream habitat parameter group are intricately linked with habitat heterogeneity. The presence these habitat stressors lower the diversity of a stream’s microhabitats and substrates, subsequently causing a reduction in the diversity of biological communities. Channelization has been used in the Gwynns Falls watershed for flood control. The purpose is to increase channel capacity and flow velocities so water moves more efficiently downstream. However, channelization is detrimental for the "well being" of streams and rivers through the elimination of suitable habitat and the creation of excessive flows. Stream bottoms are made more uniform. Habitats of natural streams contain numerous bends, riffles, runs, pools and varied flows, and tend to support healthier and more diversified plant and animal communities than those in channelized streams. The natural structures impacting stream hydrology, which were removed for channelization, also provide critical habitat for stream species and impact nutrient availability in stream microhabitats (Bolton and Schellberg 2001). The refuge cavities removed by channelization not only provide concealment for fish, but also serve as traps for detritus, and are areas colonized by benthic macroinvertebrates. Subsequently, channelized streams retained less leaf litter and supported lower densities of detritivore invertebrates than natural streams. The overall densities and biomasses of macroinvertebrates in channelized streams are very low by comparison with intact natural streams (Laasonen et al.

1998, Haapala & Muotka 1998). Consequently, streams with extensive channelization often have impaired biological community with poor IBI scores is observed.

The combined AR is used to measure the extent of stressor impact of degraded stream miles, very poor to poor biological conditions. The combined AR for the in-stream habitat stressor group is approximately 40 % suggesting these stressors result in impacts to the degraded stream miles in the Gwynns Falls (See Table 5).

Riparian Habitat Conditions

BSID analysis results for Gwynns Falls did not identify any riparian habitat parameters that have statistically significant association with a very poor to poor stream biological condition (i.e., removal of stressors would result in improved biological community).

Water Chemistry

BSID analysis results for the Gwynns Falls identified three water chemistry parameters that have statistically significant association with a very poor to poor stream biological condition (i.e., removal of stressors would result in an improved biological community). These parameters are *high conductivity*, *high chlorides*, and *ammonia acute with salmonid absent.*

High conductivity levels was identified as significantly associated with degraded biological conditions in the Gwynns Falls, and found to impact approximately 76% of the stream miles with poor to very poor biological conditions. Conductivity is a measure of water's ability to conduct electrical current and is directly related to the total dissolved salt content of the water. Most of the total dissolved salts of surface waters are comprised of inorganic compounds or ions such as chloride, sulfate, carbonate, sodium, and phosphate (IDNR 2008). Conductivity and chlorides are closely related. Streams with elevated levels of chlorides typically display high conductivity.

High chloride levels was identified as significantly associated with degraded biological conditions in the Gwynns Falls, and found to impact approximately 76% of the stream miles with very poor to poor biological conditions. High concentrations of chlorides can result from industrial discharges, metals contamination, and application of road salts in urban landscapes. There are no major National Pollutant Discharge Elimination System (NPDES) permitted municipal or industrial discharges in the watershed; however, there are twenty-six minor industrial facilities that are regulated for various parameters. Because NPDES permitting enforcement does not require chloride testing at any of these facilities, data was not available to verify/identify chlorides as a specific pollutant in this watershed. Since there is no metals impairment, application of road salts in the watershed is a likely source of the chlorides and high conductivity levels. Although chloride can originate from natural sources, most of the chloride that enters the environment is associated with the storage and application of road salt. A significant portion of the mainstem of Gwynns Falls parallels Interstate 695 (Baltimore Beltway), which is one of the primary transportation routes in and around Baltimore City.

According to Church and Friesz (1993), road salt accumulation and persistence in watersheds poses risks to aquatic ecosystems and to water quality. Approximately 55% of road-salt chlorides are transported in surface runoff, with the remaining 45% infiltrating through soils and into groundwater aquifers.

Elevated *ammonia acute with salmonid absent* levels was identified as significantly associated with degraded biological conditions in the Gwynns Falls, and found to impact approximately 15% of the stream miles with very poor to poor biological conditions. Two of the twelve MBSS sites displayed exceedence in acute ammonia threshold concentrations. Elevated levels of ammonia can result from industrial discharges, agriculture, atmospheric deposition, and household applications. There are no major NPDES permitted municipal or industrial discharges in the watershed; however, there are twenty-six minor industrial facilities that are regulated for various parameters with zero of the twenty-six permits discharging into the stream segments displaying exceedence in ammonia. Atmospheric deposition would result in more MBSS sites showing elevated ammonia levels than the current two. Detailed analysis of the land use surrounding the two MBSS sites discounts agricultural land use as a potential source of ammonia. Since both sites are located in areas with high proportions of low density urban land use, leaking infrastructure and/or failing septic systems (household applications) could possibly be the source of localized elevated levels of ammonia in the streams. The two sites exceeding acute ammonia tolerances are located in the headwaters of their perspective streams and MBSS sites further down stream show no ammonia tolerance exceedence.

In summary, water chemistry is another major determinant of the integrity of surface waters that is strongly influenced by land-use. Land development within the Gwynns Falls watershed has lead increases in contaminant loads from point and nonpoint sources by adding sediments, nutrients, road salts, toxics, petroleum products, and inorganic pollutants to surface waters. Increased levels of many pollutants like chlorides can be toxic to aquatic organisms and lead to exceedences in species tolerances. The BSID analysis results identified acute ammonia as having a statistically significant association with degraded biological condition in Gwynns Falls. There were two sites exceeding acute ammonia tolerances, which are located in the headwaters of their perspective streams, however MBSS sites further down stream show no ammonia tolerance exceedence. There are no exceedences of any numeric water quality criteria for nutrient impairment (Dissolved Oxygen (D.O.) & pH) within the watershed.

The combined AR is used to measure the extent of stressor impact of degraded stream miles, very poor to poor biological conditions. The combined AR for the water chemistry stressor group is approximately 77% suggesting that these stressors results in impacts to the degraded stream miles in Gwynns Falls (See Table 5).

Currently in Maryland there are no specific numeric criteria that quantify the impact of conductivity and chlorides on the aquatic health of non-tidal stream systems. Since the exact sources and extent of inorganic pollutant loadings are not known, MDE determined that current data are not sufficient to enable identification of the specific pollutant(s) from the array of potential inorganic pollutants inferred from the BSID analysis.

Sources

All eight stressor parameters, identified in Tables 1-3, that are significantly associated with biological degradation in the Gwynns Falls watershed BSID analysis are representative of impacts from urban landscapes. The scientific community (Booth 1991, Konrad and Booth 2002, and Meyer et al. 2005) has consistently identified negative impacts to biological conditions as a result of increased urbanization. A number of systematic and predictable environmental responses have been noted in streams affected by urbanization, and this consistent sequence of effects has been termed "urban stream syndrome" (Meyer et al. 2005). Symptoms of urban stream syndrome include flashier hydrographs, altered habitat conditions, degradation of water quality, and reduced biotic richness, with increased dominance of species tolerant to anthropogenic (and natural) stressors.

Increases in impervious surface cover that accompany urbanization alter stream hydrology, forcing runoff to occur more readily and quickly during rainfall events, decreasing the time it takes water to reach streams and causing them to be more "flashy" (Walsh et al. 2005). Land development can also cause an increase in contaminant loads from point and nonpoint sources. In virtually all studies, as the amount of impervious area in a watershed increases, fish and benthic communities exhibit a shift away from sensitive species to assemblages consisting of mostly disturbance-tolerant taxa (Walsh et al. 2005).

The BSID source analysis (Table 4) identifies various types of urban land uses as potential sources of stressors that may cause negative biological impacts.   The combined AR for the source group is approximately 77% suggesting that urban development potentially impact almost all the degraded stream miles in Gwynns Falls (See Table 6).

Summary

Land use in the Gwynns Falls Watershed ranges from a mixture of uses in the upper sections to high percentages of industrial, residential, and other impervious surfaces in the middle and southern sections. By 1994, the watershed had 5.1% agricultural land, 18.1% forested land and 75.8% developed land. Most significantly, 42.2% of the land in the watershed was covered with impervious surface (GFWA 2008). The BSID analysis results suggest that degraded biological communities in the Gwynns Falls watershed are a result of increased urban land use causing channelization and alterations to hydrologic regime. The channelization and altered hydrology has caused frequent high flow events, degradation to in-stream habitat quality, and increased sediment loads, resulting in an unstable stream ecosystem that eliminates optimal habitat.

Due to the increased proportions of urban land use in the Gwynns Falls, the watershed has experienced an increase in contaminant loads from point and nonpoint sources, resulting in levels of inorganic pollutants that can potentially be extremely toxic to aquatic organisms. Alterations to the hydrologic regime, sedimentation, physical habitat, and water chemistry, have all combined to degrade the Gwynns Falls, leading to a loss of diversity in the biological community. The combined AR for all the stressors is approximately 94%, suggesting that sediment, in-stream habitat and water chemistry stressors identified in the BSID analysis would adequately account for the biological impairment in the Gwynns Falls watershed (See Table 5).

The BSID analysis evaluates numerous key stressors using the most comprehensive data sets available that meet the requirements outlined in the methodology report. It is important to recognize that stressors could act independently or act as part of a complex causal scenarios (e.g., eutrophication, urbanization, habitat modification). Also, uncertainties in the analysis could arise from the absence of unknown key stressors and other limitations of the principal data set. The results are based on the best available data at the time of evaluation.

Final Causal Model for the Gwynns Falls

Causal model development provides a visual linkage between biological condition, habitat, chemical, and source parameters available for stressor analysis. Models were developed to represent the ecologically plausible processes when considering the following five factors affecting biological integrity: biological interaction, flow regime, energy source, water chemistry, and physical habitat (Karr, 1991 and USEPA 2007). The five factors guide the selections of available parameters applied in the BSID analyses and are used to reveal patterns of complex causal scenarios. Figure 6 illustrates the final causal model for the Gwynns Falls, with pathways bolded or highlighted to show the watershed’s probable stressors as indicated by the BSID analysis.

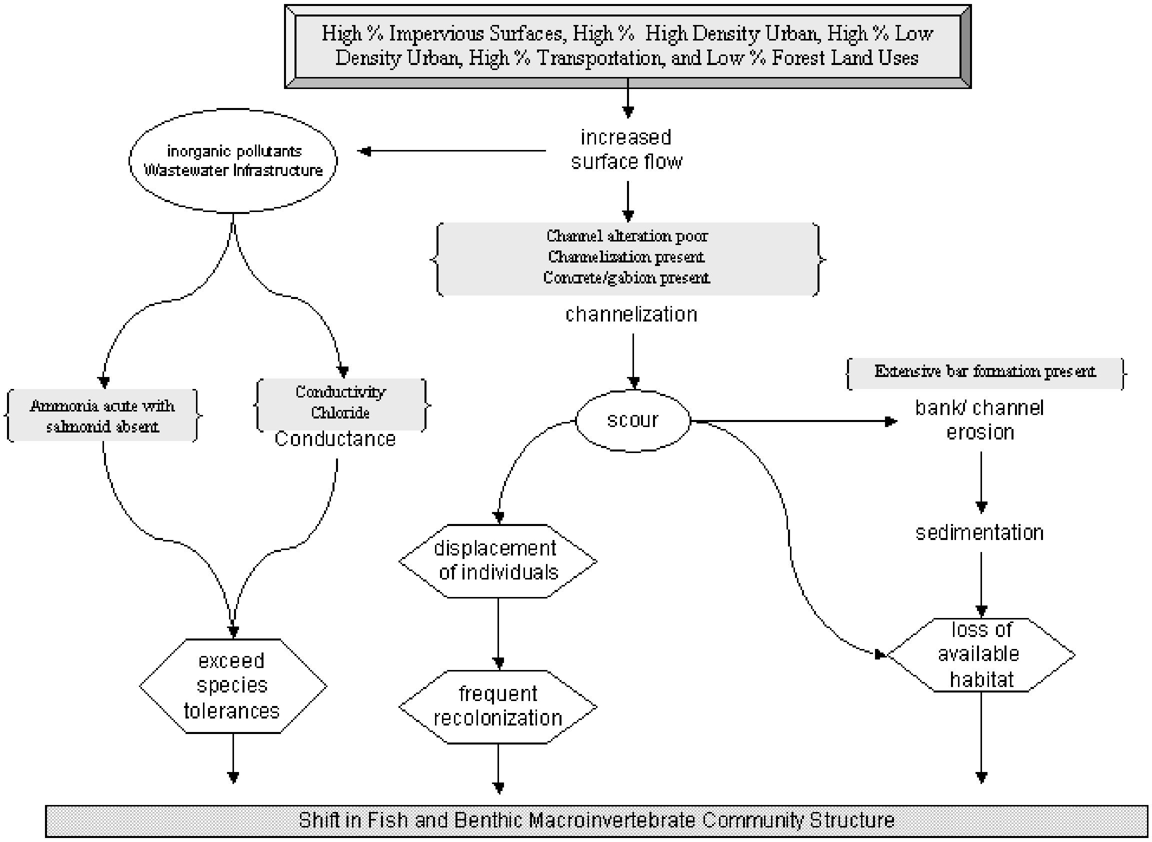


Figure 6. Final Causal Model for the Gwynns Falls

5.0 Conclusions

Data suggest that the Gwynns Falls watershed's biological communities are strongly influenced by urban land use, which alters the hydrologic regime resulting in increased erosion, sediment, and inorganic pollutant loading. There is an abundance of scientific research that directly and indirectly links degradation of the aquatic health of streams to urban landscapes, which often cause flashy hydrology in streams and increased contaminant loads from runoff. Based upon the results of the BSID analysis, the probable causes and sources of the biological impairments of the Gwynns Falls watershed are summarized as follows:

- The BSID analysis has determined that the biological communities are likely degraded due to inorganic pollutants (i.e., chlorides and conductivity). Inorganic pollutants levels are significantly associated with degraded biological conditions and found in approximately 76% of the stream miles with very poor to poor biological conditions in the Gywnns Falls watershed. Impacts on water quality due to conductivity and chloride are dependent on prolonged exposure; future monitoring of these inorganic pollutants will help in determining the spatial and temporal extent of this impairment in the watershed. Impervious surfaces and urban runoff cause an increase in contaminant loads from point and nonpoint sources by delivering an array of inorganic pollutants to surface waters. Currently, there is a lack of monitoring data for many of these substances; therefore, additional monitoring of priority inorganic pollutants is needed to more precisely determine the specific cause(s) of impairment.
- The BSID analysis has determined that the biological communities in Gwynns Falls are also likely degraded due to flow/sediment related stressors. Specifically, altered hydrology and increased runoff from urban impervious surfaces have resulted in channel erosion and subsequent elevated suspended sediment transport through the watershed, which are in turn the probable causes of impacts to biological communities. The BSID results thus confirm the 1996 Category 5 listing for total suspended solids as an impairing substance in Gwynns Falls, and link this pollutant to biological conditions in these waters.
- The BSID process has also determined that biological communities in the Gwynns Falls watershed are likely degraded due to anthropogenic channelization of stream segments. MDE considers channelization to be a form of pollution not a pollutant; therefore, a Category 5 listing for this stressor is inappropriate. However, Category 4c is for waterbody segments where the State can demonstrate that the failure to meet applicable water quality standards is a result of pollution. Category 4c listings include segments impaired due to stream channelization or the lack of adequate flow. MDE recommends a Category 4c listing for the Gwynns Falls watershed based on channelization being present in approximately 34% of degraded stream miles.
- The BSID analysis has identified one water chemistry stressor present (ammonia) at two sites showing a possible association with degraded biological conditions. A more

intensive analysis of all available data is recommended to determine if there is an ammonia toxicity impairment in the Gwynns Falls watershed.

- Although there is presently a Category 5 listing for phosphorus in Maryland's 2008 Integrated Report, the BSID analysis did not identify any nutrient stressors (i.e., total nitrogen, total phosphorus, dissolved oxygen, etc.) present and/or nutrient stressors showing a significant association with degraded biological conditions.

References

Allan, J.D. 2004. *Landscapes and Riverscapes: The Influence of Land Use on Stream Ecosystems*. Annual Review Ecology, Evolution, & Systematics. 35:257–84.

Bolton, S and Shellberg, J. 2001. *Ecological Issues in Floodplains and Riparian Corridors.* University of Washington, Center for Streamside Studies, Olympia, Washington. pp. 217-263.

Booth, D. 1991. *Urbanization and the natural drainage system – impacts, solutions and prognoses.* Northwest Environmental Journal 7: 93-118.

Church, P and P. Friesz. 1993. *Effectiveness of Highway Drainage Systems in preventing Road-Salt Contamination of Groundwater: Preliminary Findings*. Transportation Research Board. Transportation Research Record 1420.

COMAR (Code of Maryland Regulations). 2009a. *26.08.02.02* *http://www.dsd.state.md.us/comar/26/26.08.02.02.htm* (Accessed March 2009).

______________. 2009b. 26.08.02.08K(1)(c). http://www.dsd.state.md.us/comar/26/26.08.02.08.htm (Accessed March 2009).

______________. 2009c. 26.08.02.08K(3)(e). http://www.dsd.state.md.us/comar/26/26.08.02.08.htm (Accessed March 2009).

______________. 2009d. 26.08.02.08K(5)(e). http://www.dsd.state.md.us/comar/26/26.08.02.08.htm (Accessed March 2009).

Edwards, Jonathan. 1981. *A Brief Description of the Geology of Maryland*. Prepared for the Division of Coastal and Estuarine Geology, Maryland Geological Survey. Also Available at http://www.mgs.md.gov/esic/publications/download/briefmdgeo1.pdf (Accessed June 2008)

GFWA (Gwynns Falls Watershed Association) 2004 Our Watershed- Land Use. Available at http://www.gwynnsfalls.net/watersheds/landUse.shtml (Accessed April 2009).

Haapala A. and Muotka T. 1998. *Seasonal dynamics of detritus and associated macroinvertebrates in a channelized boreal stream*. Archiv. Fuer. Hydrobiologie 142(2):171-189.

Hoffman D. J., Rattner B. A. , Burton G. A.. 2003. *Handbook of ecotoxicology* Edition: 2, Published by CRC Press: 598-600.

Hill, A. B. 1965. *The Environment and Disease: Association or Causation?* Proceedings of the Royal Society of Medicine, 58: 295-300.

IDNR (Iowa Department of Natural Resources). 2008. Iowa's Water Quality Standard Review – Total Dissolved Solids (TDS) http:www.iowadnr.gov/water/standards/files/tdsissue.pdf (Accessed March 2009).

Karr, J. R. 1991. *Biological integrity - A long-neglected aspect of water resource management*. Ecological Applications. 1: 66-84.

Konrad, C. P., and D. B. Booth. 2002. *Hydrologic trends associated with urban development for selected streams in the Puget Sound Basin*. Western Washington. Water-Resources Investigations Report 02-4040. US Geological Survey, Denver, Colorado.

Laasonen, P., Muotka, T., and Kivijaervi, I. 1998. *Recovery of macroinvertebrate communities from stream habitat restoration*. Aquatic Conservation of Marine Freshwater Ecosystems. 8:101-113.Mantel, N., and W. Haenszel. (1959) *Statistical aspects of the analysis of data from retrospective studies of disease.* Journal of the National Cancer Institute, 22, 719-748.

MDE (Maryland Department of the Environment). 2008. *Draft 2008 Integrated Report of Surface Water Quality in Maryland.* http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/Maryland%20303%20dlist/2008_303d_pubnotice.asp (Accessed June, 2008).

___________. 2009. *Draft Maryland Biological Stressor Identification Process.*

MDP (Maryland Department of Planning). 2002. *Land Use/Land Cover Map Series*. Baltimore, MD: Maryland Department of Planning.

Meyer, J. L., M. J. Paul, and W. K. Taulbee. 2005. *Stream ecosystem function in urbanizing landscapes.* Journal of the North American Benthological Society. 24:602–612.

Southerland, M. T., G. M. Rogers, R. J. Kline, R. P. Morgan, D. M. Boward, P. F. Kazyak, R. J. Klauda and S. A. Stranko. 2005. *New biological indicators to better assess the condition of Maryland Streams.* Columbia, MD: Versar, Inc. with Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. CBWP-MANTA-EA-05-13. Also Available at http://www.dnr.state.md.us/streams/pubs/ea-05-13_new_ibi.pdf

USDA SCS (U.S. Department of Agriculture Soil Conservation Service). 1977. Soil Survey of Baltimore County, MD.

USEPA (United States Environmental Protection Agency). 2007. *The Causal Analysis/Diagnosis Decision Information System (CADDIS).* http://www.epa.gov/caddis (Accessed June 2008)

Van Sickle, J. and Paulson, S.G. 2008. *Assessing the attributable risks, relative risks, and regional extents of aquatic stressors*. Journal of the North American Benthological Society. 27:920-931.

Walsh, C.J., A.H. Roy, J.W. Feminella, P.D. Cottingham, P.M. Groffman, and R.P. Morgan. 2005. *The urban stream syndrome: current knowledge and the search for a cure*. Journal of the North American Benthological Society 24(3):706–723.

APPENDIX K:

Water Quality Management Plan Proposed Projects

Project Number:	GFM-02
Project Name:	***Winands Valley Estates riparian buffer enhancement***
Subwatershed:	Gwynns Falls Middle
ADC Map No:	Map 24, J10
Catchment No:	GFM_26_2
Property Ownership:	Private
Nearest Street/Road:	Mount Wilson Lane
Stream Reach ID No:	GFM-09-00-01
Project Type:	Riparian buffer enhancement

Project Description:

The stream reach from Windmill Circle to Mount Wilson Lane has a sparse riparian buffer, particularly as the reach becomes closer to Mount Wilson Lane. Improvements to the riparian buffer (500 linear feet) are recommended. Project could involve community participation and possibly reduced costs.

Project Cost (design & construction):

Riparian Buffer Improvements, assume 100 foot width (500 linear feet x $75 per linear foot) = $37,500

Riparian buffer enhancement easement (1.15 acres x $5,000/acre) = $5,750

Total Project Cost = $43,250

Annual Cost = $3,200

Project Number:	GFM-03
Project Name:	***Old Court Estates riparian buffer enhancement***
Subwatershed:	Gwynns Falls Middle
ADC Map No:	Map 25, A-B/11-12
Catchment No:	GFM_22_2
Property Ownership:	Public, appears to be in public drainage way
Nearest Street/Road:	Between Maryknoll Road and Tapscott Road
Stream Reach ID No:	GFM-08-00-01, GFM-08-00-02
Project Type:	Riparian buffer enhancement

Project Description:

The stream reaches between Maryknoll Road and Tapscott Road have sparse riparian buffers. Improvements to the riparian buffer (1,200 linear feet) are recommended. Area appears to be public drainage way. Residents should be educated regarding the benefits of the stream buffer to discourage residents from mowing the area directly adjacent to the stream channel. Project could involve community participation and possibly reduced costs.

Project Cost (design & construction):

Riparian Buffer Improvements, assume 100 foot width (1200 linear feet x $75 per linear foot) = $90,000

Total Project Cost = $90,000

Annual Cost = $6,600

Project Number:	GFM-04
Project Name:	***I-695 and I-795 riparian buffer enhancement***
Subwatershed:	Gwynns Falls Middle
ADC Map No:	Map 25, B11
Catchment No:	GFM_21_2
Property Ownership:	Public, highway right of way
Nearest Street/Road:	I-795 and I-695 interchange
Stream Reach ID No:	GFM-08-02-01, GFM-08-03-01
Project Type:	Riparian buffer enhancement

Project Description:

The stream reaches within the I-795 and I-695 interchange are in need of buffer enhancement. Improvement to the riparian buffer (500 linear feet) are recommended.

Project Cost (design & construction):

Riparian Buffer Improvements, assume 100 foot width (1200 linear feet x $75 per linear foot) = $90,000

Total Project Cost = $90,000

Annual Cost = $6,600

Project Number:	GFM-05
Project Name:	***Woodlawn Memorial Park riparian buffer enhancement & stream stabilization***
Subwatershed:	Gwynns Falls Middle
ADC Map No:	Map 33, D7
Catchment No:	GFM_02_1
Property Ownership:	Public, Woodlawn Memorial Park
Nearest Street/Road:	Kinchloe Avenue
Stream Reach ID No:	GFM-01-00-01 & GFM-01-00-02
Project Type:	Riparian buffer enhancement & stream stabilization

Project Description:

Although it appears that there is a public drainage way in this section, many residents currently mow their lawns to the edge of the stream channel. This is creating channel instabilities and bank erosion. Riparian enhancement and localized stream stabilization, particularly with bioengineering methods, is recommended for both of these reaches. Access to this area is very good. Project would make a nice demonstration project to show the community the benefits of riparian stream buffers. May be able to use citizen volunteer groups to do some of the planting.

At park entrance off Thayer Terrace

Typical stream buffer along Kinchloe Road

Project Cost (design & construction):

Riparian Buffer Improvements, assume 100 foot width (1,100 linear feet x $75 per linear foot) = $82,500

Stream stabilization with bioengineering techniques (1,000 linear foot x $80 per linear foot) = $80,000

Riparian buffer enhancement/stream stabilization easement (4.8 acres x $5,000 per acre) = $24,000

Total Project Cost = $186,500

Annual Cost = $13,700

Project Number: GFM-06

Project Name: ***West Glen riparian buffer enhancement & stream stabilization***

Subwatershed: Gwynns Falls Middle

ADC Map No: Map 33, E-F/6

Catchment No: GFM_03_3

Property Ownership: Private

Nearest Street/Road: Essex Road

Stream Reach ID No: GFM-02-00-01, GFM-02-00-02 & GFM-02-00-03

Project Type: Riparian buffer enhancement & stream stabilization

Project Description:

Although it appears that there is a public drainage way in this section, many residents currently mow their lawns to the edge of the stream channel. This is creating channel instabilities and bank erosion. Riparian enhancement for GFM-02-00-01, GFM-02-00-02 and localized stream stabilization for GFM-02-00-03 particularly with bioengineering methods, is recommended for these reaches. Access to this area is very good.

Typical stream buffer

Typical bank erosion

Project Cost (design & construction):

Riparian Buffer Improvements, assume 100 foot width (750 linear feet x $75 per linear foot) = $56,250

Stream stabilization with bioengineering techniques (750 linear foot x $80 per linear foot) = $60,000

Riparian buffer enhancement easement (5.2 acres x $5,000 per acre of easement) = $26,000

Total Project Cost = $142,300

Annual Cost = $10,500

Project Number:	GFM-07
Project Name:	***Church Lane stream stabilization***
Subwatershed:	Gwynns Falls Middle
ADC Map No:	Map 25, E11
Catchment No:	GFM_19_1, GFM_18_2
Property Ownership:	Private, potentially public drainage way
Nearest Street/Road:	Bedford Avenue, north of Church Lane
Stream Reach ID No:	GFM-15-00-02, GFM-15-00-03 & GFM-15-00-07
Project Type:	Stream stabilization & restoration

Project Description:

Bank erosion is occurring in reaches GFM-15-00-01, GFM-15-00-02 immediately downstream of Bedford Avenue. Verify that the existing stormwater management pond (not on the inspection list) is an extended detention facility. GFM-15-00-07 has been straightened and lined with gabions. The reach ends at a gabion wall/energy dissipater that has become clogged with debris. The energy dissipater is not functioning properly and is causing severe channel erosion In reach GFM-15-00-07. GFM-15-00-03 downstream from the gabion wall is in need of riparian enhancement and localized stream stabilization, particularly with bioengineering methods. It is assumed that GFM-15-00-02 and GFM-15-00-07 are located in public drainage ways. Therefore, only access easement costs were considered. GFM-15-00-03 appears to be private lands, because the project will split the parcel, DEPRM may need to consider purchasing this land. Purchase costs have been included for this portion of the stream.

GFM-15-00-02 at existing pond outfall

Straightened GFM-15-00-07

Energy dissipater dividing GFM-15-00-07 & -03

GFM-15-00-03 bank erosion

Project Cost (design & construction):

Riparian Buffer Improvements, assume 100 foot width (700 linear feet x $75 per linear foot) = $52,500

Stream stabilization with bioengineering techniques (2,000 linear foot x $200 per linear foot) = $400,000

Riparian buffer enhancement easement (3.25 acres x $5,000 per acre of easement) = $16,250

Land acquisition, stream restoration (1.5 acres x $30,000 per acre) = $45,000

Stream restoration maintenance and monitoring = $3,000 annually

Total Project Cost = $554,600

Annual Cost = $40,800

Gwynns Falls Watershed Management Plan
Proposed Projects

Project Number:	GFM-08
Project Name:	***Prince George outfall retrofit and stream stabilization***
Subwatershed:	Gwynns Falls Middle
ADC Map No:	Map 33, D/1-2
Catchment No:	GFM_11_3
Property Ownership:	Private
Nearest Street/Road:	Prince George Road east of Prince George Court
Stream Reach ID No:	GFM-17-00-01
Project Type:	Outfall retrofit & stream stabilization

Project Description:

The outfall that starts this stream reach is in need of some apron repair and an energy dissipater. Baltimore County storm drain #235 was not assessed by PB as a major outfall but was inspected as part of the stream assessment. High discharges from the culvert are eroding stream banks and threatening private fences.

Outfall needing energy dissipater

Bank erosion encroaching on a private fence

Project Cost (design & construction):

Outfall retrofit – medium = $50,000

Stream stabilization (300 linear feet x $300 per linear foot) = $90,000

Land access easement = $5,000

Total Project Cost = $145,000

Annual Cost = $10,700

Project Number:	GFM-09
Project Name:	***Ponoma Road stream stabilization***
Subwatershed:	Gwynns Falls Middle
ADC Map No:	Map 25, D10
Catchment No:	GFM_20_2
Property Ownership:	Private, open space downstream of apartment's parking lot
Nearest Street/Road:	Pomona Road
Stream Reach ID No:	GFM-14-00-03
Project Type:	Stream stabilization

Project Description:

This section of stream has severely eroded banks and has developed torturous meanders. It is in need of stream stabilization.

Project Cost (design & construction):

Stream stabilization (500 linear foot x $300 per linear foot) = $150,000

Land access easement = $5,000

Total Project Cost = $155,000

Annual Cost = $11,400

Project Number:	GFM-10
Project Name:	***Courtland Woods SWM Pond #424 Retrofit***
Subwatershed:	Gwynns Falls Middle
ADC Map No:	Map 25, B13
Catchment No:	GFM_15_3
Property Ownership:	Private access easement required
Nearest Street/Road:	Courtland Woods Circle
Stream Reach ID No:	GFM-07-00-02
Project Type:	Stormwater management pond retrofit/conversion to extended detention

Project Description:

Baltimore County SWM pond #424 (drainage area = 82.4 acres) is in need of retrofit and conversion to extended detention. It is currently an in-line pond with a modified headwall for a riser. The downstream gabion baskets are damaged and the stream flows towards I-695 and runs underneath a right of way fence. Erosion is occurring beneath fence and if left unaddressed it may cause damage to the highway embankment. It appears that there is no room for expansion.

Looking downstream at headwall/riser (Summer 2003)

Looking upstream at outfall and failed dissipators (Summer 2003)

Downstream channel along I-695 right of way fence (Summer 2003)

Project Cost (design & construction):

SWM Pond conversion to extended detention - large = $180,000

Access easement = $5,000

Maintenance of SWM Pond = $3,000 annually

Total Project Cost = $225,800

Annual Cost = $16,600

Project Number:	GFM-15
Project Name:	***Greenwood Outfall # GFM-390 retrofit and stream stabilization***
Subwatershed:	Gwynns Falls Middle
ADC Map No:	Map 25, E12
Catchment No:	GFM_16_1
Property Ownership:	Private access easement required
Nearest Street/Road:	Greenwood Road
Stream Reach ID No:	GFM-16-00-01
Project Type:	Outfall retrofit & stream stabilization

Project Description:

Baltimore County outfall #GFM-390 is a 54" stormdrain (drainage area = 50.5 acres) and is in need of a stilling basin for energy dissipation. Approximately 300 lf of stream needs to be stabilized. Debris cleanup is also recommended.

Project Cost (design & construction):

Outfall retrofit – medium = $50,000

Stream stabilization (300 linear feet x $300 per linear foot) = $90,000

Debris Removal - $1000

Land access easement = $5,000

Total Project Cost = $158,600

Annual Cost = $11,700

Project Number:	GFM-16
Project Name:	***Flag Tree Outfall #GFM-626 Outfall Retrofit and Stream Stabilization***
Subwatershed:	Gwynns Falls Middle
ADC Map No:	Map 25, C12
Catchment No:	GFM_16_3
Property Ownership:	Private access easement required
Nearest Street/Road:	Flagtree Lane
Stream Reach ID No:	GF30
Project Type:	Outfall retrofit & stream stabilization

Project Description:

Baltimore County 48" outfall #GFM-626 (drainage area = 41 acres) is in need of a stilling basin for energy dissipation. Approximately 150 lf of stream needs to be stabilized.


Looking upstream at outfall


Looking downstream at bank erosion

Project Cost (design & construction):

Outfall retrofit – medium = $50,000

Stream stabilization (150 linear feet x $500 per linear foot) = $75,000

Land access easement = $5,000

Total Project Cost = $130,000

Annual Cost = $9,600

Project Number:	DR-02
Project Name:	***Western Hills Park BMP creation and stormwater management pond retrofit***
Subwatershed:	Dead Run
ADC Map No:	Map 33, B11
Catchment No:	DR_19_1
Property Ownership:	Public/Private
Nearest Street/Road:	Adamsview Road and Half Penny Lane
Stream Reach ID No:	DRT 206
Project Type:	Stormwater management pond retrofit/conversion to extended detention & BMP creation

Project Description:

Baltimore County SWM facility #432 is a standard detention pond that treats a drainage area of 33 acres. It was originally constructed in 1993. Pond should be retrofit and converted to provide extended detention and additional water quality treatment.

Area within Western Hills Park has the potential for the creation of BMP.

Project Cost (design & construction):

SWM Pond conversion to extended detention (medium pond) = $150,000

BMP creation = $150,000

Access easement = $5,000

Maintenance of 2-BMPs = $6,000 annually

Total Project Cost = $386,500

Annual Cost = $28,400

Project Number:	DR-03
Project Name:	***Rolling Road Meadow stream restoration & BMP creation***
Subwatershed:	Dead Run
ADC Map No:	Map 33, A-B/8
Catchment No:	DR_25_2
Property Ownership:	Unknown
Nearest Street/Road:	Rolling Road & Glen Spring Road
Stream Reach ID No:	DRLF05
Project Type:	Stream restoration, stabilization, concrete channel removal & potential BMP creation

Project Description:

Involves the removal of a concrete channel and stream stabilization (1,200 lf) on DRLF05 between Rolling Road and Glen Spring Road. Property ownership of adjacent meadow is unknown. If property can be obtained, BMP creation on this property can be explored.

Project Cost (design & construction):

Stream restoration (1,200 lf x $300 per lf) = $360,000

BMP Creation (large pond) = $300,000

Land acquisition for stream restoration (2.8 ac @ $30,000/ac) = $82,600

Land acquisition for BMP creation (2.0 ac @ $50,000/ac) = $100,000

Maintenance of BMP = $3,000 annually

Total Project Cost = $883,400

Annual Cost = $65,000

Project Number:	DR-07
Project Name:	***Edmonson Heights Park outfall & stream stabilization***
Subwatershed:	Dead Run
ADC Map No:	Map 33, G12
Catchment No:	DR_07_1, DR_06_3
Property Ownership:	Public
Nearest Street/Road:	Forest Park Avenue
Stream Reach ID No:	DR-04-00-01
Project Type:	Stream and outfall stabilization & BMP creation

Project Description:

This section of stream within Edmonson Heights Park has severe bank erosion and severe headcut. Several small outfalls along the stream reach are also in need of repair. This site has the potential for BMP creation.

Tributary Outfall

U/S at bank erosion

Project Cost (design & construction):

Stream restoration (1250 lf restoration x $500 per linear foot) = $625,000

BMP Creation (large) = $375,000

BMP Maintenance = $3,000 annually

Total Project Cost = $1040,800

Annual Cost = $76,600

Project Number:	DR-09
Project Name:	***Whitehead Road outfall stabilization & BMP creation***
Subwatershed:	Dead Run
ADC Map No:	Map 33, D8
Catchment No:	DR_20_5
Property Ownership:	Private, Meadows Industrial Park
Nearest Street/Road:	Whitehead Road
Stream Reach ID No:	DR13
Project Type:	Outfall stabilization & BMP creation

Project Description:

Baltimore County storm drain #415 (drainage area = 19 acres) has potential for a BMP creation. This is the only primarily industrial/commercial land use in Dead Run (Baltimore County portion) with the potential for pond creation.

Project Cost (design & construction):

BMP Creation (small) = $250,000

Land acquisition for BMP creation (2.0 ac @ $62,500/ac) = $125,000

BMP Maintenance = $3,000 annually

Total Project Cost = $415,800

Annual Cost = $30,600

Looking U/S at headwall

Project Number:	PM-01
Project Name:	***SOUTHERN CROSS STREAM RESTORATION***
Subwatershed:	Powder Mill
ADC Map No:	Map 33, G/1-2
Catchment No:	PM_02_1, PM_03_1
Property Ownership:	Large portion of area appears to be public open space
Nearest Street/Road:	Southern Cross Drive from Parsons Avenue to Alter Street
Stream Reach ID No:	PMLFT203, PMLFT202 & PMLFT201
Project Type:	Stream stabilization & restoration

Project Description:

Field visits were made to this site in December 2003 and May 2004. The photos below show typical stream conditions during winter and spring seasons.

Lower 500 feet of Reach PM-01A, banks are vertical and/or undercutting. (May 2004)

May 2004 vegetation

Bank erosion (December 2003)

Bank erosion (December 2003)

Existing Stream Condition

This reach is an unnamed tributary to an unnamed tributary of Powder Mill Run. The project is located just upstream of the confluence with the unnamed tributary of Powder Mill Run and continues upstream approximately 1,440 feet to the box culvert at Parsons Avenue. Refer to Appendix A for project limits. Woody vegetation within the County right-of-way has been removed from both sides of the stream along the lower 500 feet of stream. Additionally, woody vegetation has been removed from the right bank (looking downstream) along the remaining reach. Most of the easement is being maintained by property owners residing along the tributary.

The stream shows signs of undergoing changes along its length. As a result of the lack of woody vegetation the channel banks are undercutting and eroding laterally. Bank erosion is contributing to the sediment load in Powder Mill Run.

The stream classification for the lower portion of this reach is C4. Type C streams are generally slightly entrenched, meandering, gravel dominated, riffle/pool channels with a well developed floodplain. Streambanks are generally composed of heterogeneous, non-cohesive, alluvial materials that are finer than the gravel-dominated bed material. As a result this stream type is susceptible to accelerated bank erosion. The rate of bank erosion is greatly influenced by the presence and condition of riparian vegetation (Rosgen, 1994; Rosgen, 1996). A summary of the geomorphic classification data is provided below.

The upper portion of this reach appears to be disconnected from its floodplain and could be classified as an F type stream. F streams are generally entrenched, moderately sinuous, riffle/pool channels. This stream type is laterally unstable and has a high bank erosion rate.

Table 1: Summary of existing geomorphic conditions, PM-01

Bankfull Width (W_{BKF})	16.69 ft	**Bankfull Water Surface Slope (S)**	0.0101 ft/ft
Mean Depth (d_{BKF})	1.01 ft	**W/D Ratio (W_{BKF}/d_{BKF})**	16.52
Bankfull Cross Sectional area (A_{BKF})	16.88 ft^2	**Entrenchment Ratio (ER)**	2.96
Sinuosity (K)	1.1	**Drainage Area (DA)**	0.3 mi^2
Bankfull Velocity (U_{BKF})	4.74 ft/s	**Bankfull Discharge (Q_{BKF})**	80.01 cfs

Proposed Project

The proposed project PM-01 is approximately 1,440 feet in length. The following is a summary of the proposed work:

Stream Restoration & Vegetative Enhancement:
- Planform adjustment and grade control
- Bank stabilization
- Riparian buffer enhancement
- Land acquisition

Public Education & Outreach:
- Prepare and distribute a brochure to inform property owners adjacent to the stream as to the importance of woody vegetation and vegetated buffers relating to stream health

Construction access:

- Access to the project area is good. This is considered a high priority project.

Pollutant Reduction Estimate

Project Name		Project Components	TSS	TP	TN	Pb	Zn
PM-01	1,440	Stream Restoration (lf)	3,672	5.04	34.56	0.10	1.01
	2,000	Riparian Buffer Enhancement (lf)	5,100	7.00	48.00	0.14	1.40
Project Total			8,772	12.04	82.56	0.24	2.41
Percent Watershed Reduction			7.2%	1.8%	0.7%	2.1%	1.1%

Cost Estimate (Design and Construction)

- Planform adjustment, grade control, bank stabilization (1,440 lf @ $300/lf) = **$432,000**
- Riparian Buffer Enhancement (2000 lf @ $80/lf) = **$160,000**
- Production and distribution of brochure (30 @ $130/ ea.) = **$3,900**
- **Annual Maintenance = $4,000**
- Land Acquisition (Land appears to be in a public drainage way. It includes 3.3 acres stream restoration and 4.6 acres for riparian buffer enhancement. Assume three access easements will be necessary) = **$36,000 additional land acquisition and $15,000 for right of way easements**

TOTAL PROJECT COST = $701,261
ANNUAL COST = $51,600

Gwynns Falls Watershed Management Plan
Proposed Projects

Project Number:	PM-02
Project Name:	***Parsons Avenue BMP & Stream Stabilization***
Subwatershed:	Powder Mill
ADC Map No:	Map 33, G/1-2
Catchment No:	PM_01_2, PM_03_1
Property Ownership:	Large portion of area appears to be public open space
Nearest Street/Road:	Between Metro Line and Parsons Avenue
Stream Reach ID No:	PM-04-00-01, PMLFT205 & PMLFT204
Project Type:	Stream stabilization & restoration, Stormwater management BMP creation

Project Description:

Field visits were made to this site in December 2003 and May 2004. The photos below show typical stream conditions during winter and spring seasons.


Looking upstream at project .May 2004


Looking upstream at outfall for project , May 2004


Bank erosion in December 2003.


Bank erosion and debris in December 2003.

Existing Stream Condition

This reach is an unnamed tributary to an unnamed tributary of Powder Mill Run. The project is located upstream of Parsons Avenue and continues upstream approximately 490 feet, to the box culvert under the Metro tracks. The reach is heavily vegetated and the banks show woody root mass in the upper half of exposed banks. The streambed in lower third of the reach shows exposed saprolite.

An evaluation of entrainment properties found excess shear. In other words, the stream is capable of moving larger bed materials. This causes vertical instability, which has resulted in bank erosion and the over-widening of the channel.

The existing channel has significant bank erosion, is disconnected from its floodplain, and has an unstable planform. The stream type in this reach classifies as an F4. Type F streams occur in more gentle gradients and have high width depth ratios. F streams are generally entrenched in highly weathered materials that make these streams laterally unstable. These streams usually have riffle/pool morphologies, moderate sinuosity, and high bank erosion rates (Rosgen, 1994; Rosgen, 1996). A summary of the geomorphic classification data is provided below.

Table 2: Summary of existing geomorphic conditions, PM-02

Bankfull Width (W_{BKF})	16.3 ft	**Bankfull Water Surface Slope (S)**	0.00747 ft/ft
Mean Depth (d_{BKF})	0.82 ft	**W/D Ratio (W_{BKF}/d_{BKF})**	19.88
Bankfull Cross Sectional area (A_{BKF})	13.36 ft^2	**Entrenchment Ratio (ER)**	1.39
Sinuosity (K)	1.2	**Drainage Area (DA)**	0.2 mi^2
Bankfull Velocity (U_{BKF})	3.23 ft/s	**Bankfull Discharge (Q_{BKF})**	43.15 cfs

Proposed Project

The proposed project PM-02 is approximately 490 feet in length. The following is a summary of the proposed work:

Stream Restoration & Vegetative Enhancement:
- Planform adjustment and grade control
- Bank stabilization, industrial areas
- Riparian buffer enhancement

Stormwater Management:
- Construct stormwater management facility below box culvert outfall

Public Education & Outreach:
- None

Construction Access:
- Access is good. However it appears to be through private property.

This project is considered a high priority as a result of its sediment contribution to Powder Mill Run.

Pollutant Reduction Estimate

Project Name		Project Components	TSS	TP	TN	Pb	Zn
PM-02	490	Stream Restoration (lf)	1,250	1.72	11.76	0.03	0.34
	1	BMP Creation (ea)	6554.72	21.92	208.45	2.96	13.47
	980	Riparian Buffer Enhancement (lf)	2,499	3.43	23.52	0.07	0.69
Project Total			10,303	27.07	243.73	3.06	14.50
Percent Watershed Reduction			8.5%	4.1%	1.9%	27.1%	6.5%

Cost Estimate (Design and Construction)

- Stormwater management facility creation, small = **$250,000**
- Planform adjustment, grade control, bank stabilization (490 lf @ $300/lf) = **$147,000**
- Riparian Buffer Enhancement (980 lf @ $80/lf) = **$78,400**
- Annual maintenance = **$3,000**
- Land acquisition (includes two access easements) = **$10,000**

TOTAL PROJECT COST = $526,200
ANNUAL COST = $38,700

Project Number:	PM-03
Project Name:	***Powder Mill Run Park Stream Restoration***
Subwatershed:	Powder Mill
ADC Map No:	Map 33, G/2-3
Catchment No:	PM_03_1, PM_02_2, PM_02_1
Property Ownership:	Private
Nearest Street/Road:	Danlou Drive to Forest Hill Road cutoff
Stream Reach ID No:	PMLF09, PMLF10, PMLF12, PMLF13 & PMLF14
Project Type:	Stream stabilization, utility protection and public outreach

Project Description:

Field visits were made to this site in December 2003 and May 2004. The photos below show typical stream conditions during winter and spring seasons.

Photos of Existing Conditions

Looking upstream below Cross Section 1

Looking downstream above Cross (May 2004)
Section 1 (May 2004)

Bank erosion (Dec 2003)

Erosion (Dec 2003)

Looking downstream from the Patterson Ave. culvert (Dec. 2004)

Existing Stream Condition

This reach is an unnamed tributary of Powder Mill Run. Woody vegetation within the County right-of-way has been removed at various locations along the reach upstream of Patterson Avenue. The channel has been armored with gabion baskets and gabion blankets approximately 100 feet upstream of the box culvert at Southern Cross and downstream to the confluence of its unnamed tributary (approximately 420 feet). There is an exposed sewer crossing approximately 200 feet upstream of Patterson Avenue. There is a grade break of approximately 2 feet downstream of the outfall at Patterson Avenue. Lastly there is a section of concrete lined bank just down gradient of the Patterson Avenue outfall.

The armored section of this tributary appears to be very stable. No work is recommended in this area.

Based on a sediment entrainment analysis, the stream channel in the vicinity of the study area is degrading due to excess shear stress. As a result of the excess shear stress, the stream channel is vertically unstable, shown by the stream's depth and slope that are deeper and steeper than what are hydraulically required to move the largest particle sizes present in the stream. However, there are visual indications that the stream is in transition to a more stable form. The contribution to sediment load through this reach appears to be lower than the contribution farther upstream.

The stream type in this reach classifies as an F4. Type F streams occur in more gentle gradients and have high width depth ratios. F streams are generally entrenched in highly weathered materials that make these streams laterally unstable. These streams usually have riffle/pool morphologies, moderate sinuosity, and high bank erosion rates (Rosgen, 1994; Rosgen, 1996). A summary of the geomorphic classification data is provided below.

Table 3: Summary of existing geomorphic conditions

Bankfull Width (W_{BKF})	28.87 ft	**Bankfull Water Surface Slope (S)**	0.0089 ft/ft
Mean Depth (d_{BKF})	1.59 ft	**W/D ratio (W_{BKF}/d_{BKF})**	18.16
Bankfull Cross Sectional area (A_{BKF})	45.79 ft^2	**Entrenchment ratio (ER)**	1.19
Sinuosity	1.1	**Drainage Area (DA)**	1.4 mi^2
Bankfull Velocity (U_{BKF})	4.02 ft/s	**Bankfull Discharge (Q_{BKF})**	184.08 cfs

Proposed Project

There are several areas of concern to be addressed. The following is a summary of the proposed work:

Stream Restoration & Vegetative Enhancement:

- Construct grade control below exposed sanitary sewer crossing and the outfall at Patterson Avenue
- Install energy dissipator at Patterson Avenue Culvert Outfall
- Remove concrete bank lining as part of the grade control construction below the Patterson Avenue outfall. Create a bankfull bench and re-vegetate the disturbed area
- Riparian buffer enhancement in cleared areas

Public Education & Outreach:

- Prepare and distribute a brochure to inform property owners adjacent to the stream as to the importance of woody vegetation and vegetated buffers relating to stream health

Construction Access:

- Construction access to the project area above Patterson Avenue is poor. However this is considered a high priority project due to the potential for further stream degradation.
- Access below Patterson Avenue is good.

Pollutant Reduction Estimate

Project Name		Project Components	TSS	TP	TN	Pb	Zn
PM-03	350	Stream Restoration (lf)	893	1.23	8.40	0.02	0.25
	2,050	Riparian Buffer Enhancement (lf)	5,228	7.18	49.20	0.14	1.44
Project Total			6,120	8.40	57.60	0.17	1.68
Percent Watershed Reduction			5.0%	1.3%	0.5%	1.5%	0.8%

Cost Estimate (design and Construction)

- Grade control, bank stabilization (350 lf @ $300/lf) = **$105,000**
- Riparian Buffer Enhancement (estimated 2050 lf @ $80/lf) = **$164,000**
- Production and distribution of brochure (estimated 50 @ $130/ ea.) = **$6,500**
- Land Acquisition (area is in public drainage way, assume 6 access easements will be needed) = **$30,000**

Total Project Cost = $305,500

Annual Cost = $22,500

Project Number:	MC-01
Project Name:	***Chrysler Drive outfall retrofit & stream stabilization***
Subwatershed:	Maiden's Choice
ADC Map No:	Map 41, E1
Catchment No:	MC_13_2
Property Ownership:	Private
Nearest Street/Road:	Chrysler Drive and Chrishem Court
Stream Reach ID No:	MC-05-01-01
Project Type:	Outfall retrofit, utility protection/relocation & stream stabilization and restoration

Project Description:

The un-assessed Baltimore County outfall #533 (38' x 60' with DA=21.70 acres) discharges to this stream reach. The reach is in need of stabilization/restoration and utility protection/relocation.

Project Cost (design & construction):

Outfall retrofit - medium = $50,000

Stream stabilization (600 linear feet x $300 per linear foot) = $180,000

Land acquisition: stream restoration (1.4 x $30,000 per acre) = $42,000

Total Project Cost = $272,000

Annual Cost = $20,000

Project Number:	MC-02
Project Name:	***Woodlawn stream stabilization***
Subwatershed:	Maiden's Choice
ADC Map No:	Map 41, F2
Catchment No:	MC_12_1, MC_13_1
Property Ownership:	Private
Nearest Street/Road:	Arbutus Avenue, Woodlawn & Kilmarnoch Drive
Stream Reach ID No:	MC-00-00-07, MC-00-00-08 & MC-00-00-09
Project Type:	Stream stabilization

Project Description:

These stream reaches are all in need of localized stabilization. Several structures including parking lots and buildings could be affected if erosion continues. Reach MC-00-00-08 could also benefit from riparian plantings.

Typical stream section

Erosion near parking lot

Project Cost (design & construction):

Stream stabilization (1,500 linear feet x $200 per linear foot) = $300,000

Land acquisition: stream restoration (3.44 acres x $30,000 per acre) = $103,300

Total Project Cost = $403,300

Annual Cost = $29,700

Project Number:	SL-01
Project Name:	***Brenbrook stream restoration & floodplain wetland creation- Phase I***
Subwatershed:	Scotts Level
ADC Map No:	Map 24, G11
Catchment No:	SL_09_1 (outfalls), SL_03_3 (drainage area)
Property Ownership:	Public drainage way
Nearest Street/Road:	South of the intersection of Winterbrook Road and Brenbrook Drive
Stream Reach ID No:	SLB 18, SLB 19, SLB 20 & SLB 21
Project Type:	Stream restoration, concrete channel removal & floodplain wetland creation

Project Description:

This project includes approximately 3,100 lf of stream restoration and stabilization including the removal of a failing concrete channel. The project also includes the creation of floodplain wetlands for 5 small (<36") and one large (42") stormdrain outfalls.

Project Cost (design & construction):

Stream restoration (3,100 lf x $200 per lf) = $620,000

Floodplain wetland creation (6 sites x $25,000 per site) = $150,000

Access easement = $5,000

Total Project Cost = $775,000

Annual Cost = $57,000

Project Number:	SL-02
Project Name:	***The Woodlands open space stream stabilization***
Subwatershed:	Scotts Level
ADC Map No:	Map 24, B9
Catchment No:	SL_02_1 (outfalls), SL_03_3 (drainage area)
Property Ownership:	Public: County Park Land (The Woodlands – Local Open Space)
Nearest Street/Road:	Scotts Level between Mariottsville Road and just south of Tiverton Road
Stream Reach ID No:	SLB 33, SLB 34 & SLB 35
Project Type:	Bioengineering, stream stabilization

Project Description:

This project features 2,500 linear feet of natural bioengineering stabilization with an emphasis on streambank vegetation.

Project Cost (design & construction):

Stream stabilization through Bioengineering Techniques

(2,500 lf x $80 per lf) = $200,000

Total Project Cost = $200,000

Annual Cost = $14,700

Project Number:	SL-03
Project Name:	***Brenbrook stream restoration & floodplain wetland creation- Phase II***
Subwatershed:	Scotts Level
ADC Map No:	Map 24, G-H/11
Catchment No:	SL_09_1 (outfalls), SL_03_3 (drainage area)
Property Ownership:	Public drainage way
Nearest Street/Road:	South of the intersection of Winterbrook Road and Brenbrook Drive
Stream Reach ID No:	SLB 16 & SLB 17
Project Type:	Stream restoration, concrete channel removal & floodplain wetland creation

Project Description:

This project includes approximately 2,500 lf of stream restoration and stabilization including the removal of a failing concrete channel. The project also includes the creation of floodplain wetlands for 4 small (<36") and 2 large (42") stormdrain outfalls. Includes Baltimore County storm drain #290 and #291.

Project Cost (design & construction):

Stream stabilization (2,500 lf x $200 per lf) = $500,000

Floodplain wetland creation (6 sites x $25,000 per site) = $150,000

Access easement for outfalls = $5,000

Total Project Cost = $655,000

Annual Cost = $48,200

Project Number:	SL-04
Project Name:	***Cedar Mills stormwater management pond retrofit***
Subwatershed:	Scotts Level
ADC Map No:	Map 24, B9
Catchment No:	SL_02_1 (outfalls), SL_03_3 (drainage area)
Property Ownership:	Private
Nearest Street/Road:	Wanda Road
Stream Reach ID No:	N/A
Project Type:	Stormwater management pond retrofit/conversion to extended detention

Project Description:

This project involves the conversion of Baltimore County SWM pond #365, existing detention pond to extended detention. The drainage area to the pond is 27 acres.

Project Cost (design & construction):

SWM Pond conversion to extended detention (medium pond) = $150,000

Access easement = $5,000

Maintenance of SWM Pond = $3,000 annually

Total Project Cost = $195,800

Annual Cost = $14,400

Project Number:	SL-05
Project Name:	***Falcon Ridge stormwater management pond retrofit***
Subwatershed:	Scotts Level
ADC Map No:	Map 24, G10
Catchment No:	SL_02_1 (outfalls), SL_03_3 (drainage area)
Property Ownership:	Private
Nearest Street/Road:	Falcon Ridge Drive
Stream Reach ID No:	N/A
Project Type:	Stormwater management pond retrofit/conversion to extended detention

Project Description:

This project involves the conversion of Baltimore County SWM pond #1191, an existing detention pond, to extended detention. The drainage area to the pond is 11 acres.

Project Cost (design & construction):

SWM Pond conversion to extended detention (small pond) = $120,000

Access easement = $5,000

Maintenance of SWM Pond = $3,000 annually

Total Project Cost = $165,800

Annual Cost = $12,200

Project Number: SL-06

Project Name: ***Winands Road wetland creation***

Subwatershed: Scotts Level

ADC Map No: Map 24, K12

Catchment No: SL_02_1

Property Ownership: Public, Scotts Level Park

Nearest Street/Road: Winands Road

Stream Reach ID No: SL-13-00-01, SL-14

Project Type: Wetland creation

Project Description:

This project involves creating a wetland pond system to treat the runoff from Baltimore County outfall #233 and #389. May have demonstrative value to public in park setting.

D/S from #233

D/S from #389

Project Cost (design & construction):

Wetland Creation - medium= $250,000

Maintenance of BMP Wetland = $3,000 annually

Total Project Cost = $290,800
Annual Cost = $21,400

APPENDIX L:

Abbreviations

Abbreviations

BCMTA	Baltimore County Marine Trade Association
BGE	Baltimore Gas & Electric
B-IBI	Benthic Index of Biotic Integrity
BMP	Best Management Practices
BWB	Blue Water Baltimore
CBP	Chesapeake Bay Program
CCBC	Community College of Baltimore County
COMAR	Code of Maryland Regulations
CRP	Community Reforestation Program
CWA	Clean Water Act
CWP	Center for Watershed Protection
DA	Drainage Area
DEPRM	Baltimore Co. Dept. of Environmental Protection & Resource Management
DNR	Maryland Department of Natural Resources
DO	Dissolved Oxygen
DPR	Baltimore County Department of Parks and Recreation
DPW	Baltimore County Department of Public Works
DRC	Dundalk Renaissance Corporation
EJ	Environmental Justice
EPS	Baltimore County Department of Environmental Protection and Sustainability
ESD	Environmental Site Design
FA	Future Allocation
GIS	Geographical Information System
HSI	Hotspot Site Investigation
IR	Maryland's 2010 Integrated Report
ISI	Institutional Site Investigation
L	Liter
LU/LC	Land Use/Land Cover
MBSS	MD DNR Maryland Biological Stream Survey
MDA	Maryland Department of Agriculture

MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
MG	Milligram
MOS	Margin of Safety
MPA	Maryland Port Administration
MS4	Municipal Separate Storm Sewer System
MW	Megawatt
NCDC	National Climatic Data Center
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NSA	Neighborhood Source Assessment
OIT	Baltimore County Office of Information Technology
PAA	Pervious Area Assessment
PCB	Polychlorinated Biphenyl
PSI	Pollution Severity Index
ROI	Restoration Opportunity Index
SAV	Submerged Aquatic Vegetation
SHA	Maryland State Highway Administration
SSO	Sanitary Sewer Overflow
SWAP	Small Watershed Action Plan
SWM	Stormwater Management
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USLE	Universal Soil Loss Equation
VA	Veteran’s Administration
WQA	Water Quality Assessment

WRE	Water Resources Element
WWTP	Wastewater Treatment Plant
YR	Year