Upper Back River
Small Watershed Action Plan

Volume 1

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Final

Prepared by:

Baltimore County Department of Environmental Protection and Resource Management

In Consultation with:

Upper Back River SWAP Steering Committee

UPPER BACK RIVER
SMALL WATERSHED ACTION PLAN (VOL. 1)
TABLE OF CONTENTS

List of Tables

List of Figures

ACKNOWLEDGEMENTS

UPPER BACK RIVER STEERING COMMITTEE

The Upper Back River Small Watershed Action Plan was developed with cooperation and input from citizen organizations and local agencies that represent the interests of the Upper Back River watershed.

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TECHNICAL ASSISTANCE/REPORTS

Development of the Upper Back River Small Watershed Action Plan was supported technically by the following assessments and technical reports:

Technical Report	*Representative*
Upland Surveys (Neighborhood Source Assessments, Hotspot Assessments, Pervious Area Assessments, and Institutional Site Assessments)	Nathan Forand, Angela Johnson, Megan Brosh – DEPRM Paul Sturm, Mike Novotney, Julie Tasillo, Tiffany Wright, Lisa Fraley-McNeal, Hye Yeong Kwon – Center for Watershed Protection Darin Crew – Herring Run Watershed Association
Stream Corridor Stability Assessment	Parsons, Brinkerhoff, Inc. in association with Coastal Resources, and EBA Engineering
Stormwater Facility Assessment	Steve Stewart, Hee Song (intern) – DEPRM
Watershed Characterization	Steve Stewart, Nathan Forand, Chris Barnes DEPRM

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CHAPTER 1

INTRODUCTION

1.1 Overview

The purpose of this report is to provide guidance on the restoration of the Upper Back River Watershed. This report outlines a series of recommendations for watershed restoration, describes management strategies for each of the 14 subwatersheds and identifies priority projects for implementation. Planning level cost estimates are provided where possible and a preliminary schedule for implementation over a 20-year horizon is outlined. Financial and technical partners for plan implementation are suggested for various recommendations and projects. The watershed plan is intended to assist the Herring Run Watershed Association, Baltimore City and Baltimore County in moving forward with restoration of the Upper Back River.

1.2 Background

A unique partnership was formed between Baltimore City, Baltimore County, The Herring Run and Jones Falls Watershed Associations, and the Center for Watershed Protection to develop Small Watershed Action Plans (SWAPs) for study areas within the Jones Falls and Back River Watersheds. This two-year effort involved working with all partners to conduct upland assessments and stream corridor assessments to identify pollution sources, environmental degradation, and restoration opportunities.

During this two-year effort the partners participated in the Steering Committee to provide technical guidance and direction on the collection of existing data and the field assessments and the development of the SWAPs. The Steering Committee partners also helped develop the materials for the three Stakeholder meetings that were held to solicit input from citizens on goals, locations of problems, and acceptable restoration practices.

This document follows in the footsteps of prior and continuing efforts to address adverse environmental conditions that exist within the Back River Watershed. These efforts include:

- Baltimore County - Back River Water Quality Management Plan (1996)
- Baltimore County - Redhouse Run Watershed Study (1997)
- Baltimore City – Moores Run Feasibility Study
- Baltimore City – Biddison Run Feasibility Study
- Baltimore City – Open Channel Drainage Facility Study for Herring Run (2004)
- Center for Watershed Protection (CWP) – Redhouse Run Study (2006)

The past restoration planning efforts by the County and City mainly detailed Capital Restoration projects, while the CWP effort documents both Capital Restoration and citizen based restoration options. None of these planning efforts provided detailed pollution removal estimates, met the

EPA A through I watershed planning criteria, nor provided planning based on developed Total Maximum Daily Loads (TMDLs); all of which are addressed in this report.

1.3 Environmental Requirements

This Small Watershed Action Plan was developed to meet diverse environmental program requirements, including, National Pollutant Discharge Elimination System – MS4 permit assessment and planning requirements, Total Maximum Daily Load (TMDL) reductions for nutrients and bacteria, and anticipated Chesapeake Bay Program development of a TMDL for nutrient and sediment reductions to meet water quality standards for the Chesapeake Bay. This is in addition to citizen needs for a healthy environment, clean water, and an aesthetically pleasing landscape to enhance community livability.

1.3.1 NPDES – MS4 Permits

Both Baltimore County (99-DP-3317, MD0068314) and Baltimore City (99-DP-3315, MD0068292) NPDES permits have a number of requirements that will be addressed by this plan.

One requirement is a systematic assessment of water quality within all of their watersheds and the development of restoration plans. This assessment must include:

- Source identification information based on GIS information
- A determination of current water quality conditions
- Identification and ranking of water quality problems
- Results of visual watershed inspections
- Identify all structural and non-structural water quality improvements opportunities, and
- Specify overall watershed restoration goals.

A second requirement requires each jurisdiction to address 10% of the impervious cover during each 5-year term of the permit, with jurisdictions seeking to address 20% of the impervious cover within their respective jurisdictions by 2010 when their current permit is up for renewal. It is anticipated that future permits will have the same requirement.

This plan meets the systematic assessment and planning requirements of the NPDES Permits and provides the mechanism for how each jurisdiction will meet the goals for addressing impervious cover.

1.3.2 TMDLs

Three TMDLs have been developed by Maryland Department of the Environment (MDE) for addressing water quality impairments within the planning area. A TMDL was developed for nutrients (Appendix H) to improve water quality in tidal Back River sufficiently to meet water quality standards for dissolved oxygen and chlorophyll a, using a Hydrologic Simulation Program Fortran model. The TMDL identified urban stormwater runoff as a contributor to the water quality degradation and based on the model determined that a 15% reduction in nitrogen and phosphorus in urban runoff was required to meet the water quality standards. Upgrades to the Back River Waste Water Treatment Plant will account for the majority of the nitrogen and phosphorus reduction with the upgrades that are anticipated to be completed by 2013.

A second TMDL for bacteria (Appendix I) was developed by MDE to address the high bacteria concentrations in the streams in Herring Run, a subwatershed of Back River. Using a Bacteria

Source Tracking (BST) methodology the sources of bacteria are partitioned between human, domestic pet, livestock, and wildlife. Herring Run bacteria TMDL requires reductions of bacteria in the range of 91%-95%. To achieve water quality standards, reductions for human and domestic pet sources would have to be 98%, while wildlife sources would have to be reduced 33-74%. The TMDL indicated that due to the large reduction requirements, the reductions would be implemented in an iterative fashion, with additional monitoring to measure progress. This document provides the first iteration on management measures to be implemented to address the Herring Run bacteria impairment.

The TMDL for chlordane in fish tissue (Appendix J) developed by MDE in 1999 recognized that there are no known current sources of chlordane and that the chlordane in fish tissue is the result of legacy concentrations in the sediment of tidal Back River. Chlordane was withdrawn from the market in 1988 and suspended for agricultural usage, other than to control termites in 1975. Given the urban nature of the Back River watershed, the most likely source of chlordane was it's use in the control of termites around residential dwellings. With the product unavailable on the market for twenty years now, the sources of chlordane have been reduced. Hazardous Waste Collection Days held by both Baltimore County and Baltimore City provide a means for homeowners to dispose of any chlordane products safely. MDE will continue to monitor chlordane in fish tissue with the expectation of decline over time. Chlordane will not be further addressed in this SWAP.

1.3.3 Chesapeake Bay Nutrient and Sediment Impairment

The Chesapeake Bay Program is in the process of developing the Phase 5 Watershed Model. This model, in conjunction with the Estuary Model will determine the sources and reductions of nitrogen, phosphorus, and sediment needed to meet the Chesapeake Bay tidal water quality standards. Previous efforts under the Phase 4.3 Watershed Model and Maryland Tributary Strategy development indicated nitrogen and phosphorus reductions in excess of 20% for nitrogen and phosphorus. The new data will be used to develop a bay-wide TMDL and may possibly be used to assign nutrient and sediment load reductions to individual local jurisdictions based on the segment loads by the end of 2010. At this time, the loads and the reductions are not known. Once the loads and load reductions are known, if this document identifies restoration opportunities that are insufficient in providing the load reductions to meet the Chesapeake Bay TMDL, then the Steering Committee will re-convene to update the SWAP.

1.4 Partner Capabilities

In order to achieve effective watershed restoration, the capabilities of many organizations must be brought together and coordinated. Within the Baltimore region the cooperation and coordination has been advancing in recent years as we all seek common goals in water quality improvement in our streams and tidal waters.

The partners in the development of this document and the Lower Jones Falls SWAP are also partners in the Baltimore Watershed Agreement that commits Baltimore County and Baltimore City to work together along with the local watershed associations to address environmental issues in our shared watersheds. This agreement provides the framework for continued cooperation and progress in meeting the environmental issues detailed above. Currently five workgroups are developing action strategies to address: stormwater, trash, public health, greening, and development/redevelopment. These action strategies overlap with the actions detailed in this report and provide further incentive to move forward with restoration activities.

1.4.1 Baltimore County

Baltimore County has a history of implementing restoration projects, including stream restoration, stormwater conversions and retrofits, reforestation, and shoreline enhancement projects. In the Back River watershed a total of two miles of streams have been restored, 598 acres of urban land has been either retrofit with stormwater management or existing stormwater management has been enhanced to provide additional water quality improvements. Approximately 7 million dollars have been spent to date on restoration activities within the entire Back River watershed. An additional 1.4 million dollars has been allocated for restoration in Back River. Many of the projects have additional funding provided through grant programs.

Baltimore County has an extensive monitoring program that assesses the current ambient water quality, efficiency of various restoration projects in relation to pollutant removal efficiency and biological community improvement, and tracks trends over time. The County also has an Illicit Connection Program that monitors storm drain outfalls, tracks pollution sources, and coordinates remediation.

Baltimore County is under a consent decree to address Sanitary Sewer Overflows. The consent decree has specific requirements for improvements to pumping stations, remediation of sanitary sewer lines, maintenance and inspection. Implementation of the consent decree requirements will help reduce bacteria contamination, as well as, reduce nitrogen and phosphorus in the streams.

The county operates street sweeping and inlet cleaning programs throughout the county that remove sediment, nitrogen, and phosphorus before they reach the waterways. These programs are tracked and estimates of the pollution removal are calculated.

Through the installation of stormwater management facilities that address runoff from new development and redevelopment, implementation of Capital Restoration projects, and operation of street sweeping and inlet cleaning programs, Baltimore County estimates that 6% of the nitrogen and 7% of the phosphorus loads in the county portion of the watershed have been reduced.

1.4.2 Baltimore City

Baltimore City has a history of implementing restoration projects, including stream restoration, stormwater retrofits, and various trash collection devices. Within the Back River watershed the city has allocated $2.6 million for restoration work that includes stream restoration, wetland creation, and monitoring.

The city has an extensive monitoring network that includes chemical and biological monitoring that allows both a determination of current water quality status, as well as trends over time. In order to assist in measuring biological community improvements as a result of restoration the city has developed an urban index to better detect improvement. The city Illicit Connection Detection and Elimination Program uses two monitoring programs to detect the presence of illicit connections; stream impact sampling (SIS) and ammonia screening (AS). When either of these two monitoring programs indicates the possible presence of an illicit connection, a Pollution Source Tracking (PST) investigation is begun to locate and eliminate the source.

Baltimore City is under a consent decree to address Sanitary Sewer Overflows. The consent decree has specific requirements for improvements to pumping stations, remediation of sanitary sewer lines, maintenance and inspection. Implementation of the consent decree requirements will help reduce bacteria contamination, as well as, reduce nitrogen and phosphorus in the streams.

The city operates street sweeping and inlet cleaning programs throughout the city. These programs result in the removal of sediment, nitrogen, and phosphorus before they reach the waterways. The city and county recently participated in a study by the Center for Watershed Protection to determine the pollutant removal efficiency of street sweeping and inlet cleaning. The results of the study will be used to determine how much sediment, nitrogen, and phosphorus are removed as a result of these activities.

1.4.3 Herring Run Watershed Association

Herring Run Watershed Association (HRWA) is a grassroots, volunteer-based watershed organization. The HRWA mobilizes volunteers for environmental stewardship through outreach, public education, and advocacy. Their main focus has been on reducing sewage in streams and changing homeowner behaviors to improve streams. They have also been active in restoration through hands-on projects that take people to the stream, show them its problems, and take actions to solve those problems. These actions include; planting trees to reduce runoff, taking action to reduce stormwater runoff from homes, monitoring streams, and creating a green urban watershed center.

1.4.4 Summary

As can be seen from the above descriptions, the partners are well placed in terms of programs and experience to implement the actions proposed in this SWAP. Additional efficiencies can be realized through continued cooperation and implementation of the Baltimore Watershed Agreement Action Strategies across the broader region.

1.5 Upper Back River Watershed Overview

The Upper Back River watershed was selected for this study based on similarity of land use, and environmental issues. The Upper Back River represents 78% of the watershed. The Tidal Back River, with additional issues related to tidal waters, will be address through a separate SWAP to be developed in 2009.

The Upper Back River was further divided into 14 subwatersheds displayed in Figure 1-1. Table 1-1 provides a summary of key characteristics of the Upper Back River watershed.

Table 1-1: Basic Profile of the Upper Back River Watershed

Drainage Area	• 27, 716.7 acres (43.3 mi^2)	
Stream length	• 139.0 miles	
Land Use	• Low-Density residential (8.5%) • Med-Density Residential (26.5%) • High-Density Residential (20.4%) • Commercial (9.9%)	• Industrial (6.5%) • Institutional (8.0%) • Open Urban (6.2%) • Forest (11.5%)
Current Impervious Cover	• 30.7% of watershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (44.5%) • Baltimore County (55.5%)	
Soils	• A Soils – 0.0% • B Soils – 17.9%	• C Soils – 33.2% • D Soils – 46.7%

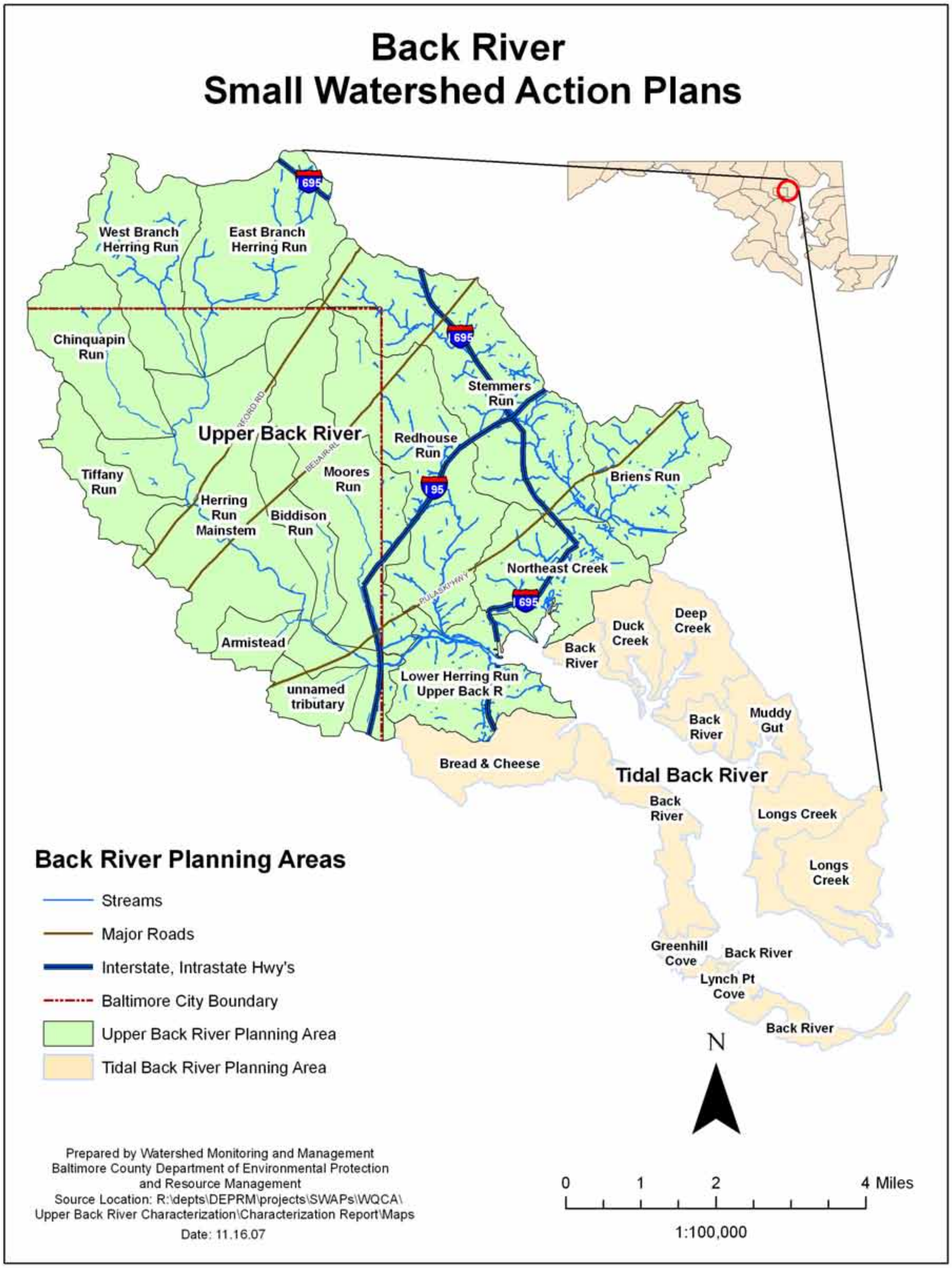

Figure 1-1: Upper Back River SWAP planning area and subwatersheds.

1.6 Report Organization

The remainder of the report is organized as follows:

Chapter 2 presents the eight watershed goals and the objectives associated with these goals.

Chapter 3 provides brief descriptions of the types of watershed restoration practices recommended for the Upper Back River Watershed in two categories – government strategies and citizen strategies.

Chapter 4 presents a prioritization of the 14 subwatersheds in the Upper Back River and summarizes their associated subwatershed-specific restoration strategies.

Chapter 5 presents the evaluation criteria and restoration monitoring framework.

A series of appendices provide additional detailed information used in the development and support for the Upper Back River SWAP. These appendices are outlined below:

- Appendix A – A table of specific restoration actions related to the goals and objectives presented in Chapter 2 are presented along with benefits, timeline, performance measure, estimated cost, and responsible party(s).
- Appendix B – A description of how the Upper Back River SWAP process meets the US Environmental Protection Agency's A through I Criteria for watershed planning.
- Appendix C – Cost analysis and a listing of potential funding sources.
- Appendix D – A copy of the Chesapeake Bay Program – Best Management Practice pollutant load reduction credits.

In addition, a second volume of appendices of supporting documentation on the condition of the Upper Back River watershed is provided. This second volume includes:

- Appendix E – Upper Back River Characterization Report (DEPRM 2008)
- Appendix F – List of stormwater retrofit and pond conversion opportunities. Detailed info on some Herring Run stormwater retrofit projects. (HRWA, CWP 2008)
- Appendix G – Stream Stability Assessment performed by Parsons Brinkerhoff in Stemmer's Run, Herring Run and Brien's Run subwatersheds. (Parsons 2008)
- Appendix H – Nutrient TMDL (MDE 2005)
- Appendix I – Bacteria TMDL-Herring Run (MDE 2006)
- Appendix J – Chlordane TMDL (MDE 1999)
- Appendix K – WQA for Zinc (MDE 2004)

CHAPTER 2

VISION STATEMENT AND GOALS

2.1 Vision Statement

The Upper Back River Steering Committee adopted the following vision statement that served as a guide in the development of the SWAP.

> *Our vision for the Upper Back River watershed in 2028 is a healthy watershed with streams that achieve water quality standards and communities that are actively engaged in their role as stewards of the streams.*

2.2 Upper Back River SWAP Goals

The goals for the Upper Back River watershed grew out of the vision statement and input from both the Steering Committee and the wider Stakeholder Group. A total of 8 goals were identified. These goals were developed through discussions with the Upper Back River SWAP Steering Committee and from watershed residents at the stakeholder meetings. The actions associated with the goals and objectives are presented in Appendix A. Many of the actions address multiple goals and objectives, therefore the Action Table laid out in Appendix A indicates the goals and objectives with which it is associated. The actions, while in many cases are expressed in a quantifiable mode (i.e. linear feet of forest buffer planted), are meant to serve as a guide and not as an absolute in achieving the goals. The Steering Committee has determined that an Adaptive Management Strategy will be emphasized as implementation goes forward. This strategy will assess the success of implementation over time and will change the implementation actions based on the acceptance of the community and availability of funding.

2.3 Goal 1: Improve and Maintain Healthy Streams

The Back River watershed is identified as being impaired by nutrients and bacteria as indicated in the Maryland 303(d) list of impaired waters. To rectify this impairment a Total Maximum Daily Load (TMDL) analysis has been completed for nitrogen, phosphorous and bacteria. The objectives below are designed to meet the nitrogen and phosphorus TMDL reduction requirements in the Upper Back River watershed and address the TMDL for bacteria. The goals of the Chesapeake Bay 2000 Agreement have been developed through Maryland's Tributary Strategy Process. These goals will also be addressed through the objectives outlined below.

<u>Objectives</u>

1. Reduce annual average Total Nitrogen and Total Phosphorus loadings to the Upper Back River watershed by 15%, compared to loading estimated for the baseline period to meet the requirements developed by the Back River watershed TMDL analysis.
2. Reduce annual average Total Phosphorous loadings to the Upper Back River watershed and Total Nitrogen loadings to meet Maryland's Tributary Strategy requirements and meet the goals of the Chesapeake Bay 2000 Agreement when developed as a Bay wide TMDL.
3. Complete sewer projects as identified and scheduled by the Federal Consent Decree to address the Back River TMDL analysis for bacteria.
4. Reduce other sources of bacteria.
5. Use the Baltimore Watershed Agreement (BWA) to identify ways to increase funding for urban stormwater projects.

2.4 Goal 2: Restore and Maintain Aquatic Biology and Habitat

The physical condition of the stream's substrate and banks are important to support aquatic life. The relationship of the stream channel with urban infrastructure such as; bridge culverts, stormdrain outfalls and sewer manhole stacks and crossings can negatively affect the stability of the stream and its ability to support aquatic life.

Objectives

1. Meet Maryland State Water Quality Standards for the in-stream biological community.
2. Develop in conjunction with the Maryland Biological Stream Survey (MBSS) a methodology to assess the biological improvements of urban streams.
3. Continue monitoring the aquatic biology in urban streams.
4. Increase stream restoration projects by providing more funding, staff and qualified contractors.

2.5 Goal 3: Improve Stream Corridors for Water Quality, Biological and Habitat Enhancement

There is an added value from forest that is adjacent to stream channels. There is an increased reduction of nutrients and sediment through the filtering of groundwater and absorption of flood flows. Wildlife use these areas as corridors for travel and the trees provide needed detritus for aquatic life. There is ultimately an improved aesthetic quality for local residents from riparian forest cover.

Objectives

1. Explore opportunities to remove concrete channels.
2. Increase forest adjacent to stream channels.
3. Raise awareness of the importance of riparian forest cover to owners of riparian property.

2.6 Goal 4: Increase Tree Cover

Trees process water to remove nutrients, provide food and habitat for wildlife and clean the air. Trees have an inherent quality of life benefit to the citizens that live in and share the watershed.

Objectives

1. Meet Baltimore City and County urban tree canopy goals by planting more trees on both public and private lands.
2. Improve management to ensure healthy trees.
3. Develop a monitoring program for tracking the quantity and health of trees.
4. Empower citizens to plant and maintain healthy trees on public and private land.
5. Continue incentive programs for trees planted by private landowners.
6. Deter the removal of healthy existing trees that are not causing any threat or substantial inconvenience to the general public.

2.7 Goal 5: Reduce Stormwater Impacts from Impervious Surfaces

The management of stormwater is one of the primary BMPs in the urban environment. Roads and buildings cover 31% of the Upper Back River watershed. These impervious surfaces are the conduits by which stormwater reaches streams. All the debris and associated pollutants covering impervious surfaces is carried by stormwater and, if left untreated, is deposited directly into streams.

Objectives

1. Disconnect impervious surfaces from the stormdrain system.
2. Remove impervious cover from unused areas.
3. Investigate removing stormdrains and "daylighting" buried streams as part of retrofit projects.
4. Conduct outreach, education and incentives for homeowners and other watershed landowners to raise awareness of water quality best management practices they can employ on their properties.
5. Use the NPDES MS4 permit to increase construction of stormwater retrofits and conversions of existing facilities to address existing impervious surfaces.

2.8 Goal 6: Increase the Use of Public Facilities and Properties as Models of Good Best Management Practices (BMPs)

Government should "lead by example" to encourage businesses and neighborhood communities to employ best management practices on their sites. Government properties should be valued as opportunities for construction of BMPs and have a secondary purpose as demonstrations of BMPs that are being promoted throughout the community.

Objectives

1. Use the Baltimore Watershed Agreement to engage County and City agencies to share resources to provide BMPs on public sites.
2. Use the NPDES general stormwater permit to engage County and City agencies into developing Pollution Prevention Plans and instituting "good housekeeping" practices at County managed facilities.

2.9 Goal 7: Improve Access to Streams

Citizens must have an awareness of local streams and the natural environment before a sense of stewardship can be expected. When citizens have an experience with a stream, they may make a personal connection and ultimately change their behavior. The Upper Back River watershed has 139 miles of open stream channels, many within community parks. It should be safe for children to play in these streams. Local parks are opportunities for neighborhoods to engage in local stream protection activities.

Objectives

1. Complete sewer projects as identified and scheduled by the Federal Consent Decree to reduce the number of water contact alerts in the Upper Back River streams.
2. Reduce the amount of trash in the streams by exploring structural controls, inlet messages, community clean-up projects and raising awareness of littering and its connection with streams.
3. Provide awareness of streams and our impact on them at local parks through information signage.
4. Connect people with streams through activities like clean-ups, invasive removal, tree planting, trail maintenance, bird watching, etc.

2.10 Goal 8: Enhance Unused Green Space

Numerous parcels and/or pieces of parcels have the potential for water quality and habitat enhancements. By examining these parcels for individual benefits, the collective result may provide significant improvements to water quality.

Objectives

1. Improve management of natural and turf areas on public, private and institutional properties.
2. Increase participation in Parks and People Foundation's community gardens program.
3. Increase participation in Baltimore County's "Neighbor Space" program.
4. Raise awareness of water quality best management practices that homeowners can employ on their own properties.

CHAPTER 3

RESTORATION STRATEGIES

3.1 Restoration Strategies Overview

The restoration strategies presented here are divided into two mutually supporting categories; government strategies (3.2) and citizen based strategies (3.3). The ultimate goal of these strategies is to find a mix of restoration activities that will, when implemented, result in achieving the goals set out in Chapter 2. In order to meet the TMDL for nutrients to improve water quality in Baltimore Harbor, a 15% reduction in nitrogen and phosphorus from urban non-point sources must be achieved. The analysis the pollutant loads is presented in the *Upper Back River Characterization Report* in Volume 2, Appendix E. Section 3.4 of this chapter summarizes the pollutant load calculations and presents the management scenario on how the reduction in phosphorus and nitrogen will be achieved.

3.2 Government Strategies

Baltimore City and County governments working together through the Baltimore Watershed Agreement play a key role in the SWAP implementation process by restoring local streams and improving water quality through capital improvement projects and government management activities (development review process, street sweeping and inlet cleaning, illicit connection programs, and sewer line rehabilitation and maintenance).

3.2.1 Stormwater Management for New Development and Redevelopment

The Maryland Stormwater Act of 2007 required Maryland Department of the Environment to develop new stormwater management requirements for new development and redevelopment using Environmental Site Design (ESD) techniques. The use of ESD best management practices (BMPs) will result in the distribution of flow throughout the development site resulting in a reduction of stormwater runoff leaving the site. This will effectively reduce pollutant loads and protect stream channels from erosion. The ESD requirements build on the design manual and regulation change in 2000 where channel protection and water quality were specifically required. However, ESD may not result in a zero pollutant load from new development. There should be water quality improvements that result from the application of ESD to redevelopment projects where water quality was not previously provided. For purposes of restoration in the Upper Back River, the water quality improvements that result from redevelopment will not be counted. Instead, redevelopment will be tracked along with new development to determine if the increase in loads from new development is balanced by redevelopment, and thereby maintain the cap that is implicit in the TMDLs (i.e. there will be no increase in either phosphorus or nitrogen as a result of development).

3.2.2 Existing Stormwater Management Facility Conversions

Stormwater facility conversions involve the re-design of existing stormwater management facilities that are currently providing limited water quality improvement, to one with more effective stormwater management capabilities. Only dry detention ponds, which are designed for water quantity control, were investigated for conversion potential. The results of assessment are presented in section 3.8 of the *Upper Back River Characterization Report* in Volume 2, Appendix E. Until further analysis is conducted to determine the extent of the conversion, it is unknown how much pollutant removal can be obtained. It was assumed that the dry pond could be converted to limited extended detention with a shallow marsh, which permits 50% removal of phosphorus and nitrogen. In addition to design limitations, there are limitations based on ownership and size. Privately owned facilities will require additional staff time to obtain easements and the owner may not be willing to grant an easement. The size of the drainage area to the facility can also be a limitation, since proportional cost of the design and construction will increase. To account for these limitations, it was assumed that only 75% of the acres available for conversion will actually be converted.

3.2.3 Stormwater Management Retrofits

Stormwater retrofits are new structural stormwater management practices that can be used to address existing stormwater management problems and water quality issues where there are currently no stormwater facilities.

The preliminary investigation by The Center for Watershed Protection of potential retrofit sites in the Upper Back River watershed will be used to determine retrofit projects to target based on priority rankings.

3.2.4 Stream Restoration

Stream corridor restoration practices are used to enhance the appearance, stability, and aquatic function of urban stream corridors. The practices range from routine stream clean-ups, simple stream repairs such as vegetative bank stabilization and localized grade control, to comprehensive repair applications such as full channel redesign and re-alignment. Primary practices for use in the Upper Back River watershed include stream repair, buffer reforestation, and stream cleanups.

Using the results of the *Upper Back River Stream Stability Assessment* (Appendix G), areas of primary concern can be targeted for restoration projects. Any restoration project will most likely have an effect on the residents or businesses whose properties border or contain the stream. Outreach to these individuals can be accomplished through community meetings, mailed questionnaires, and canvassing to determine if sufficient authorization will be granted to perform the restoration.

Areas outside of the Stream Stability Assessment area can be targeted based on citizen complaints about the streams and neighborhoods identified by the Neighborhood Source Assessment (Appendix F) to be encroaching on the stream buffer. Areas on public land, where a successful buffer planting effort or establishment of no-mow area may be more likely, should be given a priority when selecting a buffer reforestation project location.

Tables 3-4 and 3-5 identify the nutrient reductions associated with stream restoration opportunities in the Upper Back River. There were 63 reaches identified for stream restoration through the Stream Stability Assessments in Stemmer's, Herring and Brien's Run totaling 44,766 feet of restoration opportunity. This shows that 30% of the assessed reaches are recommended for restoration. Extrapolating this percentage to the entire watershed, 733,972.8 ft of stream it can be determined that 220,191.8 ft of stream possess opportunity for restoration.

The calculation of pollutant load reductions associated with stream restoration were based on the re-analysis of the Spring Branch data presented in the NPDES 2006 Annual Report, which resulted in the following pollutant load reduction estimates:

- Total Nitrogen – 0.202 pounds per linear foot of stream restoration
- Total Phosphorus – 0.0107 pounds per linear foot of stream restoration

Stream restoration can often be combined with sanitary sewer capital repair projects to leverage additional money and water quality benefits for less cost. Examples include the Stony Run stream restoration project in the Jones Falls watershed completed by Baltimore City and the Minebank Run stream restoration project in the Lower Gunpowder Falls watershed completed by Baltimore County.

3.2.5 Street Sweeping and Storm Drain Inlet Cleaning

Street sweeping removes trash, sediment and organic matter such as leaves and twigs from the curb and gutter system, preventing their entry into storm drains and nearby streams. This helps reduce sedimentation and pollutants, like oils and metals, in the stream. Excessive organic matter can clog the streams and storm drain system resulting in costly maintenance. In addition, the decay of a disproportionate amount of organic matter in the stream robs essential oxygen from the water.

Neighborhoods with street sweeping recommended through the Neighborhood Source Assessments will be referred to Baltimore City or Baltimore County Public Works offices to determine if street sweeping is conducted there and if so, at what frequency. Adding a targeted neighborhood to the sweeping route or increasing the frequency of the sweeping there would address the build up of excessive curb and gutter material in that location.

There were approximately 228 miles of street recommended throughout 67 neighborhoods in the Upper Back River for street sweeping. Based on numbers from the 2007 Street Sweeping Program from the Dept of Public Works (NPDES section 3), in the Back River watershed, there were 1.24 tons (2,480 lbs.) of material removed per mile of street sweeping. The concentrations used were 1825.92 mg/kg total nitrogen and 707.95 mg/kg total phosphorus, based on the recently completed Street Sweeping- Inlet Cleaning study (CWP 2008). Finally, the milligrams of pollutant were back calculated for pounds of pollutant removed.

The TMDL model for nutrients may not specifically include sanitary sewer overflows and may already account for street sweeping.

3.2.6 Illicit Connection Detection and Disconnection Program and Hotspot Remediation

Illicit Discharge Detection and Elimination programs have been developed by Baltimore County and Baltimore City. The objective of these programs is to find and remediate discharges into streams that are harmful to aquatic life and water quality, or that are causing erosion/ sedimentation problems.

Baltimore County and Baltimore City will continue with their Illicit Discharge Detection and Elimination programs, seeking to improve techniques and methodologies for more effective reductions of these discharges. The pollutant reduction realized from implementation of the illicit connection programs have not been incorporated into the nutrient reduction strategies due to the uncertainty in the contribution of illicit connections to the overall pollutant loading rates. These programs will provide a margin of safety in the overall nutrient reduction strategy.

3.2.7 Sanitary Sewer Consent Decrees

Two Consent Decrees have been issued by the Environmental Protection Agency (EPA) and Maryland Department of the Environment (MDE) against Baltimore County and Baltimore City. The Consent Decrees outline the agreed upon work (capital, equipment and operations improvements to be completed by 2016) with deadlines necessary for compliance with the Clean Water Act and the Maryland water pollution control laws with the goal of eliminating sanitary sewer overflows.

Over an 8 yr period (2000-2007), the documented Sanitary Sewer Overflows in the Upper Back River totaled 137,754,757.0 gallons. This is an average of 17,219,344.6 gallons/yr. Using a 30mg/L concentration for nitrogen and a 10mg/L concentration for phosphorus, pollutant load reduction estimates were calculated and are shown in Tables 3-4 and 3-5. The reduction of these sanitary sewer overflows will improve water quality by reducing the nutrients as well as the bacteria associated with these overflows.

3.3 Citizen Based Strategies

The participation of citizens in improving the health of a watershed is an essential part of the SWAP process. When large numbers of individuals become involved in citizen-based water quality improvement initiatives, changes can be made to the aesthetic and chemical aspects of the water and waterways within the watershed that would not be possible otherwise.

3.3.1 Downspout Disconnection

Rain downspout disconnection decreases flow to nearby streams during storm events, helping to quell stream bank erosion and reduce pollutants entering the stream during rainstorms. Downspout disconnection can be achieved through downspout redirection, rain barrels and/or rain gardens (see Appendix E, chapter 4).

Using a mix of outreach/awareness techniques and financial incentives, a downspout disconnection program can be implemented in neighborhoods identified by the Neighborhood Source Assessment. Initially, one or two pilot disconnection programs will be conducted in order to determine successful techniques and strategies for future success. Herring Run Watershed Association (HRWA) and the Center for Watershed Protection (CWP) have begun a pilot disconnection program in the Mayfield community. CWP is monitoring runoff from a control location to compare and assess results.

Through GIS, 1,486 rooftop acres were calculated to be in neighborhoods recommended for downspout disconnection through the Neighborhood Source Assessment. Based on percentages of potential for downspout disconnection from the neighborhood source assessment field sheets in Redhouse Run, it was determined there is an average of 60% potential for downspout disconnection among the total rooftop acres there. Through extrapolation, this calculation deems 892 rooftop acres viable for disconnection in the Upper Back River. Chesapeake Bay Program efficiencies for infiltration (50% Nitrogen, 70% Phosphorus) are used to calculate the potential nutrient reductions associated with disconnection in the Upper Back River. These reductions are shown in Tables 3-4 and 3-5.

3.3.2 Citizen Awareness

Raising awareness among citizens about some of the common activities around their homes and how those activities can negatively affect water quality is a primary citizen based strategy.

3.3.2.1 Lawn Fertilizer Application Awareness

A well-manicured and responsibly maintained lawn can be an asset to a watershed. Too often however, over-fertilization and irresponsible chemical applications result in pollutant charged runoff from lawns to local streams.

Areas identified by the Neighborhood Source Assessment as having high lawn maintenance should be targeted for awareness programs emphasizing responsible fertilizing techniques such as proper application amounts, proper time of year for fertilizing, soil testing for the nutrient requirements of the lawn and keeping fertilizers away from impervious surfaces. This education could be achieved through door-to-door canvassing, informational doorknob hangers or mailings, blurbs in community newsletters, or demonstrations at community meetings. Information on organic alternatives to chemical lawn treatments should also be included in these outreach efforts.

3.3.2.2 Pet Waste Awareness

Pet waste left on yards, sidewalks and common areas can be washed away by rain into the stormdrain and therefore into the stream. Once in the stream, this waste contributes bacteria such as E.coli and fecal coliforms that can cause health problems for people who come in contact with the contaminated stream. This waste can also contribute nutrients and its decay robs the stream of oxygen needed by fish and aquatic plants for survival.

Awareness programs emphasizing the importance of picking up after pets can include ‘pick up after your pet’ signs in common areas, informational doorknob hangers or mailings, blurbs in community newsletters, or demonstrations at community meetings.

3.3.3 Reforestation and Street Tree Planting

Trees help improve water quality by processing nitrogen and phosphorus in the groundwater which prevents these nutrients from reaching streams. Tree leaves and stems intercept precipitation, which helps to reduce the energy of raindrops and prevent any erosion that could be caused by their impact on the ground. In addition, trees strategically planted around the home can form windbreaks to reduce heating costs in the winter and when planted closer to the home, can reduce cooling costs in the summer.

Using incentive programs like Tree-Mendous Maryland and NeighborSpace of Baltimore County for planting on public property, and The Growing Home Campaign for private property plantings could increase the success of planting efforts. In addition, HRWA has obtained funding for a ½ off yard tree incentive program for canopy trees which has been successfully implemented throughout the watershed. HRWA also has piloted a successful street tree planting program in Baltimore County. Both HRWA programs were funded by the Chesapeake Bay Trust.

3.3.3.1 Riparian Buffer Reforestation

The riparian buffer is the last line of defense for the stream against nutrients in the groundwater. Buffer tree roots also help stabilize stream banks, reducing erosion and sedimentation in the stream.

The Stream Stability Assessment indicates areas within the assessed subwaterhseds that are recommended for buffer enhancement projects. The Neighborhood Source Assessment indicates 57 neighborhoods where buffer encroachment is evident. Combining this data, areas within the watershed can be targeted for buffer reforestation.

Areas on private land can be targeted for buffer awareness initiatives to encourage landowners to plant trees and/or create a no-mow area adjacent to the stream.

1,948 acres of buffer were determined to be open pervious or plantable through GIS land data. Further rough analysis in Redhouse Run showed that approximately 10% of the buffer area is feasible for establishing a forested buffer. Extrapolating this percent throughout the watershed gives a total of 194.8 acres of buffer possible for planting. The Chesapeake Bay Program removal efficiency for buffers allows for a land use change and a reduction efficiency of 25% for Nitrogen and 50% for phosphorus. In addition, ratios of 1:4 for nitrogen and 1:2 for phosphorus are used for calculating these efficiencies. In other words, 1 acre of forest buffer is theorized to treat 4 upland acres for nitrogen and 2 upland acres for phosphorus. Tables 3-4 and 3-5 show the potential nutrient reductions associated with forest buffers in the Upper Back River.

3.3.3.2 Upland Reforestation

Converting open areas in the upland portion of the watershed to forested areas by planting trees can decrease nutrients in nearby streams and reduce erosion.

Areas identified by the Pervious Area Assessment should be further investigated for potential for successful tree-planting efforts, focusing these investigations on the publicly owned parcels. A total of 123 acres were assessed, of these, 77 acres were on public property requiring minimal site preparation (Appendix E). These areas should be investigated first as the likelihood of a successful planting effort is greater here.

Many of the institutional areas assessed through the Institutional Site Assessment showed tree-planting opportunities. Using appendix 4-3 from Chapter 4 of Appendix E, institutions can be identified where tree-plantings are recommended restoration options.

3.3.3.3 Street Tree Planting

Aside from obvious aesthetic values, street trees shade concrete and can help cool an entire neighborhood while absorbing nutrients through their root systems, improving air quality and providing habitat for wildlife.

Neighborhoods recommended for street trees by the Neighborhood Source Assessment should be targeted for street tree plantings. Canvassing residents and/or contacting neighborhood associations can be effective techniques for beginning to implement a street tree planting program within a neighborhood.

3.4 Pollutant Load Reduction Analysis to Meet the Nutrient TMDL

3.4.1 TMDL Pollutant Load Reduction Requirements

In order to assess the nutrient pollutant loads in the Upper Back River planning area, a spreadsheet analysis was conducted. Using data supplied by Maryland Department of the Environment on per acre land use nitrogen and phosphorus loads and the Chesapeake Bay Program Watershed Model (Phase 4.3, segment 860-edge of stream loadings) per acre loadings for urban impervious and urban pervious loadings the nitrogen and phosphorus loads were calculated. Chapter 3 of the Upper Back River Characterization Report (Appendix E) presents the results for each subwatershed. This methodology was applied to derive the pollutant loads for nitrogen and phosphorus in anticipation of development of a Chesapeake Bay TMDL for these pollutants in 2010. The Chesapeake Bay TMDL will be based on the Phase 5 Chesapeake Bay Watershed Model linked to the Estuary Model. The Phase 5 land use loading rates are not currently available. At this time it is uncertain what the reduction requirements for urban stormwater sources of nitrogen and phosphorus will be for the Chesapeake Bay TMDL.

The land use was derived from the Maryland Department of Planning 2002 land use data layer. This information is presented in Chapter 2 of the Upper Back River Characterization Report (Appendix E).

The Maryland land use loadings assume full implementation of the tributary strategies for pollutant load reduction to the Chesapeake Bay. For this reason the urban land uses from the Chesapeake Bay program were used to determine the before restoration loadings. This will provide a before restoration loading rate and will allow a better assessment of progress made to date and further progress needed to meet the TMDL goals for urban non-point source reduction. Table 3-1 presents the per-acre loadings for nitrogen and phosphorus used in this analysis. These loading rates were also used for the reduction analysis discussed below.

Table 3-1: Land Use per Acre Nitrogen and Phosphorus Loadings (pounds/acre/year)

Land Use	Nitrogen Load per Acre	Phosphorus Load per Acre
Urban Pervious	15.77	2.28
Urban Impervious	8.06	0.51
Cropland	13.54	0.69
Pasture	5.64	0.66
Forest	1.29	0.02

The results of this analysis are presented in Table 3-2 with the annual loads of nitrogen and phosphorus split between urban, agriculture, and forest sources. A nutrient TMDL has been developed by Maryland Department of the Environment determine the load reductions needed for tidal Back River to meet water quality standards (Appendix H). The results from TMDL analysis indicated that the majority of the nitrogen and phosphorus reduction would be achieved through upgrades to the Back River Waste Water Treatment Plant. The upgrade to Enhanced Nutrient Removal (ENR) is due to be completed in 2013. In order to fully achieve water quality standards in tidal Back River the TMDL determined that an additional removal of nitrogen and phosphorus was required from urban sources with the percent reduction being set at 15% for both nitrogen and phosphorus. Table 3-2 presents the pounds removal needed to achieve this additional 15% reduction.

Table 3-2: Upper Back River Nitrogen and Phosphorus Loads

Source	# Nitrogen	# Phosphorus	15 % Nitrogen Reduction	15% Phosphorus Reduction
Urban	314,619	40,182	**48,189.6**	**6,055.8**
Agriculture	1,467	75		
Forest	5,245	116		
Total	**321,331**	**40,373**		

For purposes of this Small Watershed Action Plan the 15% reduction was applied to the total load to address the uncertainty in Best Management Practice performance and to provide a margin of safety in meeting the water quality standards in tidal Back River.

3.4.2 Pollutant Load Reduction Calculations

Most pollutant removal calculations are based on Chesapeake Bay Program models that credit nutrient reductions specific to individual scenarios as efficiencies or land use conversions. Stream restorations are credited using specific reduction amounts per stream mile restored and other practices are credited simply as a direct removal. Table 3-3 shows the Chesapeake Bay Program removal efficiencies of some stormwater management practices and Appendix D presents the full suite of best management practices and the associated efficiencies.

Table 3-3: Percent Removal Efficiency of BMPs

BMP	Pollutants		
	TSS	TP	TN
Detention Facilities	10	10	5
Extended Detention Facilities	60	20	30
Wet Ponds	80	50	50
Infiltration Practices	90	70	50
Filtration Practices	85	60	40

Detention Facilities = Detention Pond and Hydrodynamic Devices (DP, OGS, and UGS)
Extended Detention Facilities = Extended Detention Ponds (EDSD, EDSW, ED)
Wet Ponds and Wetlands = Wet Pond and Shallow Marsh (WP and SM)
Infiltration Practices = Infiltration Trench and Infiltration Basins (IB, IT and ITWQC), Porous Paving (PP), and Dry Wells (DW)
Filtration Practices = Sand filters and Bioretention Facilities (SF, BIO)

Listed in below are the specifics on best management practices and explanations about how the reduction numbers from Tables 3-4 and 3-5 are derived.

Stormwater Management Existing-based on numbers from Table 3-25 of Appendix E, The Upper Back River Characterization Report. The nitrogen and phosphorus pollutant loadings to each facility were based on the loading rates in Table 3-1. The pounds of removal were then calculated based on the facility type and the appropriate removal efficiency from Table 3-3.

Stormwater Management Conversions-based on numbers from Table 3-26 of Appendix E, The Upper Back River Characterization Report. Numbers for 'already implemented' column are from the three conversions listed in Table 7-13 of the 2008 Baltimore County NPDES Report. (Projects from the tidal Back River area not included in the calculations.)

Stormwater Management Retrofits-From Retrofit data from CWP. Numbers for 'already implemented' column are from the three retrofits listed in Table 7-13 of the 2008 Baltimore County NPDES Report. (Projects from the tidal Back River area not included in the calculations.)

Forest Buffers-Reduction numbers achieved through the Chesapeake Bay Program removal efficiency are based on a land use conversion plus a reduction efficiency. There are 1,948 acres considered open pervious in the stream buffer areas of Upper Back River. Rough GIS analysis shows approximately 10% or 194.8 acres feasible for planting. A reduction efficiency of 25% for nitrogen applied to four times the area and 50% for phosphorus applied to twice the area, yields the reduction efficiency estimates. Pollutant loads for forest are subtracted from the current urban pervious loads to obtain reductions based on the land use change. The reduction efficiency and land use change numbers are then combined to achieve the total reduction estimate.

Reforestation- Nutrient reduction numbers are based on 123 acres of pervious areas assessed (see Appendix E) and a land use conversion from urban pervious to forested. The numbers from the 'already implemented' column are based on Herring Run Watershed Association's tree planting numbers; 3,267 trees planted since 2004.

Stream Restoration-Based on recommended restoration lengths from the Parsons report on Brien's Run and county portions of Herring Run and Stemmer's Run (Appendix G), an average of 30% of the assessed streams were recommended for stream restoration. Extrapolating this percentage to the entire watershed's stream miles yields 220,192 ft or 41.7 miles of stream restoration opportunity.

The calculation of pollutant load reductions due to stream restoration are based on the re-analysis of the Spring Branch data presented in the NPDES 2006 Annual Report, which resulted in the following pollutant load reduction estimates:

Total Nitrogen – 0.202 pounds per linear foot of stream restoration
Total Phosphorus – 0.0107 pounds per linear foot of stream restoration

Existing stream restoration numbers indicated in the 'already implemented' column are derived from Table 7-13 of the 2008 Baltimore County NPDES Report.

Downspout Disconnection – The 205 neighborhoods recommended for downspout disconnection contain 1,486 impervious building acres (Table 4-1 Appendix F). Based on a 60% potential for downspout disconnection (from Redhouse Run counts), 891.5 impervious building acres were deemed feasible to disconnect. Chesapeake Bay Program efficiencies for infiltration, 50% for nitrogen and 70% for phosphorus, were used to determine nutrient reduction estimates.

Street Trees – It was determined that a total of 4,028 street trees could be planted in neighborhoods throughout the Upper Back River (Table 4-5 Appendix F). Estimated nutrient reductions were determined using the estimate of 400 trees per acre, and a land use conversion from urban pervious to forest.

Urban Nutrient Management – 134 neighborhoods were noted to have 30% or more high maintenance lawns. A total of 5,734.1 acres of pervious area exists within these neighborhoods. Using Chesapeake Bay Program loading rates for urban pervious, a reduction efficiency is applied (17% for N and 22% for P) to calculate nutrient reduction possibility.

Street Sweeping/Inlet Cleaning – The 67 neighborhoods recommended for street sweeping contain approximately 228 miles of road. Based on numbers from the 2007 Street Sweeping Program from the Dept of Public Works (NPDES section 3), in the Back River watershed, there were 1.24 tons (2,480 lbs.) of material removed per mile of street sweeping. Using a concentration of 1825.92 mg N/kg and 707.95 mg P/kg, a conversion factor was determined and potential load reductions calculated.

Sanitary Sewer Overflows-Over an 8 yr period (2000-2007), the documented Sanitary Sewer Overflows in the Upper Back River totaled 137,754,757.0 gallons. This is an average of 17,219,344.6 gallons/yr. The consent decree issued in September 2002, by EPA and MDE to the city of Baltimore will help reduce these sanitary sewer overflows and their associated nutrient loads. Based on a 30mg/L nitrogen concentration for raw sewage and 10mg/L phosphorus concentration, potential load reductions were calculated based on the elimination of these overflows.

Pollutant Load Reduction Calculation: The descriptions above for the various restoration strategies and the pollutant load reductions associated with the strategy were used in the development of the overall strategy to meet the 15% nitrogen and phosphorus reduction needed to meet the Back River TMDL. Tables 3-4 (Phosphorus) and Table 3-5 (Nitrogen) provide information on:

- The BMP type,
- How the pollution reduction is credited,
- The units available for treatment,
- A projected participation (how much of the available units are expected to be addressed),
- The pounds removed by future BMP implementation
- Pounds already removed by implementation, and
- The remaining pounds to be removed to meet the TMDL load reduction.

Table 3-4: Current and Projected Phosphorus Reductions due to BMPs

BMP	How Credited	TP Efficiency	Units Available	Projected Participation	TP Removed (lbs)	TP Removal (lbs) Already Implemented	TP Remaining (lbs)
Restoration Options							
Phosphorus to be Removed to meet the TMDL 15% Reduction							6,055.8
Stormwater Management Existing	Efficiency	Varies by Type	1,520.6 acres	NA	NA	563.4	5,492.4
Stormwater Management Conversions	Efficiency	Varies by Type	206 acres	75%	89.7	107.4	5,325.2
Stormwater Management Retrofits	Efficiency	Varies by Type	1,352 acres	75%	1,126.7	139.3	4,059.2
Riparian Forest Buffers	Land use conversion +Efficiency	50% for 2 upland acres	1,948 acres	10%	722.7		3,336.5
Reforestation	Land use conversion	Land use conversion	123 acres	40%	76.9	18.5	3,241.1
Stream Restoration	Linear Foot	.0107 lbs/ft	220,192 ft	30%	2,356.1	108.5	776.5
Downspout Disconnect	Efficiency	70%	892 acres	20%	63.7		712.8
Street Trees	Land Use Conversion	Land use conversion	10 acres	100%	22.8		690
Urban Nutrient Management	Efficiency	22%	5,734 acres	50%	1,438.1		-742.6
Street Sweeping/Inlet Cleaning	Direct removal		228 miles	100%	400.5	403.5	-1,546.6
SSO Reduction/Elimination	Direct removal			100%	1,432.6		-2,979.2
Total Pounds Phosphorus Removed							**9035.0**

Table 3-5: Current and Projected Nitrogen Reductions due to BMPs

BMP	How Credited	TN Efficiency	Units Available	Projected Participation	TN Removed	Already Implemented	TN Remaining
Restoration Options							
Nitrogen to be Removed to meet the TMDL 15% Reduction							48,189.6
Stormwater Management Existing	Efficiency	Varies by Type	1,520.6 acres	NA	NA	4,736.5	43,453.1
Stormwater Management Conversions	Efficiency	Varies by Type	206 acres	75%	827.4	938.2	41,687.5
Stormwater Management Retrofits	Efficiency	Varies by Type	2,131.6 acres	75%	5,808.7	1174.4	34,704.4
Riparian Forest Buffers	Land use conversion +Efficiency	50% for 4 upland acres	1,948 acres	10%	5,078.4		29,626.0

BMP	How Credited	TN Efficiency	Units Available	Projected Participation	TN Removed	Already Implemented	TN Remaining
Restoration Options							
Reforestation	Land use conversion	Land use conversion	123 acres	40%	713.9	118.7	28,793.4
Stream Restoration	Linear Foot	0.202 lbs/ft.	220,192 ft	30%	13,343.6	1,652.6	13,797.2
Downspout Disconnect	Efficiency	70%	892 acres	50%	718.5		13,078.7
Street Trees	Land Use Conversion	Land use conversion	10 acres	100%	146.2		12,932.5
Urban Nutrient Management	Efficiency	22%	5,734 acres	50%	7,686		5,246.5
Street Sweeping/Inlet Cleaning	Direct removal		228 miles	100%	1,032.9	1040.6	3,173.0
SSO Reduction/Elimination	Direct removal			100%	4,304.8		-1,131.8
Total Pounds Nitrogen Removed							**49,321.4**

The restoration strategies above, once implemented, will result in meeting the 15% reduction of nitrogen and phosphorus needed to meet the water quality standards for tidal Back River as determined by the Back River TMDL (Appendix H). Once the Chesapeake Bay TMDL is developed and finalized in 2010 and the urban nutrient load determined for Back River, the nutrient reduction strategy presented above will have to be reassessed to determine if it is sufficient to meet the reductions required under the Chesapeake Bay TMDL. If the strategies do not meet the reductions requirements, then within one year of TMDL approval, the strategies will be modified to meet the further reduction requirements required under the Chesapeake Bay TMDL.

Due to the uncertainty of effectiveness of best management practices and the magnitude of the reductions required, this document does not specifically address all of the actions needed to reduce bacteria levels in order to be in conformance with water quality standards. Instead, the reductions in bacteria will be conducted in an iterative fashion as recommended by MDE in the development of the TMDL (Appendix I). A bacterial monitoring program will be developed (Chapter 5) to further refine bacterial contamination sources and the effectiveness of various best management practices. The bacteria TMDL and progress being made to meet water quality standards will be reassessed in conjunction with MDE within five years of the completion of this SWAP. Based on that evaluation, a series of additional best management practices to address the bacteria TMDL may be developed.

CHAPTER 4

RESTORATION STRATEGY

4.1 Restoration Strategy Overview

An evaluation of each subwatershed in relation to ranking criteria is presented in this Chapter. Criteria were determined and are explained for the ranking methodology. Each criterion was selected because of its relation to one or several of the SWAP Goals. A score is associated with each criterion and then used to evaluate and rank the individual subwatersheds. This is a tool for targeting restoration actions by location/waterbody. A higher score has a higher priority. Some of the criteria are aimed at restoration needs and other criteria are focused on restoration potential.

The 14 Upper Back River subwatersheds are also summarized individually in this section. A profile of the land characteristics is presented in table format along with a narrative description. These characteristics are only a select few from Appendix F titled Characterization Report. A Management Strategy particular to the subwatershed is discussed. This is divided into two categories: *Engaging Citizens & Watershed Groups* and *Municipal Actions and Responsibilities.* This is consistent with the format in the previous Chapter 3.

4.2 Evaluation Criteria

Phosphorous and Nitrogen Load – Phosphorous and nitrogen loads were calculated for each subwatershed. The loads were calculated using data supplied by the Maryland Department of the Environment on per acre land use nitrogen and phosphorous loadings and the Chesapeake Bay Program Watershed Model. The method and results are summarized in the Characterization Report. For purposes of this prioritization a higher phosphorous and nitrogen load was correlated with a higher priority for restoration in the subwatershed.

Impervious surfaces – The amount of impervious surface within a watershed has been correlated with degradation in water quality. Impervious surfaces prohibit stormwater from infiltrating through the soil and prohibit the natural filtration of pollutants. The Center for Watershed Protection (CWP) has created a model that predicts stream quality with the amount of impervious cover in the subwatershed. The model has four categories for sensitive, impacted, damaged and severely damaged stream systems. For purposes of this prioritization the impervious surfaces for each subwatershed were placed into the four categories outlined in the CWPs impervious cover model.

Restoration Opportunity/Pollution Source Index – The assessment for each neighborhood contains a scoring system that categorizes the neighborhood as high, medium or low for both restoration opportunities and pollutions sources. These scores were combined in the matrix format below and then used as evaluation criteria for the prioritization of the subwatersheds. The subwatersheds that had the most neighborhoods with high potential for both restoration opportunities and as pollution sources received the highest priority score. The subwatersheds with the most neighborhoods that resulted in high and medium, received the second highest priority. The mediums scores and the high/low scores ranked as a third priority and the combined medium, low and none scores received the lowest priority.

ROI / PSI	High	Med	Low
High	***High/High***	**High/Med**	*High/Low*
Med	**Med/High**	*Med/Med*	Med/Low
Low	*Low/High*	Med/Med	Low/Low-None

NSA-Lawn Fertilizer Reduction – This category was selected form the Neighborhood Source Assessment to use in this prioritization because it has a quantitative pollution reduction efficiency related to the nutrient goals. Each neighborhood was evaluated as a pollution source for nutrients originating from lawn fertilizer. If more than 20% of the homes showed that fertilizer reduction was warranted then it became a recommendation for the neighborhood. For this prioritization process the acres associated with the recommended neighborhoods were summed. Then the acreage was divided by the total pervious acreage within the subwatershed. This normalized the acreage across the 14 subwatersheds. A ranking was then made between the subwatersheds and each received a priority score.

NSA-Downspout Disconnection/Redirection – This category was selected from the Neighborhood Source Assessment to use in this prioritization because the acres of impervious treated can be quantified and then related to the nutrient goals. Each neighborhood was evaluated as a pollution source for nutrients originating from rooftop runoff. A neighborhood in which 25% or more of the downspouts are feasible for disconnection/redirection scored for downspout disconnection/redirection as a recommended action. Feasible for disconnection was defined as downspouts either directly connected to the system or discharging to an impervious surface that leads into a storm drain inlet AND with at least 15 feet of usable pervious area to redirect the flow. For this prioritization process the impervious acres associated with the neighborhoods with downspout disconnection as a recommended action was summed. Then the acreage was divided by the total acreage of impervious buildings within the subwatershed. This normalized the acreage across the 14 subwatersheds. A ranking was then made between the subwatersheds and each received a priority score.

NSA-Trash Management – The results of the NSA include an indication of neighborhoods that are a source for trash. It was decided to use this data as a ranking tool because of it's potential of becoming a pollutant regulated by EPA through the TMDL process. Many of these neighborhoods could reduce their trash with a variety of techniques to raise awareness of the problem and ways to solve it. Some ways to raise the awareness of citizen's perception of trash as a problem include: a plaquerd marking the stormdrain inlet, a clean-up day, a recycling presentation and/or a targeted trash can inspection throughout the neighborhood. Baltimore County has regulations on homeowner trash management responsibility with regards to trashcans and lids. For purposes of the prioritization the number the neighborhoods identified as needing trash management were divided by the total number of neighborhoods in the subwatershed. This normalized the impact across the planning area and allowed a ranking of the subwatersheds. The scores were then broken into four brackets.

Institutional Site Index – The Institutional Site assessment was not finished for all of the subwatersheds in the Upper Back River planning area. This is identified as one of the actions needed in the Action Strategy (Appendix A). Institutions offer a unique opportunity to complete restoration activities on large acres of land. Usually the institutions are located on campuses that include many naturally resources. They also offer the opportunity to engage citizens, often students, in the restoration activities. This has the added benefit of raising awareness at the same time. After all of the Institutions have been assessed this prioritization may be modified to reflect the opportunity for working with institutions within certain subwatersheds.

Hotspot Site Index – Stormwater "hot spots" are commercial or industrial operations that produce higher levels of storm water pollutants, and/or present a higher potential risk for spills, leaks or illicit discharges into the storm water system. Stormwater hotspots are classified into four types of operations: commercial, industrial, municipal and transport-related. The Hot Spot Investigation is used to evaluate the potential of these types of facilities to contribute contaminated runoff to the storm drain system or directly to receiving waters. Sites were classified into four initial hotspot status categories: Not a hotspot, potential hotspot, confirmed hotspot or severe hotspot. These facilities may need further investigation or possibly need compliance with Maryland's NPDES general discharge permit. A training program for these operations may be developed to reduce the likelihood that these operations become a source for water contamination. For this prioritization process the number of hotspots where the inspection resulted in potential, confirmed or severe were summed for each subwatershed. The scores were broken into four groups and the subwatersheds were then ranked. The most hotspots were identified in the Redhouse Run subwatershed.

Pervious Area Site Index (PAA) – The Pervious Area Assessment identified sites that were open space, not developed. The site assessment included parcel size, public vs. private ownership, existing forest or wetlands and the extent of invasive species if they were present. The sites that are not providing much habitat or water quality value are then targeted for planting. Almost all of the PAAs identified in this survey were open space needing only minimal site preparation. For purposes of this prioritization, sites that are in public ownership are given a greater score because of the greater likelihood that they can be converted to tree cover. Sites that are in private ownership and are open space frequently are being planned for future development or expansion of an existing facility. The acres of PAAs in public ownership were summed and then weighted by two to give them a higher score. The acres of PAAs in private ownership were then added to this number to give a total weighted acreage. The total weighted acreage was then divided by the total acres of the subwatershed to normalize the acreage across the 14 subwatersheds. The percent of land identified as PAA was very small for all the subwatersheds. The Table 4-1 below shows the actual acreages and score.

Table 4-1: PAA Prioritization Score

	Acres PAA Public	Weighted PAA Public (x2)	Acres PAA Private	Total weighted acres	% acres per subshed acres	Score >.018 >.012 >.006 >0
Armistead Run	0	0	6.5	6.5	.016	3
Biddison Run	0	0	2.0	2.0	.003	1
Brien's	5.5	11.0	3.0	14	.009	2
Chinquapin Run	8.75	17.5	1.5	19	.012	3

	Acres PAA Public	Weighted PAA Public (x2)	Acres PAA Private	Total weighted acres	% acres per subshed acres	Score >.018 >.012 >.006 >0
East Branch Herring Run	6.0	12.0	1.0	13	.005	1
Herring Run Mainstem	9.0	18.0	6.0	24	.005	1
Lower Herring Run	0	0	5.0	5.0	.003	1
Moore's Run	16.0	32.0	4.5	36.5	.013	3
Northeast Creek	3.0	6.0	4.5	10.5	.006	2
Redhouse Run	29.5	59.0	3.0	62.0	.021	4
Stemmers Run	1.5	3.0	0	3.0	.001	1
Tiffany Run	0	0	0	0	0	1
Unnamed Tributary	0	0	0	0	0	1
West Herring Run	7.0	14.0	0	14.0	.007	2

Municipal Practices: Street Sweeping – Both Baltimore County and Baltimore City continually provide street sweeping services throughout their jurisdictions. Street sweeping immediately removes sediment and trash from the stream system network. As a part of the Neighborhood Source Assessment, street sweeping is identified as a recommended action for neighborhoods exhibiting trash and organic matter within the curb and gutter. For purposes of this prioritization the miles of roads for neighborhoods with street sweeping identified were summed. The total miles were summed. The sum for each subwatershed was ranked and placed into four equal categories. The subwatersheds with more miles of road received a higher prioritization score. These subwatersheds would receive a higher benefit from increased municipal street sweeping.

Municipal Stormwater Retrofits and Conversions - An evaluation of potential stormwater projects was conducted. The evaluation included both conversions of existing ponds and the feasibility of building new retrofit facilities. Baltimore County has a database on all of its stormwater management facilities, which includes information on the types of facility as well as drainage area and other details. The existing stormwater facilities that were classified as dry detention ponds were field assessed for their suitability for conversion to a type of facility that provides greater water quality benefits. A review of sites that indicated an opportunity for stormwater retrofit projects was conducted throughout both the City and the County portions of the planning area. This review used the Center for Watershed Protection's RRA process. Each of these assessments concluded with a list of potential stormwater facility projects. Each project was ranked on its feasibility for implementation and pollution reduction benefits. The results of these assessments are in the Upper Back River Characterization Report. For purposes of this subwatershed prioritization each facility was weighted based on its feasibility ranking and the size of its contributing drainage area. The scores for each subwatershed were totaled, then the total scores were broken into four equal categories. The subwatersheds with the best opportunity for stormwater retrofits and/or conversions received a higher prioritization.

Illicit Discharge Connection Potential - Baltimore City and Baltimore County have separate storm sewer and stormdrain systems constructed. However, the potential exists in all municipal stormdrain systems for pipes to leak into one another or to have pipes incorrectly connected. There are also many situations where private property owners have connected into the public system without approval. Baltimore County conducts a screening of outfall pipes and Baltimore City conducts an instream detection program to identify these illicit connections. A summary of the outfall monitoring data is discussed in the Characterization report (Appendix E). The outfall data values fall into four categories: no data, low, moderate or high. For purposes of this prioritization the subwatersheds with a high value were given a higher priority for action.

Stream Corridor Improvements – Stream corridors are the interface between the land and the surface water system. Within urban areas these corridors are heavily impacted from the flashy nature of the urban hydrology and the disturbance from humans. Forested stream buffers are a very important component in watershed restoration. They provide filtering of runoff that improves water quality and they provide habitat for wildlife and aquatic life within the stream system. In the Characterization Report (Appendix F) a 100-foot area was delineated using GIS and the land use within that area was categorized as forested, open pervious or impervious. For purposes of this prioritization the percent of open pervious acreage was used to indicate subwatersheds that could benefit from more stream buffer planting.

The scoring criteria are summarized in Table 4-2. This table contains the criteria, how the criteria are related to the restoration priority, the ranking categories and the corresponding scores.

Table 4-2: Restoration Prioritization Criteria, Ranking Categories, and Score

Criteria	Criteria Related to Priority	Ranking Categories	Score
Phosphorous Load	Higher Load (lbs/acre/yr) = Higher Priority	.80 ≥. 90 .70 ≥. 80 .60 ≥ .70 .50 ≥ .60	=4 =3 =2 =1
Nitrogen Load	Higher Load (lbs/acre/yr) = Higher Priority	7.5 ≥ 8.0 7.0 ≥ 7.5 6.5 ≥ 7.0 6.0 ≥ 6.5	=4 =3 =2 =1
% Impervious	Higher % Impervious = Higher Priority	≥ 40% 25% ≥ 40% 10% ≥ 25% ≤ 10%	=4 =3 =2 =1
ROI/ PSI index	Higher PSI and ROI = Higher Priority	High/High High/Med mix all Med or Low/Med mix all Low	=4 =3 =2 =1
NSA - *Lawn Fertilizer Reduction*	Higher Acres Fertilizer Reduction Opportunity (normalized per subwatershed pervious acres) = Higher Priority	% of subwatershed ≥ 60% % of subwatershed 40 ≥ 60% % of subwatershed 20 ≥ 40% % of subwatershed ≤ 20%	=4 =3 =2 =1
NSA – *Downspout Disconnection*	Higher acres feasible (normalized per subwatershed acres) = Higher Priority	60 ≥ 80 40 ≥ 60 20 ≥ 40 30 ≥ 20	=4 =3 =2 =1
NSA – *Trash Management*	Higher % of Neighborhoods = Higher Priority	75 ≥ 100% 50 ≥ 75% 25 ≥ 50% 0 ≥ 25%	=4 =3 =2 =1
HSI Index	Higher Status (number of potential, confirmed or severe per subwatershed) = Higher Priority	15 ≥ 20 10 ≥ 15 5 ≥ 10 0 ≥ 5	=4 =3 =2 =1

Criteria	Criteria Related to Priority	Ranking Categories	Score
PAA Index	Higher acreage (% per subwatershed) and public ownership = Higher Priority	.018 ≥ .024 .012 ≥ .018 .006 ≥ .012 0 ≥ .006	=4 =3 =2 =1
Municipal Mgn. Practices – Street Sweeping	Higher miles of roads (for neighborhoods w/ street sweeping recommended) = Higher Priority	45 ≥ 60 30 ≥ 45 15 ≥ 30 0 ≥ 15	=4 =3 =2 =1
Municipal SWM conversions and retrofits	Higher feasibility and drainage area = Higher Priority	≥ 1,500 1,000 ≥ 1,500 500 ≥ 1,000 0 ≥ 500	=4 =3 =2 =1
Illicit Connection Detection Potential	Higher data value = Higher prioritization	High Moderate Low No data	=4 =3 =2 =1
Stream Corridor Improvements	Higher open pervious buffer = Higher Priority	75 ≥ 100% 50 ≥ 75% 25 ≥ 50% 0 ≥ 25%	=4 =3 =2 =1

The subwatershed restoration prioritization scoring and ranking results are displayed in Table 4-3.

Table 4-3: Subwatershed Restoration Prioritization Scoring and Ranking Results

	Phosphorous Load	Nitrogen Load	% Impervious	ROI/PSI Index	NSA – Lawn Fertilizer Reduction	NSA – Downspourt Disconnection	Trash Management	HSI Index	PAA Index	Municipal Practices	Stormwater Retrofits & Conversions	Illicit Connection Potential	Stream Corridor Improvements	Total Score	Subwatershed Rank
Armistead Run	3	4	3	3	1	1	4	1	3	1	1	1	3	29	6 tied
Biddison Run	3	4	3	3	3	3	2	1	1	1	3	1	2	30	5
Brien Run	2	2	3	2	1	1	2	1	2	1	1	2	3	23	12
Chinquapin Run	3	3	3	2	3	3	1	1	3	2	4	2	2	32	2
East Branch Herring Run	3	4	3	2	2	3	1	1	1	2	1	1	3	27	8 tied
Herring Run Mainstem	3	3	3	2	1	3	2	1	1	4	4	1	3	31	3 tied
Lower Herring Run	2	2	3	2	1	1	1	1	1	1	1	1	3	20	14
Moore's	3	3	3	2	1	2	2	1	3	2	1	1	3	27	8

	Phosphorous Load	Nitrogen Load	% Impervious	ROI/PSI Index	NSA – Lawn Fertilizer Reduction	NSA – Downspout Disconnection	Trash Management	HSI Index	PAA Index	Municipal Practices	Stormwater Retrofits & Conversions	Illicit Connection Potential	Stream Corridor Improvements	Total Score	Subwatershed Rank
Run															tied
Northeast Creek	1	1	3	2	1	3	1	1	2	1	1	2	3	22	13
Redhouse Run	3	3	3	2	1	4	1	4	4	3	3	2	3	36	1
Stemmers Run	2	3	3	2	2	2	1	1	1	2	1	2	3	25	11
Tiffany Run	4	4	4	3	1	4	3	1	1	2	1	2	1	31	3 tied
Unnamed Tributary	4	4	3	2	1	1	3	1	1	1	1	2	3	27	8 tied
West Herring Run	4	4	3	2	3	3	1	1	2	1	1	1	3	29	6 tied

The subwatersheds were placed in three priority categories: very high priority, high priority, and medium priority. The results are shown in Figure 4-1. While restoration activities will have to occur throughout the Upper Back River in order to meet the environmental goals, the subwatershed prioritization provides information on where the initial focus should be located. Two subwatershed were moved from the high priority to the very high priority category based on known problems.

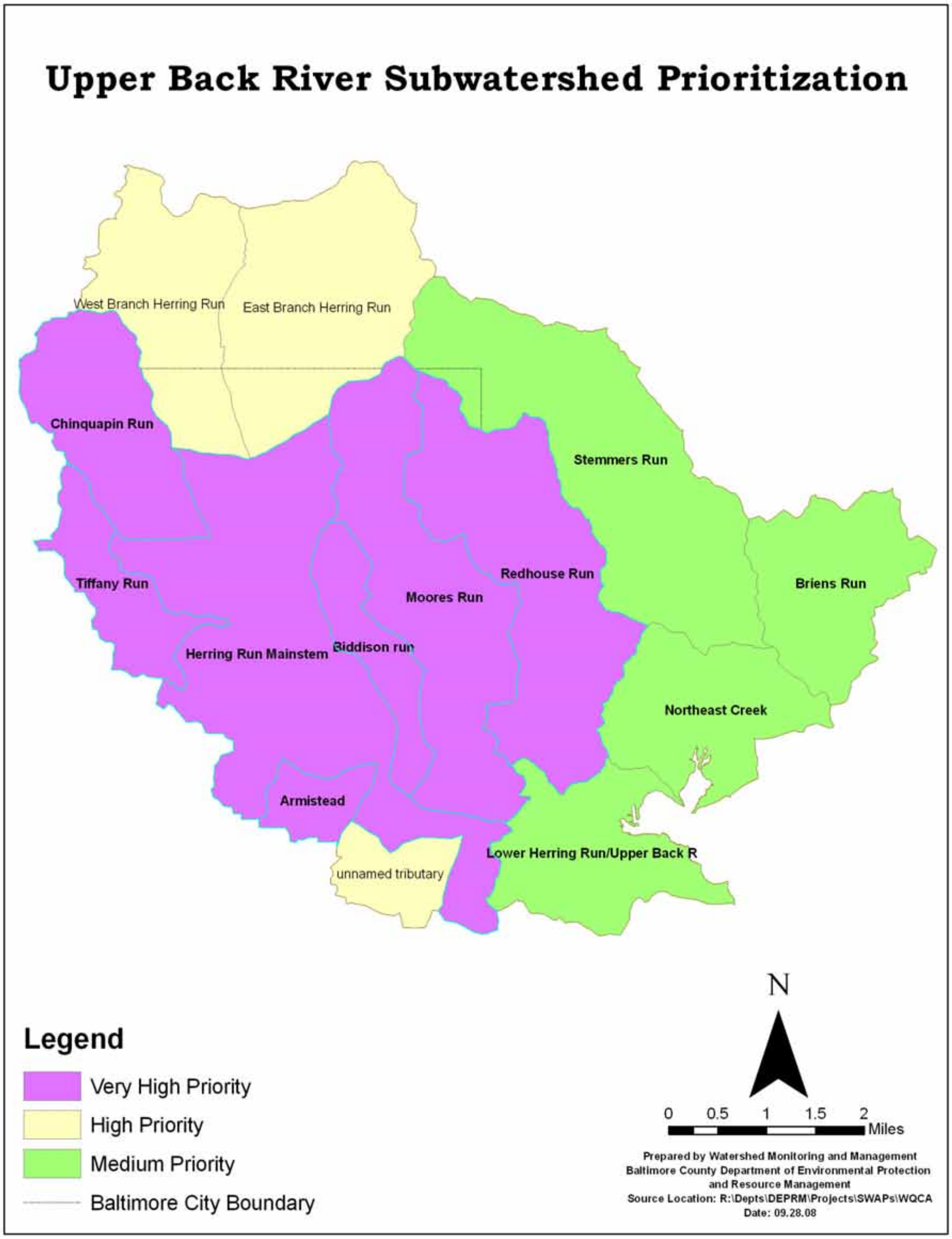

Figure 4-1: Subwatershed Prioritization Based on Scoring

4.3 Subwatershed Overviews

Subwatershed strategies are presented in this section with the subwatersheds arranged in alphabetical order. An initial table for each subwatershed presents basic profile information, including drainage area, stream length, land use, impervious cover, soils, stormwater management, and the percent distribution between Baltimore City and Baltimore County.

At the end of each subwatershed overview, the management strategy for that subwatershed is defined through a series of recommendations for citizen actions and municipal actions. A map showing the restoration opportunities locations follows the recommendations. Specific information on city streams was not included in this document, as the information was not available at the time the document was developed.

4.3.1 Armistead Run

Subwatershed Description

Armistead Run is a small industrialized subwatershed located entirely within the Baltimore City limits. The stream begins in the Orangeville Industrial Area off Edison Highway. From here, it flows east, intersects Erdman Ave. and turns northeast before flowing through the Armistead Gardens neighborhood and into Herring Run. Thirty-three percent of the stream buffer is forested. Table 4-4 presents the basic information on Armistead Run.

Table 4-4: Basic Profile of Armistead Run Subwatershed

Drainage Area	• 416.1 acres (0.7 mi^2)	
Stream length	• 1.45 miles	
Land Use	• Low-Density residential (0.0%) • Med-Density Residential (0.0%) • High-Density Residential (25.2%)	• Open Urban Land (30.4%) (includes forests) • Commercial (3.4%) • Industrial (57.5%)
Impervious Cover	• 37.3% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (100%) • Baltimore County (0%)	
Soils	• A Soils – 0.0% • B Soils – 4.5%	• C Soils – 5.0% • D Soils – 90.6%
Stormwater management	• City - No existing stormwater facilities were identified • County - NA	

Neighborhood Assessments

Two (2) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. NSA-L-63 has only 0.4 acres within the subwatershed boundary and is covered in the Herring Run Mainstem subwatershed section. Subwatershed boundaries were not used to designate neighborhood boundaries so some neighborhoods may exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include downspout disconnection, storm drain stenciling, street tree planting and buffer enhancement.

There are 1.98 impervious building acres in the neighborhood where downspout disconnection is recommended in Armistead Run. Based on an 85% potential for disconnection, 1.7 impervious building acres were deemed feasible for downspout disconnection. NSA-L-61 is a privately owned neighborhood so, similar to multi-family apartment neighborhoods; this would be a good area to target. Table 4-5 shows a summary of neighborhood recommendations.

Table 4-5. Summary of Neighborhood Assessment Recommendations in Armistead Run

Neighborhood Site ID	Median lot size (acres)	Recommended Actions: % Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Pet Waste	Buffer Enhancement	Street Trees	Notes
NSA_L_186	1/4	85			X	X				10	
NSA_L_61	Multifam	50	X		X	X			X	0	Tree planting

Typical homes in NSA-L-61

Hot Spot Assessment

Table 4-6 shows the two sites assessed in Armistead Run for hot spot status. Both assessed as confirmed hot spots.

Table 4-6. Summary of Hotspot Sites Recommendations in Armistead Run

Status	Site ID	Description	Potential Sources of Pollution: Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/Landscaping	Stormwater Management
Confirmed	HSI-L-201	Construction supply		X	X	X		X
Confirmed	HIS-L-202	Body shop/junkyard	X	X	X	X		X

Institutional Site Assessment

There were no institutional areas assessed in the Armistead Run subwatershed.

Stream Assessment

There were no stream assessments performed in Armistead Run.

Illicit Discharges

Baltimore City will continue with their Illicit Discharge Detection and Ellimination program, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

There were no retrofit or pond conversion opportunities identified in Armistead Run.

Pervious Area Restoration

Table 4-7 shows the one possible pervious area restoration site identified during the assessment. It is a large parcel owned by AK Asset Management Company. Pervious area restoration has the potential to convert areas of turf, sometimes a relatively high nutrient input land use, to forest, which can absorb rather than shed nutrients.

Table 4-7. Summary of Pervious Area Recommendations in Armistead Run

Site	Location	Description	Size (acres)	Priority
PAA-L-201	Chase & Iris	Vacant lot	6.5	

Subwatershed Management Strategy

Implementation recommendations for the Armistead Run subwatershed are as follows:

Engaging Citizens & Watershed Groups

1. Conduct downspout disconnection in each of the two neighborhoods. Most of the lots in NSA-L-61 do not have room for downspout re-direction so rain barrels are recommended. NSA-L-186 has good potential for re-direction.
2. Address buffer encroachment in NSA-L-186 by increasing tree canopy and establishing no-mow areas where possible.
3. Investigate PAA-L-201 for tree-planting possibilities. Plant street trees in NSA-L-186 and encourage residential tree planting to expand lot canopies in NSA-L-61.
4. To address trash issues, engage citizens in a storm drain stenciling program and conduct stenciling activities in both neighborhoods. Educate citizens about trash.
5. Encourage residents to implement bayscaping on their properties.

Municipal Actions

1. Conduct follow-up investigations at the two hot spot sites as both were assessed as confirmed hot spots.
2. Implement or increase street sweeping in L-61.

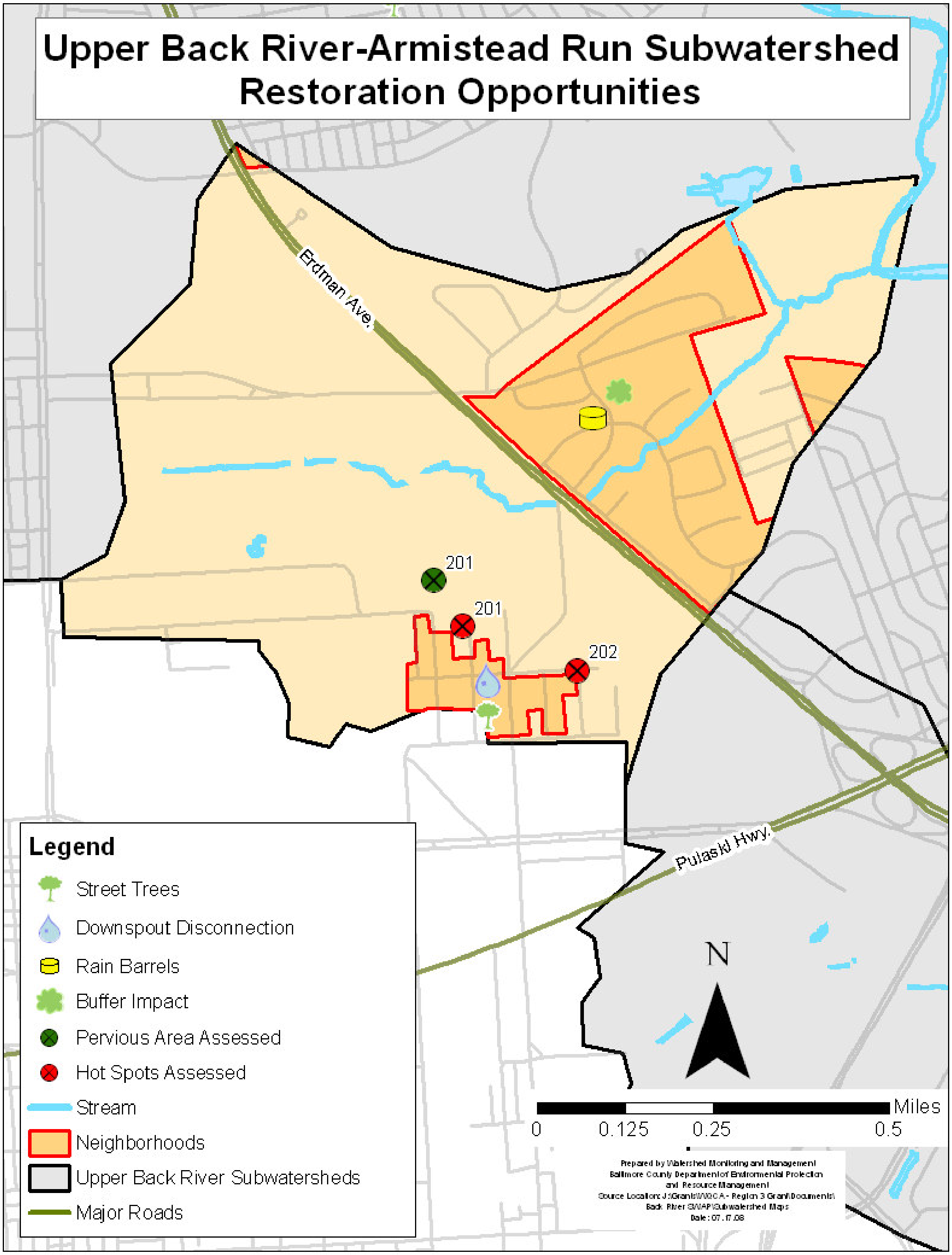

Figure 4-2 – Restoration Opportunities in Armistead Run

4.3.2 Biddison Run

Subwatershed Description

The Biddison Run stream is piped in the upper sections of the subwatershed. The stream is first daylighted in Gardenville off Sipple Ave. west of Frankford Ave. From here it passes behind the Holly Lane Apartments and follows a southerly flow passing beneath Sinclair La., past Franklin Elementary School and intersecting Moravia Rd. before joining Herring Run. 54% of the stream buffer is forested.

The northern half of Biddison where the stream is piped is almost all neighborhoods and as you travel south, the other land uses become evident. Table 4-8 displays the basic information on Biddison Run.

Table 4-8. Basic Profile of Biddison Run Subwatershed

Drainage Area	• 790.7 acres (1.2 mi^2)	
Stream length	• 3.12 miles	
Land Use	• Low-Density residential (0.0%) • Med-Density Residential (46.0%) • High-Density Residential (19.2%)	• Open Urban Land (6%) (includes forests) • Commercial (16.1%) • Institutional (8.5%)
Current Impervious Cover	• 33.6% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (100%) • Baltimore County (0%)	
Soils	• A Soils – 0.0% • B Soils – 6.7%	• C Soils – 3.4% • D Soils – 89.9%
Stormwater management	• City - No existing stormwater facilities were identified • County - NA	

Neighborhood Assessment

Nine (9) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. Subwatershed boundaries were not used to designate neighborhoods so neighborhoods often exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include downspout disconnection, storm drain stenciling, tree planting and public education (i.e. nutrient management). There seems to be ample opportunity here for stenciling and downspout disconnection.

There are 44.8 impervious building acres in neighborhoods where downspout disconnection is recommended in Biddison Run. Based on an average of 69.5% potential for disconnection, 31 impervious building acres were deemed feasible for downspout disconnection. Disconnection efforts should first concentrate on the 2 multi-family neighborhoods due to the efficiencies achieved by coordinating with one landowner instead of individual homeowners. Table 4-9 shows a summary of neighborhood recommendations.

Table 4-9. Summary of Neighborhood Assessment Recommendations in Biddison Run

Site ID	Median lot size (acres)	Recommended Actions										
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Pet Waste	Buffer Enhancement	Trash Mgmt	Street Trees	Notes
NSA_L_150	1/3	60	X		X	X					0	Rust staining on streets & sidewalks
NSA_L_164	Multifam	95		X	X	X	X		X	X	0	Trash mgmt, stained lots
NSA_L_165	Multifam	100			X	X			X	X	0	Expand buffer, tree planting
NSA_L_78	<1/4	60		X	X	X					0	
NSA_L_79	<1/4	60			X						0	
NSA_L_82	<1/4	40	X		X		X				35	Alley retrofits
NSA_L_83	<1/8	75	X		X	X				X	0	Park/garden creation or trees, alley retrofits
NSA_L_85	<1/4	90	X		X	X	X			X	0	Gutter algae
NSA_L_86	<1/4	45			X	X			X		50	

Dry weather discharge and algae in NSA-L-85

alley retrofit opportunity in NSA-L-83

dumpsters over storm drain in NSA-L-164

Hot Spot Assessment

There were no sites assessed in Biddison Run for hot spot status.

Institutional Site Assessment

There were no institutional areas assessed in the Biddison Run subwatershed.

Stream Assessment

There were no stream assessments performed in the Biddison Run subwatershed.

Illicit Discharges

Baltimore City will continue with their Illicit Discharge Detection and Ellimination program, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

There were two retrofit opportunities identified in Biddison Run and no pond conversions. Table 4-10 shows these retrofits.

Table 4-10. Summary of Retrofit Opportunities in Biddison Run

Site	Drainage Area (ac)	Description/Classification	Priority
R1	345	Wet Pond/Wetland	Medium
R3	1.5	Bioretention	Medium

Pervious Area Restoration

Table 4-11 shows the one possible pervious area restoration identified during the assessment. Pervious area restoration has the potential to convert areas of turf, sometimes a relatively high nutrient input land use, to forest which can absorb rather than shed nutrients.

Table 4-11. Summary of Pervious Area Recommendations

Site	Location	Description	Size (acres)	Priority
PAA-L-351	Off Sipple	Church open space	2	

PAA-L-351

Subwatershed Management Strategy

Engaging Citizens & Watershed Groups

1. Conduct downspout disconnection programs in each off the nine neighborhoods. Give priority to L-164 and L-165.
2. Increase tree canopies on private lots by educating citizens on the benefits of trees and about programs like The Growing Home Campaign and TreeBaltimore.
3. Engage citizens in a storm drain stenciling program and conduct stenciling activities in both neighborhoods.
4. Plant street trees in L-82 and L-86.
5. Investigate standing water/algae in L-85, Woodlea and Greenhill (see pic)
6. Reduce buffer encroachment by planting trees and establishing no-mow areas in neighborhoods listed in Table 4-9, especially L-165.
7. Address trash problems in neighborhoods indicated in Table 4-9.
8. Engage the 1st Church of God in potential tree plating on their property, PAA-L-351.
9. Investigate city trash truck depot off Moravia Rd for possible dumping/trash in stream and stream buffer area.

Municipal Actions

1. Conduct street sweeping in NSAs L-83, 85, 86 and 164.
2. Further investigate the possibility of implementing the two retrofits listed in Table 4-10.

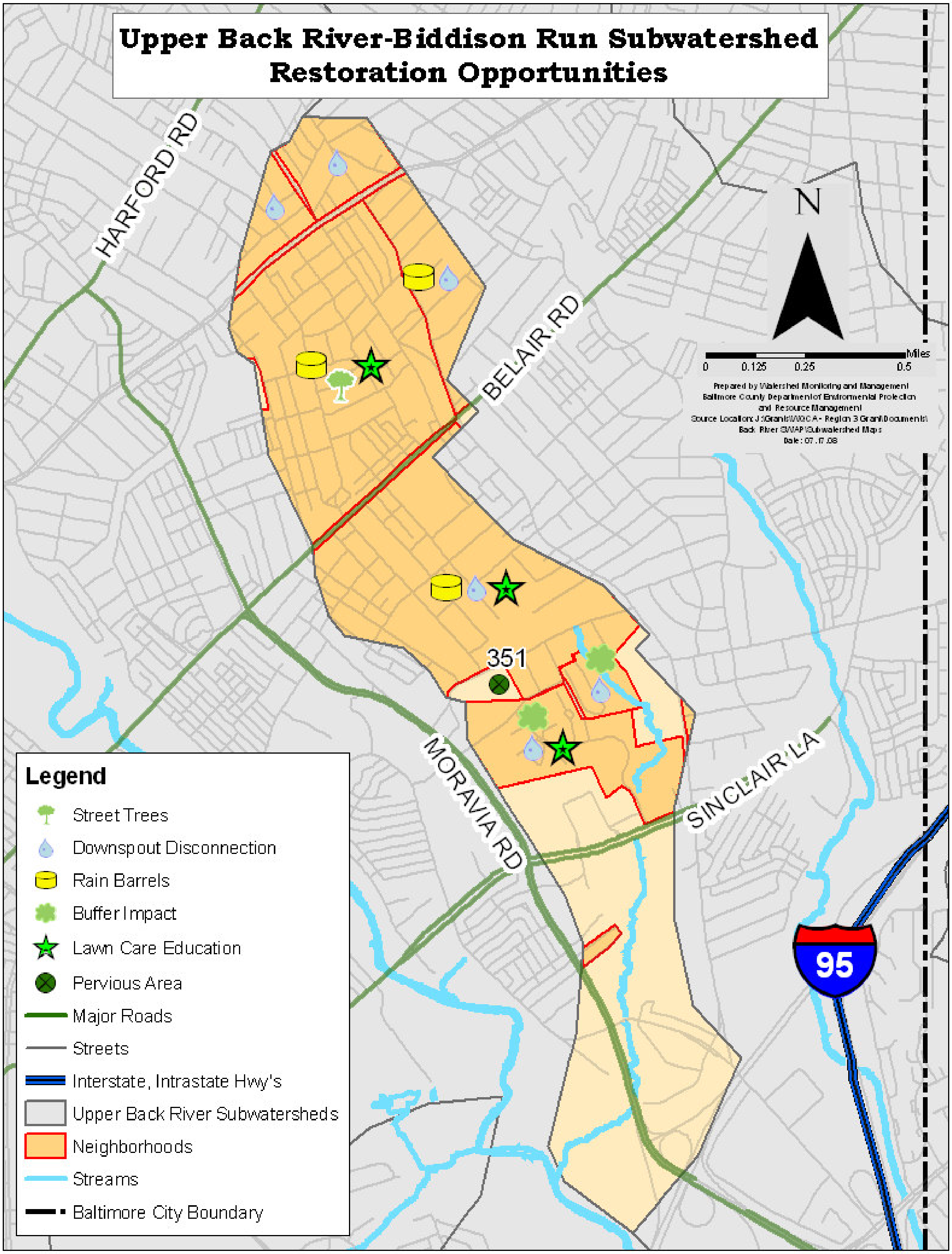

Figure 4-3 – Restoration Opportunities in Biddison Run

4.3.3 Briens Run

Subwatershed Description

Brien's Run begins below the intersection of Pulaski Highway and Middle River Road. From here, it flows southwest past Middle River Middle and Victory Villa Elementary Schools, past the Pulaski Industrial Park to the South and meets with Stemmers Run before entering Northeast Creek. 23% of the Brien's Run stream buffer is forested. 26% of the stream shows degrading vertical stability and 34% shows degrading lateral stability. Table 4-12 presents the basic information on Brien's Run.

Table 4-12. Basic Profile of Brien's Run Subwatershed

Drainage Area	• 1,636.1 acres (2.6 mi^2)	
Stream length	• 10.7 miles	
Land Use	• Low-Density residential (3.7%) • Med-Density Residential (2.5%) • High-Density Residential (36.4%)	• Open Urban Land (18.8%) (includes forests) • Commercial (11.2%) • Institutional (7.1%)
Current Impervious Cover	• 28.4% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (0%) • Baltimore County (100%)	
Soils	• A Soils – 1.8% • B Soils – 27.8%	• C Soils – 53.7% • D Soils – 16.8%
Stormwater management	• County – 24.4% of the watershed is treated by stormwater facilities • City - NA	

Neighborhood Assessment

Eleven (11) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. Subwatershed boundaries were not used to designate neighborhoods so some neighborhoods may exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include storm drain stenciling, rain barrels, street tree planting and public education (i.e. nutrient management).

Neighborhood NSA-L-39 has excellent opportunity to improve the buffer there. There is ample space for planting and the stream there looks unhealthy and cloudy. The tax parcel layer shows the area is zoned as unbuildable/environmentally constrained and no owner is indicated. Table 4-13 shows a summary of neighborhood recommendations.

Homes in NSA-L-44

Homes in NSA–L-208

Table 4-13. Summary of Neighborhood Assessment Recommendations

Recommended Actions											
Site ID	**Median lot size (acres)**	**% Opportunity for Downspout Disconnection**	**Rain Barrels**	**Rain Gardens**	**Stormdrain Stencils**	**Bayscape**	**Nutrient Management**	**Pet Waste**	**Buffer Enhancement**	**Street Trees**	**Notes**
NSA_L_129	Multifamily	0			X					10	Trash management
NSA_L_206	1/4	30		X	X		X			0	
NSA_L_207	1/2	50		X	X	X	X		X	0	
NSA_L_208	<1/4	80	X		X		X			0	New development, still building
NSA_L_39	<1/4	40	X			X	X		X	100	See PAA-L-701/ stream buffer
NSA_L_40	Multifamily	100	X							0	Trailer park
NSA_L_41	1/4	20			X	X	X			0	
NSA_L_42	<1/4	40	X		X	X				0	
NSA_L_43	1/4	65	X		X		X			15	New construction and SWM
NSA_L_44	<1/8	60	X		X					100	Alley retrofits
NSA_L_46	Multifamily	70	X		X		X			0	Dumping in wooded area/see PAA-L-702

Hot Spot Assessment

There were no hot spot investigations performed in Brien's Run.

Institutional Site Assessment

There were no institutional site assessments performed on Brien's Run.

Stream Assessment

A stream stability assessment was conducted by Parsons Brinkerhoff in the Brien's Run subwatershed. The subwatershed deficiencies as outlined in the report are as follows: 'Problems with the Brien's Run subwatershed include moderate stream bank erosion, various channel disturbances and fish blockages. Channel disturbances include invasive species and culverts causing fish blockages, as well as a large amount of waste and trash in some locations.'

Table 4-14. Summary of Stream Conditions in Brien's Run

Stream Opportunities	Number of Problems
Restoration/Stabilization	10
Buffer Enhancement	8
Bank Planting	2
Utility Conflicts	1
Wetland Enhancement	10
Yard Waste Education	23
Invasive Plant Removal	9
Trash Dumping	34

Illicit Discharges

Baltimore County uses a prioritization system for sampling outfalls for illicit discharges. Brien's Run contains five 'priority 2' outfalls and one 'priority 1' outfall. Priority 2 outfalls are sampled once per year and priority 1 outfalls are sampled four times per year.

Baltimore County will continue with their Illicit Discharge Detection and Elimination program, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

There were no retrofit opportunities identified in Brien's Run and 12 pond conversion opportunities. The conversion opportunities are displayed in Table 4-15.

Table 4-15. Summary of SWM Pond Conversion Opportunities in Brien's Run

Pond #	Drainage Area (ac)	Priority
803	1.7	High
793	3.6	High
792	3.7	High
686	1.9	High
685	2.9	High
553	9.0	High
456	1.5	Low
329	1.0	Low
554	2.9	Medium
974	2.1	Medium
692	3.7	Medium
544	2.9	Medium

Pervious Area Restoration

Table 4-16 shows the three possible pervious area restoration sites identified during the assessment. Pervious area restoration has the potential to convert areas of turf, sometimes a relatively high nutrient input land use, to forest, which can absorb rather than shed nutrients.

Table 4-16. Summary of Pervious Area Recommendations

Site	Location	Description	Size (acres)	Ownership
PAA_L_701	In NSA-L-39	Stream buffer	5.5	Public
PAA_L_702	In NSA-L-46	Forested area	1.5	Private
PAA_L_703	In NSA-L-207	Open area	1.5	Private

Subwatershed Management Strategy

Engaging Citizens & Watershed Groups

1. Implement rain barrel education/supply initiative in neighborhoods indicated in Table 4-13 including instruction on proper usage of the barrel.
2. Increase tree canopies on private lots by educating citizens on how to plant and care for trees, the benefits of trees and about programs like The Growing Home Campaign.
3. Provide lawn care education to neighborhoods identified in Table 4-13 as needing nutrient management. Work with homeowners in these neighborhoods to reduce the amount of chemicals applied to their lawn and other pollution prevention measures.
4. Improve stream buffer by planting trees on public land in PAA-L-701.
5. Plant street trees in neighborhoods indicated in Table 4-13.

6. Engage citizens in a storm drain stenciling program and conduct stenciling activities in neighborhoods indicated in Table 4-13.
7. Address trash issues in NSAs L-129 and L-46.

Municipal Actions

1. Make contact with owner of PAA-L-702 and establish conservation easement on small forested area here.
2. Focus on high priority pond conversions for implementation.

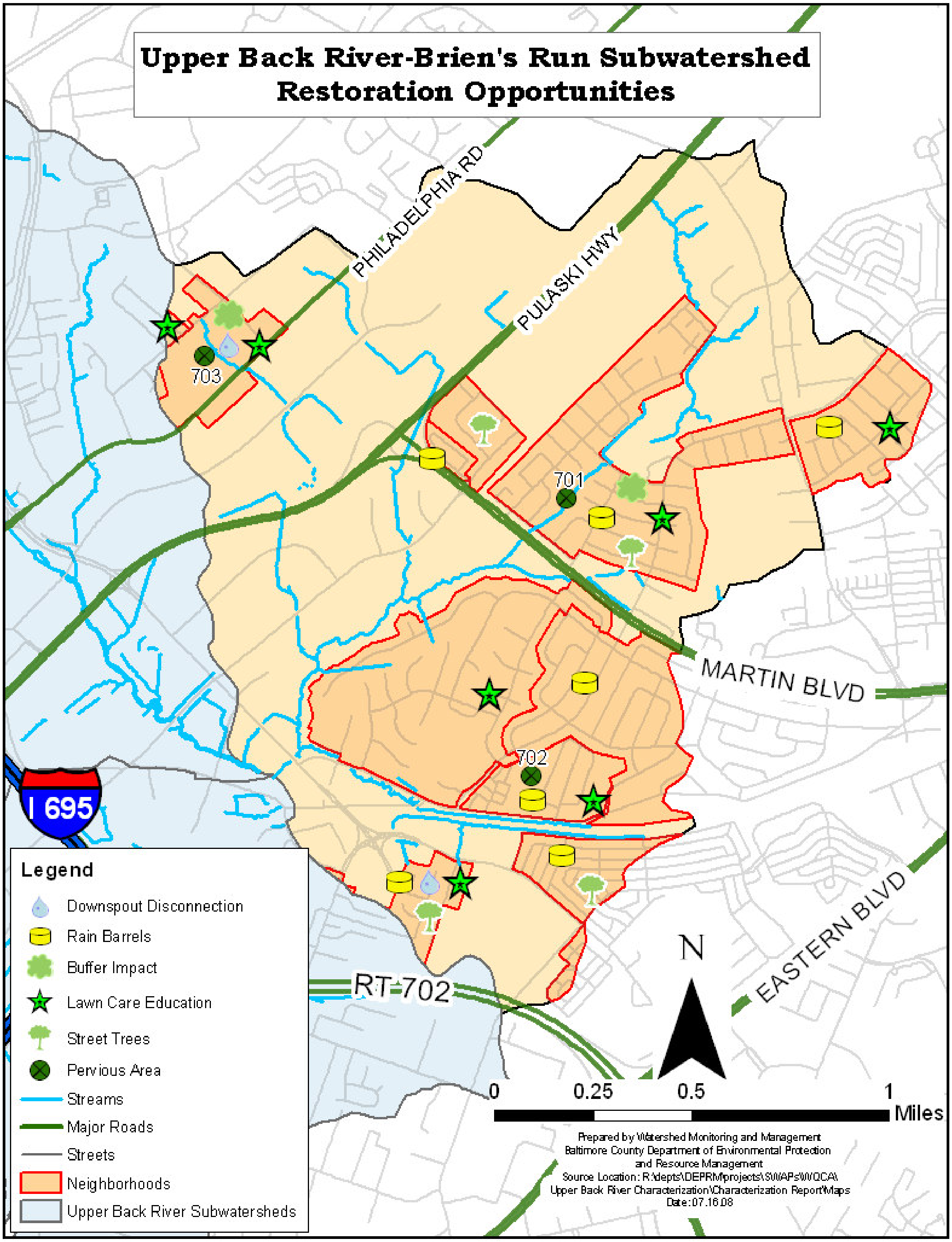

Figure 4-4 – Restoration Opportunities in Brien's Run

4.3.4 Chinquapin Run

Subwatershed Description

Chinquapin Run begins just north of the Baltimore City/ Baltimore County boundary near Regester Avenue. There are no open channels within the headwaters in Baltimore County, but the stream daylights just south of Walker Avenue at the City/ County line. The stream is bordered by City owned Chinquapin Park until it meets Hillen Road. At this point it is piped under Morgan State University until it meets the mainstem of Herring Run at the back end of the campus. (see pic)

This is primarily a residential watershed with several opportunities for downspout disconnection and storm drain stenciling within the neighborhoods. There are also numerous schools and churches with opportunities for tree planting and other onsite best management practices. Table 4-17 presents the basic information on Chinquapin Run.

Table 4-17. Basic Profile of Chinquapin Run Subwatershed

Drainage Area	• 1650 acres (2.5 mi^2)	
Stream length	• 4.94 miles	
Land Use	• Low-Density residential (0.0%) • Med-Density Residential (34.6%) • High-Density Residential (43.9%)	• Open Urban Land (7.6%) (includes forests) • Commercial (4.9%) • Institutional (8.1%)
Population	• 25,986 (2000 census)	
Current Impervious Cover	• 35.2% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (78%) • Baltimore County (22%)	
Soils: Hydrologic Soil Group	• A Soils – 1.6% • B Soils – 19.3 %	• C Soils – 8.4% • D Soils – 70.7%
Stormwater management	• County - No existing stormwater facilities were identified • City - No existing stormwater facilities were identified	

Neighborhood Assessment

Thirty-two (32) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. Subwatershed boundaries were not used to designate neighborhoods so some neighborhoods may exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include downspout disconnection, storm drain stenciling, tree planting and public education (i.e. nutrient management).

trash management problems in NSA-L-110A

Morgan State construction project in Chinquapin Run buffer area where it joins Herring Run

There are 116.8 impervious building acres in Chinquapin Run. Many of the neighborhoods in Chinquapin Run were assessed using the NSA jr form, which does not require a percent downspout disconnection number hence the 'nd' or no data entries in this associated column. Therefore the average percentage for potential for disconnection is not included here. However, disconnection efforts should first concentrate on the 14 multi-family neighborhoods due to the efficiencies achieved by coordinating with one landowner instead of individual homeowners. NSA-L-110A, the Kensington Gate Apartments, shows great potential for multiple restoration opportunities. Table 4-18 shows a summary of neighborhood recommendations.

Table 4-18. Summary of Neighborhood Assessment Recommendations

Site ID	Median lot size (acres)	Recommended Actions									Notes
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Parking Lot Retrofits	Alley Retrofits	Street Trees	
NSA_L_109	Multifamily	X			X	X		X		10	Downspout disconn
NSA_L_110A	Multifamily	X						X		0	Trash mgmt/SW
NSA_L_110B	Multifamily	nd							X	0	Impervious removal/alley
NSA_L_112	<1/4	30		X	X	X				0	Concrete buffer in park/
NSA_L_116	Multifamily	X				X		X		0	Tree planting/downspout
NSA_L_117	Multifamily	X			X			X		0	Downspout
NSA_L_130	<1/8	nd			X				X	0	Alley retrofit
NSA_L_136	1/3	80		X			X			0	
NSA_L_137	1/3	80			X		X			0	
NSA_L_149A	Multifamily	nd	X					X		0	SW retrofit
NSA_L_149B	<1/4	X			X	X				0	
NSA_L_22	<1/8	nd	X							0	Downspout disconn
NSA_L_23	<1/8	75			X	X				0	Tree planting
NSA_L_28	1/4	75			X		X			0	
NSA_L_29	Multifamily	50	X		X		X	X		0	Lot retrofit/tree planting
NSA_L_30	Multifamily	50	X		X		X		X	0	Street sweeping/alley
NSA_L_31	1/8	45			X				X	0	Alley retrofits
NSA_L_32	1/4	85	X	X		X				50	
NSA_L_33	1/8	nd	X			X				0	
NSA_L_34	<1/8	nd	X		X				X	0	
NSA_L_35	1/8	50			X	X			X	0	
NSA_L_36	<1/8	nd	X		X				X	0	Alley retrofit
NSA_L_38	<1/8	nd	X		X				X	50	
NSA_L_49	<1/4	X		X	X					0	Trash mgmt
NSA_L_50A	Multifamily	X						X		0	Downspout disconn
NSA_L_50B	<1/4	70			X	X				0	
NSA_L_51	1/4	X			X					nd	Street sweeping/street trees
NSA_L_93	Multifamily	X			X			X		25	Sediment control
NSA_L_94	Multifamily	nd	X		X					75	
NSA_L_95	Multifamily	X	X				X			0	Tree planting
NSA_L_96	Multifamily	nd					X			20	Tree planting
NSA_L_97	Multifamily	X						X		0	Downspout disconn

Hot Spot Assessment

No sites were assessed in Chinquapin Run for hot spot status. Less than 5% of the watershed is in commercial land use with the remaining area in residential or institutional land cover.

Institutional Site Assessment

Table 4-19 shows the nine institutional areas assessed in the Chinquapin Run subwatershed. Several properties offer opportunities to plant upwards of one hundred trees. The Maryland Youth Residence Center offers several opportunities that include infrastructure maintenance. Perhaps an incentive to become a registered Green School could be used to improve the campus.

Table 4-19. Summary of Recommendations for Schools and Places of Worship

Site ID	Name of Site	Public/ Private	Greening Opportunities						Notes
			Nutrient Management	Tree Planting (#)	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management	
ISI_L_103	St. Pius Church	Private	Y	145	Y	N	Y	N	SWM needed for parking lot
ISI_L_104	Nothside Baptist Church	Private	N	170	N	N	N	Y	Dumping and Invasive removal
ISI_L_105	Leith Walk Rec Center	Public	N	245	N	N	Y	Y	Trash and debris in gutters
ISI_L_106	Govans Elementary	Public	N	15	N	N	N	N	Reseed small field
ISI_L_107	MD Youth Residence Center	?	N	105	N	Y	N	Y	Debris in gutters, sediment, trash,
ISI_L_108	Messiah Evangelical	Private	N	105	N	N	N	N	Tree planting
ISI_L_109	Lois T. Murphy Special Ed. School	Public	N	62	N	N	N	N	Tree Planting
ISI_L_110	St. Mathews Church & School	Private	N	N	N	Y	N	Y	Dumpster near inlet
ISI_L_111	Faith Presbyterian	Private	N	25	N	Y	?	N	Debris in gutters

Tree planting opportunity at ISI-L-103

Impervious removal and good housekeeping at ISI-L-105

Stream Assessment

A stream stability assessment was not conducted for the Chinquapin Run watershed. The subwatershed consists of one open channel and the remaining drainage system is piped. The open channel lies entirely within Baltimore City. It has been evaluated from previous field inspections and determined to not have bank erosion problems. Therefore there are no stream opportunities identified for the Chinquapin Run in this report.

Illicit Discharges

Baltimore County uses a prioritization system for sampling outfalls for illicit discharges. Priority one describes an outfall with major problems including the presence of chemicals in the water. Priority two describes outfalls with moderate problems including erosion and trash but no chemical problems detected. Priority 1 outfalls are sampled four times per year and priority 2 outfalls are sampled once per year. There are no priority 1 or priority 2 outfalls in the county portion of Chinquapin Run.

Baltimore County and Baltimore City will continue with their Illicit Discharge Detection and Elimination programs, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

There were nine retrofit opportunities identified in Chinquapin Run and no pond conversions. Table 4-20 shows these retrofits.

Table 4-20. Summary of Retrofit Opportunities in Chinquapin Run

Site	Drainage Area (ac)	Description/Classification	Priority
R3B	45	Wet Pond/Wetland	High
R6A	84	Wet Pond/Wetland	Medium
R2B	53	Wet Pond/Wetland	Medium
R6B	300	Wet Pond/Wetland	Low
R6C	68	Wet Pond/Wetland	Low
R8	82.8	Wet Pond/Wetland	Low
R2A	3.8	Bioretention	Low
R5	44	Wet Pond/Wetland	Low
R9	1.0	Enhancement	Medium

Pervious Area Restoration

Table 4-21 shows the five possible pervious area restorations identified during the assessment. Pervious area restoration has the potential to convert areas of turf, sometimes a relatively high nutrient input land use, to forest, which can absorb rather than shed nutrients.

Table 4-21. Summary of Pervious Area Recommendations

Site	Location	Description	Size (acres)	Ownership
PAA_L_101	Kitmore Rd.	Buffer area of stream	0.75	Public
PAA_L_102	Northwood & Woodbourne	Open space behind townhomes	0.50	Unknown
PAA_L_103	Bradhurst Rd.	Walter De Wees Park	2.00	Public
PAA_L_104	Northwood ES	Open space by school	6.00	Public
PAA_L_105	Behind Alameda Shopng Cntr	Impervious area removal necessary	1.00	Private

PAA-L-101

Subwatershed Management Strategy

Engaging Citizens & Watershed Groups

1. Conduct appropriate downspout disconnection measures according to Table 4-18, focusing efforts on the multi-family neighborhoods.
2. Engage citizens in a storm drain stenciling program and conduct stenciling activities in the neighborhoods indicated in Table 4-18.
3. Plant street trees in the neighborhoods indicated in Table 4-18. There is an estimated potential for 320 street trees in this subwatershed.
4. Increase tree canopies on private lots by educating citizens on the benefits of trees and about programs like The Growing Home Campaign and TreeBaltimore.
5. Examine parking lot and alley retrofit opportunities outlined in Table 4-18. Baltimore City's Alley Gating and Greening Program could be of assistance here.
6. Further investigate 5 pervious areas in Table 4-21 for tree plating opportunities. Give priority to those on public land.
7. Table 4-19 identifies schools and churches assessed through the ISI. Leith Walk Rec Center and the Maryland Youth Resident Center each show multiple opportunities for watershed restoration activities.

Municipal Actions

1. Conduct street sweeping in NSAs L-28-30, 49 and 51.
2. Further investigate retrofit opportunities listed in Table 4-20 for implementation.

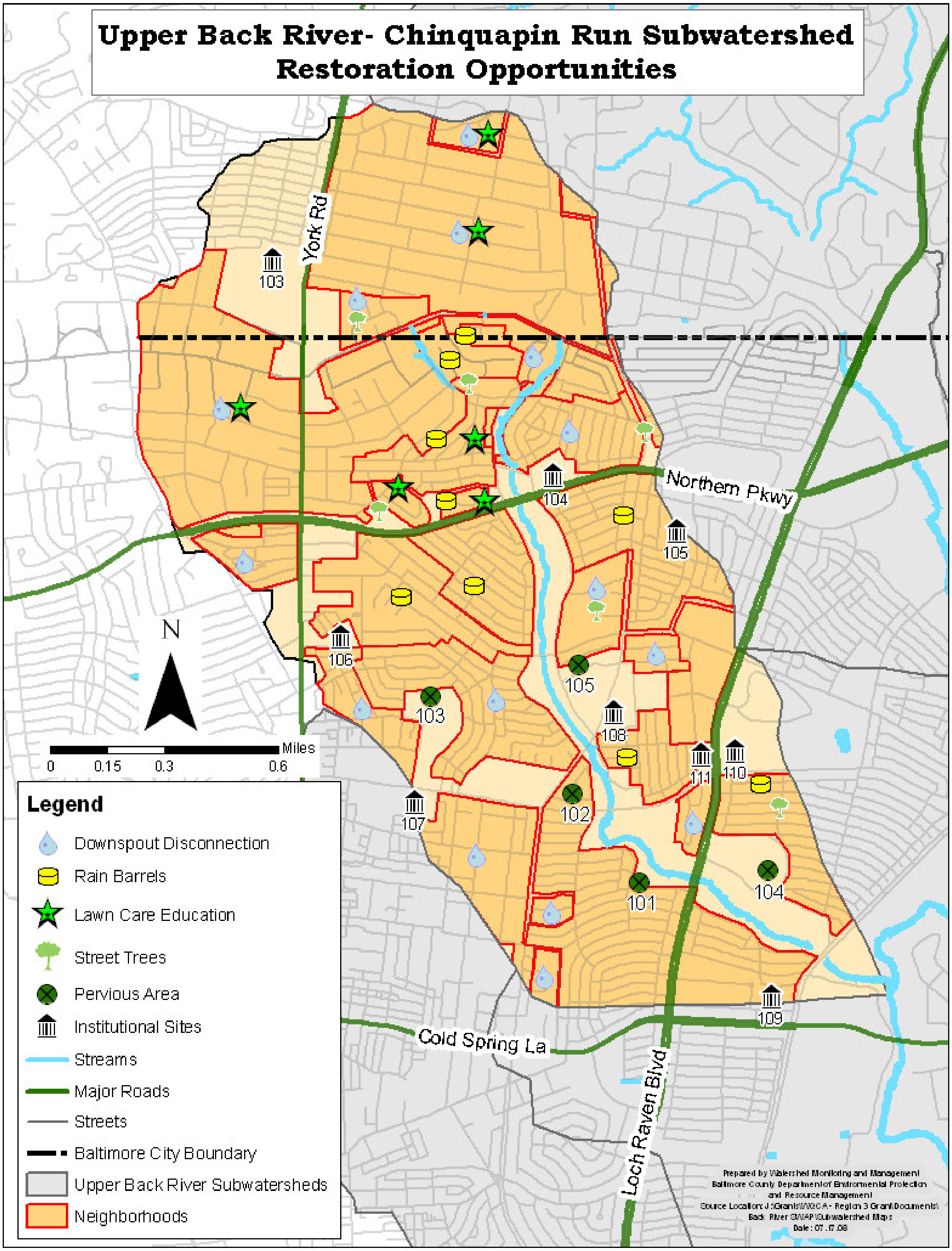

Figure 4-5 – Restoration Opportunities in Chinquapin Run

4.3.5 East Herring Run

Subwatershed Description

The Herring Run East stream begins in the proximity of the Perring Parkway/I695 interchange. From here it flows south along Perring Parkway and down behind the Perring Racquet club. The flow path turns to the west here and joins a smaller tributary of East Herring Run. This smaller tributary begins at the Baltimore County Public Library on Taylor Avenue and flows south. From the confluence of these two tributaries, East Herring Run flows south along the eastern side of Mount Pleasant Golf Course. Only 20% of the stream buffer is forested. This is tied for the lowest percentage in the entire Upper Back River. Table 4-22 presents the basic information on East Herring Run.

Table 4-22. Basic Profile of Herring Run East Subwatershed

Drainage Area	• 2690.4 acres (4.2 mi^2)	
Stream length	• 11.6 miles	
Land Use	• Low-Density residential (0.0%) • Med-Density Residential (38.7%) • High-Density Residential (29.0%)	• Open Urban Land (14.8%) (includes forests) • Commercial (8.2%) • Institutional (8.3%)
Current Impervious Cover	• 32.1% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (81%) • Baltimore County (19%)	
Soils	• A Soils – 9.6% • B Soils – 21.4%	• C Soils – 41.4% • D Soils – 27.2%
Stormwater management	• City - No existing stormwater facilities were identified • County - Only 0.9% of the county portion of the watershed is treated by stormwater facilities	

Neighborhood Assessment

Thirty-three (33) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. Subwatershed boundaries were not used to designate neighborhood boundaries so some neighborhoods may exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include downspout disconnection, storm drain stenciling, tree planting and public education (i.e. nutrient management). Buffer improvement and lot retrofits along with downspout disconnection seem to be the best opportunities here.

There are 164.6 impervious building acres in neighborhoods where downspout disconnection is recommended in Herring Run East. Based on an average of 51.7% potential for disconnection, 85 impervious building acres were deemed feasible for downspout disconnection. Disconnection efforts should first concentrate on the multi-family neighborhoods with high opportunities for disconnection due to the efficiencies achieved by coordinating with one landowner instead of individual homeowners. NSA-L-121, although 100% disconnected, shows many opportunities including lot retrofits, tree plantings and buffer improvement. Table 4-23 shows a summary of neighborhood recommendations.

Table 4-23. Summary of Neighborhood Assessment Recommendations

Site ID	Median lot size (acres)	Recommended Actions: % Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Pet Waste	Buffer Enhancement	Street Trees	Notes
NSA_L_100	Multifam	30		X	X	X			X	0	Dumpsters and mulch piles drain to stream
NSA_L_101	Multifam	10		X		X				0	Trees & bayscaping
NSA_L_102A	Multifam	40		X	X	X	X		X	0	Trees/buffer
NSA_L_102B	Multifam	10		X	X	X			X	0	Plant stream buffer
NSA_L_103	Multifam	80	X		X	X				0	Trash mgmt/bioretention
NSA_L_104A	Multifam	90			X	X				0	Trash mgmt
NSA_L_104B	Multifam	90			X	X				0	Trash mgmt
NSA_L_105	Multifam	100		X		X				0	trees
NSA_L_106A	Multifam	100			X	X				10	bioretention
NSA_L_106B	Multifam	100				X				0	
NSA_L_121	Multifam	0			X		X		X	0	Lot retrofits/increase buffer, no-mow/tree plantings
NSA_L_140	1/8	50			X	X	X			50	
NSA_L_141	1/4	60			X					50	
NSA_L_142	<1/8	25			X		X			75	Alley retrofits
NSA_L_143	<1/8	10			X		X			75	Alley retrofits
NSA_L_144	1/4	20		X	X		X		X	0	Buffer enhancement
NSA_L_145	1/2	15		X					X	50	Stream naturalization/buffer planting,no-mow
NSA_L_146	<1/8	25	X		X		X	X		100	Alley retrofits/street trees
NSA_L_147	1/2	95		X		X			X	0	Community garden
NSA_L_148	1/3	30		X		X				0	
NSA_L_19	1/8	40	X	X		X		X	X	75	Street and yard trees/buffer improvement
NSA_L_198	1/4	45			X		X			25	
NSA_L_25	1/3	85		X	X	X	X		X	0	Tree planting/stream
NSA_L_26	<1/8	85	X						X	50	
NSA_L_27	1/2	20		X	X	X	X	X	X	20	
NSA_L_69	Multifam	100		X	X	X				0	Stormwater planters
NSA_L_70	1/8	20			X	X				100	Tree plantings
NSA_L_71	Multifam	50		X	X	X			X	0	
NSA_L_72	<1/4	55		X	X	X				150	
NSA_L_73	1/4	60			X	X	X		X	50	Buffer education, no-mow, buffer plantings
NSA_L_74	1/8	40			X	X			X	100	
NSA_L_75	<1/4	60				X				50	

Site ID	Median lot size (acres)	Recommended Actions									
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Pet Waste	Buffer Enhancement	Street Trees	Notes
NSA_L_99	Multifam	65		X	X	X	X			50	

Hot Spot Assessment

Table 4-24 shows the one site assessed in Herring Run East for hot spot status, a car repair shop on Old Harford Rd. The assessment determined the site to be a confirmed hot spot due to the numerous potential sources of pollution.

Table 4-24. Summary of Hotspot Sites Recommendations

Status	Site ID	Description	Potential Sources of Pollution					
			Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/Landscaping	Stormwater Management
Confirmed	HSI_L_504	car repair	X	X	X	X		X

community garden or tree plating opportunity NSA-L-26

concrete channel in NSA-L-145

Institutional Site Assessment

Table 4-25 shows the ten institutional areas assessed in the Herring Run East subwatershed.

Table 4-25. Summary of Recommendations for Schools and Places of Worship

Site ID	Name of Site	Public/ Private	Greening Opportunities						Notes
			Nutrient Management	Tree Planting (#)	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management	
ISI_L_505	Pleasant Plains ES	Public	Y	200	X				
ISI_L_506	Halstead Academy	Public	N	100	X				
ISI_L_511	Villa Cresta ES	Public	Y	200	X				naturalize drainage channel
ISI_L_512	Former Loch Raven ES	Private	Y	100					
ISI_L_523	St. Andrews Lutheran	Private	N	117		X			
ISI_L_524	Moreland Memorial Cemetary	Private	Y	75					sediment control, buffer planting
ISI_L_525	Oakleigh ES	Public	Y	180					gutter cleaning
ISI_L_526	White Oak	Public	Y	425					storm drain stenciling
ISI_L_531	Babcock Presb.	Private	N	150		X			
ISI_L_532	Immaculate Heart of Mary	Private	N	150				X	storm drain stenciling

Stream Assessment

A stream stability assessment was conducted by Parsons Brinkerhoff in the county portion of the Herring Run subwatershed. The stream assessment performed did not discern between the Eastern and Western Branches, so the data is presented here as a combination of those two subwatersheds.

The subwatershed deficiencies as outlined in the PB report are as follows:
Problems with the Herring Run subwatershed include moderate bank erosion potential, various channel disturbances, fish blockages and only 67% of in stream habitat rated fair. Channel disturbances include culverts causing fish blockages and invasive plants. Table 4-26 shows the number of opportunities identified through the stream assessment.

Table 4-26. Summary of Stream Conditions in Herring Run

Stream Opportunities	Number of Problems (reach length ft)
Restoration/Stabilization	24
Buffer Enhancement	5
Bank Planting	54
Utility Conflicts	0
Wetland Enhancement	5
Yard Waste Education	13
Invasive Plant Removal	17
Trash Dumping	25

Illicit Discharges

Baltimore County uses a prioritization system for sampling outfalls for illicit discharges. Priority one describes an outfall with major problems including the presence of chemicals in the water. Priority two describes outfalls with moderate problems including erosion and trash but no chemical problems detected. Priority 1 outfalls are sampled four times per year and priority 2 outfalls are sampled once per year. There are four priority 2 outfalls in the county portion of Herring Run East and no priority 1 outfalls.

Baltimore County and Baltimore City will continue with their Illicit Discharge Detection and Elimination programs, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

There were nine retrofit opportunities identified in Chinquapin Run and no pond conversions. Table 4-27 shows these retrofits.

Table 4-27 Summary of Retrofit Opportunities in Chinquapin Run

Site	Drainage Area (ac)	Description/Classification	Priority
R28A	100	Wetpond/Wetland	Low
R29B	1.8	Permeable Pavement	Medium
R29D	0.1	Permeable Pavement	Medium
R29C	0.25	Bioretention	Medium
R28B	37	Wetpond/Wetland	Medium
R3	1.0	Bioretention	Medium
R29A	1.1	Bioretention	Medium
R37	0.8	Bioretention	Medium
R2B	1.0	Dry Swale	Medium

Pervious Area Restoration

Table 4-28 shows the three possible pervious area restoration sites identified during the assessment. Site 507 is a forested area owned by St. Margaret's Episcopal Church worthy of preservation. Pervious area restoration has the potential to convert areas of turf, sometimes a relatively high nutrient input land use, to forest, which can absorb rather than shed nutrients.

Table 4-28. Summary of Pervious Area Recommendations

Site	Location	Description	Size (acres)	Ownership
PAA-L-507	Off Joppa near 695	Church forested area	2	Private
PAA-L-508	End of Clearwood	Park area	4	Public
PAA-L-509	Putty Hill & Kendale	Lg median between 2 roads	2	Public

Subwatershed Management Strategy

<u>Engaging Citizens & Watershed Groups</u>

1. Reduce the unforested buffer area. Investigate neighborhoods shown in Table 4-23 to be encroaching on the buffer and extend/plant the buffer wherever possible.
2. Conduct appropriate downspout disconnection measures according to Table 4-23, focusing efforts on the multi-family neighborhoods. There are many opportunities for rain gardens in this subwatershed.
3. Engage citizens in a storm drain stenciling program and conduct stenciling activities in the neighborhoods indicated in Table 4-23.
4. Plant street trees. Table 4-23 shows a potential for over 1000 street trees plantings.

5. Increase tree canopies on private lots by educating citizens on the benefits of trees and about programs like The Growing Home Campaign and TreeBaltimore.
6. Educate citizens on the benefits of bayscaping and implement a program to encourage the establishment of bayscaping on resident's private lots.
7. Engage Institutions sited in Table 4-25 in respective restoration efforts, especially tree plantings.
8. Investigate three pervious areas listed in Table 4-28 for potential tree plantings; giving primary consideration to the two areas listed as public property.

Municipal Actions

1. Conduct stream restorations at opportunity sites listed in Table 4-26 and in further detail in Appendix G.
2. Investigate medium priority retrofits listed in Table 4-27 for implementation possibilities.

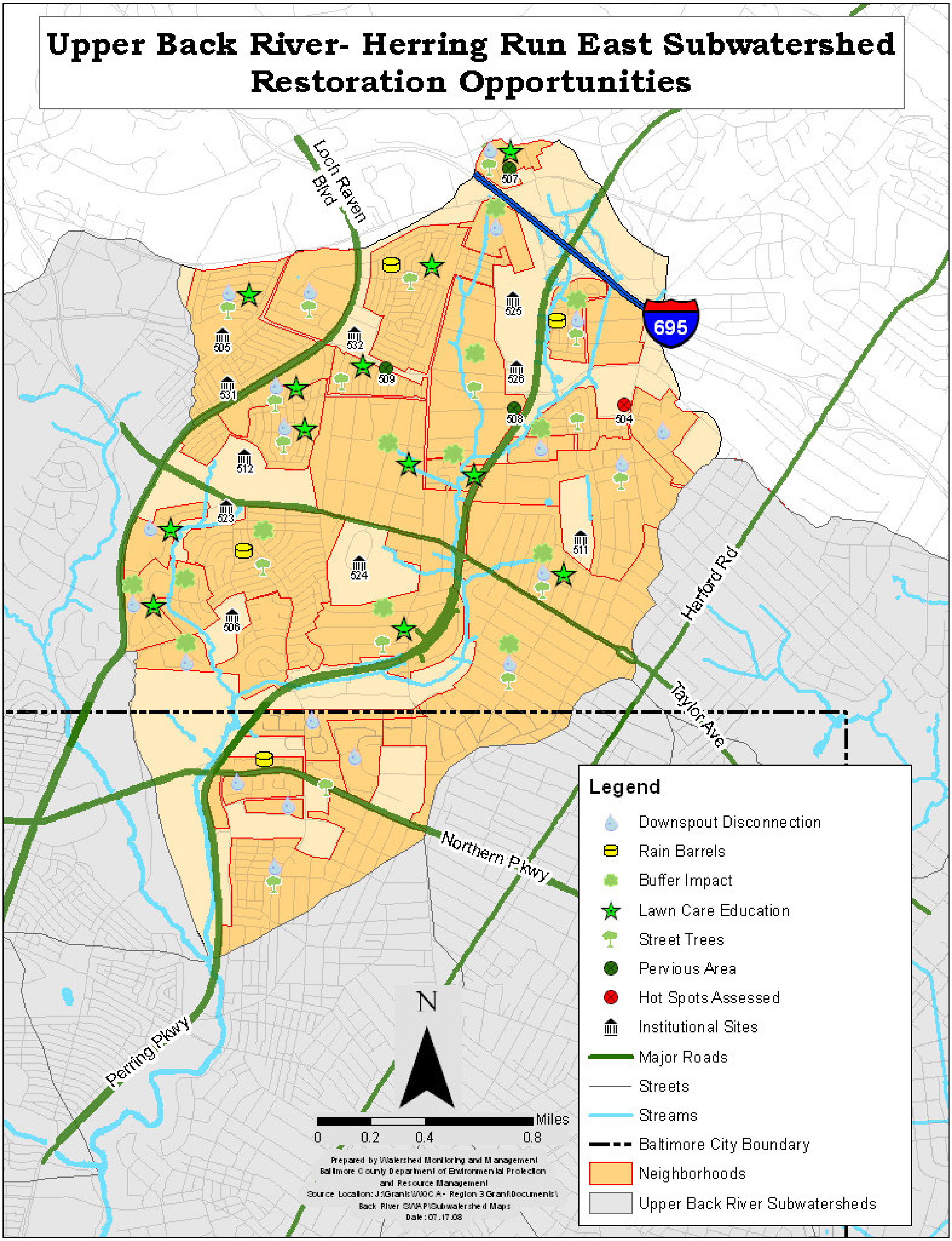

Figure 4-6 – Restoration Opportunities in the East Herring Run Subwatershed

4.3.6 Herring Run Mainstem

Subwatershed Description

The Herring Run mainstem is the largest of the subwatersheds in this SWAP. Beginning at the confluence of the Herring Run East and Herring Run West streams, which is at the southern end of Mt. Pleasant golf course, the Herring Run mainstem flows past the Morgan State University campus and through Herring Run Park crossing Harford Rd, Belair Rd and Sinclair La. Before entering the tidal Back River area, the Herring Run mainstem passes beneath 895, Rt. 40, and I 95.

This is a highly urbanized and impacted subwatershed with over 25% of the land use designated as high density residential. Table 4-29 presents the basic information the Herring Run mainstem.

Table 4-29 Basic Profile of Herring Run Mainstem Subwatershed

Drainage Area	• 4431.2 acres (6.9 mi^2)	
Stream length	• 17.1 miles	
Land Use	• Low-Density residential (0.0%) • Med-Density Residential (25.0%) • High-Density Residential (25.4%)	• Open Urban Land (21.7%) (includes forests) • Commercial (10.4%) • Institutional (11.4%)
Current Impervious Cover	• 35.0% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (97%) • Baltimore County (3%)	
Soils	• A Soils – 0.6% • B Soils – 10.9%	• C Soils – 5.9% • D Soils – 80.9%
Stormwater management	• City - No existing stormwater facilities were identified • County - Only 9% of the county portion of the watershed is treated by stormwater facilities	

Neighborhood Assessment

Thirty-nine (39) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. Subwatershed boundaries were not used to designate neighborhood boundaries so some neighborhoods may exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include downspout disconnection, storm drain stenciling, tree planting and public education (i.e. nutrient management).

There are 285.4 impervious building acres in neighborhoods where downspout disconnection is recommended in Herring Run Mainstem. Based on an average of 68.4% potential for disconnection, 195 impervious building acres were deemed feasible for downspout disconnection. Disconnection efforts should first concentrate on the multi-family neighborhoods with high opportunities for disconnection due to the efficiencies achieved by coordinating with one landowner instead of individual homeowners. NSA-L-61 is a privately owned neighborhood so, similar to multi-family apartment neighborhoods, this would be a good area to target. Table 4-30 shows a summary of neighborhood recommendations for the Herring Run Mainstem.

Table 4-30. Summary of Neighborhood Assessment Recommendations

Site ID	Median lot size (acres)	Recommended Actions									
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Street Sweeping	Buffer Enhancement	Street Trees	Notes
NSA_L_110B	Multifam	nd								0	Impervious removal/alley retrofit
NSA_L_111	Multifam	100		X		X				0	
NSA_L_117	Multifam	nd			X					0	Downspout disconn/bioretention/tree
NSA_L_118	Multifam	nd		X	X				X	0	Tree planting/curb cut opportunity
NSA_L_130	<1/8	nd			X					0	Alley retrofit
NSA_L_164	Multifam	95		X	X	X	X	X	X	0	Trash Mgmt, stained lots
NSA_L_168	<1/4	90	X							5	Alley retrofit
NSA_L_172	1/8	nd			X			X		0	Cnvert open space & condemned homes to parks
NSA_L_175	<1/8	75			X	X				0	Plant empty parcels
NSA_L_176	<1/8	100			X					0	Trees in common areas
NSA_L_20	<1/4	40		X	X		X	X		0	
NSA_L_21	<1/8	80			X	X	X	X		80	
NSA_L_37	1/8	80	X	X		X				20	
NSA_L_38	<1/8	nd	X		X					50	Downspout disconn
NSA_L_51	1/4	nd			X			X		nd	Street trees
NSA_L_54	<1/8	50	X		X			X		0	Street sweeping
NSA_L_55	<1/8	75	X		X			X		0	Trash
NSA_L_56	1/4	95		X	X		X			50	
NSA_L_57	<1/4	50	X		X			X		50	
NSA_L_58	<1/8	50	X		X					50	Trash/dumping in wooded area
NSA_L_59	<1/8	50	X		X					50	
NSA_L_60	<1/8	70	X		X					50	
NSA_L_61	Multifam	50	X		X	X		X	X	0	Tree planting
NSA_L_63	<1/8	85	X		X			X		60	Park creation 2 diff open
NSA_L_64	<1/8	50	X		X					50	
NSA_L_65	<1/8	100	X		X	X				0	Alley retrofit, imp cover
NSA_L_66A	<1/8	50	X		X					0	Heavy oil stains, trash, alley
NSA_L_66B	1/4	65			X	X				25	
NSA_L_67	<1/4	45	X			X		X		40	
NSA_L_68	<1/8	60	X		X		X			10	
NSA_L_75	<1/4	60				X		X		50	
NSA_L_76	1/4	50		X		X				40	
NSA_L_77	1/4	50		X	X	X	X	X		25	
NSA_L_78	<1/4	60		X	X	X				0	

Site ID	Median lot size (acres)	Recommended Actions: % Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Street Sweeping	Buffer Enhancement	Street Trees	Notes
NSA_L_79	<1/4	60			X					0	
NSA_L_82	<1/4	40	X		X		X			35	Alley retrofits
NSA_L_83	<1/8	75	X		X	X		X		0	Open space for planting
NSA_L_84	Multifam	100		X		X				0	Park/garden creation, open space trees
NSA_L_85	<1/4	90	X		X	X	X	X		0	Gutter algae water

impervious cover removal potential in NSA-L-65

Hot Spot Assessment

Table 4-31 shows the three sites assessed in Herring Run Mainstem for hot spot status. All three assessed as confirmed hot spots.

Table 4-31. Summary of Hotspot Sites Recommendations

Status	Site ID	Description	Potential Sources of Pollution: Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/ Landscaping	Stormwater Management
Confirmed	HSI-L-503	junkyard	X	X	X	X		X
Confirmed	HSI-L-505	Vehicle storage	X	X	X	X		X
Confirmed	HIS-L-506	junkyard	X	X	X	X		X

Institutional Site Assessment

Table 4-32 shows the five institutional areas assessed in the Herring Run West subwatershed.

Table 4-32. Summary of Recommendations for Schools and Places of Worship

Site ID	Name of Site	Public/ Private	Greening Opportunities						
			Nutrient Management	Tree Planting (#)	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management	Notes
ISI_L_507	Fort Worthington ES	Public	N	0			X		
ISI_L_508	Lakewood ES	Public	N	0			X		
ISI_L_509	St. Teresa	Public	N	20		X	X		
ISI_L_510	Armistead Gardens ES	Public	N	200					Street sweeping / sediment control
ISI_L_533	Montebello Hospital Center	Private	Y	200	X	X			

PAA-L-503, an old ball field adjacent to Herring Run buffer

Stream Assessment

There were no stream assessments performed in the Herring Run mainstem.

Illicit Discharges

Baltimore City will continue with their Illicit Discharge Detection and Elimination programs, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

There were 21 retrofit opportunities identified in Herring Run Mainstem and one pond conversion. Table 4-33 shows the retrofits and Table 4-34 shows the conversion.

Table 4-33. Summary of Retrofit Opportunities in Herring Run Mainstem

Site	Drainage Area (ac)	Description/Classification	Priority
R15A	130	Wetpond/Wetland	High
R15C	40	Wetpond/Wetland	High
R12B	60	Wetpond/Wetland	Low
R12D	9041	Wetpond/Wetland	Low
R15B	100	Wetpond/Wetland	Low
R38A	2.0	Bioretention	Medium
R14	1.0	Bioretention	Medium
R18	5.0	Bioretention	Medium
R19	2.0	Bioretention	Low
R21	0.75	Dry Swale	High
R22	12	Dry Swale	Medium
R23	0.6	Bioretention	Medium
R41B	0.15	Impervious Cover Removal	High
R12A	80	Wetpond/Wetland	Medium
R20	25	Wetpond/Wetland	Medium
R15C	40	Wetpond/Wetland	Medium
R38B	4.5	Bioretention	Medium
R41A	0.7	Bioretention	Medium
R10	1.5	Bioretention	Medium
R39	40	Wetpond/Wetland	Medium
R42A	305	Wetpond/Wetland	Low

Table 4-34 Summary of SWM Pond Conversion Opportunities in Herring Run Mainstem

Pond #	Drainage Area (ac)	Priority
305	6.5	High

Pervious Area Restoration

Table 4-35 shows the four possible pervious area restoration sites identified during the assessment. All of the sites are close to or part of the Herring Run buffer area. Pervious area restoration has the potential to convert areas of turf, sometimes a relatively high nutrient input land use, to forest, which can absorb rather than shed nutrients.

Table 4-35 Summary of Pervious Area Recommendations

Site	Location	Description	Size (acres)	Ownership
PAA-L-503	Off Armistead Way	Old baseball field	6	Private
PAA-L-504	Parkside & Sinclair	Herring Run buffer	5	Public
PAA-L-505	Parkside & Belair	Herring Run buffer	3	Public
PAA-L-506	Herring Run Rd.	Herring Run Buffer	1	Public

Subwatershed Management Strategy

<u>Engaging Citizens & Watershed Groups</u>

1. Conduct appropriate downspout disconnection measures according to Table 4-30, focusing efforts on the multi-family neighborhoods. Many of the neighborhoods in Herring Run Mainstem have smaller lots where rain barrels are recommended.
2. Plant street trees in the neighborhoods indicated in Table 4-30. There is an estimated potential for 830 street trees in this subwatershed.
3. Engage citizens in a storm drain stenciling program and conduct stenciling activities in the neighborhoods indicated in Table 4-30.
4. Increase tree canopies on private lots by educating citizens on the benefits of trees and about programs like The Growing Home Campaign and TreeBaltimore.

5. All three hot spots in this subwatershed were assessed as confirmed, so further investigation into reducing stormwater pollutants at these three locations is recommended.
6. Engage Institutions sited in Table 4-32 in restoration efforts, especially tree plantings.
7. Further investigate four pervious areas listed in Table 4-35 for potential tree plantings, giving primary consideration to the three areas listed as public property.

Municipal Actions

1. Conduct street sweeping in neighborhoods identified in Table 4-30. This will also help with the trash issues in the neighborhoods indicated in Appendix 4-1b of the Characterization Report.
2. Examine high priority storm water retrofits and pond conversion for possibilities of implementation from Table 4-33 and 4-34.

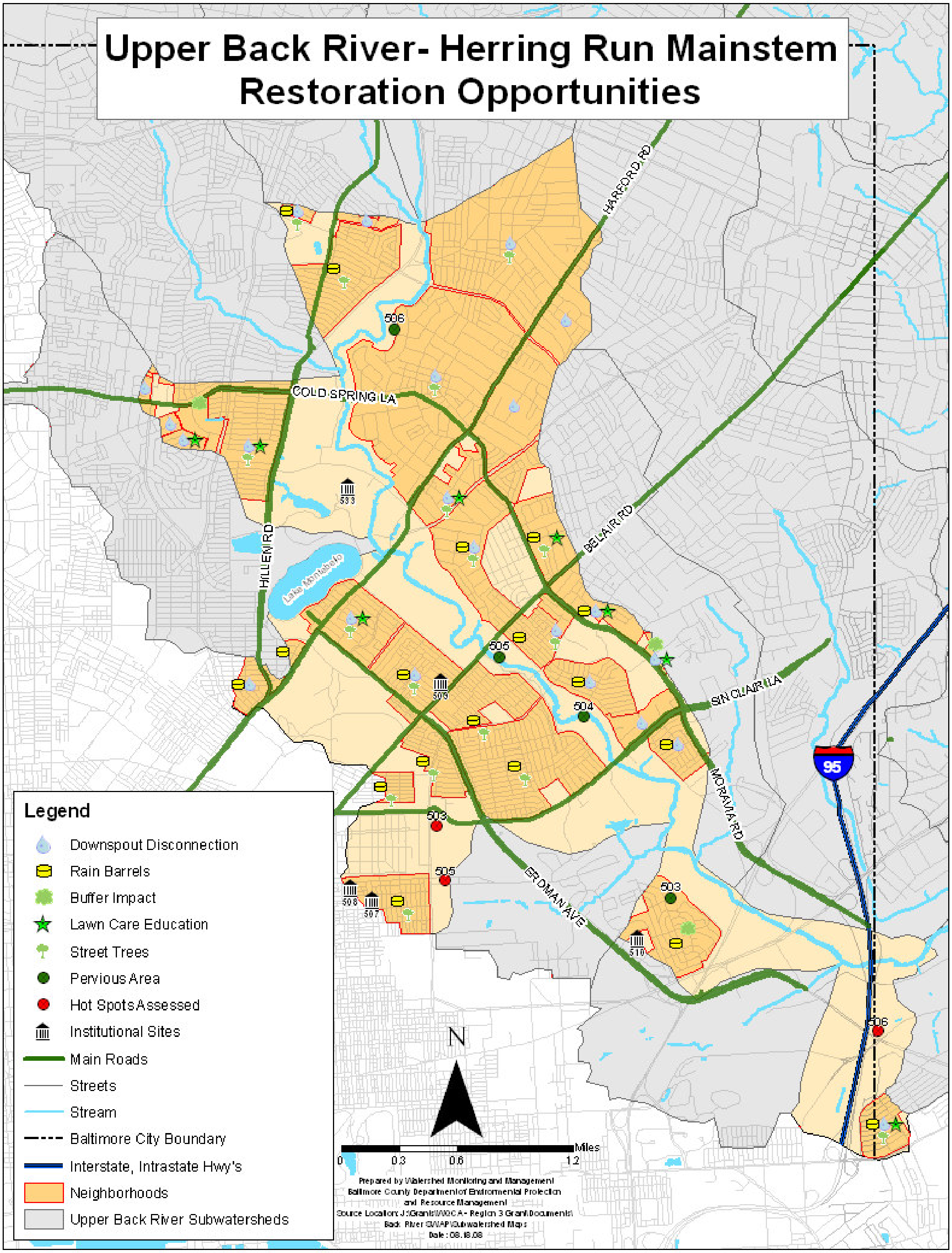

Figure 4-7- Restoration Opportunities in the Herring Run Mainstem

4.3.7 Lower Herring Run

Subwatershed Description

The Lower Herring Run /Upper Back River subwatershed actually contains the confluence of Herring Run, Moores Run and Redhouse Run where they empty to the tidal Back River area. Lower Herring Run also has a few streams and tidal creeks of its own. The most significant of which runs due north from the intersection of Merritt Blvd. and North Point Blvd. and joins this confluence about 500 feet east of I-695. The other streams are small and drain either directly to the Back River tidal area or to the confluence already mentioned. 24% of the stream buffer is unforested. Table 4-36 presents the basic information on Lower Herring Run/Upper Back River.

Table 4-36 Basic Profile of Lower Herring Run/Upper Back River Subwatershed

Drainage Area	• 1596.1 acres (2.5 mi^2)	
Stream length	• 13.48 miles	
Land Use	• Low-Density residential (0.0%) • Med-Density Residential (11.8%) • High-Density Residential (8.6%)	• Open Urban Land (23.3%) (includes forests) • Commercial (18.9%) • Industrial (22.6%)
Current Impervious Cover	• 33.0% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (0%) • Baltimore County (100%)	
Soils	• A Soils – 1.4% • B Soils – 47.4%	• C Soils – 34.3% • D Soils – 16.9%
Stormwater management	• City - NA • County – 3.9% of the county portion of the subwatershed is treated by storm water facilities	

Neighborhood Assessment

Seven (7) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. Subwatershed boundaries were not used to designate neighborhood boundaries so some neighborhoods may exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include rain barrels, storm drain stenciling, tree planting and stream buffer education.

There are 20.4 impervious building acres in the neighborhood where downspout disconnection is recommended in Lower Herring Run/Upper Back River. Based on a 60% average potential for disconnection, 12.24 impervious building acres were deemed feasible for downspout disconnection. Table 4-37 shows a summary of neighborhood recommendations for the Herring Run Mainstem.

Table 4-37. Summary of Neighborhood Assessment Recommendations

Recommended Actions												
Site ID	**Median lot size (acres)**	**% Opportunity for Downspout Disconnection**	**Rain Barrels**	**Rain Gardens**	**Stormdrain Stencils**	**Bayscape**	**Nutrient Management**	**Pet Waste**	**Buffer Enhancement**	**Street Trees**	**Notes**
NSA_L_01	1/2	80		X		X			X	0	
NSA_L_169	<1/8	30	X		X					100	Park/garden creation

Recommended Actions											
Site ID	**Median lot size (acres)**	**% Opportunity for Downspout Disconnection**	**Rain Barrels**	**Rain Gardens**	**Stormdrain Stencils**	**Bayscape**	**Nutrient Management**	**Pet Waste**	**Buffer Enhancement**	**Street Trees**	**Notes**
NSA_L_212	1/4	20			X	X	X		X	0	
NSA_L_213	1/2	65		X	X	X			X	0	
NSA_L_214	Multifam	100	X							0	Tree planting
NSA_L_216	1/4	65		X					X	0	
NSA_L_68	<1/8	60	X		X		X			100	

Hot Spot Assessment

There were no sites assessed in Lower Herring Run/Upper Back River for hot spot status.

Institutional Site Assessment

There were no institutional areas assessed in the Lower Herring Run/UBR subwatershed.

Stream Assessment

There were no stream assessments performed in Lower Herring Run/UBR.

Illicit Discharges

Baltimore County uses a prioritization system for sampling outfalls for illicit discharges. Priority one describes an outfall with major problems including the presence of chemicals in the water. Priority two describes outfalls with moderate problems including erosion and trash but no chemical problems detected. Priority 1 outfalls are sampled four times per year and priority 2 outfalls are sampled once per year. Lower Herring Run/UBR has two priority 2 outfalls and no priority 1 outfalls.

Baltimore County will continue with their Illicit Discharge Detection and Elimination program, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

There were no retrofit opportunities identified in Lower Herring Run and one pond conversion. Table 4-38 shows the conversion.

Table 4-38. Summary of SWM Pond Conversion Opportunities in Lower Herring Run

Pond #	Drainage Area (ac)	Priority
969	5.2	High

Pervious Area Restoration

Table 4-39 shows the one pervious area restoration site assessed in the Lower Herring Run/UBR. Pervious area restoration has the potential to convert areas of turf, sometimes a relatively high nutrient input land use, to forest, which can absorb rather than shed nutrients.

Table 4-39. Summary of Pervious Area Recommendations

Site	Location	Description	Size (acres)	Ownership
PAA-L-301	Diamond Point Rd.	Open Space	5	Private

typical homes in NSA-L-212

section of PAA-L-301

Subwatershed Management Strategy

Engaging Citizens & Watershed Groups

1. Increase tree canopies on private lots by educating citizens on the benefits of trees and about programs like The Growing Home Campaign and TreeBaltimore. All neighborhoods here were recommended for tree canopy improvement on private lots.
2. Conduct appropriate downspout disconnection measures according to Table 4-37, focusing efforts on the multi-family neighborhoods.
3. Plant street trees in neighborhoods L-68 and 169.
4. Engage citizens in a storm drain stenciling program and conduct stenciling activities in the neighborhoods indicated in Table 4-37.
5. The single pervious area identified here is in the Chesapeake Bay critical area where building can be constrained so despite the private ownership, a tree planting here could be successful.

Municipal Actions

1. Complete pond conversion from Table 4-38.

Figure 4-8- Restoration Opportunities in the Lower Herring Run/Upper Back River Subwatershed

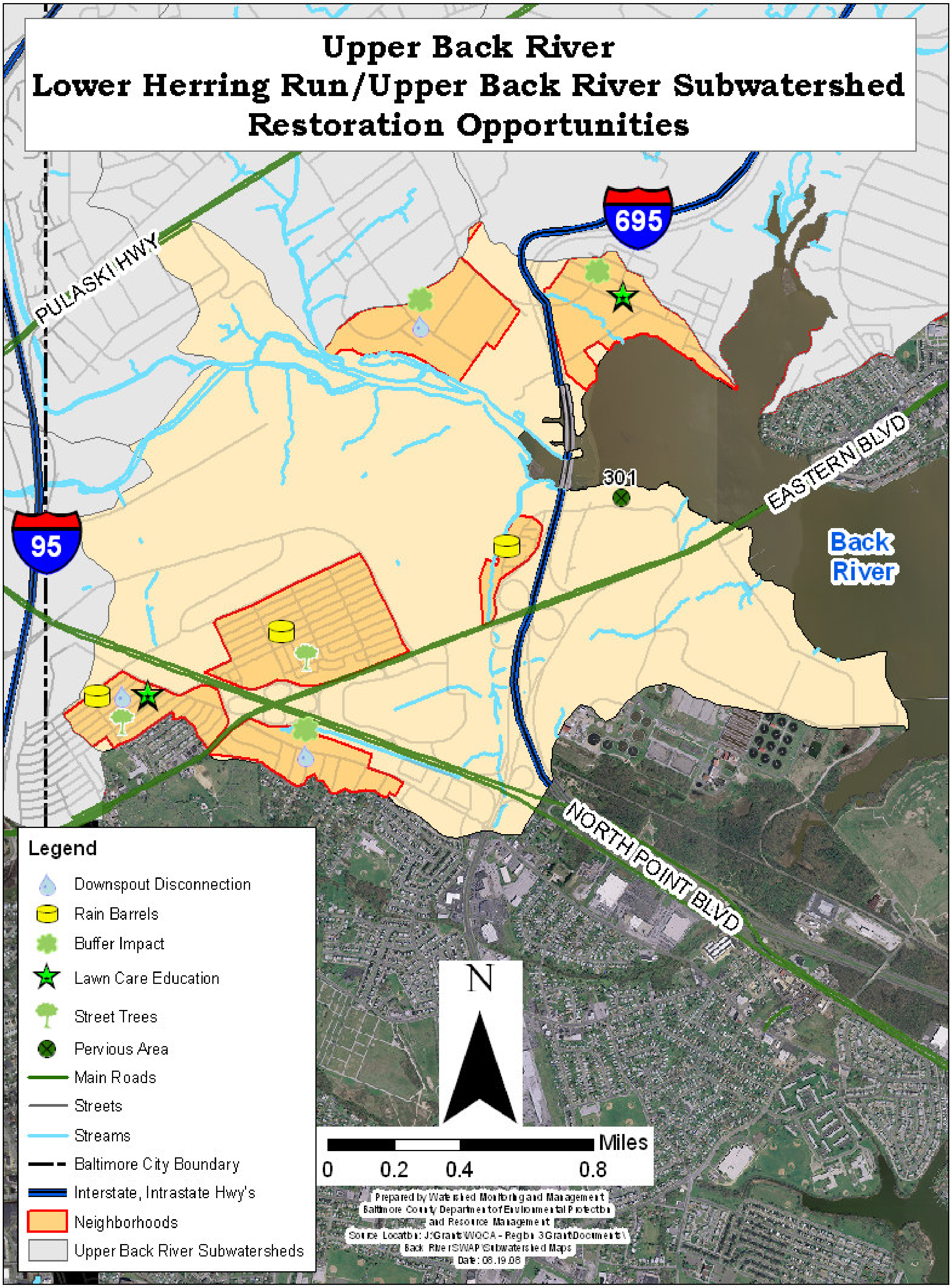

Figure 4-8- Restoration Opportunities in the Lower Herring Run Upper Back River

4.3.8 Moore's Run

Subwatershed Description

The Moore's Run stream is piped in the upper sections of the subwatershed. The stream first sees daylight traveling in a concrete channel in Gardenville near the Hazelwood Elementary/Middle School south of Hamilton Ave. From here it follows a southerly flow passing beneath 895 and 95 and follows 95 South before its confluence with Herring Run just east of the Baltimore City border.

Recent highway construction along I-95 is in close proximity to Moore's Run and is likely having an effect on water quality there. Baltimore City Public Works is also in the process of making storm drain and sanitary sewer improvements in Moore's Run north of where it intersects 895. The sewer improvements are mandated as part of Baltimore City's consent decree with the Environmental Protection Agency and the State of Maryland. Table 4-40 presents basic information about Moore's Run.

Table 4-40. Basic Profile of Moore's Run Subwatershed

Drainage Area	• 2797.7 acres (4.4 mi^2)	
Stream length	• 7.39 miles	
Land Use	• Low-Density residential (16.6%) • Med-Density Residential (19.4%) • High-Density Residential (9.1%)	• Open Urban Land (30.5%) (includes forests) • Commercial (10.9%) • Institutional (4.7%)
Current Impervious Cover	• 25.1% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (83%) • Baltimore County (17%)	
Soils	• A Soils – 0.0% • B Soils – 16.8%	• C Soils – 18.1% • D Soils – 75.1%
Stormwater management	• County - Only 5.5% of the watershed is treated by a stormwater facilities • City - No existing stormwater facilities were identified	

Neighborhood Assessment

Twenty-nine (29) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. Subwatershed boundaries were not used to designate neighborhoods so neighborhoods often exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include downspout disconnection, storm drain stenciling, tree planting and public education (i.e. nutrient management). There seems to be ample opportunity here for buffer expansions/ improvements.

There are 215.8 impervious building acres in neighborhoods where downspout disconnection is recommended in Moore's Run. Based on an average of 68.6% potential for disconnection, 148 impervious building acres were deemed feasible for downspout disconnection. Disconnection efforts should first concentrate on the 6 multi-family neighborhoods due to the efficiencies achieved by coordinating with one landowner instead of individual homeowners. NSAs L-218 & 219 especially have plenty of open space for disconnections. Table 4-41 shows a summary of neighborhood recommendations for the Herring Run Mainstem.

park or garden opportunity in NSA-L-163

downspout disconnection opp. in NSA-L-21

Table 4-41. Summary of Neighborhood Assessment Recommendations

Site ID	Median lot size (acres)	Recommended Actions									
		% Opportunity for Downspout Disconnection	Rain Barrels	Street Sweeping	Stormdrain Stencils	Bayscape	Nutrient Management	Trash Mgmt	Buffer Enhancement	Street Trees	Notes
NSA_L_04	<1/4	10	X			X				0	
NSA_L_05	1/4	40			X	X			X	50	
NSA_L_06	1/4	60	X							0	
NSA_L_09	1/4	50				X			X	0	
NSA_L_150	1/3	60	X		X	X				0	Rust staining on streets/sidewalks
NSA_L_151A	1/4	70	X		X			X		0	Dumping in forested
NSA_L_151B	<1/8	70	X		X					0	Alley retrofits/rain barrels
NSA_L_160	Multifamily	100			X	X				20	Nice tree canopy here
NSA_L_161	<1/8	100	X		X	X				100	
NSA_L_162	Multifamily	100			X	X		X	X	25	Dumping off
NSA_L_163A	<1/8	75	X		X			X		0	Park/garden
NSA_L_163B	Multifamily	65	X		X	X	X			0	
NSA_L_164	Multifamily	95		X	X	X	X	X	X	0	Most of neighborhood
NSA_L_183A	<1/8	100	X	X	X			X		100	See PAA-L-403/alley retrofits/st. sweeping
NSA_L_183B	1/2	60	X			X	X			100	
NSA_L_184	1/4	75		X	X	X		X	X	100	Some dumping in
NSA_L_187	<1/4	90			X	X			X	50	Tree panting opp in buffer area
NSA_L_189	1/4	20			X	X		X		0	
NSA_L_190	<1/4	40			X	X	X			40	
NSA_L_218	Multifamily	100			X	X	X	X		0	Pkg lot retrofits/trash mgmt/tree plantings
NSA_L_219	Multifamily	100		X		X	X	X		0	Trash mgmt
NSA_L_74	1/8	40		X	X	X			X	100	
NSA_L_75	<1/4	60		X		X		X		50	

Site ID	Median lot size (acres)	Recommended Actions									
		% Opportunity for Downspout Disconnection	Rain Barrels	Street Sweeping	Stormdrain Stencils	Bayscape	Nutrient Management	Trash Mgmt	Buffer Enhancement	Street Trees	Notes
NSA_L_79	<1/4	60			X					0	
NSA_L_80	<1/4	80			X	X	X			0	Residential tree
NSA_L_85	<1/4	90	X	X	X	X	X	X		0	Woodlea & greenhill,
NSA_L_86	<1/4	45		X	X	X			X	50	
NSA_L_87	<1/4	60	X		X	X				25	Moores Run City
NSA_L_88	<1/8	75	X		X			X		0	Buffer planting opp/yard waste

Hot Spot Assessment

Table 4-42 shows the 2 sites assessed in Stemmers Run for hot spot status.

Table 4-42. Summary of Hotspot Sites Recommendations

Status	Site ID	Description	Potential Sources of Pollution					
			Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/Landscaping	Stormwater Management
Confirmed	HSI_L_401	Small engine repair		X				X
Potential	HSI_L_402	Auto Repair Shop	X		X	X		

Institutional Site Assessment

There were no institutional areas assessed in the Moore's Run subwatershed.

Stream Assessment

There were no stream assessments performed in the Herring Run mainstem.

Illicit Discharges

Baltimore County uses a prioritization system for sampling outfalls for illicit discharges. Priority one describes an outfall with major problems including the presence of chemicals in the water. Priority two describes outfalls with moderate problems including erosion and trash but no chemical problems detected. Priority 1 outfalls are sampled four times per year and priority 2 outfalls are sampled once per year. The county portion of Moore's Run contains one 'priority 2' outfall.

Baltimore County and Baltimore City will continue with their Illicit Discharge Detection and Elimination programs, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

One retrofit opportunity was identified in Moore's Run and no pond conversions. Table 4-43 shows the retrofit.

Table 4-43. Summary of Retrofit Opportunities in Moore's Run

Site	Drainage Area (ac)	Description/Classification	Priority
R4	32	Wet Pond/Wetland	High

Pervious Area Restoration

Table 4-44 shows the four possible pervious area restorations identified during the assessment. Three of the four are in the buffer of Moore's Run and have substantial acreages so these would be priorities for restoration efforts. Pervious area restoration has the potential to convert areas of turf, sometimes a relatively high nutrient input land use, to forest which can absorb rather than shed nutrients. Along with Herring Run Watershed Association, programs like Tree-Mendous Maryland and NeighborSpace of Baltimore County could be valuable resources for planting those areas on public land or community open space.

Table 4-44. Summary of Pervious Area Recommendations

Site	Location	Description	Size (acres)	Ownership
PAA-L-401	Off Denview	Moores Run buffer	7	Public
PAA-L-402	Sinclair & Denview	Moores Run buffer	6	Public
PAA-L-403	End of Radecke	Park area	3	Public
PAA-L-404	Along Denview	Moores Run buffer	4.5	Private

Subwatershed Management Strategy

Engaging Citizens & Watershed Groups

1. Conduct appropriate downspout disconnection measures according to Table 4-41, focusing efforts on the multi-family neighborhoods.
2. There is approximately 3,500 ft of buffer that could be expanded along Moore's Run Rd., Sinclair La and Cedgate Rd.
3. Increase tree canopies on private lots by educating citizens on the benefits of trees and about programs like The Growing Home Campaign and TreeBaltimore. Most neighborhoods here were recommended for tree canopy improvement on private lots.
4. Plant street trees in the neighborhoods indicated in Table 4-41. There is an estimated potential for 810 street trees in this subwatershed.
5. Engage citizens in a storm drain stenciling program and conduct stenciling activities in the neighborhoods indicated in Table 4-41.
6. Conduct focused business education and outreach efforts to hot spot locations identified in Table 4-42.
7. Further investigate four pervious areas listed in Table 4-44 for potential tree plantings, giving primary consideration to the three areas listed as public property.

Municipal Actions

1. Conduct street sweeping in neighborhoods identified in Table 4-41. This will also help with the trash issues in the neighborhoods indicated in Table 4-41
2. Complete high priority retrofit from Table 4-43.

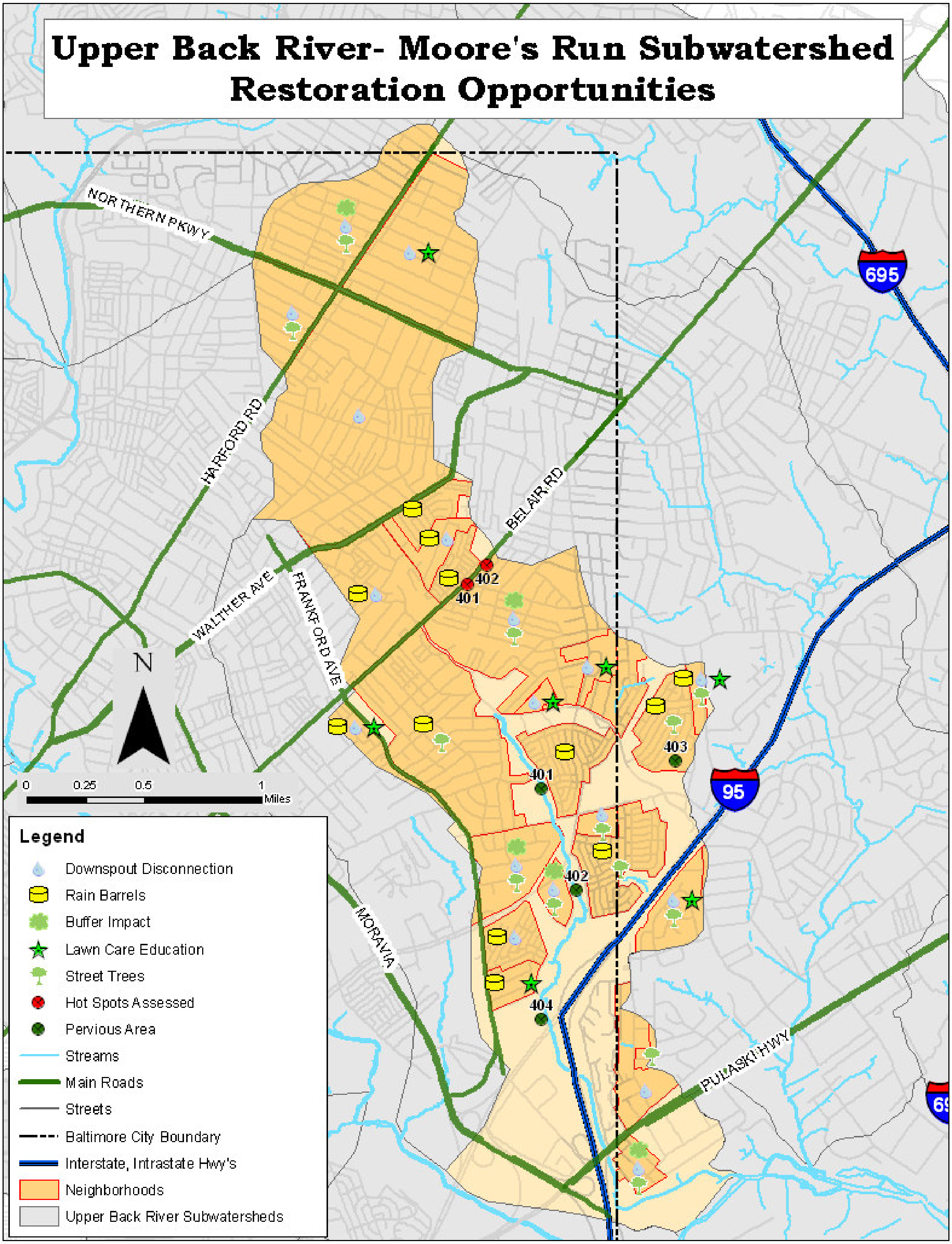

Figure 4-9- Restoration Opportunities in the Moore's Run Subwatershed

4.3.9 Northeast Creek

Subwatershed Description

Northeast Creek begins at the confluence of Stemmers Run and Brien's Run and flows beneath the 695/702 interchange. The subwatershed is characterized by small tidal creeks and a tidal area at the mouth where it empties to Back River. The stream is met by a few smaller tributaries before emptying into Back River. 25% of the stream buffer is forested.

Neighborhoods within Northeast Creek could benefit the watershed most through a downspout disconnection program and an incentive program encouraging residents to plant trees on their properties. Table 4-45 presents some basic information about Northeast Creek

Table 4-45. Basic Profile of Northeast Creek Subwatershed

Drainage Area	• 1,643.9 acres (5.8 mi^2)	
Stream length	• 17.5 miles	
Land Use	• Low-Density residential (5.1%) • Med-Density Residential (26.7%) • High-Density Residential (1.9%)	• Open Urban Land (32.9%) (includes forests) • Commercial (7.5%) • Institutional (3.2%)
Current Impervious Cover	• 21.8% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (0%) • Baltimore County (100%)	
Soils	• A Soils – 2.3% • B Soils – 31.7%	• C Soils –49.5% • D Soils – 16.4%
Stormwater management	• 10.5 % of the watershed is treated by stormwater facilities	

Neighborhood Assessment

Eleven (11) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. Subwatershed boundaries were not used to designate neighborhoods so some neighborhoods may exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include downspout disconnection, storm drain stenciling, tree planting and public education (i.e. nutrient management).

There are 57.4 impervious building acres in neighborhoods where downspout disconnection is recommended in Northeast Creek. Based on an average of 56.4% potential for disconnection, 32.4 impervious building acres are estimated feasible for downspout disconnection.

NSA-L-209 & 210 are the only neighborhoods fully contained by the subwatershed, so this would be the best place to start if implementing restoration actions within Northeast Creek. Table 4-46 shows a summary of neighborhood recommendations for Northeast Creek.

Table 4-46. Summary of Neighborhood Assessment Recommendations

Site ID	Median lot size (acres)	Recommended Actions									
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Pet Waste	Buffer Enhancement	Street Trees	Notes
NSA_L_01	1/2	80		X		X			X	0	
NSA_L_02	1/4	50	X	X	X	X				0	
NSA_L_191	1/4	70			X	X			X	0	
NSA_L_192	1/4	50				X			X	0	See PAA-L-653
NSA_L_193	<1/4	40					X		X	50	
NSA_L_209	<1/8	70			X	X	X			10	Duplexes and SFHs
NSA_L_210	1/2	70		X	X	X	X			40	PAA-L-651 & 652
NSA_L_211	1/4	45			X				X	0	
NSA_L_212	1/4	20			X	X	X		X	0	Needs more trees
NSA_L_43	1/4	65	X		X		X			15	
NSA_L_48	<1/8	60	X							25	Street sweeping

Hot Spot Assessment

There were no sites were assessed in Northeast Creek for hot spot status.

Institutional Site Assessment

There were no institutional sites assessed in Northeast Creek.

Stream Assessment

There were no stream assessments performed in Northeast Creek

Illicit Discharges

Baltimore County uses a prioritization system for sampling outfalls for illicit discharges. Northeast Creek contains three 'priority 2' outfalls. Priority 2 outfalls are sampled once per year.

Baltimore County will continue with their Illicit Discharge Detection and Elimination programs, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

No retrofits or pond conversions were identified in the Northeast Creek Subwatershed.

Pervious Area Restoration

Table 4-47 shows the three possible pervious area restorations identified during the assessment.

Table 4-47. Summary of Pervious Area Recommendations

Site	Location	Description	Size (acres)	Ownership
PAA-L-651	Off Cedar Rd.	Open space between houses	3	Public
PAA-L-652	Off Essex Rd.	Open space, mowed	2.5	Private
PAA-L-653	Near Pulaski & Berk	Abandoned Lot	2	Private

PAA-L-651 - Note Northeast Creek in the background

Subwatershed Management Strategy

Engaging Citizens & Watershed Groups

1. Conduct appropriate downspout disconnection measures according to Table 4-46.
2. Increase tree canopies on private lots by educating citizens on the benefits of trees and about programs like The Growing Home Campaign and TreeBaltimore. All of the neighborhoods here were recommended for tree canopy improvement on private lots.
3. Engage citizens in a storm drain stenciling program and conduct stenciling activities in the neighborhoods indicated in Table 4-46.
4. Provide lawn care education to neighborhoods identified with high turf management in Table 4-46. Work with homeowners in these neighborhoods to reduce the amount of nutrients applied to their lawn and other pollution prevention measures.
5. Further investigate three pervious areas listed in Table 4-47 for potential tree plantings, giving primary consideration to the one area listed as public property.

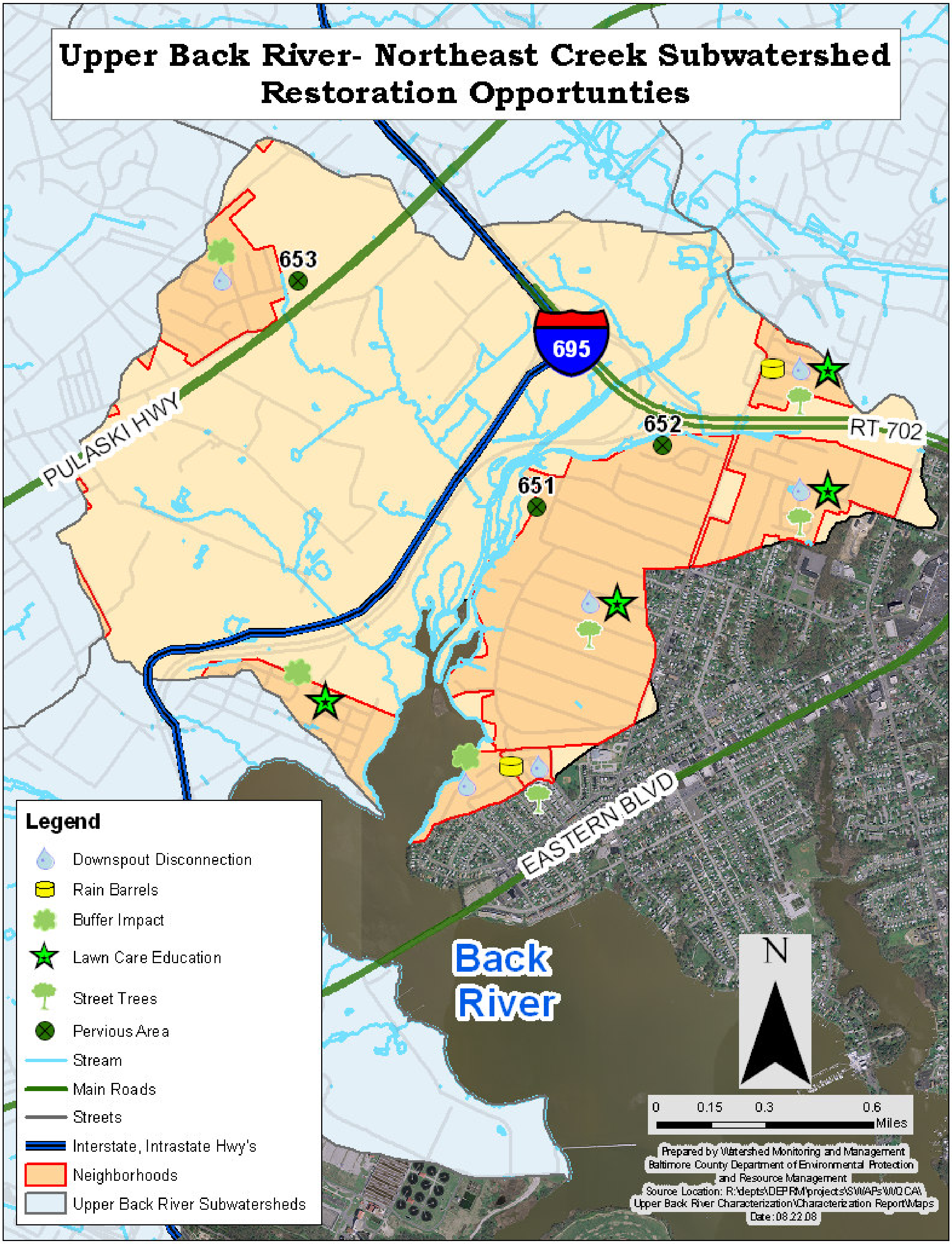

Figure 4-10- Restoration Opportunities in the Northeast Creek Subwatershed

4.3.10 Redhouse Run

Subwatershed Description

Redhouse Run begins in the northeast corner of Baltimore City between Harford and Belair roads. From here, it flows southeast into the county through Overlea then south under interstate 95 through Rosedale and enters Herring Run just south of Pulaski Highway. The land use in the subwatershed is over 70% residential and there is 25 % impervious cover. 20% of the stream buffer is forested; this is the lowest percentage in the SWAP area. Table 4-48 shows some basic information about Redhouse Run.

Table 4-48. Basic Profile of Redhouse Run Subwatershed

Drainage Area	• 3020.4 acres (5.4 mi^2)	
Stream length	• 14.7 miles	
Land Use	• Low-Density residential (47.1%) • Med-Density Residential (21.1%) • High-Density Residential (2.8%)	• Open Urban Land (12.1%) (includes forests) • Commercial (7.7%) • Institutional (7.8%)
Current Impervious Cover	• 25.1% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (22%) • Baltimore County (78%)	
Soils	• A Soils – 0.1% • B Soils – 7.4%	• C Soils – 61.2% • D Soils – 31.3%
Stormwater management	• County - Only 4.6% of the county portion of the subwatershed is treated by stormwater facilities • City - No existing stormwater facilities were identified	

Neighborhood Assessment

Forty-seven (47) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. Subwatershed boundaries were not used to designate neighborhoods so some neighborhoods may exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include downspout disconnection, storm drain stenciling, tree planting and public education (i.e. nutrient management). 157 impervious building acres were deemed feasible for downspout disconnection. Disconnection efforts should be certain to include the 4 multi-family neighborhoods due to efficiencies achieved by coordinating with one landowner instead of individual homeowners. Table 4-49 shows a summary of neighborhood recommendations for Redhouse Run.

concrete stream channel in NSA-L-81

sediment laden stream in NSA-L-18

Table 4-49. Summary of Neighborhood Assessment Recommendations

Site ID	Median lot size (acres)	Recommended Actions									
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Street Sweeping	Buffer Enhancement	Street Trees	Notes
NSA_L_01	1/2	80		X		X			X	0	some trash near stream
NSA_L_02	1/4	50	X	X	X	X				0	front yard tree planting
NSA_L_03	1/4	50	X	X	X	X				0	front yard tree planting
NSA_L_04	<1/4	10	X			X				0	
NSA_L_05	1/4	50			X	X			X	50	
NSA_L_06	1/4	60	X							0	
NSA_L_07	1/2	40		X	X	X			X	0	
NSA_L_08	1/8	35	X							0	
NSA_L_09	1/4	50		X		X			X	0	
NSA_L_10	1/2	70			X	X				0	
NSA_L_11	<1/4	15	X		X	X				50	
NSA_L_12	1/4	nd	X			X				100	
NSA_L_13	1/8	10	X							20	

Site ID	Median lot size (acres)	Recommended Actions									
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Street Sweeping	Buffer Enhancement	Street Trees	Notes
NSA_L_14	<1/8	30	X					X		0	lots of organic debris in streets & driveways
NSA_L_15	1/2	35		X	X				X	0	outreach to residents on stream
NSA_L_151A	1/4	70	X		X					0	Eliminate dumping in forested
NSA_L_151B	<1/8	70	X		X					0	Alley retrofits
NSA_L_152	<1/4	55			X	X				10	
NSA_L_153	<1/4	80			X	X				0	
NSA_L_154	1/4	70			X	X		X	X	75	
NSA_L_155A	1/4	100			X	X				0	All downspouts directly
NSA_L_156	1/4	90			X	X		X		0	Alley retrofit
NSA_L_157A	<1/4	75			X				X	0	
NSA_L_157B	Multifa	100			X	X	X			0	
NSA_L_158	Multifa	100				X				0	Existing curb cut
NSA_L_159	Multifa	100				X		X		0	Existing curb cut
NSA_L_16	<1/8	60	X		X					0	private property plantings
NSA_L_17	<1/4	50		X	X	X			X	100	Street trees
NSA_L_178	<1/4	75	X		X		X		X	30	Enhance buffer
NSA_L_18	<1/8	30		X	X	X				0	
NSA_L_180	1/4	80						X	X	100	
NSA_L_181	1/4	55			X	X			X	100	Extend buffer/no mow
NSA_L_182	1/2	50		X	X			X	X	0	Stream restoration-heavy sediment/buffer enhancement
NSA_L_183A	<1/8	100	X		X			X		100	See PAA-L-403. most of nsa in moores run
NSA_L_183B	1/2	60	X			X	X			100	
NSA_L_184	1/4	75			X	X		X	X	100	Some dumping in wooded area
NSA_L_189	1/4	20		X	X	X				0	
NSA_L_190	<1/4	40			X	X	X			40	
NSA_L_191	1/4	70			X	X			X	0	
NSA_L_192	1/4	50				X			X	0	See PAA-L-653
NSA_L_193	<1/4	40					X		X	50	Most of nsa is in stemmers
NSA_L_196	1/2	85		X		X	X			0	
NSA_L_213	1/2	65		X	X	X			X	0	
NSA_L_218	Multifa	100			X	X	X			0	Lot retrofits, trash mgmt.
NSA_L_79	<1/4	60			X					0	
NSA_L_80	<1/4	80			X	X	X			0	Plating in duplex area
NSA_L_81	<1/4	90	X		X	X			X	30	Stream restoration-concrete removal and daylighting

Hot Spot Assessment

Table 4-50 shows the 21 sites assessed for hot spot status in Redhouse Run, representing the majority of the hot spots assessed in the Upper Back River watershed. Priority should be given to the nine confirmed hot spots shown in the table below.

Table 4-50. Summary of Hotspot Sites Recommendations

Status	Site ID	Description	Potential Sources of Pollution					
			Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/Landscaping	Stormwater Management
Potential	HSI_L_451	Citgo Gas Station	X			X		X
Confirmed	HSI_L_452	Rosedale Plaza			X	X		
Confirmed	HSI_L_453	none provided	X	X	X	X		
Confirmed	HSI_L_454	Electrical Supply	X	X	X	X		
Confirmed	HSI_L_455	Car Repair/Truck Storage	X	X	X	X		
Potential	HSI_L_456	Truck Maintenance	X	X				
Potential	HSI_L_457	Refrigeration		X	X	X	X	X
Potential	HSI_L_458	Integrity Recycling		X	X	X		
Potential	HSI_L_459	Auto Repair/Junkyard	X	X	X	X		
Confirmed	HSI_L_460	Trucking Co.	X	X	X	X		
Potential	HSI_L_461	Truck Rental/Repair	X	X	X	X		
Potential	HSI_L_462	Marty's Auto Paint		X	X			
Potential	HSI_L_469	Rosedale Village		X	X	X	X	X
Not a hotspot	HSI_L_470	Rosedale Center School				X	X	X
Confirmed	HSI_L_471	Rosedale Fire Co.	X	X	X	X	X	X
Potential	HSI_L_472	School Bus Depot	X	X				X
Potential	HSI_L_473	McNew Excavating	X	X	X	X		X
Confirmed	HSI_L_474	Tire & Service Center	X	X	X	X		
Not a hotspot	HSI_L_475	Used Car Lot	X		X			X
Confirmed	HSI_L_476	Overlea Plaza			X	X		
Confirmed	HSI_L_477	Glenmore Service/Gas Station	X	X	X	X		X

Due to the large number of hot spots, a separate map was created to show their locations. See Figure 4-11.

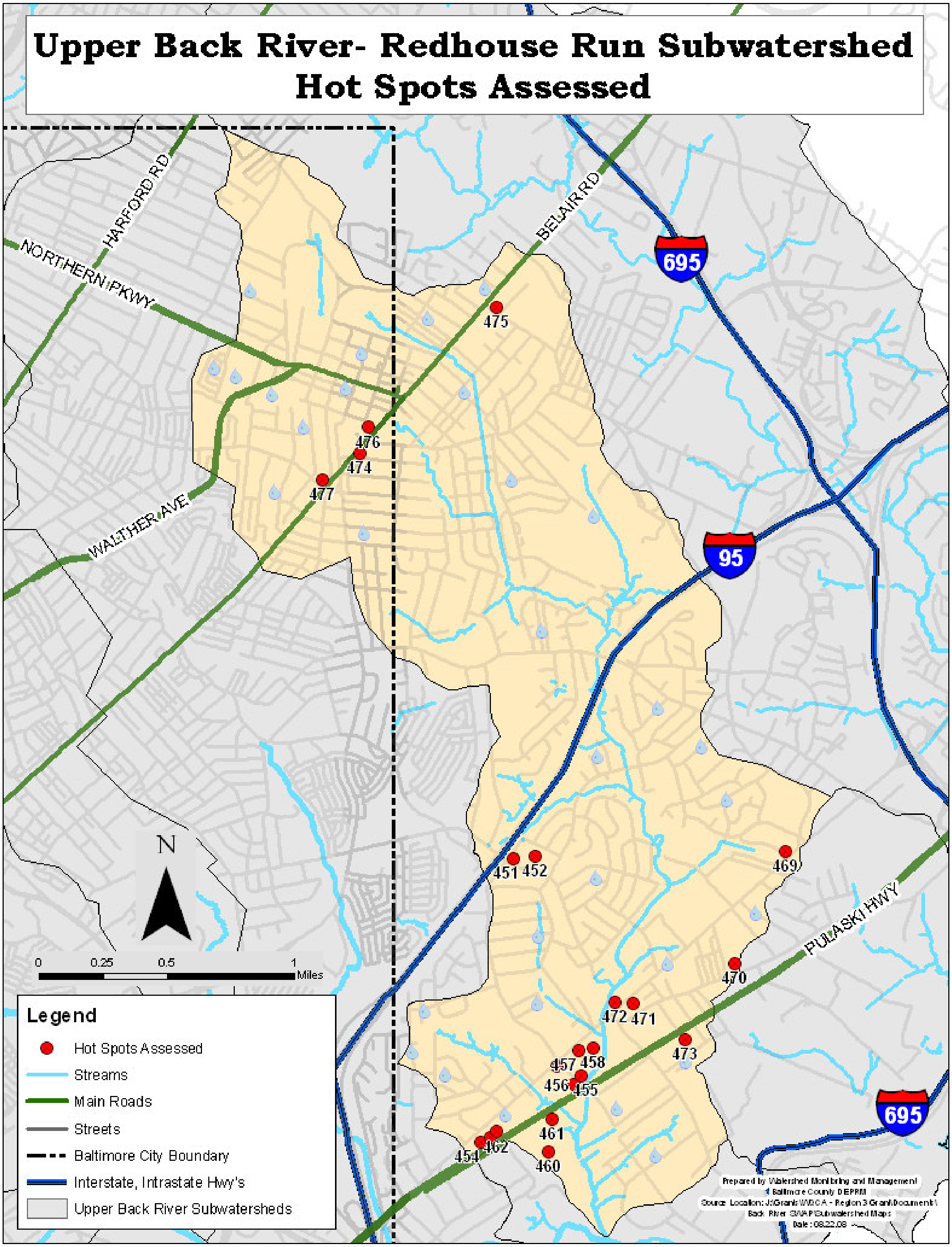

Figure 4-11- Hot Spots Assessed in the Redhouse Run Subwatershed

Institutional Site Assessment

Table 4-51 shows the six institutional areas assessed in the Redhouse Run subwatershed. Trash management and tree planting appear to be the best opportunities along with education about washwater dumping in storm drains.

Table 4-51. Summary of Recommendations for Schools and Places of Worship

Site ID	Name of Site	Public/ Private	Greening Opportunities						Notes
			Nutrient Management	Tree Planting (#)	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management	
ISI_L_451	Redhouse Run ES	Public	N	250	X			X	washwater dumping
ISI_L_452	Golden Ring MS	Public	N	50	X			X	washwater dumping
ISI_L_453	Fullerton ES / Senior Center	Public	Y	400				X	washwater dumping
ISI_L_454	McCormick ES	Public	Y	200				X	
ISI_L_455	Overlea HS	Public	Y	100	X			X	
ISI_L_456	Elmwood ES	Public	N	130				X	washwater dumping

Stream Assessment

CWP, HRWA, and other SWAP project partners, including JFWA, conducted a physical stream corridor assessment along 8 linear stream miles in the Redhouse Run subwatershed June 10th and 12th, 2006. There is a stream restoration project to be conducted by Baltimore County along the St. Patricks Rd. area of Redhouse Run.

Observations along the stream corridor by field crews included the following:

- Limited areas for streams to access floodplain. Currently the 1.5-year storm and above are confined within the stream channel.
- Habitat is severely limited by the lack of water in the channel –especially in the summer.
- Few obvious illicit discharges were noted and trash problems were limited to a number of locations.
- Limited areas for stream buffer improvements except in streamside parks and at individual homes. In both cases there may be conflicting community interests – damage to riparian planting projects were noted in these areas.
- County park maintenance staff may be persuaded to allow a larger buffer on some of the park areas as they are maintaining turf areas sometimes within 5-10ft of the streambank.

Recommended Actions:

- In tandem with stormwater retrofits, stream restoration could benefit highly eroding areas and provide relief and reduce erosive flows in park areas, such as St. Patrick Street, by lowering the floodplain as part of restoration efforts*.
- Resurvey potential illicit discharge locations throughout the watershed.

- Pursue limited trash cleanup and riparian reforestation projects.
- Work with County Park maintenance staff to allow larger buffers on park areas in the Redhouse Run.

*There is a planned stream restoration project to be conducted by Baltimore County along the St. Patrick Rd. area of Redhouse Run.

Illicit Discharges

Baltimore County uses a prioritization system for sampling outfalls for illicit discharges. Priority one describes an outfall with major problems including the presence of chemicals in the water. Priority two describes outfalls with moderate problems including erosion and trash but no chemical problems detected. Priority 1 outfalls are sampled four times per year and priority 2 outfalls are sampled once per year. Redhouse Run contains four priority 2 outfalls and one priority 1 outfall.

Baltimore County and Baltimore City will continue with their Illicit Discharge Detection and Elimination programs, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

Table 4-52 shows the 33 retrofits identified in Redhouse Run. In addition, there were three pond conversion opportunities identified and they are shown in Table 4-53.

Table 4-52. Summary of Retrofit Opportunities in Redhouse Run

Site	Drainage Area (ac)	Description/Classification	Priority
R15C	3.2	Level Spreader	Medium
R29	16.0	Bioretention	Medium
R30	8.0	Bioretention	Medium
R32	0.5	Enhance Sand Filter	High
R1A	0.25	Dry Swale	Medium
R5A	1.0	Filter Strip	Medium
R8A	1.5	Bioretention	Medium
R11	5.0	Bioretention	Medium
R14	1.0	Bioretention	Medium
R15A	2.0	Bioretention	Medium
R18A	1.8	Bioretention	Medium
R19	2.0	Sand Filter	Low
R27	1.5	Vegetated Filter Strip	Medium
R28	1.0	Bioretention	Low
R1C	0.35	Enhance Rain Garden	High
R6	0.35	Reforestation	High
R18B	336	Floodplain Restoration	Medium
R31	3.5	Enhance Dry Swale & Sand Filter	High
R1B	0.5	Permeable Pavement	Medium
R15B	4.25	Level Spreaders/Filter Strips	Medium
R20A	1.0	Downspout Disconnection	High
R4	3.5	Bioretention	High
R7	3.0	Bioretention	Medium
R8B	7.5	Bioretention	Medium
R12	4.0	Sand Filter	Low
R13	1.5	Dry Swale/Bioretention	High

R19	2.0	Bioretention	Low
R20B	2.0	Bioretention	Medium
R22	2.0	Sand Filter	Low
R23	2.0	Bioretention	Medium
R26	4.0	Bioretention	Medium
R24	2.0	Catch Basin Inlets	High

Table 4-53. Summary of SWM Pond Conversion Opportunities in Redhouse Run

Pond #	Drainage Area (ac)	Priority
1211	61.7	High
1409	2.4	Medium
560	2.4	Medium

Pervious Area Restoration

Table 4-54 shows the eight possible pervious area restorations identified during the assessment.

Table 4-54. Summary of Pervious Area Recommendations

Site	Location	Description	Size (acres)	Ownership
PAA_L_451	Southern tip of RR	Shell Gas Station	1	Private
PAA_L_452	South Redhouse Run	Church	1	Private
PAA_L_453	North Redhouse Run	Fullerton Rec Center	6	Public
PAA_L_454	NW Redhouse Run	Lillian Holt Center for Arts	5	Public
PAA_L_455	Golden Ring Middle	Golden Ring Middle	7.5	Public
PAA_L_456	End of Elm	Redhouse Run Elementary	4	Public
PAA_L_457	MD School Blind	MD School for the Blind	1	Private
PAA_L_458	End of Kolb	Park	7	Public

Subwatershed Management Strategy

Engaging Citizens & Watershed Groups

1. Reduce the unforested buffer area. Investigate neighborhoods shown in Table 4-49 to be encroaching on the buffer and extend/plant the buffer wherever possible. Also investigate buffer areas that exist as common spaces for planting opportunities and potential for using the Tree-Mendous Maryland program.
2. Conduct appropriate downspout disconnection measures according to Table 4-49, focusing efforts on the multi-family neighborhoods. There are many opportunities for rain gardens in this subwatershed.
3. Engage citizens in a storm drain stenciling program and conduct stenciling activities in the neighborhoods indicated in Table 4-49.
4. Educate citizens on the benefits of bayscaping and implement a program to encourage the establishment of bayscaping on resident's private lots.
5. Increase tree canopies on private lots by educating citizens on the benefits of trees and about programs like The Growing Home Campaign and TreeBaltimore.
6. Plant street trees. Table 4-49 shows a potential for over 1000 street trees plantings.
7. Conduct focused business education and outreach efforts to nine confirmed hot spot locations identified in Table 4-50.
8. Engage Institutions sited in Table 4-51 in respective restoration efforts, especially tree plantings.
9. Investigate eight pervious areas listed in Table 4-54 for potential tree plantings; giving primary consideration to the five areas listed as public property.

Municipal Actions*

1. County park maintenance staff may be persuaded to allow a larger buffer on some of the park areas as they are maintaining turf areas sometimes within 5-10ft of the streambank.
2. Conduct street sweeping in neighborhoods identified in Table 4-49.
3. Implement high priority storm water retrofits and pond conversions shown in Tables 4-52 and 4-53 respectively.

*NOTE: Baltimore County is in the planning stages of a stream restoration that will occur around the summer of 2009 near the St. Patricks Rd area of Redhouse Run. See Figure 4-12 below for exact location.

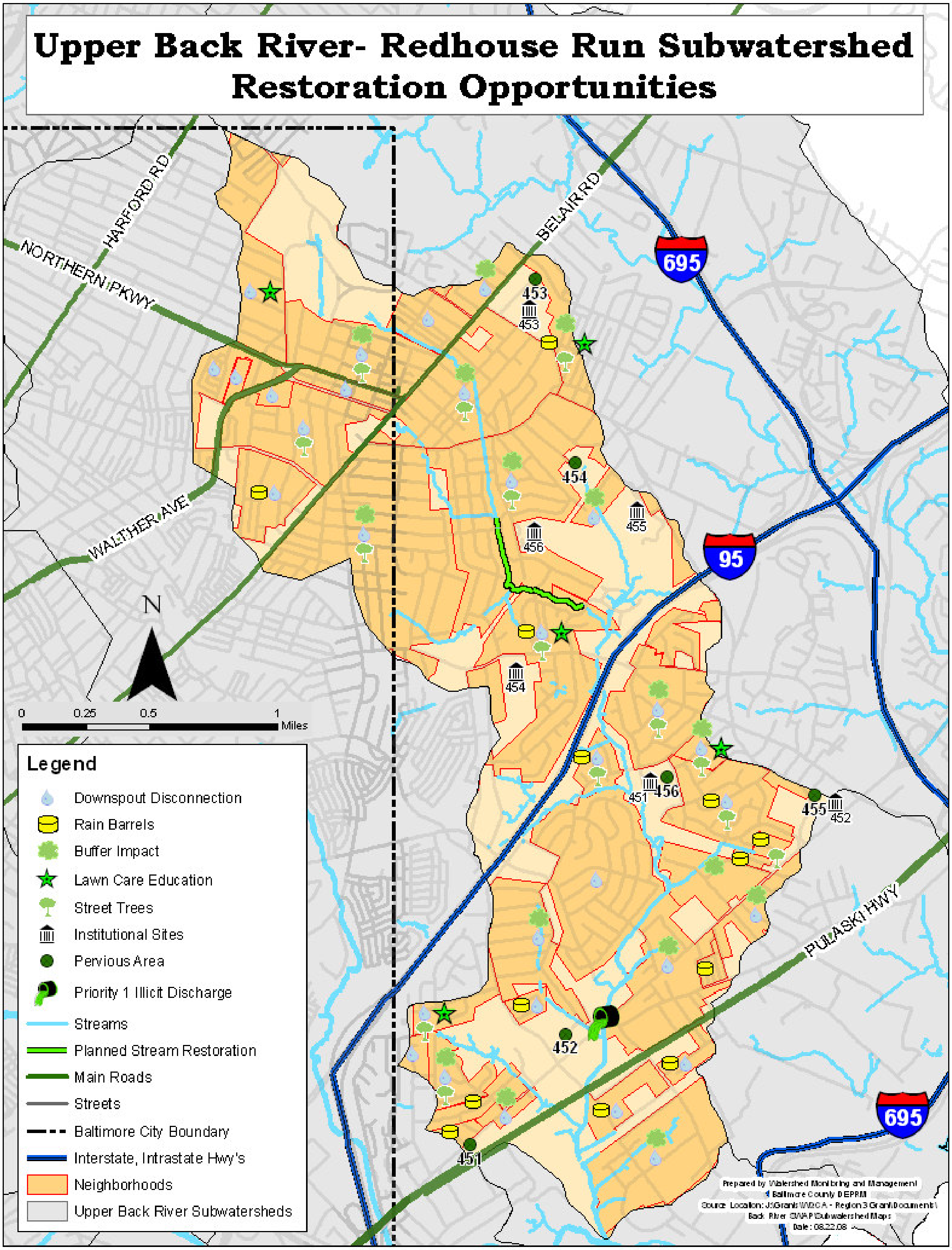

Figure 4-12- Restoration Opportunities in the Redhouse Run Subwatershed

4.3.11 Stemmer's Run

Subwatershed Description

Stemmers Run begins just northeast of Baltimore City between Harford and Belair roads at the Parkville Middle School and at the Parkwood Cemetary flowing through Double Rock Park. From here, it flows southeast along 695 through Linover Park and Gardens of Faith Cemetery and under the 695/95 interchange. Stemmers Run continues its southeasterly flow through the Golden Ring area and joins Brien's Run before entering the Northeast Creek watershed.

Stemmer's Run appears to be under some duress due to the heavy construction activity here. New neighborhood developments and the substantial construction project at the 695/95 interchange make Stemmers Run appear to be the subwatershed most impacted by construction in the Upper Back River.

The neighborhoods within Stemmers Run showed substantial opportunity for downspout disconnection, bayscaping, stormdrain stenciling and street trees. Table 4-55 shows some basic information about Stemmer's Run.

Table 4-55. Basic Profile of Stemmers Run Subwatershed

Drainage Area	• 3690.6 acres (5.8 mi^2)	
Stream length	• 26.8 miles	
Land Use	• Low-Density residential (16.6%) • Med-Density Residential (19.4%) • High-Density Residential (9.1%)	• Open Urban Land (30.5%) (includes forests) • Commercial (10.9%) • Institutional (4.7%)
Current Impervious Cover	• 25.1% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (3%) • Baltimore County (97%)	
Soils	• A Soils – 3.1% • B Soils – 13.1%	• C Soils – 66.0% • D Soils – 17.6%
Stormwater management	• County - Only 19% of the watershed is treated by a stormwater facilities • City - No existing stormwater facilities were identified	

Neighborhood Assessment

Forty-two (42) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. Subwatershed boundaries were not used to designate neighborhoods so some neighborhoods may exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include downspout disconnection, storm drain stenciling, tree planting and public education (i.e. nutrient management).

There are 239 impervious building acres in neighborhoods where downspout disconnection is recommended in Stemmers Run. Based on an average of 58.7% potential for disconnection, 140 impervious building acres were deemed feasible for downspout disconnection. Disconnection efforts should first concentrate on the 15 multi-family neighborhoods due to the efficiencies achieved by coordinating with one landowner instead of individual homeowners. Table 4-56 shows a summary of neighborhood recommendations for Stemmer's Run.

poor sediment control in NSA-L-177

car wash where runoff goes to stormdrain in NSA-L-19

Table 4-56. Summary of Neighborhood Assessment Recommendations

Site ID	Median lot size (acres)	Recommended Actions									
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Street Sweeping	Buffer Enhancement	Street Trees	Notes
NSA_L_113	1/4	55					X			0	
NSA_L_114	<1/8	75	X		X		X		X	0	Stream buffer improvement
NSA_L_115	Multifami	100	X							0	
NSA_L_12	1/4	nd	X			X				100	
NSA_L_122	Multifamily	100	X		X		X				Dumping in pkg lot by SWM
NSA_L_123	Multifami	70	X		X					0	
NSA_L_124	Multifami	50			X		X			0	
NSA_L_126	1/3	90		X			X		X	0	Buffer
NSA_L_127	1/2	65				X				0	
NSA_L_128	Multifami	100			X			X		0	
NSA_L_155A	1/4	100			X	X					
NSA_L_155B	Multifami	100		X	X		X	X		20	Possible lot retrofits
NSA_L_156	1/4	90			X	X		X			Alley retrofit
NSA_L_157A	<1/4	75			X				X	0	
NSA_L_157B	Multifami	100			X	X	X			0	
NSA_L_17	<1/4	50		X	X	X			X	100	
NSA_L_177	1/4	60	X				X	X	X	30	Poor sediment control/plant buffer,
NSA_L_178	<1/4	75	X		X		X		X	30	Buffer enhancement
NSA_L_179	1/2	80		X		X			X		
NSA_L_181	1/4	55			X	X			X	100	Extend buffer in field

Site ID	Median lot size (acres)	Recommended Actions									Notes
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Street Sweeping	Buffer Enhancement	Street Trees	
NSA_L_182	1/2	50		X	X			X	X	0	Stream restoration-heavy sediment/ buffer enhancement
NSA_L_185	<1/4	5			X	X	X		X	0	New
NSA_L_193	<1/4	40					X		X	50	
NSA_L_194	Multifamily	50				X	X			0	Many tree planting opps.
NSA_L_195	Multifamily	50				X	X			0	Car wash drains to storm drain
NSA_L_196	1/2	85		X		X	X			0	
NSA_L_197	1/4	55	X		X	X	X			0	Rust staining in driveways
NSA_L_199	1/2	20		X		X	X		X	0	Educate resident on buffer expansion
NSA_L_200	Multifami	50			X	X	X			0	
NSA_L_201	Multifamily	45			X	X	X			0	Consider open space tree planting
NSA_L_202	Multifami	0			X	X	X			0	
NSA_L_203	Multifami	15			X	X	X			0	
NSA_L_204	Multifami	5			X	X	X		X	0	Extend buffer
NSA_L_205	1/2	0			X	X	X		X	0	Dying street trees
NSA_L_206	1/4	30		X	X		X			0	
NSA_L_207	1/2	50		X	X	X	X		X	0	
NSA_L_69	Multifamily	100		X	X	X				0	Recommend Stormwater planters
NSA_L_72	<1/4	55		X	X	X				150	
NSA_L_73	1/4	60			X	X	X		X	50	Educate residents on buffer expansion/no-mow
NSA_L_74	1/8	40			X	X		X	X	100	
NSA_L_80	<1/4	80			X	X	X			0	Residential tree planting in duplex
NSA_L_81	<1/4	90	X		X	X			X	30	Stream restoration-concrete removal and daylighting

Hot Spot Assessment

Table 4-57 shows the 2 sites assessed in Stemmers Run for hot spot status.

Table 4-57. Summary of Hotspot Sites Recommendations

Status	Site ID	Description	Potential Sources of Pollution					
			Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/Landscaping	Stormwater Management
Not a hotspot	HSI_L_601	Shopping Center			X			
Potential	HSI_L_602	Construction Business	X		X	X	X	

Institutional Site Assessment

Table 4-58 shows the two institutional areas assessed in the Stemmers Run subwatershed. Parkville Middle School provides an excellent opportunity to combine a lot retrofit, tree planting effort and stream naturalization effort with education. Perhaps an incentive to become a registered Green School could further chances of a successful cooperative effort.

Table 4-58. Summary of Recommendations for Schools and Places of Worship

Site ID	Name of Site	Public/ Private	Greening Opportunities						Notes
			Nutrient Management	Tree Planting (#)	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management	
ISI_L_601	Parkville Senior Center	Public	N	20		X	X		
ISI_L_602	Parkville MS	Public	Y	60	X		X		Stream naturalization

lot retrofit and stream naturalization opportunities at ISI-L-602

Stream Assessment

A stream stability assessment was conducted by Parsons Brinkerhoff in the Stemmers Run watershed. The subwatershed deficiencies as outlined in the report are as follows:
Problems with the Stemmers Run subwatershed include moderate stream bank erosion, various channel disturbances and fish blockages. 69% of the in stream habitat was rated fair and 2% was rated good. Channel disturbances include culverts causing fish blockages and invasive species, as well as a large amount of waste and trash in some locations. Table 4-59 summarizes the stream assessment findings.

Table 4-59. Summary of Stream Conditions in Stemmers Run

Stream Opportunities	Number of Problems
Restoration/Stabilization	30
Buffer Enhancement	3
Bank Planting	20
Utility Conflicts	13
Wetland Enhancement	3
Yard Waste Education	27
Invasive Plant Removal	66
Trash Dumping	85

Illicit Discharges

Baltimore County uses a prioritization system for sampling outfalls for illicit discharges. Priority one describes an outfall with major problems including the presence of chemicals in the water. Priority two describes outfalls with moderate problems including erosion and trash but no chemical problems detected. Priority 1 outfalls are sampled four times per year and priority 2 outfalls are sampled once per year.

Stemmers Run contains four priority 2 outfalls and no priority 1 outfalls.

Baltimore County and Baltimore City will continue with their Illicit Discharge Detection and Elimination programs, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

There were no retrofits opportunities and six pond conversions identified in Stemmers Run. Table 4-60 shows these conversions.

Table 4-60. Summary of SWM Pond Conversion Opportunities in Stemmer's Run

Pond #	Drainage Area (ac)	Priority
531	11.7	High
1283	6.4	Low
828	5	Low
1741	3.8	Low
471	2.4	Medium
1829	10.8	Medium

Pervious Area Restoration

Table 4-61 shows the one possible pervious area restorations identified during the assessment.

Table 4-61. Summary of Pervious Area Recommendations

Site	Location	Description	Size (acres)	Ownership
PAA_L_601	Golden Ring Park	Golden Ring Park	1.5	Public

Subwatershed Management Strategy

Engaging Citizens & Watershed Groups

1. Increase the forested buffer area. Investigate neighborhoods shown in Table 4-56 to be encroaching on the buffer and extend/plant the buffer wherever possible.
2. Conduct appropriate downspout disconnection measures according to Table 4-56, focusing efforts on the multi-family neighborhoods. There are some opportunities for rain gardens in this subwatershed.
3. Engage citizens in a stormdrain stenciling program and conduct stenciling activities in the neighborhoods indicated in Table 4-56.
4. Educate citizens on the benefits of bayscaping and implement a program to encourage the establishment of bayscaping on resident's private lots.
5. Increase tree canopies on private lots by educating citizens on the benefits of trees and about programs like The Growing Home Campaign.
6. Plant street trees. Table 4-56 shows a potential for 760 street trees plantings.
7. Engage Institutions sited in Table 4-58 in respective restoration efforts, especially Parkville Middle which has multiple restoration opportunities.

Municipal Actions

1. Identify and conduct feasible stream restoration measures based on the many recommendations of the Parson's stream stability assessment (Table 4-59).
2. Parkville Middle has parking lot retrofit and stream channel naturalization opportunities identified through the ISI assessment.
3. Conduct or improve street sweeping in neighborhoods identified in Table 4-56.

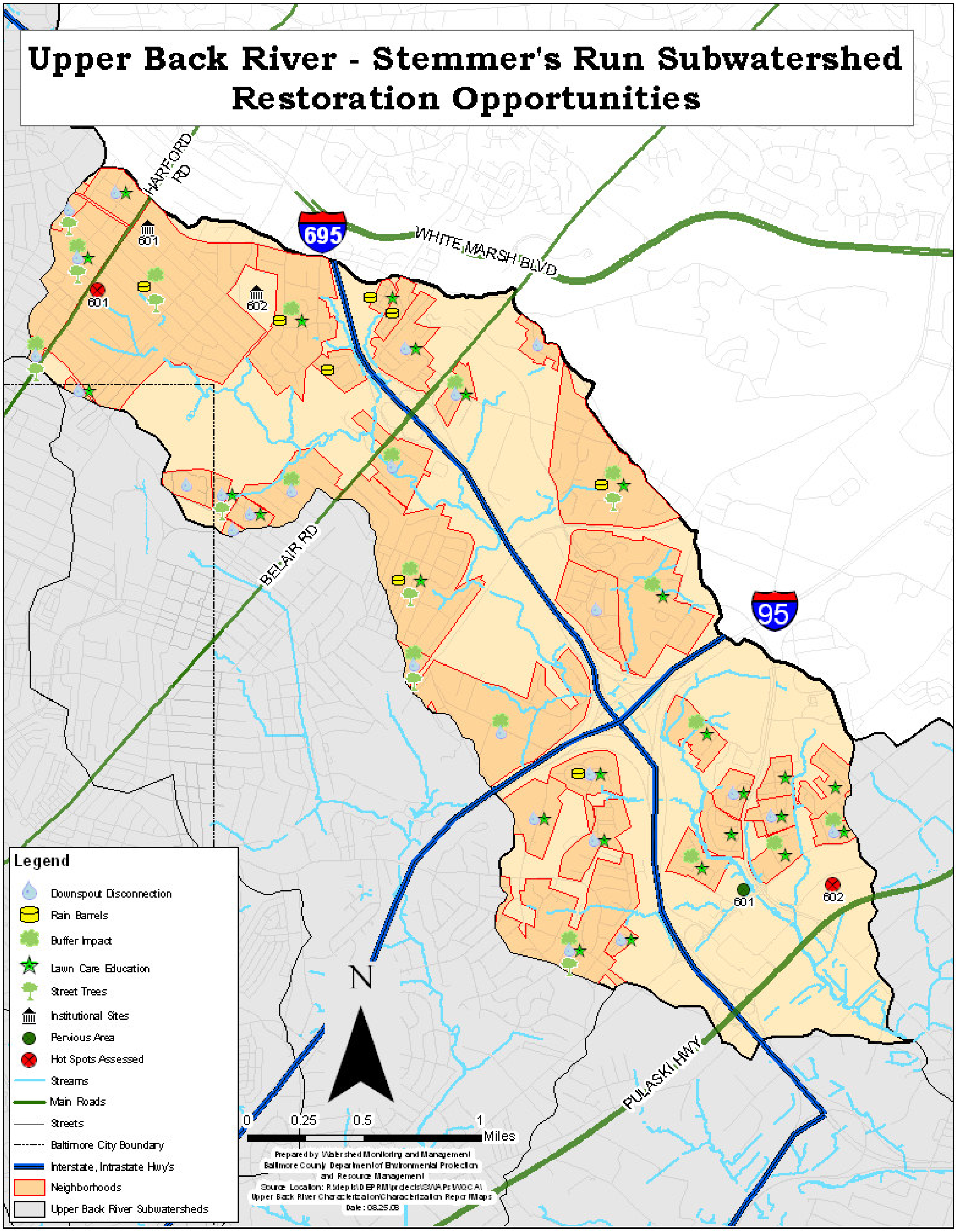

Figure 4-13- Restoration Opportunities in the Stemmer's Run Subwatershed

4.3.12 Tiffany Run

Subwatershed Description

Tiffany Run is an entirely piped stream system. The watershed begins along the Alameda near the Govans community. It flows through a network of pipes towards the south and east and then enters the mainstem of Herring Run just above Lake Montebello. Urban streams without any visible channels receive impacts from upland sources just the same as open channels. However, because of their hidden nature, it can become harder to trace the source of a pollution problem and difficult to engage the public to take action. Table 4-62 shows basic information about Tiffany Run.

Table 4-62. Basic Profile of Tiffany Run Subwatershed

Drainage Area	• 893.8 acres (1.4 mi^2)	
Stream length	• 0.16 miles	
Land Use	• Low-Density residential (0.0%) • Med-Density Residential (18.9%) • High-Density Residential (52.0%)	• Open Urban Land (0.4%) (includes forests) • Commercial (3.9%) • Institutional (20.7%)
Current Impervious Cover	• 40.5% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (100%) • Baltimore County (0%)	
Soils	• A Soils – 0.0% • B Soils – 0.8%	• C Soils – 5.5% • D Soils – 93.7%
Stormwater management	• County - NA • City - No existing stormwater facilities were identified	

Neighborhood Assessment

Sixteen (16) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. Subwatershed boundaries were not used to designate neighborhoods so some neighborhoods may exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include downspout disconnection, storm drain stenciling, street sweeping and tree planting.

There are 115 impervious building acres in Stemmers Run. Based on an average of 67.5% potential for disconnection, 77.6 impervious building acres were deemed feasible for downspout disconnection. Disconnection efforts should first concentrate on the 3 multi-family neighborhoods due to the efficiencies achieved by coordinating with one landowner instead of individual homeowners.

Many of the neighborhoods in Tiffany Run were assessed using the NSA jr form, which does not require a percent downspout disconnection number hence the ‘nd’ or no data entries in this associated column. Table 4-63 shows a summary of neighborhood recommendations for Tiffany Run.

Table 4-63. Summary of Neighborhood Assessment Recommendations

Site ID	Median lot size (acres)	Recommended Actions									
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Street Sweeping	Trash Mgmt.	Street Trees	Notes
NSA_L_118	Multifamily	nd		X	X					0	Tree planting/curb cut opportunity
NSA_L_170	<1/4	50	X		X	X		X		0	
NSA_L_171	1/8	nd			X			X		0	Alley retrofit
NSA_L_172	1/8	nd			X			X	X	0	Convert open space to parks
NSA_L_173A	Multifamily	nd			X					0	
NSA_L_173B	1/8	nd			X				X	0	
NSA_L_174	Multifamily	nd			X			X	X	0	Tree planting
NSA_L_175	<1/8	75			X	X			X	0	Plant empty parcels
NSA_L_176	<1/8	100			X					0	
NSA_L_20	<1/4	40		X	X		X	X		0	
NSA_L_21	<1/8	80			X	X	X	X	X	80	
NSA_L_49	<1/4	nd		X	X			X	X	0	Waste management
NSA_L_51	1/4	nd			X			X	X	0	Street sweeping
NSA_L_53	<1/4	70	X		X	X	X			0	
NSA_L_54	<1/8	50	X		X			X		0	Street sweep
NSA_L_55	<1/8	75	X		X			X	X	0	Waste mgmt

Hot Spot Assessment

There were no sites were assessed in Tiffany Run for hot spot status.

Stream Assessment

Due to the lack of open channel stream in this watershed, a stream assessment was not conducted here.

Illicit Discharges

Baltimore City will continue with their Illicit Discharge Detection and Elimination programs, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

There were two retrofits and no pond conversions identified in Tiffany Run. Table 4-64 shows the retrofits.

Table 4-64. Summary of Retrofit Opportunities in Moore's Run

Site	Drainage Area (ac)	Description/Classification	Priority
R1	2.0	Dry Swale/Bioretention	Medium
R2	60	Wetpond/Wetland	Medium

Pervious Area Restoration

There were no pervious area assessments performed in Tiffany Run

Institutional Site Assessment

Table 4-65 shows the two institutional areas assessed in the Tiffany Run subwatershed. Parkville Middle School provides an excellent opportunity to combine a lot retrofit, tree planting effort and stream naturalization effort with education. Perhaps an incentive to become a registered Green School could further chances of a successful cooperative effort.

Table 4-65. Summary of Recommendations for Schools and Places of Worship

Site ID	Name of Site	Public/ Private	Greening Opportunities						
			Nutrient Management	Tree Planting (#)	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management	Notes
ISI_L_153	Church of the Redeemer	Private	N	0					
ISI_L_154	Winston MS	Public	N	145			X	X	Paint dumping in storm drain

evidence of paint dumping at ISI-L-154

Subwatershed Management Strategy

Engaging Citizens & Watershed Groups

1. Conduct appropriate downspout disconnection measures according to Table 4-63, focusing efforts on the multi-family neighborhoods.
2. Engage citizens in a storm drain stenciling program and conduct stenciling activities in the neighborhoods indicated in Table 4-63.
3. Raise awareness of trash problem and take measures to reduce litter in the neighborhoods listed in Table 4-63.
4. Engage Institutions sited in Table 4-65 in respective restoration efforts.

Municipal Actions

1. Conduct street sweeping in neighborhoods identified in Table 4-63.

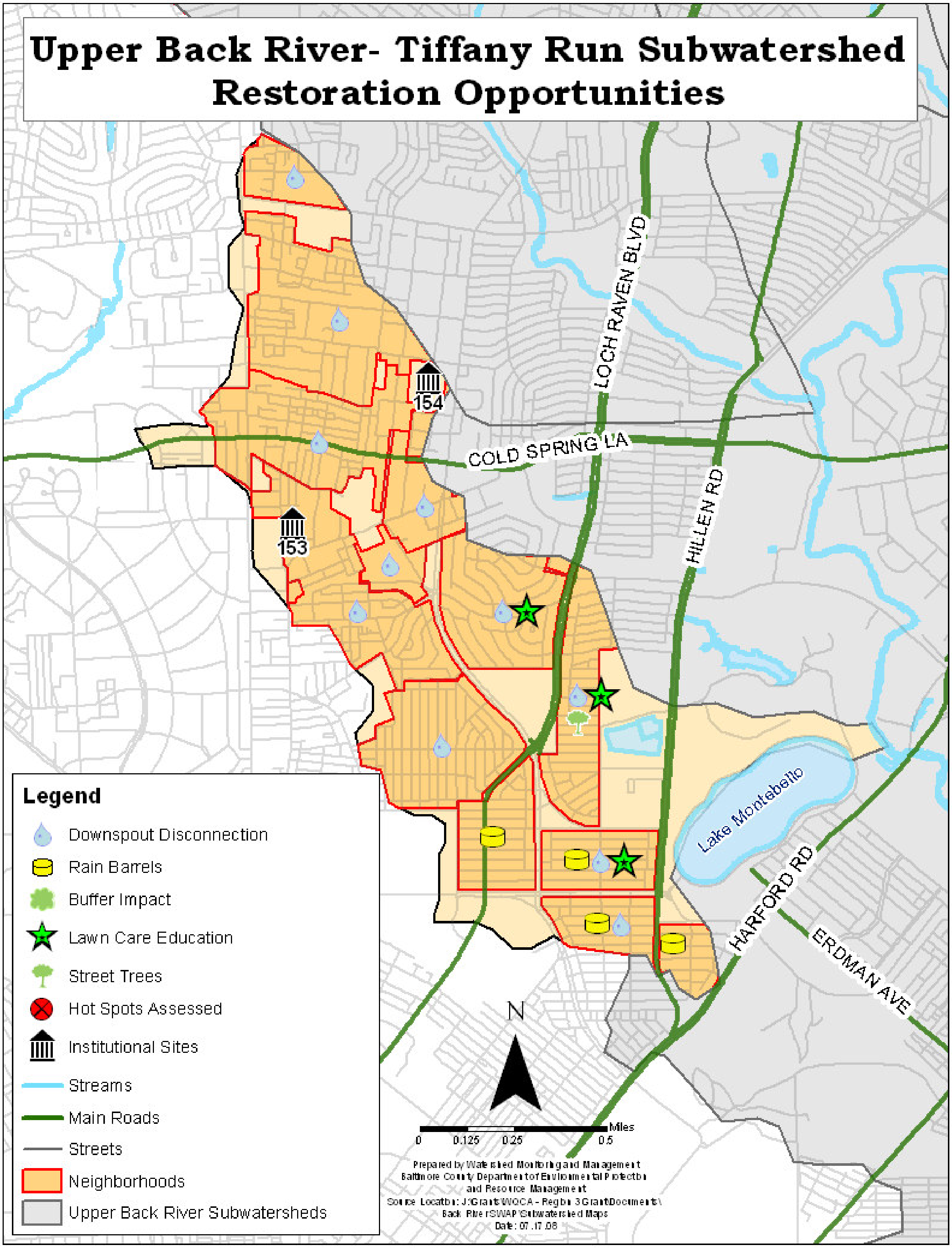

Figure 4-14 – Restoration Opportunities in Tiffany Run

4.3.13 Unnamed Tributary

Subwatershed Description

Unnamed Tributary begins east of 895 just south of the intersection with Erdman Ave. From here it flows east under the railway line and under North Point Blvd. And out to Herring Run. Percentage-wise, this is the most industrialized of the subwatersheds in the Upper Back River SWAP. Table 4-66 shows some basic information about the Unnamed Tributary subwatershed.

Table 4-66. Basic Profile of Unnamed Tributary Subwatershed

Drainage Area	• 580.3 acres (0.9 mi^2)	
Stream length	• 1.84 miles	
Land Use	• Low-Density residential (0.0%) • Med-Density Residential (0.0%) • High-Density Residential (4.5%)	• Open Urban Land (4.3%) (includes forests) • Commercial (29.8%) • Industrial (39.0%)
Current Impervious Cover	• 34.7% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (100%) • Baltimore County (0%)	
Soils	• A Soils – 0.0% • B Soils – 0.6%	• C Soils – 16.5% • D Soils – 82.9%
Stormwater management	• City - No existing stormwater facilities were identified • County - NA	

Neighborhood Assessment

Two (2) neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance totaling 28.6 acres Subwatershed boundaries were not used to designate neighborhood boundaries so some neighborhoods may exist in more than one subwatershed. In this case, only 14.6 acres of these two neighborhoods actually fall within the subwatershed.

There are 1.98 impervious building acres in the neighborhood where downspout disconnection is recommended in Armistead Run. Based on an 85% potential for disconnection, 1.7 impervious building acres were deemed feasible for downspout disconnection. NSA-L-61 is a privately owned neighborhood so, similar to multi-family apartment neighborhoods, this would be a good area to target. Table 4-67 shows a summary of neighborhood recommendations for Unnamed Tributary.

Table 4-67. Summary of Neighborhood Assessment Recommendations

		Recommended Actions									
Site ID	**Median lot size (acres)**	**% Opportunity for Downspout Disconnection**	**Rain Barrels**	**Rain Gardens**	**Stormdrain Stencils**	**Bayscape**	**Nutrient Management**	**Pet Waste**	**Buffer Enhancement**	**Street Trees**	**Notes**
NSA_L_168	<1/4	85	X							5	Clean well-kept neighborhood
NSA_L_61	Multifami	50	X		X	X			X	0	Tree planting

typical homes in NSA-L-168

Hot Spot Assessment

Table 4-68 shows the two sites assessed in Armistead Run for hot spot status. Both assessed as confirmed hot spots.

Table 4-68. Summary of Hotspot Sites Recommendations

Status	Site ID	Description	Potential Sources of Pollution					
			Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/ Landscaping	Stormwater Management
Confirmed	HSI-L-201	Construction supply		X	X	X		X
Confirmed	HIS-L-202	Body shop/junkyard	X	X	X	X		X

Institutional Site Assessment

There were no institutional areas assessed in the Armistead Run subwatershed.

Stream Assessment

There were no stream assessments performed in Armistead Run.

Illicit Discharges

Baltimore City will continue with their Illicit Discharge Detection and Elimination programs, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

There were no retrofits or pond conversions identified in Unnamed Tributary.

Pervious Area Restoration

There were no pervious area restoration sites assessed in the Unnamed tributary.

Subwatershed Management Strategy

Engaging Citizens & Watershed Groups

1. Conduct appropriate downspout disconnection measures according to Table 4-67, focusing efforts on the multi-family neighborhoods.
2. Increase tree canopies on private lots by educating citizens on the benefits of trees and about programs like The Growing Home Campaign and TreeBaltimore.

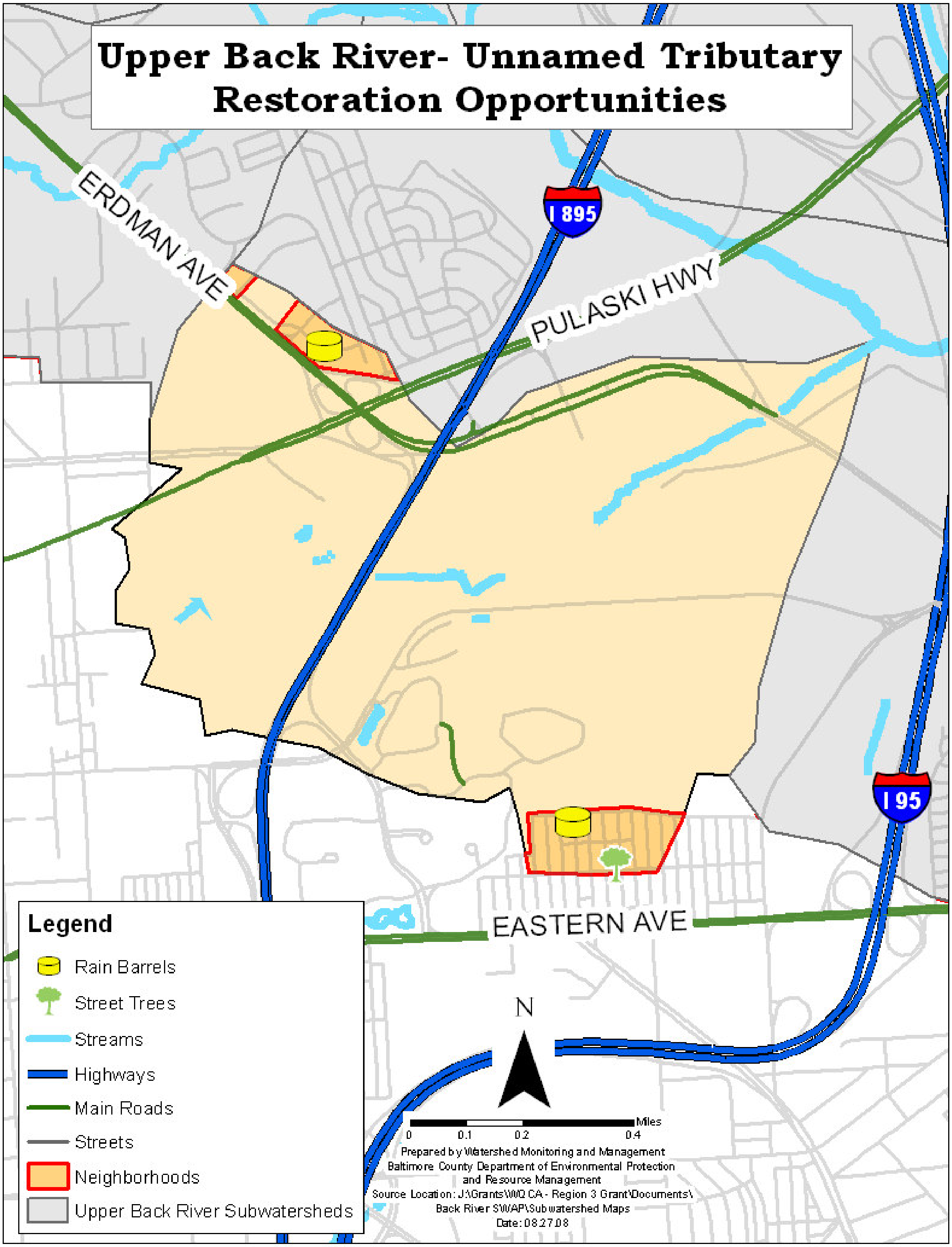

Figure 4-15 – Restoration Opportunities in Unnamed Tributary

4.3.14 West Herring Run

Subwatershed Description

Like Herring Run East, Herring Run West is composed of two tributaries that meet toward the middle of the subwatershed. The longer of the two begins near the intersection of Burke and Aigburth Avenues in Towson. From here it flows past Towson High School, through the southern portion of The Country Club of Maryland golf course and on past the Overlook Park where it joins the shorter tributary. This shorter of the two tribs begins along Loch Raven Boulevard near the Calvert Hall High School and Loch Raven Academy. It flows south past the Glenmont Apartments and the neighborhood of Glendale, past Glendale Park where it meets the first trib at Overlook Park. From the confluence at Overlook Park, Herring Run West flows southeast crossing Loch Raven Boulevard and Northern Parkway, through Mount Pleasant Golf Course where it joins with Herring Run East to form the Herring Run mainstem before crossing Perring Parkway. Table 4-69 shows some basic information about West Herring Run.

Table 4-69. Basic Profile of Herring Run West Subwatershed

Drainage Area	• 1879.7 acres (2.9 mi^2)	
Stream length	• 8.17 miles	
Land Use	• Low-Density residential (1.4%) • Med-Density Residential (37.5%) • High-Density Residential (27.3%)	• Open Urban Land (17.0%) (includes forests) • Commercial (7.1%) • Institutional (7.7%)
Current Impervious Cover	• 28.3% of subwatershed	
Jurisdictions as Percent of Subwatershed	• Baltimore City (23%) • Baltimore County (77%)	
Soils	• A Soils – 4.1% • B Soils – 46.3%	• C Soils – 23.2% • D Soils – 26.3%
Stormwater management	• City - No existing stormwater facilities were identified • County - Only 0.8% of the county portion of the watershed is treated by stormwater facilities	

Neighborhood Assessment

Thirty-three (33) distinct neighborhoods were identified and assessed within the subwatershed as part of the Unified Subwatershed and Site Reconnaissance. Subwatershed boundaries were not used to designate neighborhood boundaries so some neighborhoods may exist in more than one subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include downspout disconnection, storm drain stenciling, tree planting and public education (i.e. nutrient management). Buffer improvement and lot retrofits along with downspout disconnection seem to be the best opportunities here.

There are 164.6 impervious building acres in neighborhoods where downspout disconnection is recommended in Herring Run East. Based on an average of 51.7% potential for disconnection, 85 impervious building acres were deemed feasible for downspout disconnection. Disconnection efforts should first concentrate on the multi-family neighborhoods with high opportunities for disconnection due to the efficiencies achieved by coordinating with one landowner instead of individual homeowners. Table 4-70 shows a summary of neighborhood recommendations for West Herring Run.

poor sediment control in NSA-L-89

Table 4-70. Summary of Neighborhood Assessment Recommendations

Site ID	Median lot size (acres)	Recommended Actions									
		% Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Pet Waste	Buffer Enhancement	Street Trees	Notes
NSA_L_100	Multifamily	30		X	X	X			X	0	Dumpsters and mulch piles drain to stream
NSA_L_102A	Multifamily	40		X	X	X	X		X	0	Trees/buffer improvement/bioretention
NSA_L_107	Multifamily	15				X				30	Tree planting
NSA_L_108	Multifamily	10				X				50	Tree planting
NSA_L_110B	Multifamily	nd								0	Impervious removal/alley
NSA_L_111	Multifamily	85		X		X				0	
NSA_L_112	<1/4	30		X	X	X			X	0	Concrete buffer in park/
NSA_L_119	Multifamily	30	X		X		X			0	Lot retrofit
NSA_L_131	1/4	90		X	X	X	X			0	
NSA_L_132	1/8	60			X		X			nd	Street trees
NSA_L_133	1/3	90		X			X			0	
NSA_L_134	1/2	50		X	X	X	X			0	
NSA_L_135A	1/4	90		X		X	X		X	0	Cul de sac retrofits
NSA_L_135B	1/4	90		X		X	X		X	0	
NSA_L_136	1/3	80		X			X			nd	Street trees
NSA_L_137	1/3	80			X		X			0	
NSA_L_138A	1/3	20		X	X	X	X			0	
NSA_L_139	1/8	90			X	X	X			nd	Street trees
NSA_L_140	1/8	50			X	X	X			50	

Site ID	Median lot size (acres)	Recommended Actions: % Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Pet Waste	Buffer Enhancement	Street Trees	Notes
NSA_L_24	1/2	40		X	X					50	
NSA_L_32	1/4	85	X	X		X				50	Tree planting
NSA_L_34	<1/8	nd	X		X					0	
NSA_L_37	1/8	80	X	X		X				20	
NSA_L_89	Multifamily	90		X	X	X	X		X	50	Sediment control issue
NSA_L_90	Multifamily	50		X	X	X	X			0	
NSA_L_91	Multifamily	100			X	X				15	Sediment control
NSA_L_92	Multifamily	90		X	X	X	X		X	0	Stream naturalization

Hot Spot Assessment

Table 4-71 shows the two sites assessed in Herring Run West for hot spot status

Table 4-71. Summary of Hotspot Sites Recommendations.

Status	Site ID	Description	Potential Sources of Pollution: Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/Landscaping	Stormwater Management
Potential	HSI_L_501	Shopping center			X	X	X	X
Not a hotspot	HIS_L_502	Shopping center						X

Institutional Site Assessment

Table 4-72 shows the ten institutional areas assessed in the Herring Run West subwatershed.

Table 4-72. Summary of Recommendations for Schools and Places of Worship

Site ID	Name of Site	Public/ Private	Greening Opportunities: Nutrient Management	Tree Planting (#)	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management	Notes
ISI_L_501	Stoneleigh ES	Public	N	100	X	X			stream naturalization
ISI_L_503	Loch Raven Academy	Public	Y	65	X				
ISI_L_504	Calvert Hall	Private	Y	55					poor sediment control for construction

Site ID	Name of Site	Public/ Private	Greening Opportunities						
			Nutrient Management	Tree Planting (#)	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management	Notes
ISI_L_514	Mercy HS	Private	Y	75					
ISI_L_515	Yorkwood ES	Public	N	135			X		
ISI_L_522	Country Club of MD	Private	Y	0					
ISI_L_527	Towson HS	Public	Y	120				X	sediment control, invasive removal by stream
ISI_L_529	St. Andrews Epic.	Private	N	20		X			
ISI_L_530	Loch Raven Methodist	Private	N	20		X			
ISI_L_534	Emmanuel Lutheran Church	Private	N	110					

Stream Assessment

A stream stability assessment was conducted by Parsons Brinkerhoff in the county portion of the Herring Run subwatershed. The stream assessment performed did not discern between the Eastern and Western Branches, so the data is presented here as a combination of those two subwatersheds.

The subwatershed deficiencies as outlined in the PB report are as follows:
Problems with the Herring Run subwatershed include moderate bank erosion potential, various channel disturbances, fish blockages and only 67% of in-stream habitat rated fair. Channel disturbances include culverts causing fish blockages and invasive plants. Table 4-73 shows a summary of the problems found during the stream assessment in the county portion of Herring Run.

Table 4-73. Summary of Stream Conditions in Herring Run

Stream Opportunities	Number of Problems
Restoration/Stabilization	24
Buffer Enhancement	5
Bank Planting	54
Utility Conflicts	0
Wetland Enhancement	5
Yard Waste Education	13
Invasive Plant Removal	17
Trash Dumping	25

Illicit Discharges

Baltimore County uses a prioritization system for sampling outfalls for illicit discharges. Priority one describes an outfall with major problems including the presence of chemicals in the water. Priority two describes outfalls with moderate problems including erosion and trash but no chemical problems detected. Priority 1 outfalls are sampled four times per year and priority 2 outfalls are sampled once per year. There is one priority 1 outfall and five priority 2 outfalls in county portion of Herring Run West.

Baltimore County and Baltimore City will continue with their Illicit Discharge Detection and Elimination programs, seeking to improve techniques and methodologies for more effective reductions of these discharges.

Stormwater Retrofits and Pond Conversions

There were five retrofits and no pond conversions identified in West Herring Run. The retrofits are shown in Table 4-74.

Table 4-74. Summary of Retrofit Opportunities in West Herring Run

Site	Drainage Area (ac)	Description/Classification	Priority
R1	0.4	Rain Gardens	High
R2A	0.3	Permeable Pavers	Medium
R6A	1.0	Impervious Cover Removal	High
R6B	17.5	Piedmont Outfall	Medium

Pervious Area Restoration

Table 4-75 shows the two possible pervious area restoration sites identified during the assessment. Both sites exhibit opportunity for tree planting. Pervious area restoration has the potential to convert areas of turf, sometimes a relatively high nutrient input land use, to forest which can absorb rather than shed nutrients.

Table 4-75. Summary of Pervious Area Recommendations

Site	Location	Description	Size (acres)	Ownership
PAA-L-501	Loch Raven Blvd	Loch Raven Academy	6	Public
PAA-L-502	Glendale & Queens Ferry	Neighborhood open space	1	Public

Subwatershed Management Strategy

Engaging Citizens & Watershed Groups

1. Provide lawn care education to neighborhoods identified with high turf management in Table 4-70. Note all these neighborhoods are in the northern half of the subwatershed. Work with homeowners in these neighborhoods to reduce the amount of nutrients applied to their lawn and other pollution prevention measures.
2. Conduct appropriate downspout disconnection measures according to Table 4-70, focusing efforts on the multi-family neighborhoods. Many of the neighborhoods in Herring Run West have lots where rain gardens are recommended.
3. Increase tree canopies on private lots by educating citizens on the benefits of trees and about programs like The Growing Home Campaign and TreeBaltimore.
4. Engage Institutions sited in Table 4-72 in restoration efforts, especially tree plantings.
5. Engage citizens in a storm drain stenciling program and conduct stenciling activities in the neighborhoods indicated in Table 4-70.

Municipal Actions

1. Evaluate 2,000 ft. of concrete stream channel below Overbrook Park to the city/county line for potential naturalization.
2. Identify and conduct feasible restoration measures based on the many recommendations of the Parson's stream stability assessment (Table 4-73).

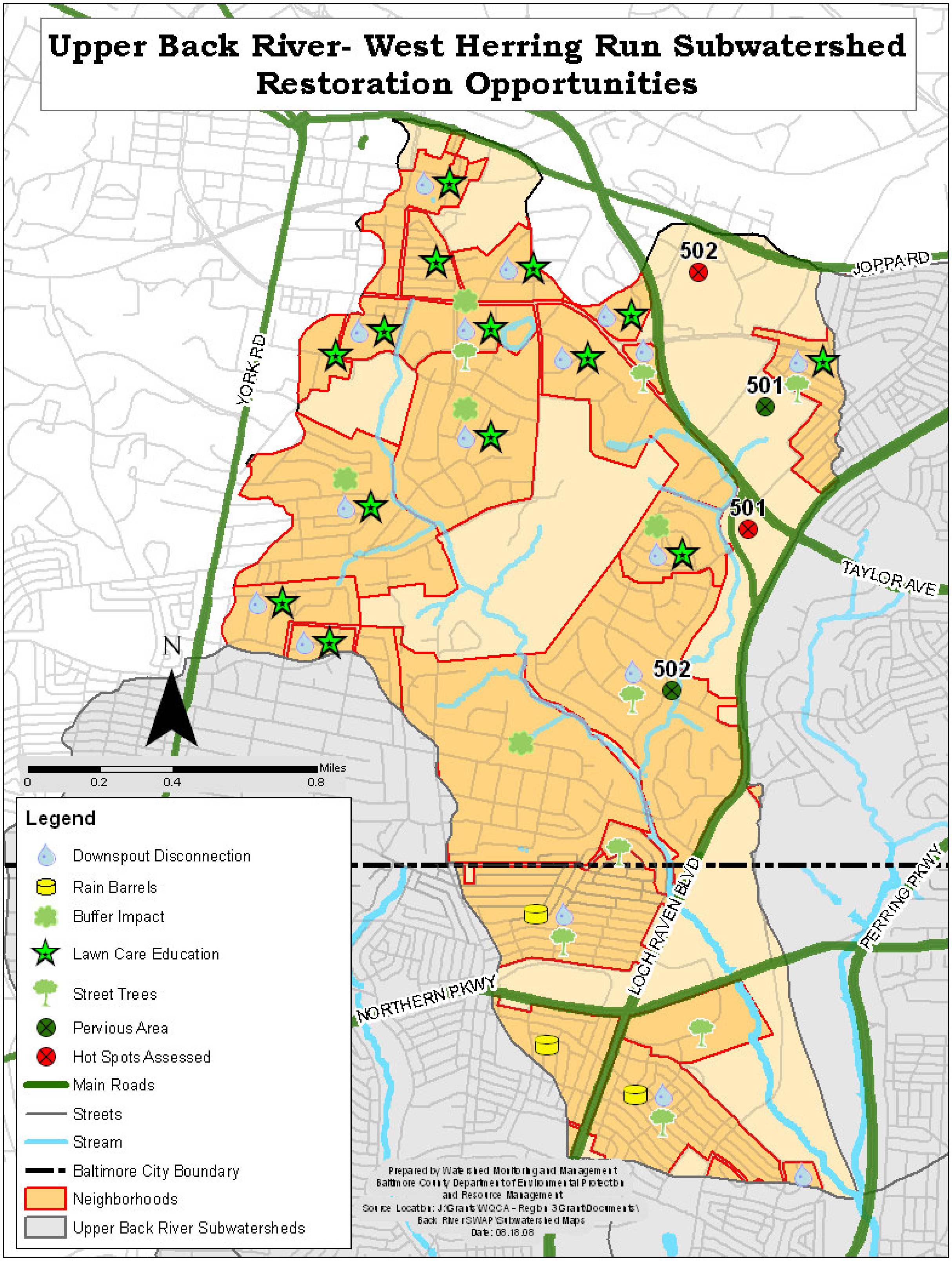

Figure 4-16 – Restoration Opportunities in the West Herring Run Subwatershed

CHAPTER 5

EVALUATION

5.1 Interim Measurable Milestones

The Upper Back River Small Watershed Action Plan (SWAP) Steering Committee plans a 20-year implementation schedule, with annual milestones as laid out in the actions detailed in Appendix A. This timeframe is necessary because of extensive restoration work that is needed to meet the nutrient TMDL, the available staff time, and funding considerations. The Upper Back River SWAP Implementation Committee (an outgrowth of the Upper Back River Steering Committee) will meet twice yearly to assess progress in meeting the goals and objectives, and to discuss funding options. The performance measures for each action are detailed in Appendix A and will be used to gauge progress. An annual progress report and a biennial report on water quality monitoring results will be produced.

The Upper Back River Steering Committee anticipates using an adaptive management approach for meeting the goals and objectives detailed in this report. As an annual interim measure, the annual progress and success of each action (Appendix A) will be evaluated, along with proposed new actions. Incorporated in this evaluation will be the inclusion of any new best management practice efficiencies and their effect on the overall progress in meeting the SWAP goals. Based on the evaluation, the action strategy may be changed to facilitate meeting the goals and objectives. The ability to implement this plan within the 20-year timeframe is dependent on the availability of staff and sufficient funding.

Additional interim measurable milestones include:

- Nutrients: Achieve a 5% reduction of both phosphorus and nitrogen after 5 years of implementation. This will be based both on the implement tracking and on the monitoring described below.
- Bacteria: Achieve a 40% reduction after 5 years of implementation, based on the Bacterial Source Tracking Monitoring Program described below.

If additional TMDLs are developed (Chesapeake Bay TMDL anticipated in 2010), or other water quality issues arise, the Upper Back River SWAP Implementation Committee will initiate a revision of the plan within six months of the TMDL approval, or the water quality issue arises, to address the water quality improvements needed to meet the new TMDL or address the issue.

5.2 Criteria for Load Reduction

The Upper Back River SWAP Steering Committee has determined that the average pollutant load reductions approved by the EPA Chesapeake Bay Program will be used to measure progress in meeting the TMDL phosphorus and nitrogen reduction goal (15% reduction). These reduction efficiencies are detailed in Appendix D. The current load reduction scenarios for phosphorus and nitrogen are presented in Chapter 3, along with specific information on how the load reductions were calculated. The Chesapeake Bay Program is currently reassessing the pollutant load reduction efficiencies. When the new efficiencies are available, they will be used to reassess the actions needed to meet the nitrogen and phosphorus load reductions in the Upper Back River watershed.

5.3 Implementation Tracking

The Upper Back River SWAP Implementation Committee will within two years develop an implementation-tracking tool that accounts for all restoration activities. Currently, there is no consistent tracking mechanism used by Baltimore County, Baltimore City, and Herring Run Watershed Association. This tracking will be developed in conjunction with the Baltimore Watershed Agreement participants to provide a consistent restoration tracking system for all Baltimore County and Baltimore City watersheds.

This tracking tool will permit the assessment of progress in meeting the interim mile stones by comparing the progress to the Performance Measures listed for each action in Appendix A. The tracking tool will also provide information on the pollutant load reduction progress that has been accomplished through the implementation of the restoration projects.

5.4 Monitoring

Baltimore County, Baltimore City, and the Herring Run Watershed Association currently conduct monitoring programs within the Upper Back River watershed (5.4.1), but additional monitoring is anticipated to assess the effectiveness of restoration projects and progress in meeting the load reductions for the nutrient TMDL (5.4.2).

5.4.1 Existing Monitoring

The existing monitoring programs described in Upper Back River – Characterization Report (Appendix E), will continue. These programs consist of:

- Chemical monitoring at fixed sentinel sites, conducted by both Baltimore County and Baltimore City
- Biological monitoring at both fixed and randomly chosen sites, conducted by both Baltimore County and Baltimore City,
- Citizen based Stream Watch Program, coordinated by Herring Run Watershed Association and
- Illicit connection monitoring conducted by both Baltimore County and Baltimore City.

Coordination of these monitoring activities among the SWAP participants (Baltimore County, Baltimore City, and Herring Run Watershed Association) will be enhanced through participation in the Upper Back River SWAP Implementation Committee and through coordination activities identified by the Baltimore Watershed Agreement Action Strategies.

5.4.2 Implementation Monitoring

Monitoring activities specific to this Small Watershed Action Plan will be focused on project specific monitoring for effectiveness and targeted monitoring of subwatersheds to measure overall improvement in water quality from multiple restoration actions within a subwatershed. The initial subwatershed targeted for monitoring is Redhouse Run, and the initial project monitoring will focus on the St. Patrick Road Stream Restoration Project. A Quality Assurance Project Plan (QAPP) is currently being developed for this monitoring component.

Additional monitoring activities targeting specific projects will be identified as restoration progresses. Given the number of restoration actions called for in the SWAP, it will not be possible to monitor all restoration projects. Additional project monitoring will be targeted at those activities that have limited monitoring data on efficiencies, such as, lawn care education and various types of rooftop disconnects. Where possible these additional monitoring activities will be conducted in Redhouse Run above the subwatershed monitoring station, and the project specific QAPP incorporated into the Redhouse Run QAPP.

During the first two years of implementation, Baltimore County and Baltimore City will develop and implement a Bacterial Source Tracking monitoring programs to address the uncertainty in the location of bacterial sources. This program will be used to target restoration activities that address the reduction in bacteria to meet the bacteria TMDL reduction requirements. Data generated by the Bacteria Source Tracking Program will also be used to determine bacteria concentration trends over time and assist Maryland Department of the Environment in determining if bacteria water quality standards are being met.

ACKNOWLEDGEMENTS

UPPER BACK RIVER STEERING COMMITTEE

The Upper Back River Small Watershed Action Plan was developed with cooperation and input from citizen organizations and local agencies that represent the interests of the Upper Back River watershed.

Organization	*Representative*
Herring Run Watershed Association	Mary Roby, Darin Crew
Baltimore City Department of Public Works – Water Quality Office	Bill Stack
Baltimore County Department of Environmental Protection and Resource Management	Steve Stewart, Nancy Pentz, Nathan Forand, Chris Barnes
Center for Watershed Protection	Paul Sturm, Julie Tasillo
Consultant	Fran Flanigan, Christel Cothran

TECHNICAL ASSISTANCE/REPORTS

Development of the Upper Back River Small Watershed Action Plan was supported technically by the following assessments and technical reports:

Technical Report	*Representative*
Upland Surveys (Neighborhood Source Assessments, Hotspot Assessments, Pervious Area Assessments, and Institutional Site Assessments)	Nathan Forand, Angela Johnson, Megan Brosh – DEPRM Paul Sturm, Mike Novotney, Julie Tasillo, Tiffany Wright, Lisa Fraley-McNeal, Hye Yeong Kwon – Center for Watershed Protection Darin Crew – Herring Run Watershed Association
Stream Corridor Stability Assessment	Parsons, Brinkerhoff, Inc. in association with Coastal Resources, and EBA Engineering
Stormwater Facility Assessment	Steve Stewart, Hee Song (intern) – DEPRM
Watershed Characterization	Steve Stewart, Nathan Forand, Chris Barnes DEPRM

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APPENDIX A

SMALL WATERSHED ACTION PLAN STRATEGIES

This appendix presents the actions related to the goals and objectives presented in Chapter 2, including the expected benefits, the timelines, the performance measures, estimated unit costs, and responsible parties. In many cases, the actions fall under a number of goals and objectives. When this occurs, multiple goals and objectives are indicated as being associated with the action.

The actions are grouped according to the type of activity. The groupings are:

- Restoration Actions
- Awareness Activities
- Monitoring Activities
- Funding Activities
- Reporting Activities

The responsible parties are indicated by numeral with the code shown in Table A-1.

Table A-1: Codes for Responsible Parties Listed for Actions in Table A-2

Organization	Numeric Code
Baltimore County Dept. of Environmental Protection and Resource Management	1
Baltimore City Government	2
Herring Run Watershed Association	3
Upper Back River SWAP Implementation Committee	4

Implementation progress will be dependant on future funding availability for the various organizations involved. The funding would be for additional staff and implementation of projects identified within Table A-2. The Upper Back River SWAP Implementation Committee will aggressively pursue grant opportunities as they become available, subject to staff capacity to manage the grants and availability of matching funds.

Table A-2: Recommended Actions to Meet the Upper Back River SWAP Goals and Objectives

Goal	Objective	Action	Benefits	Timeline	Performance Measure	Cost	Respon. Party(s)
Restoration Actions							
2 3 5	4 1, 2 3	Restore 12.5 miles of eroded stream banks (based on 30% unstable streams assessed in SR,HR,BR)	Water quality and aquatic habitat improvement	20 years	0.65 miles per year	$300/ linear foot	1, 2
1 5 7	1, 2 5 2	Convert 17 of 23 feasible existing dry detention stormwater ponds to an enhanced treatment method within 17 years addressing 103 acres of urban land.	Provides water quality improvement	17 years	1 Stormwater conversion installed per year	$120,000/ pond	1, 2
1 5 6	1, 2, 5 1,2,3,5 1	Investigate the feasibility of installing the 66 identified retrofit opportunities.	Identifies water quality opportunities	2 years	Feasible retrofits identified	Existing Staff	1, 2
1 5 6	1, 2, 5 1, 2, 3 1	Install stormwater 50 retrofits at the feasible sites.	Provides water quality	17 years	3 Stormwater retrofit installed per year	$50,000/ retrofit	1, 2, 3
6	2	Ensure that the 33 hotspots investigated have, if required, NPDES general stormwater discharge permits and are in compliance.	Provides facilities with pollution prevention plans to address spill events and other discharges	11 years	3 per years	Existing Staff	1, 2
3 5 6	2, 3 3 1	Investigate the feasibility of planting riparian buffers on publicly owned land.	Provides water quality and enhances terrestrial and aquatic habitat	2 years	Public land riparian buffers planted	Existing Staff	1, 3
3 4 7 8	2 1, 4 4 1	Reforest 200 acres of riparian buffers, minimum width of 35 feet.	Water quality improvement, stream temperature moderation, increased terrestrial and aquatic habitat	20 years	10 acres per year	$4,250/ ac.	1, 2, 3
3 4 7 8	2 1, 4 4 1	Plant forest on 50 acres PAA exhibiting "open pervious" cover type and "minimal site prep".	Land use conversion	20 years	2.5 acre of converted forest cover per year	$4,250/ acre	3
3 4 7 8	2 1, 4 4 1	Plant street trees. Maximum potential 4,000 (10 acres)	Land use conversion	20 years	200 trees per year	$4,250/ acre	3
3	2	Baltimore County and Baltimore City shall continue to require riparian buffers and forest conservation for all new development and redevelopment.	Preserves existing riparian forest buffer	On-going	Acres preserved	Existing Staff	1, 2

Goal	Objec tive	Action	Benefits	Timeline	Performance Measure	Cost	Respon. Party(s)
4 8	1,4 1	Encourage institutions to plant trees on available open space.	Potential land use conversion	10 years	1 Institution per year	Existing Staff	1, 2, 3
5	2	Remove impervious cover at the 10 institutions where removal was recommended.	Land use conversion	10 years	1 Institution per year	$	1, 2, 3
1	1,2	Assure that all turf management operations have an Urban Nutrient Management Plan when required by COMAR	Improves water quality, economic savings for lawn care operations	5 years	100% of turf management operations have an Urban Nutrient Management Plan	Existing Staff	1, MDA
1 8	1, 2 4	Reduce fertilizer use on 3,000 acres of residential high maintenance lawns.	Reduces nutrient load	20 years	150 acres per year	Existing Staff	3
6 8	1 1,2,3	Reduce lawns and plant bayscapes in the 177 neighborhoods identified.	Reduces nutrient load and lawn maintenance	20 years	9 neighborhoods per year	Existing Staff	3
1 5	1, 2 1,4	Disconnect downspouts and redirect to lawn. Install raingardens or rainbarrels on 180 acres of impervious roof top.	Water quality improvement	20 years	Address 9 impervious acres/yr..	$150/ house	3
1	1, 2	Continue municipal road maintenance street sweeping activities. Investigate the 228 miles of streets that appeared to need enhanced street sweeping for potential increase in frequency.	Reduces nutrient and sediment loads	On-going	lbs. collected	Existing operations	1, 2
7	2,4	Participate and support Project Clean Stream	Reduces trash	On-going	Lbs trash removed per year	Existing staff and volunteers	1, 2, 3
3 4 7	3 4 4	Organize 1 exotic invasive species removal activity addressing 2 acres per year.	Improves forest habitat	20 years	Exotic species removed from 2 acres per year	$500	3
6 4	1 3	Provide for on-going maintenance through periodic inspection of implemented BMPs.	Assures continued functioning of BMPs	20 years	Inspections completed	Existing Staff	1, 2, 3, 4
1 7	1,2,4 1	Baltimore County and Baltimore City shall continue to remove illicit connections when discovered through the respective Illicit Connection Programs	Reduces pollutants	On-going	Reported annually in NPDES MS4 Permits	Existing Staff	1
6	1	Implement the recommendations detailed by the Baltimore County Builders for the Bay.	Reduces impact of new development	3 years	Recommendation s implemented	Existing Staff	1
6	1	Baltimore City will continue with the on-going Builders for the Bay process.	Reduces impact of new development	1 year	B4B Report produced	$115,000	3

Goal	Objective	Action	Benefits	Timeline	Performance Measure	Cost	Respon. Party(s)
2	1	Review and comment on the Biological TMDL when developed by Maryland Department of the Environment.	Assures understanding of the TMDL	When developed by MDE	Comments produced	Existing Staff	1, 2
1 1 7	3 4 1	Baltimore County and Baltimore City shall continue to meet the requirements of there respective consent decrees for the elimination of sanitary sewer overflows	Reduces nutrients, bacteria and other pollutants	On-going	Status report	Existing Staff	1, 2
Raising Awareness							
1 8	1,2 1,4	Conduct education on urban nutrient management and create materials if needed.	Improves water quality	20 years	Distribute materials	$5,000/ year, Existing Staff	4
5 6	4 2	Prepare information for facilities that are either potential or confirmed hotspots. Include NPDES general stormwater requirements and guidance on reducing risk of having an episodic event that impacts water quality and aquatic life.	Watershed awareness to business groups	2 years	Outreach material developed	Existing Staff	1, 2
5 6	4 2	Distribute information to hotspots and provide guidance/workshops. 34 hotspots identified.	Watershed awareness to business groups	6 years	1 workshop every two years. Outreach material distributed	Existing Staff	1, 2
7	4	Continue to implement Stream Watch, a citizen-based program, to increase the ability to identify sources of water quality and habitat degradation.	Watershed education, additional identification on sources of impairment, and potential restoration locations	20 years	# of stream miles adopted.	Existing Staff	1, 3
3 4 5 8	3 4 4 4	Inform community groups about the BMPs recommended in the NSA assessment.	Watershed awareness to community groups	20 years	5 neighborhood informational meetings per year	Existing Staff $50/event	1, 2, 3, 4
3 8	3 1,2,3, 4	Inform community groups and other County and City agencies about the BMPs recommended in the PAA assessment.	Watershed awareness to community groups and government agencies	20 years	1 every two years neighborhood meetings per year	Existing Staff $50/event	1, 2, 3, 4
3 4 5 6 8	2,3 1,4 1,2,4 1 1,4	Inform institutional partners about the BMPs recommended in the ISI assessment.	Watershed awareness to institutions	20 years	2 Institution meetings per year	Existing Staff $50/event	1, 2, 3, 4

Goal	Objective	Action	Benefits	Timeline	Performance Measure	Cost	Respon. Party(s)
Measuring and Monitoring							
1 7	1,2,4 1	Baltimore County to continue the illicit connection monitoring at the 82 major outfalls in the UBR and complete one inspection at each of the 266 minor outfalls.	Identifies pollutant locations	5 years	70 outfalls per year	Existing Staff	1
1 7	1,2,4 1	Baltimore City to continue the illicit connection monitoring at the 14 sites in Upper Back River and conduct Pollution Source Tracking investigations.	Identifies pollutant locations	5 years	~ 500 samples per year	Existing Staff	2
2	2	Develop in conjunction with the Maryland Biological Stream Survey (MBSS) a methodology to assess the biological improvements of urban streams as a result of restoration.	Provides an accounting of biological improvements	3 years	Urban biological indicators developed	Existing Staff	1, 2
2	3	Baltimore County shall continue its program of probabilistic biological monitoring. Baltimore City to continue its biological monitoring program (every third year)	Provides data on the biological health of streams	Even number years	Stations monitored and report produced	Existing Staff, $4,500/ station (BA)	1
1	3,4	Develop and implement a bacteria source tracking and monitoring program.	Address bacterial impairment.	2 years	Develop a bacteria source tracking monitoring program	Existing Staff	4
1	1,2,4	Develop Quality Assurance Project Plans for monitoring projects and subwatersheds to measure restoration progress	Provides quality data to measure restoration progress	As needed (Redhouse Run QAPP within 6 months)	Progress tracking	Existing Staff	1, 2
4	2,3	Develop an urban tree management program that increases a healthy urban tree canopy and includes monitoring of the quantity and health of trees	Land use conversion	2 years	Coordinated effort for improving urban tree canopy	Existing Staff	1, 2, 3, 4
1	1,2	Develop a method to measure and monitor residential fertilizer use	Provides an accounting of nutrient reductions	5 years	Monitoring protocols developed for residential fertilizer use	Existing Staff	1, MDA

Goal	Objective	Action	Benefits	Timeline	Performance Measure	Cost	Respon. Party(s)
1	1,2,4	Continue supporting USGS gages to enhance the ability to measure flow and calculate pollutant loads.	Provides data for the calculation of pollutant loads	On-going	USGS annual data report	$7,215	1, 2
2 4 6 7	3 1, 2, 3 1 3	Implement the monitoring and measuring actions developed under the Baltimore Watershed Agreement (BWA).	Additional data for measuring improvements to streams	10 years	BWA Action Strategy Document	Existing Staff	1, 2
Funding							
1 3 5	3,5 2 5	Coordinate grant funding requests to secure funding and implement restoration projects to meet TMDL nutrient and bacteria reductions requirements within 20 years. Seek a minimum of 3 grants per year	Accelerated restoration	20 years	3 grant proposals submitted per year	Existing Staff	4
4 5	5 2,4	Increase applications for the Baltimore County – Green Building Tax Credit Program as a model.	Provide incentive for landowners to install best management practices to address water quality and habitat	10 years	Number of applications	Existing Staff	4
Reporting							
All	All	Upper Back River SWAP Implementation Committee to meet on a semi-annual basis to discuss implementation progress and assess any changes needed to meet the goals.	Assures continued progress in implementation and adaptive management	20 years	2 meeting per year	Existing Staff	4
All	All	Coordinate restoration activities between and among Baltimore County, Baltimore City, and the Herring Run Watershed Association.	Assures continued progress in implementation and adaptive management	On-going	NPDES Annual reports	Existing Staff	4
1	3	Designated County and City personnel should provide updates to the SWAP Implementation Committee/ Sewer Coalition on the status of the Consent Decree projects for sewer infrastructure repairs.	Provides coordination between local government and citizens on issues related to the Consent Decree,	10 years	Minutes from meetings	Existing Staff	1, 2
All	All	A water quality monitoring report in conjunction with the Baltimore Watershed Agreement will be produced biennially.	Summarizes the state of the watershed	Every 2 years	Report produced	Existing Staff	1, 2

Goal	Objective	Action	Benefits	Timeline	Performance Measure	Cost	Respon. Party(s)
All	All	Develop a unified restoration tracking system to track progress toward meeting TMDL reduction requirements	Provides a consistent method for tracking restoration progress	2 years	Tracking system developed	Existing Staff	4
3 4 5 7 8	3 4 1, 4 2, 4 1, 4	Continue to update the status of citizen based restoration projects and BMPs.	Provides an accounting of progress made	2 years	NPDES Annual reports	Existing Staff	3
1 2 5	1, 2, 3 4 5	Continue to update status of County and City Capital budget restoration projects and BMPs.	Provides an accounting of progress made	2 years	NPDES Annual reports	Existing Staff	1, 2

APPENDIX B

US ENVIRONMENTAL PROTECTION AGENCY

A THROUGH I CRITERIA FOR WATERSHED PLANNING

This appendix will provide information on how the development of the Upper Back River Small Watershed Action Plan addresses the A through I criteria for watershed planning. It will serve as a guide to the location within the document, including appendices, where each criterion is addressed. Table B-1 provides the location information for each of the A through I Criteria. A more detailed discussion of how the document meets the A through I Criteria is provided below Table B-1.

The text box below provides a description of each element of the EPA Watershed Planning Criteria.

a) An identification of the causes and sources or groups of sources that will need to be controlled to achieve the load reductions estimated in the watershed plan

b) Estimates of pollutant load reductions expected through implementation of proposed nonpoint source (NPS) management measures

c) A description of the NPS management measures that will need to be implemented

d) An estimate of the amount of technical and financial assistance needed to implement the plan

e) An information /education component that will be used to enhance public understanding and encourage participation

f) A schedule for implementing the NPS management measures

g) A description of interim, measurable milestones for the NPS management measures

h) A set of criteria to determine load reductions and track substantial progress towards attaining water quality standards

i) A monitoring component to evaluate effectiveness of the implementation records over time.

Table B-1: Where to Locate Information for Each Criteria Element

	EPA Criteria Element								
Section of the Report	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Chapter 1		**X**							
Chapter 2		**X**							
Chapter 3	**X**	**X**	**X**		**X**				
Chapter 4			**X**		**X**				
Chapter 5							**X**	**X**	**X**
Appendix A			**X**	**X**	**X**	**X**	**X**		
Appendix B									
Appendix C				**X**					
Appendix D		**X**						**X**	
Appendix E	**X**								
Appendix F									
Appendix G	**X**								
Appendix H	**X**								
Appendix I	**X**								
Appendix J	**X**								
Appendix K									

The following will provide a discussion on how the development of the Upper Back River Small Watershed Action Plan addresses the US Environmental Protection Agency (EPA) A through I criteria for watershed planning. It will serve as a guide to the location within the document, including the appendices, where each criteria is addressed.

a. An identification of the causes and sources or groups of sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) below.

The Back River watershed is listed on the 303(d) list as impaired by nutrients (tidal waters), bacteria (Herring Run), chlordane in fish tissue (tidal waters), PCBs in fish tissue (tidal waters), total suspended solids (tidal waters), and biologically impaired (streams). TMDLs that have been developed for nutrients, bacteria, and chlordane, that identify the causes and sources of pollutants that will need to be controlled to meet the load reductions to achieve water quality standards. These documents can be found in:

- Appendix H – Total Maximum Daily Loads of Nitrogen and Phosphorus for Back River in Baltimore City and Baltimore County, Maryland (MDE 2005)
- Appendix I – Total Maximum Daily Loads of Fecal Bacteria for Northern Portion of Herring Run in Baltimore County and Baltimore City, Maryland (MDE 2006)
- Appendix J – Total Maximum Daily Load Documentation for Chlordane in Back River (MDE 1999)

In addition, to further refine the sources of pollutants upland source assessments and stream corridor assessments were performed. The upland assessment results are presented in the Upper Back River Characterization Report (Appendix E), Chapter 4. The stream corridor assessment results are presented in Back River Characterization Report (Appendix E), Chapter 3 and Appendix G (Upper Back River Watershed Stream Stability Assessment (Parsons, Brinkerhoff (2008).

Further analysis of pollution sources are provided by a GIS analysis of potential landscape indicators of pollution presented in the Upper Back River Characterization Report (Appendix E), Chapter 2 and a specific analysis of the contribution of sanitary sewer overflows the Upper Back River Characterization Report (Appendix E), Chapter 3, pages 3-12 to 3-15.

Further pollutant load analysis is provided in the Upper Back River Characterization Report (Appendix E), Chapter 3-17 through 3-24.

b. An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded streambanks.

Expected phosphorus load reductions were based on the EPA - Chesapeake Bay Program load reduction criteria used in their Phase 5 model for the water quality impairments of the tidal Chesapeake Bay. These load reductions are presented in Appendix D. Using the information in Appendix D, the phosphorus load reductions for the various actions were calculated and presented in Appendix E (Table E-4).

c. A description of the NPS management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

The management measures that will need to be implemented to achieve the goals are detailed in Appendix A. Information on the achievement of the phosphorus and nitrogen reduction goals is provided in Chapter 3, pages 3-6 through 3-11. Chapter 4 details the management measures for each subwatershed in the Upper Back River.

d. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and the authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their 319 programs, State Revolving Funds, USDA's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.

Appendix C provides the cost analysis and the anticipated funding sources to implement the actions. Appendix A details the anticipated cost for each action on an annual or unit basis and details the organizations that will be responsible for implementation of the each action.

e. An information/education component that will be used to enhance public understanding of the project and encourage their earl and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

The educational activities to enhance public understanding and encourage participation in restoration implementation planning and the installation of best management practices are detailed in Appendix A. Chapter 3 (pages 3-5 and 3-6) detail specific education/awareness focus areas, and Chapter 4 details specific education/awareness activities for each subwatershed.

f. A schedule for implementing the NPS management measures identified in this plan that is reasonably expeditious.

A schedule for each activity is provided in Appendix A. It is anticipated that the restoration will require a 20-year timeframe. Some actions have a shorter time frame based on sequencing of actions, or on the urgency of the actions. However, most management measures have annual performance measures that will determine if the restoration is on pace to be completed within the time frame. The limitations on the pace of the implementation include staffing, and funding. Increases in staffing and funding will be used to accelerate the restoration timeline. Chapter 5 presents an adaptive management approach to implementation.

g. A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented.

Appendix A provides the annual interim measurable milestones for determining the implementation status of the NPS management measures. In addition, an annual report on implementation progress will be produced by the Implementation Committee.

h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards, and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPDES TMDL has been established, whether the NPS TMDL needs to be revised.

The load reductions due to the restoration activities will be calculated via a spreadsheet using the EPA Chesapeake Bay Program – Best Management Practice Pollutant Reduction Efficiencies (Appendix D). These efficiencies will be used in conjunction with the implementation tracking to calculate the load reductions being achieved. The efficiencies used will be modified based on any modifications of the EPA Chesapeake Bay Program efficiencies.

i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Chapter 5 details the monitoring that will occur to evaluate the effectiveness of implementation. The monitoring results will be compared to the predicted load reductions determined under h above.

Appendix C

Cost Analysis and a Listing of Potential Funding Sources

This Appendix provides an analysis of the potential cost of implementation of the Upper Back River Small Watershed Action Plan and a listing of potential funding sources. The cost analysis is a best estimate of the cost of implementation in today's dollars and has not been annualized over the anticipated 20-year implementation timeframe. In order to provide an assessment of the benefits of implementation, where possible, the cost is also expressed in dollars per pound of phosphorus removal. This is usually not the only criteria in selecting the restoration options, but does provide an additional tool for assessing which best management practices to use.

C.1 Cost Analysis

Table C-1 presents the cost analysis. The cost analysis is based on the actions detailed in Appendix A and the nitrogen and phosphorus load reductions in Chapter 3. This analysis does not include the cost of existing staff. Best estimates of the cost were used based on local information and cost information gleaned from previous Watershed Restoration Action Strategies. The table presents:

- BMP or Action
- units (acres, linear feet, number)
- pounds of nitrogen and phosphorus removal (this is for full implementation)
- the unit cost
- extended cost – the unit costs times the number of applicable units
- cost per pound of nitrogen and phosphorus removal – extended costs/pounds of nitrogen and phosphorus removal
- cost over the 20 year timeframe of implementation – this is based on the comments column, in some cases the costs in the extended column are based on an annual basis, in others it is based on full implementation
- comments – indicate whether extended cost is annual or one costs (20 years)

The total cost of implementation exclusive of staffing costs is approximately $27,000,000.00.

C.2 Funding Sources

The funding sources for implementation of this Small Watershed Action Plan include local government funding for Baltimore County and Baltimore City, contributions both in money and time to the Herring Run Watershed Association, and various grants as described below.

Baltimore County uses general funds to support staff, while Baltimore City uses Metropolitan District and Motor Vehicle funds to support staff, whose responsibility is to monitor and improve water quality through implementation of various programs including capital restoration projects. Baltimore County has a Waterway Improvement Capital Program that is funded by a combination of general funds and bonds. Approximately, $4 million per year is allocated for various restoration projects throughout the County. The capital budget is projected for six years, with a two-year cycle for changes. The Back River watershed as a whole currently has $2.95 million allocated for restoration projects over the six-year period. Baltimore County provides a $30,000 annual grant to the Herring Run Watershed Association through its Watershed Association Citizen Restoration Planning and Implementation Grant Program. These funds provide staffing for restoration project implementation and education and outreach programs.

In order to implement all the actions in Appendix A and to meet the anticipated funding needs for those actions (Table C-1) additional funding from grants will be required. Table C-2 presents the potential funding sources for implementation of the Upper Back River Small Watershed Action Plan. It presents the funding source, applicant eligibility, eligible projects, funding amount, cost share requirements, and grant cycle.

While grant funding will be sought from all of the potential funding sources, the major grant funding sources are anticipated to be:

- **The Chesapeake and Atlantic Coastal Bays 2010 Trust Fund (2010 Trust Fund)** was established during the 2008 Legislative Session by Senate Bill 213 to provide financial assistance to local governments and political subdivisions for the implementation of nonpoint source pollution control projects to achieve the State's tributary strategy developed in accordance with the Chesapeake 2000 Agreement and to improve the health of the Atlantic Coastal Bays and their tributaries. The BayStat Program directs the administration of the 2010 Trust Fund, with multiple State agencies receiving moneys from the 2010 Trust Fund - the Maryland Department of Environment (MDE), Department of Natural Resources (DNR), Maryland Department of Agriculture (MDA), and Maryland Department of Planning.

- **319 Non-point Pollution Grants** – Approximately $1,000,000 of federal money for restoration implementation is available annually through Maryland Department of the Environment.
- **Small Creeks and Estuaries Restoration Program (MDE)** - The Small Creeks and Estuaries Restoration Program offers financial assistance to local governments for voluntary stream and creek restoration projects that improve water quality and restore habitat. Funds are targeted to seriously degraded water bodies in Maryland. Types of projects funded: stream channel reconstruction; stream bank stabilization; vegetative buffers; wetlands creation; treatment of acid mine drainage and dredging.
- **Stormwater Pollution Control Cost Share Program (MDE)** - The Maryland Stormwater Pollution Control Cost-Share Program provides grant funding for stormwater management retrofit and conversion projects in urban areas

developed prior to 1984. These projects reduce nutrients, sediments and other pollutants entering the State's waterways through the use of infiltration basins, infiltration trenches, vegetated swales, extended detention ponds, bioretention basins, wetlands and other innovative structures.

- **Innovative Nutrient and Sediment Reduction Program (National Fish and Wildlife Foundation) -** The National Fish and Wildlife Foundation, in partnership with EPA and the Chesapeake Bay Program, will award grants on a competitive basis of between $200,000 and $1 million each to support the demonstration of innovative approaches to expand the collective knowledge about the most cost effective and sustainable approaches to dramatically reduce or eliminate nutrient and sediment pollution to the Chesapeake Bay and its tributaries.

- **Chesapeake Bay Stewardship Fund** - The goal of the Chesapeake Bay Stewardship Fund is to accelerate local implementation of the most innovative, sustainable and cost-effective strategies to restore and protect water quality and vital habitats within the Chesapeake Bay watershed. The Stewardship Fund offers four grant programs: The Chesapeake Bay Small Watershed Grant Program, the Chesapeake Bay Targeted Watersheds Grant Program, the Chesapeake Bay Conservation Innovation Grant Program, and the Innovative Nutrient and Sediment Reduction Program. Major funding for the Chesapeake Bay Stewardship Fund comes from the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), the U.S. Department of Agriculture Forest Service (USFS), and the National Oceanic and Atmospheric Administration (NOAA).

- **MD State Highway Administration Transportation Enhancement Program –** is a reimbursable, federal-aid funding program for transportation-related community projects designed to strengthen the intermodal transportation system. The TEP supports communities in developing projects that improve the quality of life for their citizens and enhance the travel experience for people traveling by all modes. Included among the qualifying TEP categories is environmental mitigation to address water pollution due to highway runoff or to reduce vehicle-caused wildlife mortality while maintaining habitat connectivity.

- **Chesapeake Bay Trust –** provides grants through a variety of grant programs that focus on environmental education, urban greening, fisheries, and remediation of water quality issues. Specifically the Targeted Watershed Grant Program provides funding for on-the-ground solutions that address the most pressing nonpoint source pollution challenges facing a small watershed, and that result in measurable improvements in water quality and wildlife habitat. The program also seeks to support cost-effective approaches to Bay restoration actions at the small watershed scale and establish replicable model of restoration that can be transferred and used throughout the Bay region.

Table C-1: Estimated Cost for Upper Back River Small Watershed Action Plan Implementation (Exclusive of Existing Staffing)

BMP or Action	Acres/ linear feet/no	# TP Removal	# TN Removal	Unit Cost	Extended Cost	Cost/# of Phosphorus Removal	Cost/# of Nitrogen Removal	Cost Over 20 Years	Comments
Stream Restoration	66,000	2,356.1	13,343.6	$300	$19,800,000	$8,404	$1,484	$19,800,000	One time cost
Stormwater Pond Conversions	17 ponds (155 acres)	89.7	827.4	$120,000	$2,040,000	$22,742	$2,466	$2,040,000	One time cost
Stormwater Retrofit Installations	50 retrofits (1600 acres)	1,126.7	5,808.7	$50,000	$2,500,000	$2,219	$430	$2,500,000	One time cost
Buffer Reforestation	200 acres	722.7	5078.4	$4,250	$850,000	$1,176	$167	$850,000	One time cost
Reforestation on PAAs	50 acres	111.4	713.9	$4,250	$212,500	$1,908	$298	$212,500	One time cost
Plant Street Trees	4,000 trees (10 acres)	22.8	146.2	$4,250	$42,500	$1,864	$291	$42,500	One time cost
Reduce Fertilizer use on 3,000 acres of lawn by conducting education on urban nutrient management and create materials if needed.	3,000 acres	1,438.1	7,686.0	$5000	$5000	$70	$13	$100,000	Annual Cost
Disconnect 180 acres of Impervious Rooftop Through Downspout Disconnection	180 acres 7,740 houses	63.7	718.5	$50/house	$387,000	$6075	$539	$387,000	One time cost
Organize 1 exotic/ invasive species removal activity addressing 10 acres per year	200 acres	NA	NA	$500	$500	NA	NA	$10,000	Annual cost
Inform community groups about the BMPs recommended in the NSA assessment.	5 meetings per year	NA	NA	$50	$250	NA	NA	$5,000	Annual cost
Inform community groups and other governemnt agencies	1 meeting every 2 years	NA	NA	$50	$25	NA	NA	$2,500	Annual cost

BMP or Action	Acres/ linear feet/no	# TP Removal	# TN Removal	Unit Cost	Extended Cost	Cost/# of Phosphorus Removal	Cost/# of Nitrogen Removal	Cost Over 20 Years	Comments
about the BMPs recommended in the PAA assessment.									
Inform institutional partners about the BMPs recommended in the ISI assessment.	2 meetings per year	NA	NA	$50	$100	NA	NA	$2,000	Annual cost
Baltimore County shall continue its program of probabilistic biological monitoring. Baltimore City to continue its biological monitoring program (every third year)	13 sites per year	NA	NA	$4,500	$58,500	NA	NA	$1,170,000	Annual cost
Continue supporting USGS gages to enhance the ability to measure flow and calculate pollutant loads.	1 gage	NA	NA	$7,215	$7,215	NA	NA	$144,300	Annual cost
Estimated Total Cost Over 20 Year Period								**$27,265,800**	

Table C-2: Upper Back River Small Watershed Action Plan – Potential Funding Sources

Funding Source Name (Managing Agency)	Applicant Eligibility	Eligible Projects	Funding Amount	Cost Share? / In-Kind	Project Period
Small Creeks and Estuaries Restoration Program (MDE)	Local Governments	Stream Channel Reconstruction; Stream Bank Stabilization; Vegetative Buffers; Wetlands Creation; Treatment of acid mind drainage and dredging	No specified limits	50% YES	None Specified
Targeted Watersheds Grant Program – Implementation Grant Program (EPA)	Non-profit 501(c) Universities Local Government State Government	Watershed Restoration and/or Protection Projects; must include a monitoring component	$600,000 to $900,000	25% YES	3-5 years
Targeted Watersheds Grant Program – Capacity Building Grant Program (EPA)	Non-profit organizations and institutions Local Government State Government	Promote organizational development of local watershed partnerships; Provide training and assistance to local watershed groups	$400,000 to $800,000	25% YES	2 years
Chesapeake Bay Targeted Watersheds Grant Program (NFWF)	Non-profit 501(c) Universities Local Government State Government	Innovative demonstration type restoration projects	$400,000 to $1,000,000	25% YES	2-3 years
Global ReLeaf Program (American Forests)	All Public Lands or Public-Accessible Lands Local Government State Government	Public Lands Restoration Projects which include local organizations; Use innovative restorative practices with potential for general application; minimum 20 acre project area	$1 per tree planted	Covers costs associated with tree plantings YES	6 months (?)
Chesapeake Bay Small Watersheds Grant Program (NFWF)	Non-Profit 501(c) organizations Local Government	Related to water quality restoration/conservation; Projects using innovative approaches	$20,000 to $200,000	25%	1-5 Years (?)
Targeted Watershed Initiative Grant Program (Chesapeake Bay Trust)	Non-Profit 501(c) organizations and institutions Soil/Water Conservation Districts Local Government	Involve local organizations; Address non-point source pollution; Projects related to water quality and habitat restoration	$50 to $200,000	0% YES	1-2 Years
Capacity Building	Non-Profit 501(c)	Strengthen an organization through management	$15,000 per	0%	3 Years

Funding Source Name (Managing Agency)	Applicant Eligibility	Eligible Projects	Funding Amount	Cost Share? / In-Kind	Project Period
Initiative Grant Program (Chesapeake Bay Trust)	organizations with a board on which half the members participate meaningfully and at least one paid staff (or a part-time paid staff and volunteer)	operations, technology, governance, fundraising, and communications	year	YES	
Clean Water Action Plan Nonpoint Source Program 319 Grant (DNR)	Non-Profit 501(c) organizations Universities Soil/Water Conservation Districts Local Governments State Governments	Located in a Category I and Category III watershed as outlined in the MD unified watershed assessment; Establish cover crops; Address Stream restoration and riparian buffers	$5,000 to $40,000	40%	Annual
Stewardship Grant Program (Chesapeake Bay Trust)	501(c)3 Private Non-profit organizations, Community associations Government agencies Soil/Water Conservation districts Schools Universities	Raise awareness about watershed restoration; Design plans which educate citizens on things they can do to aid watershed restoration; Educate students about local watersheds; Projects geared towards watershed restoration and protection	$5,001 to $25,000	0% YES	1 Year
Watershed Operations Program (NRCS)	State Governments Local Governments Tribes	Address watershed protection, flood mitigation, water quality, soil erosion, sediment control, habitat enhancement, and wetland creation and restoration	No specified limits	(?)% YES?	None Specified
Kodak American Greenways Awards Program (Eastman Kodak Company)	Non-profit 501(c)3 State Governments Local Governments	Have demonstrated community support and are important to local greenway development efforts; Are likely to be completed and have tangible results	$500 to $2,500	(?)% YES	None Specified
Chesapeake Bay Small Watersheds Grant Program (NFWF)	Non-profit 501(c) Local Governments	Promote locally-based protection and restoration efforts that complement watershed management strategies; directly address one of the goals of the Chesapeake 2000 Agreement	$5,000 to $50,000	(?)%	None Specified

MDE- Maryland Department of the Environment
NFWF- National Fish and Wildlife Foundation
EPA = U.S. Environmental Protection Agency
FWS = U.S. Fish and Wildlife Service

APPENDIX D

CHESAPEAKE BAY PROGRAM POLLUTANT LOAD REDUCTION EFFICIENCIES

Table 1: Nonpoint Source Best Management Practices that have been Peer-Reviewed and CBP-Approved for Phase 5.0 of the Chesapeake Bay Program Watershed Model
Revised 1/12/06

Agricultural BMPs	How Credited	TN Reduction Efficiency	TP Reduction Efficiency	SED Reduction Efficiency
Riparian Forest Buffers and Wetland Restoration - Agriculture[1]:	Landuse conversion + efficiency	Efficiency applied to 4 upland acres	Efficiency applied to 2 upland acres	Efficiency applied to 2 upland acres
Coastal Plain Lowlands	Efficiency	25%	75%	75%
Coastal Plain Dissected Uplands	Efficiency	40%	75%	75%
Coastal Plain Uplands	Efficiency	83%	69%	69%
Piedmont Crystalline	Efficiency	60%	60%	60%
Blue Ridge	Efficiency	45%	50%	50%
Mesozoic Lowlands	Efficiency	70%	70%	70%
Piedmont Carbonate	Efficiency	45%	50%	50%
Valley and Ridge Carbonate	Efficiency	45%	50%	50%
Valley and Ridge Siliciclastic	Efficiency	55%	65%	65%
Appalachian Plateau Siliciclastic	Efficiency	60%	60%	60%
Riparian Grass Buffers - Agriculture:	Landuse conversion + efficiency	Efficiency applied to 4 upland acres	Efficiency applied to 2 upland acres	Efficiency applied to 2 upland acres
Coastal Plain Lowlands	Efficiency	17%	75%	75%
Coastal Plain Dissected Uplands	Efficiency	27%	75%	75%
Coastal Plain Uplands	Efficiency	57%	69%	69%
Piedmont Crystalline	Efficiency	41%	60%	60%
Blue Ridge	Efficiency	31%	50%	50%
Mesozoic Lowlands	Efficiency	48%	70%	70%
Piedmont Carbonate	Efficiency	31%	50%	50%
Valley and Ridge Carbonate	Efficiency	31%	50%	50%
Valley and Ridge Siliciclastic	Efficiency	37%	65%	65%
Appalachian Plateau Siliciclastic	Efficiency	41%	60%	60%

[1] These peer-reviewed BMP efficiencies and/or landuse conversions will be refined with more recent data for use in Phase 5.0 of the Chesapeake Bay Program Watershed Model based on results of the EPA CBPO FY2006 BMP Literature Synthesis project. Estimated Completion Date: TBD.

Agricultural BMPs (continued)	How Credited	TN Reduction Efficiency	TP Reduction Efficiency	SED Reduction Efficiency
Conservation Plans - Agriculture[1] (Solely structural practices such as installation of grass waterways in areas with concentrated flow, terraces, diversions, drop structures, etc.):	Efficiency			
Conservation Plans on Conventional-Till	Efficiency	8%	15%	25%
Conservation Plans on Conservation-Till and Hay	Efficiency	3%	5%	8%
Conservation Plans on Pasture	Efficiency	5%	10%	14%
Cover Crops[1]:	Efficiency			
Cereal Cover Crops on Conventional-Till:	Efficiency			
Early-Planting - Up to 7 days prior to published first frost date	Efficiency	45%	15%	20%
Late-Planting - Up to 7 after published first frost date	Efficiency	30%	7%	10%
Cereal Cover Crops on Conservation-Till:	Efficiency			
Early-Planting - Up to 7 days prior to published first frost date	Efficiency	45%	0%	0%
Late-Planting - Up to 7 after published first frost date	Efficiency	30%	0%	0%
Commodity Cereal Cover Crops / Small Grain Enhancement on Conventional-Till:	Efficiency			
Early-Planting - Up to 7 days prior to published first frost date	Efficiency	25%	0%	0%
Late-Planting - Up to 7 after published first frost date	Efficiency	17%	0%	0%
Commodity Cereal Cover Crops / Small Grain Enhancement on Conservation-Till:	Efficiency			
Early-Planting - Up to 7 days prior to published first frost date	Efficiency	25%	0%	0%
Late-Planting - Up to 7 after prior to published first frost date	Efficiency	17%	0%	0%
Off-stream Watering with Stream Fencing (Pasture)	Efficiency	60%	60%	75%
Off-stream Watering without Fencing (Pasture)	Efficiency	30%	30%	38%
Off-stream Watering with Stream Fencing and Rotational Grazing (Pasture)	Efficiency	20%	20%	40%

[1] These peer-reviewed BMP efficiencies and/or landuse conversions will be refined with more recent data for use in Phase 5.0 of the Chesapeake Bay Program Watershed Model based on results of the EPA CBPO FY2006 BMP Literature Synthesis project. Estimated Completion Date: TBD.

Agricultural BMPs (continued)	***How Credited***	***TN Reduction Efficiency***	***TP Reduction Efficiency***	***SED Reduction Efficiency***
Animal Waste Management Systems - Applied to model manure acre where 1 manure acre = runoff from 145 animal units:	Reduction in manure acres			
Livestock Systems	Reduction in manure acres	100%	100%	N/A
Poultry Systems	Reduction in manure acres	100%	100%	N/A
Barnyard Runoff Control / Loafing Lot Management	Reduction in manure acres	100%	100%	N/A
Conservation-Tillage[1]	Landuse conversion	N/A	N/A	N/A
Land Retirement - Agriculture	Landuse conversion	N/A	N/A	N/A
Tree Planting - Agriculture	Landuse conversion	N/A	N/A	N/A
Carbon Sequestration / Alternative Crops	Landuse conversion	N/A	N/A	N/A
Nutrient Management Plan Implementation - Agriculture	Built into simulation	135% of modeled crop uptake	135% of modeled crop uptake	N/A
Enhanced Nutrient Management Plan Implementation – Agriculture[1]	Built into simulation	115% of modeled crop uptake	115% of modeled crop uptake	N/A
Alternative Uses of Manure / Manure Transport	Built into preprocessing	Reduction in nutrient mass applied to cropland	Reduction in nutrient mass applied to cropland	N/A
Poultry Phytase	Built into preprocessing	N/A	Reduction in nutrient mass applied to cropland	N/A

[1] These peer-reviewed BMP efficiencies and/or landuse conversions will be refined with more recent data for use in Phase 5.0 of the Chesapeake Bay Program Watershed Model based on results of the EPA CBPO FY2006 BMP Literature Synthesis project. Estimated Completion Date: TBD.

Agricultural BMPs (continued)	*How Credited*	*TN Reduction Efficiency*	*TP Reduction Efficiency*	*SED Reduction Efficiency*
Dairy Precision Feeding / and Forage Management[1]	Built into preprocessing	Reduction in nutrient mass applied to cropland	Reduction in nutrient mass applied to cropland	N/A
Swine Phytase	Built into preprocessing	N/A	Reduction in nutrient mass applied to cropland	N/A
Continuous No-Till:				
Below Fall Line	Efficiency	10%	20%	70%
Above Fall Line	Efficiency	15%	40%	70%
Water Control Structures	Efficiency	33%	N/A	N/A
Urban and Mixed Open BMPs				
Stormwater Management::	Efficiency			
Wet Ponds and Wetlands[1]	Efficiency	30%	50%	80%
Dry Detention Ponds and Hydrodynamic Structures[1]	Efficiency	5%	10%	10%
Dry Extended Detention Ponds[1]	Efficiency	30%	20%	60%
Infiltration Practices	Efficiency	50%	70%	90%
Filtering Practices	Efficiency	40%	60%	85%
Erosion and Sediment Control[1]	Efficiency	33%	50%	50%
Urban and Mixed Open BMPs (continued)	*How Credited*	*TN Reduction*	*TP Reduction*	*SED Reduction*

[1] These peer-reviewed BMP efficiencies and/or landuse conversions will be refined with more recent data for use in Phase 5.0 of the Chesapeake Bay Program Watershed Model based on results of the EPA CBPO FY2006 BMP Literature Synthesis project. Estimated Completion Date: TBD.

		Efficiency	Efficiency	Efficiency
Nutrient Management (Urban)	Efficiency	17%	22%	N/A
Nutrient Management (Mixed Open)	Efficiency	17%	22%	N/A
Abandoned Mine Reclamation	Landuse change converted to efficiency	Varies by model segment	Varies by model segment	Varies by model segment
Riparian Forest Buffers – Urban and Mixed Open	Landuse conversion + efficiency	25%	50%	50%
Wetland Restoration – Urban and Mixed Open	Landuse conversion	N/A	N/A	N/A
Stream Restoration – Urban and Mixed Open[1]	Load reduction converted to efficiency	0.02 lbs/ft	0.0035 lbs/ft	2.55 lbs/ft
Impervious Surface and Urban Growth Reduction / Forest Conservation	Landuse conversion	N/A	N/A	N/A
Tree Planting – Urban and Mixed Open	Landuse conversion	N/A	N/A	N/A
Resource and Septic BMPs				
Forest Harvesting Practices[1]	Efficiency	50%	50%	50%
Septic Denitrification	Efficiency	50%	N/A	N/A
Septic Pumping	Efficiency	5%	N/A	N/A
Septic Connections / Hook-ups	Removal of systems	N/A	N/A	N/A

[1] These peer-reviewed BMP efficiencies and/or landuse conversions will be refined with more recent data for use in Phase 5.0 of the Chesapeake Bay Program Watershed Model based on results of the EPA CBPO FY2006 BMP Literature Synthesis project. Estimated Completion Date: TBD.

Table 2: Nonpoint Source Best Management Practices Requiring Additional Peer-Review for Phase 5.0 of the Chesapeake Bay Watershed Model Revised 1/12/06

(Note: Credit and Efficiencies are listed in parenthesis since they have not received formal peer review)

Agricultural BMPs Requiring Peer Review	***How Credited***	***TN Reduction Efficiency***	***TP Reduction Efficiency***	***SED Reduction Efficiency***	***CBP Lead Status Estimated Completion Date***
Precision Agriculture	(Built into simulation)	N/A	N/A	N/A	Tributary Strategy Workgroup EPA CBPO FY2006 BMP Literature Synthesis project will determine efficiency for Phase 5.0 Completion Date: TBD Delaware Maryland Agribusiness Association plans to work with CBPO to provide tracking data for this BMP.
Manure Additives	TBD	TBD	TBD	TBD	Agriculture Nutrient Reduction Workgroup TBD TBD
Ammonia Emission Reductions	(Built into preprocessing)	(Reduction in ammonia deposition)	N/A	N/A	Tributary Strategy Workgroup EPA CBPO FY2006 BMP Literature Synthesis project will determine efficiency Completion Date: TBD
Precision Grazing	Efficiency	(25%)	(25%)	(25%)	Agriculture Nutrient Reduction Workgroup Tributary Strategy Workgroup EPA CBPO FY2006 BMP Literature Synthesis project will determine efficiency Completion Date: TBD
Mortality Composters	Efficiency	(14%)	(14%)	N/A	Tributary Strategy Workgroup EPA CBPO 2006/2007 project will determine efficiency June 2008
Horse Pasture Management	Efficiency	(20%)	(20%)	(40%)	Tributary Strategy Workgroup EPA CBPO FY2006 BMP Literature Synthesis project will determine efficiency Completion Date: TBD

Agricultural BMPs Requiring Peer Review (continued)	***How Credited***	***TN Reduction Efficiency***	***TP Reduction Efficiency***	***SED Reduction Efficiency***	***CBP Lead Status Estimated Completion Date***
Non-Urban Stream Restoration	Load reduction converted to efficiency				
Non-Urban Stream Restoration on Conventional-Till and Pasture	Load reduction converted to efficiency	(0.026 lbs/ft)	(0.0046 lbs/ft)	(3.32 lbs/ft)	Tributary Strategy Workgroup EPA CBPO FY2006 BMP Literature Synthesis project will determine efficiency Completion Date: TBD
Non-Urban Stream Restoration on Conservation-Till, Hay	Load reduction converted to efficiency	(0.02 lbs/ft)	(0.0035 lbs/ft)	(2.55 lbs/ft)	Tributary Strategy Workgroup EPA CBPO FY2006 BMP Literature Synthesis project will determine efficiency Completion Date: TBD
Urban and Mixed Open BMPs Requiring Peer Review					
Non-Urban Stream Restoration on Mixed Open	Load reduction converted to efficiency	(0.02 lbs/ft)	(0.0035 lbs/ft)	(2.55 lbs/ft)	Tributary Strategy Workgroup EPA CBPO FY2006 BMP Literature Synthesis project will determine efficiency Completion Date: TBD
Dirt & Gravel Road Erosion & Sediment Control on Mixed Open	Load reduction converted to efficiency	(0.02 lbs/ft)	(0.0035 lbs/ft)	(2.55 lbs/ft)	Tributary Strategy Workgroup EPA CBPO FY2006 BMP Literature Synthesis project will determine efficiency Completion Date: TBD
Roadway Systems	TBD	TBD	TBD	TBD	Urban Stormwater Workgroup (USWG) USWG will meet with Departments of Transportation to identify roadway BMPs and efficiencies TBD
Urban Street Sweeping and Catch Basin Inserts	Efficiency	(10%)	(10%)	(10%)	Urban Stormwater Workgroup EPA CBPO street sweeping project will provide efficiency recommendations for the Urban Stormwater Workgroup review in Fall 2007

Urban and Mixed Open BMPs Requiring Peer Review (continued)	**How Credited**	**TN Reduction Efficiency**	**TP Reduction Efficiency**	**SED Reduction Efficiency**	**CBP Lead Status Estimated Completion Date**
Riparian Grass Buffers – Urban and Mixed Open	TBD	TBD	TBD	TBD	TBD
Resource BMPs Requiring Peer Review					
Non-Urban Stream Restoration on Forest	Load reduction converted to efficiency	(0.02 lbs/ft)	(0.0035 lbs/ft)	(2.55 lbs/ft)	Tributary Strategy Workgroup EPA CBPO FY2006 BMP Literature Synthesis project will determine efficiency Completion Date: TBD
Dirt & Gravel Road Erosion & Sediment Control on Forest	Load reduction converted to efficiency	(0.02 lbs/ft)	(0.0035 lbs/ft)	(2.55 lbs/ft)	Tributary Strategy Workgroup EPA CBPO FY2006 BMP Literature Synthesis project will determine efficiency Completion Date: TBD
Voluntary Air Emission Controls within Jurisdictions (Utility, Industrial, and Mobile)	Built into preprocessing	(Reduction in nitrogen species deposition)	N/A	N/A	Nutrient Subcommittee TBD TBD

Table 3: Nonpoint Source Best Management Practices that have been Peer Reviewed and CBP Approved for the Chesapeake Bay Water Quality Model
Revised 1/12/06

Shoreline BMPs	**How Credited**	**TN Reduction Efficiency**	**TP Reduction Efficiency**	**SED Reduction Efficiency**
Structural Tidal Shoreline Erosion Control	Water Quality Model	N/A	N/A	N/A
Non-Structural Tidal Shoreline Erosion Control	Water Quality Model	N/A	N/A	N/A

Table 4: Nonpoint Source Best Management Practices Requiring Additional Peer Review for the Chesapeake Bay Water Quality Model
Revised 1/12/06

Resource BMPs	***How Credited***	***TN Reduction Efficiency***	***TP Reduction Efficiency***	***SED Reduction Efficiency***	***CBP Lead Status Estimated Completion Date***
Coastal Floodplain Flooding	TBD	TBD	TBD	TBD	Sediment Workgroup TBD TBD
SAV Planting and Preservation	Water Quality Model	TBD	TBD	TBD	Living Resources Subcommittee TBD TBD
Oyster Reef Restoration and Shellfish Aquaculture	Water Quality Model	TBD	TBD	TBD	TBD TBD TBD
Structural Shoreline Erosion Controls:					Sediment Workgroup TBD TBD
Shoreline hardening	Water Quality Model	TBD	TBD	TBD	Sediment Workgroup TBD TBD
Resource BMPs (continued)	***How Credited***	***TN Reduction Efficiency***	***TP Reduction Efficiency***	***SED Reduction Efficiency***	***CBP Lead Status Estimated Completion Date***
Off-shore breakwater	Water Quality Model	TBD	TBD	TBD	Sediment Workgroup TBD TBD
Headland control	Water Quality Model	TBD	TBD	TBD	Sediment Workgroup TBD TBD
Breakwater systems	Water Quality Model	TBD	TBD	TBD	Sediment Workgroup TBD TBD

Upper Back River
Small Watershed Action Plan

Volume 2: Appendices E Through K

November 2008

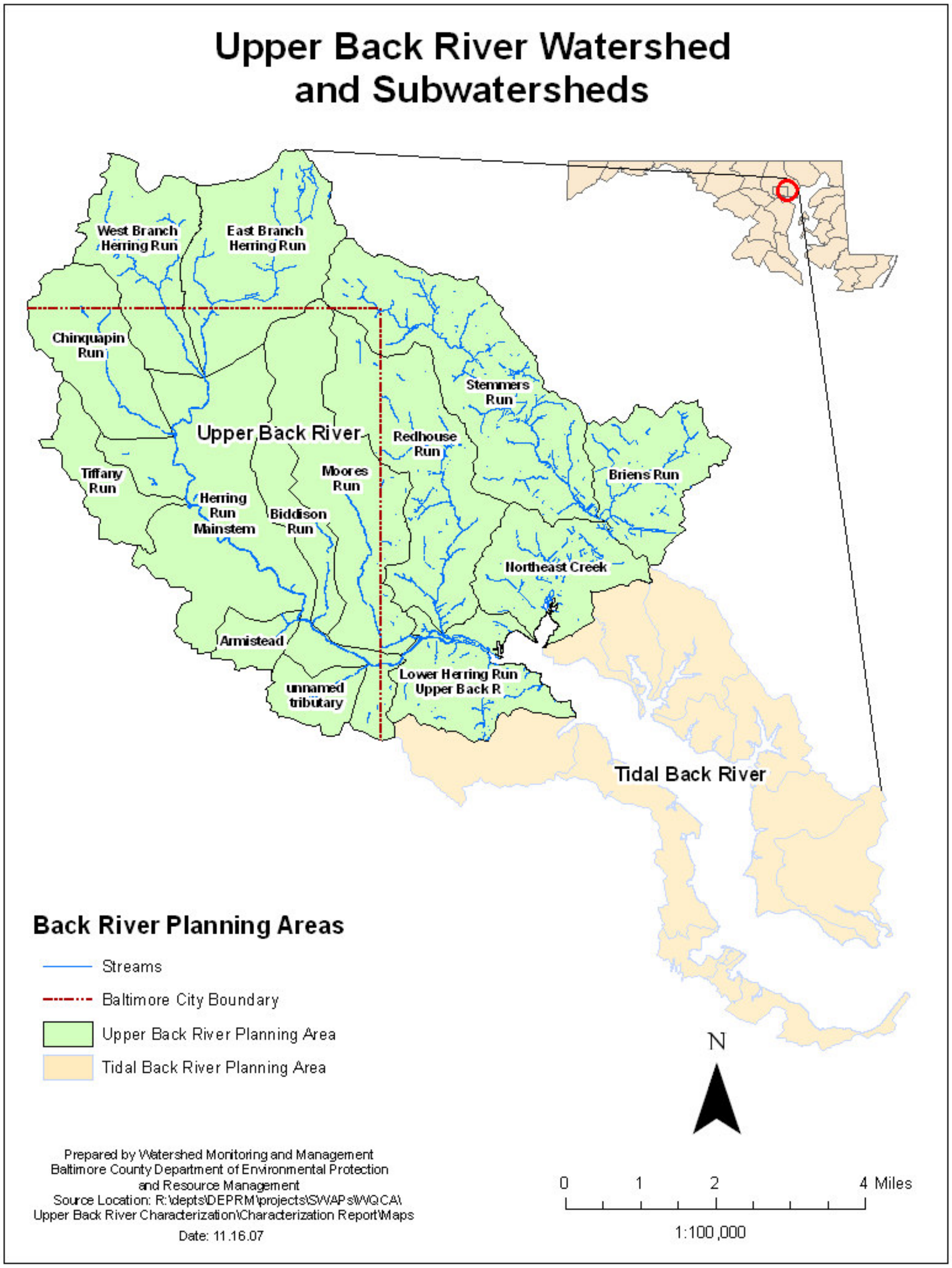
Final

Prepared by:
Baltimore County Department of Environmental Protection
and Resource Management

In Consultation with:
Upper Back River SWAP Steering Committee

Upper Back River S.W.A.P. Report (Vol. 2)
Table of Contents

Upper Back River
Watershed Characterization



Final

November 21, 2008

Upper Back River Characterization Report
Table of Contents

List of Tables

List of Figures

Appendices

CHAPTER 1

INTRODUCTION

1.1 Purpose of the Characterization

The Upper Back River Watershed Characterization Report is intended to summarize information on geomorphological, hydrological, and biological factors that may affect water quality and other natural resources and the condition of these natural resources. In addition, the report identifies and assesses the human impact on the watershed, the management framework within which this activity takes place, and finally, identifies restoration and preservation strategies and actions to achieve watershed goals. The information presented in this report, along with information provided by the Stream Stability Assessments performed in Herring Run, Stemmer's Run and Brien's Run in 2007 will be used as the basis for the formulation of the Upper Back River Watershed Restoration Action Strategy (WRAS). This characterization report has two main objectives:

- Summarize watershed information relevant to natural resources and impacts on natural resources, and
- To describe the condition of the natural resources within the watershed.

1.2 Location and Scale of Analysis

The Upper Back River watershed is located in the Back River Basin in the Piedmont and Coastal Plain regions of Maryland. The watershed contains the mouth of the Back River with portions of the watershed in Baltimore County and Baltimore City, Maryland (Figure 1-1). Table 1-1 displays the distribution of acreage between the two jurisdictions.

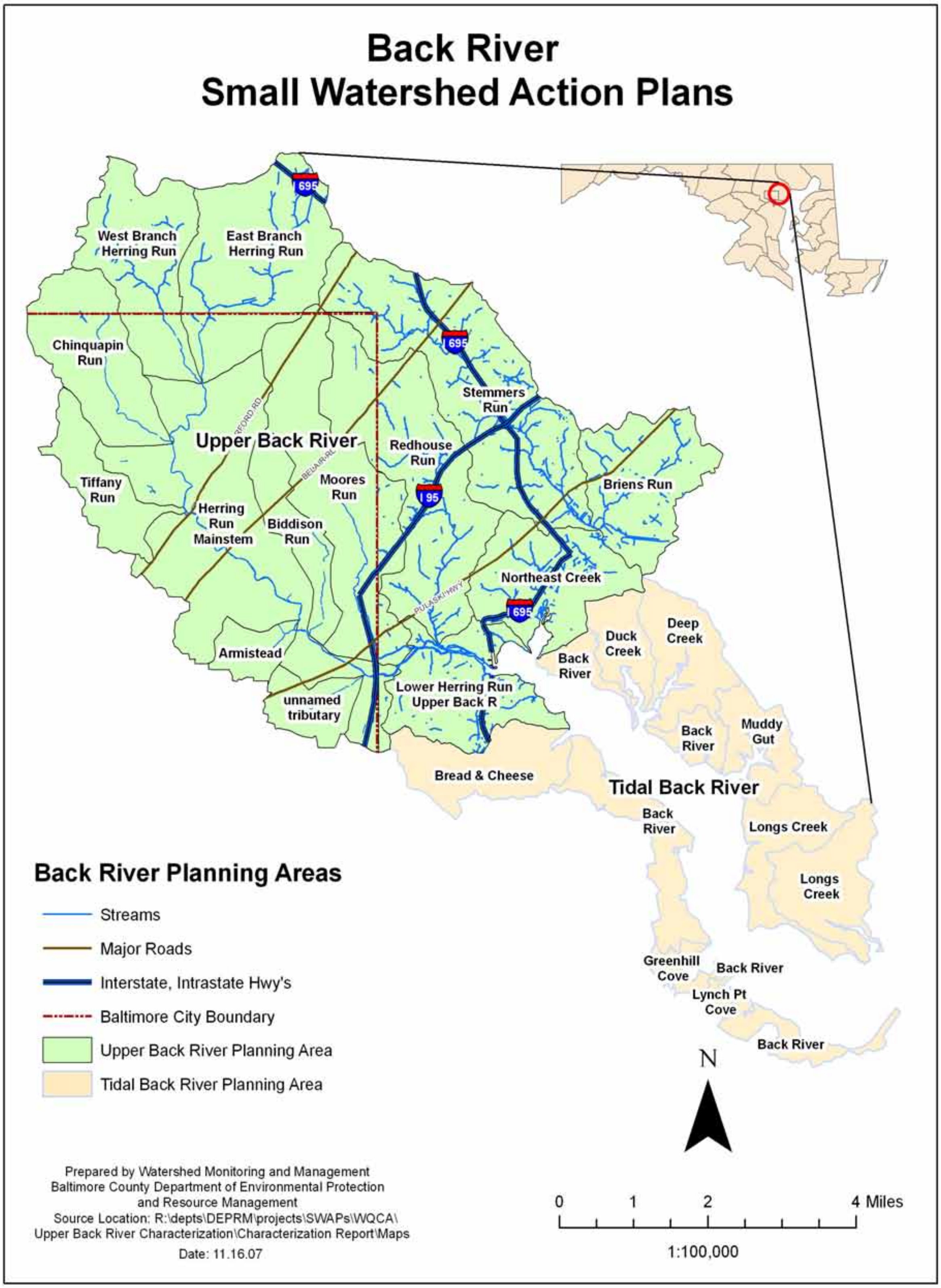


Figure 1-1: Upper Back River Watershed Location in Relation to Other Small Watershed Action Plan Area

Table 1-1: Distribution of Upper Back River Watershed Acreage

Jurisdiction	Land	
	Acres	%
Baltimore County	15,395.1	44.5
Baltimore City	12,321.9	55.5
Watershed Total	**27,716.9**	**100**

The analysis presented in this report was conducted at the subwatershed scale in addition to an analysis of the entire Upper Back River watershed. The subwatershed scale provides information on smaller drainage areas that are often the focus of intense restoration and preservation efforts. The effect of these efforts may be more easily monitored at that level. Table 1-2 presents the labels used at the various scales and their relationship to one another. Figure 1-2 presents the two levels of scale used in the analysis.

Table 1-2: Upper Back RIver Subwatershed Acreages

Subwatershed Scale	Acres
Armistead Run	416.2
Biddison Run	790.7
Brien's	1,636.1
Chinquapin Run	1,650.0
East Branch Herring Run	2,690.4
Herring Run Mainstem	4,431.2
Lower Herring Run	1,596.1
Moore's Run	2,797.7
Northeast Creek	1,643.9
Redhouse Run	3,020.4
Stemmers Run	3,690.6
Tiffany Run	893.8
Unnamed Tributary	580.3
West Branch Herring Run	1,879.7
Total	**27,716.9**

As Table 1-2 indicates, there are 14 separate subwatersheds identified for this report. Figure 1-2 depicts the location of the subwatersheds within the Upper Back River watershed.

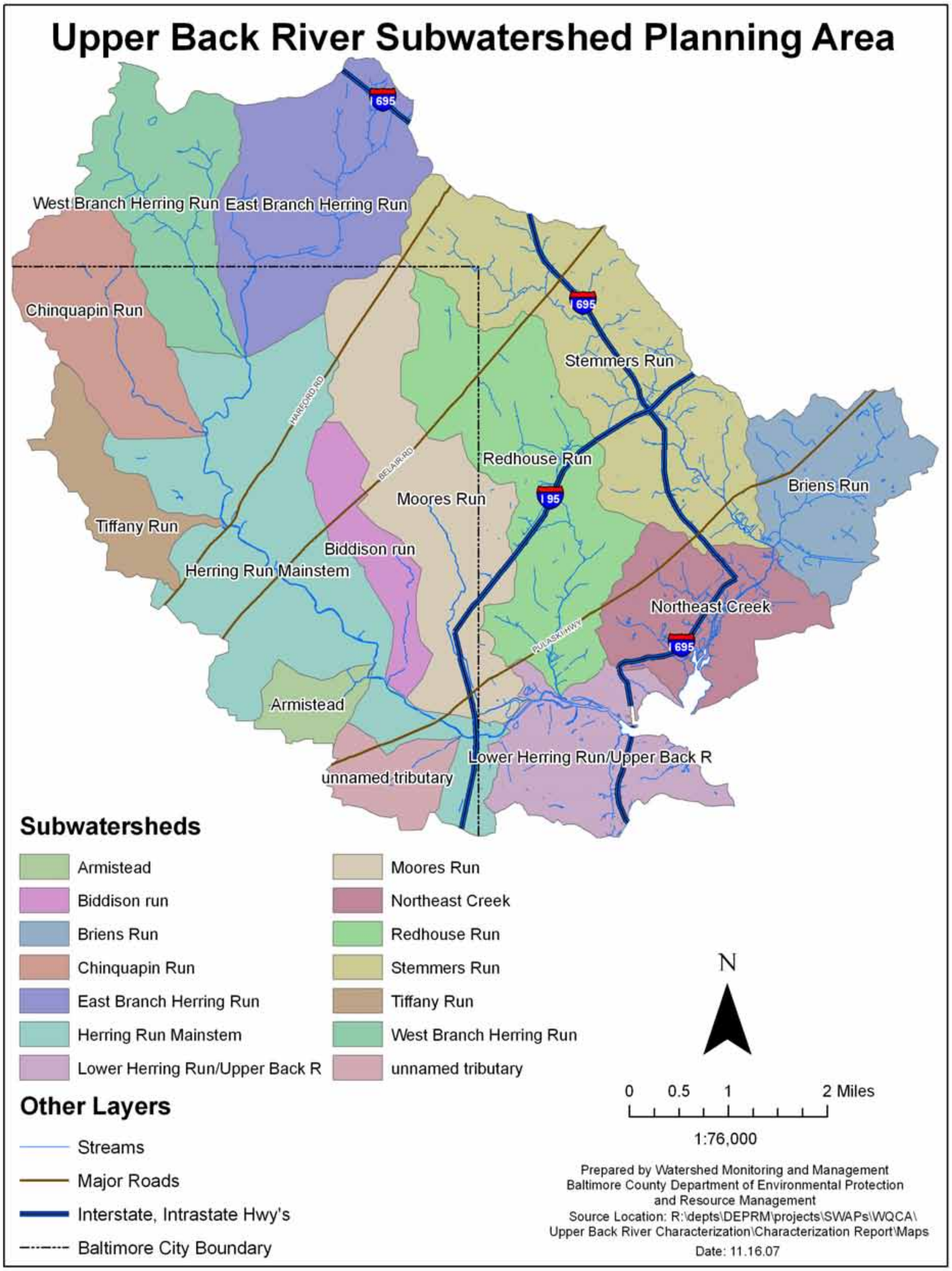


Figure 1-2: Upper Back River Subwatersheds.

1.3 Report Organization

This report is organized into five chapters. Chapter 1 presents an overview of the characterization report and the general location and acreage distribution among the three local jurisdictions.

Chapter 2 presents information on landscape characteristics that may have an effect on natural resources. Included in this chapter are some characteristics that are considered natural resources in their own right, such as, geology and soils. Data is presented on land use, impervious cover, population density, and a number of human modifications to the landscape that affect water quality.

Chapter 3 focuses on water quality and water quantity as it relates to the landscape characteristics and the potential for degradation or protection.

Chapter 4 describes the upland assessments conducted to identify major sources of stormwater pollutants and the restoration opportunities for source controls, pervious area management, and improved municipal maintenance.

Chapter 5 summarizes protection and restoration strategies, including activities that have taken place to date, and their effects on meeting the goals identified by the Upper Back River WRAS Steering Committee.

CHAPTER 2

LANDSCAPE AND LAND USE

2.1 Introduction

The physical aspects of a watershed provide the background and context for the associated biological and hydrological processes as well as for the development that takes place on the land at the hands of man. In this chapter, we will describe both the natural physical context and the human use and present state of the land in the Upper Back River Watershed. This will provide the basis for later chapters on water quality, living resources, restoration, and management.

The Upper Back River Watershed (27,717 acres) represents a portion (78%) of the larger Back River Watershed. It is one of two planning areas within the Back River watershed. The tidal Back River planning area will be addressed in a future Small Watershed Action Plan.

The Upper Back River Watershed lies within the Piedmont (41%) and Coastal Plain (59%) regions of Maryland. The watershed transcends Baltimore County and Baltimore City. The natural Piedmont landscape is characterized by rolling hills, extensive forests, thick soils on deeply weathered crystalline bedrock, and abundant forest litter that minimizes overland flow. The natural Coastal Plain is relatively flatter with soils formed from sedimentary deposits. Much of the Piedmont and Coastal Plain, including the Upper Back River Watershed, was transformed by settlement starting in the 18^{th} Century. Virgin forests were cleared for agriculture, and agricultural land use rose steadily until peaking around the beginning of the 20^{th} Century. The Upper Back River watershed is a portion of the core of Baltimore City that developed around the natural harbor starting in the early 1600s. Human development spread out from this core settlement around the harbor up the stream valleys to accommodate the agricultural base needed to supply the growing population. As the commercial aspects of Baltimore City expanded, the agricultural lands nearest the harbor were converted to residential, industrial, and commercial land uses.

This chapter will be presented in two parts: the first will document the natural background state of the natural resources of the watershed, and the second will describe the present state of the landscape as it is now after four centuries of human modification.

2.2 The Natural Landscape

The natural landscape includes many factors that provide the background context and foundation for land use. Among these factors are the physiographic province, the underlying geology and the surface soils, the climate that affects the formation and erosion of soils, the stream drainage system, and the forest and wetland cover.

2.2.1 Climate

The climate of the region can be characterized as a humid continental climate with four distinct seasons modified by the proximity of the Chesapeake Bay and Atlantic Ocean (DEPRM, 2000). Rainfall is evenly distributed through all months of the year, with most months averaging between 3.0 and 3.5 inches per month. Storms in the fall, winter, and early spring tend to be of longer duration and lesser intensity than summer storms, which are often convective in nature with scattered high intensity storm cells. The average annual rainfall, as measured at the Baltimore Washington Thurgood Marshall Airport is ~42 inches per year. The average annual snowfall is approximately 21 inches, with the majority of accumulation in December, January, and February.

The climate of a region affects the rate and form of soil formation and erosion patterns, and with the interaction of the underlying geology, the stream drainage network pattern and the resulting topography. The climate also affects the vegetative growth and species composition of the terrestrial ecosystem.

2.2.2 Physiogeographic Province and Topography

2.2.2.1 Location and watershed delineation

The Upper Back River watershed lies within the Piedmont Physiographic Province and the Western Coastal Plain. The highest point of the planning area is located at 500 feet in elevation in the Western Herring Run subwatershed. The lowest points in the watershed are located where Herring Run and Northeast Creek flow into the Back River. The Piedmont Physiographic Province is characterized by rolling hills of varying steepness, while the Coastal Plain is relatively flat.

All points of land are contained in nested watersheds based on water drainage patterns. Maryland divides its waters into 138, 8-digit watersheds, a scale finer than the USGS 8-digit hydrologic unit codes. Maryland's 8-digit watersheds contain, on average, 75 square miles. The Back River watershed is a below average-sized 8-digit watershed that contains about 35,645 acres, or 55.7 square miles. The Upper Back River planning area is 27,717 acres or 43.3 square miles in extent. For development of the Small Watershed Action Plan the Upper Back River has been further divided into 14 subwatersheds (Figure 2-1). All data will be presented on the basis of these subwatersheds.

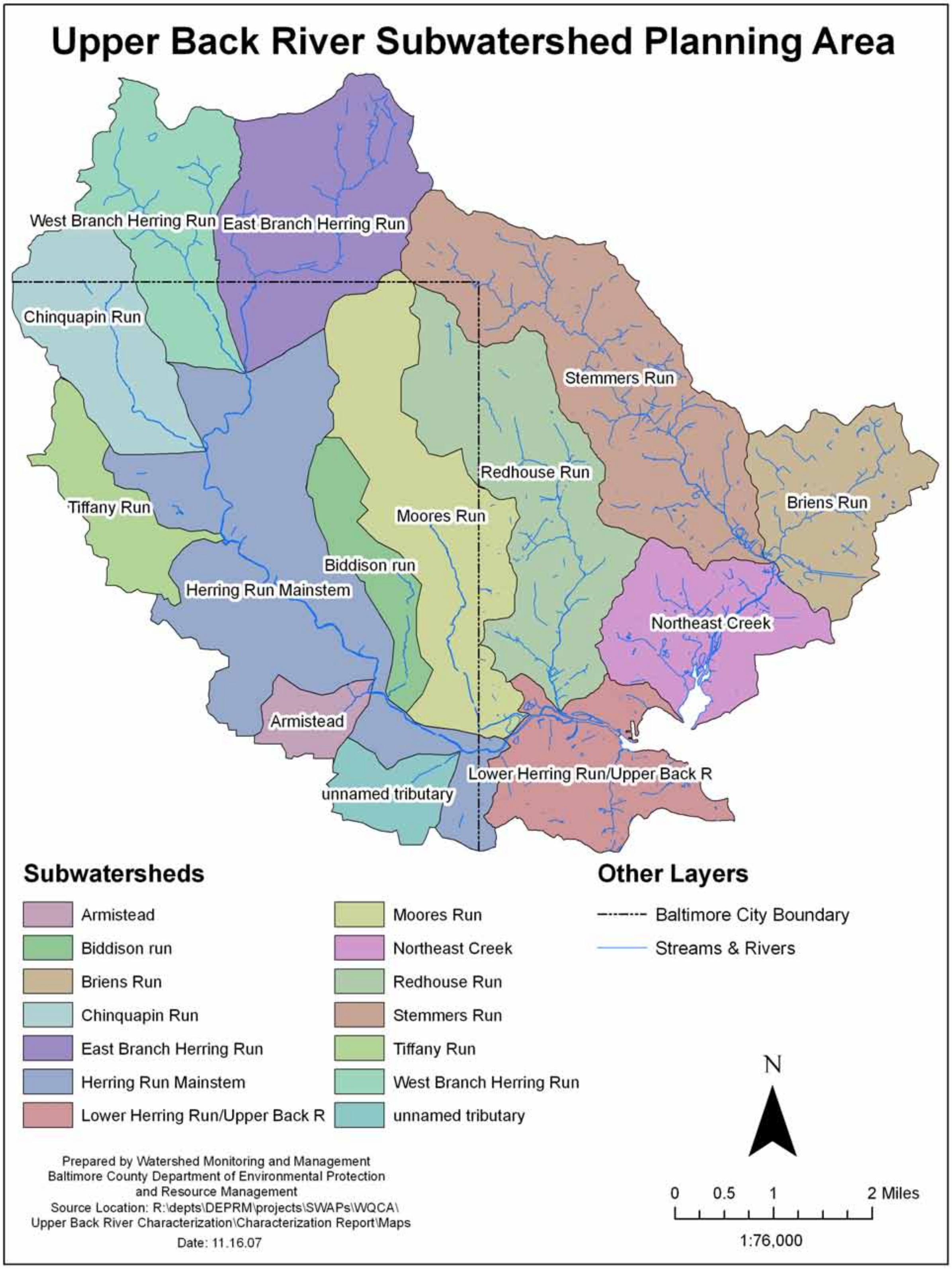


Figure 2-1: Upper Back River Planning Area Subwatersheds

<u>2.2.2.2 Topography</u>

The shape of the land, including its steepness and degree of concavity, affect surface water flows and soil erosion, as well as the suitability for development. Steep slopes are more prone to overland flow and soil erosion, and therefore have a greater potential for generation of pollutants. For this project the slopes were determined based on the soil data layers and divided into five categories: low slopes (0-3%), low to medium slopes (3 %- 8%), medium slopes (8%-15%), steep slopes (15%-25%) and extremely steep slopes (>25 %). Table 2-1 displays the results, in percentage of the area in each category, by subwatershed.

Table 2-1: Upper Back River Subwatershed Slope Categories (%)

Subwatershed	Slope Category				
	Low	Low-Medium	Medium	Steep	Extremely Steep
Armistead Run	7.3	34.6	36.4	0.0	21.7
Biddison Run	5.1	49.7	37.1	0.0	8.1
Brien’s	24.8	66.2	4.5	4.4	0.0
Chinquapin Run	4.4	65.3	24.2	1.5	4.6
East Branch Herring Run	10.9	63.0	13.5	11.4	1.2
Herring Run Mainstem	7.0	57.4	26.7	0.7	8.2
Lower Herring Run	31.6	57.2	2.4	7.5	1.3
Moore’s Run	5.4	66.8	16.1	6.5	5.2
Northeast Creek	24.4	58.8	2.8	13.6	0.4
Redhouse Run	7.5	56.5	14.6	20.3	1.1
Stemmers Run	13.6	48.1	13.6	21.7	3.0
Tiffany Run	0.1	59.1	30.3	0.0	10.5
Unnamed Tributary	0.0	25.1	27.0	0.0	47.9
West Herring Run	6.3	54.1	23.8	13.2	2.6
Total	**10.9**	**57.2**	**17.4**	**9.5**	**4.9**

The two subwatersheds with the highest proportion of steep and extremely steep slopes are in the Unnamed Tributary subwatershed (48% of the area). This subwatershed contains relatively broken topography, making it more prone to erosion, depending on soil type and land cover. Conversely, Brien’s Run and Lower Herring Run have the highest proportion of relatively flat land, making it less prone to erosion, again depending on soil type and land cover. Figure 2-2 displays the distribution of the topographic slope categories throughout the Upper Back River Planning Area.

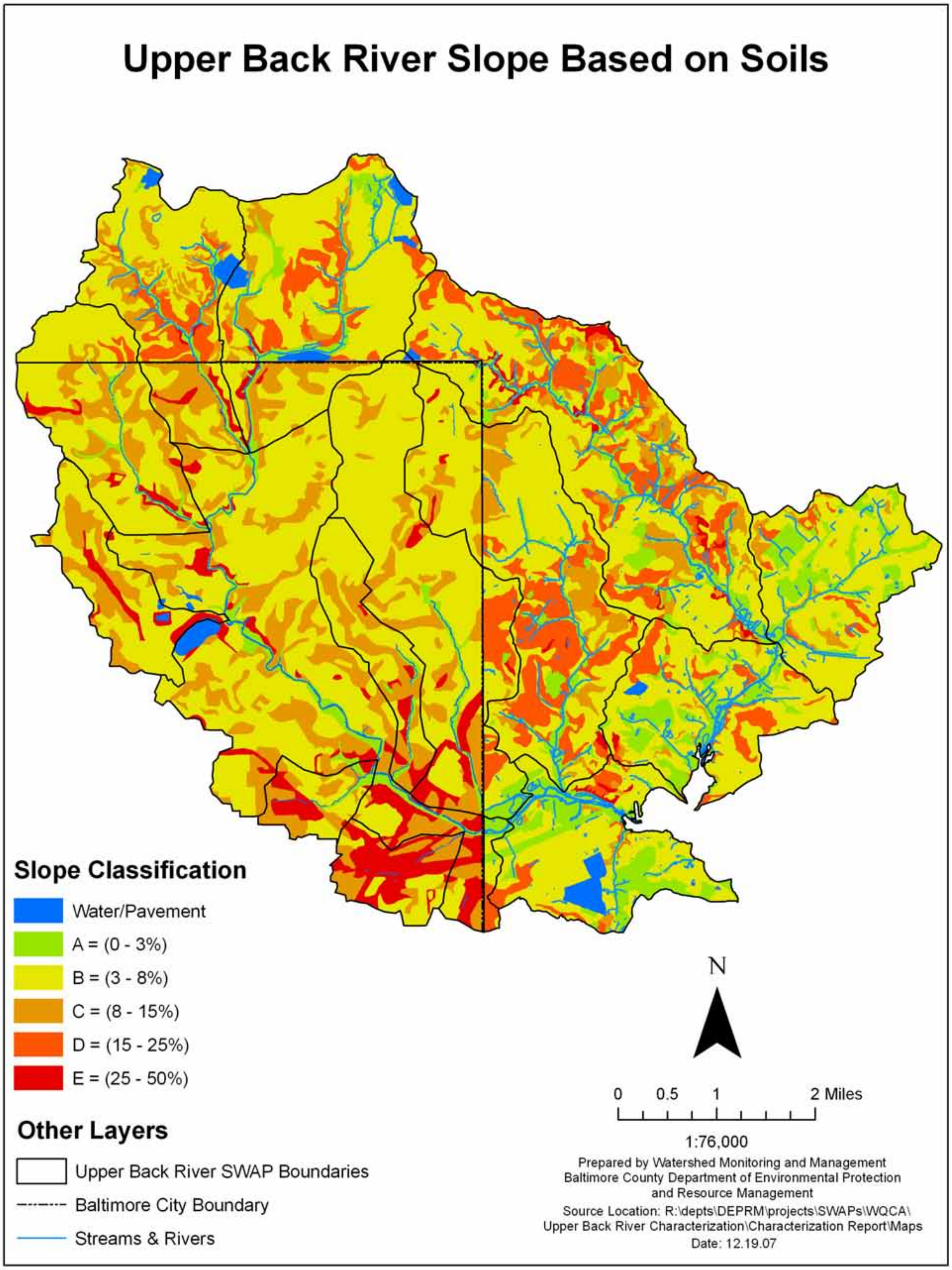


Figure 2-2. Upper Back River Watershed Topography

2.2.3 Geology

Table 2-2 displays the geology of the subwatersheds, showing both the percent distribution and the geological type. The metamorphic rock that underlies the northwestern portion of the Upper Back River watershed and much of the Piedmont consists mainly of crystalline schist and gneiss with smaller areas of marble. In general, the schist and gneiss formations have relatively low infiltration rates, giving them lower groundwater recharge rates and less vulnerability to contamination. The sedimentary formations that overlap the metamorphic rock and are part of the Coastal Plain physiographic province predominate in the southeastern portion of Lower Jones Falls.

The geological formations of the Upper Back River Watershed are shown in Figure 2-3. These formations affect the chemical composition of surface and groundwater, as well as the recharge rate to groundwater and wells. They are also key to soil formation. As such, the geology is closely correlated with water quality in pristine systems, and affects the buffering of pollution to stream systems in developed areas.

Table 2-2: Geological Composition by Subwatershed (%)

Geology	Type	Armistead Run	Biddison Run	Brien's Run	Chinquapin Run	East Herring Run	Herring Run Main	Lower Herring Run
Artificial Fill	Metamorphic	1.9	6.9	0.0	0.0	0.0	7.0	0.0
Arundel Formation	Metamorphic	31.6	0.0	55.8	0.02	0.0	2.2	6.0
Baltimore Gneiss	Metamorphic	0.0	0.0	0.0	64.2	36.9	19.6	0.0
Cockeysville Marble	Metamorphic	0.0	0.0	0.0	0.0	0.0	0.7	0.0
Gunpowder Gneiss	Metamorphic	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Loch Raven Schist	Metamorphic	0.0	5.1	0.0	0.0	0.0	6.0	0.0
Oella Formation	Metamorphic	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Patapsco Formation	Unconsolidated	0.0	0.0	44.2	0.0	0.0	5.5	94.0
Patuxent Formation	Unconsolidated	66.5	49.6	0.0	35.8	63.1	51.2	0.0
Perry Hall Gneiss	Unconsolidated	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raspeburg Amphibolite	Unconsolidated	0.0	38.4	0.0	0.0	0.0	7.2	0.0
Setters Formation/Gneiss	Metamorphic	0.0	0.0	0.0	0.0	0.0	0.4	0.0
Geology	**Type**	**Moore's Run**	**Northeast Creek**	**Redhouse Run**	**Stemmers Run**	**Tiffany Run**	**Unnamed Tributary**	**West Herring Run**
Artificial Fill	Metamorphic	2.1	0.0	0.0	0.0	0.0	24.1	0.0
Arundel Formation	Metamorphic	23.1	30.0	39.1	40.0	0.0	40.1	0.0
Baltimore Gneiss	Metamorphic	0.0	0.0	0.0	0.0	5.3	0.0	73.1
Cockeysville Marble	Metamorphic	0.0	0.0	0.0	0.0	13.4	0.0	0.0
Gunpowder Gneiss	Metamorphic	0.0	0.0	0.0	4.7	0.0	0.0	0.0
Loch Raven Schist	Metamorphic	6.9	0.0	0.0	0.5	11.1	0.0	0.0
Oella Formation	Metamorphic	0.0	0.0	0.0	0.0	0.8	0.0	0.0
Patapsco Formation	Unconsolidated	1.1	70.0	7.0	2.6	0.0	19.6	0.0
Patuxent Formation	Unconsolidated	38.7	0.0	29.5	46.4	59.1	16.2	26.2
Perry Hall Gneiss	Unconsolidated	3.4	0.0	13.3	5.7	0.0	0.0	0.0
Raspeburg Amphibolite	Unconsolidated	24.6	0.0	11.0	0.2	0.0	0.0	0.0
Setters Formation/Gneiss	Metamorphic	0.0	0.0	0.0	0.0	10.2	0.0	0.7

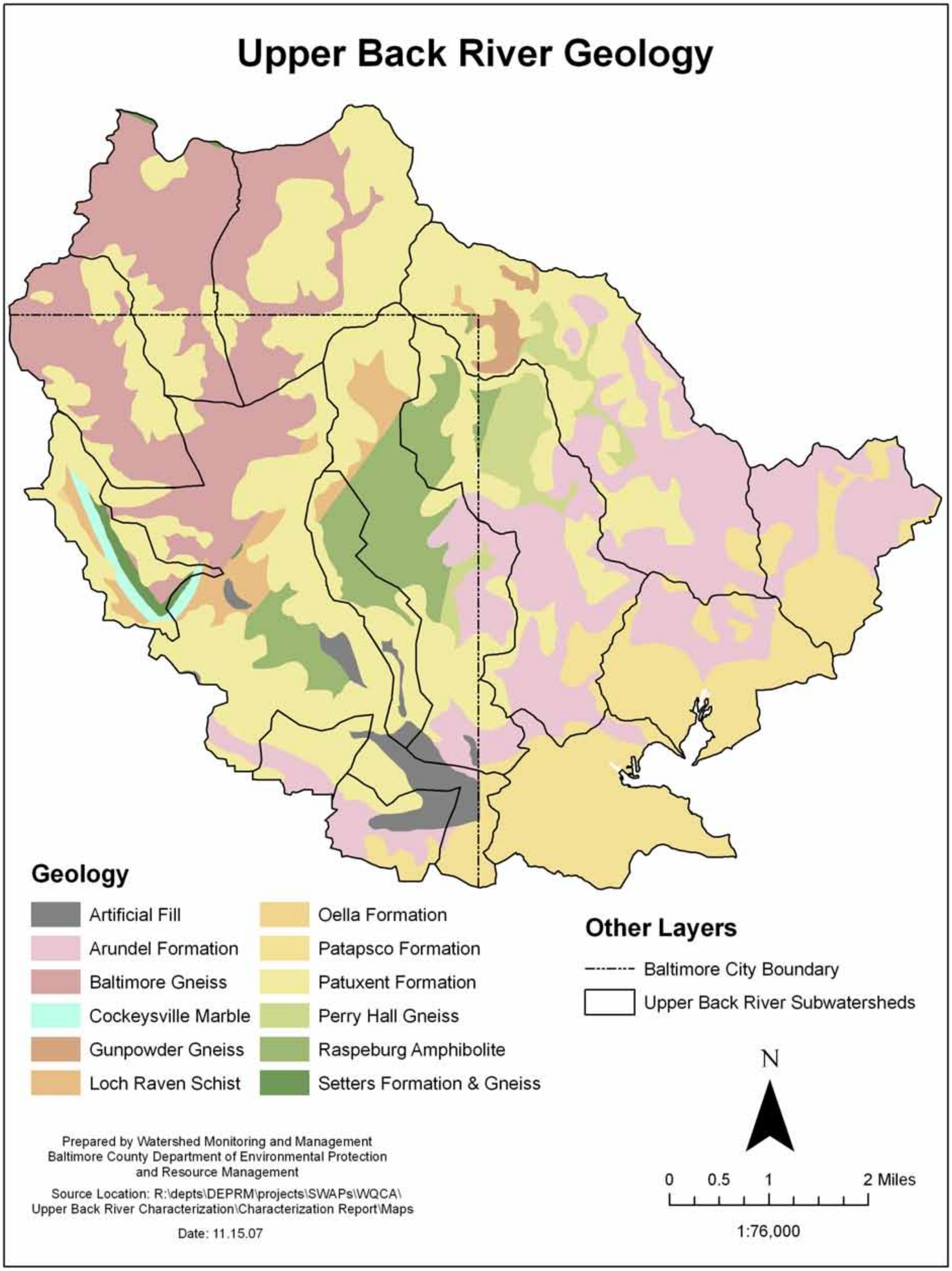


Figure 2-3. Upper Back River Watershed Geology

2.2.4 Soils

Soil type and moisture conditions greatly affect how land may be used and the potential for vegetation and habitat on the land. Soil conditions are also one determining factor for water quality and quantity in streams and rivers. Soils are an important factor to incorporate in targeting projects aimed at improving water quality or habitat.

Piedmont soils are developed from highly metamorphosed schist, gneiss, and granite, while Coastal Plain soils are developed from sedimentary deposits. Local soil conditions vary greatly from site to site.

2.2.4.1 Hydrologic Soil Groups

The Natural Resource Conservation Service classifies soils into four Hydrologic Soil Groups (HSGs) based on the soil's runoff potential. Runoff potential is the opposite of infiltration capacity; soils with high infiltration capacity will have low runoff potential, and vice versa. The four Hydrologic Soils Groups are A, B, C and D, where A's generally have the smallest runoff potential and D's the greatest. Soils with low runoff potential will be less prone to erosion, and their higher infiltration rates result in faster throughflow of precipitation to groundwater.

Details of the hydrological soils classification can be found in 'Urban Hydrology for Small Watersheds' published by the Engineering Division of the Natural Resource Conservation Service, United States Department of Agriculture, Technical Release–55.

> **Group A** is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.
> **Group B** is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
> **Group C** soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
> **Group D** soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This HSG has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling 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.

The soils data analysis is based on the Baltimore County Soil Survey of Baltimore County, Maryland (Reybold, et.al. 1976) and on the newer Soil Survey of City of Baltimore, Maryland (Levin & Griffin, 1998). The Baltimore City soils data utilizes a new classification of urban soils. The Baltimore City hydrologic soil groups are presented as a range, which reflects the differing degrees of soil compaction experienced in the process of urbanization. For purposes of this study the lower end of the range was selected to represent the hydrologic soil group. This provides a conservative estimate of the impact due to urbanization. The data are summarized in Table 2-3 and Figure 2-4.

Table 2-3: Upper Back River Subwatershed Hydrologic Soil Categories (%)

Subwatershed Scale	Hydrologic Soil Group %			
	A	B	C	D
Armistead Run	0.0	4.5	5.0	90.6
Biddison Run	0.0	6.7	3.4	89.9
Brien's	1.8	27.8	53.7	16.8
Chinquapin Run	1.6	19.3	8.4	70.7
East Branch Herring Run	9.7	21.5	41.6	27.3
Herring Run Mainstem	0.6	11.1	6.0	82.3
Lower Herring Run	1.4	47.4	34.3	16.9
Moore's Run	0.0	6.8	18.1	75.1
Northeast Creek	2.3	31.7	49.5	16.4
Redhouse Run	0.1	7.4	61.2	31.3
Stemmers Run	3.1	13.1	66.1	17.6
Tiffany Run	0.0	0.8	5.5	93.7
Unnamed Tributary	0.0	0.6	16.5	82.9
West Branch Herring Run	4.1	46.3	23.3	26.3
Total	**0.9**	**31.0**	**7.9**	**60.2**

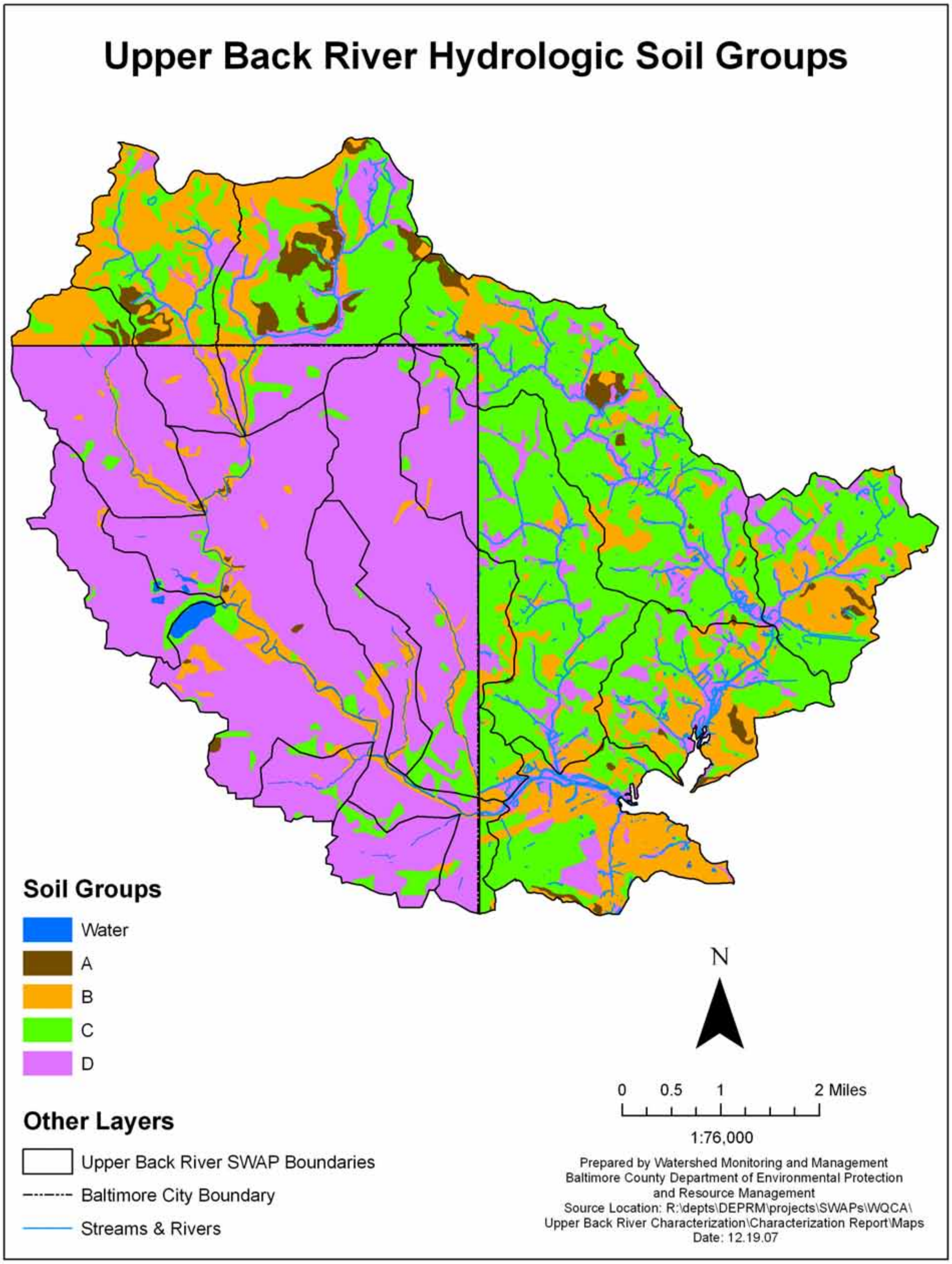


Figure 2-4. Upper Back River Watershed - Hydrological Soil Groups

2.2.4.2 Soil Erodibility

The erodibility of the soil is its intrinsic susceptibility to erosion. It is one factor (known as the K factor) in the Universal Soil Loss Equation, which estimates the rate of erosion at a particular site. Erodibility is based on the physical and chemical properties of the soil, which determine how strongly soil particles cohere with one another. Figure 2-5 shows soil erodibility in the Upper Back River Watershed, and Table 2-4 is the summary by subwatershed. Low erodibility is defined as a K factor < .24, medium is K between .24 and .32, and high is K>.32. We chose these classes based on groupings in the data that resulted in three classes. They were also chosen as they represent the breaks used in the Baltimore County – Steep Slopes and Erodible Soils Analysis for determining riparian buffer widths. They are not the same as MDNR's or MDOP's categories, but overlap with them.

The subwatersheds with the highest values for erodibility offer the greatest potential for interventions addressing soil conservation such as riparian buffer forestation. Best management practices concerned with keeping topsoil in place would be ideal for implementation in these watersheds. This indicator would be useful when combined with additional information about cropland, slope steepness, and distance to streams, as this would indicate areas where one best management practice--retirement of highly erodible land--would be most useful. High values for this indicator also raise warning flags about other, more urban activities near streams, such as road construction or utility placements.

Overall, the Upper Back River Watershed shows a fairly even distribution of soil erodibility meaning a large proportion of the watershed's soils are prone to at least moderate erosion. The medium and high erodibility classes represent 75% of the distribution. Only the East Branch Herring Run subwatershed has over 50% highly erodible soils. This would rate as a priority subwatershed for maintaining protective land cover.

Table 2-4: Upper Back River Subwatershed Soil Erodibility Categories (%)

Subwatershed Scale	Soil Erodibility Category %		
	Low	Medium	High
Armistead Run	54.5	12.3	33.2
Biddison Run	22.5	44.1	33.4
Brien's	30.3	25.5	44.2
Chinquapin Run	17.2	49.0	33.7
East Branch Herring Run	9.8	39.3	50.9
Herring Run Mainstem	30.0	36.0	34.0
Lower Herring Run	42.5	35.4	22.1
Moore's Run	18.5	37.5	43.9
Northeast Creek	48.4	31.0	20.7
Redhouse Run	35.5	19.6	44.9
Stemmers Run	39.8	13.3	46.9
Tiffany Run	30.0	34.3	35.8
Unnamed Tributary	62.6	26.3	11.1
West Branch Herring Run	15.6	61.7	22.8
Total	**24.5**	**44.6**	**31.0**

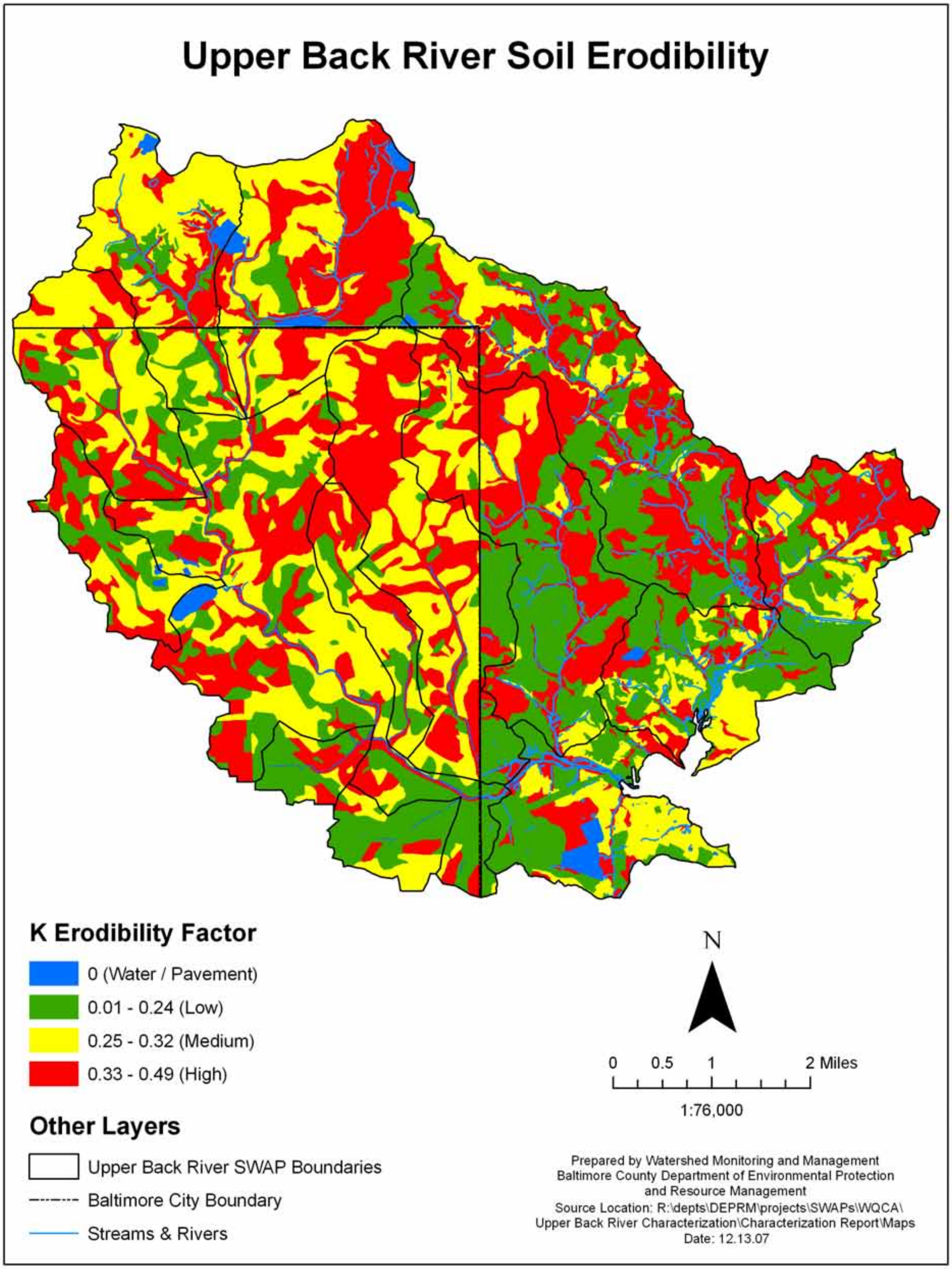


Figure 2-5. Soil Erodibility based on the K factor

2.2.5 Forest

The entire Chesapeake watershed, including the Upper Back River watershed, consisted overwhelmingly of old-growth forest at the time of European settlement. Forest cover provides the greatest protection among land cover types for the quality of the soil and water. In pristine systems, forest and soils co-evolve, and in turn shape the hydrological cycle; these systems operate within a natural range of variability, assuring healthy habitat and water quality. In human-impacted systems, forest cover still provides many of these benefits, and can help protect water quality if judiciously planned.

2.2.5.1 Forest Cover

The forest area has been greatly reduced in the Upper Back River Watershed since European settlement. Based on the Maryland Department of Planning 2002 land use classification system only ~14% forest cover remains.

Table 2-5 show that the Upper Back River Watershed contains 766 acres of forest, which is less than 3% of the total area. Stemmer's Run subwatershed contains the most forested acres while Northeast Creek has the highest percentage forested. These areas are a potential priority for preservation. In Northeast Creek there are also breeding records for the Least Bittern (*Ixobrychus exilis*), a species with In Need of Conservation status in Maryland, increasing a desire for preservation here.

Table 2-5: Upper Back River Subwatershed Forested Area

Subwatershed	Total Acres	Forested Acres	% Forested
Armistead Run	416.2	16.3	3.9
Biddison Run	790.7	52.3	6.6
Brien's	1,636.1	288.6	17.6
Chinquapin Run	1650	105.3	6.4
East Branch Herring Run	2,690.4	175.2	6.5
Herring Run Mainstem	4,431.2	424.6	9.6
Lower Herring Run	1,596.1	271.3	17.0
Moore's Run	2,797.7	223.2	8.0
Northeast Creek	1,643.9	498.9	30.3
Redhouse Run	3,020.4	279.9	9.3
Stemmers Run	3,690.6	770.6	20.9
Tiffany Run	893.8	0.0	0.0
Unnamed Tributary	580.3	0.0	0.0
West Branch Herring Run	1,879.7	108.4	5.8
Planning Area Totals	**27,717.1**	**3,214.6**	11.6

With the exception of Northeast Creek, all of the subwatersheds contain less than 25% forest cover, with Tiffany Run and Unnamed Tributary with no forest cover at all. All of these areas therefore provide ample opportunity for potential forest restoration.

2.2.6 Stream Systems

Stream systems are a watershed's circulatory system, and the most visible attribute of the hydrological cycle. The stream system is an intrinsic part of the landscape, and closely reflects conditions on the land. The streams are a fundamental natural resource, with myriad benefits for plants, animals, and humans. Maintaining a healthy stream system is a priority for many individuals and organizations, and requires insuring that stream flows and water quality closely mimic the conditions found in un-impacted watersheds. Streams are the flowing surface waters, and are distinct from both groundwater and standing surface water (such as lakes), though they are connected with both of them.

2.2.6.1 Stream System Characteristics

The Upper Back River Watershed contains approximately 139 miles of streams, all of which drain to the Back River, which empties to the Chesapeake Bay.

The Back River Watershed, which is classified as an 8-digit watershed by the State of Maryland, is part of the larger Chesapeake Bay Watershed. The Upper Back River Watershed is a subset of the Back River and is separated into 14 subwatersheds. Table 2-6 shows the stream mileage and density by subwatershed. Figure 2-10 shows the stream network and the 14 sub-watersheds. Because different scales were used for each county's digitized stream layer, these data should be interpreted with caution.

Table 2-6: Upper Back River Streams Mileage and Density

Subwatershed	County Stream Miles	City Stream Miles	Total Stream Miles	Stream Miles/Sq. Mile
Armistead Run	0.0	1.5	1.5	2.23
Biddison Run	0.0	3.1	3.1	2.53
Brien's	10.7	0.0	10.7	4.19
Chinquapin Run	0.0	4.9	5.0	1.93
East Branch Herring Run	9.3	2.3	11.6	2.77
Herring Run Mainstem	0.9	16.2	17.1	2.46
Lower Herring Run	13.5	0.0	13.5	5.41
Moore's Run	2.3	5.1	7.4	1.69
Northeast Creek	17.5	0.0	17.5	6.81
Redhouse Run	13.9	0.8	14.7	3.12
Stemmers Run	26.5	0.3	26.8	4.65
Tiffany Run	0.0	0.2	0.2	0.11
Unnamed Tributary	0.0	1.8	1.8	2.03
West Branch Herring Run	6.0	2.2	8.2	2.78
Total	**100.6**	**38.4**	**139.0**	**3.21**

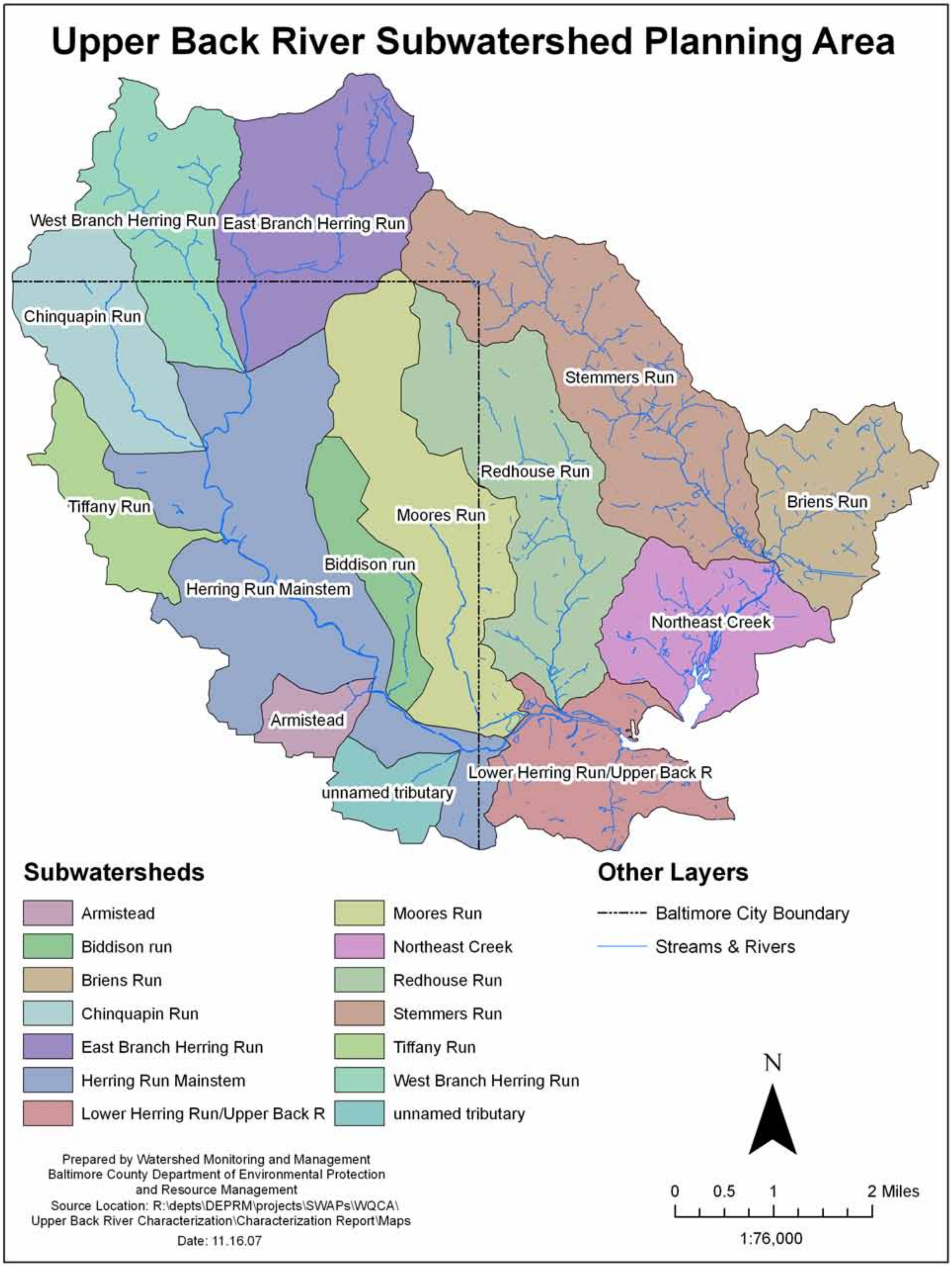


Figure 2-6. Upper Back River Watershed Stream Network & Subwatersheds

2.2.6.2 Stream Riparian Buffers

Forested buffer areas along streams play a crucial role in increasing water quality, reducing surface runoff, stabilizing stream banks, trapping sediment, mitigating floods, and providing the required habitat for all types of stream life, including fish. Tree roots capture and remove pollutants including excess nutrients from shallow flowing water, and their structure helps prevent erosion and slow down water flow, reducing sediment load and the risk of flooding. Shading from the tree canopy provides the cooler water temperatures necessary for much stream life, especially cold-water species like trout. In smaller streams such as those surveyed, terrestrial plant material falling into the stream is the primary source of plant food for stream life. Trees provide seasonal food in the form of leaves and plant parts for stream life at the base of the food chain, while fallen tree branches and trunks provide a more consistent, slow-release food source throughout the year. Tree roots and snags also provide important habitat for fish and other aquatic species. Maintaining healthy streams and forest buffers are important for reducing the nutrient and sediment loadings to the Chesapeake Bay. When stream buffers are converted from forests to agriculture or residential development, many of these benefits are lost, and the health of the stream declines.

The vegetative condition of the riparian buffer based on 100 feet of buffer on either side of the stream was analyzed by subwatershed. Three conditions were identified: forested, impervious or open previous. Table 2-7 and Figure 2-11 show the results of the buffer analysis.

Table 2-7: Land Use in the 100 Foot Riparian Buffer – Acres (%)

Subwatershed	Forested	Open Pervious	Impervious	Total
Armistead Run	14.3 (33)	24.3 (56)	4.6 (11)	**43.3 (2)**
Biddison Run	24.0 (54)	16.8 (38)	3.3 (8)	**44.1 (2)**
Brien's	60.0 (23)	179.7 (68)	22.7 (9)	**262.3 (9)**
Chinquapin Run	35.9 (42)	39.9 (47)	8.9 (11)	**84.6 (3)**
East Branch Herring Run	57.3 (20)	198.5 (68)	36.4 (12)	**292.2 (10)**
Herring Run Mainstem	110.0 (43)	129.0 (50)	17.2 (7)	**256.2 (8)**
Lower Herring Run	66.7 (24)	196.8 (72)	11.1 (4)	**274.6 (9)**
Moore's Run	42.3 (33)	75.5 (60)	9.3 (7)	**127.1 (4)**
Northeast Creek	77.6 (25)	222.2 (70)	15.7 (5)	**315.5 (11)**
Redhouse Run	70.8 (20)	264.1 (74)	22.5 (6)	**357.4 (12)**
Stemmers Run	150.7 (24)	444.0 (69)	45.3 (7)	**640.0 (22)**
Tiffany Run	1.0 (80)	0.3 (20)	0.0 (0)	**1.3 (0)**
Unnamed Tributary	7.1 (23)	18.7 (60)	5.3 (17)	**31.1 (1)**
West Branch Herring Run	48.0 (24)	138. (69)	13.9 (7)	**199.9 (7)**
Total	**765.7 (26)**	**1,947.9 (67)**	**216.1 (7)**	**2,929.7 (100)**

Although Tiffany Run shows the highest percentage of forested buffer area, the acreage is very small. Discounting Tiffany Run, the percentage of the riparian buffer that is forested ranges from a high of 54% (Biddison Run) to a low of 20% (East Branch Herring Run and Redhouse Run). The open pervious condition, covering 67% (1,948 acres) of the riparian buffer, represents potential opportunities for reforestation of the riparian buffer. Riparian buffer covered by impervious surfaces are less likely to be remediated, but may represent an opportunity to remove impervious cover and reforest the buffer.

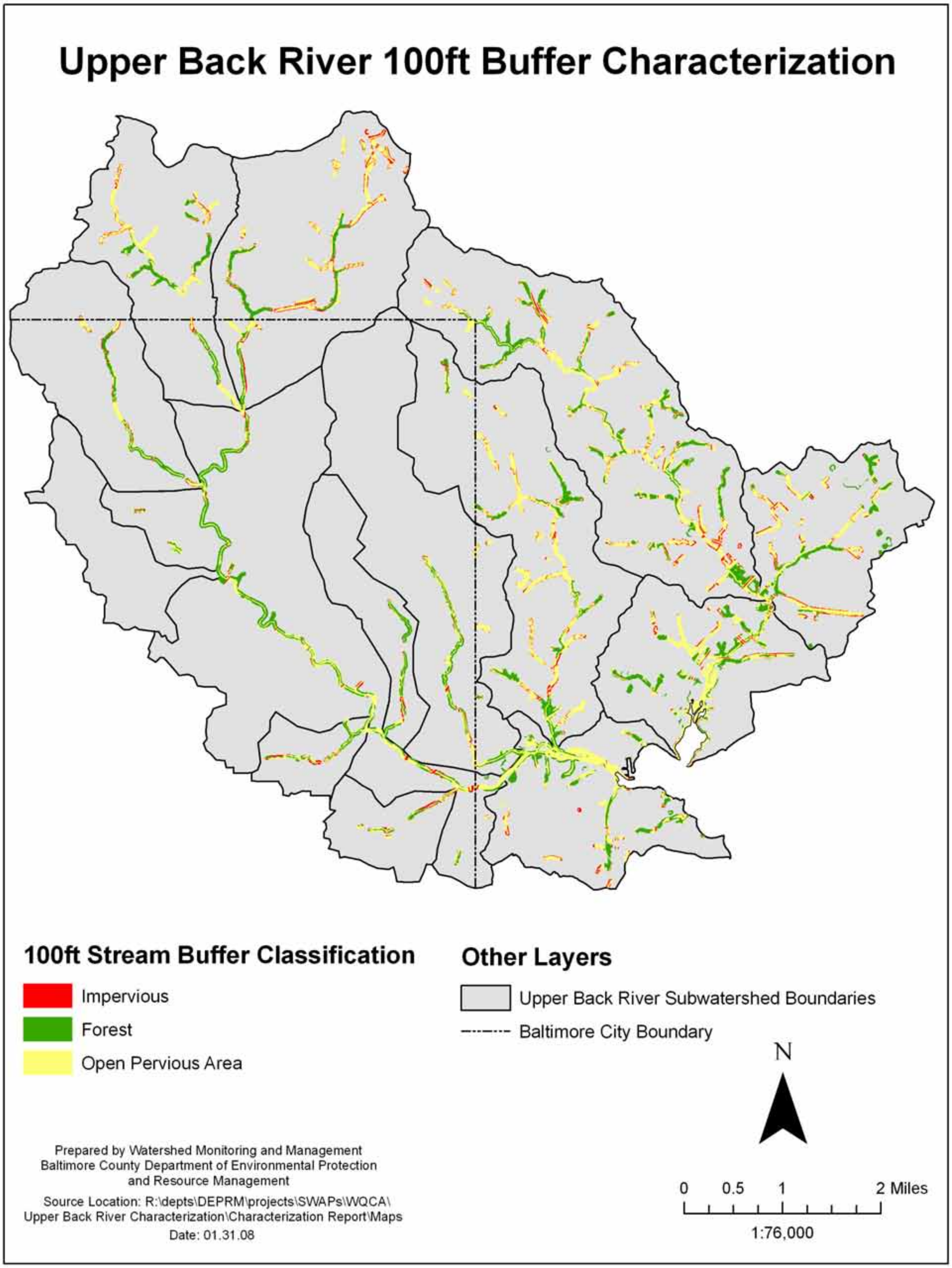


Figure 2-7. Upper Back River 100 ft. Riparian Buffer Condition

2.3 The Human Modified Landscape

The natural landscape has been modified for human use over time. The intensity of this modification has increased, starting with the colonization of Maryland in the 1600s. This modification has resulted in environmental impacts to both the terrestrial and aquatic ecosystems. This section will provide a characterization of the human modified landscape and how that modification is associated with impacts to the natural ecosystem. The characterization will progress from the general characteristics of land use and land cover to specific issues including population, impervious cover, drinking water and wastewater, storm water systems, discharge permits, zoning, and build-out analysis.

2.3.1 Land Use and Land Cover

The Upper Back River watershed has 27,717 acres of land. The dominating land use types are: urban/residential 9,248 acres (33%), forest 3,215 acres (12%) and institutional land 1,731 acres (6%).

Land use has pronounced impacts on water quality and habitat. A forested watershed absorbs nutrients and slows the flow of water into streams. Roads, parking areas, roofs and other human constructions are collectively called impervious surface. Impervious surfaces block the natural seepage of rain into the ground. Unlike many natural surfaces, impervious surfaces typically concentrate stormwater runoff, accelerate flow rates and direct stormwater to the nearest stream. This can cause bank erosion and destruction of in-stream and riparian habitat. Watersheds with small amounts of impervious surface tend to have better water quality in local streams than watersheds with greater amounts of impervious surface. Agricultural land, if not properly managed, can cause substantial increases in nutrients and coliform bacteria in streams.

The map of land use in the Lower Jones Falls watershed is summarized in Table 2-8 and presented in Figure 2-12. Additionally, the classifications for Baltimore County and Baltimore City were done separately, accounting for the apparent incongruity of land along the boundary line. The data are based on the Maryland Department of Planning (MDP) 2002 land use GIS data layer.

Table 2-8. Upper Back River Watershed Land Use

Subwatershed Scale	Armistead Run %	Biddison Run %	Brien's Run %	Chinquapin Run %	East Herring Run %	Herring Run Main %	Lower Herring Run %
Low Density Residential	0.0	0.0	3.7	0.0	0.0	0.0	0.0
Medium Density Residential	0.0	46	2.5	34.6	38.7	25.0	11.8
High Density Residential	25.5	19.2	36.4	43.9	29.0	25.4	8.6
Commercial	3.4	16.1	11.2	5.0	8.2	10.4	18.9
Industrial	57.5	0.9	18.5	0	0.7	2.5	22.6
Institutional	4.5	8.5	7.1	8.2	8.3	11.4	9.8
Extractive	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open Urban	3.4	0	1.2	1.2	8.3	12.1	6.3
Cropland	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pasture	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Deciduous Forest	3.9	6.0	16.9	6.4	6.4	8.8	8.8
Evergreen Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mixed Forest	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Brush	0.0	0.6	0.7	0.0	0.0	0.7	8.2
Water	0.0	0.0	0.0	0.0	0.0	1.5	0.8
Wetlands	0.0	0.0	0.0	0.0	0.0	0.0	4.2
Bare Ground	0.0	0.0	1.8	0.0	0.0	0.0	0.0
Transportation	2.2	2.6	0	0.7	0.4	2.1	0.0

Subwatershed Scale	Moore's Run %	Northeast Creek %	Redhouse Run %	Stemmers Run %	Tiffany Run %	Unnamed Tributary %	West Herring Run %	Totals
Low Density Residential	5.0	5.1	47.1	16.6	0.0	0.0	1.4	**8.5**
Medium Density Residential	48.8	26.7	21.2	19.4	18.9	0.0	37.5	**26.5**
High Density Residential	20.5	1.9	2.8	9.1	52.0	4.5	27.3	**20.4**
Commercial	9.4	7.5	7.7	10.9	3.9	29.8	7.1	**9.9**
Industrial	1.4	14.5	0.9	5.7	0.0	39.0	1.4	**6.5**
Institutional	2.7	3.2	7.8	4.7	20.7	19.9	7.7	**8.0**
Extractive	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Open Urban	1.8	2.6	2.9	10.6	0.4	4.3	11.2	**6.2**
Cropland	0.0	3.7	0.0	1.3	0.0	0.0	0.0	**0.4**
Pasture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Deciduous Forest	6.9	26.8	9.0	19.9	0.0	0.0	5.8	**10.5**
Evergreen Forest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Mixed Forest	0.0	0.0	0.0	0.6	0.0	0.0	0.0	**0.1**
Brush	1.0	3.5	0.2	0.4	0.0	0.0	0.0	**1.0**
Water	0.2	0.4	0.0	0.0	0.4	0.0	0.0	**0.3**
Wetlands	0.0	3.4	0.2	0.0	0.0	0.0	0.0	**0.5**
Bare Ground	0.0	0.7	0.2	0.7	0.7	0.0	0.0	**0.3**
Transportation	2.3	0.0	0.0	0.0	3.1	2.5	0.4	**0.9**

A limited amount of agriculture is still present in the Upper Back River planning area, located in the Northeast Creek and Stemmer's Run. Forest cover accounts for only 11.6% of the land use. This is indicative of the greater intensity of development in the Baltimore City urban core. Urban/suburban residential development accounts for 55% of the land use in Upper Back River

Watershed, with the majority (47%) in medium and high-density residential land use (<1 acre per dwelling unit).

Institutional land use, consisting mainly, but not exclusively of schools represents 6% of the land cover within the Upper Back River watershed. Many of these institutions are private universities and colleges, and represent an opportunity to initiate environmentally sensitive management of the grounds.

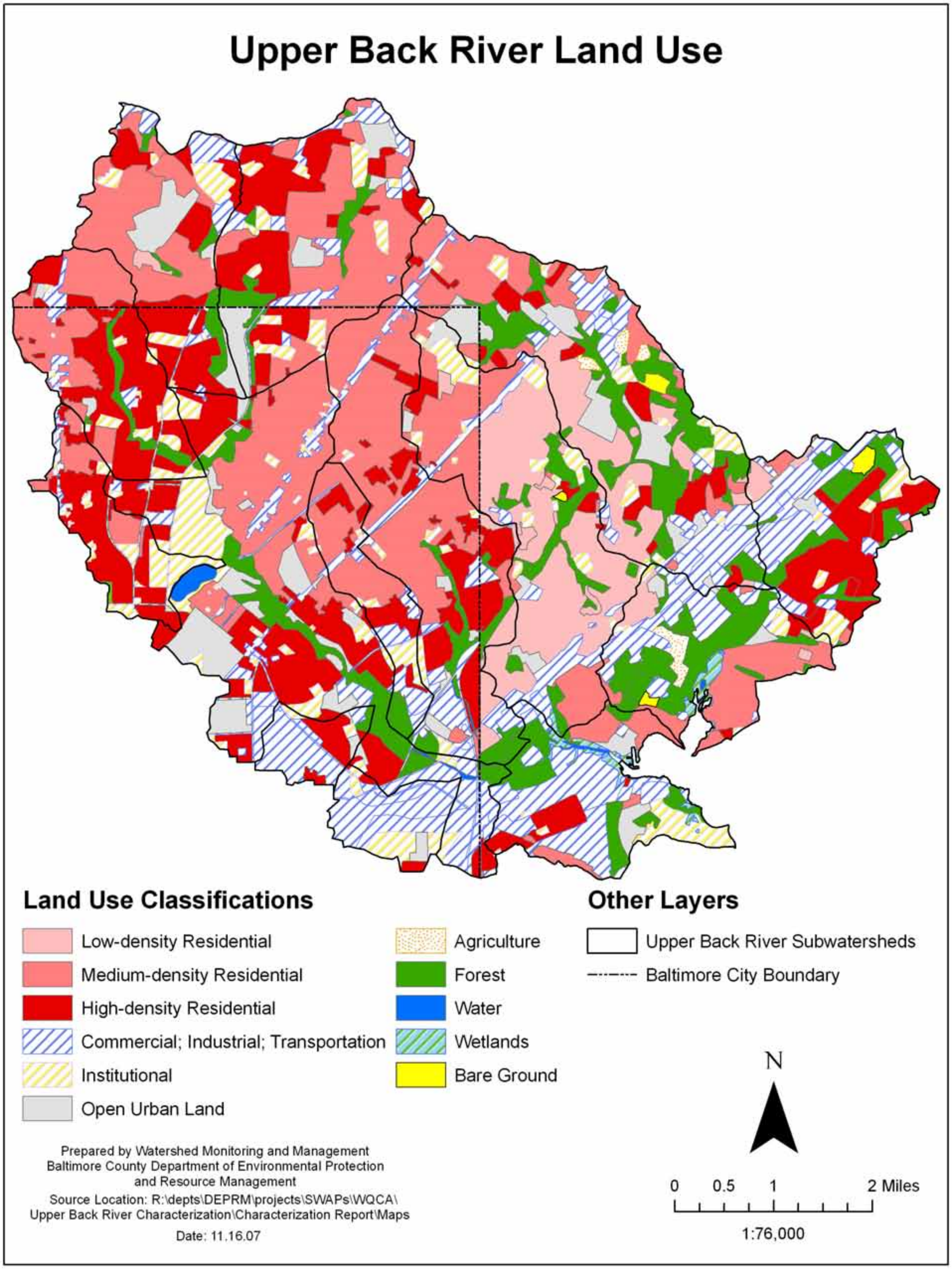


Figure 2-8. Land Use in the Upper Back River watershed.

2.3.2 Population

Population estimates based on the 2000 US census were used to evaluate the intensity of land use. A higher per acre population represents a more intense use of the land and potential for environmental degradation. However, smart growth principles are intended to direct future growth to areas of existing services, mainly where development has already occurred. This will result in less land conversion to residential and supporting commercial land uses and result in the conservation of lesser impacting land uses, such as, forest and agriculture.

Much of the degradation from urban/suburban land uses is related to the amount of impervious cover. Table 2-9 shows the subwatershed population sizes along with a calculation of the population density based on both the subwatershed acreage and the subwatershed impervious cover acreage. The population density distribution is displayed in Figure 2-9.

Table 2-9: Upper Back River Subwatershed Population Data

Subwatershed	Total Population (2000 census)	SWAP Area (acres)	Population Density (per acre)	Population Density (per impervious acre)
Armistead Run	1,796	416.2	4.32	11.56
Biddison Run	8,599	790.7	10.88	32.33
Brien's	8,926	1,636.1	5.46	19.20
Chinquapin Run	25,986	1,650	15.75	44.70
East Branch Herring Run	32,514	2,690.4	12.09	37.67
Herring Run Mainstem	58,164	4,321.2	13.25	37.48
Lower Herring Run	5,245	1,596.1	3.29	9.96
Moore's Run	30,407	2,797.7	10.87	31.81
Northeast Creek	4,288	1,643.9	2.61	11.95
Redhouse Run	21,268	3,020.4	7.04	28.03
Stemmers Run	18,888	3,681.6	5.13	20.43
Tiffany Run	16,009	893.8	17.91	44.25
Unnamed Tributary	1,266	580.30	2.18	6.28
West Branch Herring Run	17,755	1,879.7	9.45	33.37
Total	**251,661**	**27,716.9**	**9.08**	**29.60**

A general trend of increasing density from the northwestern subwatersheds to the southeastern subwatersheds is shown for both the population density per acre and the population density per acre of impervious cover. This is indicative of the historic growth from the city core eastward to the eastern suburban subwatersheds and the commercial/industrial land usage to the south.

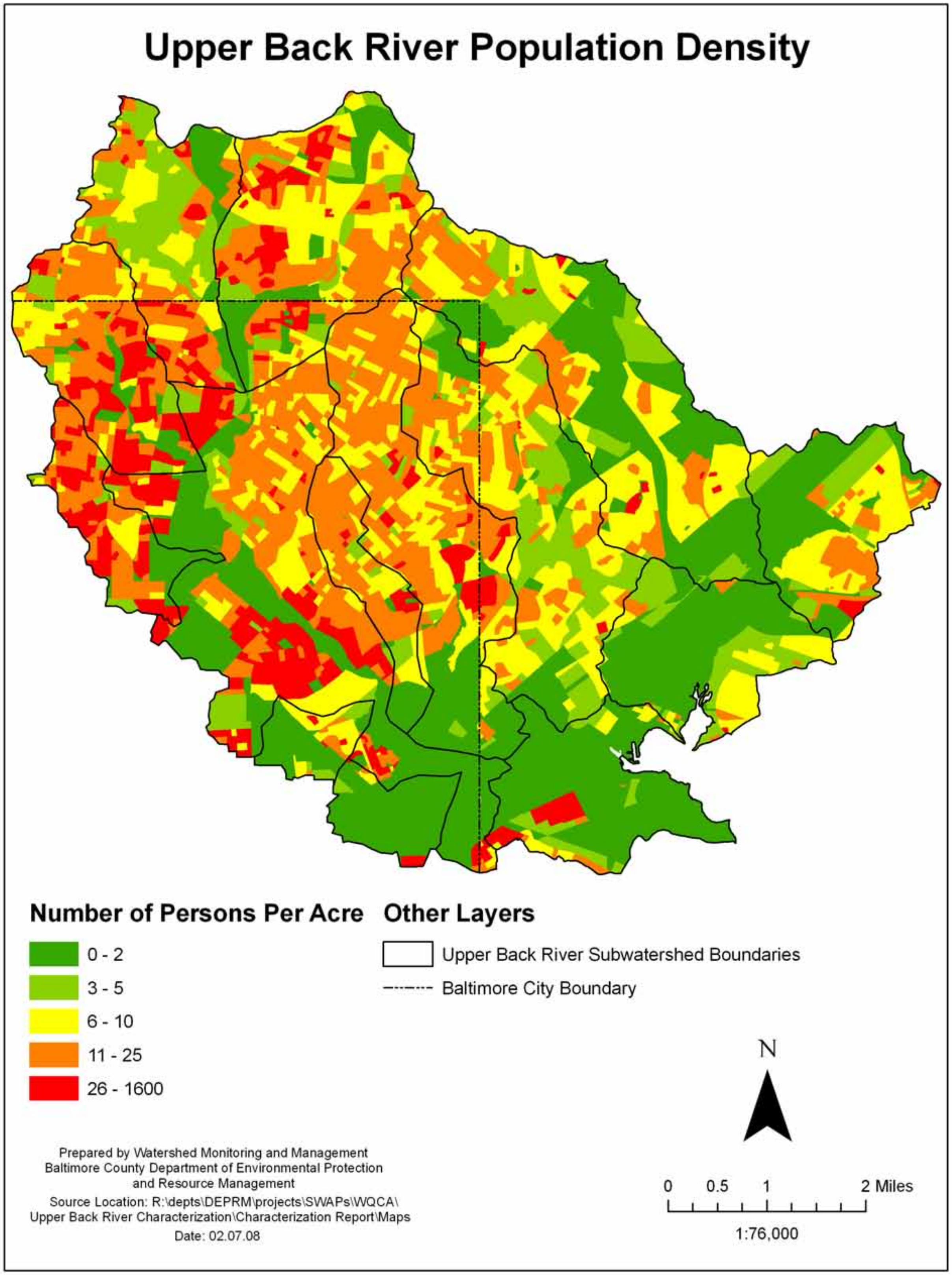


Figure 2-9 Population in the Upper Back River Watershed

2.3.3 Impervious Surfaces

Roads, parking areas, roofs and other human constructions are collectively called impervious surface. Impervious surface blocks the natural seepage of rain into the ground. Unlike many natural surfaces, impervious surface typically concentrates stormwater runoff, accelerates flow rates and directs stormwater to the nearest stream. This water has a high amount of energy and results in stream erosion that degrades habitat. Watersheds with small amounts of impervious surface tend to have better water quality in local streams than watersheds with greater amounts of impervious surface. Some aquatic species tend to disappear when the proportion of impervious area in the watershed reaches some threshold level. While this level varies by species, it can be quite low. The exact level of impervious area that can be tolerated depends partly on the watershed, and remains a topic of discussion among fisheries experts. Other species, e.g. macro-invertebrates, are also negatively impacted by increases in the impervious area, though the pertinent knowledge is often incomplete.

The Center for Watershed Protection has developed an impervious surface model to predict stream quality based on the amount of impervious cover in a drainage area. Stream quality can be a measure of the habitat, the biological community, or the chemical/physical characteristics of the stream. This model is shown graphically in Figure 2-10. The model would predict slight impact in drainage areas with less than 10% impervious cover. These watersheds would be sensitive in that an increase in impervious cover would result in degradation of stream quality. Watersheds that have an impervious cover between 10% and 25% are impacted and would show signs of degradation. The possibility exists to restore these streams to some semblance of a normally functioning stream. When the impervious cover exceeds 25% the streams are usually damaged with much of the stream either piped or channelized. Management of these streams may focus on the reduction of downstream impacts through pollutant load reduction, but the ability to return the stream to normal functions is remote. Once the impervious cover exceeds 60% in a watershed most of the natural stream system is gone. Again, restoration may focus on protecting downstream resources through pollutant load reduction. In both the damaged and severely damaged streams an additional restoration goal will be to make the remaining stream system aesthetically pleasing and an amenity to the community.

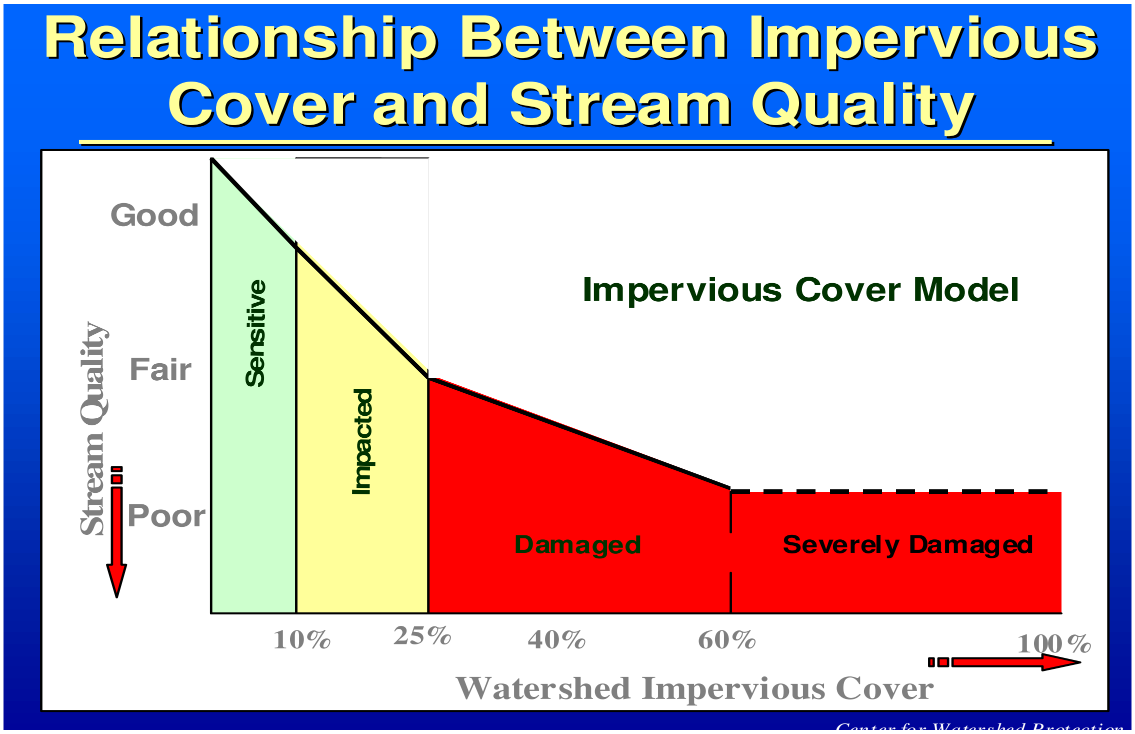


Figure 2-10. Impervious Cover Model

To derive estimates of impervious surface acreages in the Lower Jones Falls, the roads and building GIS data layers for the city and county were quantified and combined.

Table 2-10 shows the impervious cover and the calculated percent impervious by subwatershed for the Upper Back River watershed. The total amount of impervious surface in the watershed is estimated to be 8,503 acres or 30.7% of the watershed area. Compared to less urbanized watersheds in Baltimore County, this is a relatively high level of imperviousness.

Table 2-10. Estimated Impervious Surface in the Upper Back River

Subwatershed	Acres Car Habitat		Acres Buildings		% Impervious	
	City	County	City	County	City	County
Armistead Run	93.6	-	61.8	-	37.3	-
Biddison Run	171.0	-	95.0	-	33.6	-
Brien’s	-	277.1	-	187.7	-	28.4
Chinquapin Run	285.9	56.7	180.1	58.6	36.2	31.7
East Branch Herring Run	105.1	432.0	51.7	274.4	30.2	32.5
Herring Run Mainstem	919.0	28.0	590.4	14.3	34.9	38.4
Lower Herring Run	-	350.8	-	175.8	-	33.0
Moore’s Run	517.7	87.1	298.9	52.1	35.3	28.7
Northeast Creek	-	225.5	-	133.4	-	21.8
Redhouse Run	117.2	323.9	73.1	244.5	29.1	24.0
Stemmers Run	14.3	601.1	7.0	302.3	18.6	25.3
Tiffany Run	208.1	-	153.7	-	40.5	-
Unnamed Tributary	137.6	-	63.9	-	34.7	-
West Branch Herring Run	90.6	234.8	48.8	157.8	32.0	27.2
Total	**2,660.1**	**2,617**	**1,624.4**	**1,600.9**	**35.0**	**27.0**
Combined Total	***5,277.1***		***3,225.3***		***30.7***	

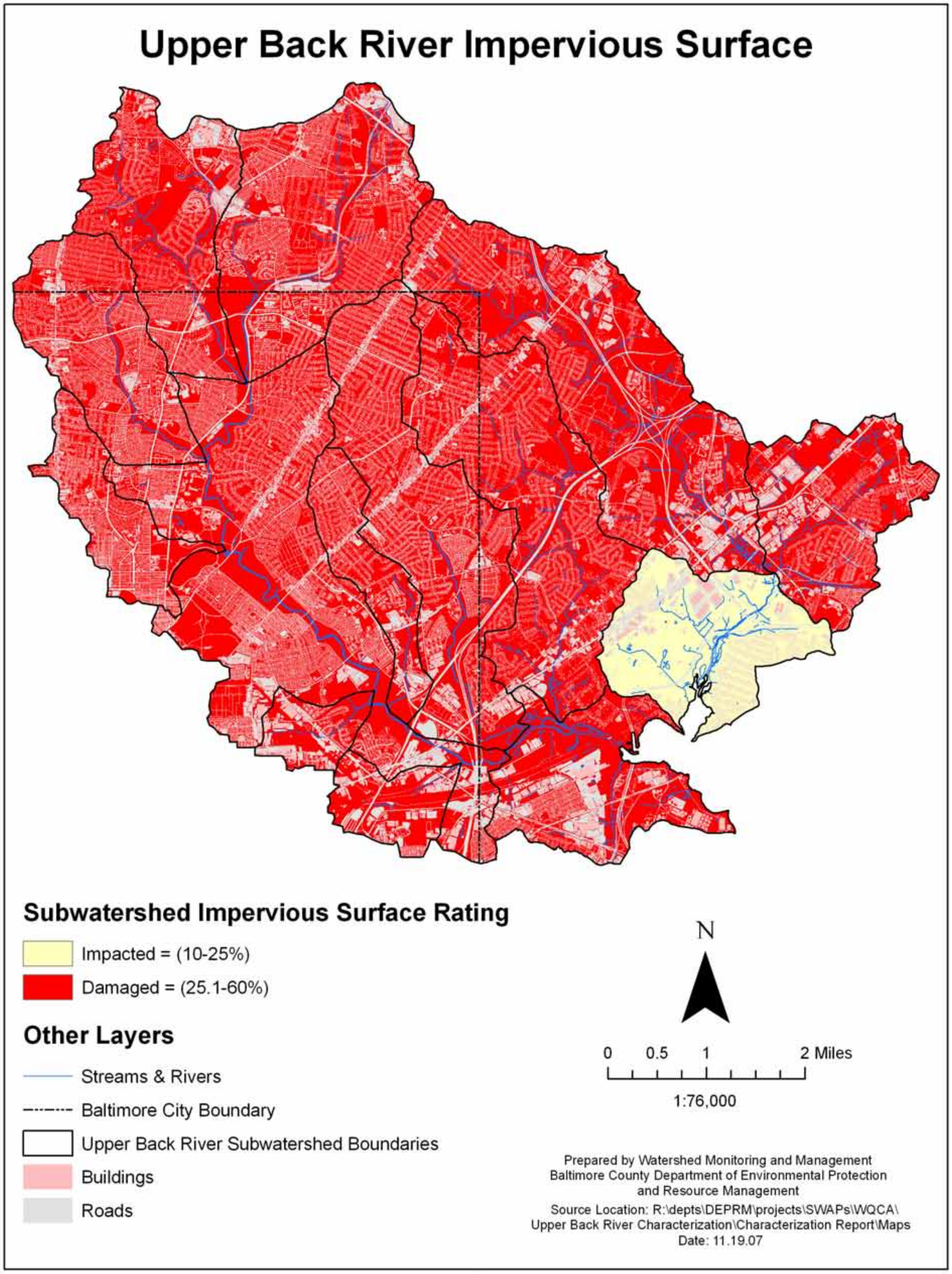


Figure 2-11. Impervious Cover Ratings by Subwatershed

2.3.4 Drinking Water

Drinking water is a fundamental need for human development. Drinking water can be supplied by either public distribution systems or by wells associated with individual developed properties. Having an adequate supply of drinking water is essential to maintaining the human population in a region. All of the development within the Upper Back River planning area is served by public water.

2.3.4.1 Public Water Supply

Environmental impacts associated with a public supply of water include the potential for increased residential development with the resulting impacts associated with impervious cover (see 2.3.2) and the potential for leaks from the system. Leaks from public water supply systems introduce chlorine into the aquatic system potentially resulting in the death of aquatic organisms. In addition, major leaks may cause erosion, which introduces sediment into the stream channels and which may bury aquatic benthic communities and degrade habitat.

2.3.5 Wastewater

Wastewater created through human use must be treated and disposed of. This may be accomplished in two ways, either through individual wastewater treatment systems (septic systems) or through public conveyance to a treatment facility. Residential wastewater consists of all of the water that is typically used by residents, including, wash water, bathing water, human waste deposal water, and any other rinse water (paint brush, floor washing, etc). Industrial operations must also dispose of any water used as part of their operation. Depending on the operation the water could contain any number of contaminants, including metals, organic compounds, detergents, or synthetic compounds. All of these wastes have the potential to harm the natural environment.

2.3.5.1 Septic Systems

Properly functioning septic systems provide treatment for virtually all of the phosphorus, but leak nitrogen in the form of nitrates. Depending on the location of the system the nitrates may either be reduced or eliminated through denitrification as the water passes through riparian buffers, particularly forested riparian buffers. Failing systems can result in increased contamination of the aquatic environment through increased releases of nitrogen, phosphorus, and other chemicals. They can also result in increased bacterial contamination of the waterways and potential for human health concerns.

2.3.5.2 Public Sewer

A public sewer system conveys wastewater from individual residences or businesses to a facility that treats the wastewater prior to discharge. The system itself consists of the piping system and cleanouts on the individual properties that are owned by the property owner. The individual landowner is responsible for the maintenance of this part of the system. The part of the system that is in the public right-of-way is owned and maintained by the local government. The public system consists of the gravity piping system, access manholes, pumping stations, and force mains. Tables 2-11 and 2-12 show sewer piping length and sewer piping length per square mile by subwatershed respectively.

Table 2-11: Sewer Piping Length

Subwatershed	Pressurized Main (ft)	Pressurized Main Abandoned (ft)	Gravity Main (ft)	Gravity Main Abandoned (ft)	House Connection (ft)	Total
Armistead Run	0	0	31,873	165	5,003	**37,040**
Biddison Run	0	0	113,391	4,433	50,198	**168,021**
Brien's	153	2,339	148,576	415	0	**151,484**
Chinquapin Run	276	0	253,149	2,244	114,173	**369,842**
East Branch Herring Run	0	3,307	326,031	3,100	15,558	**347,996**
Herring Run Mainstem	0	0	616,151	12,429	355,445	**984,024**
Lower Herring Run/UBR	32,213	6,965	101,274	2,625	0	**143,077**
Moore's Run	0	4,157	395,171	1,515	168,112	**568,955**
Northeast Creek	8,973	1,706	100,018	1,936	0	**112,633**
Redhouse Run	1,320	0	361,360	2,372	36,177	**401,229**
Stemmers Run	2,607	59	320,498	3,513	601	**327,278**
Tiffany Run	0	0	155,741	2,420	103,736	**261,897**
Unnamed Tributary	0	0	20,466	0	1,671	**22,137**
West Branch Herring Run	0	0	219,397	1,560	33,780	**254,737**
Total	**45,542**	**18,533**	**3,163,095**	**38,728**	**884,453**	**4,150,350**

Table 2-12: Sewer Piping Length Per Square Mile

Subwatershed	Pressurized Main (ft/mi^2)	Gravity Main (ft/mi^2)	House Connection (ft/mi^2)
Armistead Run	0	49,011	7,694
Biddison Run	0	174,364	77,190
Brien's	235	228,469	0
Chinquapin Run	424	389,273	175,566
East Branch Herring Run	0	501,345	23,924
Herring Run Mainstem	0	947,470	546,575
Lower Herring Run	49,535	155,731	0
Moore's Run	0	607,663	258,510
Northeast Creek	13,799	153,800	0
Redhouse Run	2,030	555,671	55,630
Stemmers Run	4008	492,837	925
Tiffany Run	0	239,486	159,518
Unnamed Tributary	0	31,470	2,570
West Branch Herring Run	0	337,371	51,944
Total	**70031**	**4863961**	**1360046**

Environmental impacts associated with the public sewer system are usually the result of sewage overflows. These overflows usually result from blockages within the sewage system, pumping station failure, or rainwater inflows exceeding the capacity of the pipe. The EPA reports there are at least 40,000 of these incidents per year. The environmental and human health consequences of these overflows can be serious. E. Coli bacteria and other pathogens can be present, posing health risks to individuals who may come in contact with contaminated water. Sewer overflows can also contain high levels of nitrogen and phosphorus that are toxic to aquatic life and feed organisms that deplete oxygen in waterways. High levels of sediment are also present in these overflows, which can clog streams and block sunlight from reaching essential aquatic plants.

2.3.5.3 Waste Water Treatment Facilities

There are no wastewater treatment facilities in the Upper Back River subwatershed. The Back River waste water treatment plant is located on the tidal waters of the Back River and is just South of the study area.

2.3.6 Stormwater

Stormwater consists of the surface and shallow subsurface water that runoffs during and immediately after storm events. As indicated above, impervious surfaces increase the amount of runoff that makes its way to the streams. Soil characteristics and slope also affect the amount of water that runs off, as well as the amount and intensity of rainfall. Stormwater can carry pollutants from impervious surfaces and agricultural operations into the streams. The increase in the amount of runoff due to impervious surfaces (high) and agricultural operations (moderate) can result in stream erosion that destroys natural habitat and the ecosystem services of streams such as nutrient reduction.

2.3.6.1 Storm Drainage System

The storm drainage system consists of either curb and gutter with associated inlets and piping system or drainage swales. The function of either system is to remove water quickly from roadways to prevent flooding and potentially hazardous situations. However, the environmental impact from the two types of systems is different. The curb and gutter system with inlets, piping and storm drain outfalls quickly and efficiently removes water from impervious surfaces and routes that water to low spots in the topography, usually directly to the stream. This type of system delivers not only increased volumes of water, but untreated pollutants associated with impervious surfaces. Drainage swales (road side ditches) do not move the water as efficiently as curb and gutter systems and therefore the water is slowed somewhat prior to entering the stream. The drainage swales also allow some infiltration into the soil thus reducing the amount of water eventually delivered. The infiltration and the slower movement of water also provide filtering of pollutants. Table 2-13 shows the components of the storm drain system by subwatershed in Upper Back River.

Table 2-13. Upper Back River Storm Drain System

Subwatershed	Storm Drain Outfalls (#)	Storm Drain Inlets (#)	Strom Drain Piping (ft)
Armistead Run	27	164	27,601
Biddison Run	39	717	89,483
Brien's	42	142	50,146
Chinquapin Run	56	1,347	165,854
East Branch Herring Run	75	661	181,065
Herring Run Mainstem	116	3,542	403,218
Lower Herring Run	9	49	35,028
Moore's Run	58	1,678	218,585
Northeast Creek	21	96	43,616
Redhouse Run	75	674	143,725
Stemmers Run	69	409	136,360
Tiffany Run	4	1,137	122,748
Unnamed Tributary	18	128	20,968

West Branch Herring Run	65	536	88,135
Total	**674**	**11280**	**1726,532**

2.3.6.2 Stormwater Management Facilities

Starting in the mid-1980s stormwater management was required by Maryland Department of the Environment for new development to control the quantity of runoff. Within that set of regulations was an exemption for large lot subdivisions (>2 acres). Large lot subdivisions only had to provide stormwater management for roads. The stormwater management regulations evolved from the initial requirement of water quantity control to including water quality control in the early 1990s; and in 2000 a new stormwater design manual was released by Maryland Department of the Environment requiring additional water quality and quantity controls along with stormwater management for large lot subdivisions.

There are a variety of types of stormwater management facilities that have different pollutant removal capabilities. The initial dry pond design for water quantity management has the lowest pollutant removal efficiency, while those facilities that infiltrate or filter the water have among the highest pollutant removal capabilities.

The following Figure 2-12 and Table 2-14 illustrate the stormwater management facilities in the Baltimore County portion of the Upper Back River watershed. Figure 2-12 shows that the stormwater management facilities are fairly well scattered throughout the county portion of the watershed. A total of 50 facilities are represented. The facility type and drainage area to the facility are listed by subwatershed in Table 2-14.

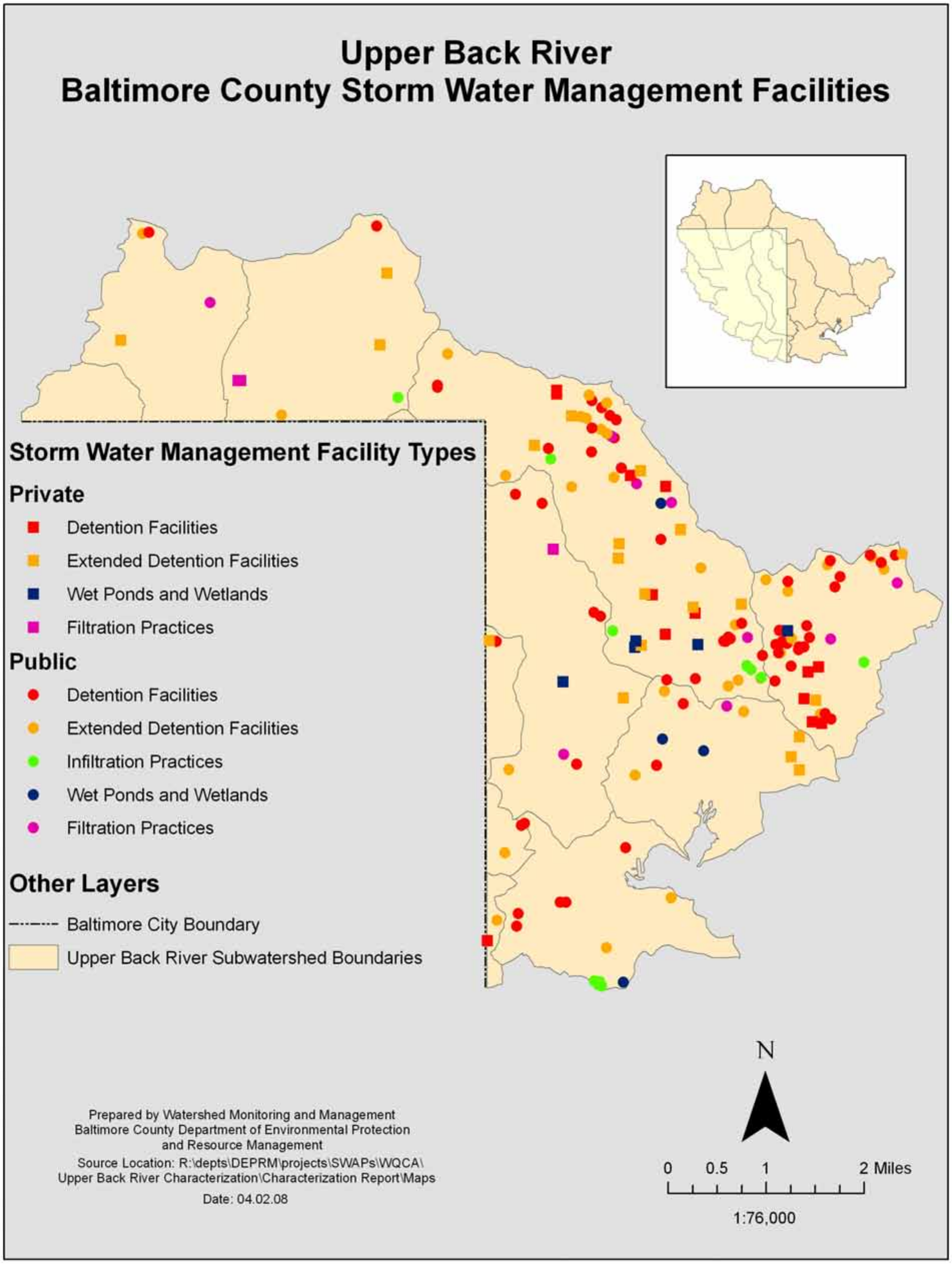


Figure 2-12. Stormwater Management

Table 2-14. Upper Back River Stormwater Management Facilities (County)

Subwatershed	**Armistead Run**	**Biddison Run**	**Brien's Run**	**Chinquapin Run**	**East Herring Run**	**Herring Run Main**	**Lower Herring Run**
Dry Pond Hydro (#) Drainage Area (acres)	0 0.0	0 0.0	30 155.5	0 0.0	1 2.1	1 6.5	7 17.8
Wet Ponds (#) Drainage Area (acres)	0 0.0	0 0.0	1 155.5	0 0.0	0 0.0	0 0.0	1 5.9
Infiltration (#) Drainage Area (acres)	0 0.0	0 0.0	1 1.0	0 0.0	1 0.8	0 0.0	6 5.1
Filtration (#) Drainage Area (acres)	0 0.0	0 0.0	2 5.3	0 0.0	2 5.3	0 0.0	0 0.0
Extended Detention (#) Drainage Area (acres)	0 0.0	0 0.0	9 82.4	0 0.0	3 12.5	1 3.8	2 32.8
Other (#) Drainage Area (acres)	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
TOTAL (#) ***TOTAL (acres)***	0 0.0	0 0.0	43 399.7	0 0.0	7 20.6	2 10.3	16 61.6

Subwatershed	**Moore's Run**	**Northeast Creek**	**Redhouse Run**	**Stemmers Run**	**Tiffany Run**	**Unnamed Tributary**	**West Herring Run**	**Totals**
Dry Pond Hydro (#) Drainage Area (acres)	1 2.9	4 21.8	5 68.3	27 205..8	0 0.0	0 0.0	1 0.8	***77*** ***481.5***
Wet Ponds (#) Drainage Area (acres)	0 0.0	2 86.5	1 -	4 263.2	0 0.0	0 0.0	0 0.0	***9*** ***511.1***
Infiltration (#) Drainage Area (acres)	0 0.0	0 0.0	0 0.0	5 8.1	0 0.0	0 0.0	0 0.0	***13*** ***15***
Filtration (#) Drainage Area (acres)	0 0.0	1 1.7	2 8.6	4 20.5	0 0.0	0 0.0	1 2.2	***12*** ***43.6***
Extended Detention (#) Drainage Area (acres)	2 23.6	7 62.2	2 31.5	24 165.5	0 0.0	0 0.0	2 8.8	***52*** ***423.1***
Other (#) Drainage Area (acres)	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	***0*** ***0.0***
TOTAL (#) ***TOTAL (acres)***	3 26.5	14 172.2	10 108.5	64 663.1	0 0.0	0 0.0	4 11.8	***163*** ***1474.3***

Table 2-14 reveals that the dry detention structures are the best-represented storm water management design in terms of number of facilities. Being that these structures have the lowest pollution removal efficiency, they present the best opportunities for conversion to a more efficient design.

Table 2-15 shows the percentage of urban land use areas in the county portion of the Upper Back River that are treated by stormwater management.

Table 2-15. Upper Back River County Urban Areas Treated by SWM

Subwatershed	Total County Acres	Urban Land Use Acres	Acres Treated by SWM	County Urban Land Use Treated by SWM (%)
Armistead Run	NA			
Biddison Run	NA			
Brien's	1,636	1,317	400	30
Chinquapin Run	364	364	0	0
East Branch Herring Run	2172	2,028	21	1
Herring Run Mainstem	110	78	10	13
Lower Herring Run	1,596	1,242	62	5
Moore's Run	486	376	27	7
Northeast Creek	1,644	1,011	172	17
Redhouse Run	2,367	2,074	109	5
Stemmers Run	3,576	2,733	663	24
Tiffany Run	NA			
Unnamed Tributary	NA			
West Branch Herring Run	1,444	1,392	11.8	1
Total	**15395**	**12,615**	**1475.8**	**102**

2.3.7 NPDES Permits

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. Table 2-16 shows the number of NPDES permits in each of the six subwatersheds in the Lower Jones Falls. Many of these (15) are for commercial swimming pool discharges.

Table 2-16: NPDES Permits in the Upper Back River Watershed

Subwatershed	# Industrial	#General	# Pools	# Of Permits
Armistead Run	4	1	0	5
Biddison Run	2	0	0	2
Brien's	3	1	1	5
Chinquapin Run	0	0	0	0
East Branch Herring Run	2	2	3	7
Herring Run Mainstem	8	1	2	11
Lower Herring Run	5	0	0	5
Moore's Run	2	1	1	4
Northeast Creek	3	1	1	5
Redhouse Run	0	1	1	2
Stemmers Run	6	0	5	11
Tiffany Run	0	1	2	3
Unnamed Tributary	12	0	0	12
West Branch Herring Run	0	0	5	5
Total	**47**	**9**	**21**	**77**

2.3.8 Zoning

"Zoning is the legal mechanism by which county government is able, for the sake of protecting the public health, safety, morals, and/or general welfare, to limit an owner's right to use privately-owned land." (Baltimore County Office of Planning, 2003). Zoning therefore controls the development patterns that are observed over time. The county and city have independently developed the zoning codes that are in place in the Lower Jones Falls watershed. The current zoning is displayed in Figure 2-13. As can be seen from this figure, there are a wide variety of zoning types; however, the majority fall into one of the residential zoning types. Tables 2-17 and 2-18 show county and city zoning data respectively. Table 2-19 shows the city and county data combined, matching the different zoning types as best as possible.

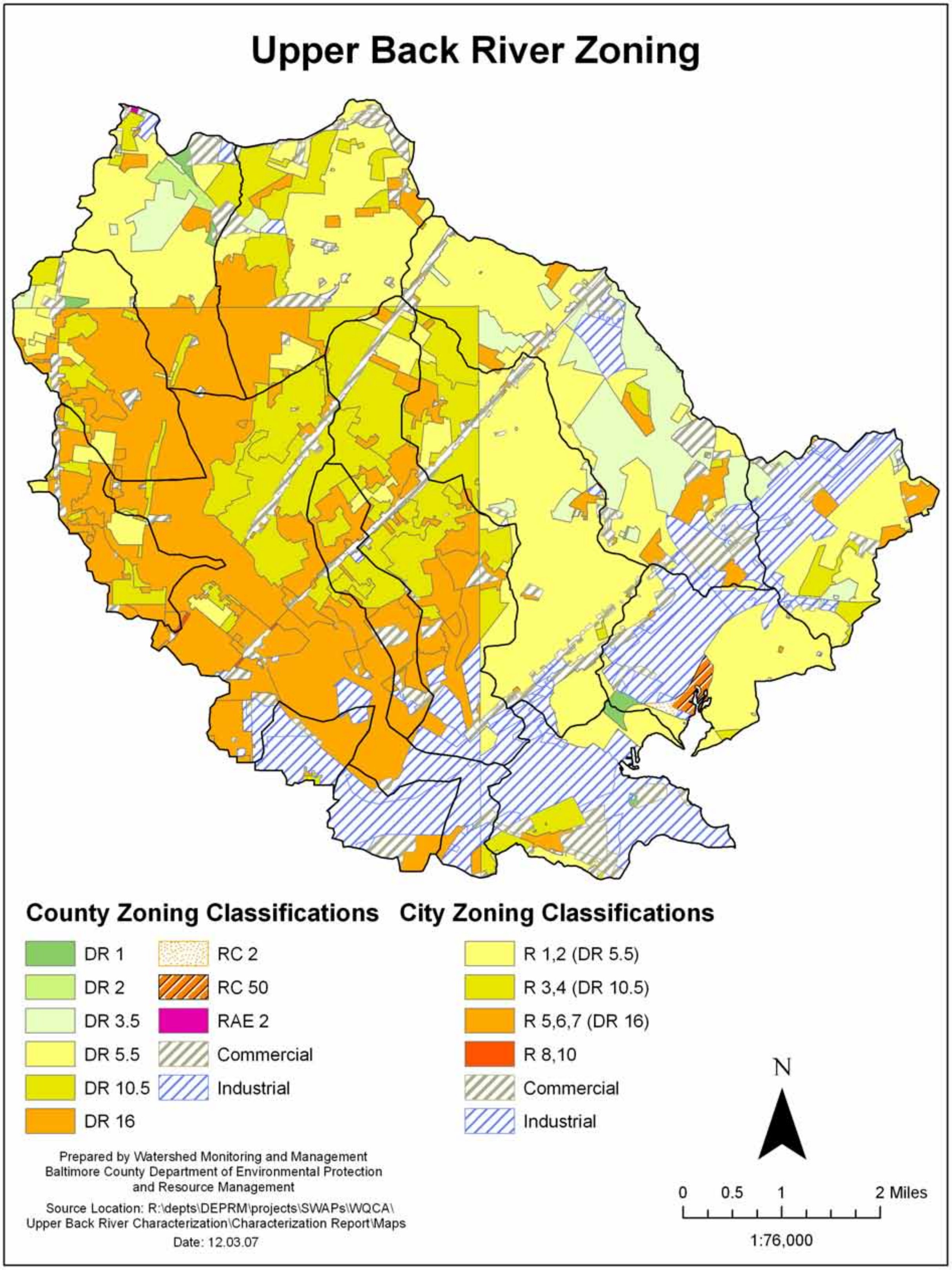


Figure 2-13. Zoning in the Upper Back River watershed

Table 2-17: Upper Back River County Zoning

Zoning Code (county)	Zoning Description	Allowed Units/Acre	Total (acres)	Total (%)
RC-5	Rural Residential	-	0.0	0.0
RC-6	Rural Conservation/Residential	-	0.0	0.0
RC-7	Resource Preservation	-	0.0	0.0
RC-50	Resource Conservation Critical Area		64.4	0.4
DR-1	Density Residential	1	93.7	0.6
DR-2	Density Residential	2	81.0	0.5
DR-3.5	Density Residential	3.5	1,458.7	9.5
DR-5.5	Density Residential	5.5	7,334.3	47.7
DR-10.5	Density Residential	10.5	1,058.9	6.9
DR-16	Density Residential	16	848.2	5.5
RAE-1	Residential Apartment	40	0.0	0.0
RAE-2	Residential Apartment	80	0.0	0.0
Commercial	Offices/Businesses	-	1,476.2	9.6
Manufacturing	Industrial	-	2,958.4	19.2
Total			**15,373.8**	**100**

Table 2-18: Upper Back River City Zoning

Zoning Code (city)	Zoning Description	Allowable Single-Family Detached Units/Acre	Allowable Single Family Semi-Detached Units /Acre	Allowable Mulit-Family Units/Acre	Allowable Single Family Attahced Units/Acre	Total (acres)	Total (%)
R-1B	Single Family Residential	2	-	-	-	0.0	2.0
R-1A	Single Family Residential	3	-	-	-	0.0	0.0
R-1	Single Family Residential	5.9	-	-	-	570.4	29.6
R-2	General Residential	5.9	5.9	5.9	-	38.1	1.7
R-3	Single Family Residential	8.7	-	-	-	2,037.3	1.8
R-4	General Residential	5.9	8.7	8.7	-	1,283.1	0.8
R-5	General Residential	5.9	14.5	17.4	17.4	3,961.5	13.3
R-6	General Residential	5.9	14.5	29	29	1,839.8	8.9
R-7	General Residential	5.9	17.4	39.6	39.6	498.4	11.9
R-8	General Residential	5.9	21.7	58	58	11.2	7.5
R-9	General Residential	5.9	21.7	79.2	58	0.0	3.3
R-10	General Residential	5.9	21.7	217.8	58	0.6	0.6
Commercial	Offices/Businesses	-	-	-	-	695.2	11.3
Manufacturing	Industrial	-	-	-	-	1,367.6	7.3
Total						**12,303.0**	**100.0**

Table 2-19: Upper Back River Zoning Combined

Zoning Code (county)	Zoning Code (city)	Zoning Description	Total (acres)	Total (%)
RC-50	-	Resource Conservation Critical Area	64.4	0.2
RC-7	-	Resource Preservation	0.0	0.0
DR-1	-	Density Residential	93.7	0.3
DR-2	R-1B	Density Residential	81.0	0.3
DR-3.5	-	Density Residential	1,458.7	5.3
DR-5.5	R-1, 2	Density Residential	7,942.9	28.7
DR-10.5	R-3, 4	Density Residential	4,379.3	15.8
DR-16	R-5, 6, 7	Density Residential	7,147.8	25.8
RAE-1	R-8, 9, 10	General residence	11.7	0.1
Commercial	Commercial	Offices/Businesses	2,171.4	7.8
Manufacturing	Manufacturing	Industrial	4,326.0	15.6
Total			**27,676.9**	**100**

The Upper Back River watershed has 21,116 acres of residentially zoned area, the predominant assessment class at 76% of the watershed area. There is a fair amount (24%) of commercial and manufacturing totaling 6,497 acres throughout the Upper Back River watershed. Resource preservation or RC-50 zoning accounts for less than 1% of the land area in the watershed. As shown in Figure 2-13, the RC-50 zoned land is in the Northeast Creek subwatershed at the mouth of the creek where it enters Back River. Note there is no land within the watershed boundaries zoned for agriculture (RC-2), watershed protection (RC-4) or environmental enhancement (RC-8).

CHAPTER 3

WATER QUALITY, LIVING RESOURCES AND HABITAT

3.1 Introduction

In addition to water quality maintenance and improvement, the Small Watershed Action Plan or SWAP program aims to provide for plants, animals, and their habitat. Natural communities require many habitat characteristics for survival. Among these are land, water, and biological conditions within ranges that provide for their needs for food, water, shelter, and reproduction. In this chapter, we will characterize the water quality, living resources and habitat of the Upper Back River watershed based on existing data.

Water is an integral part of the habitat of all species. Living resources, including all animals and plants, require water to survive. They and their habitats are intimately connected to water quality and availability. Living resources respond to changes in water and habitat conditions in ways that help us interpret the status of water bodies and the effects of watershed conditions. In some cases, water quality is measured in terms of its ability to support specific living resources like trout or shellfish. Information on living resources is presented here both to provide a gauge of water quality and to evaluate habitat conditions in the watershed. This information can help to determine if current watershed management practices are adequately providing for the needs of natural communities.

3.2 Water Quality Monitoring Data

Both Baltimore County and Baltimore City conduct chemical, biological, and illicit connection monitoring within the Upper Back River planning area. Section 3.2.1 summarizes the chemical monitoring programs for both the City and the County, section 3.2.2 summarizes the biological monitoring programs, and section 3.3.3 summarizes the Illicit Connection Program. Section 3.3.4 summarizes the results by subwatershed.

3.2.1 Chemical Data

The chemical monitoring programs of both Baltimore City and Baltimore County are mandated in part by their respective National Pollutant Discharge Elimination Program (NPDES) – Municipal Separate Storm Sewer System discharge permits. The permits require assessment of ambient water conditions, but do not specify the methodology. Figure 3-1 displays the locations of the City and County chemical monitoring. The Herring Run Watershed Association conducts an annual synoptic survey within the Back River watershed. The location of these sites are also displayed in Figure 3-1.

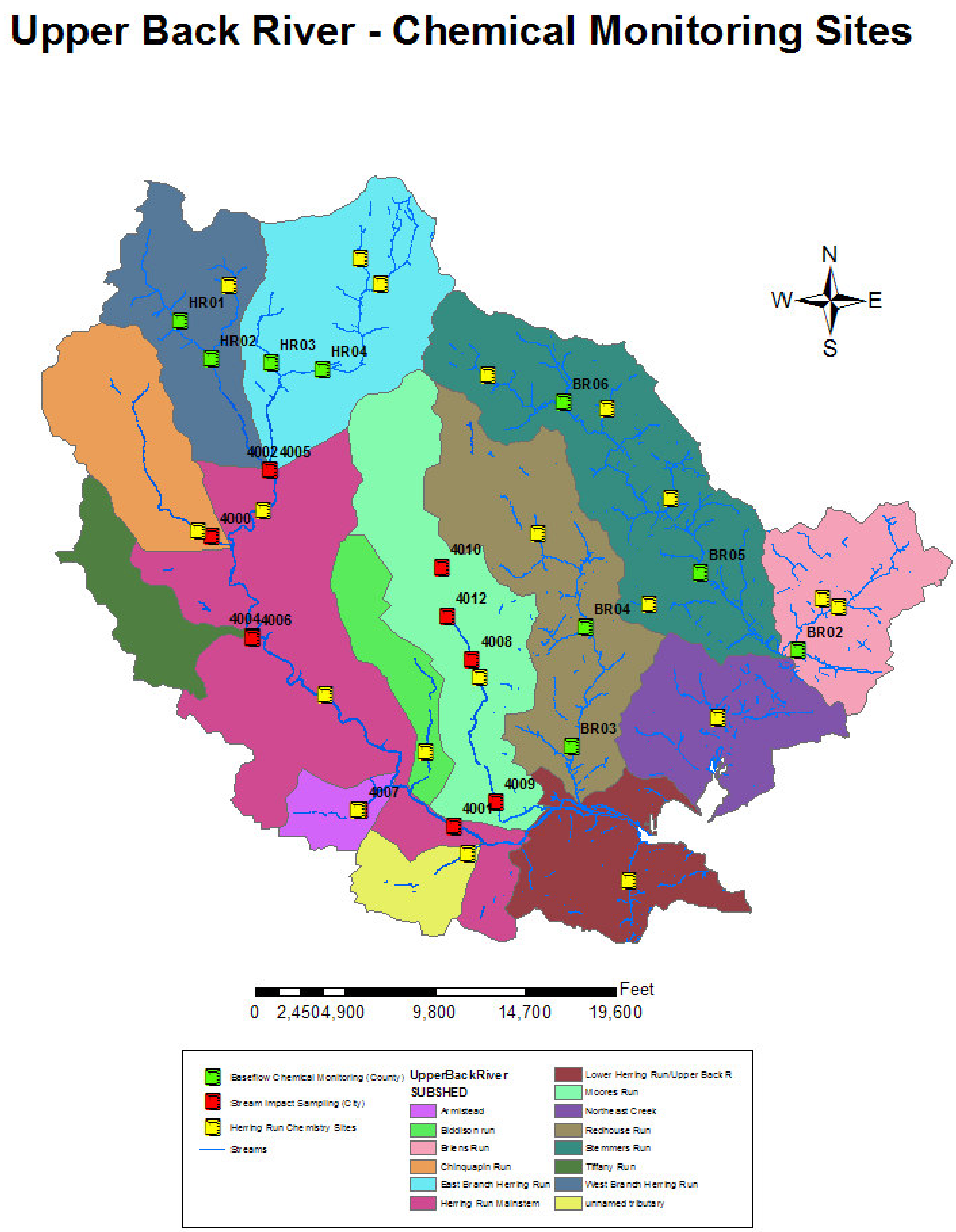


Figure 3-1. Chemical Monitoring in the Upper Back River Watershed

This section details water quality sampling data by subwatershed for a number of key parameters from the City and County's monitoring programs. The subwatershed location for each monitoring site is indicated using subwatershed abbreviations provided in Table 3-1. Key parameters were evaluated because of their importance to Total Maximum Daily Loads (TMDLs) and Bay Program Tributary Strategy goals.

Table 3-1: Upper Back River Planning Area Subwatershed Abbreviations

Subwatershed	Subwatershed Abbreviation
Armistead Run	AR
Biddison Run	BR
Back River Mainstem	BM
Chinquapin Run	CR
Herring Run Mainstem	HR
Moores Run	MR
Northeast Creek	NC
Brien Run	OR
Redhouse Run	RR
Stemmers Run	SR
Tiffany Run	TR
Unnamed Tributary	UT

Chloride in particular is reported because it is linked to chronic toxicity in urban streams and both Jones Falls and Herring Run watersheds are 303(d) listed for biological impairment. The chronic aquatic life criterion for chloride is 230 mg/l and the acute toxicity limit is 860 mg/l (USEPA, 1988).

Total nitrogen, total phosphorus and sediment were evaluated because the watersheds are 303(d) listed for nutrient and sediment impairment and these are key Chesapeake Bay Program parameters as well. Table 3-2 shows stream ratings based on total nitrogen concentration data adapted from the Maryland Department of Natural Resources (2005), who based their ratings on loading coefficients reported by Frink (1991). Total phosphorus ratings in Table 3-2 were developed by evaluating non-tidal phosphorus data from the Chesapeake Bay Program (USGS, 1999, Figure 1). Sediment moves primarily during storm events and thus elevated concentrations of sediment were not found in these baseflow samples.

Table 3-2: 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

Fecal coliform concentrations were reported due to listings for bacterial impairment. These concentrations are an important factor in water contact recreation considerations. The standard for contact recreation is 200 colonies/100ml and 576colonies/100ml is the standard for infrequent contact recreation according to USEPA (COMAR, 2005).

3.2.1.1 Baltimore City Data

In 1997, Baltimore City initiated a water quality sampling program called Stream Impact Sampling (SIS). The purpose of the program is to monitor trends in stream water quality over time. This program collects dry weather water quality samples once a month from thirty-six stations. The samples are analyzed at a lab for fifteen parameters including nitrogen, phosphorus, metals and fecal coliform (City of Baltimore, 2006). The maximum, minimum, and median values for the sites located within the Upper Back River planning area are displayed in Table 3-3.

Table 3-3: Upper Back River Watershed – Baltimore City Water Quality Data

Parameter (mg/l)		**Site**										
		4000*	4001*	4002*	4004*	4005*	4006*	4007*	4008**	4009*	4010**	4012**
		1997-2006	1997-2007	1997-2007	1997-2007	1997-2006	1997-2006	1995-2007	1995-2007	1997-2006	1995-2006	1995-2006
Subwatershed		CR	HR	HR	HR	HR	HR	AR	MR	MR	MR	MR
Chloride	Max	1870.0	312.0	1930.0	1360.0	1840.0	N/A	472.0	440.0	1231.0	1050.0	925.0
	Min	10.6	20.8	13.0	15.2	13.0	N/A	15.0	16.5	16.0	0.0	20.0
	Median	68.8	45.0	73.0	58.3	71.3	N/A	90.0	46.3	64.4	55.0	68.0
Total Nitrogen	Max	8.70	14.90	7.50	20.00	6.09	51.90	92.70	11.80	4.60	15.36	27.40
	Min	0.56	1.17	0.68	0.78	0.48	0.72	0.11	0.63	0.07	0.74	0.82
	Median	2.72	2.59	2.37	1.98	1.81	1.89	1.69	2.48	1.82	2.95	3.77
Suspended Solids	Max	49.00	58.00	31.00	19.00	52.00	47.00	290.00	0.05	224.00	240.00	49.00
	Min	0.00	0.50	0.50	0.50	0.50	1.00	0.06	52.00	0.80	0.60	0.80
	Median	2.00	2.65	2.00	2.00	2.10	4.00	5.70	2.90	6.00	4.20	3.35
Total Phosphorus	Max	0.469	0.556	0.889	1.382	0.267	0.388	0.29	1.8	0.374	1.26	2
	Min	0.0034	0.0034	0.0034	0.0034	0.0034	0.003	0.0034	0.0043	0.0034	0.0034	0.0043
	Median	0.06	0.044	0.05	0.06	0.054	0.031	0.0645	0.06	0.09	0.09	0.08
Total Coliform (colonies/100ml)	Median	750	5000	5000	7000	5000	3000	11,000	12,000	22,000	50,000	23,000
	75^{th} percentile	5,000	17,000	17,000	20,500	19,500	8,000	30,000	40,000	82,500	130,000	70,000

N/A = Data not available
* Samples taken as dry weather grab samples as part of Stream Impact Sampling (SIS).
** Samples taken as dry weather grab samples. Stations either part of long-term NPDES permit or Stony Run restoration.

The Baltimore City water quality data set is reported from 1995 to 2007. There are no reported elevated levels of median chloride though there are maximums that exceed both the chronic and acute levels of toxicity. Six sites show moderate or high median levels of total nitrogen. These six values are reported at 2.72, 2.59, 2.37, 2.48, 2.95 and 3.77 for sites Chinquapin Run (4000), the Herring Run Mainstem (4001-4002) and Moores Run 4008, 4010 and 4012 respectively. Also of note, are very high maximum concentrations for total nitrogen, likely indicative of sewage in Armistead Run, Moores Run and the mainstem of Herring Run, which is estimated to be in the range of 25 to 100 mg/l before dilution (EPA, 1980; Horsley & Witten, Inc., 2000; EPA, 2002). Three sites have moderate median levels of total phosphorus. These three values are reported at 0.080, 0.090 and 0.090 for Moores Run sites 4010, 4012 and 4009 respectively. There are no reported excessive levels of median suspended solids.

All the total coliform concentrations are very elevated considering the majority of the data is from baseflow conditions.

3.2.1.2 Baltimore County Data

The Baltimore County baseflow monitoring program was initiated in 1999. The initial effort targeted watersheds that were undergoing or about to undergo the preparation of a Water Quality Management Plan. The targeted watersheds included the Lower Gunpowder, the Little Gunpowder, the Middle River and the Baltimore Harbor watershed. In the fall of 2000, the baseflow monitoring shifted to the Back River, Jones Falls and Gwynns Falls watersheds. The shift was intended to address the lack of chemical monitoring information available for these three watersheds. These watersheds were monitored until the spring of 2001 when staffing levels curtailed the continuance of the baseflow monitoring program until the spring of 2003 (Baltimore County DEPRM, 2005).

Baseflows are monitored in the Patapsco/Back River Basin in odd-numbered years, while the Gunpowder /Deer Creek Basin is monitored in the even-numbered years. A total of 53 sites in the Patapsco/Back River Basin, and 56 sites in the Gunpowder/Deer Creek Basin are monitored. The points were chosen to maximize the number of subwatersheds monitored (Baltimore County DEPRM, 2005). Table 3-4 shows the results for the nine sites located within the Upper Back River planning area.

Table 3-4: Upper Back River Watershed – Baltimore County Water Quality Data

Parameter (mg/l)		Site								
		BR02*	BR03*	BR04*	BR05*	BR06*	HR01**	HR02**	HR03**	HR04**
Subwatershed		OR	RR	RR	SR	SR	HR	HR	HR	HR
Chloride	Max	353.4	196.7	180.1	371.4	197.3	184.2	315.0	393.9	565.8
	Min	64.8	61.7	56.0	88.8	52.3	64.4	79.1	105.1	64.4
	Median	130.4	105.2	86.4	124.7	75.7	78.6	120.7	147.2	113.6
Total Nitrogen	Max	5.03	2.12	2.92	1.54	1.32	4.27	4.30	4.12	2.22
	Min	1.65	0.80	0.92	0.34	0.53	1.86	1.47	1.36	0.76
	Median	2.34	1.46	1.46	0.97	0.84	3.02	2.39	2.46	1.52
Suspended Solids	Max	3.0	4.0	4.0	41.0	6.0	0.5	12	14.0	24.0
	Min	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Median	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total Phosphorus	Max	0.08	0.07	0.16	0.22	0.06	0.06	0.07	0.08	0.08
	Min	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.02	0.02
	Median	0.03	0.04	0.05	0.05	0.05	0.04	0.04	0.05	0.05

*Data sampled in 2000, 2003, 2005
**Data sampled in 2003 and 2006

The Baltimore County water quality data set is reported from 2000 to 2006. Five out of ten sites show moderate to high levels of median total nitrogen. These five values are reported at 2.98, 2.42, 3.06, 2.73, and 2.62 for sites Bread and Cheese Run BR01, Brien Run BR02 and Mainstem Herring Run (HR1-HR3), respectively. There are no reported excessive levels of median total phosphorus, median chloride (though all the stations have occasionally exceeded the chronic life criteria and a few have exceeded the acute criteria), and median suspended solids.

3.2.2 Biological Data

Both Baltimore City and Baltimore County conduct biological monitoring for benthic macroinvertebrates utilizing the Maryland Biological Stream Survey protocols on an annual basis. These programs and results are described below. Figure 3-2 shows biological sampling point locations.

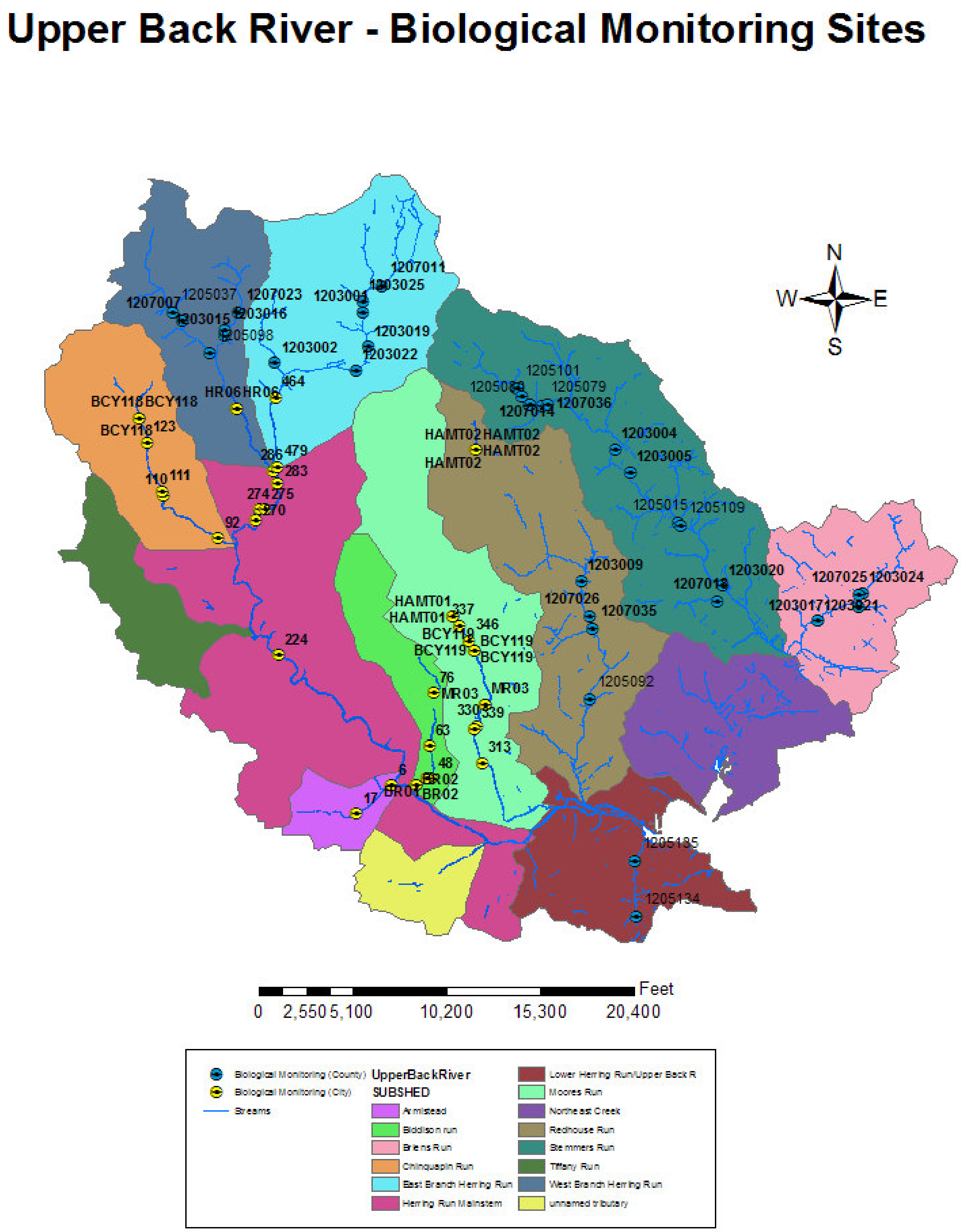


Figure 3-2. Upper Back River Biological Monitoring Sites

3.2.2.1 Baltimore City Data

The purpose of the City of Baltimore's biological sampling program is to monitor trends in fish and benthic invertebrate communities associated with restoration and/or environmental perturbation and to measure the health of living resources for targeting restoration (City of Baltimore, 2006). The program focuses on one watershed each year and follows the Maryland Biological Stream Survey (MBSS) protocol. Samples are taken from 30 sites within the watershed comprised of both random and fixed sample sites. Results include an Index of Biological Integrity (IBI) for both benthic invertebrates and fish in addition to an EPT Index. The EPT index is the sum of the number of families within the insect orders of Ephemeroptera (i.e. mayfly), Plecoptera (i.e. stonefly), and Trichoptera (i.e. caddisfly) (EA Engineering, Science, & Technology, 2001). The results for the city biological monitoring program are displayed in Table 3-5.

Table 3-5: Baltimore City Biological Monitoring Data Results

Station ID	Subwatershed	Latitude	Longitude	Sample Year	Median Values				
					Benthic IBI		Fish IBI		EPT Score
					Score	Rating	Score	Rating	
AC06	Armistead Run	39.3114	-76.5513	2004	1.4	Very Poor	N/A	N/A	1
AC17	Armistead Run	39.3072	-76.5581	2004	1.9	Very Poor	N/A	N/A	3
BCY116	Herring Run	39.3567	-76.5728	2002-03	1.8	Very Poor	N/A	N/A	2.5
BCY117	Herring Run	39.3247	-76.5633	2002-03	1.6	Very Poor	N/A	N/A	0
BCY118	Chinquapin Run	39.3664	-76.5996	2002-04	1.7	Very Poor	1	Very Poor	1
BCY119	Moores Run	39.3315	-76.5354	2002-06	1.4	Very Poor	1.9	Very Poor	2
BR01	Biddison Run	39.3123	-76.5445	2002-06	1.8	Very Poor	1.5	Very Poor	0.5
BR02	Biddison Run	39.3114	-76.5468	2003-06	1.6	Very Poor	2.4	Poor	1
BR48	Biddison Run	39.3124	-76.5437	2004	1.0	Very Poor	N/A	N/A	0
BR63	Biddison Run	39.3172	-76.5440	2004	1.0	Very Poor	N/A	N/A	1
BR76	Biddison Run	39.3251	-76.5433	2004	1.6	Very Poor	N/A	N/A	1
CR110	Chinquapin Run	39.3548	-76.5949	2004	1.9	Very Poor	N/A	N/A	1
CR111	Chinquapin Run	39.3554	-76.5952	2004	1.9	Very Poor	N/A	N/A	0
CR123	Chinquapin Run	39.3627	-76.5980	2004	1.4	Very Poor	N/A	N/A	0
CR92	Chinquapin Run	39.3483	-76.5845	2004	1.0	Very Poor	N/A	N/A	1
HAMT01	Moores Run	39.3365	-76.5394	2002-06	2.0	Poor	1	Very Poor	0
HAMT02	Redhouse Run	39.3613	-76.5349	2002-05	1.7	Very Poor	1	Very Poor	1
HR06	Herring Run	39.3677	-76.5809	2004-05	2.0	Poor	1.4	Very Poor	1
HR07	Herring Run	39.3547	-76.5731	2002-03	1.8	Very Poor	N/A	N/A	1
HR168	Herring Run	39.3079	-76.5438	2004	1.3	Very Poor	N/A	N/A	0
HR171	Herring Run	39.3091	-76.5458	2004	1.7	Very Poor	N/A	N/A	0
HR190	Herring Run	39.3186	-76.5555	2004	1.3	Very Poor	N/A	N/A	0
HR204	Herring Run	39.3242	-76.5622	2004	1.9	Very Poor	N/A	N/A	0
HR214	Herring Run	39.3268	-76.5696	2004	2.1	Poor	N/A	N/A	1
HR224	Herring Run	39.3309	-76.5729	2004	1.9	Very Poor	N/A	N/A	1
HR224R	Herring Run	39.3309	-76.5729	2004	1.7	Very Poor	N/A	N/A	1
HR225	Herring Run	39.3312	-76.5737	2004	2.1	Poor	N/A	N/A	2
HR265	Herring Run	39.3502	-76.5797	2004	1.9	Very Poor	N/A	N/A	1
HR270	Herring Run	39.3509	-76.5772	2004	1.9	Very Poor	N/A	N/A	1
HR274	Herring Run	39.3526	-76.5763	2004	1.0	Very Poor	N/A	N/A	0

Station ID	Subwatershed	Latitude	Longitude	Sample Year	Median Values				
					Benthic IBI		Fish IBI		EPT Score
					Score	Rating	Score	Rating	
HR275	Herring Run	39.3526	-76.5754	2004	2.3	Poor	N/A	N/A	0
HR279	Herring Run	39.3540	-76.5729	2004	1.9	Very Poor	N/A	N/A	1
HR283	Herring Run	39.3566	-76.5729	2004	1.3	Very Poor	N/A	N/A	0
HR286	Herring Run	39.3584	-76.5737	2004	2.3	Poor	N/A	N/A	0
HRR464	Herring Run	39.3693	-76.5733	2004	2.3	Poor	N/A	N/A	1
HRR479	Herring Run	39.3590	-76.5729	2004	2.1	Poor	N/A	N/A	1
MR03	Moores Run	39.3233	-76.5334	2002-06	1.4	Very Poor	2.7	Poor	1
MR313	Moores Run	39.3146	-76.5339	2004	1.3	Very Poor	N/A	N/A	1
MR330	Moores Run	39.3202	-76.5348	2004	1.9	Very Poor	N/A	N/A	0
MR337	Moores Run	39.3351	-76.5381	2004	1.0	Very Poor	N/A	N/A	0
MR339	Moores Run	39.3197	-76.5353	2004	1.3	Very Poor	N/A	N/A	1
MR346	Moores Run	39.3329	-76.5363	2004	1.9	Very Poor	N/A	N/A	1

There are 42 biological sampling sites in Baltimore City. Benthic IBI scores for these sites include eight sites rated as poor, and 34 sites rated as very poor biological condition. The Fish IBI scores range from very poor (six sites) to poor (three sites). The remaining 33 sites do not have data. The EPT scores in Baltimore City range from 0-3 and are all in the category of poor.

3.2.2.2 Baltimore County Data

The Baltimore County biological sampling program follows the MBSS protocol. Sample sites are randomly selected focusing on the Patapsco/Back River Basin in odd years and the Gunpowder/Deer Creek Basin in even years. The program reports benthic IBI scores for each site (Baltimore County DEPRM, 2005). The results for the county biological monitoring program are displayed in Table 3-6.

Table 3-6: Baltimore County Biological Monitoring Results

Station ID	Subwatershed	Longitude	Latitude	Sample Year	Median Values	
					Benthic IBI	
					Score	Rating
1205037	Herring Run	-76.5929	39.3821	2005	1.67	Very Poor
1205098	Herring Run	-76.5858	39.3761	2005	1.67	Very Poor
1203001	Herring Run	-76.5564	39.3820	2003	1.33	Very Poor
1203002*	Herring Run	-76.5733	39.3744	2003	1.67	Very Poor
1203022*	Herring Run	-76.5578	39.3733	2003	1.67	Very Poor
1203015	Herring Run	-76.5830	39.3787	2003	1.33	Very Poor
1203016	Herring Run	-76.5829	39.3794	2003	1.00	Very Poor
1203025	Herring Run	-76.5564	39.3836	2003	1.33	Very Poor
1203019	Herring Run	-76.5555	39.3768	2003	1.33	Very Poor
1205015	Stemmers Run	-76.4959	39.3502	2005	2.00	Poor
1205079	Stemmers Run	-76.5221	39.3679	2005	1.67	Very Poor
1205080	Stemmers Run	-76.5247	39.3681	2005	1.67	Very Poor
1205101	Stemmers Run	-76.5268	39.3704	2005	1.33	Very Poor
1205109	Stemmers Run	-76.4956	39.3499	2005	2.00	Poor
1203004	Stemmers Run	-76.5080	39.3614	2003	1.33	Very Poor
1203005	Stemmers Run	-76.5051	39.3578	2003	1.67	Very Poor
1203020*	Stemmers Run	-76.4875	39.3408	2003	2.00	Poor

1205092	Redhouse Run	-76.5133	39.3240	2005	1.67	Very Poor
1203009	Redhouse Run	-76.5147	39.3417	2003	1.67	Very Poor
1203018	Briens Run	-76.4613	39.3377	2003	2.00	Poor
1203017*	Briens Run	-76.4694	39.3355	2003	1.33	Very Poor
1205134	Back River Direct	-76.5046	39.2916	2005	2.33	Poor
1205135	Back River Direct	-76.5047	39.2999	2005	2.33	Poor
1203024	Briens Run	-76.4607	39.3397	2003	1.67	Very Poor
1203021*	Briens Run	-76.4693	39.3355	2003	1.00	Very Poor

* Indicates a Sentinel Station

Baltimore County has 25 biological sampling sites. Of these sites, six are rated as poor, and nineteen are rated as very poor.

3.2.3 Illicit Discharge and Elimination Program Data

3.2.3.1 Baltimore City Data

Baltimore City has a dry weather chemical survey that is used to detect illicit discharges. Data collected is used to show trends over time and look for changes in ambient water quality associated with changes in the watershed. In addition, the City has an ammonia screening (AS) program that started in 1998. The program collects samples three to four times per month from 46 stations.

The data is used to conduct a pollution source tracking (PST) investigation when results point to an illicit discharge. Many of the PST investigations are initiated due to citizen complaints and some are discontinued because the pollution trail is lost or becomes indeterminate. This often occurs due to the intermittent nature of the pollution source (City of Baltimore, 2005).

In Baltimore City, an ammonia concentration of 0.2 mg/l is used as an indicator of potential illicit discharge and 0.4 mg/l is used to trigger sewage spill investigations. The IDDE analysis focused on median concentrations of IDDE pollutants as this represents half the observations at a given station above the reported values. However, many of the stations occasionally exhibited much higher concentrations particularly for nitrogen and ammonia. Total nitrogen is not necessarily a positive indicator for illicit discharges but certainly any values over 2 mg/l represent elevated levels and anthropogenic inputs when compared to background concentrations. Ammonia on the other hand, is a positive indicator for illicit discharges, as ammonia does not persist long in-stream such that high concentrations usually point to a recent discharge of liquid containing ammonia such as sewage or wash water. All the IDDE monitoring sites in the City have positive indications for illicit discharges, a testament to the transitory nature and frequency of illicit discharges. The results of the ammonia screening are displayed in Table 3-7.

Table 3-7: Baltimore City Ammonia Screening 1998-2007

Table 7. Back River Watershed – Baltimore City Ammonia Screening 1998-2007				
Site	Ammonia (mg/l)			
	Subwatershed	Median	Maximum	Minimum
5002	HR	0.13	0.98	0.00
5003	MR	0.13	0.79	0.00
5004	BR	0.06	3.00	0.00
5007	CR	0.02	3.00	0.00
5008	CR	0.03	0.75	0.00

5016	MR	0.06	3.00	0.00
5017	HR	0.04	1.18	0.00
5025	HR	0.03	2.39	0.00
5029	HR	0.03	1.61	0.00
5031	HR	0.61	1.78	0.15
5033	MR	0.04	3.00	0.00
5035	HR	0.09	1.64	0.00
5038	TR	0.02	1.99	0.00
5044	AR	0.07	1.67	0.00

There is only one site (5031) that shows a high level of median ammonia reported at 0.61 mg/l.

3.2.3.2 Baltimore County Data

Baltimore County tracks illicit discharges 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, the outfall structure and the receiving channel, noting such conditions as water color, odor, vegetative condition, sedimentation, erosion, damage, etc.; and
(3) A visual inspection of each outfall that notes any structural damage.

In Baltimore County, there are approximately 3,509 total outfalls; of these, approximately 2,800 outfalls are less than 36 inches in diameter. These outfalls are not prioritized. The County has 709 outfalls with pipe diameter of 36 inches or greater of which 473 have a prioritization rating (Baltimore County DEPRM, 2005).

The County has an outfall prioritization system based on data from the outfall screening. The system allows for a more streamlined approach in selecting outfalls to screen and provides a more efficient use of manpower. In addition, the system allows for outfalls screened once or not at all *(Priority 0)* to be screened sufficiently (three or more times) and properly prioritized. The list of outfalls to be screened is generated by a Microsoft Access Query based on the prioritization scheme.

The outfall prioritization system works as follows: (1) Outfalls not screened three times are not prioritized. (2) Outfalls screened three or more times are assigned one of three priority ratings.

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

A second screening is done if nearly a decade has passed since the last 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, then an investigation begins immediately. Some sites are determined to have problems severe enough to warrant immediate investigation and/or corrective action after only one screening.

There are 24 major outfalls in the Baltimore County portion of the Upper Back River planning area. Table 3-7 summarizes the priority ratings by subwatershed.

Table 3-8: Baltimore County Storm Drain Outfall Prioritization Results

	Herring Run	Moores Run	Redhouse Run	Stemmers Run	Brien Run	Northeast Creek	Back River Direct	Total
Priority 0	2	0	2	2	1	0	0	**7**
Priority 1	1	0	1	0	1	0	0	**3**
Priority 2	10	1	4	5	5	3	1	**29**
Priority 3	13	1	9	14	4	2	0	**43**
Total	**26**	**2**	**16**	**21**	**11**	**5**	**1**	**82**

3.2.4 Subwatershed Summary

A summary of monitoring data by subwatershed is provided in Table 3-8. The table provides a summary of water quality, biological, and outfall data for each subwatershed. The average values for each subwatershed are summarized for each monitoring data parameter. The water quality and outfall data values range from low (good) to high (bad). The biological data is reported as very poor, poor, fair and good based on the average value for each subwatershed. This table provides a quick snapshot of the condition of each subwatershed in the Upper Back River planning area.

Table 3-9: Summary of Monitoring Data by Subwatershed

Subwatershed	Water Quality (mg/l)		Biological	Outfall (mg/l)		
	TN	TP	IBI	TN	TP	Ammonia
Herring Run Mainstem	Moderate	Slightly Elevated	Very Poor	High	Low	Low
Chinquapin Run	Moderate	Slightly Elevated	Very Poor	High	Low	N/A
Tiffany Run	N/A	N/A	N/A	N/A	N/A	N/A
Armistead	Moderate	Slightly Elevated	Very Poor	N/A	N/A	Low
Unnamed Tributary	N/A	N/A	N/A	N/A	N/A	N/A
Biddison Run	N/A	N/A	Very Poor	N/A	N/A	Low
Moores Run	Moderate	Moderate	Very Poor	N/A	N/A	Low
Redhouse Run	Slightly Elevated	Moderate	Very Poor	Low	Low	N/A
Stemmers Run	Baseline	Moderate	Very Poor	Low	Low	N/A

Briens Run	Moderate	Baseline	Very Poor	Low	High	N/A
Northeast Creek	N/A	N/A	N/A	N/A	N/A	N/A

N/A =no data available

Water quality data reported five subwatersheds (Herring Run Mainstem, Chinquapin Run, Moores Run and Briens Run) with moderate average total nitrogen values and three subwatersheds (Moores Run, Redhouse Run, and Stemmers Run) with moderate average total phosphorus values. Four subwatersheds (Tiffany Run, Unnamed Tributary, Biddison Run and Northeast Creek) were not sampled for water quality. The biological IBI scores for all but three subwatersheds (Tiffany Run, Unnamed Tributary, Northeast Creek) are very poor. The remaining three subwatersheds have no biological data reported. Outfall data for five subwatersheds were sampled in the County, two reported high levels of total nitrogen (Herring Run Mainstem, Chinquapin Run) and one reported high levels of total phosphorus (Briens Run). In the city the four subwatersheds (Herring Run Mainstem, Armistead, Moores Run and Biddison Run) sampled reported low levels of ammonia.

3.3 Stream Assessments

3.3.1 Stream Stability Assessment

Baltimore County contracted with Parsons, Brinkerhoff, Inc. to conduct a Stream Stability Assessment (SSA) in the Brien's Run and county portions of the Stemmer's Run and Herring Run subwatersheds. The document can be found in Volume 2 - Appendix F of the Upper Back River Small Watershed Management Plan.

The purpose of the Stream Stability Assessment was to identify both sources of stream impairment and restoration opportunities.

Approximately nine miles of stream were assessed during the summer of 2007. The study found 39% of the stream reaches have high, very high or extreme erosion potential. Restoration opportunities were identified in nine separate categories. These opportunities included stream restoration projects, buffer enhancement projects, bank plantings, utility conflict resolution, habitat enhancement, trash clean-ups, yard waste cleanup, invasive species removal, and combination projects. The results of the Stream Stability Assessment will be used to identify restoration actions.

3.4 Sewer Overflow Impacts

At present, sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs) are inevitable byproducts of our expanding population and aging sewer systems. Sewer overflows can be caused by, among other things, severe weather, insufficient maintenance and vandalism. When a sanitary sewer system is overwhelmed by volume or the infrastructure fails, raw sewage can enter nearby streams. The EPA reports there are at least 40,000 of these incidents per year. The environmental and human health consequences of these overflows can be serious. E. Coli bacteria and other pathogens can be present, posing health risks to individuals who may come in contact with contaminated water. Sewer overflows can also contain high levels of nitrogen and phosphorus that are toxic to aquatic life and feed organisms that deplete oxygen in waterways. High levels of sediment are also present in these overflows, which can clog streams and block sunlight from reaching essential aquatic plants. Table 3-7 shows the volume and number of incidents by year for Baltimore City and County.

In September 2002, the EPA and MDE issued a consent decree to the city of Baltimore to help reduce and eventually eliminate sanitary sewer overflows. The entire document can be viewed here:

http://www.epa.gov/Compliance/resources/decrees/civil/cwa/baltimore-cd.pdf

In 2005, EPA and MDE issued a consent decree to Baltimore County to reduce and eliminate sanitary sewer overflows. Implementation of the requirements of the consent decrees will result in a reduction of nutrients and bacteria entering the streams in the Upper Back River. The consent decrees, however, may not address all of the impacts associated with the sanitary sewer system, as they are targeted at overflows. The sanitary sewer system may leak without resulting in an overflow. Depending on the locations of the leaks (typically from joints) there may be impacts to the stream system.

Table 3-10: Baltimore Sewer Overflows by Year in the Upper Back River, 2001-2007

Year	City Volume	County Volume	Total Volume
2001	45,793.00	13,260.00	59,053.00
2002	40,686.00	21,815.00	62,501.00
2003	124,106,185.00	43,420.00	124,149,605.00
2004	221,045.00	713,342.00	934,387.00
2005	14,784.00	1,407,635.00	1,422,419.00
2006	159,630.00	9,757,634.00	9,917,264.00
2007	66,275.00	1,054,933.00	1,121,208.00
Total	124,654,398.00	13,100,359.00	137,754,757.00

Table 3-8 shows estimated volumes and pollutant amounts by subwatershed over a seven-year period. Calculations were determined using the following:

Total Nitrogen (TN) – based on a 30mg/L N concentration for raw sewage and a multiplier of 8.32×10^{-6}, a conversion factor of 2.5×10^{-4} is achieved for converting gallons of overflow to pounds of pollutant.

Total Phosphorus (TP) – based on 10mg/L phosphorus concentration for raw sewage and a multiplier of 8.32×10^{-6}, a conversion factor of 8.32×10^{-5} is achieved for converting gallons of overflow to pounds of pollutant.

Total Suspended Solids (TSS) – based on 225mg/L concentration for raw sewage and a conversion factor of 8.32×10^{-6} for converting gallons of overflow to pounds of pollutant.

Fecal Coliform (FC) – based on 6.4×10^{6} MPN*/100mL which converts to 2.4×10^{8}MPN/gal.
*most probable number

Table 3-11: Baltimore Sewer Overflows by Subwatershed, 2001-2007

Subwatershed	City Volume (gal)	County Volume (gal)	Total Volume	TN (lbs)	TP (lbs)	FC (MPN)
Armistead	6,165	0	6,165	1.5	0.5	1.4×10^{12}
Biddison Run	136,850	0	136,850	34.2	11.3	3.3×10^{13}
Briens Run	0	10,090	10,090	2.5	0.8	2.4×10^{12}
Chinquapin Run	208,719	2,991,029	3,199,748	799.9	263.3	7.7×10^{14}
East Branch Herring Run	11,245	764,023	775,268	193.8	63.8	1.9×10^{14}
Herring Run Mainstem	124,171,037	0	124,171,037	31,042.8	10,219.3	3.0×10^{16}
Lower Herring Run	0	6,562,200	6,562,200	1,640.6	540.1	1.6×10^{15}

Moores Run	48,346	56,650	104,996	26.2	8.6	2.5×10^{13}
Northeast Creek	0	2,570,306	2,570,306	642.6	211.5	6.2×10^{14}
Redhouse Run	4,500	46,763	51,263	12.8	4.2	1.2×10^{13}
Stemmers Run	0	80,848	80,848	20.2	6.7	1.9×10^{13}
Tiffany Run	40,166	0	40,166	10.0	3.3	9.6×10^{12}
Unnamed Tributary	25,535	0	25,535	6.4	2.1	6.1×10^{12}
West Branch Herring Run	1,835	18,450	20,285	5.1	1.7	4.9×10^{12}
Total	**124,654,398**	**13,100,359**	**137,754,757**	**34,438.6**	**11,337.2**	3.3×10^{16}

Figure 3-6 shows the volume and location of sanitary sewer overflows through the years 2000-2007.

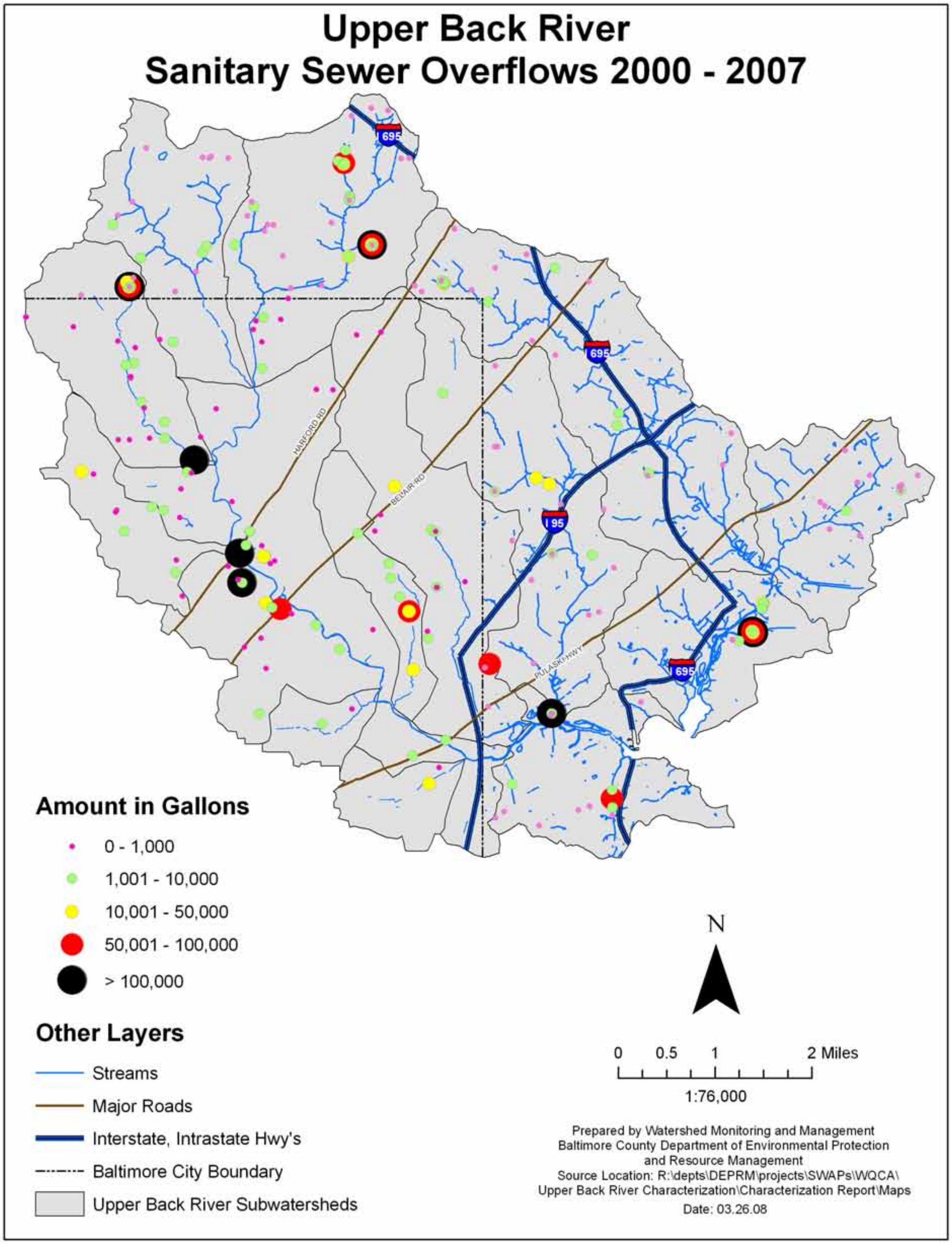


Figure 3-3 Sanitary Sewer Overflows 2000-2007

3.5 303(d) Listings and Total Maximum Daily Loads (TMDL)

The Back River watershed has been listed as being impaired in the Maryland 303(d) list of impaired waters for a variety of substances. The listings include both the streams in the watershed and the tidal receiving waters. There are two water quality segments in the Back River; segment 02130901 is the land and the streams in the watershed, while MD-BACOH is applicable to the tidal waters. Impairment in the tidal waters is related to the pollutants coming from the watershed, therefore TMDLs developed for the tidal waters will require pollutant loads to be reduced in the watershed draining to the receiving water (tidal waters in this case). Water Quality Assessments are performed to determine if the substance listed is actually impairing the waters. If it is found that the pollutant is not impairing the receiving waters, then a report documenting the findings is submitted to EPA for concurrence. Table 3-9 displays the status of the impairment listings.

Table 3-12: Water Quality Impairment Listings and Status

Impairment	Applicable Segment	Status	Approval Date
Stream Biological Community	02130901	Impaired	
PCB in Fish Tissue	MD-BACOH	TMDL Under Development	
Tidal Aquatic Life - PCBs	MD-BACOH	TMDL Under Development	
Tidal Aquatic Life - TSS	MD-BACOH	Impaired	
Chlordane	MD-BACOH	TMDL Complete	December 1999
Nutrients	MD-BACOH	TMDL Complete	June 2005
Fecal Coliform	20130901	TMDL Complete	December 2007
Zinc	MD-BACOH	Water Quality Assessment	December 2004

The Back River watershed has eight impairment listings (for purposes of this report the separate listings for nitrogen and phosphorus have been combined as nutrients). Three TMDLs and one Water Quality Assessment have been completed. A TMDL is currently in development for PCBs, which will address two of the impairment listings. Two additional listings, TSS and Stream Biological Impairment, will have TMDLs developed at some point in the future.

The Water Quality Assessment document for zinc can be found at: http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/ApprovedFinalTMDL/WQA_final_backriver_zinc.asp and in Volume 2 - Appendix G of the Upper Back River Small Watershed Management Plan.

The three TMDLs that have been approved by EPA are briefly discussed below.

3.5.1 Nutrients

The TMDL for nutrients was approved by EPA in June 2005. Based on the analysis, the bulk of the nitrogen and phosphorus reductions needed to meet water quality standards in the tidal segment of the Back River watershed will come from improvements in the Back River Waste Water Treatment Plant (WWTP). The Back River WWTP is scheduled for completion of an upgrade to Enhanced Nutrient Removal in 2013. Upon completion the discharge of nitrogen will be reduced to 3 mg/L and phosphorus will be reduced to 0.2 mg/L.

Since there is little agriculture in the watershed, the balance of the reduction needed to meet water quality standards will come from a 15% reduction in nitrogen and phosphorus from urban non-point sources. The Upper Back River Small Watershed Action Plan is intended to address the actions needed to meet the 15% reduction of nitrogen and phosphorus to help meet water quality standards.

The document entitled *Total Maximum Daily Loads of Nitrogen and Phosphorus for Back River in Baltimore City and Baltimore County, Maryland* can be found on the Maryland Department of the Environment website at this web address:

http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/ApprovedFinalTMDL/TMDL_final_backriver_eutro.asp

The document can also be found in Volume 2 - Appendix G of the Upper Back River Small Watershed Action Plan.

3.5.2 Bacteria

Only a portion of the Back River watershed has been listed as impaired by fecal bacteria. According to the listing, the impairment is limited to the Herring Run subwatershed and its tributaries. The other streams and the tidal waters are not listed as impaired by fecal coliform. Using a combination of monthly samples at three locations and an analysis methodology known as Bacterial Source Tracking (BST), MDE was able to identify the sources of the bacteria. They found that ~73% of the bacteria could be attributed to human sources, ~14% to domestic pets, ~13% to wildlife, and not surprisingly 0% to lifestock. The reductions needed to meet water quality standards are on the order of 98% and would require a near total elimination of human and domestic pet waste, as well as, a significant portion of the wildlife source. Much, but not all, of the human source reduction will be achieved through implementation of the requirements documented in the Baltimore City and Baltimore County Consent Decrees.

The document entitled *Total Maximum Daily Loads of Fecal Bacteria for the Herring Run Basin in Baltimore City and Baltimore County, Maryland* can be found on the MDE website at:

http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/ApprovedFinalTMDL/TMDL_final_Herring_Run_fc.asp

The document can also be found in Volume 2 - Appendix H of the Upper Back River Small Watershed Action Plan.

3.5.3 Chlordane

Chlordane was used as a pesticide to control termites in building foundations. Its use was restricted in 1975, and its sale was ultimately banned in 1988. With no known existing sources of chlordane (other than what exists in the sediment) and data suggesting that concentrations are decreasing, the TMDL identified a strategy of natural recovery as the means of achieving water quality standards.

The document entitled *Total Maximum Daily Load (TMDL) Documentation for Chlordane in Back River* can be found on the MDE website at:

http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/ApprovedFinalTMDL/tmdl_backriver.asp

The document can also be found in Volume 2 - Appendix I of the Upper Back River Small Watershed Action Plan.

3.6 Pollutant Loading Analysis

This section presents the Watershed Treatment Model run for the entire Back River watershed and compares the results to other modeling activities.

3.6.1 Watershed Treatment Model

This memorandum summarizes the pollutant load assessment for Jones Falls and Back River watersheds in both Baltimore City and Baltimore County conducted by the Center for Watershed Protection (CWP) in association with Baltimore County Department of Environmental Resource Management (DEPRM) and Baltimore City Department of Public Works (DPW). For the purposes of this project, the Jones Falls subwatershed was divided into two sections based on landuse-- the upper, less developed section and the lower, more intensively developed section. The Watershed Treatment Model (WTM), a spreadsheet-based model developed by CWP, was used (Caraco, 2002) in the analysis.

3.6.1.1 Description of the WTM

The Watershed Treatment Model is a simple spreadsheet model used to:

1. Estimate pollutant loading under current watershed conditions
2. Determine the effects of current management practices
3. Evaluate effects of proposed structural and non-structural management practices
4. Evaluate the effects of future development.

The Watershed Treatment Model assesses pollutant loads from both primary and secondary sources. Primary sources include urban storm water runoff loads from major land uses. Secondary sources are pollutants dispersed throughout the watershed whose magnitude cannot easily be estimated from available land use information such as sanitary sewer overflows, septic system failure, and channel erosion.

The Watershed Treatment Model is an evolution of the Simple Method (Schueler, 1987) for pollutant load calculations where impervious cover is used to estimate primary loads from various urban land uses. At its core, the Simple Method is based on the relationship between impervious cover and runoff volume. Specific concentration assumptions used for loading estimates in the WTM model are based on values for different land uses summarized in the National Stormwater Quality Database (NSQD), a summary of national stormwater data from over 200 communities nationwide (Pitt *et. al.*, 2003). Estimated runoff volumes are multiplied by pollutant concentration data to compute stormwater loads.

The existing and future management practices in the watershed directly affect calculations within the WTM. The pollutant removal of various urban stormwater management practices is based on Chesapeake Bay Program (2005) efficiencies. The National Pollutant Removal Performance Database for Stormwater Treatment Practices (Winer, 2000) and additional research compiled in the WTM (Caraco, 2002) were also used to fill in gaps.

A unique feature of the WTM is the inclusion of "treatability" and "discount" factors. Treatability is an estimated portion of pollutant abatement through the use of a treatment practice. For structural practices, treatability is best defined as the area that can be treated, while for education programs, it may reflect the fraction of the population that can be reached. Discount factors are applied to potential load reductions to account for imperfect practice application and upkeep, inability of educational programs to reach all citizens, and inadequate funding to implement all practices.

The Watershed Treatment Model, like any model, is based on a series of assumptions. Model calibration through evaluating monitoring data and comparison with other model output can help improve confidence in results. Recommendations for model calibration will be made in a second technical memo where recommendations for future monitoring and other water quality model outputs collected by DEPRM will be discussed.

3.6.1.2 Input Data and Assumptions

Most of the WTM input data for the Baltimore Subwatersheds was taken from the following sources:

- Baltimore County/City Geographic Information System (GIS) Data
- Baltimore County 2005 NPDES Annual Report
- Baltimore City 2006 NPDES Annual Report

The future management practices are based on the spectrum of possible projects identified during fieldwork.

Primary Sources

Existing Land Use

CWP analyzed land use in the watersheds using Baltimore County GIS (2002) and Baltimore City GIS (date unknown); these are summarized in Table 3-9. In this analysis, the existing land use codes in the parcel GIS layer were matched to the land use categories provided in Cappiella and Brown (2001).

Table 3-13. Land Use Summary for Upper Back River
Source: (Baltimore County GIS, 2002 and Baltimore City GIS, date unknown)

Land Use Category	Impervious Cover (%)	Acres
Agriculture	1.9%	1108
Water	2%	446
Roads*	2%	418
Railroads*	5%	217
Open Urban Land	8.6%	3936
2 Acre Lot Residential	10.6%	2
1 Acre Lot Residential	14.3%	3838
1/4 Acre Lot Residential	27.8%	7421
1/8 Acre Lot Residential	32.6%	4260
Townhome Residential	40.9%	1952
Multifamily Residential	44.4%	4924
Institutional	34.4%	3005
Light Industrial	53.4%	2786
Commercial	72.2%	3419

*The land use categories roads and railroads were called out in the Baltimore City GIS but not in the Baltimore County GIS.

Pollutant Loadings

The stormwater concentration data used in the WTM Modeling Scenario is based on the National Stormwater Quality Database (NSQD) (Pitt *et. al.*, 2003). The concentration data from the NSQD are summarized in Table 3-10. The NSQD data set was chosen as the source for concentration data due to the high number of observations in the data set and the resulting certainty that data has not been skewed by anomalies that may be present in much smaller local data sets.

Table 3-14. Primary Loading Assumptions Used in the WTM Scenarios Source: Pitt *et al.* (2003)

	Concentrations		
Land Use	**Total Nitrogen mg/l**	**Total Phosphorus mg/l**	**Total Suspended Solids mg/l**
Residential	1.9	0.3	68
Open Space	1.9	0.27	78
Commercial	2.0	0.25	54
Roadway	2.3	0.25	99
Industrial	2.1	0.2	82
These concentrations have been converted to annual pollutant loading rates based on the Simple Method.			

Secondary Sources

Secondary sources are pollutant sources dispersed throughout the watershed whose magnitude cannot easily be estimated from readily available land use information. Table 3-11 outlines secondary source data. Many secondary sources are wastewater derived, such as SSOs and septic systems. Others, such as active construction, produce land use-based loads, but typically include relatively small land areas that change rapidly. Secondary sources that were present in the watershed and quantifiable (based on available data) were considered. In most cases, this involved using GIS data or local information provided to CWP by Baltimore City, Baltimore County or the watershed associations to create estimates for secondary sources.

Table 3-15. Secondary Source Input Data Used

Input	Notes
Dwelling Units (#)	Estimated based on the land use categories provided in Table 1.
Unsewered Dwelling Units (fraction)	It was assumed that a small percentage of dwellings rely on septic systems for disposal of sewage.
Acres of Active Construction	Estimated acres under construction using GIS data and aerial photography.
SSO's	Miles of sanitary sewer calculated from GIS and use of national sewerage overflow estimates.
Lawns/Soils	Hydrologic soil group percentages calculated based on correlating soil names in GIS layer.
Channel Erosion	Studies have shown that channel erosion can comprise up to two-thirds of total instream sediment loads.
Livestock	Within the Jones Falls upper subwatershed only, a small number of livestock were estimated based on discussions with Jones Falls watershed association.

Existing Management Practices (Watershed Treatment)

This component of the WTM assesses the ability of current treatment options in a watershed to reduce the uncontrolled pollutant loads calculated in the Pollutant Sources component of the WTM. Treatment options are broadly defined as “stormwater treatment practices,” and “stormwater control programs.” The stormwater treatment practices are a suite of structural stormwater control practices that are applied as a control on new development, or as a retrofit to control existing development. Examples include stormwater ponds, wetlands, and filtering practices. Stormwater management programs include other treatment options that can reduce pollutant loads, such as lawn care education or CSO abatement.

For all treatment options, the WTM assesses the treatment (i.e., load reduction) achieved by applying the practice efficiency to the treatable load, and then adjusting, or "discounting" the total treatment achieved to reflect the level of implementation throughout the watershed. The existing management practices (Table 3-12) included in the WTM are based on data provided in Baltimore County's 2005 NPDES report and Baltimore City's 2006 NPDES report.

Table 3-16. Existing Management Practice Input Data Used

Input	Notes
Pet waste education	Assumed that substantial public education programs that reach a good percentage of population with pet waste and lawn care education were not in place in the County and City.
Lawn care education	Same as above.
Erosion and Sediment Control Program	Baltimore County and Baltimore City both have erosion and sediment control programs. They hold "responsible personnel" certification classes to educate construction site operators regarding erosion and sediment control compliance. In Baltimore County, erosion and sediment control plans are required for any construction activity disturbing an area greater than 5,000 sq ft. Assumed 90% of building permits regulated. Used a compliance factor of 0.7 (monthly inspections) and installation/maintenance factor of 0.55.
Streets Swept (Acres)	Used data from NPDES reports.
Catch Basin Cleanouts (Acres)	Used data from NPDES reports.
Structural Stormwater Management Practices	Based on databases provided by City and County in GIS. Data from County provided impervious area while City data was not comprehensive. If impervious area was not available, the treatment practice was not included.
Riparian Buffer Length (Miles) and Width (Feet)	Calculated average buffer length based on stream miles adjacent to forested land use using GIS. Used a buffer width of 50' for both the City and County. Assumed that scores of 3 or less equal no buffer. Found a percent without buffer. Used a 0.5 factor for design, which represents voluntary criteria, and a 0.7 factor for maintenance, indicating that an ordinance calls for the buffers to be maintained but no enforcement or education effort ensures their preservation (discount factors reflect slightly different policies in the City and County).

BMP Efficiencies Used (Based on CBP efficiencies)

Urban best management practice (BMP) efficiencies from the Chesapeake Bay Program were used (CWP, 2005) to compute load reductions from existing practices based on the data summarized in Table 3-13.

Table 3-17: Urban BMP Efficiencies

BMP Type	Efficiency			
	TN	TP	TSS	Bacteria
Dry Water Quantity Pond	**5%**	**10%**	**10%**	**10%**
Dry Facilities	**30%**	**20%**	**60%**	**60%**
Wet Pond	**30%**	**50%**	**80%**	**70%**
Wetland	**30%**	**50%**	**80%**	**78%**
WQ Swale*	**38%**	**34%**	**81%**	**0%**
Filters	**40%**	**60%**	**85%**	**37%**
Infiltration	**50%**	**70%**	**90%**	**90%**
*WQ swale based on CWP database -no swales were id in City/County database				

3.6.1.3 Results

The primary and secondary loads as well as the load reduction from existing practices are summarized in Table 3-14. Total loads for TN, TP, TSS and fecal coliform are reported. This loading is for the entire Back River watershed (37,600 acres) versus the Upper Back River planning area covered under this Small Watershed Action Plan (27,700 acres). The Upper Back River planning area represents ~74% of the total watershed area.

Table 3-18: Back River Annual Loads

Loads	TN	TP	TSS	FC
	lb/year	lb/year	lb/year	# billion/year
Primary loads	169,431	21,282	7,873,725	6,859,557
Secondary loads	53,083	5,266	5,002,418	6,988,486
Total	222,514	26,548	12,876,143	13,848,043
Load reduction existing practices	-26,330	-3,848	-1,598,183	-1,002,250
Total current load	**196,184**	**22,700**	**11,277,960**	**12,845,793**
Assumptions: 42 inches annual runoff, 58.74 mi^2				

3.6.1.4 Load Estimate Comparisons

Load estimate comparisons were prepared by DEPRM to check for consistency among different modeling programs to ensure computed WTM loads were consistent with total maximum daily load (TMDL) and Chesapeake Bay Program (CBP) Tributary Strategy baseline loads. The TMDL and CBP goals are the two primary goals that load reduction strategies are attempting to fulfill.

Table 3-19: Back River Loading Estimates from Several Sources

				% difference from WTM	
Source	**TN**	**TP**	**TSS**	**TN**	**TP**
WTM	196,184	22,700	11,277,960*	NA	NA
TMDL	209,348	21,967		+6.7%	-3.2%
CBP	254,583**	21,318**		+29.8%	-6.1%
Baltimore County	180,075	18,920	5,941,922	-8.2%	-16.7%
Water Quality Management Plan	177,980	17,820	6,294,400	-9.2%	-21.5%

* Includes estimate from channel erosion, often not estimated in other models.
** Baltimore County portion of the watershed only.

3.6.1.5 Discussion

In Table 3-15, the loading estimates from the TMDL, Bay Program (CBP), Baltimore County and the WTM compare favorably with one another. As expected the TSS load calculated using the WTM is higher than the other models which do not take into consideration channel erosion. These estimates will act as a base to calculate load reductions against with the proposed implementation strategy developed as part of the WQCA/ SWAP process.

3.7 Subwatershed Load Analysis

In order to assess the pollutant loads by the 14 subwatersheds within the Upper Back River planning area, a separate analysis was conducted. Using data supplied by Maryland Department of the Environment on per acre land use nitrogen and phosphorus loads and the Chesapeake Bay Program Watershed Model (Phase 4.3, segment 860-edge of stream loadings) per acre loadings for urban impervious and urban pervious loadings the nitrogen and phosphorus loads were calculated for each subwatershed. The land use was derived from the Maryland Department of Planning 2002 land use data layer. This information is presented in Chapter 2 of this Characterization Report.

The Maryland land use loadings assume full implementation of the tributary strategies for pollutant load reduction to the Chesapeake Bay. For this reason the urban land uses from the Chesapeake Bay program were used to determine the before restoration loadings. This will provide a before restoration loading rate and will allow a better assessment of progress made to date and further progress needed to meet the TMDL goals for urban non-point source reduction. Table 3-16 presents the per-acre loadings for nitrogen and phosphorus used in this analysis.

Table 3-20: Land Use per Acre Nitrogen and Phosphorus Loadings (pounds/acre/year)

Land Use	Nitrogen Load per Acre	Phosphorus Load per Acre
Urban Pervious	15.77	2.28
Urban Impervious	8.06	0.51
Cropland	13.54	0.69
Pasture	5.64	0.66
Forest	1.29	0.02

The results of this analysis are presented in Tables 3-17 and 3-18 for nitrogen and phosphorus respectively.

Table 3-21: Nitrogen Loads by Subwatershed

Subwatershed	N Load From Urban (lbs/yr)	N Load From Agricultural (lbs/yr)	N Load From Forests (lbs/yr)	N Load Total (lbs/yr)	Per Acre N Load (lbs/acre/year)
Armistead Run	5,109	0	21	5,130	12.3
Biddison Run	9,660	0	68	9,660	12.2
Briens Run	17,360	0	372	17,732	10.8
Chinquapin Run	19,851	0	136	09,987	12.1
East Branch Herring Run	32,952	0	226	33,178	12.3
Herring Run Mainstem	50,202	0	1,193	51,395	11.6
Lower Herring Run	15,521	0	558	16,079	10.1
Moore’s Run	33,101	0	356	33,457	12.0
Northeast Creek	13,237	818	779	14,834	9.0
Redhouse Run	37,171	0	370	37,541	12.4
Stemmers Run	37,861	649	994	39,504	10.7
Tiffany Run	11,188	0	32	11,220	12.6
Unnamed Tributary	7,597	0	0	7,597	13.1
West Branch Herring Run	23,809	0	140	23,949	12.8
Total	**314,619**	**1467**	**5,2456**	**311,2634**	**11.6**

Table 3-22: Phosphorus Loads by Subwatershed

Subwatershed	P Load From Urban (lbs/yr)	P Load From Agricultural (lbs/yr)	P Load From Forests (lbs/yr)	P Load Total (lbs/yr)	Per Acre N Load (lbs/acre/year)
Armistead Run	637	0	0.3	637	1.53
Biddison Run	1,213	0	1	1,214	1.53
Brien's	2,489	0	2	2,491	1.35
Chinquapin Run	2,489	0	2	2,491	1.51
East Branch Herring Run	4,199	0	4	4,202	1.56
Herring Run Mainstem	6,241	0	45	6,287	1.42
Lower Herring Run	1,899	0	14	1,913	1.20
Moore's Run	4,159	0	8	4,168	1.49
Northeast Creek	1,677	42	15	1,733	1.05
Redhouse Run	4,876	0	6	4,882	1.62
Stemmers Run	4,864	33	15	4,913	1.33
Tiffany Run	1,379	0	2	1,381	1.55
Unnamed Tributary	966	0	0	966	1.67
West Herring Run	3,094	0	2	3,094	1.65
Total	**40,182**	**75**	**116.3**	**40,372**	**1.45**

The calculations of the subwatershed pollutant loadings will be used in the prioritization of the subwatersheds for restoration efforts. The total planning pollutant load will be used to determine the necessary reductions needed to meet TMDL and Tributary Strategies reductions.

3.8 Stormwater Management Facilities

3.8.1 Stormwater Management Facility Conversion Assessment

The existing stormwater management facilities located within the Upper Back River planning area were investigated for potential conversion to water quality management. The Baltimore County Department of Environmental Protection and Resource Management database on stormwater management facilities indicated that a total of 180 stormwater management facilities have been built in the planning area. Of these facilities, 52 were determined to be of a type that is potentially suitable for conversion to a type of facility that provides greater water quality benefits. These facilities were designed as dry detention facilities to address water quantity only. The facilities were field assessed to determine their suitability for conversion. Data was collected on the pond condition and the potential for conversion. The data was then used in a ranking system to prioritize the ponds that had conversion potential.

The office assessment included:

- A determination of pond design type from the database, with only dry detention ponds being selected for field review.
- The pond drainage area was determined based on information in the database.
- Ownership – Private or Public was determined.
- Location – including ADC map reference and nearest road.

This information was used in conjunction with a Geographic Information System to produce a set of maps that enhanced efficiency in pond location and routing of the field investigations.

The field assessment included:

- Verification of the facility type based on the configuration of the riser structure.
- The condition of the riser (Good, Damaged, with a description of the damage)
- Embankment condition (No problems, Trees on embankment, Erosion, Holes in the embankment)
- Vegetative condition of the pond bottom (Wetland vegetation, Tree, Bare soil, Mowed grass)
- Condition of the fence/gate
- Conversion potential factors
    - Pond field type conducive to conversion (Yes or No)
    - Pond is on line (Yes or No) – if online generally have greater difficulties with conversion
    - Ease of Access (Easy, Moderate, Difficult)
    - Flow routing (Short Flow Path, Long Flow Path)
    - Comments on conversion potential

The information derived from the field assessment was used first to determine if any conversion potential existed and second to develop a ranking score to be used in prioritizing the facilities for conversions. The ranking system is as follows:

- Field pond type – Only the detention pond type is considered as having potential. For those ponds that have a different field pond type (database is incorrect) or those where it was not possible to determine the pond type in the field, no further consideration was given.
- Pond ownership – High priority was given to public ownership with a score of 5, whereas private ownership was given only a score of 1.
- Drainage area (acres) – Ponds with larger drainage areas were given a higher score compared to smaller drainage areas.
    - < 5 acres = 1
    - 5-10 acres = 2
    - 10-20 acres = 3
    - 20-50 acres = 4
    - >50 acres = 5
- Pond online – a negative 10 points were given to ponds that were online (had a stream flowing through them) and 5 points were given if the pond was off line.
- Accessibility – Easy access to the site was given 5 points, whereas moderate and difficult accessibility were given 3 and 1 point, respectively.
- Flow routing (distance between the inflow into the pond and outflow from the pond) – 5 points were given for short flow paths and 1 point was given for long flow paths.
- Vegetation on the pond bottom – The point system is based on whether the existing vegetation is already providing some water quality improvement

- Grass/bare soil = 5
- Wetland vegetation = -2
- Trees = -1

- Riser – If the riser was damaged or there are holes in the embankment requiring repairs a higher score of 5 was given. No damage was scored as 1.
- Land Use (based on the GIS maps) – These types generally followed a decrease impervious cover factor:
  - Commercial/Industrial = 5
  - High Density Residential = 3
  - Medium or Low Density Residential = 1
- Notes Factor – If the notes indicated a high potential by the field reviewer it was scored 5 point, whereas low potential received a –5 points.

Of the 52 stormwater management facilities assessed, only 23 were found to have conversion potential and ranked for conversion. Reasons for not considering the balance of the ponds were:

- 3 had already been converted
- 7 had the wrong field type (database was wrong)
- 3 had been replaced with newer facilities as a result of additional development (usually road widening)
- 1 was in the wrong watershed (database location wrong)
- 15 require additional information from the construction drawings to make a determination of the potential (this will be done during the implementation phase).

The results of the application of the ranking methodology described above are presented in Table 3-19. The table presents the ownership, drainage area to the facility, the total score and the subwatershed that the pond is in.

Table 3-23: Potential Conversions of Dry Ponds to Improve Water Quality

Pond Number	Ownership	Acres	Total Score	Rank	Subwatershed
1211	Public	61.7	41	High	Redhouse Run
305	Public	6.5	36	High	Herring Run Mainstem
531	Private	11.7	35	High	Stemmers Run
969	Private	5.2	34	High	Lower Herring Run
803	Private	1.7	33	High	Briens Run
793	Private	3.6	33	High	Briens Run
792	Private	3.7	33	High	Briens Run
686	Private	1.9	33	High	Briens Run
685	Private	2.9	33	High	Briens Run
553	Public	9.0	32	High	Briens Run
1409	Private	2.4	31	Medium	Redhouse Run
560	Private	2.4	31	Medium	Redhouse Run
554	Public	2.9	31	Medium	Briens Run
974	Private	2.1	29	Medium	Briens Run
692	Private	3.7	29	Medium	Briens Run
471	Private	2.4	27	Medium	Stemmers Run
1829	Public	10.8	26	Medium	Stemmers Run
544	Private	2.9	24	Medium	Briens Run
1283	Private	6.4	23	Low	Stemmers Run
828	Private	5.0	23	Low	Stemmers Run

1741	Private	3.8	22	Low	Stemmers Run
456	Private	1.5	22	Low	Briens Run
329	Private	1.0	20	Low	Briens Run

3.8.2 Stormwater Management Facility Pollutant Load Reductions Calculations

3.8.2.1 Existing Facility Pollutant Removal

The drainage areas for 154 built stormwater management facilities have been digitized into a Geographic Information System data layer. This, along with the land use data layer, permits the calculation of pollutant loads delivered to the facility based on the per acre loading rates in Table 3-15. The amount of reduction is dependant on the type of facility that receives the stormwater. Table 3-20 presents the pollutant removal efficiencies of various types of urban stormwater management BMPs. These efficiencies are derived from the Chesapeake Bay Program BMP efficiency table located at: http://archive.chesapeakebay.net/pubs/NPS_BMP_Tables_011806.pdf . These efficiencies may be changed in the future as a result of a current effort to assess the literature and factors that affect the efficiencies.

Table 3-24: Percent Removal Efficiency of BMPs

BMP	Pollutants		
	TSS	TP	TN
Detention Facilities	10	10	5
Extended Detention Facilities	60	20	30
Wet Ponds	80	50	50
Infiltration Practices	90	70	50
Filtration Practices	85	60	40

Detention Facilities = Detention Pond and Hydrodynamic Devices (DP, OGS, and UGS)
Extended Detention Facilities = Extended Detention Ponds (EDSD, EDSW, ED)
Wet Ponds and Wetlands = Wet Pond and Shallow Marsh (WP and SM)
Infiltration Practices = Infiltration Trench and Infiltration Basins (IB, IT and ITWQC), Porous Paving (PP), and Dry Wells (DW)
Filtration Practices = Sand filters and Bioretention Facilities (SF, BIO)

The analysis was done on a subwatershed basis and is presented in Table 3-21.

Table 3-25: Removal of Nitrogen and Phosphorus Due to Existing Stormwater Management Facilities by Facility Type (pounds)

Subshed	Facility Type	Acres	# Facilities	Nitrogen #s		Phosphorus #s	
				Load	Reduction	Load	Reduction
Briens Run	Detention	134.8	31	1,449.9	72.5	167.8	16.8
	Extended Detention	109.7	10	995.6	286.7	110.7	22.1
	Filtration	5.9	2	33.8	13.5	2.2	1.3
	Wet Ponds	164.6	1	2,011.6	1,005.8	247.8	123.9
	Infiltration	0.8	1	3.3	1.7	0.5	0.3
	Subwatershed Total	**415.8**	**45**	**4,494.2**	**1,380.2**	**529.0**	**164.4**
Redhouse Run	Detention	75.3	5	988.1	49.4	126.0	12.6
	Extended Detention	45.7	2	595.7	478.7	78.1	15.6
	Filtration	9.1	2	123.6	49.4	16.4	9.8
	Subwatershed Total	**130.1**	**9**	**1707.4**	**577.5**	**220.5**	**38.0**
Northeast	Detention	11.2	4	126.9	6.3	14.9	1.5

Creek	Extended Detention	87.8	8	932.6	279.8	119.7	23.9
	Wet Ponds	85.1	2	801.8	400.9	78.2	39.1
	Subwatershed Total	**184.1**	**14**	**1861.3**	**687.0**	**212.8**	**64.5**
Stemmers Run	Detention	199.0	25	2,105.8	105.3	258.7	25.9
	Extended Detention	195.7	26	2,063.3	619.0	258.7	51.7
	Filtration	4.8	4	20.9	8.4	2.4	1.5
	Wet Ponds	273.3	4	2,844.8	1,422.4	373.3	186.7
	Infiltration	4.7	1	3.6	1.8	0.5	0.4
	Subwatershed Total	**677.5**	**60**	**7038.4**	**2156.9**	**893.6**	**266.2**
Moores Run	Detention	2.4	1	31.0	1.5	3.9	0.4
	Extended Detention	17.9	2	182.1	54.6	25.0	5.0
	Subwatershed Total	**1743.5**	**151**	**18,012.5**	**5,743.9**	**2241.7**	**666.8**
West Branch Herring Run	Detention	1.5	1	14.8	0.7	1.4	0.1
	Extended Detention	9.1	2	131.0	39.3	17.9	3.6
	Filtration	2.7	1	36.3	14.5	4.8	2.9
	Subwatershed Total	**3500.3**	**306**	**36,207.1**	**11,542.3**	**4507.5**	**1340.2**
East Branch Herring Run	Detention	2.0	1	21.8	1.1	2.3	0.2
	Extended Detention	12.1	3	170.0	51.0	22.9	4.6
	Filtration	4.9	2	59.3	23.7	7.1	4.2
	Infiltration	0.8	1	12.7	6.4	1.8	1.3
	Subwatershed Total	**7020.4**	**619**	**72,678**	**23,166.8**	**9049.1**	**2690.7**
Herring Run Main Stem	Detention	35.2	1	437.0	21.8	53.1	5.3
	Extended Detention	3.5	1	30.4	9.1	2.3	0.5
	Subwatershed Total	**38.7**	**2**	**467.4**	**30.9**	**55.4**	**5.8**
Lower Herring Run	Detention	21.4	7	220.3	11.0	21.9	2.2
	Subwatershed Total	**21.4**	**7**	**220.3**	**11.0**	**21.9**	**2.2**
All Subsheds	***Grand Total***	***1,520.6***	***154***	***16,407.8***	***4,736.5***	***2,020.4***	***563.4***

3.8.2.2 Additional Pollutant Removal Based on Conversions of Detention Ponds

The increased load reductions due to conversion of existing dry detention ponds to water quality facilities is predicated on the assumption that the facility will be able to be converted to shallow marsh with at least partial extended detention. This results in improved pollutant removal efficiencies based on the efficiencies in Table 3-20 above. Nitrogen removal would improve from 5% to 50% and phosphorus removal would improve from 10% to 50%. Table 3-22 presents the summary results by subwatershed.

Table 3-26: Conversion of Dry Detention Ponds – Nutrient Pollutant Removal Calculations

Subshed	# of Facilities	Acres	Nitrogen (pounds)			Phosphorus (pounds)		
			Load to Facility	Current Removal	Converted Removal	Load to Facility	Current Removal	Converted Removal
Briens Run	12	46.2	500.2	25.0	250.1	60.7	6.1	30.4
Redhouse Run	3	73.1	964.4	48.2	482.2	123.6	124	61.8
Stemmers	6	43.1	468.2	23.4	234.1	53.2	5.3	26.6

Run								
Herring Run Main Stem	1	35.2	437.0	21.8	218.5	53.1	5.3	26.6
Lower Herring Run	1	7.9	82.0	4.1	41.0	8.3	0.8	4.1
Total	**23**	**205.5**	**2,451.7**	**122.6**	**1,225.8**	**299.0**	**29.9**	**149.5**

The conversion of all 23 dry ponds would result in an increase in the removal of nitrogen from ~123 pounds to ~1,226 pounds, and for phosphorus from ~30 pounds to ~150 pounds.

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CHAPTER 4

UPLAND ASSESSMENTS

4.1 Introduction

The Unified Subwatershed and Site Reconnaissance or USSR is a field survey used to evaluate potential water pollution sources and restoration opportunities within the upland portion of an urban watershed. The USSR manual detailing the specific techniques used to conduct the survey is one of a series developed by the Center for Watershed Protection (Wright *et. al.* 2004). The concept behind the USSR is to provide watershed groups and municipal staff a quick but thorough characterization of upland areas to identify major sources of stormwater pollutants and restoration opportunities for source controls, pervious area management, and improved municipal maintenance (i.e., education, retrofits, street sweeping, open space management, etc.)

This chapter outlines the four procedures used to accomplish data collection for the USSR in the Upper Back River watershed: the Neighborhood Source Assessment, Hot Spot Investigation, Institutional Site Investigation and Pervious Area Assessment. Assessment locations are designated using the following format: ‘xyz-L-123’ where ‘xyz’ is the type of assessment, ‘L’ designates the Upper Back River watershed and ‘123’ is the sequential numbering assigned to each location.

4.2 Neighborhood Source Assessments (NSA)

4.2.1 Assessment Protocol

The Neighborhood Source Assessment primarily followed the protocols outlined in the Unified Subwatershed and Site Reconnaissance (USSR) manual (Wright *et. al.* 2004).

Since the Back River watershed is an older, more urbanized watershed, which corresponds to high percentages of impervious urban land; a new form was developed to address sites with 0-15% greenspace in a more timely fashion. With the existing field assessment protocol, the Neighborhood Source Assessment failed to efficiently describe the character of these neighborhoods. This shortened version of the NSA field form is called the Neighborhood Source Assessment Junior (NSA Jr.) and was used in approximately 8% of the neighborhoods.

Prior to the fieldwork, neighborhood units were designated in the office through aerial photograph interpretation and neighborhood GIS maps. The neighborhoods were differentiated using factors such as age, housing density, physically defined communities and apartment or town home complexes.

The NSA form serves to quantify potential pollution sources and identify potential restoration opportunities. The assessment looks specifically at yards and lawns, rooftops and downspouts, driveways and sidewalks, curbs and common areas.

Specific actions can then be recommended. Recommended actions are a product of the assessment that will guide volunteer groups and local government. This results in a better use of volunteer resources to target specific actions where they are most needed. The following is a list of the recommended actions included on the field form:

- Downspout retrofit
- Better lawn/ nutrient management practice
- Better landscaping/ Bayscaping practice
- Better management of common space
- Storm drain stenciling
- Tree planting
- SWM pond maintenance or retrofit
- Multifamily parking lot or alley retrofit

If a different action was identified during the field visit, then it was noted as a separate comment.

The final step in the NSA is to assign indexes, using benchmarks set forth in Wright *et al.* (2004), based on all the data collected through the NSA form. Each neighborhood was given a Pollution Severity Index (PSI) of “severe”, “high”, “moderate” or “low”. The PSI rates the amount of non-point source pollution a neighborhood is likely generating based on the NSA. A Restoration Opportunity Index (ROI) was also assigned to each neighborhood as “high”, “moderate” or “low”. ROI is a measure of the feasibility of onsite retrofits and likelihood of neighborhood behavioral changes based on the NSA.

4.2.2 Summary of Sites Investigated

A total of 222 neighborhoods were assessed. Of these 222, 99 were considered to have a “high” Pollution Severity Index (PSI) and/or a “high” Restoration Opportunity Index (ROI). Of these 99, 19 had a high rank for both PSI & ROI. Statistically speaking, these 19 neighborhoods would be the best to initially target for restoration.

4.2.3 General Findings

Listed below are the recommended actions, a description of the methodologies used for evaluating the potential for these actions, and the respective results of the inquiry. The tables list the neighborhoods that are identified for specific actions. Maps are also included showing the locations of the neighborhoods that were identified by the associated assessment.

4.2.3.1 Downspout Disconnection

Rain downspout disconnection decreases flow to local streams during storm events, helping to quell stream bank erosion and reduce pollutants entering the stream during storm events. Downspout disconnection can usually be achieved through downspout redirection. This method involves redirecting the rooftop runoff from impervious areas, or from a direct connection to the storm drain system, onto a nearby lawn or other pervious area. This allows the rain gutter discharge to infiltrate through the pervious area and enter the stream through the groundwater system in a slower and more natural fashion. There must be at least 15 feet of pervious area down gradient from the spout for infiltration to occur.

Rain barrels and rain gardens are other disconnection options that can be recommended in lieu of redirection based on specific conditions. Where there is limited pervious surface available, a rain barrel may be the only feasible method of disconnection. If the average neighborhood lot has several hundred square feet down gradient from the downspout, there is potential for a rain garden, the most desirable disconnection method.

A neighborhood in which 25% or more of the downspouts are feasible for disconnection will score for downspout redirection as a recommended action. Feasible for disconnection being defined as downspouts either directly connected to the system or discharging to an impervious surface that leads into a storm drain inlet AND with at least 15 feet of usable pervious area to redirect the flow. Table 4-1 lists by subwatershed the neighborhoods that meet these criteria. A GIS data layer of building footprints was used to calculate the amount of impervious surfaces that could have runoff treated if a downspout disconnection program was initiated. This data is also included in Table 4-1. Figure 4-1 shows the locations of neighborhoods recommended for downspout redirection.

Directly connected downspouts in NSA L-155B that are suitable for redirection onto lawn

Impervious downspout drainage & staining in NSA-L-197

A typical rain barrel installation with overflow hose

Table 4-1 Acres Addressed by Downspout Redirection

Subwatershed	Number of Neighborhoods with Downspout Redirection Recommended	Impervious Rooftop Acres Addressed by Downspout Disconnection	% of Subwatershed's Impervious Rooftop Area Addressed by Downspout Disconnection*
Armistead Run	1	2.0	3.2
Biddison Run	8	44.8	47.2
Brien's Run	2	4.7	2.5
Chinquapin Run	18	116.8	48.9
East Branch Herring Run	20	164.6	50.5
Herring Mainstem	25	285.4	47.2
Lower Herring Run	4	20.4	11.6
Moore's Run	21	215.8	61.5
Northeast Creek	10	57.4	43.0
Redhouse Run	36	252.8	79.6
Stemmer's Run	28	84.9	27.5
Tiffany Run	13	114.5	74.5
Unnamed Tributary	0	0.0	0.0
West Branch Herring Run	19	121.8	59.0
Total	**205**	**1485.9**	**39.7**

*this number was calculated by dividing the rooftop acres that could be addressed by downspout disconnection by the total rooftop acres of the subwatershed.

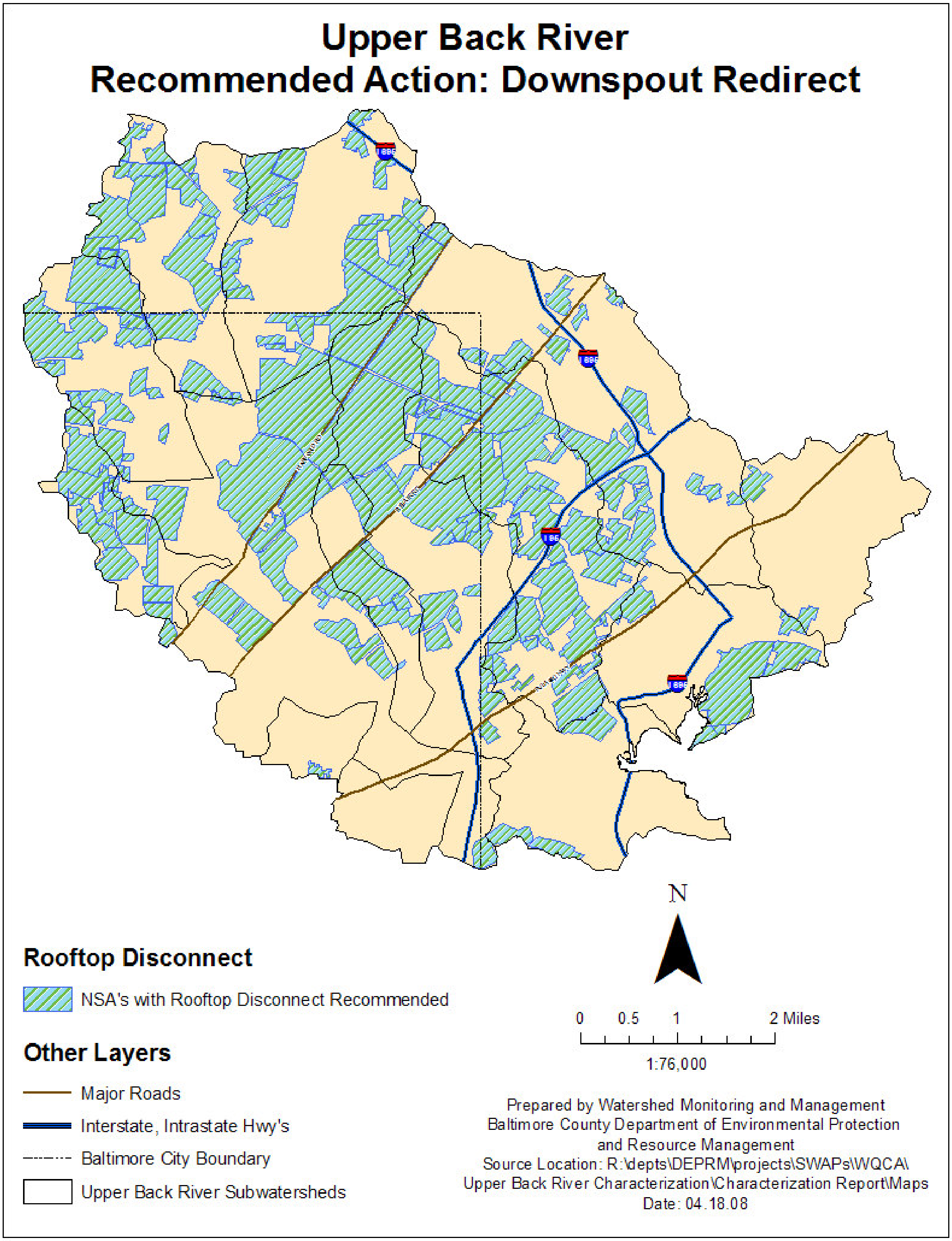


Figure 4-1. Neighborhoods with Downspout Redirection Recommended

4.2.3.2 Street Sweeping

Street sweeping removes trash, sediment and organic matter such as leaves and twigs from the curb and gutter system, preventing their entry into the storm drain system and nearby streams. This helps reduce sedimentation and pollutants, like oils and metals, in the stream. Excessive organic matter can clog streams and the storm drain system resulting in costly maintenance. In addition, the decay of a disproportionate amount of organic matter in the stream robs essential oxygen from the water. An aggressive street sweeping initiative can ease the effects of the curb and gutter storm drainage system on the receiving stream.

Neighborhoods exhibiting 20% or more of their curbs/gutters with excessive trash, sediment and/or organic matter were recommended for street sweeping. Figure 4-2 shows the locations of neighborhoods recommended for street sweeping. A GIS data layer of roads was used to tally the miles of roads for the neighborhoods that have street sweeping as a recommended action. Table 4-2 lists the neighborhoods and miles of roads by subwatershed. This information can help Baltimore City and Baltimore County agencies better target street sweeping efforts.

Trash on its way to a nearby stream in NSA-L-83

Street sweeping can help reduce sediment in streams like this one in NSA-L-182

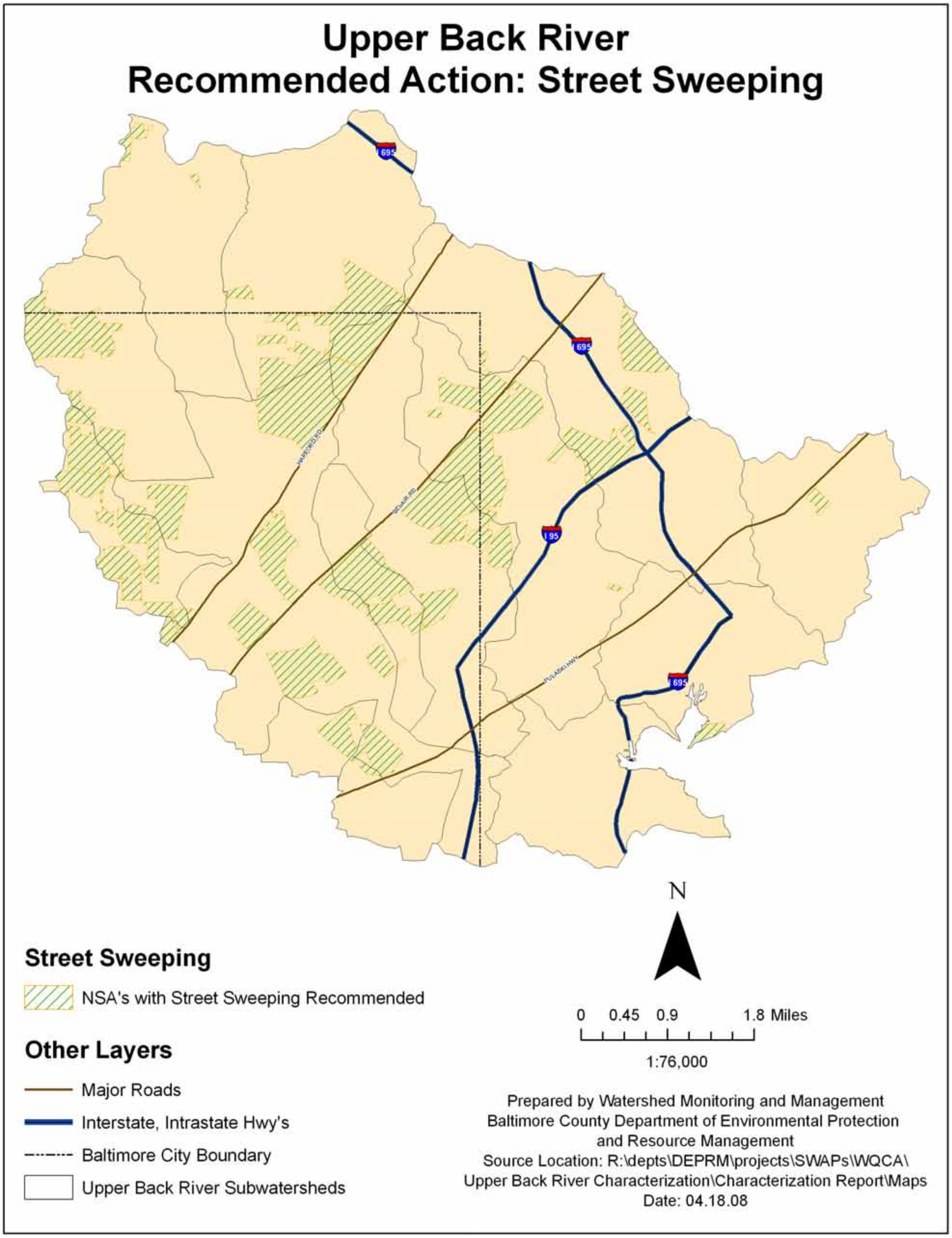


Figure 4-2 Neighborhoods with Street Sweeping Recommended

Table 4-2 Neighborhoods and Miles of Road Addressed by Street Sweeping

Subwatershed	Number of Neighborhoods with Street Sweeping Recommended	Miles Addressed by Street Sweeping
Armistead Run	2	0.2
Biddison Run	4	7.0
Brien's Run	0	0.0
Chinquapin Run	5	16.9
East Branch Herring Run	5	27.4
Herring Run Mainstem	14	57.9
Lower Herring Run	0	0.0
Moore's Run	7	29.8
Northeast Creek	2	3.1
Redhouse Run	6	36.2
Stemmer's Run	6	17.2
Tiffany Run	10	29.4
Unnamed Tributary	1	0.5
Herring Run West Branch	3	3.1
Total	**65**	**228.7**

4.2.3.3 High Lawn Maintenance

A well-manicured and responsibly maintained lawn can be an asset to the watershed. Too often however, over fertilization and irresponsible pest management result in pollutant charged runoff to local streams.

Neighborhoods where 20% or more of the homes were considered to employ high lawn maintenance practices were recommended for fertilizer reduction/education. Table 4-3 shows the number of neighborhoods and the acreage of these neighborhoods by subwatershed. Figure 4-3 shows their location. Typically, apartment complexes and town home developments employ the same lawn maintenance practice throughout their "neighborhood" so these usually assessed at 100% high or 100% medium lawn maintenance.

Fertilizer should be applied to lawns only after a soil test indicates that it is needed

Sign designating poisonous lawn care

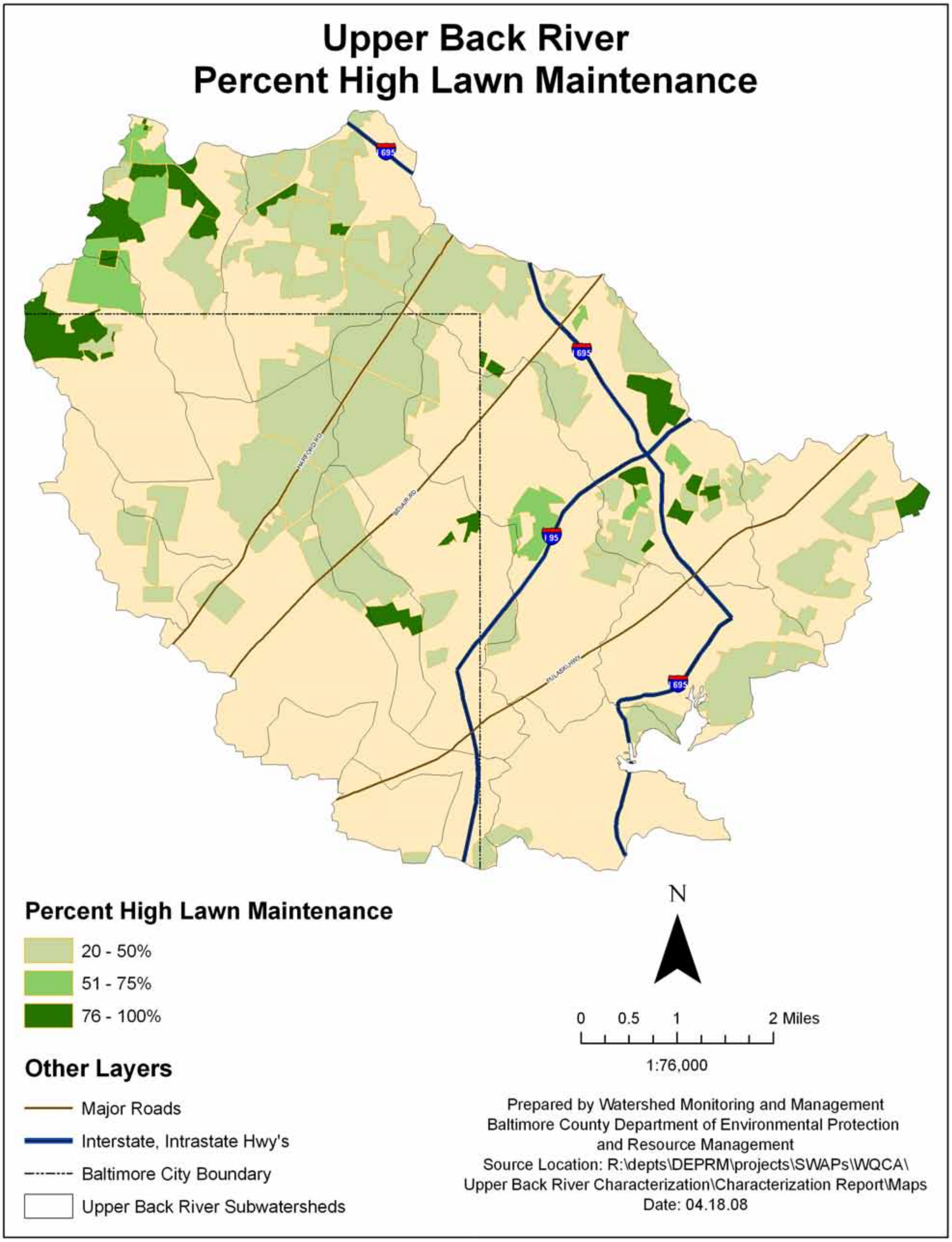


Figure 4-3 Neighborhoods with 20-100% High Maintenance Lawns

Table 4-3 Acres of Lawn Addressed by Fertilizer Reduction

Subwatershed	Nnumber of Neighborhoods with Fertilizer Reduction Recommended	Acres of Lawn Addressed by Fertilizer Reduction	% of Subwatershed Addressed by Fertilizer Reduction
Armistead Run	0	0.0	0.0
Biddison Run	6	216.7	27.4
Brien's Run	0	0.0	0.0
Chinquapin Run	7	389.1	23.6
East Branch Herring	16	408.7	15.2
Herring Run	11	312.2	7.0
Lower Herring Run	2	25.9	1.6
Moore's Run	12	263.1	9.4
Northeast Creek	5	116.5	7.1
Redhouse Run	12	168.5	5.6
Stemmer's Run	32	552.0	15.0
Tiffany Run	3	53.4	6.0
Unnamed Tributary	1	3.7	0.6
West Branch Herring	16	457.4	24.3
Total	**123**	**2967.2**	**10.2**

4.2.3.4 Bayscaping

Bayscaping employs the use of plants native to the Chesapeake Bay watershed for landscaping. These plants require less watering, fertilizers and pesticides to maintain than most exotics, and can enhance wildlife benefits. Implementing new bayscaped areas on a property also reduces lawn maintenance requirements.

Every neighborhood could use more bayscaping. In this case, however, bayscaping education and implementation was recommended in neighborhoods where the typical lot was less than 25% landscaped and impervious area on the lot would not inhibit improvement of this percentage. Table 4-4 shows the number of these neighborhoods and the acreage of land addressed by subwatershed. Figure 4-4 shows their location.

Large trees provide shade and reduce summer energy costs

Increasing mulched and planted areas reduces the need to maintain large areas of lawn

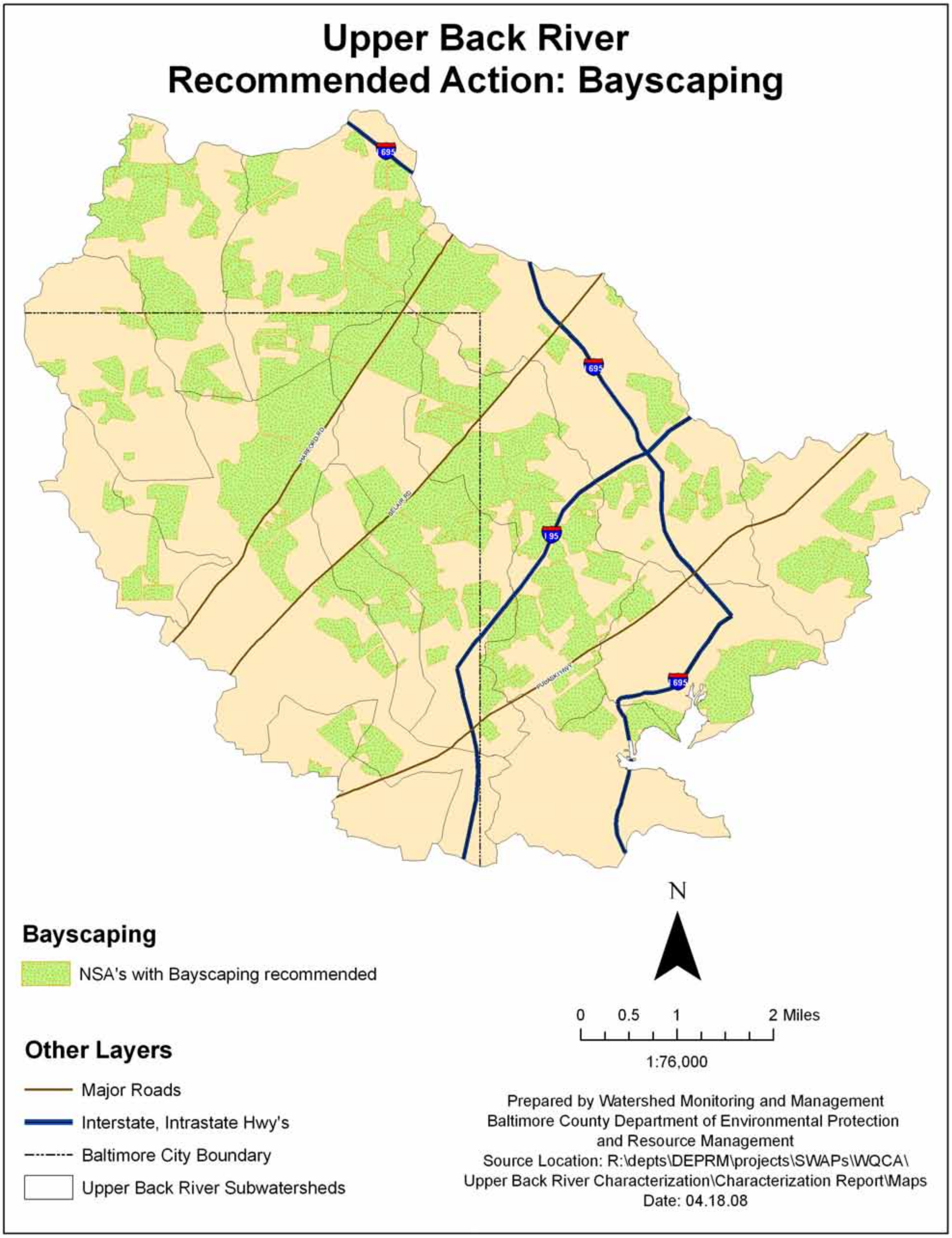


Figure 4-4 Neighborhoods with Bayscaping Recommended

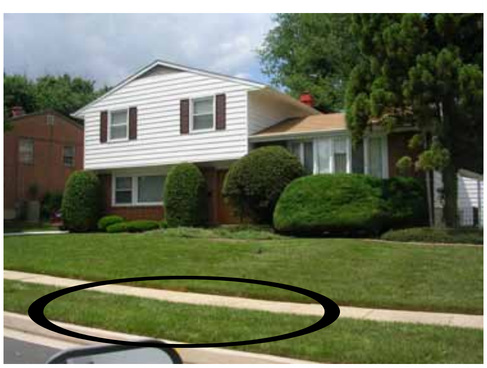
Table 4-4 Neighborhoods and Acres of Land Addressed by Bayscaping

Subwatershed	Number of Neighborhoods with Bayscaping Recommended	Acres of Land Addressed with Bayscaping
Armistead Run	2	60.8
Biddison Run	7	221.8
Brien's Run	4	317.8
Chinquapin Run	9	124.1
East Branch Herring Run	24	800.9
Herring Run Mainstem	16	848.3
Lower Herring Run	3	106.4
Moore's Run	22	852.0
Northeast Creek	7	328.4
Redhouse Run	32	1,228.4
Stemmer's Run	27	633.4
Tiffany Run	4	89.7
Unnamed Tributary	1	6.3
West Branch Herring Run	19	610.8
Total	**177**	**6229.1**

4.2.3.5 Street Trees

Street trees improve air quality, catch precipitation with their leaves and absorb precipitation and nutrients through their root systems.

Street trees were recommended for neighborhoods where at least 25% of the streets had four (4) feet or more of greenspace between the curb and sidewalk and less than 75% of these areas had trees planted. The number of trees was estimated based on a spacing of one tree per 15-20 feet. Table 4-5 shows the number of neighborhoods and the number of street trees that could be planted. Figure 4-5 shows the locations of the neighborhoods.



Street trees can be planted where there is a suitable distance between the sidewalk and road

Real estate values increase when a neighborhood is beautified with trees

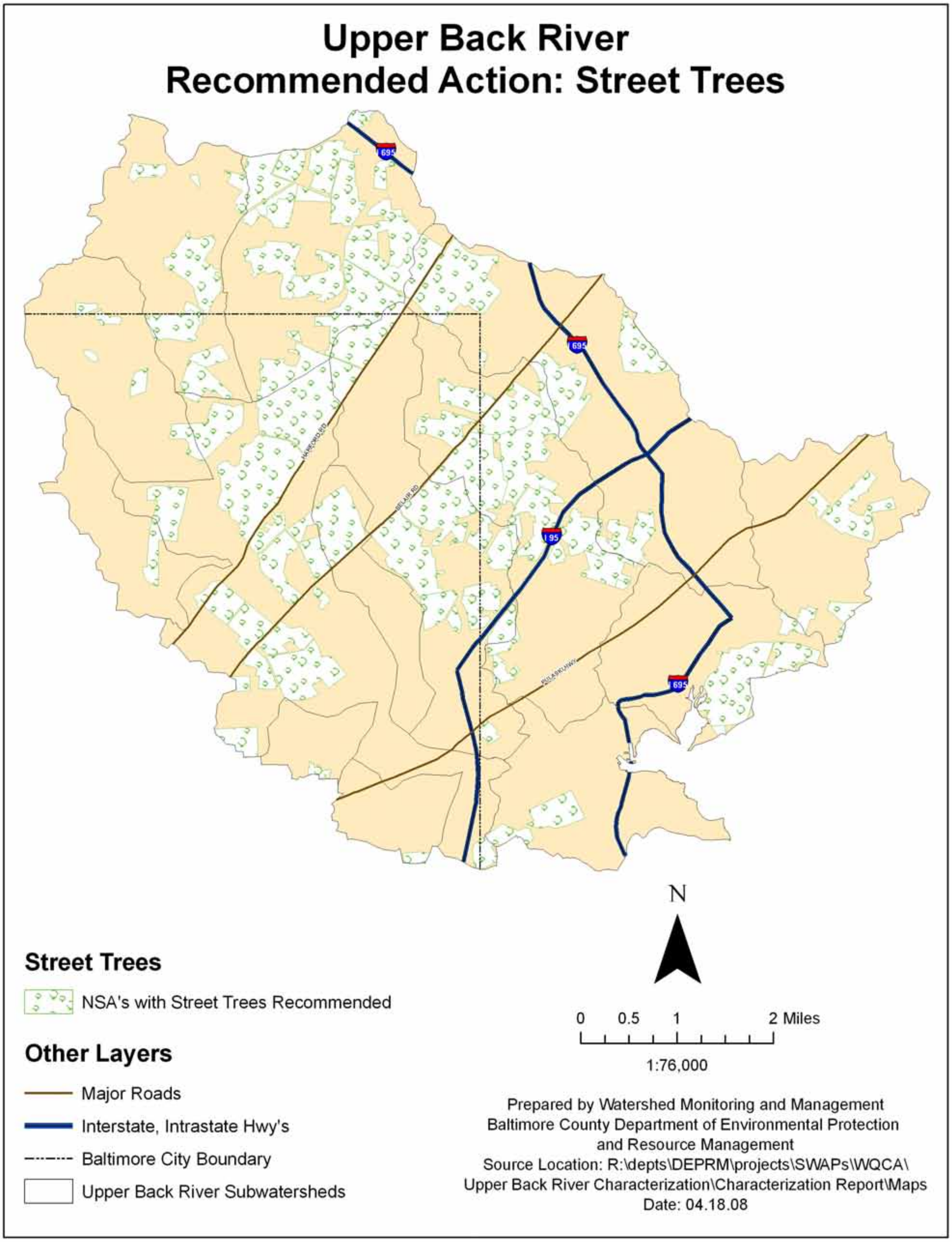


Figure 4-5 Neighborhoods with Street Tree Planting Recommended

Table 4-5 Street Tree Potential by Subwatershed

Subwatershed	Number of Neighborhoods with Street Tree Potential	Number of Street Trees That Could be Planted
Armistead Run	2	9
Biddison Run	2	25
Brien's Run	4	160
Chinquapin Run	6	235
East Branch Herring Run	17	945
Herring Run Mainstem	18	629
Lower Herring Run	2	142
Moore's Run	13	495
Northeast Creek	5	150
Redhouse Run	16	763
Stemmer's Run	11	173
Tiffany Run	1	26
Unnamed Tributary	1	2
West Branch Herring Run	8	274
Total	**106**	**4028**

4.3 Hotspot Site Investigations (HSI)

Stormwater "hot spots" are commercial or industrial operations that produce higher levels of storm water pollutants, and/or present a higher potential risk for spills, leaks or illicit discharges into the storm water system. Identifying potential hotspots using the HSI can help the appropriate local government agencies target follow-up investigations and enforcement efforts.

4.3.1 Assessment Protocol

The Hot Spot Investigation primarily followed the protocols outlined in the Unified Subwatershed and Site Reconnaissance (USSR) (Wright *et. Al.* 2004). This manual is one in a series developed by the Center for Watershed Protection. Stormwater hotspots are classified into four types of operations: commercial, industrial, municipal and transport-related. The Hot Spot Investigation is used to evaluate the potential of these types of facilities to contribute contaminated runoff to the storm drain system or directly to receiving waters.

At hotspot sites, field crews looked specifically at vehicle operations, outdoor materials storage, waste management, building conditions, turf and landscaping, and stormwater infrastructure to evaluate potential pollution sources. Based on observations at the site, the field crew may recommend enforcement measures, follow-up inspections, illicit discharge investigations, retrofits, or pollution prevention planning and awareness. The HSI data sheet was used to complete the investigation, the contents of which are outlined below:

A. Vehicle Operations: If there are vehicles stored, maintained, washed or fueled on the premises it must be noted here. Any and all vehicle activity from long-term parking to commercial fueling stations should be investigated. Staining and proximity of operations to storm drains are of particular interest here. Auto repair facilities prove to be the most likely hot spots.

B. Outdoor Materials: Many sites will require the storage of outdoor materials. Uncovered loading docks, rusting storage barrels and any exposed storage areas could be contributing to stormwater pollution. Again, stains leading from these areas to storm drains are of particular concern and can provide visual documentation of an observed pollution source.

C. Waste Management: Check for the type of waste generated, dumpster conditions and possible stains leading to storm drains.

D. Physical Plant: This section asks to check the condition of the building(s) and parking lot(s). Downspout discharge is noted here and a check for stains leading to storm drains indicating poor erosion/sediment control, cleaning & material storage practices is necessary.

E. Turf/Landscaping: Check here for treated lawns and possibility of landscape areas that drain to storm system.

F. Storm Water Infrastructure: Any on-site storm water management practices are indicated here along with gutter conditions if there are private storm drains on the property.

The overall pollution potential for each hotspot site was tallied based on observed sources of pollution and the potential of the site to generate pollutants that would likely enter the storm drain network. The hotspot designation criteria as set forth in *Wright et al*. (2004) was used to determine the status of each site based on field crew observations. Sites were classified into four initial hotspot status categories:

- Not a hotspot – no observed pollutant: few to no potential sources
- Potential hotspot – no observed pollution; some potential sources present
- Confirmed hotspot – pollution observed; many potential sources
- Severe hotspot – multiple polluting activities directly observed

Prior to going out in the field, potential hotspot locations were identified using GIS data from NAICS or North American Industry Classification System. Most of the potential hotspots were located along main roads where commercial and industrial zoning districts are planned. These road corridors tend to run as radials out from Baltimore City’s core.

4.3.2 Summary of Sites Investigated

A total of 33 hotspot candidates were investigated, 23 of which were commercial establishments. Of these 33, the initial hotspot statuses were designated as follows: zero severe, 16 confirmed and 13 potential hotspots. The remaining four were designated as not hotspots and determined to have no apparent stormwater pollution potential. Tables 4-6 through 4-8 show hot spot site status, facility type and pollution sources respectively. Figure 4-6 shows the locations of the investigations. Figure 4-7 shows the hot spot investigation pollution sources and locations.

Table 4-6 Hotspot Site Status

Subwatershed	# Severe Hotspots	# Confirmed Hotspots	# Potential Hotspots	# Not Hotspots
Armistead Run	0	2	0	0
Biddison Run	0	0	0	0
Briens Run	0	0	0	0
Chinquapin Run	0	0	0	0
East Branch Herring Run	0	1	0	0
Herring Run Mainstem	0	3	0	0
Lower Herring Run	0	0	0	0
Moore's Run	0	1	1	0
Northeast Creek	0	0	0	0
Redhouse Run	0	9	10	2
Stemmer's Run	0	0	1	1
Tiffany Run	0	0	0	0
Unnamed Tributary	0	0	0	0
West Branch Herring Run	0	0	1	1
Total	**0**	**16**	**13**	**4**

Table 4-7 Hotspot Site Type of Facility

Subwatershed	# Commercial	# Industrial	# Municipal	# Institutional
Armistead Run	1	1	0	0
Biddison Run	0	0	0	0
Briens Run	0	0	0	0
Chinquapin Run	0	0	0	0
East Branch Herring Run	1	0	0	0
Herring Run Mainstem	3	0	0	0
Lower Herring Run	0	0	0	0
Moore's Run	2	0	0	0
Northeast Creek	0	0	0	0
Redhouse Run	12	6	2	1
Stemmer's Run	2	0	0	0
Tiffany Run	0	0	0	0
Unnamed Tributary	0	0	0	0
West Herring Run	2	0	0	0
Total	**23**	**7**	**2**	**1**

Table 4-8 Hotspot Site Source of Pollution

Subwatershed	Outdoor Storage	Waste Management	Physical Plant	Turf/ Landscaping	Vehicle Operations
Armistead Run	2	2	2	0	1
Biddison Run	0	0	0	0	0
Briens Run	0	0	0	0	0
Chinquapin Run	0	0	0	0	0
East Branch Herring	1	1	1	0	1
Herring Run Mainstem	3	3	3	0	3
Lower Herring Run	0	0	0	0	0
Moore's Run	1	1	1	0	1
Northeast Creek	0	0	0	0	0
Redhouse Run	16	17	17	4	14
Stemmer's Run	0	1	0	0	0
Tiffany Run	0	0	0	0	0
Unnamed Tributary	0	0	0	0	0
West Branch Herring	0	1	1	1	0
Total	**23**	**25**	**25**	**5**	**20**

These storage drums at HSI L-601 are properly labeled but do not have secondary containment

HSI site L-502, an auto shop where vehicles are stored and repaired outside

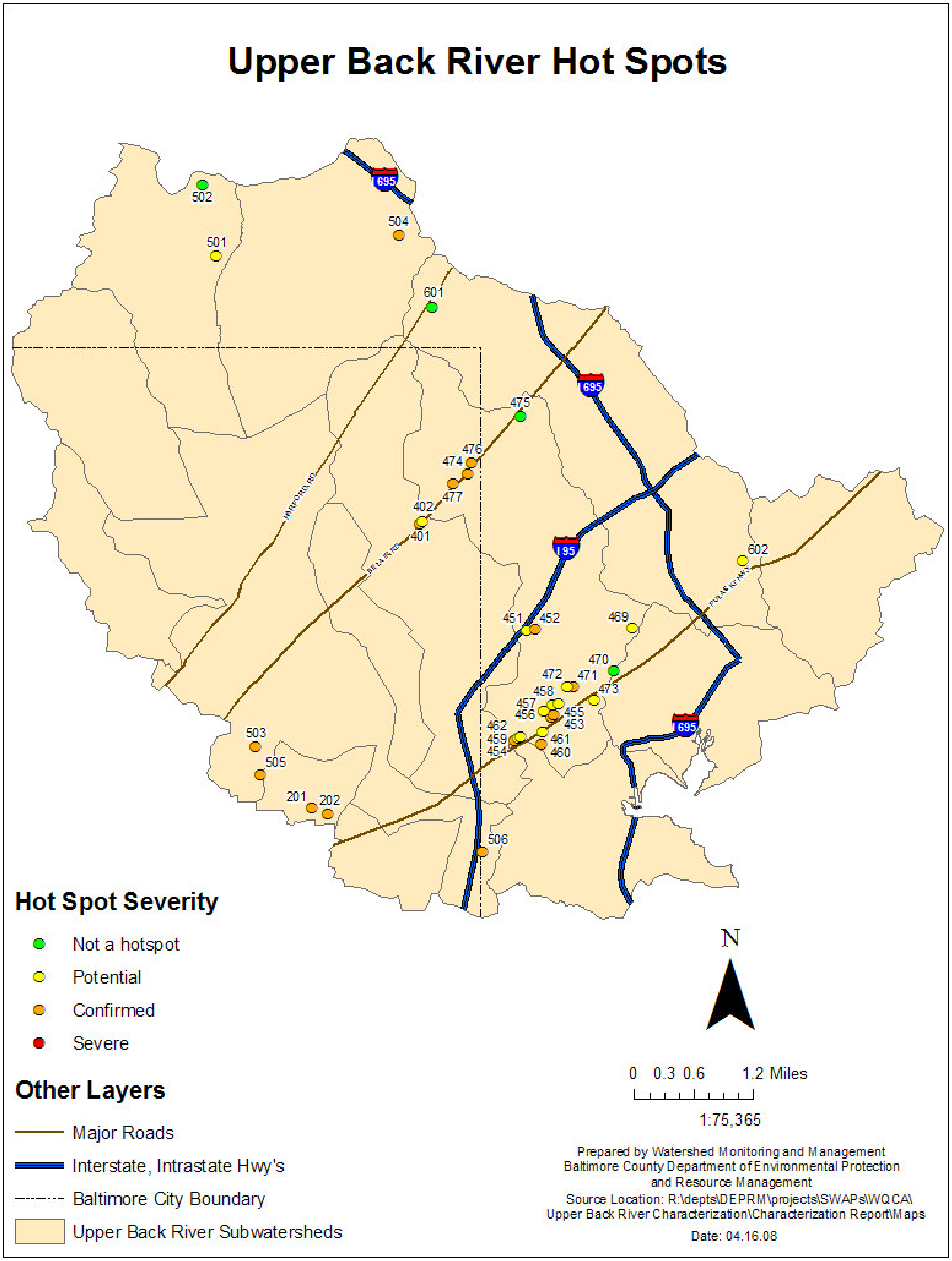
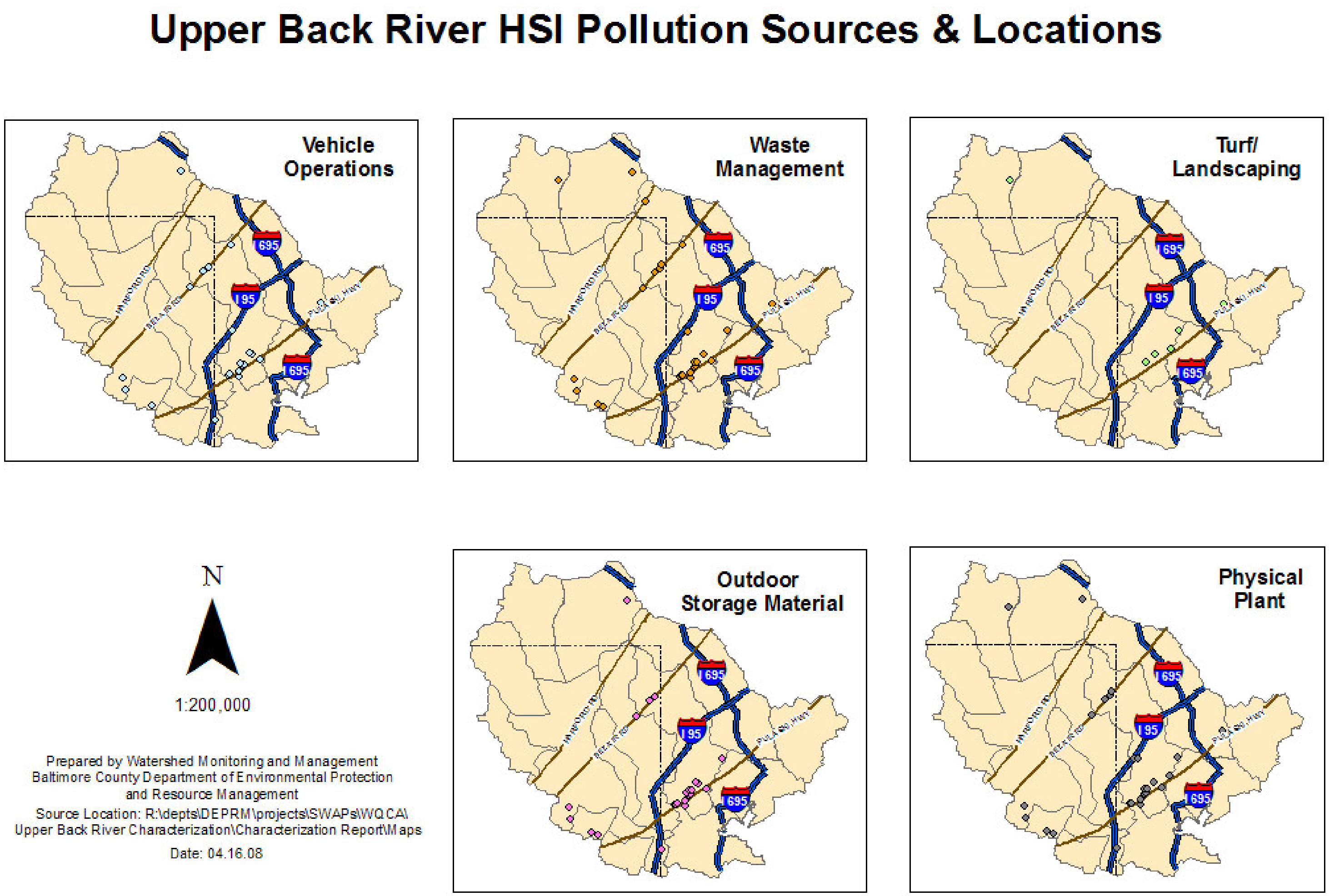


Figure 4-6 Hot Spot Investigation Locations

Figure 4-7 Hot Spot Investigation Pollution Sources and Locations



4.3.3 General Findings

See Appendix 4-1

Categorically, the auto repair shops scored the poorest, with 75% registering as a potential hotspot or worse. The biggest problems here were vehicles repaired and stored outdoors and heavy oil staining on concrete.

A glaring trend among most sites was poor waste management. Lidless/open or leaking dumpsters draining "dumpster juice" to adjacent storm drains were common.

Baltimore City and Baltimore County working together with local watershed groups can implement education and enforcement measures to address these concerns.

4.4 Institutional Site Investigations (ISI)

The unique characteristics of the Upper Back River watershed warranted modifications to some of the existing USSR assessment techniques. This became apparent to staff during the course of training and subsequent field assessment. The Back River watershed has an abundance of Institutional facilities that occupy 8% of the land surface. The existing assessment protocols in the HSI portion of the USSR manual did not exactly match with the land conditions found on the Institutional properties. A new field assessment was developed and piloted with this watershed plan. This field assessment is called the Institutional Site Investigation (ISI).

4.4.1 Assessment Protocol

Prior to conducting the fieldwork, a list was generated to determine sites of interest and a GIS map generated showing all ISI sites within the target subwatershed. In the field, ADC maps and indexes are used, along with said GIS maps to locate the targeted institution. Most institutions are listed in the ADC index.

Field investigations consist of observing the site as thoroughly as possible from a vehicle. If parts of the site are not accessible by vehicle, walking the site may be necessary. The ISI data sheet is used to complete the investigation, the contents of which are outlined here:

The ISI form indicates the type of facility from the following categories:

- Hospital
- Municipal facility
- School:
  - College
  - High school
  - Middle school
  - Elementary school

The ownership, if known, is also indicated. This is useful because different approaches may be used to contact private versus public institutions. Sometimes different partners may be making the contacts. 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.

Another piece of information that was noted about each institutional site is whether it is likely to need a nutrient management plan. The Maryland Department of Agriculture (MDA) implements an Urban Nutrient Management Program based on the Maryland Water Quality Act of 1988. This program regulates all facilities or companies that apply fertilizer to land that is either state-owned or consists of ten or more acres. Several of the Institutions in the study area potentially qualify and these will be forwarded to staff at MDA for follow up.

The field form incorporates many of the pollution source investigation categories that are used on the Hot Spot Investigation form. Some of the restoration opportunities and recommended actions from the Pervious Area Assessment and the Neighborhood Source Assessment are also incorporated. Below is a description of these categories.

Part A. Tree Planting: Potential tree planting locations are sought and estimates are noted on the field sheet. More accurate numbers can be determined during the post-fieldwork desktop analysis.

Part B. Exterior: Condition of the building(s) and parking lot(s) are noted and potential for excess impervious cover removal is determined. Although churches often seem to have potential for impervious removal, in most cases, it must be considered that on Sundays empty lots will most likely fill.

Storm drains in close proximity to the building must be examined for possible maintenance/mop water dumping. Downspout discharge is also noted here, keeping in mind the 15 ft minimum pervious area necessary for infiltration to be considered disconnected. Also, a check for stains leading to storm drains indicating poor erosion/sediment control, cleaning & material storage practices is necessary.

Part C. Waste Management: In most cases, garbage is the only waste type evident at institutions. Dumpster condition and proximity to storm drains is noted here.

Part D. Vehicle Operations was not applicable in any institutions during these investigations.

Part E. Outdoor Materials: Materials such as mulch piles, storage drums and salt for winter storms are sometimes stored on institution grounds without proper containment measures.

Part F. Turf/Landscaping Areas: Turf/landscaping/forest canopy/bare soil percentages are estimated here and confirmed in the post-fieldwork desktop analysis. Turf management status is determined based on guidelines set up in Manual 11 of the Urban Subwatershed Restoration Series. Check for storm drains connected to landscaped areas and possible effects of landscaped areas on adjacent impervious surfaces.

Part G. Storm Water Infrastructure: Check for storm drain stenciling and SWM practices. Recommended actions for ISIs include:

- storm drain stenciling
- tree planting
- downspout disconnection
- stormwater retrofit
- education
- follow-up on-site inspection
- impervious cover removal
- pervious area restoration
- consider a water pollution prevention plan

Using GIS, total acreage of the property is determined using tax boundaries. Tree planting sites identified in the field are accurately measured using GIS and tree-planting estimates are determined based on 15-20 foot spacing. These are preliminary estimates that will be more accurately estimated through follow up on-site investigations, if in fact the institution is chosen for restoration/ improvement. Turf/landscaping/forest canopy/bare soil percentages are confirmed and lat/long coordinates are noted using GIS.

4.4.2 Summary of Sites Investigated

A total of 44 ISI sites were assessed from the available GIS data layers. Table 4-9 summarizes the institution types assessed by subwatershed. Figure 4-8 shows locations, types and ownerships of all ISI sites.

Table 4-9 Institutional Types by Subwatershed

Subwatershed	Faith Based	Private School	Public School	Municipal Facility	Hospital	Cemetary	Golf Course
Armistead Run	0	0	0	0	0	0	0
Biddison Run	0	0	0	0	0	0	0
Briens Run	0	0	0	0	0	0	0
Chinquapin Run	1	0	1	0	0	0	0
East Branch Herring	3	1	5	0	0	0	1
Herring Run	0	0	4	0	1	0	0
Lower Herring Run	0	0	0	0	0	0	0
Moore's Run	0	0	0	0	0	0	0
Northeast Creek	0	0	0	0	0	0	0
Redhouse Run	0	0	6	0	0	0	0
Stemmer's Run	0	0	1	1	0	0	0
Tiffany Run	5	0	2	2	0	0	0
Unnamed Tributary	0	0	0	0	0	0	0
West Branch Herring	3	2	4	0	0	1	0
Total	**12**	**3**	**23**	**3**	**1**	**1**	**1**

Improperly stored outdoor materials at ISI site L-104

Potential impervious cover removal at ISI site L-105 in Chinquapin Run

Stream naturalization opportunity at ISI-L-602

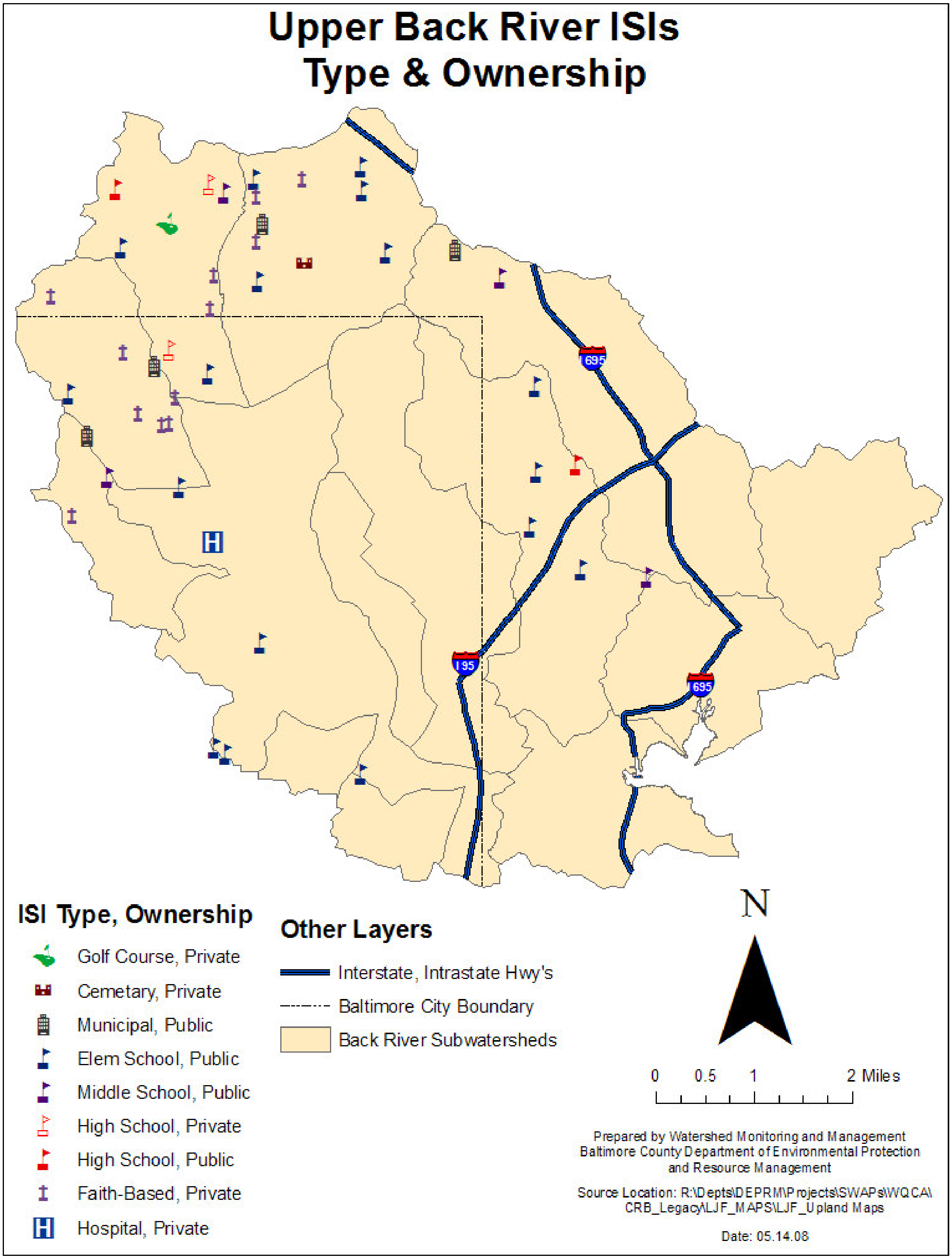


Figure 4-8 Institutional Site Investigation Locations

4.4.3 General Findings

Waste management proved to be the most frequent area in need of improvement with over 30% of the sites exhibiting this as a potential pollution source. 10 sites had areas of impervious cover that could be removed, 12 showed downspout disconnection possibilities and 10 sites had storm water retrofit potential.

It was estimated that 5112 total trees could be planted throughout 38 of the 44 institution sites surveyed. Table 4-10 summarizes the recommended actions by subwatershed.

Table 4-10 ISI Actions by Subwatershed

Subwatershed	Est. Trees	SW Rerofit	Downspout Disconn.	I. C. Removal	Trash Mgmt.
Armistead Run	0	0	0	0	0
Biddison Run	0	0	0	0	0
Briens Run	0	0	0	0	0
Chinquapin Run	845	1	4	3	5
East Branch Herring	1,697	3	2	0	1
Herring Run Mainstem	420	1	2	3	0
Lower Herring Run	0	0	0	0	0
Moore's Run	0	0	0	0	0
Northeast Creek	0	0	0	0	0
Redhouse Run	1,130	3	0	0	6
Stemmer's Run	80	1	1	2	0
Tiffany Run	240	0	0	1	1
Unnamed Tributary	0	0	0	0	0
West Branch Herring	700	2	3	1	1
Total	**5112**	**11**	**12**	**10**	**14**

Sites 501 (Stoneleigh Elementary), 527 (Towson High) and 602 (Parkville Middle) each represent unique opportunities to combine a stream restoration with education being that there is a stream running through the school grounds. Sites 501 and 602 each have streams running through concrete channels that could be naturalized and buffers planted. Site 527 has a stream where a buffer expansion and invasive species removal would be desired.

4.5 Pervious Area Assessments (PAA)

4.5.1 Assessment Protocol

The Pervious Area Assessment or PAA was used as a component of the USSR to identify and evaluate sites within the study area with potential for land reclamation, reforestation, or revegetation. The PAA primarily followed the protocols outlined in the Unified Subwatershed and Site Reconnaissance (USSR) (Wright *et. al.* 2004) Although the manual recommends remnants 2 acres or larger, due to the highly urbanized characteristics of many parts of the study area, all sites at least .25 acres were considered. Each site was evaluated based on the quality of the vegetation present and any conditions that may prevent the site from being considered a good candidate for restoration efforts.

The overall recommendation for each site was determined based on existing conditions at the sites including parcel size, ownership, invasive species, etc. The initial recommendation criteria as set forth in Wright *et al.* (2004) was used to determine the status of each site based on field crew observations. Sites were classified into four initial recommendation categories:

- Good candidate for natural regeneration
- May be reforested with minimal site preparation
- May be reforested with extensive site preparation
- Poor reforestation site requiring excessive preparation

4.5.2 Summary of Sites Investigated

A total of 36 pervious areas were assessed within the study area totaling 123.3 acres. Parcel sizes ranged from .5 acres to 7.5 acres with an average of 3.4 acres. All but sites 455, 507 & 702 (all forested areas) exhibited the "open pervious" cover type. Table 4-11 shows those sites requiring minimal site preparation on public land. Figure 4-9 shows locations of all PAAs, their respective sizes and ownership.

Table 4-11. Pervious Area Sites on Public Land

Site ID	Acres	Subwatershed	Site Prep
PAA-L-101	0.8	Chinquapin	Minimal
PAA-L-103	2.0	Chinquapin	Minimal
PAA-L-104	6.0	Chinquapin	Minimal
PAA-L-401	7.0	Moore's Run	Minimal
PAA-L-402	6.0	Moore's Run	Minimal
PAA-L-403	3.0	Moore's Run	Minimal
PAA-L-453	6.0	Redhouse Run	Minimal
PAA-L-455	7.5	Redhouse Run	Minimal
PAA-L-458	7.0	Redhouse Run	Minimal
PAA-L-501	6.0	Herring Run West	Minimal
PAA-L-502	1.0	Herring Run West	Minimal
PAA-L-504	5.0	Herring Run Main	Minimal
PAA-L-505	3.0	Herring Run Main	Minimal
PAA-L-506	1.0	Herring Run Main	Minimal
PAA-L-508	4.0	Herring Run East	Minimal
PAA-L-509	2.0	Herring Run East	Minimal
PAA-L-601	1.5	Stemmers Run	Minimal
PAA-L-651	3.0	Northeast Creek	Minimal
PAA-L-701	5.5	Brien's Run	Minimal

PAA site L-503 in Lower Herring Run

PAA site L-701 in O'Brien's Run is an opportunity for stream buffer expansion

4.5.3 General Findings

See appendix 4-2

The most likely candidates for successful pervious area restoration efforts are those on public lands with minimal site preparation required as shown in Table 4-11. There were 19 such sites identified in the study with areas ranging from .75 to 7.5 acres. Sites 455 and 458 were the largest of these sites, both on public property and good starting points for pervious area restoration efforts.

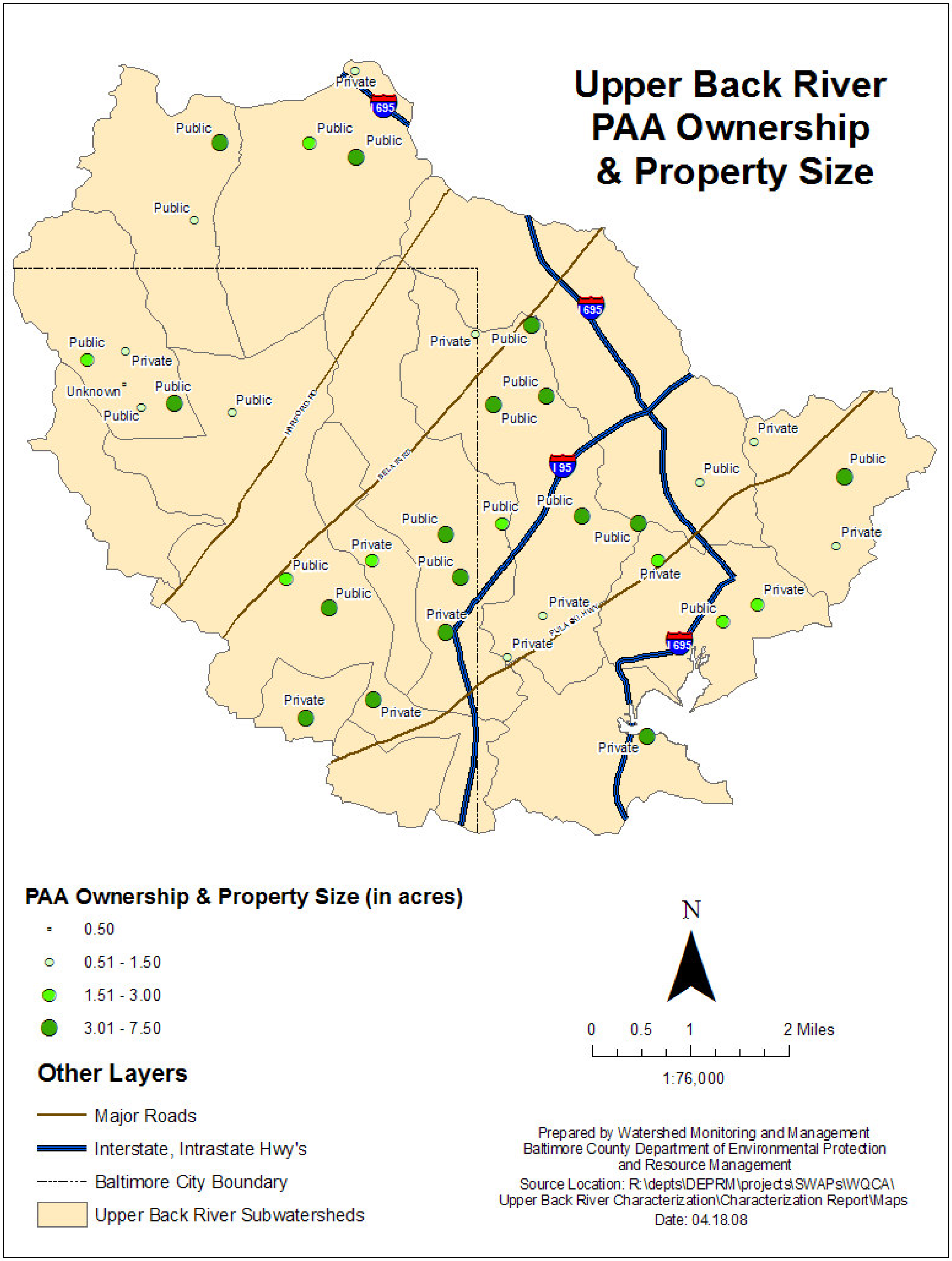


Figure 4-9 Pervious Area Assessment Locations

Appendices

Appendix 4-1a NSA Data

Neighborhood ID	PSI	ROI	Downspout Redirect	Rain Barrel	Rain Garden	Storm drain Stenciling	Bayscaping	Lot Canopy	Fertilizer Reduction	High Maintenance Lawns (%)
NSA_L_01	Moderate	Moderate	X		X		X	X		0
NSA_L_02	High	High	X	X	X	X	X	X		10
NSA_L_03	High	High	X	X	X	X	X	X		10
NSA_L_04	Moderate	Low		X			X	X		0
NSA_L_05	Moderate	High	X			X	X	X		15
NSA_L_06	Moderate	Moderate		X				X		0
NSA_L_07	Moderate	Moderate	X		X	X	X	X		10
NSA_L_08	Moderate	Moderate	X	X				X		0
NSA_L_09	High	Moderate	X		X		X	X		0
NSA_L_10	Moderate	Moderate	X			X	X	X		10
NSA_L_11	Moderate	High	X	X		X	X			0
NSA_L_12	Moderate	Moderate	X	X			X	X		20
NSA_L_13	None	Moderate		X				X		0
NSA_L_14	Moderate	Moderate		X						0
NSA_L_15	Moderate	High			X	X				10
NSA_L_16	Moderate	Moderate		X		X		X		0
NSA_L_17	Moderate	High	X		X	X	X	X		10
NSA_L_18	Moderate	High			X	X	X	X		0
NSA_L_19	Moderate	High	X	X	X		X	X		5
NSA_L_20	High	Moderate	X		X	X			X	30
NSA_L_21	High	Moderate	X			X	X	X	X	40
NSA_L_22	Moderate	Low		X						0
NSA_L_23	High	Moderate	X			X	X	X		0
NSA_L_24	Moderate	Moderate	X		X			X		20
NSA_L_25	Moderate	Moderate	X		X	X	X	X	X	40
NSA_L_26	Moderate	Moderate		X				X		20
NSA_L_27	High	Moderate			X	X	X	X	X	35
NSA_L_28	Moderate	Moderate	X			X			X	98
NSA_L_29	Moderate	Moderate		X		X		X	X	100
NSA_L_30	Moderate	Moderate		X		X		X	X	30
NSA_L_31	Moderate	Moderate	X			X		X		10
NSA_L_32	Moderate	Moderate	X	X	X		X	X		5
NSA_L_33	Moderate	Low		X			X			0
NSA_L_34	Moderate	Low		X		X				0
NSA_L_35	High	Moderate	X			X	X	X		10
NSA_L_36	None	Low		X		X				0
NSA_L_37	Moderate	Moderate	X	X	X		X	X		0
NSA_L_38	High	Moderate		X		X				30
NSA_L_39	Moderate	Moderate		X			X	X	X	25
NSA_L_40	Moderate	Moderate		X				X		10
NSA_L_41	Moderate	Moderate				X	X	X	X	40
NSA_L_42	Moderate	Moderate		X		X	X	X		10
NSA_L_43	High	Moderate	X	X		X		X	X	35
NSA_L_44	Moderate	Moderate		X		X		X		10
NSA_L_46	Moderate	Moderate		X		X			X	40
NSA_L_48	Moderate	Moderate	X	X		X		X		15
NSA_L_49	High	Moderate	X		X	X				
NSA_L_50A	None	Low	X							
NSA_L_50B	Moderate	Moderate	X			X	X	X		10
NSA_L_51	High	Low	X			X				
NSA_L_53	Moderate	Moderate	X	X		X	X	X	X	50
NSA_L_54	High	Moderate	X	X		X				0
NSA_L_55	High	Moderate		X		X				0
NSA_L_56	Moderate	High	X		X	X			X	25
NSA_L_57	Moderate	Moderate	X	X		X		X		5
NSA_L_58	Moderate	Moderate		X		X		X		0
NSA_L_59	Moderate	Moderate		X		X		X		0
NSA_L_60	Moderate	Moderate		X		X		X		5

Neighborhood ID	PSI	ROI	Downspout Redirect	Rain Barrel	Rain Garden	Storm drain Stenciling	Bayscaping	Lot Canopy	Fertilizer Reduction	High Maintenance Lawns (%)
NSA_L_61	High	High		X		X	X	X		15
NSA_L_63	Moderate	High		X		X		X		10
NSA_L_64	Moderate	Moderate		X		X		X		0
NSA_L_65	Moderate	Moderate	X	X		X	X	X		15
NSA_L_66A	Moderate	Moderate		X		X		X		5
NSA_L_66B	Moderate	Moderate	X			X	X	X		5
NSA_L_67	Moderate	Moderate	X	X			X			15
NSA_L_68	Moderate	Moderate	X	X		X		X	X	25
NSA_L_69	Moderate	Moderate	X		X	X	X	X		0
NSA_L_70	None	Moderate				X	X	X		10
NSA_L_71	Moderate	High	X		X	X	X	X		0
NSA_L_72	Moderate	Moderate	X		X	X	X	X		20
NSA_L_73	Moderate	Moderate	X			X	X	X	X	35
NSA_L_74	Moderate	High	X			X	X	X		20
NSA_L_75	High	Moderate	X				X	X		20
NSA_L_76	Moderate	Moderate	X		X		X	X		20
NSA_L_77	Moderate	High	X		X	X	X	X	X	35
NSA_L_78	High	Moderate	X		X	X	X	X		20
NSA_L_79	Moderate	Moderate	X			X				20
NSA_L_80	High	Moderate	X			X	X	X	X	30
NSA_L_81	Moderate	High		X		X	X			20
NSA_L_82	High	High		X		X		X	X	45
NSA_L_83	Moderate	Moderate	X	X		X	X	X		10
NSA_L_84	Moderate	Moderate	X		X		X	X		0
NSA_L_85	High	Moderate	X	X		X	X	X	X	35
NSA_L_86	Moderate	High	X			X	X	X		20
NSA_L_87	Moderate	Moderate		X		X	X	X		15
NSA_L_88	Moderate	Moderate		X		X		X		15
NSA_L_89	Moderate	High	X		X	X	X	X	X	100
NSA_L_90	Moderate	Moderate	X		X	X	X	X	X	100
NSA_L_91	Moderate	Moderate	X			X	X	X		0
NSA_L_92	Moderate	Moderate	X		X	X	X	X	X	100
NSA_L_93	Moderate	High	X			X				0
NSA_L_94	Moderate	Moderate		X		X		X		0
NSA_L_95	None	Moderate		X				X	X	100
NSA_L_96	Moderate	Moderate							X	100
NSA_L_97	Moderate	Moderate	X							
NSA_L_99	Moderate	Moderate	X		X	X	X	X	X	100
NSA_L_100	Moderate	High	X		X	X	X			
NSA_L_101	Moderate	Moderate			X		X			0
NSA_L_102A	Moderate	Moderate	X		X	X	X	X	X	0
NSA_L_102B	Moderate	Moderate			X	X	X	X		0
NSA_L_103	Moderate	Low		X		X	X			0
NSA_L_104A	Moderate	Moderate	X			X	X	X		0
NSA_L_104B	Moderate	Moderate	X			X	X	X		0
NSA_L_105	Moderate	High	X		X		X	X		0
NSA_L_106A	Moderate	High				X	X	X		0
NSA_L_106B	Moderate	Moderate	X				X	X		0
NSA_L_107	Moderate	Moderate					X	X		0
NSA_L_108	None	Moderate					X			
NSA_L_109	Moderate	Moderate	X			X	X	X		0
NSA_L_110A	None	Low	X							
NSA_L_110B	Moderate	Moderate								
NSA_L_111	Moderate	Moderate	X		X		X	X		0
NSA_L_112	Moderate	Moderate			X	X	X			
NSA_L_113	Moderate	Moderate	X						X	35
NSA_L_114	Moderate	Moderate		X		X			X	35
NSA_L_115	Moderate	Moderate		X						10

Neighborhood ID	PSI	ROI	Downspout Redirect	Rain Barrel	Rain Garden	Storm drain Stenciling	Bayscaping	Lot Canopy	Fertilizer Reduction	High Maintenance Lawns (%)
NSA_L_116	None	Low	X				X	X		0
NSA_L_117	Moderate	Low	X			X				0
NSA_L_118	Moderate	High			X	X				
NSA_L_119	Moderate	Moderate		X		X		X	X	100
NSA_L_121	Moderate	Moderate				X		X	X	100
NSA_L_122	Moderate	Moderate		X		X		X	X	50
NSA_L_123	Moderate	Moderate		X		X		X		0
NSA_L_124	Moderate	High	X			X			X	35
NSA_L_126	Moderate	Moderate	X		X				X	60
NSA_L_127	Moderate	Moderate	X				X	X		20
NSA_L_128	Moderate	Moderate	X			X				0
NSA_L_129	High	Moderate				X				0
NSA_L_130	Moderate	High				X				
NSA_L_131	Moderate	High	X		X	X	X	X	X	70
NSA_L_132	Moderate	Moderate				X		X	X	60
NSA_L_133	High	Moderate	X		X				X	70
NSA_L_134	Moderate	Moderate	X		X	X	X		X	80
NSA_L_135A	Moderate	High	X		X		X		X	80
NSA_L_135B	Moderate	High	X		X		X	X	X	70
NSA_L_136	Moderate	Moderate	X		X				X	80
NSA_L_137	High	High	X			X		X	X	70
NSA_L_138A	Moderate	Moderate			X	X	X	X	X	50
NSA_L_138B	Moderate	Moderate				X		X	X	50
NSA_L_139	Moderate	Moderate	X			X	X	X	X	45
NSA_L_140	Moderate	Moderate	X			X	X	X	X	30
NSA_L_141	Moderate	Moderate	X			X				20
NSA_L_142	Moderate	Moderate	X			X		X	X	35
NSA_L_143	Moderate	Moderate				X		X	X	30
NSA_L_144	Moderate	Moderate			X	X			X	30
NSA_L_145	Moderate	Moderate			X					20
NSA_L_146	Moderate	Moderate		X		X		X	X	25
NSA_L_147	Moderate	Moderate	X		X		X	X		20
NSA_L_148	Moderate	Moderate			X		X	X		10
NSA_L_149A	None	Low		X						
NSA_L_149B	Moderate	Low	X			X	X			0
NSA_L_150	High	Moderate	X	X		X	X	X		15
NSA_L_151A	High	Moderate	X	X		X				10
NSA_L_151B	Moderate	Low		X		X				5
NSA_L_152	Moderate	High	X			X	X			10
NSA_L_153	Moderate	Moderate	X			X	X	X		10
NSA_L_154	High	High	X			X	X	X		10
NSA_L_155A	Moderate	Moderate	X			X	X	X		10
NSA_L_155B	Moderate	High	X		X	X			X	100
NSA_L_156	High	High	X			X	X	X		20
NSA_L_157A	Moderate	Moderate	X			X		X		0
NSA_L_157B	Moderate	Moderate	X			X	X	X	X	100
NSA_L_158	Moderate	Moderate	X				X	X		0
NSA_L_159	High	Moderate	X				X			0
NSA_L_160	Moderate	Moderate	X			X	X			0
NSA_L_161	Moderate	Moderate		X		X	X	X		5
NSA_L_162	High	Moderate	X			X	X			0
NSA_L_163A	Moderate	Moderate	X	X		X				5
NSA_L_163B	Moderate	Moderate		X		X	X		X	35
NSA_L_164	High	High	X			X	X	X	X	100
NSA_L_165	Moderate	Moderate	X			X	X	X		0

Neighborhood ID	PSI	ROI	Downspout Redirect	Rain Barrel	Rain Garden	Storm drain Stenciling	Bayscaping	Lot Canopy	Fertilizer Reduction	High Maintenance Lawns (%)
NSA_L_168	Moderate	Moderate		X				X		20
NSA_L_169	Moderate	Moderate		X		X		X		15
NSA_L_170	Moderate	Moderate		X		X	X	X		0
NSA_L_171	Moderate	High	X			X				0
NSA_L_172	High	High	X			X				0
NSA_L_173A	Moderate	Moderate	X			X				0
NSA_L_173B	High	High	X			X				0
NSA_L_174	High	High	X			X				0
NSA_L_175	Moderate	Moderate	X			X	X			0
NSA_L_176	Moderate	Moderate	X			X				0
NSA_L_177	High	High		X				X	X	35
NSA_L_178	Moderate	Moderate		X		X			X	35
NSA_L_179	Moderate	Moderate	X		X		X			10
NSA_L_180	High	High	X					X		5
NSA_L_181	Moderate	High	X			X	X	X		10
NSA_L_182	Moderate	High	X		X	X				15
NSA_L_183A	Moderate	High		X		X				10
NSA_L_183B	High	Moderate	X	X			X		X	60
NSA_L_184	High	High	X			X	X	X		15
NSA_L_185	Moderate	Moderate				X	X	X	X	95
NSA_L_186	Moderate	High	X			X	X	X		5
NSA_L_187	Moderate	High	X			X	X	X		10
NSA_L_189	Moderate	Moderate	X		X	X	X	X		15
NSA_L_190	High	High	X			X	X	X	X	50
NSA_L_191	Moderate	Moderate	X			X	X	X		5
NSA_L_192	Moderate	Moderate	X				X	X		15
NSA_L_193	Moderate	High	X					X	X	35
NSA_L_194	Moderate	Moderate	X				X	X	X	100
NSA_L_195	Moderate	Moderate	X				X	X	X	75
NSA_L_196	High	Moderate	X		X		X	X	X	30
NSA_L_197	Moderate	Moderate	X	X		X	X	X	X	80
NSA_L_198	Moderate	Moderate	X			X			X	35
NSA_L_199	Moderate	Moderate			X		X	X	X	60
NSA_L_200	High	Moderate	X			X	X	X	X	100
NSA_L_201	Moderate	Moderate	X			X	X	X	X	100
NSA_L_202	Moderate	Moderate				X	X	X	X	35
NSA_L_203	Moderate	Moderate				X	X	X	X	50
NSA_L_204	Moderate	Moderate				X	X	X	X	80
NSA_L_205	Moderate	Moderate				X	X	X	X	50
NSA_L_206	Moderate	Moderate			X	X		X	X	35
NSA_L_207	High	High	X		X	X	X		X	40
NSA_L_208	High	Moderate		X		X		X	X	100
NSA_L_209	High	High	X			X	X	X	X	30
NSA_L_210	Moderate	Moderate	X		X	X	X	X	X	30
NSA_L_211	High	High	X			X		X		15
NSA_L_212	Moderate	Moderate				X	X	X	X	25
NSA_L_213	Moderate	High	X		X	X	X	X		15
NSA_L_214	Moderate	Moderate		X				X		10
NSA_L_216	Moderate	Moderate	X		X			X		15
NSA_L_218	High	Moderate	X			X	X	X	X	100
NSA_L_219	High	High	X				X	X	X	100

Appendix 4-1b NSA Data cont

Neighborhood ID	Trash Management	Buffer Impact	Street Trees	Open Space Trees	Park Creation	Parking Lot Retrofit	Alley Retrofit	Street Sweeping	Total Acres	Impervious Acres	Pet waste
NSA_L_01	X	X	0	0					112	16	
NSA_L_02			0	0					13	3	
NSA_L_03			0	0					24	3	
NSA_L_04			0	0					25	5	
NSA_L_05		X	50	0					30	9	
NSA_L_06			0	0					5	1	
NSA_L_07		X	0	0					8	1	
NSA_L_08			0	0					9	3	
NSA_L_09		X	0	0					71	16	
NSA_L_10			0	0					152	41	
NSA_L_11			50	0					18	41	
NSA_L_12			100	0					75	7	
NSA_L_13			20	0					6	16	
NSA_L_14				0				X	5	11	
NSA_L_15		X		0					45	10	
NSA_L_16			0	0					7	5	
NSA_L_17		X	100	0					80	5	
NSA_L_18			0	20		X			21	12	
NSA_L_19		X	75	75					27	2	X
NSA_L_20			0	0			X	X	72	3	
NSA_L_21	X		80	0				X	152	11	
NSA_L_22			0	0					59	17	
NSA_L_23	X		0	0					69	28	
NSA_L_24			50	0					166	39	X
NSA_L_25			0	0					27	6	
NSA_L_26		X	50	25	X		X		117	43	
NSA_L_27		X	20	0					106	29	
NSA_L_28			0	0				X	231	60	X
NSA_L_29			0	50		X		X	5	2	
NSA_L_30			0	0			X	X	37	14	
NSA_L_31			0	0			X		39	15	
NSA_L_32			50	150					89	32	
NSA_L_33			0	0					44	17	
NSA_L_34				0			X		103	39	
NSA_L_35			0	0			X		9	3	
NSA_L_36			0	0			X		23	9	
NSA_L_37			20	50					78	29	
NSA_L_38			50	0			X		153	61	
NSA_L_39		X	100	250					139	38	
NSA_L_40			0	0					6	2	
NSA_L_41			0	20					151	34	
NSA_L_42			0	0					170	30	
NSA_L_43			15	0					44	9	
NSA_L_44			100	0					81	16	
NSA_L_46	X		0	0					35	9	
NSA_L_48			25	0				X	14	3	
NSA_L_49	X			0				X	44	15	
NSA_L_50A				0		X			2	1	
NSA_L_50B			0	0					20	9	
NSA_L_51	X		0	0				X	150	51	
NSA_L_53			0	0					31	12	
NSA_L_54			0	0				X	64	27	
NSA_L_55	X		0	0				X	24	12	
NSA_L_56			50	0					82	30	
NSA_L_57	X		50	0				X	83	41	
NSA_L_58	X		50	0					28	9	
NSA_L_59			50	0					44	22	

Neighborhood ID	Trash Management	Buffer Impact	Street Trees	Open Space Trees	Park Creation	Parking Lot Retrofit	Alley Retrofit	Street Sweeping	Total Acres	Impervious Acres	Pet waste
NSA_L_60			50	0					88	34	
NSA_L_61	X	X	0	100				X	175	57	
NSA_L_63	X		60	100			X	X	184	79	
NSA_L_64			50	50					69	41	
NSA_L_65				0	X		X		56	24	
NSA_L_66A	X		0	0			X		34	20	
NSA_L_66B			25	0					13	4	
NSA_L_67			40	0				X	104	39	
NSA_L_68			100	10					96	35	
NSA_L_69			0	100					34	14	
NSA_L_70			100	100					28	11	
NSA_L_71		X	0	50					13	5	
NSA_L_72			150	100					119	31	
NSA_L_73		X	50	0					199	59	
NSA_L_74		X	100	0				X	358	112	
NSA_L_75	X		50	0				X	489	169	
NSA_L_76			40	0					367	116	
NSA_L_77			25	0				X	44	17	
NSA_L_78				0					121	43	
NSA_L_79			0	0					520	173	
NSA_L_80			0	0					262	86	
NSA_L_81		X	30	0					296	84	
NSA_L_82			35	0			X		259	94	
NSA_L_83	X		0	30	X		X	X	39	19	X
NSA_L_84			0	100	X				31	11	
NSA_L_85	X		0	0				X	237	71	
NSA_L_86		X	50	0				X	64	19	
NSA_L_87			25	0					211	76	
NSA_L_88	X		0	100	X		X		74	28	
NSA_L_89	X	X	50	100					32	8	
NSA_L_90			0	75					30	5	
NSA_L_91			15	10				X	5	2	
NSA_L_92		X	0	0					36	19	
NSA_L_93			25	0		X			14	4	
NSA_L_94			75	0					16	6	
NSA_L_95			0	20					1	1	
NSA_L_96			20	100					7	2	
NSA_L_97	X	X	0	20		X			2	0	
NSA_L_99			50	100					26	11	
NSA_L_100	X	X	0	0				X	19	7	
NSA_L_101			0	100		X			42	16	
NSA_L_102A		X	0	100					31	11	
NSA_L_102B		X	0	30					25	10	
NSA_L_103	X		0	10					16	5	
NSA_L_104A	X		0	20				X	16	5	
NSA_L_104B	X		0	20				X	33	12	
NSA_L_105			0	50		X			7	2	
NSA_L_106A			10	20		X			7	3	
NSA_L_106B			0	50					28	11	
NSA_L_107			30	100					36	8	
NSA_L_108			50	50					11	4	
NSA_L_109			100	100		X			24	8	
NSA_L_110A	X			0		X			8	3	
NSA_L_110B				0			X		32	10	
NSA_L_111			0	50					15	5	
NSA_L_112		X	0	0					173	31	
NSA_L_113			0	0					28	7	

Neighborhood ID	Trash Management	Buffer Impact	Street Trees	Open Space Trees	Park Creation	Parking Lot Retrofit	Alley Retrofit	Street Sweeping	Total Acres	Impervious Acres	Pet waste
NSA_L_114		X	0	0					98	25	
NSA_L_115			0	60					16	6	
NSA_L_116			0	25		X			5	3	
NSA_L_117			0	25		X			7	4	
NSA_L_118		X	0	100		X			24	6	
NSA_L_119			0	0		X			3	1	
NSA_L_121	X	X	0	75		X			13	4	
NSA_L_122	X			0					7	3	
NSA_L_123			0	0					12	5	
NSA_L_124			0	0					42	11	
NSA_L_126		X	0	40					13	2	
NSA_L_127			0	0					15	2	
NSA_L_128			0	40				X	49	17	
NSA_L_129	X		10	15	X			X	22	8	
NSA_L_130	X			0			X		159	65	
NSA_L_131				0				X	40	8	
NSA_L_132			0	0					19	6	
NSA_L_133			0	0					49	6	
NSA_L_134			0	0					76	11	
NSA_L_135A		X	0	0					143	25	
NSA_L_135B		X	0	0					106	26	
NSA_L_136			0	0					19	4	
NSA_L_137			0	0					257	63	
NSA_L_138A			0	0					33	2	
NSA_L_138B				0					6		
NSA_L_139			0	0					17	5	
NSA_L_140			50	0					140	48	
NSA_L_141			50	0					53	17	
NSA_L_142			75	0			X		56	22	
NSA_L_143			75	0					24	10	
NSA_L_144		X	0	0					140	29	
NSA_L_145		X	50	0					106	15	
NSA_L_146			100	15					100	39	
NSA_L_147		X		0	X				25	3	X
NSA_L_148			0	50					33	6	
NSA_L_149A				0		X			4	1	
NSA_L_149B			0	0					27	8	
NSA_L_150			0	0					156	50	
NSA_L_151A	X		0	0					129	17	
NSA_L_151B			0				X			22	
NSA_L_152			10	0					84	24	
NSA_L_153				0			X		15	4	
NSA_L_154		X	75	0				X	80	22	
NSA_L_155A				0					17	4	
NSA_L_155B			20	15		X		X	7	3	
NSA_L_156				0			X	X	35	9	
NSA_L_157A		X	0	0					65	12	
NSA_L_157B			0	0					13	4	
NSA_L_158			0	75					6	2	
NSA_L_159	X		0	25				X	7	2	
NSA_L_160			20	20					12	4	
NSA_L_161			100	15			X		80	28	
NSA_L_162	X	X	25	25					16	6	
NSA_L_163A	X		0	0	X		X		35	13	
NSA_L_163B			0						20	9	
NSA_L_164	X	X	0	150				X	70	20	

Neighborhood ID	Trash Management	Buffer Impact	Street Trees	Open Space Trees	Park Creation	Parking Lot Retrofit	Alley Retrofit	Street Sweeping	Total Acres	Impervious Acres	Pet waste
NSA_L_165	X	X	0	75					14	4	
NSA_L_168			5	0			X		59	11	
NSA_L_169			100	0	X				93	41	
NSA_L_170			0	0				X	37	14	
NSA_L_171			0	0			X	X	72	34	
NSA_L_172	X		0	0	X		X	X	82	36	
NSA_L_173A			0	0					1	1	X
NSA_L_173B	X		0	0					94	34	
NSA_L_174	X		0	0				X	14	6	
NSA_L_175	X		0	0					35	9	
NSA_L_176			0	20					8	3	
NSA_L_177		X	30	0				X	121	14	
NSA_L_178		X	30	0					184	46	
NSA_L_179		X		0					36	6	
NSA_L_180		X	100	0				X	137	36	
NSA_L_181		X	100	0					226	52	
NSA_L_182		X	0	0				X	161	19	
NSA_L_183A	X		100	0				X	55	19	
NSA_L_183B			100						150	32	
NSA_L_184	X	X	100	0				X	479	136	
NSA_L_185		X	0	15					119	8	
NSA_L_186	X		10	0					15	5	
NSA_L_187		X	50	25					21	6	
NSA_L_189	X		0	0					59	11	
NSA_L_190			40	0					76	17	
NSA_L_191		X	0	0					92	28	
NSA_L_192		X	0	0					83	21	
NSA_L_193		X	50	0					150	33	
NSA_L_194			0	30					6	3	
NSA_L_195			0	50		X			30	9	
NSA_L_196			0	0					39	5	
NSA_L_197			0	0					30	8	
NSA_L_198			25	0					40	4	
NSA_L_199		X	0	0					28	2	
NSA_L_200			0	25					16	5	
NSA_L_201			0	150					16	7	
NSA_L_202			0	0					22	7	
NSA_L_203			0	20					14	6	
NSA_L_204		X	0	100					23	7	
NSA_L_205		X	0	0					22	3	
NSA_L_206			0	0					40	5	
NSA_L_207	X	X	0	100					45	7	
NSA_L_208			0	50					65	15	
NSA_L_209			100	0		X			82	16	
NSA_L_210			40	100					264	59	
NSA_L_211		X	0	0				X	61	5	
NSA_L_212		X	0	100					102	19	
NSA_L_213		X	0	0					66	11	
NSA_L_214			0	0					15	4	
NSA_L_216		X	0	0					86	10	
NSA_L_218	X		0	100		X			23	9	
NSA_L_219	X		0	100				X	7	2	

Appendix 4-2 Hot Spot Facility Categories and Status

Hotspot ID	Description	HSI Category			HSI Status			
		Commercial or Industrial	Municipal or Institutional	Transport-Related	Not a Hotspot	Potential	Confirmed	Severe
HSI_L_201	Construction Supply	X					X	
HSI_L_202	Body Shop/Junkyard	X					X	
HSI_L_401	Lawnmower Repair	X					X	
HSI_L_402	DiFatta Bros Car Parts	X				X		
HSI_L_451	Citgo Gas Station	X				X		
HSI_L_452	Rosedale Plaza	X					X	
HSI_L_453	none provided	X					X	
HSI_L_454	Electrical Supply	X					X	
HSI_L_455	Car Repair/Truck Storage	X					X	
HSI_L_456	Truck Maintenance	X				X		
HSI_L_457	Refrigeration	X				X		
HSI_L_458	Integrity Recycling	X				X		
HSI_L_459	Auto Repair/Junkyard	X				X		
HSI_L_460	Trucking Co.	X					X	
HSI_L_461	Truck Rental/Repair	X				X		
HSI_L_462	Marty’s Auto Paint	X				X		
HSI_L_469	Rosedale Village	X				X		
HSI_L_470	Rosedale Center School		X		X			
HSI_L_471	Rosedale Fire Co.		X				X	
HSI_L_472	School Bus Depot		X			X		
HSI_L_473	McNew Excavating	X				X		
HSI_L_474	Tire & Service Center	X					X	
HSI_L_475	Used Car Lot	X			X			
HSI_L_476	Overlea Plaza	X			X			
HSI_L_477	Glenmore Service/Gas Station	X					X	
HSI_L_501	Loch Raven Plaza	X				X		

Hotspot ID	Description	HSI Category			HSI Status			
		Commercial or Industrial	Municipal or Institutional	Transport-Related	Not a Hotspot	Potential	Confirmed	Severe
HSI_L_502	Towson Place	X			X			
HSI_L_503	Junkyard	X					X	
HSI_L_504	M & M Best Car Care	X					X	
HSI_L_601	Belair Beltway Shpping Center	X			X			

Appendix 4-2b Hot Spot Facility Operations

Hotspot ID	Description	Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/Land-scaping
HSI_L_201	Construction Supply		X	X	X	
HSI_L_202	Body Shop/Junkyard	X	X	X	X	
HSI_L_401	Lawnmower Repair		X			
HSI_L_402	DiFatta Bros Car Parts	X		X		
HSI_L_451	Citgo Gas Station	X		X		
HSI_L_452	Rosedale Plaza			X	X	
HSI_L_453	none provided	X	X	X	X	
HSI_L_454	Electrical Supply	X	X	X	X	
HSI_L_455	Car Repair/Truck Storage	X	X	X	X	
HSI_L_456	Truck Maintenance	X	X			
HSI_L_457	Refrigeration		X	X	X	
HSI_L_458	Integrity Recycling		X	X		
HSI_L_459	Auto Repair/Junkyard	X	X	X	X	
HSI_L_460	Trucking Co.	X	X	X	X	
HSI_L_461	Truck Rental/Repair	X	X	X	X	
HSI_L_462	Marty's Auto Paint		X	X		
HSI_L_463	McCormick Elementary School			X		X
HSI_L_464	Overlea High School		X	X	X	X
HSI_L_465	Elmwood Elementary		X	X	X	X

Hotspot ID	Description	Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/Land-scaping
HSI_L_466	Fullerton Elementary			X		X
HSI_L_467	Redhouse Run Elementary		X	X	X	X
HSI_L_468	Golden Ring Middle School		X	X	X	X
HSI_L_469	Rosedale Village		X	X		X
HSI_L_470	Rosedale Center School			X	X	X
HSI_L_471	Rosedale Fire Co.	X	X	X	X	X
HSI_L_472	School Bus Depot	X	X	X		
HSI_L_473	McNew Excavating	X	X	X		
HSI_L_474	Tire & Service Center	X	X	X	X	
HSI_L_475	Used Car Lot	X		X		
HSI_L_476	Overlea Plaza			X	X	
HSI_L_477	Glenmore Service/Gas Station	X	X	X	X	
HSI_L_501	Loch Raven Plaza			X	X	X
HSI_L_502	Towson Place					
HSI_L_503	Junkyard	X	X	X	X	
HSI_L_504	M & M Best Car Care	X	X	X	X	
HSI_L_601	Belair Beltway Shpping Center			X		
Total		**14**	**16**	**14**	**10**	**5**

Appendix 4-3 Institutional Site Investigations

Institution ID	Description	Type	Public or Private?	Nutrient Mgmt. Plan Req?	Tree Planting (#)	Downspout Disconnect	Impervious Cover Removal	Trash Mgmt.
ISI_L_103	St. Pius X	Faith-Based	Private	N	145		X	
ISI_L_104	Northside Baptist Church	Faith-Based	Private	N	170	X		X
ISI_L_105	Leith Walk Rec Center	Municipal	Public	N	245		X	X

Institution ID	Description	Type	Public or Private?	Nutrient Mgmt. Plan Req?	Tree Planting (#)	Downspout Disconnect	Impervious Cover Removal	Trash Mgmt.
ISI_L_106	Govans ES	School	Public	N	15			X
ISI_L_107	MD Youth Residence Center	Municipal	Public	N	105	X		X
ISI_L_108	Messiah Evangelical	Faith-Based	Private	N	105			
ISI_L_109	Lois T Murray	School	Public	N	60			
ISI_L_110	Roman Catholic Archbishop	Faith-Based	Private	N	0	X		X
ISI_L_111	Faith Presbyterian	Faith-Based	Private	N	0	X	X	
ISI_L_153	Church of the Redeemer	Faith-Based	Private	N	0			
ISI_L_154	Winston MS	School	Public	N	145		X	X
ISI_L_451	Redhouse Run ES	School	Public	N	250			X
ISI_L_452	Golden Ring MS	School	Public	N	50			X
ISI_L_453	Fullerton ES / Senior Center	School	Public	Y	400			X
ISI_L_454	McCormick ES	School	Public	Y	200			X
ISI_L_455	Overlea HS	School	Public	Y	100			X
ISI_L_456	Elmwood ES	School	Public	N	130			X
ISI_L_501	Stoneleigh ES	School	Public	N	100	X		
ISI_L_503	Loch Raven Academy	School	Public	Y	65			
ISI_L_504	Calvert Hall	School	Private	Y	55			
ISI_L_505	Pleasant Plains ES	School	Public	Y	200			
ISI_L_506	Halstead Academy	School	Public	N	100			
ISI_L_507	Fort Worthington ES	School	Public	N	0		X	
ISI_L_508	Lakewood ES	School	Public	N	0		X	
ISI_L_509	St. Teresa	School	Public	N	20	X	X	
ISI_L_510	Armistead Gardens ES	School	Public	N	200			
ISI_L_511	Villa Cresta ES	School	Public	Y	200			
ISI_L_512	Former Loch Raven ES	School	Private	Y	100			
ISI_L_514	Mercy HS	School	Private	Y	75			
ISI_L_515	Yorkwood ES	School	Public	N	135		X	
ISI_L_522	Country Club of MD	Unknown	Private	Y	0			

Institution ID	Description	Type	Public or Private?	Nutrient Mgmt. Plan Req?	Tree Planting (#)	Downspout Disconnect	Impervious Cover Removal	Trash Mgmt.
ISI_L_523	St. Andrews Lutheran	Faith-Based	Private	N	117	X		
ISI_L_524	Moreland Memorial Cemetary	Unknown	Unknown	Y	75			
ISI_L_525	Oakleigh ES	School	Public	Y	180			
ISI_L_526	White Oak	School	Public	Y	425			
ISI_L_527	Towson HS	School	Public	Y	120			X
ISI_L_529	St. Andrews Epic.	Faith-Based	Private	N	20	X		
ISI_L_530	Loch Raven Methodist	Faith-Based	Private	N	20	X		
ISI_L_531	Babcock Presb.	Faith-Based	Private	N	150	X		
ISI_L_532	Immaculate Heart of Mary	Faith-Based	Private	N	150			X
ISI_L_533	Montebello Hospital Center	Hospital	Private	Y	200	X		
ISI_L_534	Emmanuel Lutheran Church	Faith-Based	Private	N	110			
ISI_L_601	Parkville Senior Center	Municipal	Public	N	20	X	X	
ISI_L_602	Parkville MS	School	Public	Y	60		X	

Appendix 4-4 PAA Data

Site ID	Ownership	Acres	Subwatershed	Site Prep	% Turf
PAA-L-101	Public	0.75	Chinquapin Run	Minimal	100
PAA-L-102	Unknown	0.50	Chinquapin Run	Minimal	100
PAA-L-103	Public	2.0	Chinquapin Run	Minimal	80
PAA-L-104	Public	6.0	Lower Jones Falls	Minimal	100
PAA-L-105	Private	1.0	Chinquapin Run	Excessive	0
PAA-L-201	Private	6.5	Armistead	Minimal	0
PAA-L-301	Private	5.0	Herring Run Lower	Extensive	0
PAA-L-351	Private	2.0	Biddison Run	Minimal	95
PAA-L-401	Public	7.0	Moore’s Run	Minimal	60
PAA-L-402	Public	6.0	Moore’s Run	Minimal	75
PAA-L-403	Public	3.0	Moore’s Run	Minimal	95
PAA-L-404	Private	4.5	Moore’s Run	No Site Prep	75
PAA-L-451	Private	1.0	Redhouse Run	Extensive	100
PAA-L-452	Private	1.0	Redhouse Run	Minimal	100
PAA-L-453	Public	6.0	Redhouse Run	Minimal	20
PAA-L-454	Public	5.0	Redhouse Run	Excessive	20
PAA-L-455	Private	7.5	Redhouse Run	Minimal	90
PAA-L-456	Public	4.0	Redhouse Run	Minimal	90
PAA-L-457	Private	1.0	Redhouse Run	Minimal	0
PAA-L-458	Public	7.0	Redhouse Run	Minimal	75
PAA-L-501	Public	6.0	Herring Run West	Minimal	80
PAA-L-502	Public	0.50	Herring Run West	Minimal	0
PAA-L-503	Private	6.0	Herring Run Main	Minimal	100
PAA-L-504	Public	5.0	Herring Run Main	Minimal	98
PAA-L-505	Public	3.0	Herring Run Main	Minimal	95
PAA-L-506	Public	1.0	Herring Run Main	Minimal	99
PAA-L-507	Private	1.0	Herring Run East	None	0
PAA-L-508	Public	4.0	Herring Run East	Minimal	40
PAA-L-509	Public	2.0	Herring Run East	Minimal	40
PAA-L-601	Public	1.5	Stemmers Run	Minimal	95
PAA-L-651	Public	3.0	Northeast Creek	Minimal	100
PAA-L-652	Private	2.5	Northeast Creek	Minimal	70
PAA-L-653	Private	2.0	Northeast Creek	Extensive	0

Site ID	Ownership	Acres	Subwatershed	Site Prep	% Turf
PAA-L-701	Public	5.5	Brien's Run	Minimal	80
PAA-L-702	Private	1.5	Brien's Run	None	0
PAA-L-703	Private	1.5	Brien's Run	Minimal	100

CHAPTER 5

RESTORATION & PRESERVATION PRACTICES

5.1 Introduction

This section of the plan presents an overview of the key management practice recommendations for the Upper Back River watershed. These practices are primarily geared toward restoring degraded resources in the urban/suburban study areas of the watershed.

Restoration practices recommended to address problem areas in the watershed include stormwater retrofits, downspout disconnection, stream corridor restoration, illicit discharge detection and prevention, pervious area restoration, pollution source control, and municipal practices and programs.

Table 5.1 provides more information on specific components of these practices. Each practice is described in more detail below and referenced throughout the remainder of this report.

Table 5.1 Urban Best Management Practices Recommended in the Upper Back River Watershed

Type		Practices
Restoration Practices	Stormwater Retrofits*	• Storage (large off-site or on-site ponds and wetland facilities) • On-site water quality treatments (rain gardens, rain barrels, bioretention, infiltration, etc.) • On-site design measures (impervious area reduction, rooftop disconnects)
	Stream Corridor Restoration	• Simple stream repair (bank stabilization), stream channel restoration, and habitat enhancements** • Buffer reforestation (tree planting, invasive removal) • Stream cleanups **
	Dry Weather Discharge Prevention	• Discharge investigation and elimination • Community hotline • Education and employee training • Outfall monitoring
	Pervious Area Restoration	• Natural regeneration • Tree plantings
	Pollution Prevention/Source Control Education***	• Residential pollution prevention • Hotspot source control

	Municipal Practices and Programs	• Street sweeping, winter road treatment • School and grounds maintenance (schools and recreational fields) • Inspection and maintenance programs (ESC, SWM, catch basin cleanouts) • Spill prevention and response • Maintenance facility pollution prevention plans
* See Manual 3, Appendix A for more detail and guidance ** See Manual 4, Appendix B for more detail on stream repair practices *** See Manual 8, Appendix C for more detail on residential and hotspot source control practices		

5.2 Stormwater Retrofits

The Center for Watershed Protection breaks retrofits into three major categories – storage retrofits; onsite residential treatments, such as bioretention and filtering practices; and onsite commercial treatments such as sand filters or underground storage and filtering systems. Appendix X provides more detailed examples of retrofit opportunities that were encountered in the field. The application of practices in the different categories varies according to the impervious cover and land use makeup of a subwatershed as well as the restoration goals being pursued. Storage retrofits such as ponds and wetlands provide the widest range of watershed restoration benefits, however, they can be challenging to implement in a developed subwatershed. A large part of the challenge is finding adequate available space. Onsite residential retrofit practices such as bioretention and filtering practices and impervious area reduction can provide a substantial benefit when applied over large areas. Onsite commercial retrofit practices include the use of sand filters or underground storage or filtering systems. The goal of the retrofit assessment was to identify candidate sites within all three categories of retrofits, with the primary objective of increasing water quality treatment and recharge to mitigate known water quality concerns in the watershed.

With the notable exception of Herring Run Park, the developed nature of the watershed provides limited potential for implementing new storage projects other than retrofitting existing stormwater ponds (Figure 5-1). Due to these limitations, an important aspect of this study was to identify smaller, on-site practices and water quality improvements for implementation within existing neighborhoods. An additional objective was to identify retrofit practices that would improve habitat and reduce channel erosion conditions in local neighborhood streams.

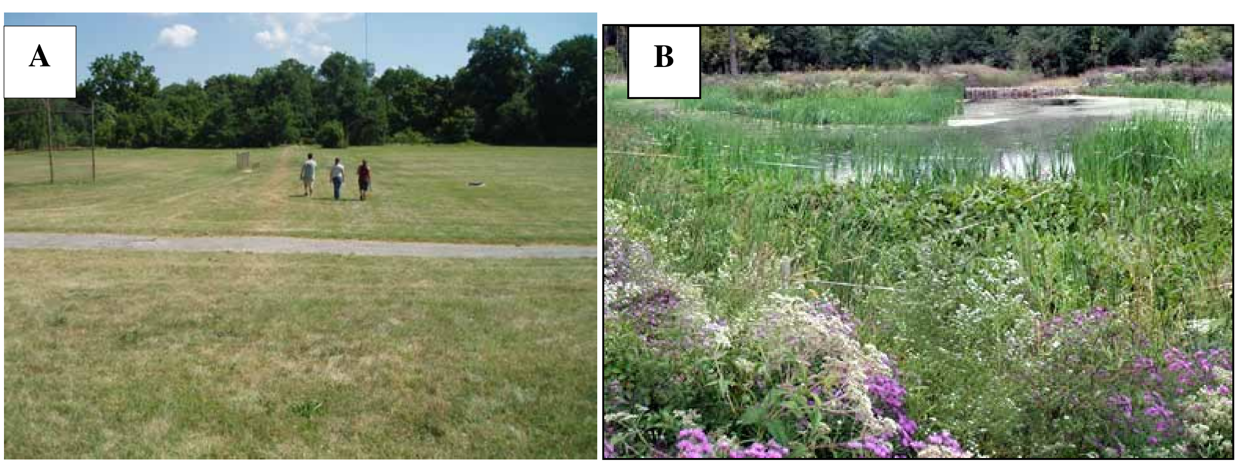


Figure 5-1. Available space for a stormwater retrofit (A) and an example of a stormwater wetland on Staten Island (B).

There is great potential in both neighborhoods and institutions in the watershed for on-site residential retrofit practices. These opportunities include simple disconnection of downspouts in neighborhoods and schools where storm drains are directly connected to the street or storm drains (Figure 5-2). In addition, impervious cover removal and bioretention are good options to help treat and reduce stormwater at schools.

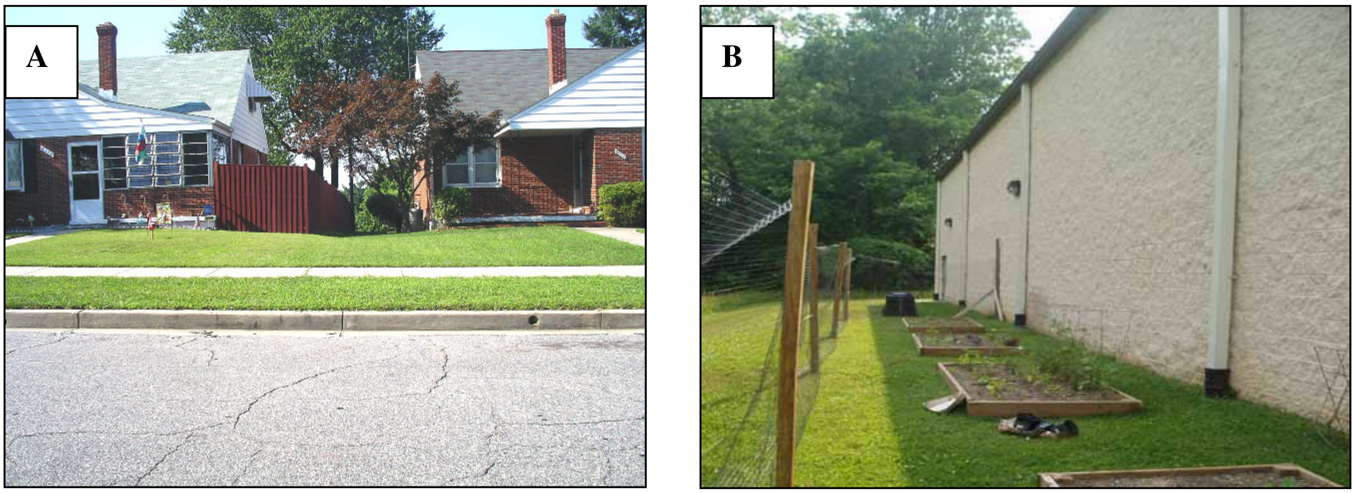


Figure 5-2. Downspout Disconnection Opportunities in a Neighborhood (A) and at a School (B).

5.3 Stream Corridor Restoration

Stream corridor restoration practices are used to enhance the appearance, stability, and aquatic function of urban stream corridors. These practices range from routine stream clean-ups, simple stream repairs such as vegetative bank stabilization and localized grade control, to comprehensive repair applications such as full channel redesign and re-alignment. Stream repair practices are often combined with stormwater retrofits and riparian management practices to meet subwatershed restoration objectives. Primary practices for use in the Upper Back River watershed include stream repair, buffer reforestation, and stream cleanups.

5.3.1 Stream Repair

The practice of urban stream repair is relatively new; most of our experience has occurred in the last two decades. We have learned that controlling upstream hydrology is the most sustainable way to achieve actual stream restoration in urbanized systems, as opposed to simple repair efforts. If the upland sources of sediment and stormwater are not properly managed, stream repair practices have a greater chance of failure. However, in highly urban channels, such as in the Upper Back River, where upland stormwater treatment prospects are limited, it is still often necessary and justified to pursue stream repair in instances where infrastructure and property is adversely impacted. Stream restoration projects, particularly where there is ample room to reconnect the stream with its floodplain, are shown to improve water quality especially during baseflow conditions (Kaushal et. al., 2008). Figure 5-3 provides an example of stream restoration in Stony Run located in the Jones Falls Watershed.

Figure 5-3. Stream restoration along Stony Run in the Jones Falls Watershed.

Other studies in similar urban areas have found that the process of stream channel adjustment to accommodate the increased flows associated with urbanization can take as much as 50 years (MacRae, 1992). Although a detailed assessment of channel evolution and geomorphology was not in the scope of this study, the general conclusion is that in many areas, streams are still actively adjusting to increased flow volumes after more than 30 -40 years of development. If left unaddressed, these actively eroding reaches could continue to generate significant amounts of sediment for many years until a new stable channel dimension is formed. This process will continue to impact sediment loads and adsorption of nutrients to sediment particles. Therefore, stream repair combining upland stormwater retrofits and runoff reduction from neighborhoods is the recommended approach as reflected in the priority project descriptions.

5.3.2 Buffer Reforestation

Another aspect of stream corridor restoration is the enhancement or reforestation of impacted stream buffers. The benefits of stream buffers include wildlife habitat, filtration of pollutants, stream shading, etc. (Wenger, 1999). In the Upper Back River watershed, many of the streams are piped and many of the additional streams that are not piped have undergone stream restoration or will in the near future. However there are a number of small areas that could benefit from improved riparian buffers. This can be accomplished by conducting a targeted education program to the property owners.

In addition, invasive plant species control is identified as a priority in the watershed. This problem should be addressed through education, training of City and County grounds maintenance staff, and development of a dedicated group of volunteer “weed warriors”.

Last, several neighborhoods exhibited evidence of homeowners dumping yard waste and other refuse in the stream buffer. In some cases, homeowners may not understand the benefits of stream buffers. Stream buffer signs and outreach tools should be used to educate residents.

5.3.3 Stream Clean Ups

Stream cleanups are a simple practice used to enhance the appearance of the stream corridor by removing unsightly trash, litter, and debris. Cleanups are commonly conducted by volunteers and continue to be one of the most effective outlets for generating community awareness and involvement in watershed activities.

5.4 Dry Weather Discharge Prevention

Discharge prevention targets dry weather flows that contain significant pollutant loads. Examples include illicit discharges, sewage overflows, or industrial and transportation spills. These dry weather discharges can be continuous, intermittent, or transitory, and depending on the volume and type, can cause extreme water quality problems in a stream. Sewage discharges can directly affect public health (e.g. bacteria), while other discharges can be toxic to aquatic life (e.g., oil, chlorine, pesticides, and trace metals). Discharge prevention focuses on four types of discharges that can occur in a subwatershed, as described in Table 5.2 and are discussed in detail in *Illicit Discharge Detection and Elimination* (Brown et al., 2004).

Table 5.2 Types of Discharges

Illicit Sewage Discharges	Sewage can get into urban streams when septic systems fail or sewer pipes are mistakenly or illegally connected to the storm drain pipe network. In other cases, "straight pipes" discharge sewage to the stream or ditch without treatment, or sewage from RVs or boats is illegally dumped into the storm drain network.
Commercial and Industrial Illicit Discharges	Some businesses mistakenly or illegally use the storm drain network to dispose of liquid wastes that can exert a severe water quality impact on streams. Examples include shop drains that are connected to the storm drain system; improper disposal of used oil, paints, and solvents; and disposal of untreated wash water or process water into the storm drain system.
Industrial and Transport Spills	Tanks rupture, pipelines break, accidents cause spills, and law-breaking individuals dump pollutants into the storm drain system. It is only a matter of time before these events occur in most urban subwatersheds, allowing potentially hazardous materials to move through the storm drain network and reach the stream.
Failing Sewage Lines	Sewer lines often follow the stream corridor, where they may leak, overflow or break, sending sewage directly to the stream. The frequency of failure depends on the age, condition and capacity of the existing sanitary sewer system.

The Center, together with the City, County, Jones Falls and Herring Run watershed associations, identified a handful of outfalls with evidence of illicit discharges during several IDDE training sessions. This survey, combined with past surveys, revealed a fairly high frequency of illicit discharges in the City, even after trunk sewer lines were replaced. Several recommendations were identified as a result of the IDDE fieldwork. Improvements are needed in the screening of outfalls in order to detect a broader range of illicit discharges. Last, the partnerships developed between the City agencies and the watershed associations will help with reducing illicit discharges. The City has a contract with the HRWA to conduct IDDE that provides extra eyes on the water.

Several discharge prevention activities should be implemented throughout the watershed that are simple to do, can involve watershed volunteers, and can increase community awareness about the watershed issues. Examples of implementation projects include:

- Marking outfalls with potential problems or known past illicit discharge locations with unique identifiers to facilitate locating and tracking suspicious discharges
- Educating residents that live near outfalls with suspected problems about 24hr hotline (311) for reporting suspicious discharges
- Creating illicit discharge fact sheets to be distributed to homeowners and businesses and/or posted on a website

5.5 Pervious Area Restoration

Pervious areas and natural area remnants provide important natural recharge functions in the drainage area, and should be optimized to promote natural infiltration properties. These areas also present an opportunity for reforestation in the watershed. Reforestation is generally the highest priority in terms of improving the infiltration and recharge functions, however, other techniques such as soil aeration, amendments, and establishing native plantings and meadows also serve a higher function than turf grass. Priority sites should have little evidence of soil compaction, invasive plants, and trash/dumping, and be reforested with minimal site preparation. Parcels that meet these criteria are good candidates for more detailed investigations and landowner contact. Most pervious areas are municipally owned, but institutional landowners in the watershed also had extensive opportunities for reforestation including planting to improve energy efficiency.

5.6 Pollution Prevention/Source Control Education

Residents and businesses engage in behaviors and activities that can negatively influence water quality, including over-fertilizing lawns (Figure 5-4), using excessive amounts of pesticides, poor housekeeping practices such as inappropriate disposal of paints, household cleaners or automotive fluids, and dumping into storm drains. Alternatively, positive behaviors such as tree planting, disconnecting rooftops, and picking up pet waste can help improve water quality. Whether a pollution prevention program is designed to discourage negative behaviors or encourage positive ones, targeted education is needed to deliver a specific message that promotes behavior changes. Local watershed organizations (Herring Run and Jones Falls) and other civic groups such as the Master Gardeners are in a position to be able to influence these changes using pollution prevention education and outreach to teach citizens how to properly care for the watershed.

Figure 5-4. Evidence of residential over-fertilization

Pollution source control also includes the management of "hotspots" which are certain commercial, industrial, institutional, municipal, and transport-related operations in the watershed. These hotspots tend to produce higher concentrations of polluted stormwater runoff than other land uses and also have a higher risk for spills. Specific on-site operations and maintenance pollution prevention practices can significantly reduce the occurrence of "hotspot" pollution problems. Local government agencies must adopt pollution prevention practices for their facilities and operations and lead by example, followed with 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.

5.7 Municipal Practices and Programs

Municipal programs and practices can directly support subwatershed restoration efforts. These programs range from more efficient trash/recycling pickup and street sweeping to construction inspection (especially erosion and sediment control enforcement) and educating municipal staff to increase awareness of potential pollution sources.

Several observations were made regarding the current state of municipal practices in the watershed. Good practices included evidence of stenciled storm drains, though they were frequently old and faded, dumpster drop off programs and residential recycling programs. The following observations represent recommendations for improvement:

- Storage and pollution prevention at certain municipal facilities
- Improved erosion and sediment control practices at several locations

5.7.1 Street Sweeping

Both the City and County have active street sweeping programs 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 pickup days or seasonal changes such as leaf litter in the fall and more frequent lawn care activities by residents in spring and summer.

5.7.2 Spill prevention and response

Spill prevention and response plans describe operational procedures to reduce spill risks and ensure that proper controls are in place when they do occur. Spill prevention plans standardize everyday procedures and rely heavily on employee training and education. The investment is a good one for most operations, since spill prevention plans reduce potential liability, fines and costs associated with spill cleanup.

5.8 References

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Appendix F

Proposed Stormwater Retrofits in the Herring Run Watershed

February 20, 2008

Memo

To: Bill Stack, DPW- Environmental Services Division

From: Darin Crew, HRWA

Paul Sturm, CWP

Cc:

Date: February 20, 2008

Re: Proposed Stormwater Retrofit Projects in the Herring Run Watershed

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The stormwater retrofitting effort is part of a larger effort to create a watershed implementation plan for the Back River watershed that was funded by EPA Region III and is a cooperative project between Herring Run Watershed Association, Center for Watershed Protection, Baltimore City and Baltimore County. Some of the original retrofitting efforts date back to a National Fish and Wildlife Foundation project funded for Redhouse Run and City portions of Herring Run. In this memo, we have prioritized and summarized priority retrofit sites within the Herring Run Watershed. The retrofits are focused mainly on parkland and institutional sites within the City and also include a demonstration project in a park in the County. A number of these projects represent opportunities to treat large areas of untreated impervious area within parkland and others represent opportunities for Herring Run Watershed Association to lead the project management and funding of demonstration projects at schools and other publicly owned land. Our goal is to generate support and begin discussions on working together to bring both the small and large projects to fruition.

The potential projects resulting from this retrofit inventory have been compiled and ranked using an Objective Prioritization Tool that was created for EPA by Boise State University. The objectives analyzed included size, amount of impervious area treated, presence of utility conflicts, and location of the project. A description of each objective and the corresponding rating criteria is shown in Table 1.

Using these objectives and the corresponding criteria, six projects were identified as high-priority for implementation in the next five years, meaning that these projects have both the potential to make significant storm water improvements, and will be feasible to construct.

In order of priority, the high-priority projects are:

- RC121: Stormwater wetland in Herring Run Park
- RC7: Stormwater wetland in Chinquapin Park
- RC8A: Stormwater wetland in Chinquapin Park
- RC208: Rain Garden in Overlook Park (implementable by HRWA)
- RC116: Stormwater wetland in Herring Run Park
- RC2: Bioretention-Rain Garden at W.E.B. Dubois High School (implementable by HRWA)

The scoring and ranking of all the projects considered is provided in Table 2. A score of 1.00 was given for each criterion rated "High," with a score of 0.67 for each "Medium" rating, 0.33 for each "Low" rating, and 0.00 for each "Against" rating.

The highest ranked, "high-priority" projects are further described in the following pages.

It should be noted that Herring Run Park is undergoing a master planning process and the projects that exist in the planning area (from Argonne Dr. to Sinclair Ln) should be promoted and included in the plan.

Project Partners:
Center for Watershed Protection
Baltimore City DPW- Water Quality Section
Herring Run Watershed Association
Baltimore County Department of Environmental Protection and Management

Table 1: Retrofit objectives and ranking criteria.

Objective	Rating Level	Criteria
1. Education and outreach opportunity	High	On school grounds, in apparent view, along bike path, visible from street or other travel pathway.
	Medium	Partially visible but not visible by car, or directly by bike path or foot path.
	Low	In an obscure location.
2. Community interest	High	Interest is high in community.
	Medium	Community lukewarm to idea.
	Low	Community is indifferent.
	Against	Community against project.
3. Treats water quality volume before entering stream and impacting living resources	High	Treats all of the SW from pipe.
	Medium	Treats 50-75% of SW in practice.
	Low	Treats less than 50% of SW.
	Against	Directs baseflow or stormflow into BMP (over 75% of treatment is stream stormflow).
4. Impervious acres of watershed treated	High	Over 40 acres.
	Medium	5-50 acres.
	Low	Less than 5 acres.
5. Project maintenance issues	High	Low probability of need for maintenance, community is trash-free, once/5yr needed.
	Medium	Annual maintenance needed.
	Low	Monthly maintenance needed.
	Against	Maintenance/cleanup needed after most rain events (high catchment trash factor).
6. Complexity of design and project management	High	Straightforward design and project management, no major design or construction challenges.
	Medium	Moderate design and project management, some design and construction challenges.
	Low	Complex design and project management, major design and construction challenges.
	Against	New pilot project requiring major project review/design work to get approval and implement since project is untested in jurisdiction.
7. Site and utility constraints	High	No utility or existing land use conflicts with proposed project.
	Medium	Minor utility or existing land use conflicts with proposed project.
	Low	Major utility or existing land use conflicts with proposed project; conflicts reduce size of proposed retrofit and constrain project.
	Against	Against= utility or existing land use conflicts preclude the implementation of the proposed project.

Table 2: Retrofit Project Scoring and Rating.

Objective	Weight	RC4: Coastal Plain Outfall at Yorkville E.S.	RC7: Stormwater wetland in Chinquapin Park	RC8A: Stormwater wetland in Chinquapin Park	RC11: Stream Daylighting at Walter De Wees Park	RC116: Stormwater wetland in Herring Run Park	RC121: Stormwater wetland in Herring Run Park	RC118: Stormwater wetland in Herring Run Park	RC208: Rain Garden in Overlook Park	RC2: Bioretention-Rain Garden at W.E.B. DuBois H.S.	RC17: Stormwater wetland in Herring Run Park	RC18: Outfall Tratment at Herring Run Park
1. Education	10%	1.00	1.00	0.67	0.67	1.00	0.67	0.67	1.00	0.67	1.00	1.00
2. Community interest	5%	1.00	0.67	0.67	0.67	0.67	0.67	0.67	1.00	1.00	1.00	1.00
3. Treats WQv	10%	1.00	1.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	0.67	0.33
4. Impervious Area	30%	0.33	0.67	1.00	0.67	0.67	1.00	1.00	0.33	0.33	1.00	1.00
5. Maintenance	10%	0.67	0.33	0.67	0.33	0.67	0.67	0.67	1.00	1.00	1.00	0.67
6. Complexity	15%	0.67	1.00	0.67	0.00	1.00	1.00	0.00	1.00	1.00	0.33	0.33
7. Site Constraints	20%	0.33	1.00	0.67	0.00	0.67	1.00	0.00	1.00	1.00	0.33	0.33
Total	100%	**0.58**	**0.82**	**0.80**	**0.37**	**0.78**	**0.92**	**0.57**	**0.80**	**0.77**	**0.73**	**0.67**
Ranking		**9**	**2**	**3**	**11**	**5**	**1**	**10**	**3**	**6**	**7**	**8**

High-Priority Projects:

Project: **RC121** (includes RC119 & RC120)
Project Type: Stormwater Wetland
Location: Herring Run Park along Parkside Dr. from Sinclair Ln. to Homesdale Ave.

Total Contributing Drainage Area (CDA): 130 acres
Imperivous Cover Area: 63.5 acres
Area available for project implementation: 4+ acres

Project description:
A stormwater wetland could be created within an approximately 4 acre stretch along Parkside Drive within Herring Run Park. This would provide a great water quality treatment practice in a portion of the park that is currently not being utilized for recreation activities. This location is also adjacent to a playground and the future Herring Run Bike Path.

Figure 1: RC121 site photo. Project would begin after tree in foreground and extend along Parkside and Buffer to Sinclair Lane.

Figure 2: Aerial photo of RC119 project area. (To be combined with RC121).

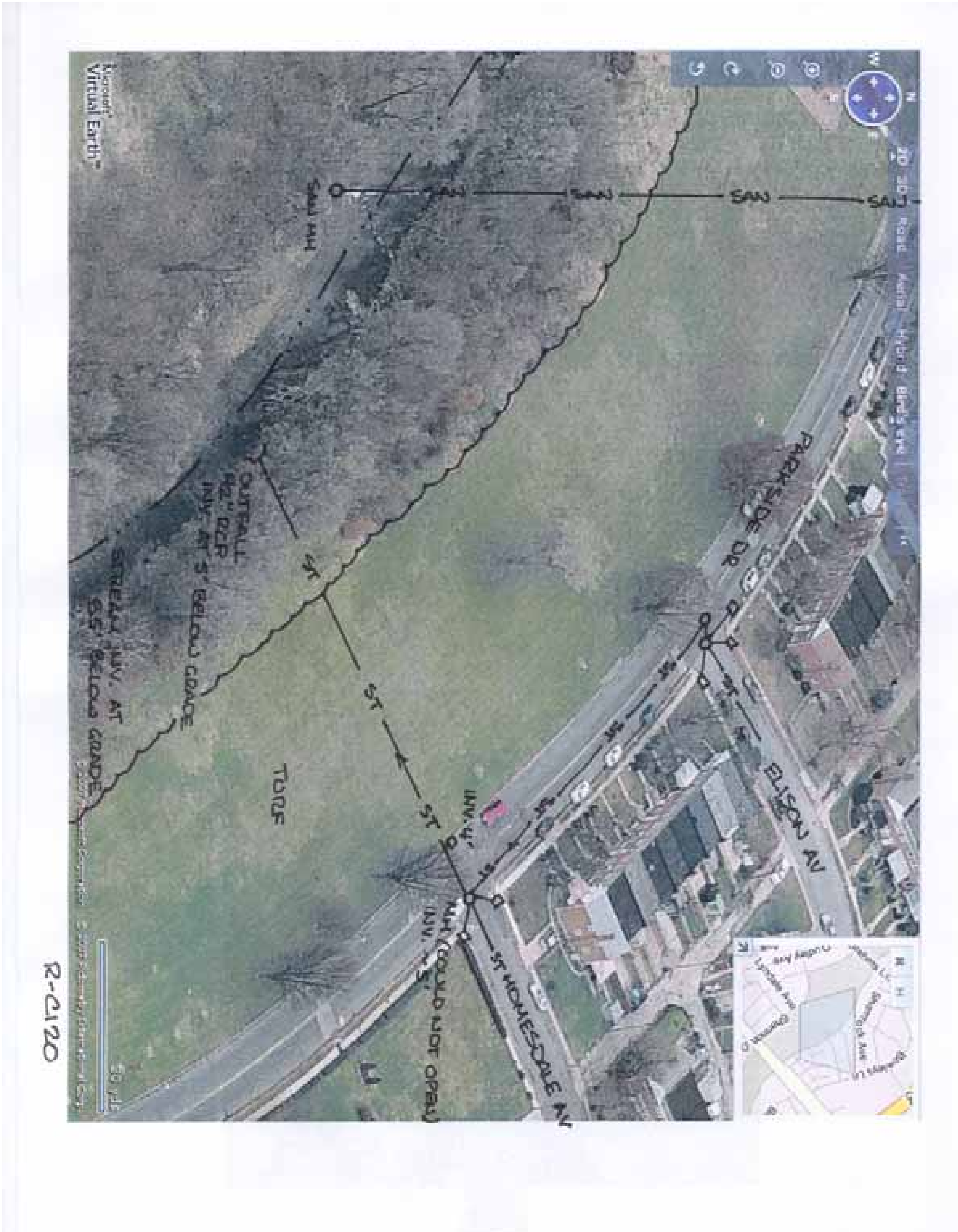


Figure 3: Aerial photo of RC120 project area (To be combined with RC121).

Figure 4: Aerial photo of RC121 project area.

Table 3: Field Notes for RC121

Project	Location	Area	Notes
RC121	Herring Run Park, 3rd Outfall Above Sinclair Ln	Stormwater Wetland CDA = 90 ac RC 120 = 20 ac RC 119 = 20 ac Total= 130 ac	Initial site visit by PES on 8/17/06 Subsequent site visit by MEN on 1/25/08 Site located in Herring Run Park between Roberton and Sinclair Ln on Parkside 3 outfalls (6.4 ft x 4.3 ft at Roberton, 42 in at Homesdale, 36 in at Haldane), onvey off-site flow under the site Invert elevation of Roberton line in manhole at Roberton and Parkside (upstream of outfall) is approximately 6.5 ft below grade; it is approximately 8 ft below grade at the outfall Invert elevation of Homesdale line in manhole at Homesdale and Parkside (upstream of outfall) is approximately 5 ft below grade; it is approximately 5 ft below grade at the outfall Invert elevation of Haldane line in manhole at Haldane and Parkside (upstream of outfall) is approximately 7 ft below grade; it is approximately 6 ft below grade at the outfall A sanitary sewer runs bisects the site, running from the intersection of Roberton and Parkside to a trunk line in the Herring Run stream corridor at a depth of 13.5 ft below grade; proposed retrofit would not conflict with the sanitary sewer, as retrofit would begin downstream of sanitary line Water supply structure observed on site near intersection of Parkside and Haldane; may represent project constraint Site is generally unused open space, planted with turf grass Plenty of space to construct proposed retrofit as a long, linear practice along the stream corridor Few trees would be lost, but significant excavation would be needed along length of project (existing storm drain inverts are between 5 ft and 7 ft below grade) Could be an attraction within the park system

Project: **RC7**
Project Type: Stormwater Wetland
Location: Chinquapin Park along Chinquapin Parkway between Gleneagle Rd. and Elbank Ave.

Total CDA: 29.5 acres
Imperivous Cover Area: 15 acres
Area available for project implementation: 0.75 acres +

Project description:
A stormwater wetland could be created within Chinquapin Park. This would provide a great water quality treatment practice in a portion of the park not being utilized by recreation activities.

Figure 5: RC7 site photo.

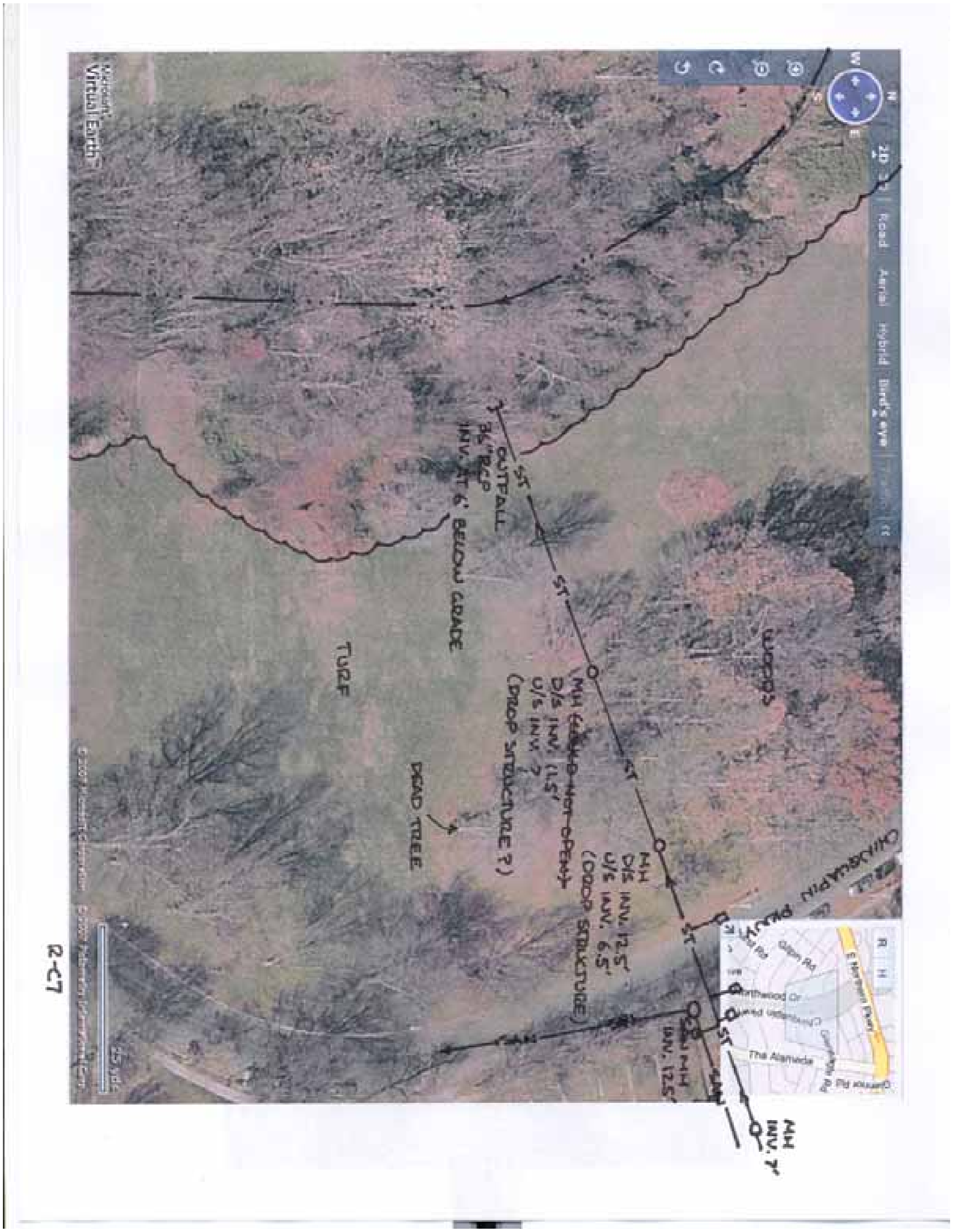


Figure 6: Aerial photo of RC 7 project area.

Table 4: Field notes for RC7.

Project	Location	Area	Notes
RC7	Chinquapin Run Park, 2nd & 3rd outfalls below Northern Parkway	Stormwater Wetland CDA = 29.5 ac	Initial site visit by SCH on 8/16/06 Subsequent site visit by MEN on 1/25/08 Site located between Gleneagle and Elbank on Chinquapin Pkwy 2 outfalls (36 in at Gleneagle, 27 in at Elbank), convey off-site flow under the site Drop structures are used along each of the storm drain lines through the park Invert elevation where flow would be split from Gleneagle line is 6.5 ft below grade (in woods below Chinquapin Pkwy); this depth is quickly lost because of existing site slope Invert elevation where flow would be split from Elbank line is 8 ft below grade (under Chinquapin Pkwy); this depth is quickly lost because of existing site slope No sanitary sewer lines are thought to cross the site No other utility conflicts observed Site is generally unused open space, planted with turf grass Few trees would be lost, but significant excavation would be needed, particularly at downstream end of site (approximately 7 ft higher than upstream end of site)

Project: **RC8A**
Project Type: Stormwater Wetland
Location: Chinquapin Park along Northwood Dr. South of Belvedere Ave.

Total CDA: 84 acres
Imperivous Cover Area: 45 acres (estimated from RHR study)
Area available for project implementation: 1.25 acres

Project description:
A stormwater wetland could be created within Chinquapin Park. This would provide a great water quality treatment practice in a portion of the park not being utilized by recreation activities. A footbridge on the downstream side is relatively close by.

Figure 7: RC8A Site Photo. The stormwater pipe is present below the rise in the field. Downstream, this this wetland could be implemented around mature trees.

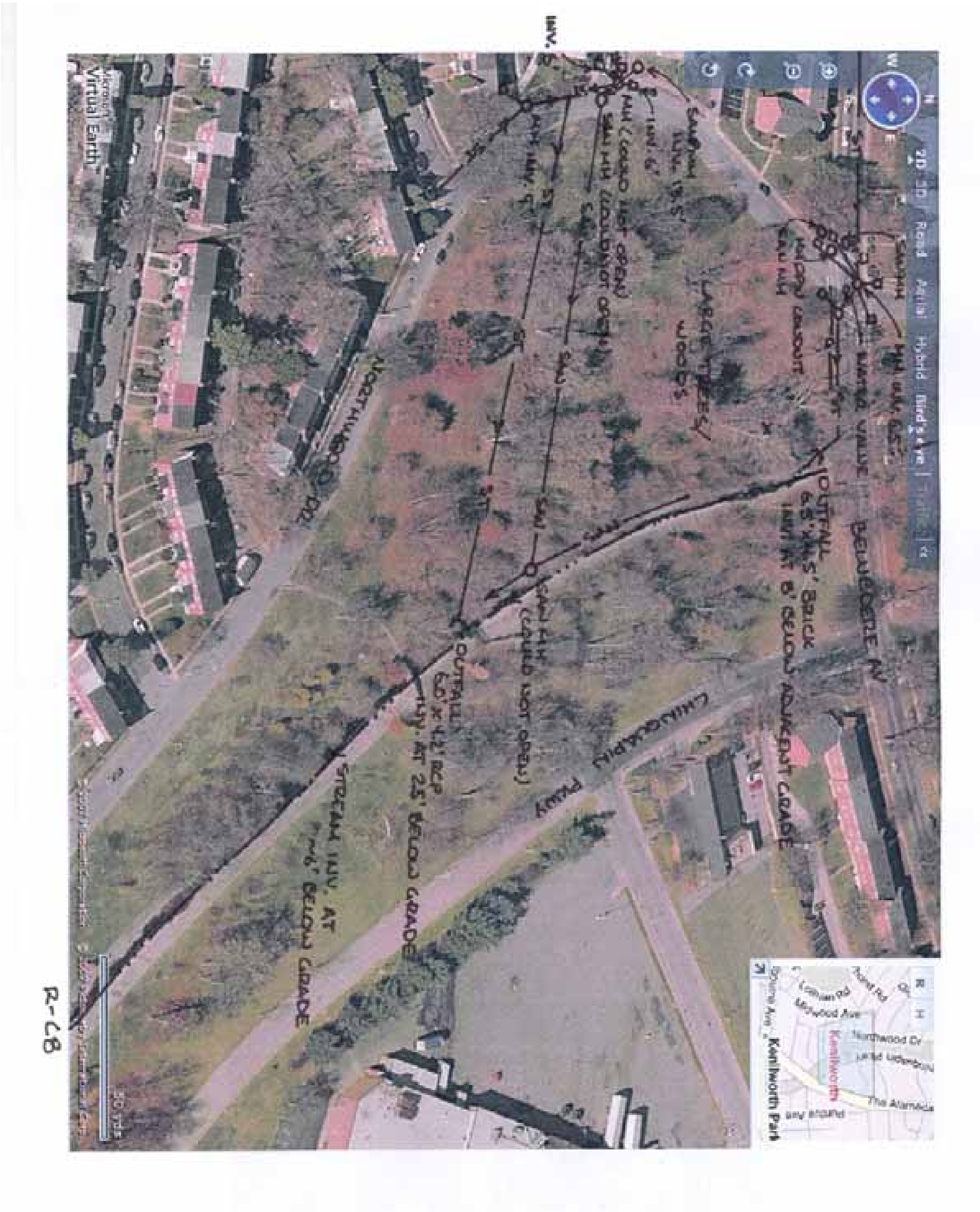


Figure 8: Aerial photo of RC8A project area.

Table 5: Field notes for RC8A

Project	Location	Area	Notes
RC8A	Chinquapin Run Park, Belvedere West	Stormwater Wetland CDA = 84 ac	Initial site visit by SCH on 8/16/06 Subsequent site visit by MEN on 1/25/08 Site located between Belvedere and The Alameda on Northwood 2 outfalls (6.5 ft x 4.5 ft at Belvedere, 6.0 ft x 4.2 ft at St. Dunstans), convey off-site flow under the site. Belvedere line not feasible. Invert elevation of St. Dunstans line upstream of outfall (at Northwood) is approximately 9 ft below grade; this depth is quickly lost because of existing site slope A sanitary sewer line bisects the site, running from St. Dunstans to Chinquapin Run at a depth of approximately 13.5 ft below grade No other utility conflicts observed <u>ALTERNATE:</u> Treat only the St. Dunstans only; would reduce CDA to 84 acres, but would avoid sanitary sewer line, lose fewer trees and would be less space constrained

Project: **RC208**
Project Type: Rain Garden
Location: Overlook Park off Register Ave.

Total CDA: 1 acre
Impervious Cover Area: 0.3 acres
Area available for project implementation: 1,500 sq ft.

Project description:
A rain garden can be created within Overlook Park. This would provide a great water quality treatment practice in a portion of the park not being utilized by recreation activities. It is a highly visible location and would serve as a demonstration project for the adjacent communities.

Figure 9: RC208 site photo. This location provides an opportunity for a demonstration rain garden to capture runoff and address existing erosion problem at this site.

Table 6: Field notes for RC208

Project	Location	Area	Notes
RC208	Overlook Park	Rain Garden CDA = 0.30 ac	Initial site visit by MEN on 5/3/07 Subsequent site visit by MEN on 1/3/08 Site located at downstream end of parking lot to treat on-site runoff Site is currently eroded and is not used (ball field and volleyball court are located adjacent to the proposed retrofit site) No utility conflicts observed Minimal excavation required and no underdrain should be needed Should provide pre-treatment (pea gravel diaphragm at downstream end of parking lot, ahead of proposed rain garden). Potential to complete additional projects on site (buffer expansion, dry swale enhancement)

Project: **RC116**
Project Type: Stormwater Wetland
Location: Herring Run Park along Shannon Dr. @ Lyndale Ave.

Total CDA: 40 acres
Imperivous Cover Area: 20 acres
Area available for project implementation: 2+ acres

Project description:
A stormwater wetland could be created at this location within Herring Run Park. This would provide a great water quality treatment practice in a portion of the park currently not being utilized by recreation activities. This location is also adjacent to a ballfield and the existing Herring Run Bike Path.

Figure 10: RC116 site photo. Proposed retrofit would fit adjacent to underutilized baseball diamond.

Table 7: Field Notes for RC116

Project	Location	Area	Notes
RC116	Herring Run Park, Shannon and Lyndale	Stormwater Wetland CDA = 40 ac	Initial site visit by PES on 8/17/06 Subsequent site visit by MEN on 1/25/08 Site located in Herring Run Park below the intersection of Shannon and Lyndale Storm drain line (36 in) conveys off-site runoff under the site Invert elevation of storm drain line is 4 ft below grade at outfall and approximately 6 ft below grade at Shannon Sanitary sewer runs parallel to Shannon and perpendicular to storm drain line, approximately 80 ft from Shannon and at a depth of 16.5 ft below grade; would probably constrain width of proposed retrofit No other utility conflicts observed Site is generally unused ball fields and open space, planted with turf grass Few trees would be lost

Project: **RC2**
Project Type: Biorentention – Rain garden
Location: W.E.B. DuBois High School

Total CDA: 1.1 acres
Impervious Cover Area: 1.1 acres
Area available for project implementation: 4,000 sq ft.

Project description:
A rain garden can be created at the backside of W.E.B. DuBois High School. This would provide a great water quality treatment practice at the school that is not being utilized by recreation activities. It would serve as a demonstration project for other schools and serve as an educational component for this environmentally-themed neighborhood school.

Figure 11: RC2 site photo. The area along the back of W.E.B. DuBois HS is prime for a biorention facility.

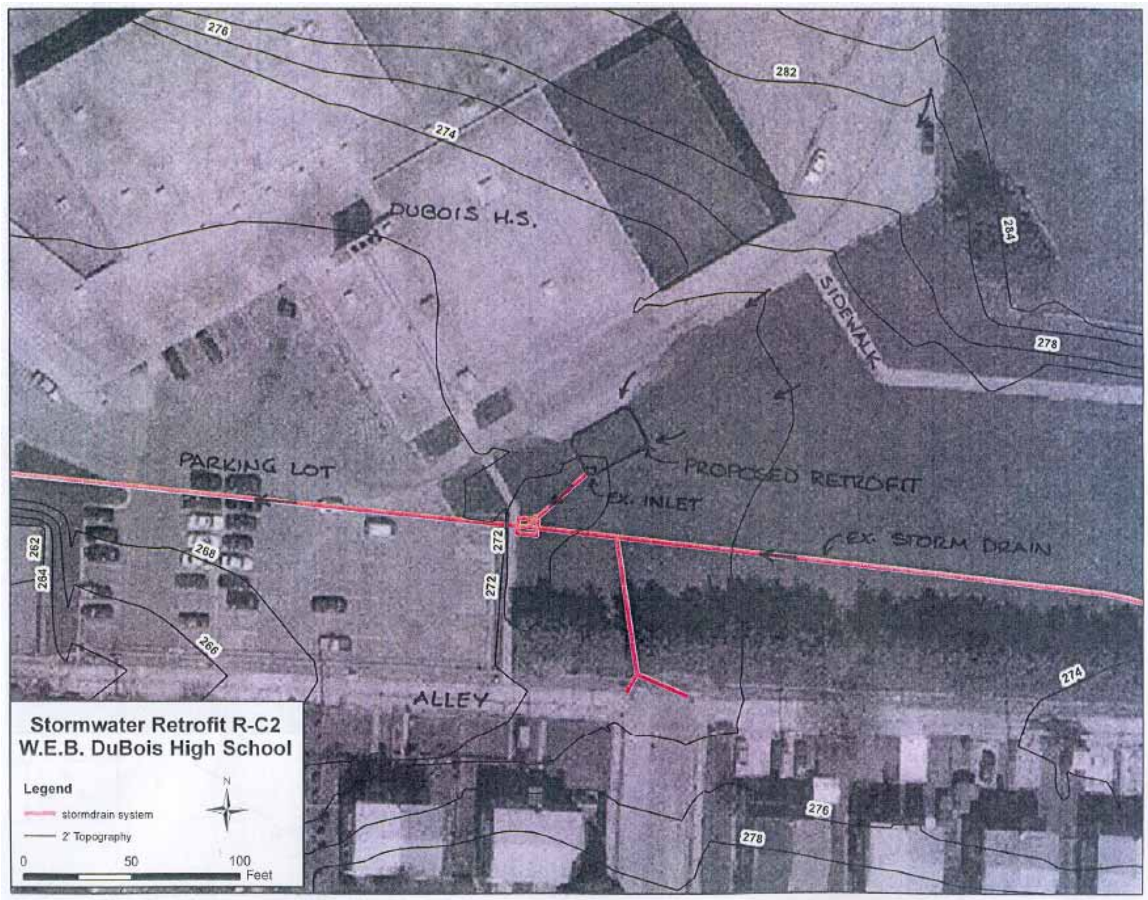


Figure 12: Aerial photo of RC2 project area.

Table 8: Field notes for RC2

Project	Location	Area	Notes
RC2	W.E.B. DuBois HS	Bioretention CDA = 1.1 ac	Initial site visit by SCH on 8/16/06 Subsequent site visit by MEN on 1/3/08 Site located in existing depressional area below rear parking lot Site is unused open space, planted with turf grass, and has some erosion Sanitary sewer runs parallel to driveway, through proposed retrofit site, at a depth of approximately 16' below grade; may create concerns about infiltration and inflow, but providing an underdrain should prevent much of this from occurring No other utility conflicts observed Provide underdrain; adjacent storm drain line invert is approximately 20 ft below grade Will need to divert flow around upstream catch basin; suggest removing or capping the structure

Appendix G

Upper Back River Watershed Stream Stability Assessment

July 2008

UPPER BACK RIVER WATERSHED STREAM STABILITY ASSESSMENT

(STEMMERS RUN, HERRING RUN & BRIEN RUN SUBWATERSHEDS)

July 2008

Prepared for: Baltimore County DEPRM
Towson, Maryland

Prepared by: PB Americas, Inc.
Baltimore, Maryland

In Association with: EBA Engineering, Inc.
Baltimore, Maryland
Coastal Resources, Inc
Annapolis, Maryland

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

UPPER BACK RIVER

STREAM STABILITY ASSESSMENT

I. INTRODUCTION

The Baltimore County Department of Environmental Protection and Resource Management (DEPRM) has requested that PB prepare a planning level stream stability assessment of three subsheds in the Upper Back River Watershed. The Upper Back River Watershed system is located in the southeastern portion of Baltimore County and northeastern portion of Baltimore City, Maryland. The streams of interest include Herring Run, Stemmers Run and Brien Run subsheds. The headwaters of Herring Run originate in the vicinity of Towson, Stemmers Run is in the vicinity of Overlea and Rosedale, and Brien Run is in the vicinity of Rosedale.

PB conducted these planning level stream stability assessments in support of County initiatives in watershed action planning, addressing TMDL's, for comparison of baseline conditions, and stream management/restoration needs.

This document will be used in partial fulfillment of the federally mandated National Pollutant Discharge Elimination System Permit (NPDES) – Municipal Stormwater Discharge Permit (99-DP-3317) for Baltimore County.

Figure 1 and Figure 2 show the location of the study watersheds within Baltimore County. More detailed mapping is included in the Appendices. Watershed boundaries within Baltimore City have been omitted.

Study Components

This study is divided into six primary sections. Section 1 includes the introduction and general watershed overview. Section 2 describes the stream stability assessment methodology. Section 3 provides a summary of current stream conditions. Section 4 details management measures that can be incorporated into the watershed. Section 5 describes the identification of stream reach needs. The appendices contain the detailed data, mapping and prioritization tables for planning purposes.

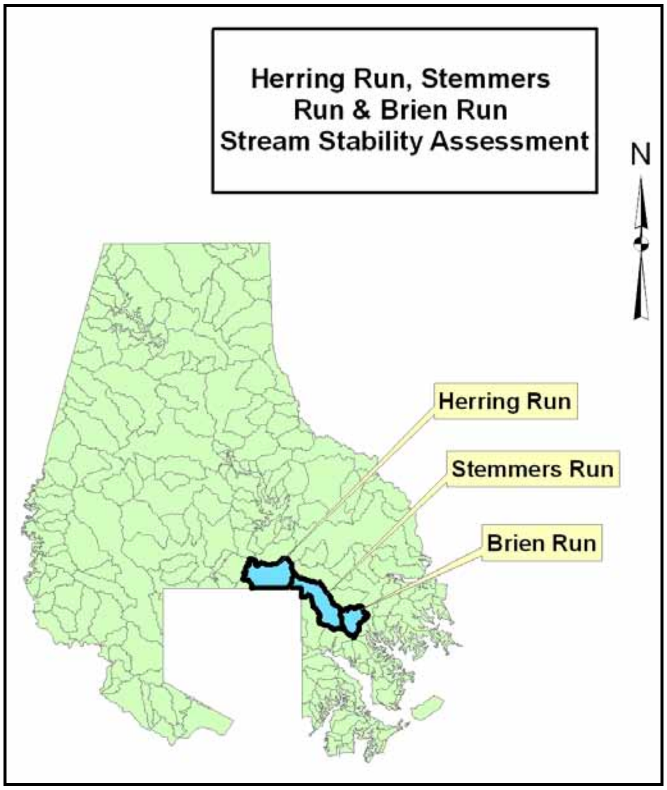


Figure 1: Study Area Location Map

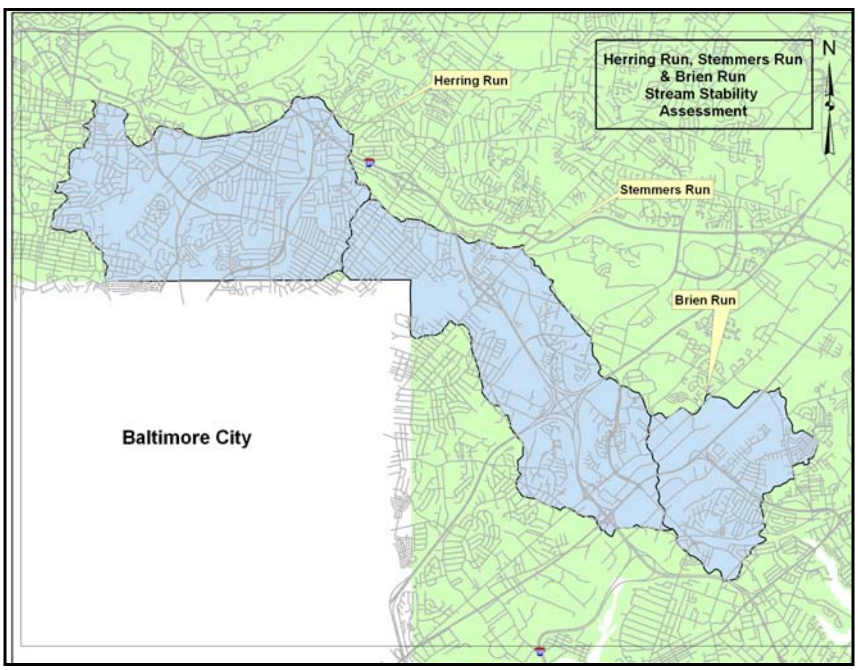


Figure 2: Upper Back River Subwatersheds

II. STREAM STABILITY ASSESSMENT

The Herring Run, Stemmers Run and Brien Run subwatersheds were selected for assessment with the goals of identifying stream instabilities and to provide opportunities for stream corridor restoration and reduction in phosphorus, nitrogen and sediment concentration in the watersheds.

Approximately 28.56 miles of stream channel within the watershed was assessed. The 28.56 miles were broken down into individual assessment reaches averaging 700 linear feet for a total of 211 reaches. If stream segments were less than 250 feet long, they were excluded from this study.

Cruised Assessment

Cruised reach assessments were conducted on 28.56 miles of first, second and third order stream reaches that were not previously assessed by the County. “Cruising” is defined as a team of stream surveyors walking the entire length of each reach and performing rapid field assessments. “Reaches” are defined as lengths of stream divided up based on tributary confluences, geomorphic changes, or preset distances. The items included in the rapid assessment were divided into four major categories:

- Channel Morphology,
- Channel Disturbances,
- Channel Habitat,
- Restoration Opportunities.

Field crews of two team members assessed the cruised reaches. Field crews consisted of one senior staff member who served as the team leader and one junior staff member. Team leader training was done prior to beginning the field work to provide consistency in the assessments. Supervisory staff worked with the team leaders to ensure continuity in data collection. Measurements using a stretched tape and survey rod were performed to assess geomorphic features such as bankfull width, depth and floodprone width. Detailed cross sections were not taken at each reach. A representative riffle section of the reach was selected for assessment and the section was photographed for future reference.

Prior to beginning field work, all streams were divided into reaches of approximately 500 feet. Reach breaks were adjusted in the field if stream type and characteristics changed significantly. The final cruised reach assessment yielded an average stream reach of 700 feet.

The methodology and data collection parameters for each category are defined below.

Channel Morphology

Flow Regime

Streamflow regime exhibits a strong influence on channel morphology, aquatic habitat and riparian vegetation. Flow regime categories were based on the Level III Rosgen Methodologies. Table 1 lists the categories used in this field assessment.

Table 1: Flow regime categories

Code	Flow Regime Category
E	Ephemeral stream channel, flow only in response to precipitation
S	Subterranean stream channel, flows parallel to and near the surface for various seasons
I	Intermittent stream channel, flow in which exists seasonally or sporadically
PI	Piped
P	Perennial stream channel, flow in which exists year round

Stream Size

Bankfull width is often used to assess stream size because many hydrologic and geomorphic interpretations can be derived from width measurements. Stream size can be used to provide perspective for interpreting hydraulic processes, sediment transport and biological processes. Table 2 lists the stream size categories based on Rosgen Level III classification that were determined from measurement of bankfull widths for each stream reach. All bankfull widths assessed as part of this study were less than 50 feet.

Table 2: Stream size classification

Code	Stream Size
S-1	Bankfull Width less than 1 foot
S-2	Bankfull Width from 1 to 5 feet
S-3	Bankfull Width from 5 to 15 feet
S-4	Bankfull Width from 15 to 30 feet
S-5	Bankfull Width from 30 to 50 feet

Entrenchment Ratio Range

Entrenchment describes the relationship of a stream to its floodplain. The entrenchment ratio describes the vertical containment of a stream. It has been defined by Rosgen as the ratio of the width of the floodprone area to the surface width of the bankfull channel. The entrenchment ratio was computed for each stream reach and then divided into three categories: slight entrenchment, moderate entrenchment and entrenched. Table 3 shows the entrenchment characteristics of the Upper Back River Watershed.

Table 3: Entrenchment ratio range categories

Category
Slight to No Entrenchment (> 2.2)
Moderate Entrenchment (1.41 - 2.2)
Entrenched (1.0 - 1.4)

Sinuosity Range

Channel sinuosity is defined as the ratio of stream channel length to down-valley distance. It can also be computed as the ratio of valley slope to channel slope. Sinuosity is a primary indicator of Rosgen stream type and also provides an indication of how the stream slope has adjusted in comparison with the valley slope. The actual sinuosity was not field measured for each cruised reach, however, the sinuosity range was determined visually in the field. Table 4 shows the classification categories used in this analysis.

Table 4: Sinuosity range categories

Code	Category
Low	Sinuosity Ratio of 1.0 to 1.2
Moderate	Sinuosity Ratio of 1.2 to 1.5
High	Sinuosity Ratio greater than 1.5

Depositional Features

Depositional patterns are easily observed channel features that are beneficial in interpreting stream condition. Depositional patterns can be used to illustrate the effects of past land management on sediment supply and storage and the effects on channel form and stability. Table 5 lists the depositional features used to assess the cruised reaches in this study.

Table 5: Depositional feature categories

Code	Category
B-1	Point Bars
B-2	Point Bars with Few Mid Channel Bars
B-3	Many Mid Channel Bars
B-4	Side Bars
B-5	Diagonal Bars
B-6	Main Branching with Many Mid Bars and Islands
B-7	Mixed Side Bar and Mid Channel Bars exceeding 2-3 times the width
B-8	Delta Bars
NONE	No Depositional Patterns Observed

Channel Substrate

Channel bed and bank materials influence the cross sectional form, plan view and longitudinal profile of rivers. They also determine the extent of sediment transport and resistance to hydraulic stress. It is also important for addressing the biological function and stability of rivers.

Table 6 shows the channel substrate categories used in the cruised reach assessment. The channel substrate was visually estimated as the field crew cruised the reach. There were no physical samples taken nor was the channel subpavement assessed.

Table 6: Channel substrate classifications

Category
Boulder
Cobble
Gravel
Sand
Silt and Silt/Clay

Stream Classification Type (Rosgen)

The cruised reaches were visually assessed and classified according to Rosgen's stream classification system. The entrenchment ratio, width to depth ratio and sinuosity were used in stream type selection. Table 7 shows the stream type classifications used within the Upper Back River Watershed.

Table 7: Rosgen stream classification

Rosgen Classification
A
B
C
D
E
F
G

Channel Slope Range

The water surface slope is a major determinant of river channel morphology and of its related sediment, hydraulic and biological function. An average slope range was estimated from visual observation and topographic maps for each stream reach. Detailed profile measurements were not taken for each reach. Table 8 shows the slope ranges used in the assessments.

Table 8: Channel slope range categories

Category
Channel Slope < 2%
2% < Channel Slope < 4%
Channel Slope > 4%

Width to Depth Ratio Range

The width to depth ratio is defined as the ratio of the bankfull width to the mean depth of the bankfull channel. The width to depth ratio is the key to understanding the distribution of available energy within a channel and the ability of various discharges within the channel to move sediment. Of Rosgen's Level II parameters, the width to depth ratio is the most sensitive and positive indicator of trends in channel instability.

For channels with high width to depth ratios, the distribution of energy in the channel is such that stress is placed within the near bank region. As the width to depth ratio decreases, the hydraulic stress against the banks increases and bank erosion potential increases.

The actual width to depth ratio was computed using the field measured bankfull width and average bankfull depth. Table 9 summarizes the categories for the width to depth ratio which were taken from the Rosgen classification system. Cutoff values of 12 and 40 are used to distinguish between the various Rosgen stream types.

Table 9: Width to Depth ratio categories

Category
Width/Depth Ratio < 12
40 > Width/Depth Ratio > 12
Width/Depth Ratio >40

Meander Pattern

Channel meander patterns provide a plan view of lateral channel adjustments, meander width ratios and lateral containment characteristics for all of the stream types. The meander patterns provide insight into how the stream channel adjusts its slope in relation to the stream valley. Table 10 shows the Rosgen meander classifications used in the cruised reach study.

Table 10: Meander pattern classifications

Rosgen Code	Category
M-1	Regular Meanders
M-2	Tortuous Meanders
M-3	Irregular Meanders
M-4	Truncated Meanders
M-5	Unconfined Meander Scrolls
M-6	Confined Meander Scrolls
M-7	Distorted Meander Loops
M-8	Irregular Meanders with Oxbows and Oxbow Cutoffs

Bank Failure Assessment

Assessment of bank failure is based on a combination of field measured parameters:

- Length and Height of bank instability,
- Unstable to Stable Stream Ratio (or percentage),
- Average Bank Height versus Bankfull Depth (low, medium or high erosion potential),
- Bank Angle,
- Root Density, and
- Bank Material.

Length and Height of Bank Instability

The length and height of unstable banks were estimated for the left and right banks of each reach. The unstable bank measurements were used to determine the average eroded area per foot of stream channel. Normalizing the erosion per length of channel allows the comparison of erosion severity between reaches of varying lengths.

Unstable to Stable Stream Ratio (or percentage)

The final factor in the bank erosion analysis was the ratio of unstable stream length to total stream length. 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 ratio between 25 and 50 percent. High erosion potential was given to any reaches that had more than 50% unstable to stable lengths.

Average Bank Height versus Bankfull Depth

The ratio of average bank height versus bankfull depth is an important indicator of potential bank erosion and one of the components of the modified BEHI analysis. Low erosion potential ratios were between 1.0 and 1.19, medium erosion potential ratios were between 1.2 and 1.59, and high erosion potential ratios were defined as being greater than 1.6.

Bank Angle

Bank angle is also an erosion potential indicator and was rated as follows: low potential was assigned to banks sloping away from the stream, medium potential was assigned to nearly vertical banks and high potential was assigned to undercut banks, sloping in towards the stream.

Root Density

Root density was another factor considered in the bank erosion potential analyses. Low erosion potential was given to banks with dense roots throughout the entire bank, medium potential was given to banks with dense roots in the upper half of the banks and high erosion potential was given to banks with minimal root density.

Bank Material

Bank material can limit or accelerate bank erosion potential. Banks with sandy layers or stream banks with stratified layers have higher erosion potential while banks with a high percentage of cobble material will have lower erosion potential. Points were added to the BEHI rating for sandy bank material or stratified bank material while points were subtracted for cobbley banks. All other bank types received a neutral rating of zero.

BEHI Rating

A modified bank erosion hazard index (BEHI) was developed based on the following components:

- Bank Height/ Bankfull Height,
- Bank Angle,
- Root Density,
- % Surface Protection,
- Root Depth / Bank Height,

- Bank Material (Sandy, stratified or cobbley).

The BEHI methodology is based on a modified version of the Rosgen Bank Erosion Hazard Index. The primary difference between the method used for the Upper Back River study and the Rosgen methodology is that the Upper Back River methodology uses average reach values as opposed to bank specific values. Appendix D contains detailed BEHI scoring methodology. The individual BEHI component scores were summed to obtain the overall BEHI score. The scores were then adjusted to account for sandy, stratified or cobbley bank materials. The final point totals were then assigned an erosion potential rating as follows:

- High Erosion Potential 14 to 15 points
- Moderate to High 12 to 13 points
- Moderate Erosion Potential 9 to 11 points
- Low to Moderate Erosion Potential 8 points
- Low Erosion Potential Less than 8 points

Channel Stability – Vertical and Lateral

Each stream reach was assessed for its vertical and lateral channel stability. Table 11 was used to assist the field crews with the classification of vertical and lateral channel stability. Throughout the watershed, 36.5.9% of the cruised stream reaches were assessed as vertically unstable. 49.3% of the cruised stream reaches were assessed as laterally unstable.

Table 11: Field Indicators to assess vertical and lateral stream stability

Field Indicators for Stream Degradation or Aggradation		
Observed Condition	**Degrading**	**Aggrading**
Channel Form:		
Straightened Channel	X	
Active Head Cuts	X	
Active Meander Development		X
Channel Avulsions		X
Loss of Channel Bars	X	
Channel Bars Developing		X
Mass Wasting of Banks	X	
Vertical or Steepened Banks	X	
Tributary Stream Hanging or Steepened	X	
Hydraulic Conditions:		
Decrease in Energy Slope		X
Increase in Energy Slope	X	
Stage Control Downstream		X
Stage Control Upstream	X	
Dam or Reservoir Upstream	X	
Hydrologic Conditions:		
Logging/Land Clearing		X
Watershed Urbanizing	X	
Clearwater Diversion		X
Drought Period		X
Wet Period	X	
Sediment:		
Reduction in Supply	X	
Increase in Supply		X
Alluvial Fan Downstream	X	
Alluvial Fan Upstream		X
Vegetation:		
Vegetation High Relative to Flow Line	X	
Trees Leaning into Channel	X	

Geologic Controls

Any geologic controls (bedrock) found in a reach were noted in the data collection forms. Bedrock outcrops within the stream channel and in the adjacent floodplains were commonly found throughout the Herring Run, Stemmers Run and Brien Run subsheds.

Channel Evolution Stage (Schumm, et al 1984)

The incised channel evolution model (Schumm *et al*, 1984) was used to classify each of the cruised stream reaches. The intent of the channel evolution model is to determine if the reach is in a stable, incising, widening or stabilizing state. The five evolution stages are defined as follows:

- **Stage I**: Well developed baseflow and bankfull geometry; consistent floodplain features easily identified; *one terrace* apparent above active floodplain; predictable pattern and stream bed morphology; floodplain covered by diverse vegetation; stream banks less than 45 degree angle.
- **Stage II**: Headcuts; exposed cultural features; sediment deposits absent or sparse; exposed bedrock; streambank slopes > 45 degree angle.
- **Stage III**: Streambanks sloughing; sloughed material eroding; streambank slopes greater than 60 degrees, vertical or concave.
- **Stage IV**: Streambanks aggrading; sloughed material not eroded; soughed material colonized by vegetation; baseflow, bankfull and floodplain channel developing; predictable, sinuous pattern developing; streambank slopes less than or equal to 45 degrees.
- **Stage V**: Well developed baseflow and bankfull channel; consistent floodplain features easily identified; two or more terraces apparent above active floodplain; predictable pattern and streambed morphology; streambank angle less than 45 degrees.

Stages I and V were assumed to be stable, Stage II and III were assumed to be degrading and Stage IV was assumed to be aggrading.

Channel Successional Stage (Rosgen)

Rosgen defines a series of nine channel successional stages as a means of determining future channel state. The Rosgen successional stage in conjunction with the current Rosgen stream classification can provide insight into whether the channel in evolving towards a more stable state. The Rosgen Successional Stages are shown in Figure 3.

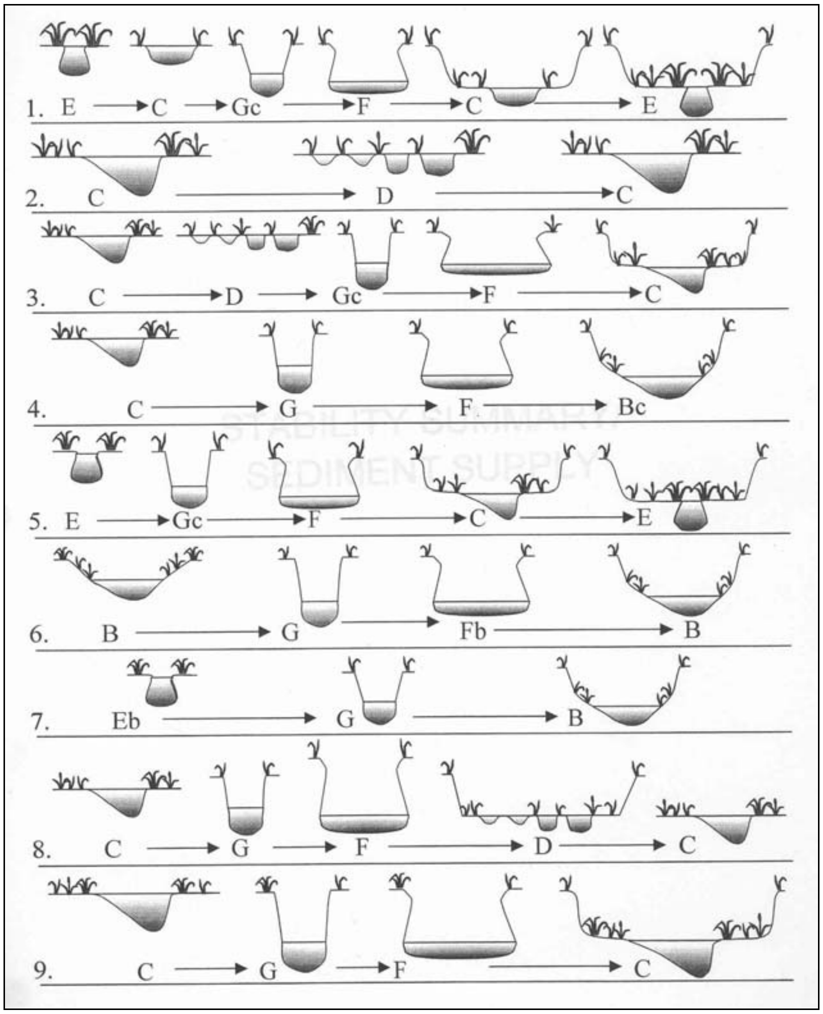


Figure 3: Stream Type Succession Stages (Rosgen 2001)

Channel Disturbances

Bank Instabilities

Localized bank instabilities were recorded in each reach. The length and average height of unstable bank were measured throughout the reaches with separate values recorded for the left and right bank. Bank instabilities that threatened private structures were also recorded.

Additional information on bank instabilities can be found throughout the channel morphology and habitat section of the cruised reach assessment.

Channel Disturbances

Due to the predominantly low density residential and forest cover land use of the Upper Back River watershed, there were a significant number of stream channels that have been modified through the use of riprap, gabion or lining by concrete. To maintain consistency with other County watershed assessments, any channel disturbances found during the field assessment were documented. Specific items of interest included:

- Concrete Lined,
- Riprap/Gabion Lined ,

- Private Structure Threatened,
- Culvert within Reach.

Debris Blockages

Debris blockages occurred on many of the stream reaches throughout the cruised reach assessment. The severity of the debris blockage was classified using the frequency descriptions listed in Table 12. Appendix D contains the debris photo descriptions used by field crews during the assessment.

Table 12: Debris blockage Classification for in the Upper Back River assessed reaches

Description
None
Infrequent
Moderate
Numerous
Extensive

Utilities

Utility conflicts are commonly found in urban stream channels. All reaches with the following characteristics were noted during the assessment:

- Exposed Crossings,
- Leaking Utility,
- Exposed manholes in or near the channel.

Channel Habitat

Habitat refers to the physical components of an organism's surroundings. Three components of in-stream habitat were examined as part of this study: presence of fish blockages, vegetation and in-stream channel condition. Each of the components will be explained below.

Fish Blockages

Stream reaches with fish blockages were noted during the field assessment. Each fish blockage was classified as having one of the causes shown in Table 13.

Table13: Fish blockage categories

Causes of Fish Blockages
Debris Blockages
Shallow Depth of Flow
Excessive Height

Vegetation

Riparian cover along both the left and right overbanks of the stream was assessed. The width, composition and density of each riparian zone were quantified. Density was classified as low, medium or high. Table 14 shows the vegetation categories that were used for the assessed reaches.

Table 14: Vegetation cover categories

Vegetation
Bare
Forbs only
Annual grass with forbs
Brush
Deciduous overstory
Deciduous overstory with brush understory
Wetland vegetation

In addition to the adjacent riparian zone, the canopy cover immediately over the stream was assessed. Canopy cover was broken into five categories as shown in Table 15.

Table 15: Canopy cover categories

Canopy Cover
0 to 10%
10 to 25%
25 to 50%
50 to 75%
75 to 100%

Habitat Assessment

Habitat quality can be positively correlated with overall aquatic community health. Aquatic habitat was visually evaluated within each reach utilizing the Maryland Biological Stream Survey (MBSS) Physical Habitat Index (PHI). Although this assessment is typically only performed in 75-meter segments within larger reaches, those reaches less than 75 meters (246 feet) in length were also evaluated in this study. This assessment was based on the February 2001 MBSS guidelines (Kazyak, 2001). The MBSS PHI, in Piedmont streams, is calculated using the following parameters:

- *Instream habitat structure* – looks at the variety of cobbles, boulders, submerged logs, undercut banks, snags, rootwads, aquatic plants and other stable habitat within the stream channel.
- *Epifaunal substrate* – looks at the amount and variety of hard, stable substrates usable by benthic macroinvertebrates.
- *Shading* – percent of summertime shading over the habitat reach.
- *Number of instream rootwads and woody debris* – large woody debris (>4 inches in diameter and > 5 feet long) and rootwads (>6 inch DBH) were counted in each 75 meter habitat reach.
- *Bank stability* – the length and severity of erosion on each side of the 75 meter habitat reach.
- *Riffle/run quality* - quantifies depth of flow, stability of channel substrate and diversity of current velocities at riffles or runs.
- *Distance to the nearest road (remoteness)* – distance from edge of habitat reach to nearest roadway. Measured via GIS.
- *Embeddedness* – percent that gravel, cobble and boulder particles are surrounded by fine sediment(silt, sand, or clay) or flocculent material.

These metrics were determined by MBSS to be important in discriminating healthy sites from degraded sites. The physical habitat data were analyzed using a method developed for the 1994-2000 MBSS data. Four categories of habitat health were established for the PHI as follows:

- Scores of 72 to 100 are rated good.
- Scores of 42 to 71.9 are rated fair.
- Scores of 12 to 41.9 are rated poor.
- Scores of 0 to 11.9 are rated very poor.

Overall in the assessed reaches of the Upper Back River watershed, the majority of the reaches rated fair and were limited by a lack of instream habitat and epifaunal substrate and woody debris, due to shallow depth or lack of flow. These reaches are lacking the substrate characteristics that provide optimal epifaunal habitat, which include well developed riffles dominated by cobble, and stable woody debris. Table 16 lists the results of the habitat characteristics assessment by subwatershed.

Table 16: Habitat Characteristics of the Assessed Upper Back River Subwatersheds

Subwatershed	MBSS PHI Rating			Limiting Characteristic
	Good	Fair	Poor	
Herring Run	0.0%	66.7%	33.3%	shallow flow, lack of instream habitat, lack of woody debris
Stemmers Run	2.0%	69.0%	29.0%	shallow flow, lack of epifaunal habitat, lack of woody debris
Brien Run	0.0%	52.6%	47.4%	shallow flow, lack of epifaunal habitat, lack of woody debris
Combined Subwatersheds	0.9%	65.3%	33.8%	shallow flow, lack of epifaunal habitat, lack of woody debris

Restoration Opportunities

It was determined that the first screening for potential restoration sites would occur during the stream assessments. As the field crews collected the data above, they were also looking at the sites in terms of potential restoration projects. Types of the potential restoration opportunities are listed below. Restoration projects that did not fit into the categories below were noted in the comments section of the form. Restoration opportunities are summarized in management and recommendations section of this report.

- Channel Restoration/Stabilization,
- Buffer Enhancement,
- Bank Planting,
- Utility Conflict Resolution,
- Wetland Enhancement,
- Trash Cleanup,
- Yard Waste Cleanup,
- Invasive Species Removal.

III. SUMMARY OF STREAM CONDITIONS

Section II of this report summarized the assessment parameters used in the Upper Back River cruised reach assessment. This section of the report summarizes the characteristics of the individual Upper Back River subwatersheds. It is divided into the following subsections:

- Channel Morphology – including flow regime, Rosgen stream type, bankfull indicator, channel substrate, meander pattern and depositional features.
- Channel Stability – lateral and vertical stability, ratio of unstable to stable banks, channel evolution stage and BEHI ranking.
- Channel Disturbances – debris jams, utility conflicts, riprap/gabion lined channels.
- Riparian Characteristics – composition, density, width.
- Habitat – MBSS PHI score.
- Deficiencies – major problems within the watershed.

Herring Run

Herring Run has a drainage area of 3.6 square miles and is located in the Maryland Piedmont physiographic region. It is composed primarily of C type hydrologic soils and the land use is split between urban area (82.1%) and forested lands (5.8%). The watershed contains approximately 48.0% impervious area. The basin has a relief of 100 feet with an average channel slope of 0.75%.

Seventy five reaches with a total reach length of 53,066 feet (10.05 miles) were assessed in the Herring Run subwatershed. A summary of the reach length statistics is provided in Table 17. Figure 4 shows typical stream reaches.

Table 17: Assessed Reach Length Statistics Herring Run

Reach Length Statistics	Reach Length in feet	Reach Length in miles
Total	53,066	10.05
Mean	708	0.13
Maximum	1,956	0.37
Minimum	179	0.03
Standard Deviation	443	0.08

Figures 4A & B: HW-00-00-09 upstream and HE-00-00-06 downstream, respectively.

Existing Condition Summary

<u>Channel Morphology</u>

Of the seventy five reaches assessed, 90.7% are perennial streams, 8% are intermittent streams and 1.3% are ephemeral streams. Slope breaks were identified as the bankfull indicator in the majority of these reaches (90.7%). Depositional features were selected as bankfull indicators in less than 2% of the reaches in this subwatershed. A combination of bankfull indicators were used in the remaining 5.3% of the reaches.

All reaches were classified in accordance with the Rosgen Stream Classification of Natural Rivers. 35% of the reaches are F channels. B channels constitute 26.7%, and E channels are 21.3%. A, C, and G make up the remaining 14.7% of the assessed reaches with 12% of them being G channels.

Gravel (68%) channel materials made up the majority of the reaches, while silt (13.3%), boulder (8%) and cobble (5.3%) were also identified as the median channel materials for the remaining reaches. Bedrock outcrops were identified in 41.3% of the assessed reaches. The majority of the reaches had irregular meander patterns (96%) and no depositional features (45.3%), typical characteristics of F channels. Table 18 summarizes the dominant channel morphology characteristics of the Herring Run subwatershed.

Table 18: Dominant Channel Morphology Characteristics of the Herring Run Subwatershed

Flow Regime	Perennial
Bankfull Indicator	Slope Break
Stream Type	F, B and E channels
Channel Substrate	Gravel – 68% with bedrock outcrops
Meander Pattern	Irregular
Depositional Features	None

<u>Channel Stability</u>

The existing stability of the Herring Run subwatershed is predominantly vertically stable (57.3%). However, a relatively small percentage is laterally stable (37.3%). The average reach unstable to stable stream ratio is 20.9%. Table 19 lists the existing channel stability characteristics for the Herring Run subwatershed.

Table 19: Existing Channel Stability, Herring Run Subwatershed

Stability Rating	Vertical Stability		Average Ratio of Unstable to Stable Stream Banks
	Percent of Reaches	Length of Reaches (miles)	
Aggrading	25.3%	3.33	20.9%
Degrading	17.4%	1.25	
Stable	57.3%	5.47	
Not Evaluated	0%	0.00	
Stability Rating	**Lateral Stability**		
	Percent of Reaches	**Length of Reaches (miles)**	
Aggrading	0%	0.00	
Degrading	62.7%	6.51	
Stable	37.3%	3.54	
Not Evaluated	0%	0.00	

Approximately 30% of the Herring Run reaches can be classified as channel evolution stage I or stage III, less than 15% each are stage II or V. 17.3% of the reaches are classified as stage IV. The average BEHI rating is low or low to moderate (33.3% each), as shown in the following table.

Table 20: Potential Channel Stability, Herring Run Subwatershed

Channel Evolution Stage	Percent of Reaches per Channel Evolution Stage	Length of Reaches per Channel Evolution Stage (miles)
Stage I	30.7%	2.75
Stage II	13.3%	1.01
Stage III	33.3%	3.53
Stage IV	17.3%	2.38
Stage V	2.7%	0.23
Not Evaluated	2.7%	0.15
BEHI Rating	**Percent of Reaches per BEHI Rating**	**Length of Reaches per BEHI Rating (miles)**
Low	5.3%	0.28
Low to Moderate	6.7%	0.67
Moderate	46.7%	4.65
Moderate to High	30.7%	3.46
High	9.3%	0.91
Not Evaluated	1.3%	0.09

Channel Successional Stage (Rosgen) was also determined for the 75 assessed reaches in the Herring Run subwatershed. Table 21 summarizes the channel successional stage of the Herring Run subwatershed.

Table 21: Channel Successional Stage, Herring Run Subwatershed

Channel Successional Stage (Rosgen)	Percent of Reaches per channel Evolution Stage
Stage 1	1.3%
Stage 2	0%
Stage 3	1.3%
Stage 4	22.7%
Stage 5	32%
Stage 6	28%
Stage 7	8%
Stage 8	0%
Stage 9	4%
Unknown	2.7%
Total	**100%**

Channel Disturbances

A significant number of reaches in the Herring Run subwatershed have infrequent debris jams (32%). 10.7% of the reaches have moderate blockages and 4% have numerous blockages. Twenty five reaches included culverts and eleven of those had culvert instabilities. Most had fish blockage issues and a few had aggradation upstream of the culvert.

Riparian Characteristics

The majority of this subwatershed's riparian area consists of high-density deciduous overstory with brush/grass understory (81.3% on both the left and the right bank). The reaches primarily have 50% to 75% canopy cover (32% of the reaches) and riparian widths between 75 and 100 feet. The following tables (22 through 24) present the riparian characteristic data for the Herring Run subwatershed. Lower density vegetation typically occurred when the stream was adjacent to roads, driveways or agricultural fields.

Table 22: Riparian Composition and Density, Herring Run Subwatershed

Riparian Composition	Riparian Density					
	Percent of Reaches Left Bank			Percent of Reaches Right Bank		
	High	Moderate	Low	High	Moderate	Low
Deciduous with Brush/Grass Understory	2.7%	50.7%	26.7%	1.3%	45.3%	30.7%
Grass and Forbs	0%	0%	16%	0%	0%	16.0%
Total	**2.7%**	**50.7%**	**42.7%**	**1.3%**	**45.3%**	**46.7%**

Table 23: Canopy Cover, Herring Run Subwatershed

Percent Canopy Cover	Percent of Reaches
0-10%	13.3%
10-25%	16%
25-50%	25.3%
50-75%	32%
75-100%	12%
Not Evaluated	1.3%
Total	**100%**

Table 24: Riparian Width, Herring Run Subwatershed

Riparian Width	Percent of Reaches
0-10 feet	5.3%
10-25 feet	6.7%
25-50 feet	26.7%
50-75 feet	18.7%
75-100 feet	44.0%
Total	**100%**

Habitat Characteristics

The MBSS PHI rating for 66.7% of the Herring Run reaches is fair, and 33.3% of the reaches are rated poor. The fair reaches are mainly limited by a lack of instream habitat and woody debris. Poor reaches are limited by a lack of instream habitat, epifaunal habitat, and woody debris. Table 25 summarizes the MBSS PHI rating for Herring Run subwatershed. Fish blockages are present in 41.3% of the reaches: 18.7% are affected by shallow depth of flow, and 37.3% by excessive height.

Table 25: Habitat Characteristics, Herring Run Subwatershed

MBSS PHI Rating	Percent of Reaches
Good	0.0%
Fair	66.7%
Poor	33..3%
Total	**100%**

Subwatershed Deficiencies

Problems within the Herring Run subwatershed included moderate bank erosion potential, various channel disturbances, fish blockages, and only 67% of instream habitat ranked as fair. Channel disturbances include culverts causing fish passage issues and invasive plants.

Stemmers Run

Stemmers Run has a drainage area of 5.8 square miles and is located in the Maryland western coastal plains region. It is composed primarily of C type hydrologic soils and urban areas (61.6%) are the predominant land uses. Forested lands (21.2%) comprise another major portion of the watershed. The watershed contains approximately 34.7% impervious area. The basin has a relief of 160 feet with an average channel slope of 1.0%.

One hundred reaches with a total reach length of 71,222 feet (13.49 miles) were assessed in the Stemmers Run subwatershed. A summary of the reach length statistics is provided in Table 26. Figure 5 shows typical reaches within the watershed.

Table 26: Assessed Reach Length Statistics Stemmers Run

Reach Length Statistics	Reach Length in feet	Reach Length in Miles
Total	71,222	13.49
Mean	712	0.13
Maximum	1,988	0.38
Minimum	188	0.04
Standard Deviation	396	0.08

Figures 5 A & B: SR-02-00-01 upstream and SR-02-00-02 00 upstream, respectively

Existing Condition Summary

<u>Channel Morphology</u>

Of the 100 reaches assessed, 67% are perennial streams, 27% are intermittent, and 3% are ephemeral. Slope breaks were identified as the bankfull indicator in the majority of these reaches (61%), depositional and erosional features formed another 15%, and the rest (17%) were active floodplain and vegetative features. 7% were not evaluated.

All reaches were classified with the Rosgen Stream Classification of Natural Rivers. 31% of the reaches are B channels, G channels constitute 25%, C, F, and E were each 15%, 18% and 10%. There were no D channels.

Gravel (64%), cobble (11%), sand (10%) and silt (10%) channel materials make up the reaches. There was one concrete channel. Bedrock outcrops were identified in 2% of the assessed reaches.

The majority of the reaches have irregular meander patterns (92%) and no depositional features (38%), which are typical characteristics of B and G channels. Table 27 summarizes the dominant channel morphology characteristics of the Stemmers Run subwatershed.

Table 27: Dominant Channel Morphology Characteristics of the Stemmers Run Subwatershed

Flow Regime	Perennial
Bankfull Indicator	Slope Break
Stream Type	B and G channels
Channel Substrate	Gravel – 64% with bedrock outcrops
Meander Pattern	Irregular
Depositional Features	None

Channel Stability

The existing stability of the Stemmers Run subwatershed is predominantly vertically stable (69%) and laterally stable (55%). The average ratio of unstable to stable stream reaches is 20.3%. The following table lists the existing channel stability characteristics for the Stemmers Run subwatershed.

Table 28: Existing Channel Stability, Stemmers Run Subwatershed

Stability Rating	Vertical Stability		Average Ratio of Unstable to Stable Stream Banks
	Percent of Reaches	Length of Reaches (miles)	
Aggrading	12%	1.95	20.3%
Degrading	18%	2.20	
Stable	69%	9.33	
Not Evaluated	0%	0.00	
Stability Rating	**Lateral Stability**		
	Percent of Reaches	**Length of Reaches (miles)**	
Aggrading	5%	0.64	
Degrading	39%	5.58	
Stable	55%	7.28	
Not Evaluated	0%	0.00	

16% of the reaches within the Stemmers Run subwatershed are stage I, 21% are stage II, 35% are stage III, 15% are stage IV, and 13% are stage V. The average BEHI rating is moderate (10.2).

Table 29: Potential Channel Stability, Stemmers Run Subwatershed

Channel Evolution Stage	Percent of Reaches per Channel Evolution Stage	Length of Reaches per Channel Evolution Stage (miles)
Stage I	16%	1.60
Stage II	21%	2.67
Stage III	35%	4.69
Stage IV	15%	2.35
Stage V	13%	2.17
Not Evaluated	0%	0.00
BEHI Rating	**Percent of Reaches per BEHI Rating**	**Length of Reaches per BEHI Rating (miles)**
Low	10%	1.05
Low to Moderate	8%	0.96
Moderate	54%	7.91
Moderate to High	27%	3.36
High	1%	0.21
Not Evaluated	0%	0.00

Table 30: Channel Evolution Stage, Stemmers Run Subwatershed

Channel Successional Stage (Rosgen)	Percent of Reaches per channel Evolution Stage
Stage 1	1%
Stage 2	0%
Stage 3	0%
Stage 4	12%
Stage 5	4%
Stage 6	32%
Stage 7	17%
Stage 8	2%
Stage 9	5%
Other	22%
Total	**100%**

Channel Successional Stage (Rosgen) was also determined for the assessed reaches. It was found that reaches in the Stemmers Run subwatershed were predominantly Channel Successional Stage 6 (32%). Table 30 summarized the channel evolution stages of the 100 assessed reaches within the Stemmers Run subwatershed.

Channel Disturbances

Most reaches of the Stemmers Run subwatershed had infrequent debris jams (38%). 18% of the reaches evaluated have numerous debris jams. Only five of the Stemmers Run reaches have culverts, of which two have excessive downstream scour and one has fish passage issues.

Riparian Characteristics

The majority of this subwatershed's riparian area consists of high-density deciduous overstory with brush/grass understory (79% of the left bank and 77% of the right bank). The reaches primarily have 50% to 75% canopy cover (44% of the reaches) and riparian widths between 75 and 100 feet (46%). The following tables (Tables 31 through 33) present the riparian characteristic data for the Stemmers Run subwatershed.

Table 31: Riparian Composition and Density, Stemmers Run Subwatershed

Riparian Composition	Riparian Density					
	Percent of Reaches Left Bank			Percent of Reaches Right Bank		
	High	Moderate	Low	High	Moderate	Low
Brush	1%	6%	4%	4%	6%	3%
Deciduous Overstory	2%	3%	0%	1%	1%	6%
Deciduous with Brush/Grass Understory	21%	55%	5%	18%	55%	4%
Forested Wetlands	1%	1%	0%	1%	2%	0%
Total	**25%**	**65%**	**9%**	**23%**	**62%**	**13%**

Table 32: Canopy Cover, Stemmers Run Subwatershed

Percent Canopy Cover	Percent of Reaches
0-10%	6.0%
10-25%	10.0%
25-50%	31.0%
50-75%	44.0%
75-100%	8.0%
Total	**100%**

Table 33: Riparian Width, Stemmers Run Subwatershed

Riparian Width	Percent of Reaches
0-10 feet	8.0%
10-25 feet	13.0%
25-50 feet	17.0%
50-75 feet	11.0%
75-100 feet	46.0%
100-200 feet	4.0%
Total	**100%**

Habitat Characteristics

The MBSS PHI rating for 2.0% of the Stemmers Run reaches is good, 69.0% are rated fair, and 29.0% of the reaches are rated poor. Table 34 summarizes the habitat characteristics for the Stemmers Run subwatershed. The habitat is limited by a lack of woody debris as well as lack of optimal instream and epifaunal habitats. Fish blockages are present in 83.0% of the reaches. They are affected by shallow depth of flow, excessive height and debris blockages.

Table 34: Habitat Characteristics, Stemmers Run Subwatershed

MBSS PHI Rating	Percent of Reaches
Good	2.0%
Fair	69.0%
Poor	29.0%
Total	**100%**

Subwatershed Deficiencies

Problems within the Stemmers Run subwatershed included moderate bank erosion potential, various channel disturbances, fish blockages. 69% of the instream habitat was rated fair and 2% was rated good. Channel disturbances include culverts causing fish blockages, and invasive species, as well as a large amount of waste and trash in some locations. 13 of the assessed reaches in the Stemmers Run subwatershed were identified for utility conflict resolution.

Brien Run

Brien Run has a drainage area of 2.5 square miles and is located in the Maryland western coastal plains region. It is composed primarily of C type hydrologic soils and urban areas (72.5%) are the predominant land uses. 17.5% of the area is forested wetlands. The watershed contains approximately 53% impervious area. The basin has a relief of 58 feet with an average channel slope of 3.5%.

Thirty-eight reaches with a total reach length of 26,524 feet (5.02 miles) were assessed in the Brien Run subwatershed. A summary of the reach length statistics is provided in Table 35. Figure 5 shows typical reaches within the watershed.

Table 35: Assessed Reach Length Statistics Brien Run

Reach Length Statistics	Reach Length in feet	Reach Length in Miles
Total	26,524	5.02
Minimum	136	0.03
Maximum	1,659	0.31
Mean	698	0.13
Standard Deviation	325	0.06

Existing Condition Summary

Channel Morphology

Of the 38 reaches assessed, 5.3% are perennial streams, 57.9% are intermittent, and 28.9% were ephemeral. Slope breaks were identified as the bankfull indicator in the majority of these reaches (52.6%).

All reaches were classified with the Rosgen Stream Classification of Natural Rivers. 23.7% of the reaches are G channels. B and F channels each made up 18.4%, C and E were each 15.8% and there were only 2.6% A channels. There was no D channel.

Gravel (42.1%), and silt (39.5%) channel materials make up the reaches. There were only 7.9% channel with a sand substrate, and 2.6% of the channels had cobble and sapprolite substrate. There was one channels with a bedrock outcrop.

The majority of the reaches have irregular meander patterns (89.5%) and no depositional features (31.6%), which are typical characteristics of G channels. Table 36 summarizes the dominant channel morphology characteristics of the Brien Run subwatershed.

Table 36: Dominant Channel Morphology Characteristics of the Brien Run Subwatershed

Flow Regime	Intermittent
Bankfull Indicator	Slope Break
Stream Type	G channels
Channel Substrate	Gravel-42.1%
Meander Pattern	Irregular
Depositional Features	None

Channel Stability

The existing stability of the Brien Run subwatershed is predominantly vertically stable (52.6%) and laterally stable (55.3%). The average ratio of unstable to stable stream reaches is 18.2%. The following table lists the existing channel stability characteristics for the Brien Run subwatershed.

Table 37: Existing Channel Stability, Brien Run Subwatershed

<table>
<tr><th rowspan="2">Stability Rating</th><th colspan="2">Vertical Stability</th><th rowspan="2">Average Ratio of Unstable to Stable Stream Banks</th></tr>
<tr><th>Percent of Reaches</th><th>Length of Reaches (miles)</th></tr>
<tr><td>Aggrading</td><td>13.2%</td><td>0.65</td><td rowspan="12">18.2%</td></tr>
<tr><td>Degrading</td><td>26.3%</td><td>1.38</td></tr>
<tr><td>Stable</td><td>52.6%</td><td>2.82</td></tr>
<tr><td>Not Evaluated</td><td>0%</td><td>0.00</td></tr>
<tr><th rowspan="2">Stability Rating</th><th colspan="2">Lateral Stability</th></tr>
<tr><th>Percent of Reaches</th><th>Length of Reaches (miles)</th></tr>
<tr><td>Aggrading</td><td>2.6%</td><td>0.10</td></tr>
<tr><td>Degrading</td><td>34.2%</td><td>1.69</td></tr>
<tr><td>Stable</td><td>55.3%</td><td>3.04</td></tr>
<tr><td>Not Evaluated</td><td>0%</td><td>0.00</td></tr>
</table>

31.6% of the reaches within the Brien Run subwatershed are stage I, 23.7% are stage II, 21.1% are stage III, 13.2% are stage IV, and 2.6% are stage V. The average BEHI rating is moderate (9.8), as shown in the Table 38.

Table 38: Potential Channel Stability, Brien Run Subwatershed

Channel Evolution Stage	Percent of Reaches per Channel Evolution Stage	Length of Reaches per Channel Evolution Stage (miles)
Stage I	31.6%	1.38
Stage II	23.7%	0.95
Stage III	21.1%	1.21
Stage IV	13.2%	0.74
Stage V	5.3%	0.41
Not Evaluated	0%	0.00
BEHI Rating	**Percent of Reaches per BEHI Rating**	**Length of Reaches per BEHI Rating (miles)**
Low	7.9%	0.35
Low to Moderate	5.3%	0.23
Moderate	60.5%	3.12
Moderate to High	18.4%	0.92
High	5.3%	0.21
Not Evaluated	0%	0.00

Channel Successional Stage (Rosgen) was also determined for the assessed reaches in the Brien Run subwatershed. It was found that reaches in the Brien Run subwatershed were predominantly Channel Successional Stage 5 (26.3%). Table 39 summarized the channel evolution stages for the assessed reaches in the Brien Run subwatershed.

Table 39: Channel Evolution Stage, Brien Run Subwatershed

Channel Successional Stage (Rosgen)	Percent of Reaches per channel Evolution Stage
Stage 1	1%
Stage 2	0%
Stage 3	0%
Stage 4	12%
Stage 5	4%
Stage 6	32%
Stage 7	17%
Stage 8	2%
Stage 9	5%
Other	22%
Total	**100%**

Channel Disturbances

21.0% of the Brien Run subwatershed reaches evaluated have numerous debris jams. Only one of the Brien Run reaches has a culvert.

Riparian Characteristics

The majority of this subwatershed's riparian area consists of moderate-density deciduous with brush/grass understory (52.6% of the left bank and 68.4% of the right bank). The reaches primarily have 50% to 75% canopy cover (44.7% of the reaches) and riparian widths between 75 and 100 feet (57.9% of the reaches). The following tables (Tables 40 through 42) present the riparian characteristic data for the Brien Run subwatershed.

Table 40: Riparian Composition and Density, Brien Run Subwatershed

Riparian Composition	Riparian Density					
	Percent of Reaches Left Bank			Percent of Reaches Right Bank		
	High	Moderate	Low	High	Moderate	Low
Forested Wetlands	2.6%	18.4%	0%	2.6%	13.2%	4.3%
Deciduous Overstory	0%	2.6%	0%	0%	2.6%	0%
Deciduous with Brush/Grass Understory	5.3%	52.6%	7.9%	0%	68.4%	5.3%
Grass and Forbs	0%	2.6%	0%	0%	2.6%	0%
Total	**7.9%**	**76.2%**	**7.9%**	**2.6%**	**86.8%**	**9.6%**

Table 41: Canopy Cover, Brien Run Subwatershed

Percent Canopy Cover	Percent of Reaches
0-10%	0.0%
10-25%	7.9%
25-50%	39.5%
50-75%	44.7%
75-100%	5.3%
Total	**100%**

Table 42: Riparian Width, Brien Run Subwatershed

Riparian Width	Percent of Reaches
0-10 feet	10.5%
10-25 feet	13.2%
25-50 feet	7.9%
50-75 feet	5.3%
75-100 feet	57.9%
Total	**100%**

Habitat Characteristics

The MBSS PHI rating for none of the Brien Run reaches is good. However, 52.6% are rated fair, and 47.4% of the reaches are rated poor. Table 43 summarizes the habitat characteristics of the Brien Run subwatershed. The habitat is limited by a lack of woody debris as well as lack of optimal instream and epifaunal habitats. Fish blockages are present in 76.3% of the reaches, of which most are affected by shallow depth of flow.

Table 43: Habitat Characteristics, Brien Run Subwatershed

MBSS PHI Rating	Percent of Reaches
Good	0.0%
Fair	52.6%
Poor	47.4%
Total	**100%**

Subwatershed Deficiencies

Problems within the Brien Run subwatershed included moderate bank erosion potential; various channel disturbances and fish blockages. Channel disturbances include culverts causing fish blockages, and invasive species, as well as a large amount of waste and trash in some locations. One reach out of the assessed reaches in the Brien Run subwatershed was identified for utility conflict resolution.

IV. IDENTIFICATION OF REACH NEEDS FOR MANAGEMENT MEASURES

Based on the results of the stream stability assessment, a series of management measures were developed for the Upper Back River watershed. The management measures are a combination of capital improvement projects, community efforts and educational programs.

The data collected during the field surveys was used to determine whether each study reach is in need of specific management measures. Unit costs were developed based on the type of project and project components. These unit costs are based on statistics of past projects and experience with stream restoration and water quality retrofit projects in Maryland. Baltimore County DEPRM's stream restoration database was used to compute stream restoration related costs based upon project size.

Management Measures

The scope of the Upper Back River watershed assessment covered first though third order streams in local neighborhoods. The focus of this assessment is to identify individual reaches in need of attention and not to combine these reaches into larger projects. As funds become available, DEPRM will be able to use this report and the associated database in order to develop projects based on individual reach needs. Each stream reach was assessed to determine what, if any, management measures were needed.

Management Measure 1: Stream Restoration/Stabilization

High sediment loads and the pollutants they carry create water quality concerns and impair downstream habitat. The assessed streams contain over 1,700 square yards of eroded streambanks. If each of these banks eroded an average of 1 foot per year, unstable streambanks are dumping approximately 565 CY of sediment into downstream channels. In addition, lateral channel migration can threaten utilities and other public infrastructure. Restoration/stabilization is recommended for reaches that are currently experiencing moderate to severe vertical and lateral channel instabilities. Reaches were selected for stream restoration/stabilization based on the following criteria:

- Eroded Area/Reach Length > 3.0
- Unstable to Stable Stream Ratio > 50%
- Identified as in need of stream restoration/stabilization in field

To aid in identifying restoration potential, all reaches were prioritized based on the following conditions. First priority was given to reaches that meet all three criteria. Second priority was given to reaches with Eroded Area/Reach Length > 2.0 and Unstable to Stable Stream Ratio > 50%. Third priority was given to reaches with Eroded Area/Reach Length > 2.0 and Unstable to Stable Stream Ratio > 25%. Appendix E shows the reaches identified for stream restoration/stabilization within the Upper Back River subwatersheds. Several reaches did not meet the Eroded Area/Reach Length and Unstable to Stable Stream Ratios, but were field identified as potential reaches based on the severity of localized bank erosion or potential for that erosion to worsen. These reaches have been identified as Priority 4 reaches.

Estimated costs of stream restoration/stabilization projects are based on the following criteria:

- Unit of measurement = linear foot of stream channel restored
- Assume that projects will be greater than 200 feet long
- Costs exclude land acquisition and access easements

Figure 6: Erosion in HW-03-01-01

Management Measure 2: Buffer Enhancement

Riparian buffers play an important role in stream stability and water quality. Maintaining adequate stream buffers is important to overall stream health and habitat quality. Many of the reaches assessed have adequate buffer widths as a result of the County's buffer requirements. In some cases, buffer management is in need of improvement. Reaches were selected for buffer enhancement based on the following criteria:

- Grass buffer composition – if the existing stream buffer consisted of grass only, the reach was considered a potential candidate for riparian buffer enhancement
- Buffer width – areas with riparian buffers less than 50 feet were considered candidates for buffer enhancement.
- Identified during field assessment

Estimated costs are based on the following criteria:

- Unit of measurement = linear foot of stream buffer enhancement
- Assume maximum buffer enhancement width of 100 feet
- Costs exclude land acquisition and access easements

Management Measure 3: Bank Plantings

During the field assessment, several reaches were identified that were in need of stream bank plantings. The majority of these reaches has ample stream buffers, but were in need of vegetation to be planted along the stream banks to help provide additional bank stability. All of these stream reaches were identified during the field assessment.

Estimated costs are based on the following criteria:

- Unit of measurement = linear foot of stream bank plantings
- Assume stream bank plantings are needed over 75% of the reach length
- Costs exclude land acquisition and access easements

Figure 7: Lack of bank plantings in OR-02-00-01

Management Measure 4: Utility Conflict Resolution

Head cuts and the lateral migration of stream channels often threaten buried utility lines. In other locations, exposed manhole risers are in or adjacent to the stream channel. Unprotected risers have the potential to leak during high flows impacting water quality.

Estimated costs are based on the following criteria:

- Unit of measurement = relocation of each exposed utility line or riser.
- Assume utility line will be protected or relocated outside of the stream channel when possible.
- Costs exclude land acquisition and access easements

Thirteen reaches in the Stemmers Run subshed and one reach in the Brien Run subshed were identified for utility conflict resolution.

Management Measure 5: Wetland Enhancement

Wetland enhancement projects were considered separately from stream restoration/stabilization. It is anticipated that wetland enhancement measures will either be incorporated into the stream restoration/stabilization design or will be used to identify potential wetland mitigation sites. All of the streams were assessed for wetland enhancement and eighteen stream reaches were identified as potential wetland enhancement sites. Reaches were identified for wetland enhancement based on topography, floodplain connection, and limited presence of wetland vegetation.

Estimated costs are based on the following criteria:

- Unit of measurement = linear foot of enhancement
- Costs exclude land acquisition and access easements

Figure 8: Wetland Enhancement potential in OR-09-00-01

Management Measure 6: Trash Cleanup

Stream cleanups are a simple, community based practice that enhances the appearance of the stream corridor by removing trash, litter and debris. Local community groups such as schools, churches and neighborhood associations are great sources for regular cleanup volunteers. It is recommended that annual or semi-annual stream cleanups be initiated at the identified stream reaches.

144 reaches were identified for trash cleanup. Reaches were selected for trash cleanup based on the following criteria:

- Identification during field assessment

Traditional trash clean cost estimates are based on the following criteria:

- Volunteers will remove trash from stream channel on an annual/semi annual basis
- County will supply materials such as gloves, trash bags, etc. to residents who volunteer to clean up their stream corridor.
- County maintenance department will need to remove all trash collected from the site

Figure 9: Trash in OR-08-00-02

Management Measure 7: Yard Waste Cleanup

Due to the close proximity of many of the headwater streams to neighborhood homes and businesses, yard waste was found in several stream channels. Excessive dumping of lawn clippings and leaves into the stream channel can damage sensitive habitats and introduce pollutants such as fertilizers and other chemicals directly into the stream system. Local residents need to be educated on the proper way to dispose of yard waste in and around their property. 63 reaches were in need of traditional yard waste cleanup. Reaches were selected for trash cleanup based on the following criteria:

- Identification during field assessment

Estimated costs are based on the following criteria:

- County will supply educational materials to residents along the stream corridor.

Figure 10: Yard Waste in SR-19-00-03

Management Measure 8: Invasive Plant Removal

Invasive species were found in several reaches. Field crews are not experts in invasive species identification; however, they can identify major areas with invasive species. Because these species spread rapidly and take over the native species along the stream channel, reaches with excessive growth were noted in the comments section of the report. A total of 92 reaches were identified for invasive species removal. Several of these reaches are already recommended for other enhancements or restoration. In these cases, the invasive species should be removed as part of the other enhancements.

Figure 11: Invasive species in SR-16-00-04

Reach Needs Identification

Projects were identified based on the rating characteristics established in the above minimum measures. The results of the field assessment and the photographs were used to confirm the project identification methodologies. Appendix E contains list all the potential reaches for each of the eight management measures.

A sampling of potential project reaches is included below:

HW-03-01-01: This reach in the Herring Run watershed has a considerably high unstable to stable ratio (52.95%) and has the second highest ratio of eroded area to reach length (5.80). The stream is deeply entrenched G type channel that has been degrading both vertically and laterally. The reach is bedrock controlled in the upstream portion and has significant debris and trash. The height of erosion is more than 9' at some locations and the reach is consistently downcutting, making it a significant source of sediment supply. Refer to Figure 12 for photos.


Figures 12A & B: Erosion and debris in HW-03-01-01

HW-02-00-01: This Herring Run reach has had a stable restoration project in the upper 200 feet of reach. However, downstream of the project, the stream has numerous debris blockages and significant erosion primarily seen at the meander bends. This erosion has caused multiple trees to fall into the channel. Several roots have been exposed in the banks due to bank erosion, and an exposed manhole riser was also seen in the channel. Refer to Figure 13 for photos.

Figures 13A, B, C & D: Erosion at meander bends and fallen trees debris in HW-02-00-01

HW-08-00-01: This segment has the highest Eroded Area/Reach Length ratio (8.84) in Herring Run and a relatively high Unstable to Stable Stream Ratio (55.24%). The reach is a steep gully, Rosgen G type channel. The reach also has a fallen utility pipe. Refer to Figure 14 for photos.

Figures 14A & B: Eroded areas in upstream reach of HW-08-00-01

SR-10-00-02: This segment of Stemmers Run is adjacent to the beltway and thus; has a lot of trash buildup. The reach is undergoing extreme erosion with the height of bank erosion approaching nearly twelve feet at some locations. The erosion is also undermining the stability of the beltway. The reach is a Rosgen type F channel which is degrading. The unstable to stable ratio for this reach is 54.91% and the ratio of eroded area to reach length is 6.43. Figure 15 shows the erosion in the downstream and upstream segments and adjacent to the beltway**.**

Figures 15A, B & C: Erosion in downstream and upstream segments and adjacent to the beltway in SR-10-00-02.

SR-12-00-03: This reach has the second highest ratio of eroded area to reach length (8.22) and the unstable to stable ratio is 58.74%. The stream reach has vertical bedrock control for the most part which is causing the stream to increase its meander width and leading to excessive erosion at the meander bends. Figure 16 shows the erosion and debris in SR-12-00-03.

Figures 16A, B & C: Erosion and debris in SR-12-00-03

SR-19-00-01: This reach has the highest ratio of eroded area to reach length (8.94) and the second highest unstable to stable ratio (69.03%) in Stemmers Run. The stream is a Rosgen F type channel with considerable erosion and debris. It has also been recommended for trash cleanup and yard waste cleanup. Refer to figure 17 for photos.

Figures 17A & B: Erosion at downstream and debris at upstream in SR-19-00-01

SR-08-02-01: Although the unstable to stable ratio for this stream is less than 50% (40.41%), it is characterized by extreme localized erosion, in addition to fallen debris. The ratio of eroded area to reach length is 3.59. The stream also has a few broken and exposed utility pipes and a threatened manhole. The channel is Rosgen type G entrenched gully which is laterally degrading. Refer to figure 18 for photos.

Figures 18A & B: Exposed utility and erosion in SR-08-02-01

Reach Cost Estimates

A generalized cost was determined for each proposed enhancement type. Table 44 summarizes the cost per individual management measure. The summation of management measure costs plus maintenance costs will become the total project cost for the individual reach. Cost estimates are in annualized format and include initial capital construction costs. Cost estimates are based on planning level design & construction cost-curves or other unit cost relationships and do not include land acquisition. Appendix E details the total and annualized project costs per project.

Table 44: Reach Unit Costs

Management Measure	Measurement Unit	Constraints	Unit Cost
Stream restoration/stabilization	Linear Foot per Reach Length	> 800 feet long	$225
		400 to 800 feet long	$300
		< 400 feet long	$400
Buffer Enhancement	Lump Sum Cost based on Reach Length (100' width)	> 800 feet long	$50,000
		400 to 800 feet long	$25,000
		< 400 feet long	$10,000
Bank Plantings	Lump Sum Cost based on Reach Length	> 800 feet long	$10,000
		400 to 800 feet long	$7,500
		< 400 feet long	$5,000
Utility Conflict Resolution	Each	Relocate utility outside stream channel or protect	$25,000
Habitat Enhancement	Lump Sum Cost based on Reach Length	> 800 feet long	$60,000
		400 to 800 feet long	$40,000
		< 400 feet long	$20,000
Trash Cleanup – traditional trash cleanup only	LS per Reach	Per Year	$500
Yard Waste Removal – tradition yard waste cleanup only	LS per Reach	Per Year	$500
Invasive Plant Removal	Lump Sum based on Reach Length	> 800 feet long	$10,000
		400 to 800 feet long	$7,500
		< 400 feet long	$5,000

V. REACH IMPROVEMENT BENEFITS

Based on the assessment of the reaches and application of management measures, a total of 202 reaches have been recommended for enhancement. Stemmers Run has the largest number of recommended reach enhancements (96), Herring Run has 72 and Brien Run has 34. Table 45 provides a breakdown of project types recommended throughout the Upper Back River watershed. The total estimated cost for the 202 reach enhancements is $27.65 million.

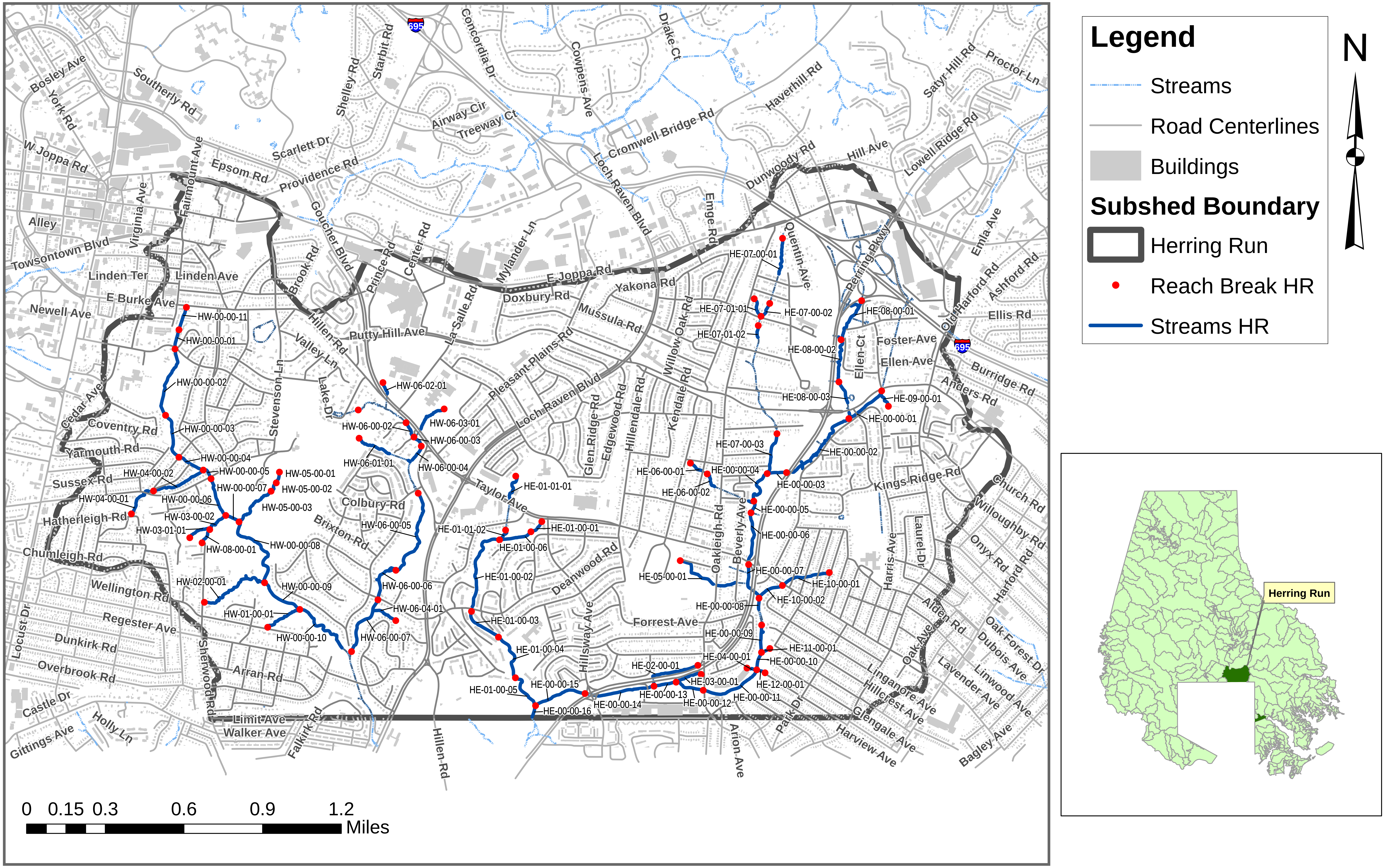
Table 45: Recommended projects by management measure

Management Measure	No. of Recommended Reaches	Project Benefits
Stream restoration/stabilization	126 (50 HR, 59 SR, 17 OR)	17.75 miles (6.8 mi HR, 8.46 mi SR, 2.49 mi OR)
Buffer Enhancement	16 (5 HR, 3 SR, 8 OR)	1.99 miles (0.0.40 mi HR, 0.44 mi SR, 1.15 mi OR)
Bank Plantings	76 (54 HR, 20 SR, 2 OR)	11.08 miles (7.89 mi HR, 2.92 mi SR, 0.27 mi OR)
Utility Conflict Resolution	14 (13 SR, 1 OR)	2.35 miles (2.28 mi SR, 0.07 mi OR)
Wetland Enhancement	18 (5 HR, 3 SR, 10 OR)	2.38 miles (0.43 mi HR, 0.44 mi SR, 1.51 mi OR)
Trash Cleanup	144 (25 HR, 85 SR, 34 OR)	20.71 miles (4.30 mi HR, 11.87 mi SR, 4.54 mi OR)
Yard Waste Removal	63 (13 HR, 27 SR, 23 OR)	9.76 miles (2.3 mi HR, 4.3 mi SR, 3.16 mi OR)
Invasive Plant Removal	92 (17 HR, 66 SR, 9 OR)	12.48 miles (2.37 mi HR, 9.03 mi SR, 1.08 mi OR)

.

APPENDIX A

- Reach ID Maps



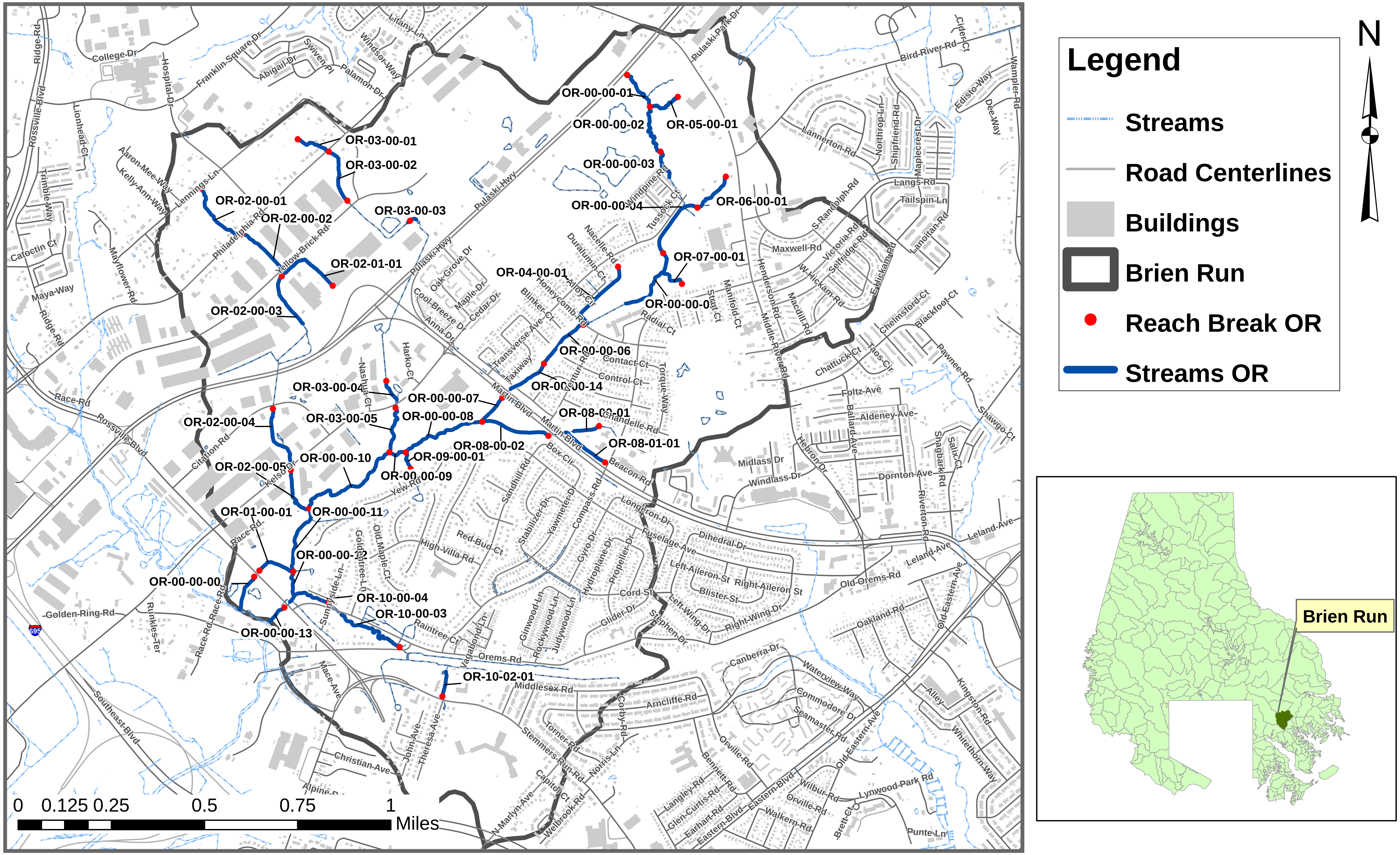
Date:
September 2007

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Subwatershed Map

Herring Run

Figure B1.1

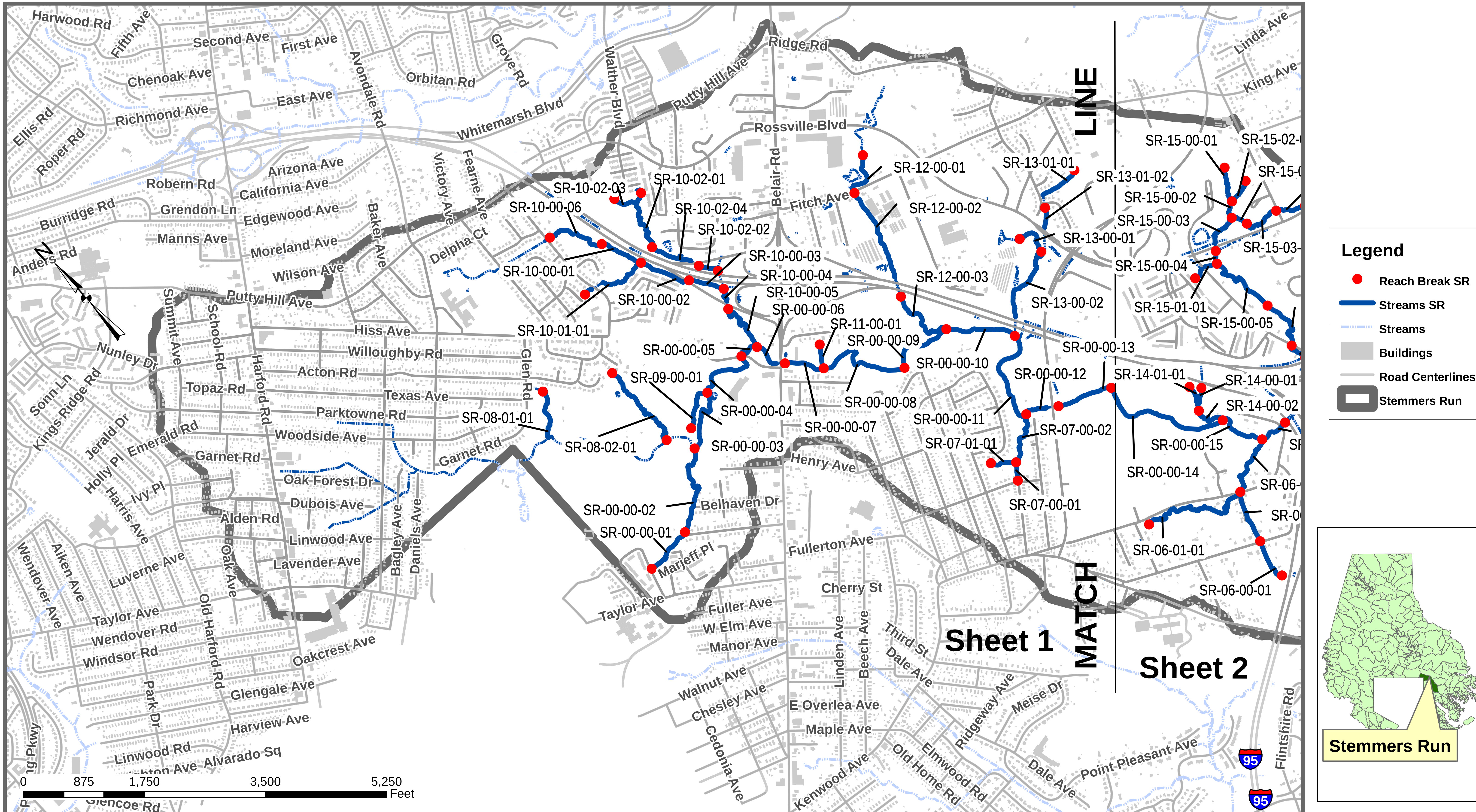


Date:
September 2007

Figure B2.1

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Subwatershed Map
Brien Run

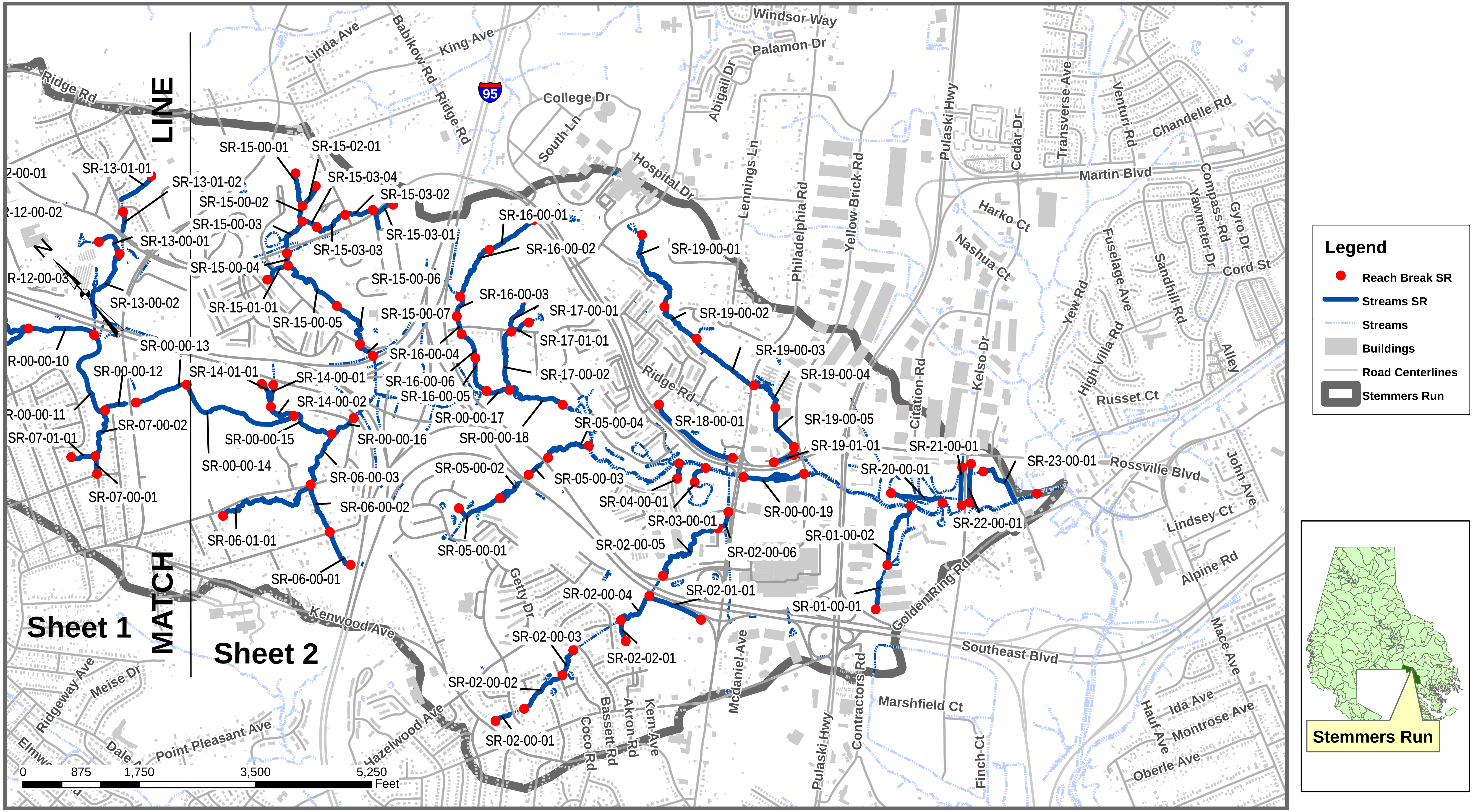


Date:
October 2007

Figure B3.1

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Subwatershed Map
Stemmers Run



Date:
October 2007

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

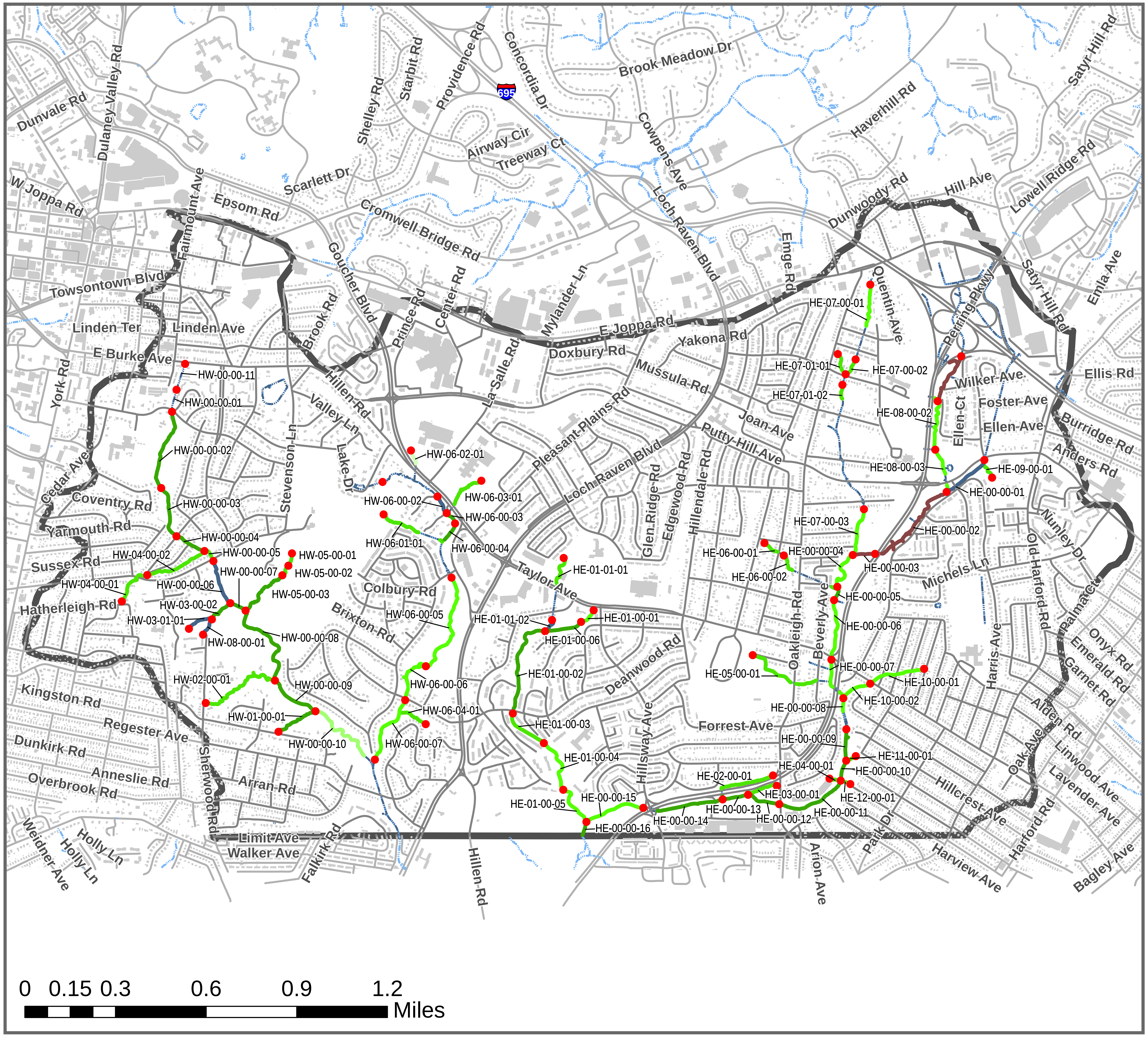
Subwatershed Map
Stemmers Run

Figure B3.1

APPENDIX B

Assessment Maps

- Channel Succession
- Channel Evolution
- BEHI Ranking
- Rosgen Classification
- Fish Blockage



Legend

Herring Run

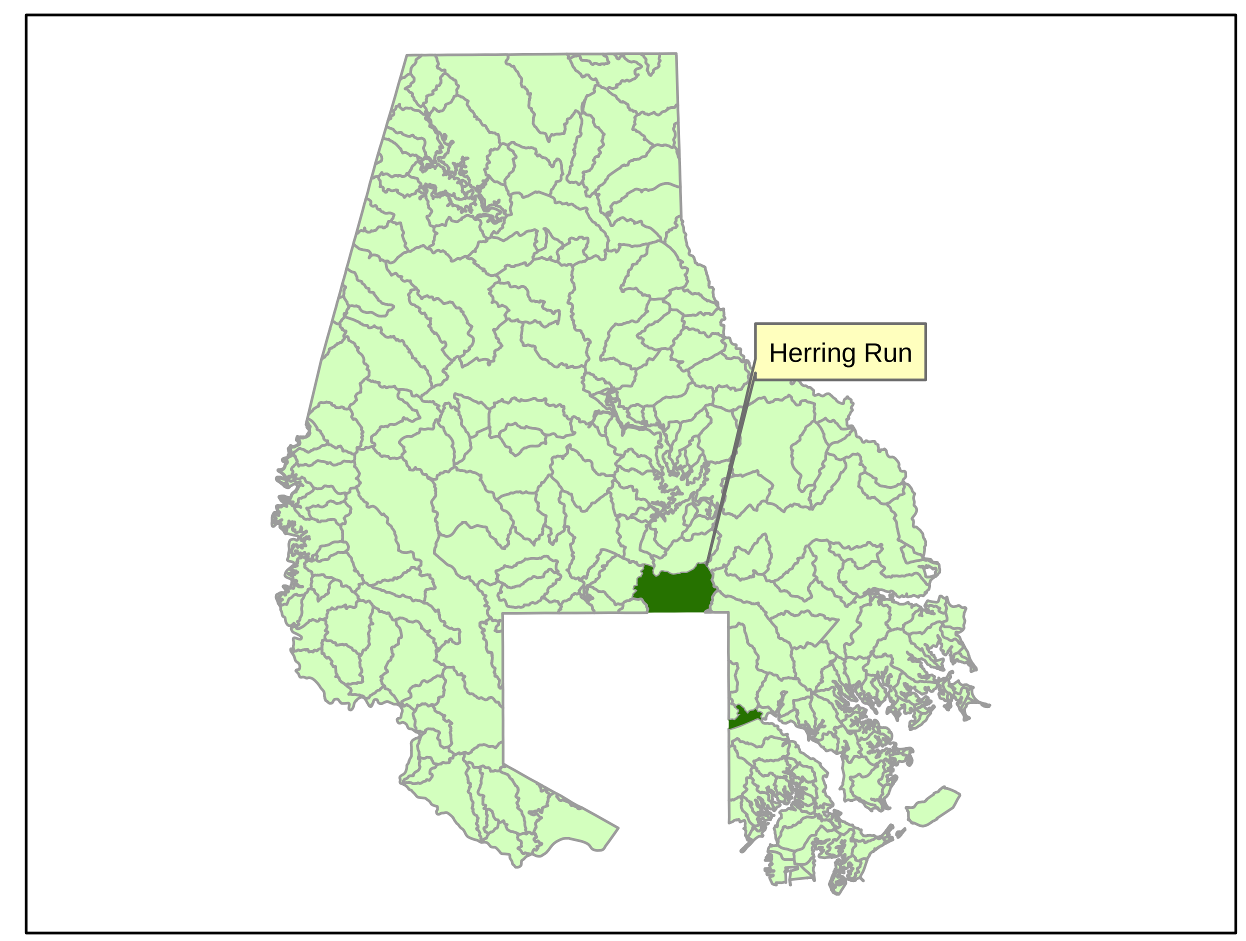
Rosgen Stream Succession

- 1
- 3
- 4
- 5
- 6
- 7
- 9
- Streams
- Road Centerlines
- Buildings

Subshed Boundary

- Herring Run

N

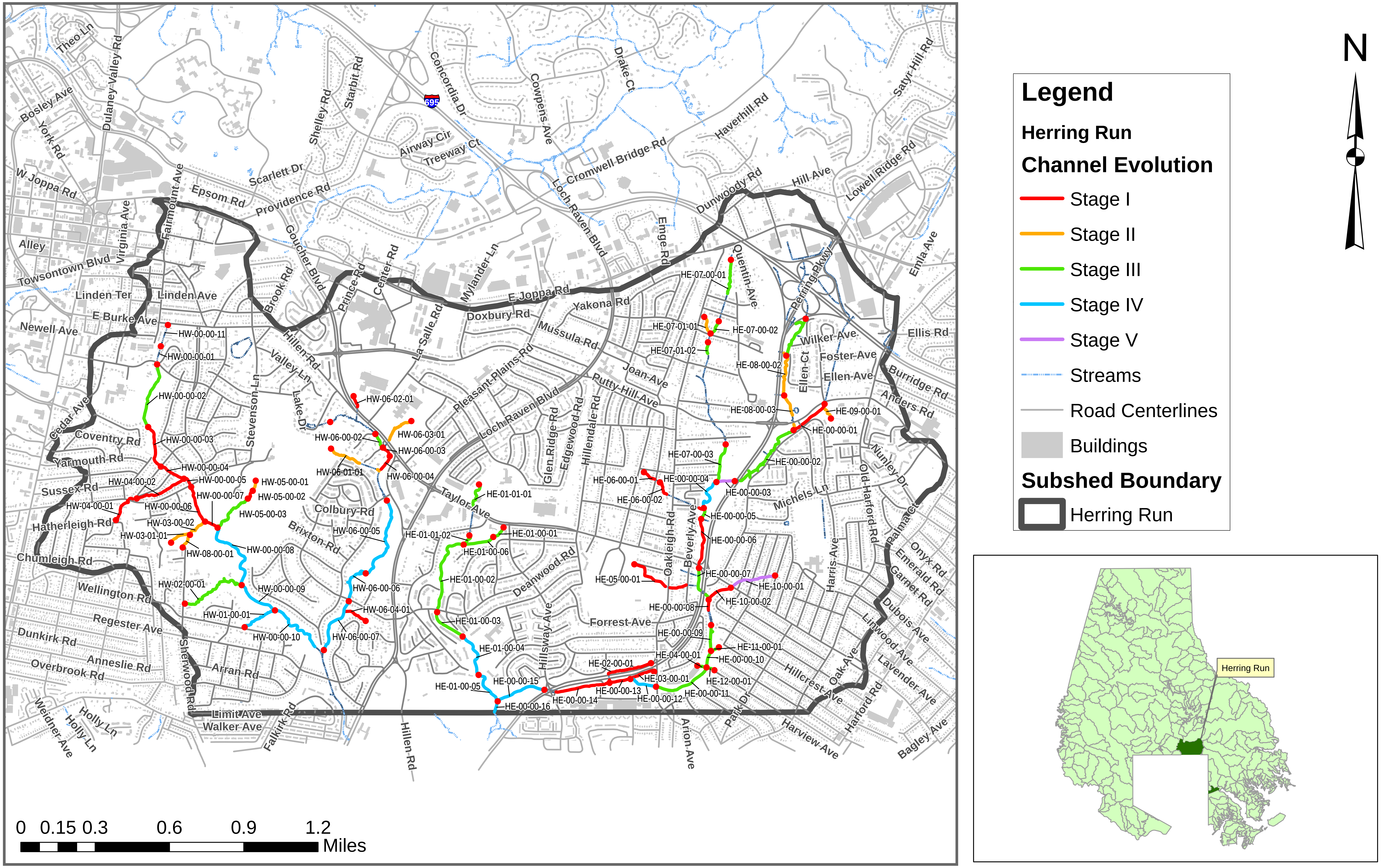


Date:
September 2007

Figure B1.2

UPPER BACK RIVER WATERSHED STREAM STABILITY ASSESSMENT

Rosgen Stream Succession
Herring Run



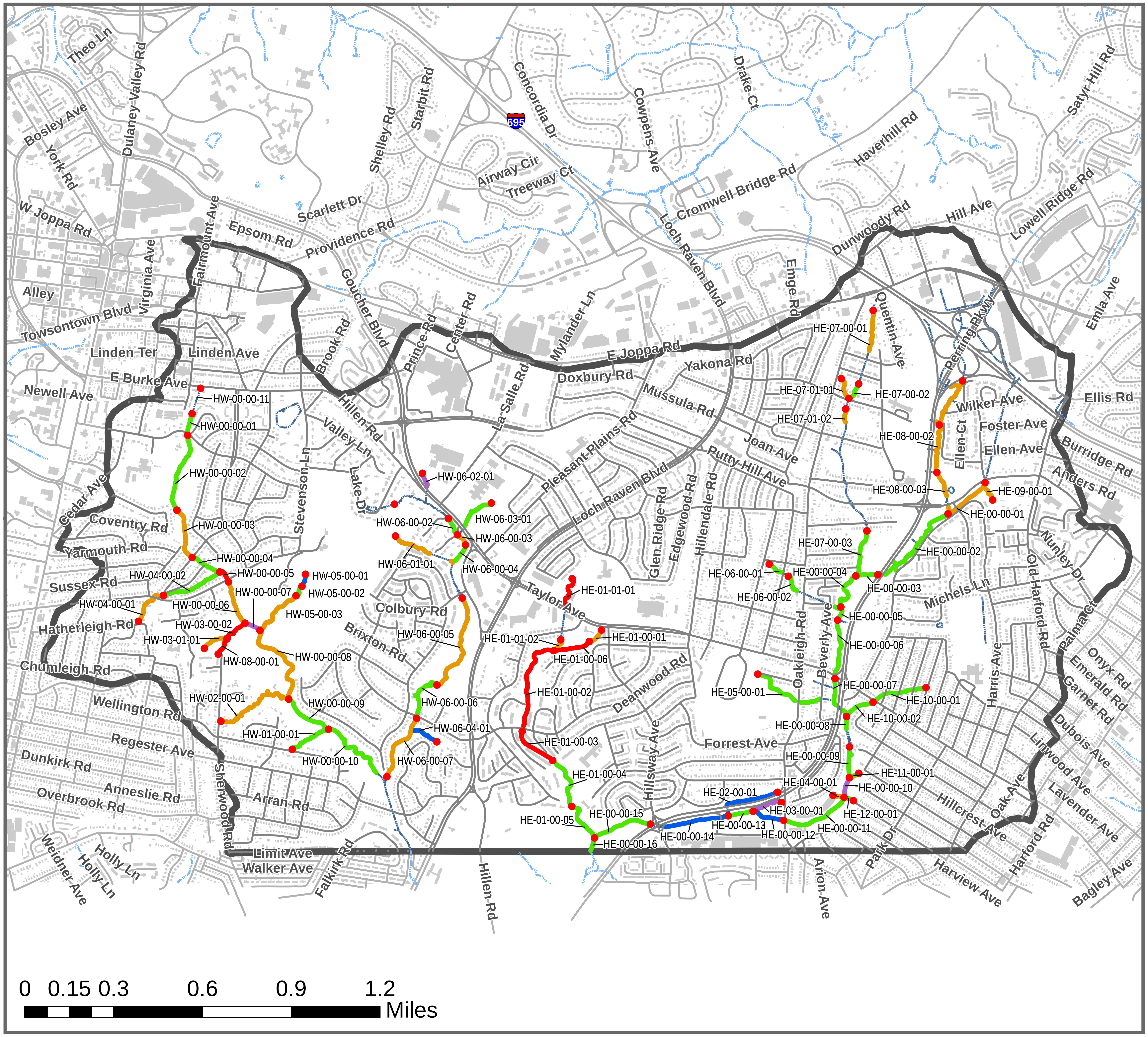
Date:
September 2007

Figure B1.3

UPPER BACK RIVER WATERSHED STREAM STABILITY ASSESSMENT

Channel Evolution

Herring Run



N

Legend

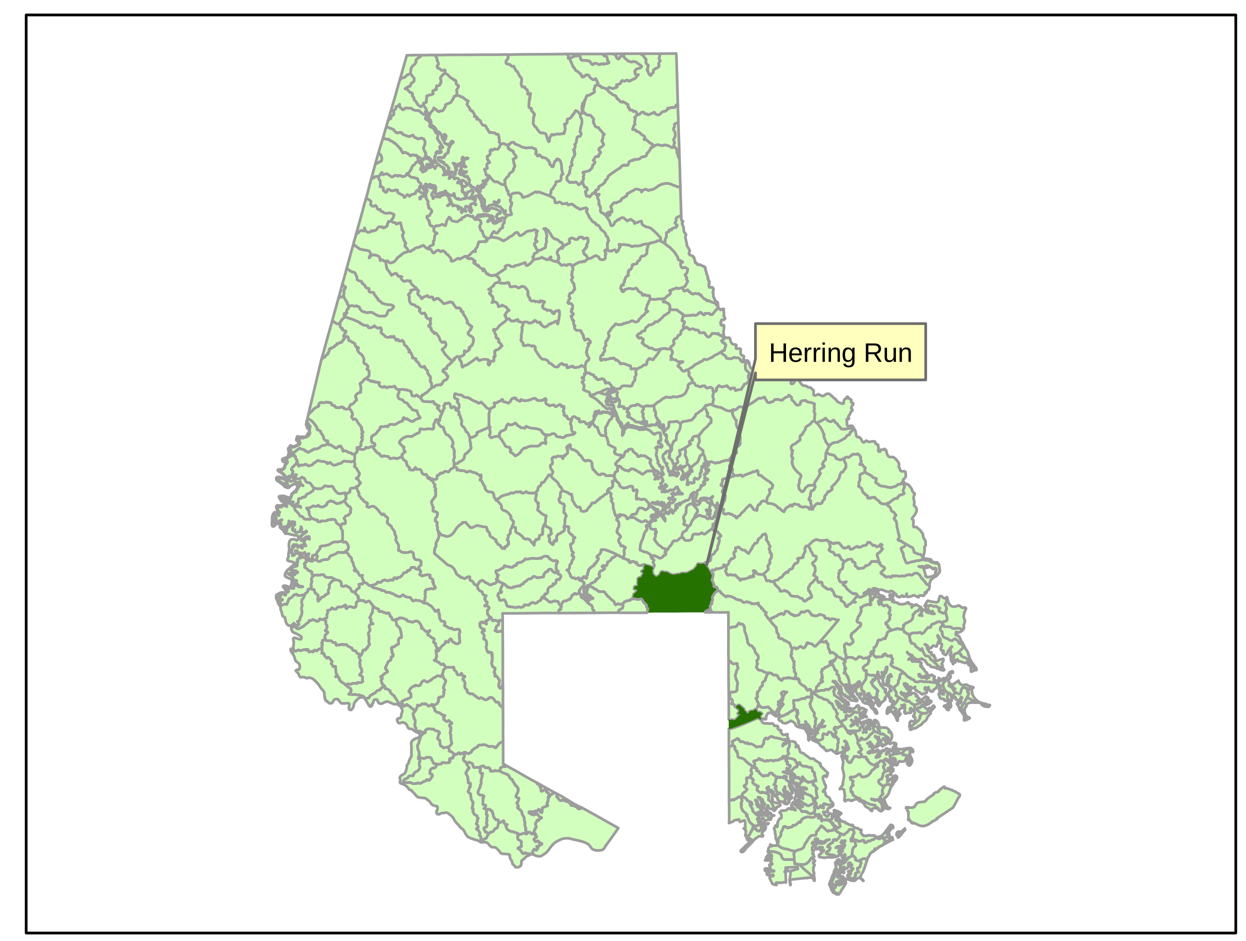
Herring Run

BEHI Ranking

- High
- Moderate to High
- Moderate
- Low to Moderate
- Low
- Streams
- Road Centerlines
- Buildings

Subshed Boundary

- Herring Run

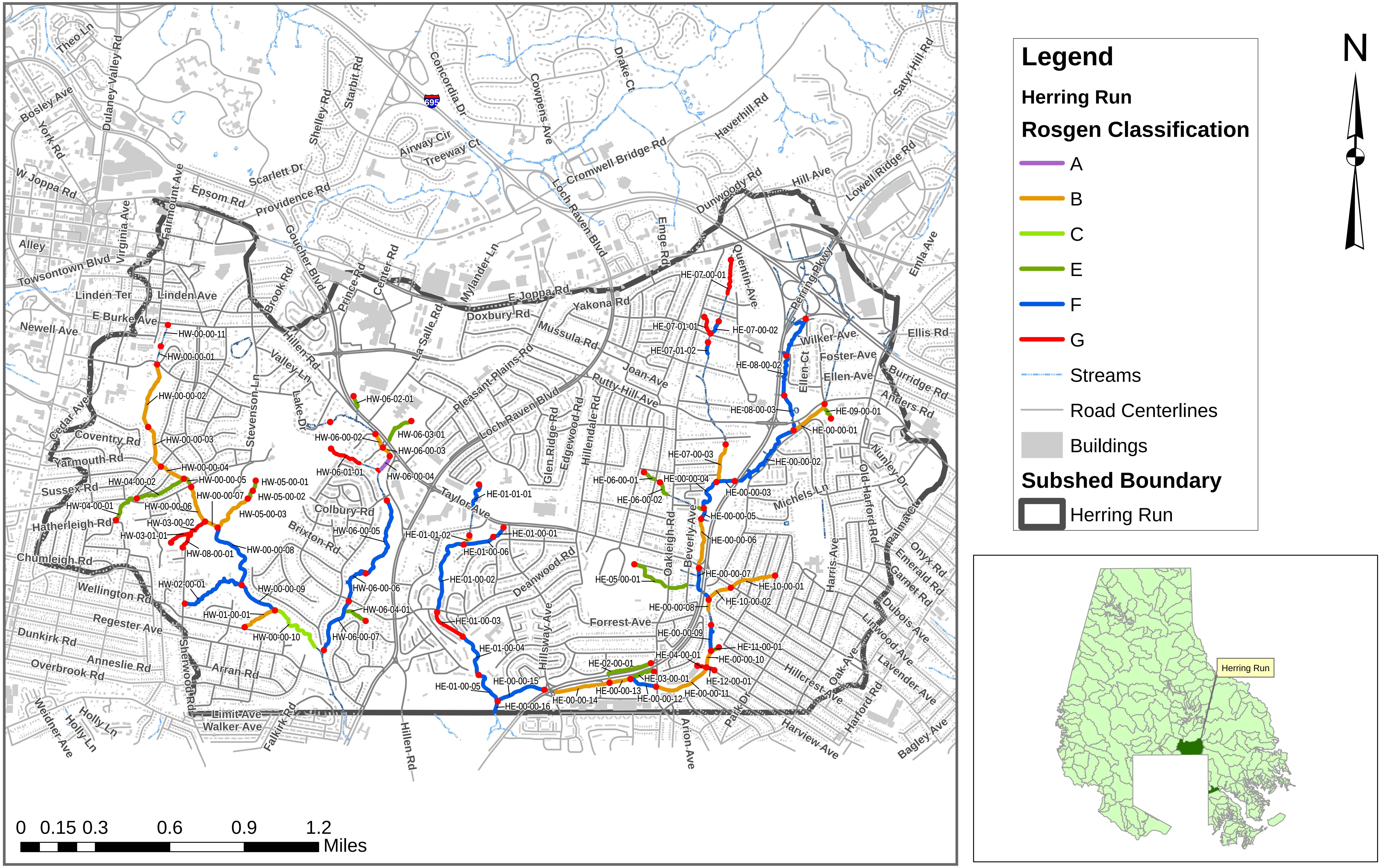


Date:
September 2007

Figure B1.4

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

BEHI Ranking
Herring Run



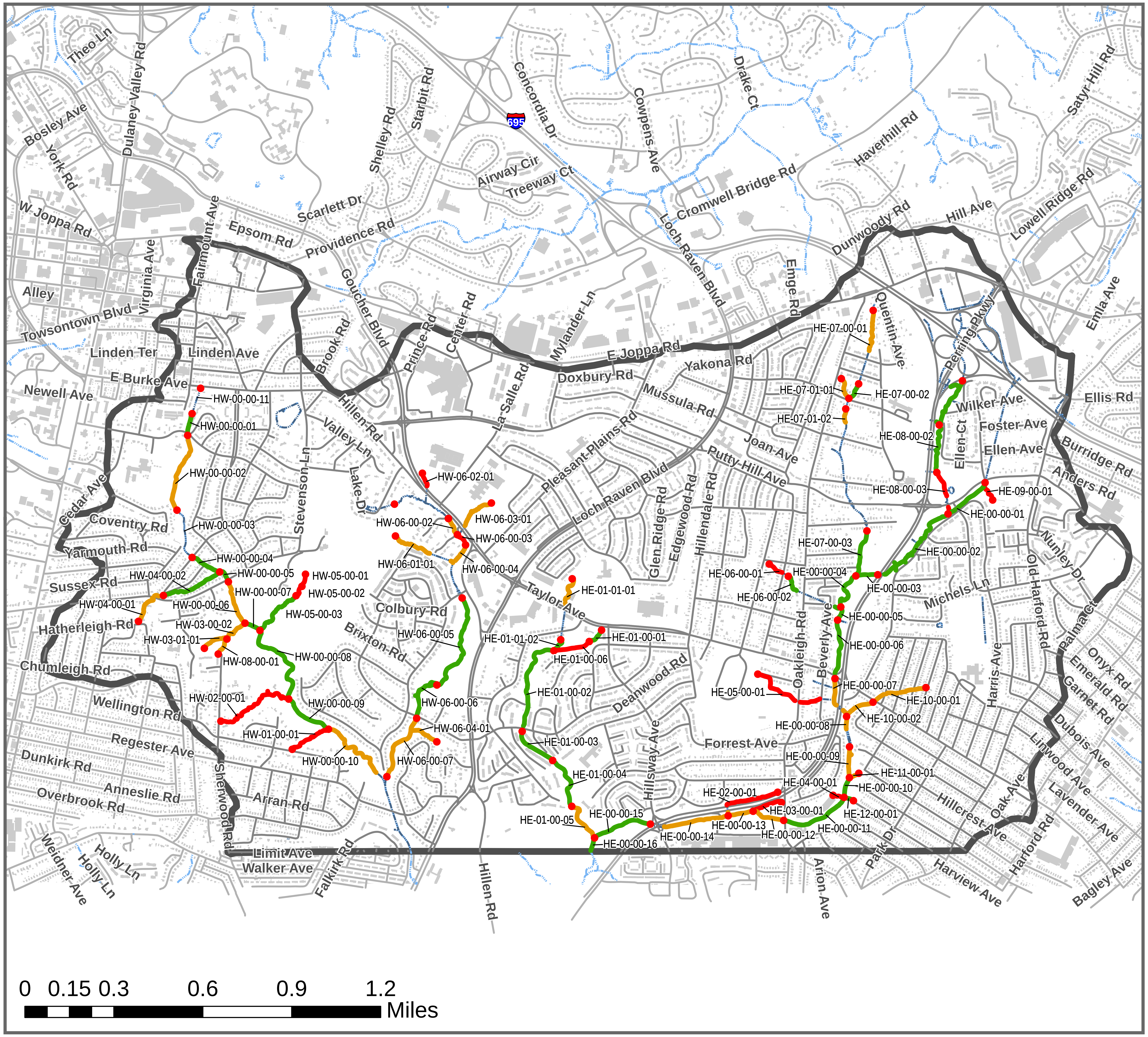
Date:
September 2007

Figure B1.5

UPPER BACK RIVER WATERSHED STREAM STABILITY ASSESSMENT

Rosgen Stream Classification

Herring Run



Legend

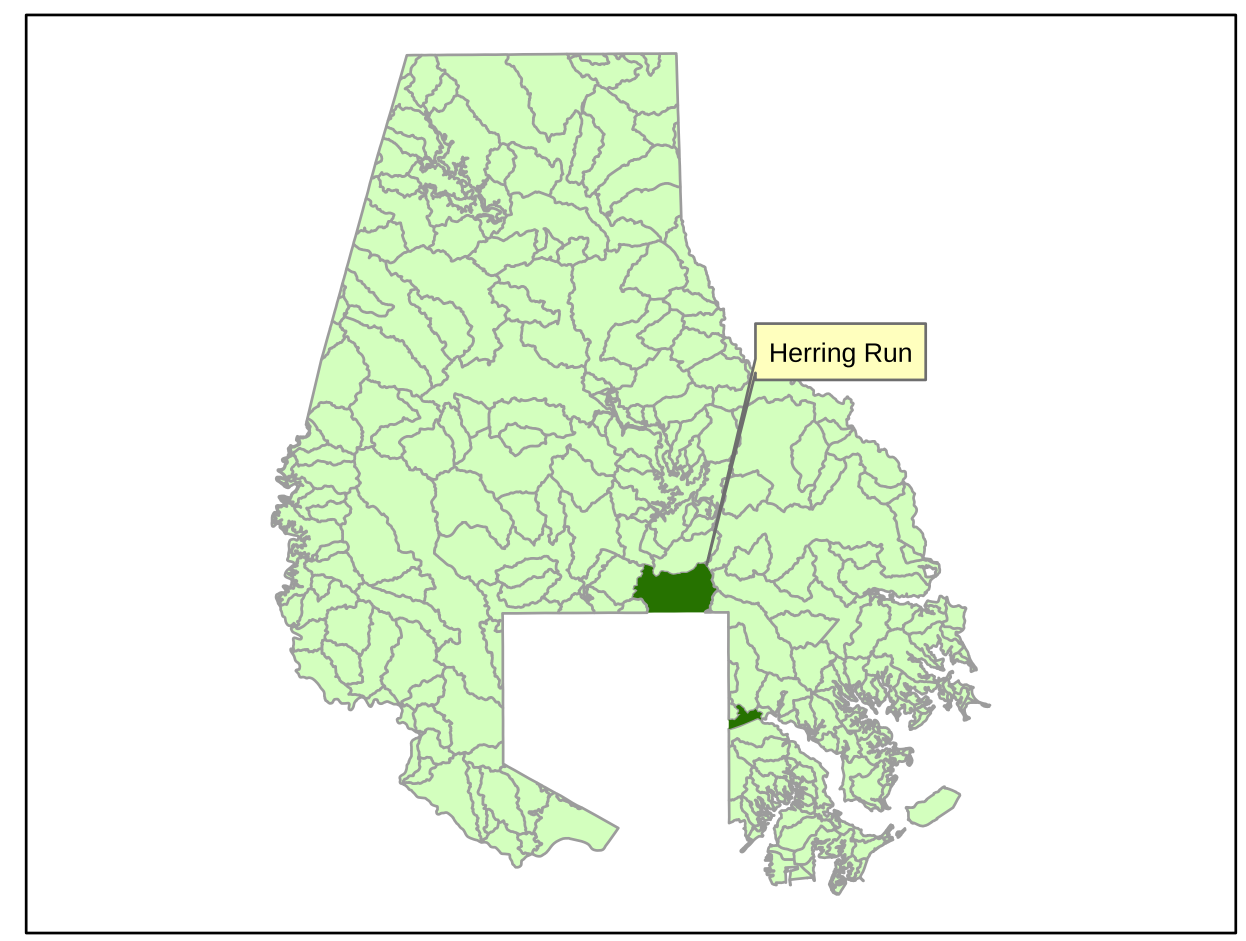
Herring Run

Fish Blockage

- Shallow Depth of Flow
- Excessive Height
- None
- Streams
- Road Centerlines
- Buildings

Subshed Boundary

- Herring Run



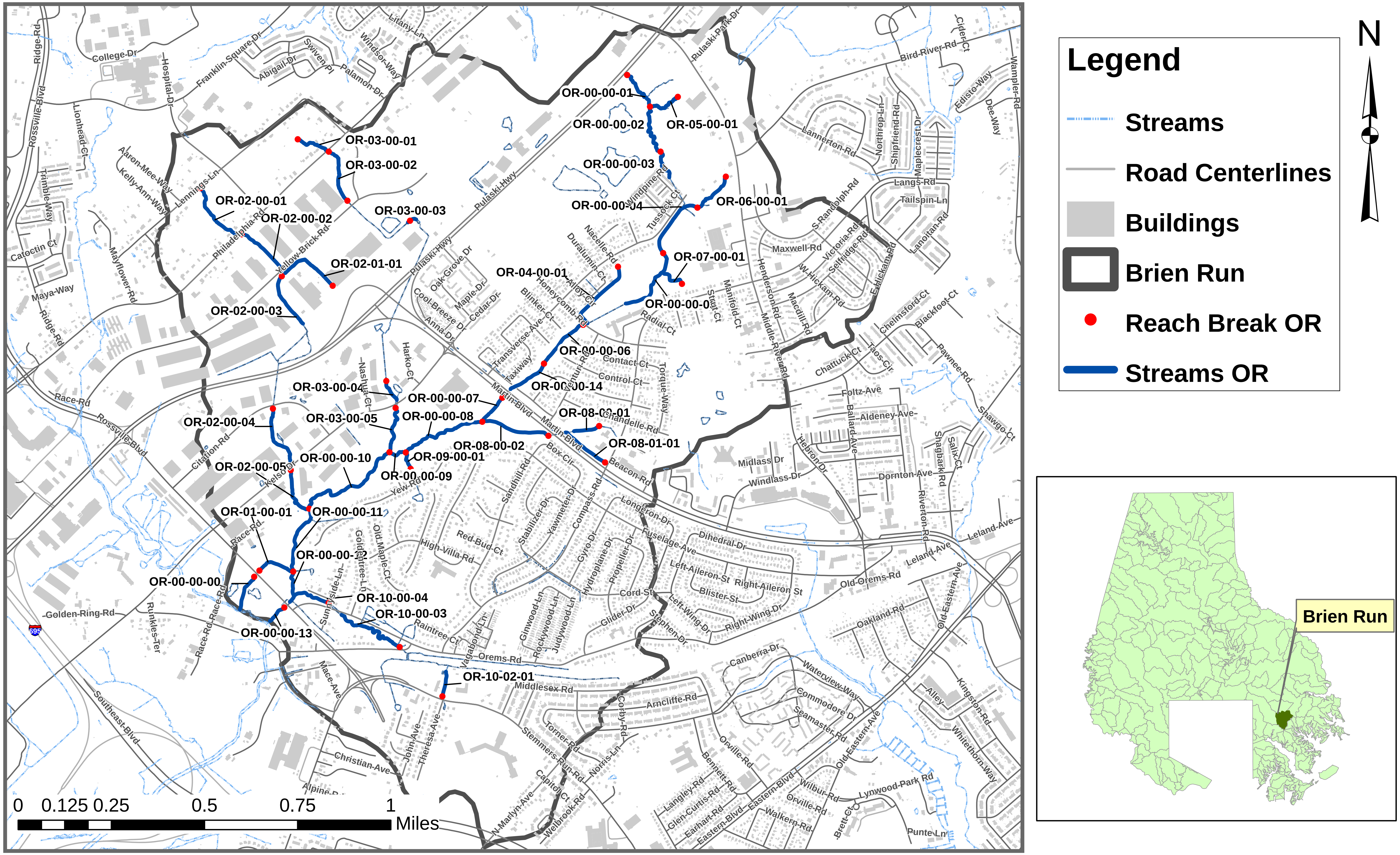
Date:
September 2007

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Fish Blockage

Herring Run

Figure B1.6

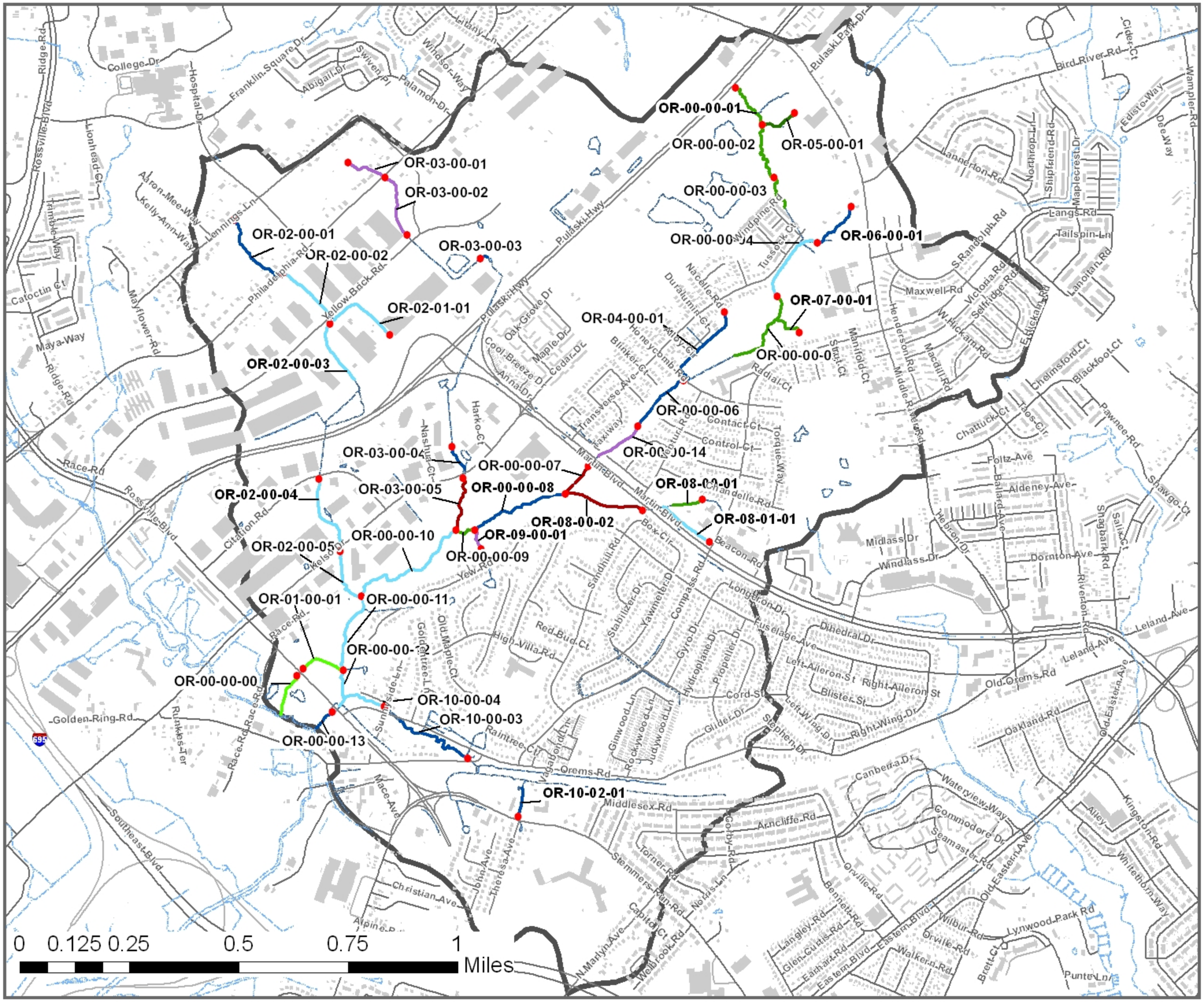


Date:
September 2007

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Subwatershed Map
Brien Run

Figure B2.1



Legend

Brien Run

Rosgen Stream Succession

- 1
- 4
- 5
- 6
- 7
- 9
- Other
- Road Centerlines
- Buildings
- Brien Run

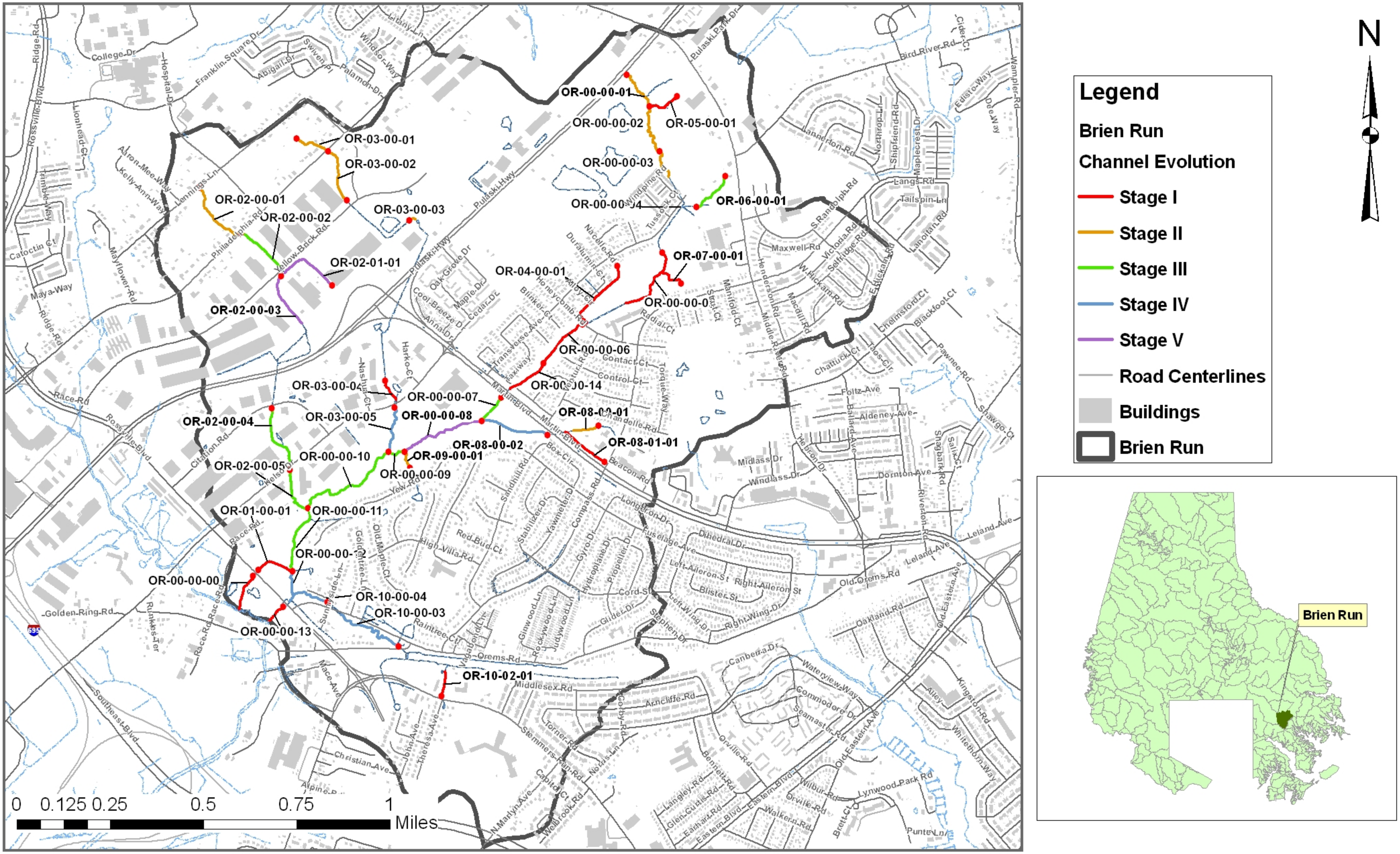
N

Date:
September 2007

Figure B2.2

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Rosgen Stream Succession
Brien Run

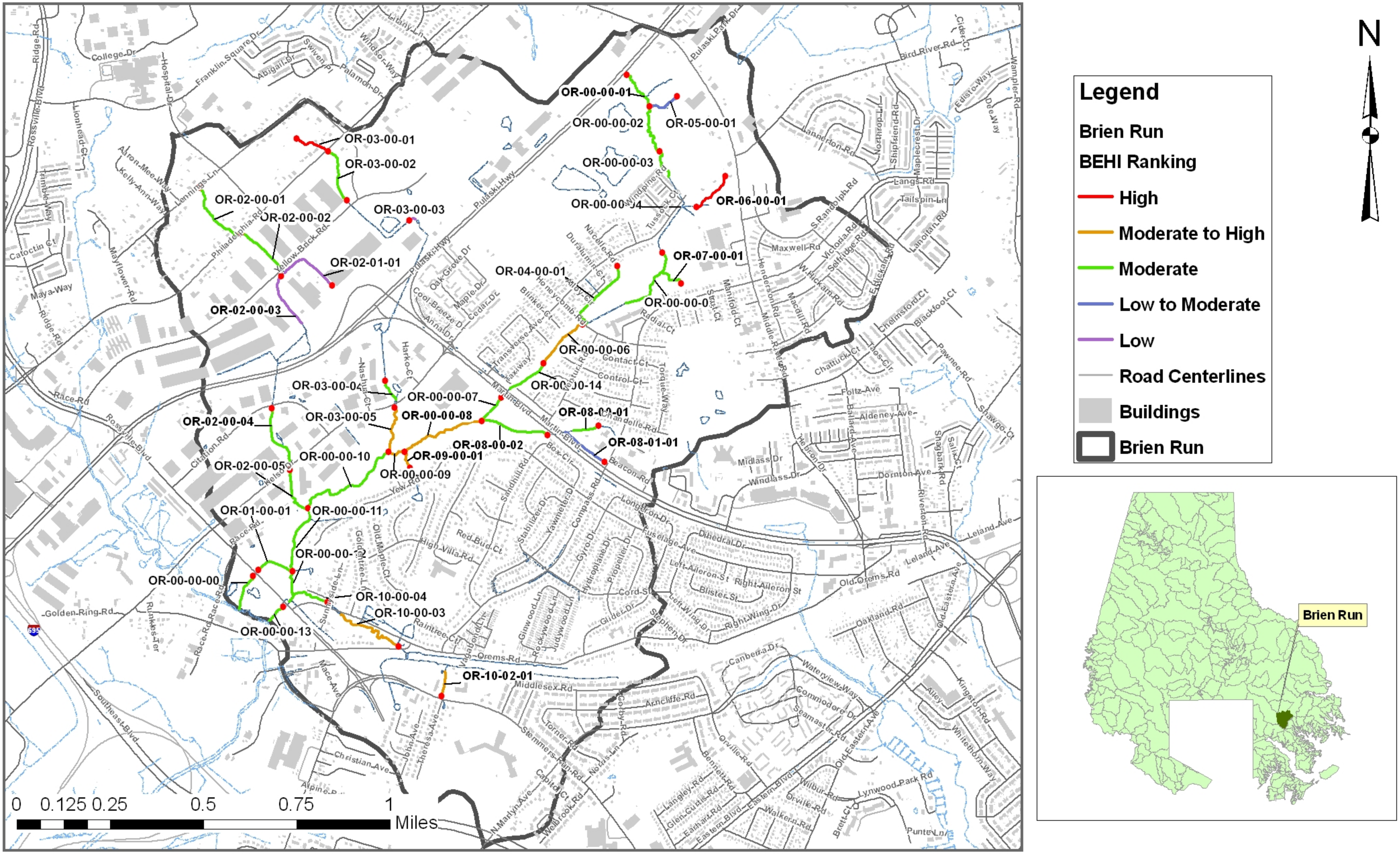


Date:
September 2007

Figure B2.3

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Channel Evolution
Brien Run

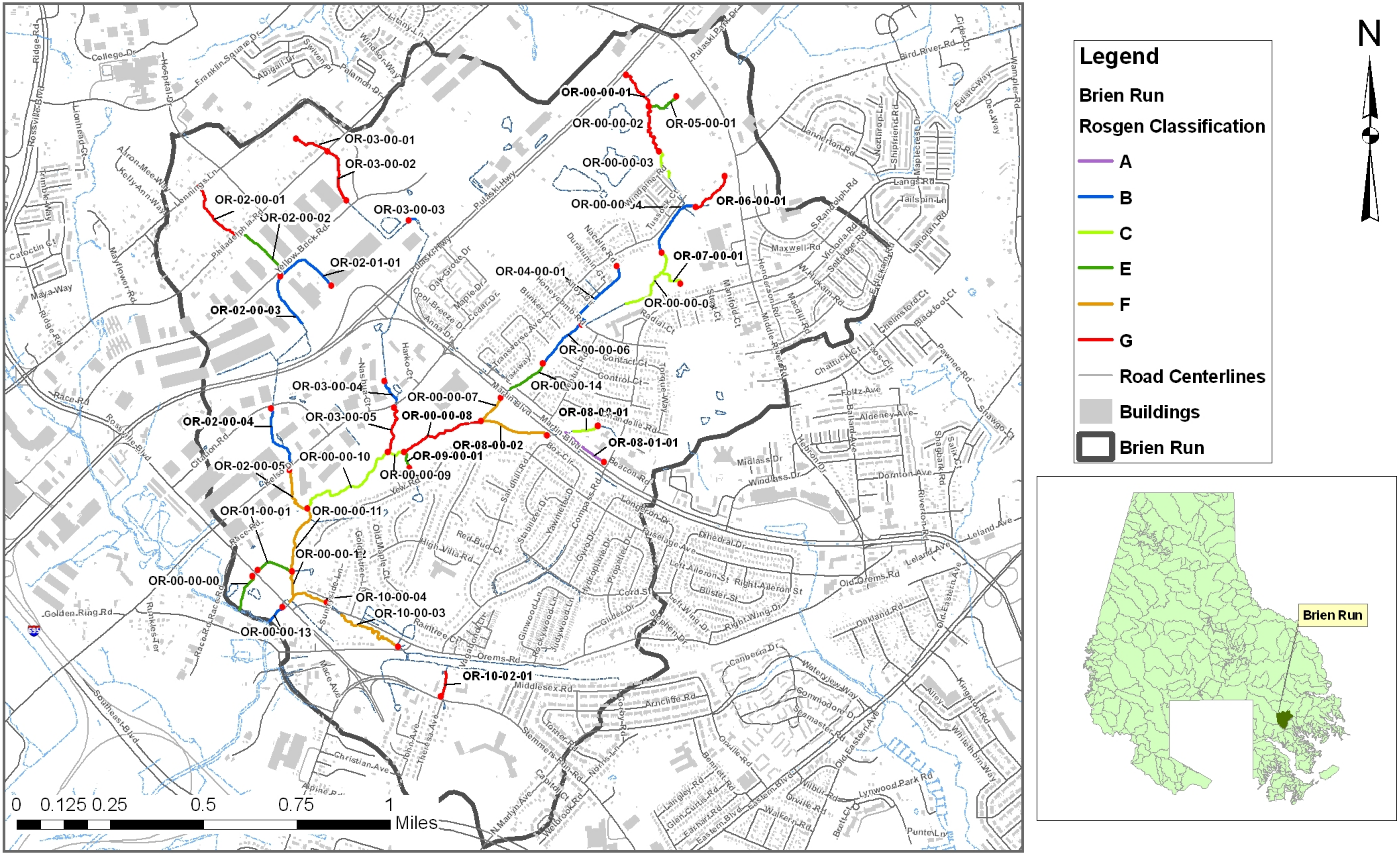


Date:
September 2007

Figure B2.4

UPPER BACK RIVER WATERSHED STREAM STABILITY ASSESSMENT

BEHI Ranking
Brien Run

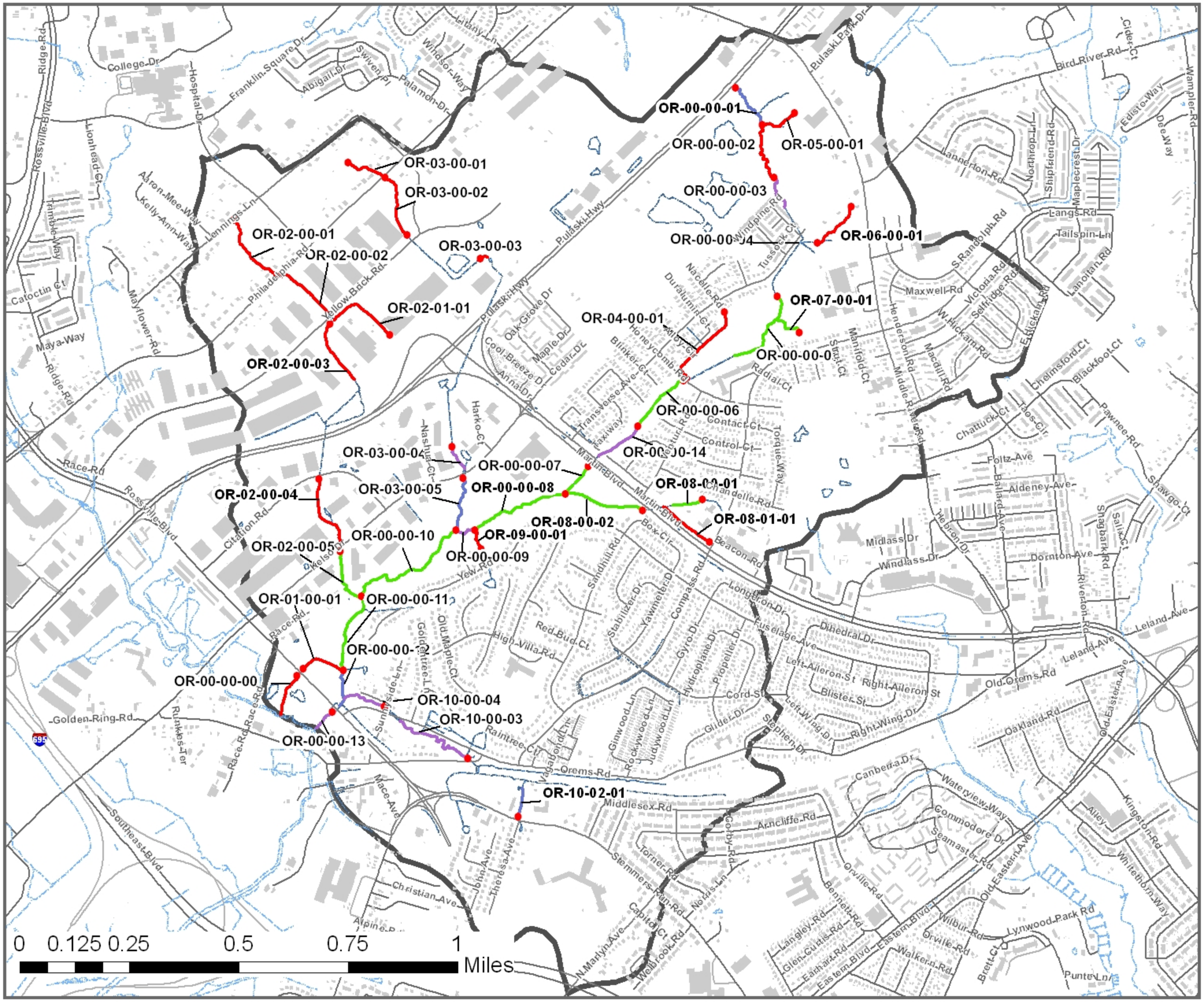


Date:
September 2007

Figure B2.5

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Rosgen Stream Classification
Brien Run



Legend

Brien Run

Fish Blockage

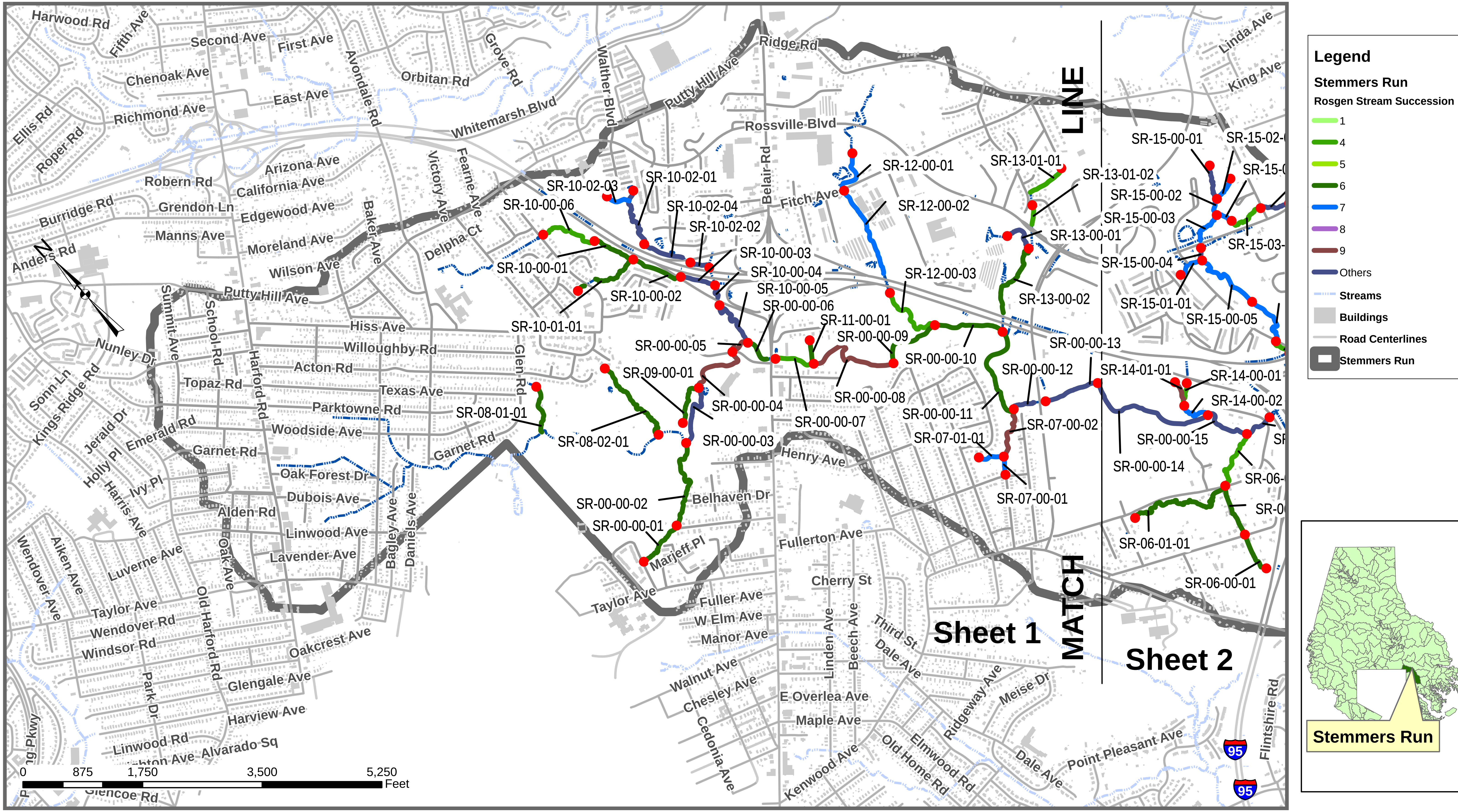
- Shallow Depth of Flow
- Debris Blockage
- Excessive Height
- None
- Road Centerlines
- Buildings
- Brien Run

Date:
September 2007

Figure B2.6

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Fish Blockage
Brien Run

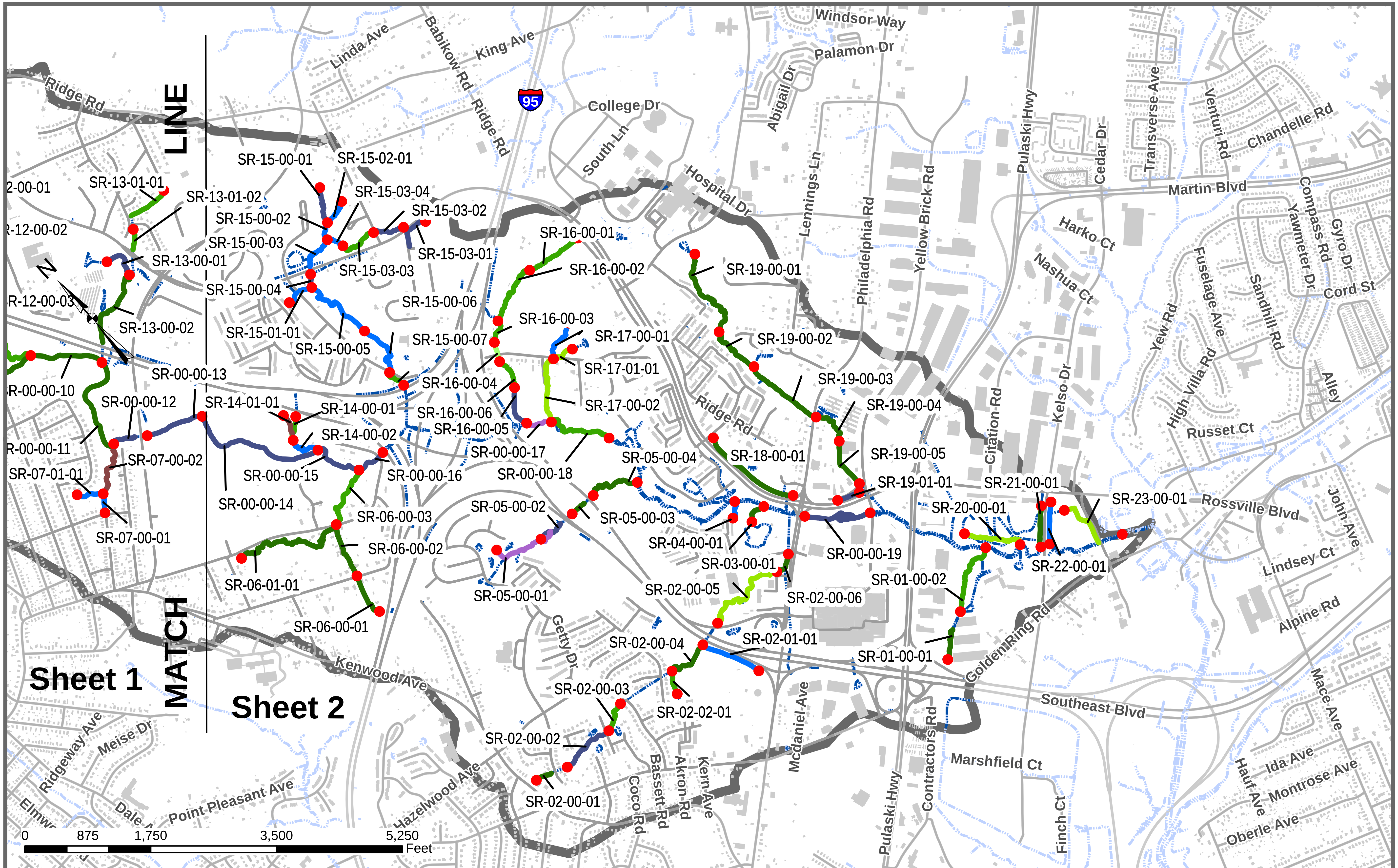


Date:
October 2007

Figure B3.2

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Rosgen Stream Succession
Stemmers Run

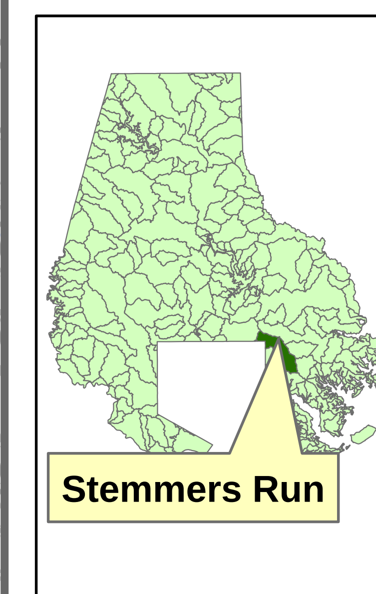


Legend

Stemmers Run

Rosgen Stream Succession

- 1
- 4
- 5
- 6
- 7
- 8
- 9
- Others
- Streams
- Buildings
- Road Centerlines
- Stemmers Run

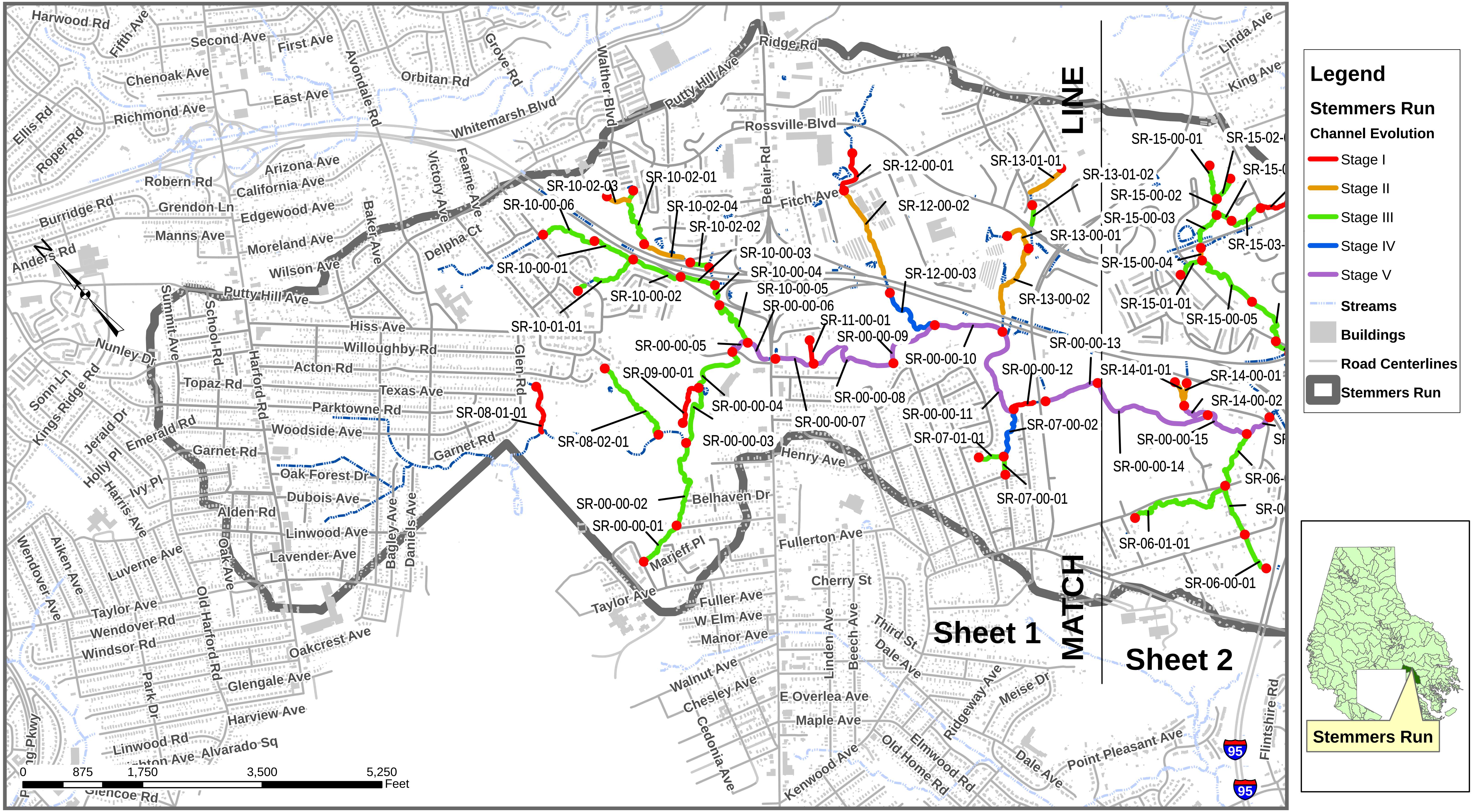


Date:
October 2007

Figure B3.2

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Rosgen Stream Succession
Stemmers Run

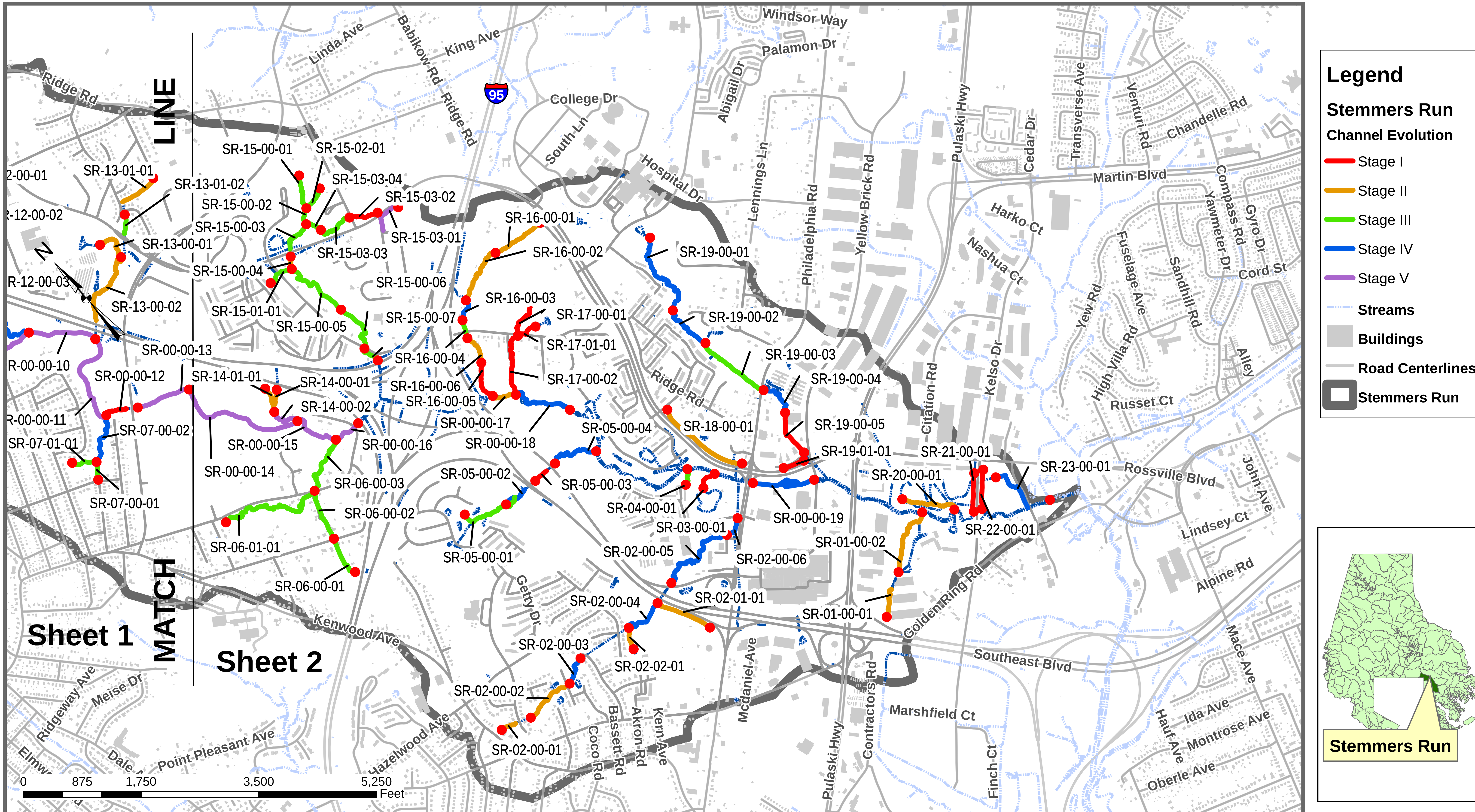


Date:
October 2007

Figure B3.3

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Channel Evolution
Stemmers Run

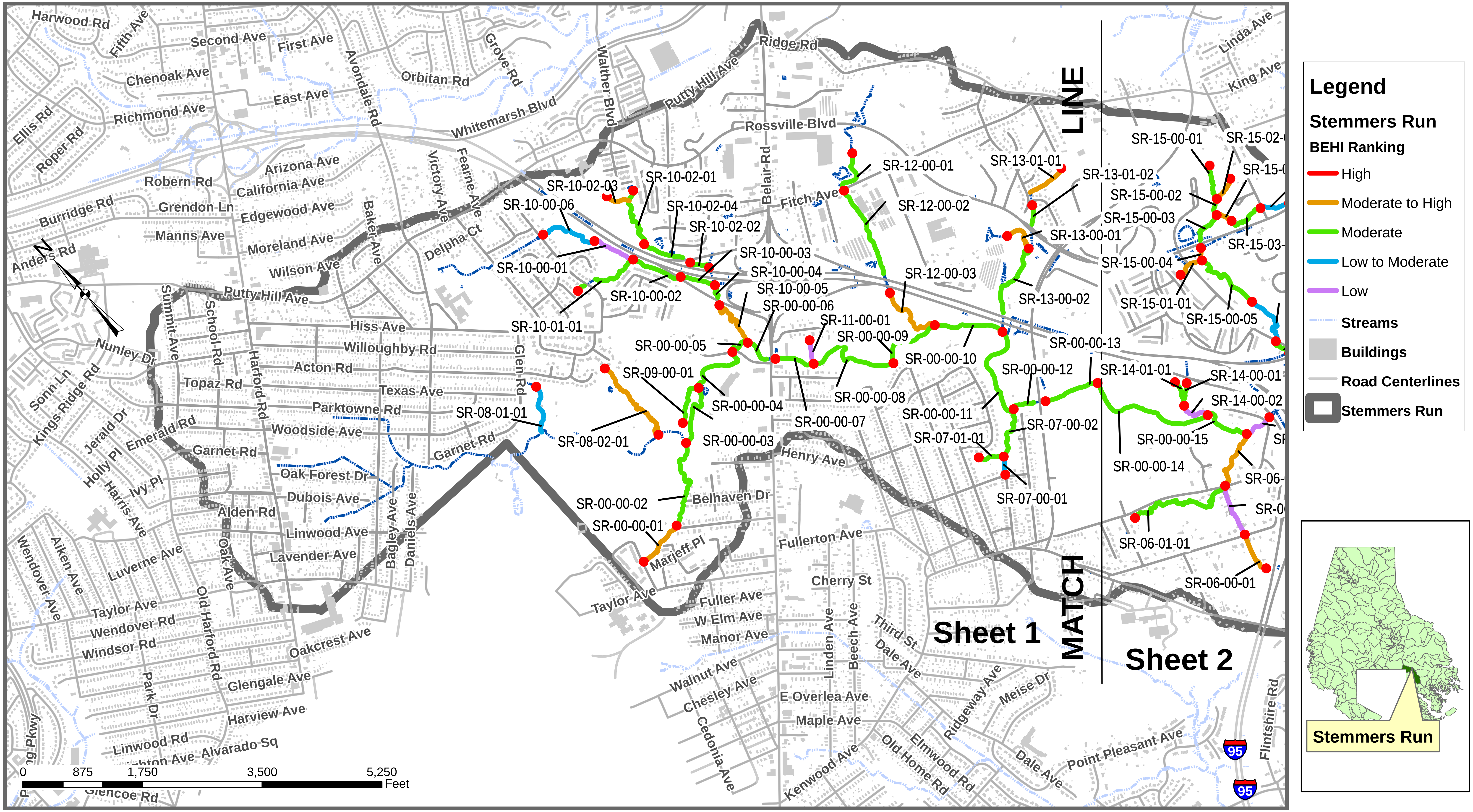


Date:
October 2007

Figure B3.3

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Channel Evolution
Stemmers Run

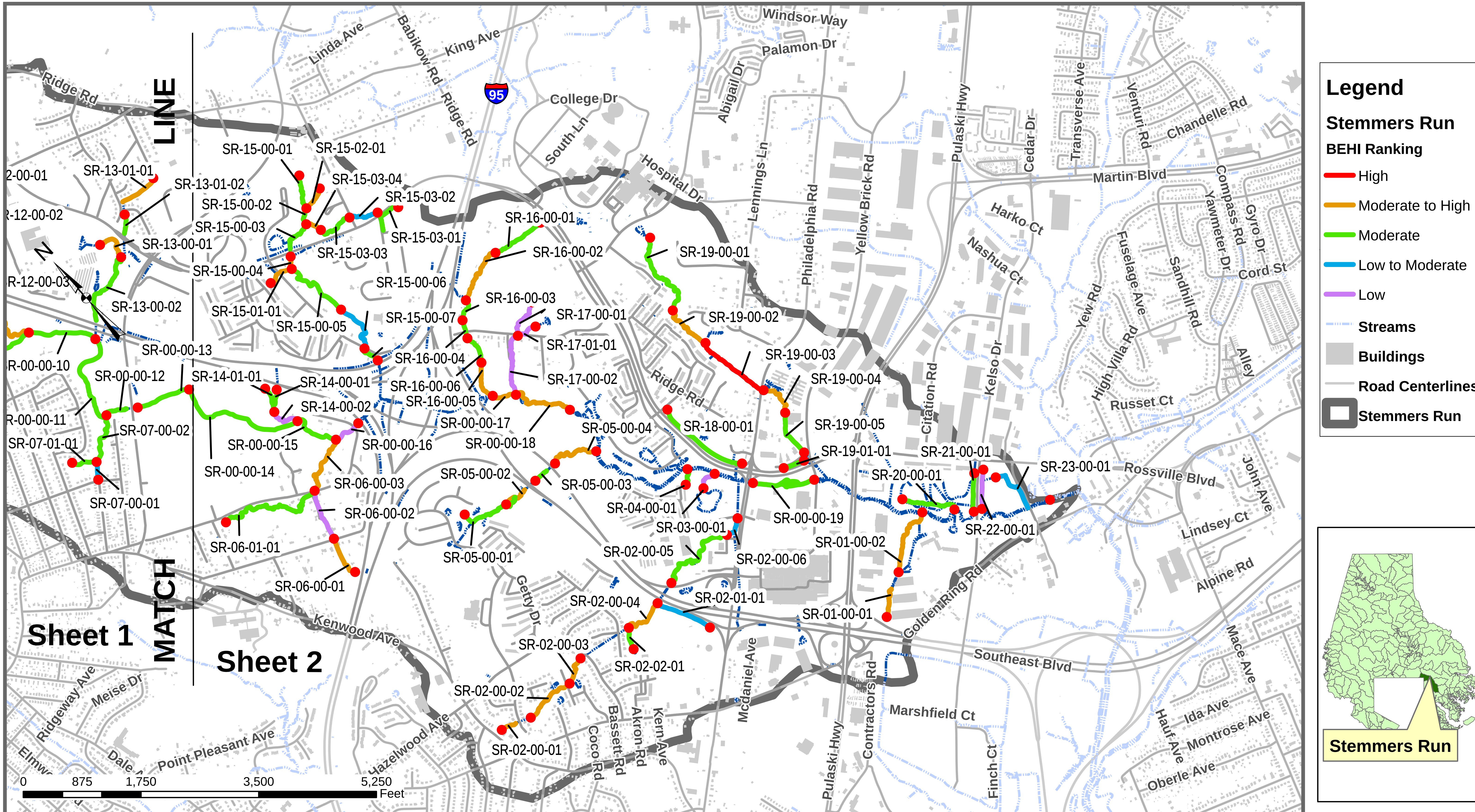


Date:
October 2007

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

BEHI Ranking
Stemmers Run

Figure B3.4

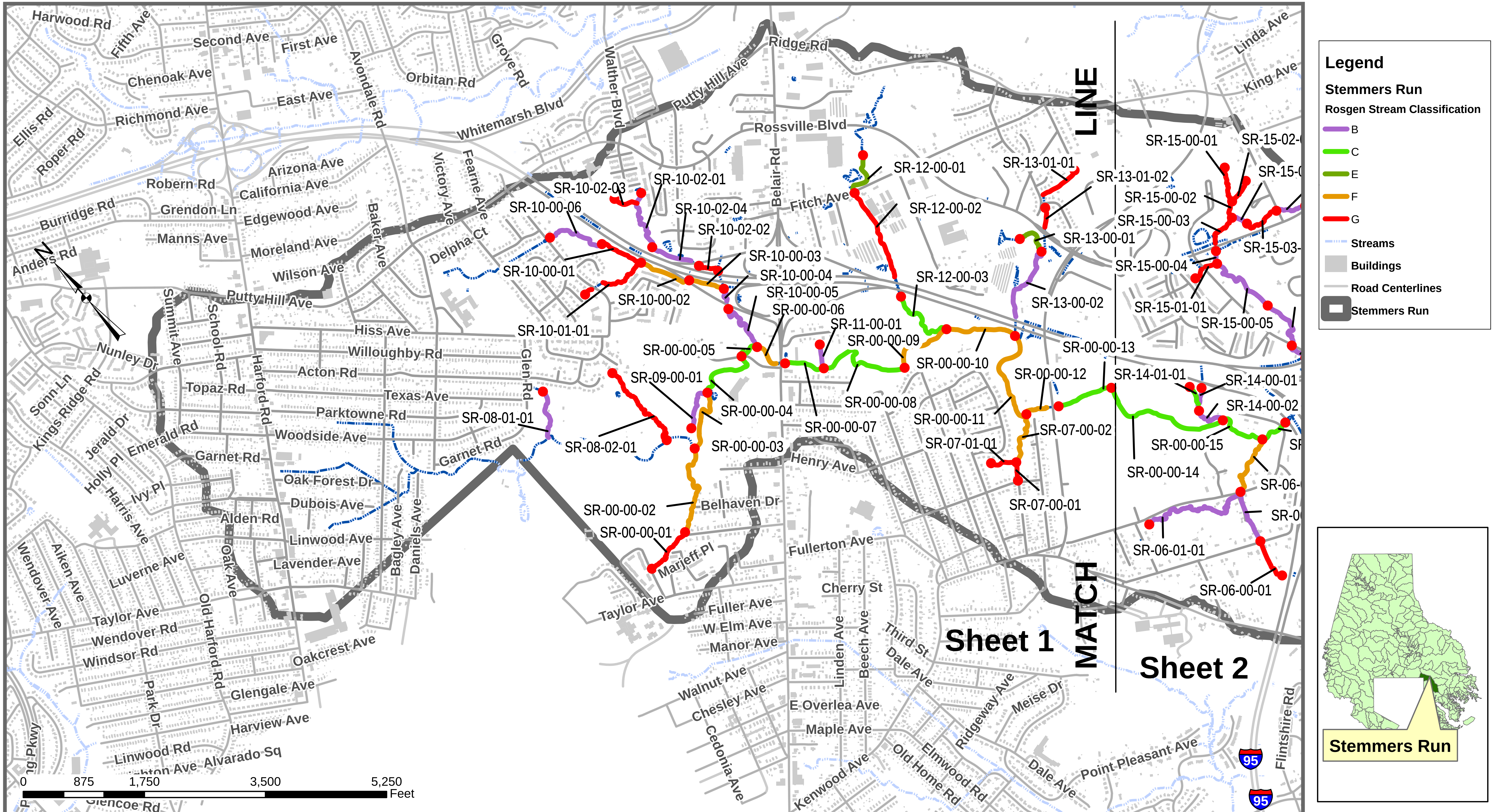


Date:
October 2007

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

BEHI Ranking
Stemmers Run

Figure B3.4

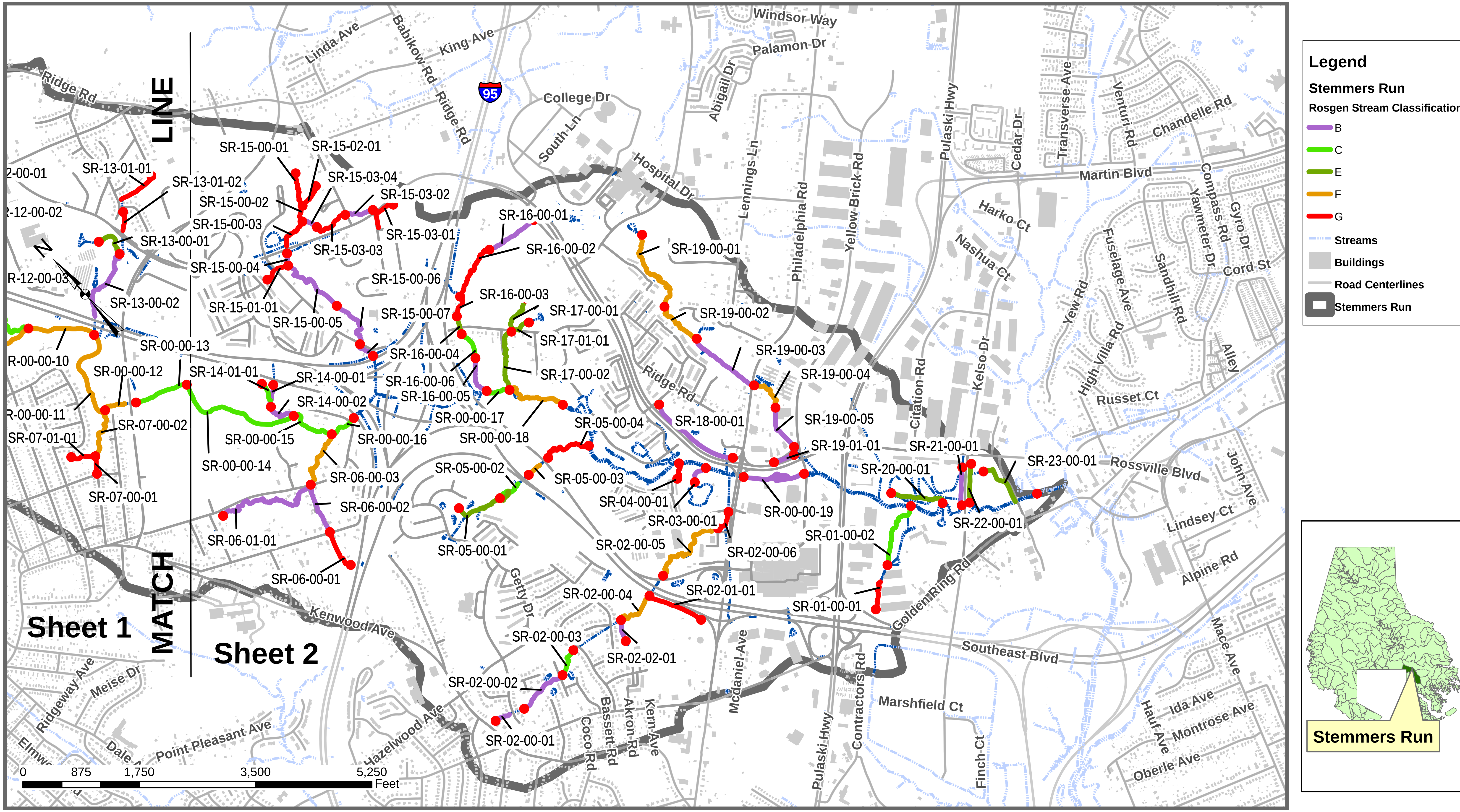


Date:
October 2007

Figure B3.5

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Rosgen Stream Classification
Stemmers Run

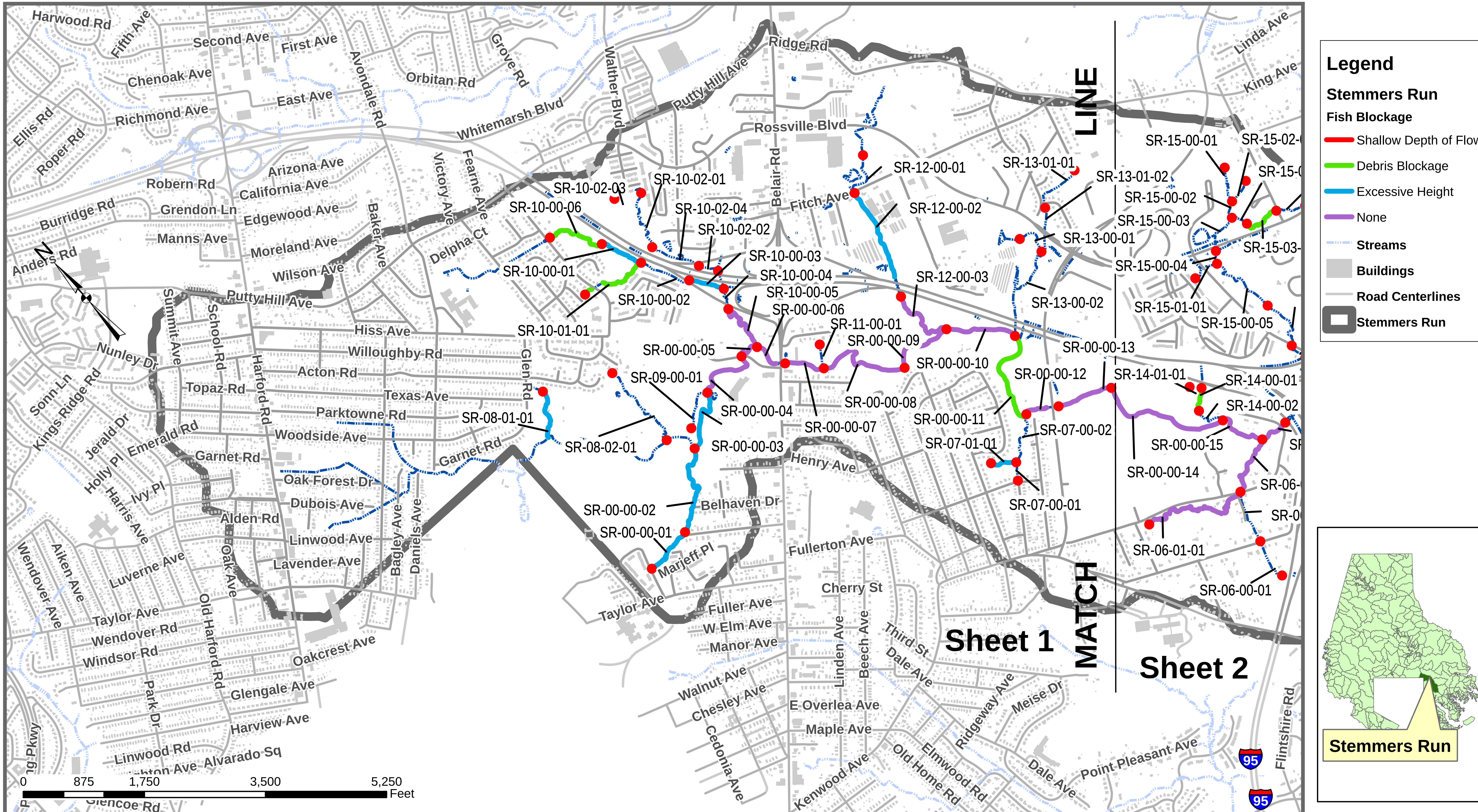


Date:
October 2007

Figure B3.5

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Rosgen Stream Classification
Stemmers Run

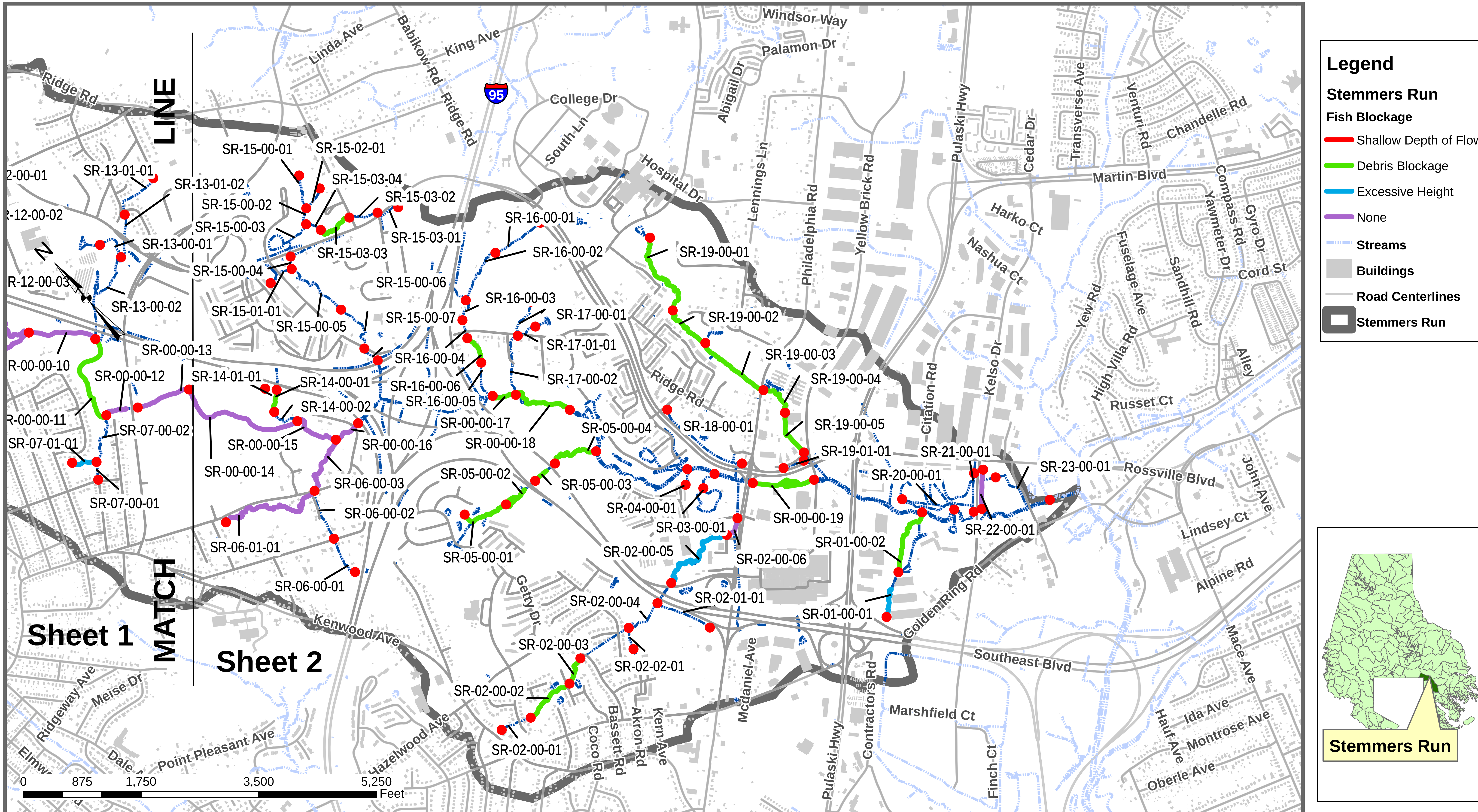


Date:
October 2007

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Fish Blockage
Stemmers Run

Figure B3.6



Date:
October 2007

UPPER BACK RIVER WATERSHED
STREAM STABILITY ASSESSMENT

Fish Blockage
Stemmers Run

Figure B3.6

APPENDIX C

- Database

Reach	Length	Subshed	Team	Date	FlowRegime	Bankfull Depth	Max Bankfull Depth	Sinuosity	Meander Pattern	Depositional Features	Channel Stability V	Channel Stability L	Left Unstable Bank Length	Left Unstable Bank Height	Right Unstable Bank Length	Unstable-Stable Ratio	Right Unstable Bank Height
HE-00-00-01	811	HERRING RUN	CG JN	5/17/2007 13:06	Perennial	1	1.5	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	111	2	0	6.85%	0
HE-00-00-02	1956	HERRING RUN	CG JN	5/17/2007 11:42	Perennial	0.84	1.3	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	328	6	479	20.63%	5
HE-00-00-03	392	HERRING RUN	CG JN	5/17/2007 9:12	Perennial	1.7	1.8	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	246	2.7	180	54.37%	1.7
HE-00-00-04	813	HERRING RUN	SC JN	5/16/2007 13:03	Perennial	1	1.3	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Aggrading	Degrading	190	4	310	30.73%	4
HE-00-00-05	260	HERRING RUN	SC JN	5/16/2007 11:50	Perennial	1.1	1.4	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	150	4	0	28.83%	0
HE-00-00-07	632	HERRING RUN	[SC JN	5/16/2007 10:32	Perennial	1.2	1.4	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	175	2	170	27.30%	2.8
HE-00-00-08	224	HERRING RUN	SC JN	5/16/2007 10:13	Perennial	1	1.3	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	150	2.5	0	33.54%	0
HE-00-00-09	594	HERRING RUN	SC JN	5/15/2007 13:33	Perennial	1.3	1.5	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Degrading	65	3	30	8.00%	4
HE-00-00-11	1228	HERRING RUN	SC JN	5/15/2007 10:50	Perennial	1.6	1.9	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	365	5	120	19.75%	3.7
HE-00-00-12	597	HERRING RUN	SC JN	5/15/2007 9:41	Perennial	1.6	1.9	Low, 1.0 to 1.2	M3, Irregular	w\Few Mid	Aggrading	Degrading	125	3	0	10.47%	0
HE-00-00-13	453	HERRING RUN	SC|AS	5/10/2007 14:35	Perennial	1.7	2	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Stable	0	0	55	6.07%	0.7
HE-00-00-14	1223	HERRING RUN	SC|AS	5/10/2007 12:47	Perennial	2.5	3	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	185	1.5	150	13.70%	2
HE-00-00-15	1083	HERRING RUN	SC|AS	5/10/2007 12:10	Perennial	1.2	1.4	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Degrading	70	16.5	90	7.39%	11.5
HE-00-00-16	241	HERRING RUN	SC|AS	5/10/2007 11:23	Perennial	1.9	2.4	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Degrading	80	2	130	43.51%	7
HE-01-00-01	320	HERRING RUN	MH SC	5/9/2007 9:21	Perennial	1.4	1.7	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	65	4	65	20.34%	3.5
HE-01-00-06	676	HERRING RUN	MH SC	5/9/2007 10:11	Perennial	1.3	1.9	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	40	4	0	2.96%	0
HE-01-00-02	1741	HERRING RUN	MH SC	5/9/2007 11:23	Perennial	1.2	1.5	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Aggrading	Degrading	300	4	385	19.67%	9
HE-01-00-03	810	HERRING RUN	MH SC	5/9/2007 14:17	Perennial	2	2.5	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	360	3	365	44.74%	2
HE-01-00-04	1030	HERRING RUN	SC|AS	5/10/2007 9:49	Perennial	1.5	1.7	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Degrading	430	7.3	85	25.00%	4
HE-01-00-05	797	HERRING RUN	SC|AS	5/10/2007 10:20	Perennial	1.2	1.6	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Degrading	245	4.5	190	27.29%	4
HE-01-01-01	570	HERRING RUN	MH SC	5/9/2007 9:13	Perennial	0.7	1	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	145	4	215	31.56%	5.5
HE-01-01-02	276	HERRING RUN	MH SC	5/9/2007 10:28	Perennial	1.3	1.5	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Degrading	Degrading	100	4	35	24.44%	3
HE-02-00-01	951	HERRING RUN	SC JN	5/15/2007 10:25	Intermittent	1.2	1.6	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
HE-03-00-01	547	HERRING RUN	SC JN	5/15/2007 9:17	Intermittent	0.5	0.9	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
HE-05-00-01	1290	HERRING RUN	SCJN	5/16/2007 10:58	Intermittent	1.6	2.3	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	50	2	0	1.94%	0
HE-06-00-01	289	HERRING RUN	JN & CMG	5/15/2007 14:12	Intermittent	1.4	1.7	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	35	6.06%	2.5
HE-06-00-02	459	HERRING RUN	CG JN	5/17/2007 8:38	Perennial	0.9	1.15	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	36	3	10	5.01%	3.5
HE-07-00-01	765	HERRING RUN	SC JN	5/22/2007 11:19	Perennial	1.1	1.4	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Degrading	385	5	185	37.24%	4.3
HE-07-00-02	585	HERRING RUN	SC JN	5/22/2007 10:30	Perennial	0.7	0.9	Low, 1.0 to 1.2	M3, Irregular	None	Aggrading	Degrading	145	4.5	30	14.95%	2
HE-07-00-03	863	HERRING RUN	CG JN	5/17/2007 9:57	Perennial	1.8	2	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	234	3.5	173	23.58%	5.5
HE-07-01-01	407	HERRING RUN	sc jn	5/22/2007 10:09	Perennial	1.2	1.7	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Degrading	40	3	35	9.21%	2.5
HE-07-01-02	251	HERRING RUN	SC JN	5/22/2007 10:48	Perennial	1.6	2	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Degrading	0	0	130	25.94%	3.75
HE-08-00-01	1135	HERRING RUN	CG JN	5/17/2007 15:06	Perennial	1.1	1.6	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	491	5	400	39.27%	5
HE-08-00-02	1009	HERRING RUN	CG JN	5/17/2007 14:27	Perennial	0.8	1.5	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Degrading	Degrading	141	8	276	20.66%	3.5
HE-08-00-03	601	HERRING RUN	CG JN	5/17/2007 13:37	Perennial	0.8	1	Low, 1.0 to 1.2			Degrading	Stable	139	2	81	18.31%	4
HE-09-00-01	315	HERRING RUN	CG JN	5/17/2007 12:39	Ephemeral	1.42	1.9	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Degrading	90	3	165	40.50%	3
HE-10-00-01	798	HERRING RUN	SC JN	5/16/2007 9:27	Perennial	1	1.3	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Stable	20	2	160	11.27%	1.7
HE-10-00-02	558	HERRING RUN	SC JN	5/16/2007 9:50	Perennial	1.3	2.1	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	60	3	20	7.17%	1
HE-11-00-01	188	HERRING RUN	SC JN	5/15/2007 11:56	Perennial	0.8	1.1	Low, 1.0 to 1.2	M3, Irregular	None	Aggrading	Degrading	60	4.5	20	21.32%	2
HE-12-00-01	179	HERRING RUN	SC JN	5/15/2007 11:40	Perennial	0.7	0.9	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Degrading	90	3	0	25.18%	0
HE-04-00-01	206	HERRING RUN	SC JN	5/15/2007 13:17	Intermittent	1.1	1.9	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Degrading	115	2	55	41.18%	2
HW-00-00-11	482	HERRING RUN	SC & CMG	4/24/2007 11:30	Perennial	2	2.3		M1, Regular	None	Stable	Stable	57	2.5	0	5.92%	0
HW-00-00-01	336	HERRING RUN	SC & CMG	4/24/2007 11:55	Perennial	1.7	2.3	Low, 1.0 to 1.2	M1, Regular	None	Stable	Stable	39	2	15	8.03%	6
HW-00-00-02	892	HERRING RUN	CG SC	4/24/2007 14:54	Perennial	1.6	2.7	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Degrading	296	2	255	30.88%	3
HW-00-00-03	1508	HERRING RUN	SC & CMG	4/24/2007 14:13	Perennial	1.4	1.8	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Stable	65	1	57	4.05%	1.5
HW-00-00-04	557	HERRING RUN	SC & CMG	4/24/2007 13:30	Perennial	1.6	1.9	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Stable	87	2	24	9.96%	1
HW-00-00-05	205	HERRING RUN	SC & CMG	4/25/2007 11:12	Perennial	1.6	1.9	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Degrading	24	7	15	9.52%	2
HW-00-00-06	812	HERRING RUN	SC & CMG	4/25/2007 11:50	Perennial	1.4	1.7	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	27	3	138	10.15%	4
HW-00-00-07	300	HERRING RUN	SC & CMG	4/25/2007 14:18	Perennial	1.6	1.9	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	102	2	82	30.64%	2.5
HW-00-00-08	1720	HERRING RUN	SC & MH	4/17/2007 14:08	Perennial	1.7	2.9	Low, 1.0 to 1.2	M3, Irregular	nt Bars w\Few M	Aggrading	Degrading	190	5	375	16.43%	4
HW-00-00-09	934	HERRING RUN	SC & MH	5/1/2007 13:54	Perennial	1.2	1.75	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Degrading	155	3.8	70	12.04%	4.5
HW-00-00-10	1363	HERRING RUN	SC & MH	5/1/2007 15:50	Perennial	0.9	1.8	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Stable	120	2.7	130	9.17%	2.8
HW-01-00-01	793	HERRING RUN	SC & MH	4/17/2007 10:01	Perennial	1.1	1.6	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Stable	155	4	140	18.61%	4
HW-02-00-01	1668	HERRING RUN	SC & MH	4/3/2007 22:57	Perennial	0.7	1.2	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Degrading	545	7	340	26.53%	5
HW-03-00-02	474	HERRING RUN	SC & CMG	4/25/2007 12:45	Perennial	2.1	2.65	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Degrading	Degrading	82	4	144	23.86%	4
HW-03-01-01	483	HERRING RUN	SC & CMG	4/25/2007 13:27	Perennial	2	2.4	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Degrading	244	6	267	52.95%	5
HW-04-00-01	625	HERRING RUN	SC & CMG	4/25/2007 10:41	Perennial	1.4	1.9	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	119	3	154	21.84%	2.5
HW-04-00-02	1123	HERRING RUN	SC & CMG	4/25/2007 9:51	Perennial	1.6	2.2	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	270	4.5	52	14.34%	1.5
HW-05-00-01	232	HERRING RUN	SC & MH	4/24/2007 10:10	Perennial	0.8	1.3	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Degrading	220	2.5	120	73.39%	3
HW-05-00-02	218	HERRING RUN	SC & MH	4/25/2007 10:12	Perennial	0.8	1.2	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	110	2	110	50.55%	2
HW-05-00-03	1002	HERRING RUN	SC & MH	4/17/2007 10:01	Perennial	0.8	1.1	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	62	2	40	5.09%	2
HW-06-00-01	1162	HERRING RUN	SC AZ MH	5/7/2007 9:46	Perennial	1	1.2	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	260	2	290	23.67%	2.5
HW-06-00-02	326	HERRING RUN	SC AZ MH	5/8/2007 12:50	Perennial	1	1.5	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Degrading	30	3	68	15.04%	3
HW-06-00-03	226	HERRING RUN	SC AZ MH	5/8/2007 13:02	Perennial	1.2	1.9	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
HW-06-00-04	348	HERRING RUN	SC AZ MH	5/8/2007 13:18	Perennial	2	2.7	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	15	3	0	2.15%	0

Reach	Bank Bankfull Ratio	Bank Angle	Bank Material	Root Density	Debris Blockages	Leaking Utility	Exposed MH Riser	Left Bank Riparian Width	Right Bank Riparian Width	Left Bank Riparian Comp	Right Bank Riparian Comp	Bedrock Outcrop	Left Bank Riparian Density	Right Bank Riparian Density
HE-00-00-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	Sandy	High, Minimal Roots	Infrequent	0	0	50	60	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HE-00-00-02	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Cobbley	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	1	30	75	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HE-00-00-03	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Cobbley	Med, Dense Roots Upper 1/2 Bank	None	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HE-00-00-04	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	80	80	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HE-00-00-05	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	1	80	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	Moderate
HE-00-00-07	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	50	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Low	Low
HE-00-00-08	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	50	75	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
HE-00-00-09	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	Cobbley	Med, Dense Roots Upper 1/2 Bank	None	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Low
HE-00-00-11	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	Cobbley	High, Minimal Roots	None	0	1	75	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
HE-00-00-12	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	50	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Low
HE-00-00-13	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	25	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Low	Moderate
HE-00-00-14	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout	None	0	0	50	25	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Low	Low
HE-00-00-15	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	Sandy	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Low
HE-00-00-16	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	Cobbley	High, Minimal Roots	None	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
HE-01-00-01	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Infrequent	0	1	100	40	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HE-01-00-06	High, BF Lower 1/2 of Bank	High, Undercut Sloping to Strm	None	High, Minimal Roots	None	0	0	20	80	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Low	Moderate
HE-01-00-02	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Extensive	0	1	20	85	Grass and Forbs	Decid. w\Brush-Grass Understory	0	Low	Moderate
HE-01-00-03	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Infrequent	0	1	25	20	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Low	Low
HE-01-00-04	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	1	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
HE-01-00-05	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	Cobbley	High, Minimal Roots	Extensive	0	1	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
HE-01-01-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Infrequent	0	1	70	70	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Low
HE-01-01-02	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Cobbley	High, Minimal Roots	Numerous	0	0	100	50	Decid w\Brush-Grass Under	Grass and Forbs	0	Moderate	Low
HE-02-00-01	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	20	100	Grass and Forbs	Decid. w\Brush-Grass Understory	0	Low	High
HE-03-00-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	40	30	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Low
HE-05-00-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Moderate	0	1	50	50	Grass and Forbs	Decid. w\Brush-Grass Understory	0	Low	Low
HE-06-00-01	Low, BF at Top of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	50	10	Grass and Forbs	Decid. w\Brush-Grass Understory	0	Low	Low
HE-06-00-02	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	70	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
HE-07-00-01	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Infrequent	0	0	50	60	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Low
HE-07-00-02	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	65	70	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Low
HE-07-00-03	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	100	40	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Low
HE-07-01-01	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Infrequent	0	0	50	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Low
HE-07-01-02	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	0	40	35	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Low
HE-08-00-01	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	75	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HE-08-00-02	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	40	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Moderate
HE-08-00-03	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Infrequent	0	0	100	80	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HE-09-00-01	Low, BF at Top of Bank	Med, Nearly Vertical	Sandy	High, Minimal Roots	Moderate	0	0	100	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Low
HE-10-00-01	Low, BF at Top of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Infrequent	0	0	50	40	Grass and Forbs	Grass and Forbs	0	Low	Low
HE-10-00-02	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	75	70	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
HE-11-00-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Low, Dense Roots Throughout	Infrequent	0	0	50	100	Grass and Forbs	Decid. w\Brush-Grass Understory	0	Low	Moderate
HE-12-00-01	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	Cobbley	High, Minimal Roots	Infrequent	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HE-04-00-01	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Infrequent	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HW-00-00-11					None	0	0	10	0	Decid w\Brush-Grass Under	Bare	0	Moderate	Low
HW-00-00-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	Cobbley	High, Minimal Roots	None	0	0	5	10	Brush	Decid. w\Brush-Grass Understory	0	Low	Low
HW-00-00-02	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	1	20	10	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Low
HW-00-00-03	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	1	50	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HW-00-00-04	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	0	50	20	Grass and Forbs	Grass and Forbs	0	Low	Low
HW-00-00-05	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Sandy	High, Minimal Roots	None	0	0	20	75	Decid w\Brush-Grass Under	Grass and Forbs	0	Low	Low
HW-00-00-06	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	1	100	100	Grass and Forbs	Grass and Forbs	1	Low	Low
HW-00-00-07	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	Cobbley	Med, Dense Roots Upper 1/2 Bank	None	0	0	15	100	Grass and Forbs	Grass and Forbs	0	Low	Low
HW-00-00-08	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	1	100	100	Grass and Forbs	Grass and Forbs	1	Low	Low
HW-00-00-09	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	Cobbley	High, Minimal Roots	None	0	1	75	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Low	Moderate
HW-00-00-10	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	0	40	85	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Low	Moderate
HW-01-00-01	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1		
HW-02-00-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Cobbley	High, Minimal Roots	Numerous	0	1	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HW-03-00-02	High, BF Lower 1/2 of Bank	High, Undercut Sloping to Strm	None	High, Minimal Roots	Moderate	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HW-03-01-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Cobbley	High, Minimal Roots	Infrequent	0	1	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
HW-04-00-01	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	0	50	75	Decid w\Brush-Grass Under	Grass and Forbs	0	Moderate	Low
HW-04-00-02	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	10	20	Grass and Forbs	Decid. w\Brush-Grass Understory	1		
HW-05-00-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	100	80	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HW-05-00-02	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	100	100	Grass and Forbs	Grass and Forbs	0	Low	Low
HW-05-00-03	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	0	100	30	Decid w\Brush-Grass Under	Deciduous Overstory	1	High	Moderate
HW-06-00-01	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	0	80	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
HW-06-00-02	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	30	90	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Moderate
HW-06-00-03	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	0	15	55	Grass and Forbs	Decid. w\Brush-Grass Understory	1	Low	Low
HW-06-00-04	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	0	20	70	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Low	Low

Reach	Channel Mod	Photo Taken	Comment	Private Structure Threatend	Fish Blockage	BF Indicator	Chnl Restoration	Buffer Enhncmnt	Utilility Resol	Habitat Enhcmnt	Bankfull Width	Width Depth Ratio	Substrate	Canopy Cover	Chnl Restoration	Floodprone Width	Entrenchment	Chnl Evol	Channel Slope	Rosgen Class	Succession
HE-00-00-01	0	1	0	0	None	Slope Break	0	1	0	0	11	10.8	Gravel	75-100%	0	24.8	2.296296	Stage I	<2%	B	7
HE-00-00-02	0	1	0	0	None	Slope Break	1	1	1	0	19	22.619048	Gravel	50-75%	1	20.5	1.078947	Stage III	<2%	F	9
HE-00-00-03	0	1	0	0	None	Slope Break	0	0	0	0	24	13.823529	Gravel	50-75%	0	28.5	1.212766	Stage V	<2%	F	9
HE-00-00-04	0	1	0	0	None	Slope Break	1	0	0	0	40	40	Gravel	50-75%	1	50	1.25	Stage IV	<2%	F	4
HE-00-00-05	0	1	0	0	None	Slope Break	1	0	1	0	26	23.636364	Gravel	50-75%	1	30	1.153846	Stage III	<2%	F	6
HE-00-00-07	0	0	0	0	Excessive Height	Slope Break	1	1	0	0	25	20.833333	Gravel	50-75%	1	30	1.2	Stage III	<2%	F	4
HE-00-00-08	0	1	0	0	Excessive Height	Slope Break	0	1	0	0	28	28	Gravel	75-100%	0	35	1.25	Stage I	<2%	B	4
HE-00-00-09	0	1	0	0	Excessive Height	Slope Break	1	1	1	0	23	17.692308	Gravel	75-100%	1	25	1.086957	Stage III	<2%	F	6
HE-00-00-11	0	1	0	0	None	Slope Break	1	1	1	0	29	17.8125	Gravel	50-75%	1	46	1.614035	Stage III	<2%	B	6
HE-00-00-12	0	1	1	0	Excessive Height	Slope Break	1	1	0	0	33	20.625	Gravel	50-75%	1	42	1.272727	Stage IV	<2%	F	6
HE-00-00-13	0	1	0	0	Excessive Height	Slope Break	0	1	0	0	25	14.705882	Gravel	25-50%	0	38	1.52	Stage I	<2%	B	6
HE-00-00-14	0	1	0	0	Excessive Height	Slope Break	0	1	0	0	30	12	Gravel	25-50%	0	50	1.666667	Stage I	<2%	B	6
HE-00-00-15	0	1	0	0	None	Slope Break	1	0	0	0	29	24.166667	Gravel	50-75%	1	35	1.206897	Stage IV	<2%	F	4
HE-00-00-16	0	1	0	0	None	Slope Break	1	0	0	0	48	25.263158	Cobble	50-75%	1	56	1.166667	Stage IV	<2%	F	6
HE-01-00-01	1	1	0	0	None	Slope Break	1	1	1	0	16	11.071429	Cobble	25-50%	1	18.5	1.193548	Stage III	<2%	F	4
HE-01-00-06	1	1	0	0	Shallow Depth of Flow	Slope Break	1	1	0	0	25	19.230769	Cobble	25-50%	1	31	1.24	Stage III	<2%	F	6
HE-01-00-02	0	1	0	0	None	Slope Break	1	1	0	0	29	23.75	Gravel	10-25%	1	39	1.368421	Stage III	<2%	F	6
HE-01-00-03	0	1	0	0	None	Vegetative Feature	1	1	1	0	18	9	Gravel	10-25%	1	25	1.388889	Stage III	<2%	G	5
HE-01-00-04	0	1	0	0	None	Slope Break	1	0	1	0	31	20.666667	Gravel	25-50%	1	36	1.16129	Stage IV	<2%	F	4
HE-01-00-05	0	1	0	0	Excessive Height	Slope Break	1	0	1	0	33	27.5	Boulder	50-75%	1	39	1.181818	Stage IV	2% to 4%	F	4
HE-01-01-01	0	1	0	0	Excessive Height	Slope Break	1	1	1	0	12	17.142857	Gravel	25-50%	1	18	1.5	Stage III	<2%	F	5
HE-01-01-02	0	1	0	0	None	Slope Break	1	1	0	0	15	11.153846	Gravel	10-25%	1	25	1.724138	Stage III	<2%	B	7
HE-02-00-01	0	1	1	0	Shallow Depth of Flow	Slope Break	0	1	0	0	9	7.5	Silt	50-75%	0	18	2	Stage I	<2%	E	5
HE-03-00-01	0	1	1	0	Shallow Depth of Flow	Slope Break	0	1	0	0	8	15	Silt	50-75%	0	11	1.466667	Stage I	<2%	E	5
HE-05-00-01	0	1	0	1	Shallow Depth of Flow	Slope Break	0	1	1	0	7	4.0625	Silt	25-50%	0	90	13.846154	Stage I	<2%	E	5
HE-06-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	1	0	0	7	5	Gravel	0-10%	0	47	6.714286	Stage I	<2%	E	5
HE-06-00-02	1	1	0	0	None	Slope Break	0	0	0	0	8	8.888889	Gravel	75-100%	0	19.5	2.4375	Stage I	<2%	E	5
HE-07-00-01	0	0	0	0	Excessive Height	Slope Break	1	1	0	0	9	8.181818	Gravel	50-75%	1	13	1.444444	Stage III	<2%	G	4
HE-07-00-02	0	0	0	0	None	Slope Break	1	1	0	0	14	20	Gravel	50-75%	1	17	1.214286	Stage III	<2%	F	5
HE-07-00-03	0	1	0	0	None	Depositional Features	0	1	0	0	18	9.777778	Gravel	75-100%	0	27.6	1.568182	Stage III	<2%	B	4
HE-07-01-01	0	0	0	0	Excessive Height	Slope Break	1	1	0	0	10	7.916667	Gravel	25-50%	1	15	1.578947	Stage II	<2%	G	5
HE-07-01-02	0	0	1	1	Excessive Height	Slope Break	1	1	0	0	16	10	Gravel	50-75%	1	19	1.1875	Stage III	<2%	F	5
HE-08-00-01	0	1	0	0	None	Slope Break	1	1	1	0	14	12.545455	Gravel	75-100%	1	14.9	1.07971	Stage III	<2%	F	9
HE-08-00-02	0	1	0	0	None	Slope Break	1	1	0	0	14	16.875	Gravel	50-75%	1	15.7	1.162963	Stage II	<2%	F	4
HE-08-00-03	0	1	0	0	Shallow Depth of Flow	Slope Break	0	1	1	0	14	17.25	Gravel	50-75%	0	15.8	1.144928	Stage II	<2%	F	4
HE-09-00-01	0	0	0	0	Shallow Depth of Flow	Slope Break	1	1	0	1	3	2.253521	Silt	50-75%	1	83.2	26	Stage II	<2%	E	5
HE-10-00-01	0	1	0	0	Excessive Height	Slope Break	0	1	0	0	16	16	Sand	10-25%	0	30	1.875	Stage V	<2%	B	4
HE-10-00-02	0	1	0	0	Excessive Height	Slope Break	0	1	0	0	16	12.307692	Bedrock	75-100%	0	28	1.75	Stage I	<2%	B	4
HE-11-00-01	0	1	0	0	Excessive Height	Slope Break	1	1	0	0	6	7.5	Gravel	10-25%	1	12	2	Stage III	<2%	E	5
HE-12-00-01	0	1	0	0	None	Slope Break	1	1	0	0	5	6.428571	Silt	75-100%	1	7.5	1.666667	Stage III	<2%	G	5
HE-04-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	1	0	0	0	4	3.636364	Silt	75-100%	1	6	1.5	Stage III	<2%	G	5
HW-00-00-11	1	1	1	0		Slope Break	0	0	0	0	13	6.25			0	0	0		<2%		
HW-00-00-01	1	1	1	0	None	Slope Break	0	1	0	0	13	7.647059	Cobble	0-10%	0	25	1.923077		<2%		
HW-00-00-02	1	1	0	0	Excessive Height	Slope Break	0	1	0	0	14	8.4375	Gravel	0-10%	0	33	2.444444	Stage III	<2%	B	6
HW-00-00-03	1	1	1	0		Slope Break	0	1	1	0	18	12.5	Gravel	10-25%	0	27.5	1.571429	Stage I	<2%	B	6
HW-00-00-04	0	1	0	0	None	Active Floodplain	0	1	0	0	16	9.6875	Gravel	0-10%	0	29.5	1.903226	Stage I	<2%	B	6
HW-00-00-05	0	1	0	0	None	Slope Break	1	1	0	0	15	9.5	Gravel	0-10%	1	36	2.368421	Stage I	<2%	E	5
HW-00-00-06	0	1	0	0	Excessive Height		1	1	0	0	21	15	Boulder	0-10%	1	34	1.619048	Stage I	2% to 4%	B	7
HW-00-00-07	0	1	0	0	None	Slope Break	0	1	0	0	20	12.5	Gravel	0-10%	0	36	1.8	Stage I	<2%	B	6
HW-00-00-08	0	1	0	0	None	Slope Break	1	1	1	0	25	14.705882	Boulder	0-10%	1	35	1.4	Stage IV	<2%	F	6
HW-00-00-09	0	1	0	0	None	Slope Break	1	1	1	0	34	27.916667	Gravel	10-25%	1	45	1.343284	Stage IV	<2%	F	6
HW-00-00-10	0	1	0	0	Excessive Height	Slope Break	0	1	0	0	37	41.111111	Gravel	10-25%	0	100	2.702703	Stage IV	<2%	C	3
HW-01-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	1	0	0	0	21	19.090909	Gravel	50-75%	1	35	1.666667	Stage IV	<2%	B	6
HW-02-00-01	0	1	1	0	Shallow Depth of Flow	Slope Break	1	1	1	0	17	23.571429	Gravel	25-50%	1	20	1.212121	Stage III	<2%	F	5
HW-03-00-02	0	1	0	0	Excessive Height	Slope Break	1	1	0	0	14	6.47619	Gravel	25-50%	1	25.5	1.875	Stage II	2% to 4%	G	6
HW-03-01-01	0	1	0	0	Excessive Height	Slope Break	1	1	1	0	9	4.25	Gravel	25-50%	1	12.5	1.470588	Stage II	2% to 4%	G	7
HW-04-00-01	0	1	0	0	Excessive Height	Slope Break	1	1	0	0	10	6.928571	Gravel	50-75%	1	27	2.783505	Stage I	<2%	E	5
HW-04-00-02	0	1	0	1	None		1	1	0	0	13	8.0625	Gravel	0-10%	1	41	3.178295	Stage I	<2%	E	5
HW-05-00-01	1	0	0	0	Shallow Depth of Flow	Slope Break	1	1	0	1	6	6.875	Silt	25-50%	1	60	10.909091	Stage II	<2%	E	5
HW-05-00-02	1	0	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	3	3.75	Silt	0-10%	0	9	3	Stage I	<2%	E	5
HW-05-00-03	1	1	0	0	None	Slope Break	0	1	0	0	13	15.625	Boulder	50-75%	0	17	1.36	Stage III	2% to 4%	B	6
HW-06-00-01	0	1	0	0	Excessive Height	Slope Break	1	1	0	0	9	9.2	Gravel	50-75%	1	33	3.586957	Stage III	<2%	E	5
HW-06-00-02	0	1	0	0	Excessive Height	Slope Break	0	1	0	0	30	29.5	Gravel	25-50%	0	40	1.355932	Stage III	<2%	B	7
HW-06-00-03	0	1	0	0	Shallow Depth of Flow	Slope Break	0	1	0	0	16	13.333333	Boulder	10-25%	0	26	1.625	Stage I	<2%	B	6
HW-06-00-04	0	1	0	0	Excessive Height	Slope Break	0	1	0	0	15	7.5	Boulder	10-25%	0	22.5	1.5	Stage I	2% to 4%	A	6

Reach	Surface Protection	Root Depth Bnk HT Ratio	Concrete Lined	Riprap Gabion Lined	Culvert	Culvert Instabilities	Trash Cleanup	Approximate DA (ac)	Dist to Nearest Road (ft)	Dist to Nearest Road (m)	Left Erosion Extent	Left Erosion Extent (m)	Left Erosion Severity	Lt Erosion Severity Conversion	Right Erosion Extent	Right Erosion Extent (m)	Right Erosion Severity	Rt Erosion Severity Conversion	Instream Habitat
HE-00-00-01	High, <30% protection	High, Roots in Upper 1/3	0	0	1	Fish Passage Issu	1	10	66.67	20.32	51	15.54	1	1	0	0.00	0	0	8
HE-00-00-02	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	1	1	Fish Passage Issu	1	10	88.89	27.09	198	60.35	3	2	54	16.46	3	2	7
HE-00-00-03	High, <30% protection	Low, Roots Extend to Lower 1/3	0	0	0		0	10	111.11	33.87	198	60.35	2	1.5	99	30.18	2	1.5	7
HE-00-00-04	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	244.44	74.51	160	48.77	2	1.5	210	64.01	2	1.5	9
HE-00-00-05	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	1	0		0	10	222.22	67.73	150	45.72	2	1.5	0	0.00	0	0	10
HE-00-00-07	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	1	1	Fish Passage Issu	0	10	88.89	27.09	135	41.15	2	1.5	170	51.82	2	1.5	6
HE-00-00-08	High, <30% protection	High, Roots in Upper 1/3	1	0	0		0	10	133.33	40.64	150	45.72	1	1	0	0.00	0	0	6
HE-00-00-09	High, <30% protection	Med, Roots Extend to Middle 1/3	0	1	0		0	10	166.67	50.80	65	19.81	2	1.5	40	12.19	2	1.5	7
HE-00-00-11	High, <30% protection	High, Roots in Upper 1/3	0	0	1		1	10	244.44	74.51	220	67.06	2	1.5	120	36.58	2	1.5	8
HE-00-00-12	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	1	0	0		0	10	222.22	67.73	125	38.10	2	1.5	0	0.00	0	0	9
HE-00-00-13	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	388.89	118.53	0	0.00	0	0	55	16.76	1	1	10
HE-00-00-14	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	1		1	10	177.78	54.19	60	18.29	1	1	0	0.00	0	0	6
HE-00-00-15	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	155.56	47.41	0	0.00	0	0	30	9.14	3	2	7
HE-00-00-16	Low, >60% protection	High, Roots in Upper 1/3	0	0	0		1	10	166.67	50.80	80	24.38	1	1	130	39.62	2	1.5	8
HE-01-00-01	High, <30% protection	High, Roots in Upper 1/3	0	1	0		1	10	111.11	33.87	65	19.81	2	1.5	65	19.81	2	1.5	4
HE-01-00-06	High, <30% protection	High, Roots in Upper 1/3	1	1	0		1	10	244.44	74.51	40	12.19	1	1	0	0.00	0	0	4
HE-01-00-02	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	177.78	54.19	30	9.14	1	1	225	68.58	3	2	4
HE-01-00-03	High, <30% protection	High, Roots in Upper 1/3	1	1	0		0	10	177.78	54.19	210	64.01	2	1.5	160	48.77	1	1	6
HE-01-00-04	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	466.67	142.24	170	51.82	3	2	35	10.67	2	1.5	6
HE-01-00-05	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	488.89	149.01	50	15.24	2	1.5	100	30.48	1	1	6
HE-01-01-01	High, <30% protection	High, Roots in Upper 1/3	0	1	0	Fish Passage Issu	0	10	288.89	88.05	30	9.14	2	1.5	120	36.58	3	2	5
HE-01-01-02	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	211.11	64.35	100	30.48	2	1.5	35	10.67	1	1	5
HE-02-00-01	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	0	1		0	10	288.89	88.05	50	15.24	1	1	30	9.14	1	1	1
HE-03-00-01	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	0	0		0	10	311.11	94.83	0	0.00	0	0	0	0.00	0	0	0
HE-05-00-01	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	1	1		1	10	111.11	33.87	50	15.24	1	1	0	0.00	0	0	1
HE-06-00-01	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	1	1		0	10	133.33	40.64	0	0.00	0	0	35	10.67	1	1	1
HE-06-00-02	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	1	0		0	10	222.22	67.73	10	3.05	1	1	10	3.05	2	1.5	6
HE-07-00-01	High, <30% protection	High, Roots in Upper 1/3	0	1	0		1	10	288.89	88.05	185	56.39	3	2	135	41.15	3	2	2
HE-07-00-02	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	1	1	0		0	10	200.00	60.96	145	44.20	2	1.5	30	9.14	1	1	3
HE-07-00-03	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	1	0		1	10	222.22	67.73	87	26.52	2	1.5	69	21.03	3	2	7
HE-07-01-01	High, <30% protection	High, Roots in Upper 1/3	1	1	0		1	10	155.56	47.41	40	12.19	1	1	35	10.67	1	1	3
HE-07-01-02	High, <30% protection	High, Roots in Upper 1/3	1	1	0		0	10	266.67	81.28	0	0.00	0	0	130	39.62	2	1.5	4
HE-08-00-01	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	133.33	40.64	252	76.81	3	2	264	80.47	3	2	5
HE-08-00-02	High, <30% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	133.33	40.64	87	26.52	3	2	157	47.85	2	1.5	6
HE-08-00-03	High, <30% protection	High, Roots in Upper 1/3	1	0	1	Fish Passage Issu	0	10	222.22	67.73	61	18.59	1	1	81	24.69	2	1.5	9
HE-09-00-01	High, <30% protection	High, Roots in Upper 1/3	0	1	0		0	10	288.89	88.05	90	27.43	2	1.5	165	50.29	2	1.5	1
HE-10-00-01	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	1	1	pstream Aggradati	1	10	111.11	33.87	20	6.10	1	1	120	36.58	1	1	4
HE-10-00-02	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	1	0		1	10	177.78	54.19	60	18.29	2	1.5	0	0.00	0	0	11
HE-11-00-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	1	0		0	10	244.44	74.51	60	18.29	2	1.5	20	6.10	1	1	2
HE-12-00-01	High, <30% protection	Med, Roots Extend to Middle 1/3	0	1	0		0	10	200.00	60.96	90	27.43	2	1.5	0	0.00	0	0	2
HE-04-00-01	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	1	0		0	10	288.89	88.05	115	35.05	1	1	55	16.76	1	1	0
HW-00-00-11			1	0	0		0	10	155.56	47.41	57	17.37	1	1	0	0.00	0	0	0
HW-00-00-01	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	1	1	Fish Passage Issu	1	10	155.56	47.41	39	11.89	1	1	15	4.57	1	1	10
HW-00-00-02	High, <30% protection	Med, Roots Extend to Middle 1/3	0	1	0		0	10	333.33	101.60	138	42.06	1	1	144	43.89	2	1.5	8
HW-00-00-03	High, <30% protection	High, Roots in Upper 1/3	0	1	0		0	10	155.56	47.41	0	0.00	0	0	45	13.72	1	1	10
HW-00-00-04	High, <30% protection	High, Roots in Upper 1/3	0	1	0		0	10	288.89	88.05	87	26.52	1	1	24	7.32	1	1	13
HW-00-00-05	High, <30% protection	High, Roots in Upper 1/3	1	1	0		0	10	88.89	27.09	24	7.32	3	2	15	4.57	1	1	12
HW-00-00-06	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	1	0		0	10	377.78	115.15	0	0.00	0	0	0	0.00	0	0	10
HW-00-00-07	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		0	10	711.11	216.75	102	31.09	1	1	82	24.99	1	1	12
HW-00-00-08	High, <30% protection	High, Roots in Upper 1/3	0	0	1		0	10	555.56	169.33	55	16.76	1	1	150	45.72	1	1	8
HW-00-00-09	High, <30% protection	High, Roots in Upper 1/3	0	0	0		0	10	222.22	67.73	0	0.00	0	0	30	9.14	2	1.5	11
HW-00-00-10	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		0	10	288.89	88.05	0	0.00	0	0	50	15.24	1	1	9
HW-01-00-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		0	10	333.33	101.60	50	15.24	2	1.5	35	10.67	2	1.5	11
HW-02-00-01	High, <30% protection	High, Roots in Upper 1/3	0	1	1		0	10	355.56	108.37	165	50.29	3	2	95	28.96	2	1.5	6
HW-03-00-02	High, <30% protection	High, Roots in Upper 1/3	0	0	0		0	10	466.67	142.24	72	21.95	3	2	114	34.75	3	2	2
HW-03-01-01	High, <30% protection	High, Roots in Upper 1/3	0	0	0		0	10	511.11	155.79	130	39.62	3	2	177	53.95	3	2	1
HW-04-00-01	High, <30% protection	High, Roots in Upper 1/3	0	1	1		0	10	244.44	74.51	95	28.96	3	2	66	20.12	1	1	10
HW-04-00-02	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	1	1	1		0	10	133.33	40.64	69	21.03	1	1	0	0.00	0	0	10
HW-05-00-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	1		0	10	311.11	94.83	220	67.06	2	1.5	120	36.58	2	1.5	2
HW-05-00-02	High, <30% protection	High, Roots in Upper 1/3	0	1	1		0	10	288.89	88.05	110	33.53	1	1	110	33.53	1	1	2
HW-05-00-03	High, <30% protection	High, Roots in Upper 1/3	0	0	0		0	10	355.56	108.37	220	67.06	1	1	0	0.00	0	0	5
HW-06-00-01	High, <30% protection	High, Roots in Upper 1/3	1	1	1	sue;Excessive Do	0	10	133.33	40.64	30	9.14	1	1	25	7.62	1	1	12
HW-06-00-02	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	1	1	Fish Passage Issu	0	10	133.33	40.64	30	9.14	1	1	52	15.85	1	1	9
HW-06-00-03	High, <30% protection	High, Roots in Upper 1/3	1	1	1	Fish Passage Issu	0	10	88.89	27.09	0	0.00	0	0	0	0.00	0	0	1
HW-06-00-04	Low, >60% protection	High, Roots in Upper 1/3	0	1	0		0	10	88.89	27.09	15	4.57	1	1	0	0.00	0	0	1

Reach	Epifaunal Substrate	Riffle Run Quality	Embeddedness	Shading	Instream Woody Debris	Instream Rootwads	Total Woody Debris	Yard Waste	Reference Reach	Bank Planting	Root Depth/ Bank Ht Score	Surface Protection Score	Root Density Score	Bank Angle Score	Bank Material	Bank Ht/BF Ht Score	BEHI Score	BEHI Ranking	Remoteness Calc.	Shading Calc.	Epifaunal Calc.	Instream Habitat Calc.	Woody Calc.	Bank Stability Calc.
HE-00-00-01	6	10	60	70	0	1	1	0	0	1	3	3	3	1	1.5	1	12.5	Mod to High	24.49	41.24	29.41	58.87	8.33	100.00
HE-00-00-02	7	10	1	70	2	2	4	1	0	1	3	2	2	2	-1.5	3	10.5	Mod	27.69	41.24	35.29	52.52	33.33	77.39
HE-00-00-03	5	11	80	75	3	0	3	0	0	0	1	3	2	2	-1.5	3	9.5	Mod	30.50	45.22	23.53	52.52	25.00	71.19
HE-00-00-04	7	8	25	75	3	3	6	0	0	0	3	2	2	1	0	3	11	Mod	43.39	45.22	35.29	65.23	50.00	60.23
HE-00-00-05	8	7	25	75	1	0	1	0	0	0	3	2	2	1	0	3	11	Mod	41.55	45.22	41.18	71.58	8.33	90.28
HE-00-00-07	6	6	30	70	3	1	4	0	0	1	3	2	2	2	0	2	11	Mod	27.69	41.24	29.41	46.17	33.33	70.05
HE-00-00-08	6	5	40	80	1	2	3	0	0	0	3	3	2	1	0	1	10	Mod	33.05	49.49	29.41	46.17	25.00	96.12
HE-00-00-09	7	8	60	65	0	0	0	0	0	0	2	3	2	1	-1.5	3	9.5	Mod	36.50	37.43	35.29	52.52	0.00	95.55
HE-00-00-11	7	6	40	70	2	1	3	0	0	1	3	3	3	1	-1.5	3	11.5	Mod	43.39	41.24	35.29	58.87	25.00	64.89
HE-00-00-12	12	8	30	55	1	1	2	0	0	1	2	2	2	1	0	1	8	Low to Mod	41.55	30.16	64.71	65.23	16.67	93.24
HE-00-00-13	11	9	30	40	0	0	0	0	0	0	3	2	2	1	0	2	10	Mod	53.72	19.42	58.82	71.58	0.00	100.00
HE-00-00-14	9	7	30	70	0	0	0	0	0	1	2	2	1	1	0	2	8	Low to Mod	37.57	41.24	47.06	46.17	0.00	100.00
HE-00-00-15	7	4	65	50	2	1	3	0	0	1	2	2	2	1	1.5	3	11.5	Mod	35.39	26.59	35.29	52.52	25.00	100.00
HE-00-00-16	8	10	50	15	2	0	2	0	0	1	3	1	3	1	-1.5	3	9.5	Mod	36.50	0.00	41.18	58.87	16.67	86.23
HE-01-00-01	6	5	25	40	1	0	1	0	0	1	3	3	3	1	0	3	13	Mod to High	30.50	19.42	29.41	33.47	8.33	92.65
HE-01-00-06	9	9	20	35	0	1	1	0	0	1	3	3	3	3	0	3	15	High	43.39	15.75	47.06	33.47	8.33	100.00
HE-01-00-02	2	5	50	20	3	1	4	1	0	1	3	3	3	2	0	3	14	High	37.57	3.69	5.88	33.47	33.33	78.33
HE-01-00-03	1	3	85	20	0	3	3	0	0	1	3	3	3	2	0	3	14	High	37.57	3.69	0.00	46.17	25.00	68.36
HE-01-00-04	7	8	50	70	2	1	3	0	0	1	3	2	2	1	0	3	11	Mod	58.48	41.24	35.29	46.17	25.00	83.51
HE-01-00-05	8	6	40	50	1	1	2	0	0	1	2	1	3	1	-1.5	3	8.5	Mod	59.77	26.59	41.18	46.17	16.67	94.21
HE-01-01-01	2	2	80	4	0	1	1	0	0	1	3	3	3	2	0	3	14	High	46.83	0.00	5.88	39.82	8.33	90.28
HE-01-01-02	2	5	80	10	2	0	2	0	0	1	3	3	3	2	-1.5	3	12.5	Mod to High	40.59	0.00	5.88	39.82	16.67	93.43
HE-02-00-01	3	0	100	85	0	0	0	0	0	1	2	1	2	1	0	2	8	Low to Mod	46.83	54.18	11.76	14.42	0.00	100.00
HE-03-00-01	0	0	100	75	0	0	0	0	0	0	2	1	2	1	0	1	7	Low	48.46	45.22	0.00	8.06	0.00	100.00
HE-05-00-01	1	0	100	90	0	0	0	1	0	1	3	2	3	1	0	1	10	Mod	30.50	59.59	0.00	14.42	0.00	100.00
HE-06-00-01	1	1	5	90	0	0	0	0	0	0	3	2	2	2	0	1	10	Mod	33.05	59.59	0.00	14.42	0.00	100.00
HE-06-00-02	6	6	5	70	3	1	4	1	0	0	3	2	2	1	0	1	9	Mod	41.55	41.24	29.41	46.17	33.33	100.00
HE-07-00-01	1	1	70	65	3	0	3	1	0	1	3	3	3	1	0	3	13	Mod to High	46.83	37.43	0.00	20.77	25.00	67.87
HE-07-00-02	2	4	35	60	0	0	0	0	0	1	2	2	2	1	0	3	10	Mod	39.61	33.76	5.88	27.12	0.00	88.47
HE-07-00-03	7	10	40	70	1	1	2	1	0	1	3	2	2	1	0	2	10	Mod	41.55	41.24	35.29	52.52	16.67	89.56
HE-07-01-01	2	2	40	60	0	0	0	0	0	1	3	3	3	1	0	3	13	Mod to High	35.39	33.76	5.88	27.12	0.00	100.00
HE-07-01-02	3	5	65	70	1	0	1	0	0	1	3	3	3	1	0	3	13	Mod to High	45.15	41.24	11.76	33.47	8.33	92.65
HE-08-00-01	4	9	35	90	0	0	0	1	0	0	3	3	2	2	0	2	12	Mod to High	33.05	59.59	17.65	39.82	0.00	32.90
HE-08-00-02	6	7	50	60	2	2	4	1	0	1	2	3	2	2	0	3	12	Mod to High	33.05	33.76	29.41	46.17	33.33	78.46
HE-08-00-03	6	10	50	65	0	0	0	0	0	1	3	3	3	1	0	3	13	Mod to High	41.55	37.43	29.41	65.23	0.00	93.63
HE-09-00-01	1	1	100	90	0	0	0	0	0	1	3	3	3	2	1.5	1	13.5	Mod to High	46.83	59.59	0.00	14.42	0.00	76.99
HE-10-00-01	6	0	90	40	0	1	1	0	0	1	3	2	3	2	0	1	11	Mod	30.50	19.42	29.41	33.47	8.33	96.88
HE-10-00-02	11	6	25	80	0	0	0	0	0	0	3	2	2	1	0	1	9	Mod	37.57	49.49	58.82	77.93	0.00	100.00
HE-11-00-01	3	3	40	30	1	1	2	0	0	1	2	2	1	2	0	3	10	Mod	43.39	11.95	11.76	20.77	16.67	99.13
HE-12-00-01	2	0	80	85	0	0	0	0	0	1	2	3	3	2	-1.5	2	10.5	Mod	39.61	54.18	5.88	20.77	0.00	97.26
HE-04-00-01	1	0	100	80	0	0	0	0	0	0	3	2	3	1	0	3	12	Mod to High	46.83	49.49	0.00	8.06	0.00	94.59
HW-00-00-11	2	0	0	20	0	0	0	0	0	0					0		0		35.39	3.69	5.88	8.06	0.00	100.00
HW-00-00-01	12	10	1	5	3	0	3	0	0	0	3	2	3	1	-1.5	1	8.5	Mod	35.39	0.00	64.71	71.58	25.00	100.00
HW-00-00-02	10	8	30	0	1	2	3	0	0	1	2	3	2	1	0	3	11	Mod	50.02	0.00	52.94	58.87	25.00	79.51
HW-00-00-03	7	10	20	5	0	0	0	0	0	1	3	3	3	1	0	3	13	Mod to High	35.39	0.00	35.29	71.58	0.00	100.00
HW-00-00-04	15	12	60	10	0	1	1	0	0	1	3	3	3	1	0	1	11	Mod	46.83	0.00	82.35	90.63	8.33	99.06
HW-00-00-05	10	7	5	35	0	0	0	0	0	0	3	3	3	2	1.5	3	15.5	High	27.69	15.75	52.94	84.28	0.00	100.00
HW-00-00-06	8	12	50	0	0	0	0	0	0	0	3	2	3	1	0	3	12	Mod to High	53.00	0.00	41.18	71.58	0.00	100.00
HW-00-00-07	14	12	40	0	0	0	0	0	0	1	2	2	2	1	-1.5	2	7.5	Low	71.29	0.00	76.47	84.28	0.00	93.51
HW-00-00-08	7	11	20	5	0	0	0	0	0	1	3	3	3	1	0	3	13	Mod to High	63.46	0.00	35.29	58.87	0.00	91.87
HW-00-00-09	13	13	40	45	0	0	0	0	0	1	3	3	3	1	-1.5	3	11.5	Mod	41.55	23.03	70.59	77.93	0.00	100.00
HW-00-00-10	7	12	15	25	1	1	2	0	0	0	2	2	3	1	0	2	10	Mod	46.83	7.96	35.29	65.23	16.67	100.00
HW-01-00-01	7	8	50	60	2	1	3	0	0	0	2	2	2	1	0	3	10	Mod	50.02	33.76	35.29	77.93	25.00	97.82
HW-02-00-01	5	4	35	45	1	0	1	0	0	1	3	3	3	2	-1.5	3	12.5	Mod to High	51.54	23.03	23.53	46.17	8.33	76.32
HW-03-00-02	1	2	75	50	3	0	3	1	0	1	3	3	3	3	0	3	15	High	58.48	26.59	0.00	20.77	25.00	85.90
HW-03-01-01	1	1	80	70	0	0	0	0	0	1	3	3	3	2	-1.5	3	12.5	Mod to High	61.02	41.24	0.00	14.42	0.00	69.76
HW-04-00-01	12	12	10	75	0	0	0	0	0	0	3	3	3	1	0	2	12	Mod to High	43.39	45.22	64.71	71.58	0.00	91.59
HW-04-00-02	13	8	10	40	0	1	1	1	0	1	2	2	2	1	0	2	9	Mod	33.05	19.42	70.59	71.58	8.33	100.00
HW-05-00-01	3	3	10	50	0	0	0	0	0	1	2	2	2	1	0	1	8	Low to Mod	48.46	26.59	11.76	20.77	0.00	64.89
HW-05-00-02	1	2	45	0	0	0	0	0	0	1	3	3	2	1	0	2	11	Mod	46.83	0.00	0.00	20.77	0.00	90.68
HW-05-00-03	5	8	80	50	2	0	2	0	0	1	3	3	3	1	0	3	13	Mod to High	51.54	26.59	23.53	39.82	16.67	90.68
HW-06-00-01	10	8	50	75	0	0	0	0	0	1	3	3	3	1	0	2	12	Mod to High	33.05	45.22	52.94	84.28	0.00	100.00
HW-06-00-02	8	7	60	65	0	1	1	1	0	1	3	2	2	1	0	2	10	Mod	33.05	37.43	41.18	65.23	8.33	100.00
HW-06-00-03	1	1	0	15	0	0	0	1	0	1	3	3	3	1	0	2	12	Mod to High	27.69	0.00	0.00	14.42	0.00	100.00
HW-06-00-04	10	2	20	10	0	0	0	0	0	0	3	1	3	1	0	2	10	Mod	27.69	0.00	52.94	14.42	0.00	100.00

Reach	Riffle Quality Calc.	Embeddness Calc.	PHI	Habitat Rating	Lt Eroded Area	Rt Eroded Area	Eroded Area/Reach Length	Measure 1: Stream Restoration	Buffer Enhancement Recommende	Measure 2: Buffer Enhancement	Measure 3: Bank Planting	Meaure 4: Utility Conflict Resolution	Measure 5: Wetland Enhancement	Measure 6: Trash Cleanup	Measure 7: Yard Waste Cleanup	Unstable Stable Ratio > 25%	Eroded Area/Reach Length > 2.0	Stream Stabilization Recommende	Measure 8: Invasive Species	Total No of Recommended Measures	Total Cost	Comments
HE-00-00-01	91.65	44.44	49.81	Fair	222.00	0.00	0.27	0	0	0	1	0	0	1	0	0	0	0	1	3	$20,500	
HE-00-00-02	91.65	100.00	57.39	Fair	1,968.00	2,395.00	2.23	1	0	0	1	0	0	1	1	0	1	1	0	4	$451,000	
HE-00-00-03	96.74	22.22	45.87	Fair	664.20	306.00	2.48	1	0	0	0	0	0	0	0	1	1	0	0	1	$156,718	
HE-00-00-04	81.47	83.33	58.02	Fair	760.00	1,240.00	2.46	1	0	0	0	0	0	1	0	1	1	1	1	3	$193,524	Roadside stabilization is
HE-00-00-05	76.38	83.33	57.23	Fair	600.00	0.00	2.31	1	0	0	0	0	0	0	0	1	1	1	1	2	$109,049	
HE-00-00-07	71.28	77.78	49.62	Fair	350.00	476.00	1.31	1	0	0	1	0	0	0	0	1	0	1	0	2	$197,067	
HE-00-00-08	66.19	66.67	51.51	Fair	375.00	0.00	1.68	1	0	0	0	0	0	0	0	1	0	0	0	1	$89,449	
HE-00-00-09	81.47	44.44	47.90	Fair	195.00	120.00	0.53	1	0	0	0	0	0	0	0	0	0	1	0	1	$178,195	
HE-00-00-11	71.28	66.67	50.83	Fair	1,825.00	444.00	1.85	1	0	0	1	0	0	1	0	0	0	1	0	3	$286,743	
HE-00-00-12	81.47	77.78	58.85	Fair	375.00	0.00	0.63	1	0	0	1	0	0	0	0	0	0	1	0	2	$186,557	enhancement and bank planting
HE-00-00-13	86.56	77.78	58.49	Fair	0.00	38.50	0.08	0	0	0	0	0	0	1	0	0	0	0	0	1	$500	
HE-00-00-14	76.38	77.78	53.27	Fair	277.50	300.00	0.47	0	0	0	1	0	0	1	0	0	0	0	0	2	$10,500	
HE-00-00-15	61.10	38.89	46.85	Fair	1,155.00	1,035.00	2.02	1	0	0	1	0	0	1	0	0	1	1	0	3	$254,211	
HE-00-00-16	91.65	55.56	48.33	Fair	160.00	910.00	4.43	1	0	0	1	0	0	1	0	1	1	1	0	3	$102,029	
HE-01-00-01	66.19	83.33	45.41	Fair	260.00	227.50	1.53	1	0	0	1	0	0	1	0	0	0	1	0	3	$133,339	
HE-01-00-06	86.56	88.89	52.93	Fair	160.00	0.00	0.24	1	0	0	1	0	0	1	0	0	0	1	0	3	$210,828	concrete lined for meander bend
HE-01-00-02	66.19	55.56	39.25	Poor	1,200.00	3,465.00	2.68	1	0	0	1	0	0	1	1	0	1	0	0	4	$402,726	
HE-01-00-03	56.01	16.67	31.68	Poor	1,080.00	730.00	2.23	1	0	0	1	0	0	0	0	1	1	1	0	2	$192,295	
HE-01-00-04	81.47	55.56	53.34	Fair	3,139.00	340.00	3.38	1	0	0	1	0	0	1	0	0	1	1	0	3	$242,250	
HE-01-00-05	71.28	66.67	52.82	Fair	1,102.50	760.00	2.34	1	0	0	1	0	0	1	0	1	1	1	0	3	$247,093	one large debris jam; photo taken
HE-01-01-01	50.91	22.22	33.04	Poor	580.00	1,182.50	3.09	1	0	0	1	0	0	0	0	1	1	1	0	2	$178,621	there is extensive bank erosion. Bank
HE-01-01-02	66.19	22.22	35.60	Poor	400.00	105.00	1.83	1	0	0	1	0	0	1	0	0	0	1	0	3	$115,955	near stream looks wet, so there is
HE-02-00-01	40.73	0.00	33.49	Poor	0.00	0.00	0.00	0	0	0	1	0	0	0	0	0	0	0	1	2	$20,000	
HE-03-00-01	40.73	0.00	30.31	Poor	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	1	1	$7,500	US BITUMINOUS LINED CHANNELS
HE-05-00-01	40.73	0.00	30.65	Poor	100.00	0.00	0.08	0	0	0	1	0	0	1	1	0	0	0	1	4	$21,000	
HE-06-00-01	45.82	100.00	44.11	Fair	0.00	87.50	0.30	0	0	0	0	0	0	0	0	0	0	0	1	1	$5,000	
HE-06-00-02	71.28	100.00	57.87	Fair	108.00	35.00	0.31	0	0	0	0	0	0	0	1	0	0	0	1	2	$8,000	
HE-07-00-01	45.82	33.33	34.63	Poor	1,925.00	795.50	3.55	1	0	0	1	0	0	1	1	1	1	1	1	5	$245,579	
HE-07-00-02	61.10	72.22	41.02	Poor	652.50	60.00	1.22	1	0	0	1	0	0	0	0	0	0	1	0	2	$183,112	
HE-07-00-03	91.65	66.67	54.39	Fair	819.00	951.50	2.05	1	0	0	1	0	0	1	1	0	1	0	0	4	$205,145	
HE-07-01-01	50.91	66.67	39.97	Poor	120.00	87.50	0.51	1	0	0	1	0	0	1	0	0	0	1	1	4	$137,633	
HE-07-01-02	66.19	38.89	42.21	Fair	0.00	487.50	1.95	1	0	0	1	0	0	0	0	1	0	1		2	$105,245	retaining wall protecting private yard
HE-08-00-01	86.56	72.22	42.72	Fair	2,455.00	2,000.00	3.93	1	0	0	0	0	0	1	1	1	1	1	1	4	$266,278	
HE-08-00-02	76.38	55.56	48.26	Fair	1,128.00	966.00	2.07	1	0	0	1	0	0	1	1	0	1	1	1	5	$248,114	
HE-08-00-03	91.65	55.56	51.81	Fair	278.00	324.00	1.00	0	0	0	1	0	0	0	0	0	0	0	0	1	$7,500	
HE-09-00-01	45.82	0.00	30.46	Poor	270.00	495.00	2.43	1	1	1	1	0	1	0	0	1	1	1	1	5	$165,918	
HE-10-00-01	40.73	11.11	33.73	Poor	40.00	272.00	0.39	0	0	0	1	0	0	1	0	0	0	0	1	3	$15,500	
HE-10-00-02	71.28	83.33	59.80	Fair	180.00	20.00	0.36	0	0	0	0	0	0	1	0	0	0	0	0	1	$500	
HE-11-00-01	56.01	66.67	40.79	Poor	270.00	40.00	1.65	1	0	0	1	0	0	0	0	0	0	1	0	2	$80,030	
HE-12-00-01	40.73	22.22	35.08	Poor	270.00	0.00	1.51	1	0	0	1	0	0	0	0	1	0	1	0	2	$76,479	
HE-04-00-01	40.73	0.00	29.96	Poor	230.00	110.00	1.65	1	0	0	0	0	0	0	0	1	0	1	0	1	$82,571	
HW-00-00-11	40.73	100.00	36.72	Poor	142.50	0.00	0.30	0	0	0	0	0	0	0	0	0	0	0	0	0	$0	
HW-00-00-01	91.65	100.00	61.04	Fair	78.00	90.00	0.50	0	0	0	0	0	0	1	0	0	0	0	0	1	$500	
HW-00-00-02	81.47	77.78	53.20	Fair	592.00	765.00	1.52	1	0	0	1	0	0	0	0	1	0	0	0	2	$210,711	
HW-00-00-03	91.65	88.89	52.85	Fair	65.00	85.50	0.10	0	0	0	1	0	0	0	0	0	0	0	0	1	$10,000	
HW-00-00-04	100.00	44.44	58.96	Fair	174.00	24.00	0.36	0	0	0	1	0	0	0	0	0	0	0	0	1	$7,500	
HW-00-00-05	76.38	100.00	57.13	Fair	168.00	30.00	0.97	1	0	0	0	0	0	0	0	0	0	1	0	1	$81,920	
HW-00-00-06	100.00	55.56	52.66	Fair	81.00	552.00	0.78	1	0	0	0	0	0	0	0	0	0	1	0	1	$182,807	
HW-00-00-07	100.00	66.67	61.53	Fair	204.00	205.00	1.36	1	0	0	1	0	0	0	0	1	0	0	0	2	$125,119	
HW-00-00-08	96.74	88.89	54.39	Fair	950.00	1,500.00	1.42	1	0	0	1	0	0	0	0	0	0	1	0	2	$396,936	
HW-00-00-09	100.00	66.67	59.97	Fair	589.00	315.00	0.97	1	0	0	1	0	0	0	0	0	0	1	0	2	$220,241	
HW-00-00-10	100.00	94.44	58.30	Fair	324.00	364.00	0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	$0	
HW-01-00-01	81.47	55.56	57.11	Fair	620.00	560.00	1.49	1	0	0	0	0	0	0	0	0	0	1	0	1	$237,799	outfall at top of stream requires work
HW-02-00-01	61.10	72.22	45.28	Fair	3,815.00	1,700.00	3.31	1	0	0	1	0	0	0	0	1	1	1	0	2	$385,346	4 exposed manholes, smell of trash d/s of cross section
HW-03-00-02	50.91	27.78	36.93	Poor	328.00	576.00	1.91	1	0	0	1	0	0	0	1	0	0	1	0	3	$150,053	
HW-03-01-01	45.82	22.22	31.81	Poor	1,464.00	1,335.00	5.80	1	0	0	1	0	0	0	0	1	1	1	1	3	$159,752	
HW-04-00-01	100.00	100.00	64.56	Fair	357.00	385.00	1.19	1	0	0	0	0	0	0	0	0	0	1	0	1	$187,525	
HW-04-00-02	81.47	100.00	60.56	Fair	1,215.00	78.00	1.15	1	0	0	1	0	0	0	1	0	0	1	0	3	$263,121	
HW-05-00-01	56.01	100.00	41.06	Poor	550.00	360.00	3.93	1	1	1	1	0	1	0	0	1	1	1	0	4	$127,650	head cut_wetland at top of reach
HW-05-00-02	50.91	61.11	33.79	Poor	220.00	220.00	2.02	1	0	0	1	0	0	0	0	1	1	0	0	2	$92,044	RANDOM CULVERTS NO E&S
HW-05-00-03	81.47	22.22	44.06	Fair	124.00	80.00	0.20	0	0	0	1	0	0	0	0	0	0	0	0	1	$10,000	
HW-06-00-01	81.47	55.56	56.56	Fair	520.00	725.00	1.07	1	0	0	1	0	0	0	0	0	0	1	1	3	$281,458	
HW-06-00-02	76.38	44.44	50.75	Fair	90.00	204.00	0.90	0	0	0	1	0	0	0	1	0	0	0	0	2	$5,500	
HW-06-00-03	45.82	100.00	35.99	Poor	0.00	0.00	0.00	0	0	0	1	0	0	0	1	0	0	0	0	2	$5,500	
HW-06-00-04	50.91	88.89	41.86	Poor	45.00	0.00	0.13	0	0	0	0	0	0	0	0	0	0	0	0	0	$0	

Reach	Length	Subshed	Team	Date	FlowRegime	Bankfull Depth	Max Bankfull Depth	Sinuosity	Meander Pattern	Depositional Features	Channel Stability V	Channel Stability L	Left Unstable Bank Length	Left Unstable Bank Height	Right Unstable Bank Length	Unstable-Stable Ratio	Right Unstable Bank Height
HW-06-00-05	1899	HERRING RUN	SC & MH	4/20/2007 8:23	Perennial	1	1.6	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Degrading	375	7.5	485	22.65%	5
HW-06-00-06	1032	HERRING RUN	SC & MH	5/2/2007 15:33	Perennial	1.6	2.1	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Degrading	195	3.75	110	14.78%	4
HW-06-00-07	260	HERRING RUN	SC & MH	4/20/2007 9:18	Perennial	1.4	1.7	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Degrading	180	4	90	51.96%	6
HW-06-01-01	786	HERRING RUN	SC AZ MH	5/8/2007 14:04	Perennial	1.2	1.6	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Degrading	Degrading	165	2.5	180	21.94%	3
HW-06-02-01	251	HERRING RUN	SC AZ MH	5/8/2007 11:26	Perennial	0.9	1.1	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	10	1.99%	1
HW-06-03-01	710	HERRING RUN	SC AZ MH	5/2/2007 15:15	Perennial	1.2	1.4	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Degrading	310	2	255	39.80%	2.5
HW-06-04-01	535	HERRING RUN	SC & MH	4/20/2007 8:26	Perennial	1.1	1.6	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	50	2	30	7.47%	2
HW-08-00-01	322	HERRING RUN	SC & CMG	4/25/2007 13:55	Intermittent	1.6	2.1	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Degrading	155	8	201	55.24%	8
SR-00-00-01	757	STEMMERS RUN	CRG\AZ	6/19/2007 9:34	Perennial	0.8	0.9	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Stable	Degrading	150	3	287	28.85%	3.5
SR-00-00-02	1470	STEMMERS RUN	CRG\AZ	6/19/2007 10:55	Perennial	0.9	1.4	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Stable	Degrading	429	3	340	26.17%	4
SR-00-00-03	1015	STEMMERS RUN	CRG\AZ	6/19/2007 8:05	Perennial	0.8	1.1	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Stable	Aggrading	462	3	284	36.75%	4
SR-00-00-04	998	STEMMERS RUN	CRG\AZ	6/19/2007 7:40	Perennial	1.2	1.6	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Stable	Degrading	345	4	276	31.12%	5
SR-00-00-05	343	STEMMERS RUN	CRG\AZ	6/12/2007 14:04	Perennial	1.1	1.3	Moderate, 1.2 to 1.5	M1, Regular	B1, Point Bars	Stable	Stable	32	4	60	13.42%	4
SR-00-00-06	406	STEMMERS RUN	CRG\AZ	6/12/2007 11:25	Perennial	1.1	5	Low, 1.0 to 1.2	M1, Regular	B4, Side Bars	Stable	Stable	60	1	78	16.97%	4
SR-00-00-07	593	STEMMERS RUN	CRG\AZ	6/12/2007 12:04	Perennial	1.8	1.9	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Stable	Stable	0	0	110	9.28%	5
SR-00-00-08	1548	STEMMERS RUN	CRG\AZ	6/12/2007 10:31	Perennial	1.2	1.5	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Stable	Stable	498	4	190	22.22%	4
SR-00-00-09	966	STEMMERS RUN	CRG\AZ	6/12/2007 9:56	Perennial	1	1.3	Moderate, 1.2 to 1.5	M3, Irregular	3, Many Mid Ba	Stable	Stable	30	6	49	4.09%	8
SR-00-00-10	1038	STEMMERS RUN	CRG\AZ	6/12/2007 9:24	Perennial	0.9	1.1	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Stable	Stable	102	7	154	12.33%	4
SR-00-00-11	1558	STEMMERS RUN	CRG\AZ	6/12/2007 8:22	Perennial	1.1	1.4	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Stable	Stable	90	7	56	4.68%	3
SR-00-00-12	357	STEMMERS RUN	JML/MJM	6/12/2007 14:17	Perennial	1.65	2	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Stable	45	5	52	13.58%	5
SR-00-00-13	823	STEMMERS RUN	JML\MJM	6/12/2007 13:20	Perennial	2.5	3.4	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Stable	202	6	90	17.74%	9
SR-00-00-14	1988	STEMMERS RUN	JML/MJM	6/12/2007 11:24	Perennial	2	3.1	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Stable	Degrading	365	5	343	17.81%	6.5
SR-00-00-15	752	STEMMERS RUN	JML/MJM	6/5/2007 16:12	Perennial	1.75	2.05	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Degrading	300	6.5	243	36.09%	4.7
SR-00-00-16	427	STEMMERS RUN	JML/RM	6/5/2007 11:34	Perennial	2.7	3.2	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Stable	0	0	24	2.81%	5
SR-00-00-17	383	STEMMERS RUN	CRG\AZ	6/26/2007 8:47	Perennial	1.2	1.8	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Degrading	Stable	44	10	80	16.18%	10
SR-00-00-18	1028	STEMMERS RUN	CRG\AZ	6/26/2007 9:27	Perennial	1.2	1.6	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Aggrading	Stable	180	7	132	15.18%	7
SR-00-00-19	1318	STEMMERS RUN	CRG\AZ	5/29/2007 14:08	Perennial	0.6	0.8	Low, 1.0 to 1.2	M3, Irregular	nt Bars w\Few M	Aggrading	Stable	72	1	120	7.28%	3
SR-01-00-01	461	STEMMERS RUN	CRG\AZ	6/5/2007 8:23	Perennial	0.8	1	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Stable	280	2	416	75.42%	3.5
SR-01-00-02	1088	STEMMERS RUN	CRG\AZ	6/5/2007 9:19	Perennial	0.5	0.7	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Degrading	Stable	172	3	272	20.41%	3.5
SR-02-00-01	238	STEMMERS RUN	RM CRG	5/22/2007 8:29	Intermittent	0.45	0.65	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Stable	0	0	0	0.00%	0
SR-02-00-02	726	STEMMERS RUN	RM CRG	5/21/2007 19:12	Perennial	0.9	1.1	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Degrading	Stable	157	6	210	25.29%	6
SR-02-00-03	454	STEMMERS RUN	RM CRG	5/22/2007 10:14	Perennial	0.375	0.45	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Aggrading	Stable	64	6	56	13.22%	6
SR-02-00-04	706	STEMMERS RUN	CRG\AZ	5/22/2007 14:45	Perennial	0.6	0.8	Low, 1.0 to 1.2	M3, Irregular	nt Bars w\Few M	Aggrading	Stable	66	3	70	9.63%	4.5
SR-02-00-05	1406	STEMMERS RUN	CRG\RM	5/22/2007 12:39		0.9	1.2	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Aggrading	Stable	0	0	0	0.00%	0
SR-02-00-06	332	STEMMERS RUN	CRG\AZ	5/29/2007 14:39	Perennial	0.8	0.9	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	60	1	0	9.05%	0
SR-02-01-01	872	STEMMERS RUN	CRG\AZ	5/29/2007 8:35	Intermittent	4	5	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
SR-02-02-01	337	STEMMERS RUN	RM CRG	5/22/2007 11:45	Intermittent	0.55	0.7	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Aggrading	Stable	0	0	40	5.94%	9
SR-03-00-01	314	STEMMERS RUN	CRG\AZ	5/29/2007 13:43	Intermittent	0.3	0.5	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
SR-04-00-01	268	STEMMERS RUN	CRG\AZ	5/29/2007 12:48	Intermittent	0.6	1	Moderate, 1.2 to 1.5	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
SR-05-00-01	1017	STEMMERS RUN	CRG\AZ	6/5/2007 14:35	Perennial	0.75	0.9	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Stable	304	4	410	35.09%	4
SR-05-00-02	397	STEMMERS RUN	CRG\AZ	6/5/2007 14:04	Perennial	0.5	0.9	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Aggrading	Degrading	128	6	130	32.50%	3
SR-05-00-03	222	STEMMERS RUN	CRG\AZ	6/5/2007 13:42	Perennial	0.6	0.8	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Stable	132	2	142	61.59%	1
SR-05-00-04	857	STEMMERS RUN	CRG\AZ	6/5/2007 11:13	Perennial	1.4	1.5	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Aggrading	Degrading	422	5	474	52.26%	5
SR-06-00-01	598	STEMMERS RUN	JML/RM	6/5/2007 10:48	Intermittent	0.5	0.55	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Degrading	30	4	48	6.52%	5
SR-06-00-02	767	STEMMERS RUN	JML/RM	6/5/2007 9:40	Perennial	0.8	1.1	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Degrading	36	3.5	90	8.21%	3
SR-06-00-03	970	STEMMERS RUN	JML/RM	6/5/2007 11:36	Perennial	0.375	0.5	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Stable	Degrading	220	3	138	18.45%	3
SR-06-01-01	1880	STEMMERS RUN	JML/RM	6/5/2007 9:18	Perennial	0.45	0.55	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Stable	Degrading	276	3	385	17.58%	3
SR-07-00-01	268	STEMMERS RUN	JML/MJM	6/12/2007 15:43	Perennial	1	1.15	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	15	2.80%	0.5
SR-07-00-02	833	STEMMERS RUN	JML\MJM	6/12/2007 14:17	Perennial	0.65	1.1	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Stable	Degrading	160	2.3	236	23.77%	3
SR-07-01-01	385	STEMMERS RUN	JML/MJM	6/12/2007 16:06	Perennial	1	1.25	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	75	3.5	133	27.01%	2.25
SR-08-01-01	707	STEMMERS RUN	CRG\AZ	6/19/2007 13:47	Perennial	1.6	2	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Stable	89	2	105	13.73%	1
SR-08-02-01	1458	STEMMERS RUN	CRG\AZ	6/19/2007 8:34	Intermittent	1	1.5	Moderate, 1.2 to 1.5	M3, Irregular	None	Stable	Degrading	518	5	660	40.41%	4
SR-09-00-01	670	STEMMERS RUN	CRG\AZ	6/19/2007 7:52	Intermittent	0.3	0.4	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	27	2	0	2.01%	0
SR-10-00-06	916	STEMMERS RUN	JML/MJM	6/19/2007 11:29	Perennial	0.7	1.3	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Stable	Degrading	475	3.5	229	38.43%	7
SR-10-00-01	656	STEMMERS RUN	JML/MJM	6/19/2007 10:34	Perennial	1.65	1.95	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Degrading	280	5	90	28.20%	4.25
SR-10-00-02	698	STEMMERS RUN	JML-MJM	6/19/2007 9:21	Perennial	1.5	2	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Degrading	550	6	217	54.91%	5.5
SR-10-00-03	523	STEMMERS RUN	JML-MJM	6/19/2007 15:17	Perennial	1.1	1.3	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Degrading	305	6	140	42.51%	4.5
SR-10-00-04	228	STEMMERS RUN	JML/MJM	6/19/2007 12:32	Perennial	0.9	1.1	Moderate, 1.2 to 1.5	M1, Regular	B1, Point Bars	Stable	Degrading	60	5	90	32.95%	6
SR-10-00-05	913	STEMMERS RUN	JML/MJM	6/19/2007 13:58	Perennial	0.5	1.2	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Stable	Degrading	256	5	324	31.75%	3.5
SR-10-01-01	864	STEMMERS RUN	JML/MJM	6/19/2007 8:38	Perennial	0.9	1.15	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Degrading	620	3.75	378	57.75%	4
SR-10-02-01	1020	STEMMERS RUN	MJM/RM	7/3/2007 10:00	Perennial	1.05	1.2	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Stable	Degrading	220	3.25	285	24.77%	3
SR-10-02-02	311	STEMMERS RUN	JML/MJM	6/19/2007 14:48	Perennial	0.9	1	Low, 1.0 to 1.2	M1, Regular	None	Stable	Stable	39	2.5	75	18.31%	3.5
SR-10-02-03	363	STEMMERS RUN	MJM/RM	7/3/2007 7:02	Intermittent	0.6	0.8	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Degrading	80	4	70	20.64%	4.25
SR-10-02-04	615	STEMMERS RUN	MJM/RM	7/3/2007 8:38	Perennial	1.05	1.2	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Degrading	Degrading	160	4	310	38.23%	4
SR-11-00-01	352	STEMMERS RUN	CRG\AZ	6/12/2007 11:09	Intermittent	0.1	0.2	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0

Reach	Bank Bankfull Ratio	Bank Angle	Bank Material	Root Density	Debris Blockages	Leaking Utility	Exposed MH Riser	Left Bank Riparian Width	Right Bank Riparian Width	Left Bank Riparian Comp	Right Bank Riparian Comp	Bedrock Outcrop	Left Bank Riparian Density	Right Bank Riparian Density
HW-06-00-05	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Cobbley	High, Minimal Roots	Moderate	0	1	100	80	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Low	Low
HW-06-00-06	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	Cobbley	High, Minimal Roots	Moderate	0	0	100	70	Decid w\Brush-Grass Under	Grass and Forbs	1	Moderate	Low
HW-06-00-07	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Infrequent	0	1	100	35	Decid w\Brush-Grass Under	Grass and Forbs	0	Moderate	Low
HW-06-01-01	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Numerous	0	1	100	25	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Low
HW-06-02-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout		0	0	100	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Low
HW-06-03-01	Low, BF at Top of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Infrequent	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
HW-06-04-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	65	30	Decid w\Brush-Grass Under	Grass and Forbs	0	Moderate	Low
HW-08-00-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Infrequent	0	1	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-00-00-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	30	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-00-00-02	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	1	100	30	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-00-00-03	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-00-00-04	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	1	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-00-00-05	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	80	70	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-00-00-06	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout	None	0	0	40	40	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-00-00-07	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	50	40	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-00-00-08	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	80	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-00-00-09	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	75	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-00-00-10	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	50	75	Decid w\Brush-Grass Under	Brush	1	Low	Low
SR-00-00-11	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Infrequent	0	0	25	75	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-00-00-12	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	Cobbley	Med, Dense Roots Upper 1/2 Bank	None	0	0	20	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Low	Moderate
SR-00-00-13	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	1	100	20	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	High	Moderate
SR-00-00-14	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	1	0	100	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	High	Moderate
SR-00-00-15	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	Stratified	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	60	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	Moderate
SR-00-00-16	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	Cobbley	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	20	30	Deciduous Overstory	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-00-00-17	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Infrequent	0	1	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	High
SR-00-00-18	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Infrequent	0	1	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	High
SR-00-00-19	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	35	30	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	High
SR-01-00-01	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	50	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-01-00-02	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Moderate	0	0	70	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-02-00-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	10	30	Brush	Brush	0	Moderate	Moderate
SR-02-00-02	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	50	75	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	High
SR-02-00-03	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	75	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-02-00-04	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	75	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	Moderate
SR-02-00-05	High, BF Lower 1/2 of Bank	High, Undercut Sloping to Strm	None	Low, Dense Roots Throughout	Extensive	0	0	50	25	Forested Wetland	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-02-00-06	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	40	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-02-01-01	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Low, Dense Roots Throughout	Numerous	0	0	75	100	Brush	Brush	0	Moderate	High
SR-02-02-01	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	15	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	High
SR-03-00-01	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout	Infrequent	0	0	15	30	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-04-00-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	High
SR-05-00-01	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	100	80	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-05-00-02	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Moderate	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	High
SR-05-00-03	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	100	Brush	Decid. w\Brush-Grass Understory	0	Low	Moderate
SR-05-00-04	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	High
SR-06-00-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Infrequent	0	0	8	8	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Low
SR-06-00-02	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Cobbley	Low, Dense Roots Throughout	Infrequent	0	0	20	25	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Low
SR-06-00-03	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Extensive	0	1	40	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	High
SR-06-01-01	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	40	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-07-00-01	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout	Moderate	0	0	5	5	Brush	Brush	0	Low	Low
SR-07-00-02	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	1	50	25	Decid w\Brush-Grass Under	Deciduous Overstory	1	Moderate	Moderate
SR-07-01-01	Low, BF at Top of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	25	30	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-08-01-01	Low, BF at Top of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	1	70	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-08-02-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	1	1	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-09-00-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Infrequent	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-10-00-06	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	1	85	90	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-10-00-01	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	Cobbley	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	10	100	Brush	Decid. w\Brush-Grass Understory	1	Moderate	High
SR-10-00-02	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Cobbley	Med, Dense Roots Upper 1/2 Bank	Moderate	0	1	5	55	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-10-00-03	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Cobbley	High, Minimal Roots	Infrequent	0	0	15	100	Brush	Forested Wetland	1	Moderate	High
SR-10-00-04	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank		0	1	60	80	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-10-00-05	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	1	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-10-01-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	100	75	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	High	High
SR-10-02-01	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	Sandy	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	80	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-10-02-02	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	60	10	Decid w\Brush-Grass Under	Brush	0	Moderate	Low
SR-10-02-03	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Sandy	Med, Dense Roots Upper 1/2 Bank	Extensive	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-10-02-04	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	Sandy	Med, Dense Roots Upper 1/2 Bank	Numerous	0	1	50	25	Decid w\Brush-Grass Under	Brush	1	Moderate	Moderate
SR-11-00-01	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout	None	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate

Reach	Channel Mod	Photo Taken	Comment	Private Structure Threatend	Fish Blockage	BF Indicator	Chnl Restoration	Buffer Enhncmnt	Utilility Resol	Habitat Enhcmnt	Bankfull Width	Width Depth Ratio	Substrate	Canopy Cover	Chnl Restoration	Floodprone Width	Entrenchment	Chnl Evol	Channel Slope	Rosgen Class	Succession
HW-06-00-05	0	1	0	0	None	Slope Break	1	1	1	0	39	39	Cobble	25-50%	1	45	1.153846	Stage IV	<2%	F	4
HW-06-00-06	0	1	0	0	None	Slope Break	0	1	0	0	30	18.75	Gravel	10-25%	0	40	1.333333	Stage IV	<2%	F	4
HW-06-00-07	1	1	0	0	Excessive Height	Slope Break	1	1	1	0	28	19.642857	Gravel	10-25%	1	28	1.018182	Stage IV	<2%	F	4
HW-06-01-01	0	1	0	0	Excessive Height	Slope Break	1	1	1	1	15	12.083333	Gravel	25-50%	1	24.5	1.689655	Stage II	<2%	G	5
HW-06-02-01	0	1	0	0	Shallow Depth of Flow	Active Floodplain	0	1	0	1	6	6.666667	Silt	25-50%	0	22	3.666667	Stage I	<2%	E	1
HW-06-03-01	0	1	0	0	Excessive Height	Active Floodplain	1	1	0	1	6	5	Gravel	25-50%	1	55	9.166667	Stage II	<2%	E	5
HW-06-04-01	0	1	0	0	Excessive Height	Slope Break	0	1	0	0	10	8.636364	Silt	25-50%	0	80	8.421053	Stage I	<2%	E	5
HW-08-00-01	0	1	1	0	Excessive Height	Slope Break	1	1	1	0	9	5.3125	Gravel	25-50%	1	10	1.176471	Stage II	2% to 4%	G	7
SR-00-00-01	0	1	0	0	Excessive Height	Erosional Feature	1	1	0	0	6	7.75	Cobble	25-50%	1	9.2	1.483871	Stage III	2% to 4%	G	6
SR-00-00-02	0	1	0	1	Excessive Height	Slope Break	1	0	0	0	15	16.777778	Cobble	25-50%	1	18.6	1.231788	Stage III	2% to 4%	F	6
SR-00-00-03	0	1	0	0	Excessive Height	Slope Break	0	0	0	0	35	44	Gravel	10-25%	0	38.7	1.099432	Stage III	2% to 4%	F	Other
SR-00-00-04	0	1	0	0	None	Active Floodplain	0	0	0	0	25	20.5	Cobble	25-50%	0	100	4.065041	Stage III	2% to 4%	C	9
SR-00-00-05	0	1	0	0	None	Slope Break	0	0	0	0	22	19.545455	Gravel	0-10%	0	100	4.651163	Stage V	2% to 4%	C	9
SR-00-00-06	0	1	0	0	None	Slope Break	0	0	0	0	27	24.181818	Cobble	25-50%	0	30	1.12782	Stage V	2% to 4%	F	6
SR-00-00-07	0	1	0	1	None		0	0	0	0	39	21.666667	Cobble	10-25%	0	100	2.564103	Stage V	<2%	C	4
SR-00-00-08	0	1	0	0	None	Slope Break	0	0	0	0	25	20.833333	Gravel	10-25%	0	100	4	Stage V	2% to 4%	C	9
SR-00-00-09	0	1	0	0	None	Slope Break	0	0	0	0	25	25	Gravel	10-25%	0	36	1.44	Stage V	2% to 4%	F	6
SR-00-00-10	0	1	0	0	None		0	0	0	0	16	18	Cobble	0-10%	0	21.2	1.308642	Stage V	2% to 4%	F	6
SR-00-00-11	0	1	0	0	Debris Blockage	Active Floodplain	0	0	0	0	48	43.818182	Cobble	10-25%	0	69.2	1.435685	Stage V	<2%	F	6
SR-00-00-12	0	1	0	0	None	Slope Break	0	0	0	0	44	26.666667	Gravel	25-50%	0	49	1.113636	Stage I	2% to 4%	F	Other
SR-00-00-13	0	0	0	1	None	Depositional Features	1	0	0	0	34	13.64	Gravel	25-50%	1	200	5.865103	Stage V	<2%	C	Other
SR-00-00-14	0	1	1	1	None	Depositional Features	1	0	1	0	40	19.75	Cobble	25-50%	1	300	7.594937	Stage V	<2%	C	Other
SR-00-00-15	0	1	1	0	None	Active Floodplain	1	1	0	0	32	18	Gravel	25-50%	1	120	3.809524	Stage V	<2%	C	Other
SR-00-00-16	0	1	1	0	None	Slope Break	0	1	0	0	32	11.851852	Cobble	10-25%	0	130	4.0625	Stage V	<2%	C	Other
SR-00-00-17	0	1	0	0	Debris Blockage	Active Floodplain	1	0	0	0	44	36.333333	Gravel	0-10%	1	100	2.293578	Stage II	<2%	C	8
SR-00-00-18	0	1	0	0	Debris Blockage	Erosional Feature	1	0	0	0	43	35.833333	Gravel	10-25%	1	53	1.232558	Stage IV	2% to 4%	F	4
SR-00-00-19	0	1	0	0	Debris Blockage	Slope Break	0	0	0	0	18	30.333333	Gravel	50-75%	0	22.5	1.236264	Stage IV	2% to 4%	B	Other
SR-01-00-01	0	1	0	0	Excessive Height	Slope Break	0	0	0	0	6	6.875	Gravel	50-75%	0	6.8	1.236364	Stage II	2% to 4%	G	6
SR-01-00-02	0	1	0	0	Debris Blockage	Active Floodplain	0	0	0	0	6	11	Gravel	75-100%	0	14.6	2.654545	Stage II	2% to 4%	C	4
SR-02-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	5	11.777778	Gravel	25-50%	0	8.2	1.54717	Stage II	<2%	B	6
SR-02-00-02	0	1	0	0	Debris Blockage		1	0	0	0	11	12.222222	Gravel	50-75%	1	12.4	1.127273	Stage II	<2%	B	Other
SR-02-00-03	0	1	0	0	Debris Blockage	Active Floodplain	1	0	0	0	7	19.733333	Gravel	25-50%	1	22.7	3.067568	Stage IV	<2%	C	4
SR-02-00-04	0	1	0	0	Shallow Depth of Flow	Slope Break	1	0	0	0	12	19.333333	Gravel	50-75%	1	12.9	1.112069	Stage IV	<2%	F	6
SR-02-00-05	0	1	0	0	Excessive Height	Vegetative Feature	1	0	0	0	14	15.888889	Gravel	25-50%	1	16.7	1.167832	Stage IV	<2%	F	5
SR-02-00-06	1	1	0	0	None	Slope Break	0	0	0	0	8	9.75	Gravel	50-75%	0	11.5	1.474359	Stage IV	<2%	G	6
SR-02-01-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	4	0.95	Gravel	75-100%	0	3.7	0.973684	Stage II	<2%	G	7
SR-02-02-01	0	1	0	0	Shallow Depth of Flow	Slope Break	1	0	0	0	9	15.818182	Gravel	25-50%	1	11.2	1.287356	Stage II	2% to 4%	B	4
SR-03-00-01	0	0	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	4	13.666667	Silt	75-100%	0	5.7	1.390244	Stage I	2% to 4%	B	6
SR-04-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	6	10.5	Sand	75-100%	0	9	1.428571	Stage III	<2%	G	7
SR-05-00-01	0	1	0	0	Debris Blockage		0	0	0	0	4	5.866667	Gravel	50-75%	0	8.5	1.931818	Stage III	<2%	E	8
SR-05-00-02	0	1	0	0	Debris Blockage	Active Floodplain	1	0	0	0	7	13	Gravel	50-75%	1	15.3	2.353846	Stage IV	<2%	C	Other
SR-05-00-03	0	1	0	0	Debris Blockage	Slope Break	0	0	0	0	8	13.5	Gravel	25-50%	0	9.5	1.17284	Stage I	<2%	F	6
SR-05-00-04	0	1	0	0	Debris Blockage	Slope Break	1	0	0	0	12	8.714286	Gravel	50-75%	1	14.3	1.172131	Stage IV	2% to 4%	G	6
SR-06-00-01	0	1	1	0	Shallow Depth of Flow	Slope Break	1	1	0	0	4	7.8	Silt	25-50%	1	5	1.282051	Stage III	<2%	G	6
SR-06-00-02	0	1	1	0	Shallow Depth of Flow	Slope Break	1	1	0	0	8	10.25	Gravel	25-50%	1	12.9	1.573171	Stage III	<2%	B	6
SR-06-00-03	0	1	1	0	None	Slope Break	1	0	0	0	8	20	Silt	50-75%	1	8.5	1.133333	Stage III	<2%	F	4
SR-06-01-01	0	1	0	0	None	Active Floodplain	1	1	0	0	6	13.555556	Gravel	50-75%	1	9.4	1.540984	Stage III	2% to 4%	B	6
SR-07-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	1	0	0	5	5.1	Gravel	10-25%	0	8.2	1.607843	Stage III	<2%	G	7
SR-07-00-02	0	0	0	1	Shallow Depth of Flow	Slope Break	1	1	1	0	14	21.076923	Gravel	50-75%	1	17.7	1.291971	Stage IV	<2%	F	9
SR-07-01-01	0	1	0	0	Excessive Height	Slope Break	0	1	0	0	9	9	Gravel	25-50%	0	13.4	1.488889	Stage III	<2%	G	7
SR-08-01-01	0	1	0	0	Excessive Height		0	1	1	0	18	10.9375	Gravel	25-50%	0	28.5	1.628571	Stage I	2% to 4%	B	6
SR-08-02-01	0	1	0	0	Shallow Depth of Flow	Erosional Feature	1	0	1	0	10	10	Gravel	50-75%	1	13.5	1.35	Stage III	> 4%	G	6
SR-09-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	6	18.666667	Silt	25-50%	0	11.5	2.053571	Stage I	2% to 4%	B	6
SR-10-00-06	1	1	0	0	Debris Blockage	Depositional Features	1	0	1	0	22	30.857143	Gravel	75-100%	1	39	1.805556	Stage III	<2%	B	4
SR-10-00-01	1	1	1	0	Excessive Height	Slope Break	1	0	0	0	13	7.818182	Gravel	25-50%	1	18	1.395349	Stage III	2% to 4%	G	6
SR-10-00-02	0	1	1	1		Slope Break	1	0	1	0	18	12.133333	Bedrock	25-50%	1	22	1.208791	Stage III	<2%	F	6
SR-10-00-03	0	1	1	0	Excessive Height	Slope Break	1	0	0	0	13	11.818182	Bedrock	25-50%	1	18	1.384615	Stage III	> 4%	F	Other
SR-10-00-04	0	1	1	0	Shallow Depth of Flow	Depositional Features	1	0	1	0	16	17.333333	Gravel	50-75%	1	25.1	1.608974	Stage III	<2%	B	Other
SR-10-00-05	0	1	0	1	None	Depositional Features	1	0	1	0	17	34.8	Gravel	50-75%	1	28	1.609195	Stage III	<2%	B	Other
SR-10-01-01	0	1	1	0	Debris Blockage	Slope Break	1	0	0	0	8	8.888889	Gravel	50-75%	1	12.5	1.5625	Stage III	2% to 4%	G	6
SR-10-02-01	1	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	10	9.047619	Gravel	50-75%	0	13.9	1.463158	Stage III	<2%	B	Other
SR-10-02-02	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	7	8	Sand	10-25%	0	9.2	1.277778	Stage III	<2%	G	Other
SR-10-02-03	0	1	1	0	Shallow Depth of Flow	Erosional Feature	1	0	0	0	4	7.333333	Gravel	50-75%	1	5.1	1.159091	Stage II	2% to 4%	G	7
SR-10-02-04	1	1	0	0	Shallow Depth of Flow	Slope Break	1	1	1	0	8	7.619048	Gravel	25-50%	1	11.25	1.40625	Stage II	2% to 4%	B	Other
SR-11-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	5	45	Sand	25-50%	0	6	1.333333	Stage I	2% to 4%	B	6

Reach	Surface Protection	Root Depth Bnk HT Ratio	Concrete Lined	Riprap Gabion Lined	Culvert	Culvert Instabilities	Trash Cleanup	Approximate DA (ac)	Dist to Nearest Road (ft)	Dist to Nearest Road (m)	Left Erosion Extent	Left Erosion Extent (m)	Left Erosion Severity	Lt Erosion Severity Conversion	Right Erosion Extent	Right Erosion Extent (m)	Right Erosion Severity	Rt Erosion Severity Conversion	Instream Habitat
HW-06-00-05	High, <30% protection	High, Roots in Upper 1/3	1	1	0		1	10	266.67	81.28	135	41.15	3	2	140	42.67	3	2	8
HW-06-00-06	High, <30% protection	High, Roots in Upper 1/3	0	1	1		0	10	200.00	60.96	45	13.72	1	1	0	0.00	0	0	7
HW-06-00-07	High, <30% protection	High, Roots in Upper 1/3	1	0	0		0	10	177.78	54.19	150	45.72	2	1.5	50	15.24	3	2	7
HW-06-01-01	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		0	10	222.22	67.73	60	18.29	2	1.5	60	18.29	2	1.5	6
HW-06-02-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	1	1		0	10	66.67	20.32	0	0.00	0	0	10	3.05	0	0	4
HW-06-03-01	High, <30% protection	Med, Roots Extend to Middle 1/3	0	1	1	Fish Passage Issu	0	10	200.00	60.96	50	15.24	1	1	40	12.19	1	1	3
HW-06-04-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	1	0	1		0	10	200.00	60.96	50	15.24	1	1	30	9.14	1	1	2
HW-08-00-01	High, <30% protection	High, Roots in Upper 1/3	0	0	0		0	10	466.67	142.24	140	42.67	3	2	160	48.77	3	2	1
SR-00-00-01	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	1	0		1	10	400.0	121.9	75	22.86	1	1	98	29.87	2	1.5	5
SR-00-00-02	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	1	0		1	10	505.3	154.0	96	29.26	2	1.5	40	12.19	2	1.5	2
SR-00-00-03	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	189.5	57.8	88	26.82	1	1	15	4.57	2	1.5	14
SR-00-00-04	Low, >60% protection	Low, Roots Extend to Lower 1/3	0	1	0		1	10	84.2	25.7	45	13.72	3	2	120	36.58	3	2	13
SR-00-00-05	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	1	0		1	10	168.4	51.3	0	0.00	0	0	0	0.00	0	0	14
SR-00-00-06	High, <30% protection	Med, Roots Extend to Middle 1/3	1	0	0		1	10	210.5	64.2	15	4.57	2	1.5	60	18.29	1	1	15
SR-00-00-07	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	1	0		1	10	357.9	109.1	0	0.00	0	0	20	6.10	2	1.5	14
SR-00-00-08	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	315.8	96.3	0	0.00	0	0	0	0.00	0	0	15
SR-00-00-09	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	1	0	0		1	10	189.5	57.8	0	0.00	0	0	0	0.00	0	0	13
SR-00-00-10	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	1	0		1	10	273.7	83.4	0	0.00	0	0	0	0.00	0	0	14
SR-00-00-11	Low, >60% protection	Med, Roots Extend to Middle 1/3	1	1	0		1	10	284.2	86.6	0	0.00	0	0	40	12.19	3	2	13
SR-00-00-12	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		0	10	421.1	128.3	45	13.72	2	1.5	52	15.85	2	1.5	15
SR-00-00-13	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	0	0		0	10	1157.9	352.9	90	27.43	3	2	50	15.24	2	1.5	15
SR-00-00-14	Low, >60% protection	High, Roots in Upper 1/3	0	0	0		1	10	305.3	93.0	0	0.00	0	0	120	36.58	3	2	15
SR-00-00-15	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	1	0		1	10	63.2	19.3	0	0.00	0	0	123	37.49	2	1.5	14
SR-00-00-16	Low, >60% protection	Low, Roots Extend to Lower 1/3	0	1	0		0	10	463.2	141.2	0	0.00	0	0	7	2.13	2	1.5	15
SR-00-00-17	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	336.8	102.7	0	0.00	0	0	0	0.00	0	0	8
SR-00-00-18	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	189.5	57.8	0	0.00	0	0	12	3.66	3	2	10
SR-00-00-19	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	389.5	118.7	0	0.00	0	0	20	6.10	3	2	13
SR-01-00-01	High, <30% protection	High, Roots in Upper 1/3	0	1	0		1	10	736.8	224.6	112	34.14	1	1	142	43.28	2	1.5	4
SR-01-00-02	High, <30% protection	High, Roots in Upper 1/3	0	1	0		1	10	189.5	57.8	18	5.49	1	1	74	22.56	2	1.5	8
SR-02-00-01	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	189.5	57.8	0	0.00	0	0	0	0.00	0	0	1
SR-02-00-02	High, <30% protection	High, Roots in Upper 1/3	1	0	0		1	10	189.5	57.8	80	24.38	3	2	0	0.00	0	0	2
SR-02-00-03	High, <30% protection	High, Roots in Upper 1/3	1	1	0		1	10	315.8	96.3	18	5.49	3	2	0	0.00	0	0	4
SR-02-00-04	High, <30% protection	High, Roots in Upper 1/3	0	1	0		1	10	336.8	102.7	21	6.40	3	2	0	0.00	0	0	5
SR-02-00-05	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	1	0		1	10	63.2	19.3	0	0.00	0	0	0	0.00	0	0	4
SR-02-00-06	Med, 30% to 60% protection	Low, Roots Extend to Lower 1/3	1	0	0		1	10	63.2	19.3	60	18.29	1	1	0	0.00	0	0	6
SR-02-01-01	Med, 30% to 60% protection	Low, Roots Extend to Lower 1/3	0	0	0		0	10	168.4	51.3	0	0.00	0	0	0	0.00	0	0	5
SR-02-02-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	1	0		1	10	231.6	70.6	20	6.10	3	2	0	0.00	0	0	3
SR-03-00-01	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	294.7	89.8	0	0.00	0	0	0	0.00	0	0	0
SR-04-00-01	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	189.5	57.8	10	3.05	1	1	0	0.00	0	0	1
SR-05-00-01	High, <30% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	273.7	83.4	134	40.84	2	1.5	104	31.70	2	1.5	7
SR-05-00-02	High, <30% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	189.5	57.8	45	13.72	3	2	24	7.32	2	1.5	5
SR-05-00-03	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		0	10	421.1	128.3	20	6.10	1	1	25	7.62	1	1	8
SR-05-00-04	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	442.1	134.8	44	13.41	3	2	52	15.85	3	2	6
SR-06-00-01	High, <30% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	189.5	57.8	30	9.14	3	2	0	0.00	0	0	6
SR-06-00-02	Low, >60% protection	Low, Roots Extend to Lower 1/3	0	1	0		1	10	400.0	121.9	20	6.10	2	1.5	72	21.95	3	2	6
SR-06-00-03	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	84.2	25.7	75	22.86	2	1.5	48	14.63	2	1.5	12
SR-06-01-01	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	105.3	32.1	36	10.97	2	1.5	39	11.89	2	1.5	14
SR-07-00-01	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	210.5	64.2	0	0.00	0	0	15	4.57	1	1	4
SR-07-00-02	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		0	10	168.4	51.3	90	27.43	2	1.5	99	30.18	2	1.5	7
SR-07-01-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	315.8	96.3	50	15.24	3	2	39	11.89	2	1.5	8
SR-08-01-01	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	715.8	218.2	30	9.14	1	1	45	13.72	1	1	8
SR-08-02-01	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	652.6	198.9	75	22.86	3	2	73	22.25	2	1.5	1
SR-09-00-01	High, <30% protection	Med, Roots Extend to Middle 1/3	0	0	0		0	10	84.2	25.7	0	0.00	0	0	0	0.00	0	0	0
SR-10-00-06	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	84.2	25.7	135	41.15	2	1.5	144	43.89	3	2	12
SR-10-00-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	63.2	19.3	185	56.39	3	2	15	4.57	2	1.5	11
SR-10-00-02	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	84.2	25.7	117	35.66	3	2	145	44.20	3	2	13
SR-10-00-03	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	168.4	51.3	180	54.86	3	2	140	42.67	2	1.5	11
SR-10-00-04	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	189.5	57.8	90	27.43	3	2	60	18.29	3	2	13
SR-10-00-05	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	168.4	51.3	90	27.43	2	1.5	30	9.14	2	1.5	15
SR-10-01-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	1	sive Downstream	1	10	252.6	77.0	150	45.72	2	1.5	93	28.35	2	1.5	9
SR-10-02-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	63.2	19.3	150	45.72	2	1.5	125	38.10	2	1.5	8
SR-10-02-02	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	252.6	77.0	39	11.89	2	1.5	75	22.86	2	1.5	5
SR-10-02-03	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	52.6	16.0	70	21.34	2	1.5	40	12.19	3	2	1
SR-10-02-04	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	252.6	77.0	90	27.43	2	1.5	155	47.24	2	1.5	4
SR-11-00-01	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	0	0		0	10	63.2	19.3	0	0.00	0	0	0	0.00	0	0	0

Reach	Epifaunal Substrate	Riffle Run Quality	Embeddedness	Shading	Instream Woody Debris	Instream Rootwads	Total Woody Debris	Yard Waste	Reference Reach	Bank Planting	Root Depth/ Bank Ht Score	Surface Protection Score	Root Density Score	Bank Angle Score	Bank Material	Bank Ht/BF Ht Score	BEHI Score	BEHI Ranking	Remoteness Calc.	Shading Calc.	Epifaunal Calc.	Instream Habitat Calc.	Woody Calc.	Bank Stability Calc.
HW-06-00-05	9	4	35	20	2	1	3	0	0	1	3	3	3	2	-1.5	3	12.5	Mod to High	45.15	3.69	47.06	58.87	25.00	74.27
HW-06-00-06	7	11	40	20	0	0	0	0	0	1	3	3	3	1	-1.5	3	11.5	Mod	39.61	3.69	35.29	52.52	0.00	100.00
HW-06-00-07	14	5	50	25	1	0	1	0	0	1	3	3	3	1	0	3	13	Mod to High	37.57	7.96	76.47	52.52	8.33	84.14
HW-06-01-01	4	5	50	35	3	0	3	1	0	1	3	2	3	1	0	3	12	Mod to High	41.55	15.75	17.65	46.17	25.00	93.82
HW-06-02-01	4	4	60	25	0	0	0	0	0	1	2	2	1	1	0	1	7	Low	24.49	7.96	17.65	33.47	0.00	100.00
HW-06-03-01	5	1	70	40	0	0	0	0	0	1	2	3	3	2	0	1	11	Mod	39.61	19.42	23.53	27.12	0.00	100.00
HW-06-04-01	6	0	5	30	1	0	1	0	0	0	2	2	2	1	0	1	8	Low to Mod	39.61	11.95	29.41	20.77	8.33	100.00
HW-08-00-01	1	1	80	40	0	0	0	0	0	1	3	3	3	2	0	3	14	High	58.48	19.42	0.00	14.42	0.00	70.76
SR-00-00-01	5	7	40	40	0	1	1	1	0	1	3	2	2	2	0	3	12	Mod to High	54.43	19.42	23.53	39.82	8.33	90.52
SR-00-00-02	7	10	50	40	1	2	3	1	0	1	3	2	2	2	0	2	11	Mod	60.70	19.42	35.29	20.77	25.00	91.95
SR-00-00-03	14	11	60	60	1	4	5	0	0	0	3	2	2	2	0	2	11	Mod	38.66	33.76	76.47	96.98	41.67	99.09
SR-00-00-04	14	10	60	50	1	3	4	0	0	0	1	1	2	2	0	3	9	Mod	27.05	26.59	76.47	90.63	33.33	88.47
SR-00-00-05	14	13	50	20	0	1	1	0	0	0	2	1	2	2	0	2	9	Mod	36.67	3.69	76.47	96.98	8.33	100.00
SR-00-00-06	15	15	30	40	0	3	3	0	0	0	2	3	1	1	0	3	10	Mod	40.54	19.42	82.35	100.00	25.00	100.00
SR-00-00-07	14	14	40	20	1	1	2	0	0	0	3	2	2	1	0	2	10	Mod	51.69	3.69	76.47	96.98	16.67	100.00
SR-00-00-08	13	12	60	20	0	2	2	0	0	0	3	2	2	2	0	2	11	Mod	48.79	3.69	70.59	100.00	16.67	100.00
SR-00-00-09	13	13	45	20	0	0	0	0	0	0	2	2	2	2	0	2	10	Mod	38.66	3.69	70.59	90.63	0.00	100.00
SR-00-00-10	14	13	60	0	0	0	0	0	0	0	3	2	2	1	0	2	10	Mod	45.69	0.00	76.47	96.98	0.00	100.00
SR-00-00-11	13	11	40	25	0	0	0	0	0	0	2	1	3	2	0	2	10	Mod	46.48	7.96	70.59	90.63	0.00	100.00
SR-00-00-12	15	12	35	45	0	1	1	0	0	0	2	2	2	2	-1.5	2	8.5	Mod	55.74	23.03	82.35	100.00	8.33	96.47
SR-00-00-13	12	11	45	50	1	0	1	0	0	0	2	1	2	2	0	2	9	Mod	89.91	26.59	64.71	100.00	8.33	91.47
SR-00-00-14	15	14	20	65	2	4	6	0	0	0	3	1	2	2	0	2	10	Mod	48.03	37.43	82.35	100.00	50.00	93.82
SR-00-00-15	14	11	40	45	0	2	2	1	0	1	2	2	2	2	0	2	10	Mod	23.94	23.03	76.47	96.98	16.67	93.47
SR-00-00-16	14	16	50	25	2	0	2	0	0	0	1	1	2	1	-1.5	2	5.5	Low	58.28	7.96	76.47	100.00	16.67	100.00
SR-00-00-17	6	7	70	10	1	0	1	1	0	0	3	3	3	1	0	2	12	Mod to High	50.26	0.00	29.41	58.87	8.33	100.00
SR-00-00-18	8	9	70	20	1	1	2	0	0	0	3	2	3	2	0	3	13	Mod to High	38.66	3.69	41.18	71.58	16.67	100.00
SR-00-00-19	15	12	35	70	5	4	9	0	0	0	2	2	2	2	0	3	11	Mod	53.76	41.24	82.35	90.63	75.00	100.00
SR-01-00-01	4	6	90	70	1	0	1	0	0	1	3	3	2	2	0	2	12	Mod to High	72.50	41.24	17.65	33.47	8.33	82.02
SR-01-00-02	8	8	60	75	3	4	7	1	0	0	3	3	3	1	0	2	12	Mod to High	38.66	45.22	41.18	58.87	58.33	97.71
SR-02-00-01	1	1	30	45	0	0	0	1	0	0	3	2	2	2	0	3	12	Mod to High	38.66	23.03	0.00	14.42	0.00	100.00
SR-02-00-02	3	6	40	80	0	0	0	1	0	0	3	3	2	2	0	3	13	Mod to High	38.66	49.49	11.76	20.77	0.00	98.39
SR-02-00-03	3	5	40	20	2	0	2	1	0	0	3	3	2	2	0	3	13	Mod to High	48.79	3.69	11.76	33.47	16.67	100.00
SR-02-00-04	6	6	30	80	0	0	0	1	0	0	3	3	2	1	0	3	12	Mod to High	50.26	49.49	29.41	39.82	0.00	100.00
SR-02-00-05	7	6	40	30	5	2	7	1	0	0	2	2	1	3	0	3	11	Mod	23.94	11.95	35.29	33.47	58.33	100.00
SR-02-00-06	8	7	40	70	0	0	0	0	0	0	1	2	2	1	0	2	8	Low to Mod	23.94	41.24	41.18	46.17	0.00	100.00
SR-02-01-01	6	1	25	75	0	0	0	0	0	0	1	2	1	2	0	2	8	Low to Mod	36.67	45.22	29.41	39.82	0.00	100.00
SR-02-02-01	6	1	35	60	0	0	0	1	0	0	2	2	2	1	0	3	10	Mod	42.33	33.76	29.41	27.12	0.00	100.00
SR-03-00-01	0	0	100	65	0	0	0	0	0	0	2	1	1	1	0	2	7	Low	47.27	37.43	0.00	8.06	0.00	100.00
SR-04-00-01	1	1	1	90	0	0	0	0	0	0	2	1	2	2	0	3	10	Mod	38.66	59.59	0.00	14.42	0.00	100.00
SR-05-00-01	6	6	85	70	2	1	3	1	0	0	2	3	2	2	0	2	11	Mod	45.69	41.24	29.41	52.52	25.00	79.25
SR-05-00-02	7	7	40	65	1	1	2	0	0	0	2	3	3	2	0	2	12	Mod to High	38.66	37.43	35.29	39.82	16.67	99.61
SR-05-00-03	8	8	50	35	2	2	4	0	0	1	2	2	2	1	0	2	9	Mod	55.74	15.75	41.18	58.87	33.33	100.00
SR-05-00-04	7	7	70	75	4	1	5	0	0	0	3	3	2	2	0	3	13	Mod to High	57.02	45.22	35.29	46.17	41.67	96.58
SR-06-00-01	4	4	85	40	1	0	1	0	0	1	2	3	3	2	0	3	13	Mod to High	38.66	19.42	17.65	46.17	8.33	100.00
SR-06-00-02	6	4	75	60	0	0	0	0	0	1	1	1	1	2	-1.5	3	6.5	Low	54.43	33.76	29.41	46.17	0.00	97.03
SR-06-00-03	9	6	65	70	1	1	2	1	0	0	3	2	2	2	0	3	12	Mod to High	27.05	41.24	47.06	84.28	16.67	93.47
SR-06-01-01	17	6	35	80	0	1	1	0	0	1	3	2	2	2	0	2	11	Mod	29.79	49.49	94.12	96.98	8.33	98.95
SR-07-00-01	5	5	75	25	0	0	0	0	0	1	2	1	1	1	0	3	8	Low to Mod	40.54	7.96	23.53	33.47	0.00	100.00
SR-07-00-02	9	6	50	50	3	1	4	1	0	0	2	2	2	2	0	2	10	Mod	36.67	26.59	47.06	52.52	33.33	85.52
SR-07-01-01	9	5	60	75	0	0	0	0	0	0	2	2	2	2	0	1	9	Mod	48.79	45.22	47.06	58.87	0.00	97.37
SR-08-01-01	7	7	30	40	1	2	3	0	0	1	2	1	2	2	0	1	8	Low to Mod	71.51	19.42	35.29	58.87	25.00	100.00
SR-08-02-01	1	1	80	60	0	1	1	0	0	1	3	3	2	2	0	3	13	Mod to High	68.46	33.76	0.00	14.42	8.33	90.52
SR-09-00-01	0	0	100	50	0	0	0	0	0	0	2	3	3	1	0	1	10	Mod	27.05	26.59	0.00	8.06	0.00	100.00
SR-10-00-06	12	8	60	85	3	1	4	0	0	0	2	2	2	1	0	1	8	Low to Mod	27.05	54.18	64.71	84.28	33.33	73.72
SR-10-00-01	11	7	70	40	0	1	1	0	0	1	2	2	2	1	-1.5	2	7.5	Low	23.94	19.42	58.82	77.93	8.33	84.14
SR-10-00-02	14	7	5	65	0	0	0	0	0	1	3	2	2	2	-1.5	3	10.5	Mod	27.05	37.43	76.47	90.63	0.00	76.05
SR-10-00-03	10	8	10	50	0	0	0	0	0	1	3	2	3	2	-1.5	3	11.5	Mod	36.67	26.59	52.94	77.93	0.00	67.87
SR-10-00-04	13	7	40	65	0	0	0	0	0	0	2	2	2	2	0	2	10	Mod	38.66	37.43	70.59	90.63	0.00	90.28
SR-10-00-05	14	8	40	65	2	3	5	0	0	0	3	3	2	2	0	2	12	Mod to High	36.67	37.43	76.47	100.00	41.67	93.82
SR-10-01-01	13	5	45	65	1	3	4	1	0	0	2	2	2	2	0	3	11	Mod	44.04	37.43	70.59	65.23	33.33	78.59
SR-10-02-01	9	5	40	65	2	1	3	1	0	0	2	2	2	1	1.5	2	10.5	Mod	23.94	37.43	47.06	58.87	25.00	74.27
SR-10-02-02	4	5	85	20	1	0	1	0	0	1	3	2	2	1	0	3	11	Mod	44.04	3.69	17.65	39.82	8.33	94.52
SR-10-02-03	2	2	30	65	1	1	2	1	0	0	3	2	2	2	1.5	3	13.5	Mod to High	22.19	37.43	5.88	14.42	16.67	94.98
SR-10-02-04	5	5	40	50	3	1	4	1	0	0	2	2	2	2	1.5	2	11.5	Mod	44.04	26.59	23.53	33.47	33.33	78.33
SR-11-00-01	0	0	0	0	0	0	0	0	0	0	2	1	1	1	0	2	7	Low	23.94	0.00	0.00	8.06	0.00	100.00

Reach	Riffle Quality Calc.	Embeddness Calc.	PHI	Habitat Rating	Lt Eroded Area	Rt Eroded Area	Eroded Area/Reach Length	Measure 1: Stream Restoration	Buffer Enhancement Recommende	Measure 2: Buffer Enhancement	Measure 3: Bank Planting	Meaure 4: Utility Conflict Resolution	Measure 5: Wetland Enhancement	Measure 6: Trash Cleanup	Measure 7: Yard Waste Cleanup	Unstable Stable Ratio > 25%	Eroded Area/Reach Length > 2.0	Stream Stabilization Recommende	Measure 8: Invasive Species	Total No of Recommended Measures	Total Cost	Comments
HW-06-00-05	61.10	72.22	48.42	Fair	2,812.50	2,425.00	2.76	1	0	0	1	0	0	1	0	0	1	1	0	3	$437,733	
HW-06-00-06	96.74	66.67	49.32	Fair	731.25	440.00	1.14	0	0	0	1	0	0	0	0	0	0	0	0	1	$10,000	
HW-06-00-07	66.19	55.56	48.59	Fair	720.00	540.00	4.85	1	0	0	1	0	0	0	0	1	1	1	0	2	$108,919	reach HW-06-00-07 and HW-06-00-08 combined to form one reach
HW-06-01-01	66.19	55.56	45.21	Fair	412.50	540.00	1.21	1	1	1	1	0	1	0	1	0	0	1	0	5	$308,905	
HW-06-02-01	61.10	44.44	36.14	Poor	0.00	10.00	0.04	0	1	1	1	0	1	0	0	0	0	0	0	3	$35,000	
HW-06-03-01	45.82	33.33	36.10	Poor	620.00	637.50	1.77	1	1	1	1	0	1	0	0	1	0	1	0	4	$285,465	
HW-06-04-01	40.73	100.00	43.85	Fair	100.00	60.00	0.30	0	0	0	0	0	0	0	0	0	0	0	0	0	$0	
HW-08-00-01	45.82	22.22	28.89	Poor	1,240.00	1,608.00	8.84	1	0	0	1	0	0	0	0	1	1	1	0	2	$133,885	Exposed SS parallel channel.
SR-00-00-01	76.38	66.67	47.39	Fair	450.00	1,004.50	1.92	1	1	0	1	0	0	1	1	1	0	1	0	4	$235,743	
SR-00-00-02	91.65	55.56	50.04	Fair	1,287.00	1,360.00	1.80	1	0	0	1	0	0	1	1	1	0	1	1	5	$351,639	
SR-00-00-03	96.74	44.44	65.98	Fair	1,386.00	1,136.00	2.48	1	0	0	0	0	0	1	0	1	1	0	0	2	$228,856	
SR-00-00-04	91.65	44.44	59.83	Fair	1,380.00	1,380.00	2.77	1	0	0	0	0	0	1	0	1	1	0	1	3	$234,958	
SR-00-00-05	100.00	55.56	59.71	Fair	128.00	240.00	1.07	0	0	0	0	0	0	1	0	0	0	0	1	2	$5,500	
SR-00-00-06	100.00	77.78	68.14	Fair	60.00	312.00	0.92	0	0	0	0	0	0	1	0	0	0	0	1	2	$8,000	
SR-00-00-07	100.00	66.67	64.02	Fair	0.00	550.00	0.93	0	0	0	0	0	0	1	0	0	0	0	1	2	$8,000	
SR-00-00-08	100.00	44.44	60.52	Fair	1,992.00	760.00	1.78	0	0	0	0	0	0	1	0	0	0	0	1	2	$10,500	
SR-00-00-09	100.00	61.11	58.08	Fair	180.00	392.00	0.59	0	0	0	0	0	0	1	0	0	0	0	1	2	$10,500	
SR-00-00-10	100.00	44.44	57.95	Fair	714.00	616.00	1.28	0	0	0	0	0	0	1	0	0	0	0	1	2	$10,500	
SR-00-00-11	96.74	66.67	59.88	Fair	630.00	168.00	0.51	0	0	0	0	0	0	1	0	0	0	0	1	2	$10,500	
SR-00-00-12	100.00	72.22	67.27	Fair	225.00	260.00	1.36	0	0	0	0	0	0	0	0	0	0	0	1	1	$5,000	
SR-00-00-13	96.74	61.11	67.36	Fair	1,212.00	810.00	2.46	1	0	0	0	0	0	0	0	0	1	1	1	2	$195,196	
SR-00-00-14	100.00	88.89	75.07	Good	1,825.00	2,229.50	2.04	1	0	0	0	1	0	1	0	0	1	1	1	4	$482,841	
SR-00-00-15	96.74	66.67	61.75	Fair	1,950.00	1,142.10	4.11	1	1	0	1	0	0	1	1	1	1	1	1	5	$241,669	
SR-00-00-16	100.00	55.56	64.37	Fair	0.00	120.00	0.28	0	1	0	0	0	0	0	0	0	0	0	1	1	$7,500	
SR-00-00-17	76.38	33.33	44.57	Fair	440.00	800.00	3.24	1	0	0	0	0	0	1	1	0	1	1	1	4	$159,293	
SR-00-00-18	86.56	33.33	48.96	Fair	1,260.00	924.00	2.12	1	0	0	0	0	0	1	0	0	1	1	1	3	$241,797	
SR-00-00-19	100.00	72.22	76.90	Good	72.00	360.00	0.33	0	0	0	0	0	0	1	0	0	0	0	1	2	$10,500	
SR-01-00-01	71.28	11.11	42.20	Fair	560.00	1,456.00	4.37	1	0	0	1	0	0	1	0	1	1	0	0	3	$146,431	
SR-01-00-02	81.47	44.44	58.24	Fair	516.00	952.00	1.35	0	0	0	0	0	0	1	1	0	0	0	1	3	$11,000	
SR-02-00-01	45.82	77.78	37.46	Poor	0.00	0.00	0.00	0	0	0	0	0	0	1	1	0	0	0	0	2	$1,000	
SR-02-00-02	71.28	66.67	44.63	Fair	942.00	1,260.00	3.04	1	0	0	0	0	0	1	1	1	1	1	1	4	$226,157	
SR-02-00-03	66.19	66.67	43.40	Fair	384.00	336.00	1.59	1	0	0	0	0	0	1	1	0	0	1	0	3	$137,197	
SR-02-00-04	71.28	77.78	52.26	Fair	198.00	315.00	0.73	1	0	0	0	0	0	1	1	0	0	1	0	3	$212,880	
SR-02-00-05	71.28	66.67	50.12	Fair	0.00	0.00	0.00	1	0	0	0	0	0	1	1	0	0	1	0	3	$317,460	
SR-02-00-06	76.38	66.67	49.45	Fair	60.00	0.00	0.18	0	0	0	0	0	0	1	0	0	0	0	1	2	$5,500	
SR-02-01-01	45.82	83.33	47.53	Fair	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	$0	
SR-02-02-01	45.82	72.22	43.83	Fair	0.00	360.00	1.07	1	0	0	0	0	0	1	1	0	0	1	0	3	$135,779	
SR-03-00-01	40.73	0.00	29.19	Poor	0.00	0.00	0.00	0	0	0	0	0	0	1	0	0	0	0	0	1	$500	
SR-04-00-01	45.82	100.00	44.81	Fair	0.00	0.00	0.00	0	0	0	0	0	0	1	0	0	0	0	0	1	$500	
SR-05-00-01	71.28	16.67	45.13	Fair	1,216.00	1,640.00	2.81	1	0	0	0	0	0	1	1	1	1	0	0	3	$229,936	
SR-05-00-02	76.38	66.67	51.32	Fair	768.00	390.00	2.92	1	0	0	0	0	0	1	0	1	1	1	0	2	$159,252	
SR-05-00-03	81.47	55.56	55.24	Fair	264.00	142.00	1.83	1	0	0	1	0	0	0	0	1	0	0	0	2	$93,982	
SR-05-00-04	76.38	33.33	53.96	Fair	2,110.00	2,370.00	5.23	1	0	0	0	0	0	1	0	1	1	1	1	3	$203,377	
SR-06-00-01	61.10	16.67	38.50	Poor	120.00	240.00	0.60	1	1	0	1	0	0	1	0	0	0	1	0	3	$187,424	
SR-06-00-02	61.10	27.78	43.71	Fair	126.00	270.00	0.52	1	1	0	1	0	0	1	0	0	0	1	1	4	$245,697	
SR-06-00-03	71.28	38.89	52.49	Fair	660.00	414.00	1.11	1	0	0	0	0	0	1	1	0	0	1	1	4	$229,244	
SR-06-01-01	71.28	72.22	65.15	Fair	828.00	1,155.00	1.05	1	1	0	1	0	0	1	0	0	0	1	1	4	$443,515	
SR-07-00-01	66.19	27.78	37.43	Poor	0.00	7.50	0.03	0	1	0	1	0	0	1	0	0	0	0	1	3	$10,500	
SR-07-00-02	71.28	55.56	51.07	Fair	368.00	708.00	1.29	1	1	0	0	1	0	0	1	0	0	1	1	4	$222,952	
SR-07-01-01	66.19	44.44	50.99	Fair	262.50	299.25	1.46	1	1	0	0	0	0	1	0	1	0	0	1	3	$159,539	
SR-08-01-01	76.38	77.78	58.03	Fair	178.00	105.00	0.40	0	1	0	1	1	0	1	0	0	0	0	0	3	$33,000	
SR-08-02-01	45.82	22.22	35.44	Poor	2,590.00	2,640.00	3.59	1	0	0	1	1	0	1	0	1	1	1	0	4	$363,475	
SR-09-00-01	40.73	0.00	25.30	Poor	54.00	0.00	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0	$0	
SR-10-00-06	81.47	44.44	57.90	Fair	1,662.50	1,603.00	3.57	1	0	0	0	1	0	1	0	1	1	1	1	4	$241,582	
SR-10-00-01	76.38	33.33	47.79	Fair	1,400.00	382.50	2.72	1	0	0	1	0	0	1	0	1	1	1	1	4	$212,299	
SR-10-00-02	76.38	100.00	60.50	Fair	3,300.00	1,193.50	6.43	1	0	0	1	1	0	1	0	1	1	1	1	5	$250,039	
SR-10-00-03	81.47	100.00	55.43	Fair	1,830.00	630.00	4.70	1	0	0	1	0	0	1	0	1	1	1	1	4	$172,523	
SR-10-00-04	76.38	66.67	58.83	Fair	300.00	540.00	3.69	1	0	0	0	1	0	1	0	1	1	1	1	4	$121,557	
SR-10-00-05	81.47	66.67	66.77	Fair	1,280.00	1,134.00	2.64	1	0	0	0	1	0	1	0	1	1	1	1	4	$241,035	
SR-10-01-01	66.19	61.11	57.06	Fair	2,325.00	1,512.00	4.44	1	0	0	0	0	0	1	1	1	1	1	1	4	$205,406	
SR-10-02-01	66.19	66.67	49.93	Fair	715.00	855.00	1.54	0	0	0	0	0	0	1	1	0	0	0	1	3	$11,000	
SR-10-02-02	66.19	16.67	36.36	Poor	97.50	262.50	1.16	0	0	0	1	0	0	1	0	0	0	0	1	3	$10,500	
SR-10-02-03	50.91	77.78	40.03	Poor	320.00	297.50	1.70	1	0	0	0	0	0	1	1	0	0	1	1	4	$151,357	
SR-10-02-04	66.19	66.67	46.52	Fair	640.00	1,240.00	3.06	1	1	0	0	1	0	1	1	1	1	1	1	5	$217,893	
SR-11-00-01	40.73	100.00	34.09	Poor	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	1	1	$5,000	

Upper Back River Watershed Stream Stability Assessment
Herring Run-Stemmers Run-Brien Run

Reach	Length	Subshed	Team	Date	FlowRegime	Bankfull Depth	Max Bankfull Depth	Sinuosity	Meander Pattern	Depositional Features	Channel Stability V	Channel Stability L	Left Unstable Bank Length	Left Unstable Bank Height	Right Unstable Bank Length	Unstable-Stable Ratio	Right Unstable Bank Height
SR-12-00-02	1398	STEMMERS RUN	CRG\AZ	6/19/2007 11:27	Perennial	1	1.2	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Stable	634	3	229	30.87%	3
SR-12-00-03	1070	STEMMERS RUN	CRG\AZ	6/12/2007 8:07	Perennial	1.2	1.3	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Aggrading	Stable	596	7	661	58.74%	7
SR-12-00-01	691	STEMMERS RUN	CRG\AZ	6/19/2007 13:06	Perennial	0.25	0.35	Moderate, 1.2 to 1.5	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
SR-13-00-01	551	STEMMERS RUN	RM/MJM	6/22/2007 11:00		0.7	0.85	Moderate, 1.2 to 1.5	M3, Irregular	None	Degrading	Stable	90	3.5	90	16.33%	3.5
SR-13-00-02	1185	STEMMERS RUN	RM/MJM	6/22/2007 8:55		1	1.2	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Degrading	Degrading	255	4	320	24.26%	2.5
SR-13-01-01	594	STEMMERS RUN	RM/MJM	6/22/2007 12:04	Intermittent	0.7	0.9	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Degrading	130	2.5	115	20.61%	3
SR-13-01-02	287	STEMMERS RUN	RM/MJM	6/22/2007 8:35	Intermittent	0.8	1.2	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Degrading	40	3	50	15.65%	3
SR-14-00-01	320	STEMMERS RUN	JML/MJM	6/12/2007 9:55	Perennial	0.6	0.8	Low, 1.0 to 1.2	M1, Regular	B4, Side Bars	Degrading	Degrading	280	0.8	99	59.23%	1.2
SR-14-00-02	502	STEMMERS RUN	JML/MJM	6/12/2007 8:47	Perennial	0.7	1	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Stable	Stable	150	0.6	54	20.30%	1
SR-14-01-01	292	STEMMERS RUN	JML/MJM	6/12/2007 10:46	Perennial	0.45	0.75	Moderate, 1.2 to 1.5	M1, Regular	None	Degrading	Stable	110	1.6	60	29.11%	2
SR-15-00-01	557	STEMMERS RUN	MJM/MY	6/26/2007 10:30	Intermittent	0.25	0.4	Moderate, 1.2 to 1.5	M3, Irregular	None	Stable	Degrading	5	0.5	70	6.73%	1.25
SR-15-00-02	267	STEMMERS RUN	MJM/MY	6/26/2007 11:07	Intermittent	0.4	0.5	Moderate, 1.2 to 1.5	M3, Irregular	None	Stable	Aggrading	80	1	10	16.83%	1.5
SR-15-00-03	538	STEMMERS RUN	MJM/MY	6/26/2007 11:20	Intermittent	0.75	0.85	Moderate, 1.2 to 1.5	M3, Irregular	None	Stable	Degrading	82.5	1.3	125	19.28%	1.5
SR-15-00-04	188	STEMMERS RUN	RM/MJM	6/22/2007 15:50	Perennial	0.8	0.9	Low, 1.0 to 1.2	M1, Regular	nt Bars w\Few M	Degrading	Degrading	50	2	35	22.58%	3
SR-15-00-05	1131	STEMMERS RUN	MJM/MY	6/26/2007 12:58	Perennial	0.85	1.05	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Stable	Degrading	180	3.5	270	19.90%	2.5
SR-15-00-06	811	STEMMERS RUN	MJM/MY	6/26/2007 13:42	Perennial	0.6	0.7	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Stable	Degrading	135	4	220	21.90%	3.5
SR-15-00-07	280	STEMMERS RUN	MJM/MY	6/26/2007 14:12	Perennial	0.6	0.85	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Stable	Degrading	20	5	70	16.05%	3.25
SR-15-01-01	360	STEMMERS RUN	RM/MJM	6/22/2007 14:14	Intermittent	1.1	1.4	Moderate, 1.2 to 1.5	M3, Irregular	None	Degrading	Degrading	140	4.75	175	43.76%	5
SR-15-02-01	381	STEMMERS RUN	MJM/MY	6/26/2007 9:57	Intermittent	0.4	0.6	Moderate, 1.2 to 1.5	M3, Irregular	None	Stable	Degrading	105	2	55	20.98%	105
SR-15-03-01	521															0.00%	
SR-15-03-02	409	STEMMERS RUN	MJM/MY	6/26/2007 8:32	Intermittent	0.27	0.35	Moderate, 1.2 to 1.5	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
SR-15-03-03	598	STEMMERS RUN	MJM/MY	6/26/2007 8:44	Intermittent	0.5	0.65	Moderate, 1.2 to 1.5	M3, Irregular	None	Stable	Degrading	122	1.5	122	20.41%	1.5
SR-15-03-04	252	STEMMERS RUN	MJM/MY	6/26/2007 9:42	Intermittent	0.5	0.6	Moderate, 1.2 to 1.5	M3, Irregular	None	Stable	Aggrading	40	1.5	60	19.81%	1.5
SR-16-00-01	803	STEMMERS RUN	KEB/RM	5/30/2007 10:04	Intermittent	0.9	0.95	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Stable	132	1.75	105	14.76%	1.5
SR-16-00-02	952	STEMMERS RUN	KEB/RM	5/30/2007 9:35	Intermittent	1.5	2	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Degrading	Stable	375	5	330	37.04%	4
SR-16-00-03	348	STEMMERS RUN	KEB/RM	5/30/2007 12:57	Ephemeral	1.9	2.2	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Aggrading	50	7	30	11.51%	2
SR-16-00-04	236	STEMMERS RUN	KEB/RM	5/30/2007 13:12	Ephemeral	1.4	1.95	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Degrading	0	0	50	10.59%	3
SR-16-00-06	450	STEMMERS RUN	CRG\AZ	6/26/2007 7:39	Perennial	0.6	0.8	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Aggrading	Stable	0	0	60	6.67%	4
SR-16-00-05	590	STEMMERS RUN	CRG\AZ	6/26/2007 7:51	Perennial	0.5	0.6	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
SR-17-00-01	571	STEMMERS RUN	KEB/RM	5/30/2007 10:40	Ephemeral	0.7	0.8	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	10	0.88%	0.7
SR-17-00-02	1056	STEMMERS RUN	KEB/RM	5/30/2007 13:45	Intermittent	1	1.15	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
SR-17-01-01	317	STEMMERS RUN	KEB/RM	5/30/2007 11:22	Perennial	1.2	1.45	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Stable	110	1.25	15	19.69%	2
SR-18-00-01	1436	STEMMERS RUN	CRG\AZ	5/29/2007 8:57	Intermittent	0.5	1.1	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Stable	0	0	13	0.45%	2
SR-19-00-01	1485	STEMMERS RUN	CRG AC	5/31/2007 9:40	Perennial	0.6	0.85	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Aggrading	Aggrading	1072	6	978	69.03%	7
SR-19-00-02	805	STEMMERS RUN	CRG AC	5/31/2007 10:33	Perennial	0.6	0.75	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Aggrading	Stable	0	0	0	0.00%	0
SR-19-00-03	1098	STEMMERS RUN	CRG\AC	5/31/2007 11:35	Perennial	0.5	0.6	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Stable	Stable	652	5	614	57.65%	6
SR-19-00-04	591	STEMMERS RUN	CRG\AZ	5/29/2007 11:04	Perennial	0.75	0.8	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Stable	Degrading	120	8	128	20.98%	5
SR-19-00-05	714	STEMMERS RUN	CRG\AZ	5/29/2007 9:54	Perennial	0.5	0.75	Low, 1.0 to 1.2	M3, Irregular	nt Bars w\Few M	Stable	Stable	63	4	66	9.04%	3
SR-19-01-01	320	STEMMERS RUN	CRG\AZ	5/29/2007 12:25	Intermittent	0.5	1	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
SR-20-00-01	863	STEMMERS RUN	CRG\AZ	6/5/2007 10:36	Perennial	0.3	0.6	Low, 1.0 to 1.2	M3, Irregular	3, Many Mid Bar	Degrading	Degrading	162	4	92	14.72%	2
SR-21-00-01	576	STEMMERS RUN	CRG\AC	5/31/2007 13:35	Intermittent	0.45	0.6	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
SR-22-00-01	585	STEMMERS RUN	CRG\AZ	5/31/2007 14:37	Perennial	0.7	0.8	Low, 1.0 to 1.2	M3, Irregular	nt Bars w\Few M	Stable	Stable	156	0.5	152	26.32%	0.5
SR-23-00-01	781	STEMMERS RUN	CRG\AZ	6/5/2007 7:59	Perennial	0.5	0.8	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
OR-00-00-00	532	OBRIAN RUN	CRG\AZ	7/11/2007 12:08	Perennial	0.8	1	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
OR-00-00-01	627	OBRIAN RUN	CRG\AZ	6/26/2007 10:21	Perennial	0.9	1	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Aggrading	Degrading	246	5	240	38.73%	4
OR-00-00-02	848	OBRIAN RUN	CRG\AZ	6/26/2007 12:32	Perennial	0.6	0.7	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Aggrading	Stable	125	5	158	16.69%	5
OR-00-00-03	460	OBRIAN RUN	CRG\AZ	6/26/2007 12:47	Perennial	0.4	0.6	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Degrading	Degrading	70	2	52	13.27%	2
OR-00-00-04	985	OBRIAN RUN	CRG/MY	7/3/2007 8:44	Perennial	0.9	1.2	Low, 1.0 to 1.2					0	0	0	0.00%	0
OR-00-00-05	1084	OBRIAN RUN	CRG\JEK	7/5/2007 7:58	Perennial	1.2	1.4	Low, 1.0 to 1.2	M3, Irregular	nt Bars w\Few M	Stable	Stable	220	2	154	17.26%	2
OR-00-00-06	801	OBRIAN RUN	CRG/JEK	7/5/2007 10:29		0.9	1.2	Low, 1.0 to 1.2	M3, Irregular	nt Bars w\Few M	Stable	Stable	33	3	127	9.98%	4
OR-00-00-07	416	OBRIAN RUN	CRG\JEK	7/5/2007 14:13	Perennial	1.4	1.9	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Stable	0	0	0	0.00%	0
OR-00-00-08	1274	OBRIAN RUN	CRG\AZ	7/11/2007 8:15	Perennial	1.8	1.9	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Stable	Stable	693	5	725	55.64%	3
OR-00-00-09	278	OBRIAN RUN	CRG\AZ	7/11/2007 8:51	Intermittent	1.1	1.4	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Stable	Degrading	103	4	0	18.52%	0
OR-00-00-10	1659	OBRIAN RUN	CRG\AZ	7/11/2007 9:37	Perennial	1.5	2	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Degrading	Stable	437	4	584	30.78%	3
OR-00-00-11	1005	OBRIAN RUN	CRG\AZ	7/11/2007 10:45	Perennial	0.9	1.1	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Stable	Stable	618	2	490	55.10%	4
OR-00-00-12	474	OBRIAN RUN	MJM/RM	7/3/2007 14:11		0.65	0.8	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Aggrading	Degrading	60	3.25	145	21.62%	3.5
OR-00-00-13	289	OBRIAN RUN	CRG\AZ	7/11/2007 11:43	Perennial	1	1.5	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Stable	Stable	0	0	214	37.01%	2.5
OR-00-00-14	615	OBRIAN RUN	CRG/JEK	7/5/2007 10:07	Perennial	1.2	1.75	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Degrading	314	4	152	37.86%	2
OR-01-00-01	564	OBRIAN RUN	CRG\AZ	7/11/2007 12:45	Intermittent	0.3	0.5	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
OR-02-00-01	991	OBRIAN RUN	MJM/RM	7/5/2007 11:41	Intermittent	0.4	0.45	Moderate, 1.2 to 1.5	M3, Irregular	None	Degrading	Degrading	70	2	85	7.82%	2
OR-02-00-02	727	OBRIAN RUN	MJM/RM	7/5/2007 13:45	Intermittent	0.8	0.95	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Degrading	20	3	30	3.44%	6
OR-02-00-03	810	OBRIAN RUN	JML/RM	9/11/2007 0:00	Perennial	0.7	0.9	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
OR-02-00-04	911	OBRIAN RUN	MJM/RM	7/3/2007 10:42	Perennial	0.4	0.6	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Degrading	Degrading	90	2.5	65	8.51%	2.5
OR-02-00-05	739	OBRIAN RUN	MJM/RM	7/3/2007 12:42	Perennial	0.6	0.8	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Degrading	125	3.5	50	11.84%	2.2
OR-02-01-01	888	OBRIAN RUN	BRIAN RU	JML/RM	Ephemeral	0.9	1.2	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	#VALUE!	0
OR-03-00-01	475	OBRIAN RUN	MJM/RM	7/5/2007 9:23	Intermittent	0.3	0.4	Low, 1.0 to 1.2	M1, Regular	None	Degrading	Degrading	72	1.25	30	10.74%	1.25

Reach	Bank Bankfull Ratio	Bank Angle	Bank Material	Root Density	Debris Blockages	Leaking Utility	Exposed MH Riser	Left Bank Riparian Width	Right Bank Riparian Width	Left Bank Riparian Comp	Right Bank Riparian Comp	Bedrock Outcrop	Left Bank Riparian Density	Right Bank Riparian Density
SR-12-00-02	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	90	90	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-12-00-03	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Infrequent	0	1	100	75	Deciduous Overstory	Decid. w\Brush-Grass Understory	1	Moderate	Moderate
SR-12-00-01	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	100	80	Forested Wetland	Forested Wetland	0	High	Moderate
SR-13-00-01	Med, BF in Upper 1/2 of Bank	High, Undercut Sloping to Strm	Sandy	Med, Dense Roots Upper 1/2 Bank	Extensive	0	1	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-13-00-02	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	Sandy	Low, Dense Roots Throughout	Numerous	0	1	100	100	Brush	Brush	0	Moderate	Moderate
SR-13-01-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Sandy	Med, Dense Roots Upper 1/2 Bank	Extensive	0	0	25	75	Decid w\Brush-Grass Under	Grass and Forbs	0	Moderate	Moderate
SR-13-01-02	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	Sandy	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	25	85	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Moderate
SR-14-00-01	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	100	100	Deciduous Overstory	Deciduous Overstory	0	High	High
SR-14-00-02	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout	Moderate	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-14-01-01	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	Sandy	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	100	Deciduous Overstory	Decid. w\Brush-Grass Understory	0	High	High
SR-15-00-01	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	60	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	Moderate
SR-15-00-02	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	100	75	Decid w\Brush-Grass Under	Brush	0	Moderate	Low
SR-15-00-03	Low, BF at Top of Bank	Med, Nearly Vertical	Sandy	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	60	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	Moderate
SR-15-00-04	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	Sandy	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	75	75	Decid w\Brush-Grass Under	Brush	0	Moderate	Moderate
SR-15-00-05	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Low, Dense Roots Throughout	Infrequent	1	0	50	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-15-00-06	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Low, Dense Roots Throughout	Infrequent	0	1	100	30	Decid w\Brush-Grass Under	Brush	0	High	Moderate
SR-15-00-07	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	25	40	Decid w\Brush-Grass Under	Brush	0	Moderate	Moderate
SR-15-01-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Sandy	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	100	75	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-15-02-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Sandy	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-15-03-01														
SR-15-03-02	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	75	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-15-03-03	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Sandy	Low, Dense Roots Throughout	Numerous	0	0	80	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Moderate
SR-15-03-04	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	Sandy	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	100	Deciduous Overstory	Decid. w\Brush-Grass Understory	0	Moderate	High
SR-16-00-01	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	200	200	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	High
SR-16-00-02	High, BF Lower 1/2 of Bank	High, Undercut Sloping to Strm	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	200	200	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	High
SR-16-00-03	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	200	40	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	Low
SR-16-00-04	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	50	5	Brush	Decid. w\Brush-Grass Understory	0	Low	Low
SR-16-00-06	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	5	20	Brush	Brush	0	Moderate	High
SR-16-00-05	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	0	0	0			0		
SR-17-00-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout	Infrequent	0	0	200	200	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	High
SR-17-00-02	Low, BF at Top of Bank	Med, Nearly Vertical	None	Low, Dense Roots Throughout	None	0	0	50	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-17-01-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout	Infrequent	0	0	100	200	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-18-00-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	None	0	0	80	15	Decid w\Brush-Grass Under	Brush	0	Moderate	
SR-19-00-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	100	75	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-19-00-02	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	70	70	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-19-00-03	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Extensive	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-19-00-04	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	1	50	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	High
SR-19-00-05	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	40	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-19-01-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Infrequent	0	0	0	0	Bare	Bare	0	Low	Low
SR-20-00-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	Sandy	High, Minimal Roots	Moderate	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
SR-21-00-01	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	25	100	Brush	Decid. w\Brush-Grass Understory	0	High	High
SR-22-00-01	Low, BF at Top of Bank	Med, Nearly Vertical	None	Low, Dense Roots Throughout	Infrequent	0	0	100	50	Decid w\Brush-Grass Under	Brush	0	Moderate	High
SR-23-00-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Moderate	0	0	15	100	Brush	Forested Wetland	0	Low	Moderate
OR-00-00-00	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Numerous	0	0	100	60	Decid w\Brush-Grass Under	Wetland Vegetation	0	High	Moderate
OR-00-00-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-00-00-02	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-00-00-03	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	100	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-00-00-04						0	0	0	0			0		
OR-00-00-05	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-00-00-06	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	10	10	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Low
OR-00-00-07	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-00-00-08	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	100	100	Forested Wetland	Forested Wetland	0	Moderate	Moderate
OR-00-00-09	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	100	100	Forested Wetland	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-00-00-10	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	100	100	Forested Wetland	Forested Wetland	0	Moderate	Moderate
OR-00-00-11	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	1	100	100	Forested Wetland	Forested Wetland	0	Moderate	Moderate
OR-00-00-12	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	Sandy	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	75	75	Forested Wetland	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-00-00-13	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	20	50	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-00-00-14	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	15	10	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Low
OR-01-00-01	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	100	75	Forested Wetland	Wetland Vegetation	0	Moderate	High
OR-02-00-01	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	Sandy	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	5	5	Grass and Forbs	Grass and Forbs	0	Low	Low
OR-02-00-02	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	100	60	Wetland Vegetation	Decid. w\Brush-Grass Understory	0	High	Moderate
OR-02-00-03	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout	Numerous	0	0	40	40	Wetland Vegetation	Wetland Vegetation	0	High	High
OR-02-00-04	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	Sandy	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	60	60	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-02-00-05	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	Sandy	Med, Dense Roots Upper 1/2 Bank	Extensive	0	0	90	60	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-02-01-01	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout	Infrequent	0	0	35	10	Wetland Vegetation	Wetland Vegetation	0	Moderate	Moderate
OR-03-00-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Sandy	High, Minimal Roots	Moderate	0	0	25	40	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Low	Moderate

Reach	Channel Mod	Photo Taken	Comment	Private Structure Threatend	Fish Blockage	BF Indicator	Chnl Restoration	Buffer Enhncmnt	Utilility Resol	Habitat Enhcmnt	Bankfull Width	Width Depth Ratio	Substrate	Canopy Cover	Chnl Restoration	Floodprone Width	Entrenchment	Chnl Evol	Channel Slope	Rosgen Class	Succession
SR-12-00-02	0	1	0	0	Excessive Height	Erosional Feature	0	0	0	0	8	7.8	Gravel	25-50%	0	13	1.666667	Stage II	2% to 4%	G	7
SR-12-00-03	0	1	0	0	None	Slope Break	1	0	0	0	26	21.666667	Gravel	25-50%	1	100	3.846154	Stage IV	2% to 4%	C	4
SR-12-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	1	3	12	Gravel	50-75%	0	8	2.666667	Stage I	<2%	E	7
SR-13-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	1	0	1	0	3	4.428571	Sand	50-75%	1	6.7	2.16129	Stage II	<2%	E	Other
SR-13-00-02	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	1	0	10	10	Gravel	25-50%	0	13.1	1.31	Stage II	2% to 4%	B	6
SR-13-01-01	0	1	1	1	Shallow Depth of Flow	Active Floodplain	1	1	0	0	5	7	Gravel	50-75%	1	5.1	1.040816	Stage II	2% to 4%	G	4
SR-13-01-02	0	1	1	0	Shallow Depth of Flow	Erosional Feature	1	1	0	0	8	10.0625	Gravel	50-75%	1	12.6	1.565217	Stage III	<2%	G	4
SR-14-00-01	0	1	1	0	Debris Blockage	Slope Break	0	0	0	0	7	11	Gravel	50-75%	0	11.4	1.727273	Stage II	<2%	B	4
SR-14-00-02	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	6	9	Sand	50-75%	0	9.3	1.47619	Stage V	<2%	B	7
SR-14-01-01	1	1	1	0	Shallow Depth of Flow	Active Floodplain	0	0	0	0	8	18	Sand	50-75%	0	32.2	3.975309	Stage II	2% to 4%	C	9
SR-15-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	1	0	0	0	4	14.8	Gravel	50-75%	1	5.5	1.486486	Stage III	2% to 4%	G	Other
SR-15-00-02	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	4	10	Cobble	50-75%	0	5.2	1.3	Stage III	2% to 4%	G	7
SR-15-00-03	0	1	1	0		Slope Break	0	0	0	0	6	8.133333	Gravel	50-75%	0	29.5	4.836066	Stage III	2% to 4%	G	7
SR-15-00-04	0	1	0	0	Shallow Depth of Flow	Slope Break	1	0	0	0	11	13.125	Gravel	25-50%	1	13.6	1.295238	Stage II	2% to 4%	B	Other
SR-15-00-05	0	1	1	0	Shallow Depth of Flow	Vegetative Feature	1	0	1	0	7	8.647059	Gravel	50-75%	1	10.9	1.482993	Stage III	2% to 4%	B	7
SR-15-00-06	0	1	0	0	Shallow Depth of Flow	Vegetative Feature	1	0	1	0	9	14.166667	Gravel	50-75%	1	13	1.529412	Stage III	2% to 4%	B	7
SR-15-00-07	0	1	1	0	Shallow Depth of Flow	Active Floodplain	0	0	0	0	8	13.333333	Gravel	50-75%	0	13.4	1.675	Stage III	2% to 4%	B	4
SR-15-01-01	0	1	1	0	Shallow Depth of Flow	Slope Break	1	0	0	0	10	9.5	Gravel	50-75%	1	13.65	1.30622	Stage III	2% to 4%	G	7
SR-15-02-01	0	1	0	0	Shallow Depth of Flow	Vegetative Feature	1	0	0	0	4	9	Gravel	50-75%	1	6.3	1.75	Stage III	2% to 4%	G	7
SR-15-03-01																					
SR-15-03-02	0	1	1	0	Shallow Depth of Flow	Slope Break	1	0	0	0	3	12.592593	Sand	50-75%	1	5.5	1.617647	Stage I	2% to 4%	B	Other
SR-15-03-03	1	1	0	0	Debris Blockage	Slope Break	0	0	0	0	5	10	Silt	50-75%	0	7	1.4	Stage III	2% to 4%	G	4
SR-15-03-04	0	1	0	0	Shallow Depth of Flow	Vegetative Feature	0	0	0	0	6	11.2	Cobble	50-75%	0	12	2.142857	Stage III	2% to 4%	B	7
SR-16-00-01	0	1	1	0	Shallow Depth of Flow	Slope Break	0	0	0	0	10	11	Gravel	75-100%	0	17.7	1.787879	Stage II	2% to 4%	B	4
SR-16-00-02	0	1	1	0	Shallow Depth of Flow	Erosional Feature	1	0	0	0	12	7.733333	Gravel	50-75%	1	19	1.637931	Stage II	2% to 4%	G	4
SR-16-00-03	1	1	1	0	Shallow Depth of Flow	Erosional Feature	1	0	0	0	17	9.157895	Gravel	50-75%	1	20	1.149425	Stage IV	2% to 4%	G	4
SR-16-00-04	1	1	1	0	Shallow Depth of Flow	Slope Break	1	1	0	0	10	6.857143	Sand	10-25%	1	50	5.208333	Stage III	<2%	E	1
SR-16-00-06	0	1	0	0	Debris Blockage	Slope Break	0	1	0	0	7	11.333333	Silt	0-10%	0	14	2.058824	Stage II	<2%	C	4
SR-16-00-05	0	1	0	0	Shallow Depth of Flow	Erosional Feature	0	1	0	0	6	12	Silt	0-10%	0	12	2	Stage I	2% to 4%	B	Other
SR-17-00-01	0	1	1	0	Shallow Depth of Flow	Slope Break	0	0	0	0	3	4.285714	Sand	75-100%	0	50	16.666667	Stage I	2% to 4%	E	7
SR-17-00-02	0	1	1	0	Shallow Depth of Flow	Slope Break	0	0	0	0	5	5	Sand	50-75%	0	75	15	Stage I	<2%	E	5
SR-17-01-01	0	1	1	0	Shallow Depth of Flow	Slope Break	1	0	0	0	5	3.916667	Gravel	50-75%	1	80	17.021277	Stage I	2% to 4%	E	5
SR-18-00-01	0	1	0	0	Shallow Depth of Flow	Erosional Feature	1	0	0	0	6	12	CONCRETE	25-50%	1	13.5	2.25	Stage II	2% to 4%	B	6
SR-19-00-01	0	1	0	0	Debris Blockage	Slope Break	1	0	0	0	11	17.666667	Gravel	50-75%	1	13.2	1.245283	Stage IV	2% to 4%	F	6
SR-19-00-02	0	1	0	0	Debris Blockage	Slope Break	1	0	0	0	11	17.666667	Gravel	25-50%	1	12	1.132075	Stage IV	2% to 4%	F	6
SR-19-00-03	0	1	0	0	Debris Blockage	Slope Break	1	0	0	0	8	15.8	Gravel	25-50%	1	10.6	1.341772	Stage III	<2%	B	6
SR-19-00-04	0	1	0	0	Debris Blockage	Slope Break	1	0	0	0	12	16.533333	Gravel	50-75%	1	13.9	1.120968	Stage IV	2% to 4%	F	6
SR-19-00-05	0	1	0	0	Debris Blockage	Slope Break	0	0	0	0	11	21	Gravel	25-50%	0	12.5	1.190476	Stage I	2% to 4%	B	6
SR-19-01-01	0	1	0	0	Shallow Depth of Flow		0	0	0	0	6	12		0-10%	0	13.6	2.266667	Stage I	<2%	B	Other
SR-20-00-01	0	1	0	0	Shallow Depth of Flow	Active Floodplain	0	0	0	1	4	13.333333	Silt	50-75%	0	100	25	Stage II	<2%	E	5
SR-21-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	6	12.444444	Silt	75-100%	0	8.5	1.517857	Stage I	2% to 4%	B	6
SR-22-00-01	0	1	0	0	None	Slope Break	0	0	0	0	4	5	Gravel	50-75%	0	16.5	4.714286	Stage I	<2%	E	7
SR-23-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	1	5	9.2	Silt	50-75%	0	100	21.73913	Stage IV	<2%	E	5
OR-00-00-00	0	1	0	0	Shallow Depth of Flow	Active Floodplain	0	0	0	1	5	6.25	Silt	75-100%	0	100	20	Stage I	<2%	E	1
OR-00-00-01	0	1	0	0	Excessive Height	Erosional Feature	1	0	0	0	8	8.888889	Gravel	50-75%	1	9	1.125	Stage II	2% to 4%	G	4
OR-00-00-02	0	1	0	0	Shallow Depth of Flow	Erosional Feature	1	0	0	0	7	12	Gravel	50-75%	1	10.2	1.416667	Stage II	2% to 4%	G	4
OR-00-00-03	0	1	0	0	None	Active Floodplain	1	0	0	0	5	11.75	Silt	50-75%	1	16	3.404255	Stage II	2% to 4%	C	4
OR-00-00-04	1	1	1	0		Erosional Feature	0	0	0	0	7	7.777778	Sapprolite		0	100	14.285714		<2%	B	
OR-00-00-05	0	1	0	0	Debris Blockage	Slope Break	0	0	0	1	16	13.333333	Silt	50-75%	0	100	6.25	Stage I	<2%	C	4
OR-00-00-06	1	1	0	0	Debris Blockage	Active Floodplain	0	1	0	0	18	20.444444	Silt	25-50%	0	18	0.978261	Stage I	2% to 4%	B	6
OR-00-00-07	0	1	0	0	Debris Blockage	Erosional Feature	1	0	0	0	17	12.142857	Gravel	25-50%	1	24.25	1.426471	Stage III	<2%	F	9
OR-00-00-08	0	1	0	0	Debris Blockage	Slope Break	1	0	0	1	17	9.166667	Gravel	50-75%	1	19.5	1.181818	Stage V	2% to 4%	G	6
OR-00-00-09	0	1	0	0	None	Slope Break	0	0	0	1	18	16.454545	Gravel	50-75%	0	100	5.524862	Stage III	2% to 4%	C	4
OR-00-00-10	0	1	0	0	Debris Blockage	Slope Break	0	0	0	1	20	13.333333	Gravel	50-75%	0	100	5	Stage III	2% to 4%	C	Other
OR-00-00-11	0	1	0	0	Debris Blockage	Active Floodplain	0	0	0	1	15	16.777778	Gravel	25-50%	0	8.7	0.576159	Stage III	<2%	F	Other
OR-00-00-12	0	1	0	0	Excessive Height	Slope Break	0	0	0	1	16	24.615385	Gravel	50-75%	0	18.6	1.1625	Stage IV	<2%	F	Other
OR-00-00-13	0	1	0	0	None	Slope Break	0	0	0	0	20	20	Silt	25-50%	0	38	1.9	Stage I	2% to 4%	B	6
OR-00-00-14	1	1	0	0	None	Slope Break	0	1	0	0	10	8.416667	Silt	25-50%	0	100	9.90099	Stage I	<2%	E	7
OR-01-00-01	0	1	0	0	Shallow Depth of Flow	Active Floodplain	0	0	0	0	4	12.666667	Silt	75-100%	0	100	26.315789	Stage I	<2%	E	1
OR-02-00-01	0	1	1	0	Shallow Depth of Flow	Vegetative Feature	0	1	0	1	3	8.5	Sand	10-25%	0	5.8	1.705882	Stage II	<2%	G	6
OR-02-00-02	0	1	0	0	Shallow Depth of Flow	Slope Break	1	1	0		6	7.5625	Cobble	25-50%	1	100	16.528926	Stage III	2% to 4%	E	Other
OR-02-00-03	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	30	42.85	Silt	25-50%	0	40	1.333333333	State V	<2%	B	Other
OR-02-00-04	0	1	1	0	Shallow Depth of Flow	Vegetative Feature	1	1	0	0	8	19.375	Gravel	50-75%	1	9.8	1.264516	Stage III	2% to 4%	B	Other
OR-02-00-05	0	1	0	0	Debris Blockage	Slope Break	0	1	0		11	18.666667	Sand	25-50%	0	12.05	1.075893	Stage III	<2%	F	Other
OR-02-01-01	0	0	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	14	15.555	Sand	25-50%	0	19		Stage V	<2%	B	Other
OR-03-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	1	0	0	2	6	Silt	25-50%	0	2.6	1.444444	Stage II	2% to 4%	G	7

Reach	Surface Protection	Root Depth Bnk HT Ratio	Concrete Lined	Riprap Gabion Lined	Culvert	Culvert Instabilities	Trash Cleanup	Approximate DA (ac)	Dist to Nearest Road (ft)	Dist to Nearest Road (m)	Left Erosion Extent	Left Erosion Extent (m)	Left Erosion Severity	Lt Erosion Severity Conversion	Right Erosion Extent	Right Erosion Extent (m)	Right Erosion Severity	Rt Erosion Severity Conversion	Instream Habitat
SR-12-00-02	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	1	0		1	10	231.6	70.6	100	30.48	1	1	0	0.00	0	0	7
SR-12-00-03	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	442.1	134.8	44	13.41	1	1	150	45.72	2	1.5	9
SR-12-00-01	Med, 30% to 60% protection	Low, Roots Extend to Lower 1/3	0	1	0		1	10	147.4	44.9	0	0.00	0	0	0	0.00	0	0	6
SR-13-00-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	1	0		1	10	315.8	96.3	90	27.43	2	1.5	90	27.43	2	1.5	1
SR-13-00-02	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	168.4	51.3	10	3.05	2	1.5	70	21.34	2	1.5	8
SR-13-01-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	105.3	32.1	110	33.53	2	1.5	60	18.29	2	1.5	1
SR-13-01-02	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	1	0	Fish Passage Issu	1	10	210.5	64.2	50	15.24	3	2	40	12.19	3	2	1
SR-14-00-01	High, <30% protection	Low, Roots Extend to Lower 1/3	0	1	0		1	10	421.1	128.3	135	41.15	1	1	51	15.54	2	1.5	6
SR-14-00-02	Med, 30% to 60% protection	Low, Roots Extend to Lower 1/3	0	0	0		0	10	189.5	57.8	25	7.62	2	1.5	18	5.49	0	0	7
SR-14-01-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	231.6	70.6	110	33.53	2	1.5	60	18.29	2	1.5	7
SR-15-00-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	252.6	77.0	0	0.00	0	0	45	13.72	2	1.5	2
SR-15-00-02	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	210.5	64.2	80	24.38	1	1	10	3.05	1	1	1
SR-15-00-03	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	105.3	32.1	82	24.99	1	1	105	32.00	2	1.5	1
SR-15-00-04	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	252.6	77.0	50	15.24	1	1	35	10.67	2	1.5	6
SR-15-00-05	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	1	0	0		1	10	273.7	83.4	77	23.47	3	2	100	30.48	3	2	11
SR-15-00-06	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	0	1		1	10	63.2	19.3	75	22.86	3	2	145	44.20	2	1.5	14
SR-15-00-07	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	1		1	10	84.2	25.7	20	6.10	2	1.5	70	21.34	2	1.5	12
SR-15-01-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	231.6	70.6	80	24.38	2	1.5	85	25.91	3	2	3
SR-15-02-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	42.1	12.8	105	32.00	2	1.5	50	15.24	1	1	0
SR-15-03-01								10	84.2	25.7		0.00		0		0.00		0	
SR-15-03-02	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		0	10	84.2	25.7	0	0.00	0	0	0	0.00	0	0	0
SR-15-03-03	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	231.6	70.6	82	24.99	2	1.5	105	32.00	2	1.5	1
SR-15-03-04	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	442.1	134.8	40	12.19	2	1.5	6	1.83	2	1.5	5
SR-16-00-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	252.6	77.0	50	15.24	1	1	40	12.19	1	1	5
SR-16-00-02	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	210.5	64.2	150	45.72	2	1.5	150	45.72	3	2	5
SR-16-00-03	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	21.1	6.4	40	12.19	7		0	0.00	0	0	5
SR-16-00-04	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	252.6	77.0	30	9.14	1	1	50	15.24	1	1	4
SR-16-00-06	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	252.6	77.0	20	6.10	3	2	0	0.00	0	0	4
SR-16-00-05	High, <30% protection	High, Roots in Upper 1/3	0	0	0		0	10	252.6	77.0	0	0.00	0	0	0	0.00	0	0	0
SR-17-00-01	Low, >60% protection	Low, Roots Extend to Lower 1/3	0	0	0		0	10	210.5	64.2	0	0.00	0	0	0	0.00	0	0	0
SR-17-00-02	Med, 30% to 60% protection	Low, Roots Extend to Lower 1/3	0	0	0		0	10	84.2	25.7	0	0.00	0	0	0	0.00	0	0	0
SR-17-01-01	Low, >60% protection	Low, Roots Extend to Lower 1/3	0	0	1	sive Downstream	0	10	31.6	9.6	10	3.05	1	1	15	4.57	1	1	5
SR-18-00-01	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	0	0		1	10	168.4	51.3	0	0.00	0	0	7	2.13	2	1.5	1
SR-19-00-01	High, <30% protection	Low, Roots Extend to Lower 1/3	0	1	0		1	10	168.4	51.3	113	34.44	3	2	122	37.19	3	2	9
SR-19-00-02	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	231.6	70.6	102	31.09	3	2	83	25.30	2	1.5	10
SR-19-00-03	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	336.8	102.7	122	37.19	2	1.5	250	76.20	3	2	6
SR-19-00-04	High, <30% protection	Med, Roots Extend to Middle 1/3	0	1	0		1	10	315.8	96.3	59	17.98	2	1.5	42	12.80	3	2	7
SR-19-00-05	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	1	0	0		1	10	42.1	12.8	24	7.32	2	1.5	18	5.49	2	1.5	9
SR-19-01-01	Low, >60% protection	High, Roots in Upper 1/3	1	0	0		1	10	726.3	221.4	0	0.00	0	0	0	0.00	0	0	1
SR-20-00-01	High, <30% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	63.2	19.3	0	0.00	0	0	0	0.00	0	0	2
SR-21-00-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	1	0		1	10	63.2	19.3	0	0.00	0	0	0	0.00	0	0	1
SR-22-00-01	Med, 30% to 60% protection	Low, Roots Extend to Lower 1/3	0	1	0		1	10	42.1	12.8	40	12.19	1	1	0	0.00	0	0	7
SR-23-00-01	Low, >60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10			0	0.00	0	0	0	0.00	0	0	3
OR-00-00-00	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	210.5	64.2	0	0.00	0	0	0	0.00	0	0	4
OR-00-00-01	High, <30% protection	Low, Roots Extend to Lower 1/3	0	1	0		1	10	315.8	96.3	80	24.38	3	2	100	30.48	3	2	7
OR-00-00-02	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	842.1	256.7	50	15.24	1	1	60	18.29	2	1.5	5
OR-00-00-03	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	1052.6	320.8	12	3.66	1	1	40	12.19	1	1	7
OR-00-00-04			1	0	0		1	10	231.6	70.6	0	0.00	0	0	0	0.00	0	0	0
OR-00-00-05	High, <30% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	400.0	121.9	60	18.29	1	1	35	10.67	1	1	6
OR-00-00-06	High, <30% protection	High, Roots in Upper 1/3	1	0	0		1	10	105.3	32.1	8	2.44	3	2	50	15.24	2	1.5	7
OR-00-00-07	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	1	0		1	10	231.6	70.6	150	45.72	1	1	100	30.48	1	1	5
OR-00-00-08	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	336.8	102.7	174	53.04	2	1.5	90	27.43	2	1.5	8
OR-00-00-09	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	505.3	154.0	50	15.24	3	2	0	0.00	0	0	8
OR-00-00-10	High, <30% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	400.0	121.9	100	30.48	1	1	0	0.00	0	0	10
OR-00-00-11	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	1	0		1	10	315.8	96.3	50	15.24	1	1	50	15.24	1	1	12
OR-00-00-12	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	252.6	77.0	60	18.29	2	1.5	65	19.81	2	1.5	14
OR-00-00-13	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	252.6	77.0	0	0.00	0	0	100	30.48	2	1.5	8
OR-00-00-14	High, <30% protection	Med, Roots Extend to Middle 1/3	0	1	0		1	10	157.9	48.1	75	22.86	1	1	70	21.34	2	1.5	6
OR-01-00-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	336.8	102.7	0	0.00	0	0	0	0.00	0	0	3
OR-02-00-01	Med, 30% to 60% protection	Low, Roots Extend to Lower 1/3	0	0	0		1	10	147.4	44.9	5	1.52	1	1	30	9.14	1	1	1
OR-02-00-02	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	105.3	32.1	20	6.10	2	1.5	30	9.14	3	2	1
OR-02-00-03	Med, 30% to 60% protection	Low, Roots Extend to Lower 1/3	0	0	0		0	10	70.0	21.3	0	0.00	0	0	0	0.00	0	0	7
OR-02-00-04	Med, 30% to 60% protection	Low, Roots Extend to Lower 1/3	0	0	0		1	10	378.9	115.5	60	18.29	2	1.5	30	9.14	2	1.5	5
OR-02-00-05	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	1	1		1	10	421.1	128.3	95	28.96	2	1.5	30	9.14	1	1	7
OR-02-01-01	Med, 30% to 60% protection	Low, Roots Extend to Lower 1/3	0	0	0		0	10	80.0	24.4	0	0.00	0	0	0	0.00	0	0	5
OR-03-00-01	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	0	0		1	10	168.4	51.3	27	8.23	1	1	20	6.10	1	1	0

Reach	Epifaunal Substrate	Riffle Run Quality	Embeddedness	Shading	Instream Woody Debris	Instream Rootwads	Total Woody Debris	Yard Waste	Reference Reach	Bank Planting	Root Depth/ Bank Ht Score	Surface Protection Score	Root Density Score	Bank Angle Score	Bank Material	Bank Ht/BF Ht Score	BEHI Score	BEHI Ranking	Remoteness Calc.	Shading Calc.	Epifaunal Calc.	Instream Habitat Calc.	Woody Calc.	Bank Stability Calc.
SR-12-00-02	5	8	70	40	3	1	4	1	0	0	2	2	2	2	0	2	10	Mod	42.33	19.42	23.53	52.52	33.33	99.87
SR-12-00-03	8	9	80	40	1	3	4	0	0	1	3	3	3	2	0	2	13	Mod to High	57.02	19.42	41.18	65.23	33.33	86.72
SR-12-00-01	5	6	80	90	1	0	1	0	0	0	1	2	2	2	0	2	9	Mod	34.55	59.59	23.53	46.17	8.33	100.00
SR-13-00-01	1	1	85	60	0	0	0	1	0	0	2	2	2	3	1.5	2	12.5	Mod to High	48.79	33.76	0.00	14.42	0.00	86.64
SR-13-00-02	11	8	50	55	3	1	4	1	0	0	2	2	1	1	1.5	3	10.5	Mod	36.67	30.16	58.82	58.87	33.33	98.39
SR-13-01-01	3	1	20	60	0	0	0	0	0	0	2	2	2	2	1.5	3	12.5	Mod to High	29.79	33.76	11.76	14.42	0.00	87.87
SR-13-01-02	3	1	50	65	0	0	0	1	0	0	2	2	2	1	1.5	2	10.5	Mod	40.54	37.43	11.76	14.42	0.00	97.26
SR-14-00-01	6	4	75	75	0	0	0	0	0	0	1	3	2	2	0	2	10	Mod	55.74	45.22	29.41	46.17	0.00	91.35
SR-14-00-02	5	6	90	80	1	0	1	0	0	0	1	2	1	1	0	2	7	Low	38.66	49.49	23.53	52.52	8.33	100.00
SR-14-01-01	6	5	80	75	4	2	6	0	0	0	2	2	2	2	1.5	2	11.5	Mod	42.33	45.22	29.41	52.52	50.00	87.87
SR-15-00-01	2	4	50	65	1	2	3	0	0	0	2	2	2	1	0	3	10	Mod	44.04	37.43	5.88	20.77	25.00	100.00
SR-15-00-02	3	2	50	45	0	1	1	0	0	0	2	2	2	2	0	2	10	Mod	40.54	23.03	11.76	14.42	8.33	100.00
SR-15-00-03	5	5	40	50	0	2	2	0	0	0	2	1	2	2	1.5	1	9.5	Mod	29.79	26.59	23.53	14.42	16.67	89.12
SR-15-00-04	9	6	50	40	2	0	2	0	0	0	3	2	2	2	1.5	2	12.5	Mod to High	44.04	19.42	47.06	46.17	16.67	99.69
SR-15-00-05	14	11	60	50	1	2	3	0	0	0	2	2	1	2	0	2	9	Mod	45.69	26.59	76.47	77.93	25.00	87.01
SR-15-00-06	15	14	60	50	2	1	3	0	0	0	2	1	1	2	0	2	8	Low to Mod	23.94	26.59	82.35	96.98	25.00	81.60
SR-15-00-07	14	12	50	55	1	1	2	0	0	0	3	2	2	1	0	2	10	Mod	27.05	30.16	76.47	84.28	16.67	97.26
SR-15-01-01	4	5	45	70	1	2	3	0	0	1	2	2	2	2	1.5	3	12.5	Mod to High	42.33	41.24	17.65	27.12	25.00	88.47
SR-15-02-01	3	5	75	65	2	4	6	0	0	0	2	2	2	2	1.5	3	12.5	Mod to High	20.26	37.43	11.76	8.06	50.00	91.67
SR-15-03-01							0								0		0		27.05	0.00	0.00	8.06	0.00	100.00
SR-15-03-02	1	2	20	65	2	2	4	0	0	0	2	2	2	1	0	1	8	Low to Mod	27.05	37.43	0.00	8.06	33.33	100.00
SR-15-03-03	3	5	40	40	2	3	5	0	0	0	2	2	1	2	1.5	3	11.5	Mod	42.33	19.42	11.76	14.42	41.67	85.77
SR-15-03-04	5	6	70	60	0	2	2	0	0	0	3	2	2	2	1.5	2	12.5	Mod to High	57.02	33.76	23.53	39.82	16.67	100.00
SR-16-00-01	6	0	35	85	0	0	0	0	0	0	2	2	2	2	0	2	10	Mod	44.04	54.18	29.41	39.82	0.00	100.00
SR-16-00-02	6	0	50	75	0	0	0	0	0	0	2	2	2	3	0	3	12	Mod to High	40.54	45.22	29.41	39.82	0.00	70.76
SR-16-00-03	6	1	50	65	0	0	0	0	0	0	2	2	2	2	0	3	11	Mod	15.45	37.43	29.41	39.82	0.00	#VALUE!
SR-16-00-04	4	0	80	40	1	0	1	0	0	0	2	2	2	2	0	2	10	Mod	44.04	19.42	17.65	33.47	8.33	100.00
SR-16-00-06	4	5	90	10	1	0	1	1	0	1	2	2	2	1	0	3	10	Mod	44.04	0.00	17.65	33.47	8.33	100.00
SR-16-00-05	0	0	0	0	0	0	0	0	0	1	3	3	3	1	0	2	12	Mod to High	44.04	0.00	0.00	8.06	0.00	100.00
SR-17-00-01	5	0	75	85	0	0	0	0	0	0	1	1	1	1	0	1	5	Low	40.54	54.18	23.53	8.06	0.00	100.00
SR-17-00-02	0	0	0	70	0	0	0	0	0	0	1	2	1	2	0	1	7	Low	27.05	41.24	0.00	8.06	0.00	100.00
SR-17-01-01	6	1	65	65	0	0	0	0	0	0	1	1	1	1	0	1	5	Low	18.06	37.43	29.41	39.82	0.00	100.00
SR-18-00-01	1	1	1	30	0	0	0	1	0	1	3	2	3	1	0	1	10	Mod	36.67	11.95	0.00	14.42	0.00	100.00
SR-19-00-01	9	8	35	50	7	1	8	1	0	0	1	3	2	2	0	3	11	Mod	36.67	26.59	47.06	65.23	66.67	79.65
SR-19-00-02	10	10	60	45	0	0	0	1	0	0	3	3	2	2	0	3	13	Mod to High	42.33	23.03	52.94	71.58	0.00	86.02
SR-19-00-03	8	9	60	40	4	0	4	1	0	0	3	3	3	2	0	3	14	High	50.26	19.42	41.18	46.17	33.33	59.91
SR-19-00-04	7	6	50	60	5	1	6	0	0	0	2	3	2	2	0	3	12	Mod to High	48.79	33.76	35.29	52.52	50.00	96.01
SR-19-00-05	10	9	60	75	2	0	2	0	0	0	2	2	2	2	0	3	11	Mod	20.26	45.22	52.94	65.23	16.67	100.00
SR-19-01-01	1	1	100	0	0	0	0	0	0	0	3	1	3	1	0	1	9	Mod	72.01	0.00	0.00	14.42	0.00	100.00
SR-20-00-01	2	6	100	85	0	0	0	0	0	0	2	3	3	1	1.5	1	11.5	Mod	23.94	54.18	5.88	20.77	0.00	100.00
SR-21-00-01	1	1	90	95	0	0	0	0	0	0	2	2	2	1	0	2	9	Mod	23.94	66.44	0.00	14.42	0.00	100.00
SR-22-00-01	8	7	70	75	0	0	0	0	0	0	1	2	1	2	0	1	7	Low	20.26	45.22	41.18	52.52	0.00	100.00
SR-23-00-01	2	4	100	65	0	0	0	0	0	0	2	1	3	1	0	1	8	Low to Mod	3.84	37.43	5.88	27.12	0.00	100.00
OR-00-00-00	2	2	95	80	0	0	0	0	0	0	2	2	3	1	0	1	9	Mod	40.54	49.49	5.88	33.47	0.00	100.00
OR-00-00-01	5	6	80	60	2	3	5	1	0	0	1	3	2	2	0	3	11	Mod	48.79	33.76	23.53	52.52	41.67	86.64
OR-00-00-02	6	5	90	60	1	2	3	0	0	0	3	2	2	1	0	3	11	Mod	77.24	33.76	29.41	39.82	25.00	96.88
OR-00-00-03	4	6	90	60	4	2	6	1	0	1	3	3	2	1	0	2	11	Mod	85.90	33.76	17.65	52.52	50.00	100.00
OR-00-00-04	0	0	0	0	0	0	0	0	0	0					0		0		42.33	0.00	0.00	8.06	0.00	100.00
OR-00-00-05	4	7	90	70	2	1	3	1	0	0	2	3	2	1	0	2	10	Mod	54.43	41.24	17.65	46.17	25.00	100.00
OR-00-00-06	6	9	90	40	0	5	5	1	0	0	3	3	2	1	0	3	12	Mod to High	29.79	19.42	29.41	52.52	41.67	100.00
OR-00-00-07	4	6	90	40	2	0	2	1	0	0	2	2	2	2	0	2	10	Mod	42.33	19.42	17.65	39.82	16.67	88.27
OR-00-00-08	6	9	80	60	3	1	4	1	0	0	3	3	2	2	0	2	12	Mod to High	50.26	33.76	29.41	58.87	33.33	75.77
OR-00-00-09	5	9	85	50	1	0	1	1	0	0	3	3	2	2	0	2	12	Mod to High	60.70	26.59	23.53	58.87	8.33	100.00
OR-00-00-10	7	12	75	50	1	2	3	1	0	0	2	3	2	1	0	2	10	Mod	54.43	26.59	35.29	71.58	25.00	99.87
OR-00-00-11	12	15	75	60	2	1	3	1	0	0	2	2	2	1	0	2	9	Mod	48.79	33.76	64.71	84.28	25.00	99.87
OR-00-00-12	13	12	10	50	3	2	5	0	0	0	2	2	2	2	1.5	2	11.5	Mod	44.04	26.59	70.59	96.98	41.67	93.24
OR-00-00-13	4	3	95	40	0	1	1	0	0	0	3	2	2	1	0	2	10	Mod	44.04	19.42	17.65	58.87	8.33	96.12
OR-00-00-14	4	8	90	40	0	1	1	1	0	0	2	3	2	2	0	2	11	Mod	35.63	19.42	17.65	46.17	8.33	93.82
OR-01-00-01	2	1	100	80	0	0	0	0	0	0	2	2	2	1	0	2	9	Mod	50.26	49.49	5.88	27.12	0.00	100.00
OR-02-00-01	3	4	20	10	0	0	0	1	0	1	1	2	2	1	1.5	2	9.5	Mod	34.55	0.00	11.76	14.42	0.00	100.00
OR-02-00-02	3	2	25	40	0	0	0	1	0	0	2	2	2	1	0	2	9	Mod	29.79	19.42	11.76	14.42	0.00	100.00
OR-02-00-03	6	5	80	60	0	0	0	0	0	0	1	2	1	1	0	2	7	Low	25.00	33.76	29.41	52.52	0.00	100.00
OR-02-00-04	7	9	50	45	3	2	5	1	0	0	1	2	2	1	1.5	3	10.5	Mod	53.08	23.03	35.29	39.82	41.67	97.26
OR-02-00-05	6	7	15	40	3	1	4	0	0	0	2	2	2	1	1.5	2	10.5	Mod	55.74	19.42	29.41	52.52	33.33	94.40
OR-02-01-01	4	1	80	60	0	0	0	0	0	0	1	2	1	1	0	2	7	Low	26.47	33.76	17.65	39.82	0.00	100.00
OR-03-00-01	1	1	15	20	0	0	0	1	0	0	3	2	3	2	1.5	3	14.5	High	36.67	3.69	0.00	8.06	0.00	100.00

Reach	Riffle Quality Calc.	Embeddness Calc.	PHI	Habitat Rating	Lt Eroded Area	Rt Eroded Area	Eroded Area/Reach Length	Measure 1: Stream Restoration	Buffer Enhancement Recommende	Measure 2: Buffer Enhancement	Measure 3: Bank Planting	Meaure 4: Utility Conflict Resolution	Measure 5: Wetland Enhancement	Measure 6: Trash Cleanup	Measure 7: Yard Waste Cleanup	Unstable Stable Ratio > 25%	Eroded Area/Reach Length > 2.0	Stream Stabilization Recommende	Measure 8: Invasive Species	Total No of Recommende d Measures	Total Cost	Comments
SR-12-00-02	81.47	33.33	48.23	Fair	1,902.00	687.00	1.85	1	0	0	0	0	0	1	1	1	0	0	0	3	$315,535	
SR-12-00-03	86.56	22.22	51.46	Fair	4,172.00	4,627.00	8.22	1	0	0	1	0	0	1	0	1	1	1	1	4	$261,236	
SR-12-00-01	71.28	22.22	45.71	Fair	0.00	0.00	0.00	0	0	1	0	0	1	1	0	0	0	0	1	4	$73,000	
SR-13-00-01	45.82	16.67	30.76	Poor	315.00	315.00	1.14	1	0	0	0	1	0	1	1	0	0	1	1	5	$198,823	
SR-13-00-02	81.47	55.56	56.66	Fair	1,020.00	800.00	1.54	0	0	0	0	1	0	1	1	0	0	0	1	4	$36,000	
SR-13-01-01	45.82	88.89	39.04	Poor	325.00	345.00	1.13	1	1	0	0	0	0	1	0	0	0	1	1	3	$186,298	
SR-13-01-02	45.82	55.56	37.85	Poor	120.00	150.00	0.94	1	1	0	0	0	0	1	1	0	0	1	1	4	$120,992	
SR-14-00-01	61.10	27.78	44.60	Fair	224.00	118.80	1.07	1	0	0	0	0	0	1	0	1	0	0	0	2	$128,468	
SR-14-00-02	71.28	11.11	44.37	Fair	90.00	54.00	0.29	0	0	0	0	0	0	0	0	0	0	0	1	1	$7,500	
SR-14-01-01	66.19	22.22	49.47	Fair	176.00	120.00	1.01	1	0	0	0	0	0	1	0	1	0	0	0	2	$117,316	
SR-15-00-01	61.10	55.56	43.72	Fair	2.50	87.50	0.16	1	0	0	0	0	0	1	0	0	0	1	1	3	$175,103	
SR-15-00-02	50.91	55.56	38.07	Poor	80.00	15.00	0.36	0	0	0	0	0	0	1	0	0	0	0	1	2	$5,500	
SR-15-00-03	66.19	66.67	41.62	Poor	107.25	187.50	0.55	0	0	0	0	0	0	1	0	0	0	0	1	2	$8,000	
SR-15-00-04	71.28	55.56	49.99	Fair	100.00	105.00	1.09	1	0	0	0	0	0	1	0	0	0	1	1	3	$80,788	
SR-15-00-05	96.74	44.44	59.98	Fair	630.00	675.00	1.15	1	0	0	0	1	0	1	0	0	0	1	1	4	$289,888	
SR-15-00-06	100.00	44.44	60.11	Fair	540.00	770.00	1.62	1	0	0	0	1	0	1	0	0	0	1	1	4	$217,903	
SR-15-00-07	100.00	55.56	60.93	Fair	100.00	227.50	1.17	0	0	0	0	0	0	1	0	0	0	0	1	2	$5,500	
SR-15-01-01	66.19	61.11	46.14	Fair	665.00	875.00	4.28	1	0	0	1	0	0	1	0	1	1	1	1	4	$154,456	
SR-15-02-01	66.19	27.78	39.14	Poor	210.00	5,775.00	15.69	1	0	0	0	0	0	1	0	0	1	1	1	3	$158,039	
SR-15-03-01	40.73	100.00	34.48	Poor	0.00	0.00	0.00	0	0	0						0	0	0		0	$0	
SR-15-03-02	50.91	88.89	43.21	Fair	0.00	0.00	0.00	1	0	0	0	0	0	0	0	0	0	1	0	1	$122,794	
SR-15-03-03	66.19	66.67	43.53	Fair	183.00	183.00	0.61	0	0	0	0	0	0	1	0	0	0	0	1	2	$8,000	
SR-15-03-04	71.28	33.33	46.93	Fair	60.00	90.00	0.59	0	0	0	0	0	0	1	0	0	0	0	1	2	$5,500	
SR-16-00-01	40.73	72.22	47.55	Fair	231.00	157.50	0.48	0	0	0	0	0	0	1	0	0	0	0	0	1	$500	
SR-16-00-02	40.73	55.56	40.26	Poor	1,875.00	1,320.00	3.36	1	0	0	0	0	0	1	0	1	1	1	0	2	$214,631	
SR-16-00-03	45.82	55.56	#####	######	350.00	60.00	1.18	1	0	0	0	0	0	1	0	0	0	1	0	2	$139,529	
SR-16-00-04	40.73	22.22	35.73	Poor	0.00	150.00	0.64	1	1	0	0	0	0	1	0	0	0	1	1	3	$99,900	
SR-16-00-06	66.19	11.11	35.10	Poor	0.00	240.00	0.53	0	1	0	1	0	0	1	1	0	0	0	1	4	$16,000	
SR-16-00-05	40.73	100.00	36.60	Poor	0.00	0.00	0.00	0	1	0	1	0	0	0	0	0	0	0	0	1	$7,500	
SR-17-00-01	40.73	27.78	36.85	Poor	0.00	7.00	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	$0	
SR-17-00-02	40.73	100.00	39.64	Poor	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	1	1	$10,000	
SR-17-01-01	45.82	38.89	38.68	Poor	137.50	30.00	0.53	1	0	0	0	0	0	0	0	0	0	1	0	1	$127,000	
SR-18-00-01	45.82	100.00	38.61	Poor	0.00	26.00	0.02	1	0	0	1	0	0	1	1	0	0	1	0	4	$334,085	
SR-19-00-01	81.47	72.22	59.44	Fair	6,432.00	6,846.00	8.94	1	0	0	0	0	0	1	1	1	1	1	0	3	$335,100	
SR-19-00-02	91.65	44.44	51.50	Fair	0.00	0.00	0.00	1	0	0	0	0	0	1	1	0	0	1	1	4	$192,166	
SR-19-00-03	86.56	44.44	47.66	Fair	3,260.00	3,684.00	6.32	1	0	0	0	0	0	1	1	1	1	1	0	3	$248,043	
SR-19-00-04	71.28	55.56	55.40	Fair	960.00	640.00	2.71	1	0	0	0	0	0	1	0	0	1	1	1	3	$185,334	
SR-19-00-05	86.56	44.44	53.91	Fair	252.00	198.00	0.63	0	0	0	0	0	0	1	0	0	0	0	1	2	$8,000	
SR-19-01-01	45.82	0.00	29.03	Poor	0.00	0.00	0.00	0	0	0	0	0	0	1	0	0	0	0	0	1	$500	
SR-20-00-01	71.28	0.00	34.51	Poor	648.00	184.00	0.96	0	0	1	0	0	1	1	0	0	0	0	1	4	$120,500	
SR-21-00-01	45.82	11.11	32.72	Poor	0.00	0.00	0.00	0	0	0	0	0	0	1	0	0	0	0	1	2	$8,000	
SR-22-00-01	76.38	33.33	46.11	Fair	78.00	76.00	0.26	1	0	0	0	0	0	1	0	1	0	0	1	3	$183,506	
SR-23-00-01	61.10	0.00	29.42	Poor	0.00	0.00	0.00	0	0	1	0	0	1	1	0	0	0	0	0	3	$65,500	
OR-00-00-00	50.91	5.56	35.73	Poor	0.00	0.00	0.00	0	0	0	0	0	1	1	0	0	0	0	1	3	$48,000	
OR-00-00-01	71.28	22.22	47.55	Fair	1,230.00	960.00	3.49	1	0	0	0	0	0	1	1	1	1	1	0	3	$189,209	
OR-00-00-02	66.19	11.11	47.43	Fair	625.00	790.00	1.67	1	0	0	0	0	0	1	0	0	0	1	0	2	$191,251	
OR-00-00-03	71.28	11.11	52.78	Fair	140.00	104.00	0.53	1	0	0	1	0	0	1	1	0	0	1	0	4	$146,363	
OR-00-00-04	40.73	100.00	36.39	Poor	0.00	0.00	0.00	0	0	0	0	0	0	1	0	0	0	0	0	1	$500	channel ends. Conc lined
OR-00-00-05	76.38	11.11	46.50	Fair	440.00	308.00	0.69	0	0	0	0	0	1	1	1	0	0	0	0	3	$61,000	
OR-00-00-06	86.56	11.11	46.31	Fair	99.00	508.00	0.76	0	1	1	0	0	0	1	1	0	0	0	0	3	$51,000	MODIFIED REACH
OR-00-00-07	71.28	11.11	38.32	Poor	0.00	0.00	0.00	1	0	0	0	0	0	1	1	0	0	1	0	3	$125,740	
OR-00-00-08	86.56	22.22	48.77	Fair	3,465.00	2,175.00	4.43	1	0	0	0	0	1	1	1	1	1	1	0	4	$347,730	
OR-00-00-09	86.56	16.67	47.66	Fair	412.00	0.00	1.48	0	0	0	0	0	1	1	1	0	0	0	0	3	$21,000	
OR-00-00-10	100.00	27.78	55.07	Fair	1,748.00	1,752.00	2.11	1	0	0	0	0	1	1	1	1	1	0	0	4	$434,191	
OR-00-00-11	100.00	27.78	60.52	Fair	1,236.00	1,960.00	3.18	1	0	0	0	0	1	1	1	1	1	0	0	4	$287,209	
OR-00-00-12	100.00	100.00	71.64	Fair	195.00	507.50	1.48	0	0	0	0	0	1	1	0	0	0	0	1	3	$48,000	
OR-00-00-13	56.01	5.56	38.25	Poor	0.00	535.00	1.85	1	0	0	0	0	0	1	0	1	0	0	1	3	$121,135	
OR-00-00-14	81.47	11.11	39.20	Poor	1,256.00	304.00	2.53	1	1	1	0	0	0	1	1	1	1	0	0	4	$210,632	modified reach break
OR-01-00-01	45.82	0.00	34.82	Poor	0.00	0.00	0.00	0	0	0	0	0	0	1	0	0	0	0	0	1	$500	
OR-02-00-01	61.10	88.89	38.84	Poor	140.00	170.00	0.31	0	1	1	1	0	1	1	1	0	0	0	1	6	$131,000	Ditches adjacent to roadway .
OR-02-00-02	50.91	83.33	38.71	Poor	60.00	180.00	0.33	1	1	1	0	0		1	1	0	0	1	1	5	$251,632	
OR-02-00-03	66.19	22.22	41.14	Poor	0.00	0.00	0.00	0	0	0	0		0	0	0	0	0	0	0	0	$0	$0
OR-02-00-04	86.56	55.56	54.03	Fair	225.00	162.50	0.43	1	1	1	0	0	0	1	1	0	0	1	1	5	$265,994	Questionable water quality
OR-02-00-05	76.38	94.44	56.96	Fair	437.50	110.00	0.74	0	1	1	0	0		1	0	0	0	0	1	3	$33,000	
OR-02-01-01	45.82	22.22	35.72	Poor	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	$0	
OR-03-00-01	45.82	94.44	36.09	Poor	90.00	37.50	0.27	0	1	1	0	0	0	1	1	0	0	0	1	4	$33,500	

Upper Back River Watershed Stream Stability Assessment

Herring Run-Stemmers Run-Brien Run

Reach	Length	Subshed	Team	Date	FlowRegime	Bankfull Depth	Max Bankfull Depth	Sinuosity	Meander Pattern	Depositional Features	Channel Stability V	Channel Stability L	Left Unstable Bank Length	Left Unstable Bank Height	Right Unstable Bank Length	Unstable-Stable Ratio	Right Unstable Bank Height
OR-03-00-02	823	OBRIAN RUN	MJM/RM	7/5/2007 9:33	Intermittent	0.45	0.55	Moderate, 1.2 to 1.5	M3, Irregular	B1, Point Bars	Degrading	Degrading	175	3	145	19.45%	3
OR-03-00-03	136	OBRIAN RUN	MJM/RM	7/5/2007 10:55	Intermittent	0.3	0.35	Moderate, 1.2 to 1.5	M3, Irregular	None	Degrading	Stable	0	0	0	0.00%	0
OR-03-00-04	326	OBRIAN RUN	CRF\AZ	7/24/2007 9:28	Perennial	0.8	1	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Stable	Stable	108	1	150	39.60%	4
OR-03-00-05	723	OBRIAN RUN	CRG\AZ	7/11/2007 9:07	Perennial	1	1.3	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Stable	Stable	160	4.5	150	21.44%	1
OR-04-00-01	1082	OBRIAN RUN	CRG\MY	7/3/2007 9:07	Intermittent	0.8	1.1	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	30	4	80	5.08%	4
OR-05-00-01	513	OBRIAN RUN	CRG\AZ	6/26/2007 12:14	Ephemeral	0.2	0.3	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	0	0	0	0.00%	0
OR-06-00-01	649	OBRIAN RUN	CRG/MY	6/21/2007 15:49	Intermittent	1	1.2	Low, 1.0 to 1.2	M3, Irregular	B1, Point Bars	Stable	Degrading	261	5	233	38.05%	4
OR-07-00-01	397	OBRIAN RUN	CRG/JEK	7/5/2007 7:40	Perennial	0.5	0.75	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Stable	Stable	55	2	50	13.22%	3
OR-08-00-01	372	OBRIAN RUN	CRG\JEK	7/5/2007 10:07	Perennial	1	1.3	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Degrading	Stable	24	1	10	4.57%	0.5
OR-08-00-02	994	OBRIAN RUN	CRG/JEK	7/5/2007 13:23		1	1.3	Low, 1.0 to 1.2	M3, Irregular	B4, Side Bars	Aggrading	Stable	662	3	702	68.63%	3
OR-08-01-01	715	OBRIAN RUN	CRG/JEK	7/5/2007 10:48	Intermittent	1.1	1.6	Low, 1.0 to 1.2	M3, Irregular	None	Degrading	Stable	76	3	38	7.97%	3
OR-09-00-01	264	OBRIAN RUN	CRG\AZ	7/11/2007 8:26	Perennial	0.8	1.3	Moderate, 1.2 to 1.5	M3, Irregular	None	Stable	Stable	40	2	75	21.74%	1.5
OR-10-00-03	1165	OBRIAN RUN	CRG\AZ	7/24/2007 15:53	Perennial	1.1	1.4	Moderate, 1.2 to 1.5	M3, Irregular	B4, Side Bars	Stable	Degrading	462	5	438	38.62%	4
OR-10-00-04	554	OBRIAN RUN	MJM/RM	7/3/2007 15:33	Perennial	0.375	0.45	Moderate, 1.2 to 1.5	M3, Irregular	nt Bars w\Few M	Stable	Aggrading	45	2.25	125	15.35%	2.5
OR-10-02-01	357	OBRIAN RUN	CRG\AZ	7/24/2007 8:57	Perennial	0.9	1.2	Low, 1.0 to 1.2	M3, Irregular	None	Stable	Stable	10	3	22	4.48%	2

Upper Back River Watershed Stream Stability Assessment
Herring Run-Stemmers Run-Brien Run

Reach	Bank Bankfull Ratio	Bank Angle	Bank Material	Root Density	Debris Blockages	Leaking Utility	Exposed MH Riser	Left Bank Riparian Width	Right Bank Riparian Width	Left Bank Riparian Comp	Right Bank Riparian Comp	Bedrock Outcrop	Left Bank Riparian Density	Right Bank Riparian Density
OR-03-00-02	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	Stratified	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	40	35	Deciduous Overstory	Deciduous Overstory	1	Moderate	Moderate
OR-03-00-03	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout	None	0	0	100	80	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	High	Moderate
OR-03-00-04	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	50	60	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-03-00-05	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Infrequent	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-04-00-01	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Infrequent	0	0	15	10	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-05-00-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	None	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-06-00-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	High, Minimal Roots	Numerous	0	0	80	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-07-00-01	Low, BF at Top of Bank	Low, Sloping Away From Stream	None	High, Minimal Roots	Numerous	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-08-00-01	High, BF Lower 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	0	30	30	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-08-00-02	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Med, Dense Roots Upper 1/2 Bank	Numerous	0	0	100	100	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-08-01-01	Med, BF in Upper 1/2 of Bank	Low, Sloping Away From Stream	None	Low, Dense Roots Throughout	Moderate	0	0	20	30	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-09-00-01	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	None	High, Minimal Roots	None	0	0	100	100	Forested Wetland	Forested Wetland	0	Moderate	Moderate
OR-10-00-03	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Moderate	0	1	100	70	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-10-00-04	Med, BF in Upper 1/2 of Bank	Med, Nearly Vertical	Sandy	Med, Dense Roots Upper 1/2 Bank	Infrequent	0	0	80	45	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate
OR-10-02-01	High, BF Lower 1/2 of Bank	Med, Nearly Vertical	None	Med, Dense Roots Upper 1/2 Bank	Infrequent	1	1	10	70	Decid w\Brush-Grass Under	Decid. w\Brush-Grass Understory	0	Moderate	Moderate

Upper Back River Watershed Stream Stability Assessment

Herring Run-Stemmers Run-Brien Run

Reach	Channel Mod	Photo Taken	Comment	Private Structure Threatend	Fish Blockage	BF Indicator	Chnl Restoration	Buffer Enhncmnt	Utilility Resol	Habitat Enhcmnt	Bankfull Width	Width Depth Ratio	Substrate	Canopy Cover	Chnl Restoration	Floodprone Width	Entrenchment	Chnl Evol	Channel Slope	Rosgen Class	Succession
OR-03-00-02	0	1	0	0	Shallow Depth of Flow	Change in Particle Size	1	1	0	0	4	9.111111	Silt	25-50%	1	4.7	1.146341	Stage II	2% to 4%	G	7
OR-03-00-03	1	1	1	0	Shallow Depth of Flow	Slope Break	0	0	0	0	2	7.333333	Silt	10-25%	0	3.35	1.522727	Stage II	<2%	B	6
OR-03-00-04	0	1	0	0	None	Slope Break	0	0	0	0	10	12	Gravel	50-75%	0	15.8	1.645833	Stage I	<2%	B	6
OR-03-00-05	0	1	0	0	Excessive Height	Active Floodplain	0	0	0	0	12	12	Gravel	25-50%	0	15	1.25	Stage IV	<2%	G	9
OR-04-00-01	0	1	1	0	Shallow Depth of Flow	Erosional Feature	0	0	0	0	9	11.375	Silt	50-75%	0	12.5	1.373626	Stage I	<2%	B	6
OR-05-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	2	8	Silt	25-50%	0	5	3.125	Stage I	<2%	E	5
OR-06-00-01	1	1	1	0	Shallow Depth of Flow	Slope Break	1	0	0	0	8	8.1	Sand	50-75%	1	11.4	1.407407	Stage III	<2%	G	6
OR-07-00-01	0	1	0	0	Debris Blockage	Active Floodplain	0	0	0	1	16	32.8	Silt	50-75%	0	100	6.097561	Stage I	<2%	C	4
OR-08-00-01	0	1	0	0	Debris Blockage	Slope Break	1	0	0	0	6	5.9	Silt	50-75%	1	15.3	2.59322	Stage II	<2%	C	4
OR-08-00-02	0	1	0	0	Debris Blockage	Slope Break	1	0	0	0	18	17.5	Gravel	25-50%	1	20.7	1.182857	Stage IV	2% to 4%	F	9
OR-08-01-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	0	7	6.363636	Gravel	25-50%	0	10.7	1.528571	Stage I	2% to 4%	A	Other
OR-09-00-01	0	1	0	0	Shallow Depth of Flow	Slope Break	0	0	0	1	7	8.5	Silt	10-25%	0	100	14.705882	Stage II	<2%	E	7
OR-10-00-03	0	1	0	0	None	Slope Break	1	0	1	0	19	16.818182	Gravel	50-75%	1	29.5	1.594595	Stage IV	2% to 4%	F	6
OR-10-00-04	0	1	0	0	None	Depositional Features	0	0	0	0	10	26.533333	Gravel	50-75%	0	14.6	1.467337	Stage IV	<2%	F	Other
OR-10-02-01	0	1	0	0	Excessive Height	Slope Break	0	0	1	0	6	7	Gravel	50-75%	0	7.3	1.15873	Stage I	2% to 4%	G	6

Reach	Surface Protection	Root Depth Bnk HT Ratio	Concrete Lined	Riprap Gabion Lined	Culvert	Culvert Instabilities	Trash Cleanup	Approximate DA (ac)	Dist to Nearest Road (ft)	Dist to Nearest Road (m)	Left Erosion Extent	Left Erosion Extent (m)	Left Erosion Severity	Lt Erosion Severity Conversion	Right Erosion Extent	Right Erosion Extent (m)	Right Erosion Severity	Rt Erosion Severity Conversion	Instream Habitat
OR-03-00-02	Med, 30% to 60% protection	Low, Roots Extend to Lower 1/3	0	0	0		1	10	168.4	51.3	145	44.20	2	1.5	70	21.34	2	1.5	2
OR-03-00-03	Med, 30% to 60% protection	Low, Roots Extend to Lower 1/3	0	0	0		1	10	442.1	134.8	0	0.00	0	0	0	0.00	0	0	1
OR-03-00-04	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	1	0	0		1	10	168.4	51.3	26	7.92	3	2	30	9.14	1	1	10
OR-03-00-05	High, <30% protection	Med, Roots Extend to Middle 1/3	0	1	0		1	10	189.5	57.8	50	15.24	3	2	50	15.24	1	1	10
OR-04-00-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	1	0	0		1	10	63.2	19.3	0	0.00	0	0	0	0.00	0	0	1
OR-05-00-01	High, <30% protection	Low, Roots Extend to Lower 1/3	0	0	0		0	10	715.8	218.2	0	0.00	0	0	0	0.00	0	0	0
OR-06-00-01	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	357.9	109.1	54	16.46	2	1.5	75	22.86	2	1.5	1
OR-07-00-01	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	378.9	115.5	10	3.05	1	1	5	1.52	1	1	2
OR-08-00-01	Med, 30% to 60% protection	High, Roots in Upper 1/3	0	1	0		1	10	294.7	89.8	20	6.10	1	1	0	0.00	0	0	3
OR-08-00-02	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	252.6	77.0	130	39.62	1	1	130	39.62	2	1.5	11
OR-08-01-01	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	63.2	19.3	15	4.57	1	1	20	6.10	1	1	0
OR-09-00-01	High, <30% protection	High, Roots in Upper 1/3	0	0	0		1	10	442.1	134.8	75	22.86	2	1.5	0	0.00	0	0	4
OR-10-00-03	Med, 30% to 60% protection	High, Roots in Upper 1/3	1	1	0		1	10	84.2	25.7	55	16.76	2	1.5	100	30.48	2	1.5	12
OR-10-00-04	Med, 30% to 60% protection	Med, Roots Extend to Middle 1/3	0	0	0		1	10	168.4	51.3	0	0.00	0	0	50	15.24	2	1.5	12
OR-10-02-01	High, <30% protection	Med, Roots Extend to Middle 1/3	1	1	0		0	10	294.7	89.8	0	0.00	0	0	0	0.00	0	0	6

Upper Back River Watershed Stream Stability Assessment

Herring Run-Stemmers Run-Brien Run

Reach	Epifaunal Substrate	Riffle Run Quality	Embeddedness	Shading	Instream Woody Debris	Instream Rootwads	Total Woody Debris	Yard Waste	Reference Reach	Bank Planting	Root Depth/ Bank Ht Score	Surface Protection Score	Root Density Score	Bank Angle Score	Bank Material	Bank Ht/BF Ht Score	BEHI Score	BEHI Ranking	Remoteness Calc.	Shading Calc.	Epifaunal Calc.	Instream Habitat Calc.	Woody Calc.	Bank Stability Calc.
OR-03-00-02	3	4	20	30	2	1	3	0	0	0	1	2	2	2	0	3	10	Mod	36.67	11.95	11.76	20.77	25.00	82.24
OR-03-00-03	1	2	10	20	0	0	0	0	0	0	1	2	1	1	0	2	7	Low	57.02	3.69	0.00	14.42	0.00	100.00
OR-03-00-04	10	8	60	75	2	1	3	0	0	0	2	2	2	2	0	3	11	Mod	36.67	45.22	52.94	71.58	25.00	100.00
OR-03-00-05	7	9	90	40	1	2	3	0	0	0	2	3	3	1	0	3	12	Mod to High	38.66	19.42	35.29	71.58	25.00	98.01
OR-04-00-01	1	0	100	50	0	0	0	1	0	0	2	2	3	1	0	3	11	Mod	23.94	26.59	0.00	14.42	0.00	100.00
OR-05-00-01	0	0	0	40	0	0	0	0	0	0	1	3	2	1	0	1	8	Low to Mod	71.51	19.42	0.00	8.06	0.00	100.00
OR-06-00-01	1	1	100	60	0	0	0	1	0	0	3	3	3	2	0	3	14	High	51.69	33.76	0.00	14.42	0.00	92.77
OR-07-00-01	1	7	100	60	0	1	1	1	0	0	3	3	3	1	0	1	11	Mod	53.08	33.76	0.00	20.77	8.33	100.00
OR-08-00-01	1	7	100	60	1	1	2	1	0	0	3	2	2	1	0	3	11	Mod	47.27	33.76	0.00	27.12	16.67	100.00
OR-08-00-02	4	8	80	50	2	1	3	1	0	0	2	2	2	1	0	2	9	Mod	44.04	26.59	17.65	77.93	25.00	82.02
OR-08-01-01	6	6	70	45	0	0	0	1	0	0	2	2	1	1	0	2	8	Low to Mod	23.94	23.03	29.41	8.06	0.00	100.00
OR-09-00-01	2	2	100	20	0	0	0	1	0	0	3	3	3	2	0	2	13	Mod to High	57.02	3.69	5.88	33.47	0.00	98.95
OR-10-00-03	10	10	50	75	1	2	3	0	0	0	3	2	2	2	0	3	12	Mod to High	27.05	45.22	52.94	84.28	25.00	89.68
OR-10-00-04	12	10	45	55	1	1	2	1	0	0	2	2	2	2	1.5	2	11.5	Mod	36.67	30.16	64.71	84.28	16.67	100.00
OR-10-02-01	8	5	40	75	1	0	1	1	0	0	2	3	2	2	0	3	12	Mod to High	47.27	45.22	41.18	46.17	8.33	100.00

Reach	Riffle Quality Calc.	Embeddness Calc.	PHI	Habitat Rating	Lt Eroded Area	Rt Eroded Area	Eroded Area/Reach Length	Measure 1: Stream Restoration	Buffer Enhancement Recommende	Measure 2: Buffer Enhancement	Measure 3: Bank Planting	Meaure 4: Utility Conflict Resolution	Measure 5: Wetland Enhancement	Measure 6: Trash Cleanup	Measure 7: Yard Waste Cleanup	Unstable Stable Ratio > 25%	Eroded Area/Reach Length > 2.0	Stream Stabilization Recommende	Measure 8: Invasive Species	Total No of Recommended Measures	Total Cost	Comments
OR-03-00-02	61.10	88.89	42.30	Fair	525.00	435.00	1.17	1	1	1	0	0	0	1	0	0	0	1	0	3	$235,563	
OR-03-00-03	50.91	100.00	40.76	Poor	0.00	0.00	0.00	0	0	0	0	0	0	1	0	0	0	0	0	1	$500	and wetland areas observed. Reach
OR-03-00-04	81.47	44.44	57.17	Fair	108.00	600.00	2.17	1	0	0	0	0	0	1	0	1	1	0	0	2	$130,802	
OR-03-00-05	86.56	11.11	48.20	Fair	720.00	150.00	1.20	0	0	0	0	0	0	1	0	0	0	0	0	1	$500	
OR-04-00-01	40.73	0.00	25.71	Poor	120.00	320.00	0.41	0	0	0	0	0	0	1	1	0	0	0	0	2	$1,000	OF CHANNEL CHANNEL MOSTLY
OR-05-00-01	40.73	100.00	42.47	Fair	0.00	0.00	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	$0	
OR-06-00-01	45.82	0.00	29.81	Poor	1,305.00	932.00	3.45	1	0	0	0	0	0	1	1	1	1	1	0	3	$195,735	channel ends
OR-07-00-01	76.38	0.00	36.54	Poor	110.00	150.00	0.65	0	0	0	0	0	1	1	1	0	0	0	0	3	$21,000	
OR-08-00-01	76.38	0.00	37.65	Poor	24.00	5.00	0.08	1	0	0	0	0	0	1	1	0	0	1	0	3	$149,934	
OR-08-00-02	81.47	22.22	47.12	Fair	1,986.00	2,106.00	4.12	1	0	0	0	0	0	1	1	1	1	1	0	3	$224,596	
OR-08-01-01	71.28	33.33	36.13	Poor	228.00	114.00	0.48	0	0	0	0	0	0	1	1	0	0	0	0	2	$1,000	
OR-09-00-01	50.91	0.00	31.24	Poor	80.00	112.50	0.73	0	0	0	0	0	1	1	1	0	0	0	0	3	$21,000	
OR-10-00-03	91.65	55.56	58.92	Fair	2,310.00	1,752.00	3.49	1	0	0	0	0	0	1	0	1	1	1	0	2	$262,702	
OR-10-00-04	91.65	61.11	60.65	Fair	101.25	312.50	0.75	0	0	0	0	0	0	1	1	0	0	0	1	3	$8,500	
OR-10-02-01	66.19	66.67	52.63	Fair	30.00	44.00	0.21	0	0	0	0	1	0	0	1	0	0	0	0	2	$25,500	

APPENDIX D

Assessment Criteria

- BEHI Scoring
- Debris Assessment

UPPER BACK RIVER BANK EROSION HAZARD POTENTIAL

Use general rating criteria to look at 5 main components of the BEHI.

1) Bank Height/Bankfull Height:
    a. High (3 pts) BF in lower half of bank
    b. Med (2 pts) BF in upper half of bank
    c. Low (1 pt) BF at top of bank

2) Bank Angle
    a. High (3 pts) Undercut bank
    b. Med (2 pts) Nearly vertical bank
    c. Low (1 pt) Gently sloping bank

3) Root Density
    a. High (3 pts) Minimal roots
    b. Med (2 pts) Dense roots in upper half of bank
    c. Low (1 pt) Dense roots throughout bank

4) % Surface Protection
    a. High (3 pts) < 30% of bank has surface protection
    b. Med (2 pts) 30 to 60% of bank has surface protection
    c. Low (1 pt) 60% or more of bank has surface protection

5) Root Depth/Bank Height
    a. High (3 pts) Roots only extend in upper third of bank
    b. Med (2 pts) Roots extend in middle third of bank
    c. Low (1 pt) Roots extend into lower third of bank

To determine the overall Bank Erosion Hazard potential, sum up the points from each of the 5 categories.

Adjust for Bank Material:
If banks are sandy, add 1.5 pts
If banks are cobble, subtract 1.5 pts.

Final Ranking:

• High Erosion Potential	14 to 15 points
• Moderate to High	12 to 13 points
• Moderate Erosion Potential	9 to 11 points
• Low to Moderate Erosion Potential	8 points
• Low Erosion Potential	Less than 8 points

UPPER BACK RIVER DEBRIS ASSESSMENT

PREDOMINANT DEBRIS BLOCKAGE PATTERN FOUND THROUGHOUT ENTIRE REACH

- **None**

- **Infrequent** – Debris consists of small, easily moved, floatable material, i.e. leaves, needles, small limbs, twigs, etc.

- **Moderate** – Increasing frequency of small to medium sized material, such as medium limbs, branches and small logs.

- **Numerous** – Significant build up of medium to large sized materials, i.e. large limbs, branches, small logs or portions of trees

- **Extensive** – Debris jams consist of larger materials such as branches, logs, trees, etc. Debris jams often extend across the entire channel.

APPENDIX E

Project Identification, Project Costs & Prioritization

- Stream Restoration/Stabilization
- Buffer Enhancement
- Bank Plantings
- Utility Conflict Resolution
- Habitat Enhancement
- Trash Cleanup
- Yard Waste Cleanup
- Invasive Species Removal
- Combination Projects

TABLE E.1:

STREAM RESTORATION/STABILIZATION PROJECTS

Reach	Length	Subshed	Unstable-Stable Ratio	Eroded Area/Reach Length	Measure 1: Stream Restoration	Cost of Measure	Total Cost	Comments
HW-05-00-01	232	Herring Run	73.39%	3.93	1	$92,650	$127,650	head cut_wetland at top of reach
HW-08-00-01	322	Herring Run	55.24%	8.84	1	$128,885	$133,885	Exposed SS parallel channel.
HE-00-00-03	392	Herring Run	54.37%	2.48	1	$156,718	$156,718	
HW-03-01-01	483	Herring Run	52.95%	5.80	1	$144,752	$159,752	
HW-06-00-07	260	Herring Run	51.96%	4.85	1	$103,919	$108,919	HW-06-00-07 & HW-06-00-08 combined to form one reach
HW-05-00-02	218	Herring Run	50.55%	2.02	1	$87,044	$92,044	Random culv no e&s
HE-01-00-03	810	Herring Run	44.74%	2.23	1	$182,295	$192,295	
HE-00-00-16	241	Herring Run	43.51%	4.43	1	$96,529	$102,029	
HE-04-00-01	206	Herring Run	41.18%	1.65	1	$82,571	$82,571	
HE-09-00-01	315	Herring Run	40.50%	2.43	1	$125,918	$165,918	
HW-06-03-01	710	Herring Run	39.80%	1.77	1	$212,965	$285,465	
HE-08-00-01	1135	Herring Run	39.27%	3.93	1	$255,278	$266,278	
HE-07-00-01	765	Herring Run	37.24%	3.55	1	$229,579	$245,579	
HE-00-00-08	224	Herring Run	33.54%	1.68	1	$89,449	$89,449	
HE-01-01-01	570	Herring Run	31.56%	3.09	1	$171,121	$178,621	Reach is in a wooded section with erosion.
HW-00-00-02	892	Herring Run	30.88%	1.52	1	$200,711	$210,711	
HE-00-00-04	813	Herring Run	30.73%	2.46	1	$183,024	$193,524	Stream is migrating towards road. Roadside stabilization is recommended.
HW-00-00-07	300	Herring Run	30.64%	1.36	1	$120,119	$125,119	
HE-00-00-05	260	Herring Run	28.83%	2.31	1	$104,049	$109,049	
HE-00-00-07	632	Herring Run	27.30%	1.31	1	$189,567	$197,067	
HE-01-00-05	797	Herring Run	27.29%	2.34	1	$239,093	$247,093	one large debris jam; photo taken
HW-02-00-01	1668	Herring Run	26.53%	3.31	1	$375,346	$385,346	4 exposed manholes, smell of trash d/s of cross section
HE-07-01-02	251	Herring Run	25.94%	1.95	1	$100,245	$105,245	retaining wall protects private yard
HE-12-00-01	179	Herring Run	25.18%	1.51	1	$71,479	$76,479	
SR-01-00-01	461	Stemmers Run	75.42%	4.37	1	$138,431	$146,431	
SR-19-00-01	1485	Stemmers Run	69.03%	8.94	1	$334,100	$335,100	
SR-05-00-03	222	Stemmers Run	61.59%	1.83	1	$88,982	$93,982	
SR-14-00-01	320	Stemmers Run	59.23%	1.07	1	$127,968	$128,468	
SR-12-00-03	1070	Stemmers Run	58.74%	8.22	1	$240,736	$261,236	
SR-10-01-01	864	Stemmers Run	57.75%	4.44	1	$194,406	$205,406	
SR-19-00-03	1098	Stemmers Run	57.65%	6.32	1	$247,043	$248,043	
SR-10-00-02	698	Stemmers Run	54.91%	6.43	1	$209,539	$250,039	
SR-05-00-04	857	Stemmers Run	52.26%	5.23	1	$192,877	$203,377	
SR-15-01-01	360	Stemmers Run	43.76%	4.28	1	$143,956	$154,456	

Reach	Length	Subshed	Unstable-Stable Ratio	Eroded Area/Reach Length	Measure 1: Stream Restoration	Cost of Measure	Total Cost	Comments
SR-10-00-03	523	Stemmers Run	42.51%	4.70	1	$157,023	$172,523	
SR-08-02-01	1458	Stemmers Run	40.41%	3.59	1	$327,975	$363,475	
SR-10-00-06	916	Stemmers Run	38.43%	3.57	1	$206,082	$241,582	
SR-10-02-04	615	Stemmers Run	38.23%	3.06	1	$184,393	$217,893	
SR-16-00-02	952	Stemmers Run	37.04%	3.36	1	$214,131	$214,631	
SR-00-00-03	1015	Stemmers Run	36.75%	2.48	1	$228,356	$228,856	
SR-00-00-15	752	Stemmers Run	36.09%	4.11	1	$225,669	$241,669	
SR-05-00-01	1017	Stemmers Run	35.09%	2.81	1	$228,936	$229,936	
SR-10-00-04	228	Stemmers Run	32.95%	3.69	1	$91,057	$121,557	
SR-05-00-02	397	Stemmers Run	32.50%	2.92	1	$158,752	$159,252	
SR-10-00-05	913	Stemmers Run	31.75%	2.64	1	$205,535	$241,035	
SR-00-00-04	998	Stemmers Run	31.12%	2.77	1	$224,458	$234,958	
SR-12-00-02	1398	Stemmers Run	30.87%	1.85	1	$314,535	$315,535	
SR-14-01-01	292	Stemmers Run	29.11%	1.01	1	$116,816	$117,316	
SR-00-00-01	757	Stemmers Run	28.85%	1.92	1	$227,243	$235,743	
SR-10-00-01	656	Stemmers Run	28.20%	2.72	1	$196,799	$212,299	
SR-07-01-01	385	Stemmers Run	27.01%	1.46	1	$154,039	$159,539	
SR-22-00-01	585	Stemmers Run	26.32%	0.26	1	$175,506	$183,506	
SR-00-00-02	1470	Stemmers Run	26.17%	1.80	1	$330,639	$351,639	
SR-02-00-02	726	Stemmers Run	25.29%	3.04	1	$217,657	$226,157	
OR-08-00-02	994	Brien Run	68.63%	4.12	1	$223,596	$224,596	
OR-00-00-08	1274	Brien Run	55.64%	4.43	1	$286,730	$347,730	
OR-00-00-11	1005	Brien Run	55.10%	3.18	1	$226,209	$287,209	
OR-03-00-04	326	Brien Run	39.60%	2.17	1	$130,302	$130,802	
OR-00-00-01	627	Brien Run	38.73%	3.49	1	$188,209	$189,209	
OR-10-00-03	1165	Brien Run	38.62%	3.49	1	$262,202	$262,702	
OR-06-00-01	649	Brien Run	38.05%	3.45	1	$194,735	$195,735	Reach break mod. at conc channel end
OR-00-00-14	615	Brien Run	37.86%	2.53	1	$184,632	$210,632	modified reach break
OR-00-00-13	289	Brien Run	37.01%	1.85	1	$115,635	$121,135	
OR-00-00-10	1659	Brien Run	30.78%	2.11	1	$373,191	$434,191	

TABLE E.2:

BUFFER ENHANCEMENT PROJECTS

Reach	Length	Subshed	Measure 2: Buffer Enhancement	Cost of Measure	Total Costs
HE-09-00-01	315	Herring Run	1	$10,000	$165,918
HW-05-00-01	232	Herring Run	1	$10,000	$127,650
HW-06-01-01	786	Herring Run	1	$25,000	$308,905
HW-06-02-01	251	Herring Run	1	$10,000	$35,000
HW-06-03-01	710	Herring Run	1	$25,000	$285,465
SR-12-00-01	691	Stemmers Run	1	$25,000	$73,000
SR-20-00-01	863	Stemmers Run	1	$50,000	$120,500
SR-23-00-01	781	Stemmers Run	1	$25,000	$65,500
OR-00-00-06	801	Brien Run	1	$50,000	$51,000
OR-00-00-14	615	Brien Run	1	$25,000	$210,632
OR-02-00-01	991	Brien Run	1	$50,000	$131,000
OR-02-00-02	727	Brien Run	1	$25,000	$251,632
OR-02-00-04	911	Brien Run	1	$50,000	$265,994
OR-02-00-05	739	Brien Run	1	$25,000	$33,000
OR-03-00-01	475	Brien Run	1	$25,000	$33,500
OR-03-00-02	823	Brien Run	1	$50,000	$235,563

TABLE E.3:

BANK PLANTING PROJECTS

Reach	Length	Subshed	Measure 3: Bank Planting	Cost of Measure	Total Cost
HE-00-00-01	811	Herring Run	1	$10,000	$20,500
HE-00-00-02	1956	Herring Run	1	$10,000	$451,000
HE-00-00-06	993	Herring Run	1	$10,000	$20,500
HE-00-00-07	632	Herring Run	1	$7,500	$197,067
HE-00-00-10	368	Herring Run	1	$5,000	$5,000
HE-00-00-11	1228	Herring Run	1	$10,000	$286,743
HE-00-00-12	597	Herring Run	1	$7,500	$186,557
HE-00-00-14	1223	Herring Run	1	$10,000	$10,500
HE-00-00-15	1083	Herring Run	1	$10,000	$254,211
HE-00-00-16	241	Herring Run	1	$5,000	$102,029
HE-01-00-01	320	Herring Run	1	$5,000	$133,339
HE-01-00-06	676	Herring Run	1	$7,500	$210,828
HE-01-00-02	1741	Herring Run	1	$10,000	$402,726
HE-01-00-03	810	Herring Run	1	$10,000	$192,295
HE-01-00-04	1030	Herring Run	1	$10,000	$242,250
HE-01-00-05	797	Herring Run	1	$7,500	$247,093
HE-01-01-01	570	Herring Run	1	$7,500	$178,621
HE-01-01-02	276	Herring Run	1	$5,000	$115,955
HE-02-00-01	951	Herring Run	1	$10,000	$20,000
HE-05-00-01	1290	Herring Run	1	$10,000	$21,000
HE-07-00-01	765	Herring Run	1	$7,500	$245,579
HE-07-00-02	585	Herring Run	1	$7,500	$183,112
HE-07-00-03	863	Herring Run	1	$10,000	$205,145
HE-07-01-01	407	Herring Run	1	$7,500	$137,633

Reach	Length	Subshed	Measure 3: Bank Planting	Cost of Measure	Total Cost
HE-07-01-02	251	Herring Run	1	$5,000	$105,245
HE-08-00-02	1009	Herring Run	1	$10,000	$248,114
HE-08-00-03	601	Herring Run	1	$7,500	$7,500
HE-09-00-01	315	Herring Run	1	$5,000	$165,918
HE-10-00-01	798	Herring Run	1	$7,500	$15,500
HE-11-00-01	188	Herring Run	1	$5,000	$80,030
HE-12-00-01	179	Herring Run	1	$5,000	$76,479
HW-00-00-02	892	Herring Run	1	$10,000	$210,711
HW-00-00-03	1508	Herring Run	1	$10,000	$10,000
HW-00-00-04	557	Herring Run	1	$7,500	$7,500
HW-00-00-07	300	Herring Run	1	$5,000	$125,119
HW-00-00-08	1720	Herring Run	1	$10,000	$396,936
HW-00-00-09	934	Herring Run	1	$10,000	$220,241
HW-02-00-01	1668	Herring Run	1	$10,000	$385,346
HW-03-00-02	474	Herring Run	1	$7,500	$150,053
HW-03-01-01	483	Herring Run	1	$7,500	$159,752
HW-04-00-02	1123	Herring Run	1	$10,000	$263,121
HW-05-00-01	232	Herring Run	1	$5,000	$127,650
HW-05-00-02	218	Herring Run	1	$5,000	$92,044
HW-05-00-03	1002	Herring Run	1	$10,000	$10,000
HW-06-00-01	1162	Herring Run	1	$10,000	$281,458
HW-06-00-02	326	Herring Run	1	$5,000	$5,500
HW-06-00-03	226	Herring Run	1	$5,000	$5,500
HW-06-00-05	1899	Herring Run	1	$10,000	$437,733
HW-06-00-06	1032	Herring Run	1	$10,000	$10,000
HW-06-00-07	260	Herring Run	1	$5,000	$108,919
HW-06-01-01	786	Herring Run	1	$7,500	$308,905
HW-06-02-01	251	Herring Run	1	$5,000	$35,000

Reach	Length	Subshed	Measure 3: Bank Planting	Cost of Measure	Total Cost
HW-06-03-01	710	Herring Run	1	$7,500	$285,465
HW-08-00-01	322	Herring Run	1	$5,000	$133,885
SR-00-00-01	757	Stemmers Run	1	$7,500	$235,743
SR-00-00-02	1470	Stemmers Run	1	$10,000	$351,639
SR-00-00-15	752	Stemmers Run	1	$7,500	$241,669
SR-01-00-01	461	Stemmers Run	1	$7,500	$146,431
SR-05-00-03	222	Stemmers Run	1	$5,000	$93,982
SR-06-00-01	598	Stemmers Run	1	$7,500	$187,424
SR-06-00-02	767	Stemmers Run	1	$7,500	$245,697
SR-06-01-01	1880	Stemmers Run	1	$10,000	$443,515
SR-07-00-01	268	Stemmers Run	1	$5,000	$10,500
SR-08-01-01	707	Stemmers Run	1	$7,500	$33,000
SR-08-02-01	1458	Stemmers Run	1	$10,000	$363,475
SR-10-00-01	656	Stemmers Run	1	$7,500	$212,299
SR-10-00-02	698	Stemmers Run	1	$7,500	$250,039
SR-10-00-03	523	Stemmers Run	1	$7,500	$172,523
SR-10-02-02	311	Stemmers Run	1	$5,000	$10,500
SR-12-00-03	1070	Stemmers Run	1	$10,000	$261,236
SR-15-01-01	360	Stemmers Run	1	$5,000	$154,456
SR-16-00-06	450	Stemmers Run	1	$7,500	$16,000
SR-16-00-05	590	Stemmers Run	1	$7,500	$7,500
SR-18-00-01	1436	Stemmers Run	1	$10,000	$334,085
OR-00-00-03	460	Brien Run	1	$7,500	$146,363
OR-02-00-01	991	Brien Run	1	$10,000	$131,000

TABLE E.4:

UTILITY CONFLICT RESOLUTION NEEDS

Reach	Length	Subshed	Measure 4: Utility Conflict Resolution	Cost of Measure	Total Cost
SR-00-00-14	1988	Stemmers Run	1	$25,000	$482,841
SR-07-00-02	833	Stemmers Run	1	$25,000	$222,952
SR-08-01-01	707	Stemmers Run	1	$25,000	$33,000
SR-08-02-01	1458	Stemmers Run	1	$25,000	$363,475
SR-10-00-06	916	Stemmers Run	1	$25,000	$241,582
SR-10-00-02	698	Stemmers Run	1	$25,000	$250,039
SR-10-00-04	228	Stemmers Run	1	$25,000	$121,557
SR-10-00-05	913	Stemmers Run	1	$25,000	$241,035
SR-10-02-04	615	Stemmers Run	1	$25,000	$217,893
SR-13-00-01	551	Stemmers Run	1	$25,000	$198,823
SR-13-00-02	1185	Stemmers Run	1	$25,000	$36,000
SR-15-00-05	1131	Stemmers Run	1	$25,000	$289,888
SR-15-00-06	811	Stemmers Run	1	$25,000	$217,903
OR-10-02-01	357	Brien Run	1	$25,000	$25,500

TABLE E.5:

WETLAND ENHANCEMENT NEEDS

Reach	Length	Subshed	Measure 5: Wetland Enhancement	Cost of Measure	Total Cost
HE-09-00-01	315	Herring Run	1	$20,000	$165,918
HW-05-00-01	232	Herring Run	1	$20,000	$127,650
HW-06-01-01	786	Herring Run	1	$40,000	$308,905
HW-06-02-01	251	Herring Run	1	$20,000	$35,000
HW-06-03-01	710	Herring Run	1	$40,000	$285,465
SR-12-00-01	691	Stemmers Run	1	$40,000	$73,000
SR-20-00-01	863	Stemmers Run	1	$60,000	$120,500
SR-23-00-01	781	Stemmers Run	1	$40,000	$65,500
OR-00-00-00	532	Brien Run	1	$40,000	$48,000
OR-00-00-05	1084	Brien Run	1	$60,000	$61,000
OR-00-00-08	1274	Brien Run	1	$60,000	$347,730
OR-00-00-09	278	Brien Run	1	$20,000	$21,000
OR-00-00-10	1659	Brien Run	1	$60,000	$434,191
OR-00-00-11	1005	Brien Run	1	$60,000	$287,209
OR-00-00-12	474	Brien Run	1	$40,000	$48,000
OR-02-00-01	991	Brien Run	1	$60,000	$131,000
OR-07-00-01	397	Brien Run	1	$20,000	$21,000
OR-09-00-01	264	Brien Run	1	$20,000	$21,000

TABLE E.6:

TRASH CLEANUP NEEDS

Reach	Length	Subshed	Measure 6: Trash Cleanup	Cost of Measure	Total Cost
HE-00-00-01	811	Herring Run	1	$500	$20,500
HE-00-00-02	1956	Herring Run	1	$500	$451,000
HE-00-00-04	813	Herring Run	1	$500	$193,524
HE-00-00-06	993	Herring Run	1	$500	$20,500
HE-00-00-11	1228	Herring Run	1	$500	$286,743
HE-00-00-13	453	Herring Run	1	$500	$500
HE-00-00-14	1223	Herring Run	1	$500	$10,500
HE-00-00-15	1083	Herring Run	1	$500	$254,211
HE-00-00-16	241	Herring Run	1	$500	$102,029
HE-01-00-01	320	Herring Run	1	$500	$133,339
HE-01-00-06	676	Herring Run	1	$500	$210,828
HE-01-00-02	1741	Herring Run	1	$500	$402,726
HE-01-00-04	1030	Herring Run	1	$500	$242,250
HE-01-00-05	797	Herring Run	1	$500	$247,093
HE-01-01-02	276	Herring Run	1	$500	$115,955
HE-05-00-01	1290	Herring Run	1	$500	$21,000
HE-07-00-01	765	Herring Run	1	$500	$245,579
HE-07-00-03	863	Herring Run	1	$500	$205,145
HE-07-01-01	407	Herring Run	1	$500	$137,633
HE-08-00-01	1135	Herring Run	1	$500	$266,278
HE-08-00-02	1009	Herring Run	1	$500	$248,114
HE-10-00-01	798	Herring Run	1	$500	$15,500
HE-10-00-02	558	Herring Run	1	$500	$500
HW-00-00-01	336	Herring Run	1	$500	$500
HW-06-00-05	1899	Herring Run	1	$500	$437,733
SR-00-00-01	757	Stemmers Run	1	$500	$235,743
SR-00-00-02	1470	Stemmers Run	1	$500	$351,639
SR-00-00-03	1015	Stemmers Run	1	$500	$228,856
SR-00-00-04	998	Stemmers Run	1	$500	$234,958
SR-00-00-05	343	Stemmers Run	1	$500	$5,500
SR-00-00-06	406	Stemmers Run	1	$500	$8,000
SR-00-00-07	593	Stemmers Run	1	$500	$8,000
SR-00-00-08	1548	Stemmers Run	1	$500	$10,500
SR-00-00-09	966	Stemmers Run	1	$500	$10,500
SR-00-00-10	1038	Stemmers Run	1	$500	$10,500
SR-00-00-11	1558	Stemmers Run	1	$500	$10,500
SR-00-00-14	1988	Stemmers Run	1	$500	$482,841
SR-00-00-15	752	Stemmers Run	1	$500	$241,669

Reach	Length	Subshed	Measure 6: Trash Cleanup	Cost of Measure	Total Cost
SR-00-00-17	383	Stemmers Run	1	$500	$159,293
SR-00-00-18	1028	Stemmers Run	1	$500	$241,797
SR-00-00-19	1318	Stemmers Run	1	$500	$10,500
SR-01-00-01	461	Stemmers Run	1	$500	$146,431
SR-01-00-02	1088	Stemmers Run	1	$500	$11,000
SR-02-00-01	238	Stemmers Run	1	$500	$1,000
SR-02-00-02	726	Stemmers Run	1	$500	$226,157
SR-02-00-03	454	Stemmers Run	1	$500	$137,197
SR-02-00-04	706	Stemmers Run	1	$500	$212,880
SR-02-00-05	1406	Stemmers Run	1	$500	$317,460
SR-02-00-06	332	Stemmers Run	1	$500	$5,500
SR-02-02-01	337	Stemmers Run	1	$500	$135,779
SR-03-00-01	314	Stemmers Run	1	$500	$500
SR-04-00-01	268	Stemmers Run	1	$500	$500
SR-05-00-01	1017	Stemmers Run	1	$500	$229,936
SR-05-00-02	397	Stemmers Run	1	$500	$159,252
SR-05-00-04	857	Stemmers Run	1	$500	$203,377
SR-06-00-01	598	Stemmers Run	1	$500	$187,424
SR-06-00-02	767	Stemmers Run	1	$500	$245,697
SR-06-00-03	970	Stemmers Run	1	$500	$229,244
SR-06-01-01	1880	Stemmers Run	1	$500	$443,515
SR-07-00-01	268	Stemmers Run	1	$500	$10,500
SR-07-01-01	385	Stemmers Run	1	$500	$159,539
SR-08-01-01	707	Stemmers Run	1	$500	$33,000
SR-08-02-01	1458	Stemmers Run	1	$500	$363,475
SR-10-00-06	916	Stemmers Run	1	$500	$241,582
SR-10-00-01	656	Stemmers Run	1	$500	$212,299
SR-10-00-02	698	Stemmers Run	1	$500	$250,039
SR-10-00-03	523	Stemmers Run	1	$500	$172,523
SR-10-00-04	228	Stemmers Run	1	$500	$121,557
SR-10-00-05	913	Stemmers Run	1	$500	$241,035
SR-10-01-01	864	Stemmers Run	1	$500	$205,406
SR-10-02-01	1020	Stemmers Run	1	$500	$11,000
SR-10-02-02	311	Stemmers Run	1	$500	$10,500
SR-10-02-03	363	Stemmers Run	1	$500	$151,357
SR-10-02-04	615	Stemmers Run	1	$500	$217,893
SR-12-00-02	1398	Stemmers Run	1	$500	$315,535
SR-12-00-03	1070	Stemmers Run	1	$500	$261,236
SR-12-00-01	691	Stemmers Run	1	$500	$73,000
SR-13-00-01	551	Stemmers Run	1	$500	$198,823
SR-13-00-02	1185	Stemmers Run	1	$500	$36,000
SR-13-01-01	594	Stemmers Run	1	$500	$186,298
SR-13-01-02	287	Stemmers Run	1	$500	$120,992
SR-14-00-01	320	Stemmers Run	1	$500	$128,468

Reach	Length	Subshed	Measure 6: Trash Cleanup	Cost of Measure	Total Cost
SR-14-01-01	292	Stemmers Run	1	$500	$117,316
SR-15-00-01	557	Stemmers Run	1	$500	$175,103
SR-15-00-02	267	Stemmers Run	1	$500	$5,500
SR-15-00-03	538	Stemmers Run	1	$500	$8,000
SR-15-00-04	188	Stemmers Run	1	$500	$80,788
SR-15-00-05	1131	Stemmers Run	1	$500	$289,888
SR-15-00-06	811	Stemmers Run	1	$500	$217,903
SR-15-00-07	280	Stemmers Run	1	$500	$5,500
SR-15-01-01	360	Stemmers Run	1	$500	$154,456
SR-15-02-01	381	Stemmers Run	1	$500	$158,039
SR-15-03-03	598	Stemmers Run	1	$500	$8,000
SR-15-03-04	252	Stemmers Run	1	$500	$5,500
SR-16-00-01	803	Stemmers Run	1	$500	$500
SR-16-00-02	952	Stemmers Run	1	$500	$214,631
SR-16-00-03	348	Stemmers Run	1	$500	$139,529
SR-16-00-04	236	Stemmers Run	1	$500	$99,900
SR-16-00-06	450	Stemmers Run	1	$500	$16,000
SR-18-00-01	1436	Stemmers Run	1	$500	$334,085
SR-19-00-01	1485	Stemmers Run	1	$500	$335,100
SR-19-00-02	805	Stemmers Run	1	$500	$192,166
SR-19-00-03	1098	Stemmers Run	1	$500	$248,043
SR-19-00-04	591	Stemmers Run	1	$500	$185,334
SR-19-00-05	714	Stemmers Run	1	$500	$8,000
SR-19-01-01	320	Stemmers Run	1	$500	$500
SR-20-00-01	863	Stemmers Run	1	$500	$120,500
SR-21-00-01	576	Stemmers Run	1	$500	$8,000
SR-22-00-01	585	Stemmers Run	1	$500	$183,506
SR-23-00-01	781	Stemmers Run	1	$500	$65,500
OR-00-00-00	532	Brien Run	1	$500	$48,000
OR-00-00-01	627	Brien Run	1	$500	$189,209
OR-00-00-02	848	Brien Run	1	$500	$191,251
OR-00-00-03	460	Brien Run	1	$500	$146,363
OR-00-00-04	985	Brien Run	1	$500	$500
OR-00-00-05	1084	Brien Run	1	$500	$61,000
OR-00-00-06	801	Brien Run	1	$500	$51,000
OR-00-00-07	416	Brien Run	1	$500	$125,740
OR-00-00-08	1274	Brien Run	1	$500	$347,730
OR-00-00-09	278	Brien Run	1	$500	$21,000
OR-00-00-10	1659	Brien Run	1	$500	$434,191
OR-00-00-11	1005	Brien Run	1	$500	$287,209
OR-00-00-12	474	Brien Run	1	$500	$48,000
OR-00-00-13	289	Brien Run	1	$500	$121,135
OR-00-00-14	615	Brien Run	1	$500	$210,632
OR-01-00-01	564	Brien Run	1	$500	$500

Reach	Length	Subshed	Measure 6: Trash Cleanup	Cost of Measure	Total Cost
OR-02-00-01	991	Brien Run	1	$500	$131,000
OR-02-00-02	727	Brien Run	1	$500	$251,632
OR-02-00-04	911	Brien Run	1	$500	$265,994
OR-02-00-05	739	Brien Run	1	$500	$33,000
OR-03-00-01	475	Brien Run	1	$500	$33,500
OR-03-00-02	823	Brien Run	1	$500	$235,563
OR-03-00-03	136	Brien Run	1	$500	$500
OR-03-00-04	326	Brien Run	1	$500	$130,802
OR-03-00-05	723	Brien Run	1	$500	$500
OR-04-00-01	1082	Brien Run	1	$500	$1,000
OR-06-00-01	649	Brien Run	1	$500	$195,735
OR-07-00-01	397	Brien Run	1	$500	$21,000
OR-08-00-01	372	Brien Run	1	$500	$149,934
OR-08-00-02	994	Brien Run	1	$500	$224,596
OR-08-01-01	715	Brien Run	1	$500	$1,000
OR-09-00-01	264	Brien Run	1	$500	$21,000
OR-10-00-03	1165	Brien Run	1	$500	$262,702
OR-10-00-04	554	Brien Run	1	$500	$8,500

TABLE E.7:

YARD WASTE EDUCATION NEEDS

Reach	Length	Subshed	Measure 7: Yard Waste Cleanup	Cost of Measure	Total Cost
HE-00-00-02	1956	Herring Run	1	$500	$451,000
HE-01-00-02	1741	Herring Run	1	$500	$402,726
HE-05-00-01	1290	Herring Run	1	$500	$21,000
HE-06-00-02	459	Herring Run	1	$500	$8,000
HE-07-00-01	765	Herring Run	1	$500	$245,579
HE-07-00-03	863	Herring Run	1	$500	$205,145
HE-08-00-01	1135	Herring Run	1	$500	$266,278
HE-08-00-02	1009	Herring Run	1	$500	$248,114
HW-03-00-02	474	Herring Run	1	$500	$150,053
HW-04-00-02	1123	Herring Run	1	$500	$263,121
HW-06-00-02	326	Herring Run	1	$500	$5,500
HW-06-00-03	226	Herring Run	1	$500	$5,500
HW-06-01-01	786	Herring Run	1	$500	$308,905
SR-00-00-01	757	Stemmers Run	1	$500	$235,743
SR-00-00-02	1470	Stemmers Run	1	$500	$351,639
SR-00-00-15	752	Stemmers Run	1	$500	$241,669
SR-00-00-17	383	Stemmers Run	1	$500	$159,293
SR-01-00-02	1088	Stemmers Run	1	$500	$11,000
SR-02-00-01	238	Stemmers Run	1	$500	$1,000
SR-02-00-02	726	Stemmers Run	1	$500	$226,157
SR-02-00-03	454	Stemmers Run	1	$500	$137,197
SR-02-00-04	706	Stemmers Run	1	$500	$212,880
SR-02-00-05	1406	Stemmers Run	1	$500	$317,460
SR-02-02-01	337	Stemmers Run	1	$500	$135,779
SR-05-00-01	1017	Stemmers Run	1	$500	$229,936
SR-06-00-03	970	Stemmers Run	1	$500	$229,244
SR-07-00-02	833	Stemmers Run	1	$500	$222,952
SR-10-01-01	864	Stemmers Run	1	$500	$205,406
SR-10-02-01	1020	Stemmers Run	1	$500	$11,000
SR-10-02-03	363	Stemmers Run	1	$500	$151,357
SR-10-02-04	615	Stemmers Run	1	$500	$217,893
SR-12-00-02	1398	Stemmers Run	1	$500	$315,535
SR-13-00-01	551	Stemmers Run	1	$500	$198,823

Reach	Length	Subshed	Measure 7: Yard Waste Cleanup	Cost of Measure	Total Cost
SR-13-00-02	1185	Stemmers Run	1	$500	$36,000
SR-13-01-02	287	Stemmers Run	1	$500	$120,992
SR-16-00-06	450	Stemmers Run	1	$500	$16,000
SR-18-00-01	1436	Stemmers Run	1	$500	$334,085
SR-19-00-01	1485	Stemmers Run	1	$500	$335,100
SR-19-00-02	805	Stemmers Run	1	$500	$192,166
SR-19-00-03	1098	Stemmers Run	1	$500	$248,043
OR-00-00-01	627	Brien Run	1	$500	$189,209
OR-00-00-03	460	Brien Run	1	$500	$146,363
OR-00-00-05	1084	Brien Run	1	$500	$61,000
OR-00-00-06	801	Brien Run	1	$500	$51,000
OR-00-00-07	416	Brien Run	1	$500	$125,740
OR-00-00-08	1274	Brien Run	1	$500	$347,730
OR-00-00-09	278	Brien Run	1	$500	$21,000
OR-00-00-10	1659	Brien Run	1	$500	$434,191
OR-00-00-11	1005	Brien Run	1	$500	$287,209
OR-00-00-14	615	Brien Run	1	$500	$210,632
OR-02-00-01	991	Brien Run	1	$500	$131,000
OR-02-00-02	727	Brien Run	1	$500	$251,632
OR-02-00-04	911	Brien Run	1	$500	$265,994
OR-03-00-01	475	Brien Run	1	$500	$33,500
OR-04-00-01	1082	Brien Run	1	$500	$1,000
OR-06-00-01	649	Brien Run	1	$500	$195,735
OR-07-00-01	397	Brien Run	1	$500	$21,000
OR-08-00-01	372	Brien Run	1	$500	$149,934
OR-08-00-02	994	Brien Run	1	$500	$224,596
OR-08-01-01	715	Brien Run	1	$500	$1,000
OR-09-00-01	264	Brien Run	1	$500	$21,000
OR-10-00-04	554	Brien Run	1	$500	$8,500
OR-10-02-01	357	Brien Run	1	$500	$25,500

TABLE E.8:

INVASIVE PLANT REMOVAL NEEDS

Reach	Length	Subshed	Measure 8: Invasive Species Removal	Cost of Measure	Total Cost
HE-00-00-01	811	Herring Run	1	$10,000	$20,500
HE-00-00-04	813	Herring Run	1	$10,000	$193,524
HE-00-00-05	260	Herring Run	1	$5,000	$109,049
HE-00-00-06	993	Herring Run	1	$10,000	$20,500
HE-02-00-01	951	Herring Run	1	$10,000	$20,000
HE-03-00-01	547	Herring Run	1	$7,500	$7,500
HE-05-00-01	1290	Herring Run	1	$10,000	$21,000
HE-06-00-01	289	Herring Run	1	$5,000	$5,000
HE-06-00-02	459	Herring Run	1	$7,500	$8,000
HE-07-00-01	765	Herring Run	1	$7,500	$245,579
HE-07-01-01	407	Herring Run	1	$7,500	$137,633
HE-08-00-01	1135	Herring Run	1	$10,000	$266,278
HE-08-00-02	1009	Herring Run	1	$10,000	$248,114
HE-09-00-01	315	Herring Run	1	$5,000	$165,918
HE-10-00-01	798	Herring Run	1	$7,500	$15,500
HW-03-01-01	483	Herring Run	1	$7,500	$159,752
HW-06-00-01	1162	Herring Run	1	$10,000	$281,458
SR-00-00-02	1470	Stemmers Run	1	$10,000	$351,639
SR-00-00-04	998	Stemmers Run	1	$10,000	$234,958
SR-00-00-05	343	Stemmers Run	1	$5,000	$5,500
SR-00-00-06	406	Stemmers Run	1	$7,500	$8,000
SR-00-00-07	593	Stemmers Run	1	$7,500	$8,000
SR-00-00-08	1548	Stemmers Run	1	$10,000	$10,500
SR-00-00-09	966	Stemmers Run	1	$10,000	$10,500
SR-00-00-10	1038	Stemmers Run	1	$10,000	$10,500
SR-00-00-11	1558	Stemmers Run	1	$10,000	$10,500
SR-00-00-12	357	Stemmers Run	1	$5,000	$5,000
SR-00-00-13	823	Stemmers Run	1	$10,000	$195,196
SR-00-00-14	1988	Stemmers Run	1	$10,000	$482,841
SR-00-00-15	752	Stemmers Run	1	$7,500	$241,669
SR-00-00-16	427	Stemmers Run	1	$7,500	$7,500
SR-00-00-17	383	Stemmers Run	1	$5,000	$159,293

Reach	Length	Subshed	Measure 8: Invasive Species Removal	Cost of Measure	Total Cost
SR-00-00-18	1028	Stemmers Run	1	$10,000	$241,797
SR-00-00-19	1318	Stemmers Run	1	$10,000	$10,500
SR-01-00-02	1088	Stemmers Run	1	$10,000	$11,000
SR-02-00-02	726	Stemmers Run	1	$7,500	$226,157
SR-02-00-06	332	Stemmers Run	1	$5,000	$5,500
SR-05-00-04	857	Stemmers Run	1	$10,000	$203,377
SR-06-00-02	767	Stemmers Run	1	$7,500	$245,697
SR-06-00-03	970	Stemmers Run	1	$10,000	$229,244
SR-06-01-01	1880	Stemmers Run	1	$10,000	$443,515
SR-07-00-01	268	Stemmers Run	1	$5,000	$10,500
SR-07-00-02	833	Stemmers Run	1	$10,000	$222,952
SR-07-01-01	385	Stemmers Run	1	$5,000	$159,539
SR-10-00-06	916	Stemmers Run	1	$10,000	$241,582
SR-10-00-01	656	Stemmers Run	1	$7,500	$212,299
SR-10-00-02	698	Stemmers Run	1	$7,500	$250,039
SR-10-00-03	523	Stemmers Run	1	$7,500	$172,523
SR-10-00-04	228	Stemmers Run	1	$5,000	$121,557
SR-10-00-05	913	Stemmers Run	1	$10,000	$241,035
SR-10-01-01	864	Stemmers Run	1	$10,000	$205,406
SR-10-02-01	1020	Stemmers Run	1	$10,000	$11,000
SR-10-02-02	311	Stemmers Run	1	$5,000	$10,500
SR-10-02-03	363	Stemmers Run	1	$5,000	$151,357
SR-10-02-04	615	Stemmers Run	1	$7,500	$217,893
SR-11-00-01	352	Stemmers Run	1	$5,000	$5,000
SR-12-00-03	1070	Stemmers Run	1	$10,000	$261,236
SR-12-00-01	691	Stemmers Run	1	$7,500	$73,000
SR-13-00-01	551	Stemmers Run	1	$7,500	$198,823
SR-13-00-02	1185	Stemmers Run	1	$10,000	$36,000
SR-13-01-01	594	Stemmers Run	1	$7,500	$186,298
SR-13-01-02	287	Stemmers Run	1	$5,000	$120,992
SR-14-00-02	502	Stemmers Run	1	$7,500	$7,500
SR-15-00-01	557	Stemmers Run	1	$7,500	$175,103
SR-15-00-02	267	Stemmers Run	1	$5,000	$5,500
SR-15-00-03	538	Stemmers Run	1	$7,500	$8,000
SR-15-00-04	188	Stemmers Run	1	$5,000	$80,788
SR-15-00-05	1131	Stemmers Run	1	$10,000	$289,888
SR-15-00-06	811	Stemmers Run	1	$10,000	$217,903
SR-15-00-07	280	Stemmers Run	1	$5,000	$5,500

Reach	Length	Subshed	Measure 8: Invasive Species Removal	Cost of Measure	Total Cost
SR-15-01-01	360	Stemmers Run	1	$5,000	$154,456
SR-15-02-01	381	Stemmers Run	1	$5,000	$158,039
SR-15-03-03	598	Stemmers Run	1	$7,500	$8,000
SR-15-03-04	252	Stemmers Run	1	$5,000	$5,500
SR-16-00-04	236	Stemmers Run	1	$5,000	$99,900
SR-16-00-06	450	Stemmers Run	1	$7,500	$16,000
SR-17-00-02	1056	Stemmers Run	1	$10,000	$10,000
SR-19-00-02	805	Stemmers Run	1	$10,000	$192,166
SR-19-00-04	591	Stemmers Run	1	$7,500	$185,334
SR-19-00-05	714	Stemmers Run	1	$7,500	$8,000
SR-20-00-01	863	Stemmers Run	1	$10,000	$120,500
SR-21-00-01	576	Stemmers Run	1	$7,500	$8,000
SR-22-00-01	585	Stemmers Run	1	$7,500	$183,506
OR-00-00-00	532	Brien Run	1	$7,500	$48,000
OR-00-00-12	474	Brien Run	1	$7,500	$48,000
OR-00-00-13	289	Brien Run	1	$5,000	$121,135
OR-02-00-01	991	Brien Run	1	$10,000	$131,000
OR-02-00-02	727	Brien Run	1	$7,500	$251,632
OR-02-00-04	911	Brien Run	1	$10,000	$265,994
OR-02-00-05	739	Brien Run	1	$7,500	$33,000
OR-03-00-01	475	Brien Run	1	$7,500	$33,500
OR-10-00-04	554	Brien Run	1	$7,500	$8,500

TABLE E.9:

PROPOSED REACH ENHANCEMENTS, HERRING RUN, STEMMERS RUN & BRIEN RUN SUBWATERSHEDS

Reach	Length	Subshed	Measure 1: Stream Restoration	Measure 2: Buffer Enhancement	Measure 3: Bank Planting	Measure 4: Utility Conflict Resolution	Measure 5: Wetland Enhancement	Measure 6: Trash Cleanup	Measure 7: Yard Waste Cleanup	Measure 8: Invasive Species Removal	Total No of Recommended Measures	Total Cost
HE-00-00-01	811	Herring Run	0	0	1	0	0	1	0	1	3	$20,500
HE-00-00-02	1956	Herring Run	1	0	1	0	0	1	1	0	4	$451,000
HE-00-00-03	392	Herring Run	1	0	0	0	0	0	0	0	1	$156,718
HE-00-00-04	813	Herring Run	1	0	0	0	0	1	0	1	3	$193,524
HE-00-00-05	260	Herring Run	1	0	0	0	0	0	0	1	2	$109,049
HE-00-00-06	993	Herring Run	0	0	1	0	0	1	0	1	3	$20,500
HE-00-00-07	632	Herring Run	1	0	1	0	0	0	0	0	2	$197,067
HE-00-00-08	224	Herring Run	1	0	0	0	0	0	0	0	1	$89,449
HE-00-00-09	594	Herring Run	1	0	0	0	0	0	0	0	1	$178,195
HE-00-00-10	368	Herring Run	0	0	1	0	0	0	0	0	1	$5,000
HE-00-00-11	1228	Herring Run	1	0	1	0	0	1	0	0	3	$286,743
HE-00-00-12	597	Herring Run	1	0	1	0	0	0	0	0	2	$186,557
HE-00-00-13	453	Herring Run	0	0	0	0	0	1	0	0	1	$500
HE-00-00-14	1223	Herring Run	0	0	1	0	0	1	0	0	2	$10,500
HE-00-00-15	1083	Herring Run	1	0	1	0	0	1	0	0	3	$254,211
HE-00-00-16	241	Herring Run	1	0	1	0	0	1	0	0	3	$102,029
HE-01-00-01	320	Herring Run	1	0	1	0	0	1	0	0	3	$133,339
HE-01-00-06	676	Herring Run	1	0	1	0	0	1	0	0	3	$210,828
HE-01-00-02	1741	Herring Run	1	0	1	0	0	1	1	0	4	$402,726
HE-01-00-03	810	Herring Run	1	0	1	0	0	0	0	0	2	$192,295
HE-01-00-04	1030	Herring Run	1	0	1	0	0	1	0	0	3	$242,250
HE-01-00-05	797	Herring Run	1	0	1	0	0	1	0	0	3	$247,093
HE-01-01-01	570	Herring Run	1	0	1	0	0	0	0	0	2	$178,621
HE-01-01-02	276	Herring Run	1	0	1	0	0	1	0	0	3	$115,955
HE-02-00-01	951	Herring Run	0	0	1	0	0	0	0	1	2	$20,000
HE-03-00-01	547	Herring Run	0	0	0	0	0	0	0	1	1	$7,500
HE-05-00-01	1290	Herring Run	0	0	1	0	0	1	1	1	4	$21,000
HE-06-00-01	289	Herring Run	0	0	0	0	0	0	0	1	1	$5,000
HE-06-00-02	459	Herring Run	0	0	0	0	0	0	1	1	2	$8,000
HE-07-00-01	765	Herring Run	1	0	1	0	0	1	1	1	5	$245,579
HE-07-00-02	585	Herring Run	1	0	1	0	0	0	0	0	2	$183,112
HE-07-00-03	863	Herring Run	1	0	1	0	0	1	1	0	4	$205,145
HE-07-01-01	407	Herring Run	1	0	1	0	0	1	0	1	4	$137,633
HE-07-01-02	251	Herring Run	1	0	1	0	0	0	0		2	$105,245
HE-08-00-01	1135	Herring Run	1	0	0	0	0	1	1	1	4	$266,278
HE-08-00-02	1009	Herring Run	1	0	1	0	0	1	1	1	5	$248,114
HE-08-00-03	601	Herring Run	0	0	1	0	0	0	0	0	1	$7,500
HE-09-00-01	315	Herring Run	1	1	1	0	1	0	0	1	5	$165,918
HE-10-00-01	798	Herring Run	0	0	1	0	0	1	0	1	3	$15,500
HE-10-00-02	558	Herring Run	0	0	0	0	0	1	0	0	1	$500
HE-11-00-01	188	Herring Run	1	0	1	0	0	0	0	0	2	$80,030
HE-12-00-01	179	Herring Run	1	0	1	0	0	0	0	0	2	$76,479
HE-04-00-01	206	Herring Run	1	0	0	0	0	0	0	0	1	$82,571
HW-00-00-01	336	Herring Run	0	0	0	0	0	1	0	0	1	$500
HW-00-00-02	892	Herring Run	1	0	1	0	0	0	0	0	2	$210,711
HW-00-00-03	1508	Herring Run	0	0	1	0	0	0	0	0	1	$10,000
HW-00-00-04	557	Herring Run	0	0	1	0	0	0	0	0	1	$7,500
HW-00-00-05	205	Herring Run	1	0	0	0	0	0	0	0	1	$81,920
HW-00-00-06	812	Herring Run	1	0	0	0	0	0	0	0	1	$182,807
HW-00-00-07	300	Herring Run	1	0	1	0	0	0	0	0	2	$125,119
HW-00-00-08	1720	Herring Run	1	0	1	0	0	0	0	0	2	$396,936
HW-00-00-09	934	Herring Run	1	0	1	0	0	0	0	0	2	$220,241
HW-01-00-01	793	Herring Run	1	0	0	0	0	0	0	0	1	$237,799
HW-02-00-01	1668	Herring Run	1	0	1	0	0	0	0	0	2	$385,346
HW-03-00-02	474	Herring Run	1	0	1	0	0	0	1	0	3	$150,053
HW-03-01-01	483	Herring Run	1	0	1	0	0	0	0	1	3	$159,752
HW-04-00-01	625	Herring Run	1	0	0	0	0	0	0	0	1	$187,525
HW-04-00-02	1123	Herring Run	1	0	1	0	0	0	1	0	3	$263,121
HW-05-00-01	232	Herring Run	1	1	1	0	1	0	0	0	4	$127,650
HW-05-00-02	218	Herring Run	1	0	1	0	0	0	0	0	2	$92,044
HW-05-00-03	1002	Herring Run	0	0	1	0	0	0	0	0	1	$10,000
HW-06-00-01	1162	Herring Run	1	0	1	0	0	0	0	1	3	$281,458
HW-06-00-02	326	Herring Run	0	0	1	0	0	0	1	0	2	$5,500
HW-06-00-03	226	Herring Run	0	0	1	0	0	0	1	0	2	$5,500
HW-06-00-05	1899	Herring Run	1	0	1	0	0	1	0	0	3	$437,733
HW-06-00-06	1032	Herring Run	0	0	1	0	0	0	0	0	1	$10,000
HW-06-00-07	260	Herring Run	1	0	1	0	0	0	0	0	2	$108,919
HW-06-01-01	786	Herring Run	1	1	1	0	1	0	1	0	5	$308,905

Reach	Length	Subshed	Measure 1: Stream Restoration	Measure 2: Buffer Enhancement	Measure 3: Bank Planting	Measure 4: Utility Conflict Resolution	Measure 5: Wetland Enhancement	Measure 6: Trash Cleanup	Measure 7: Yard Waste Cleanup	Measure 8: Invasive Species Removal	Total No of Recommended Measures	Total Cost
HW-06-02-01	251	Herring Run	0	1	1	0	1	0	0	0	3	$35,000
HW-06-03-01	710	Herring Run	1	1	1	0	1	0	0	0	4	$285,465
HW-08-00-01	322	Herring Run	1	0	1	0	0	0	0	0	2	$133,885
SR-00-00-01	757	Stemmers Run	1	0	1	0	0	1	1	0	4	$235,743
SR-00-00-02	1470	Stemmers Run	1	0	1	0	0	1	1	1	5	$351,639
SR-00-00-03	1015	Stemmers Run	1	0	0	0	0	1	0	0	2	$228,856
SR-00-00-04	998	Stemmers Run	1	0	0	0	0	1	0	1	3	$234,958
SR-00-00-05	343	Stemmers Run	0	0	0	0	0	1	0	1	2	$5,500
SR-00-00-06	406	Stemmers Run	0	0	0	0	0	1	0	1	2	$8,000
SR-00-00-07	593	Stemmers Run	0	0	0	0	0	1	0	1	2	$8,000
SR-00-00-08	1548	Stemmers Run	0	0	0	0	0	1	0	1	2	$10,500
SR-00-00-09	966	Stemmers Run	0	0	0	0	0	1	0	1	2	$10,500
SR-00-00-10	1038	Stemmers Run	0	0	0	0	0	1	0	1	2	$10,500
SR-00-00-11	1558	Stemmers Run	0	0	0	0	0	1	0	1	2	$10,500
SR-00-00-12	357	Stemmers Run	0	0	0	0	0	0	0	1	1	$5,000
SR-00-00-13	823	Stemmers Run	1	0	0	0	0	0	0	1	2	$195,196
SR-00-00-14	1988	Stemmers Run	1	0	0	1	0	1	0	1	4	$482,841
SR-00-00-15	752	Stemmers Run	1	0	1	0	0	1	1	1	5	$241,669
SR-00-00-16	427	Stemmers Run	0	0	0	0	0	0	0	1	1	$7,500
SR-00-00-17	383	Stemmers Run	1	0	0	0	0	1	1	1	4	$159,293
SR-00-00-18	1028	Stemmers Run	1	0	0	0	0	1	0	1	3	$241,797
SR-00-00-19	1318	Stemmers Run	0	0	0	0	0	1	0	1	2	$10,500
SR-01-00-01	461	Stemmers Run	1	0	1	0	0	1	0	0	3	$146,431
SR-01-00-02	1088	Stemmers Run	0	0	0	0	0	1	1	1	3	$11,000
SR-02-00-01	238	Stemmers Run	0	0	0	0	0	1	1	0	2	$1,000
SR-02-00-02	726	Stemmers Run	1	0	0	0	0	1	1	1	4	$226,157
SR-02-00-03	454	Stemmers Run	1	0	0	0	0	1	1	0	3	$137,197
SR-02-00-04	706	Stemmers Run	1	0	0	0	0	1	1	0	3	$212,880
SR-02-00-05	1406	Stemmers Run	1	0	0	0	0	1	1	0	3	$317,460
SR-02-00-06	332	Stemmers Run	0	0	0	0	0	1	0	1	2	$5,500
SR-02-02-01	337	Stemmers Run	1	0	0	0	0	1	1	0	3	$135,779
SR-03-00-01	314	Stemmers Run	0	0	0	0	0	1	0	0	1	$500
SR-04-00-01	268	Stemmers Run	0	0	0	0	0	1	0	0	1	$500
SR-05-00-01	1017	Stemmers Run	1	0	0	0	0	1	1	0	3	$229,936
SR-05-00-02	397	Stemmers Run	1	0	0	0	0	1	0	0	2	$159,252
SR-05-00-03	222	Stemmers Run	1	0	1	0	0	0	0	0	2	$93,982
SR-05-00-04	857	Stemmers Run	1	0	0	0	0	1	0	1	3	$203,377
SR-06-00-01	598	Stemmers Run	1	0	1	0	0	1	0	0	3	$187,424
SR-06-00-02	767	Stemmers Run	1	0	1	0	0	1	0	1	4	$245,697
SR-06-00-03	970	Stemmers Run	1	0	0	0	0	1	1	1	4	$229,244
SR-06-01-01	1880	Stemmers Run	1	0	1	0	0	1	0	1	4	$443,515
SR-07-00-01	268	Stemmers Run	0	0	1	0	0	1	0	1	3	$10,500
SR-07-00-02	833	Stemmers Run	1	0	0	1	0	0	1	1	4	$222,952
SR-07-01-01	385	Stemmers Run	1	0	0	0	0	1	0	1	3	$159,539
SR-08-01-01	707	Stemmers Run	0	0	1	1	0	1	0	0	3	$33,000
SR-08-02-01	1458	Stemmers Run	1	0	1	1	0	1	0	0	4	$363,475
SR-10-00-06	916	Stemmers Run	1	0	0	1	0	1	0	1	4	$241,582
SR-10-00-01	656	Stemmers Run	1	0	1	0	0	1	0	1	4	$212,299
SR-10-00-02	698	Stemmers Run	1	0	1	1	0	1	0	1	5	$250,039
SR-10-00-03	523	Stemmers Run	1	0	1	0	0	1	0	1	4	$172,523
SR-10-00-04	228	Stemmers Run	1	0	0	1	0	1	0	1	4	$121,557
SR-10-00-05	913	Stemmers Run	1	0	0	1	0	1	0	1	4	$241,035
SR-10-01-01	864	Stemmers Run	1	0	0	0	0	1	1	1	4	$205,406
SR-10-02-01	1020	Stemmers Run	0	0	0	0	0	1	1	1	3	$11,000
SR-10-02-02	311	Stemmers Run	0	0	1	0	0	1	0	1	3	$10,500
SR-10-02-03	363	Stemmers Run	1	0	0	0	0	1	1	1	4	$151,357
SR-10-02-04	615	Stemmers Run	1	0	0	1	0	1	1	1	5	$217,893
SR-11-00-01	352	Stemmers Run	0	0	0	0	0	0	0	1	1	$5,000
SR-12-00-02	1398	Stemmers Run	1	0	0	0	0	1	1	0	3	$315,535
SR-12-00-03	1070	Stemmers Run	1	0	1	0	0	1	0	1	4	$261,236
SR-12-00-01	691	Stemmers Run	0	1	0	0	1	1	0	1	4	$73,000
SR-13-00-01	551	Stemmers Run	1	0	0	1	0	1	1	1	5	$198,823
SR-13-00-02	1185	Stemmers Run	0	0	0	1	0	1	1	1	4	$36,000
SR-13-01-01	594	Stemmers Run	1	0	0	0	0	1	0	1	3	$186,298
SR-13-01-02	287	Stemmers Run	1	0	0	0	0	1	1	1	4	$120,992
SR-14-00-01	320	Stemmers Run	1	0	0	0	0	1	0	0	2	$128,468
SR-14-00-02	502	Stemmers Run	0	0	0	0	0	0	0	1	1	$7,500
SR-14-01-01	292	Stemmers Run	1	0	0	0	0	1	0	0	2	$117,316
SR-15-00-01	557	Stemmers Run	1	0	0	0	0	1	0	1	3	$175,103
SR-15-00-02	267	Stemmers Run	0	0	0	0	0	1	0	1	2	$5,500
SR-15-00-03	538	Stemmers Run	0	0	0	0	0	1	0	1	2	$8,000
SR-15-00-04	188	Stemmers Run	1	0	0	0	0	1	0	1	3	$80,788
SR-15-00-05	1131	Stemmers Run	1	0	0	1	0	1	0	1	4	$289,888
SR-15-00-06	811	Stemmers Run	1	0	0	1	0	1	0	1	4	$217,903

Reach	Length	Subshed	Measure 1: Stream Restoration	Measure 2: Buffer Enhancement	Measure 3: Bank Planting	Measure 4: Utility Conflict Resolution	Measure 5: Wetland Enhancement	Measure 6: Trash Cleanup	Measure 7: Yard Waste Cleanup	Measure 8: Invasive Species Removal	Total No of Recommended Measures	Total Cost
SR-15-00-07	280	Stemmers Run	0	0	0	0	0	1	0	1	2	$5,500
SR-15-01-01	360	Stemmers Run	1	0	1	0	0	1	0	1	4	$154,456
SR-15-02-01	381	Stemmers Run	1	0	0	0	0	1	0	1	3	$158,039
SR-15-03-02	409	Stemmers Run	1	0	0	0	0	0	0	0	1	$122,794
SR-15-03-03	598	Stemmers Run	0	0	0	0	0	1	0	1	2	$8,000
SR-15-03-04	252	Stemmers Run	0	0	0	0	0	1	0	1	2	$5,500
SR-16-00-01	803	Stemmers Run	0	0	0	0	0	1	0	0	1	$500
SR-16-00-02	952	Stemmers Run	1	0	0	0	0	1	0	0	2	$214,631
SR-16-00-03	348	Stemmers Run	1	0	0	0	0	1	0	0	2	$139,529
SR-16-00-04	236	Stemmers Run	1	0	0	0	0	1	0	1	3	$99,900
SR-16-00-06	450	Stemmers Run	0	0	1	0	0	1	1	1	4	$16,000
SR-16-00-05	590	Stemmers Run	0	0	1	0	0	0	0	0	1	$7,500
SR-17-00-02	1056	Stemmers Run	0	0	0	0	0	0	0	1	1	$10,000
SR-17-01-01	317	Stemmers Run	1	0	0	0	0	0	0	0	1	$127,000
SR-18-00-01	1436	Stemmers Run	1	0	1	0	0	1	1	0	4	$334,085
SR-19-00-01	1485	Stemmers Run	1	0	0	0	0	1	1	0	3	$335,100
SR-19-00-02	805	Stemmers Run	1	0	0	0	0	1	1	1	4	$192,166
SR-19-00-03	1098	Stemmers Run	1	0	0	0	0	1	1	0	3	$248,043
SR-19-00-04	591	Stemmers Run	1	0	0	0	0	1	0	1	3	$185,334
SR-19-00-05	714	Stemmers Run	0	0	0	0	0	1	0	1	2	$8,000
SR-19-01-01	320	Stemmers Run	0	0	0	0	0	1	0	0	1	$500
SR-20-00-01	863	Stemmers Run	0	1	0	0	1	1	0	1	4	$120,500
SR-21-00-01	576	Stemmers Run	0	0	0	0	0	1	0	1	2	$8,000
SR-22-00-01	585	Stemmers Run	1	0	0	0	0	1	0	1	3	$183,506
SR-23-00-01	781	Stemmers Run	0	1	0	0	1	1	0	0	3	$65,500
OR-00-00-00	532	Brien Run	0	0	0	0	1	1	0	1	3	$48,000
OR-00-00-01	627	Brien Run	1	0	0	0	0	1	1	0	3	$189,209
OR-00-00-02	848	Brien Run	1	0	0	0	0	1	0	0	2	$191,251
OR-00-00-03	460	Brien Run	1	0	1	0	0	1	1	0	4	$146,363
OR-00-00-04	985	Brien Run	0	0	0	0	0	1	0	0	1	$500
OR-00-00-05	1084	Brien Run	0	0	0	0	1	1	1	0	3	$61,000
OR-00-00-06	801	Brien Run	0	1	0	0	0	1	1	0	3	$51,000
OR-00-00-07	416	Brien Run	1	0	0	0	0	1	1	0	3	$125,740
OR-00-00-08	1274	Brien Run	1	0	0	0	1	1	1	0	4	$347,730
OR-00-00-09	278	Brien Run	0	0	0	0	1	1	1	0	3	$21,000
OR-00-00-10	1659	Brien Run	1	0	0	0	1	1	1	0	4	$434,191
OR-00-00-11	1005	Brien Run	1	0	0	0	1	1	1	0	4	$287,209
OR-00-00-12	474	Brien Run	0	0	0	0	1	1	0	1	3	$48,000
OR-00-00-13	289	Brien Run	1	0	0	0	0	1	0	1	3	$121,135
OR-00-00-14	615	Brien Run	1	1	0	0	0	1	1	0	4	$210,632
OR-01-00-01	564	Brien Run	0	0	0	0	0	1	0	0	1	$500
OR-02-00-01	991	Brien Run	0	1	1	0	1	1	1	1	6	$131,000
OR-02-00-02	727	Brien Run	1	1	0	0		1	1	1	5	$251,632
OR-02-00-04	911	Brien Run	1	1	0	0	0	1	1	1	5	$265,994
OR-02-00-05	739	Brien Run	0	1	0	0		1	0	1	3	$33,000
OR-03-00-01	475	Brien Run	0	1	0	0	0	1	1	1	4	$33,500
OR-03-00-02	823	Brien Run	1	1	0	0	0	1	0	0	3	$235,563
OR-03-00-03	136	Brien Run	0	0	0	0	0	1	0	0	1	$500
OR-03-00-04	326	Brien Run	1	0	0	0	0	1	0	0	2	$130,802
OR-03-00-05	723	Brien Run	0	0	0	0	0	1	0	0	1	$500
OR-04-00-01	1082	Brien Run	0	0	0	0	0	1	1	0	2	$1,000
OR-06-00-01	649	Brien Run	1	0	0	0	0	1	1	0	3	$195,735
OR-07-00-01	397	Brien Run	0	0	0	0	1	1	1	0	3	$21,000
OR-08-00-01	372	Brien Run	1	0	0	0	0	1	1	0	3	$149,934
OR-08-00-02	994	Brien Run	1	0	0	0	0	1	1	0	3	$224,596
OR-08-01-01	715	Brien Run	0	0	0	0	0	1	1	0	2	$1,000
OR-09-00-01	264	Brien Run	0	0	0	0	1	1	1	0	3	$21,000
OR-10-00-03	1165	Brien Run	1	0	0	0	0	1	0	0	2	$262,702
OR-10-00-04	554	Brien Run	0	0	0	0	0	1	1	1	3	$8,500
OR-10-02-01	357	Brien Run	0	0	0	1	0	0	1	0	2	$25,500

Appendix H

Total Maximum Daily Loads of
Nitrogen and Phosphorus for Back River in
Baltimore City and Baltimore County, Maryland

June 29, 2005

Total Maximum Daily Loads of Nitrogen and Phosphorus for Back River in Baltimore City and Baltimore County, Maryland

FINAL

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Table of Contents

List of Figures

List of Tables

List of Abbreviations

BNR	Biological Nutrient Removal
BREM	Back River Eutrophication Model
CBP	Chesapeake Bay Program
CE-QUAL-ICM	Army Corps pf Engineers Water Quality Integrated Compartment Model
CEAM	Center for Exposure Assessment Modeling
CEWES	Army Corps of Engineers Waterways Experiment Station
CH3D-WES	Curvilinear Hydrodynamics in Three Dimensions – Waterways Experiment Station
Chla	Active Chlorophyll *a*
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
CWAP	Clean Water Action Plan
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphorus
DO	Dissolved Oxygen
DON	Dissolved Inorganic Nitrogen
DOP	Dissolved Organic Phosphorus
ENR	Enhanced Nutrient Removal
EPA	Environmental Protection Agency
FSA	Farm Service Agency
HSPF	Hydrological Simulation Program Fortran
LA	Load Allocation
lbs/yr	Pounds per Year
LPON	Labile Particulate Organic Nitrogen
LPOP	Labile Particulate Organic Phosphorus
m^3/s	Cubic Meters per Second
MD	Maryland
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
mg/l	Milligrams per Liter
mgd	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Cover
NBOD	Nitrogenous Biochemical Oxygen Demand
NH_3	Ammonia
NOAA	National Oceanic and Atmospheric Administration
NO_{2-3}	Nitrate + Nitrite
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source

ON	Organic Nitrogen
OP	Organic Phosphorus
PO_4	Ortho-Phosphate
RPON	Refractory Particulate Organic Nitrogen
RPOP	Refractory Particulate Organic Phosphorus
SOD	Sediment Oxygen Demand
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WQIA	Water Quality Improvement Act
WQLS	Water Quality Limited Segment
WWTP	Waste Water Treatment Plant
μg/l	Micrograms per Liter

EXECUTIVE SUMMARY

This document establishes Total Maximum Daily Loads (TMDLs) for nitrogen and phosphorus in the tidal stream segment of the Back River (basin number 02130901). The Back River drains into the Chesapeake Bay and is part of the Patapsco/Back River Tributary Strategy Basin. The tidal stream segment of the Back River (basin number 02130901) was first identified on the 1996 303(d) list submitted to EPA by the Maryland Department of the Environment (MDE) as being impaired by nutrients due to signs of eutrophication, expressed as high chlorophyll *a* levels. Eutrophication is the over-enrichment of aquatic systems by excessive inputs of nutrients (nitrogen and/or phosphorus). The nutrients act as a fertilizer leading to the excessive growth of aquatic plants. These plants eventually die and decompose, leading to bacterial consumption of dissolved oxygen (DO). For these reasons, this document proposes to establish TMDLs for the nutrients nitrogen and phosphorus in the Back River. The Back River was also identified on the 303(d) list as being impaired by bacteria (fecal coliform), toxics (PCBs), metals (Zinc) and suspended sediments. The impairments due to these contaminants have been or will be addressed in separate analyses by MDE.

The water quality goal of these TMDLs is to reduce high chlorophyll *a* concentrations that reflect excessive algal blooms, and to maintain the dissolved oxygen criterion at a level whereby the designated uses for the Back River will be met. The TMDLs for the nutrients nitrogen and phosphorus were determined using a time-variable, three-dimensional water quality eutrophication model package, which includes the water quality model, Corps of Engineers-Water Quality-Integrated Compartment Model (CE-QUAL-ICM), a sediment process model, and the hydrodynamic model, Curvilinear Hydrodynamic in Three Dimensions (CH3D). Loading caps for total nitrogen and total phosphorus entering the Back River are established for low flow conditions and for annual average flow conditions.

The low flow TMDL for nitrogen is 113,321 lbs/month, and the low flow TMDL for phosphorus is 7,995 lbs/month. These TMDLs apply during the period May 1 through October 31. The allowable loads have been allocated between point and nonpoint sources. The nonpoint sources are allocated 1,345 lbs/month of total nitrogen, and 34 lbs/month of total phosphorus. The point sources, including a National Pollutant Discharge Elimination System (NPDES) wastewater treatment plant (WWTP) loads and NPDES stormwater loads are allocated 111,299 lbs/month of nitrogen, and 7,888 lbs/month of phosphorus. An explicit margin of safety makes up the remainder of the nitrogen and phosphorus allocations.

The average annual TMDL for nitrogen is 1,773,100 lbs/yr, and the average annual TMDL for phosphorus is 99,171 lbs/yr. The allowable loads have been allocated between point and nonpoint sources. The nonpoint source loads are allocated 26,323 lbs/year of total nitrogen and 1,239 lbs/year of total phosphorus. The point sources, including a NPDES wastewater treatment plant (WWTP) loads and NPDES stormwater loads are allocated 1,737,626 lbs/year of total nitrogen and 96,896 lbs/year of total phosphorus. An explicit margin of safety makes up the balance of the allocation.

Four factors provide assurance that these TMDLs will be implemented. First, National Pollutant Discharge Elimination System (NPDES) permits (including both wastewater treatment plants and stormwater permits) and point source loading goals under the Chesapeake Bay Program's Enhanced Nutrient Removal Strategy (ENR) will play important roles in assuring implementation. Second, Maryland has several well-established programs that will be drawn upon, including Maryland's Tributary Strategies for Nutrient Reductions developed in accordance with the Chesapeake Bay Agreement. Third, Maryland's Water Quality Improvement Act of 1998 requires that nutrient management plans be implemented for all agricultural lands throughout Maryland. Finally, Maryland has adopted a watershed cycling strategy, which will assure that routine future monitoring and TMDL evaluations are conducted.

1.0 INTRODUCTION

Section 303(d)(1)(C) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (EPA) implementing regulations direct each State to develop a Total Maximum Daily Load (TMDL) for each water quality limited segment (WQLS) on the Section 303(d) list, taking into account seasonal variations and a protective margin of safety (MOS) to account for uncertainty. A TMDL reflects the total pollutant loading of the impairing substance a water body can receive and still meet water quality standards.

TMDLs are established to achieve and maintain water quality standards. A water quality standard is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Designated uses include activities such as swimming, drinking water supply, and shellfish propagation and harvest. Water quality criteria consist of narrative statements and numeric values designed to protect the designated uses. Criteria may differ among waters with different designated uses.

The tidal stream segment of the Back River (basin number 02130901) was first identified on the 1996 303(d) list submitted to EPA by the Maryland Department of the Environment (MDE) as being impaired by nutrients due to signs of eutrophication, expressed as high chlorophyll *a* levels. Eutrophication is the over-enrichment of aquatic systems by excessive inputs of nutrients (nitrogen and/or phosphorus). The nutrients act as a fertilizer leading to the excessive growth of aquatic plants. These plants eventually die and decompose, leading to bacterial consumption of dissolved oxygen (DO). For these reasons, this document proposes to establish TMDLs for the nutrients nitrogen and phosphorus in the Back River. The Back River was also identified on the 303(d) list as being impaired by bacteria (fecal coliform), toxics (PCBs), metals (Zinc) and suspended sediments. The impairments due to these contaminants have been or will be addressed in separate analyses by MDE.

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1 General Setting and Source Assessment

The Back River Watershed is located in the western shore region of Maryland, northeast of the Baltimore Harbor and it drains into the Chesapeake Bay (Figure 1). It is located on the western shore of the Upper Chesapeake Bay about 160 miles from the Virginia Capes at the entrance to the Bay. It is a relatively small estuary, with average depths of approximately 25 feet (near the mouth), nine feet (lower estuary), and five feet (upper estuary). The tidal range in the estuary is approximately 1.2 feet (Maryland Environmental Service, 1974).

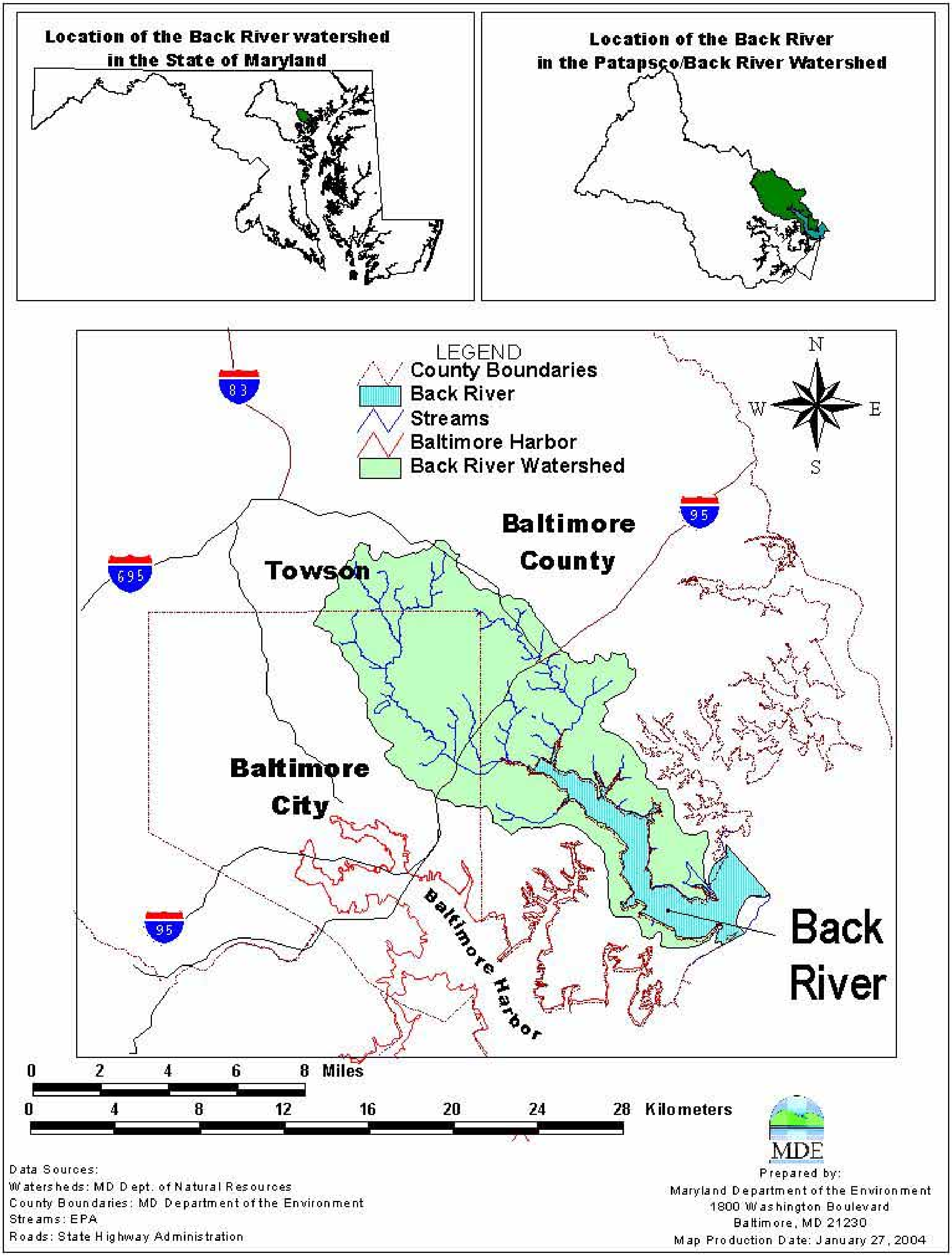


Figure 1: Location Map of Back River Drainage Basin

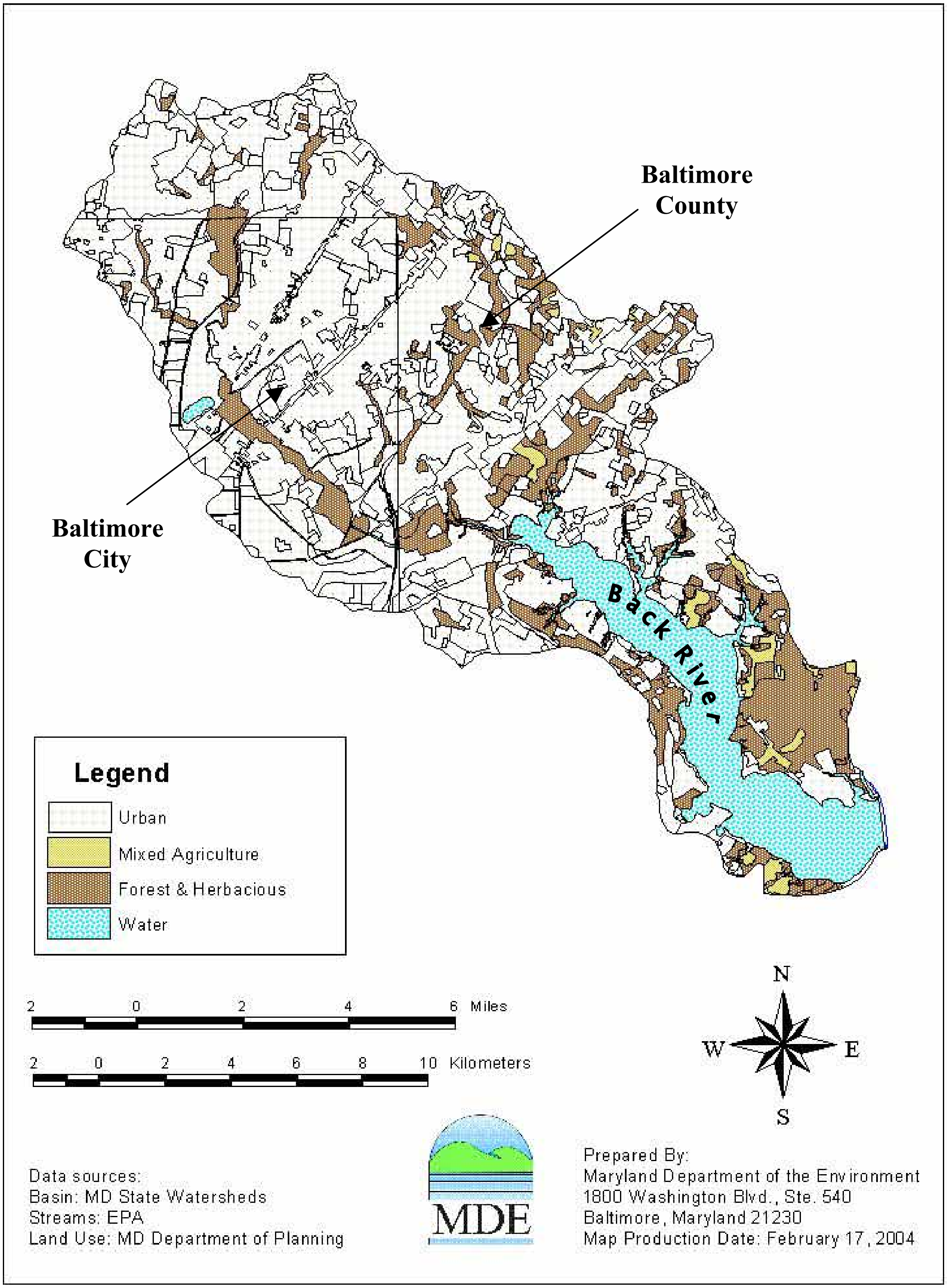


Figure 2: Predominant Land Uses in the Back River Drainage Basin

2.2 Land Use

Land Use in the Back River Watershed is primarily urban but also consists of some forested areas, rural areas and farms, suburban areas, and industrial areas. The Back River Watershed has an area of approximately 39,075 acres or 158.1 square kilometers. The land uses in the watershed consist of urban (28,037 acres or 71.7 %), and non-urban which comprises mixed agriculture and forest and other herbaceous (6,753 acres or 17.3 %) and water (4,295 acres or 11.0 %). The land use is based on 1997 Maryland Office of Planning land use/land cover data. Figure 3 shows the relative amounts of the different land uses in the Back River Watershed.

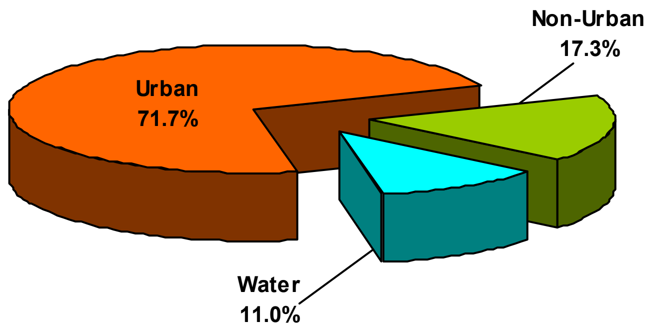


Figure 3: Proportions of Land Use in the Back River Drainage Basin

2.3 Geology

The Back River Watershed lies within the Piedmont and Coastal Plain provinces of Central Maryland. The surficial geology is characterized by crystalline rocks of volcanic and sedimentary 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 southwest 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 surficial geology is characterized by thick, unconsolidated marine sediments deposited over the crystalline rock of the piedmont province (*Coastal Environmental Services, 1995*).

2.4 Point Sources: Wastewater Treatment Plants Loads

The model was calibrated using point source loading data and flows from the period 1992-1997. The Back River WWTP is the only municipal point source that currently discharges into the Back River, and which was discharging during the model calibration period. Eastern Stainless is the only industrial point source that discharged into the Back River during the 1992-1997 period. The estimated average annual nitrogen and phosphorus loads from the Back River WWTP for the 1992 to 1997 period is *4,080,417 lbs/yr or 1,854,735 kg/yr and 84,427 lbs/yr or 38,375 kg/yr, respectively.* This information was obtained from discharge monitoring reports stored in MDE's point source database. The Back River WWTP average annual point source loads for 1992 to 1997 are presented in Table 1.

Table 1: Back River WWTP Flows and Loads for the Period 1992 to 1997

Back River Flows and Point Source Loads					
Year	**Flow**	**TN**		**TP**	
	mgd	lbs/yr	kg/day	lbs/yr	kg/day
1992	107	4,587,967	5,771	194,534	241
1993	117	4,521,061	5,691	79,674	99
1994	113	4,335,097	5,477	71,456	91
1995	104	3,985,318	5,005	63,574	79
1996	115	4,081,197	5,084	57,872	72
1997	86	2,971,863	3,703	39,451	49
Average	107	4,080,417	5,122	84,427	105

These average annual flows and point source load estimates represent actual discharge into the Back River from the WWTP from 1992 to 1997. It is important to note that this WWTP, while not discharging at its maximum flow capacity during this period, had nitrogen concentrations around 12 mg/l – 12.5 mg/l, higher than current nitrogen concentrations. The Biological Nutrient Removal (BNR) process went into operation in July 1998, the year after the model calibration period and concentrations since then are lower, averaging 8-9 mg/l. In the same context, the phosphorus concentrations discharged from 1992 to 1997 are higher than the current permitted concentrations. For the Back River WWTP, the average annual load, with current permit flow and concentrations, could decrease to 3,167,002 lbs/yr from 4,080,417 lbs/yr of total nitrogen and to 79,175 lbs/yr from 84,427 lbs/yr of total phosphorus assuming the plant is discharging at its maximum allowable current permit flow of 130 MGD and the current goal concentration for TN of 8 mg/l and TP permit limit concentration of 0.2 mg/l. The flow discharged from the Back River WWTP into Back River does not represent the total output of the Back River WWTP. Of the 180 MGD design capacity of the plant, 50-70 MGD are discharged into Outfall 002, to be used by Bethlehem Steel (currently International Steel Group, ISG) as cooling water, and then discharged into Bear Creek and other tributaries of the Baltimore Harbor.

The Eastern Stainless point source discharged into Back River an average TN load of 62,755 lbs/yr and an average TP load of 106 lbs/yr from 1992 to 1997.

2.5 Nonpoint Source Loads and Urban-Stormwater Loads

Nonpoint source loads and urban-stormwater loads entering the Back River were estimated using the Hydrologic Simulation Program-Fortran (HSPF). The HSPF model is used to estimate flows, suspended solids and nutrient loads from the watershed's sub-basins, which are linked to a three-dimensional, time variable hydrodynamic model and a water quality model designed specifically for the Back River. The water quality model is used to determine the maximum load of nutrients that can enter Back River while maintaining the water quality criteria associated with the designated use of Back River. The water quality modeling framework is shown in Section 4.2. The simulation of the Back River Watershed used the following assumptions: (1) variability in patterns of precipitation were estimated from existing National Oceanic and Atmospheric Administration (NOAA) meteorological stations; (2) hydrologic response of land areas were estimated for a simplified set of land uses in the basin; and (3) agricultural information was estimated from the Maryland Department of Planning (MDP) land use data, the 1997 Agricultural Census Data, and the Farm Service Agency (FSA). The HSPF simulates nonpoint source and urban-stormwater loads and integrates all natural and human induced sources, including direct atmospheric deposition, and loads from septic tanks, which are associated with river base flow during low flow conditions. Details of the HSPF watershed model developed to estimate these urban and non-urban loads can be found in "Patapsco/Back River Watershed HSPF Model Report, (MDE, 2001)".

Figure 4 shows the relative amounts of nitrogen and phosphorus nonpoint, point source and urban loadings during the 1995 to 1997 period for the Back River.

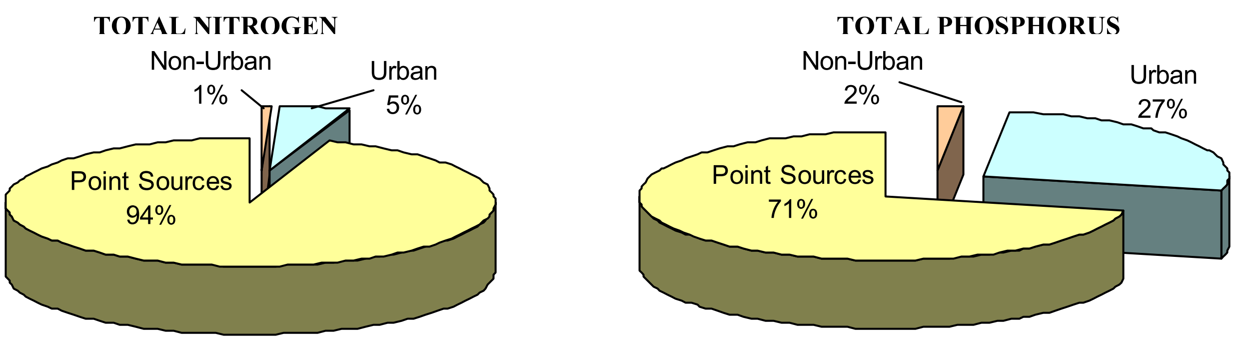


Figure 4: Percentages of Average Annual Nitrogen and Phosphorus Loads from WWTP point sources, urban and non-urban sources in the Back River between 1995 and 1997

2.6 Water Quality Characterization

Historical and recent data show clear indications of extreme eutrophication in the Back River. Some of the highest chlorophyll-*a* concentrations observed in the entire Chesapeake system have been routinely recorded in the Back River (Boynton *et al*., 1998). Abnormally high chlorophyll *a* concentrations, 200-300 µg/l, were observed in the upstream reaches of this river. In contrast, the chlorophyll *a* levels in Baltimore Harbor, just 10 km south of Back River, are 50-100 µg/l, which are also much higher than the values usually observed in the Chesapeake Bay. As for the DO concentrations, hypoxia/anoxia have rarely occurred in Back River although large diel excursions of DO have been documented (Boynton *et al*., 1998).

There are 10 water quality stations located in the Back River that were surveyed during the model calibration period 1992 to 1997. One of these is a Chesapeake Bay Program long-term monitoring station. Five are MDE water quality stations and four more stations are Baltimore City stations. The reader is referred to Figure 5 for the locations of the water quality sampling stations. Table 2 presents the distance of each station from station M01 located at the mouth of the river.

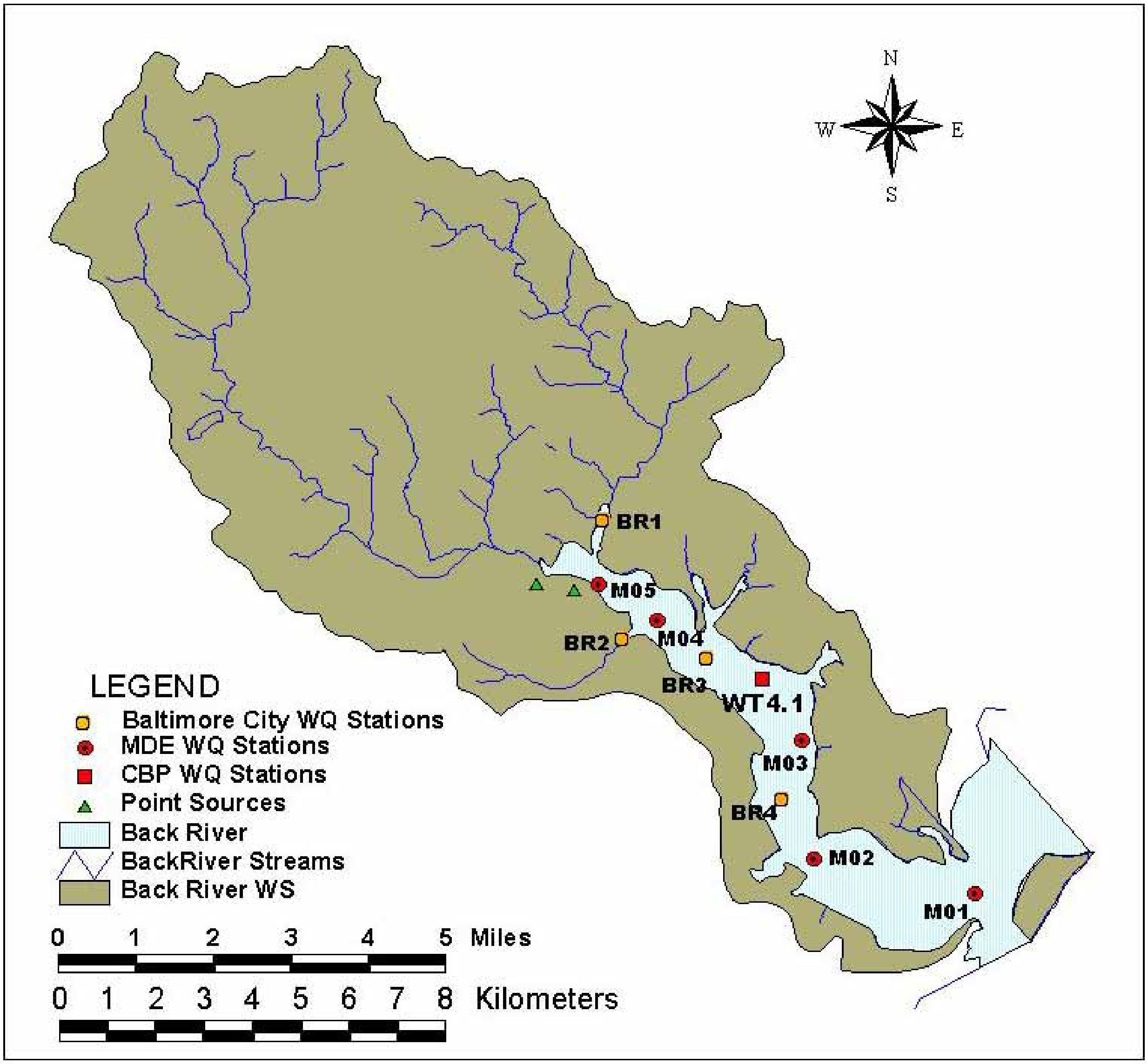


Figure 5: Location of Water Quality Stations in the Back River

Table 2: Location of Water Quality Monitoring Stations

Water Quality Station	Kilometers from the Mouth of the River
BACK RIVER	
M01 (mouth)	0
M02	3.6
BR4	4.5
M03	6.1
WT4.1 (middle)	7.1
BR3	7.5
M04 / BR2	8.5 / 9.5
M05 / BR1 (head)	10.0 / 11.2

Data for the 1992-1997 period have been selected for the development of the eutrophication model for subsequent nutrients TMDLs analysis. During this period, monitoring was sponsored by the Chesapeake Bay Program (CBP), MDE, and the City of Baltimore.

The Chesapeake Bay Program has maintained a long-term water quality sampling station (WT4.1) in the Back River since 1984 to monitor its physical, chemical, and biological parameters. MDE also monitored the Back River intensively at the other five stations during the period March 1994 to May 1995 for parameters similar to those monitored by the CBP. Baltimore City (BC) also sponsored monitoring at sites located close to the MDE surveys during the period June to December 1993, 1994, 1995, 1996 and 1997 for similar parameters. A detailed list of all the parameters measured in these surveys can be found in the Back River section of the report "The development of a water quality model for Baltimore Harbor, Back River and the adjacent Upper Chesapeake Bay" Part II: "Biological, chemical and physical characteristics of the Baltimore Harbor and Back River in the Upper Chesapeake Bay, (Wang *et al*, 1999)".

The water quality time series for chlorophyll *a*, DO, TN and TP for the period 1992 to 1997 of the CBP long-term station WT 4.1 in the Back River are presented in Figures 6, 8, 10, and 12. The water quality longitudinal profiles of the river showing MDE and BC data for the same parameters at stations M01 (mouth), M02, BR4, M03, WT 4.1, BR3, M04 and M05 (upstream) are also presented in figures 7, 9, 11, and 13. Stations BR1 and BR2 located outside the model domain near stations M05 and M04 respectively, were included in the data set as follows: water quality data at station BR1 was included with data from station M05, and data from station BR2 was included with data from station M04. Please note the not all stations show data for all the parameters shown. The discussion below is a summary of the data from these monitoring programs for the period used in the development of the eutrophication model. Detailed analyses and interpretation of the results are presented in the Back River section of the report "The development of a water quality model for Baltimore Harbor, Back River and the adjacent Upper Chesapeake Bay" Part II: "Biological, chemical and physical characteristics of the Baltimore Harbor and Back River in the Upper Chesapeake Bay", (Wang *et al*, 1999) and in Part A of Appendix 1.

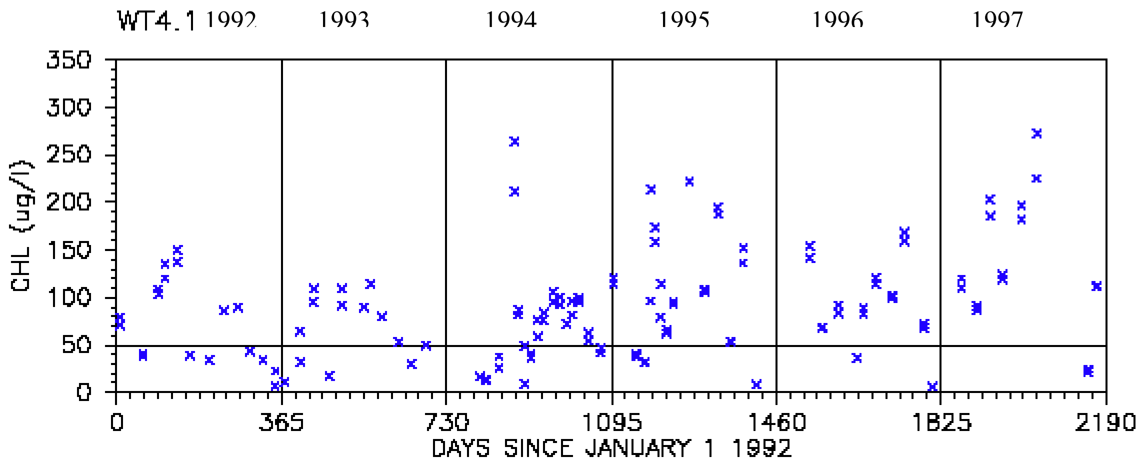


Figure 6: Time Series of Chlorophyll *a* Data at Back River Station WT 4.1

Figure 6 presents the time series of chlorophyll *a* concentrations in the Back River from January 1992 to December 1997 for the CBP long-term monitoring station WT4.1, a seven-year period that includes wet and dry years. WT4.1 is located in the middle of the Back River, approximately 7.8 km from the mouth. Chlorophyll *a* concentrations throughout the water column are above 50 µg/l every year with maximum concentrations close to 300 µg/l during the summers of 1994 and 1997. Chlorophyll *a* concentrations have a seasonal pattern: higher during the warmer months and lower during the coldest months.

Figure 7 below presents a longitudinal profile of chlorophyll *a* from May 1 to October 31, and from January 1 to April 30/November 1 to December 31 of 1995, 1996 and 1997 in the Back River. Water quality data for BC stations BR1 and BR2 were combined with the data from MDE stations M05 and M04, respectively. The figures show symbols representing the mean values of chlorophyll *a* concentrations with minimum/maximum value bars at each station and period in the Back River. The numbers on the upper part of each graph represents the number of samples averaged at each particular station.

A difference of chlorophyll *a* distribution between the May-October period and the November-April period was observed in the surface water along the longitudinal profile of the river system as shown in the figure. Highest chlorophyll *a* concentrations in surface water were located at the head of the river throughout the May 1 to October 31 period and concentrations decreased downstream. In 1995, chlorophyll *a* values were the highest of the three years with concentrations decreasing in 1996 and 1997. Spring algal blooms developed throughout the water column and the chlorophyll *a* concentrations were relatively high throughout both periods.

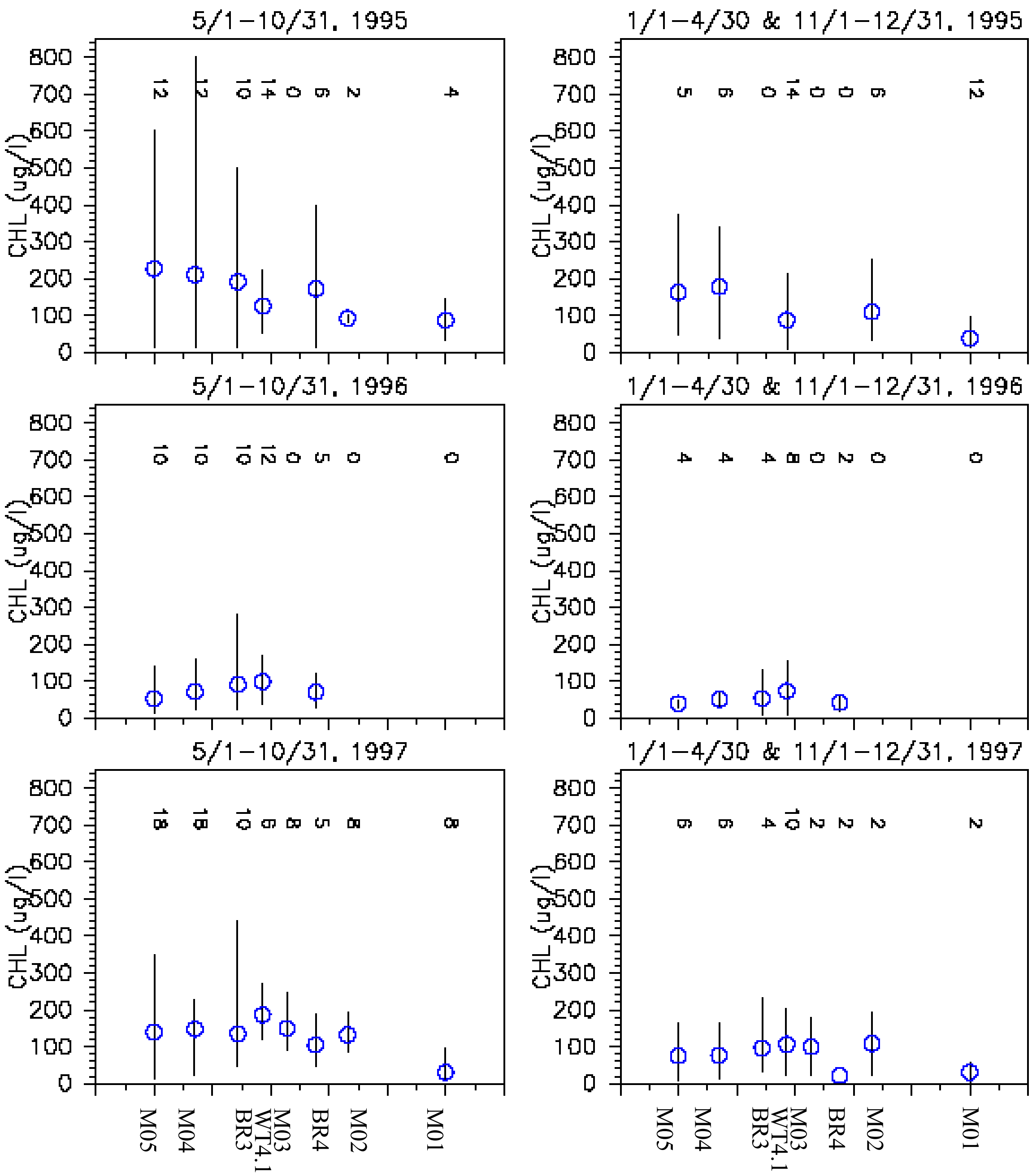


Figure 7: Longitudinal Profile of Chlorophyll *a* During the Period of May 1 to October 31, and during the periods of January 1 to April 30 and November 1 to December 31 of 1995, 1996 and 1997 in the Back River.

A similar time series for DO concentrations at station WT4.1 is depicted in Figure 8. It shows that the observed DO levels at station WT4.1 do not fall below 5.0 mg/l, except in the summer of 1992. The DO ranged from 3.8 to 18.8 mg/l with average DO concentrations close to 10 mg/l. The DO concentrations fall slightly every summer to levels close to 5.0 mg/l but only fell below

5.0 mg/l in 1992. DO concentrations in 1997 appear to be slightly elevated relative to prior years, consistent with reduced nutrient loads as shown in Table 1.

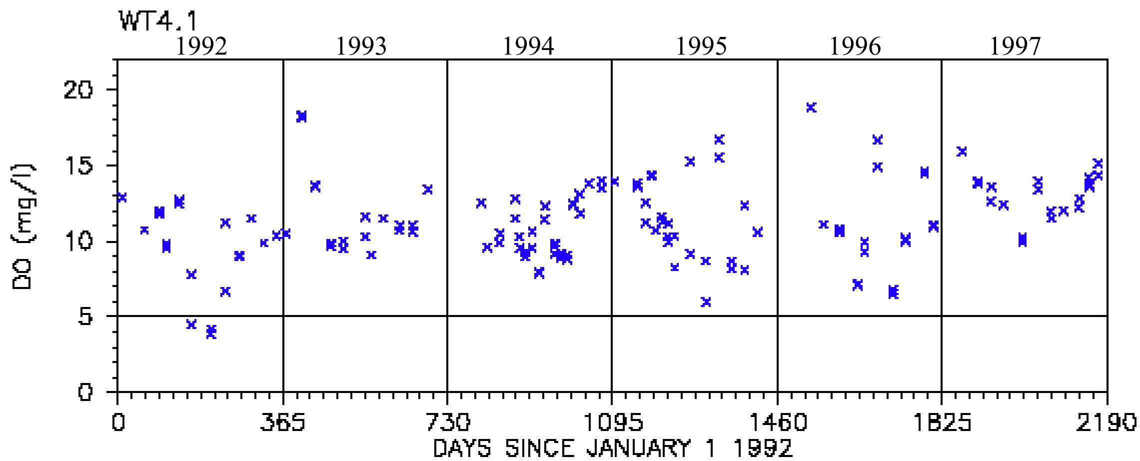


Figure 8: Time Series of Dissolved Oxygen Data at Back River Station WT 4.1

Figure 9 presents a longitudinal profile of chlorophyll *a* from May 1 to October 31, and from January 1 to April 30/November 1 to December 31 of 1995, 1996 and 1997 in the Back River. The figures show symbols representing the mean values of chlorophyll *a* concentrations with minimum/maximum value bars at each station and period in the Back River. The numbers on the upper part of each graph represents the number of samples averaged at each particular station. There was no significant seasonal variation in the Back River system. DO levels remained high at the region. DO concentrations increased upstream during the warmer months but slightly decreased or remained constant heading upstream during the colder months.

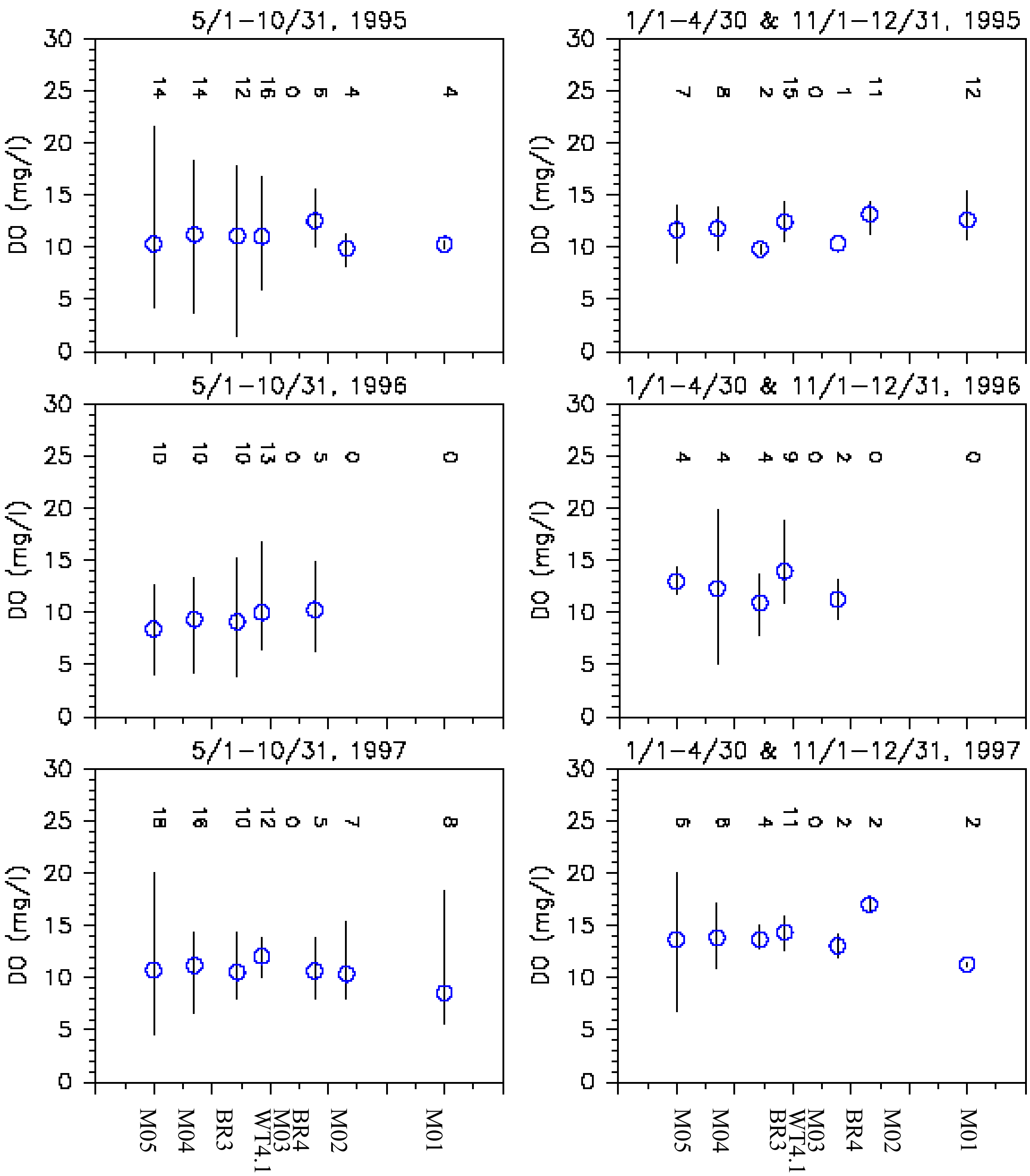


Figure 9: Longitudinal Profile of Dissolved Oxygen (DO) During the Period of May 1 to October 31, and during the periods of January 1 to April 30 and November 1 to December 31 of 1995, 1996 and 1997 in the Back River.

Figure 10 presents a time series of Total Nitrogen (TN), Total Dissolved Nitrogen (TDN) and Particulate Nitrogen (PN) levels measured during the 1992-1997 period at station WT 4.1 in the Back River. The TN levels of most samples are below 9 mg/l with the highest values near 10 mg/l only in the winter of 1993 and spring of 1995. The dissolved species (TDN) of this total nitrogen, which includes NH_4 and NO_{23}, represents approximately 70-75% of the TN in the water column (between 2 and 6 mg/l), while the PN accounts for approximately 25% of the total nitrogen (between 0 and 3 mg/l for most samples).

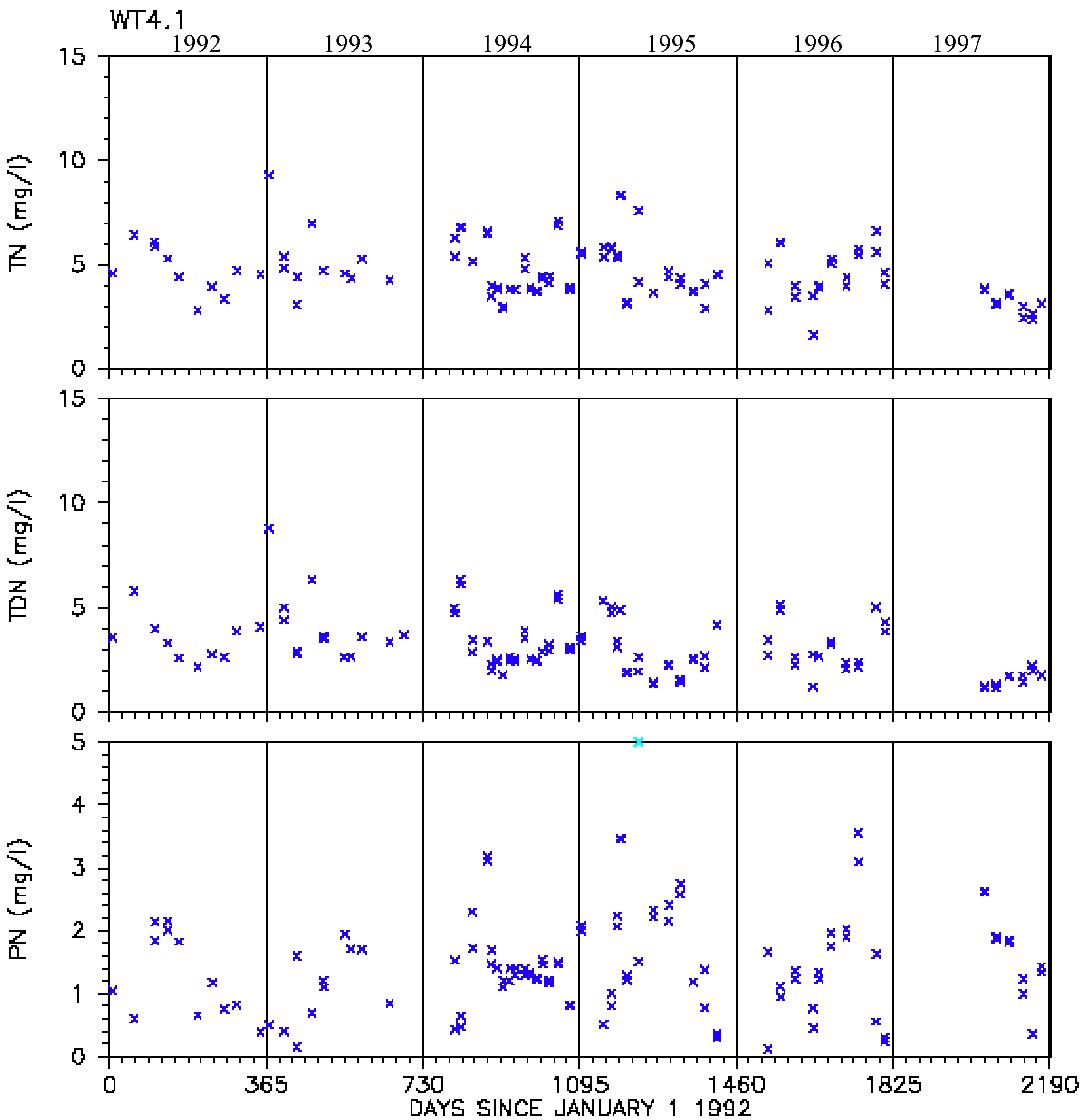


Figure 10: Time Series of Total Nitrogen (TN), Total Dissolved Nitrogen (TDN) and Particulate Nitrogen (PN) Data at Back River Station WT 4.1

Figure 11 presents the longitudinal profile of TN during the period of May 1 to October 31, and during the period of January 1 to April 30/November 1 to December 31 of 1995, 1996 and 1997 in the Back River. The figures show symbols representing the mean values of chlorophyll *a* concentrations with minimum/maximum value bars at each station and period in the Back River. The numbers on the upper part of each graph represents the number of samples averaged at each particular station. In general, TN concentrations are higher upstream and appear to decrease over time when comparing 1995 with 1996 and 1997 values. TN concentrations do not show any seasonality, with average values in the warmer months very similar to those in the colder months.

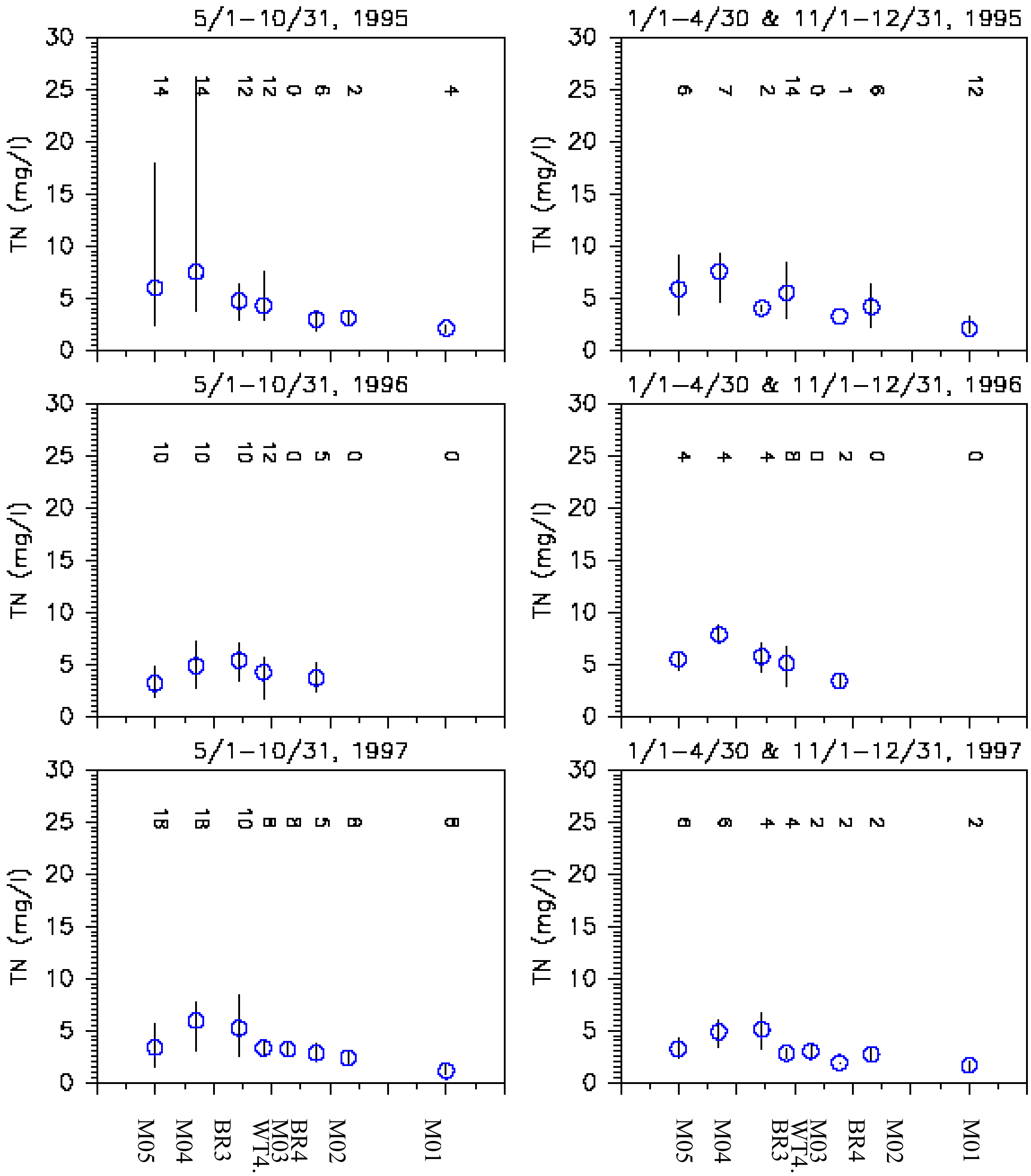


Figure 11: Longitudinal Profile of TN During the Period of May 1 to October 31, and during the periods of January 1 to April 30 and November 1 to December 31 of 1995, 1996 and 1997 in the Back River.

Figure 12 present time series of Total Phosphorus (TP), Total Dissolved Phosphorus (TDP) and Particulate Phosphorus (PP) levels measured during the 1992-1997 period at station WT4.1 in the Back River. The TP levels of most samples are between 0.1 mg/l and 0.5 mg/l, with a one time highest value near 1.1 mg/l, in the spring of 1995. The reason for this high TP concentration is unclear. The total dissolved phosphorus (TDP) of this total phosphorus represents a smaller percentage of the TP than the percentage of PP in the water column. This suggests a higher concentration of phosphorus in the suspended solids of the system than in dissolved form.

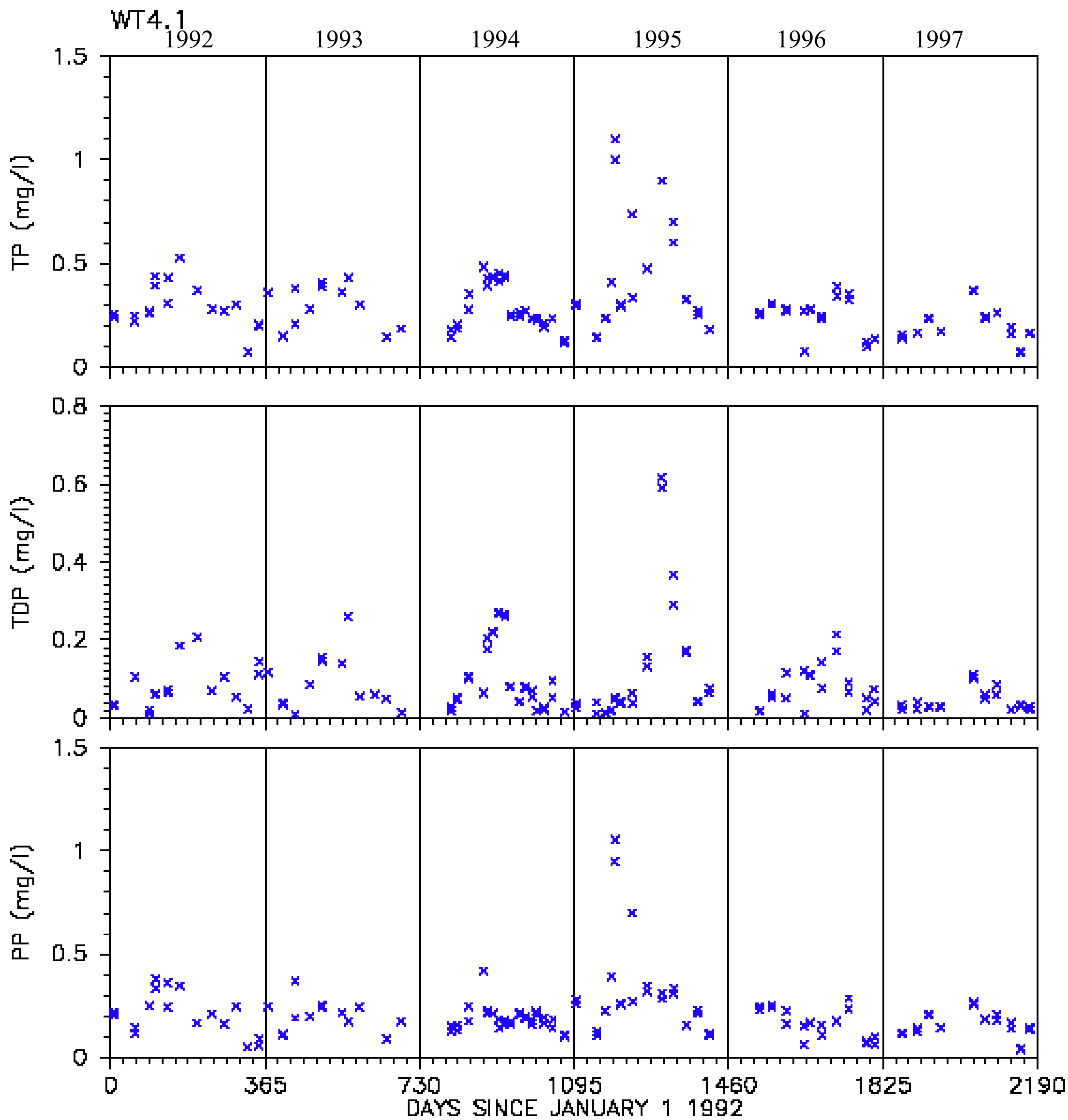


Figure 12: Time Series of TP, TDP, and PP Data at Back River Station WT 4.1

Figure 13 presents the seasonal variation of TP during the period of May 1 to October 31, and during the period of January 1 to April 30/November 1 to December 31 of 1995, 1996 and 1997 in the Back River. The figures show symbols representing the mean values of chlorophyll *a* concentrations with minimum/maximum value bars at each station and period in the Back River. The numbers on the upper part of each graph represents the number of samples averaged at each particular station.

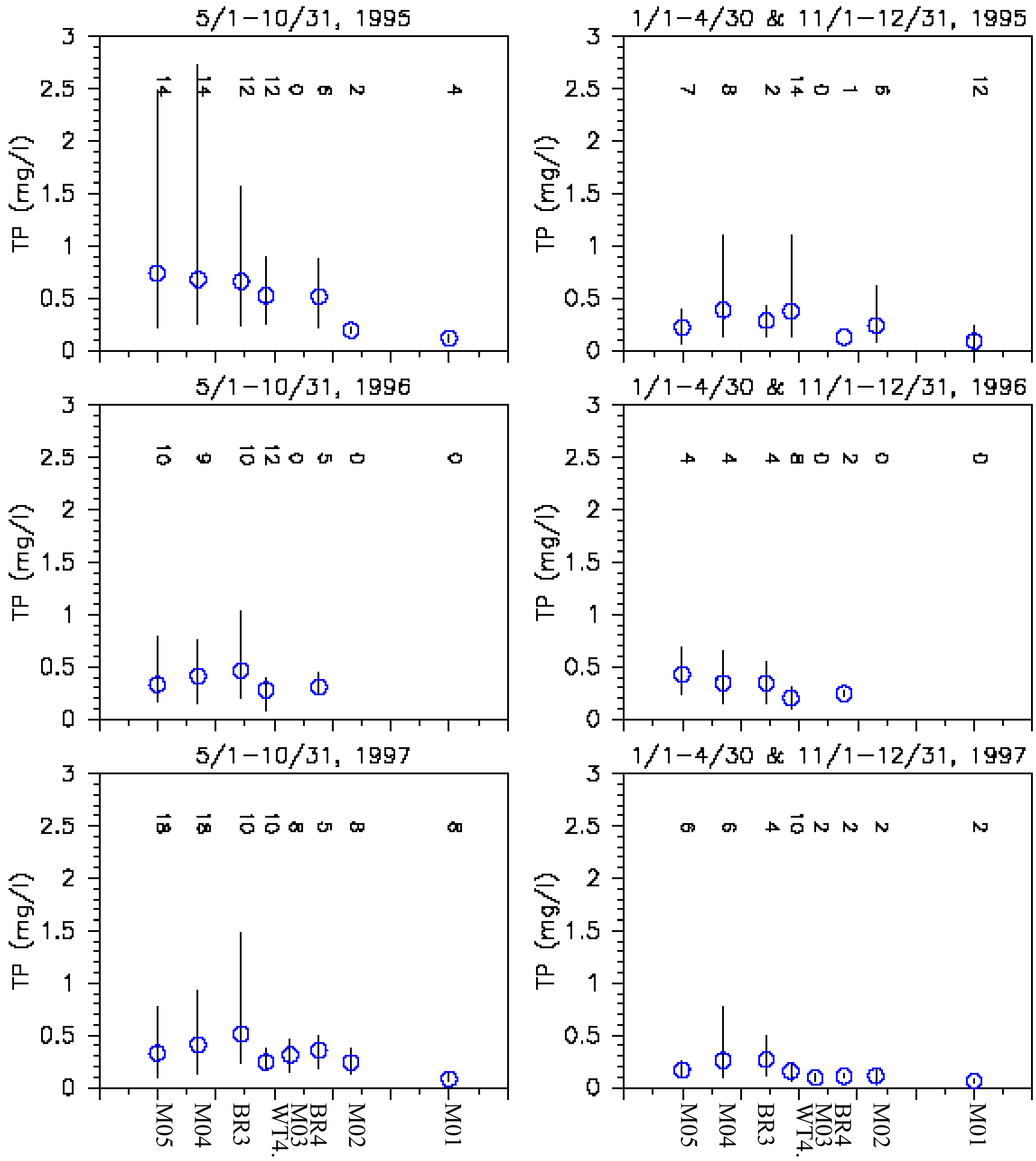


Figure 13: Longitudinal Profile of TP during the period of May 1 to October 31, and during the periods of January 1 to April 30 and November 1 to December 31 of 1997 in the Back River.

TP concentrations are higher at the upstream stations compared to the downstream stations. These TP concentrations are higher during the warmer months than concentrations observed during the colder months, especially during 1995. Seasonality is not so obvious in 1996 but it is significant again in 1997. In general, TP concentrations seem to decrease slightly over time.

2.7 Water Quality Impairment

The Maryland Water Quality Standards Surface Water Use Designation [Code of Maryland Regulations (COMAR) 26.08.02.07] for the tidal waters of the Back River is Use I - water contact recreation, fishing, and protection of aquatic life and wildlife. The water quality impairment of the Back River system being addressed by this TMDL analysis consists of a higher than acceptable level of chlorophyll *a* (See Section 2.6 figures). The substances causing this water quality exceedance are the nutrients - nitrogen and phosphorus. Excessive nitrogen and phosphorus over-enrich aquatic systems. The nutrients act as a fertilizer leading to the excessive growth of aquatic plants. These plants eventually die and decompose, leading to bacterial consumption of dissolved oxygen (DO).

According to the numeric criteria for DO for Use I waters, concentrations may not be less than 5.0 mg/L at any time unless resulting from natural conditions (COMAR 26.08.02.03.A(2)). The achievement of 5.0 mg/L is expected in the well-mixed surface waters and throughout the water column of the Back River system.

Maryland's General Water Quality Criteria prohibit pollution of waters of the State by any material in amounts sufficient to create a nuisance or interfere directly or indirectly with designated uses. See Code of Maryland Regulations (COMAR) 26.08.02.03B(2). Excessive eutrophication, indicated by elevated levels of chlorophyll *a*, can produce nuisance levels of algae and interfere with designated uses such as fishing and swimming. The chlorophyll *a* concentration in the upper reaches of Back River regularly exceeds the desired level of 50 µg/L. These levels have been associated with excess eutrophication.

3.0 TARGETED WATER QUALITY GOAL

The objective of the nutrient TMDLs established in this document is to assure the chlorophyll *a* levels support the Use I designations for the tidal waters of the Back River. Specifically, the TMDLs for nitrogen and phosphorus in Back River are intended to control excessive algal growth. Excessive algal growth can lead to violations of the numeric DO criteria, associated fish kills, and the violation of various narrative criteria associated with nuisances, such as odors, and impedance of direct contact use and the loss of habitat for the growth and propagation of aquatic life and wildlife.

In summary, the TMDLs for nitrogen and phosphorus are intended to:

1. Assure a minimum DO concentration of 5.0 mg/l is maintained throughout the tidal waters of the Back River; and

2. Resolve violations of narrative criteria associated with excess nutrient enrichment of the Back River, as reflected in chlorophyll *a* levels greater than 50 µg/l in the Back River system.

The dissolved oxygen level is based on specific numeric criteria for Use I waters set forth in the COMAR 28.08.02. The chlorophyll *a* level is based on the designated uses of Back River, 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). These guidelines acknowledge it is acceptable to maintain chlorophyll *a* concentrations below a maximum of 100 µg/L, with a target threshold of less than 50 µg/L.

4.0 TOTAL MAXIMUM DAILY LOADS AND ALLOCATIONS

4.1 Overview

The following section describes the modeling frameworks for simulating nutrient loads, hydrology, and water quality responses. The second sections summarize the scenarios that were explored using the model. The third section describes how the nutrient TMDLs and load allocations for point sources and nonpoint sources were developed for the Back River. The assessment investigates water quality responses using 1995 to 1997 stream flow and different nutrient loading conditions. The fourth section presents the modeling results in terms of a TMDL and allocate the TMDL between point sources and nonpoint sources. The last section explains the rationale for the margin of safety. Finally, the pieces of the equations are combined in a summary accounting of the TMDL for seasonal low flow conditions and for average annual flows.

4.2 Analysis Framework

4.2.1 Computer Modeling Framework

To develop a TMDL, a linkage must be defined between the selected targets or goals and the identified sources. This linkage establishes the cause-and-effect relationship between the sources of the pollutant of concern and the water quality response of the impaired water quality segment to that pollutant. The relationship can vary seasonally, particularly for nonpoint sources, with factors such as precipitation. Once defined, the linkage yields the estimate of total loading capacity or TMDL (U.S. EPA, 1999).

The Department chose a time variable water quality model as the analysis tool to link the nutrient source loadings to the DO criteria and chlorophyll *a* goal. The computational framework chosen for the Back River TMDLs is the three-dimensional, time-variable water quality model CE-QUAL-ICM package. This water quality simulation package provides a generalized framework for modeling contaminant fate and transport in surface waters and is based on the unstructured cell-centered finite-volume approach (Cerco and Cole, 1995). CE-QUAL-ICM was originally developed by U.S. Army Corps of Engineers Waterways Experiment Station (CEWES), Vicksburg, MS (Cerco and Cole, 1995) for the Chesapeake Bay. This eutrophication model package, which includes a sediment flux sub-model, incorporates twenty-two water quality constituents in the water column and in the sediment bed. For detailed information, please refer to the report "The development of a water quality model for Baltimore Harbor, Back River and the adjacent Upper Chesapeake Bay, (Wang *et al*, 2004)".

The CE-QUAL-ICM model is externally coupled with the three-dimensional, time-variable hydrodynamic model CH3D-WES (Curvilinear Hydrodynamic in Three Dimensions), which was developed at the U.S. Army Engineer Waterways Experiment Stations. As its name indicates, CH3D-WES makes hydrodynamic computations on a curvilinear or boundary-fitted platform grid that provides enhancement to fit the deep navigation channel and the irregular shoreline. The CH3D-WES simulates physical processes such as tides, wind, density effects (salinity and temperature), freshwater inflows, turbulence, and the effect of the earth's rotation. The outputs include three-dimensional velocities, water surface elevation, salinity, temperature, and the turbulent mixing coefficients, which in turn are used to drive the water quality model CE-QUAL-ICM, (Johnson *et al*., 1991).

Since many studies have shown significant influence of Chesapeake Bay water on its tributaries, the spatial domain of the Back River Eutrophication Model (BREM) extends longitudinally from the mouth of the Susquehanna River about 90 miles seaward to the mouth of the Patuxent River, which is defined as the upper Chesapeake Bay. Back River is a relatively small estuary located on the western shoreline of the upper Chesapeake Bay. This modeling domain is represented by CE-QUAL-ICM model segments. A diagram of the model segmentation is presented also in Wang *et al*, (2004). There are 3,758 active horizontal cells and a maximum of 19 vertical layers, resulting in 16,149 computational cells. The grid resolution is 1.52 m in the vertical, approximately 0.2 km laterally and 0.4 km longitudinally. Freshwater flows and nonpoint loadings from watersheds are evenly distributed into the adjacent water quality model cells.

The sediment flux model developed by DiToro and Fitzpatrick (1993) and coupled with CE-QUAL-ICM for the Chesapeake Bay water quality modeling is used in the present model application. The model state variables and the resulting fluxes in this sediment flux model and complete model documentation of the sediment flux model can be found in Wang *et al*, (2004) and also in DiToro and Fitzpatrick, (1993).

The water quality model CE-QUAL-ICM described above was calibrated to reproduce observed water quality characteristics for 1992 to 1997 conditions. The calibration of the model for these six years establishes an analysis tool that may be used to assess a range of scenarios with differing flow and nutrient loading conditions. Observed 1992 to 1997 water quality data were used to support the calibration process, as explained further in Wang *et al*, (2004).

4.2.2 TMDL Analysis Framework

The nutrient TMDL analysis consists of two broad elements: an assessment of low flow loading conditions and an assessment of average annual loading conditions. Both the low flow and the average annual flow TMDL analysis investigate the critical conditions under which symptoms of eutrophication are typically most acute, i.e. for average annual flow in dry years or very wet years and/or for low flow, especially late summer when flows are very low, when this system is poorly flushed and when sunlight and temperatures are most conducive to excessive algal production.

The eutrophication model simulates twenty-two state variables, constituting five interacting systems: e.g., phytoplankton dynamics, nitrogen cycle, phosphorus cycle, silicate cycle, and oxygen dynamics. The water column eutrophication model solves the mass-balance equation for each state variable and for each model cell. A detailed description of the water column eutrophication model can be found in Cerco and Cole (1994).

Stream flow used in the calibration of the model was based on the three-dimensional, time-variable hydrodynamic model CH3D-WES developed at the US Army Engineer Waterways Experiment Station. The numerical grid employed in the model domain is shown in Wang *et al*, (2004). The number of cells and the grid resolution are the same as those of the water quality eutrophication model as described above. The detailed description of this model can be found in Johnson *et al*. (1991).

There were only two point sources of nutrients in the Back River watershed during the 1992-1997 model calibration period: the Back River municipal WWTP located in Baltimore County and one minor industrial discharge, Eastern Stainless. The Eastern Stainless plant stopped discharging into the Back River in 1999 and it is only considered in the calibration of the model. The Back River treatment plant had a flow that averaged 107 mgd or 4.7 m^3/s during the 1992-1997 model calibration period, and the flow from the Eastern Stainless plant was very small, approximately 0.2 mgd or 0.0088 m^3/s. (See Section 2.1, General Setting and Source Assessment for more discussion). The Back River WWTP and the Esatern Stainless plant have been accounted for at the water quality model cells 3617 and 3634 of the eutrophication model, respectively.

As stated above, the stormwater loads and nonpoint source loads estimation is described in Section 4.3. In brief, the HSPF model, which simulates the fate and transport of pollutants over the entire hydrologic cycle, was used to estimate nutrient loads from the watershed sub-basins. See “Patapsco/Back River Watershed HSPF Model Report, (MDE, 2001)”.

The concentrations of the nutrients (nitrogen and phosphorus) are modeled in their speciated forms. Nitrogen is simulated as ammonium nitrogen (NH_4), nitrate+nitrite nitrogen ($NO_{2\text{-}3}$), refractory particulate organic nitrogen (RPON), labile particulate organic nitrogen (LPON), and dissolved organic nitrogen (DON). Phosphorus is simulated as total phosphate (PO_4t), refractory particulate organic phosphorus (RPOP), labile particulate organic phosphorus (LPOP), and dissolved organic phosphorus (DOP). NH_4, $NO_{2\text{-}3}$, DON and PO_4, and DOP represent the dissolved forms of nitrogen and phosphorus. The dissolved forms of nutrients are the forms more readily available for biological processes such as algae growth, which affect chlorophyll *a* levels and DO concentrations.

4.3 Scenario Descriptions

The Back River eutrophication model was applied to investigate different nutrient loading scenarios under the stream flow conditions of the period between 1995 to 1997. These analyses allow a comparison of conditions, when water quality problems exist with future conditions that project the water quality response to various simulated load reductions of the impairing substances. By modeling three years consecutively, the analyses account for seasonality, a necessary element of the TMDL development process. The analyses are grouped according to *baseline conditions* and *future conditions,* the latter being associated with the TMDLs. Both scenarios were used to estimate low flow and average annual TMDLs.

Observed water quality and hydrological data collected in the last three years of the five-year model calibration period – 1995 through 1997 – were used to establish the baseline conditions. The baseline conditions are intended to provide a point of reference by which to compare the future scenarios that simulate conditions of a TMDL. The baseline conditions correspond roughly to the notion of "current conditions"; however, these current conditions have limitations. The notion of "current" is unstable and confusing because there is no single reference point in time over the long process of TMDL analysis, review and approval.

The baseline condition for urban-stormwater loads and nonpoint source loads typically reflects an approximation of loads during the monitoring time frame, in this case, the last three years of the calibration period (1995 to 1997). Baseline point source loads were also estimated using 1995 to 1997 discharge monitoring data for nutrients and flow. The baseline condition reflects a fixed current condition. Specific baseline loading assumptions for the point sources are presented in Wang *et al*, (1999).

4.3.1 Baseline Conditions Scenario

The baseline conditions scenario represents the observed conditions of the stream 1995 to 1997. This scenario simulates these three consecutive years, each with different flow and nutrient loadings. Simulating the system for three years accounts for different loading conditions and different hydrological conditions, addressing likely critical conditions of the system. For example, the 1995 – 1997 period simulates an average year (1995), a very wet year (1996) and a dry year (1997), and the summer months when the river system is poorly flushed, and sunlight and warm water temperatures are most conducive to creating the water quality problems associated with excessive nutrient enrichment. The hydrodynamics of the system was simulated using the CH3D-WES model and it is described in more detail in Wang *et al*, (1999).

The urban-stormwater concentrations and the nonpoint nutrient concentrations for the calibration and baseline scenario were estimated from the HSPF model of the Back River watershed, using observed data collected from 1995 to 1997. The HSPF simulates stormwater and nonpoint loads and integrate all natural and human induced sources, including direct atmospheric deposition, and loads from septic tanks, which are associated with river base flow during low flow conditions.

The 1995 to 997 point sources loadings used in this scenario were the same as in the calibration of the model. The WWTP discharge and the industrial discharge monitoring information were obtained from discharge monitoring reports stored in MDE's point source database. For more details on the calibration/baseline conditions scenario, please refer to Wang *et al*, (1999).

4.3.2 Baseline Condition Scenario Results

Results for this scenario, the calibration of the model, of which the three last years also represent the baseline conditions scenario, are summarized in Figures 14 to 17. Only DO and chlorophyll *a* calibration time series for water quality station WT4.1, and longitudinal profiles of the Back River for the same parameters are shown below. Model calibration results showing the other parameters time series and longitudinal profiles are presented in Part B of Appendix 1.

Figures 14 to 17 represent the 1992 – 1997 calibration of the model and also serve to show the 1995-1997 period used as the baseline condition scenario. As shown in figures 14 and 15, under the 1995-1997 baseline conditions, chlorophyll *a* concentrations throughout the length of the river exceed 50 µg/l, with values reaching close to 300 µg/l. Figures 16 and 17 show average DO concentrations remain above the water quality criterion of 5.0 mg/l throughout the entire length of the river and throughout the simulation period with minimum values below 5.0 mg/l at the headwaters near the Back River WWTP (For all other stations figures, see Appendix 1B).

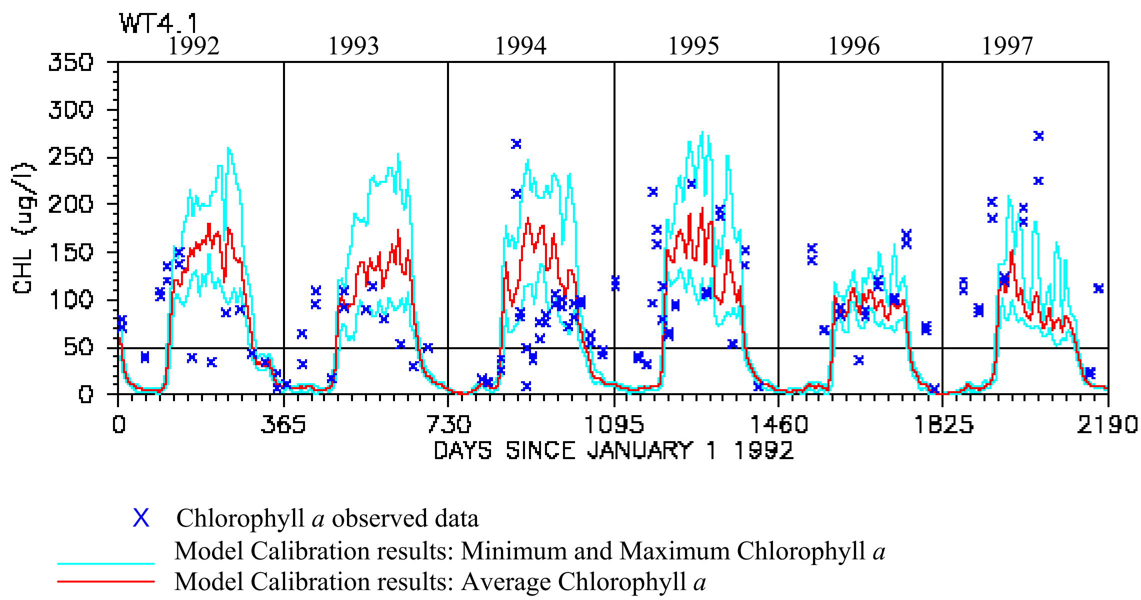
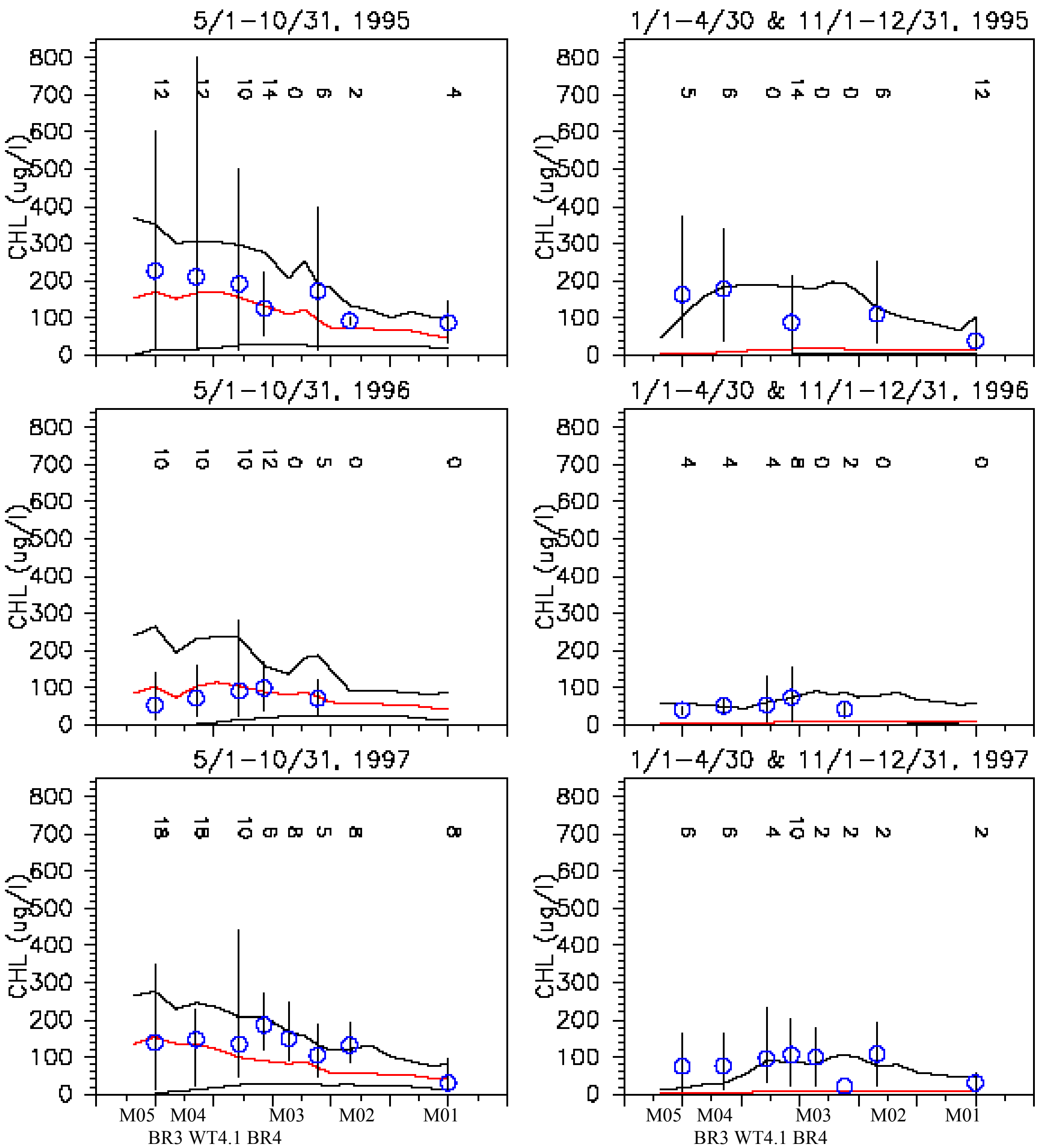
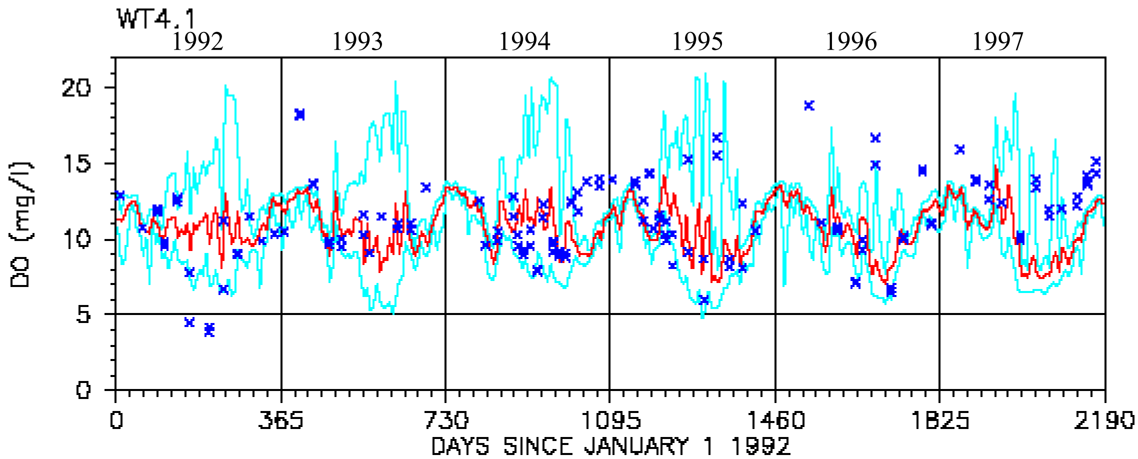


Figure 14: Station WT4.1: Model Results for the Calibration (1992 to 1997) and Baseline Conditions Scenario (1995 to 1997) for Chlorophyll *a* in the Back River



Average Chlorophyll *a* observed data
Model Calibration results: Minimum and Maximum Chlorophyll *a*
Model Calibration results: Average Chlorophyll *a*

Figure 15: Longitudinal Profile of the Calibration (1992 to 1997) and/or Baseline Conditions (1995 to 1997) for Chlorophyll *a* in the Back River



X Observed data

Model Calibration results: Weekly Minimum and Maximum DO

Model Calibration results: Weekly Average DO

Figure 16: Station WT4.1: Model Results for the Calibration (1992 to 1997) and/or Baseline Conditions Scenario (1995 to 1997) for DO in the Back River

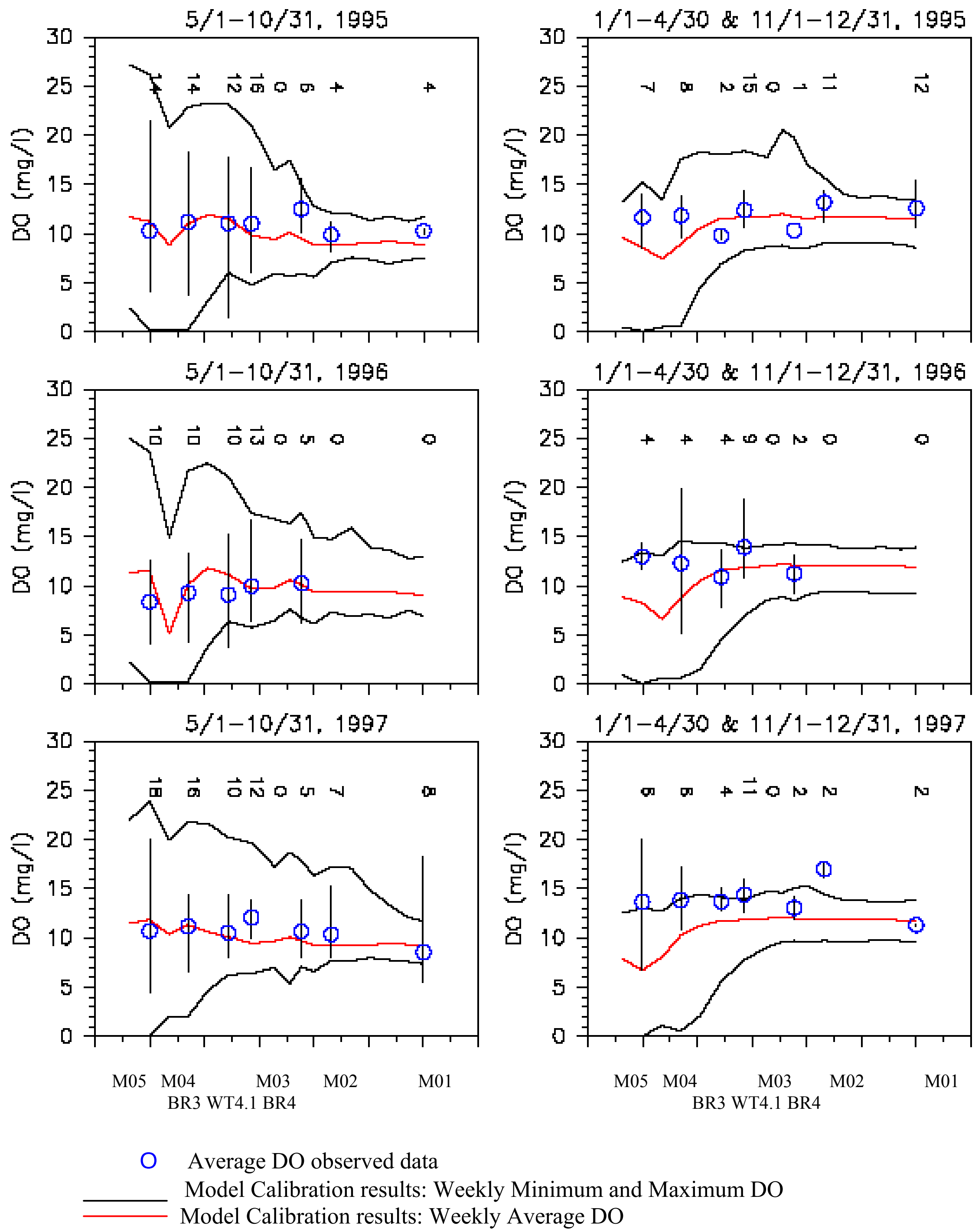


Figure 17: Longitudinal Profile of the Calibration (1992 to 1997) and/or Baseline Conditions (1995 to 1997) for DO in the Back River

4.3.3 Future Conditions (TMDLs) Scenario

This scenario provides an estimate of future conditions of the Back River system at maximum allowable average annual and summer (May 1st to October 31st) loads. The scenario uses the same flows and hydrological and environmental conditions as the calibration/baseline scenario, but simulates a maximum design flow with lower concentrations of PS nitrogen and phosphorus discharges and a 15% reduction in nitrogen and phosphorus urban loads for the four subwatersheds of the Back River system. This future conditions scenario was used to estimate both low flow and average annual flow TMDLs.

In summary, the future conditions scenario represents a reduction in the point source nutrient loadings and a reduction taken from the baseline urban loads estimated by the HSPF watershed model, as described in "Patapsco/Back River Watershed HSPF Model Report", (MDE, 2001).

In this scenario, the point source loads from the Back River WWTP were set at very stringent limits necessary to meet water quality criteria. These point source loads (Back River WWTP only) were based on the NPDES permit flow of 130 MGD and concentrations of TN equal to 4 mg/l annual average (3 mg/L in May - October, 5 mg/L in November – April) and current NPDES permit limit for TP of 0.2 mg/l.

The nonpoint source load reduction was applied to urban-stormwater loads only. Urban areas account for approximately 80% of the total area of the Back River watershed, with corresponding urban-stormwater loads representing 87.4% of the annual average TN loads from the watershed (not including treatment plants loads), 94.4% of the annual average TP, 91.0% of the summer TN and 97.7% of the summer TP. Therefore, non-urban loads, including agricultural and forest loads represents a minor contribution to the total load.

Urban-stormwater TN and TP loads for this scenario were reduced by 15% from the baseline urban-stormwater loads in order to reach the water quality goals for Chesapeake Bay waters. This reduction is based on a combination of Best Management Practices (BMPs) efficiencies over the different land uses in the Back River watershed and followed the same assumptions made by the Chesapeake Bay Program and MD's Tributary Strategies. The urban-stormwater load reduction was also based on the combination of management programs implemented in both jurisdictions comprised by the watershed (Baltimore City and Baltimore County) during and after the 1995 – 1997 period. These management programs are still being implemented in the watershed and already account for reductions in nutrients loadings. For example, the 2003 Municipal Stormwater Discharge Permit (NPDES) Annual Report from Baltimore County shows among several projects that in the Back River watershed, nine stormwater retrofit/conversion projects, addressing 598 acres of drainage area have either been completed or are in the design stage. Also in the Baltimore County part of the Back River watershed, seven stream restoration projects addressing 7,181 linear feet of degraded stream channel have either been completed or are in the design phase (Baltimore County NPDES Municipal Stormwater Discharge Permit, 2003 Annual Report (June 15, 2003). From a similar report from Baltimore City Department of Public Works, there are currently five stormwater projects being initiated in the City's Back River watershed; three stormwater retrofits, which are in the design phase (costs: $1,500,000 and $1,000,000 and $174,000), one stream channel study ($205,788), and one monitoring station that is under construction ($100,000) (City of Baltimore, NPDES Stormwater Permit Program Annual Report. May 3, 2004).

4.3.4 Future Condition (TMDLs) Scenario Results

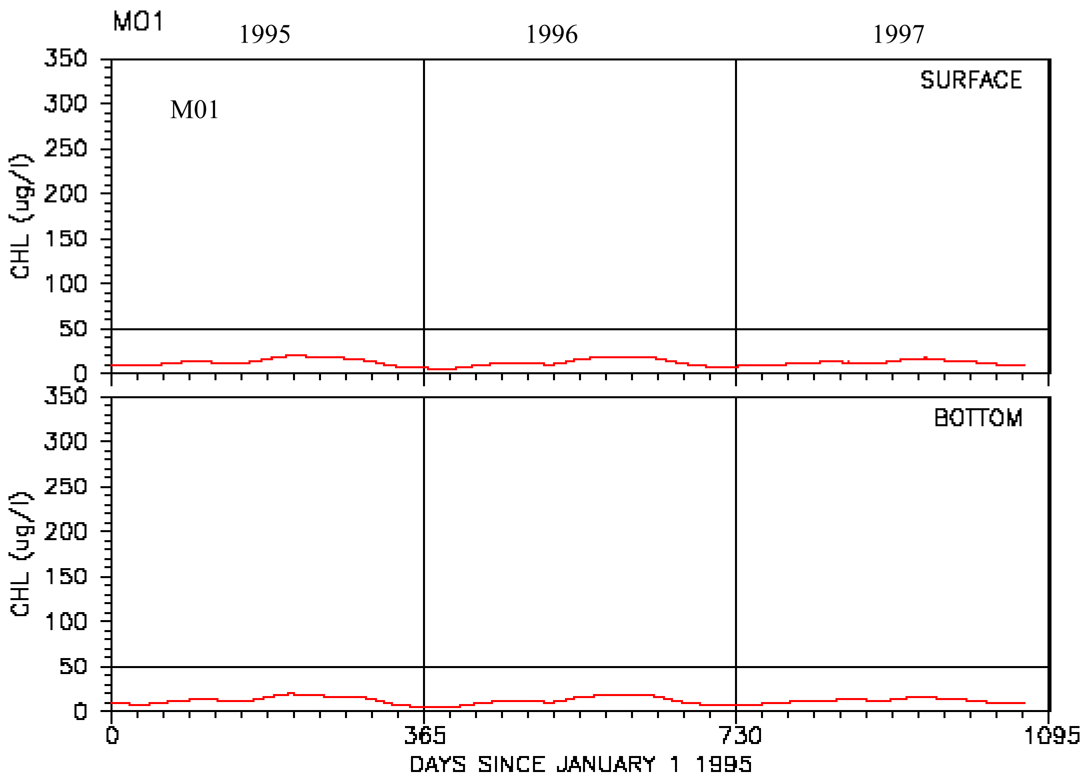
Figures 18 to 23 below represent the results of the TMDLs scenario.

As shown in the figures, under the nutrient load reduction conditions described above for this scenario, rolling monthly average chlorophyll *a* concentrations remain below 50 µg/l along the entire simulation period and throughout length of the Back River. The chlorophyll *a* attainment was checked using time series of "rolling monthly average Chla concentrations" against the 50 µg/l goal. For DO, the attainment was also checked comparing time series of minimum DO concentrations against the DO criteria of 5 mg/l. The comparison shows the nutrient load reductions result in little change, maintaining the minimum DO concentrations above 5 mg/l along the length of the river.

For the Back River WWTP, the total nitrogen concentration for this scenario is set at a level determined by the Enhanced Nutrient Removal Strategy (ENR) to a maximum of 5.0 mg/l from November 1 to April 30th and a maximum of 3.0 mg/l from May 1st to October 31st. The total phosphorus is set at the current permit limit of 0.2 mg/l, with a maximum allowable flow of 130 mgd, which corresponds to the current permit flow of the facility that can be discharged into the Back River. The Eastern Stainless industrial plant does not discharge any longer into the Back River and was not considered for this scenario.

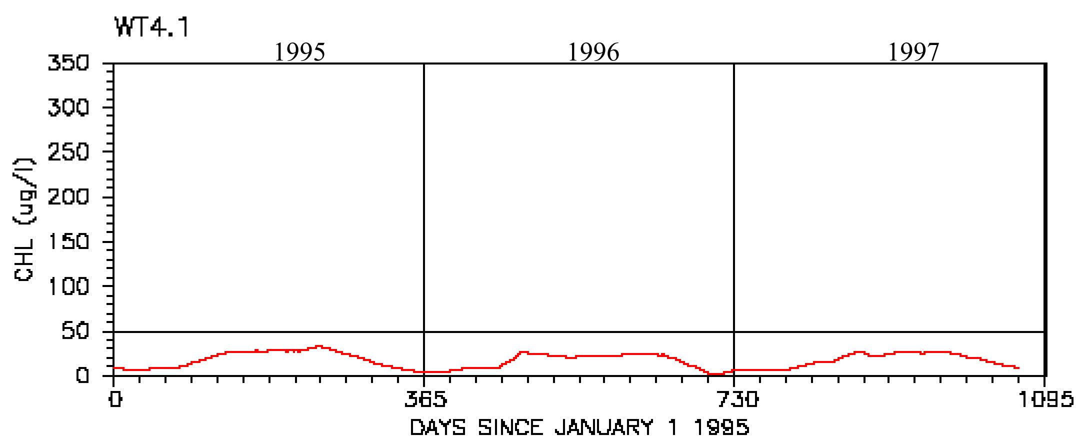
Model results for the TMDL scenario are summarized in Figures 18 to 23. Only DO and chlorophyll *a* TMDLs time series for water quality stations M01 (mouth of the river), WT4.1 (long term station, middle of the river) and M05 (upstream of the river), are shown below. Model results for all parameters associated with this scenario can be found in Part C of Appendix 1.

As seen in the figures below, under the TMDLs scenario conditions, the minimum DO in the Back River during the 1995-1997 period is above 5.0 mg/l and monthly average chlorophyll *a* concentrations is below the goal of 50 µg/l. Using rolling monthly average chlorophyll *a* values as a statistical tool to estimate chlorophyll *a* criteria attainment, the TMDL scenario model results show the river maintains chlorophyll *a* attainment, below 50 µg/l, throughout the TMDL period of 1995 to 1997. Chlorophyll *a* rolling monthly average values were used to estimate criteria attainment. The system shows a maximum chlorophyll *a* monthly rolling average of 49.8 µg/l for May 1 to October 31 at station M05, the most critical location in the estuary. Minimum DO levels also are always above 5.0 mg/l at all locations and throughout the 1995-1997 TMDL scenario period.



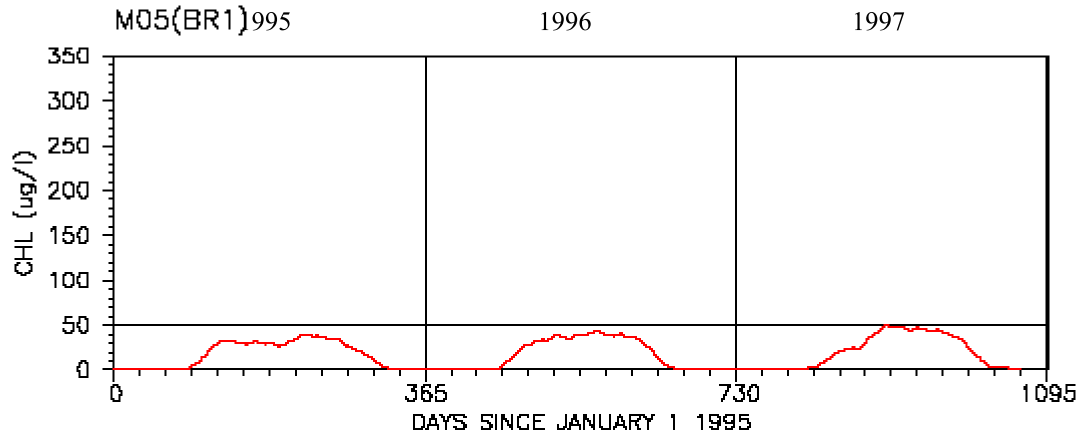
TMDLs Scenario results: Rolling monthly average Chlorophyll *a*

Figure 18: Station M01: Model Results for the TMDLs Scenario for Chlorophyll *a*



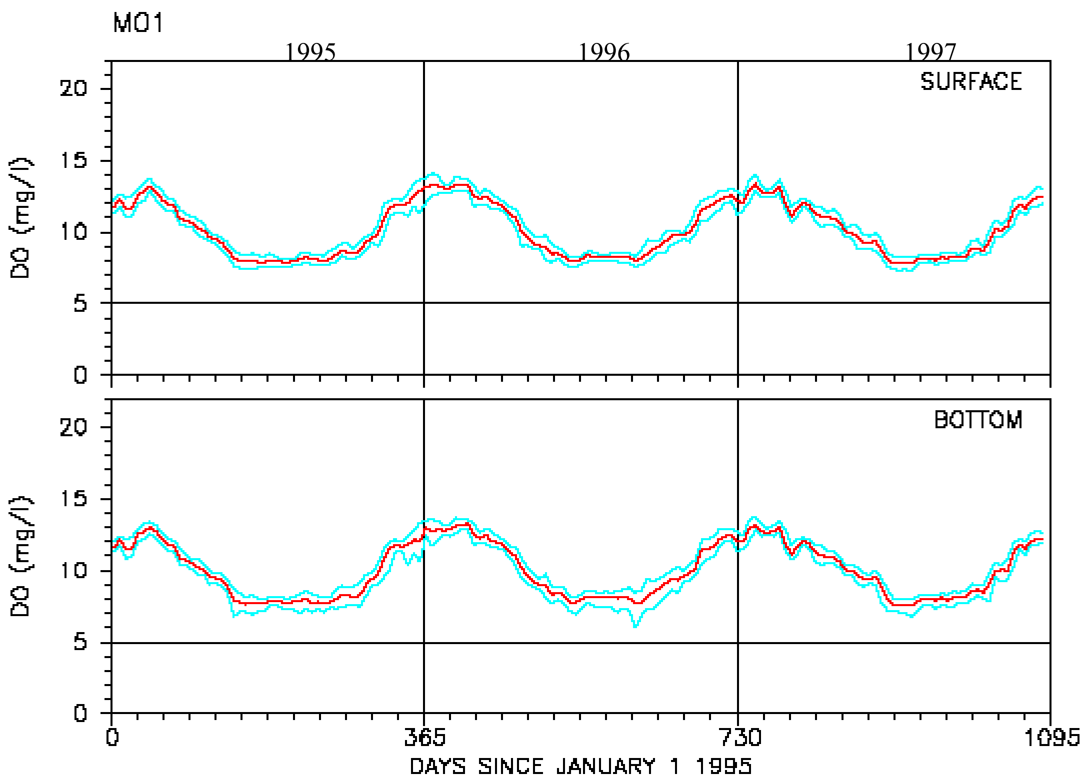
TMDLs Scenario results: Rolling monthly average Chlorophyll *a*

Figure 19: Station WT4.1: Model Results for the TMDLs Scenario for Chlorophyll *a*



TMDLs Scenario results: Rolling monthly average Chlorophyll *a*

Figure 20: Station M05: Model Results for the TMDLs Scenario for Chlorophyll *a*



TMDLs Scenario results: Weekly Minimum and Maximum DO

TMDLs Scenario results: Weekly Average DO

Figure 21: Station M01: Model Results for the TMDLs Scenario for Dissolved Oxygen

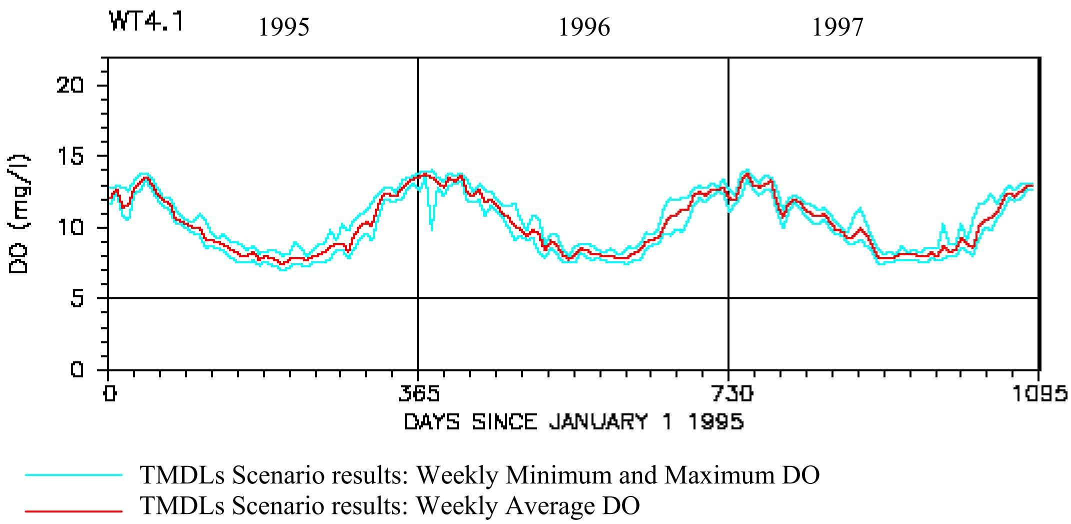


Figure 22: Station WT4.1: Model Results for the TMDLs Scenario for Dissolved Oxygen

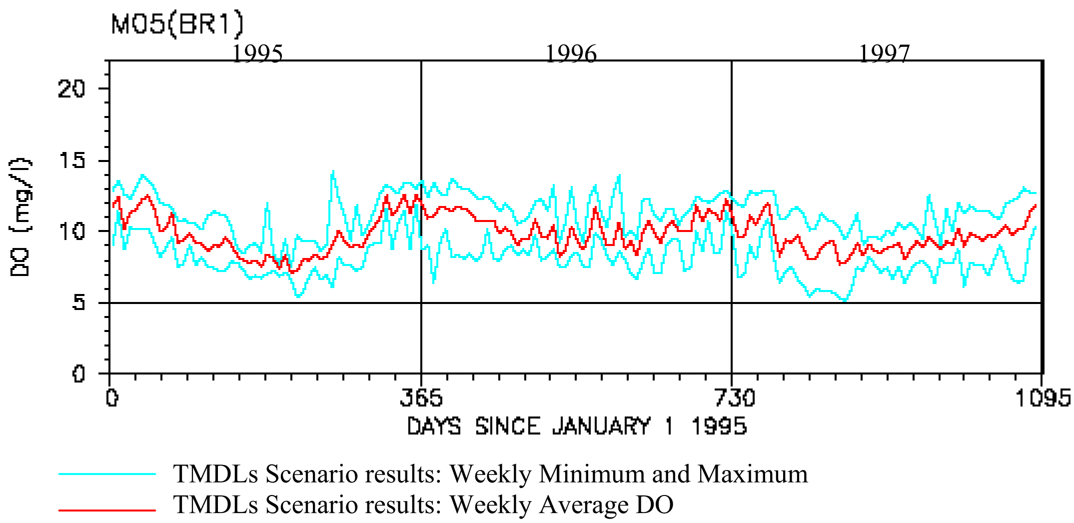


Figure 23: Station M05: Model Results for the TMDLs Scenario for Dissolved Oxygen

4.4 TMDL Loading Caps

This section presents the TMDLs for nitrogen and phosphorus. The outcomes are presented in terms of an average annual TMDL and a low flow TMDL. The TMDLs were estimated based on the nutrient loadings as explained in Section 4.3 and the resulting water quality of the Back River for the simulated years 1995, 1996 and 1997. This period was selected to estimate the TMDLs because it covers a period with a dry year as well as wet year, accounting for seasonality and critical conditions. The low flow TMDLs are stated in monthly terms because this critical condition occurs for a limited period of time. The detailed calculation of TMDL loading caps can be found in Part D of Appendix 1.

For the period of May 1 through October 31, the following TMDLs apply:

Low Flow TMDLs:

NITROGEN TMDL 113,321 ***lbs/month***

PHOSPHORUS TMDL 7,995 ***lbs/month***

The average annual TMDLs for nitrogen and phosphorus are:

Average Annual TMDLs:

NITROGEN TMDL 1,773,100 ***lbs/year***

PHOSPHORUS TMDL 99,171 ***lbs/year***

4.5 Load Allocations Between Point Sources and Nonpoint Sources

During the 1995 to 1997 period, the watersheds draining into the Back River had two permitted point sources discharging nutrients directly to the river. For the TMDL scenario, only the Back River WWTP is given an allocation. The Eastern Stainless plant has not discharged into the Back River since 1999. The allocations described in this section demonstrate how the TMDLs can be implemented to achieve water quality criteria in local waters and Chesapeake Bay waters. Specifically, these allocations show that the sum of nitrogen and phosphorus nutrient loadings to the Back River from existing point and nonpoint sources can be maintained safely within the TMDLs established herein. The State reserves the right to adjust future allocations provided such adjustments are consistent with achieving water quality standards.

4.5.1 Low Flow TMDL Allocations

Low flow TMDL allocations are intended for the period of May 1st to October 31st.

Load Allocations (LA)

- **Nonpoint Source Loads**
  The nonpoint loads of nitrogen and phosphorus simulated in the TMDLs scenario represent the same loads as in the calibration/baseline scenario for both the low flow period and the remaining months of the year from 1995 to 1997. Nonpoint source loads including agricultural loads and forest loads are assigned to the TMDL as LA. The calibration/baseline scenario loads were based on the MDE HSPF model of the Back

River watershed. The modeling of the watershed accounted for both "natural" and human-induced components, including atmospheric deposition and septic loadings. Details on the HSPF model can be found in "Patapsco/Back River Watershed HSPF Model Report", (MDE, 2001).

Waste Load Allocations (WLA)

- **Stormwater Loads**
  In November 2002, EPA advised States that NPDES-regulated stormwater discharges must be addressed by the wasteload allocation (WLA) component of a TMDL. See 40 C.F.R. § 130.2(h). NPDES-regulated stormwater discharges may not be addressed by the load allocation (LA) component of a TMDL. EPA also provided guidance on ways to reflect the stormwater wasteload allocation (WLA) in a TMDL. As explained in Section 4.3.3, the stormwater discharges loads of nitrogen and phosphorus simulated in the Back River TMDL scenario represent a 15% reduction in TN and TP from baseline urban-stormwater loads for both the low flow and the remaining months of the year. Urban-stormwater loads are now part of the WLA.

  Current stormwater Phase I individual permits and new stormwater Phase II permits will be considered point sources subject to WLA assignment in the TMDL, instead of LA assignment as in the past. EPA recognizes that limitations in the available data and information usually preclude stormwater allocations to specific outfalls. Therefore, the Agency guidance allows this stormwater WLA to be expressed as a gross allotment, rather than individual allocations for separate pipes, ditches, construction sites, etc. Available information for the Back River allows the stormwater WLA for this analysis to be defined separately for Baltimore City and Baltimore County; however, these WLAs aggregate municipal and industrial stormwater, including the loads from construction activity.

  Waste load allocations from point source dischargers are usually based on the relative contribution of pollutant load to the waterbody. Estimating a load contribution to a particular waterbody from the stormwater Phase I and II sources is imprecise, given the variability in sources, runoff volumes, and pollutant loads over time. Therefore, the stormwater WLA portion of the TMDL is based on the best loadings estimate currently available.

- **Wastewater Treatment Plants Loads**
  In addition to nonpoint source loads and stormwater point sources, waste load allocations to the Back River WWTP for these low flow TMDLs plus a 5% MOS, estimated as explained in the next section, make up the balance of the total allowable load.

  The Back River WWTP maximum allowable current permit flow of 130 MGD is used for this scenario, with concentrations set to achieve water quality goals to a maximum of total nitrogen of 3 mg/l from May 1st to October 31st. Total phosphorus limit is 0.2 mg/l year round. As explained before, the Eastern Stainless industrial plant did not discharge into Back River since 1999, and it is not considered in the TMDLs scenario. All significant point sources are addressed by this allocation and are described further in the technical memorandum entitled "*Significant Nutrient Point Sources in the Back River Watershed"*. The nitrogen and phosphorus allocations for low flow conditions are presented in Table 3.

The TMDL including loads from stormwater discharges are expressed as:

TMDL = WLA [non-stormwater point sources + regulated stormwater point source] + LA + MOS

Table 3: Low Flow Allocations

	Total Nitrogen *(lbs/month)*	**Total Phosphorus *(lbs/month)***
Nonpoint Source[1]	1,345	34
Point Source[2]	111,299	7,888
MOS[3]	677	73
Total	113,321	7,995

1. Excluding urban-stormwater loads.
2. Including urban-stormwater loads.
3. Representing 5% of baseline urban/stormwater loads.

4.5.2 Average Annual TMDL Allocations

Load Allocations (LA)

- **Nonpoint Source Loads**
  The average annual nonpoint nitrogen and phosphorus allocations are represented as the average of the HSPF simulated loads from 1995 to 1997. The nonpoint loads simulated in the HSPF model account for both "natural" and human-induced components. Nonpoint source loads include agricultural loads, forest loads and atmospheric.

Waste Load Allocations (WLA)

- **Stormwater Loads**
  The stormwater discharge loads of nitrogen and phosphorus simulated in the TMDLs scenario represent a 15% reduction in TN and TP from baseline urban-stormwater loads for the average annual TMDL scenario. Urban-stormwater loads are now part of the WLA.

- **Wastewater Treatment Plants Loads**
  Waste load allocations to the Back River WWTP plus a 5% MOS for the average annual conditions make up the balance of the total allowable load.

The Back River WWTP flow is the same as set for the low flow TMDLs allocations. TN concentration was set to a maximum of total nitrogen of 5 mg/l from November 1st to April 30th and to a maximum of 3 mg/l from May 1st to October 31st as indicated above. The load from urban-stormwater discharge is incorporated into the point source load as part of the annual waste load allocations. The point sources are addressed by this allocation and are described further in the technical memorandum entitled, *"Significant Nitrogen and Phosphorus Nonpoint Sources and Point Sources in the Back River Watershed.*" The nonpoint and point source nitrogen and phosphorus allocations for average annual flow conditions are shown in Table 4.

Table 4: Average Annual Allocations

	Total Nitrogen *(lbs/yr)*	**Total Phosphorus *(lbs/yr)***
Nonpoint Source[1]	26,323	1,239
Point Source[2]	1,737,626	96,896
MOS[3]	9,151	1,036
Total	1,773,100	99,171

1. Excluding urban-stormwater loads.
2. Including urban-stormwater loads.
3. Representing 5% of baseline urban/stormwater loads.

4.6 Margins of Safety

A MOS is required as part of a TMDL in recognition of many uncertainties in the understanding and simulation of water quality in natural systems. For example, knowledge is incomplete regarding the exact nature and magnitude of pollutant loads from various sources and the specific impacts of those pollutants on the chemical and biological quality of complex, natural water bodies. The MOS is intended to account for such uncertainties in a manner that is conservative from the standpoint of environmental protection.

Based on EPA guidance, the MOS can be achieved through 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 = Load Allocation (LA) + Waste Load Allocation (WLA) + MOS). The second approach is to incorporate the MOS as conservative assumptions used in the TMDL analysis.

Maryland has adopted a MOS for these TMDLs using the above-mentioned first approach. The reserved load allocated to the MOS was computed as 5% of the urban-stormwater loads for nitrogen and phosphorus. For the low flow and the average annual flow TMDLs in the Back River, this MOS also represents a 5% of the total urban-stormwater loads. These explicit nitrogen and phosphorus margins of safety are summarized in Table 5.

Table 5: Low Flow and Average Annual Margins of Safety (MOS)

	Total Nitrogen	Total Phosphorus
MOS Low Flow	677 lbs/month	73 lbs/month
MOS Annual	9,151 lbs/yr	1,036 lbs/yr

4.7 Summary of Total Maximum Daily Loads

The Low Flow TMDLs, applicable from May 1 – October 31 for the Back River follow:

For Nitrogen:

TMDL (*lbs/month*)	=	LA	+	WLA	+	MOS
113,321	=	**1,345**	+	**111,299**	+	**677**

For Phosphorus:

TMDL (*lbs/month*)	=	LA	+	WLA	+	MOS
7,995	=	**34**	+	**7,888**	+	**73**

The average annual flow TMDLs for the Back River follow:

For Nitrogen

TMDL (*lbs/year*)	=	LA	+	WLA	+	MOS
1,773,100	=	**26,323**	+	**1,737,626**	+	**9,151**

For Phosphorus (*lbs/year*):

TMDL (*lbs/year*)	=	LA	+	WLA	+	MOS
99,171	=	**1,239**	+	**96,896**	+	**1,036**

Where:

TMDL = Total Maximum Daily Load
LA = Load Allocation (Nonpoint Source)
WLA = Waste Load Allocation (Point Source)
MOS = Margin of Safety

Average Daily Loads:

On average, the low flow TMDLs will result in loads of approximately 3,777 lbs/day of nitrogen and 266 lbs/day of phosphorus. Similarly, the average annual flow TMDLs will result in loads of approximately 4,852 lbs/day of nitrogen and 271 lbs/day of phosphorus.

5.0 ASSURANCE OF IMPLEMENTATION

This section provides the basis for reasonable assurances that the nitrogen and phosphorus TMDLs will be achieved and maintained. For both TMDLs, Maryland has several well-established programs that will be drawn upon: the Water Quality Improvement Act of 1998 (WQIA), the Clean Water Action Plan (CWAP) framework, and the Chesapeake Bay Agreement's Tributary Strategies for Nutrient Reduction. Also, Maryland has adopted procedures to assure that future evaluations are conducted for all TMDLs that are established.

The implementation of point source nutrient controls will be executed through ENR strategy and NPDES permits. The ENR program provides cost-share grant funds to local governments to retrofit or upgrade wastewater treatment plants (WWTP) to remove a greater portion of nutrients from discharges. Enhanced nutrient removal technologies allow sewage treatment plants to provide a highly advanced level of nutrient removal. The ENR strategy builds on the success of the biological nutrient removal (BNR) program already in place. The NPDES permits for the Back River WWTP will include nutrient goals that have been established, and, upon completion of the upgrade, the permittee shall make a best effort to meet the load goals, which provide a reasonable assurance of implementation. The NPDES permits should also be consistent with the assumptions made in the TMDL (e.g., flow, nutrients effluent concentrations, CBOD, DO, etc.).

Maryland's WQIA requires that comprehensive and enforceable nutrient management plans be developed, approved and implemented for all agricultural lands throughout Maryland. This act specifically requires that nutrient management plans for nitrogen be developed and implemented by 2002, and plans for phosphorus to be done by 2005. Maryland's CWAP has been developed in a coordinated manner with the State's 303(d) process. All Category I watersheds identified in Maryland's Unified Watershed Assessment process are totally coincident with the impaired waters list for 2002 approved by EPA. The State is giving a high-priority for funding assessment and restoration activities to these watersheds.

In 1983, the States of Maryland, Pennsylvania, and Virginia, the District of Columbia, the Chesapeake Bay Commission, and the U.S. EPA joined in a partnership to restore the Chesapeake Bay. In 1987, through the Chesapeake Bay Agreement, Maryland made a commitment to reduce nutrient loads to the Chesapeake Bay. In 1992, the Bay Agreement was amended to include the development and implementation of plans to achieve these nutrient reduction goals. Maryland's resultant Tributary Strategies for Nutrient Reduction provide a framework supporting the implementation of nonpoint source controls in the Patapsco/Back Tributary Strategy Basin, which includes the Back River watershed. Maryland is in the forefront of implementing quantifiable nonpoint source controls through the Tributary Strategy efforts. This will help to assure nutrient control activities are targeted to areas in which nutrient TMDLs have been established.

In November 1990, EPA required jurisdictions with a population greater than 100,000 to apply for NPDES Permits for stormwater discharges. 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. The two jurisdictions where the Back River watershed is located, Baltimore City and Baltimore County, are required to participate in the stormwater NPDES program, and have to comply with the NPDES Permit regulations for stormwater discharges. Several management programs have been implemented in different areas served by the County and the City municipal separate storm sewer system. These jurisdiction-wide programs are designed to control stormwater discharges to the maximum extent practicable.

It is reasonable to expect that nonpoint loads can be reduced during low flow conditions. The nutrient loads sources during low flow include dissolved forms of the impairing substances from groundwater, the effects of agricultural ditching and animals in the stream, and deposition of nutrients and organic matter to the stream bed from higher flow events. When these sources are controlled in combination, it is reasonable to achieve nonpoint reductions of the magnitude identified by this TMDL allocation.

Finally, Maryland uses a five-year watershed cycling strategy to manage its waters. Pursuant to this strategy, the State is divided into five regions and management activities will cycle through those regions over a five-year period. The cycle begins with intensive monitoring, followed by computer modeling, TMDL development, implementation activities, and follow-up evaluation. The choice of a five-year cycle is motivated by the five-year federal NPDES permit cycle. This continuing cycle ensures that every five years intensive follow-up monitoring will be performed. Thus, the watershed cycling strategy establishes a TMDL evaluation process that assures accountability.

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BACK RIVER NUTRIENTS TMDLS

APPENDIX 1

PART A

BACK RIVER NUTRIENTS TMDLS

APPENDIX 1

PART B

BACK RIVER NUTRIENTS TMDLS

APPENDIX 1

PART C

BACK RIVER NUTRIENTS TMDLS

APPENDIX 1

PART D

Appendix I

Total Maximum Daily Loads of Fecal Bacteria for Northern Portion of Herring Run in Baltimore County and Baltimore City, Maryland

May 2006

Total Maximum Daily Loads of Fecal Bacteria for Northern Portion of Herring Run in Baltimore County and Baltimore City, Maryland

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May 2006

EPA Submittal Date:
EPA Approval Date:

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ARA	Antibiotic Resistance Analysis
ARCC	Average rates of correct classification
BMP	Best Management Practice
BST	Bacteria Source Tracking
CAFO	Confined Animal Feeding Operations
cfs	Cubic Feet per Second
CFR	Code of Federal Regulations
CFU	Colony Forming Units
COMAR	Code of Maryland Regulations
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DNR	Department of Natural Resources
EPA	Environmental Protection Agency
FA	Future Allocation
GIS	Geographic Information System
LA	Load Allocation
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
MRLC	Multi-Resolution Land Cover
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
SSURGO	Soil Survey Geographic
SWMM	Stormwater Management Model
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WQIA	Water Quality Improvement Act
WLA	Wasteload Allocation
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 fecal bacteria in the northern portion of Herring Run of the Back River watershed (basin number 021309011042). 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.

The Maryland Department of the Environment (MDE) has identified the northern portion of Herring Run, [Code of Maryland Regulations (COMAR) 26.08.02.08K] in the State's 2002 303(d) List as impaired by fecal bacteria. Herring Run, as part of the Back River Basin, has also been identified as impaired by nutrients (1996), sediments (1996), and impacts to biological communities (2002). This document proposes to establish a TMDL of fecal bacteria for the northern portion of Herring Run to allow for the attainment of the designated use of Primary Contact Recreation. A TMDL for nutrients for the entire Back River was completed in 2005.The listings for suspended sediments 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, using flow strata estimated from United States Geological Survey (USGS) daily flow monitoring data and bacteria monitoring data, was used. The pollutant loads set forth in this document are for the northern portion of the Herring Run watershed. The sources of fecal bacteria are estimated at a representative station in the Herring Run 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 the northern portion of Herring Run 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 and not a literal daily limit.

Two scenarios were developed, the first assessing if attainment of current water quality standards could be achieved with the maximum practicable reductions (MPRs) applied, and the second with the maximum practicable reduction constraints relaxed. 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 source categories. In the Herring Run watershed it was estimated that water quality standards could not be attained with the MPRs. Thus, for the Herring Run watershed, the second scenario was used to establish the TMDL.

The fecal bacteria (*E. coli*) TMDL developed for the Herring Run watershed is 167.4 billion MPN/day. The TMDL is distributed between load allocations (LA) for nonpoint sources and waste load allocations (WLA) for point sources (wastewater treatment plants (WWTPs) and municipal separate storm sewer systems (MS4)). The entire watershed is covered by MS4 permits, therefore the LA is 0.0 billion MPN/day. There are no WWTPs with permits regulating the discharge of *E. coli* in Herring Run. The WLA (MS4) is 167.4 billion MPN/day. The margin of safety (MOS) is implicit in this TMDL.

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 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 Herring Run subwatersheds, using the MPR scenario. This may occur in watersheds where wildlife is a significant component or in subwatersheds that require very high reductions of fecal bacteria loads to meet water quality standards. In these cases, it is expected that the first stage of TMDL implementation will be to implement the MPR scenario. MDE cannot provide EPA reasonable assurance at this time that the TMDL allocations can be met, given the magnitude of the MS4 allocation and known efficiencies for relevant urban Best Management Practices. However, progress will be made through the iterative implementation process described above and the situation will be reevaluated in the future.

1.0 INTRODUCTION

Section 303(d)(1)(C) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency (EPA) implementing regulations direct each State to develop a Total Maximum Daily Load (TMDL) for each impaired water quality limited segment (WQLS) on the Section 303(d) list, taking into account seasonal variations and a protective margin of safety (MOS) to account for uncertainty. A TMDL reflects the total pollutant loading of the impairing substance a 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 northern portion of Herring Run of the Back River watershed (basin number 021309011042) has been designated a Use IV (Recreational Trout Waters) waterbody [Code of Maryland Regulations (COMAR) 26.08.02.08K]. The Maryland Department of the Environment (MDE) has identified the northern portion of Herring Run on the State's 303(d) List as impaired by fecal bacteria (2002); and, as part of the Back River watershed, as impaired by the following: nutrients (1996); sediments (1996); and impacts to biological communities (2002). This document, upon approval by the EPA, establishes a TMDL of fecal bacteria for the northern portion of Herring Run to allow for the attainment of the beneficial use designation of primary contact recreation. A TMDL for nutrients for the entire Back River was completed in 2005. The listings for suspended sediments 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 coliforms and fecal streptococci) found in the wastes of warm-blooded animals. Their presence in water is used to assess the sanitary quality of water used for primary contact recreation, molluscan bivalve (shellfish) consumption and 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" whereby 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. Most *E. coli* are harmless and are found in great quantities in the intestines of people and warm-blooded animals; however, 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 either *E. coli* or enterococci.

The Herring Run watershed was listed on the Maryland 303(d) list using fecal coliform as the indicator organism. Based on EPA's 1986 guidance, 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 (EPA, 1986). 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 Herring Run TMDL analysis was *E. coli.*

2.0 SETTING AND WATER QUALITY DESCRIPTION

2.1 General Setting

Location

The Herring Run watershed is a subwatershed of the Back River basin located in Southern Baltimore County northern Baltimore City, Maryland (see Figure 2.1.1). The headwaters of Herring Run begin somewhere in the center of Towson in Baltimore County. An unnamed tributary to Herring Run flows through the Country Club of Maryland and continues through Regester Avenue near the Baltimore City line. Once the unnamed tributary flows under Northern Parkway (ADC map 27 G12), it connects with the mainstem of Herring Run. The mainstem of Herring Run originates in the region known as Loch Raven near Taylor Avenue and Perring Parkway. Herring Run and all its tributaries are non-tidal.

Geology/Soils

The Herring Run watershed encompasses 7,088 acres (11.075 sq. mi). The watershed lies entirely in the Piedmont physiographic province. This province is characterized by gentle to steep rolling topography, low hills and ridges. The surficial geology is characterized by crystalline igneous and metamorphic rocks of volcanic origin consisting primarily of schist and gneiss.

The Herring Run watershed lies predominantly in the Othello soil series (see Figure 2.1.2). Soils in this series are fine-loamy, mixed, mesic Typic Ochraquults and are very deep and poorly drained soils (Soil Conservation Service (SCS). *Soil Survey of Baltimore, MD*, 1995).

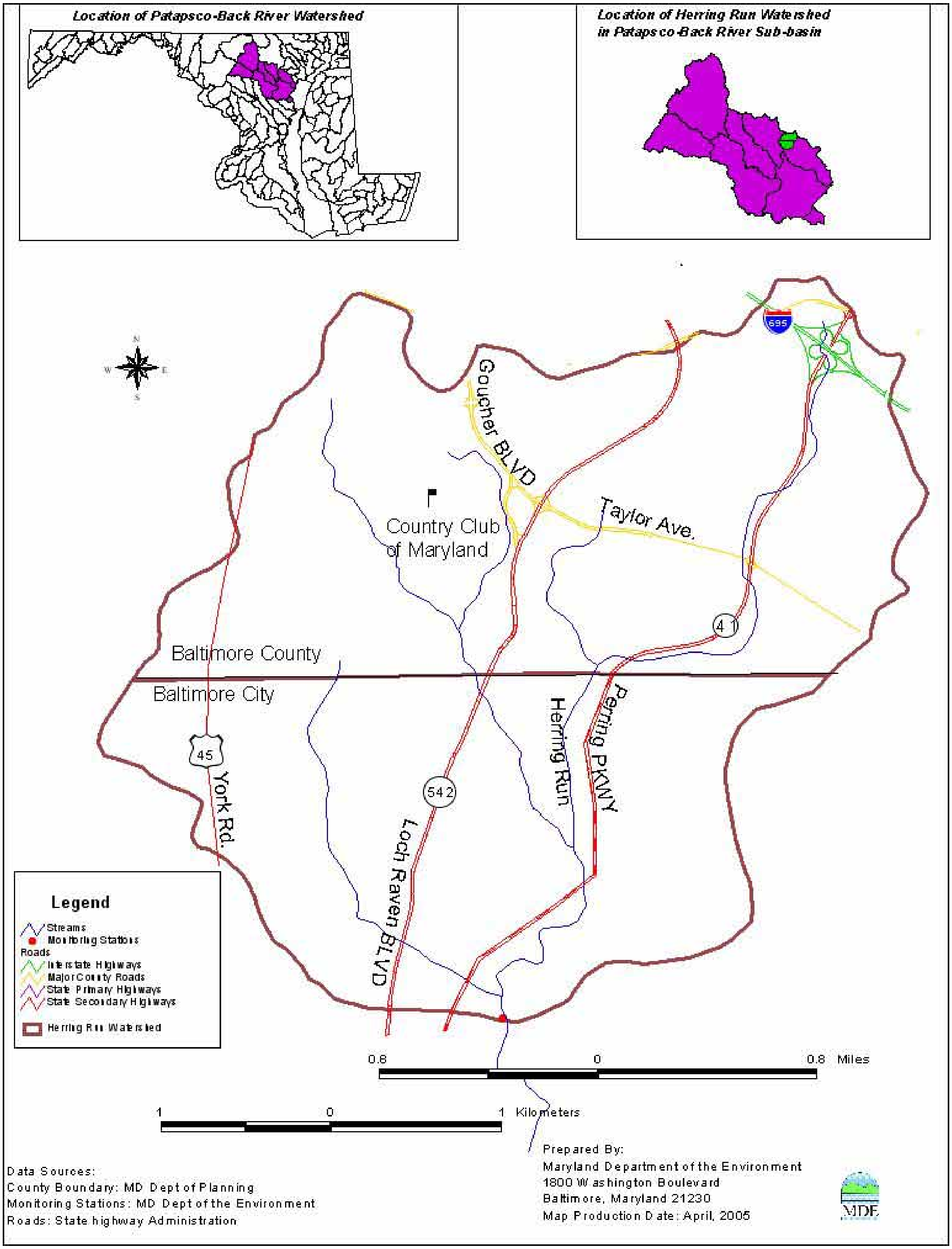
Location of Patapsco-Back River Watershed
Location of Herring Run Watershed in Patapsco-Back River Sub-basin
Goucher BLVD
Taylor Ave.
Country Club of Maryland
Baltimore County
Baltimore City
45
York Rd.
542
Loch Raven BLVD
Herring Run
Herring PKWY
41
695
Legend
Streams
Monitoring Stations
Roads
Interstate Highways
Major County Roads
State Primary Highways
State Secondary Highways
Herring Run Watershed
0.8
0
0.8 Miles
1
0
1 Kilometers
Data Sources:
County Boundary: MD Dept of Planning
Monitoring Stations: MD Dept of the Environment
Roads: State highway Administration
Prepared By:
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, Maryland 21230
Map Production Date: April, 2005
MDE

Figure 2.1.1: Location Map of the Herring Run Watershed

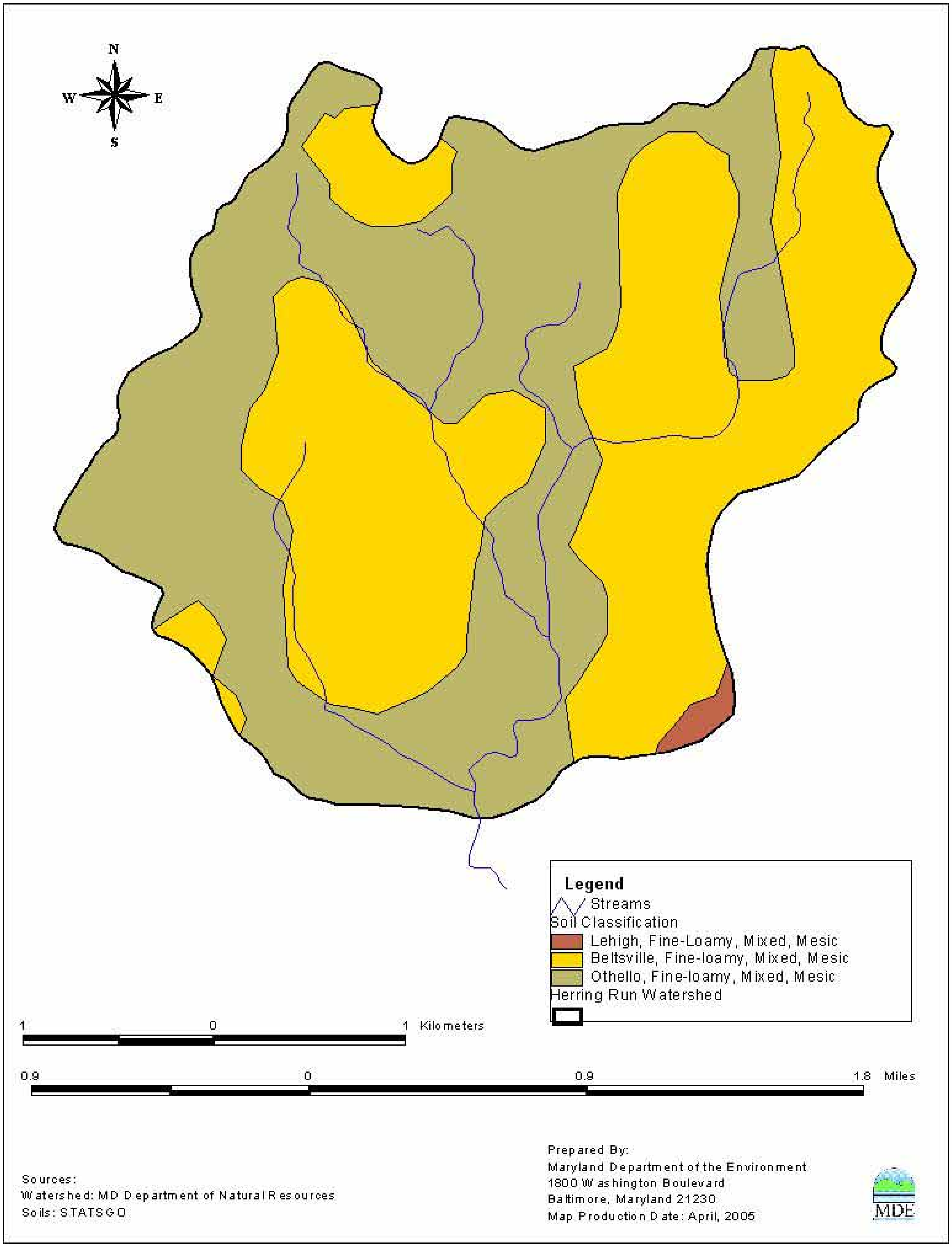

Figure 2.1.2: General Soil Series in the Herring Run Watershed

Land Use

The 2002 Maryland Department of Planning (MDP) land use/land cover data show that the watershed is primarily urban. The watershed has been significantly affected by high-density residential and commercial development. The land use percentage distribution for Herring Run Watershed is shown in Table 2.1.1, and spatial distributions for each land use are shown in Figure 2.1.3.

Table 2.1.1: Land Use Percentage Distribution for Herring Run Watershed

Land Type	Acreage	Percentage
Commercial	1,624	23%
Forest	446	6%
Residential	5,018	71%
Totals	7,088	100%

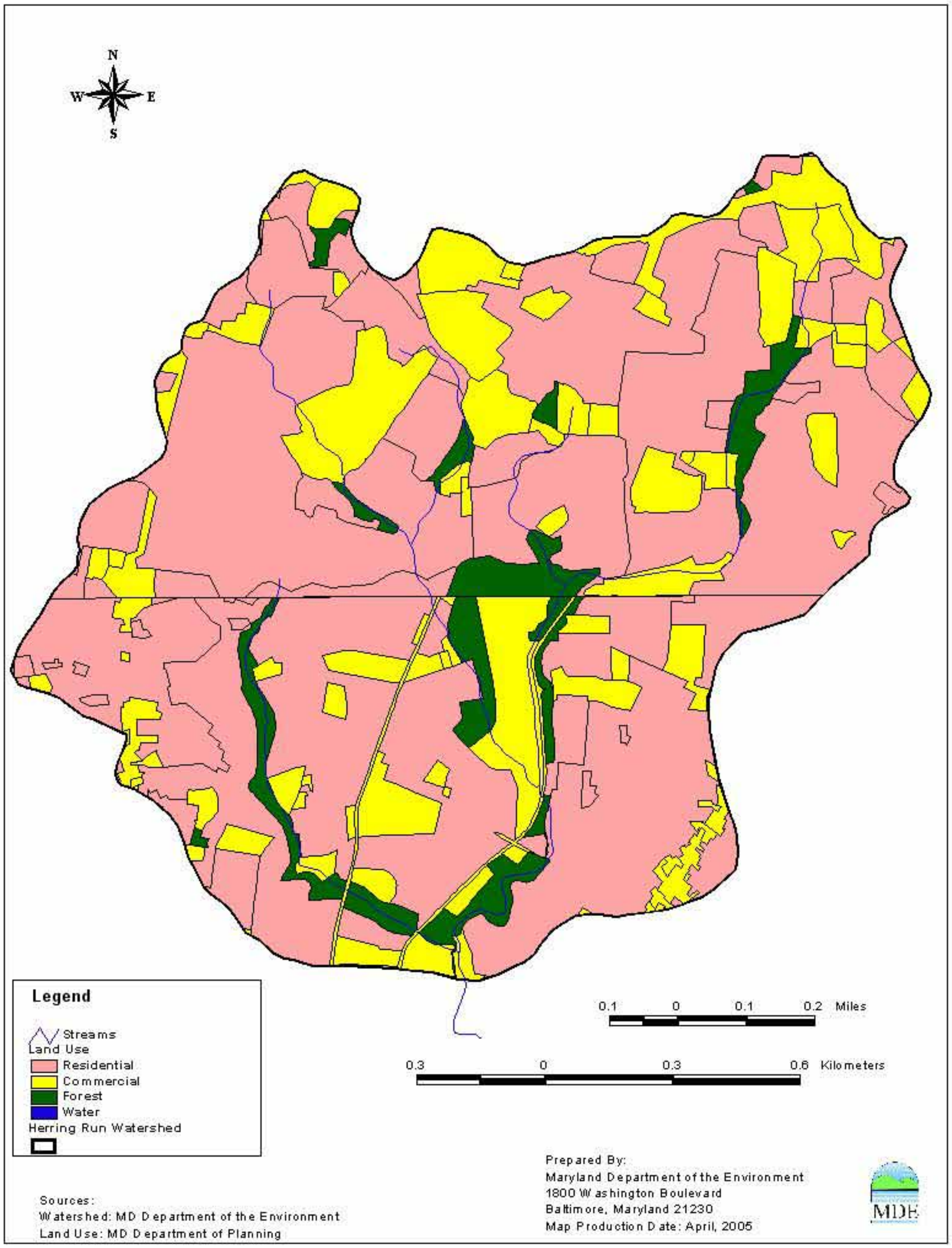

Figure 2.1.3: Land Use of the Herring Run Watershed

Population

The total population in the Herring Run watershed is estimated to be approximately 35,270. Figure 2.1.4 depicts 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 MDP Land Use 2002 Cover that includes the Herring Run watershed. Since the Herring Run watershed is a sub-area of the Census Block, percentages of each land use within the watershed were used to extract the areas from the 2000 Census Block. Table 2.1.2 shows the number of dwellings per acre in the Herring Run watershed. The number of dwellings per acre was derived from information for residential density (low, medium, high) from MDP land use cover.

Table 2.1.2: Number of Dwellings Per Acre

Land Use Code	Dwelling Per Acres
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 (Table 2.1.3.)

Table 2.1.3: Total Population in Herring Run Watershed

Watershed Name	Number of Households	Population
HER0065	31,485	31,906

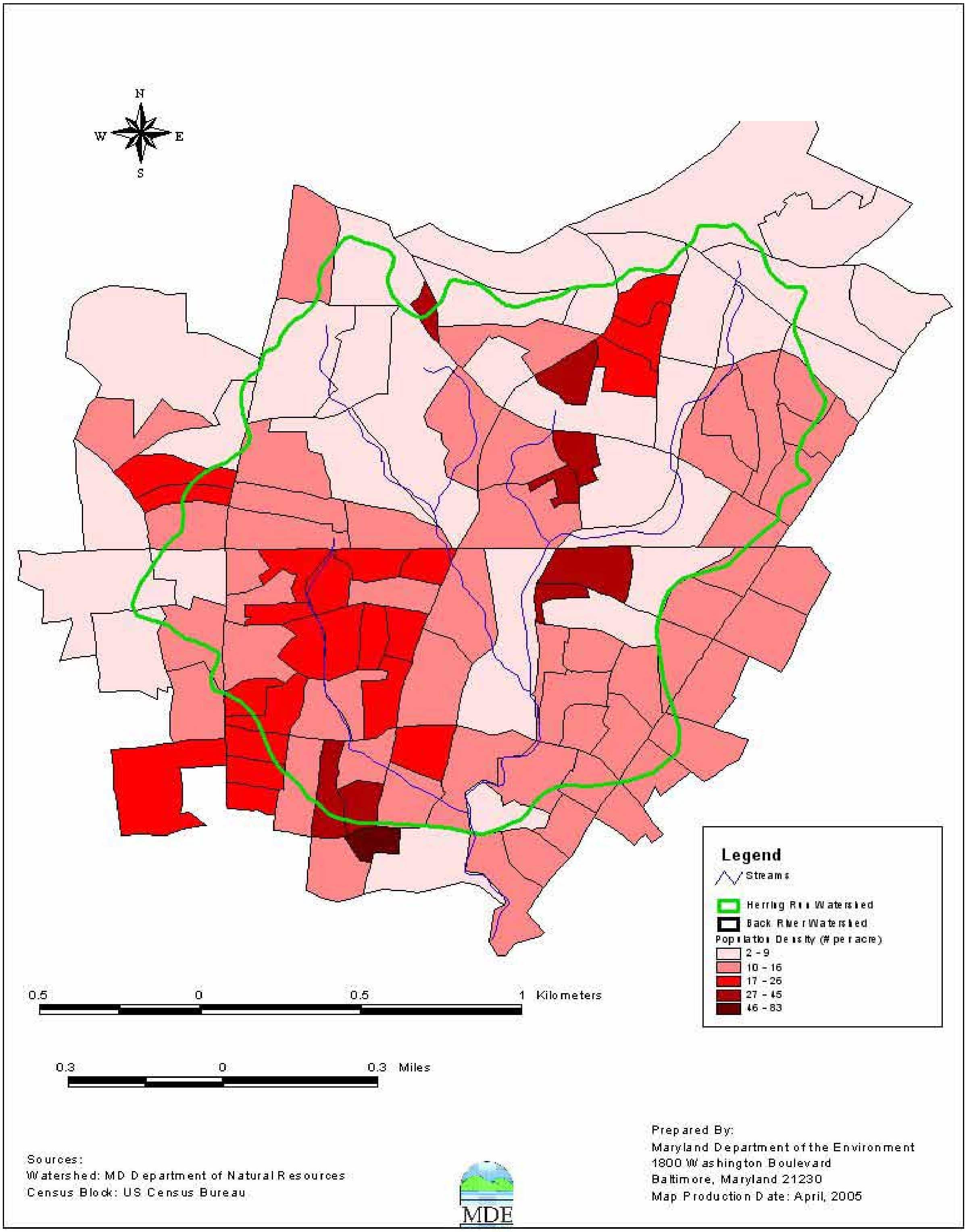

Figure 2.1.4: Population Density in the Herring Run Watershed

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 bacteria listings were originally assessed using fecal coliform bacteria. 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 (USEPA, 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 assure that risk levels are acceptable.

Bacteria Monitoring

Table 2.2.1 lists the historical monitoring data for the Herring Run watershed. HER0065 is the only MDE monitoring station in the Herring Run watershed, which was used to identify the bacterial impairment. MDE conducted intensive monitoring from October 2002 through October 2003. USGS gage station 01585200 located in the Herring Run watershed was used in the estimation of the surface flow. The gage flow data is incomplete for this station; therefore, the flow for unobserved periods (01/01/1992 to 10/01/1996) was estimated using MDE's Stormwater Management Model (SWMM) calibrated to USGS gage station 01585200.

Bacteria counts are highly variable in the Herring Run. This is typical for all streams due to the nature of bacteria and its relationship to flow. Results of bacteria counts for the monitoring station HER0065 are shown in Appendix A. Data were collected from November 2002 through October 2003. Ranges were typically between 60 and 36,500 MPN/100 ml.

The locations of these stations are shown in Table 2.2.2 and Table 2.2.3 and illustrated in Figure 2.2.1. Observations recorded during the period 2002-2003 from MDE's monitoring station are displayed in Table A-1 and illustrated in Figure A-1 in Appendix A.

Table 2.2.1: Historical Monitoring Data in the Herring Run Watershed

Sponsor	Location	Date	Design	Summary
Baltimore City	MD	01/98 to 12/02	Fecal coliform	
MDE	MD	11/02 to 09/03	*E. coli*	1 station Enumeration 2x per month
MDE	MD	11/02 to 09/03	BST (*E. coli*)	1 station ARA Bacteria Source Tracking (BST) 1x per month

Table 2.2.2: Location of MDE Monitoring Station in the Herring Run Watershed

Monitoring Station	Observations Period	Total Observations	LATITUDE Deg-min	LONGITUDE Deg-min
HER0065	2002-2003	24	39^{o} 20.72'	76^{o} 34.85'

Table 2.2.3: Location of USGS Gage Station (Herring Run)

Monitoring Station	Observations Period	Total Observations	LATITUDE Deg-min	LONGITUDE Deg-min
1585200	1997-2004	2,829	39^{o} 22.42'	76^{o} 35.06'

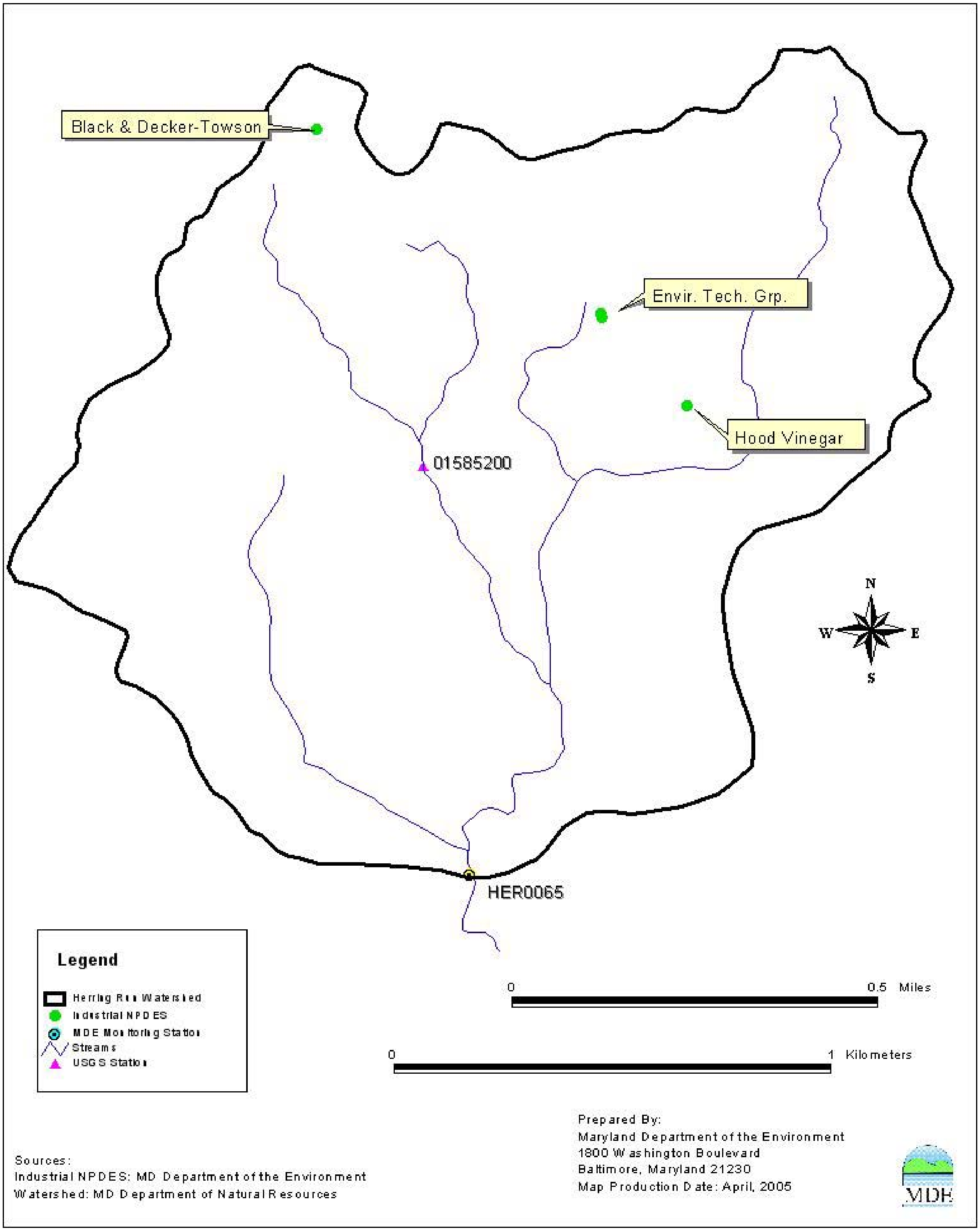

Figure 2.2.1: Monitoring Station in the Herring Run Watershed

2.3 Water Quality Impairment

Designated Uses and Water Quality Standard

The Maryland water quality standards Surface Water Use Designation for this watershed area is Use IV – Recreational Trout Waters (COMAR 26.08.02.08K). Herring Run has been included on the final 2004 Integrated 303(d) List as impaired by bacteria. The State standards for bacteria used for ALL Use waters are as follow (COMAR 26.08.02.03-3) [1]:

A. Criteria for Use I Waters—Water Contact Recreation and Protection of Aquatic Life.

(1) Bacteriological. There may not be any sources of pathogenic or harmful organisms in sufficient quantities to constitute a public health hazard. A public health hazard will be presumed:

(a) "If the steady-state geometric mean indicator density in Table 1 [Table 2.3.1] is exceeded based on at least five samples taken representatively over 30 days;
(b) If, at designated natural bathing areas, as defined under COMAR 26.08.09.01B(2), the single sample maximum allowable densities in Table 1 [Table 2.3.1] are exceeded; OR
(c) Except when a sanitary survey approved by the Department of the Environment discloses no significant health hazard, §A(1)(a) and (b) do not apply.

(2) Assessment of Areas Not Designated as Beaches. If five samples taken over 30 days are not available to assess a water body segment for the purpose of assessment for the National Water Quality Inventory Report (305(b) Report) or the List of Impaired Waters (303(d) List), a geometric mean of sequential monitoring results may be used as long as at least five sample results are available. The single sample maximum shall apply only at beach areas.

Table 2.3.1: Table 1 From COMAR 26.08.02.03-3 Water Quality Criteria Specific to Designated Uses.

Indicator	Steady-state Geometric Mean Indicator Density
Freshwater	
E. coli*	126 MPN/100ml
Enterococci	33 MPN/100ml
Marine Water	
Enterococci	35 MPN/100ml

*Used in the Herring Run TMDL analysis

[1] COMAR 26.08.02.03-3 - Sections 3 and 4 are hereby incorporated by reference

Water Quality Assessment

Bacteria water quality impairment in this watershed was assessed by comparing the steady-state geometric mean of *E. coli* concentrations with the water quality criterion. The steady-state condition is defined as 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, and therefore the criterion value for bacteria (EPA, 1986). The steady-state geometric mean condition can be estimated as follows:

1. A stratified monitoring design will be 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 without bias.

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 could result in a biased estimate of the steady-state geometric mean. The potential bias of the steady-state geometric mean 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.

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.

A routine monitoring design was used to collect bacteria data in the Herring Run watershed. To estimate the steady-state geometric mean, the monitoring data was 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 mean 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.

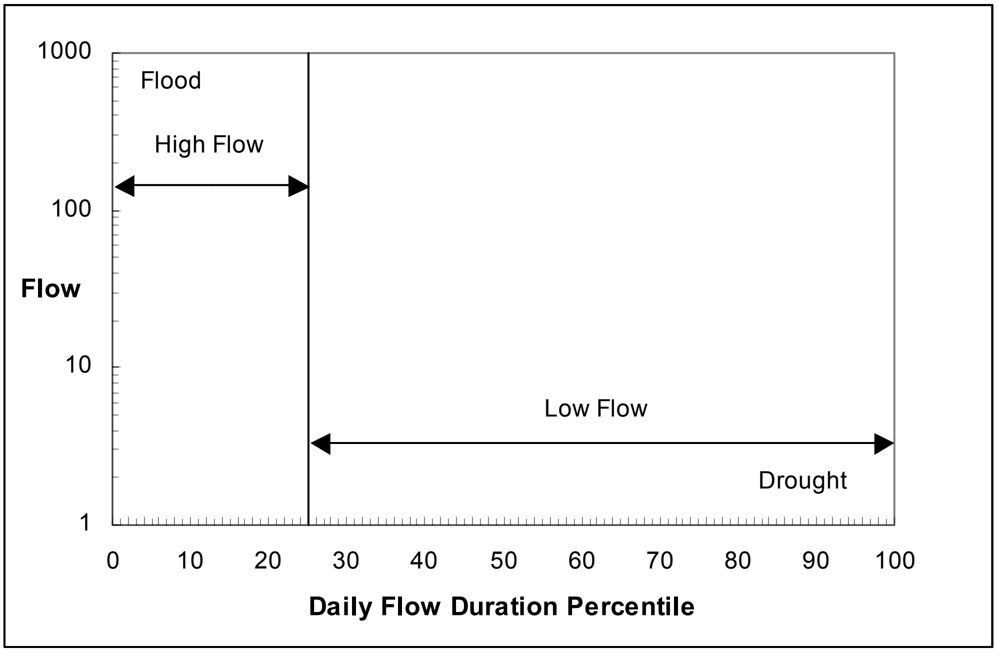

Figure 2.3.1: Conceptual Diagram of Flow Duration Zones

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 steady-state geometric mean from routine monitoring data. The daily flow duration intervals that define these regions and supporting details of how these zones were developed are 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 stratum represents. The weighting factors are presented in the following table (Table 2.3.2).

Table 2.3.2: Weighting factors for Annual Average Hydrology Year Used for Estimation of Geometric Means in the Herring Run Watershed

Flow Duration Zone	Duration Interval	Weighting Factor
High Flows	0 – 25%	0.25
Low Flows	25 – 100%	0.75

Bacteria enumeration results for samples within a specified 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 = 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 concentration

Table 2.3.3 present the geometric means by stratum and the overall steady-state geometric mean for Herring Run watershed for the annual average and the seasonal (May 1st –September 30th) periods.

Table 2.3.3: Herring Run Steady-state Geometric Mean by Stratum

Tributary	Station	Period	Flow Stratum	Steady-state Geometric Mean MPN/100ml	Overall Steady-state Geometric Mean MPN/100ml
Herring Run	HER0065	Annual	High	2,406	1,064
			Low	811	
		Seasonal	High	1,473	1,622
			Low	1,675	

Summary of Water Quality Data

The water quality impairment was assessed by comparing the annual and seasonal (May 1st - September 30th) steady-state geometric means concentrations at each monitoring station with the water quality criterion. Graphs illustrating these results can be found in Appendix B. Steady-state geometric means of the monitoring data for both periods assessed and the water quality criterion are shown in Table 2.3.4.

Table 2.3.4: Herring Run Monitoring Data and Steady-state Geometric Means (Annual and Seasonal Periods)

Tributary	Station	Period	# Samples	*E. coli* Minimum Concentration MPN/100ml	*E. coli* Maximum Concentration MPN/100ml	*E. coli* Steady-state Geometric Mean Concentration MPN/100ml	*E. coli* Criterion MPN/100ml
Herring Run	HER0065	Annual	24	60	36,500	1,064	126
		Seasonal	12	190	36,500	1,622	

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. Many 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 leaking infrastructure (*i.e*., sewer systems). Land use in the Herring Run watershed is primarily urban; therefore, sources associated with forest and agricultural land use (*i.e.,* livestock) are not a consideration in this analysis. Furthermore, because the entire watershed is covered by two National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) individual permits, contributions from domestic animal, wildlife and human sources will be considered under point sources or Waste Load Allocations.

Septic and Sewer Systems

There are no septic systems in the Herring Run watershed. Rather, the watershed is serviced entirely by publicly owned treatment works, including a separate sanitary sewer system that runs through both Baltimore County and Baltimore City, where the sewerage is treated at one of two municipal wastewater treatment plants. In addition, storm water 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.

Point Source Assessment

Stormwater Discharges

The Herring Run watershed is located in Baltimore City and Baltimore County; both are Phase I National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit jurisdictions. The MS4 permit covers stormwater discharges from the municipal separate stormwater sewer system in the City and County.

Baltimore City has done 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 counts are much higher in Herring Run during dry weather, because the sanitary system is exfiltrating into the stream.

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) occur when the capacity of a separate sanitary sewer is exceeded, normally during storm events. There are several factors that may contribute to SSOs from a sewerage 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.

In 2002, Baltimore City, MDE, and U.S. Environmental Protection Agency (EPA) entered into a civil consent decree to address SSOs and combined sewer overflows (CSOs)[2] within the City's jurisdictional boundaries. See U.S., et al., v. Mayor and City Council of Baltimore, JFM-02-12524, Consent Decree (entered 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 (entered 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.

In the Herring Run watershed, there were a total of 19 SSOs reported to MDE between February 2002 and December 2003. Approximately 124 million gallons of SSO discharge was released into the Herring Run through various waterways (surface water, groundwater, sanitary sewers, *etc*.) (MDE, Water Management Agency). Figure 2.4.1 depicts the location of sanitary sewer overflows in the Herring Run watershed.

[2] 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 area served by a combined system and has completed that separation.

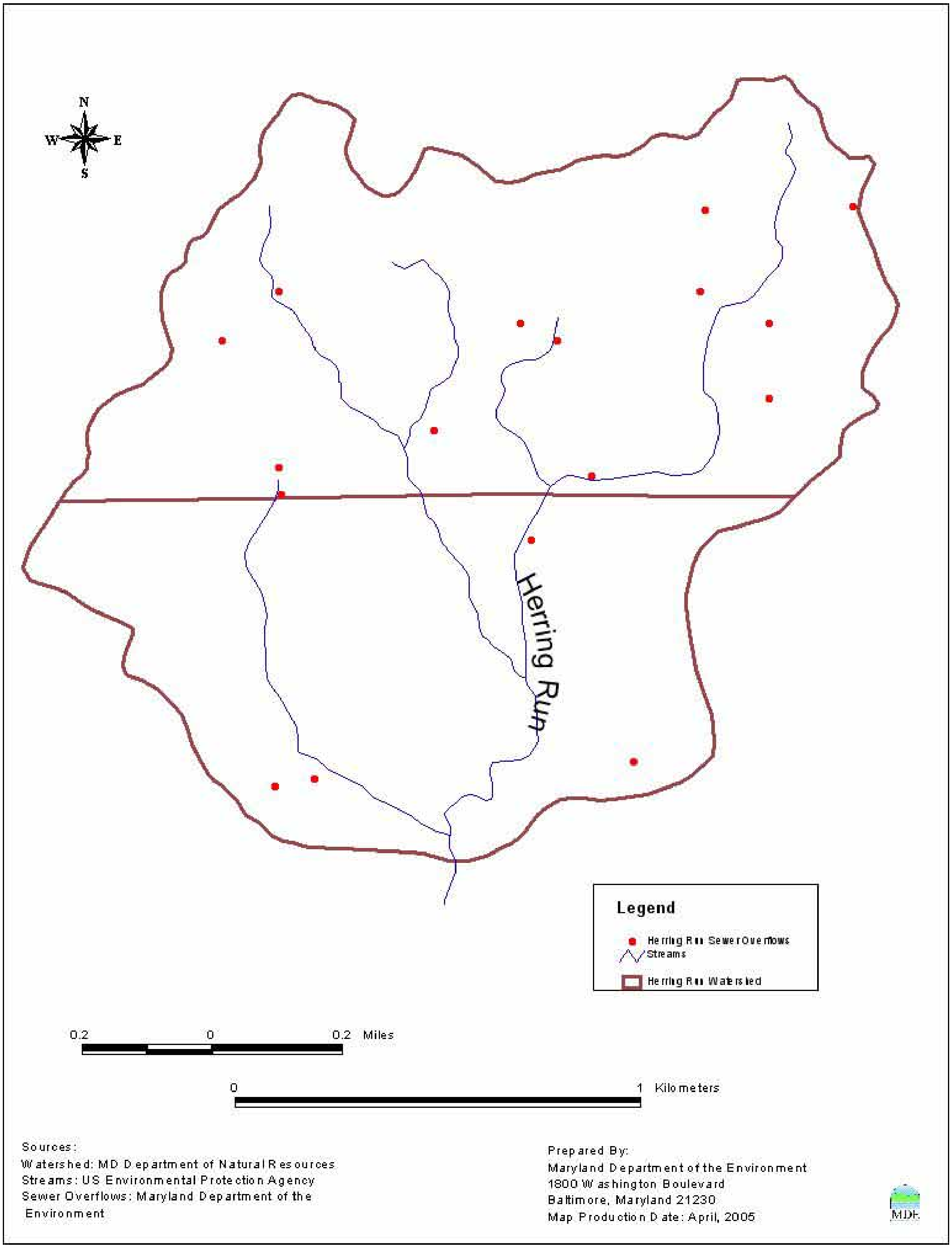

Figure 2.4.1: Location of Sanitary Sewer Overflows in the Herring Run Watershed

Municipal and Industrial Wastewater Treatment Plants (WWTPs)

There are no municipal WWTPs and three industrial NPDES point sources (Black & Decker-Towson, Hood Vinegar and Environment Tech. Group) in the watershed. None of these industrial WWTPs have permits regulating the discharge of fecal bacteria directly into Herring Run or its tributaries.

Bacteria Source Tracking

Bacteria source tracking (BST) was used to identify the relative contribution of bacteria in in-stream water samples. BST monitoring was conducted at one station in the Herring Run 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), wildlife (mammals and waterfowl) and unknown. 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 average source observed at each monitoring station is estimated by using a stratified weighted mean of the identified sample results. The weighting factors are based on the $\log_{10}$ of the bacteria concentration and the percent of time that represents the high stream flow or low stream flow. 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). The weighting is based on the $\log_{10}$ 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 (*i.e.*, high flow=0.25, low flow=0.75).

The weighted mean of each source category for the annual and critical condition is calculated using the following equations:

$$MS_k = \sum_{i=1}^{3} M_{i,k} * W_i \qquad (4)$$

where

$$MS_{i,k} = \frac{\sum_{j=1}^{n_i} \log_{10}(C_{i,j}) * S_{i,j,k}}{n_i} \qquad (5)$$

MS_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 = samples
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 period source loads are listed in Table 2.4.2. Details of the BST data can be found in Appendix C.

Table 2.4.2: Distribution of Fecal Bacteria Source Loads in the Herring Run Watershed (Annual and Seasonal Period)

Station	Period	Flow Stratum	% Domestic Animals	% Human	% Livestock	% Wildlife	% Unknown
HER0065	Seasonal	High	13	37	0	0	50
		Low	8	57	0	14	21
		Weighted	9	52	0	10	29
	Annual	High	20	40	0	0	40
		Low	11	57	0	11	21
		Weighted	13	53	0	8	26

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 assure attainment of water quality standards in the Herring Run watershed area. 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. Included is a discussion on the many complexities involved with the estimation of bacteria concentrations, loads and sources. The second section describes the analysis framework for estimating a representative geometric mean fecal bacteria concentration. The analysis methodology is based on available monitoring data and specific to a free flowing stream system. The third section presents the estimation of baseline loads. 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 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, the Code of Federal Regulations (40 CFR 130.2(i)) states 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 accurate estimation of source inputs are 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.*, Enterococci, *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 (APHA, 1998). Enumeration results indicate the extreme variability in the total bacteria counts. The distribution of the enumeration results from water samples tends to be log-normal, 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 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 (for near-field 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, appears to provide reasonable results (Cleland, 2003). Using this approach, Maryland can address more impaired streams in the same time period than using the traditional water quality modeling methods.

4.2 Analysis Framework

This TMDL analysis uses flow duration curves to identify flow intervals that are used as indicator 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.

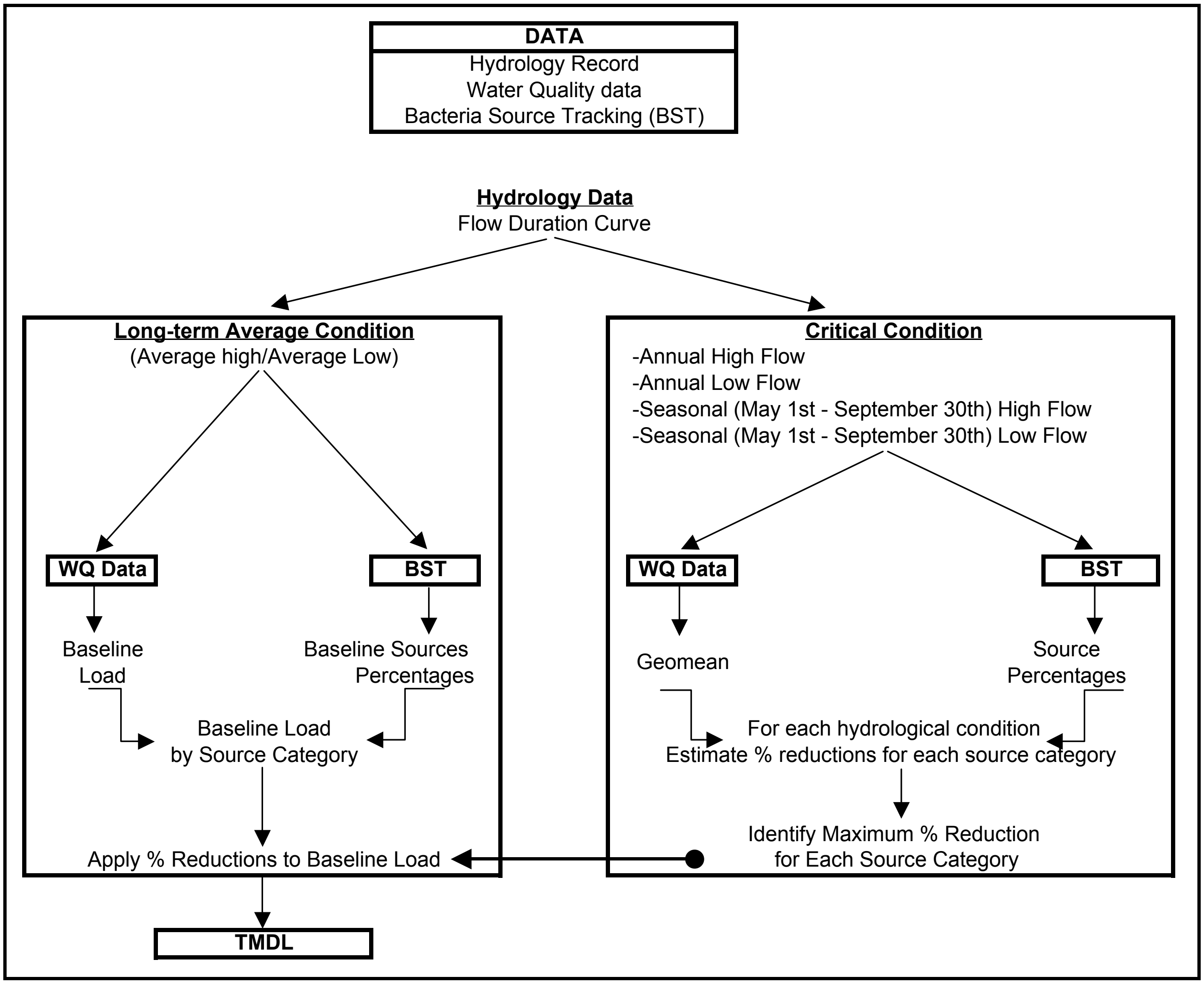

Figure 4.2.1: Diagram Non-tidal Bacteria TMDL Analysis

4.3 Estimating Baseline Loads

Baseline loads estimated in this TMDL analysis are reported in 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 transformation 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.

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:

$$L_i = Q_i * C_i * F_1 * F_2 \qquad (6)$$

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= Unit conversion factor from cfs*MPN/100ml to MPN/day (2.4466×10^7)
F_2= Bias correction factor.

To total baseline load is estimated as follows:

$$L_t = \sum_{i=1}^{2} L_i * W_i \qquad (7)$$

where

L_t = Daily average load at station (MPN/day)
W_i= Proportion or weighting factor of stratum i

In the Herring Run watershed, a weighting factor of 0.25 for high flow and 0.75 for low flow were used to estimate the annual baseline load expressed as billion MPN *E. coli*/day. Results are as follows:

Table 4.3.1: Baseline Load Calculations

Station	Area (sq. miles)	USGS Reference Gage	High Flow			Low Flow			Baseline Load (billion MPN/day)
			Unit flow (cfs/sq, mile)	Q (cfs)	*E. coli* Concentration (MPN/100ml)	Unit flow (cfs/sq. mile)	Q (cfs)	*E. coli* Concentration (MPN/100ml)	
HER0065	12.3	1585200 (est)	4.3	52.3	2,406	0.5	5.7	811	2,958

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 occurring when the daily flow duration interval is less than 25% and a low flow condition occurring when the daily flow duration interval is greater than 25%, critical hydrological condition can be estimated by the percent of high or low flows during a specific period.

As stated above, the proposed fecal bacteria TMDL for Herring Run has been determined by assessing various hydrological conditions to account for annual and seasonal averaging periods. Table 4.4.1 presents the five hydrological conditions used in the TMDL analysis (and includes conditions used to account for critical condition).

Table 4.4.1: Hydrological Conditions Used In the TMDL Analysis

Time Period	Hydrological Condition	Water Quality Data Used	Fraction High Flow	Fraction Low Flow	Condition Period
Annual (Long Term)	Average	All	0.25	0.75	Long Term Average
Annual (Moving 365 days)	High Flow	All	0.51	0.49	Feb 2003 - Feb 2004
	Low Flow	All	0.10	0.90	April 2001 - April 2002 and Aug 2001- Aug 2002
Seasonal (May 1st-Sept 30th)	High Flow	May 1st – Sept 30th	0.41	0.59	May 2003 - Sep 2003
	Low Flow	May 1st – Sept 30th	0.10	0.90	May 1997 - Sep 1997

The critical condition is determined by the maximum reduction per source that satisfies the four conditions. These reductions are 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.*, pets waste reduced 75%).

The monitoring data for the station located in the Herring Run watershed cover a sufficient temporal span (at least one year), to estimate annual and seasonal conditions loads.

Table 4.4.2: Required Reductions to Meet Water Quality Standards

Time Period	Hydrological Condition	Domestic %	Human %	Livestock %	Wildlife %
Annual (Long Term)	Average	95.0%	95.0%	0.0%	34.8%
Annual (Moving 365 days)	High flow	98.0%	98.0%	0.0%	2.4%
	Low flow	98.0%	98.0%	0.0%	7.7%
Seasonal (May 1st – September 30th)	High flow	98.0%	98.0%	0.0%	44.5%
	Low flow	98.0%	98.0%	0.0%	64.8%
Maximum Source Reduction		**98.0%**	**98.0%**	**0.0%**	**64.8%**

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, estimating the loading capacity of the stream based on a reduced (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 cap presented in this section is for the watershed located upstream of monitoring station HER0065.

The TMDL is based on a long-term average hydrological condition, and therefore the loads are not literal daily limits. 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 cap is estimated by first determining the baseline or current condition load 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. It is assumed that a reduction in concentration is proportional to a reduction in load and thus the TMDL is equal to the current baseline load multiplied by one minus the required reduction.

$$TMDL = L_b * (1 - R) \qquad (1)$$

where

L_b = Current or baseline load estimated from monitoring data
R = Reduction required from baseline to meet water quality criterion

The bacteria TMDL for the watershed upstream of monitoring station HER0065 is:

Table 4.6.1: Herring Run Watershed TMDL Summary

Station	Baseline Load *E. coli* (Billion MPN/day)	TMDL Load *E. coli* (Billion MPN/day)	% Target Reduction
HER0065	2,958.5	167.4	94.3

4.7 Scenario Descriptions

Source Distribution

The final source distribution is derived from the source proportions listed in Table 2.4.2. For the purposes of the TMDL analysis and allocations, the percentage of sources identified as "unknown" was 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 Loads Source Distributions

Watershed	Domestic		Human		Livestock		Wildlife		Total *E. coli*/day
	%	Load *E. coli*/day	%	Load *E. coli*/day	%	Load *E. coli*/day	%	Load *E. coli*/day	
HER0065	18.0	533.0	71.0	2,099.8	0.0%	0.0	11.0%	325.7	2,958.5

Practicable Reduction Targets

The maximum practicable reduction (MPR) per 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 have the highest risk of causing gastrointestinal illness and therefore should have the highest reduction. 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. The livestock category is not relevant in this analysis.

Table 4.7.2: Maximum Practicable Reduction Targets

	Human	**Domestic**	**Livestock**	**Wildlife**
Max Practical Reduction per Source	95%	75%	75%	0%
Rationale	(1) Direct source inputs (2) Human pathogens more prevalent in humans than animals. (3) Enteric viral diseases spread from human to human	Target goal reflects uncertainty in effectiveness of urban BMPs[1] and is also based on best professional judgment	Target goal based on sediment reductions from BMPs[2] 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]

1. USEPA. 1984. Health Effects Criteria for Fresh Recreational Waters. EPA-600/1-84-004. U.S. Environmental Protection Agency, Washington, D.C.
2. USEPA. 1999. Preliminary Data Summary of Urban Stormwater 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., Mackney 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 (USEPA, 1999). The MPR to agricultural lands was based on sediment reductions identified by the EPA (USEPA, 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 animals and livestock next (3), and wildlife the lowest (1) (See Table 4.7.2). The model was defined as follows:

$$Min\sum_{i=1}^{4}(Ph*5+Pd*3+Pl*3+Pw*1) \qquad i = \text{hydrological condition}$$

Subject to

$C = C_{cr}$
$0 <= R_h <= 95\%$
$0 <= R_l <= 75\%$
$0 <= R_d <= 75\%$
$R_w = 0$
$P_h, P_l, P_d, P_w >= 0\%$

Where

P_h = % human source in final allocation
P_d = % domestic animal source in final allocation
P_l = % livestock source in final allocation
P_w = % wildlife source in final allocation
C = Instream concentration
C_{cr} = Water quality criterion
R_h = Reduction applied to human sources
R_l = Reduction applied to livestock sources
R_d = Reduction applied to domestic animal sources

The constraints of this scenario could not be satisfied for Herring Run, 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				Achievable
	Domestic %	Human %	Livestock %	Wildlife %	
HER0065	75%	95%	75%	0%	No

The TMDL must specify load allocations that will meet the water quality standards. In the practicable reduction targets scenario the watershed could not meet water quality standards based on MPRs. To further develop the TMDL, the constraints on the model were changed to allow for higher than MPRs reductions. In the Herring Run watershed the water quality attainment was not achievable with the MPRs. In this scenario, the maximum allowable reduction was 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:

$$\text{Min} \sum_{i=1}^{4} (Ph*5 + Pd*3 + Pl*3 + Pw*1) \qquad i = \text{hydrological condition}$$

Subject to

C = Ccr
0 <= Rh <= 98%
0 <= Rl <= 98%
0 <= Rd <= 98%
0 <= Rw <= 98%
Ph , Pl, Pd, Pw >= 0%

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
Rd = Reduction applied to domestic animal sources
Rl = Reduction applied to livestock sources
Rw = Reduction applied to wildlife sources

The summary of the analysis is presented in Table 4.7.4.

Table 4.7.4: TMDL Reduction Results: % Reductions Based on Optimization Model Up to 98% Reduction

Station	Domestic %	Human %	Livestock %	Wildlife %	% Target Reduction
HER0065	98.0	98.0	0.0	64.8	94.3

Table 4.7.5: TMDL Reduction Results: Reduced Loads by Source

Station	Domestic	Human	Livestock	Wildlife	Total
	MPN *E. coli*/day				
HER0065	10.7	42.0	0.0	114.7	167.4

4.8 TMDL Allocation

The TMDL allocation includes load allocation (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 implicit and not a separate term. The final loads represent loads based on average hydrological conditions but taking 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 allocations 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
Human			X
Domestic			X
Livestock			
Wildlife			X

The entire Herring Run 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 and wildlife loads are also allocated entirely to WLA-MS4. There are no livestock contributions in the Herring Run watershed. Note that only the final WLA is reported in this TMDL.

Load Allocation (LA)

The entire Herring Run watershed is covered by two National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) individual permits; therefore, there is no load allocation in this TMDL for nonpoint sources.

Waste Load Allocation (WLA)

Municipal and Industrial Wastewater Treatment Plants (WWTPs)

As explained in Section 2.4 (Source Assessment), there are no municipal WWTPs and three industrial NPDES point sources (Black & Decker-Towson, Hood Vinegar and Environment Tech. Group). None of these industrial WWTPs have permits regulating the discharge of fecal bacteria directly into Herring Run or its tributaries; therefore, no allocation is given to these facilities.

Stormwater Discharges

In November 2002, EPA advised States that NPDES-regulated stormwater discharges *must be addressed by the WLA component* of a TMDL (40 C.F.R. § 130.2(h)). NPDES-regulated stormwater discharges may not be addressed by the LA component of a TMDL.

Current stormwater Phase I individual permits and new stormwater Phase II general permits are point sources subject to WLA assignment in the TMDL. The stormwater WLA is expressed as a gross allotment, rather than individual allocations for separate pipes, ditches, construction sites, etc. The Herring Run watershed is covered by two Phase I individual permits: Baltimore City and Baltimore County MS4 permits.

Waste load allocations from stormwater point source dischargers are based on the relative contribution of pollutant load to the waterbody. Estimating a load contribution to a particular waterbody from the stormwater Phase I and Phase II sources is imprecise, given the variability in sources, runoff volumes, and pollutant loads over time. Therefore, any stormwater WLA portion of the TMDL is based on an estimate.

Table 4.8.2: MS4 Stormwater Allocations

Station	**WLA – MS4 Loads (Billion MPN/day)**	
	Baltimore City	Baltimore County
HER0065	72.3	95.1
Total	167.4	

4.9 Summary

The TMDL for the Herring Run watershed is presented below.

Table 4.9.1: Herring Run Watershed TMDL

Station	TMDL Load (Billion MPN/day)	LA Load (Billion MPN/day)	WLA-PS Load (Billion MPN/day)	WLA – MS-4 Load (Billion MPN/day)
HER0065	167.4	0.0	0.0	167.4

In Herring Run, based on the practicable reduction rates specified, water quality standards can 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 reductions are increased beyond MPRs 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 Herring Run watershed, the TMDL analysis indicates that reduction of fecal bacteria loads from all sources including wildlife are beyond the maximum practicable reduction (MPR) targets. Herring Run 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 Herring Run are not feasible by effluent limitations or by implementing cost-effective and reasonable best management practices. Therefore, MDE cannot assure that the TMDL allocations can be implemented.

Based on the above, the final scenario for the Herring Run watershed resulted in reductions that are beyond the MPR targets. These MPR targets were defined based on a literature review of BMPs effectiveness and assuming a zero reduction for wildlife sources. The uncertainty of BMPs effectiveness for bacteria, reported within the literature, is quite large. As an example, pet waste education programs have varying results based on stakeholder involvement. Additionally, the extent of wildlife reduction associated with various BMPs 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 Herring Run watershed is located, Baltimore County and Baltimore City, are required to participate in the stormwater NPDES program, and have to 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.

MDE's Managing for Results document states the following related to sewage 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, long term control plans (LTCP), and collection system improvements in capacity, inflow and infiltration reduction, operation and maintenance.

Strategy 4.5.1: MDE will implement regulations adopted in FY 2004 to ensure that all jurisdictions are reporting all sewage overflows to the Department, notifying the public about significant overflows, and are taking appropriate steps to address the cause(s) of the overflows.

Strategy 4.5.2: MDE will inspect and take enforcement actions against those CSO jurisdictions that have not developed long-term control plans with schedules for completion and require that enforceable schedules are incorporated in consent decrees 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 consent decrees with the State and Federal Governments, Baltimore City and Baltimore County have agreed to undertake a comprehensive, system-wide repair and upgrade program for their aged sewerage system. Compliance with these agreements will bring the City and the County into long-term compliance with the Clean Water Act and will also end the discharges of raw sewage into city streets and local waterways.

Implementation and Wildlife Sources

It is expected that in some waters for which TMDLs will be developed, the bacteria source analysis indicates that after controls are in place for all anthropogenic sources, the waterbody will not meet water quality standards. However, while neither Maryland, nor EPA is proposing the elimination of wildlife to allow for the attainment of water quality standards, managing the overpopulation of wildlife remains 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, Maryland anticipates that implementation to reduce the controllable sources may also reduce some wildlife inputs to the waters.

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Appendix A – Fecal Bacteria Raw Data

Table A-1: Bacteria Concentration Raw Data per Sampling Date with Corresponding Daily Flow Frequency

SAMPLING STATION IDENTIFIER	Date	Daily flow frequency	E.coli MPN/100ml
HER0065	11/13/2002	50.3765	1,080
HER0065	11/25/2002	75.7016	60
HER0065	12/03/2002	72.3477	2600
HER0065	12/17/2002	50.3765	570
HER0065	01/07/2003	33.9493	4,350
HER0065	01/22/2003	65.9138	90
HER0065	02/04/2003	8.3504	13,000
HER0065	03/04/2003	20.6023	5,170
HER0065	03/18/2003	28.7132	1,520
HER0065	04/22/2003	37.7481	460
HER0065	05/06/2003	39.9726	1,160
HER0065	05/20/2003	39.9726	24,190
HER0065	06/03/2003	10.2327	440
HER0065	06/17/2003	11.0883	1,160
HER0065	06/24/2003	27.2758	590
HER0065	07/08/2003	47.1937	5,480
HER0065	07/22/2003	8.0082	1,960
HER0065	08/05/2003	54.2094	3,130
HER0065	08/19/2003	63.3812	290
HER0065	08/26/2003	19.8836	190
HER0065	09/09/2003	50.3765	450
HER0065	09/23/2003	0.2738	36,500
HER0065	10/07/2003	69.0623	170
HER0065	10/21/2003	54.2094	170

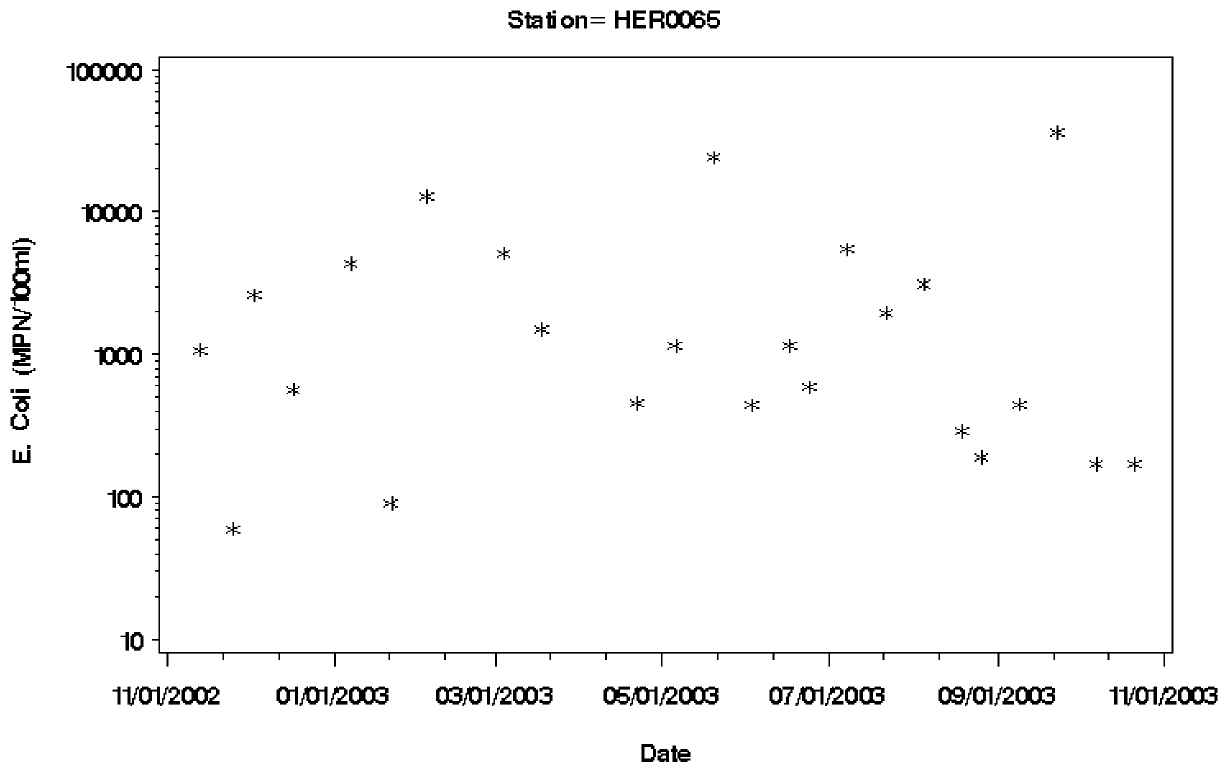

Figure A-1: *E. coli* Concentration vs. Time for Herring Run Monitoring Station HER0065

Appendix B - Flow Duration Curve Analysis to Define Strata

The Herring Run 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 Herring Run watershed. The gage flow data is incomplete for this station therefore the flow for unobserved periods (1/01/1992 to 10/01/1996) was estimated using MDE's SWMM calibrated to USGS gage station (0185200). The gage and dates of information used are as follows:

Table B-1: USGS Gages used in the Herring Run Watershed

USGS Gage #	Dates used	Description
01585200	Jan 1, 1997 to Sep 30, 2004	USGS Active Gage 01585200 on Herring Run at
01585200 (estimate)	Jan 1, 1992 to Dec 31, 1996	Estimated flow based on SWMM calibrated to USGS Gage 01585200 (MDE, 2001)

The flow duration curve for the estimated gage is presented in figure B-1.

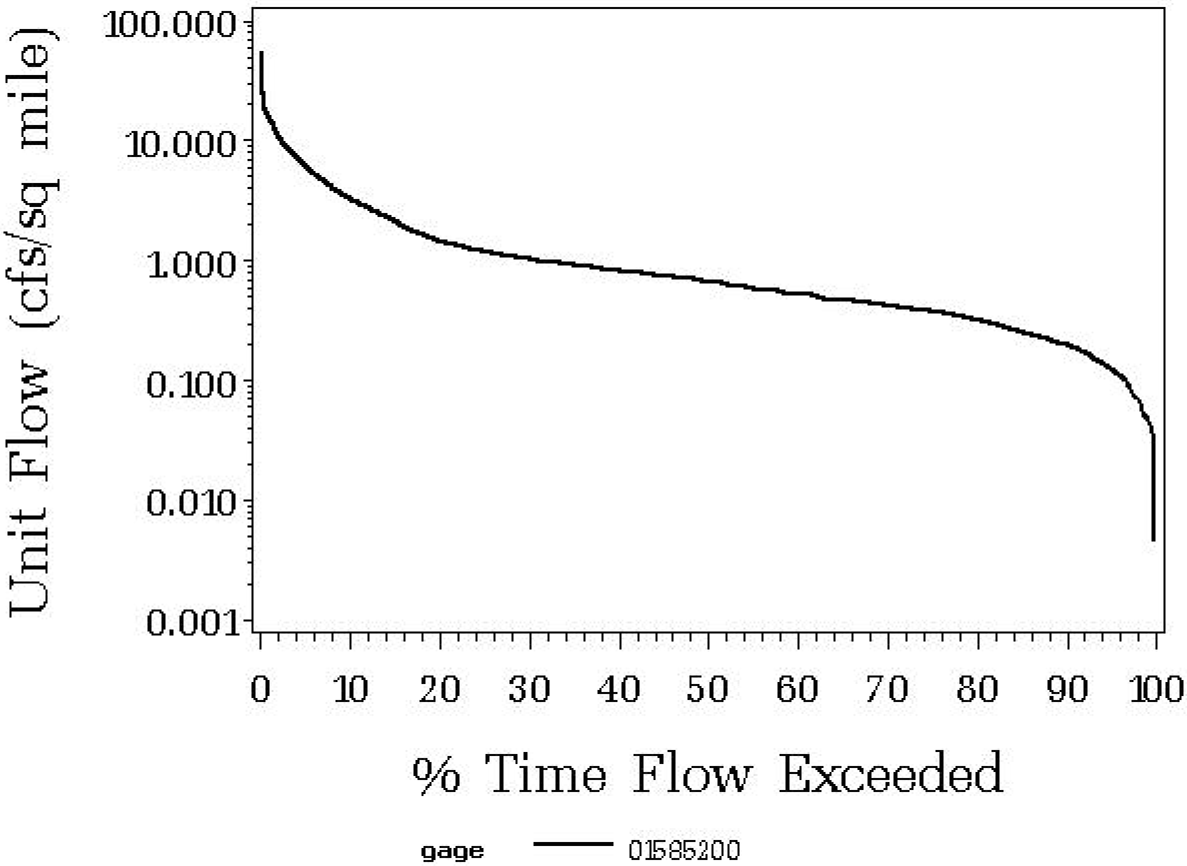

Figure B-1: Herring Run Flow Duration Curves

Based on the long-term flow data for the Herring Run watershed and other watersheds in the area (*i. e.*,Jones Falls, Gwyn Falls), the long term average daily unit flows ranges 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 occurring when flows are higher than the long-term average flow and a low flow condition 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.
Mid flow	Represents conditions where stream flow tends to be more dominated by groundwater flow.

Low Flow	Represents drought conditions.

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-3 and B-4 show the Herring Run *E. coli* monitoring data with corresponding flow frequency for the annual average and the seasonal conditions.

Maryland’s water quality standards for bacteria states that, when available, the geometric mean indicator should be based on at least five samples taken representatively over 30 days. Therefore, in situations in which fewer than five samples “fall” within a particular flow regime interval, the interval and the adjacent interval will be joined. In Herring Run, there are sufficient samples in the high flow and mid flow strata to estimate the geometric means. For the low flow strata only three 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-3 to B-4.

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 (Long Term)	Average Flow	365 days	All	0.25	0.75
Annual (Moving 365 days)	High Flow	365 days	All	0.51	0.49
	Low Flow	365 days	All	0.10	0.90
Seasonal (May 1st – Sept 30th)	High Flow	May 1st – Sept 30th	May 1st – Sept 30th	0.41	0.59
	Low Flow	May 1st – Sept 30th	May 1st – Sept 30th	0.10	0.90

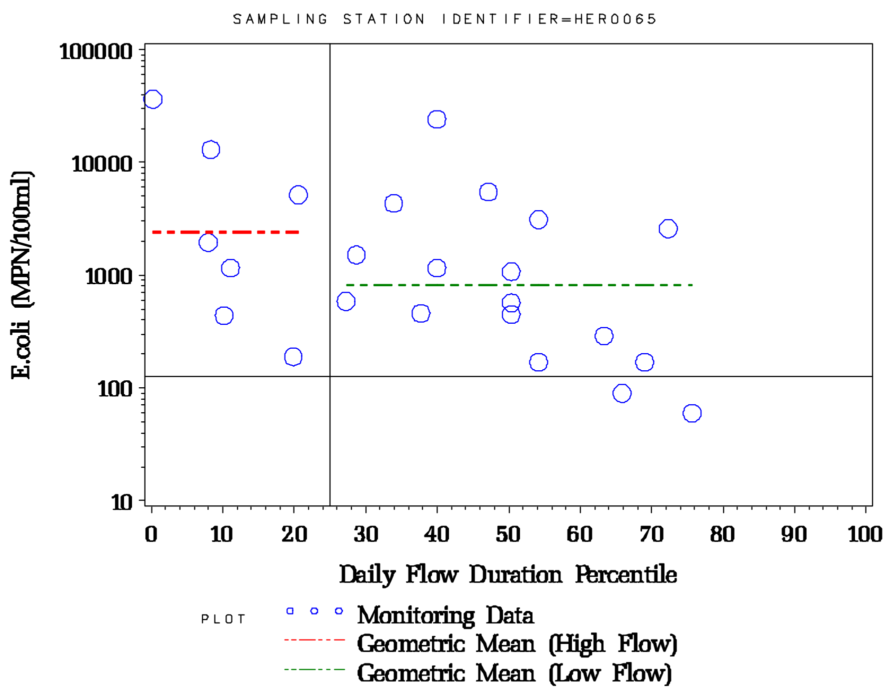

Figure B-2: *E. coli* Concentration vs. Flow Duration for Station HER0065 (Annual Period)

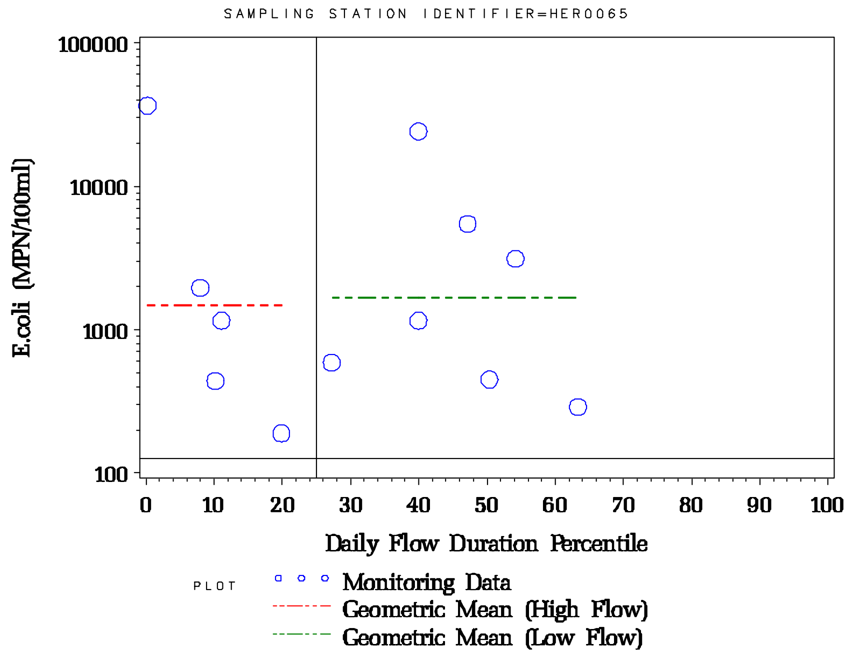

Figure B-3: *E. coli* Concentration vs. Flow Duration for Station HER0065 (Seasonal Period)

Appendix C - BST Report

Maryland Department of the Environment
Contract Number U00P4200187

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

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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 watersheds: Gwynns Falls, Jones Falls, Herring Run, Georges Creek, and Wills Creek. 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

Pulsed-Field Gel Electrophoresis: DNA characterization was performed using contour-clamped homogenous electric field (CHEF) PFGE. *Enterococcus* isolates were identified to species (*E. faecalis, E. faecium, E. casseliflavus*) using the Biolog, Inc. Microstation™ System and MicroLog™ software. Isolates were then prepared for analysis using CHEF Bacterial Genomic DNA Plug Kit (Bio-Rad Laboratories, Inc., Hercules, CA). The DNA in each plug was cut with *Sma*I restriction enzyme. DNA fragments were separated according to base pair size using the CHEF Mapper® XA Chiller System (Bio-Rad Laboratories, Inc., Hercules, CA.). Gel bands were stained with either ethidium bromide or SYBR® green and were photographed on a long-wave UV transilluminator and analyzed with Kodak Digital Science Electrophoresis Documentation and Analysis System (Eastman Kodak Co., Rochester, NY.). Banding patterns were analyzed using BioNumerics®, a product of Applied Maths, Inc., Austin, TX.

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.

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.

Known-Source Library. The 630 known-source isolates in the library were grouped into three categories: pet (specifically dog), human, livestock (none), and wildlife (goose) (Table 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

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[1] The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Hastie T, Tibshirani R, and Friedman J. Springer 2001.

[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.

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: Category, potential sources, total number, and number of unique patterns in the known-source library.

Category	Potential Sources	Total Isolates	Unique Patterns
Pet	dog	103	63
Human	human	425	274
Wildlife	goose	102	32
Total		**630**	**369**

Table C-3: 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%	78%
.375	0	0%	78%
.50	0	0%	78%
.60	19	3%	78%
.70	82	13%	80%
.80	193	31%	89%
.90	391	62%	94%

A cutoff probability of 0.80 (80%) was shown to yield an ARCC of 89%. 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 193 isolates that were not useful in the prediction of probable sources were removed, leaving 437 isolates remaining in the library. This library was then used in the statistical prediction of probable sources of bacteria in water samples collected from the Herring Run Watershed. The rates of correct classification for the three categories of sources in the library, at 0.80 (80%) probability cutoff, are shown in Table C-4 below.

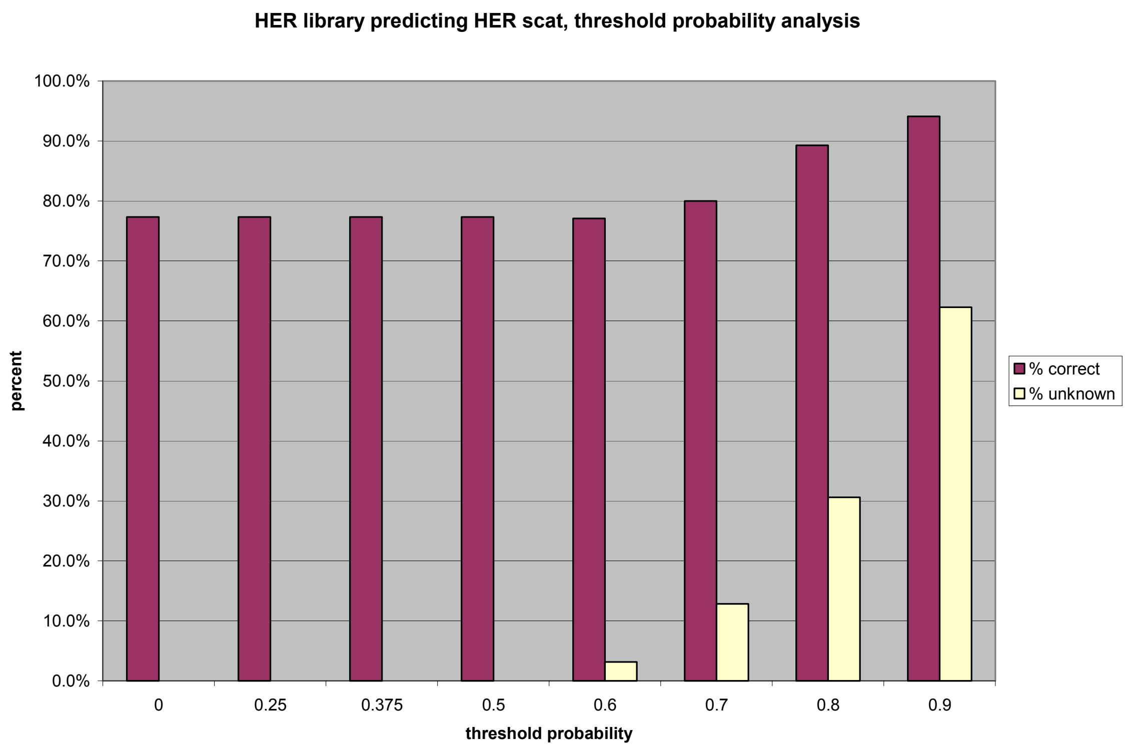

Figure C-1: Classification Model: Percent Correct versus Percent Unknown.

Table C-4: Actual species categories versus predicted categories, at an 80% probability cutoff, with rates of correct classification (RCC) for each category.

	Predicted →				
Actual ↓	HUMAN	PET	WILDLIFE	TOTAL	RCC[1]
HUMAN	**276**	13	25	314	88%
PET	3	**45**	4	52	87%
WILDLIFE	1	0	**71**	72	99%
Total	**280**	**58**	**100**	**438**	**89%**

[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%.

Herring Run Water Samples. Monthly monitoring from one (1) station on Herring Run 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 262 *Enterococcus* isolates were analyzed by statistical analysis. The BST results by species category, shown in Table C-5, indicates that 73% of the water isolates were classified after excluding unknowns when using a 0.80 (80%) probability cutoff.

Table C-5: 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)
HUMAN	134	51%	70%
LIVESTOCK	-	-	-
PET	36	14%	19%
WILDLIFE	21	8%	11%
UNKNOWN	71	27%	
Missing Data	0		
Total	262		
% Classified	**73%**		

The seasonal distribution of water isolates from samples collected at each sampling station is shown below in Table C-6.

Table C-6: *Enterococcus* isolates obtained from water collected during the fall, winter, spring, and summer seasons for the one (1) monitoring station.

Station	Spring	Summer	Fall	Winter	Total
HER0065	72	61	81	48	262
Total	**72**	**61**	**81**	**48**	**262**

Tables C-7 and C-8 below show the number and percent of probable sources of *Enterococcus* contamination in the watershed.

Table C-7: BST Analysis - Number of Isolates per Station per Date

Station	date	% domestic	% human	% livestock	% wildlife	% unknown
HER0065	**11/13/2002**	1	9	0	4	10
HER0065	**12/03/2002**	3	15	0	1	5
HER0065	**01/07/2003**	9	15	0	0	0
HER0065	**02/04/2003**	8	11	0	0	5
HER0065	**04/22/2003**	1	20	0	1	2
HER0065	**05/06/2003**	3	2	0	6	13
HER0065	**06/03/2003**	5	5	0	0	14
HER0065	**07/08/2003**	1	18	0	0	1
HER0065	**08/05/2003**	3	12	0	2	5
HER0065	**09/09/2003**	0	13	0	5	1
HER0065	**09/23/2003**	2	11	0	0	11
HER0065	**10/07/2003**	0	3	0	2	4

Table C-8: Percentage of Sources per Station per Date

Station	date	% domestic	% human	% livestock	% wildlife	% unknown
HER0065	**11/13/2002**	4.1667	37.5000	0	16.6667	41.6667
HER0065	**12/03/2002**	12.5000	62.5000	0	4.1667	20.8333
HER0065	**01/07/2003**	37.5000	62.5000	0	0.0000	0.0000
HER0065	**02/04/2003**	33.3333	45.8333	0	0.0000	20.8333
HER0065	**04/22/2003**	4.1667	83.3333	0	4.1667	8.3333
HER0065	**05/06/2003**	12.5000	8.3333	0	25.0000	54.1667
HER0065	**06/03/2003**	20.8333	20.8333	0	0.0000	58.3333
HER0065	**07/08/2003**	5.0000	90.0000	0	0.0000	5.0000

Station	date	% domestic	% human	% livestock	% wildlife	% unknown
HER0065	**08/05/2003**	13.6364	54.5455	0	9.0909	22.7273
HER0065	**09/09/2003**	0.0000	68.4211	0	26.3158	5.2632
HER0065	**09/23/2003**	8.3333	45.8333	0	0.0000	45.8333
HER0065	**10/07/2003**	0.0000	33.3333	0	22.2222	44.4444

Table C-9: *E. coli* Concentration and Percentage of Sources by Stratum (Annual Period)

SAMPLING STATION IDENTIFIER	DATE START SAMPLING	flow regime (1=high/ 2=low)	ecoli conc MPN/100ml	log mean conc	% domestic	% human	% livestock	% wildlife	% unknown
HER0065	**11/13/2002**	2	1080	3.03342	4.1667	37.5000	0	16.666	41.6667
HER0065	**11/25/2002**	2	60	1.77815	.	.	.	.	.
HER0065	**12/03/2002**	2	2600	3.41497	12.5000	62.5000	0	4.1667	20.8333
HER0065	**12/17/2002**	2	570	2.75587	.	.	.	.	.
HER0065	**01/07/2003**	2	4350	3.63849	37.5000	62.5000	0	0.0000	0.0000
HER0065	**01/22/2003**	2	90	1.95424	.	.	.	.	.
HER0065	**02/04/2003**	1	13000	4.11394	33.3333	45.8333	0	0.0000	20.8333
HER0065	**03/04/2003**	1	5170	3.71349	.	.	.	.	.
HER0065	**03/18/2003**	2	1520	3.18184	.	.	.	.	.
HER0065	**04/22/2003**	2	460	2.66276	4.1667	83.3333	0	4.1667	8.3333
HER0065	**05/06/2003**	2	1160	3.06446	12.5000	8.3333	0	25.000	54.1667
HER0065	**05/20/2003**	2	24190	4.38364	.	.	.	.	.
HER0065	**06/03/2003**	1	440	2.64345	20.8333	20.8333	0	0.0000	58.3333
HER0065	**06/17/2003**	1	1160	3.06446	.	.	.	.	.
HER0065	**06/24/2003**	2	590	2.77085	.	.	.	.	.
HER0065	**07/08/2003**	2	5480	3.73878	5.0000	90.0000	0	0.0000	5.0000
HER0065	**07/22/2003**	1	1960	3.29226	.	.	.	.	.
HER0065	**08/05/2003**	2	3130	3.49554	13.6364	54.5455	0	9.0909	22.7273
HER0065	**08/19/2003**	2	290	2.46240	.	.	.	.	.
HER0065	**08/26/2003**	1	190	2.27875	.	.	.	.	.
HER0065	**09/09/2003**	2	450	2.65321	0.0000	68.4211	0	26.315	5.2632

SAMPLING STATION IDENTIFIER	DATE START SAMPLING	flow regime (1=high/ 2=low)	ecoli conc MPN/100ml	log mean conc	% domestic	% human	% livestock	% wildlife	% unknown
HER0065	09/23/2003	1	36500	4.56229	8.3333	45.8333	0	0.0000	45.8333
HER0065	10/07/2003	2	170	2.23045	0.0000	33.3333	0	22.222	44.4444
HER0065	10/21/2003	2	170	2.23045	.	.	.	.	.

Table C-10: Percentage of Sources per Station by Stratum (Annual Period)

SAMPLING STATION IDENTIFIER	flow regime (1=high/2=low)	% domestic	% human	% livestock	% wildlife	% unknow n
HER0065	1	20.3382	39.9952	0	0.0000	39.6666
HER0065	2	11.0099	56.7472	0	10.8713	21.3716

Table C-11: Overall Percentage of Sources per Station (Annual Period)

SAMPLING STATION IDENTIFIER	% Domestic	% Human	% Livestock	% Wildlife	% Unknown	% Total
HER0065	13.34	52.56	0.00	8.15	25.95	100.00%

Herring Run Summary

The use of ARA was successful for identification of bacterial sources in the Herring Run Watershed as evidenced by the acceptable ARCC (89%) for the library. The RCCs ranged from 87% to 99%. When water isolates were compared to the library and potential sources predicted, 73% of the isolates were classified by statistical analysis. The largest category of potential sources in the watershed as a whole was human (70%), followed by pet and wildlife (19% and 11% of the classified water isolates, respectively).

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Appendix J

Total Maximum Daily Load
Documentation for Chlordane in Back River

July 1999

Total Maximum Daily Load (TMDL) Documentation for Chlordane in Back River

Prepared by the
Maryland Department of the Environment
2500 Broening Highway
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Submitted to:

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

July 1999

TABLE OF CONTENTS

ATTACHMENTS

Total Maximum Daily Load (TMDL) for Chlordane in Back River

Basin Code: 02-13-09-01

EXECUTIVE SUMMARY

Chlordane, a pesticide no longer authorized for use in the United States, has been detected in certain Back River fish tissues at levels that required the issuance of a consumption advisory. This advisory has been in place since February 5, 1986 (attachment 1). As a consequence of this impairment by chlordane, Back River was identified as a water quality limited segment on the 1996 Section 303(d) list. This document establishes a TMDL of 0.00059 ug/L in the water column based on the United States Environmental Protection Agency water quality criterion for chlordane and the U.S. Food and Drug Administration guidance level of 0.3 mg/kg in fish tissue. Since the TMDL value is impracticable to monitor directly in the water column, the U.S. FDA guidance level will serve as the targeted endpoint. In the absence of any defined current sources of chlordane other than sporadic low levels from urban runoff sources, there is no opportunity to allocate loadings among point and non-point sources. The State intends to periodically monitor the contaminant levels of fish and sediments in Back River to track the expected gradual declines, which are indicated in currently available sediment data. The goal of the monitoring program will be to identify fish tissue levels that would allow for the withdrawal of the fish consumption advisory.

PREFACE

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

On the basis of water quality problems associated with Back River, the watershed was identified on the Maryland's 1996 list of WQLSs as being impaired by toxic contaminants, specifically the pesticide chlordane. This report documents the proposed establishment of the chlordane TMDL for the Back River.

Once the TMDL is approved by the United States Environmental Protection Agency (EPA), the approved TMDL will be documented through the State's Continuing Planning Process. In the future, the established TMDL will document monitoring activities required to track restoration of the impaired resource and the lifting of the associated fish consumption advisory.

1.0 INTRODUCTION

The Clean Water Act Section 303(d)(1)(C) and federal regulation 40 CFR 130.7(c)(1) direct each State to develop a Total Maximum Daily Load (TMDL) for all impaired waters on its Section 303(d) list. A TMDL reflects the maximum pollutant loading of the impairing substance a waterbody can receive and still meet water quality standards. A TMDL can be expressed in mass per time, toxicity, or any other appropriate measure (40 CFR 130.2(i)). TMDLs must take into account seasonal variations and a margin of safety (MOS) to allow for uncertainty. Maryland's 1996 303(d) list, submitted to EPA by the Maryland Department of the Environment (MDE), lists the Back River watershed segment for toxics, specifically the pesticide chlordane. That 1996 listing was prompted by historical fish tissue data and an associated fish consumption advisory based on 1980s monitoring of the fish resources.

This report documents the development of a Total Maximum Daily Load (TMDL) for chlordane in the estuarine portion of Back River. This watershed, referred to as basin 02-13-09-01, was first identified as being impaired because of chlordane on Maryland's 303(d) list for 1996.

Chlordane has been identified as a pollutant of concern because it is a bioaccummulative pesticide that can cause both acute toxic and longer-term chronic effects, and it has carcinogenic potential in animals. Chlordane was used from its introduction in the 1940s until it was withdrawn from the market in 1988 as a broad-spectrum pesticide for agricultural, home, and commercial control of insects. Its polycyclic chlorinated organic structure produces biological effects similar to those of DDT, PCBs, and other related substances.

The Maryland Department of Agriculture suspended broad-based uses of chlordane in 1975 by restricting its use to termite control. Only certified applicators were authorized to purchase quantities greater than ½ gallon after that date. The U.S. Environmental Protection Agency (EPA) reached an agreement with the sole producer of the product on July 1, 1986, which led to the further restriction of use to the exterior of buildings, and to the ultimate termination of all sales by April 15, 1988. EPA officially cancelled the product's registration in 1993.

Concerns with the substance were largely brought to the State's attention through results of its fish tissue monitoring, which has been an element of the State's water quality monitoring efforts since the 1970s. Water quality impairments in the estuary of Back River were initially suggested as a result of fish taken from waters of the tidal portion of the basin in 1981. The levels were of sufficient magnitude to justify the issuance of a fish consumption advisory. All available evidence indicates that the source of the chlordane in the fish tissue is the historical accumulation of chlordane in the sediments of the tidal reaches of the watershed.

The river's designation as a "water quality limited segment" is based upon violations of the use designation for the waterbody and the narrative standard for toxic substances in the State's regulations. Specifically, the use designation of Class I waters, which requires at Code of Maryland Regulations (COMAR) Title 26.08.02.01 B (2) (a), that "All waters of this State shall be protected for the basic uses of water contact recreation, fish, other aquatic life, wildlife, and water supply." Later in the regulations at COMAR 26.08.02.01 C, the narrative statement concerning toxic pollution states that "the waters of this State may not be polluted by: . . . (3) high temperature, toxic, corrosive or other deleterious substances attributable to sewage, industrial wastes, or other waste in concentrations or combinations which: . . . (b) are harmful to human, animal, plant, or aquatic life." Because the fish inhabiting the waters cannot be consumed without restriction, the river is considered to be impaired.

2.0 WATERSHED CHARACTERIZATION AND WATER QUALITY DESCRIPTION

2.1 General Setting

Back River is a tidal estuary of the Chesapeake Bay located on the western shore just north of Baltimore Harbor (see attachment 2). The watershed of Back River is fed primarily by Herring Run, Redhouse Run, and Stemmers Run. The entire watershed is about 15 miles long and 6 miles wide at its widest point. The watershed has a northwest to southeast longitudinal orientation.

The upper-most portion of the watershed originates in the Piedmont Plateau region of the State. At about six miles from its origin, the primary tributary, Herring Run begins to traverse the Fall Line, which separates the Piedmont Plateau from the Coastal Plain. Thus, a majority of the watershed lies within the Coastal Plain Province.

The watershed is largely developed, with most being in residential use. There is some industrial development along the lower end of the free flowing portion of Herring Run, and along the south shore of the tidal portion of the basin. The largest wastewater discharge is from the Back River sewage treatment plant. It discharges approximately 120 million gallons per day of treated wastewater to the upper tidal reaches of the estuarine portion of the system.

2.2 Water Quality Characterization

Water quality information on chlordane in ambient waters of the basin is limited. Data from an unpublished 1994 urban stormwater runoff study by the Department of the Environment (MDE draft August 1997) suggests that the occurrence of chlordane is unpredictable in spatial scope and temporal extent. Seven of the ten samples taken from Back River watershed stations (ZHR0001-upstream and HRR0033-downstream) produced chlordane levels that were either not detected (ND), or less than the level of quantification. Of the three that were measurable, one was at the level of quantification (0.02 ug/L or parts per billion - ppb), one was at 0.03 ug/L, and the third was at 0.08 ug/L (Table 1). Downstream observations were equal to or less than upstream observations.

Table 1 Pesticides in Back River Tributary – 1994

Herring Run	Winter	Spring	Summer-1	Summer-2	Fall
ZHR0001[a]	0.03	ND	0.02	<0.02	0.08
HRR0033[b]	<0.02	ND	<0.02	<0.02	<0.02

Units in ug/L or ppb.

a. Upstream

b. Downstream

Since the level of detection in this study was two orders of magnitude above the EPA water quality criterion for chlordane, and the measured levels were relatively close to the level of detection, the reliability of the data for determining absolute conditions is considered to be questionable.

The only chlordane data from point sources in the watershed is from the Back River wastewater treatment plant. In 1989 no chlordane was detected. More recent sampling in May and August 1998 also produced no detectable chlordane. The detection levels in 1998 were 0.086 ug/L (personal communication – John Martin, Baltimore City DPW).

2.3 Supporting Data

Fish tissue samples serve as a key source of data for chlordane. Two or more fish species, representing bottom feeders and higher trophic level predators, are targeted for collection at each statewide monitoring location. Species having a wide range of occurrence are targeted to allow for regional comparisons in addition to the temporal trends at each network site. Chlordane has been identified in almost every fish tissue sample collected under the State's fish tissue monitoring program, which was institutionalized in 1976. The fish tissue monitoring program currently consists of a network of over thirty monitoring locations where triennial sampling allows for statewide trend assessments. This network is supplemented with additional monitoring sites of suspected concern.

Statewide, most fish tissue chlordane levels have been well below the 0.3 ppm action level established by the U.S. Food and Drug Administration (USFDA). Elevated levels of chlordane in fish tissue have appeared most commonly in urban areas, especially those located near the head of tidal influence. Among the sites of greatest accumulation were Baltimore Harbor (Patapsco River) and Back River. In these water bodies, and Lake Roland (an impoundment on Jones Falls and a tributary to the Patapsco River), the levels of chlordane in selected fish tissues frequently exceeded the action guidelines of the USFDA.

Following the initial surveys of the 1970s, where the results indicated a potential for problems in selected urban areas, additional monitoring efforts were focused on the areas of greatest concern, which included Back River. The limited monitoring conducted in Back River in 1981 substantiated the concern for urban waters and resulted in additional and more definitive monitoring in subsequent years. Results of the monitoring in the Back River watershed are contained in the files of the Department of the Environment and are summarized in Table 2.

Table 2. Fish Tissue Data from Back River

Sampling Year	Species	Sample Type	Concentration mg/kg wet weight	Number of Fish	River Region
1981	Brown bullhead	Whole fish	**0.50**	N/A	1
	White perch	Whole fish	**0.46**	N/A	1
1982	Gizzard shad	Edible portion	0.24	N/A	N/A
	Channel catfish	Edible portion	0.15	N/A	N/A
	White catfish	Edible portion	**0.60**	N/A	N/A
	White perch	Edible portion	0.13	N/A	N/A
1983	American eel	No skin, no head	0.07	1	4
	Brown bullhead	Fillet	**0.31**	15	1
	Channel catfish	Fillet	**0.67**	14	1
	White perch	Fillet	**0.49**	5	1
	White perch	Fillet	0.20	14	4
	Yellow perch	Fillet	0.10	3	1
1985	Channel catfish	Fillet	**1.06**	10	1
	Channel catfish	Fillet	**0.82**	4	2
	Channel catfish	Fillet	**0.77**	5	3
	Channel catfish	Fillet	0.17	24	4
	White perch	Fillet	0.29	20	1
	White perch	Fillet	0.08	3	2
	White perch	Fillet	0.16	19	3
	White perch	Fillet	0.10	27	4
	American eel	No skin, no head	**0.33**	5	1
	American eel	No skin, no head	**0.44**	1	2
	American eel	No skin, no head	0.18	1	4
	Brown bullhead	Fillet	0.24	23	1
	Brown bullhead	Fillet	0.16	18	2
	Brown bullhead	Fillet	0.13	18	3
	Brown bullhead	Fillet	0.15	38	4
	Spot	Fillet	0.08	1	4
	White catfish	Fillet	0.12	1	4
1986	Brown bullhead	Fillet	**0.31**	16	1
	Brown bullhead	Fillet	**0.38**	4	2
	Channel catfish	Fillet	**1.34**	2	1
	Hogchoker	Whole fish	0.15	31	3
	White catfish	Fillet	**1.25**	5	1
	White catfish	Fillet	**0.39**	2	2
	White perch	Fillet	**0.38**	4	1
	White perch	Fillet	0.16	4	2
	White perch	Fillet	0.17	7	3
1987	Channel catfish	Fillet	0.25	11	2
	White catfish	Fillet	**0.39**	1	1
	White catfish	Fillet	0.26	2	4
	Hogchoker	Whole fish	0.08	5	2
	Hogchoker	Whole fish	0.08	5	3
	White perch	Fillet	0.05	1	1
	White perch	Fillet	0.12	11	3
	White perch	Fillet	**0.34**	2	4

N/A – Information not available
*River region = 1 – head of tide, 2 – upper middle, 3, lower middle, 4 – lower region (attachment 3)
Concentrations in bold exceed the USFDA guidance level of 0.3 mg/kg

Since chlordane was detected in a number of fish tissue samples above the 0.3 ppm USFDA action level, primarily in the headwaters region of the estuary, the waterbody was considered to be impaired.

2.4 Technical Methods

Because chlordane was banned nearly 15 years ago, chlordane loadings other than those from existing bottom sediments are expected to be negligible (see Section 4.0, Source Assessment). Consequently the bottom sediments are assumed to be the dominant current day source of chlordane in Back River water and fish tissue[1]. This means that the rate of reduction of chlordane concentrations in the biologically active sediment layer will ultimately control the water column and fish tissue concentrations. Chlordane concentrations in sediments are reduced by a number of processes.

- Burial/dilution of contaminated sediments;
- Dissolution into, followed by vaporization from, the water column;
- Uptake by biota living in the sediment;
- Chemical degradation; and
- Biological degradation.

The dominant processes are likely burial and/or dissolution followed by volatilization from the water body. Eskin *et al.* (1996) estimated sedimentation rates in the Back River estuary to range from 0.2 to 0.93 cm/yr. Howard (1991) provides estimated volatilization half-lives from a representative environmental pond, river and lake as 8-26, 3.6-5.2, and 14.4-20.6 days, respectively. Howard also states that adsorption to sediments can significantly affect the importance of volatilization. Within this system, neither uptake by biota or degradation are expected to significantly reduce chlordane levels in sediments.

Water quality criteria have been developed by EPA to protect marine aquatic life from toxic effects (0.004 ug/L) and to protect humans from the consumption of aquatic organisms (0.0022 ug/L) (EPA 1999). These values were recently updated from the earlier water quality criteria developed by EPA to protect marine aquatic life from toxic effects (0.0043 ug/L) and to protect humans from the consumption of aquatic organisms (0.00059 ug/L) (EPA 1999). As an added margin of safety, the earlier and more conservative ambient water quality criteria for the protection of humans from the consumption of organisms was employed, adding a safety margin of over a factor of three to the TMDL.

An equilibrium approach, based on the EPA 1993 sediment criteria development methodology (EPA 1993), was employed to provide an upper estimate of the dissolved water column concentration based on recent sediment concentrations following the steps provided below.

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[1] Note that Observed data (Eskin 1996), and other analyses (See Section 2.4) suggest that the sediment concentrations of chlordane in the Back River are declining over time due to natural recovery of the estuary, through gradual biodegradation, dispersal, and natural burial by sedimentation.

First, the log K_{oc} is estimated from the log K_{ow} from the empirically derived equation provided below.

$$\log K_{oc} = 0.00028 + 0.983 \times \log K_{ow}$$

where:

K_{ow} = octanol/water equilibrium partition coefficient
K_{oc} = octanol/organic carbon equilibrium partition coefficient

Substituting the experimentally determined log K_{ow} chlordane (5.54) from Howard, 1991 into this equation yields:

$$\log K_{oc} = 0.00028 + 0.983 \times 5.54$$

$$\log K_{oc} = 5.45$$

$$K_{oc} = 279{,}000 \text{ L/kg}$$

The concentration in water in equilibrium with this sediment can be estimated by the equation provided below. It should be emphasized that this best represents the pore water concentration and the overlying water column may be subject to greater dilution.

$$C_w = C_s / (f_{oc} \times K_{oc})$$

where:

C_w = concentration in water (ug/L)
C_s = concentration in sediment (ug/kg)
f_{oc} = fraction organic carbon (unitless)
K_{oc} = organic carbon/water equilibrium partition coefficient (L/kg)

Recent measurements of Back River sediments (Baker *et al.* 1997) indicate an average concentration of 1.12 ng/g (dry weight) for chlordane, 5.06% total carbon (dry weight). Applying these values yields a predicted water column concentration of 0.0000793 ug/L (7.93×10^{-5} ug/L), significantly lower than the most conservative water quality criteria.

$$C_w = C_s / (f_{oc} \times K_{oc})$$

$$C_w = 1.12 \text{ ug/kg} / (0.0506 \text{ g/g} \times 279{,}000 \text{ L/kg})$$

$$C_w = 0.0000793 \text{ ug/L} = 7.93 \times 10^{-5}$$

This equilibrium approach can also be used to estimate a sediment quality benchmark (SQB) from the water quality criteria as shown in the equation below (EPA 1993).

$$SQB = WQC \times f_{oc} \times K_{oc}$$

where:

WQC = water quality criteria

Substituting 0.00059 ug/L value for the water quality criteria in the above equation:

$$SQB = 0.00059 \text{ ug/L} \times 0.0506 \text{ g/g} \times 279{,}000 \text{ L/kg}$$

$$SQB = 8.33 \text{ ug/kg or } 8.33 \text{ ng/g}$$

Current sediment levels (1.12 ng/g dry weight) are well below the calculated SQB. This represents indirect evidence that sediment concentrations of chlordane have declined below levels that would result in elevated fish tissue levels.

Direct evidence of this decline is provided by comparing the recent concentration of chlordane in Back River sediments to older studies. Baker *et al.* 1997 report an average chlordane concentration of 1.12 ng/g in Back River sediments while Eskin *et al.* 1996 report 22.4 ng/g in 1991. Although historical data are sparse, these data indicate a twenty-fold decrease in measured chlordane concentrations over a five year period. This indicates that natural attenuation processes have already reduced chlordane levels below all pertinent water quality criteria and sediment quality benchmarks. Further, it is anticipated that continued watershed monitoring efforts will indicate a corresponding reduction in fish tissue concentrations as well as continued reductions in sediment concentrations.

3.0 TARGETED WATER QUALITY GOALS

Although the State has not adopted any specific guidance levels for chlordane in its regulations or water quality standards, it does take action on environmental contaminants that significantly increase the risk of cancer. The level of significance used by the State in these analyses is that level that produces an increased risk greater than one in 100,000 of the population. This is generally expressed as a risk that is greater than 1.0×10^{-5}. Assuming that the general population has a risk of cancer from all causes of at least 25%, or 25,000 in 100,000, the threshold for concern for a single substance would increase the general risk to 25,00<u>1</u> in 100,000.

The United States Food and Drug Administration (USFDA) has established specific guidance levels for fish tissue in the commercial market. This level of 0.3 mg/kg (≈ parts per million (ppm)), in association with the assumed average daily consumption of fish (6.5 grams per day), produces an estimated excess cancer risk associated with chlordane of 1.0×10^{-5}. Since this value approximates the 1.0×10^{-5} level of risk used by the State for determining levels of significant excess cancer risk, Maryland generally considers waters to be impaired when edible fish tissue levels for any species exceed the USFDA guidance level of 0.3 mg/kg. Project endpoints for the control or mitigation of chlordane as it affects the edibility of fish taken from Back River in the future would be linked to the achieving of a reduction of chlordane in the targeted fish tissues to a level of 0.3 mg/kg or less.

4.0 SOURCE ASSESSMENT

The majority of environmental loadings of chlordane were required to cease as of 1988 with the end of authorized commercial use. However, stocks held by homeowners could be a continuing source, as would be the erosion and transport of existing soils previously contaminated by chlordane and related compounds. Occasional studies of urban and agricultural runoff, as presented in Section 2.2, detect minute amounts of chlordane, but the occurrence is not sufficiently stable to allow for the identification of definitive sources (MDE draft 1997, see Section 2.2). Thus, there do not appear to be any defined sources of chlordane to control or regulate at this time. These undefined sources are gradually diminishing, and are not believed to constitute a significant contribution to the existing conditions in the estuary.

Chlordane is not an expected substance in point source discharges. If it were to occur in municipal discharges, it would be through intermittent, illicit, and generally untraceable sources. Therefore, further regulation and control of point sources is not considered to be a viable means of controlling the environmental occurrence of chlordane. Efforts to enhance these source reductions are being promoted by local governments through the offering of "household hazardous chemical disposal days." These offerings have been ongoing since the late 1980s and are continuing to provide local citizens with an environmentally acceptable means of disposal. Similar efforts have been extended to farmers for disposal of agricultural chemicals no longer suitable for use.

5.0 TOTAL MAXIMUM DAILY LOADS AND LOAD ALLOCATIONS

Chlordane is a persistent substance, which has a high affinity for sediment adsorption and generally settles to the bottom with the sediment in the estuary. Water column measurements are thus generally extremely low and difficult to achieve in a manner that would allow for the adequate characterization of a large estuarine system. Sediment analyses are also costly and provide information only on the precise location where sampling occurred. Fish tissue, however, serves to accumulate and integrate bioaccumulative contaminants, such as chlordane, and is, therefore, the preferred endpoint measure of environmental contamination for this substance.

Water Quality Endpoint: As noted above, the water quality endpoint for this TMDL is expressed in terms of achieving the specific criterion for which Back River was identified on the 303(d) list. Specifically, the current US FDA guidance level for fish tissue concentrations of 0.3 mg/kg were used to determine the need to list Back River as being impaired by chlordane. Consequently, this value is the appropriate water quality endpoint.

Total Maximum Daily Load: The computations provided above establish a linkage of the fish tissue water quality endpoint of 0.3 mg/kg to a water column concentration of 0.00059 ug/L or less (EPA 1980). Thus, MDE is establishing a concentration of 0.00059 ug/L as the appropriate measure for the Back River chlordane TMDL.

Seasonal Variations and Critical Conditions: The TMDL is represented as a concentration level that is protective of toxic human health effects *at all times*. Implicitly, the TMDL accounts for seasonal variations since it is protective throughout the year (i.e., "at all times"). This situation does not present an issue of controlling for critical conditions for several reasons. First, the notion of "critical conditions" does not arise in the traditional sense for this TMDL. The allowable concentrations of chlordane are based on human fish consumption over a long time period, which averages out any critical events. Additionally, human health standards, upon which the TMDL is founded, account critical sub-populations that might be more susceptible to toxic risk. Second, the TMDL is protective at all times, which implies that any "critical conditions" within that timeframe are considered. Finally, the TMDL level established to be protective of human health are more conservative than the chlordane levels established to protect environmental resources, implying that critical conditions for environmental resources are also addressed by the previous logic that applied to human health.

TMDL Allocation: The studies referenced above suggest that the transient events, in which minute levels of chlordane have been observed in association with point and nonpoint sources, are too insignificant to support the quantification of meaningful allocations to these sources. Existing chlordane in the bottom sediment layer of the estuary is the only significant source causing elevated fish tissue concentrations. Therefore, the sole allocation of chlordane is to the existing bottom sediments of the Back River estuary.

Margin of Safety: EPA's TMDL guidance requires each TMDL to include a margin of safety (MOS) that accounts for uncertainty in the relationship between pollutant sources and the quality of the receiving waters. The USDA fish tissue guidance level, which serves as the water quality measurement endpoint, identified the specific need for a TMDL.
The older and more conservative US EPA ambient water quality standard for the protection of humans from the ingestion of aquatic life (0.00059 ug/L) serves as the basis of the TMDL. This criterion is more conservative than the current ambient water quality criteria (0.0022 ug/L) and was employed to add a margin of safety.

TMDL Summary:

Based on the previous discussion, the TMDL or Chlordane may be summarized as follows:

TMDL	=	WLA	+	LA	+	MOS
0.00059	=	0	+	0.00059	+	built-in

(ug/l – at all times). No future allocation is provided.

Where, WLA is Waste Load Allocation
LA is Load Allocation, and
MOS is Margin of Safety

Reasonable Assuredness of Implementation: The State of Maryland is committed to protecting the State's rivers, streams, lakes, wetlands, and estuaries. Observed data (Eskin 1996) suggest that the sediment concentrations of chlordane in the Back River are declining over time due to natural recovery of the estuary, through gradual biodegradation, dispersal, and natural burial by sedimentation. The computations provided in Section 2.4 suggest that current sediment concentrations of chlordane are below levels expected to result in elevated fish tissue concentrations. No observations of fish tissue are currently available to confirm this, and older fish may continue to have elevated levels due to past bioaccumulation.

Aside from the processes of natural recovery, dredging of this shallow estuary would be the only other means of removing the chlordane-contaminated sediments. Environmental concerns and the high costs associated with dredging place the chlordane impairment in Back River in the category of "Extremely Difficult Problems" as defined in Chapter 6 of the Report of the Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program.

In consideration of the very difficult and extremely costly process that would be involved in removing the contaminated sediments, Maryland is proposing to institute an iterative monitoring and evaluation process to track the natural attenuation of the contaminant as the means of ensuring minimal impact to human health and the environment. Routine sediment and fish tissue monitoring in the estuary, with occasional stream and water column samples, will be established on a time frame sufficient to ensure the discernment of trends. At a minimum, triennial monitoring of the fish and surficial sediments will be conducted in the estuarine or tidal portion of the river. An evaluation of the required sampling frequency will be considered each year as information from the statewide monitoring network is developed.

6.0 PUBLIC INVOLVEMENT

Maryland's inventory of water quality is documented in a report prepared under section 305(b) of the Clean Water Act (CWA). This report, commonly called the "305(b) Report", serves as the primary source of information used to develop Maryland's 303(d) list of water quality limited segments. The 305(b) report is developed with consideration of information provided by State agencies, local governments, and citizens. The 303(d) list, which is updated every two years, undergoes a formal public comment process.

In reviewing options for managing the concerns regarding chlordane in fish tissue, the State opted to issue fish consumption guidelines. A press release issued on February 5, 1986 provided the initial information to the public and continuing information is provided via notification in the fishing guidebooks provided to all licensed anglers in the State.

Notice has been published annually in the State's tidewater fishing guide since the late 1980's. The specific language in the guide is as follows:

Salt Water Fishing Health Advisory

- “Individuals are advised to limit their consumption of channel catfish and American eels from Back River and the Baltimore Harbor because the contamination level of chlordane exceeds FDA’s approved standards.
- These fish should not be used as a substantial part of the daily diet.
- These fish should be avoided by women of childbearing age, infants, and children.”

Various public information and education documents have been prepared to help reduce the potential for unacceptable exposure by the fish-consuming public. Fact sheets advising of “Contaminants and Toxicity” (attachment 4) and “Monitoring Contamination Levels in Fish, Shellfish and Crabs” (attachment 5) have been produced and distributed by the Department of the Environment. Additional public information literature has been prepared to assist individuals in minimizing risks through proper preparation of fish for consumption.

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Appendix K

Water Quality Analysis of Zinc in Back River, Baltimore County and Baltimore City, Maryland

December 23, 2004

Water Quality Analysis of Zinc in Back River, Baltimore County and Baltimore City, Maryland

FINAL

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Table of Contents

List of Figures

List of Tables

List of Abbreviations

Ag	Silver
As	Arsenic
AVS	Acid Volatile Sulfide
BWO	Baltimore/Washington International Airport
CBL	Chesapeake Biological Laboratory
Cd	Cadmium
cm	Centimeter
COMAR	Code of Maryland Regulations
Cr	Chromium
Cu	Copper
CWA	Clean Water Act
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EPA	Environmental Protection Agency
ERM	Effects Range Median
HAC	Hardness Adjusted Criteria
MDE	Maryland Department of the Environment
mg/l	Milligrams per Liter
NPDES	National Pollution Discharge Elimination System
NWS	National Weather Service
Pb	Lead
PCBs	Polychlorinated biphenyls
ppt	Parts per Thousand
SCS	Soil Conservation Service
SEM	Simultaneously Extracted Metals
SSURGO	Soil Survey Geographic
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WER	Water Effects Ratio
WQA	Water Quality Analysis
WQLS	Water Quality Limited Segment
µg/l	Micrograms per Liter
Zn	Zinc

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, the State is to either establish a Total Maximum Daily Load (TMDL) for the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met.

Back River (basin code 02-13-09-01), located in Baltimore County and Baltimore City, MD, was identified on the State's list of WQLSs as impaired by nutrients (1996 listing), suspended sediments (1996 listing), chlordane (1996 listing), polychlorinated biphenyls (PCBs) - sediments (1998 listing), zinc (Zn) (1998 listing), fecal coliform (2002 listing) and impacts to biological communities (2002 listing). All impairments were listed for the tidal waters except for the impacts to biological communities, which are listed for the non-tidal region. Code of Maryland Regulations (COMAR) defines the Back River as a fresh waterbody. This report provides an analysis of recent monitoring data, including hardness data, which shows that the aquatic life criteria and designated uses associated with Zn are being met in the Back River. The analyses support the conclusion that a TMDL for Zn is not necessary to achieve water quality standards in this case. Barring the receipt of any contradictory data, this report will be used to support the removal of the Back River from Maryland's list of WQLSs for Zn when the Maryland Department of the Environment (MDE) proposes the revision of Maryland's 303(d) list for public review in the future. The listings for nutrient, PCBs, suspended sediment, fecal coliform and impacts to biological communities will be addressed separately at a future date. A TMDL for chlordane was completed in 1999.

Although the tidal waters of the Back River do not display signs of toxic impairments due to Zn, the State reserves the right to require additional pollution controls in the Back River watershed if evidence suggests that Zn from the basin is contributing to downstream water quality problems.

1.0 INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) and U.S. Environmental Protection Agency (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. This list of impaired waters is commonly referred to as the "303(d) list". For each WQLS, the state is to either establish a Total Maximum Daily Load (TMDL) for the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met.

A segment identified as a WQLS may not require the development and implementation of a TMDL if current information contradicts the previous finding of an impairment. The most common factual scenarios obviating the need for a TMDL are as follows: 1) more recent data indicating that the impairment no longer exists (i.e., water quality criteria are being met); 2) more recent and updated water quality modeling demonstrates that the segment is now attaining criteria; 3) refinements to water quality criteria, or the interpretation of those standards, which result in standards being met; or 4) correction to errors made in the initial listing.

Back River (basin code 02-13-09-01) was identified on the State's 1996 303(d) list as impaired by nutrients, suspended sediment and chlordane, with zinc (Zn) and polychlorinated biphenyls (PCBs) impairments added to the list in 1998, and fecal coliform and impacts to biological communities added to the list in 2002. All impairments were listed for the tidal waters except for the biological impairment, which is listed for the non-tidal region. Code of Maryland Regulations (COMAR) defines the Back River as a fresh waterbody.

The initial listing for Zn was based on seven sediment samples collected in the Back River for the Baltimore Harbor Spatial Mapping Study conducted in 1996 (Baker, 1997). All seven samples exceeded the Effects Range Median (ERM) for Zn indicating the potential for toxicity. Current studies suggest that an exceedance of the ERM is an insufficient indicator of toxicity due to mitigating factors such as the presence of sulfide, which binds metals in a non-toxic form. A Water Quality Analysis (WQA) of Zn for the tidal waters of Back River was conducted using recent water column chemistry data, sediment chemistry data and sediment toxicity data. Results show no impairment for Zn. The nutrient, suspended sediment, PCB, sedimentation and fecal coliform impairments will be addressed separately at a future date. A TMDL for chlordane was completed in 1999.

The remainder of this report lays out the general setting of the waterbody within the Back River watershed, presents a discussion of the water quality characterization process, and provides conclusions with regard to the characterization. The most recent data establishes that the Back River is achieving water quality standards for Zn.

2.0 GENERAL SETTING

The Back River watershed is located in the Patapsco/Back River region of the Chesapeake Bay watershed within Maryland (see Figure 1). The watershed covers a portion of Baltimore County and Baltimore City. The watershed area covers 34,887 acres.

The Back River watershed lies within the Piedmont and Coastal Plain provinces of Central Maryland. The Piedmont Province is characterized by gentle to steep rolling topography, low hills and ridges. The surficial 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 stream bed. 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 surficial 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 (Coastal Environmental Services, 1995).

The Back River watershed drains from northwest to southeast, following the dip of the underlying crystalline bedrock in the Piedmont Province. The surface elevations range from approximately 500 feet to sea level at the Chesapeake Bay shorelines. Stream channels of the sub-watersheds are well incised in the Eastern Piedmont, and exhibit relatively straight reaches and sharp bends, reflecting their tendency to following zones of fractured or weathered rock. The stream channels broaden abruptly as they flow down across the fall line and into the soft, flat Coastal Plain sediments (Coastal Environmental Services, 1995).

The watershed is comprised primarily of B and C type soils. Soil type is categorized by four hydrologic soil groups developed by the Soil Conservation Service (SCS). The definitions of the groups are as follows (SCS, 1976):

> Group A: Soils with high infiltration rates, typically deep well-drained to excessively drained sands or gravels.
> Group B: Soils with moderate infiltration rates, generally moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
> Group C: Soils with slow infiltration rates, mainly soils with a layer that impedes downward water movement or soils with moderately fine to fine texture.
> Group D: Soils with very slow infiltration rates, mainly clay soils, soils with a permanently high water table, and shallow soils over nearly impervious material.

The soil distribution within the watershed is approximately 1.6% soil group A, 38.2% soil group B, 38.7% soil group C and 21.5% soil group D. Soil data was obtained from Soil Survey Geographic (SSURGO) coverages created by the National Resources Conservation Service.

The Back River watershed is comprised primarily of residential, commercial and industrial land uses (see Figure 2). There are no major industrial facilities discharging zinc within the watershed. The Back River Waste Water Treatment Plant, a major municipal waste facility, discharges metals including zinc at the outlet of Bread and Cheese Creek, a tributary of the Back River Estuary. The land use distribution in the watershed is approximately 17.7 % forest/herbaceous, 79.0 % urban, 1.9 % agricultural and 1.4 % water (Maryland Department of Planning, 2000).

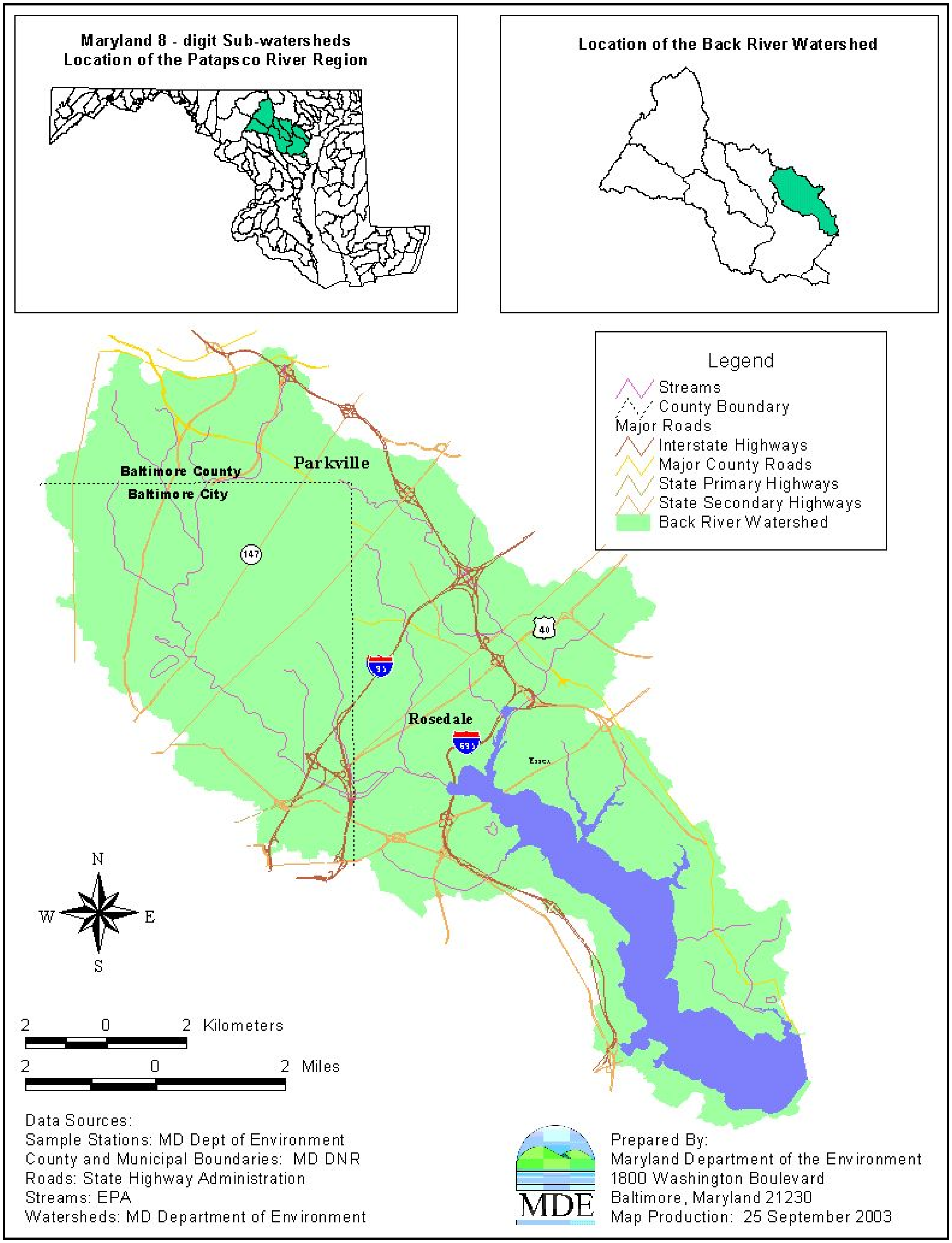

Figure 1: Watershed Map of the Back River

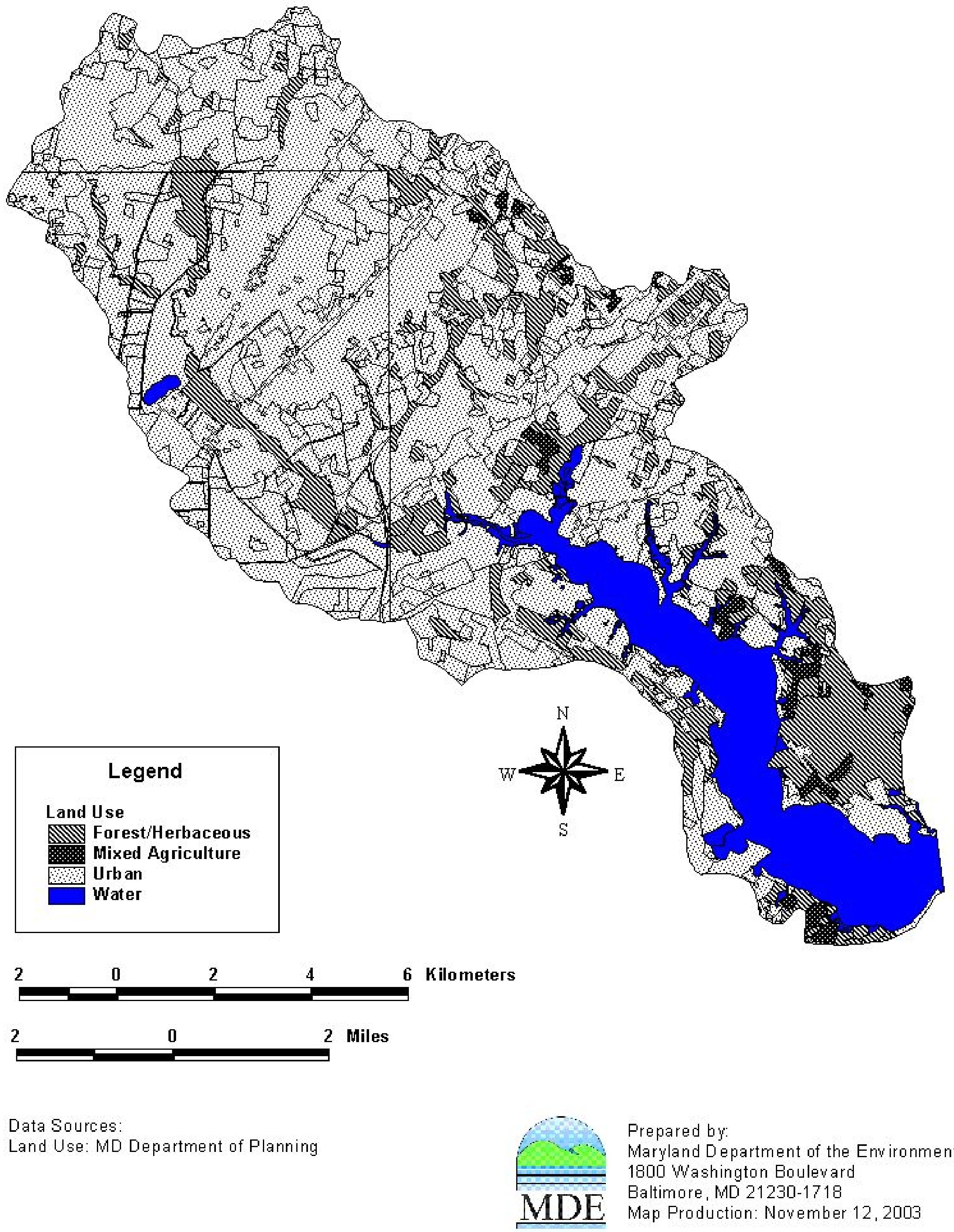

Figure 2: Land Use Map of Back River Watershed

3.0 WATER QUALITY CHARACTERIZATION

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 different designated uses may differ and are dependent on the specific designated use(s) of a waterbody. Maryland's water quality standards presently include numeric criteria for metals and other toxic substances based on the need to protect aquatic life, wildlife and human health. Water quality standards for toxic substances also address sediment quality to ensure the bottom sediment of a waterbody is capable of supporting aquatic life, thus protecting the designated uses.

The Maryland Surface Water Use Designation (COMAR 26.08.02.08J) for the Patapsco River (basin code 02-13-09) and its tributaries (including Back River) is Use I – *water contact recreation, fishing, and protection of aquatic life and wildlife.* COMAR 26.08.02.03-1(B)(3)(j)(ii) defines the tidal region of the Back River basin considered in this WQA as being freshwater.* The freshwater aquatic life criterion for Zn is displayed below in Table 1 (COMAR 26.08.02.03-2G). The water column data presented in Section 3.1, Table 5 through Table 9, show that concentrations of Zn in the water column do not exceed water quality criterion. An ambient sediment bioassay and sediment chemistry analysis conducted in the Back River establishes that there is no toxicity in the sediment bed as a result of zinc contamination. The water column and sediment in the Back River are, therefore, not impaired by Zn. Thus the designated uses are supported and the water quality standard is being met.

Table 1: Numeric Water Quality Criteria

Metal	Fresh Water Aquatic Life Acute Criteria (μg/l)	Fresh Water Aquatic Life Chronic Criteria (μg/l)
Zn	120	120

Water column surveys, used to support this WQA, were conducted at five stations throughout the Back River estuary from January 2001 to September 2001. For every water column sample, the dissolved concentration of Zn was determined. Water column sampling was performed four times at each station from January 2001 to September 2001 to capture seasonal variation. The sampling dates were as follows: 1/24/01 (winter dry weather); 2/25/01 (winter wet weather); 7/23/01 (summer dry weather); 9/20/01 (summer wet weather). Sediment samples were also collected at 21 stations throughout the Back River estuary including those sampled in the water column survey. Sediment samples were analyzed for metals chemistry and toxicity. Table 2

* Even though COMAR 26.08.02.03-1(B)(3)(j)(ii) defines the Back River as a freshwater body, significant variability in salinity concentrations were found during the water column survey. A comparison of zinc concentrations with saltwater aquatic life criteria was also conducted based on new EPA guidance and no exceedances occurred.

shows the list of stations with their geographical coordinates, descriptive location and water quality characterization analyses performed. The station locations are presented in Figure 3.

Table 2: Sample Stations for Back River

Station	Latitude	Longitude	Description	Water Column Chemistry	Sediment Chemistry	Sediment Toxicity
BR-14	39.241	-76.416	Mid Channel below Claybank Point	-	X	X
BR-26	39.243	-76.400	Outlet of Back River between Cedar and Cuckold Point	-	X	X
BR-27	39.247	-76.449	Greenhill Cove	-	X	X
BR-29	39.247	-76.435	East of Lynch Point	-	X	X
BR-36	39.265	-76.453	Shoreline southwest of Stansbury Point	-	X	X
BR-50	39.254	-76.411	Rock Point Park	-	X	X
BR-55	39.259	-76.446	Mid-Channel west of Witchcoat Point	-	X	X
BR-60	39.269	-76.453	Cove below Stansbury Point	-	X	X
BR-74	39.275	-76.445	Mid-Channel northeast of Stansbury Point	-	X	X
BR-89	39.283	-76.439	Muddy Gut	-	X	X
BR-91	39.287	-76.467	Mid-Channel below Cox Point	-	X	X
BR-101	39.289	-76.485	Bread & Cheese Creek	-	X	X
BR-120	39.300	-76.485	Mid-Channel above Greenmarsh Point	-	X	X
BR-126	39.305	-76.499	Headwaters of Back River	-	-	X
BR-134	39.309	-76.490	Northeast Creek	-	-	X
BR-169	39.303	-76.491	Mid-Channel above Eastern Avenue Bridge	-	-	X
XIF-4450	39.238	-76.409	West of Cuckold Point	X	-	-
XIF-5633	39.256	-76.441	Mid-Channel Northwest of Porter Point	X	-	-
XIF-6633	39.272	-76.440	Near Shoreline east of Stansbury Point	X	X	-
XIF-7615	39.290	-76.472	East of Wetherby Point	X	X	X
XIF-8008	39.300	-76.484	Mid-Channel above Greenmarsh Point	X	X	X

X means data is available - means no data available

For the water quality evaluation, a comparison is made between Zn water column concentrations and fresh water aquatic life chronic criterion, the most stringent of the numeric water quality criterion for Zn. Hardness concentrations were obtained for each station to adjust the fresh water aquatic life chronic criteria that were established at a hardness of 100 mg/l for Zn. The State uses hardness adjustment to calculate fresh water aquatic life chronic criteria for Zn whose toxicity is a function of total hardness. According to EPA's National Recommended Water

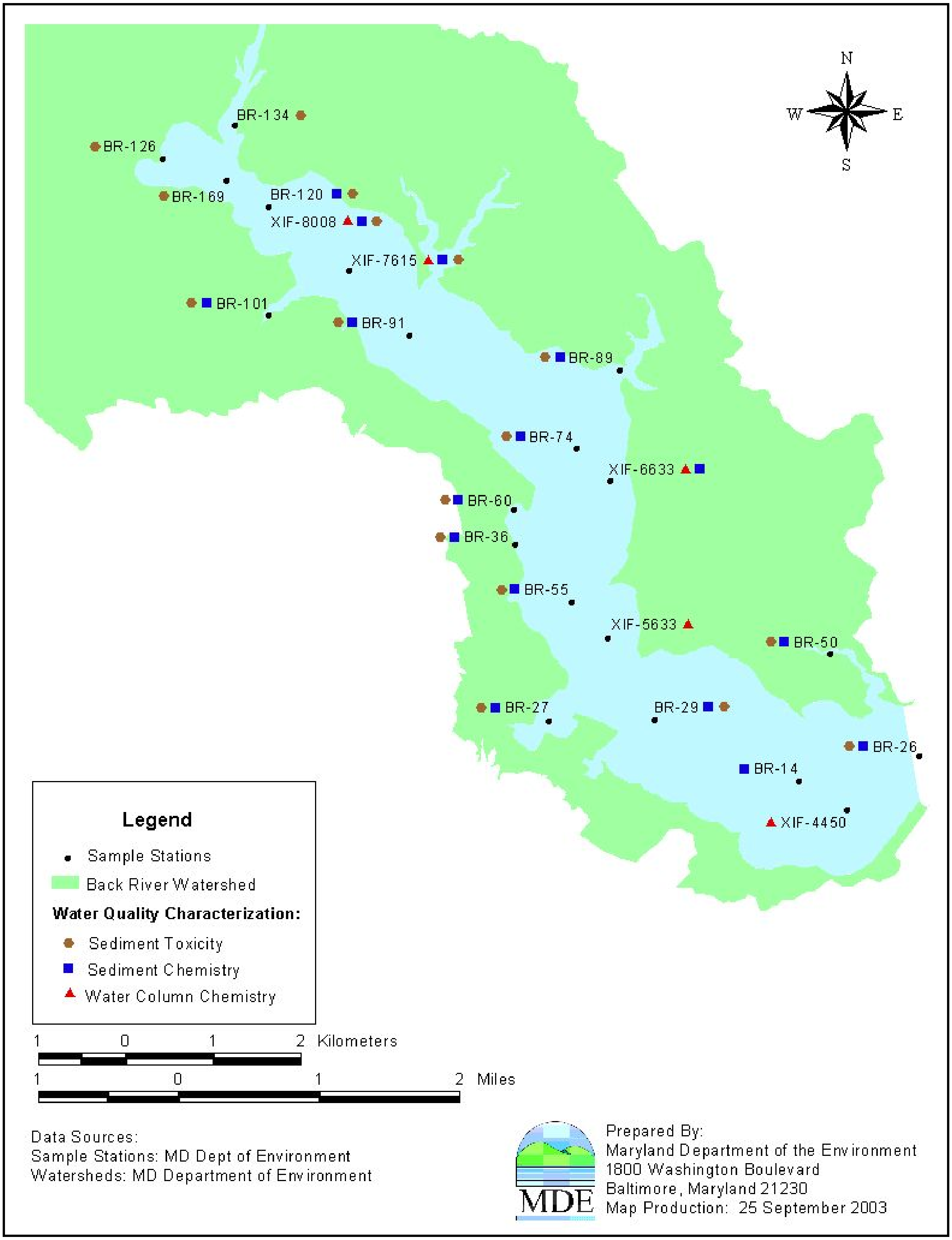

Figure 3: Sample Station Location Map

Quality Criteria (EPA, 2002), allowable hardness values must fall within the range of 25 - 400 mg/l. MDE uses an upper limit of 400 mg/l in calculating the hardness adjusted criteria (HAC) when the measured hardness exceeds this value. Based on technical information, EPA's Office of Research and Development does not recommend a lower limit on hardness for adjusting criterion (EPA, 2002). MDE adopts this recommendation. The HAC equation for Zn is as follows (EPA, 2002):

$$HAC = e^{(m[\ln(Hardness(mg/l))]+b)} * CF$$

Where,

HAC = Hardness Adjusted Criteria (µg/l)
m = slope
b = y intercept
CF = Conversion Factor (conversion from totals to dissolved numeric criteria)

The HAC parameters for Zn are presented in Table 3 (EPA, 2002).

Table 3: HAC Parameters (Fresh Water Aquatic Life Chronic Criteria)

Chemical	Slope (m)	y Intercept (b)	Conversion Factor (CF)
Zn	0.8473	0.884	0.986

The State performs a scientific review of all data submitted where a water quality criterion exceedance was the result of a hardness adjustment below 50 mg/l. This review is necessary because of the scientific uncertainty existing for hardness-toxicity relationships below 50 mg/l due to:

A. Paucity of toxicity test data below 50 mg/l that was used to develop the relationship between hardness and toxicity.
B. Presence/absence of sensitive species in the waterbody of concern.
C. Existence of other environmental conditions (e.g. high Dissolved Organic Carbon (DOC)), which might mitigate the toxicity of metals due to competitive binding/complexation of metals.

In instances where hardness data is not available, the State will calculate an average of existing hardness concentrations for each station. In applying average hardness, the sampling date for which hardness data is unavailable must not fall during a storm event substantially greater than the sampling dates used to calculate the average. A major rainfall event has the potential to reduce hardness below the average. An analysis of rainfall data from the National Weather Service (NWS) precipitation gauge (0180465) at Baltimore/Washington International Airport (BWI) shows no significant variation in storm events for the sampling dates, thus the average will apply. This is the closest gauge to Back River and is likely to be representative of the rainfall events that occur within the watershed.

3.1 WATER COLUMN EVALUATION

A data solicitation for metals was conducted by MDE, and all readily available data from the past five years was considered in the WQA. The water column data is presented in Table 5 through Table 9 for each station and is evaluated using the fresh water aquatic life chronic HAC, the more stringent of the numeric water quality criterion for Zn (Baker, 2001). Each table displays hardness (mg/l), sample concentration (µg/l) and fresh water chronic HAC (µg/l) by sampling date. For example, in Table 5 for the sampling date of 9/20/01 the hardness is 1862 mg/l (400mg/l is used for HAC calculation because of the hardness limit), the hardness adjusted criterion for Zn is 382.4 µg/l and the Zn sample concentration is 5.74 µg/l. The hardness concentrations reported in bold are for sampling dates in which hardness was not measured and an average value was applied. The detection limits for the zinc analysis is displayed in Table 4. A hardness limit of 400 mg/l is applied for fresh water HAC as defined by EPA's National Recommended Water Quality Criteria (EPA, 2002).

Table 4: Metals Analysis Detection Limits

Analyte	Detection Limit (µg/l)
Zn	0.25

Table 5: Station XIF-4450 Water Column Data

Sampling Date	1/24/01		2/25/01		7/23/01		9/20/01	
Hardness (mg/l)	**1490**		**1490**		1118		1862	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Zn	0.3	382.4	14.8	382.4	ND	382.4	5.74	382.4

* Fresh Water Aquatic Life Chronic HAC
ND - Not detected
If hardness is greater than 400 mg/l, then a hardness value of 400 mg/l is used for the HAC calculation.

Table 6: Station XIF-5633 Water Column Data

Sampling Date	1/24/01		2/25/01		7/23/01		9/20/01	
Hardness (mg/l)	**1207**		**1207**		881		1533	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Zn	12.9	382.4	11.3	382.4	ND	382.4	11.1	382.4

* Fresh Water Aquatic Life Chronic HAC
ND - Not detected
If hardness is greater than 400 mg/l, then a hardness value of 400 mg/l is used for the HAC calculation.

Table 7: Station XIF-6633 Water Column Data

Sampling Date	1/24/01		2/25/01		7/23/01		9/20/01	
Hardness (mg/l)	1038		1038		755		1322	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Zn	16.9	382.4	15.1	382.4	ND	382.4	4.3	382.4

* Fresh Water Aquatic Life Chronic HAC
ND - Not detected
If hardness is greater than 400 mg/l, then a hardness value of 400 mg/l is used for the HAC calculation.

Table 8: Station XIF-7615 Water Column Data

Sampling Date	1/24/01		2/25/01		7/23/01		9/20/01	
Hardness (mg/l)	539		539		320		758	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Zn	38.3	382.4	21.6	382.4	ND	316.5	6.1	382.4

* Fresh Water Aquatic Life Chronic HAC
ND - Not detected
If hardness is greater than 400 mg/l, then a hardness value of 400 mg/l is used for the HAC calculation.

Table 9: Station XIF-8008 Water Column Data

Sampling Date	1/24/01		2/25/01		7/23/01		9/20/01	
Hardness (mg/l)	354		354		221		486	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Zn	24.6	344.8	24	344.8	ND	231.3	2.9	382.4

* Fresh Water Aquatic Life Chronic HAC
ND - Not detected
If hardness is greater than 400 mg/l, then a hardness value of 400 mg/l is used for the HAC calculation.

The range of concentrations for Zn sampled in the field survey is as follows:

Zn = ND to 38.3 µg/l

Hardness ranged from 221 mg/l to 1862 mg/l. The concentration range of Zn is well below the associated fresh water aquatic life chronic HAC. The criterion was not exceeded by any of the Zn samples.

3.2 SEDIMENT QUALITY EVALUATION

To complete the WQA, sediment quality in the Back River was evaluated using 28-day whole sediment tests with the estuarine amphipod *Leptocheirus plumulosus* (Fisher, 2002*).* This species was chosen because of its ecological relevance to the waterbody of concern. *L. plumulosus* is an EPA-recommended test species for assessing the toxicity of marine and estuarine sediments (EPA, 2001). Eighteen surficial sediment samples were collected using a petite ponar dredge (top 2 cm) by in the Back River. Refer back to Figure 3 for the station locations. The samples were collected in two batches. The first batch was collected by CBL on 7/23/01 at fifteen stations throughout the Back River. The second batch was collected by the MDE field office on 8/17/01 at three stations in the upper tidal reaches of Back River. A separate sediment toxicity test was required for each batch. The results of Test I (fifteen samples) and Test II (three samples) are presented in Table 10 and Table 11. Twenty amphipods were exposed to the sediment in each sample test. The table displays amphipod survival (#), amphipod growth rate (mg/day), neonates (#), average amphipod survival (%), average amphipod growth rate (mg/day) and average neonates per survivor.

The test considers three performance criteria, which are survival, growth rate, and reproduction. For the test to be valid the average survival of control sample replicates must be greater than 80%, and there must be a measurable growth rate and reproduction of neonates in the control samples. Survival of amphipods in the field sediment samples was not significantly less than the average survival demonstrated in the control samples. This comparison was made using Fisher's Least Significance Difference (LSD) test (ά = 0.05). The average survival for control samples in Test I and II were 84% and 89%. The field sediment sample average survival results were no lower than 77% for Test I and no lower than 88% for Test II. No sediment samples in the Back River exhibited toxicity contributing to mortality.

Table 10: Sediment Toxicity Test I Results

Sample	Amphipod Survival (#)	Amphipod Growth Rate (mg/day)	Neonates (#)	Average Amphipod Survival (%)	Average Amphipod Growth Rate (mg/day)	Average Neonates/survivor
Control A	18	0.052	61	84	0.046	3.3
Control B	15	0.057	75			
Control C	16	0.05	46			
Control D	20	0.036	80			
Control E	15	0.035	30			
BR-126 A	16	0.026	7	77	0.039	1.2
BR-126 B	18	0.045	21			
BR-126 C	14	0.054	7			
BR-126 D	18	0.038	25			
BR-126 E	11	0.034	29			
BR-134 A	16	0.064	58	82	0.045	1.7
BR-134 B	17	0.036	31			
BR-134 C	17	0.027	21			
BR-134 D	14	0.057	7			
BR-134 E	18	0.039	16			
BR-169 A	15	0.033	20	82	0.041	1.5
BR-169 B	15	0.048	18			
BR-169 C	19	0.036	0			
BR-169 D	20	0.042	25			
BR-169 E	13	0.045	51			

Table 11: Sediment Toxicity Test II Results

Sample	Amphipod Survival (#)	Amphipod Growth Rate (mg/day)	Neonates (#)	Average Amphipod Survival (%)	Average Amphipod Growth Rate (mg/day)	Average Neonates/survivor
Control A	17	0.069	86	89	0.068	4.1
Control B	17	0.065	76			
Control C	20	0.075	118			
Control D	16	0.068	43			
Control E	19	0.063	49			
BR-14 A	20	0.05	47	99	0.057	3.6
BR-14 B	20	0.067	145			
BR-14 C	20	0.051	58			
BR-14 D	20	0.054	72			
BR-14 E	19	0.064	37			
BR-26 A	20	0.058	64	98	0.055*	3.3
BR-26 B	19	0.066	95			
BR-26 C	20	0.056	89			
BR-26 D	19	0.045	36			
BR-26 E	20	0.052	64			
BR-27 A	20	0.056	149	99	0.063	8.3
BR-27 B	20	0.059	191			
BR-27 C	20	0.067	120			
BR-27 D	20	0.064	184			
BR-27 E	19	0.066	172			
BR-29 A	19	0.076	139	93	0.063	4.7
BR-29 B	20	0.061	87			
BR-29 C	17	0.053	51			
BR-29 D	18	0.069	101			
BR-29 E	19	0.057	65			
BR-36 A	16	0.047	88	89	0.055*	4.9
BR-36 B	18	0.058	33			
BR-36 C	19	0.058	95			
BR-36 D	16	0.06	109			
BR-36 E	20	0.051	107			
BR-50 A	20	0.05	239	99	0.059	7
BR-50 B	20	0.065	146			
BR-50 C	19	0.061	128			
BR-50 D	20	0.064	117			
BR-50 E	20	0.053	70			
BR-55 A	19	0.071	169	97	0.058	6.7
BR-55 B	20	0.053	132			
BR-55 C	20	0.06	75			
BR-55 D	19	0.053	141			
BR-55 E	19	0.055	131			

* Sample Toxicity

BR-60 A	18	0.048	72	89	0.06	6.5
BR-60 B	20	0.055	111			
BR-60 C	17	0.065	182			
BR-60 D	15	0.079	109			
BR-60 E	19	0.053	100			
BR-74 A	20	0.067	157	92	0.07	6.6
BR-74 B	19	0.064	79			
BR-74 C	19	0.063	134			
BR-74 D	17	0.064	147			
BR-74 E	17	0.092	88			
BR-89 A	18	0.06	142	95	0.059	6.7
BR-89 B	20	0.046	110			
BR-89 C	21	0.064	158			
BR-89 D	19	0.063	89			
BR-89 E	18	0.064	140			
BR-91 A	19	0.056	65	95	0.073	7.6
BR-91 B	20	0.081	263			
BR-91 C	18	0.092	134			
BR-91 D	18	0.076	142			
BR-91 E	22	0.061	131			
BR-101 A	19	0.064	79	90	0.053*	3.3
BR-101 B	20	0.056	83			
BR-101 C	18	0.056	55			
BR-101 D	17	0.048	72			
BR-101 E	16	0.041	19			
BR-120 A	19	0.064	130	88	0.063	5.1
BR-120 B	17	0.066	87			
BR-120 C	17	0.057	36			
BR-120 D	18	0.055	25			
BR-120 E	17	0.072	170			
XIF-7615 A	20	0.051	119	90	0.06	6.1
XIF-7615 B	18	0.052	141			
XIF-7615 C	20	0.07	121			
XIF-7615 D	15	0.057	74			
XIF-7615 E	17	0.068	101			
XIF-8008 A	19	0.065	92	94	0.065	5.3
XIF-8008 B	19	0.067	108			
XIF-8008 C	19	0.055	132			
XIF-8008 D	17	0.074	111			
XIF-8008 E	20	0.062	46			

* Sample Toxicity

Similarly, measurable average amphipod reproduction observed in the field sediment samples, which ranged from 1.2 to 1.7 neonates/survivor in Test I and 3.3 to 8.3 neonates/survivor in Test II, were not significantly less than the reproduction of 3.3 and 4.1 neonates/survivor observed in the control samples for Test I and Test II. This comparison was made using Fisher's Least Significance difference (LSD) test. No sediment samples exhibited toxicity contributing to a lower reproduction.

Average amphipod growth rates were not significantly less than the control samples, with the exception of three stations in Test II, BR-26, BR-36 and BR-101. This comparison was made using Fisher's Least Significance difference (LSD) test. The control sample exhibited an average growth rate of 0.068 mg/day, in contrast to 0.055 mg/day at stations BR-26 and BR-36 and 0.053 mg/day at station BR-101, therefore these stations exhibit toxicity contributing to a reduction in growth.

Ambient sediment bioassays are only capable of establishing the existence of sediment toxicity therefore further analysis was required to determine whether zinc contamination was the primary source of toxicity. A sediment chemistry analysis was conducted in order to measure Zn concentrations within the sediment (Baker, 2001). The analysis was conducted on sixteen of the sediment samples. The sediment concentrations are presented in Table 12 in units of mg/kg dry weight.

Table 12: Zinc Sediment Concentrations

Station	Date	Concentration (mg/kg)
BR-14	7/23/01	349
BR-26	7/23/01	237
BR-27	7/23/01	573
BR-29	7/23/01	358
BR-36	7/23/01	87
BR-50	7/23/01	384
BR-55	7/23/01	664
BR-60	7/23/01	461
BR-74	7/23/01	508
BR-89	7/23/01	132
BR-91	7/23/01	1107
BR-101	7/23/01	1569
BR-101	8/14/03	1110
BR-120	7/23/01	437
XIF-6633	7/23/01	275
XIF-7615	7/23/01	788
XIF-8008	7/23/01	721
XIF-8008	8/13/03	627

The Effects Range Median (ERM) concentration has been used as a screening level indicator of toxicity within the sediment. If the concentration of the pollutant exceeds the ERM it is likely (i.e., a 50% chance) that sediment toxicity will occur. The ERM cannot solely predict toxicity due to mitigating factors such as the presence of acid volatile sulfide (AVS) which reduces the bioavailability of Zn through the formation of an insoluble metallic sulfide compound. The ERM concentration of Zn is 410 mg/kg (dry weight). Stations BR-27, BR-55, BR-60, BR-74, BR-91, XIF-7614 and XIF-8008 exceeded the ERM but did not show signs of sediment toxicity as established by the ambient sediment bioassay, therefore Zn has likely formed an insoluble metallic sulfide and is biologically unavailable to the benthic organisms. Stations BR-26 and BR-36 have Zn concentrations of 237 mg/kg and 87 mg/kg, which are significantly lower than the ERM of 410 mg/kg, thus Zn is not a source of toxicity. Station BR-101 has Zn concentrations of 1569 mg/kg and 1110 mg/kg, which are significantly higher than the ERM.

An AVS-Simultaneously Extracted Metals (SEM) analysis was conducted for station BR-101 to determine whether AVS had completely bound Zn within the sediment (Baker, 2003). AVS-SEM is generally used as an indicator of toxicity due to metals. When the AVS/SEM concentration ratio is greater than one, metals within the sediment are no longer bioavailable due to the formation of insoluble metallic sulfides resulting in no metals toxicity. The concentrations of AVS and its associated metals (Zn, Chromium (Cr), Copper (Cu), Arsenic (As), Silver (Ag), Cadmium (Cd) and Lead (Pb)) are presented in Table 13 in units of µmol/g (dry weight).

Table 13: AVS-SEM Concentrations

Substance	Concentration (umol/g)
AVS	20.4
Cr	1.34
Cu	0.349
Zn	12.3
As	0.0081
Ag	0.0022
Cd	0.0427
Pb	0.823
Sum SEM umol/g=	**14.9**
AVS/SEM Ratio =	**1.4**

With an AVS/SEM ratio of 1.4, Zn is not a source of toxicity. A porewater analysis of this sample was conducted at the same time to confirm that Zn was primarily bound as a metallic sulfide compound and did not partition into the dissolved phase (Baker, 2003). The Zn porewater concentration was 0.65 µg/l which is significantly lower than the fresh water chronic aquatic life criterion of 120 µg/l. The dissolved Zn concentration in the porewater is much lower than in the water column due to anoxic conditions and high levels of sulfide in the sediment.

Significant sulfide binding results in greater partitioning of metals to the sediment relative to the partitioning of metals to suspended particles in the water column.

4.0 CONCLUSION

The WQA shows that the water quality standard for Zn is being achieved. Water column samples collected at five monitoring stations in the Back River, from January 2001 to September 2001, demonstrate that numeric water quality criterion is being met. Bottom sediment samples collected at eighteen monitoring stations, and used for bioassay toxicity tests, demonstrate no impacts on survival and reproduction, and growth rate impacts at three of the eighteen stations, BR-26, BR36 and BR-101. A sediment chemistry analysis demonstrated that Zn concentrations at Stations BR-26 and BR-36 were significantly below the ERM, therefore Zn was not an impairing substance. Even though station BR-101 exhibited a zinc concentration much greater than the ERM, an AVS-SEM and porewater analysis also demonstrated that Zn was not a source of toxicity. Barring the receipt of any contradictory data, this information provides sufficient justification to revise Maryland's 303(d) list to remove Zn as impairing substances in the Back River.

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