Lower Jones Falls Watershed Small Watershed Action Plan

Prepared for

Baltimore County Department of Environmental Protection and Resource Management
Towson, Maryland

and

U.S. Environmental Protection Agency
Region III

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ACKNOWLEDGEMENTS

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TECHNICAL ASSISTANCE/REPORTS

Development of the Lower Jones Falls 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 Suzanne Greene – Jones Falls Watershed Association
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Watershed Characterization	Steve Stewart, Nathan Forand, Chris Barnes - DEPRM

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Executive Summary

E1. Introduction

The Lower Jones Falls watershed is a unique state and local resource in the Metropolitan Baltimore region. The lower portion of the watershed is densely populated containing several landmarks including the Baltimore Zoo, Pimlico Race Course, and many high schools, colleges and universities including Loyola College, College of Notre Dame and John Hopkins University. The river lends its name to the Jones Falls Expressway, Route I-83, one of the primary transportation routes into Baltimore City, which parallels the river until the river flows into a stormdrain near Penn Station. The Jones Falls River then emerges at Fayette Street and, within a few blocks, discharges into the Baltimore Inner Harbor. Common in most cities, much of the water quality degradation is due to urbanization that occurred prior to modern stormwater regulations. The River is listed on the State of Maryland's 303d list of impaired waters for nutrients, sediment, PCBs and fecal coliform (MDE, 2006), but at the same time, the upper portion of the watershed supports a reproducing trout population.

This Small Watershed Action Plan (SWAP) for the Lower Jones Falls Watershed (Figure 1.1) details the actions necessary to improve conditions in the watershed, based on a series of fieldwork assessments and a stakeholder process. This SWAP was developed as part of a larger watershed planning effort in the Back River and Jones Falls Watersheds which both drain from Baltimore City and County. The process involved a unique partnership between Baltimore City (the City), Baltimore County (the County), the Herring Run (HRWA) and Jones Falls Watershed Associations (JFWA) and the Center for Watershed Protection, Inc. (the Center). This study focused on six subwatersheds in the Jones Falls watershed that predominantly have urban land use.

Existing Geographic Information System (GIS) data was the basis for much of the initial compilation of data. Along with this data collection, partners participated in a technical advisory committee, stakeholder process meetings, and fieldwork assessments. The technical advisory committee consisted of representatives from each partner that met regularly to guide the watershed planning process. In addition, three stakeholder meetings with the partners and volunteers were held to provide input to the process.

A series of fieldwork assessments conducted included stream impact assessments (Unified Stream Assessment), limited geomorphic assessments, an upland pollution source assessment of neighborhoods, institutions, hotspots and pervious areas (Unified Subwatershed and Site Reconnaissance), limited illicit discharge surveys and an assessment of stormwater retrofit opportunities. The results of the assessments are presented by subwatershed in Section 4.0, and are described in more detail in the *Jones Falls Characterization Report* (Baltimore County, 2008). Select stormwater retrofit field forms and conceptual stormwater retrofit project plans are provided in Appendix E. Overall watershed strategies are first presented in Section 2.0 and later in Section 5.0 with associated costs, location, responsible parties, and milestones. A draft schedule for implementation and the expected benefits of implementation are also presented.

E2. Priority Pollutants and Concerns

As part of this report, a number of priority pollutants and concerns were identified for the Lower Jones Falls watershed. Table E-1 lists each pollutant and concern, data source, potential sources of contamination and the negative effects it has on the watershed. Although not classified as a pollutant, hydrologic alteration remains a fundamental driver for pollutant loadings, stream bank erosion and habitat loss and therefore is key consideration in restoration efforts. The leading contributor of each pollutant or concern is urbanization.

Table E-1. Priority Pollutants and Concerns in the Jones Falls Watershed

Pollutant or Concern	Data Source	Potential Sources of Contamination	Watershed Effects
1. Nutrients (Nitrogen and Phosphorus)* 15% reduction goals for Nitrogen and Phosphorus due to nonpoint source pollution[2]	MD 303d list[1]	• Urban runoff • Turf grass and lawns • Atmospheric deposition • Sewage leaks and overflows • Pet waste	• Eutrophication • Dead zones • Contribution to Chesapeake Bay pollution
2. Sediment	MD 303d list[1]	• Streambank erosion • Urban runoff • Construction sites	• In-stream habitat loss • Reduced depth in tidal creeks • Reduced light penetration for SAV growth
3. Bacteria ** Reductions needed to meet water quality standards range from a 92-98% reduction[2]	MD 303d list[1]	• Urban runoff • Pet waste • Wildlife • Septic systems • Improper disposal of boat waste	• Swimming and water contact related illnesses • Shellfish harvesting concerns
4. Biological Impairment	MD 303d list[1]	• Hydrologic alteration stormwater • Illicit discharges • Thermal impacts	• Loss of sensitive species
5. Polychlorinated Biphenyls (PCBs) (Lake Roland)	MD 303d list[1] State of Maryland	• Old electrical transformers • landfills	• Fish and biological contamination
Reference: [1]MDE 2006; *Nutrient TMDL issued for Baltimore Harbor – MDE 2007, ** Bacteria TMDL finalized [2]More detail on the TMDL can be found in the Watershed Characterization Report in Appendix E			

E3. Goals and Strategies

After receiving input from residents and other watershed stakeholders on what goals were deemed important to the community at large, the following set of goals were drafted to guide strategies of the Lower Jones Falls Watershed Management Plan.

1. Improve conditions in stream to achieve standards of swimmable, fishable, and water contact recreation in streams by 2022. Ensure that the streams are safe for our children to play in.
2. Improve the condition of the biology in the stream
3. Implement effective watershed education.
4. Increase the involvement of the population
5. Disconnect impervious surfaces from the stormdrain system
6. Integrate stormwater and watershed planning goals in new and redevelopment.
7. Continue collaboration between Baltimore City/County, watershed groups and citizens.
8. Engage the business community in restoration
9. Improve management of natural and turf areas including parks, trails, trees, and streams
10. Improve government management of roadways, streetscapes and public works yards to reduce their impact on stream quality.

Implementation strategies to meet these goals are as follows:

1. **Implement high priority stormwater retrofits** identified throughout the watershed**.**
2. **Develop a neighborhood restoration program** that includes downspout disconnection, tree planting, storm drain stenciling, proper lawn care, watershed education and trash clean-ups.
3. **Continue to investigate illicit discharges along Stony Run, Lower mainstem, and Western Run. Efforts to monitor streams with known illicit discharges are critical to increasing awareness of illicit discharges.**
4. **Increase the tree canopy** by planting trees or other vegetation on large expanses of managed turf identified throughout the watershed**.**
5. **Create a downspout disconnection program** to reduce the volume of stormwater entering the stream.
6. **Support future stream restoration projects** in the form of public education and buffer planting.
7. **Create a watershed education campaign** to reach people on a broad scale.
8. **Provide education on proper lawn care** that reduces the amount of fertilizers and pesticides applied to lawns.
9. **Develop a Business Stewardship Outreach Program** that engages the business community in watershed restoration.
10. **Develop a green institution program that** includes reforestation, stormwater retrofits and pollution prevention.
11. **Integrate stormwater and watershed planning goals into new and redevelopment** projects within the watershed.

E4. Implementation Costs and Schedules

Table E-2 provides the goals achieved, location, responsible parties, and long-term milestones for implementation of each strategy. Table E-3 provides a draft implementation schedule and associated costs for implementing each strategy. The cumulative estimate for implementing the 11 strategies presented in Section 2.0 over the next ten years exceeds $15 million dollars. It should be noted that approximately 45% of that cost is associated with stream restoration. Goal 1, achieve swimmable, fishable, and water contact recreation by 2022, aligns with all of the strategies as it takes a multi-faceted approach to achieve this goal. Preliminary cost estimates and potential responsible partners have been identified so that financial resources can be allocated and staff roles can be defined. Real watershed restoration requires a multi-faceted approach, which combines land use decisions with on-the-ground implementation, education and protection of watershed functions.

Table E-2. Priorities and Costs for Restoration in Lower Jones Falls Watershed				
Goals Met	**Strategy**	**Location**	**Responsible Parties**	**Long-term Milestones**
1,2,3,7	Continue to investigate illicit discharges along Stony Run and Western Run.	Watershed wide with focus on Stony Run, Western Run	• Baltimore City DPW • Baltimore County DEPRM • Baltimore Harborkeeper • CWP • JFWA	• 25+ illicit discharges identified and corrected throughout Lower Jones Falls (Stony and Western Runs are priorities) • Increased citizen awareness of illicit discharges
1,2,3,7	Implement and support Stream restoration	Portions of subwatersheds targeted for stream restoration	• Baltimore City Public Works • Baltimore County DEPRM • JFWA	• Restore 4 miles of streams • Educate neighborhood groups to increase awareness of and implement stream buffer plantings
1,2,3,7	Create a downspout disconnection program	Watershed wide with greatest opportunity in Stony Run and Western Run	• Baltimore City Public Works • Baltimore County DEPRM Baltimore Harborkeeper • CWP • JFWA	• Conduct training workshops and at least one demonstration downspout disconnection in at least 10 neighborhoods • Disconnect 20 apartment complexes • Continue implementing program to disconnect 500 downspouts
1,2,3,4,7	Create a watershed education campaign	Watershed wide then city and county wide	• Baltimore City Public Works Baltimore County DEPRM • Fran Flanigan • HRWA • JFWA	• Develop outreach campaign with messages and materials for use on buses, billboards and other media • Implement the campaign and track awareness through surveys
1,2,4,7	Develop a green institution program that includes addressing pollution prevention, stormwater retrofits, and tree planting.	Watershed wide at public and private schools, places of worship and hospitals	• Baltimore City Public Works • Baltimore City Sustainability • Baltimore County DEPRM Baltimore Harborkeeper • CWP • JFWA • Maryland Port Authority	• Develop program and install retrofits at two schools. • Remove 10 acres of impervious cover; plant 200 trees and educate 200 students • Change lawn care policies of institutions to a low-input level

Table E-2. Priorities and Costs for Restoration in Lower Jones Falls Watershed				
Goals Met	**Strategy**	**Location**	**Responsible Parties**	**Long-term Milestones**
1,2,6,7,10	Integrate stormwater and watershed planning goals into new and redevelopment	Watershed wide	• Baltimore City DPW • Baltimore City Sustainability	• Review of and adjustments to development codes to ensure that they allow practices that meet stormwater and watershed goals
1,2,5,7,10	Implement high priority stormwater retrofits	Watershed wide	Baltimore City DPW • Baltimore County DEPRM • JFWA	• Install five priority retrofits
1,2,4,5,7	Develop a neighborhood restoration program	Watershed wide	Baltimore City DPW • Baltimore County DEPRM • JFWA	• Restoration program is developed and implemented in at least eight neighborhoods • Residents surveyed for increased awareness and stewardship
1,2,4,7,9	Increase the tree canopy	Watershed wide	• Baltimore City Forestry • Baltimore County DEPRM HRWA • JFWA	• At least 400 trees on a combination of public and private property
1,2,3,4,7	Provide education on proper lawn care	Watershed wide	Baltimore City DPW • Baltimore County DEPRM • JFWA	• Create a lawn care pledge and work with groups to gain public support • Conduct 20 lawn care education workshops • Determine success and adjust as necessary
1,2,3,7,8	Develop a business stewardship outreach program	Watershed wide	Baltimore City DPW • Baltimore County DEPRM • JFWA	• Develop a pilot program and test with two willing businesses • Refine program and work with 20 businesses to implement it • Measure success

Table E-3. Anticipated Actions and Costs				
Strategy	**Action**	**Short term (year 1)**	**Mid-Term (years 2-4)**	**Long Term (year 5+)**
1. Continue to investigate illicit discharges along Stony and Western Runs[a]	• Monitor East Stony Run and Lower Jones Falls and track illicit discharges in Stony, Western. • Expand to other subwatersheds.	$200,000	$500,000	$200,000
2. Implement and support Stream restoration[b]	• Coordinate with City and County to plant trees and provide education	$693,600	$2,684,400	$3,228,000
3. Create a downspout disconnection program[c]	• Full time coordinator with municipal and CWP support	$150,000	$350,000	$150,000
4. Create a watershed education campaign[d]	• Ongoing education that includes watershed awareness, lawn care and pet waste	$75,000	$200,000	$150,000
5. Develop a green institution program	• Oversee greening and retrofit projects	$60,000	$150,000	$60,000
6. Integrate stormwater and watershed planning goals into new and redevelopment	• Conduct a code review • Adjust codes, where feasible, to incorporate	$20,000	$50,000	$40,000
7. Implement high priority stormwater retrofits[e]	• Hire contractors to design and install retrofits	$500,000	$1,500,000	$3,000,000
8. Develop a neighborhood restoration program[f]	• Identify neighborhood captains • Develop informational brochures	$60,000	$120,000	$60,000
9. Increase the tree canopy[g]	• Encourage residential tree planting • Work with institutions and neighborhoods to plant trees	$65,000	$195,000	$65,000
10. Provide education on proper lawn care[f]	• Target neighborhoods with high input lawns	$60,000	$100,000	$90,000
11. Develop a business stewardship outreach program	• Provide education on pollution prevention to targeted businesses and Implement stormwater retrofits	$60,000	$140,000	$80,000
Annual Totals		**$1,943,600**	**$5,989,400**	**$7,123,000.00**
Grand Total		**$15,056,000**		

Shading indicates projects have already been submitted for funding.
a. Cost includes supplies, contractual services, tracking ($3k/illicit discharge), and monitoring analysis (Brown et al 2004)

Table E-3. Anticipated Actions and Costs				
Strategy	**Action**	**Short term (year 1)**	**Mid-Term (years 2-4)**	**Long Term (year 5+)**
b. Costs include restoration of 4 miles of stream ($1,584,000/mi), materials and staff time for stream buffer planting and education (Cappiella et al 2006) *c. Costs include supplies and labor for 1,000 homes/yr (@ $100/house), staff time, mileage and printing* *d. Costs include design and graphics, radio and newspaper advertising, and staff time* *e. Planning level cost of $50,000/IA represents a mix on on-site and storage retrofits including final design, permitting, construction, contractors, materials, and construction oversight (Schueler et al 2007)* *f. Costs based on $15/household for outreach and education, not including staff time ($30k) and materials ($15k) (Schueler and Kitchell 2005)* *g. Costs include trees, materials and staff time (Cappiella et al 2006)*				

E5. Load Reductions

Table E-4 shows the pollutant load reduction estimates based on the strategies outlined in Section 2.0 as well as on-going implementation actions by the City and County that include Sanitary Sewer Overflow (SSO) abatement and street sweeping. The load reductions are based on realistic implementation scenarios over the next ten years. Citations are provided for each of the load reduction calculations and are based on conservative assumptions. Overall the effect of restoration implementation would result in a 22% reduction in total nitrogen, close to a 30% reduction in total phosphorus, an 8% reduction in total suspended solids and a 38% reduction in fecal coliform. The watershed action plan would result in meeting the 15% TMDL reduction for nitrogen and phosphorus but fall slightly short of the Chesapeake Bay Tributary Strategy reductions of 24% and 42% reductions for total nitrogen and phosphorus respectively.

Table E-4. Lower Jones Falls Watershed Annual Loads and Anticipated Restoration Strategy Reductions

Loads	TN (lb/year)	TP (lb/year)	TSS (lb/year)	Fecal Coliform (# billion/year)
Jones Falls estimated loads	111,160	14,357	5,440,332	12,496,165
Load reduction from existing practices	-7,751	-1,166	-418,556	-326,325
Total current load	**103,409**	**13,191**	**2,511**	**12,169,840**
Restoration strategy	**23,146**	**3,887**	**204.9**	**4,679,348**
Percent load reduction	**22.4%**	**29.5%**	**8.2%**	**38.4%**

Section 1.0 Introduction

The purpose of this report is to provide guidance on the restoration of the Jones Falls Watershed. The report outlines a series of strategies for watershed restoration, describes management strategies for each of the six subwatersheds, and identifies priority projects for implementation. Planning level cost estimates are provided where feasible and a preliminary schedule for implementation over a ten-year horizon is outlined. Financial and technical partners for plan implementation are suggested for various strategies and projects. The watershed plan is intended to assist the Jones Falls Watershed Association, Baltimore City and Baltimore County in moving forward with restoration of the Lower Jones Falls Watershed.

1.1 Background

A unique partnership was formed between Baltimore City (the City), Baltimore County (the County), the Herring Run Watershed Association (HRWA) and Jones Falls Watershed Association (JFWA) and the Center for Watershed Protection, Inc. (the Center) to develop Small Watershed Action Plans (SWAPs). The SWAPs were developed for planning areas in the Back River and Jones Falls Watersheds, both with drainage shared between Baltimore City and County. This two-year effort involved working with all partners to conduct upland assessments to identify restoration opportunities.

This study focused on six subwatersheds in the Jones Falls watershed that predominantly have urban land use. This area represents 45% of the watershed and is referred to as the Lower Jones Falls Watershed. The Lower Jones Falls has been further divided into six subwatersheds (Figure 1.1). A detailed review of the natural resources and landscape of the watershed is provided in the *Jones Falls Baseline Report* (Baltimore County, 2008). Table 1.1 provides a summary of key characteristics of the watershed based on this report.

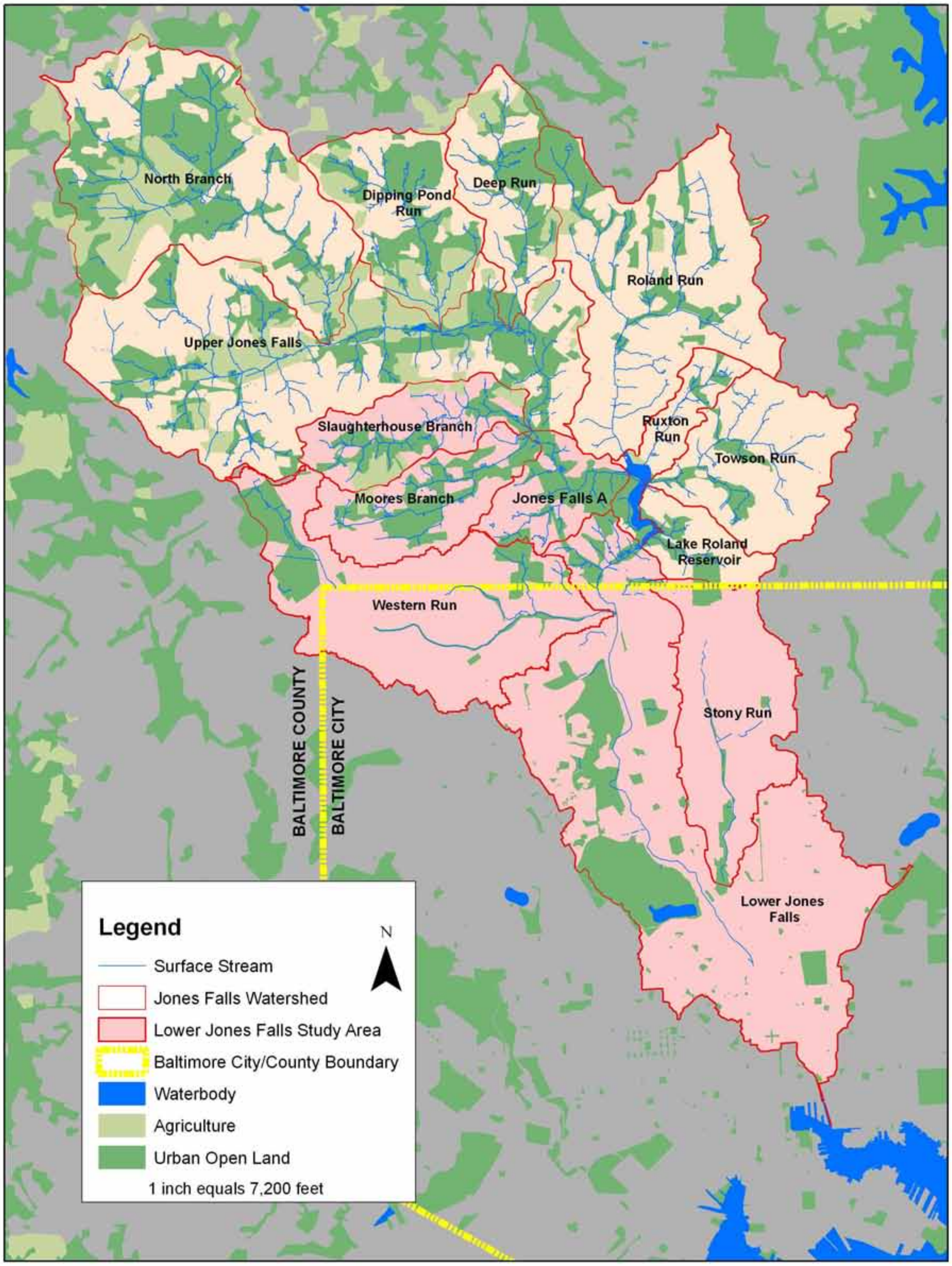

Figure 1.1. Map of the Lower Jones Falls Watershed.

Table 1.1 Key Characteristics of the Lower Jones Falls Watershed		
Drainage Area	• 16,550 acres (25.9 mi^2)	
Stream length	• 54 miles	
Land Use	• Forest (13.6%) • Commercial (6.9%) • Agricultural (1.3%) • Industry (2.4%) • Institutional (10.5%) • Low Density Residential (11.1%) • Medium Density Residential (23.7%)	• High Density Residential (21.1%) • Highway (1.9%) • Open Urban Land (6.1%) • Bare ground (0.6%) • Extractive (0.6%) • Water (0.3%)
Current Impervious Cover	• 31.8%	
Jurisdictions as Percent of Subwatershed	• Baltimore City (69.91%) • Baltimore County (30.09%)	
Soils	• A Soils – 0.9% • B Soils – 31.0%	• C Soils – 7.9 % • D Soils – 60.2%
Subwatersheds	• Jones Falls A • Jones Falls Lower • Moores Run	• Slaughterhouse Run • Stony Run • Western Run

As a first step, existing Jones Falls Watershed reports were reviewed in order to identify areas of the watershed where assessments had already been completed, identify any deficiencies in the data, and develop a list of assessment gaps. This review also included discussions with the City, County and JFWA. Concurrently, a technical memo was written that provides a review of existing water quality data from both the City and County for the Jones Falls Watershed. The memo provides a summary of monitoring programs and a summary of data from the water quality sampling program, illicit discharge detection and elimination program, and biological sampling program. The memo also provides strategies that identify data gaps and future monitoring needs (CWP, 2007). The information from this memo is also found in the *Jones Falls Watershed Characterization Report* (Baltimore County, DEPRM, 2008). The information from these two data reviews informed the location of fieldwork in the watershed.

Starting in the spring of 2006 and continuing through the spring of 2007, the project partners along with several volunteers conducted a series of upland assessments to identify sources and causes of water quality loads and impairments. Evaluated were potential opportunities for stormwater retrofits, stream corridor restoration, pollution prevention, and illicit discharge detection and elimination in the watershed. More detail on assessment methods and findings and our assessment of the sources and causes are also found in the *Jones Falls Watershed Characterization Report* (Baltimore County, 2008).

Throughout this process, stakeholders were actively engaged through three meetings. The first meeting presented existing conditions in the watershed and engaged participants in the process of setting goals for each subwatershed as well as the watershed as a whole.

The second introduced the baseline assessment and fieldwork that was performed by the Center. The last presented the findings from the fieldwork and actions that stakeholders can take to help restore the watershed. At each of these meetings, input was gathered from stakeholders and incorporated into a larger summary of goals for the watershed. This report provides the goals and strategies, field findings, and restoration opportunities for the Lower Jones Falls Watershed.

1.2 U.S. EPA Watershed Planning "A-I Criteria"

In 2003, the U.S. Environmental Protection Agency (EPA) began to require that all watershed restoration projects funded under Section 319 of the federal Clean Water Act to be supported by a watershed plan that includes the following nine minimum elements, known as the "a-i criteria":

a.) Identification of the causes and 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
h.) A set of criteria to determine load reductions and track substantial progress towards attaining water quality standards
i.) A monitoring component to determine whether the watershed plan is being implemented

This watershed plan meets the a-i criteria. Table 1.2 shows where these criteria are addressed throughout this watershed plan.

Table 1.2 U.S. EPA Watershed Planning Criteria

Section of the Report	A	B	C	D	E	F	G	H	I
Section 1.0 Introduction	X	X							
Section 2.0 Watershed Goals and Strategies			X						
Section 3.0 Watershed Protection Practices					X				
Section 4.0 Subwatershed Management Plans					X				
Section 5.0 Implementation Costs and Schedules	X			X	X	X	X	X	X
Section 6.0 Monitoring Plan									X

1.3 Report Organization

The remainder of the report is organized as follows:

Section 2.0 presents watershed goals and strategies. The ten watershed goals are based on input from residents and other watershed stakeholders and were drafted to guide strategies of the Lower Jones Falls Watershed Management Plan.

Section 3.0 provides a brief description of the types of watershed restoration practices recommended for the Jones Falls Watershed. Restoration practices include stormwater retrofits, stream corridor restoration, illicit discharge detection and elimination, pervious area restoration, pollution prevention/source control education, public education and municipal practices and programs. More detail on stormwater retrofitting can be found in Appendix A. More detail on stream corridor restoration can be found in Appendix B. Supplemental information on residential and hotspot source control practices can be found in Appendix C.

Section 4.0 is dedicated to management strategies for each of the six subwatersheds. A list of restoration opportunities for each assessment is provided. In addition, an overview of the recommended restoration practices is provided. Detailed management maps depicting project locations are provided in Appendix D.

Section 5.0 provides planning level cost estimates and a schedule for implementing watershed strategies over the next 5+ years. Unit cost assumptions for the various restoration practices and cost estimates for priority projects are provided where feasible.

Section 6.0 outlines a basic monitoring and project tracking strategy to evaluate progress in plan implementation.

Section 2.0 Watershed Goals and Strategies

Since the public and other stakeholders will have to live with the decisions developed during the watershed planning process, they play a vital role in the creation and implementation of a watershed management plan. Their participation gives them a stake in the outcome and helps to ensure the implementation of the plan. Stakeholders also bring to the table issues that are important to the community, and participate in activities to achieve nutrient and water quality goals.

The stakeholder meetings resulted in the following set of goals was drafted to guide strategies of the Lower Jones Falls Watershed Management Plan:

1. **Improve conditions in stream to achieve standards of swimmable, fishable, and water contact recreation in streams by 2022.** Ensure that the streams are safe for our children to play in.

2. **Improve the condition of the biology in the stream by planting more stream buffers along streams and removing concrete stream channels.** In addition, improving the altered urban hydrology and daylighting buried streams.

3. **Implement effective watershed education.** Watershed education efforts should focus on a wide audience ranging from city and state employees, local residents and students. Education topics include the reduction of fertilizers, pesticide and salt application, use of native landscaping, pet waste and proper disposal of trash. A mass media education campaign, effective brochures and websites can help achieve this goal.

4. **Increase the involvement of the population** through the organization of more events that connect residents to the stream, incorporating environmental education in the schools and encouraging participation in the Adopt a Stream Program.

5. **Disconnect impervious surfaces from the stormdrain system** by incorporating stormwater retrofits in parking lots and the streetscape and disconnecting rooftop downspouts where applicable. The amount of existing impervious cover should be reduced through the removal of unused asphalt at schools.
6. **Integrate stormwater and watershed planning goals in new and redevelopment.** Future environmental impacts can be reduced through changes to existing regulations that promote green building and design, stormwater management and smart growth.

7. **Continue collaboration between Baltimore City/County, watershed groups and citizens**. All partners should meet on a bi-annual basis to examine goals and objectives, progress and revise implementation plan.

8. **Engage the business community in restoration** through a program that provides recognition for businesses that implement green practices such as stormwater treatment, pollution prevention, etc.

9. **Improve management of natural and turf areas** including parks, trails, trees, and streams through on-going trail maintenance and increased access to streams. Continue to increase the tree canopy and improve tree management and education through existing programs in the City and County.

10. **Improve government management of roadways, streetscapes and public works yards** to reduce their impact on stream quality. Include elements of green infrastructure into roadway redesigns such as street trees and stormwater capture. City and County public works yards should provide an example with regard to pollution prevention and stormwater management practices.

2.1 Strategies

This section describes the 11 strategies for restoration for the Lower Jones Falls Watershed. These strategies are based on the stakeholder goals and fieldwork findings and are not listed in order of priority. Since there isn't one strategy for all watershed restoration, it is important that implementation of strategies needs to occur in tandem with each other. Currently, emphasis is placed on the practices of stream restoration and stormwater retrofits. While beneficial, these practices are expensive and when used alone do not solve the problem. Current restoration practices need to be combined with practices that prevent the pollution sources such as pollution prevention control and education.

Over the next ten years, a watershed wide program will be developed for each strategy that has dedicated staff, partners and funding. This is necessary to keep the program active and cover the entire watershed. Implementation may seem daunting at first, but there are certainly areas where efficiencies can be achieved through shared resources for multiple programs and expansion of existing programs. For example, the existing JFWA school greening program includes tree planting and can be expanded to include the disconnection of downspouts at schools. In addition, many of these strategies are similar in the adjacent watershed, the Back River Watershed, and thus programs can be developed across watershed boundaries.

1. **Implement high priority stormwater retrofits.** Over 61 stormwater retrofits were identified throughout the watershed including both large storage retrofits and small, on-site ones. A complete list of identified stormwater retrofits is listed by subwatershed in Section 4.0. An example high priority large retrofit includes the creation of a wooded stormwater wetland to treat stormwater runoff from upstream drainage area (LJ_R_38). Smaller, on-site, high priority stormwater retrofits include a rain garden at Edgecombe Circle Elementary School (LJ_R_10B).

2. **Develop a neighborhood restoration program.** Using the restoration information that was collected for each neighborhood, develop a program that can be used to green neighborhoods. Identify and train a neighborhood captain to lead the restoration effort. Restoration opportunities identified in neighborhoods include downspout disconnection, tree planting, storm drain stenciling, proper lawn care, watershed education and trash clean-ups. Further information on these practices is found in Appendices B and C. Project partners can provide education and training to neighborhood captains and provide technical and program assistance as needed. In addition, project partners would provide materials needed for restoration practices such as trees, soil test kits and other materials as necessary.

3. **Continue to investigate illicit discharges along Stony Run, Lower mainstem, and Western Run.** Efforts to monitor streams with known illicit discharges are critical to increasing awareness of illicit discharges. Illicit discharges were found in Stony Run and Western Run that contain sewage, wash water and drinking water. Based on these findings, it is recommended that outfalls be monitored more frequently and when found, illicit discharges will be eliminated. In Stony Run, a high number of illicit discharges were identified even though the sewer line was replaced. Based on chemical analysis and flow data, over 12 million gallons of wash water and sewage were estimated to flow into Stony Run on an annual basis. Because the City and County have limited staff and resources, it is critical that they partner with the JFWA to assist in IDDE monitoring. To ensure that reported problems are fixed in a timely manner, the City may need to allocate additional resources to tracking the sources of contamination to the stream.

4. **Increase the tree canopy** by planting trees or other vegetation on large expanses of managed turf identified throughout the watershed**.** These areas ranged from neighborhood open space to school yards to vacant lots. The JFWA will continue their active school reforestation program. The partners will use the list of identified areas for tree planting in Section 4.0 to help meet determined tree canopy goals in the City and County.

5. **Create a downspout disconnection program.** Conduct downspout disconnection in multi-family and ¼ acre or larger residential lots. In the Jones Falls, over 640 acres of impervious rooftop has been identified for possible disconnection through neighborhood and institutional downspout assessments. Section 4.0 summarizes neighborhoods identified for downspout disconnection. A program and technical specifications were developed and reviewed by the City of Baltimore (Novotney et al. 2008). The program was based on the established downspout disconnection program from the City of Portland, Oregon. Downspout disconnection includes simple disconnection, use of rain barrels and rain gardens. Section 3.0 provides a detailed description of these practices.

6. **Implement and support stream restoration projects.** Stream restoration projects are not always seen as a positive project through the eyes of the public.

During construction, stream restoration can be messy and often seem as if more harm than good will result. The JFWA can assist the City and County with future stream restoration projects by educating the neighbors about the long-term benefits of stream restoration as well as taking the lead on re-vegetating the banks of the stream once the construction is complete. This is a great way to engage and educate the public about the benefits of stream restoration.

7. **Create a watershed education campaign** to reach people on a broad scale. The message should be simple, to the point**,** and straightforward connections to everyday actions. The JFWA and HRWA conducted a study of public attitudes about stormwater in the Baltimore area (OpinionWorks 2008). The results revealed that the public at large is extremely uninformed about what a watershed is and how stormwater is managed. For example, one resident in six knows for sure that stormwater is not treated before it enters our waterways. Though uninformed, the public is extremely well intentioned and willing to be engaged. It was found that people are particularly motivated by health concerns.

8. **Provide education on proper lawn care.** Lawns make up more than a large percent of the watershed area. During the neighborhood and institutional assessments, over 3,500 acres were assessed as having high or medium percentages of high input lawn care. A lawn care education program will be developed to provide educational efforts targeted toward neighborhoods and institutions with high nutrient input lawn care. Section 4.0 summarizes neighborhoods and institutions identified for education on lawn practices during field assessments. The program will include lawn care pledges, free soil tests, educational articles in the daily newspaper and free technical guidance for implementation.

9. **Develop a Business Stewardship Outreach Program** that engages the business community in watershed restoration. Commercial and industrial areas make up 9.3% of the watershed and will be targeted for pollution prevention and implementation of stormwater retrofits. Many of these businesses were identified during field investigations as hotspots that contain sources of pollution such as improper storage of outside materials, waste materials or highly managed turf. Partners can work with businesses to implement pollution prevention practices on site and in return become recognized as a "green business."

10. **Develop a green institution program** that includes reforestation, stormwater retrofits and pollution prevention. Institutions include schools, places of worship and hospitals. They make up a significant portion of the watershed (10.5%) and generally contain large amounts of impervious cover and green space which is an ideal area to treat stormwater runoff. A summary of identified opportunities at these sites is listed by subwatershed in Section 4.0. For example, at several schools, large concrete play areas are no longer utilized due to concerns about children being injured. At these sites the concrete can be removed and trees and other vegetation planted. Currently, three demonstration projects are slated for

construction in the next year at the Park School, Poly/Western High Schools and Guilford Elementary School. An additional 10 acres will be treated through cost sharing partnerships with foundations and private schools.

11. **Integrate stormwater and watershed planning goals into new and redevelopment** projects within the watershed. Improving water quality in redevelopment projects and limiting the impacts of new development are critical aspects of meeting watershed goals over time. Baltimore County conducted a Builders for the Bay site planning roundtable that recommends improvements to codes and ordinances that will promote environmentally sensitive development and redevelopment. Baltimore City has committed to a similar goal as part of the 2006 Watershed Agreement. In addition, both jurisdictions have passed green building incentives that are a great start to achieving this strategy.

Section 3.0 Watershed Restoration Practices

This section of the plan presents an overview of the key strategies for restoring the Jones Falls watershed. Watershed restoration will occur as a partnership between the local government, watershed group and citizens. The actions of each partner are critical to the success of the total effort. Local governments are able to implement large capital projects such as stream restoration, large-scale stormwater retrofits and changes in municipal operations (e.g., pollution prevention, good housekeeping, etc.), and large-scale public awareness. In contrast, watershed groups and citizens are able to implement smaller scale programs including street trees, downspout disconnection, lawn care education, rain gardens, etc. It is important that restoration occurs at all levels to ensure a wide range of projects is implemented.

The variety of restoration practices recommended include stormwater retrofits, stream corridor restoration, illicit discharge detection and elimination, pervious area restoration, pollution prevention/source control education, public education and municipal practices and programs. Table 3.1 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. The applicable partners are identified with each practice as either local (watershed group and citizens), capital (local government) or both.

Table 3.1 Urban Management Practices Recommended in the Jones Falls Watershed

	Type	Practices	Partner
Restoration Practice	**Stormwater Retrofits***	• Storage (large off-site or on-site ponds and wetland facilities)	Capital
		• On-site residential (rain gardens, rain barrels, etc.)	Local
		• On-site commercial (sand filters, underground storage, etc.)	Capital
	Stream Corridor Restoration	• Simple stream repair (bank stabilization), stream channel restoration, and habitat enhancements**	Capital
		• Buffer reforestation (tree planting, invasive removal)	Both
		• Stream cleanups **	Local
	Illicit Discharge Detection and Elimination	• Discharge investigation and elimination	Capital
		• Community hotline	Capital
		• Education and employee training	Capital
		• Outfall monitoring	Capital
	Pervious Area Restoration	• Natural regeneration	Both
		• Tree plantings	Local
	Pollution Prevention/Source Control Education* **	• Residential pollution prevention	Both
		• Tree plantings	Local
	Public Education	• Regional scale public awareness	Both
		• Ad campaigns, public service announcements	Capital
	Municipal Practices and Programs	• Street sweeping, winter road treatment	Capital
		• School and grounds maintenance (schools and recreational fields)	Capital
		• Inspection and maintenance programs (ESC, SWM, catch basin cleanouts)	Capital
		• Spill prevention and response	Capital
		• Maintenance facility pollution prevention plans	Capital
* See Appendix A for more detail on stormwater retrofits			

Table 3.1 Urban Management Practices Recommended in the Jones Falls Watershed		
Type	**Practices**	**Partner**
** See Appendix B for more detail on stream repair practices *** See Appendix C for more detail on residential and hotspot source control practices		

3.1 Stormwater Retrofits

The Center breaks stormwater 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 F provides a detailed list of retrofit opportunities that were encountered in the field.

Impervious cover, land use, and restoration goals are the important components to deciding which type of stormwater retrofit practice to use. 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 this 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 watersheds.

Because the Lower Jones Falls Watershed is highly urbanized, there is limited potential for implementing new storage projects other than retrofitting existing stormwater ponds (Figure 3.1). Due to these limitations, an important aspect of this study was to identify smaller, on-site residential retrofit 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 3.1. A. Available Space for a Stormwater Retrofit B. and an Example of a Stormwater Wetland.

On-site practices provide a great potential in both neighborhoods and institutions in the watershed. These opportunities include simple disconnection of downspouts in neighborhoods and schools where storm drains are directly connected to the street or storm drains (Figure 3.2). In addition, impervious cover removal, tree planting and bioretention are good options to help treat and reduce stormwater at schools.

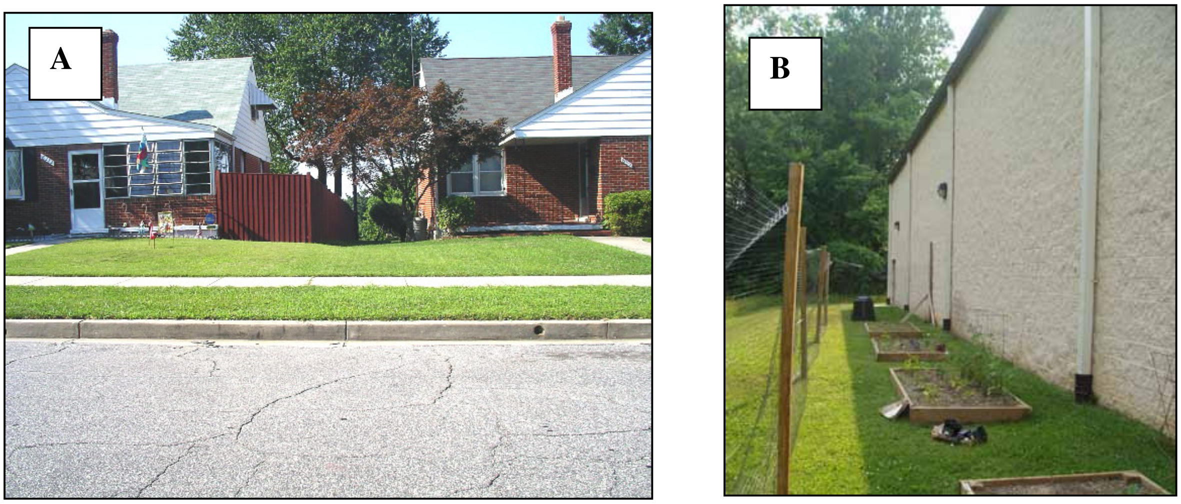

Figure 3.2. Downspout Disconnection Opportunities in a Neighborhood (A) and a School (B).

3.2 Stream Restoration

Stream 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. Stream repair practices are often combined with stormwater retrofits and riparian management practices to meet subwatershed restoration objectives. Primary practices for use in the Jones Falls watershed include stream repair, buffer reforestation, and stream cleanups. Each practice is described in detail below.

Stream Repair

The practice of urban stream repair is relatively new with most of the experience occurring in the last two decades. Controlling upstream hydrology is the most sustainable way to achieve actual stream restoration in urbanized systems, as opposed to simple in-stream 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 Jones Falls, where upland stormwater treatment prospects are limited, pursuing stream repair in instances where infrastructure and property is adversely impacted is necessary and justified. 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 3.3 provides an example of stream restoration in Stony Run located in the Jones Falls Watershed.

Figure 3.3 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 many area 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, a combination of stream repair with upland stormwater retrofits and runoff reduction from neighborhoods is the recommended approach as reflected in the priority project descriptions.

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 Jones Falls watershed, many of the streams are piped and those not piped have been restored or will be 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 both watersheds. This problem should be addressed through education, training of City and County grounds maintenance staff, and development of a dedicated group of volunteer “urban weed warriors.” The urban weed warrior program is implemented by the Baltimore City Department of Recreation and Parks to train citizen volunteers to assist in invasive plant removal.

Lastly, 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. Signs and outreach tools should be used to educate residents.

Stream Clean Up

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 methods for generating community awareness and involvement in watershed activities.

3.3 Illicit Discharge Detection and Elimination

Illicit Discharge Detection and Elimination (IDDE) targets dry weather flows that contain significant pollutant loads. Examples include sewage overflows and industrial and transportation spills. These 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, described in Table 3.2 and discussed in detail in *Illicit Discharge Detection and Elimination* (Brown et al 2004).

Table 3.2. 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 network. In other cases, "straight pipes" discharge sewage to a stream or ditch without treatment, while sewage from RVs or boats might be 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 strategies were identified as a result of the IDDE field work. 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 an extra set of 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

3.4 Pervious Area Restoration

Pervious areas and natural area remnants include parks, schools, open space, and rights of way that can be reforested or re-vegetated. These areas provide important natural recharge functions in the drainage area, and should be optimized to promote natural infiltration properties. 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 (Wright et al. 2008). 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 the energy efficiency of buildings.

3.5 Pollution Prevention/Source Control Education

Residents and businesses engage in behaviors and activities that can influence water quality. Some behaviors that negatively influence water quality include over-fertilizing lawns (Figure 3.4), 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 and other civic groups such as the Master Gardeners are in a position to influence these changes using pollution prevention education and outreach to teach citizens how to properly care for the watershed.

Figure 3.4. Evidence of 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. They include auto repair shops, department of public works yards, restaurants, etc. Specific on-site operations and maintenance combined with 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.

3.6 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 (Novotney and Winer, 2008).

Several observations were made regarding the current state of municipal practices in the watersheds. Good practices included evidence of stenciled storm drains, though they were frequently old and faded, dumpster drop off programs and residential recycling programs. The two strategies for improvement include: storage and pollution prevention at certain municipal facilities and improved erosion and sediment control practices at several locations.

Watershed Education

Residents and business owners engage in many behaviors and activities that can influence water quality. Behaviors such as over-fertilizing, oil dumping, littering, and excessive pesticide use can negatively impact water quality. Conversely, positive behaviors such as tree planting, disconnecting rooftops, and proper storage of materials can help improve water quality. Targeted education to deliver a specific message can promote behavioral changes (Schueler et al, 2004).

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 activities such as 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. A number of areas have been identified for organic matter debris removal and street sweeping.

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.

Section 4.0 Subwatershed Management Strategies

This section details management strategies and implementation priorities for each subwatershed. Restoration opportunities include stream restoration, stormwater retrofits, tree plantings, neighborhood and institution restoration, and illicit discharge elimination and pollution prevention measures. Priorities are based on existing stream and upland conditions, the widespread application of the restoration practice, and the feasibility of implementation. A brief summary of existing stream corridor and upland conditions is presented here, but are described in more detail in the *Jones Falls Characterization Report* (Baltimore County, 2008). Subwatershed management maps that show the locations of restoration opportunities are included in Appendix D. Estimated implementation costs and a schedule for restoration projects can be found in Section 5.0 of this report.

This section contains the following subsections for each subwatershed:

Subwatershed Description – Summary of current conditions of the subwatershed including land use, impervious cover, stream length, drainage area, and a summary of field findings. Refer to the *Jones Falls Characterization Report* for more information.

Subwatershed Management Strategy – Summary of implementation strategies based on the results of the field findings. Refer to Section 3.0 for a description of what these practices entail, and refer to Appendices A, B, and C for more information on stormwater retrofits, stream repair practices, and residential and hotspot source control practices, respectively.

Summary of Assessments and Related Findings – A description of each field assessment completed with a summary of the field finding results. Field assessments include an assessment of streams, neighborhoods, hotspots, institutions, illicit discharge detection and elimination, stormwater retrofits, and pervious area restoration. For each assessment a summary table of field findings is provided. Appendix E provides a copy of selected stormwater retrofit field forms and concepts for the watershed.

Management Map – Subwatershed maps depicting restoration opportunities are located in Appendix D.

Table 4.1 summarizes the general characteristics and management strategies for the six subwatershed management areas.

Table 4.1. Summary of the Jones Falls Subwatershed Characteristics		
Subwatershed	**General Characteristics**	**Primary Restoration Strategies**
Jones Falls A	• 862 acres (1.3 mi^2) • Located entirely within Baltimore County • 43.5% forest land use • Drains into Roland Lake	• Downspout disconnection • Stormdrain stenciling • Lawn care education • Trash pick-up • Tree planting at institutions
Lower Jones Falls	• 7287.36 acres (5.4 mi^2) • Located mostly in Baltimore City (94%) • Discharges through outfall into Baltimore Inner Harbor • Contains densely developed downtown Baltimore	• At institutions, remove impervious cover, plant trees and install stormwater retrofits • Downspout disconnection • Watershed education and involvement through trash clean-ups and stormdrain stenciling • Downspout disconnection • Stormdrain stenciling • Lawn care education • Trash pick-up • Tree planting at institutions
Moores Branch	• 1396 acres (2.18 mi^2) • Located entirely in Baltimore County • Land use mainly low and medium density residential (42.6%) and forested (27.9%)	• Tree planting and stormwater retrofits at schools • Protect existing forest cover • Downspout disconnection • Lawn care education • Install retrofit MO_R_17, to create a bioretention area, that will treat 12 acres
Slaughterhouse Run	• 1272.02 acres (1.9 mi^2) • Located entirely in Baltimore County • Land use mainly low density residential (47.9%) and forest (24%)	• Plant stream buffer • Downspout disconnection • Lawn care education • Tree plantings and stormwater retrofits at institutions • Stormdrain stenciling program • Install retrofits SL_R_2 and SL_R_3 that will treat over 47 acres
Stony Run	• 2242.23 acres (3.5 mi^2) • Located mostly in Baltimore City (98%) • Primarily residential land use (66%) • Several large institutions (College of Notre Dame, Loyola College)	• Illicit discharge elimination • Downspout Disconnection • Lawn care education • Increase tree canopy • Engage places of worship • Install stormwater retrofits at schools
Western Run	• 3487.4 acres (5.4 mi^2) • Located in Baltimore County (42%) and Baltimore City (58%) • Mostly residential land use (72.3%)	• Downspout Disconnection • Increase tree canopy • Lawn care education • Engage places of worship • Assist with outreach for stream future restoration

4.1 Jones Falls A Subwatershed

Jones Falls A is located in the center of the greater Jones Falls watershed. The drainage area extends north Falls Rd. where it passes under the Jones Falls Expressway, I-83 and south to near the Baltimore City/County line. The eastern portion reaches almost to Greenspring Ave. and in the west the stream drains into Roland Lake. The area is cut almost in half by I-83. East of I-83 the subwatershed in a mix of single and multi-family residences, while west to the of it, aside from one industrial/commercial area, the area is mostly forested, including Robert E. Lee Park and several relatively low density developments (Table 4.2).

There are considerable opportunities for stormdrain stenciling, downspout disconnection, and lawn care education and outreach in residential areas. There are no stormwater retrofits, hotspots or illicit discharges assessed in this subwatershed. Two institutions were identified for tree planting and potential stormwater treatment. One pervious area was assessed for potential tree planting opportunity.

Table 4.2. Basic Profile of Jones Falls A Subwatershed		
Drainage Area	• 862 acres (1.3 mi^2)	
Stream length	• 6.9 miles	
Land Use	• Forest (43.5%) • Commercial (2.4%) • Industry (5.3%) • Institutional (0.2%)	• Low Density Residential (11.3%) • Medium Density Residential (8.6%) • High Density Residential (18.3%) • Open Urban Land (2.2%) • Bare Ground (0.8%)
Current Impervious Cover	• 19.99%	
Jurisdictions as Percent of Subwatershed	• Baltimore City (0%) • Baltimore County (100%)	
Soils	• A Soils – 0% • B Soils – 61.8%	• C Soils – 5.1% • D Soils – 33.1%
Stormwater Management	• County – 13 stormwater management facilities that treat 221.7 acres	

Summary of Assessments and Related Findings

Stream Assessment
Baltimore County (2007) conducted a stream assessment in the Jones Falls A subwatershed that identified the in-stream conditions including channel alteration, erosion, exposed pipe, fish barriers, inadequate buffers, in-stream construction, pipe outfalls and trash dumping. The results are summarized in Table 4.3. Detailed information on stream assessments can be found in Baltimore County DEPRM, 2008.

Table 4.3. Summary of Stream Conditions in Jones Falls A	
Stream Impact	**Number of Problems (estimated length)**
Channel Alteration	3
Erosion	16 (8640 ft)
Fish Barrier	11
Inadequate Buffer	11 (5802 ft)
Pipe Outfall	28
Exposed Pipe	0
In-Stream Construction	0
Trash Dumping	7

Neighborhood Assessment

Fourteen neighborhoods were assessed (Figure 4.1 and Table 4.4). Stormdrain stenciling and lawn care education (i.e. nutrient management) were key pollution prevention opportunities to address stormwater pollutants. Others include tree planting and downspout disconnection, as outlined in Table 4.4 and Figure 4.1. Stenciled storm drains were absent from most of the neighborhoods and recommended as a project that would both engage homeowners and increase awareness. Over 30 acres of rooftops could be disconnected and redirected to pervious areas. Detailed information on these practices is found in Baltimore County DEPRM, 2008.

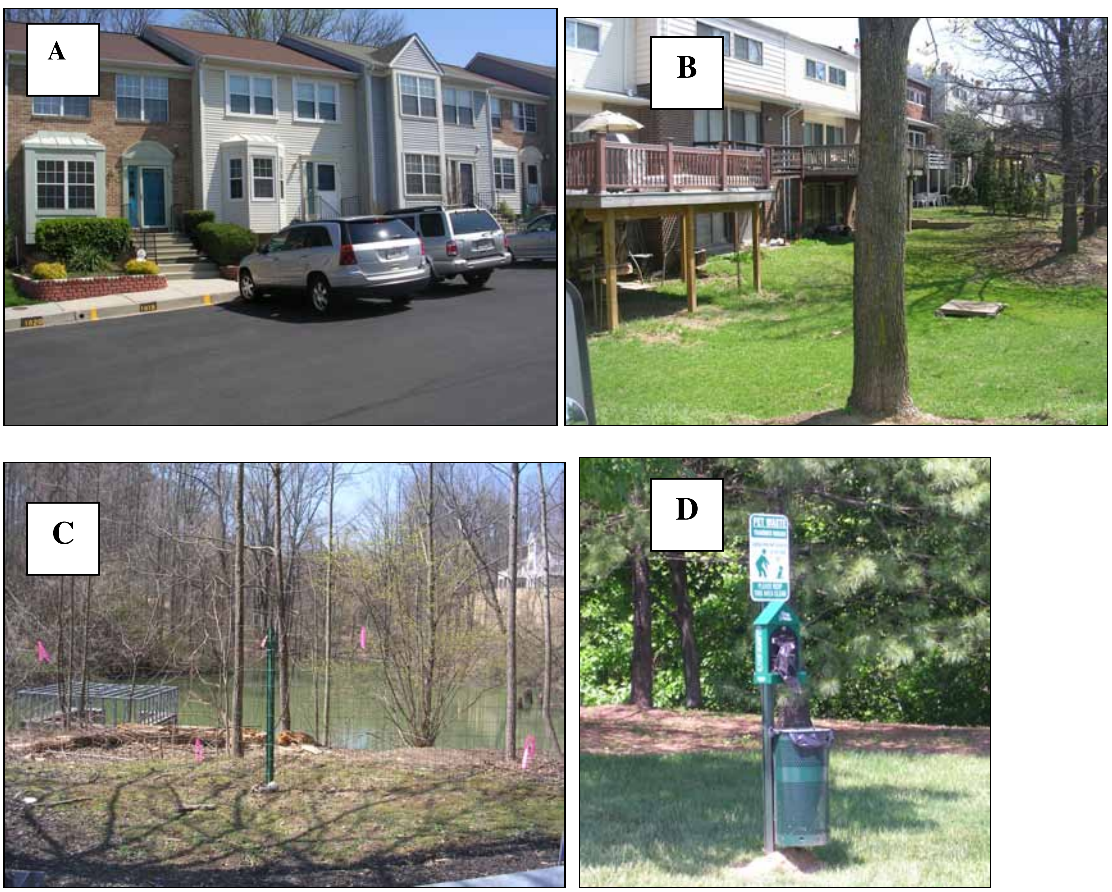

Figure 4.1. A.and B. Two Examples of Typical Townhome Developments. C. Stormwater Management Pond on Newsted Ct. in Rockland Ridge (NSA_H_36) and D. A Good Example of Pet Waste Control Found in Jones Valley (NSA_H_34).

Table 4.4. Summary of Neighborhood Assessment Strategies

Neighborhood	Recommended Actions											
	Site ID	**Median lot size (acres)**	**Opportunity for Downspout Disconnection**	**Rain Barrels**	**Rain Gardens**	**Stormdrain Stencils**	**Bayscape**	**Nutrient Management**	**Pet Waste**	**Buffer Encroach**	**Street Trees**	**Notes**
Bonnie Ridge	NSA_H_22	Multifamily	95%			X		X				Space for bioretention at rd ends, Existing dry pond BMPs
Pickwick	NSA_H_23	¼	0%		X	X		X				None
Pheasant Cross	NSA_H_24	½	60%		X	X		X		X		SW pond retrofit
Rockland Run	NSA_H_25	1	50%	X	X			X				None
Greengate Townhomes	NSA_H_32	Multifamily	50%	X		X						Possible parking lot retrofit
The Falls	NSA_H_33	Multifamily	75%			X		X			X	Lot retrofit at end of Clearwind possible; scattered tree planting opportunities; SWM ponds inaccessible
Jones Valley	NSA_H_34	Multifamily	50%			X						Buffer planting possible, gutter sweeping
Rockland Ridge	NSA_H_36	<1/8	80%			X	X	X		X	X	Neighborhood still in development, neighborhood sprays lawns not owned by residents; bayscaping education and tree planting possible
Falls Gable and Falls Garden	NSA_H_46	Multifamily	50%	X		X		X			X	Lot retrofits at Tyler Falls & Falls Gable Ln.; possible open space tree planting
Bonnie Ridge	NSA_H_49	Multifamily	35%	X		X		X		X	X	Possibility for retrofit at end of Bonnie Ridge Ct., stream channel naturalization, and buffer planting
Twin Ridge and Rockland Run Condos	NSA_H_50	Multifamily	50%	X		X		X			X	~15 Street Trees
Greengate Apartments	NSA_H_51	Multifamily	100%			X		X			X	Possible lot, downspout, and pond retrofits; ~30 open space trees
Brookstone	NSA_H_52	Multifamily	70%	X		X		X				Neighborhood likely open to restoration possibilities
N/A	NSA_H_104	¼	70%		X					X		Add buffer to streams in front yards; erosion control for construction sites

Hotspot Assessment
Hotspots were not assessed in the Jones Falls A subwatershed.

Assessment of Institutions
One hospital and one school were assessed (Figure 4.2 and Table 4.5). Institutions include schools, medical centers and places of worship. The opportunity identified at both institutions was tree planting. At Summit Park Elementary School (ISI_H_503) opportunities also exist for improving nutrient management of turf and installing a stormwater retrofit.

Figure 4.2. The Two Institutions Assessed Include A. the Home and Hospital Center and B. Summit Park Elementary School.

Table 4.5. Summary of Strategies for Institutions

Site ID	Name of Site	Public/ Private	Opportunities					
			Nutrient Management	Tree Planting (#)	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management
ISI_H_101	Home and Hospital Center	Public		250				
ISI_H_503	Summit Park Elementary School	Public	X	250	X			

Stream Restoration
There are no plans for stream restoration in the Jones Falls A subwatershed at this time.

Illicit Discharge Detection and Elimination
No illicit discharges were inventoried in the Jones Falls A as part of this plan. Information on Baltimore County's and City's IDDE program is found in Section 3.0.

Stormwater Retrofits
No opportunities were identified for stormwater retrofits within the watershed.

Pervious Area Restoration

One potential pervious area restoration site, covering one acre, was identified in Jones Falls A (Table 4.6 and Figure 4.3). Pervious area restoration has the potential to convert turf area to forest, reducing nutrient input to streams.

Table 4.6. Summary of Potential Pervious Area Restoration Sites				
Site	Location	Description	Size (acres)	Ranking
PAA-H-100	Between Great Summit Rd. and Ruby Field Ct.	Open common space behind homes on Ruby Field and Diamond Crest Courts	1	High

Figure 4.3. PAA-H-100

Subwatershed Management Strategy

Strategies for the Jones Falls A subwatershed include:

1. Conduct downspout disconnection in both multi-family units and at ¼ acre single-family lots. Use the information from Table 4.4 to identify neighborhoods for downspout disconnection. This is represented by the percent of connected downspouts. Neighborhoods with a high percent of downspouts connected to the stormdrain should be considered for disconnection. This practice includes simple disconnection, and the use of rain barrels and rain gardens.
2. Conduct stormdrain stenciling with residents in identified neighborhoods. This activity will educate residents and provide a message to keep trash out of the storm drain system.
3. Provide lawn care education to neighborhoods identified with high turf management. Work with the homeowners to reduce the amount of nutrients applied to their lawn and other pollution prevention measures.
4. Work with the Home and Hospital Center and Summit Park Elementary School to plant trees in turf areas. A further investigation of the school should be completed to identify stormwater retrofits.

5. Conduct trash pick-up at the seven trash sites identified in Table 4.2. The location and description of these sites are further detailed in Baltimore County DEPRM, 2008 and Section 3.0.

4.2 Lower Jones Falls Subwatershed

Lower Jones Falls drains the southern portion of the watershed and discharges into the Baltimore Inner Harbor from a stormdrain pipe. The watershed is bordered by the Gwynns Falls watershed to the West, Baltimore Inner Harbor to the south, Falls Road and the Back River watershed to the east and Old Pimlico Road to the North. A major interstate, the Jones Falls Expressway (I-83) is located directly over the river and intersects the subwatershed in a north-south direction. The mainstem is a concrete channel that runs through the heart of Downtown Baltimore, flowing under the Jones Falls Expressway until it is piped near North Avenue and discharges to the Baltimore Inner Harbor. Despite the dense development of downtown Baltimore, the subwatershed contains 12.3% of forested land. The forested land consists of public parks located in the subwatershed that include Druid Hill Park, Cylburn Park, Medfield Heights Park, Roosevelt Park, Cylburn Arboretum and parts of Robert E. Lee Park and Jones Falls Park.

The urban subwatershed mostly consists of dense residential (32.3%), commercial (11.8%) and institutional (12.2%) land use (Table 4.7). The institutional land use consists of hospitals and both public and private schools. Typical residential neighborhoods in Baltimore consist of row homes interspersed with corner bars, restaurants and stores. The subwatershed contains a mix of dilapidated row homes and thriving neighborhoods within a few blocks of each other. Heading north in the subwatershed, past Northern Parkway, lot sizes expand to ½ acre and greater. In these neighborhoods lawn care education was identified as a strategie. In the more densely urban neighborhoods, potential restoration projects include storm drain stenciling to increase awareness, and trash clean-ups and/or management. In all neighborhoods, regardless of lot size, downspout disconnection was identified as a priority strategy. Several stormwater retrofits were identified at hospitals, schools and street ends to treat pollutants. In addition, both small and large-scale tree planting opportunities were identified mostly at schools.

Table 4.7. Basic Profile of Lower Jones Falls Subwatershed	
Drainage Area	• 7287.36 acres (5.4 mi^2)
Stream length	• 15.1 miles
Land Use	• Forest (12.3%) • Commercial (11.8%) • Industry (4.7%) • Institutional (12.2%) • Low Density Residential (6.0%) • Medium Density Residential (8.6%) • High Density Residential (32.3%) • Highway (3.6%) • Open Urban Land (7.1%) • Bare Ground (0.8%) • Water (0.7%)
Current Impervious Cover	• 39.87%
Jurisdictions as Percent of Subwatershed	• Baltimore City (94%) • Baltimore County (6%)
Soils	• A Soils – 1.7% • B Soils – 19.0% • C Soils – 5.5% • D Soils – 73.8%
Stormwater management	• County – Three (3) stormwater management facilities that treat 24.6 acres • City – One (1) trash collector at the outfall

Summary of Assessments and Related Findings

Stream Assessment

Baltimore County (2007) conducted a stream assessment in the county portion of the Lower Jones Falls subwatershed that identified the in-stream conditions including channel alteration, erosion, exposed pipe, fish barriers, inadequate buffers, in-stream construction, pipe outfalls and trash dumping. The results are summarized in Table 4.8. Detailed information on stream assessments can be found in Section 3.0.

Table 4.8. Summary of Stream Conditions in Lower Jones Falls

Stream Impact	Number of Problems (estimated length)
Channel Alteration	1
Erosion	8 (8495 ft)
Fish Barrier	4
Inadequate Buffer	6 (3722 ft)
Pipe Outfall	10
Exposed Pipe	1
In-Stream Construction	0
Trash Dumping	0

Neighborhood Assessment

Over 32 neighborhoods were assessed within the Lower Jones Falls Subwatershed. Pollution prevention opportunities identified to address stormwater volume and pollutants include downspout disconnection, stormdrain stenciling, tree planting and lawn care education as outlined in Table 4.9 and Figure 4.4. The subwatershed predominantly contains dense rowhome residential development that increases to ½ acre-1 acre residential lots north of Northern Parkway. Strategies in the denser developed area include storm drain stenciling and trash clean-ups to engage homeowners and increase awareness. A portion of the more densely developed neighborhoods have boarded-up vacant rowhomes and abandoned lots that are used as dumping sites.

Lawn care education is identified as particularly important for neighborhoods with multifamily houses or lot sizes ½ acre and greater in the northern portion of the subwatershed. The majority of neighborhoods, regardless of lot size, were candidates for downspout disconnection either through rain barrels, rain gardens or simple disconnection of a rooftop downspout to a pervious area. Detailed information on these practices is found in Baltimore County DEPRM, 2008.

Figure 4.4. A and B. Representative Rowhome Neighborhoods. C. Representative ½ Acre to One-acre Neighborhood (NSA_H_88A) and D. Multifamily Townhomes (NSA_H_88B).

Table 4.9. Summary of Neighborhood Assessment Strategies													
	Recommended Actions												
Neighborhood	**Site ID**	**Median lot size (acres)**	**% Opportunity for Downspout Disconnection**	**Rain Barrels**	**Rain Gardens**	**Stormdrain Stencils**	**Bayscape**	**Nutrient Management**	**Pet Waste**	**Buffer Encroach**	**Street Trees**	**Notes**
Charles Village	NSA_H_57	<1/8	N/A	X		X					X	Trash clean-up/education
Charles Village	NSA_H_58	<1/8	N/A	X		X					X	Downspouts go to alley
Charles Village	NSA_H_59	Multifamily	N/A									Predominantly commercial area; possible alley retrofit
Better Waverly	NSA_H_60	Multifamily	N/A		X		X	X	X			Trash clean-up/education and tree planting in common areas
Guilford	NSA_H_61	1/2	80%		X		X	X			X	Plant trees in median
Waverly	NSA_H_62	<1/8	30%		X			X	X			None
Ednor Gardens	NSA_H_63	<1/8									X	50-75 street trees possible
Remington	NSA_H_64	<1/8	90%	X	X				X		X	Trash clean-up/education
Remington	NSA_H_65	1/8	90%			X						Tree plantings
Station North	NSA_H_66	<1/8									X	Trash clean-up/education
Pimlico	NSA_H_67	<1/4	30%	X	X	X	X		X			None
Pimlico	NSA_H_68	1/8	50%			X	X					None
Coldstream/Homestead/Montebello	NSA_H_69	<1/8	N/A								X	Trash clean-up/education
Park Heights	NSA_H_70	Multifamily	20%	X		X						Trash clean-up/education
Roland Park	NSA_H_78	>1	75%	X	X			X		X		Possible bioretention in street islands
Medfield Heights	NSA_H_79	1/2	10%	X	X		X	X				Neighborhood is clean
Hampden	NSA_H_80	1/8	N/A		X	X						Most downspouts are in alley
Hampden	NSA_H_81	1/4	40%	X		X	X					Neighborhood is clean
Mt. Washington	NSA_H_88A	1/2	65%		X	X		X				Gutters have heavy organic matter
Mt. Washington	NSA_H_88B	Multifamily	45%	X		X		X				Lot retrofits and curb cuts possible; Retrofit existing stormwater pond
Roland Park	NSA_H_89	1	100%		X	X	X	X				None
The Terraces	NSA_H_90A	1/4	100%	X		X		X		X		Existing forest conservation area
The Terraces	NSA_H_90B	1/4	60%				X					Tree planting opp. at end of street
Roland Park North	NSA_H_91	Multifamily	50%	X		X		X				Few tree planting opp.; pond retrofit
Roland Park	NSA_H_92	>1	75%		X	X	X	X				Poor yard waste disposal habits

Table 4.9. Summary of Neighborhood Assessment Strategies

	Recommended Actions											
Neighborhood	**Site ID**	**Median lot size (acres)**	**% Opportunity for Downspout Disconnection**	**Rain Barrels**	**Rain Gardens**	**Stormdrain Stencils**	**Bayscape**	**Nutrient Management**	**Pet Waste**	**Buffer Encroach**	**Street Trees**	**Notes**
Park Heights	NSA_H_93	<1/8 - <1/4	25%	X		X						Some trash in alleys
Bolton Hill	NSA_H_94A	<1/8	100%	X								Noted street sweeping activity
Madison Park	NSA_H_94B	<1/8	100%	X								Plantings in vacant lots
Mt. Vernon	NSA_H_95	<1/8/Multifamily	N/A	X		X			X			Business/Residential area
Charles Village	NSA_H_96	<1/8	N/A	X		X						Tree planting in vacant lots/trash education
Coldstream/Homestead/Montebello	NSA_H_97	<1/8	N/A	X		X						Trash clean-up/education
Better Waverly	NSA_H_99	<1/8/Duplexes	N/A	X		X						Trash clean-up/education
N/A =data wasn’t recorded on the field sheet.												

Hotspot Assessment

Of the 16 hotspots that were assessed in the Lower Jones Falls subwatershed, four were classified as confirmed hotspots, six were classified as potential hotspots and six were classified as not a hotspot (Table 4.10 and Figure 4.5). The majority of the hotspots consist of automotive repair shops, commercial strip malls and a few gas stations. Identified sources of pollution include storage, disposal and treatment of materials from automotive repair activities, storage of automotive and restaurant grease and better management of trash at sites.

These pollutants can be reduced through focused business education and outreach efforts. Most of the identified hotspots are located in economically depressed areas of the city. A green job program that educates and employs local residents is recommended to address hotspots in this subwatershed. This program should work across watershed boundaries with the Back River to target environmental clean-up in northeastern Baltimore.

Additional information on each practice is found in Appendix C.

Table 4.10. Summary of Hotspot Sites Strategies

Status	Site ID	Description and Location	Potential Sources of Pollution					
			Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/Landscaping	Stormwater Management
Confirmed	HSI_H_202	Shop and Save Grocery Store Harford Rd and Lanvale St.		X	X			
Confirmed	HSI_H_205	Strip Mall Harford and Northern Pkwy		X	X			
Confirmed	HSI_H_213	Industrial Strip Mall 30th St. and Sisson St.	X	X				
Confirmed	HSI_H_401	MJ's Collision Shop Belvedere Ave.	X	X		X		X
Potential	HSI_H_201	Catering, banquet and meeting Hall, 2014 Harford Rd.	X	X	X			
Potential	HSI_H_204	Sole Food Harford Rd. and North Ave.		X	X			
Potential	HSI_H_207	Automotive Repair 25th St. and Homewood		X				
Potential	HSI_H_209	Automotive Repair Kurt and Curtain St.	X	X	X			
Potential	HSI_H_210	Carroll Fuel 41st St.	X	X				
Potential	HSI_H_212	Wash Center North Ave.	X	X	X			X
Not a hotspot	HSI_H_200	City Bus Maintenance Facility 20th St. and Harford Rd.	X					
Not a hotspot	HSI_H_203	Top Gasoline, Greenmount and 25th St.				X		
Not a	HSI_H_206	Automotive Repair Shop	X	X	X			

Table 4.10. Summary of Hotspot Sites Strategies								
			Potential Sources of Pollution					
Status	Site ID	Description and Location	Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/Landscaping	Stormwater Management
hotspot		2504 Harford Rd.						
Not a hotspot	HSI_H_208	MTA Bus Storage and Fueling Kirk Ave. and Curtain Ave.	X					
Not a hotspot	HSI_H_211	Pepsi Distribution, 41st St.	X					X
Not a hotspot	HSI_H_400	Automotive Repair Shop 5115 Pimlico Rd.	X					

Figure 4.5. A and B. HSI_H_207 an Automotive Repair Shop with Automotive Fluids Stored Outdoors. C. HSI_H_201 A Variety of Trash Stored Adjacent to a Strip Mall. D. HSI_H_205 Outdoor Storage of 55-gallon Drums.

Assessment of Institutions

Institutions include schools, medical centers and places of worship. Twenty-two schools and two medical centers were assessed. Of the schools assessed, 19 are public and three are private schools. At the schools, major opportunities identified were tree planting, education on trash management, and the removal of impervious cover as outlined in Table 4.11 and Figure 4.6. At the places of worship, trash management and tree planting were identified as priorities. Barclay Elementary School had impervious cover removed through the Baltimore City and Port Administration program.

Figure 4.6. A. Extensive Impervious Cover Removal was Identified at Robert Pool Middle School and High School (ISI_H_206). B. Trash Management was Identified as a Necessary Pollution Prevention Practice at Waverly Middle School (ISI_H_207). Several Restoration Opportunities Identified at Sinai Hospital (ISI_H_200) include C. Retrofitting the Existing Dry Pond and D. Tree Planting in Pervious Areas.

Table 4.11. Summary of Strategies for Institutions								
			Greening Opportunities					
Site ID	Name of Site	Public/ Private	Nutrient Management	Tree Planting (#)	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management
			Medical Centers					
ISI_H_200	Sinai Hospital	Private		500	X			X
ISI_H_216	Mt. Washington Pediatric Hospital	Public		45		X		X
			Schools					
ISI_H_201	Poly Western High School	Public	X	500+	X	X		X
ISI_H_202	Pimlico Elementary School	Public		0	X		X	X
ISI_H_203	Edgecombe Circle Elementary School	Public		0		X	X	X
ISI_H_204	Waldorf School	Private		50	X	X	X	
ISI_H_205	Martin Luther King, Jr. Elementary School	Public	X	50	X			X
ISI_H_206	Robert Poole Middle/High School	Public		0	X	X	X	X
ISI_H_207	Waverly Middle School	Public		100	X		X	X
ISI_H_209	Johnston Square Elementary School	Public		50	X	X	X	
ISI_H_210	St. Mary's Seminary & University	Private	X	500	X		X	
ISI_H_211	Roland Park Country School	Private		50				
ISI_H_212	Coldstream Park Elementary School	Public		100				X
ISI_H_213	Cecil Elementary School	Public		43			X	X
ISI_H_214	Dallas F Nichols Elementary School	Public		15				X
ISI_H_215	George G Kelson Elementary School	Public		60				X
ISI_H_217	Medfield Heights Elementary School	Public		40			X	X
ISI_H_218	Booker T Washington Elementary/Middle School	Public		50				X
ISI_H_219	Metro Delta Head Start	Public		40			X	X
ISI_H_220	John Eager Howard Elementary School	Public		30			X	X
ISI_H_221	Mt. Royal Elementary/Middle School	Public		0			X	X
ISI_H_222	Barclay Elementary/Middle School*	Public		30				X
ISI_H_223	Margaret Brent Elementary School	Public		0				
ISI_H_224	Ujima Village Academy, Dr. Roland, N. Patterson, Sr. Academy	Public		150	X			

Stream Restoration

There are no plans for stream restoration in the Lower Jones Falls subwatershed at this time.

Illicit Discharge Detection and Elimination

No illicit discharges were inventoried in the Lower Jones Falls as part of this plan, although, a key strategy is to investigate illicit discharges in the future. Information on Baltimore City's IDDE program can be found in Section 3.0.

Stormwater Retrofits

Fourteen stormwater retrofits were identified at nine sites within the watershed (Table 4.12). These include several opportunities to treat large drainage areas, including one at Druid Hill Park (LJ_R_19), which has an estimated drainage area of 90 acres. There are also some relatively small on-site retrofits that are possible at some of the business and school sites.

Table 4.12. Summary of Stormwater Retrofit Strategies

Site	Location	Description	Estimated Drainage area (acres)*	Priority
LJ_R_2A	Sinai Hospital	Enhance existing dry extended detention basin to treat parking lot and rooftop runoff	12	High
LJ_R_2B	Sinai Hospital	Bioretention areas in existing landscaping areas in parking lot to treat parking lot runoff	8.5	Medium
LJ_R_3	Tamarind Rd. and Springarden Dr.	Bioretention area at end of roadway to treat roadway runoff	1	Medium
LJ_R_6	Pimlico Elementary School	Bioretention area in existing landscaping areas in parking lot to treat parking lot runoff	1	Medium
LJ_R_7A	Waldorf School	Rain garden to treat small pervious landscaping area	0.25	Medium
LJ_R_7B	Waldorf School	Downspout disconnection	0.25	Medium
LJ_R_7C	Waldorf School	Impervious cover removal	0.25	Low
LJ_R_9	West Old Coldspring Ln. and Brand Ave.	Stormwater wetland to treat stormwater runoff from upstream	22	Medium
LJ_R_10A	Edgecombe Circle Elementary School	Impervious cover removal	3	High
LJ_R_10B	Edgecombe Circle Elementary School	Rain garden to treat small pervious landscaping area	0.25	High
LJ_R_11	Edgecombe Park	Site reforestation/revegetation	5	High
LJ_R_19	Druid Hill Park, Druid Hill Park Dr. and Greenspring Ave.	Stream and floodplain restoration to treat stormwater runoff from upstream drainage area	90	Medium
LJ_R_38	Wood Heights Ave. and La Plata Ave.	Wooded stormwater wetland to treat stormwater runoff from upstream drainage area	10	High
LJ_R_44	Northern Pkwy., W. of Greenspring Ave.	Bioretention in existing landscaping area in roadway median to treat roadway runoff	1	Medium

Pervious Area Restoration

Nineteen potential pervious area restoration sites were identified in the Lower Jones Falls subwatershed (Table 4.13 and Figure 4.7). The largest, PAA-H-218, covers 10 acres. Pervious area restoration has the potential to convert turf area to forest, reducing nutrient input to streams. Several of the pervious areas are located at schools and vacant lots identified throughout the subwatershed.

Table 4.13. Summary of Potential Pervious Area Restoration Sites

Site	Location	Description	Size (acres)	Ranking
PAA-H-200	Edgecombe Circle E.S.	Potential to plant trees around the school	2.0	Medium
PAA-H-201	Off Druid Hill Ave.	Turf area between rowhomes	0.5	Low
PAA-H-202	Dr. Martin Luther King Jr. E.S.	Plant trees around school	2.0	High
PAA-H-203	Barclay E.S.	Plant trees around school	2.0	Low
PAA-H-204	City College H.S.	Plant trees in open space	1.0	High
PAA-H-205	Abbottston E.S.	Plant trees in vacant turf area	1.0	High
PAA-H-206	City College H.S.	Plant trees on vacant turf	7.0	High
PAA-H-207	Druid Hill Ave.& Retreat St.	Empty lot with existing turf	0.5	Medium
PAA-H-208	Linden Ave. & Whitelock St.	Empty lot with existing turf	0.25	Low
PAA-H-209	Pimlico Rd. & Thorndale Ave.	Potential for pavement removal	1.0	Low
PAA-H-210	Atkinson St. & 28th St.	Abandoned Lot	0.75	Low
PAA-H-211	23rd St. & Calvert St.	Existing park/plant additional trees and add pet waste station/invasive removal	1.0	Medium
PAA-H-212	Johnson Square E. Chase St. & Homewood Ave.	Tree planting at school and park	2.5	Medium
PAA-H-213	Old Town Mall Forrest St. & McElderry St.	Tree planting, impervious cover removal	2.0	Low
PAA-H-214	Reisterstown Rd & Classen Ave.	Existing turf area in rundown neighborhood	0.5	Low
PAA-H-215	Divine Life Church 5928 Falls Rd	Buffer enhancement along Jones Falls mainstem	3.0	Medium
PAA-H-216	Booker T. Washington School	Unused mowed area	1.0	High
PAA-H-217	Helman Williams Fire Station	Large site for tree planting	1.5	High
PAA-H-218	Falls Rd & Lake Ave.	Large site for tree planting	10.0	High

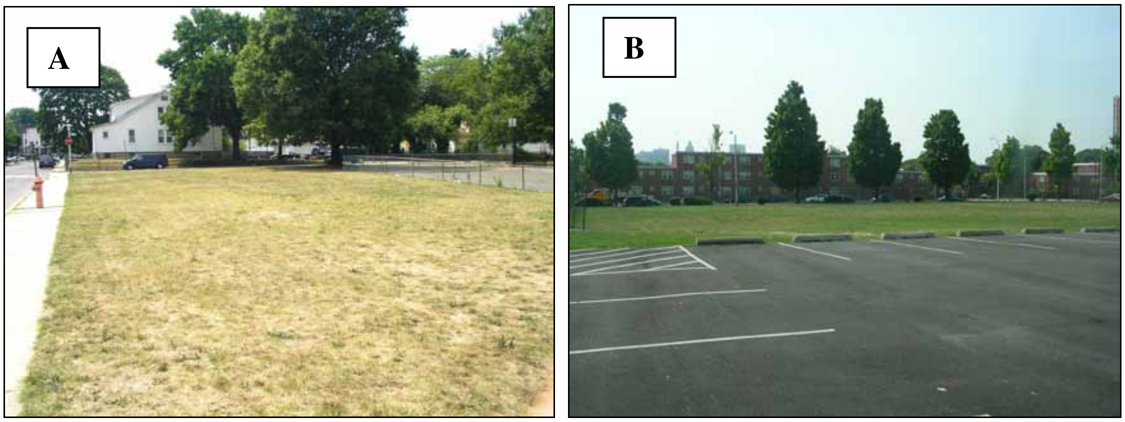

Figure 4.7. Locations for Potential Tree Planting A. Edgecombe Circle E.S. (PAA_H_200) and B. Booker T. Washington School (PAA_H_216).

Subwatershed Management Strategy

Implementation strategies for the Lower Jones Falls subwatershed are as follows:

1. Work with the schools to remove excess impervious cover and convert that area to a vegetated cover that includes trees. Where recommended, integrate stormwater management practices to treat runoff at the school.
2. In the northern portion of the subwatershed, target ¼ acre and larger residential homes for downspout disconnection and lawn management. Work with residents to conduct a test of nutrients in their soil to determine the needed application rate.
3. Engage homeowners in the more denser populated areas of the subwatershed in trash clean-up, storm drain stenciling and general environmental education.
4. Conduct downspout disconnection in both multi-family and ¼ acre residential lots. Use the information collected from Table 4.9 to identify neighborhoods for downspout disconnection. This is represented by the percent of connected downspouts. Neighborhoods with a high percent of downspouts connected to the stormdrain will be considered for disconnection. Refer to Baltimore County DEPRM, 2008 for more detailed information.
5. Provide an environmental jobs training program for residents in the economically depressed sections of the subwatershed. The program should focus on tree planting, trash clean-up in neighborhoods and parks, etc. The program will help increase environmental awareness, restore the subwatershed and provide jobs.
6. Provide education to businesses along the Harford Road corridor regarding good housekeeping practices.
7. Install small retrofits at schools to be used as demonstration sites. These projects will have high visibility for parents and teachers and should involve the students in their implementation.

4.3 Moores Branch Subwatershed

Moores Branch is situated entirely within Baltimore County between Slaughterhouse Branch and Moores Branch. Encompassing mainly low density residential areas and forested land use, the Moores Branch empties into the mainstem to the west of I-83 near the Sorrento Run neighborhood. It is bordered by I-83 to the west, I-695 to the north, Stevenson Rd to the east and Smith Ave to the South. Greenspring Quarry Lake, an old stone quarry is located in the middle of the subwatershed. The old quarry is being developed as a mix of residential, commercial and office space.

There were no hotspots identified in this subwatershed as the subwatershed is more than half residential (56%; Table 4.14). The assessment of the neighborhoods identified restoration opportunities including downspout disconnection, nutrient management education and storm drain stenciling. Tree planting and stormwater treatment projects at three schools were identified.

Table 4.14. Basic Profile of Moores Branch Subwatershed

Drainage Area	• 1396 acres (2.18 mi^2)	
Stream length	• 8.1 miles	
Land Use	• Forest (27.9%) • Commercial (0.9%) • Agricultural (2.3%) • Industry (7.3%) • Institutional (11.0%)	• Low Density Residential (21.0%) • Medium Density Residential (21.6%) • High Density Residential (13.3%) • Bare Ground (2.3%) • Extractive (7.3%)
Current Impervious Cover	• 15.31%	
Jurisdictions as Percent of Subwatershed	• Baltimore City (0%) • Baltimore County (100%)	
Soils	• A Soils – 0% • B Soils – 74.5%	• C Soils – 9.8% • D Soils – 15.7%
Stormwater management	• County – Thirteen (13) stormwater management facilities that treat 1,202.9 acres	

Summary of Assessments and Related Findings

Stream Assessment
Baltimore County (2007) conducted a stream assessment in Moores Branch that identified the in-stream conditions including channel alteration, erosion, exposed pipe, fish barriers, inadequate buffers, in-stream construction, pipe outfalls and trash dumping. The results are summarized in Table 4.15. Detailed information on stream assessments if found in Section 3.0.

Table 4.15. Summary of Stream Conditions in Moores Branch	
Stream Impact	**Number of Problems (estimated length)**
Channel Alteration	3
Erosion	20 (17,025 ft)
Exposed Pipe	7
Fish Barrier	11
Inadequate Buffer	26 (11,828 ft)
In-Stream Construction	8
Pipe Outfall	1
Trash Dumping	1

Neighborhood Assessment

Eighteen neighborhoods were assessed in the Moores Branch Subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include public education, downspout disconnection, stormdrain stenciling, tree planting and lawn care education (i.e. nutrient management) as outlined in Table 4.16. Stenciled storm drains were absent from most of the neighborhoods and recommended as a project that would both engage homeowners and increase awareness. In addition, every neighborhood had highly managed lawns that allow nutrients and chemicals to enter the stream (Figure 4.8). Education of homeowners on the proper maintenance of their lawn is critical. Downspout disconnection is a restoration opportunity in almost every neighborhood that includes either capturing water with a rain barrel, rain garden or by simple disconnection to a pervious area. Other restoration options include tree planting and converting turf to bayscapes are also important goals. Detailed information on these practices is found in Baltimore County DEPRM, 2008.

Hotspot Assessment

There were no potential hotspots identified in Moores Run.

Figure 4.8. A. A Typical High Maintenance Lawn from Long Meadow Estates (NSA_H_6) and B. A Large Area for Potential Tree Planting in Rockland (NSA_H_3).

Table 4.16. Summary of Neighborhood Assessment Strategies

	Recommended Actions												
Neighborhood	**Site ID**	**Median lot size (acres)**	**Opportunity for Downspout Disconnection**	**Rain Barrels**	**Rain Gardens**	**Stormdrain Stencils**	**Bayscape**	**Nutrient Management**	**Pet Waste**	**Buffer Encroach**	**Street Trees**	**Notes**
Dumbarton	NSA_H_01	¼- ½	65%		X	X	X	X		X		Buffer plantings
Greengate	NSA_H_02	1	40%		X	X	X	X			X	None
Rockland	NSA_H_03	¼	70%		X	X		X		X		Large pervious area to plant trees
Long Meadow Est.	NSA_H_06	¼ - ½	85%		X	X	X	X				High management lawns, organic matter and sediment
Dumbarton	NSA_H_11	¼	50%		X	X		X			X	50+ Street trees
Pickwick	NSA_H_13	<¼	30%					X		X	X	100 Street trees, sediment and debris in gutters
Summit Chase	NSA_H_23	¼	35%		X	X		X				None
Summit Chase	NSA_H_24	¼ - ½	60%		X	X	X	X		X		Buffer planting, private land
Rockland Run	NSA_H_25	½ - 1	50%					X				None
Stevenson Post	NSA_H_26	Multifamily	95%	X	X	X		X				3 SWM ponds here, plant trees
Helmsley Court	NSA_H_27	1	50%	X		X	X	X		X		Stormwater pond retrofit
Eden Roc	NSA_H_28	1	75%		X	X	X	X				None
Greengate	NSA_H_29	½	85%	X	X	X	X	X		X		Plant trees in yard
Greengate	NSA_H_30	Multifamily	35%			X	X	X				Plant trees in open space
Greenspring East	NSA_H_31	1	80%		X	X		X				None
Sorrento Run	NSA_H_36	<1/8	80%			X		X			X	None
Dumbarton Heights	NSA_H_42	Multifamily	75%					X		X	X	Scattered tree planting opportunities
Greengate	NSA_H_45	Multifamily	50%			X		X		X		Potential for ~100 trees to be planted

Assessment of Institutions
Institutions include medical centers, schools and places of worship. In Moores Branch three schools were assessed for subwatershed restoration opportunities as shown in Table 4.17. Opportunities were identified at The Park School (ISI_H_500) for tree planting, stormwater retrofitting, and downspout disconnection. The Park School has worked with the Jones Falls Watershed Association to plant trees, and is currently pursing funding to install a bioretention to treat parking lot runoff shown in Figure 4.9.B.

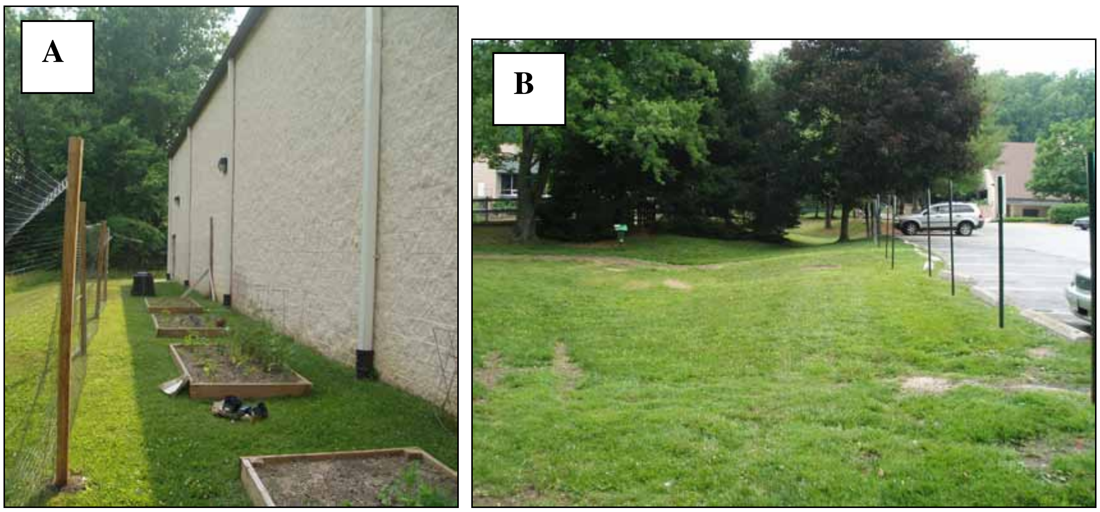

Figure 4.9. Restoration Opportunities at The Park School A. Downspout Disconnection B. Stormwater Retrofit to Treat Parking Lot Runoff.

Table 4.17. Summary of Strategies for Schools and Places of Worship

Site ID	Name of Site	Public/ Private	Greening Opportunities					
			Nutrient Management	Tree Planting (#)	Stormwater Retrofit	Downspout Disconnectio n	Impervious Cover Removal	Trash Management
ISI_H_500	The Park School	Private		50+	x	x		
ISI_H_501	Pikesville Middle School	Public		225				
ISI_H_502	Pikesville High School	Public		150				x

Stream Restoration
A stream restoration project is proposed as mitigation from the developers of the Greenspring Quarry.

Illicit Discharge Detection and Elimination
No illicit discharges were inventoried in Moores Branch as part of this plan. Information on Baltimore County's IDDE program is found in Section 3.0.

Stormwater Retrofits
Five opportunities were identified for stormwater retrofits within the subwatershed (Table 4.18). Stream and floodplain restoration in two areas (MO_R_10, 16) have the potential to treat over a combined drainage area of almost 250 acres. Another bioretention area (MO_R_17) could treat a 12-acre drainage area. Two smaller retrofits at The Park School (MO_R_8) are also possible.

Table 4.18. Summary of Stormwater Retrofit Strategies

Site	Location	Description	Estimated Drainage area (acres)*	Priority
MO_R_8A	The Park School	Dry swale/bioretention area to replace existing grass and concrete channels and treat parking lot runoff	1.44	High
MO_R_8B	The Park School	Downspout disconnection to riparian buffer to treat rooftop runoff	0.25	Medium
MO_R_10	Greenspring East, Valley Park Dr. and Stream Crossing Rd.	Stream and floodplain restoration with removal of in-stream detention basin	180	Medium
MO_R_16	Dumbarton Heights, above Humboldt Rd.	Stream and floodplain restoration to treat stormwater runoff from upstream drainage area	60	Medium
MO_R_17	Stevenson Crossing, Old Court Rd. and Old Crossing Dr.	Bioretention area in existing dry detention basin to treat stormwater runoff from upstream drainage area	12	High

Pervious Area Restoration
Pervious area restoration has the potential to convert turf area to forest, reducing nutrient input to streams. One potential pervious area restoration site, totaling 7.5 acres, was identified in Moores Branch (Table 4.17).

Table 4.19. Summary of Pervious Area Strategies

Site	Location	Description	Size (acres)	Ranking
PAA-H-500	Stone Mill and Old Court Rd.	Existing turf area	7.5	Medium

Subwatershed Management Strategy

Implementation strategies for the Moores Branch subwatershed are as follows:

1. Pursue tree planting and stormwater management opportunities at local schools.
2. Develop a neighborhood wide education program on nutrient management.
3. Expand the pilot downspout disconnection program into this subwatershed using a variety of practices including rain barrels, rain gardens and simple downspout disconnection.
4. Encourage the protection of existing forest cover. Currently the forest cover is 28% for this subwatershed.
5. Install retrofit MO_R_17, to create a bioretention area in an existing dry detention basin to treat stormwater runoff from the upstream drainage area.

4.4 Slaughterhouse Branch Subwatershed

Slaughterhouse Branch is a mostly suburban subwatershed located entirely in Baltimore County. It drains the northern-most part of the watershed study area emptying into the Upper Jones Falls subwatershed located near I-83. The subwatershed is bordered by Stevenson Road to the west, Woodvalley Drive to the north, Old Court Road (133) to the south and I-83 to the east. The Baltimore Beltway, I-695, runs east-west, cutting through the subwatershed. The subwatershed consists of mostly low density residential (47.9%) and forest (24%) land use (Table 4.20). The residential neighborhoods are mostly one-acre lots with tree canopy present. There is some agricultural land in the subwatershed with horse farms. There are no hotspots or illicit discharges assessed in this subwatershed. Restoration strategies focus on reducing nutrients used on residential lawns, downspout disconnection, planting stream buffers, installing stormwater retrofits and working with schools to plant trees and treat stormwater on-site.

Table 4.20. Basic Profile of Slaughterhouse Branch Subwatershed	
Drainage Area	• 1272.02 acres (1.9 mi^2)
Stream length	• 10.2 miles
Land Use	• Forest (24%) • Agricultural (14.1%) • Institutional (2.1%) • Low Density Residential (47.9%) • Medium Density Residential (8.8%) • High Density Residential (7.4%)
Current Impervious Cover	• 12.7%
Jurisdictions as Percent of Subwatershed	• Baltimore City (0%) • Baltimore County (100%)
Soils	• A Soils – 0% • B Soils – 82.9% • C Soils – 7.7% • D Soils – 9.3%
Stormwater management	• County – Four (4) stormwater management facilities that treats 36.5 acres

Summary of Assessments and Related Findings

Stream Assessment

A Stream Stability Assessment (SSA) was conducted by Parsons Brinkerhoff, Inc. in the Slaughterhouse Branch subwatershed. The study assessed 8.8 stream miles and the results of the assessment are summarized in Table 4.21. Detailed information on stream assessments is found in Section 3.0.

Table 4.21. Summary of Stream Conditions in Slaughterhouse Branch

Stream Impact	Number of Problems
Erosion	39% of stream
Fish Barrier	55.9% of stream
Inadequate Buffer	3.4 miles
Habitat Condition	60% Fair, 44.1% Poor
Exposed Pipe	17 exposed manhole risers, 7 utility conflicts

Neighborhood Assessment

Twelve neighborhoods were assessed in Slaughterhouse Branch Subwatershed. Most neighborhoods are one acre or larger lot sizes with a few multi-family residences. Pollution prevention opportunities identified to address stormwater volume and pollutants include public education, downspout disconnection, stormdrain stenciling, tree planting and lawn care education (i.e. nutrient management) as outlined in Table 4.22 and shown in Figure 4.10. Stenciled storm drains were absent from all of the neighborhoods and recommended as a project that would both engage homeowners and increase awareness. In addition, several opportunities for downspout disconnection were identified that include rain gardens, rain barrels and simple disconnection. High lawn care maintenance through the use of professional landscaping was common. An education program that provides alternative turf management is recommended.

Figure 4.10. A. Professional Landscaping Typical in Parts of Dumbarton Heights (NSA_H_7A) B. An Example of the Need for Stream Buffers in Halcyon Gate (NSA_H_41).

Hotspot Assessment

There were no potential hotspots identified in Slaughterhouse Branch.

Assessment of Institutions

In Slaughterhouse Branch, three schools were assessed for subwatershed restoration opportunities (Table 4.23). Opportunities were identified at St. Timothy School (ISI_H_600) and Chizuk Amuno Congregation (ISI_H_601) for tree planting, stormwater retrofits, and downspout disconnection. Trash management and impervious cover removal were identified at Chizuk Amuno Congregation. Planting trees throughout the Fort Garrison Elementary School (ISI_H_602) is recommended.

Stream Restoration

No stream restoration projects are proposed for this subwatershed.

Table 4.22. Summary of Neighborhood Assessment Strategies

Neighborhood	Site ID	Median lot size (acres)	Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Pet Waste	Buffer Encroach	Street Trees	Notes
	Recommended Actions											
Greengate	NSA_H_02	1	40%		X	X		X			X	None
Rockland	NSA_H_03	¼	70%		X	X		X		X		Large pervious area to plant trees
Dumbarton Heights	NSA_H_07	½	60%		X	X		X				Evidence of professional landscaping, 40 pools
Dumbarton Heights	NSA_H_07A	½	50%			X	X	X		X	X	None
Halcyon Gate	NSA_H_08	1	70%		X	X	X					None
Stevenson Post	NSA_H_26	Multifamily	95%	X	X	X		X				3 SWM ponds here, plant trees
Eden Roc	NSA_H_28	1	75%		X	X	X	X				None
Greenspring East	NSA_H_31	1	80%		X	X		X				None
Knollcrest Farms	NSA_H_39	>1	70%		X	X	X	X				Extensive existing turf, opportunity to plant trees
Brookwood	NSA_H_40	>1	40%		X	X		X		X		None
Halcyon Gate	NSA_H_41	>1	0%					X		X		Large wooded lots, plant stream buffer
Dumbarton Heights	NSA_H_42	Multifamily	75%					X		X	X	Scattered tree planting opportunities

Table 4.23. Summary of Strategies for Institutions								
			Greening Opportunities					
Site ID	**Name of Site**	**Public/ Private**	**Nutrient Management**	**Tree Planting**	**Stormwater Retrofit**	**Downspout Disconnection**	**Impervious Cover Removal**	**Trash Management**
ISI_H_600	St. Timothy's School	Private		x	x	x		
ISI_H_601	Chizuk Amuno Congregation	Private		x		x	x	x
ISI_H_602	Fort Garrison Elementary School	Private		x				

Illicit Discharge Detection and Elimination
No illicit discharges were inventoried in the Slaughterhouse Branch as part of this plan. Information on Baltimore County's IDDE program is found in Section 3.0.

Stormwater Retrofits
Six stormwater retrofit opportunities were identified at three locations within the subwatershed (Table 4.24). There is the potential for the creation of two bioretention areas (SL_R_2, SL_R_3) in existing dry detention basins that would treat an estimated combined drainage area of 47 acres. In addition, four potential retrofits were identified at Fort Garrison Elementary School (SL_R_1) including bioretention, dry swale, rain gardens and reforestation.

Table 4.24. Summary of Stormwater Retrofit Strategies				
Site	**Location**	**Description**	**Estimated Drainage area (acres)***	**Ranking**
SL_R_1A	Fort Garrison Elementary School	Bioretention area to replace existing grass swale/detention area, treat parking lot runoff	1	High
SL_R_1B	Fort Garrison Elementary School	Dry swale to replace existing grass swale and treat runoff from compacted pervious area (e.g. ball fields)	4	Low
SL_R_1C	Fort Garrison Elementary School	Rain gardens to treat rooftop runoff and prevent soil erosion	0.8	Medium
SL_R_1D	Fort Garrison Elementary School	Site reforestation/revegetation in compacted pervious areas	0.6	Medium
SL_R_2	Stevenson Crossing, Old Post Dr. & Old Crossing Dr.	Bioretention area in existing dry detention basin to treat stormwater runoff from upstream drainage area	12	Medium
SL_R_3	Stevenson Crossing, E. of Old Crossing Dr., S. of Old Post Dr.	Bioretention area in existing dry detention basin to treat stormwater runoff from upstream drainage area	35	Medium

Pervious Area Restoration

Pervious area restoration has the potential to convert turf area to forest, reducing nutrient input to streams. One potential pervious area restoration site, totaling 2 acres, was identified in Slaughterhouse Branch (Table 4.25). The site functions as a common area for the adjacent townhomes located off Crossing Drive. Contingent upon landowner approval, the site is ideal for tree planting.

Table 4.25. Summary of Potential Pervious Area Restoration Sites				
Site	**Location**	**Description**	**Size (acres)**	**Ranking**
PAA-H-600	Off Crossing Drive	Townhome common area	2.0	Medium

Subwatershed Management Strategy

Implementation strategies for the Slaughterhouse Branch subwatershed are as follows:

1. Install retrofits SL_R_2 and SL_R_3 that will enhance stormwater treatment in existing dry detention ponds and treat over 47 acres.
2. Using the identified inadequate stream buffer data, work with the county and landowners to plant stream buffers where they are needed.
3. Contact the landowner of the pervious area, PAA_H_600, to determine if a tree planting project is feasible. This project should include townhome residents' involvement in both the design and implementation of the plantings.
4. Develop a stormdrain stenciling program that engages and educates residents about stormwater and pollutants. This program should target the neighborhoods identified in table 4.22. The program is recommended to be used watershed wide.
5. Conduct downspout disconnection at both multi-family and one-acre residential lots. Use the information collected from Table 4.22 to identify neighborhoods for downspout disconnection. This is represented by the percent of connected downspouts. Neighborhoods with a high percent of downspouts connected to the stormdrain will be considered for disconnection. This practice includes simple disconnection, and the use of rain barrels and rain gardens. Refer to chapter 4 for more detailed information.
6. Work with the Fort Garrison Elementary School, St. Timothy School and the Chizuk Amuno Congregation to implement the identified stormwater retrofits and plant trees. The retrofits and tree plantings will improve aesthetics, treat stormwater runoff and could be incorporated into an environmental education program for the students or congregation. Additional details on retrofits are found in Appendix F.
7. Provide lawn care education to neighborhoods identified with high turf management. Work with the homeowners that live in the neighborhoods identified in Table 4.22 to reduce the amount of nutrients applied to their lawn and other pollution prevention measures.

4.5 Stony Run Subwatershed

Stony Run subwatershed drains the northeastern portion of the watershed in the City of Baltimore with only a small portion draining from Baltimore County near Lake Avenue. Stony Run is just over 66% residential, with half of the subwatershed comprised of medium density residential. Another significant land use is institutional and makes up over 20% of the subwatershed (Table 4.26). The large institutional component includes part of Johns Hopkins University, Loyola College, College of Notre Dame, and many private high schools and grade schools. The City of Baltimore has completed 5,300 linear feet of stream restoration in Stony Run to reconnect the stream with its floodplain and reduce bank erosion. Future plans to restore portions of lower Stony Run and Little Stony Run have been designed and are set for construction in the next two years.

Simple downspout disconnection could be implemented at residential neighborhoods and schools to reduce the volume of stormwater entering the stormdrain system. Illicit discharges were also plentiful in this watershed including a number of active sewage and washwater discharges. There is also considerable potential to work with large institutional landholders to install stormwater retrofits (often bioretention for parking lots), tree planting, pollution prevention techniques including nutrient reduction in lawn care, and downspout disconnection. Many of the schools have already participated in tree planting and rain garden construction with the Jones Falls Watershed Association and there is tremendous opportunity to continue this effort to treat larger amounts of impervious cover and convert turf to forest cover.

Table 4.26. Basic Profile of Stony Run Subwatershed		
Drainage Area	• 2242.23 acres (3.5 mi^2)	
Stream length	• 3.7 miles	
Land Use	• Forest (4.9%) • Low Density Residential (5.0%) • Medium Density Residential (50.2%) • High Density Residential (11.1%)	• Highway (1.8%) • Open Urban Land (3.8%) • Water (0.3%) • Commercial (2.3%) • Institutional (20.6%)
Current Impervious Cover	• 31.7%	
Jurisdictions as Percent of Subwatershed	• Baltimore City (98%) • Baltimore County (2%)	
Soils	• A Soils – 1.3% • B Soils – 14.6%	• C Soils – 5.0% • D Soils – 79.1%
Stormwater management	• County – There are no stormwater management facilities • City – There are no stormwater management facilities	

Summary of Assessments and Related Findings

Stream Assessment
EA Engineering, Science and Technology, Inc. prepared a watershed restoration plan for Stony Run in 2001. As part of this plan, the Rapid Stream Assessment Technique (RSAT) was completed for Stony Run. The assessment identified areas along the stream with erosion, illicit discharges, trash, and a lack of stream buffer.

Neighborhood Assessment
Twenty-four neighborhoods were assessed in the Stony Run Subwatershed. Pollution prevention opportunities to address stormwater volume and pollutants include public education, downspout disconnection, stormdrain stenciling, tree planting and lawn care education (i.e. nutrient management) as outlined in Table 4.27 and shown in Figure 4.11. Storm drains were not stenciled through most of the neighborhoods and this was recommended as a project that would both engage homeowners and increase awareness. Over 200 acres of rooftops could be disconnected and redirected to pervious areas.

The highest priorities for rooftop disconnection in Stony Run includes ¼ acre or larger residential and multi family residential areas due to the efficiencies achieved by coordinating with one landowner instead of several individual homeowners. In addition, tree planting and the conversion of turf to bayscapes are also important goals based on the low percentage of forest present and the extent of lawn area on poor soils (77%). Detailed information on these practices is found in Baltimore County DEPRM, 2008.

Figure 4.11. A. Pesticide Free Lawn B. Residential Downspout Disconnected to the Lawn.

Hotspot Assessment
One potential and one confirmed hotspot were identified in Stony Run (Table 4.28 and Figure 4.12). Several identified areas of pollution prevention include the storage of outdoor materials, waste management, landscaping and stormwater management. An incentive program with technical support and cost share may be helpful for businesses interested in stormwater retrofits. Additional information on each practice is found in Appendix C.

Table 4.27. Summary of Neighborhood Assessment Strategies													
	Recommended Actions												
Neighborhood	Site ID	Median lot size (acres)	Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Pet Waste	Buffer Encroach	Street Trees	Notes
Homeland	NSA_H_201	1/2	X	X	X	X	X	X				
Mid-Charles	NSA_H_202	Multifamily	X	X		X	X	X				
Radnor-Winston	NSA_H_203	1/8	X	X		X	X					
Kernewood	NSA_H_204	1/2	X	X		X	X	X				
Guilford	NSA_H_205	1/2	X	X		X	X	X	X			
Tuscany-Canterbury	NSA_H_206	1/4	X			X	X				75	
Remington	NSA_H_207	<1/8				X			X		20	
The Orchards	NSA_H_208	1/2	X	X	X	X	X	X	X			
Bellona-Gittings	NSA_H_209	1/2	X	X		X	X	X	X			
Homeland West	NSA_H_210	1/2	X	X		X	X	X				
Poplar Hill	NSA_H_211	1/2	X	X	X	X	X	X				
Wyndhurst	NSA_H_212	1/4	X	X			X		X			
Roland Park	NSA_H_213	1/2	X	X	X	X	X	X				
Blythewood	NSA_H_214	1	X	X	X		X	X				
Evergreen	NSA_H_215	1/4	X	X	X		X		X		5	
Keswick	NSA_H_216	1/2	X	X			X	X	X			
Keswick West	NSA_H_217	Multifamily	X			X	X	X				
Roland Park South	NSA_H_218	1/2	X	X	X	X	X	X				
Hamden East	NSA_H_219											
Wyman Park	NSA_H_220	1/2		X			X		X		15	
Hamden North	NSA_H_221	1/4				X	X		X			
Hamden West	NSA_H_222	1/8					X		X			
Hamden	NSA_H_223	<1/8	X	X		X			X			
Wyman Park	NSA_H_224	<1/8	X	X			X		X		1	

Table 4.28. Summary of Hotspot Sites Strategies								
			Potential Sources of Pollution					
Status	Site ID	Description	Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/ Landscaping	Stormwater Management
Potential	HSI_H_300	Elkridge Golf Course			X			X
Confirmed	HSI_H_301	Homeland Auto Body	X		X	X	X	

Figure 4.12. Homewood Autobody (HSI_H_300)

Assessment of Institutions

Eight (8) schools and three places of worship were assessed in Stony Run (Table 4.29 and Figure 4.13). Schools and places of worship are a key component of overall subwatershed restoration. The major restoration opportunities identified include tree planting, downspout disconnection, and education on trash management. In addition, trash management and tree planting were identified as priorities at several places of worship.

Figure 4.13. Opportunities at Boy's Latin School: A. Dry Pond for Planting or Conversion to Bioretention B. High Input Turf at College of Notre Dame.

Table 4.29. Summary of Strategies for Institutions								
			Greening Opportunities					
Site ID	**Name of Site**	**Public/ Private**	**Nutrient Management**	**Tree Planting (#)**	**Stormwater Retrofit**	**Downspout Disconnection**	**Impervious Cover Removal**	**Trash Management**
Schools								
ISI_H_304	Hampden ES	Public		10			X	X
ISI_H_308	Roland Park ES/MS	Public		0		X		X
ISI_H_300	Boys Latin HS	Private	X	50-100	X	X		X
ISI_H_301	College of Notre Dame of Maryland	Private	X	100	X			
ISI_H_303	Loyola College	Private		200				X
ISI_H_305	Gilman School	Private	X	0		X		
PAA–300	Guilford ES	Public		50			X	
Places of Worship								
ISI_H_306	Grace United Methodist	Private		20				
ISI_H_307	Cathedral of Mary Our Queen	Private	X	75		X		
ISI_H_309	First Christian Church	Private		50		X		

Stream Restoration

There are two sections of Stony Run where stream restoration projects are planned. The first project begins below Coldspring Lane where it ends just before Ridgemead Road. Work continues just below University Parkway for another 1400 feet. The project length is approximately 4,300 feet, although a portion of the stream system flows through underground culverts. The upstream drainage area is 2,700 acres. The section immediately below Coldspring Lane is severely entrenched, with limited floodplain area, failing gabions and concrete channels throughout. The natural channel design approach may not be applicable above University Parkway. The project will try to stabilize the substrate and remove potential fish blockages. Construction is expected to begin in late summer of 2008 (Seldon, 2008).

The second project has two phases. The first phase is in the lower stream section (800 linear feet), and extends to the property of the College of Notre Dame. The second phase would have included the section of stream (1,535 linear feet) that goes through the property of the College of Notre Dame. Both phases have had easement issues with the adjoining property owner, causing major delays. The City and the College of Notre Dame are currently negotiating a cost sharing agreement for the second phase of the project. The college would be responsible for design and construction and the City would provide cost sharing. The design is expected to begin in the summer of 2008 (Seldon, 2008).

Illicit Discharge Detection and Elimination

Twenty three outfalls were assessed for potential illicit discharges along Stony Run. Of these, 12 were identified as illicit discharges based on laboratory analysis (Table 4.30). The illicit discharges were a mix of sewage and washwater discharges interspersed throughout the length of Stony Run mainstem. Little Stony Run was not surveyed or sampled, though water quality sampling performed by Baltimore City indicates elevated levels of nutrients and bacteria. A number of the illicit discharge sources were identified and should be fixed immediately. These include outfall IDs 1, 101, 113, 318 and 325. In the meantime, public health notice signs should be posted adjacent to the stream due to the potential health hazard associated with the input of pathogenic bacteria to Stony Run.

Table 4.30. Identified Illicit Discharges in Stony Run

Outfall ID	Outfall Size (in)	Flow (gal/ min)	*Annual Flow Estimate (gal/yr)	Detergents (mg/l)	Ammonia, NH_3 (mg/l)	Potassiun (mg/l)	Fluoride (mg/l)	*E. Coli* (MPN/10 ml)	Notes
1	24	15.85	8,332,000	**2.0**	0.0	9.0	**0.83**	<1.0	**
10	8	0.09	45,000	**0.5**	*0.27*	12.0	**1.11**	*547.5*	Intermittent flow
15	6	0.01	3,000	**>3.0**	*0.2*	NA	NA	2.0	Intermittent flow - likely from house at 3925 Linkwood
101	36	0.99	521,000	0.25	**0.51**	16.0	**0.83**	**>2419.2**	**
112	24	N/A	N/A	0.0	**>0.5**	10.0	*0.5*	NA	Trickle
113	18	5.28	2,777,000	**2.0**	0.05	11.0	**0.67**	NA	**
203	48	1.28	670,000	0.25	-0.01	14	0.37	**>2419.2**	None
207*	21	0.34	177,000	**0.5**	*0.12*	17	0.35	325.5	None
301*	21	0.25	131,000	Gross Contamination (Sewage Fungus) at Outfall					** Tracked to break in sanitary sewer line
303	12	0.25	131,000	0.25	**>0.5**	18	**1.12**	**>2419.2**	** Baltimore City has previously tracked to Coldwell Banker
318	27	1.56	819,000	**2.0**	**>0.5**	17	**1.33**	**>2419.2**	** Tracked to vicinity of Cathedral School
325	4	N/A	N/A	Gross Contamination - Leaking Sanitary Sewer Crossing					** Ready to be fixed
Total annual washwater and sewage flow estimate			13,606,000 gallons						

** High priority for tracking
Shaded, bolded cells indicate values that exceed typical benchmark concentrations for the parameter of interest.

Stormwater Retrofits

Ten opportunities for stormwater retrofits were identified in Stony Run (Table 4.31). Several stormwater wetland projects were identified to treat significant drainage areas. In addition, institutions provide a large potential to treat stormwater runoff. For example, a high priority retrofit at the College of Notre Dame includes the retrofit of an existing dry pond.

Table 4.31. Summary of Stormwater Retrofit Strategies

Site	Location	Description	Estimated Drainage area (acres)*	Ranking
ST_R_1	Wyman Park, below Tudor Arms Ave. and Gilman Terr.	Stormwater wetland to treat stormwater runoff from upstream drainage area	60	Medium
ST_R_2A	Green School	Bioretention area in existing depression to treat roadway runoff	0.25	Medium
ST_R_2B	Green School	Site reforestation/revegetation in compacted pervious areas	0.5	Medium
ST_R_4	Calvert School	Underground detention to provide extended detention and partial treatment of stormwater runoff from upstream drainage area	120	Low
ST_R_5	Guilford Neighborhood Tulip Park, Greenway and Stratford Rd.	Stormwater wetland to treat stormwater runoff from upstream residential development.	45	Low
ST_R_7	Friends School	Bioretention area in existing landscaping area in parking lot to treat parking lot runoff	0.8	Medium
ST_R_8	Cathedral of Mary Our Queen	Bioretention areas in existing landscaping areas in parking lot to treat parking lot runoff	2.5	Medium
ST_R_9	Cotswold Rd. and Amberly Way	Enhance existing outfall retrofit to provide additional treatment of stormwater runoff from upstream drainage area	55	Medium
ST_R_10	Knights of Columbus	Bioretention area in existing pervious area to treat parking lot and rooftop runoff	0.3	Medium
ST_R_14	College of Notre Dame of Maryland	Enhance existing dry detention basin to treat stormwater from upstream drainage area	25	High

Pervious Area Restoration

One potential pervious area restoration site, at Guilford Elementary School was identified in Stony Run (Table 4.32). The area is a one-acre site that currently consists of concrete. The concrete will be removed and trees can be planted in its place. Pervious area restoration has the potential to convert turf area to forest, reducing nutrient input to streams.

Table 4.32. Summary of Pervious Area Strategies

Site	Location	Description	Size (acres)	Ranking
PAA-H-300	Guilford Elementary	Pavement removal and turf areas	1.0	

Subwatershed Management Strategy

Implementation strategies for the Stony Run subwatershed are as follows:

1. Address the illicit discharges (8-10) located in Stony Run mainstem and perform monitoring on outfalls in the east branch and Little Stony Run. Baseflow concentrations in Little Stony suggest potential illicit discharges (Baltimore County DEPRM, 2008).
2. Develop a program in coordination with the City to disconnect downspouts in Stony Run. Simple downspout disconnection can be performed in many of the medium and low-density neighborhoods in Stony Run and at schools. Use the information collected from Table 4.25 to identify neighborhoods for downspout disconnection. Refer to Section 3.0 for more detailed information.
3. Provide lawn care education to neighborhoods and institutions identified with high turf management. Work with the homeowners, lawn care companies and schools identified in Table 4.25 to reduce the amount of nutrients applied to lawns and other pollution prevention measures.
4. Install stormwater retrofits identified at several schools and colleges in the watershed as part of a holistic greening approach. This includes tree planting (conversion of lawn to forest), stormwater treatment of parking lots, pollution prevention and downspout disconnection are important parts of the approach.
5. Continue to increase the tree canopy in this watershed with tree giveaways and coupons. Assist Baltimore City in reaching their tree canopy goals by planting trees in identified neighborhoods (Table 4.25), pervious areas (Table 4.30) and schools (Table 4.27).
6. Engage active places of worship in the subwatershed. Several places of worship are identified Table 4.27. Outreach should be conducted to these communities to involve them in the subwatershed restoration effort.

4.6 Western Run Subwatershed

Western Run drains from the west side of the watershed into the Jones Falls near Mt. Washington, spanning the Baltimore City/County line and extends from the Mt. Washington and Pimlico neighborhoods, up to the Baltimore Beltway, I-695, along Park Heights Avenue. The subwatershed predominantly consists of residential land uses (72.3%) with much of the development in 1/8 or ¼ acre lots and multi-family residential (Table 4.33). The headwaters contain a golf course, a cemetery, several on-line ponds and a major highway (I-695), which contributes to the flashy hydrology.

Considerable opportunities for downspout disconnection, and lawn care education and outreach in the multi-family and single-family residential areas exist in this subwatershed. There are limited opportunities for traditional stormwater retrofits due to space and soil infiltration constraints. However, a stormwater retrofit opportunity was identified just below I-695. This retrofit would treat stormwater runoff from I-695 and development upstream. As restoration efforts move forward in this subwatershed, planting trees to increase forest cover will be a key strategy.

Table 4.33. Basic Profile of Western Run Subwatershed	
Drainage Area	• 3487.4 acres (5.4 mi^2)
Stream length	• 9.2 miles
Land Use	• Forest (5.1%) • Commercial (5.6%) • Institutional (5.5%) • Highway (0.3%) • Open Urban Land (11.1%) • Low Density Residential (7.6%) • Medium Density Residential (46.8%) • High Density Residential (17.9%)
Current Impervious Cover	• 31.02%
Jurisdictions as Percent of Subwatershed	• Baltimore City (58%) • Baltimore County (42%)
Soils	• A Soils – 0% • B Soils - 22.4% • C Soils - 14.5% • D Soils - 63.2%
Stormwater management	• County – Seventeen (17) stormwater management facilities that treat 86.5 acres • City - No existing stormwater practices were identified

Summary of Assessments and Related Findings

Stream Assessment

Baltimore County (2007) conducted a stream assessment in Western Run that identified the in-stream conditions including channel alteration, erosion, exposed pipe, fish barriers, inadequate buffers, in-stream construction, pipe outfalls and trash dumping. The results are summarized in Table 4.34. Detailed information on stream assessments if found in Section 3.0.

Table 4.34. Summary of Stream Conditions in Western Run	
Stream Impact	**Number of Problems (estimated length)**
Channel Alteration	5
Erosion	11 (9,785 ft)
Exposed Pipe	6
Fish Barrier	11
Inadequate Buffer	11 (10,718 ft)
In-Stream Construction	0
Pipe Outfall	28
Trash Dumping	7

Neighborhood Assessment

In Western Run, 40 neighborhoods were assessed. Pollution prevention opportunities to address stormwater volume and pollutants include public education, downspout disconnection, stormdrain stenciling, tree planting and lawn care education (i.e. nutrient management) as outlined in Table 4.35 and shown in Figure 4.14. Stenciled storm drains were absent from most of the neighborhoods and recommended as a project that would both engage homeowners and increase awareness. Over 200 acres of rooftops could be disconnected and redirected to pervious areas. The highest priority for rooftop disconnection includes multi-family residential areas due to the efficiencies achieved by coordinating with one landowner instead of several individual ones. In addition, tree planting and the conversion of turf to bayscapes are also important goals based on the low percentage of forest present and the extent of lawn area on poor soils (77%). Detailed information on these practices is found in Section 4.0.

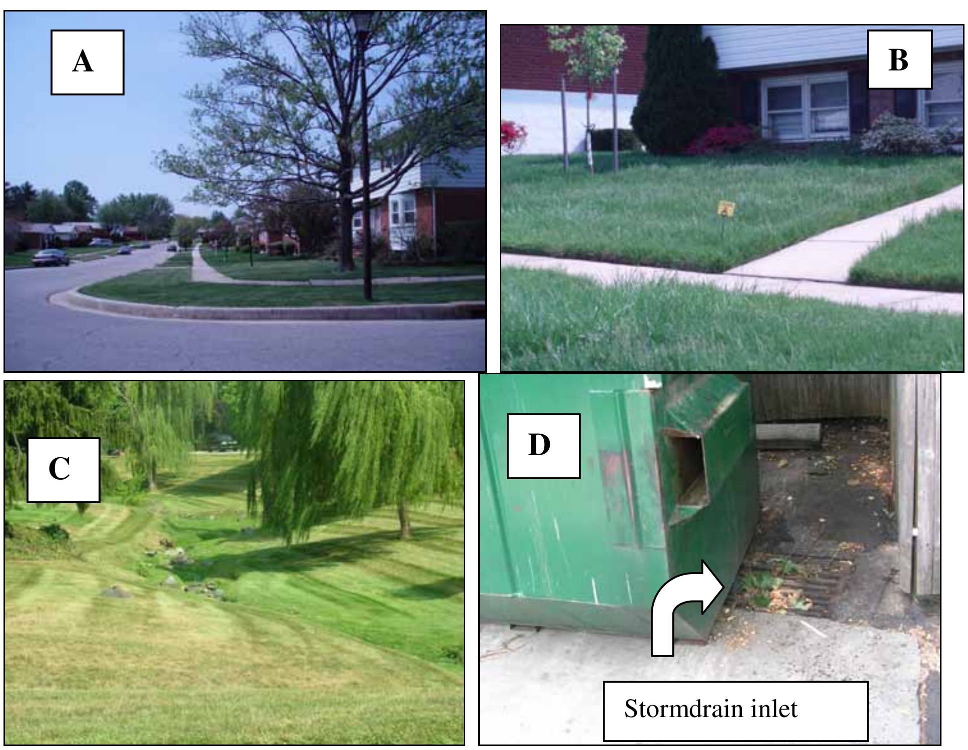

Figure 4.14. A and B. A Representative Neighborhood in Western Run with Highly Manicured Lawns. C. Stream Buffer Mowed to the Edge of Stream at NSA_H_102b, Mt. Washington Apartments and D. Dumpster Located Adjacent to the Storm Drain Inlet in NSA_H_98b, Fox Glenn Apartments.

Table 4.35. Summary of Neighborhood Assessment Strategies

Neighborhood	Recommended Actions											
	Site ID	Median lot size (acres)	Opportunity for Downspout Disconnection	Rain Barrels	Rain Gardens	Stormdrain Stencils	Bayscape	Nutrient Management	Pet Waste	Buffer Encroach	Street Trees	Notes
Dumbarton	NSA_H_01	¼- ½	65%		x	x	x	x		x		Buffer plantings
Long Meadow Est. Fields of Stevenson	NSA_H_04	¼ - ½	85%		x	x		x			x	High management lawns, possible street trees
Long Meadow Est. (Anneh Woods)	NSA_H_05	Multifamily	95%	x		x		x				High management lawns, possible BMP retrofit
Long Meadow Est.	NSA_H_06	¼ - ½	85%		x	x	x	x				High management lawns, organic matter and sediment
Dumbarton	NSA_H_09	¼	50%	x		x						None
Dumbarton	NSA_H_10	¼	50%	x		x	x				x	100+ Street trees
Mount Washington	NSA_H_100	½	25%		x	x		x				Maybe more disconnection opportunities – difficult to tell
Cheswolde (Heather Ridge)	NSA_H_101	Multifamily	75%	x		x		x				Limited lawn area down gradient for disconnection, possible curb cuts
Cheswolde	NSA_H_102 A	Multifamily	60%		x	x		x				None
Cheswolde Brookview/ Mt. Washington Apts	NSA_H_102 B	Multifamily	100%		x	x	x	x		x		High management lawns, no buffer, opportunities for 40 trees
Dumbarton	NSA_H_11	¼	50%		x	x		x			x	50+ Street trees
Pickwick	NSA_H_12	¼	15%			x	x	x			x	100+ Street trees
Pickwick	NSA_H_13	<¼	30%					x		x	x	100 Street trees, sediment and debris in gutters
Colonial Village (Ralston)	NSA_H_14	<¼	60%		x	x	x	x			x	Gutter organic debris
Colonial Village	NSA_H_17	¼	40%		x	x	x					None
Colonial Village	NSA_H_18	<¼	5%		x	x	x		x			Sediment and organic accumulation
Pickwick	NSA_H_20	¼	15%		x	x	x					Sheldrick Lane and Lincoln Ave drain has running water
RanchLeigh	NSA_H_21	¼	25%		x		x	x			x	Good potential for street trees on Farrington Rd

Table 4.35. Summary of Neighborhood Assessment Strategies

	Recommended Actions												
Neighborhood	**Site ID**	**Median lot size (acres)**	**Opportunity for Downspout Disconnection**	**Rain Barrels**	**Rain Gardens**	**Stormdrain Stencils**	**Bayscape**	**Nutrient Management**	**Pet Waste**	**Buffer Encroach**	**Street Trees**	**Notes**
Bonnie Ridge	NSA_H_22	Townhomes	95%			x		x				Space for bioretention at rd ends, Existing dry pond BMPs
Pickwick	NSA_H_23	¼	0%		x	x		x				None
RanchLeigh	NSA_H_35	¼	25%			x		x				Open space tree planting (15+)
Colonial Village (Slade Village)	NSA_H_43	Multifamily	0%	x		x	x	x				High management lawn, downspouts mostly connected but little space for treatment, possible parking area retrofits
Pickwick	NSA_H_44	Multifamily	0%		x	x	x	x				Lots of turf, trees and bayscaping
Pickwick East	NSA_H_55	Multifamily	100%			x	x					Rachuba Group Management
Pickwick	NSA_H_56	Multifamily	0%	x		x	x				x	Same management as Pickwick East but disconnected
Glen	NSA_H_71	½	10%		x	x						Rain garden opportunities
Glen	NSA_H_72	¼	30%		x	x	x					None
Glen	NSA_H_73	¼ and <¼	50%		x	x	x	x				Alley retrofits
Cheswolde	NSA_H_74	¼	30%		x	x	x	x		x		Possible buffer planting
Cheswolde	NSA_H_75	Multifamily	50%		x	x	x	x		x		Possible buffer planting
Dixon Hill (The Terraces)	NSA_H_76	1 acre +	0%		x	x						Rain gardens
Dixon Hill	NSA_H_77	½ - 1	25%			x						Possible to add green streets (wide streets)
Cross Country	NSA_H_82	Multifamily	100%			x	x	x				Disconnect and add more trees, street trees, bayscaping
Glen	NSA_H_83	1/8 - ¼	100%		x	x	x					Sediment in gutters – street cleaning
Cross Country	NSA_H_84	¼ and <¼	45%			x	x	x				Possible alley retrofits
Cross Country	NSA_H_85	Multifamily	0%		x	x	x	x				None
Cross Country	NSA_H_86	¼ - ½	100%		x	x		x			x	Street trees 30+ on Labyrinth
Fallstaff	NSA_H_87	<1/8	30%			x	x		x			Oil on roads, alley retrofits, mostly duplexes
Glen	NSA_H_98A	<¼	60%			x				x		No mow or buffer area on stream
Glenn (Fox Glen apts.)	NSA_H_98B	Multifamily	0%									Parking lot retrofit – dumpster over storm drain

Hotspot Assessment

A limited number of potential hotspots were identified in Western Run with only one assessed as a confirmed hotspot (Table 4.36). Greenspring Shopping Center (HSI_H_402) was rated as severe and warrants immediate attention. Problems include the presence of 55 gallon drums stored outside adjacent to a stormdrain with no secondary containment, overflowing dumpsters, and high turf management. The remainder of the sites can be addressed through targeted business education and outreach efforts. Several identified areas of pollution prevention include the storage of outdoor materials, waste management, landscaping and stormwater management. An incentive program with technical support and cost share may be helpful for businesses interested in stormwater retrofits. Additional information on each practice is found in Appendix C.

Table 4.36. Summary of Hotspot Sites Strategies

Status	Site ID	Description	Potential Sources of Pollution					
			Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/ Landscaping	Stormwater Management
Severe	HSI_H_402	Greenspring Shopping Center		x	x		x	x
Confirmed	HSI_H_403	Pimlico Race Course		x	x	x	x	x
Potential	HSI_H_404	Strip Mall		x	x	x		x
Potential	HSI_H_405	7 Mile Market			x	x	x	x
Potential	HSI_H_406	Pikes Diner		x	x	x		x
Potential	HSI_H_407	Golf Course	x				x	
Potential	HSI_H_408	Druid Ridge Cemetery	x	x		x		x

Assessment of Institutions

Seven schools and five places of worship were assessed. Institutions include schools, medical centers and places of worship. Pollution prevention opportunities identified to address stormwater volume and pollutants include public education, downspout disconnection, stormdrain stenciling, tree planting and lawn care education (i.e. nutrient management) as outlined in Table 4.37 and shown in Figure 4.15. Identified opportunities include; tree planting, impervious cover removal, and one site, Fallstaff Middle School (ISI_H_401), where downspout disconnection is possible. The downspout disconnection at Fallstaff Middle School has the potential to disconnect a lot of impervious cover if combined with impervious cover removal near the downspouts. None of these schools have had impervious cover removed through the Baltimore City and Port Administration program. In addition, trash management and tree planting were identified as priorities at several places of worship.

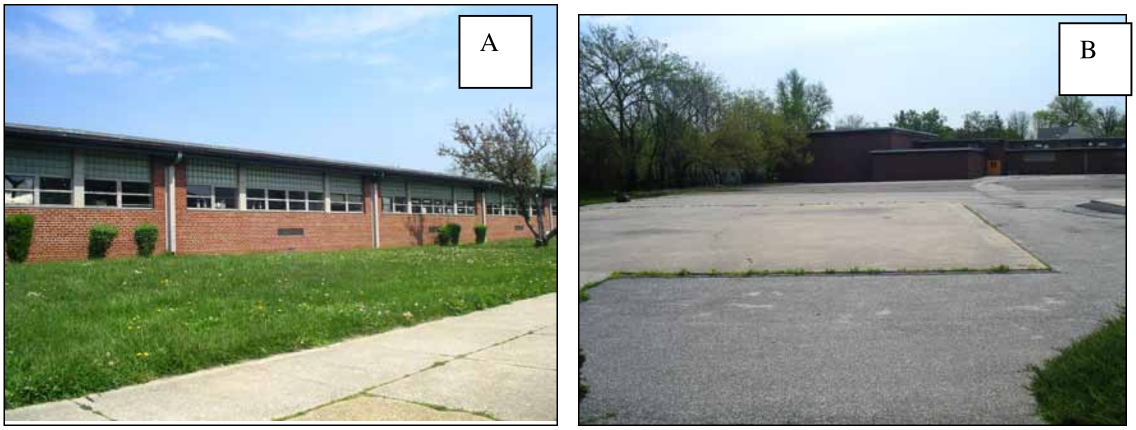

Figure 4.15. Opportunities at Fallstaff Middle School A. Downspout Disconnection and Tree Planting B. Impervious Cover Removal.

Table 4.37. Summary of Strategies for Institutions

Site ID	Name of Site	Public/ Private	Greening Opportunities					
			Nutrient Management	Tree Planting (#)	Stormwater Retrofit	Downspout Disconnection	Impervious Cover Removal	Trash Management
ISI_H_401	Fallstaff MS	Public		50		x	x	
ISI_H_402	Cross Country ES	Public		20			x	x
ISI_H_403	Pimlico MS*	Public	x	200			x	
ISI_H_412	Baltimore Hebrew University	Public		0				x
ISI_H_406	Bais Yaakov ES	Private		10				
ISI_H_407	Mt. Washington ES	Public		15			x	x
ISI_H_410	Northwestern HS	Public		60				x
Places of Worship								
ISI_H_408	Greenspring Valley Synagogue	Private		0				x
ISI_H_409	Congregation Shomrei Emunah	Private		0				
ISI_H_405	Baltimore Hebrew Congregation	Private		20				
ISI_H_411	Bnai Jacob Shaarei Zion Congregation	Private		5				x
ISI_H_404	Oheb Shalom Congregation	Private		20				

Stream Restoration

The City plans to stabilize approximately 3,000 feet of stream reach on the main stem of Western Run, in the vicinity of Greenspring Avenue and Pimlico Road, and along Cross Country Boulevard. The stream work for the project begins at a pedestrian bridge located upstream and west of the Glenn Avenue intersection with Cross Country Boulevard and continues to 450-feet downstream of the Pimlico Road crossing of Western Run. The stream reaches within this project were recommended in the Western Run Assessment Report as some of the highest ranked reaches for stabilization and improvements. Given the proximity of the existing sanitary sewers within the stream channel, this stream project will also provide additional protection for the sanitary sewer line. The estimated advertisement date for construction is October 2008 (Seldon, 2008).

Illicit Discharge Detection and Elimination

Seven illicit discharges were identified in Western Run (Table 4.38). In the upper subwatershed several wash water discharges were identified along with the potential for many others. This may be the result of the age of the housing development where plumbing for washing machines in the basements was uncommon. Several more illicit discharges were identified in the City portion of Western Run. Source tracking is needed to trace these illicit discharges to their points of origin.

Table 4.38. Identified Illicit Discharges in Western Run

Outfall ID	City/ County	Outfall Size	Flow (gal/min)	*Annual Flow Estimate (gal/yr)	Detergents (Mg/L)	Ammonia, NH_3 (Mg/L)	Potassium (Mg/L)	Fluoride (Mg/L)	E. Coli (MPN/100 ML)	Notes
415	County	4 in	1L in 8sec	NA	Washwater discharge	Intermittent flow	415	NA	NA	Upper Western Run near Park Heights
1000	City	27 in	0.6350	333,777	0.25	0	NA	0.19	NA	None
1011	City	38 in x 84 in	3.95	2,076,120	**0.5**	0.22	NA	0.2	NA	Balto City has investigated but no luck
1020	City	27 in	NA	NA	0.25	0.09	NA	0.32	NA	Sample collected from pool -- Go up pipe for sample
1070	City	52 in x 80 in	0.3506	184,321	0.25	-0.03	NA	0.25	NA	None
1100	City	27 in	0.0324	17,067	NA	**>6**	NA	NA	NA	Used test strip; not sampled in lab

Stormwater Retrofits

Eight opportunities are available for stormwater retrofits within the subwatershed to treat approximately 76 acres of impervious cover (Table 4.39). In addition, several of the existing stormwater facilities were in relatively good condition and well functioning. Several large storage retrofits (WE_R_10,11,12) could treat stormwater runoff from I-695, other roads and high-density residential developments. There are also some relatively small on-site retrofits that are possible at some of the school sites.

Table 4.39. Summary of Stormwater Retrofit Strategies				
Site	**Location**	**Description**	**Estimated Drainage area (acres)**	**Ranking**
WE_R_3	Pimlico Middle School	Impervious cover removal	1	High
WE_R_4	Cross Country Elementary School	Permeable pavement to replace conventional pavement in existing parking lot	0.5	Low
WE_R_6A	Falstaff Middle School	Impervious cover removal	0.25	Medium
WE_R_6B	Falstaff Middle School	Downspout disconnection to treat rooftop runoff	1.25	Low
WE_R_7	Wellwood Elementary School	Vegetated filter strip to replace existing concrete channel to treat runoff from small impervious area (e.g. basketball courts)	0.3	Low
WE_R_10	Windridge Estates, Park Heights Ave. and Starburst Dr.	Enhance existing dry extended detention basin to provide additional runoff reduction	35	High
WE_R_11	Windridge Estates, Park Heights Ave. and Starburst Dr.	Bioretention area in existing depression to treat roadway runoff with underground detention using existing storm drain system	12	Medium
WE_R_12	Western Run Headwaters, Utility Easement South of I-695	Stream and floodplain restoration to treat stormwater runoff from I-695 and residential development north of I-695.	26	High

Pervious Area Restoration

Three possible pervious area restoration sites were identified in Western Run. The largest, Irvin Luckman Memorial Park, totals 5.5 acres (Table 4.40). Pervious area restoration has the potential to convert turf area to forest, reducing nutrient input to streams.

Table 4.40. Summary of Potential Pervious Area Restoration Sites				
Site	**Location**	**Description**	**Size (acres)**	**Ranking**
PAA-H-400	Fallstaff Rd. & Reisterstown Rd	Vacant lot owned by Shapiro and Company	0.5	Low
PAA-H-401	Key Ave. & Glen Ave.	Irvin Luckman Memorial Park	5.5	Medium
PAA-H-402	Park Heights Ave. at Fallstaff Rd.	Northwestern High School	2.0	Medium

Subwatershed Management Strategy

Implementation strategies for the Western Run subwatershed are as follows:

1. Conduct downspout disconnection in both multi-family and ¼ acre residential lots. Use the information collected from Table 4.35 to identify neighborhoods for downspout disconnection. This is represented by the percent of connected downspouts. Neighborhoods with a high percentage of downspouts connected to the stormdrain should be considered for disconnection. This practice includes

simple disconnection, and the use of rain barrels and rain gardens. Refer to Section 4.0 for more detailed information.

2. Install retrofit WE_R_12 that is adjacent to I-695. This retrofit will treat stormwater runoff from I-695 and adjacent impervious cover. Additional details on retrofits are found in Appendix A.
3. Provide lawn care education to neighborhoods identified with high turf management. Work with the homeowners that live in the neighborhoods identified in Table 4.35 to reduce the amount of nutrients applied to their lawn and other pollution prevention measures.
4. Increase the tree canopy with tree giveaways and coupons. Forest is a small percent of land use in the subwatershed. Assist Baltimore City and County in reaching their tree canopy goals by planting trees in identified neighborhoods (Table 4.35), pervious areas (Table 4.40) and schools (Table 4.37).
5. Engage places of worship in the subwatershed. Several places of worship are identified in Table 4.37. Outreach should be conducted to these communities to involve them in the subwatershed restoration effort.
6. Assist the City with outreach for stream restoration projects. Work with homeowners and the business community to build a greater awareness of the stream and the roles individuals can play in subwatershed restoration.
7. Develop a strategy to reduce the non-native geese and duck population at cemeteries and golf courses to minimize the nutrient loadings associated with these species.

Section 5.0 Implementation

Implementation is by far the longest and most expensive step in the watershed restoration process. In fact, restoration costs for a single urban subwatershed can easily range from half a million to two million dollars depending on the extent of restoration activities, number of jurisdictions involved, land costs, and other factors. Salaries, land acquisition and construction of restoration projects often account for a majority of these costs. A minimum of ten years is usually needed to design and construct all the necessary restoration projects, which are normally handled in several annual "batches." Sustaining progress over time and adapting the plan as more experience is gained are vital aspects of implementation.

This section presents planning level costs, phasing for implementing watershed strategies, and planning partners for the construction of priority stream restoration projects, stormwater retrofits, illicit discharge detection and elimination, education, and pollution prevention practices. Overall costs presented here are planning level estimates only and should be used to guide JFWA, the County and City in estimating annual operational and implementation budgets for the Lower Jones Falls Watershed. Estimates should be adapted to include more appropriate local costs where available.

The implementation costs should be distributed across implementation partners, existing programs, and responsible property owners (i.e., the City; County; institutions; MD SHA; businesses and landowners).

5.1 Costs and Schedule

Table 5.1 provides the goals achieved, location, responsible parties, and long-term milestones for implementation of each strategy. Table 5.2 provides a draft implementation schedule and associated costs for implementing each strategy. The cumulative estimate for implementing the 11 strategies presented in Section 2.0 over the next ten years exceeds $15 million dollars. Approximately, 45% of that cost is associated with stream restoration much of which is already programmed in the City and County capital budgets. Goal 1 which is aimed at achieving swimmable, fishable, and water contact recreation by 2022, aligns with all of the strategies as it takes a multi-faceted approach to achieve this goal. Preliminary cost estimates and responsible partners have been identified so that financial resources can be allocated and staff roles can be defined. Real watershed restoration requires a multi-faceted approach, which combines land use decisions with on-the-ground implementation, education and protection of watershed functions.

Table 5.1. Priorities and Costs for Restoration in Lower Jones Falls Watershed				
Goals Met	**Strategy**	**Location**	**Responsible Parties**	**Long-term Milestones**
1,2,3,7	Continue to investigate illicit discharges along Stony Run and Western Run.	Watershed wide with focus on Stony Run, Western Run	• Baltimore City DPW • Baltimore County DEPRM • Baltimore Harborkeeper • CWP • JFWA	• 25+ illicit discharges identified and corrected throughout Lower Jones Falls (Stony and Western Runs are priorities) • Increased citizen awareness of illicit discharges
1,2,3,7	Implement and support Stream restoration	Portions of subwatersheds targeted for stream restoration	• Baltimore City Public Works • Baltimore County DEPRM • JFWA	• Restore 4 miles of streams • Educate neighborhood groups to increase awareness of and implement stream buffer plantings
1,2,3,7	Create a downspout disconnection program	Watershed wide with greatest opportunity in Stony Run and Western Run	• Baltimore City Public Works • Baltimore County DEPRM Baltimore Harborkeeper • CWP • JFWA	• Conduct training workshops and at least one demonstration downspout disconnection in at least 10 neighborhoods • Disconnect 20 apartment complexes • Continue implementing program to disconnect 500 downspouts
1,2,3,4,7	Create a watershed education campaign	Watershed wide then city and county wide	• Baltimore City Public Works Baltimore County DEPRM • Fran Flanigan • HRWA • JFWA	• Develop outreach campaign with messages and materials for use on buses, billboards and other media • Implement the campaign and track awareness through surveys
1,2,4,7	Develop a green institution program that includes addressing pollution prevention, stormwater retrofits, and tree planting.	Watershed wide at public and private schools, places of worship and hospitals	• Baltimore City Public Works • Baltimore City Sustainability • Baltimore County DEPRM Baltimore Harborkeeper • CWP • JFWA • Maryland Port Authority	• Develop program and install retrofits at two schools. • Remove 10 acres of impervious cover; plant 200 trees and educate 200 students • Change lawn care policies of institutions to a low-input level

Table 5.1. Priorities and Costs for Restoration in Lower Jones Falls Watershed				
Goals Met	**Strategy**	**Location**	**Responsible Parties**	**Long-term Milestones**
1,2,6,7,10	Integrate stormwater and watershed planning goals into new and redevelopment	Watershed wide	• Baltimore City DPW • Baltimore City Sustainability	• Review of and adjustments to development codes to ensure that they allow practices that meet stormwater and watershed goals
1,2,5,7,10	Implement high priority stormwater retrofits	Watershed wide	Baltimore City DPW • Baltimore County DEPRM • JFWA	• Install five priority retrofits
1,2,4,5,7	Develop a neighborhood restoration program	Watershed wide	Baltimore City DPW • Baltimore County DEPRM • JFWA	• Restoration program is developed and implemented in at least eight neighborhoods • Residents surveyed for increased awareness and stewardship
1,2,4,7,9	Increase the tree canopy	Watershed wide	• Baltimore City Forestry • Baltimore County DEPRM HRWA • JFWA	• At least 400 trees on a combination of public and private property
1,2,3,4,7	Provide education on proper lawn care	Watershed wide	Baltimore City DPW • Baltimore County DEPRM • JFWA	• Create a lawn care pledge and work with groups to gain public support • Conduct 20 lawn care education workshops • Determine success and adjust as necessary
1,2,3,7,8	Develop a business stewardship outreach program	Watershed wide	Baltimore City DPW • Baltimore County DEPRM • JFWA	• Develop a pilot program and test with two willing businesses • Refine program and work with 20 businesses to implement it • Measure success

Table 5.2. Anticipated Actions and Costs				
Strategy	**Action**	**Short term (year 1)**	**Mid-Term (years 2-4)**	**Long Term (year 5+)**
1. Continue to investigate illicit discharges along Stony and Western Runs[a]	• Monitor East Stony Run and Lower Jones Falls and track illicit discharges in Stony, Western. • Expand to other subwatersheds.	$200,000	$500,000	$200,000
2. Implement and support Stream restoration[b]	• Coordinate with City and County to plant trees and provide education	$693,600	$2,684,400	$3,228,000
3. Create a downspout disconnection program[c]	• Full time coordinator with municipal and CWP support	$150,000	$350,000	$150,000
4. Create a watershed education campaign[d]	• Ongoing education that includes watershed awareness, lawn care and pet waste	$75,000	$200,000	$150,000
5. Develop a green institution program	• Oversee greening and retrofit projects	$60,000	$150,000	$60,000
6. Integrate stormwater and watershed planning goals into new and redevelopment	• Conduct a code review • Adjust codes, where feasible, to incorporate	$20,000	$50,000	$40,000
7. Implement high priority stormwater retrofits[e]	• Hire contractor to design and install retrofits	$500,000	$1,500,000	$3,000,000
8. Develop a neighborhood restoration program[f]	• Identify neighborhood captains • Develop informational brochures	$60,000	$120,000	$60,000
9. Increase the tree canopy[g]	• Encourage residential tree planting • Work with institutions and neighborhoods to plant trees	$65,000	$195,000	$65,000
10. Provide education on proper lawn care[f]	• Target neighborhoods with high input lawns	$60,000	$100,000	$90,000
11. Develop a business stewardship outreach program	• Provide education on pollution prevention to targeted businesses and Implement stormwater retrofits	$60,000	$140,000	$80,000
Annual Totals		**$1,943,600**	**$5,989,400**	**$7,123,000**
Grand Total		**$15,056,000**		

Shading indicates projects have already been submitted for partial funding.
a. Cost includes supplies, contractual services, tracking ($3k/illicit discharge), and monitoring analysis (Brown et al 2004)

Table 5.2. Anticipated Actions and Costs				
Strategy	**Action**	**Short term (year 1)**	**Mid-Term (years 2-4)**	**Long Term (year 5+)**

b. Costs include restoration of 4 miles of stream ($1,584,000/mi), materials and staff time for stream buffer planting and education (Cappiella et al 2006)
c. Costs include supplies and labor for 1,000 homes/yr (@ $100/house), staff time, mileage and printing
d. Costs include design and graphics, radio and newspaper advertising, and staff time
e. Planning level cost of $50,000/IA represents a mix on on-site and storage retrofits including final design, permitting, construction, contractors, materials, and construction oversight (Schueler et al 2007)
f. Costs based on $15/household for outreach and education, not including staff time ($30k) and materials ($15k) (Schueler and Kitchell 2005)
g. Costs include trees, materials and staff time (Cappiella et al 2006)

5.2 Pollutant Load Reductions

Table 5.3 shows the pollutant load reduction estimates based on the strategies outlined in Section 2.0 as well as on-going implementation actions by the City and County that include Sanitary Sewer Overflow (SSO) abatement and street sweeping. The load reductions are based on realistic implementation scenarios over the next ten years. For example, through the fieldwork it was estimated that 635 impervious rooftop acres were available for downspout disconnection in the Lower Jones Falls; a conservative project goal was set of disconnecting less than 40% of connected rooftops for a total of 250 rooftop impervious acres. The City of Portland has reached implementation rates of close to 80% during the life of their program. The nutrient management goal for high and medium input lawns was for two-thirds of the lawns to incorporate improved nutrient management. Citations are provided for each of the load reduction calculations and are again based on conservative assumptions. Each restoration practice in Table 5.3 is followed by the strategies that it meets, the implementation goal, the assumption leading to the load reduction shown in parentheses. Overall the effect of restoration implementation would result in a 22% reduction in total nitrogen, close to a 30% reduction in total phosphorus, an 8% reduction in total suspended solids and a 38% reduction in fecal coliform (Table 5.4).

This restoration strategy will allow us to meet the 15% nutrient reduction goal for nitrogen and phosphorus and help make progress toward meeting the 92-98% TMDL reduction goal for fecal coliform (MDE, 2007). The TMDL strategy focuses first on reducing the human sources that were estimated to account for between 40-70% of the load by addressing sanitary sewer overflows and illicit discharges (MDE, 2007). The goal is to reduce 100% of the human sources. Other key programs to address fecal coliform include pet waste education and stormwater retrofits. Overall the approach is expected to reduce fecal coliform loads by a minimum of 38% but it is realized that an iterative adaptive management approach will be necessary to meet the bacteria TMDL due to the disparate sources that include pets, humans, livestock and wildlife (Table 5.4).

Table 5.3. Pollutant Load Reduction Calculations for Total Nitrogen, Total Phosphorus and Total Suspended Sediment

Practice	Strategy Met[1]	Project Goal	TN Reduction (lbs/year)	TP Reduction (lbs/year)	TSS Reduction (tons/year)	Citation
Conduct Illicit discharge detection and elimination	3,7,9,11	10 million gallons /yr reduction of sewage	30 mg/l reduced to 0 mg/l (2,494lbs)	10 mg/l reduced to 0 mg/l (832 lbs)	225 mg/l reduced to 0 mg/l (9.2 tons)	Brown et al, 2004
		30 million gallons/ yr reduction in washwater	10 mg/l reduced to 0 mg/l (2,496lbs)	5 mg/l reduced to 0 mg/l (1,246 lbs)	175 mg/l reduced to 0 mg/l (21.8 tons)	Brown et al, 2004

Table 5.3. Pollutant Load Reduction Calculations for Total Nitrogen, Total Phosphorus and Total Suspended Sediment						
Practice	**Strategy Met**[1]	**Project Goal**	**TN Reduction (lbs/year)**	**TP Reduction (lbs/year)**	**TSS Reduction (tons/year)**	**Citation**
Downspout Disconnection Program	2,5,10	250 impervious acres of rooftops disconnected	50% (2,009 lbs)	50% (301lbs)	80% (64 tons)	MDE, 2008 and CWP, 2008
Urban Nutrient Management / Pet waste education	2,7,8,10	Nutrients reduced on 2210 acres of high input turf	17% (3,926 lbs) (3,708 lbs)	22% (134 lbs) (484 lbs)	0%	DNR, 2005 via Bay Program Caraco, 2001
Implement high priority stormwater retrofits	1,9,10,11	100 impervious acres treated (10acres IC removal, 5 acres of green roof)	65% Bioretention 90% IC reduction (1,133 lbs)	55% Bioretention 90% IC reduction (170 lbs)	85% Bioretention 90% IC reduction (29 tons)	CWP, 2008 and DNR, 2005
Stream Restoration	6,2,7	20,000ft of stream	0.202 lbs/ft (4,040 lbs)	0.0107 lbs/ft (214 lbs)	3.58 lbs/ft (35.8 tons)	DEPRM, 2008
Strong stormwater redevelopment criteria	11	100 acres redeveloped over 10yrs – 25 impervious acres treated	65% Bioretention (261 lbs)	55% Bioretention (39 lbs)	85% Bioretention (7 tons)	CWP, 2008
Conversion of urban turf to forest/ meadow	2,4,7,9,10	25 acres	10 lbs/ac/yr reduced to 1.8 lbs/ac/yr (200 lbs)	0.8 lbs/ac/yr reduced to 0.08 lbs/ac/yr (18 lbs)	0%	DNR, 2005
Increase Tree Canopy	2,4,7,9,10	Plant 1000 street trees (each tree at maturity reduces stormwater 500 – 750 gallons/yr)	2.2mg/l to 0 (volume reduction) (170 lbs)	0.3 mg/l to 0 (volume reduction) (23 lbs)	80 mg/l to 0 (volume reduction) (2.6 tons)	CUFR, 2001
SSO Abatement	3	90% reduction	30 mg/l reduced to 0 mg/l (1,813lbs)	10 mg/l reduced to 0 mg/l (302 lbs)	225 mg/l reduced to 0 mg/l (6 tons)	Caraco, 2001
Street sweeping		1100 acres weekly (from NPDES reports)	5% reduction (896 lbs)	5% reduction (124 lbs)	10% reduction (29.5 tons)	DNR, 2005
Totals			23,146 lbs	3,887 lbs	204.9 tons	
[1] Refer to section 2.1 of this document for the corresponding strategy.						

Table 5.4. Lower Jones Falls Watershed Annual Loads and Anticipated Restoration Strategy Reductions				
Loads	**TN (lb/year)**	**TP (lb/year)**	**TSS (tons/year)**	**Fecal Coliform (# billion/year)**
Jones Falls estimated loads	111,160	14,357	2,720	12,496,165
Load reduction from existing practices	-7,751	-1,166	-209	-326,325
Total current load	**103,409**	**13,191**	**2,511**	**12,169,840**
Restoration strategy	**23,146**	**3,887**	**204.9**	**4,679,348**
Percent load reduction	**22.4%**	**29.5%**	**8.2%**	**38.4%**

Caveats

- Fate and transport of nutrients and sediments is not accounted for in this modeling scenario (nor is it accounted for in typical modeling scenarios including the Chesapeake Bay Model). Stream channel simplification and incision (disconnection from the floodplain) present in this watershed are likely to reduce much of the natural processing of nutrients and storage of sediment that would have occurred if this was not such a highly disturbed urban watershed.
- There are several in-stream ponds in the upper portion of Western Run, in the county portion of the mainstem and include Lake Roland. These ponds likely store sediment and process nutrients. Although according to City staff, Lake Roland is largely filled in with sediment and likely traps primarily coarse sediment and has less nutrient processing ability particularly during stormflow.
- Culverts that are undersized or have downed trees near them act as strainers and can attenuate sediment in urban watersheds. This situation was identified where Stony Run goes underground before entering the mainstem of the Jones Falls.
- Based on the bullets listed, load reductions do not fully represent the load that is ultimately transported to the receiving waters. The watershed factors mentioned should be considered when determining where best management practices are located that have the greatest benefit to downstream receiving waters.

Section 6.0 Monitoring Plan

The JFWA, the City, the County, funders, and other restoration partners have a vested interest in measuring whether the restoration projects they implement are successful. Success can be measured in a number of ways including direct improvements in watershed indicators (e.g. reduced pollutant loading or improved aquatic insect communities) or indirectly (e.g. number of rain gardens installed, number of volunteers, acres conserved). The monitoring plan includes the assessment of individual restoration projects, the monitoring of stream indicators at sentinel monitoring stations, and illicit discharge monitoring. Information can be input to a tracking system and then used to revise or improve the restoration plan over a five to ten-year cycle. Each part of the monitoring plan is described below:

• *Project monitoring* at a small scale (reach or smaller) to illustrate benefits of individual restoration efforts. A long term monitoring station has been established in Stony Run and can be used to track the long-term benefits of stream restoration, illicit discharges and other restoration efforts including downspout disconnection on a subwatershed scale. Monitoring on a small catchment scale has also been established in an adjacent subwatershed in Herring Run to measure the benefits of downspout disconnection. In addition, both the City and County maintain significant numbers of biological monitoring stations that can assist in tracking catchment scale improvements in water quality. The biological and long-term stations are described in the Lower Jones Falls Characterization Report (Appendix E).

• *Sentinel station monitoring* to track long-term health and water quality trends. Sentinel monitoring stations are fixed, long-term monitoring stations which are established to measure trends in key indicators over many years. Sentinel monitoring is perhaps the best way to determine if conditions are changing in a subwatershed or watershed. Both the City and the County have existing sentinel stations that will continue to be monitored these are summarized in the Characterization Report as well (Appendix E).

• *Illicit discharge monitoring* will be used to facilitate identifying and tracking down inappropriate discharges. Illicit discharge detection and investigation are critical elements of watershed restoration and planning especially when there are obvious indicators of illicit discharges as in the Lower Jones Falls Watershed. Illicit discharges are often a significant source of pollution in a watershed that occurs repeatedly in association with specific polluting behaviors. Monitoring and keeping watch on individual outfalls and heading up the pipe to determine possible entry points for illicit discharge connections are critical to removing them. Locations identified for further IDDE investigation (Table 4.28 and 4.36) will be investigated to determine sources of the discharge and fix the problem. As part of the illicit discharge monitoring nutrients, bacteria and flow will be measured in order to estimate the water quality benefits of addressing the discharges.

6.1 Project Tracking

Managing the delivery of a large group of restoration projects within a subwatershed can be a complex enterprise. Creating a master project spreadsheet linked to a GIS system can help track the status of individual projects through final design, permitting, construction, inspection, maintenance and any performance monitoring. For non-structural efforts, tracking systems will include measures such as number of outfalls inventoried, number of discharges removed, number of hotline calls, or number of dedicated volunteers. By tracking the delivery of restoration projects, implementation progress can be assessed over time, which in turn, helps explain future changes in stream quality. Project tracking can also improve the delivery of future projects, and creates reports that can document implementation progress for key funders and stakeholders.

The watershed coordinator will manage implementation tracking. This person will setup project information in spreadsheet/GIS format, and periodically report on the status of implementation quarterly to the implementation team. The tracking system will account for all restoration practices undertaken in the subwatershed plan regardless of their type or size, and track the progress of outlined milestones.

Interim Goals

Five-year interim goals have been set to mark progress to ensure the implementation of the watershed action plan adheres to a schedule to meet the defined outcomes.

- Meet project goals from Table 5.3 for illicit discharges, street sweeping, nutrient management, pet waste education and stronger redevelopment criteria.
- Meet ½ of the load reduction goals for stream restoration, downspout disconnection, stormwater retrofitting, urban turf conversion, SSO abatement, street trees
- Reduce baseflow concentrations of bacteria at downstream elevated mainstream stations by 90%.
- Quantify load reductions estimates made due to illicit discharge detection and elimination.
- Track improvements in the biological community using the existing monitoring sites in Appendix E. Evaluate at 5 years any improvements in trends that may have occurred due to implementation efforts.

References

Baltimore County Department of Environmental Protection and Resource Management (DEPRM), 2008. *Lower Jones Falls Characterization Report.* Baltimore County, MD.

Baltimore County Department of Environmental Protection and Resource Management (DEPRM). 2008. Personal Communication.

Brown, E., D. Caraco and R. Pitt. 2004. *Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments*. Prepared for the U.S. Environmental Protection Agency Office of Wastewater Management. Center for Watershed Protection. Ellicott City, MD.

Cappiella, K., T. Schueler, J. Tomlinson and T. Wright. 2006. *Urban Watershed Forestry Manual. Part 3: Urban Tree Planting Guide.* USDA Forest Service, Newtown Square, PA.

Caraco, D. 2002. *The watershed treatment model: Version 3.1*. U.S. Environmental Protection Agency, Region V. Center for Watershed Protection. Ellicott City, MD.

Center for Watershed Protection. 2005. *A User's Guide to Watershed Planning in Maryland.* Prepared for the Maryland Department of Natural Resources.

Center for Urban Forest Research. 2001. *Benefits of the urban forest: Fact Sheet #1*. Davis, CA: USDA Forest Service, Pacific Southwest Research Station.

Kaushal, S.S., P. Groffman, P. Mayer, E. Striz and A. Gold. 2008. "Effects of Stream Restoration on Denitrification in an Urbanizing Watershed." *Ecological Applications* 18 (3): 789-804.

MacRae, C., and A. Rowney. 1992. *The Role of Moderate Flow Events and Bank Structure in the Determination of Channel Response to Urbanization.* 45th Annual Conference. Resolving Conflicts and Uncertainty in Water Management. Proceedings of the Canadian Water Resources Association, Kingston, Ontario.

Maryland Department of the Environment (MDE), 2006. *2006 List of Impaired Surface Waters [303(d) List] and Integrated Assessment of Water Quality in Maryland.* Baltimore, MD.

Maryland Department of the Environment (MDE). *Draft Chapter 5. Environmental Site Design*. http://www.mde.state.md.us/assets/document/sedimentStormwater/Chapter_5_1st_Draft.pdf

Novotney, M., J. Tasillo, C. Swann and P. Sturm. 2008. *Downspout Disconnection in Baltimore, MD.* A technical memorandum to Bill Stack in the City of Baltimore, MD.

Novotney, M. and R. Winer. 2008. *Municipal Pollution Prevention and Good Housekeeping Practices*. Manual 9 in the Urban Subwatershed Restoration Manual series. Center for Watershed Protection. Ellicott City, MD.

OpinionWorks. 2008. Upstream, Downstream. From Good Intentions to Cleaner Waters. Annapolis, Maryland.

PB Americas, Inc. 2007. Lower Jones Falls Watershed Stream Stability Assessment (Slaughterhouse Branch Subwatershed). Prepared for Baltimore County DEPRM.

Schueler, T., C. Swann, T. Wright, and S. Sprinkle. 2004. *Pollution Source Control Practices.* Manual 8 in the Urban Subwatershed Restoration Manual series. Center for Watershed Protection. Ellicott City, MD.

Schueler, T., and A. Kitchell. 2005. *Methods to Develop Restoration Plans for Small Urban Watersheds.* Manual 2 in the Urban Subwatershed Restoration Manual series. Center for Watershed Protection. Ellicott City, MD.

Schueler, T., D. Hirschman, M. Novotney, and J. Zielinski. 2007. *Urban Stormwater Retrofit Practices.* Manual 3 in the Urban Subwatershed Restoration Manual series. Center for Watershed Protection. Ellicott City, MD.

Schueler, T., D. Hirschman, and K. Collins. 2008. *Technical Memorandum: The Runoff Reduction Method.* Center for Watershed Protection (CWP). Ellicott City, MD.

Seldon, N. 2008. "Baltimore SWAPs Stream Restoration Information". Email to Julie Tasillo. Dated July 30, 2008.

Sturm, P., and J. Tasillo. 2007. *Technical Memo. Data Analysis for Existing Sampling Programs in Jones Falls and Back River Watersheds*. Prepared for Baltimore County DEPRM and City of Baltimore. Ellicott City, MD.

Wenger, S. 1999. *A review of the scientific literature on riparian buffer width, extent, and vegetation.* Publication of the Office of Public Service and Outreach, Institute of Ecology, University of Georgia. 58pp.

Wright, T. C. Swann, K. Cappiella, T. Schueler. 2004. *Unified Subwatershed and Site Reconnaisance*. Manual 11 in the Urban Subwatershed Restoration Manual series. Center for Watershed Protection. Ellicott City, MD.

Appendix A

Retrofit Design Sheets

Technical Memorandum

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Date: September 15, 2008

To: Bill Stack, P.E.
City of Baltimore, Department of Public Works, Bureau of Water and Wastewater, Water Quality Management Office, Environmental Services Division

From: Michael Novotney
Center for Watershed Protection

Subject: Baltimore City Stormwater Retrofit Inventory

This technical memorandum presents the results of the stormwater retrofit inventory that was completed by the Center for Watershed Protection in the Baltimore City portion of the Baltimore Harbor, Herring Run and Jones Falls watersheds. It summarizes the tasks that were completed during the retrofit inventory and contains recommendations on an approach that the City can use to begin implementing these stormwater retrofit projects. The memorandum has been organized as follows:

Section 1.0 Introduction
Section 2.0 Project Tasks
Section 3.0 Discussion
Section 4.0 Initial Retrofit Evaluation & Ranking
Section 5.0 Recommendations
Appendix A Stormwater Retrofit Location Maps
Appendix B Stormwater Retrofit Evaluation Spreadsheet

1.0 INTRODUCTION

The City of Baltimore is faced with meeting the requirements of a number of environmental policies, programs and regulations, including Chesapeake Bay Program Tributary Strategy goals and current and future Total Maximum Daily Load (TMDL) regulations. The City has recognized that satisfying these requirements requires a comprehensive approach to watershed protection and restoration. Part of this approach has involved working with local watershed groups, such as the Baltimore Harbor, Herring Run and Jones Falls Watershed Associations, to conduct watershed assessments and identify potential watershed restoration practices, including:

- Stormwater retrofit practices
- Stream repair practices
- Riparian management practices
- Discharge prevention practices
- Pervious area restoration practices

- Pollution source control practices
- Municipal good housekeeping practices

Of these watershed restoration practices, stormwater retrofits have perhaps the greatest potential to improve conditions within the City's rivers and streams. Stormwater retrofit practices are stormwater management practices installed in areas where they previously did not exist or where they did not meet local stormwater management goals and objectives. They can be used to meet a number of watershed restoration objectives since they can reduce stormwater pollution, minimize channel erosion and help restore watershed hydrology. Although the Center for Watershed Protection (Center) has previously identified a number of potential stormwater retrofit projects at various locations throughout the City (Sturm et al., 2006), and the City itself continues to implement large-scale stormwater wetland retrofits within its stream corridors, many more stormwater retrofits are needed to significantly improve conditions within the City's rivers and streams.

Recognizing this reality, the City retained the Center to identify additional stormwater retrofit opportunities within the Baltimore City portion of the Baltimore Harbor, Herring Run and Jones Falls watersheds and evaluate their potential to help meet local Chesapeake Bay Program Tributary Strategy goals and current and future TMDL regulations. This technical memorandum presents the results of our stormwater retrofit inventory, which was completed using the guidance provided in the Center's *Urban Stormwater Retrofit Practices* manual (Schueler et al., 2007).

2.0 PROJECT TASKS

This project involved three major tasks:

- *Task 1. Desktop Retrofit Analysis:* During this task, the Center identified potential retrofit locations by completing a desktop analysis of available mapping data. More than 160 potential retrofit locations were identified and targeted for further investigation. Maps illustrating the potential retrofit locations were created to guide the subsequent fieldwork.

- *Task 2. Retrofit Reconnaissance Investigation:* The Center completed a retrofit reconnaissance investigation (RRI) to further investigate 80 of the potential retrofit locations identified during the Desktop Retrofit Analysis. The RRI is a rapid field assessment that can be used to investigate the feasibility of potential stormwater retrofit projects and collect the information necessary to support initial retrofit concept design. More than 90 viable retrofit projects were identified during the RRI.

- *Task 3. Compute Retrofit Pollutant Removal:* During this task, the Center evaluated the pollutant load reduction that would be provided by each of the viable stormwater retrofit projects identified during the RRI. The Center used Chesapeake Bay Program stormwater management practice pollutant removal efficiency data, information presented in the *Urban Stormwater Retrofit Practices* manual (Schueler et al., 2007) and recent stormwater management practice performance research (CWP, 2008, Hirschman et al., 2008) to conduct this analysis.

Each of these tasks is described in more detail below.

2.1 DESKTOP RETROFIT ANALYSIS

During this task, the Center identified potential retrofit locations by completing a desktop analysis of available mapping data. This task was helpful in focusing the subsequent fieldwork on potential retrofit locations that provide the best opportunities to help meet local Chesapeake Bay Program Tributary Strategy goals and current and future TMDL regulations. This task involved the following steps:

- Secure available mapping data
- Conduct a desktop search for potential retrofit sites
- Prepare field maps for the RRI

Each of these steps is described in more detail below.

2.1.1 SECURE AVAILABLE MAPPING DATA

Table 1 lists the Geographic Information System (GIS) data that was obtained from the City and utilized during the Desktop Retrofit Analysis.

Table 1: GIS Data Utilized During the Desktop Retrofit Analysis	
Data Type	**Layers**
Hydrology	Topography 2 Foot Contours Streams
Boundaries	Watershed Boundaries Subwatershed Boundaries Parcel Boundaries Municipal Boundaries
Land Use and Land Cover	Aerial Photography Land Use/Land Cover Property Ownership
Utilities	Storm Drain System Stormwater Management Practices Stormwater Outfalls Sanitary Sewer System Water Distribution System

2.1.2 CONDUCT A DESKTOP SEARCH FOR POTENTIAL RETROFIT SITES

During this step, the Center used the available mapping data to identify potential retrofit locations in the Baltimore City portion of the Baltimore Harbor, Herring Run and Jones Falls watersheds. The simple desktop search relied on a visual inspection of the available mapping data and the basic search criteria outlined in Tables 2 and 3 to identify potential retrofit sites. While Table 2 outlines the search criteria for the six most common storage retrofit locations that can be found within an urbanized watershed, Table 3 outlines the search criteria for the seven most common on-site retrofit locations that can be found within an urbanized watershed.

Table 2: Desktop Search Criteria for Storage Retrofits	
Retrofit Location	**What to Look For**
Existing Pond	Evaluate stormwater layer to find existing stormwater ponds with a contributing drainage area greater than 5 acres *or* superimpose topography, drainage layers and aerial photos to identify low points in the drainage network where dry ponds may exist.
Above Roadway Culvert	Superimpose topography and headwater stream layers (zero, first and second order) over the local and state road network to identify road crossings.
Below Stormwater Outfall	Superimpose publicly-owned stream corridor land parcels at least two acres in area with storm drain outfalls with a diameter greater than 12 inches and less than 60 inches.
In Conveyance System	Superimpose ditch lines, zero-order streams, conveyance easements or open channels with open land adjacent to the drainage network
In Transportation Right-of-Way	Compare local, state or federal highway right-of-way layers against the stream or drainage network to identify open spaces one acre or greater *or* review highway agency GIS for existing stormwater infrastructure or treatment practices suitable for retrofitting.
Large Parking Lot	Match large contiguous parking areas/rooftops greater than 5 acres in size with adjacent open land in public or institutional ownership, or owned by the same landowner.

Table 3: Desktop Search Criteria for On-Site Retrofits	
Retrofit Location	**What to Look For**
Hotspot Facility	Review land use maps to identify commercial, industrial, or municipal land uses *or* search permit databases to identify industrial operations that hold stormwater permits.
Small Parking Lot	Search for parking lots less than five acres in size that are municipally or institutionally owned.
Individual Street	Screen for streets that meet street retrofit feasibility criteria, such as slope, right-of-way width, open section drainage, presence/absence of sidewalks and parking lanes.
Individual Rooftop	Superimpose property ownership layers with aerial photos or planimetric data to locate large municipal, institutional, commercial or industrial buildings that may be assessed for demonstration rooftop retrofits *or* look for clusters of building permit data that indicates areas experiencing active redevelopment
Small Impervious Area	A desktop search is not helpful in finding specific locations for little retrofits, although a GIS can help find tax reverted vacant lots and publicly owned parcels, such as parks, schools, recreation centers to investigate in the field.
Landscapes and Hardscapes	A desktop search is not helpful in finding specific locations for landscaping and hardscaping retrofits although it can find the general public spaces with high exposure and outdoor amenities, such as parks, schools, central business districts, spaces etc.
Underground	A desktop search is not helpful in finding specific locations for underground retrofits, although storm sewer and utility maps are essential for field investigations.

During the desktop assessment, 22 potential retrofit locations in the Baltimore Harbor watershed, 69 potential retrofit locations in the Herring Run watershed, and 72 potential retrofit locations in the Jones Falls watershed were identified and targeted for further investigation. Tables 4, 5 and 6 present basic information about each of these sites.

Table 4: Potential Retrofit Locations in the Baltimore Harbor Watershed		
Subwatershed	**Site ID**	**Location**
Harris Creek	HA-R1	Canton Waterfront Park, below Boston St. at East Ave.
Harris Creek	HA-R2	Canton Waterfront Park, below Boston St. at Ellwood Ave.
Harris Creek	HA-R3	Canton Waterfront Park, below Boston St. at Linwood Ave.
Harris Creek	HA-R4	Below Boston St., between Hudson St. and Lakewood Ave.
Harris Creek	HA-R5	Patterson Park

Table 4: Potential Retrofit Locations in the Baltimore Harbor Watershed		
Subwatershed	**Site ID**	**Location**
Harris Creek	HA-R6	Patterson Park Adjunct
Harris Creek	HA-R7	Unnamed Park, at Orleans St. and Ellwood Ave.
Harris Creek	HA-R8	Unnamed Park, at Orleans St. and Ellwood Ave.
Harris Creek	HA-R9	Unnamed Park, at Orleans St. and Ellwood Ave.
Harris Creek	HA-R10	Highlandtown ES
Harris Creek	HA-R11	Industrial Site, at Edison Hwy. and Madison St.
Harris Creek	HA-R12	Frank C. Bocek Park
Harris Creek	HA-R13	Unnamed School, at Chase St. and Patterson Park Ave.
Harris Creek	HA-R14	Unnamed Park, at Patterson Park Ave. and Preston St.
Harris Creek	HA-R15	Lombard MS
Harris Creek	HA-R16	Fayette St. and Caroline St.
Harris Creek	HA-R18	Unnamed Park, at Caroline St. and Eager St.
Harris Creek	HA-R19	Harford Heights ES
Harris Creek	HA-R20	Clifton Park Adjunct, W. of St. Lo Dr. at Sinclair Ln. and Wolfe St.
Harris Creek	HA-R21	Clifton Park Adjunct, E. of St. Lo Dr. at Sinclair Ln. and St. Lo Dr.
Harris Creek	HA-R22	Fairmont Harford HS
Harris Creek	HA-R23	Clifton Park, Harford Rd. and St. Lo Dr.

Table 5: Potential Retrofit Locations in the Herring Run Watershed		
Subwatershed	**Site ID**	**Location**
Armistead Run	AR-R1	West of Erdman Ave., between Duncanwood Ln. and Macon St.
Armistead Run	AR-R2	Archbishop Curley HS
Biddison Run	BI-R1	North of Sipple Ave. at end of Mayview Terr., Barbara Ave., Parkwood Ave. and Valley View Ave.
Biddison Run	BI-R2	Parkside Shopping Center, Sinclair Ln. and Moravia Rd.
Biddison Run	BI-R3	Thurgood Marshall MS
Chinquapin Run	CH-R1	Chinquapin Run Park, between Loch Raven Blvd. and Perring Pkwy.
Chinquapin Run	CH-R2	Northwood ES and Recreation Center
Chinquapin Run	CH-R3	Chinquapin Run Park, between Northern Pkwy. and Belvedere Ave.
Chinquapin Run	CH-R4	Chinquapin MS
Chinquapin Run	CH-R5	Walter De Wees Park
Chinquapin Run	CH-R6	Chinquapin Run Park, between Belvedere Ave. and The Alameda
Chinquapin Run	CH-R7	Chinquapin Run Park, between Woodbourne Ave. and Loch Raven Blvd.
Chinquapin Run	CH-R8	Chinquapin Run Park, between The Alameda and Woodbourne Ave.
Chinquapin Run	CH-R9	Good Samaritan Hospital
Chinquapin Run	CH-R11	Morgan State University
Chinquapin Run	CH-R12	Walker Ave. and Northwood Dr.
Chinquapin Run	CH-R13	Walker Ave. and Castle Dr.
Chinquapin Run	CH-R14	Chinquapin Run Park, between Lake Ave. and Northern Pkwy.
Chinquapin Run	CH-R15	Leith Walk ES
Herring Run	HR-R2	Mt. Pleasant Ice Arena, Hillen Rd. and Northern Pkwy.
Herring Run	HR-R3	North Harford Recreation Center, Northern Pkwy. and Laurelton Ave.
Herring Run	HR-R5	Leith Walk ES
Herring Run	HR-R6	Yorkwood ES
Herring Run	HR-R7	Good Samaritan Hospital
Herring Run	HR-R8	Mt. Pleasant Park, between Perring Pkwy., Echodale Ave. and Herring Run
Herring Run	HR-R9	Mt. Pleasant Park, between Echodale Ave., Laurelton Ave. and Herring Run
Herring Run	HR-R10	Mt. Pleasant Park, at Perring Pkwy. and Laurelton Ave.
Herring Run	HR-R11	Morgan State University
Herring Run	HR-R12	Herring Run Park, between Harford Rd. and Belair Rd.
Herring Run	HR-R13	Chinquapin MS

Table 5: Potential Retrofit Locations in the Herring Run Watershed		
Subwatershed	**Site ID**	**Location**
Herring Run	HR-R14	Brehms Lane ES
Herring Run	HR-R15	Herring Run Park, between Brehms Ln. and Sinclair Ln.
Herring Run	HR-R17	Northeast MS
Herring Run	HR-R18	Sinclair Lane ES
Herring Run	HR-R19	Archbishop Curley HS
Herring Run	HR-R20	Armistead Gardens, Armistead Way and Hewitt Dr.
Herring Run	HR-R21	Pep Boys, Harford Rd. and Moravia Rd.
Herring Run	HR-R22	Herring Run Park, between Harford Rd. and Argonne Dr.
Herring Run	HR-R23	Safeway, Harford Rd. and Montebello Terr.
Herring Run	HR-R24	Northwood Shopping Center, Hillen Rd. and Wood Rd.
Herring Run	HR-R25	Garrett Heights ES
Herring Run	HR-R27	Mt. Pleasant Park, between Perring Pkwy., Laurelton Ave. and Herring Run
Herring Run	HR-R28	Perring Pkwy., below Pioneer Dr. at Westfield Ave.
Herring Run	HR-R29	WEB DuBois HS
Herring Run	HR-R30	US Marine Corps Training Center
Herring Run	HR-R38	Clifton Park
Herring Run	HR-R39	Herring Run Park, between Belair Rd. and Mannasota Ave.
Herring Run	HR-R40	Herring Run Park, between Sinclair Ln. and BGE Utility Corridor
Herring Run	HR-R41	Montebello ES
Herring Run	HR-R42	Herring Run Park, between Mannasota Ave. and Brehms Ln.
Herring Run	HR-R43	Below Montebello Filtration Plant, N. of Harford Rd., E. of Herring Run
Herring Run	HR-R47	Herring Run Park, between BGE Utility Corridor and I-895
Herring Run	HR-R51	Mercy HS
Herring Run	HR-R52	Orangeville Industrial Area, E. of Edison Hwy. and Biddle St.
Moores Run	MO-R1	Hamilton ES
Moores Run	MO-R2	Hamilton MS
Moores Run	MO-R3	Hazelwood ES
Moores Run	MO-R4	Radecke Playfield, Radecke Ave. and Gardenwood Ave.
Moores Run	MO-R5	Moores Run Park , between Radecke Ave. and Sinclair Ln.
Moores Run	MO-R6	Moores Run Park , between Hamilton Ave. and Radecke Ave.
Moores Run	MO-R7	Moores Run Park , between Sinclair Ln. and I-895
Redhouse Run	RE-R1	Woodhome ES/MS
Redhouse Run	RE-R33	Keyes Field
Tiffany Run	TI-R1	Merganthaler Vocational-Technical HS
Tiffany Run	TI-R2	Walter P. Carter ES
Tiffany Run	TI-R3	Winston MS
Tiffany Run	TI-R4	Memorial Stadium
Tiffany Run	TI-R5	Johns Hopkins University, East Campus, 33rd St.
Tiffany Run	TI-R6	Abbottson ES/Baltimore City College HS

Table 6: Potential Retrofit Locations in the Jones Falls Watershed		
Subwatershed	**Site ID**	**Location**
Lower Jones Falls	LJ-R2	Sinai Hospital
Lower Jones Falls	LJ-R3	Tamarind Rd. and Springarden Dr.
Lower Jones Falls	LJ-R5	Lacrosse Field, Kelly Ave. and Cottonworth Ave.
Lower Jones Falls	LJ-R6	Pimlico ES
Lower Jones Falls	LJ-R7	Waldorf School
Lower Jones Falls	LJ-R8	Poly Western HS
Lower Jones Falls	LJ-R9	West Old Coldspring Ln. and Brand Ave.
Lower Jones Falls	LJ-R10	Edgecombe Circle ES
Lower Jones Falls	LJ-R11	Edgecombe Park

Table 6: Potential Retrofit Locations in the Jones Falls Watershed		
Subwatershed	**Site ID**	**Location**
Lower Jones Falls	LJ-R12	Cold Spring Ln. and Greenspring Ave.
Lower Jones Falls	LJ-R13	Greenspring MS
Lower Jones Falls	LJ-R14	41st St. and Buena Vista Ave.
Lower Jones Falls	LJ-R15	Martin Luther King Jr. ES
Lower Jones Falls	LJ-R16	Falls Rd. and Hillside Rd.
Lower Jones Falls	LJ-R17	Medfield Heights ES
Lower Jones Falls	LJ-R18	Greenspring Community Center
Lower Jones Falls	LJ-R19	Druid Hill Park, Druid Hill Park Dr. and Greenspring Ave.
Lower Jones Falls	LJ-R20	James D. Gross Roosevelt Park
Lower Jones Falls	LJ-R21	I-83 and North Ave.
Lower Jones Falls	LJ-R22	Laurens St. and Bolton St.
Lower Jones Falls	LJ-R23	Mount Royal Station, Howard St. and Mount Royal Ave.
Lower Jones Falls	LJ-R24	Homewood Ave. and Biddle St.
Lower Jones Falls	LJ-R25	Wyman Park Dell
Lower Jones Falls	LJ-R26	Greenmount Ave. and Loch Raven Blvd.
Lower Jones Falls	LJ-R27	Cecil ES
Lower Jones Falls	LJ-R28	Aisquith St. and Curtain Ave.
Lower Jones Falls	LJ-R29	Kirk Ave. and 25th St.
Lower Jones Falls	LJ-R30	Green School
Lower Jones Falls	LJ-R32	Coldstream Park ES
Lower Jones Falls	LJ-R33	Abbottson ES/Baltimore City College HS
Lower Jones Falls	LJ-R34	Waverly ES/MS
Lower Jones Falls	LJ-R35	Dolphin St. and McCulloh St.
Lower Jones Falls	LJ-R36	Calhoun St. and Presstman St.
Lower Jones Falls	LJ-R37	Ensor St. and Monument St.
Lower Jones Falls	LJ-R38	Wood Heights Ave. and La Plata Ave.
Lower Jones Falls	LJ-R39	Greenspring Ave. and Shirley Ave.
Lower Jones Falls	LJ-R41	Baltimore City Public Works Yard, Falls Rd., S. of 28th St.
Lower Jones Falls	LJ-R42	Memorial Stadium
Lower Jones Falls	LJ-R43	John Eager Howard Elementary School
Lower Jones Falls	LJ-R44	Northern Pkwy., W. of Greenspring Ave.
Lower Jones Falls	LJ-R45	Johns Hopkins University, East Campus, 33rd St.
Stony Run	ST-R1	Wyman Park, below Tudor Arms Ave. and Gilman Terr.
Stony Run	ST-R2	Stony Run Park, below Wyman Park Dr.
Stony Run	ST-R4	Calvert School
Stony Run	ST-R5	Guilford Neighborhood Tulip Park, Greenway and Stratford Rd.
Stony Run	ST-R6	Loyola College Fitness and Aquatic Center, Wyndhurst Ave. and Charles St.
Stony Run	ST-R7	Friends School
Stony Run	ST-R8	Cathedral of Mary Our Queen
Stony Run	ST-R9	Cotswold Rd. and Amberly Way
Stony Run	ST-R10	Knights of Columbus
Stony Run	ST-R11	Bryn Mawr
Stony Run	ST-R12	Gilman Country
Stony Run	ST-R13	Roland Park ES/MS
Stony Run	ST-R14	Notre Dame College of Maryland
Stony Run	ST-R15	Homewood, Homeland Ave. and Spring Lake Way
Stony Run	ST-R16	Below San Martin Dr.
Stony Run	ST-R17	Gilman Terr. and 33rd St.
Stony Run	ST-R18	Boys Latin HS
Stony Run	ST-R19	Lake Ave. and Lakehurst Dr.
Stony Run	ST-R20	Elkridge Hunt Club

Table 6: Potential Retrofit Locations in the Jones Falls Watershed		
Subwatershed	**Site ID**	**Location**
Western Run	WE-R1	Cross Country Blvd. and Chilham Ave.
Western Run	WE-R2	Glen Ave. and Merville Ave.
Western Run	WE-R3	Pimlico MS
Western Run	WE-R4	Cross Country ES
Western Run	WE-R5	Northwestern HS
Western Run	WE-R6	Falstaff MS
Western Run	WE-R14	Cross Country Blvd. and Dale Rd.
Western Run	WE-R15	Cross Country Blvd. and Kelly Ave.
Western Run	WE-R16	Kelly Ave. and Poplin Ave.
Western Run	WE-R18	Baltimore City Community College, Reisterstown Plaza Center
Western Run	WE-R23	Falstaff Rd. and Gage Ct.
Western Run	WE-R25	Greenspring Ave. and Fallstaff Rd.

2.1.3 PREPARE FIELD MAPS FOR THE RRI

Using a GIS, the Center added the potential stormwater retrofit locations to maps of each watershed. The maps helped guide field crews during the RRI and also helped them accurately record findings and basic information about each potential retrofit site. Each of the potential stormwater retrofit locations are shown on the maps presented in Appendix A.

2.2 RETROFIT RECONNAISSANCE INVESTIGATION

During this task, the Center completed a RRI to further investigate 80 of the potential retrofit locations that were identified during the Desktop Retrofit Analysis. The RRI is a rapid field assessment that can be used to investigate the feasibility of potential stormwater retrofit projects and collect the information necessary to support initial retrofit concept design. Additional information about the RRI is provided below.

2.2.1 RETROFIT RECONNAISSANCE INVESTIGATION METHODS

During the RRI, field crews used a variety of equipment and the RRI form to conduct an assessment of each potential retrofit location (Figure 1). Using the methods outlined in the *Urban Stormwater Retrofit Practices* manual (Schueler et al., 2007), the feasibility of implementing a stormwater retrofit project at each site was evaluated by investigating drainage patterns, drainage areas, impervious cover, available space, and other site constraints (e.g., conflicts with existing utilities and land uses, site access and potential impacts to natural areas). Unless there were obvious site constraints and/or evidence that a particular project would conflict with existing land use, at least one initial stormwater retrofit concept was developed for each site.

Each of the initial stormwater retrofit concepts were developed based on the characteristics of the potential retrofit site, the size of the contributing drainage area, the amount of impervious cover found within the contributing drainage area and the overall watershed restoration objectives being pursued. For this project, the primary objective was to identify opportunities to reduce sediment and nutrient loads to help the City of Baltimore meet local Chesapeake Bay Program Tributary Strategy goals and current and future TMDL regulations.

Figure 1: Activities Conducted During the Retrofit Reconnaissance Inventory

2.2.2 RETROFIT RECONNAISSANCE INVESTIGATION RESULTS

Initial stormwater retrofit concepts were developed at 54 of the potential retrofit sites. Because of the size and configuration of many of the potential retrofit sites, multiple concepts were developed at a number of the sites. Consequently, a total of 92 initial stormwater retrofit concepts were developed during the RRI.

Additional information about each of the initial stormwater retrofit concepts is presented in Tables 7, 8 and 9. Note that 11 viable retrofit projects in the Baltimore Harbor watershed, 48 viable retrofit projects in the Herring Run watershed, and 33 viable retrofit projects in the Jones Falls watershed were identified. The locations of each of the viable stormwater retrofit projects are shown on the maps presented in Appendix A.

Table 7: Viable Stormwater Retrofit Projects in the Baltimore Harbor Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Description**	**Contributing Drainage Area (acre)***
HA-R2	Canton Waterfront Park, below Boston St. at Ellwood Ave.	On-Site	Bioretention Area, Underdrain	Bioretention area in existing landscaping area to treat stormwater runoff from small impervious area	1.6
HA-R3	Canton Waterfront Park, below Boston St. at Linwood Ave.	On-Site	Bioretention Area, Underdrain	Bioretention area in existing landscaping area to treat stormwater runoff from small impervious area	0.7
HA-R5A	Patterson Park	On-Site	Bioretention Area, Underdrain	Bioretention area in existing depression to treat stormwater runoff from disturbed pervious areas	1.5
HA-R5B	Patterson Park	Storage	Underground Detention System	Underground detention to provide extended detention and partial treatment of stormwater runoff from upstream drainage area	872.4
HA-R6	Patterson Park Adjunct	Storage	Dry Swale	Dry swale in existing landscaping area at toe of slope to treat stormwater runoff from disturbed pervious area	11.9
HA-R8	Unnamed Park, at Orleans St. and Ellwood Ave.	On-Site	Bioretention Area, Underdrain	Dry swale/bioretention area in existing open space area to treat stormwater runoff from disturbed pervious area	2.4
HA-R16	Fayette St. and Caroline St.	On-Site	Bioretention Area, Underdrain	Bioretention area in existing depression/open space area to treat parking lot and roadway runoff	1.4
HA-R19	Harford Heights ES	On-Site	Bioretention Area, Underdrain	Bioretention area in existing open space area to treat stormwater runoff from small impervious area	0.7
HA-R20	Clifton Park Adjunct, W. of St. Lo Dr. at Sinclair Ln. and Wolfe St.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	5.8
HA-R22	Fairmont Harford HS	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	34.4
HA-R23	Clifton Park, Harford Rd. and St. Lo Dr.	On-Site	Bioretention Area, Underdrain	Bioretention area in existing landscaping area to treat roadway runoff	2.8
Notes: * Estimated contributing drainage area, based on available mapping data					

Table 8: Viable Stormwater Retrofit Projects in the Herring Run Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Description**	**Contributing Drainage Area (acre)***
BI-R1	North of Sipple Ave. at end of Mayview Terr., Barbara Ave., Parkwood Ave. and Valley View	Storage	Stormwater Pond/ Wetland System	Stream daylighting with stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	345.0

Table 8: Viable Stormwater Retrofit Projects in the Herring Run Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Description**	**Contributing Drainage Area (acre)***
	Ave.				
BI-R3	Thurgood Marshall MS	On-Site	Bioretention Area, Underdrain	Bioretention area in existing open space area to treat parking lot runoff	1.5
CH-R2A	Northwood ES and Recreation Center	On-Site	Bioretention Area, Underdrain	Bioretention area in existing landscaping area to treat stormwater runoff from small impervious area	3.8
CH-R2B	Northwood ES and Recreation Center	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	53.0
CH-R3B	Chinquapin Run Park, between Northern Pkwy. and Belvedere Ave., below Chinquapin Pkwy. between Elbank Ave. and Gleneagle Rd.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	45.0
CH-R5	Walter De Wees Park	Storage	Stormwater Pond/ Wetland System	Stream daylighting with stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	44.0
CH-R6A	Chinquapin Run Park, between Belvedere Ave. and The Alameda, below Northwood Dr. between St. Dunstans Rd. and The Alameda	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	84.0
CH-R6B	Chinquapin Run Park, between Belvedere Ave. and The Alameda, below Northwood Dr. between Belvedere Ave. and The Alameda	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	300.0
CH-R6C	Chinquapin Run Park, between Belvedere Ave. and The Alameda, below Chinquapin Pkwy. at Walters Ave.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	68.0
CH-R8	Chinquapin Run Park, between The Alameda and Woodbourne Ave., below Northwood Dr. at Woodbourne Ave.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	82.8
CH-R9	Good Samaritan Hospital	On-Site	Dry Swale	Convert existing grass channel to dry swale to improve performance and treat driveway runoff	1.0
HR-R2A	Mt. Pleasant Ice Arena, Hillen Rd. and Northern Pkwy.	On-Site	Permeable Pavement, Underdrain	Permeable pavers or pervious concrete to replace existing porous asphalt in parking lot	0.3
HR-R2B	Mt. Pleasant Ice Arena, Hillen Rd.	On-Site	Dry Swale	Convert existing grass channel to dry swale to	1.0

Table 8: Viable Stormwater Retrofit Projects in the Herring Run Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Description**	**Contributing Drainage Area (acre)***
	and Northern Pkwy.			improve performance	
HR-R3	North Harford Recreation Center, Northern Pkwy. and Laurelton Ave.	On-Site	Bioretention Area, Underdrain	Bioretention area in existing landscaping area to treat parking lot runoff	1.0
HR-R6A	Yorkwood ES	On-Site	Impervious Cover Removal	Impervious cover removal on playground with site reforestation/revegetation	1.0
HR-R6B	Yorkwood ES	Storage	Piedmont Outfall	Piedmont outfall below existing outfall to treat stormwater runoff from upstream drainage area	17.5
HR-R10	Mt. Pleasant Park, at Perring Pkwy. and Laurelton Ave.	On-Site	Bioretention Area, Underdrain	Bioretention area in existing depression to treat roadway runoff	1.5
HR-R12A	Herring Run Park, between Harford Rd. and Belair Rd., below Chesterfield Ave. at Norman Ave.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	80.0
HR-R12B	Herring Run Park, between Harford Rd. and Belair Rd., below Chesterfield Ave. at Cardenas Ave.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	60.0
HR-R12D	Eastwood Field, Herring Run Park, between Harford Rd. and Belair Rd.	Storage	Stream Restoration	Stormwater wetland and stream and floodplain restoration to treat stormwater runoff from upstream drainage area	9,041
HR-R14	Brehms Lane ES	On-Site	Bioretention Area, Underdrain	Bioretention areas in existing depressions to treat stormwater runoff from disturbed pervious area	1.0
HR-R15A	Herring Run Park, between Brehms Ln. and Sinclair Ln., below Parkside Dr., between Roberton Ave. and Sinclair Ln.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	130.0
HR-R15B	Herring Run Park, between Brehms Ln. and Sinclair Ln., below Shannon Dr. at Elmora Ave.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	100.0
HR-R15C	Herring Run Park, between Brehms Ln. and Sinclair Ln., below Shannon Dr. at Lyndale Ave.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	40.0
HR-R18	Sinclair Lane ES	On-Site	Bioretention Area, Underdrain	Bioretention area in existing landscaping area to treat stormwater runoff from parking lot and disturbed pervious area	5.0
HR-R19	Archbishop Curley HS	On-Site	Bioretention Area, Underdrain	Bioretention area in existing landscaping area to treat parking lot runoff	2.0

Table 8: Viable Stormwater Retrofit Projects in the Herring Run Watershed

Retrofit ID	Location	Retrofit Type	Stormwater Management Practice	Description	Contributing Drainage Area (acre)*
HR-R20	Armistead Gardens, Armistead Way and Hewitt Dr.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	25.0
HR-R21	Pep Boys, Harford Rd. and Moravia Rd.	On-Site	Dry Swale	Dry swale to replace existing grass channel and treat parking lot runoff	0.8
HR-R22	Herring Run Park, between Harford Rd. and Argonne Dr.	Storage	Dry Swale	Dry swale to convey and treat stormwater runoff from upstream drainage area	12.0
HR-R23	Safeway, Harford Rd. and Montebello Terr.	On-Site	Bioretention Area, Underdrain	Bioretention area in parking lot to treat parking lot runoff	0.6
HR-R28A	Perring Pkwy., below Pioneer Dr. at Westfield Ave.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	100.0
HR-R28B	Perring Pkwy., below Pioneer Dr. at Cloville Ave.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	37.0
HR-R29A	WEB DuBois HS	On-Site	Bioretention Area, Underdrain	Bioretention area in existing landscaping area to treat stormwater runoff from parking lot and disturbed pervious area	1.1
HR-R29B	WEB DuBois HS	On-Site	Permeable Pavement, Underdrain	Permeable pavement to replace conventional pavement in existing parking lot and alley	1.8
HR-R29C	WEB DuBois HS	On-Site	Bioretention Area, Underdrain	Bioretention area in existing landscaping area to treat driveway runoff	0.3
HR-R29D	WEB DuBois HS	On-Site	Permeable Pavement, Underdrain	Permeable pavement to replace conventional pavement in existing small parking lot	0.1
HR-R38A	Clifton Park	On-Site	Bioretention Area, Underdrain	Dry swale/bioretention area in existing depression to treat stormwater runoff from golf course	2.0
HR-R38B	Clifton Park	On-Site	Bioretention Area, Underdrain	Bioretention area in existing depression to treat roadway runoff	4.5
HR-R39	Herring Run Park, between Belair Rd. and Mannasota Ave., below Shannon Dr. at Kavon Ave.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	40.0
HR-R41A	Montebello ES	On-Site	Bioretention Area, Underdrain	Bioretention areas in existing landscaping areas to treat parking lot runoff	0.7
HR-R41B	Montebello ES	On-Site	Impervious Cover Removal	Impervious cover removal on playground with site reforestation/revegetation	0.2
HR-R42A	Herring Run Park, between Mannasota Ave. and Brehms Ln., below Shannon Dr. at Mannasota	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	305.0

Table 8: Viable Stormwater Retrofit Projects in the Herring Run Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Description**	**Contributing Drainage Area (acre)***
	Ave.				
MO-R4	Radecke Playfield, Radecke Ave. and Gardenwood Ave.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	32.0
RE-R1A	Woodhome ES/MS	On-Site	Dry Swale	Dry swale to replace existing concrete channel and treat stormwater runoff from small impervious area	0.3
RE-R1B	Woodhome ES/MS	On-Site	Permeable Pavement, Underdrain	Permeable pavement to replace conventional pavement in existing parking lot	0.5
RE-R1C	Woodhome ES/MS	On-Site	Rain Garden	Enhance existing rain garden to improve pollutant removal performance and increase runoff reduction	0.4
TI-R1	Merganthaler Vocational-Technical HS	On-Site	Bioretention Area, Underdrain	Dry swale/bioretention area in existing landscaping area to treat parking lot runoff	2.0
TI-R2	Walter P. Carter ES	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	60.0
Notes: * Estimated contributing drainage area, based on available mapping data					

Table 9: Viable Stormwater Retrofit Projects in the Jones Falls Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Description**	**Contributing Drainage Area (acre)***
LJ-R2A	Sinai Hospital	Storage	Wet Extended Detention Pond	Convert existing dry detention basin to wet extended detention pond to treat parking lot and rooftop runoff	12.0
LJ-R2B	Sinai Hospital	Storage	Bioretention Area, Underdrain	Bioretention areas in existing landscaping areas in parking lot to treat parking lot runoff	8.5
LJ-R3	Tamarind Rd. and Springarden Dr.	On-Site	Bioretention Area, Underdrain	Bioretention area at end of roadway to treat roadway runoff	1.0
LJ-R6	Pimlico ES	On-Site	Bioretention Area, Underdrain	Bioretention area in existing landscaping areas in parking lot to treat parking lot runoff	1.0
LJ-R7A	Waldorf School	On-Site	Rain Garden	Rain garden to treat small pervious landscaping area	0.3
LJ-R7B	Waldorf School	On-Site	Simple Downspout Disconnection	Downspout disconnection to treat rooftop runoff	0.3
LJ-R7C	Waldorf School	On-Site	Impervious Cover Removal	Impervious cover removal with site reforestation/revegetation	0.3

Table 9: Viable Stormwater Retrofit Projects in the Jones Falls Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Description**	**Contributing Drainage Area (acre)***
LJ-R8A	Poly Western HS	On-Site	Green Roof	Green roof to replace existing conventional rooftop	0.5
LJ-R8B	Poly Western HS	On-Site	Bioretention Area, Underdrain	Bioretention areas in existing landscaping areas in parking lot to treat parking lot runoff	2.1
LJ-R8C	Poly Western HS	On-Site	Bioretention Area, Underdrain	Bioretention areas in existing impervious islands in parking lot to treat parking lot runoff	1.3
LJ-R8D	Poly Western HS	On-Site	Permeable Pavement, Underdrain	Permeable pavement to replace conventional pavement in existing parking lot	1.7
LJ-R9	West Old Coldspring Ln. and Brand Ave.	Storage	Shallow Extended Detention Wetland	Stormwater wetland to treat stormwater runoff from upstream drainage area	22.0
LJ-R10A	Edgecombe Circle ES	On-Site	Impervious Cover Removal	Impervious cover removal with site reforestation/revegetation	3.0
LJ-R10B	Edgecombe Circle ES	On-Site	Rain Garden	Rain garden to treat small pervious landscaping area and rooftop runoff	0.3
LJ-R11	Edgecombe Park	On-Site	Site Reforestation/ Revegetation	Site reforestation/revegetation	5.0
LJ-R19	Druid Hill Park, Druid Hill Park Dr. and Greenspring Ave.	Storage	Stream Restoration	Stream and floodplain restoration to treat stormwater runoff from upstream drainage area	90.0
LJ-R30A	Green School	On-Site	Bioretention Area, Underdrain	Bioretention area in existing depression to treat roadway runoff	0.3
LJ-R30B	Green School	On-Site	Site Reforestation/ Revegetation	Site reforestation/revegetation in compacted pervious areas	0.5
LJ-R38	Wood Heights Ave. and La Plata Ave.	Storage	Shallow Wetland	Wooded stormwater wetland to treat stormwater runoff from upstream drainage area	10.0
LJ-R44	Northern Pkwy., W. of Greenspring Ave.	On-Site	Bioretention Area, Underdrain	Bioretention in existing landscaping area in roadway median to treat roadway runoff	1.0
LJ-R45	Johns Hopkins University, East Campus, 33rd St.	On-Site	Bioretention Area, Underdrain	Bioretention in parking lot to treat parking lot runoff	4.0
ST-R1	Wyman Park, below Tudor Arms Ave. and Gilman Terr.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream drainage area	60.0
ST-R4	Calvert School	Storage	Underground Detention System	Underground detention to provide extended detention and partial treatment of stormwater runoff from upstream drainage area	120.0
ST-R5	Guilford Neighborhood Tulip Park, Greenway and Stratford Rd.	Storage	Stormwater Pond/ Wetland System	Stormwater pond/wetland system to treat stormwater runoff from upstream residential development.	45.0

Table 9: Viable Stormwater Retrofit Projects in the Jones Falls Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Description**	**Contributing Drainage Area (acre)***
ST-R7	Friends School	On-Site	Bioretention Area, Underdrain	Bioretention area in existing landscaping area in parking lot to treat parking lot runoff	0.8
ST-R8	Cathedral of Mary Our Queen	On-Site	Bioretention Area, Underdrain	Bioretention areas in existing landscaping areas in parking lot to treat parking lot runoff	2.5
ST-R9	Cotswold Rd. and Amberly Way	Storage	Stormwater Pond/ Wetland System	Convert/enhance existing outfall retrofit to stormwater pond/wetland system to provide additional treatment of stormwater runoff from upstream drainage area	55.0
ST-R10	Knights of Columbus	On-Site	Bioretention Area, Underdrain	Bioretention area in existing pervious area to treat parking lot and rooftop runoff	0.3
ST-R14	Notre Dame College of Maryland	Storage	Bioretention Area, Underdrain	Multi-cell bioretention area in existing dry detention basin to treat stormwater runoff from upstream drainage area	25.0
WE-R3	Pimlico MS	On-Site	Impervious Cover Removal	Impervious cover removal with site reforestation/revegetation	1.0
WE-R4	Cross Country ES	On-Site	Permeable Pavement, Underdrain	Permeable pavement to replace conventional pavement in existing parking lot	0.5
WE-R6A	Falstaff MS	On-Site	Impervious Cover Removal	Impervious cover removal with site reforestation/revegetation	0.3
WE-R6B	Falstaff MS	On-Site	Simple Downspout Disconnection	Simple downspout disconnection to treat rooftop runoff	1.3
Notes: * Estimated contributing drainage area, based on available mapping data					

2.3 COMPUTE RETROFIT POLLUTANT REMOVAL

During this task, the Center used up-to-date stormwater management practice pollutant removal efficiency information to evaluate the potential sediment and nutrient pollutant load reduction benefits that would be provided by each of the viable stormwater retrofit projects. The purpose of this evaluation was to help determine how the identified stormwater retrofit projects can be used by the City to help meet local Chesapeake Bay Program Tributary Strategy goals and TMDL regulations. Additional information about this evaluation is provided below.

2.3.1 POLLUTANT REMOVAL COMPUTATION METHODS

The pollutant load removal that would be provided by each of the viable stormwater retrofit projects was evaluated by applying up-to-date stormwater management practice pollutant removal efficiencies to the annual pre-retrofit pollutant loads generated within each contributing drainage area. Annual pre-retrofit pollutant loads were estimated using the Simple Method (Box 1) and the input parameters listed in Table 10.

Box 1: Simple Method Used to Estimate Annual Pre-Retrofit Pollutant Loads

$$L = [(P)(P_j)(R_v) \div (12)(C)(A)(2.72)]$$

Where:
P = Annual Precipitation (in/yr)
P_j = Fraction of Runoff Producing Events
R_v = Runoff Coefficient = 0.05 + 0.009(I)
I = Site Imperviousness
C = Mean Concentration of Pollutant of Concern (mg/L)
A = Area (acres)
12 = Unit Conversion Factor
2.72 = Unit Conversion Factor

Table 10: Simple Method Input Parameters

Parameter	Parameter Description	Parameter Input
P	Annual Precipitation (in/yr)	42
P_j	Fraction of Runoff Producing Events	0.9
I	Site Imperviousness (%)	Site Dependent
R_v	Runoff Coefficient	Site Dependent
C	Mean Concentration of TP (mg/L)	0.27
	Mean Concentration of TN (mg/L)	2.0
	Mean Concentration of TSS (mg/L)	59
A	Area (acres)	Site Dependent

The stormwater management practice pollutant removal efficiencies that were applied to the annual pre-retrofit pollutant loads during this analysis are outlined in Table 11. To develop these pollutant removal efficiencies, the Center reviewed the Chesapeake Bay Program's stormwater management practice pollutant removal efficiencies, information presented in the *Urban Stormwater Retrofit Practices* manual (Schueler et al., 2007) and recent stormwater management practice performance research (Fraley-McNeal et al., 2008, Hirschman et al., 2008). The goal was to use the best available data to produce realistic planning-level estimates of the pollutant load removal that would be provided by each of the viable stormwater retrofit projects.

Table 11: Stormwater Management Practice Pollutant Removal Efficiencies				
Stormwater Management Practice	**TSS**	**TP**	**TN**	**Notes**
Dry Detention Pond	5%	20%	5%	TSS, TP and TN based on NPRPD Version 3[1].
Underground Detention System	5%	20%	5%	TSS, TP and TN based on best professional judgment. Assumed similar to dry detention pond.
Dry Extended Detention Pond	50%	20%	25%	TSS, TP and TN based on NPRPD Version 2[2].
Wet Pond	80%	50%	30%	TSS, TP and TN based on NPRPD Version 3[1].
Wet Extended Detention Pond	80%	50%	30%	TSS, TP and TN based on NPRPD Version 3[1].
Shallow Wetland	70%	50%	25%	TSS, TP and TN based on NPRPD Version 3[1].
Shallow Extended Detention Wetland	70%	50%	25%	TSS, TP and TN based on NPRPD Version 3[1].
Pond/Wetland System	80%	50%	30%	TSS, TP and TN based on Retrofit Manual[3].
Bioretention Area, Underdrain	85%	65%	70%	TSS based on CBP Data[4]. TP and TN based on RR Memo[5].
Bioretention Area, No Underdrain	85%	90%	90%	TSS based on CBP Data[4]. TP and TN based on RR Memo[5].
Surface Sand Filter	85%	60%	30%	TSS, TP and TN based on NPRPD Version 3[1].
Perimeter Sand Filter	85%	60%	30%	TSS, TP and TN based on NPRPD Version 3[1].
Underground Sand Filter	85%	60%	30%	TSS, TP and TN based on NPRPD Version 3[1].
Infiltration Trench	90%	85%	85%	TSS based on NPRPD Version 3[1]. TP and TN based on RR Memo[5].
Infiltration Basin	90%	85%	85%	TSS based on NPRPD Version 3[1]. TP and TN based on RR Memo[5].
Dry Swale	80%	60%	60%	TSS based on NPRPD Version 3[1]. TP and TN based on RR Memo[5].
Wet Swale	80%	30%	30%	TSS based on NPRPD Version 3[1]. TP and TN based on RR Memo[5].
Soil Restoration	75%	75%	75%	TSS based on best professional judgment. TP and TN based on RR Memo[5].
Site Reforestation/ Revegetation	75%	75%	75%	TSS, TP and TN based on best professional judgment. Assumed similar to soil restoration.
Undisturbed Natural Area	80%	50%	50%	TSS, TP and TN based on best professional judgment.
Vegetated Filter Strip	80%	25%	25%	TSS based on best professional judgment. TP and TN based on RR Memo[5].
Grass Channel	60%	25%	30%	TSS based on best professional

Table 11: Stormwater Management Practice Pollutant Removal Efficiencies				
Stormwater Management Practice	TSS	TP	TN	Notes
				judgment. TP and TN based on RR Memo[5].
Simple Downspout Disconnection	80%	25%	25%	TSS, TP and TN based on best professional judgment. Assumed similar to vegetated filter strip.
Rain Garden	85%	65%	70%	TSS, TP and TN based on best professional judgment. Assumed similar to bioretention, underdrain.
Stormwater Planter	85%	65%	70%	TSS, TP and TN based on best professional judgment. Assumed similar to bioretention, underdrain.
Dry Well	90%	85%	85%	TSS based on best professional judgment. TP and TN based on RR Memo[5].
Rainwater Harvesting	Varies	Varies	Varies	Varies according to storage capacity of cistern.
Green Roof	85%	50%	50%	TSS based on best professional judgment. TP and TN based on RR Memo[5].
Permeable Pavement, Underdrain	90%	55%	55%	TSS based on best professional judgment. TP and TN based on RR Memo[5].
Permeable Pavement, No Underdrain	90%	85%	85%	TSS based on best professional judgment. TP and TN based on RR Memo[5].
Impervious Cover Removal	95%	95%	95%	Based on Simple Method modeling.
Piedmont Outfall	80%	60%	60%	TSS, TP and TN based on best professional judgment. Assumed similar to dry swale.
Stream Restoration	2.55 lb/lf	0.0035 lb/lf	0.02 lb/lf	TSS, TP and TN based on CBP Data[4].

Notes:
1) National Pollutant Removal Performance Database, Version 3 (Fraley-McNeal et al., 2008)
2) National Pollutant Removal Performance Database, Version 2 (Winer, 2000)
3) Urban Stormwater Retrofit Practices Manual (Schueler et al., 2007)
4) Chesapeake Bay Program Stormwater Management Practice Pollutant Removal Efficiency Data (CBP, No Date)
5) Runoff Reduction Method Technical Memorandum (Hirschman et al., 2008)

2.3.1 POLLUTANT REMOVAL COMPUTATION RESULTS

Using the pollutant removal efficiencies listed in Table 10, a spreadsheet was created to evaluate the pollutant load reduction that would be provided by each of the viable stormwater retrofit projects. A copy of the spreadsheet is presented in Appendix B. The results of the analysis are presented in Tables 12, 13 and 14. Note that the viable stormwater retrofit projects in the Baltimore Harbor, Herring Run and Jones Falls watersheds would remove up to 500,950 pounds of sediment, 1,705 pounds of total phosphorus, and 7,215 pounds of total phosphorus from the stormwater runoff that makes its way into the City's rivers and streams each year. These numbers translate into 19%, 14% and 8% reductions in the annual sediment, phosphorus and nitrogen loads, respectively, that are currently generated within these contributing drainage areas.

These percentages are significantly higher when the identified stream restoration projects are not considered in the calculations. When the stream restoration projects are left out of the calculations, the stormwater retrofit projects would remove up to 493,300 pounds of sediment, 1,695 pounds of phosphorus and 7,155 pounds of nitrogen from the stormwater runoff that makes its way into the City's rivers and streams each year. Although these numbers are lower than what they were when the stream restoration projects were included in the calculations, they translate into 52%, 39% and 22% reductions in the annual sediment, phosphorus and nitrogen loads, respectively, that are currently generated within these contributing drainage areas.

Table 12: Pollutant Removal Provided by Viable Stormwater Retrofit Projects in the Baltimore Harbor Watershed											
Retrofit ID	Contributing Drainage Area (acre)*	Total Impervious Cover (%)	Annual Pre-Retrofit TSS Load (lb)	Annual Pre-Retrofit TP Load (lb)	Annual Pre-Retrofit TN Load (lb)	Stormwater Management Practice	Annual TSS Load Removed (lb)	Annual TP Load Removed (lb)	Annual TN Load Removed (lb)	Nominalized Project Score	Priority
HA-R2	1.6	85%	638.5	2.9	21.6	Bioretention Area, Underdrain	542.8	1.9	15.2	2.00	Medium
HA-R3	0.7	100%	331.3	1.5	11.2	Bioretention Area, Underdrain	281.6	1.0	7.9	2.00	Medium
HA-R5A	1.5	15%	140.3	0.6	4.8	Bioretention Area, Underdrain	119.2	0.4	3.3	2.33	High
HA-R5B	872.4	80%	339,551.0	1,553.9	11,510.2	Underground Detention System	16,977.5	310.8	575.5	1.33	Low
HA-R6	11.9	5%	571.4	2.6	19.4	Dry Swale	457.2	1.6	11.6	2.33	High
HA-R8	2.4	5%	115.2	0.5	3.9	Bioretention Area, Underdrain	98.0	0.3	2.7	2.00	Medium
HA-R16	1.4	85%	576.7	2.6	19.6	Bioretention Area, Underdrain	490.2	1.7	13.7	2.33	High
HA-R19	0.7	100%	326.5	1.5	11.1	Bioretention Area, Underdrain	277.6	1.0	7.7	2.00	Medium
HA-R20	5.8	90%	2,521.3	11.5	85.5	Stormwater Pond/ Wetland System	2,017.0	5.8	25.6	1.67	Medium
HA-R22	34.4	55%	9,476.6	43.4	321.2	Stormwater Pond/ Wetland System	7,581.3	21.7	96.4	2.67	High
HA-R23	2.8	100%	1,320.6	6.0	44.8	Bioretention Area, Underdrain	1,122.5	3.9	31.3	1.67	Medium
Baltimore Harbor Watershed Totals			**355,570**	**1,627**	**12,053**		**29,965**	**350**	**791**		
Notes: * Estimated contributing drainage area, based on available mapping data											

Table 13: Pollutant Removal Provided by Viable Stormwater Retrofit Projects in the Herring Run Watershed											
Retrofit ID	Contributing Drainage Area (acre)*	Total Impervious Cover (%)	Annual Pre-Retrofit TSS Load (lb)	Annual Pre-Retrofit TP Load (lb)	Annual Pre-Retrofit TN Load (lb)	Stormwater Management Practice	Annual TSS Load Removed (lb)	Annual TP Load Removed (lb)	Annual TN Load Removed (lb)	Nominalized Project Score	Priority
BI-R1	345.0	50%	87,194.5	399.0	2,955.7	Stormwater Pond/ Wetland System	69,755.6	199.5	886.7	1.67	Medium
BI-R3	1.5	100%	720.3	3.3	24.4	Bioretention Area, Underdrain	612.3	2.1	17.1	1.67	Medium
CH-R2A	3.8	50%	960.4	4.4	32.6	Bioretention Area, Underdrain	816.3	2.9	22.8	2.00	Medium

Table 13: Pollutant Removal Provided by Viable Stormwater Retrofit Projects in the Herring Run Watershed											
Retrofit ID	**Contributing Drainage Area (acre)***	**Total Impervious Cover (%)**	**Annual Pre-Retrofit TSS Load (lb)**	**Annual Pre-Retrofit TP Load (lb)**	**Annual Pre-Retrofit TN Load (lb)**	**Stormwater Management Practice**	**Annual TSS Load Removed (lb)**	**Annual TP Load Removed (lb)**	**Annual TN Load Removed (lb)**	**Nominalized Project Score**	**Priority**
CH-R2B	53.0	50%	13,395.1	61.3	454.1	Stormwater Pond/ Wetland System	10,716.1	30.6	136.2	1.67	Medium
CH-R3B	45.0	50%	11,373.2	52.0	385.5	Stormwater Pond/ Wetland System	9,098.6	26.0	115.7	2.33	High
CH-R5	44.0	50%	11,120.5	50.9	377.0	Stormwater Pond/ Wetland System	8,896.4	25.4	113.1	1.33	Low
CH-R6A	84.0	60%	25,051.3	114.6	849.2	Stormwater Pond/ Wetland System	20,041.1	57.3	254.8	2.00	Medium
CH-R6B	300.0	60%	89,469.1	409.4	3,032.9	Stormwater Pond/ Wetland System	71,575.3	204.7	909.9	1.33	Low
CH-R6C	68.0	50%	17,186.2	78.6	582.6	Stormwater Pond/ Wetland System	13,748.9	39.3	174.8	1.33	Low
CH-R8	82.8	50%	20,926.7	95.8	709.4	Stormwater Pond/ Wetland System	16,741.3	47.9	212.8	1.33	Low
CH-R9	1.0	50%	252.7	1.2	8.6	Dry Swale	50.5	0.4	2.6	2.33	High
HR-R2A	0.3	100%	144.1	0.7	4.9	Permeable Pavement, Underdrain	129.7	0.4	2.7	1.67	Medium
HR-R2B	1.0	30%	161.8	0.7	5.5	Dry Swale	32.4	0.3	1.6	2.00	Medium
HR-R3	1.0	100%	480.2	2.2	16.3	Bioretention Area, Underdrain	408.2	1.4	11.4	2.00	Medium
HR-R6A	1.0	100%	480.2	2.2	16.3	Impervious Cover Removal	456.2	2.1	15.5	2.33	High
HR-R6B	17.5	50%	4,422.9	20.2	149.9	Piedmont Outfall	3,538.3	12.1	97.5	2.00	Medium
HR-R10	1.5	50%	379.1	1.7	12.9	Bioretention Area, Underdrain	322.2	1.1	9.0	2.00	Medium
HR-R12A	80.0	40%	16,579.6	75.9	562.0	Stormwater Pond/ Wetland System	13,263.7	37.9	168.6	2.00	Medium
HR-R12B	60.0	40%	12,434.7	56.9	421.5	Stormwater Pond/ Wetland System	9,947.8	28.5	126.5	1.33	Low
HR-R12D	9,041	35%	1,668,050.3	7,633.5	56,544.1	Stream Restoration	4,590.0	6.3	36.0	1.33	Low
HR-R14	1.0	40%	207.2	0.9	7.0	Bioretention Area, Underdrain	176.2	0.6	4.9	2.00	Medium
HR-R15A	130.0	50%	32,855.9	150.4	1,113.8	Stormwater Pond/ Wetland System	26,284.7	75.2	334.1	2.33	High

Table 13: Pollutant Removal Provided by Viable Stormwater Retrofit Projects in the Herring Run Watershed											
Retrofit ID	**Contributing Drainage Area (acre)***	**Total Impervious Cover (%)**	**Annual Pre-Retrofit TSS Load (lb)**	**Annual Pre-Retrofit TP Load (lb)**	**Annual Pre-Retrofit TN Load (lb)**	**Stormwater Management Practice**	**Annual TSS Load Removed (lb)**	**Annual TP Load Removed (lb)**	**Annual TN Load Removed (lb)**	**Nominalized Project Score**	**Priority**
HR-R15B	100.0	50%	25,273.8	115.7	856.7	Stormwater Pond/ Wetland System	20,219.0	57.8	257.0	1.33	Low
HR-R15C	40.0	50%	10,109.5	46.3	342.7	Stormwater Pond/ Wetland System	8,087.6	23.1	102.8	2.33	High
HR-R18	5.0	30%	808.8	3.7	27.4	Bioretention Area, Underdrain	687.4	2.4	19.2	1.67	Medium
HR-R19	2.0	100%	960.4	4.4	32.6	Bioretention Area, Underdrain	816.3	2.9	22.8	1.00	Low
HR-R20	25.0	40%	5,181.1	23.7	175.6	Stormwater Pond/ Wetland System	4,144.9	11.9	52.7	2.00	Medium
HR-R21	0.8	100%	360.2	1.6	12.2	Dry Swale	288.1	1.0	7.3	2.33	High
HR-R22	12.0	60%	3,578.8	16.4	121.3	Dry Swale	2,863.0	9.8	72.8	2.00	Medium
HR-R23	0.6	100%	288.1	1.3	9.8	Bioretention Area, Underdrain	244.9	0.9	6.8	1.67	Medium
HR-R28A	100.0	35%	18,449.8	84.4	625.4	Stormwater Pond/ Wetland System	14,759.9	42.2	187.6	1.33	Low
HR-R28B	37.0	40%	7,668.1	35.1	259.9	Stormwater Pond/ Wetland System	6,134.4	17.5	78.0	2.00	Medium
HR-R29A	1.1	50%	278.0	1.3	9.4	Bioretention Area, Underdrain	236.3	0.8	6.6	2.00	Medium
HR-R29B	1.8	100%	864.4	4.0	29.3	Permeable Pavement, Underdrain	777.9	2.2	16.1	1.67	Medium
HR-R29C	0.3	100%	120.1	0.5	4.1	Bioretention Area, Underdrain	102.0	0.4	2.8	1.67	Medium
HR-R29D	0.1	100%	48.0	0.2	1.6	Permeable Pavement, Underdrain	43.2	0.1	0.9	1.67	Medium
HR-R38A	2.0	10%	141.5	0.6	4.8	Bioretention Area, Underdrain	120.3	0.4	3.4	2.00	Medium
HR-R38B	4.5	50%	1,137.3	5.2	38.6	Bioretention Area, Underdrain	966.7	3.4	27.0	1.67	Medium
HR-R39	40.0	50%	10,109.5	46.3	342.7	Stormwater Pond/ Wetland System	8,087.6	23.1	102.8	2.00	Medium
HR-R41A	0.7	100%	336.1	1.5	11.4	Bioretention Area, Underdrain	285.7	1.0	8.0	2.00	Medium
HR-R41B	0.2	100%	72.0	0.3	2.4	Impervious Cover Removal	68.4	0.3	2.3	2.33	High

Table 13: Pollutant Removal Provided by Viable Stormwater Retrofit Projects in the Herring Run Watershed

Retrofit ID	Contributing Drainage Area (acre)*	Total Impervious Cover (%)	Annual Pre-Retrofit TSS Load (lb)	Annual Pre-Retrofit TP Load (lb)	Annual Pre-Retrofit TN Load (lb)	Stormwater Management Practice	Annual TSS Load Removed (lb)	Annual TP Load Removed (lb)	Annual TN Load Removed (lb)	Nominalized Project Score	Priority
HR-R42A	305.0	40%	63,209.7	289.3	2,142.7	Stormwater Pond/ Wetland System	50,567.7	144.6	642.8	1.33	Low
MO-R4	32.0	40%	6,631.8	30.3	224.8	Stormwater Pond/ Wetland System	5,305.5	15.2	67.4	2.33	High
RE-R1A	0.3	80%	97.3	0.4	3.3	Dry Swale	77.8	0.3	2.0	2.00	Medium
RE-R1B	0.5	100%	240.1	1.1	8.1	Permeable Pavement, Underdrain	216.1	0.6	4.5	1.67	Medium
RE-R1C	0.4	100%	168.1	0.8	5.7	Rain Garden	67.2	0.2	2.0	2.33	High
TI-R1	2.0	60%	596.5	2.7	20.2	Bioretention Area, Underdrain	507.0	1.8	14.2	2.00	Medium
TI-R2	60.0	60%	17,893.8	81.9	606.6	Stormwater Pond/ Wetland System	14,315.1	40.9	182.0	2.00	Medium
Herring Run Watershed Totals			**2,188,469**	**10,015**	**74,185**		**421,192**	**1,207**	**5,546**		

Notes:
* Estimated contributing drainage area, based on available mapping data

Table 14: Pollutant Removal Provided by Viable Stormwater Retrofit Projects in the Jones Falls Watershed

Retrofit ID	Contributing Drainage Area (acre)*	Total Impervious Cover (%)	Annual Pre-Retrofit TSS Load (lb)	Annual Pre-Retrofit TP Load (lb)	Annual Pre-Retrofit TN Load (lb)	Stormwater Management Practice	Annual TSS Load Removed (lb)	Annual TP Load Removed (lb)	Annual TN Load Removed (lb)	Nominalized Project Score	Priority
LJ-R2A	12.0	80%	4,670.6	21.4	158.3	Wet Extended Detention Pond	3,502.9	6.4	39.6	2.33	High
LJ-R2B	8.5	100%	4,081.7	18.7	138.4	Bioretention Area, Underdrain	3,469.4	12.1	96.9	2.00	Medium
LJ-R3	1.0	80%	389.2	1.8	13.2	Bioretention Area, Underdrain	330.8	1.2	9.2	1.67	Medium
LJ-R6	1.0	90%	434.7	2.0	14.7	Bioretention Area, Underdrain	369.5	1.3	10.3	2.00	Medium
LJ-R7A	0.3	20%	29.1	0.1	1.0	Rain Garden	24.7	0.1	0.7	2.33	High
LJ-R7B	0.3	100%	120.1	0.5	4.1	Simple Downspout Disconnection	96.0	0.1	1.0	2.33	High
LJ-R7C	0.3	100%	120.1	0.5	4.1	Impervious Cover Removal	114.0	0.5	3.9	2.00	Medium

Table 14: Pollutant Removal Provided by Viable Stormwater Retrofit Projects in the Jones Falls Watershed											
Retrofit ID	**Contributing Drainage Area (acre)***	**Total Impervious Cover (%)**	**Annual Pre-Retrofit TSS Load (lb)**	**Annual Pre-Retrofit TP Load (lb)**	**Annual Pre-Retrofit TN Load (lb)**	**Stormwater Management Practice**	**Annual TSS Load Removed (lb)**	**Annual TP Load Removed (lb)**	**Annual TN Load Removed (lb)**	**Nominalized Project Score**	**Priority**
LJ-R8A	0.5	100%	244.9	1.1	8.3	Green Roof	208.2	0.6	4.2	1.33	Low
LJ-R8B	2.1	100%	1,013.2	4.6	34.3	Bioretention Area, Underdrain	861.2	3.0	24.0	2.00	Medium
LJ-R8C	1.3	85%	543.8	2.5	18.4	Bioretention Area, Underdrain	462.2	1.6	12.9	2.00	Medium
LJ-R8D	1.7	100%	801.9	3.7	27.2	Permeable Pavement, Underdrain	721.7	2.0	15.0	1.67	Medium
LJ-R9	22.0	40%	4,559.4	20.9	154.6	Shallow Extended Detention Wetland	3,191.6	10.4	38.6	1.67	Medium
LJ-R10A	3.0	100%	1,440.6	6.6	48.8	Impervious Cover Removal	1,368.6	6.3	46.4	2.00	Medium
LJ-R10B	0.3	0%	6.3	0.0	0.2	Rain Garden	5.4	0.0	0.1	2.33	High
LJ-R11	5.0	10%	353.8	1.6	12.0	Site Reforestation/ Revegetation	265.4	1.2	9.0	2.67	High
LJ-R19	90.0	30%	14,557.6	66.6	493.5	Stream Restoration	3,060.0	4.2	24.0	2.00	Medium
LJ-R30A	0.3	100%	120.1	0.5	4.1	Bioretention Area, Underdrain	102.0	0.4	2.8	2.00	Medium
LJ-R30B	0.5	0%	12.6	0.1	0.4	Site Reforestation/ Revegetation	9.5	0.0	0.3	2.33	High
LJ-R38	10.0	40%	2,072.4	9.5	70.3	Shallow Wetland	1,450.7	4.7	17.6	2.00	Medium
LJ-R44	1.0	100%	480.2	2.2	16.3	Bioretention Area, Underdrain	408.2	1.4	11.4	1.67	Medium
LJ-R45	4.0	100%	1,920.8	8.8	65.1	Bioretention Area, Underdrain	1,632.7	5.7	45.6	2.00	Medium
ST-R1	60.0	30%	9,705.1	44.4	329.0	Stormwater Pond/ Wetland System	7,764.1	22.2	98.7	2.00	Medium
ST-R4	120.0	30%	19,410.2	88.8	658.0	Underground Detention System	970.5	17.8	32.9	1.33	Low
ST-R5	45.0	30%	7,278.8	33.3	246.7	Stormwater Pond/ Wetland System	5,823.1	16.7	74.0	1.67	Medium
ST-R7	0.8	100%	384.2	1.8	13.0	Bioretention Area, Underdrain	326.5	1.1	9.1	2.00	Medium
ST-R8	2.5	100%	1,200.5	5.5	40.7	Bioretention Area, Underdrain	1,020.4	3.6	28.5	1.67	Medium

Table 14: Pollutant Removal Provided by Viable Stormwater Retrofit Projects in the Jones Falls Watershed											
Retrofit ID	**Contributing Drainage Area (acre)***	**Total Impervious Cover (%)**	**Annual Pre-Retrofit TSS Load (lb)**	**Annual Pre-Retrofit TP Load (lb)**	**Annual Pre-Retrofit TN Load (lb)**	**Stormwater Management Practice**	**Annual TSS Load Removed (lb)**	**Annual TP Load Removed (lb)**	**Annual TN Load Removed (lb)**	**Nominalized Project Score**	**Priority**
ST-R9	55.0	35%	10,147.4	46.4	344.0	Stormwater Pond/ Wetland System	7,610.5	13.9	86.0	2.00	Medium
ST-R10	0.3	100%	144.1	0.7	4.9	Bioretention Area, Underdrain	122.5	0.4	3.4	2.00	Medium
ST-R14	25.0	30%	4,043.8	18.5	137.1	Bioretention Area, Underdrain	3,235.0	8.3	89.1	2.67	High
WE-R3	1.0	100%	480.2	2.2	16.3	Impervious Cover Removal	456.2	2.1	15.5	2.33	High
WE-R4	0.5	100%	240.1	1.1	8.1	Permeable Pavement, Underdrain	216.1	0.6	4.5	1.67	Medium
WE-R6A	0.3	100%	120.1	0.5	4.1	Impervious Cover Removal	114.0	0.5	3.5	2.33	High
WE-R6B	1.3	100%	600.3	2.7	20.3	Simple Downspout Disconnection	480.2	0.7	19.7	2.33	High
Jones Falls Watershed Totals			**91,728**	**420**	**3,109**		**49,794**	**151**	**878**		

Notes:
* Estimated contributing drainage area, based on available mapping data

3.0 DISCUSSION

Because much of the development within the Baltimore Harbor, Herring Run and Jones Falls watersheds is more than thirty years old, there are relatively few stormwater management practices already in the ground within these watersheds. Consequently, there are few opportunities to retrofit the existing stormwater management infrastructure; new stormwater practices must be constructed to help meet local Chesapeake Bay Program Tributary Strategy goals and TMDL regulations. Although new stormwater management practices will need to be constructed to help meet local watershed restoration goals and objectives, there are abundant stormwater retrofit opportunities within these watersheds.

This project identified 163 potential stormwater retrofit locations within the Baltimore City portion of the Baltimore Harbor, Herring Run and Jones Falls watersheds. Although only 80 of these potential retrofit locations were further investigated during this study, a total of 11 viable retrofit projects in the Baltimore Harbor watershed, 48 viable retrofit projects in the Herring Run watershed, and 33 viable retrofit projects in the Jones Falls watershed were identified. These 92 viable stormwater retrofit projects could remove up to 500,950 pounds of sediment, 1,705 pounds of total phosphorus, and 30,670 pounds of total phosphorus from the stormwater runoff that makes its way into the City's rivers and streams each year. As shown in Tables 7, 8 and 9, these viable stormwater retrofit projects can be broken up into two distinct groups:

- *Storage Retrofits*: Storage retrofits are used to treat stormwater runoff from drainage areas larger than 5 acres in size. Consequently, storage retrofits can only be constructed on sites where large volumes of stormwater runoff can be retained and managed. Storage retrofits are often located on publicly-owned land and make use of stormwater management practices such as wet ponds, wet extended detention ponds, stormwater wetlands, stormwater pond/wetland systems and multi-cell bioretention areas.

- *On-Site Retrofits*: On-site retrofits are generally used to treat stormwater runoff from drainage areas smaller than 5 acres in size. They are commonly used to treat the stormwater runoff generated on individual impervious surfaces, such as rooftops, small parking lots, streets and other small impervious areas. On-site retrofits are often located on both publicly- and privately-owned land and make use of stormwater management practices such as bioretention areas, filtration and infiltration practices, swales, downspout disconnection practices and other small-scale stormwater management practices.

Storage and on-site retrofits represent two different approaches to stormwater retrofitting and watershed restoration (Table 15). As a general rule, storage retrofits represent the most cost-effective way to meet watershed restoration goals and objectives. However, because of the amount of urbanization that has occurred in the Baltimore City portion of the Baltimore Harbor, Herring Run and Jones Falls watersheds, both on-site and storage retrofits will need to be used to provide enough stormwater treatment to meet local watershed restoration goals and objectives. There are simply not enough storage retrofit locations within these watersheds to meet local Chesapeake Bay Program Tributary Strategy goals and TMDL regulations. Some on-site retrofits will need to be used.

Table 15: Different Approaches to Stormwater Retrofitting and Watershed Restoration	
Storage Retrofits	**On-Site Retrofits**
Treat drainage areas larger than 5 acres	Treat drainage areas smaller than 5 acres
Generally constructed on public land	Generally constructed on private land
May need dozens to provide desired level of stormwater treatment	May need hundreds to provide desired level of stormwater treatment
Assessed at subwatershed scale	Assessed at catchment/neighborhood scale
Moderate cost per impervious acre treated	High cost per impervious acre treated
Impractical in heavily urbanized watersheds	Practical in heavily urbanized watersheds
Permitting requirements can be high	Few permits typically needed
Delivered through municipal construction	Delivered through municipal programs
Involve the use of wet ponds, wet extended detention ponds and stormwater wetlands	Involve the use of bioretention areas, filtration and infiltration practices and swales

Table 16 divides the viable stormwater retrofit projects that were identified during this project into storage and on-site retrofits. Although a majority (e.g., 55) of the initial concepts that were developed were small-scale, on-site retrofit projects, a number (e.g., 37) of large-scale, storage retrofit concepts were also developed. Many of these large-scale, storage retrofit projects are located in the large, linear streamside park system that can be found within the Herring Run watershed. Baltimore City should craft a retrofit strategy that will provide for implementation of both storage and on-site retrofit projects.

Table 16: Types of Viable Stormwater Retrofit Projects Identified During the RRI			
Retrofit Type	**Stormwater Management Practice**	**# Identified**	**Sites**
Storage Retrofits	Stormwater Pond/Wetland System	25	BH-HA-R20 BH-HA-R22 HR-BI-R1 HR-CH-R2 HR-CH-R3 HR-CH-R5 HR-CH-R6 HR-CH-R8 HR-HR-R12 HR-HR-R15 HR-HR-R20 HR-HR-R28 HR-HR-R39 HR-HR-R42 HR-MO-R4 HR-TI-R2 JF-ST-R1 JF-ST-R5 JF-ST-R9
	Wet Extended Detention Pond	1	JF-LJ-R2
	Shallow Wetland	1	JF-LJ-R38
	Shallow Extended Detention Wetland	1	JF-LJ-R9
	Bioretention Area, Underdrain	2	JF-LJ-R2 JF-ST-R14
	Dry Swale	2	BH-HA-R6 HR-HR-R22

Table 16: Types of Viable Stormwater Retrofit Projects Identified During the RRI			
Retrofit Type	**Stormwater Management Practice**	**# Identified**	**Sites**
	Piedmont Outfall	1	HR-HR-R6
	Underground Detention System	2	BH-HA-R5 JF-ST-R4
	Stream Restoration	2	HR-HR-R12 JF-LJ-R19
On-Site Retrofits	Bioretention Area, Underdrain	31	BH-HA-R2 BH-HA-R3 BH-HA-R5 BH-HA-R8 BH-HA-R16 BH-HA-R19 BH-HA-R23 HR-BI-R3 HR-CH-R2 HR-HR-R3 HR-HR-R10 HR-HR-R14 HR-HR-R18 HR-HR-R19 HR-HR-R23 HR-HR-R29 HR-HR-R38 HR-HR-R41 HR-TI-R1 JF-LJ-R3 JF-LJ-R6 JF-LJ-R8 JF-LJ-R30 JF-LJ-R44 JF-LJ-R45 JF-ST-R7 JF-ST-R8 JF-ST-R10
	Dry Swale	4	HR-CH-R9 HR-HR-R2 HR-HR-R21 HR-RE-R1
	Rain Garden	3	HR-R3-R1 JF-LJ-R7 JF-LJ-R10
	Simple Downspout Disconnection	2	JF-LJ-R7 JF-WE-R6
	Impervious Cover Removal	6	HR-HR-R6 HR-HR-R41 JF-LJ-R7 JF-LJ-R10 JF-WE-R3 JF-WE-R6
	Green Roof	1	JF-LJ-R8

Table 16: Types of Viable Stormwater Retrofit Projects Identified During the RRI			
Retrofit Type	**Stormwater Management Practice**	**# Identified**	**Sites**
	Permeable Pavement, Underdrain	6	HR-HR-R2 HR-HR-R29 HR-RE-R1 JF-LJ-R8 JF-WE-R4
	Reforestation/Revegetation	2	JF-LJ-R11 JF-LJ-R30

4.0 INITIAL RETROFIT EVALUATION & RANKING

This project identified a total of 92 stormwater retrofit projects in the Baltimore City portion of the Baltimore Harbor, Herring Run and Jones Falls watersheds. An initial retrofit evaluation and ranking exercise was completed by the Center to help put these viable stormwater retrofit projects in context and produce a prioritized list. The prioritized list can be used as guide for implementation because the City can use it to ascertain which projects provide the best opportunities to help meet local watershed restoration goals and objectives. However, it should be noted that the prioritized list should be used only as a guide, and that professional judgment, funding opportunities, and broader City goals and objectives should also play a strong role in determining which projects should be implemented at a given time. Additional information about the initial retrofit evaluation and ranking process completed by the Center is provided below.

4.1 SCREENING FACTORS

The screening factors used to compare the viable stormwater retrofit projects to one another included physical feasibility, difficulty of design and watershed benefit. To facilitate a quantitative comparison between each of the viable retrofit projects, a tiered scoring system was developed for each of the screening factors. Table 17 outlines the initial screening factors and the corresponding scoring system that was developed for each of them.

Table 17: Initial Retrofit Screening Factors and Scoring Criteria		
Initial Screening Factor	**Description**	**Scoring System**
Physical Feasibility	Screening factor that considers the hurdles that will need to be overcome to actually implement the project, including site characteristics and constraints, available space, construction and maintenance access issues and probability of acceptance by landowner and neighbors.	High = 3 Medium = 2 Low = 1 Very Low = 0*
Difficulty of Design	Screening factor that evaluates the overall complexity of the project by considering factors such as the need for special engineering studies or analysis and the number and type of environmental permits that may need to be obtained.	Very High = 0 High = 1 Medium = 2 Low = 3
Watershed Benefit	Screening factor that considers the size of the contributing drainage area treated by the stormwater retrofit project.	CDA ≤ 5.0 acres = 1 5.0 acres < CDA < 10.0 acres = 2 CDA ≥ 10.0 acres = 3
Notes: * Any project receiving a score of "very low" in the physical feasibility screening factor was not considered to be a		

viable retrofit project.

4.2 INITIAL RETROFIT EVALUATION & RANKING

The screening factors listed in Table 17 were applied to each of the viable stormwater retrofit projects located in the Baltimore Harbor, Herring Run and Jones Falls watersheds. Scores for each of the screening criteria were assigned to each project by a Center staff member that was familiar with the particular stormwater retrofit project in question. These scores were then summed and divided by the number screening factors (e.g., 3), which produced a nominalized 3-point scale that could be used for project ranking. Projects receiving a nominalized score of 2.33 or greater were considered to be high priority projects, while projects receiving a nominalized score of between 1.50 and 2.33 were considered to be medium priority projects. Projects receiving a nominalized score of between 0.50 and 1.49 were considered to be low priority projects, while projects receiving a nominalized score of less than 0.49 were considered to be very low priority projects. All of this scoring information was compiled into a single spreadsheet. A copy of this spreadsheet is presented in Appendix B.

4.3 INITIAL RETROFIT EVALUATION & RANKING RESULTS

After all the nominized scores were entered into the spreadsheet, a prioritized list of projects was produced (Tables 18, 19 and 20). The prioritized list summarizes the viable retrofit projects in the Baltimore Harbor, Herring Run and Jones Falls watersheds, shows the nominalized score that they received and ranks them according to their priority for further investigation and implementation.

Table 18: Prioritized List of Stormwater Retrofit Projects in the Baltimore Harbor Watershed

Retrofit ID	Location	Retrofit Type	Stormwater Management Practice	Nominalized Project Score	Priority
HA-R22	Fairmont Harford HS	Storage	Stormwater Pond/ Wetland System	2.67	High
HA-R5A	Patterson Park	On-Site	Bioretention Area, Underdrain	2.33	High
HA-R6	Patterson Park Adjunct	Storage	Dry Swale	2.33	High
HA-R16	Fayette St. and Caroline St.	On-Site	Bioretention Area, Underdrain	2.33	High
HA-R2	Canton Waterfront Park, below Boston St. at Ellwood Ave.	On-Site	Bioretention Area, Underdrain	2.00	Medium
HA-R3	Canton Waterfront Park, below Boston St. at Linwood Ave.	On-Site	Bioretention Area, Underdrain	2.00	Medium
HA-R8	Unnamed Park, at Orleans St. and Ellwood Ave.	On-Site	Bioretention Area, Underdrain	2.00	Medium
HA-R19	Harford Heights ES	On-Site	Bioretention Area, Underdrain	2.00	Medium
HA-R20	Clifton Park Adjunct, W. of St. Lo Dr. at Sinclair Ln. and Wolfe St.	Storage	Stormwater Pond/ Wetland System	1.67	Medium
HA-R23	Clifton Park, Harford Rd. and St. Lo Dr.	On-Site	Bioretention Area, Underdrain	1.67	Medium

HA-R5B	Patterson Park	Storage	Underground Detention System	1.33	Low

Table 19: Prioritized List of Stormwater Retrofit Projects in the Herring Run Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Nominalized Project Score**	**Priority**
CH-R3B	Chinquapin Run Park, between Northern Pkwy. and Belvedere Ave., below Chinquapin Pkwy. between Elbank Ave. and Gleneagle Rd.	Storage	Stormwater Pond/ Wetland System	2.33	High
CH-R9	Good Samaritan Hospital	On-Site	Dry Swale	2.33	High
HR-R6A	Yorkwood ES	On-Site	Impervious Cover Removal	2.33	High
HR-R15A	Herring Run Park, between Brehms Ln. and Sinclair Ln., below Parkside Dr., between Roberton Ave. and Sinclair Ln.	Storage	Stormwater Pond/ Wetland System	2.33	High
HR-R15C	Herring Run Park, between Brehms Ln. and Sinclair Ln., below Shannon Dr. at Lyndale Ave.	Storage	Stormwater Pond/ Wetland System	2.33	High
HR-R21	Pep Boys, Harford Rd. and Moravia Rd.	On-Site	Dry Swale	2.33	High
HR-R41B	Montebello ES	On-Site	Impervious Cover Removal	2.33	High
MO-R4	Radecke Playfield, Radecke Ave. and Gardenwood Ave.	Storage	Stormwater Pond/ Wetland System	2.33	High
RE-R1C	Woodhome ES/MS	On-Site	Rain Garden	2.33	High
CH-R2A	Northwood ES and Recreation Center	On-Site	Bioretention Area, Underdrain	2.00	Medium
CH-R6A	Chinquapin Run Park, between Belvedere Ave. and The Alameda, below Northwood Dr. between St. Dunstans Rd. and The Alameda	Storage	Stormwater Pond/ Wetland System	2.00	Medium
HR-R2B	Mt. Pleasant Ice Arena, Hillen Rd. and Northern Pkwy.	On-Site	Dry Swale	2.00	Medium
HR-R3	North Harford Recreation Center, Northern Pkwy. and Laurelton Ave.	On-Site	Bioretention Area, Underdrain	2.00	Medium
HR-R6B	Yorkwood ES	Storage	Piedmont Outfall	2.00	Medium
HR-R10	Mt. Pleasant Park, at Perring Pkwy. and Laurelton Ave.	On-Site	Bioretention Area, Underdrain	2.00	Medium
HR-R12A	Herring Run Park, between Harford Rd. and Belair Rd., below Chesterfield Ave. at Norman Ave.	Storage	Stormwater Pond/ Wetland System	2.00	Medium
HR-R14	Brehms Lane ES	On-Site	Bioretention Area, Underdrain	2.00	Medium
HR-R20	Armistead Gardens, Armistead	Storage	Stormwater Pond/	2.00	Medium

Table 19: Prioritized List of Stormwater Retrofit Projects in the Herring Run Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Nominalized Project Score**	**Priority**
	Way and Hewitt Dr.		Wetland System		
HR-R22	Herring Run Park, between Harford Rd. and Argonne Dr.	Storage	Dry Swale	2.00	Medium
HR-R28B	Perring Pkwy., below Pioneer Dr. at Cloville Ave.	Storage	Stormwater Pond/ Wetland System	2.00	Medium
HR-R29A	WEB DuBois HS	On-Site	Bioretention Area, Underdrain	2.00	Medium
HR-R38A	Clifton Park	On-Site	Bioretention Area, Underdrain	2.00	Medium
HR-R39	Herring Run Park, between Belair Rd. and Mannasota Ave., below Shannon Dr. at Kavon Ave.	Storage	Stormwater Pond/ Wetland System	2.00	Medium
HR-R41A	Montebello ES	On-Site	Bioretention Area, Underdrain	2.00	Medium
RE-R1A	Woodhome ES/MS	On-Site	Dry Swale	2.00	Medium
TI-R1	Merganthaler Vocational-Technical HS	On-Site	Bioretention Area, Underdrain	2.00	Medium
TI-R2	Walter P. Carter ES	Storage	Stormwater Pond/ Wetland System	2.00	Medium
BI-R1	North of Sipple Ave. at end of Mayview Terr., Barbara Ave., Parkwood Ave. and Valley View Ave.	Storage	Stormwater Pond/ Wetland System	1.67	Medium
BI-R3	Thurgood Marshall MS	On-Site	Bioretention Area, Underdrain	1.67	Medium
CH-R2B	Northwood ES and Recreation Center	Storage	Stormwater Pond/ Wetland System	1.67	Medium
HR-R2A	Mt. Pleasant Ice Arena, Hillen Rd. and Northern Pkwy.	On-Site	Permeable Pavement, Underdrain	1.67	Medium
HR-R18	Sinclair Lane ES	On-Site	Bioretention Area, Underdrain	1.67	Medium
HR-R23	Safeway, Harford Rd. and Montebello Terr.	On-Site	Bioretention Area, Underdrain	1.67	Medium
HR-R29B	WEB DuBois HS	On-Site	Permeable Pavement, Underdrain	1.67	Medium
HR-R29C	WEB DuBois HS	On-Site	Bioretention Area, Underdrain	1.67	Medium
HR-R29D	WEB DuBois HS	On-Site	Permeable Pavement, Underdrain	1.67	Medium
HR-R38B	Clifton Park	On-Site	Bioretention Area, Underdrain	1.67	Medium
RE-R1B	Woodhome ES/MS	On-Site	Permeable Pavement, Underdrain	1.67	Medium
CH-R5	Walter De Wees Park	Storage	Stormwater Pond/ Wetland System	1.33	Low
CH-R6B	Chinquapin Run Park, between Belvedere Ave. and The Alameda, below Northwood Dr. between Belvedere Ave. and The	Storage	Stormwater Pond/ Wetland System	1.33	Low

Table 19: Prioritized List of Stormwater Retrofit Projects in the Herring Run Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Nominalized Project Score**	**Priority**
	Alameda				
CH-R6C	Chinquapin Run Park, between Belvedere Ave. and The Alameda, below Chinquapin Pkwy. at Walters Ave.	Storage	Stormwater Pond/ Wetland System	1.33	Low
CH-R8	Chinquapin Run Park, between The Alameda and Woodbourne Ave., below Northwood Dr. at Woodbourne Ave.	Storage	Stormwater Pond/ Wetland System	1.33	Low
HR-R12B	Herring Run Park, between Harford Rd. and Belair Rd., below Chesterfield Ave. at Cardenas Ave.	Storage	Stormwater Pond/ Wetland System	1.33	Low
HR-R12D	Eastwood Field, Herring Run Park, between Harford Rd. and Belair Rd.	Storage	Stream Restoration	1.33	Low
HR-R15B	Herring Run Park, between Brehms Ln. and Sinclair Ln., below Shannon Dr. at Elmora Ave.	Storage	Stormwater Pond/ Wetland System	1.33	Low
HR-R28A	Perring Pkwy., below Pioneer Dr. at Westfield Ave.	Storage	Stormwater Pond/ Wetland System	1.33	Low
HR-R42A	Herring Run Park, between Mannasota Ave. and Brehms Ln., below Shannon Dr. at Mannasota Ave.	Storage	Stormwater Pond/ Wetland System	1.33	Low
HR-R19	Archbishop Curley HS	On-Site	Bioretention Area, Underdrain	1.00	Low

Table 20: Prioritized List of Stormwater Retrofit Projects in the Jones Falls Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Nominalized Project Score**	**Priority**
LJ-R11	Edgecombe Park	On-Site	Site Reforestation/ Revegetation	2.67	High
ST-R14	Notre Dame College of Maryland	Storage	Bioretention Area, Underdrain	2.67	High
LJ-R2A	Sinai Hospital	Storage	Wet Extended Detention Pond	2.33	High
LJ-R7A	Waldorf School	On-Site	Rain Garden	2.33	High
LJ-R7B	Waldorf School	On-Site	Simple Downspout Disconnection	2.33	High
LJ-R10B	Edgecombe Circle ES	On-Site	Rain Garden	2.33	High
LJ-R30B	Green School	On-Site	Site Reforestation/ Revegetation	2.33	High
WE-R3	Pimlico MS	On-Site	Impervious Cover Removal	2.33	High
WE-R6A	Falstaff MS	On-Site	Impervious Cover Removal	2.33	High

Table 20: Prioritized List of Stormwater Retrofit Projects in the Jones Falls Watershed					
Retrofit ID	**Location**	**Retrofit Type**	**Stormwater Management Practice**	**Nominalized Project Score**	**Priority**
WE-R6B	Falstaff MS	On-Site	Simple Downspout Disconnection	2.33	High
LJ-R2B	Sinai Hospital	Storage	Bioretention Area, Underdrain	2.00	Medium
LJ-R6	Pimlico ES	On-Site	Bioretention Area, Underdrain	2.00	Medium
LJ-R7C	Waldorf School	On-Site	Impervious Cover Removal	2.00	Medium
LJ-R8B	Poly Western HS	On-Site	Bioretention Area, Underdrain	2.00	Medium
LJ-R8C	Poly Western HS	On-Site	Bioretention Area, Underdrain	2.00	Medium
LJ-R10A	Edgecombe Circle ES	On-Site	Impervious Cover Removal	2.00	Medium
LJ-R19	Druid Hill Park, Druid Hill Park Dr. and Greenspring Ave.	Storage	Stream Restoration	2.00	Medium
LJ-R30A	Green School	On-Site	Bioretention Area, Underdrain	2.00	Medium
LJ-R38	Wood Heights Ave. and La Plata Ave.	Storage	Shallow Wetland	2.00	Medium
LJ-R45	Johns Hopkins University, East Campus, 33rd St.	On-Site	Bioretention Area, Underdrain	2.00	Medium
ST-R1	Wyman Park, below Tudor Arms Ave. and Gilman Terr.	Storage	Stormwater Pond/ Wetland System	2.00	Medium
ST-R7	Friends School	On-Site	Bioretention Area, Underdrain	2.00	Medium
ST-R9	Cotswold Rd. and Amberly Way	Storage	Stormwater Pond/ Wetland System	2.00	Medium
ST-R10	Knights of Columbus	On-Site	Bioretention Area, Underdrain	2.00	Medium
LJ-R3	Tamarind Rd. and Springarden Dr.	On-Site	Bioretention Area, Underdrain	1.67	Medium
LJ-R8D	Poly Western HS	On-Site	Permeable Pavement, Underdrain	1.67	Medium
LJ-R9	West Old Coldspring Ln. and Brand Ave.	Storage	Shallow Extended Detention Wetland	1.67	Medium
LJ-R44	Northern Pkwy., W. of Greenspring Ave.	On-Site	Bioretention Area, Underdrain	1.67	Medium
ST-R5	Guilford Neighborhood Tulip Park, Greenway and Stratford Rd.	Storage	Stormwater Pond/ Wetland System	1.67	Medium
ST-R8	Cathedral of Mary Our Queen	On-Site	Bioretention Area, Underdrain	1.67	Medium
WE-R4	Cross Country ES	On-Site	Permeable Pavement, Underdrain	1.67	Medium
LJ-R8A	Poly Western HS	On-Site	Green Roof	1.33	Low
ST-R4	Calvert School	Storage	Underground Detention System	1.33	Low

It is important to note that the prioritized project lists provided in Tables 18, 19 and 20 are based solely on the initial retrofit evaluation and ranking exercise completed during this study. Although this evaluation and ranking considered important screening criteria (e.g., physical feasibility, difficult of design, watershed benefit) it did not consider other screening factors, such as cost effectiveness, maintenance burden and visibility, which may be important to the City and its watershed restoration partners. Consequently, the prioritized lists should be used only as a guide; professional judgment, funding opportunities, and other watershed restoration goals and objectives should also play a strong role in determining which of the projects should be pursued and implemented at a given time.

5.0 RECOMMENDATIONS

Watershed restoration is a major, long-term commitment that requires dozens or even hundreds of individual stormwater retrofit projects to be built over a multi-year timeframe. The process can also be quite costly. Given the large number of potential storage and on-site stormwater retrofit projects that have been identified within the Baltimore City portion of the Baltimore Harbor, Herring Run and Jones Falls watersheds, it is important to discuss the strategies that can be used to deliver them in a widespread and cost-effective manner.

A multi-phased approach to delivering both storage and on-site stormwater retrofits on public and private land should be used by the City of Baltimore to help meet local Chesapeake Bay Program Tributary Strategy goals and current and future TMDL regulations. Figure 2 shows a conceptual representation of a multi-phased approach that uses a combination of financing, education, subsidies, permit coordination and stormwater regulations to deliver stormwater retrofit projects. To some extent, the retrofit delivery methods illustrated in the figure are sequential in nature -- the first methods can be implemented early; whereas latter methods can be used to provide expanded treatment in the future. A more detailed discussion about the retrofit delivery strategies illustrated in Figure 2 can be found in the *Urban Stormwater Retrofit Practices* manual (Schueler et al., 2007).

For the City of Baltimore, the most likely near-term retrofit delivery strategies include:

- *Further Investigate and Implement High Priority Stormwater Retrofits:* A total of 23 high priority stormwater retrofit projects were identified throughout the Baltimore Harbor, Herring Run and Jones Falls watersheds. Many of these projects are located on public land, including parks and schools, which means that it will be easier to push them through to implementation. These projects, which include both large-scale storage and small scale on-site retrofit projects, should be included in master plans, such as the Herring Run Park master plan, and in capital improvement project lists. In the mean time, the City can continue to work with the Baltimore Harbor, Herring Run and Jones Falls Watershed Associations to secure grant funding to further investigate, design and implement these projects.

- *Build Demonstration and Education Retrofits on Public Land*: The high-priority on-site and storage retrofit projects located on public land should be used to demonstrate proper stormwater management and help develop a “culture of watershed restoration” in the City of Baltimore. The City has already implemented a number of notable watershed restoration projects, including stream restoration and stormwater retrofit projects, within its jurisdictional boundaries. Several additional high-profile stormwater retrofit projects on public land, both large and small, could be used to demonstrate the City's commitment to watershed restoration and spark additional interest in stormwater retrofitting on both public and private land. By carefully choosing these initial retrofit projects, the City can help build this "restoration culture", which, over time, can lead to more meaningful improvements in the conditions of the City's rivers and streams.

Figure 2: Retrofit Implementation and Delivery Strategies

- *Develop a School Stormwater Retrofit Program*: A majority of the small-scale, on-site stormwater retrofit projects identified by this study are located at the numerous public and private schools found within the Baltimore City portion of Baltimore Harbor, Herring Run and Jones Falls watersheds. These sites are ideal locations for stormwater retrofits, as they typically contain large amounts of open space that can be used to construct demonstration retrofits, which can be used to educate students and the rest of the general public on the importance of stormwater management. By setting up a school stormwater retrofit program, and providing mini-grants to public and private institutions that are interested in implementing on-site stormwater retrofits, the City of Baltimore can increase public participation and involvement in its stormwater management efforts and systematically implement a large number of small-scale stormwater retrofits across the Baltimore Harbor, Herring Run and Jones Falls watersheds.

- *Create a Downspout Disconnection Program*: Although this study identified a number of viable large-scale, storage retrofits projects that could be constructed on public land, it is unlikely that these projects, by themselves, will allow the City to meet local Chesapeake Bay Program Tributary Strategy goals and current and future TMDL regulations. Consequently, the City must consider how to deliver on-site stormwater retrofits on both public and private land. One particular group of small-scale, on-site stormwater retrofits that could be implemented systematically, and in large numbers across the City, is downspout disconnection practices. By developing a downspout disconnection program, such as the one outlined by Novotney et al. (2008) and reviewed with City staff earlier this year, Baltimore City can programmatically implement a large number of on-site stormwater retrofits across the Baltimore Harbor, Herring Run and Jones Falls watersheds. When implemented in large numbers, these small-scale projects can lead to significant improvements in the conditions of the City's rivers and streams.

Baltimore City is encouraged to consider the retrofit implementation strategies presented above as well as the other ideas provided in the *Urban Stormwater Retrofit Practices* manual (Schueler et al., 2007). As with all complex undertakings, interdepartmental coordination and communication will be key ingredients to the City's watershed restoration and stormwater retrofit efforts. The City's efforts will enjoy wider acceptance and success if there is a single point-of-contact within the City government to coordinate and manage the stormwater retrofit implementation efforts.

REFERENCES

Chesapeake Bay Program (CWP). No Date. *Stormwater Best Management Practice Categories and Pollutant Removal Efficiencies*. Urban Stormwater Workgroup. Chesapeake Bay Program. Annapolis, MD. Available Online: http://www.chesapeakebay.net/pubs/subcommittee/nsc/uswg/BMP_Pollutant_Removal_Efficiencies.pdf

Fraley-McNeal, L., T. Schueler and R. Winer. 2008. *National Pollutant Removal Performance Database*. Version 3. Center for Watershed Protection. Ellicott City, MD. Available Online: http://www.cwp.org

Hirschman, D., K. Collins and T. Schueler. 2008. *The Runoff Reduction Method*. Technical Memorandum. Center for Watershed Protection. Ellicott City, MD. Available Online: http://www.cwp.org

Novotney, M., P. Sturm, C. Swann and J. Tasillo. 2008. *Downspout Disconnection in Baltimore, MD.* Technical Memorandum. Prepared for: City of Baltimore, MD. Center for Watershed Protection. Ellicott City, MD.

Schueler, T., D. Hirschman, M. Novotney and J. Zielinski. 2007. *Urban Stormwater Retrofit Practices*. *Version 1.0*. Manual 3. Urban Subwatershed Restoration Manual Series. Center for Watershed Protection. Ellicott City, MD. Available Online: http://www.cwp.org

Sturm, P., J. Tasillo and M. Novotney. 2006. *Findings and Recommendations from the Redhouse Run Stream Corridor, Retrofit and Upland Assessments and the Baltimore City Public Land Retrofit Assessment*. Technical Memorandum. Center for Watershed Protection. Ellicott City, MD.

Winer, R. 2000. *National Pollutant Removal Performance Database*. Version 2. Center for Watershed Protection. Ellicott City, MD. Available Online: http://www.cwp.org

Appendix I: Retrofit Design Sheets

ST-1d

Retrofit Design Sheets

EXTENDED DETENTION

Typical Constraints

Some common constraints for retrofitting extended detention ponds include:

Space Required: A typical ED pond requires a footprint of 1 to 3% of its contributing drainage area, depending on depth of the pond (the deeper the pond, the smaller footprint needed).

Available Head: Bottom elevations for ED retrofits are typically determined by the existing elevation of the downstream conveyance system (e.g., a stream, channel or pipe). Backwater in the upstream conveyance system can also constrain the head available at the retrofit site. Typically, a minimum of about six to 10 feet of head is needed to construct an ED retrofit.

Contributing Drainage Area: A minimum contributing drainage area is recommended for each ED design variant. For micropool ED ponds, a minimum of 10 acres is suggested in humid regions to sustain a permanent micropool to prevent clogging. A minimum of 25 acres is recommended in humid regions to maintain constant water elevations in wet ED ponds and ED wetlands. The minimum drainage area may increase in arid or semi-arid climates. A water balance should be conducted if the designer needs to maintain a constant pool elevation. ED may still work on drainage areas less than 10 acres, but designers should be aware that these "pocket" ponds will have very small orifices that will be prone to clogging, experience fluctuating water levels, and generate future maintenance problems.

Minimum Setbacks: Local ordinances and design criteria should be consulted to determine minimum setbacks to property lines, structures, and wells. Generally, ED retrofits should be setback at least 10 feet from property lines, 25 feet from building foundations, 50 feet from septic system fields, and 100 feet from private wells.

Utilities: Site designers should check to see if any utilities cross the proposed retrofit site. ED retrofits should not submerge existing sewer manholes as this can lead to infiltration/inflow problems and make maintenance access more difficult. Dry utilities such as underground electric or cable should never be inundated.

Depth to Water Table: The depth to the groundwater table is typically not a major concern for ED retrofits. In fact, intercepting a high water table can sustain a shallow pool or pocket wetland within the retrofit. Designers should keep in mind that groundwater inputs may reduce retrofit pollutant removal capability and could sharply increase excavation costs.

Depth to Bedrock: If bedrock layers are discovered near the surface of the proposed retrofit, it may be too difficult or expensive to excavate the storage needed for ED retrofits.

Special Community and Environmental Considerations about ED Retrofits

ED retrofits can create several community and environmental concerns to anticipate during design:

Aesthetics: ED retrofits tend to accumulate sediment and trash, especially if they are undersized. Many residents perceive dry ED ponds as being unsightly and creating nuisance conditions. Fluctuating water levels in ED retrofits also create a tough landscaping environment. In general, designers should avoid retrofit designs that rely solely on dry ED.

Existing Wetlands: ED retrofits should not be constructed within existing natural wetlands nor should they inundate or otherwise change the hydroperiod of existing wetlands.

Existing Forests: Clearing of mature trees should be avoided during retrofit layout. Designers should be aware that even modest changes in inundation frequency can kill upstream trees (Wright *et al.*, 2007).

Stream Warming Risk: ED ponds have less risk of stream warming than other pond options, but can warm streams if their low flow channel is not shaded. If the retrofit discharges to temperature-sensitive waters, the pond should be forested and have a maximum detention time of 12 hours or less to minimize potential stream warming.

Safety Risk: Dry ED ponds are generally considered to be safer than other pond options since they have few deep pools. Steep side-slopes and unfenced headwalls, however, can still create some safety risks.

Mosquito Risk: The fluctuating water levels within dry ED ponds have potential to create conditions that lead to mosquito breeding. Mosquitoes tend to be more prevalent in irregularly flooded ponds than in ponds with a permanent pool (Santana *et al*., 1994). Designers can minimize the risk by combining ED with a wet pond or wetland.

ED Retrofit Design Issues

ED retrofits are normally squeezed into very tight sites, so designers are always tempted to eliminate standard design features to maximize storage. However, designers should think twice before dropping the following critical design features:

Low Flow Orifice: Unless the drainage area to an ED retrofit is unusually large, the diameter of the ED orifice will be less than six inches in diameter. Small diameter pipes are prone to chronic clogging by organic debris and sediment. Retrofit designers should always look at upstream conditions to assess the potential for higher sediment and woody debris loads. The risk of clogging in such small openings can be reduced by:

- Sticking to a minimum orifice diameter of three inches or greater, even if this means walking away from the proposed retrofit site.
- Protecting the ED low flow orifice by installing a reverse-sloped pipe that extends to mid-depth of the permanent pool or micropool.
- Providing an over-sized forebay to trap sediment, trash and debris before it reaches the ED low flow orifice.
- Installing a trash rack to screen the low flow orifice.

Maximum Vertical Depth of ED: Designers often seek to maximize the depth of ED retrofits to treat a greater volume of runoff within a smaller footprint. Increasing the vertical fluctuation or "bounce" within an ED retrofit, however, can reduce pollutant removal, promote invasive species and create a difficult landscaping environment. In the context of retrofitting, the vertical elevation of ED storage should not extend more than 5 feet above the normal water surface elevation. The bounce effect is not as critical for channel protection or flood control storm events. These storms can exceed the 5 foot vertical limit if they are managed by a multi-stage outlet structure.

ED Retrofit Pond Maintenance Issues

Several maintenance issues can be addressed during retrofit design and future maintenance operations:

Clogging: Retrofits are prone to higher clogging risk at the ED low flow orifice and any upstream flow splitters. These aspects of retrofit plumbing should be inspected at least twice a year after initial construction. Designers should provide easy access to both the micropool and the pond drain to allow maintenance crews to dewater the retrofit.

Sediment Removal: Good maintenance access is also needed to allow crews to remove accumulated sediments. Designers should check to see whether sediments can be spoiled on-site or must be hauled away. The frequency of sediment removal should be increased if:

- A micropool is used within the ED retrofit
- The retrofit is undersized relative to the target WQv
- Significant development activity or winter road sanding is projected to occur in the retrofit's contributing drainage area

Vegetation Management: The constantly changing hydrologic regime of ED retrofits makes it hard to mow or manage vegetative growth. The bottom of dry ED retrofits often become soggy, and water-loving trees such as willows may take over. Retrofit designers should carefully evaluate how vegetation will be cost-effectively managed in the future. Landscape architects can prepare a planting plan that allows the retrofit to mature into a native forest in the right places yet keeps mowable turf along the embankment and all access areas. The wooded wetland concept proposed by Cappiella *et al*., (2005) may be a good option for many ED retrofits.

Trash Removal: Trash, debris and litter tend to accumulate in the forebay, micropool and on the bottom of ED ponds. The maintenance plan should schedule cleanups at least once a year.

A retrofit maintenance plan should be created to address each of the items listed above. The maintenance plan should identify the responsible party and contain a legally enforceable agreement that specifies maintenance duties and schedules.

Adaptation ED for Special Climates and Terrain

Cold Climates: Winter conditions can cause freezing problems within inlets, flow splitters, and ED outlet pipes due to ice formation. Designers can minimize these problems by:

- Not submerging inlet pipes

- Increasing the slope of inlet pipes by a minimum of 1% to discourage standing water and potential ice formation in upstream pipes
- Placing all pipes below the frost line to prevent frost heave and pipe freezing
- Designing low flow orifices to withdraw at least six inches below the typical ice layer
- Placing trash racks at a shallow angle to prevent ice formation

Sand loadings to ED retrofits may increase due to winter road maintenance. Consequently, designers may want to over-size forebays and/or micropools to account for the higher sedimentation rate. ED retrofits can also be designed to operate in a seasonal mode that provides additional WQv storage to treat snowmelt runoff (MSSC, 2005; Caraco *et al*., 1997).

Arid regions: Water rights can be significant issue when it comes to capturing and detaining stormwater runoff in Western states. Also, ED retrofits in arid regions are subject to high sediment loads and may lack vigorous vegetative cover unless they receive supplemental irrigation (Caraco, 2000). The higher evaporation rates and limited inflows of arid regions always make it hard to sustain a permanent pool in the micropool and/or forebay. Designers may want to compute a water balance to determine if pools can be sustained, or if supplemental irrigation will be needed to maintain vegetative cover.

Karst Terrain: Geotechnical investigations are recommended when ED retrofit ponds are situated in active karst areas to minimize the risk of groundwater contamination and avoid sinkhole formation. An impermeable liner and a minimum three foot vertical separation distance from the underlying rock layer is recommended.

Costs to Install ED Retrofits

Extended detention ranks among the least expensive stormwater options, particularly when free storage can be obtained at pond and crossing retrofit sites (SR-1 and SR-2). The cost to install dry ED ponds at new development sites can be determined from the cost equations of Brown and Schueler (1997). The equations (updated to 2006 dollars) predict the base construction cost of new ED construction based on the storage volume of the pond, including excavation, control structures, and appurtenances:

$$BCC = (10.97)(V_s^{0.780})$$

Vs = Total storage volume (ft^3)
BCC = Base construction cost (2006 dollars)

The median cost to construct a new ED pond is about $3,800 per impervious acre treated (range: $2,200 to $7,500). Please note that ED retrofit construction costs are generally at least three times greater (see Chapter 2 and Appendix E).

Design Resources

Several state stormwater manuals provide extensive guidance on ED pond design:

Georgia Stormwater Management Manual
http://www.georgiastormwater.com

Minnesota Stormwater Management Manual
http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html

Vermont Stormwater Management Manual
http://www.anr.state.vt.us/dec/waterq/cfm/ref/Ref_Stormwater.cfm

ST-2d	Retrofit Design Sheets	
	WET PONDS	

Typical Constraints

Some common constraints hinder the use of wet pond retrofits in developed watersheds:

Space Required: The proposed surface area for a wet pond retrofit should be at least 1 to 3 % of its contributing drainage area, depending on the pond's depth.

Contributing Drainage Area: A minimum contributing drainage area of 10 to 25 acres is recommended for wet pond retrofits to maintain constant water elevations, although these can vary by design type and climatic region. Smaller drainage areas may be treated if the retrofit will intercept the groundwater table (but this may reduce pollutant removal and increase excavation costs). Wet ponds can still work on drainage areas less than 10 acres, but designers should be aware that these "pocket" ponds will be prone to clogging, experience fluctuating water levels, and generate more nuisance conditions. A water balance should be conducted if the designer needs to maintain constant pool elevations.

Utilities: Most utilities do not permit existing underground pipes or dry utilities to be submerged as a result of retrofit construction. It may be possible to submerge water or sewer lines if manholes are raised above the maximum water surface elevation of the pond and if the pipes were originally constructed in a watertight manner.

Excavation: Wet ponds normally entail several feet of excavation. Retrofit designers need to understand the quality of subsoils in terms of their suitability for embankment fill, potential excavation problems and whether they need to be hauled off-site.

Available Head: The depth of a wet pond retrofit is usually determined by the head available on the site. The bottom elevation is normally set by the existing downstream conveyance system to which the retrofit discharges (e.g., a stream, channel or pipe). While it is possible to excavate a pool below the outlet invert, this resulting dead storage may not mix well with the rest of the pond, thereby reducing performance and creating nuisance problems. Typically, a minimum of six to eight feet of head are needed to construct a wet pond retrofit.

Minimum Setbacks: Local ordinances and design criteria should be consulted to determine minimum setbacks to property lines, structures, and wells. As a general rule, wet pond retrofits should be setback at least 10 feet from property lines, 25 feet from building foundations, 50 feet from septic system fields, and 100 feet from private wells.

Depth to Water Table: The depth to the water table can be a design concern for wet pond retrofits. If the water table is close to the surface, it may make excavation difficult and expensive. Groundwater inputs can also reduce the pollutant removal rates. On the other hand, a high groundwater table can help provide a constant pool elevation to maintain a pocket pond when the contributing drainage area is small.

Depth to Bedrock: If bedrock layers occur near the surface of a proposed retrofit, it may be too expensive to blast the site to get enough storage volume.

Community and Environmental Considerations for Wet Pond Retrofits

Wet ponds are readily accepted by communities if they are properly designed and maintained. Pond retrofits, however, can generate several community and environmental concerns:

Aesthetic Issues: Many residents feel that wet ponds are an attractive landscape feature, promote a greater sense of community and are an attractive habitat for fish and wildlife. Designers should note that these benefits are often diminished if retrofits are under-sized or have small contributing drainage areas.

Existing Wetlands: A wet pond retrofit should not be constructed within an existing natural wetland. Any discharges from the retrofit into an existing natural wetland should be minimized to prevent changes to its hydroperiod.

Existing Forests: Construction of wet pond retrofits may involve major clearing of existing forest cover. Designers can expect a great deal of neighborhood opposition if they do not make a concerted effort to save mature trees during retrofit design and layout.

Stream Warming Risk: Wet ponds can warm streams by two to 10 degrees Fahrenheit, although this may not be a major problem for degraded urban streams (Galli, 1990). To minimize stream warming, wet pond retrofits should be shaded and provide shorter ED detention times (e.g., 12 hours vs. 24).

Safety Risk: Pond safety is an important community concern, as young children have perished by drowning in wet ponds after falling through the ice. Gentle side slopes and safety benches should be provided to avoid potentially dangerous drop-offs, especially when retrofits are located near residential areas. Residents may request fences around the pond or its outfalls in some retrofit situations.

Mosquito Risk: Mosquitoes are not a major problem for larger wet ponds (Santana *et al*., 1994; Ladd and Frankenburg, 2003). However, fluctuating water levels in smaller or under-sized wet ponds could pose some risk for mosquito breeding. Mosquito problems can be minimized through simple design features and maintenance operations described in Chapter 4 and MSSC (2005).

Geese and Waterfowl: Wet ponds with extensive turf and shallow shorelines can attract nuisance populations of resident geese and other waterfowl whose droppings can reduce pond nutrient and bacteria removal. Several design and landscaping features can make a pond retrofit much less attractive to geese (see Schueler, 1992).

Wet Pond Retrofit Design Issues

Wet pond retrofits are often squeezed into very tight sites, so designers can be tempted to eliminate standard design features in order to obtain maximum pool storage. It is generally advisable to sacrifice some storage volume in order to incorporate design features critical to retrofit performance, function and longevity. The following design features should be included in wet pond retrofits:

Pretreatment: Sediment forebays located at major inlets help extend the longevity of wet pond retrofits. Each forebay should be sized to have about 10% of the total retrofit storage volume and have easy access for sediment cleanouts.

Long Flow Path: Retrofits should have an irregular shape and a long flow path from inlet to outlet to increase residence time and pond performance (ideally 2:1). Internal berms can be used to extend flow paths and create multiple pond cells.

Safety/Access Bench: Retrofits should include a flat bench just outside of the perimeter of the permanent pool to allow for maintenance access and reduce safety risks. The bench can be variable in width (10 to 15 feet).

Aquatic Bench: Aquatic benches are shallow areas just inside the perimeter of the normal pool that promote growth of aquatic and wetland plants. The bench also serves as a safety feature, reduces shoreline erosion and conceals floatable trash. In retrofit situations, the aquatic bench can vary in width from three to 10 feet.

Avoid Deep Pools: Designers often seek to maximize the depth of a wet pond retrofit to store a greater runoff volume within a smaller footprint. Pool depths greater than eight feet, however, should be avoided in most retrofit situations. Deep ponds can cause seasonal pond stratification that release pollutants stored in bottom sediments back into the water column (and have a much greater safety risk).

Wet Pond Retrofit Maintenance Issues

Wet ponds normally have less routine maintenance requirements than other stormwater treatment options. The frequency of maintenance operations may need to be scaled up if retrofits are undersized or have a small contributing drainage area. Designers should consult CWP (2004b) for more information on wet pond maintenance problems and solutions. Several maintenance issues can be addressed during retrofit design and future maintenance operations:

Maintenance Access: Good maintenance access should always be provided to the sediment forebay, access bench, riser and outlet structure so crews can more easily perform maintenance tasks. The riser structure should be placed within the embankment.

Sediment Removal: Sediments excavated from wet ponds are not normally classified as toxic or hazardous material, and can be safely disposed by either land application or land filling. Sediment testing may be needed prior to sediment disposal if the retrofit serves a hotspot land use.

Clogging: There is always some risk that the low flow orifice or upstream flow splitter may clog. These aspects of retrofit hydraulics should be inspected frequently after construction. The retrofit should have a pond drain so crews can de-water the pond to relieve clogging and remove sediments.

Vegetation Management: The maintenance plan should clearly outline how vegetation in the pond and its buffer will be managed or harvested in the future. Methods to establish desired aquatic plants and control invasive plant species should be outlined. Annual mowing of the pond buffer is only required along maintenance rights-of-way and the embankment. The remaining buffer can be managed as a meadow (mowing every other year) or as forest.

Trash Removal: The maintenance plan should schedule a shoreline cleanup at least once a year to remove trash and floatables.

Adapting Wet Ponds for Special Climates and Terrain

Cold climates: The performance of wet pond retrofits in cold climates can be enhanced when designers:

- Treat larger runoff volumes in the spring by adopting seasonal operation of the permanent pool (see MSSC, 2005)
- Plant salt-tolerant vegetation in pond benches
- Do not submerge inlet pipes and provide a minimum 1% pipe slope to discourage ice formation
- Locate low flow orifices so they withdraw at least 6 inches below the typical ice layer
- Angle trash racks to prevent ice formation
- Oversize riser and weir structures to avoid ice formation and freezing pipe
- Increase forebay size if road sanding is prevalent in the contributing drainage area

Arid Climates: Wet pond retrofits require special design in regions with low annual rainfall or high evapotranspiration. Ponds are generally not a preferred option if the permanent pool cannot be maintained without supplemental irrigation. Some tips for designing wet ponds in arid climates include the following:

- Pond vegetation flourishes when temperatures are warm and the growing season is long or year-round, which can result in prolific growth of algae, wetland plants, shrubs and trees (Figure 1). Regular mowing or even plant harvesting should be considered to keep vegetative growth in check.
- Designers should always check to make sure there is an adequate water balance to support a permanent pool throughout the year- otherwise the potential of algal blooms, odors and other nuisances can increase sharply. When in doubt, install a clay or synthetic liner to prevent water loss via infiltration.
- Arid regions generate higher sediment loads, so designers should consider adding extra sediment trapping capability in retrofit forebays (Caraco, 2000).

Karst Terrain: Deep pools increase the risk of sinkhole formation and groundwater contamination in regions with active karst. Designers should always conduct geotechnical investigations to assess this risk. Pond retrofits in karst areas should include impermeable liners and maintain at least three feet of vertical separation from the underlying rock layer.

Wet Pond Installation Costs

Wet ponds are more expensive on a unit area basis than constructed wetlands and ED ponds, primarily due to the need for deeper excavation and safety features such as side-slope control and benches (Wossink and Hunt, 2003). Several cost equations (updated to 2006 dollars) can predict the

Figure 1: Warm temperatures have led to algal blooms in this wet pond.

base construction cost of new wet ponds, given their proposed storage volume or drainage area treated.

Wet Extended Detention Ponds (Brown and Schueler, 1997)
BCC = $(10.97)(V_s^{0.750})$

Wet Ponds (Brown and Schueler, 1997)
BCC = $(263.99)(V_s^{0.553})$

Wet Ponds (Wossink and Hunt, 2003)
BCC = $(17,333)(A^{0.672})$

Vs = Total storage volume (ft^3)
A = area treated (acres)
BCC = Base construction cost (2006 dollars)

Solving these equations for a range of common pond sizes yields a median construction cost for a new wet pond of $ 8,350 per impervious acre treated (range: $ 3,100 to $28,750). Please note that the wet pond retrofit construction costs are typically 1.5 to 2 times higher than new pond construction (see Chapter 2 and Appendix E).

Wet Pond Design Resources

Many existing state and local stormwater manuals provide extensive guidance on wet pond design:

Vermont Stormwater Management Manual
http://www.anr.state.vt.us/dec/waterq/cfm/ref/Ref_Stormwater.cfm

Minnesota Stormwater Management Manual
http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html

Austin, TX Drainage Criteria Manual
http://www.cityofaustin.org/watershed/publications.htm

New York State Stormwater Management Design Manual
http://www.dec.state.ny.us/website/dow/toolbox/swmanual/index.html

Maryland Stormwater Design Manual
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

ST-3d	Retrofit Design Sheets	
	CONSTRUCTED WETLANDS	

Typical Constraints

Constructed wetlands are subject to several constraints when it comes to retrofitting:

Contributing Drainage Area: The contributing drainage area must be large enough to sustain a permanent water level within a stormwater wetland. A minimum of 25 acres of drainage area is typically needed to maintain constant water elevations in humid regions, although the precise area varies based on local hydrology. The minimum drainage area can be relaxed if the bottom of the retrofit intercepts the groundwater table or if designers are willing to accept periodic wetland drawdown. Designers should note that these “pocket” wetlands will have lower pollutant removal, higher excavation costs, and a greater risk of invasive plant colonization.

Space Requirements: Wetland retrofits require a footprint ranging between 3 and 5% of the contributing drainage area, depending on the average depth of the wetland and the extent of its deep pool features.

Available Head: The depth of a wetland retrofit is usually constrained by the head available on the site. The bottom elevation is fixed by the elevation of the existing downstream conveyance system to which the retrofit will ultimately discharge. Head requirements for constructed wetlands are typically less than wet ponds because of their shallow nature - a minimum of two to four feet of head is usually needed.

Minimum Setbacks: Local ordinances and design criteria should be consulted to determine minimum setbacks to property lines, structures, utilities, and wells. As a general rule, wetland retrofits should be setback at least 10 feet from property lines, 25 feet from building foundations, 50 feet from septic system fields and 100 feet from private wells.

Depth to Water Table: The depth to the groundwater table is not a major constraint for constructed wetlands as a high water table can maintain wetland conditions within the retrofit. Designers should keep in mind that high groundwater inputs may reduce pollutant removal rates and increase excavation costs.

Community and Environmental Considerations for Constructed Wetlands

Constructed wetlands can generate several community and environmental concerns:

Aesthetics: Wetland retrofits can create wildlife habitat and become an attractive community feature. Designers should carefully think through how the wetland community will evolve over time, as the future plant community seldom resembles the one initially planted. Constructed wetlands require continual vegetative management to maintain desired wetland species, control woody growth and prevent invasive plants from taking over.

Existing Wetlands: It can be tempting to construct a stormwater wetland within an existing natural wetland, but this should never be done unless it is part of a broader effort to restore a degraded urban wetland approved by the local or state wetland review authority. Designers should investigate the wetland status of adjacent areas to determine if the discharge from the constructed wetland will change the hydroperiod of a downstream natural wetland (see Cappiella et al., 2006b, for guidance on minimizing stormwater discharges to existing wetlands).

Regulatory Status: Constructed wetlands built for the express purpose of stormwater treatment are not considered jurisdictional wetlands in most regions of the country, but designers should check with their wetland permit authority to ensure this is the case.

Existing Forests: Given the large footprint of constructed wetlands, there is a strong chance that construction may cause extensive tree clearing. Designers should preserve mature trees during retrofit layout, and may want to use a wooded wetland concept to create a forested wetland community (see Cappiella *et al*., 2006b).

Stream Warming Risk: Constructed wetlands have a moderate risk of stream warming. If the retrofit discharges to temperature-sensitive waters, designers should consider the wooded wetland design, and any ED storage should be released in less than 12 hours.

Safety Risk: Constructed wetlands are safer than other pond options, although forebays and micropools should be designed with benches to reduce safety risks.

Mosquito Risk: Mosquito control can be a concern for stormwater wetlands if they are under-sized or have a small contributing drainage area. Few mosquito problems are reported for well designed, properly-sized and frequently maintained constructed wetlands (Santana *et al*., 1994) but no design can eliminate them completely. Simple precautions can be taken to minimize mosquito breeding habitat within a wetland retrofit, such as constant inflows, benches that create habitat for natural predators, and constant pool elevations (see Walton 2003 and MSSC, 2005).

Design Issues for Constructed Wetland Retrofits

Several elements should be considered when designing constructed wetland retrofits:

Sediment Forebays: Forebays should be located at all major inlets to trap sediment and preserve the capacity of the main wetland treatment cell. A major inlet is defined as serving at least 10% of the retrofit is contributing drainage area. The forebay should be at least four feet deep, contain about 15% of the total retrofit WQv, and have a variable width aquatic bench.

Constructed Wetland Layout: The layout of the stormwater wetland affects its pollutant removal capability and plant diversity. Performance is enhanced when the wetland has multiple cells, longer flowpaths, and a high surface area to volume ratio. Whenever possible, constructed wetlands should be irregularly shaped with a long, sinuous flow path.

Microtopography: Retrofits should have variable microtopography - a mix of shallow, intermediate, and deep areas that promote dense and diverse vegetative cover.

Planting Strategy: Wetland retrofits should outline a realistic, long-term planting strategy to establish and maintain desired wetland vegetation. The plan should indicate how wetland plants will be established within each pondscaping zone (e.g., wetland plants, seed-mixes, volunteer colonization, and tree and shrub stock) and whether soil amendments are needed to get plants started. The future species trajectory of wetland retrofits is hard to predict, so several different strategies should be considered. Several excellent resources on wetland planting strategies are available (Schueler, 1992; and Shaw and Schmidt, 2003).

Wooded Wetland vs. Emergent Wetland Model: The traditional model for constructed wetlands has been a shallow emergent marsh. In many parts of the country, however, forested wetlands are the most common natural wetland community. In these regions, it may be desirable to design the wetland as a wooded wetland to more closely match local wetland types and reduce future wetland management problems (Cappiella et al., 2006a).

Maintenance Access: Good maintenance access should always be provided to the forebay so that crews can remove sediments and preserve wetland treatment capacity. More frequent sediment removal will be needed if the retrofit is undersized or has a small contributing drainage area.

Maintenance Issues for Constructed Wetland Retrofits

Several maintenance issues can be addressed during the design of constructed wetland retrofits:

Sediment Removal: Frequent sediment removal from the forebay is essential to maintain the function and performance of a constructed wetland. Maintenance plans should schedule cleanouts every five years or so, or when inspections indicate that 50% of the forebay capacity has been lost. Designers should also check to see whether removed sediments can be spoiled on-site or must be hauled away. Sediments excavated from constructed wetlands are not usually considered toxic or hazardous, and can be safely disposed by either land application or land filling.

Clogging: There is always some risk that the low flow orifice and any upstream flow splitters may clog. Clogging can quickly change design water elevations for the wetland and possibly kill wetland vegetation. The inlet and outlet structures to the wetland should be inspected frequently to discover any clogging problems.

Vegetation Management: Managing wetland vegetation is an important ongoing maintenance task. Designers should expect significant changes in wetland species composition over time. Invasive plants should be dealt with as soon as they colonize the wetland. Vegetation may need to be periodically harvested if the retrofit becomes overgrown. Construction contracts should include a care and replacement warranty extending at least two growing seasons after initial planting to selectively replant portions of the wetland that fail to take.

Trash Removal: Cleanups should be scheduled at least once a year to remove trash and debris from the retrofit.

Adapting Constructed Wetlands for Special Climates and Terrain

Cold Climates: Wetland performance decreases when snowmelt runoff delivers high pollutant loads. Shallow constructed wetlands can freeze in the winter, which allows runoff to flow over the ice layer and exit without treatment. Inlet and outlet structures close to the surface may also freeze, further diminishing wetland performance. Several design tips can improve wintertime performance for wetland retrofits (see Profile Sheets ST-1d and ST-2d).

Salt loadings are higher in cold climates due to winter road maintenance. High chloride inputs have a detrimental effect on native wetland vegetation, and can shift the wetland to more salt-tolerant species such as cattails (Wright *et al*., 2007). Designers should choose salt-tolerant species when crafting their planting plan and consider reducing salt application in the contributing drainage area to the retrofit.

Arid Climates: Constructed wetlands are hard to establish in regions with low annual rainfall and high evapotranspiration rates. These climates make it difficult to maintain a constant pool water elevation throughout the growing season. Designers should always check to make sure there is an adequate water balance to support a wetland throughout the year - otherwise the potential of algal blooms, odors and other nuisances will increase sharply. When in doubt, install clay or synthetic liners to prevent water loss via infiltration. Wetland vegetation flourishes when temperatures are warm and the growing season is long or year-round. Regular mowing or even harvesting should be considered to keep vegetative growth in check.

Karst Terrain: Even shallow pools in active karst terrain can increase the risk of sinkhole formation and groundwater contamination. Designers should always conduct geotechnical investigations in karst terrain to assess this risk. If in doubt, designers should employ an impermeable liner and maintain at least three feet of vertical separation from the underlying karst layer.

Constructed Wetland Installation Costs

Constructed wetlands are less expensive on a unit area basis than wet ponds and extended detention ponds since they require less excavation and need fewer safety features (Wossink & Hunt, 2003). On the other hand, some constructed wetlands have a larger surface footprint. These construction cost savings may disappear if land must be acquired to install the retrofit.

Wossink and Hunt (2003) developed an equation to predict the cost of new wetland construction based on the acreage of the contributing drainage area treated (updated to 2006 dollars):

$$BCC = (4{,}465)(A^{0.484})$$

Where:
A = Size of contributing drainage area (acres)
BCC = Base construction cost (2006 dollars)

Brown and Schueler (1997) devised a similar equation for new wetland and pond construction based on storage volume needed that yields slightly higher costs:

$$BCC = (27.95)(V_s^{0.701})$$

Where:
V_s = Total storage volume (ft^3)
BCC = Base construction cost (2006 dollars)

Based on typical wetland sizes, the equations yield a median construction cost of $2,900 per impervious acre treated (range: $2,000 to $9,600). Few retrofit sites will meet the criteria for use of these equations. Under most retrofit conditions, wetland retrofit construction costs will be 3 to 4 times greater than new wetland construction (see Chapter 2 and Appendix E).

Constructed Wetland Design Resources

Vermont Stormwater Management Manual
http://www.anr.state.vt.us/dec/waterq/cfm/ref/Ref_Stormwater.cfm

Connecticut 2004 Stormwater Management Manual
http://dep.state.ct.us/wtr/stormwater/strmwtrman.htm#download

Stormwater Management Manual for Western Washington
http://www.ecy.wa.gov/programs/wq/stormwater/manual.html

Minnesota Stormwater Manual
http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html

ST-4d	Retrofit Design Sheets	
	BIORETENTION	

Typical Constraints

Bioretention can be applied in most soils or topography since runoff percolates through an engineered soil bed and is returned to the stormwater system. Key constraints when retrofitting with bioretention include:

Available Space: Not every open area will be a good candidate for bioretention. To start with, designers should look for open areas that are at least five to 10% of the contributing drainage area and are free of underground utilities.

Site Topography: Bioretention is best applied when contributing slopes are more than 1% and less than 5%. Ideally, the proposed treatment area will be located in depression to minimize excavation costs.

Available Head: Bioretention retrofits are fundamentally constrained by the invert elevation of the existing conveyance system they discharge to. These elevations generally establish the bottom elevation needed to tie the underdrain from the bioretention area into the storm drain system. In general, four to five feet of elevation above this invert is needed to drive stormwater through a proposed bioretention area. Less head is needed if underlying soils are permeable enough to dispense with the underdrain.

Water Table: Bioretention should always be separated from the water table to ensure groundwater does not intersect with the filter bed. Mixing can lead to possible groundwater contamination or practice failure. A separation distance of 3 feet is recommended between the bottom of the filter bed and the seasonally high water table.

Overhead Wires: Designers should also check whether future tree growth in the bioretention area will interfere with existing overhead utility lines.

Soils: Soil conditions do not constrain the use of bioretention although they determine whether an underdrain is needed. Impermeable soils in Hydrologic Soil Group C or D usually require an underdrain, whereas A or B soils often do not. Designers should verify soil permeability when designing a bioretention retrofit, using the on-site soil investigation methods presented in Appendix H.

Community and Environmental Considerations for Bioretention Retrofits

Bioretention is a popular practice, since it can meet local landscaping requirements and improve site appearance. The only major drawbacks relate to who will handle future landscape maintenance and whether landowners will modify or replace the bioretention area in the future. If bioretention areas will be installed on private lots, homeowners need to be educated on their routine maintenance tasks and fully understand their intended stormwater function.

Design Issues for Bioretention

Several issues should be considered when designing bioretention retrofits:

Pretreatment: Pretreatment can prevent premature clogging and prolong the effective function of bioretention retrofits. Several pretreatment measures can be used, including directing runoff over a grass filter strip, adding a three to six inch drop or installing a pea gravel diaphragm that spreads flow evenly and drops out larger sediment particles. A two-cell design is recommended when bioretention is used as a storage retrofit or for larger on-site applications. The first cell is a sediment forebay that pretreats runoff and traps sediment before discharge into the main bioretention cell.

Landscaping is critical to the function and appearance of bioretention areas. Where possible, a combination of native trees, shrubs, and herbaceous plant species are preferred. Plants should be able to tolerate both wet and dry conditions. Most upland vegetation does not do well in the deepest center areas that are more frequently inundated. "Wet footed" plants, such as wetland forbs, should be planted near the center, whereas upland species are better for the edges of the bioretention area. Regional lists of plant species suitable for bioretention areas can be found at the end of this profile sheet.

Type of media: The choice of filter media is important to provide adequate drainage, support plant growth and optimize pollutant removal within the filter bed. Early design guidance recommended a mix of 50-60% sand, 20-30% topsoil and 20-30% organic leaf compost. The topsoil component should consist of loamy sand, sandy loam, or loam with a clay content no greater than 5%. Hunt and Lord (2006a) has recently advocated a bioretention soil mix with a greater proportion of sand (85-88% sand; 8-12% fines; and 3-5% organic matter) as a more effective choice for pollutant removal. They also strongly recommend that topsoil be tested to ensure that it has a low phosphorus index value to prevent phosphorus leaching. If nitrogen removal is the goal, it may be advisable to increase the percentage of soil fines.

Designers should also ensure that the media is well mixed and homogeneous. The media should have an infiltration rate of 1.0 to 2.0 inches per hour as recent research indicates that pollutant removal is optimized in this range.

Depth of Media: Early bioretention design guidance recommended a minimum filter bed depth of 4 feet. However, the filter bed may be reduced in depth to 1.5 to 2.5 feet in certain retrofit applications, particularly when available head is limited. Research has shown that good pollutant removal can still be achieved in filter beds as shallow as 1.5 feet, with the possible exception of nitrogen (Davis, 2005, and Hunt *et al.*, 2006). It is doubtful that filter beds less than 1.5 feet deep can provide reliable pollutant removal efficiency over the long run. Designers should also remember that filter beds need to be at least 4 feet deep to provide enough soil volume for the root structure of mature trees (i.e., use turf, perennials or shrubs instead of trees for shallower filter beds).

Underdrain: In many bioretention retrofits, filtered runoff will be collected by a perforated underdrain and conveyed to the storm drain system. If the site has permeable soils, however, the underdrain can be reduced or eliminated altogether. The need for an underdrain depends on the permeability of the underlying soils, which have often been previously altered or compacted in many retrofit situations. Soil permeability rates should always be verified when designing a bioretention retrofit (see Appendix H). If an underdrain is required at a bioretention retrofit, it should have a minimum diameter of 6 inches and be placed in a foot deep gravel bed.

Overflow: Designers should always incorporate an overflow structure to safely bypass larger storms around the bioretention retrofit. The invert of the overflow should be placed at the maximum water surface elevation of the bioretention area, which is typically 6 to 12 inches above the surface of the filter bed.

Surface Cover: A three-inch layer of hardwood mulch on the surface of the filter bed enhances plant survival, suppresses weed growth, and pretreats runoff before it reaches the filter bed. Shredded hardwood bark mulch makes a very good surface cover, as it retains a significant amount of nitrogen and typically will not float away. On the other hand, hardwood mulch needs to be replaced every few years, may not be durable or attractive enough for certain retrofit situations, and may not be available in some regions of the country. In these situations, designers may wish to consider alternative covers such as turf, river stone, gravel or pumice stone.

Contributing Drainage Area: Designers should always verify that the actual contributing area and inlet elevations are accurately determined at the retrofit site. Designers should walk the site during a rainstorm to look at actual flowpaths to the proposed treatment area, and confirm these boundaries using fine resolution topographic surveys.

Bioretention Maintenance Issues

Bioretention requires seasonal landscaping maintenance to establish and maintain vigorous plant cover:

Vegetation Management: Vegetation management is an important to sustain the pollutant removal and landscaping benefits of the bioretention area. The construction contract should include a care and replacement warranty to ensure vegetation gets properly established and survives during the first growing season after construction.

Surface Cover/Filter Bed: The surface of the filter bed can become clogged with fine sediments over time. Core aeration or deep tilling may relieve the problem. The surface cover layer will need to be removed and replaced every two or three years. The inlets and pretreatment measures for the bioretention retrofit also need frequent inspections to ensure they are working properly and to remove deposited sediments.

Training Landscape Contractors: Maintenance can be performed by landscaping contractors who are already providing similar landscaping services on the property, but they will need training on bioretention maintenance tasks.

Adapting Bioretention for Special Climates and Terrain

Bioretention areas can be applied almost everywhere, with the proper design modifications:

Arid Climates: Bioretention areas should be landscaped with drought-tolerant plant species. A xeriscaping approach is preferred since supplemental irrigation makes little sense in arid and semi-arid climates. It may also be advisable to switch from mulch to a more durable surface cover such as riverstone or pumice. The planting plan may also have fewer trees and plants to minimize the need for supplemental irrigation. Designers should recognize that longer growing seasons increase both the frequency and cost of landscape maintenance.

Cold Climates: Bioretention areas can be used for snow storage as long as an overflow is provided and they are planted with salt-tolerant, non-woody plant species (for a species list, consult MSSC, 2005). While several studies have shown that bioretention operates effectively in winter conditions, it is a good idea to extend the filter bed and underdrain pipe below the frost line and/or oversize the underdrain by one pipe size to reduce the freezing potential.

Karst Terrain: Bioretention should utilize impermeable liners and underdrains when located in an active karst area. A geotechnical investigation may be needed to confirm that three feet of vertical separation exists from the underlying rock layer.

Bioretention Installation Costs

The cost to construct bioretention areas are extremely variable, and are strongly influenced by the area treated, the depth of filter bed, the presence or absence of an underdrain and whether it is professionally designed, installed or landscaped. Wossink and Hunt (2003) report that bioretention has the lowest construction costs of all new stormwater treatment options serving smaller drainage areas from 1 to 5 acres. On the other hand, the unit costs to retrofit bioretention in highly urban settings may be 10 to 20 times higher (See Appendix E). The long-term maintenance costs for bioretention areas are not expected to be very different from normal landscaping maintenance costs.

Brown and Schueler (1997) developed equations to predict the base construction cost of bioretention as a function of the water quality volume provided. When these equations are adjusted to 2006 dollars, they yield:

$$BCC = (7.62)(WQ_v^{0.990})$$

Where:
WQ_v = Water quality volume (ft^3)
BCC = Base construction cost (2006 dollars)

More recently, Wossink and Hunt (2003) developed equations to predict the cost of new bioretention construction as a function of their contributing drainage area. This equation yields lower cost estimates compared to the Brown equation:

$$BCC = (11{,}781)(A^{1.088})$$

Where:
A = Size of contributing drainage area (acres)
BCC = Base construction cost (2006 dollars)

Using these equations, it is possible to establish median bioretention costs of $25,400 per impervious acre treated (range: $19,900 to $41,750). Construction cost drops sharply when site soils are permeable enough to dispense with an underdrain (although this is not a common retrofit situation).

Bioretention Design Resources

Several state and local stormwater manuals provide useful bioretention design guidance:

Prince George's Co., MD Bioretention Manual
http://www.goprincegeorgescounty.com/Government/AgencyIndex/DER/ESD/Bioretention/bioretention.asp?nivel=foldmenu(7)

Lake Co., OH Bioretention Guidance Manual
http://www2.lakecountyohio.org/smd/Forms.htm

Low Impact Development Technical Guidance Manual for Puget Sound, WA
http://www.psat.wa.gov/Publications/LID_tech_manual05/lid_index.htm

Wisconsin Stormwater Management Technical Standards
http://www.dnr.state.wi.us/org/water/wm/nps/stormwater/techstds.htm#Post

Maryland Stormwater Design Manual
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

ST-5d	Retrofit Design Sheets	
	FILTRATION	

Typical Constraints

Stormwater filters can be applied in most regions of the country and most types of urban land. It is important to note that stormwater filters are not always cost-effective to retrofit on a widespread basis, given their high unit cost and small area served. Design constraints for filter retrofits include:

Available Head: The principal retrofit constraint for stormwater filters is available head which is defined as the vertical distance between the top elevation of the filter and the bottom elevation of the existing storm drain system that accepts its runoff. Designers can quickly estimate available head at a proposed retrofit site by locating the closest stormwater inlet or manhole. The difference in elevation between the surface and the invert elevation of the underground storm drain pipe gives a rough approximation of the available head. The head required for stormwater filters ranges from two to ten feet, depending on the design variant. Thus, it is difficult to employ filters in extremely flat terrain since they require gravity flow through the filter. The one exception is the perimeter sand filter, which can be applied at sites with as little as two feet of head.

Contributing Drainage Area: Sand filters are best applied on small sites that are as close to 100% impervious as possible. A maximum contributing drainage area of five acres is recommended for surface sand filters, and a maximum contributing drainage area of two acres is recommended for perimeter or underground filters (Claytor and Schueler, 1996). Filters have been used on larger drainage areas in the past, but they tend to experience greater clogging problems.

Space Required: The amount of space required for a filter retrofit depends on the design variant selected. Both sand and organic surface filters typically consume about 2 to 3% of the contributing drainage area, while perimeter sand filters typically consume less than 1%. Underground stormwater filters generally consume no surface land except manholes needed for maintenance access.

Community and Environmental Concerns for Filter Retrofits

Stormwater filters have a few community and environmental concerns:

Aesthetics: The main drawback with stormwater filters is their appearance - many are imposing concrete boxes that tend to accumulate a lot of trash and debris. Retrofit designers should try to soften up the appearance of surface filters and make sure they are routinely maintained.

Mosquito Breeding: There is a risk that underground and perimeter filters may create potential habitat for mosquito breeding. If this is a concern, designers should keep standing water in sedimentation chambers to a minimum.

Groundwater: Filters are recommended when groundwater protection is an issue since they do not normally interact with groundwater and therefore have less potential to contaminate it.

Design Issues for Filter Retrofit Applications

Several unique design issues are involved with filter retrofits, as follows:

Pretreatment: Adequate pretreatment is needed to prevent premature filter clogging and ensure retrofit longevity. Either wet or dry pretreatment chambers can be used to capture and remove coarse sediment particles before they reach the filter bed. Designers should allocate at least 25% of the total WQv to pretreatment. Additional pretreatment measures may include a grass filter strip installed prior to the filter and regular sweeping of the street or parking lot. If a proprietary filter is used, designers should check to see whether the device has adequate pretreatment volume. The sedimentation chamber should be designed to allow maintenance crews to get vactor trucks close to the retrofit for cleanouts.

Type of Media: The normal filter media consists of clean, washed concrete sand with individual grains between 0.02 and 0.04 inches in diameter. Alternatively, organic media can be used, such as a peat/sand mixture or a leaf compost mixture. The decision to use organic media in a stormwater filter depends on which stormwater pollutants are targeted for removal. Organic media may enhance pollutant removal performance with respect to metals and hydrocarbons (Claytor & Schueler, 1996). Recent research, however, has shown that organic media can actually leach soluble nitrate and phosphorus, suggesting it is a poor choice when nutrients are the pollutant of concern.

Type of Filter: The choice of which sand design filter design to apply depends on available space and head, and the desired level of pollutant removal. In ultra-urban situations where surface space is at a premium, underground sand filters are often the only design that can be used. Surface and perimeter filters are often a more economical choice when adequate surface area is available.

Depth of Media: The depth of the filter media plays a role in how quickly stormwater moves through the filter bed and how well it removes pollutants. Recent design guidance recommends that a minimum filter bed depth ranging from 18 and 24 inches.

Impervious Drainage Area: In retrofit situations, the contributing drainage area should be as close to 100% impervious as possible in order to reduce the risk that eroded sediments will clog the filter.

Overflow: Most filtering practices are designed as off-line systems so that all flows enter the filter, but larger flows overflow to an outlet chamber, and are not treated. Exceptions include the perimeter filter and most underground filters. Runoff from larger storm events should be bypassed using an overflow structure or a flow splitter. Claytor and Schueler (1996) and ARC (2001) provide design guidance for flow splitters for filtering practices.

Drawdown: Stormwater filters should be designed to drain or dewater within 48 hours after a storm event to reduce the potential for nuisance conditions.

Maintenance Issues for Filter Retrofits

Several maintenance issues can addressed during retrofit design to reduce future maintenance operations, including:

Access: Good maintenance access is needed to allow crews to perform regular inspections and maintenance activities. Stormwater filters should be clearly visible at the retrofit site so inspectors and maintenance crews can easily find them. Adequate signs or markings should be provided at manhole access points for underground filters.

Confined Space Issues: Underground filters are often classified as an underground confined space. Consequently, special OSHA rules and training are needed to protect the workers that access them. These procedures often involve training on confined space entry, venting and the use of gas probes.

Sediment/Filter Bed Removal: Sediments will need to be regularly removed from the pretreatment chamber every three to five years. The filter bed media may also need to be replaced on the same schedule.

Site Inspections: Regular site inspections are critical to schedule sediment removal operations, replace filter media and relieve any surface clogging. Frequent inspections are especially needed for underground and perimeter filter retrofits since they are out of sight and can be easily forgotten.

Sediment Testing: Designers should check to see whether the filter is treating runoff from a hotspot site. If so, crews may need to test sediments before disposing of trapped sediments or filter bed media. Sediment testing is not needed if the filter does not receive runoff from a designated stormwater hotspot.

Adapting Filters for Special Climates and Terrain

Stormwater filters can be successfully employed when certain design modifications are made:

Cold Climates: Surface or perimeter filters may not always be effective during the winter months. The main problem is ice that forms over and within the filter bed. Ice formation may briefly cause nuisance flooding if the filter bed is still frozen when spring melt occurs. To avoid these problems, filters should be inspected before the onset of winter (prior to the first freeze) to dewater wet chambers and scarify the filter surface. Other measures to improve winter performance include:

- Placing a weir placed between the pretreatment chamber and filter bed to reduce ice formation as a more effective substitute than a traditional standpipe orifice.
- Extending the filter bed below the frost line to prevent freezing within the filter bed
- Oversizing the underdrain to encourage more rapid drainage to minimize freezing of the filter bed
- Expanding the sediment chamber to account for road sanding. Pretreatment chambers should be sized for up to 40% of the WQv

Arid Climates: Designers may want to increase storage in the pretreatment chamber to handle higher sediment loads expected in arid climates. Dry sedimentation chambers should be sized up to 40% of the WQv. Wet pretreatment is seldom feasible in arid climates.

Karst Terrain: Stormwater filters are a good option in active karst areas since they are not connected to groundwater and therefore minimize the risk of sinkhole formation and groundwater contamination.

Installation Costs for Filtering Practices

Stormwater filters have one of the highest unit construction costs of any stormwater treatment option treating small drainage areas. The cost to construct a stormwater filter depends on the region and design variant used (Table 1). For surface sand filters, Brown and Schueler (1997) reported construction costs ranging between about $3.00 and $8.00 per cubic foot of water quality volume treated (2006 dollars). Wossink and Hunt (2003) developed a cost prediction equation for stormwater filter construction based on drainage area treated. The updated equation is:

$$BCC = (55{,}515)(A^{0.882})$$

Where:

A = Size of contributing drainage area (acres)

BCC = Base construction cost (2006 dollars)

While underground and perimeter sand filters are the most expensive filtering practice, they consume minimal surface land, making them a cost-effective practice in ultra-urban areas where land prices are at a premium.

Design Resources

Several existing stormwater manuals provide useful guidance on stormwater filter design:

District of Columbia Stormwater Management Guidebook
http://dchealth.dc.gov/DOH/site/default.asp?dohNav=|33110|

The Minnesota Stormwater Manual
http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html

Maryland Stormwater Design Manual
http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Design of Stormwater Filtering Systems. Center for Watershed Protection
http://www.cwp.org/PublicationStore/special.htm

Georgia Stormwater Management Manual
http://www.georgiastormwater.com

Design Variant	Median Cost Per Impervious Acre Treated	Range in Cost
Simple Surface Filter	$ 18,150	$ 10,900 to $29,000
Structural Sand Filter	$ 72,000	$ 58,100 to $79,900
Underground Sand Filter	$ 234,000	$ 100,800 to $ 270,000
See Appendix E: Simple surface filter lacks structural elements and reinforced concrete		

ST-6d	Retrofit Design Sheets	
	INFILTRATION	

Typical Constraints

Numerous constraints need to be assessed to ensure infiltration is feasible at a proposed retrofit site, including:

Soils: Soil permeability is the single biggest factor when evaluating infiltration retrofits. A minimum infiltration rate of <u>at least</u> 0.5 inches/hour is needed to make the retrofit work. Several studies have shown that ultimate infiltration rates decline by as much as 50% from initial rates, so designers should be very conservative and not force infiltration on questionable soils. On-site infiltration investigations should always be conducted to establish the actual infiltration capacity of underlying soils using methods presented in Appendix H.

Avoid Stormwater Hotspots: Never infiltrate runoff from a hotspot operation. Make sure to conduct a HSI on all operations in the contributing area to determine the potential risk of groundwater contamination. If a site is classified as a stormwater hotspot, then runoff must be fully treated by another practice prior to infiltration.

Contributing Drainage Area: Infiltration retrofits are best applied to small contributing drainage areas that are as close to 100% impervious as possible. If the contributing contains any pervious area, it must be properly stabilized with dense vegetation, both during and after construction, to prevent eroded sediments from prematurely clogging the facility. Additionally, the maximum contributing drainage area to an infiltration trench should be limited to one acre or less. The maximum contributing drainage area to underground infiltration systems should be limited to five acres or less. Infiltration practices serving larger drainage areas tend to experience more chronic clogging problems.

Space Required: The typical footprint of an infiltration retrofit ranges from 5 to 10% of its contributing drainage area, but varies depending on its depth, storage void, space, and infiltration rate.

Minimum Setbacks: As a general rule, infiltration retrofits should be setback at least 10 feet from property lines, 25 feet from building foundations, 100 feet from septic system fields, 100 feet from private wells, 100 feet from surface waters, 400 feet from surface drinking water sources and 1,200 feet from public water supply wells.

Depth to Water Table/Bedrock: Infiltration retrofits should be separated at least three feet from the water table to ensure groundwater never intersects with the floor of the infiltration practice, which could cause groundwater contamination or practice failure. A three foot separation distance should be maintained between the bottom of the infiltration retrofit and any confining bedrock layer.

Community and Environmental Considerations for Infiltration Retrofits

Several community and environmental concerns can arise when infiltration retrofits are proposed:

Nuisance Conditions: Poorly designed infiltration retrofits can create potential nuisance problems such as basement flooding, poor yard drainage and standing water. In most cases, these problems can be minimized through adequate setbacks, on-site soil testing and pretreatment.

Mosquito Risk: Infiltration retrofits can potentially create mosquito breeding conditions if they clog and have standing water for extended periods.

Groundwater Protection: Communities that rely on groundwater for drinking water are often concerned about potential stormwater contamination. Designers should investigate the prevailing land use in the contributing drainage area. Runoff from potential stormwater hotspots should never be infiltrated. For residential and institutional land uses, infiltration is desirable since it replenishes groundwater supplies. Infiltration retrofits in these areas should have over-sized and redundant pretreatment to reduce the risk that stormwater pollutants or spills will reach groundwater.

Groundwater Injection Permits: Groundwater injection permits may be required in some areas of the country. Designers should investigate whether or not a proposed infiltration retrofit is subject to a state or local groundwater injection permit.

Design Issues for Infiltration Retrofit Applications

The design of infiltration retrofits should be more conservative than the design of new infiltration practices to promote longevity. A series of design elements can minimize the risk of practice failure:

Pretreatment is essential to extend the longevity of infiltration retrofits. Designers should include at least two pretreatment measures in every retrofit, such as grass swales, filter strips, sump pits, sediment forebays or plunge pools.

Off-line Design: Infiltration retrofits should be designed off-line so they only receive the target WQv and bypass larger storm flows. A flow splitter or overflow structure can be used for this purpose; design guidance for small flow splitters can be found in Claytor and Schueler (1996) and ARC (2001).

Small Contributing Drainage Areas: The contributing drainage area to each infiltration retrofit should be less than one acre, and be distributed in multiple locations around the site. Ideally, the contributing drainage area should be entirely impervious to preclude the possibility that eroded sediments from pervious areas will clog the retrofit. Designers should also try to keep the depth of the infiltration retrofit to less than four to six feet.

Rapid Drawdown: When possible, infiltration retrofits should be sized so that the target WQv rapidly infiltrates within 24 to 36 hours (rather than the standard 48 hour drawdown limit for new practices). This design approach provides a factor of safety to prevent nuisance ponding conditions.

Conservative Infiltration Rates. Underlying soils should have a minimum infiltration rate of at least 0.5 inches per hour. Several test pits are needed to measure the infiltration rates across a proposed retrofit site. Appendix H provides guidance on performing infiltration testing. However, infiltration rates of 1.0 to 2.0 inches per hour are ideal. Designers may wish to cut measured infiltration rates in half to approximate the long term infiltration rate.

No Filter Fabric on Bottom: The use of geotextile filter fabric along the bottom of infiltration retrofits should be avoided. Experience has shown that filter fabric is prone to clogging, and that a layer of coarse washed stone (choker stone) is a more effective substitute.

Observation Wells: One or more observation wells should be installed within infiltration retrofits so that drawdown rate can be measured after storm events. Observation wells typically consist of perforated PVC pipes that are four to six inches in diameter and extend from the surface to the bottom of the infiltration retrofit.

Maintenance Issues with Infiltration Retrofits

Historically, infiltration practices have had a high failure rate compared to other stormwater treatment options (Galli, 1992). A conservative retrofit design approach should greatly reduce the risk of initial retrofit failure (Figure 1). Even so, the future performance of infiltration requires a strong commitment to regular inspection and maintenance. Designers should only choose infiltration when they are confident that the landowner or municipal agency will be a responsible maintainer in the future. The maintainer should be expected to handle the following ongoing tasks:

Figure 1: Failed Infiltration Trench

Site Inspections: Regular site inspections are critical to the performance and longevity of infiltration retrofits. The drawdown rate of the retrofit should be measured at the observation wells at least twice a year. It is recommended that infiltration rates be checked in observation wells three days following a storm event greater than one half inch in depth. If standing water is still observed in the well after three days, this is a clear sign that that clogging has become a problem. Additionally, pretreatment devices and flow diversion structures should be checked for sediment buildup and structural damage.

Sediment Removal/Trench Reconstruction: Sediment will need to be regularly removed from pretreatment facilities. If major clogging occurs, the practice may need to be reconstructed. Good maintenance access is needed to allow crews and heavy equipment to perform maintenance tasks.

A maintenance plan should be created that identifies the party responsible for maintenance and specifies ongoing maintenance tasks over a prescribed schedule.

Adapting Infiltration for Special Climates and Terrain

Although infiltration practices have been successfully employed in both cold and arid climates, several design modifications are needed to ensure they function properly:

Cold Climates: Infiltration retrofits are generally not feasible in extremely cold climates experiencing permafrost, but they can be designed to withstand more moderate winter conditions. The main problem is ice forming in the voids or the subsoils below which may briefly cause nuisance flooding when spring melt occurs. These problems can be avoided if the bottom of the retrofit extends below the frost line.

If the retrofit treats roadside runoff, it may be desirable to divert flow in the winter to prevent movement of chlorides into groundwater and prevent clogging by road sand. Alternatively, pretreatment measures can be oversized to account for the additional sediment load caused by road sanding (up to 40% of the WQv). Care should be taken to ensure that infiltration retrofits are setback at least 25 feet from roadways to prevent potential frost heaving of road pavements.

Arid Climates: The key concern in arid and semi-arid watersheds is the greater risk of potential clogging due to higher sediment loads. Consequently, over-sized pretreatment should be strongly emphasized, and the contributing drainage area should be kept as close to 100% impervious as possible.

Karst Terrain: Infiltration retrofits should not be used in active karst regions unless geotechnical investigations have eliminated concerns about sinkhole formation and groundwater contamination.

Installation Costs for Infiltration Retrofits

Very little construction cost information about infiltration practices is available. Because their construction methods are similar, the cost for infiltration practices are assumed to be comparable to bioretention areas (Appendix E). Consequently, the cost to construct infiltration practices at new development sites is estimated to be $25,400 per impervious acre treated (range: $19,900 to $41,750). Few retrofit sites will meet new development conditions; however, most retrofits will cost 1.5 to 2.0 times more than new infiltration practices.

Infiltration Design Resources

Several recent stormwater manuals present updated design criteria for infiltration practices:

New Jersey Stormwater Best Management Practices Manual
http://www.nj.gov/dep/watershedmgt/bmpmanualfeb2004.htm

Pennsylvania Draft Stormwater Best Management Practices Manual
http://www.dep.state.pa.us/dep/subject/advcoun/Stormwater/stormwatercomm.htm

Green Technology: The Delaware Urban Runoff Management Approach
http://www.dnrec.state.de.us/DNREC2000/Divisions/Soil/Stormwater/New/GT_Stds%20&%20Specs_06-05.pdf

New York State Stormwater Management Design Manual
http://www.dec.state.ny.us/website/dow/toolbox/swmanual/index.html

ST-7d	Retrofit Design Sheets	
	SWALES	

Typical Constraints

Constraints to consider when evaluating a potential swale retrofit include:

Contributing Drainage Area: The maximum contributing drainage area to a swale retrofit should be five acres and preferably less.

Space Required: Swale retrofits usually consume about five to 15% of their contributing drainage area.

Site Topography: Site topography constrains swale retrofits; some gradient is needed to provide water quality treatment but not so much that treatment is impeded. Swales generally work best on sites with relatively flat slopes (e.g., less than 5% slope for grass channels and 2% for wet and dry swales). Steeper slopes create rapid runoff velocities that can cause erosion and do not allow enough contact time for infiltration or filtering. Swales perform poorly in extremely flat terrain because they lack enough grade to create storage cells, and lack head to drive the system.

Available Head: A minimum amount of head is needed to implement each swale retrofit. Dry swales typically require three to five feet of head since they require a filter bed and underdrain. Wet swales require about two feet of head, whereas grass swales need only a foot. Designers should measure gradient in the field to ensure enough head exists to drive the swale retrofit.

Hydraulic Capacity of Existing Open Channel: Most open channels were originally sized with enough capacity to convey runoff from the ten-year storm, and be non-erosive during the two-year design storm event. In many cases, the open channel may be under-capacity due to upstream development or past sedimentation. The capacity of the existing open channel should be verified during the retrofit project investigation. Field observations that may indicate an existing channel is undersized channel include excessive erosion of the channel side slopes, poor vegetative stabilization and overbank debris.

Width of Existing Right of Way or Easement: Designers should investigate whether the existing right of way or stormwater easement is wide enough to accommodate retrofit construction and maintenance access. In most cases, the existing channel will need to be widened or flows split into adjacent off-channel treatment cells.

Depth to Water Table: Designers should separate the bottom of the swale from the groundwater by at least two feet for dry swales and grass channels. It is permissible to intersect the water table for wet swales, since the pool enhances water quality treatment.

*Soils: S*oil permeability influences which swale design variant will work best in the existing channel. Designers should note that past construction and compaction may have severely reduced the permeability of the original swale soils. Several on-site tests should be conducted at the proposed retrofit to measure actual soil infiltration retrofit rates (see Appendix H). In general, grass swales are restricted to soils in Hydrologic Soil Groups A or B. Dry swales also work well on these soils, but can be applied to more impermeable C or D soils if an underdrain is used. Wet swales work best on more impermeable C or D soils.

Utilities: Many utilities run along or underneath open channels, so designers should always check for utility lines or crossings at each swale retrofit site. The presence of dry or wet utilities usually renders a swale retrofit infeasible.

Community and Environmental Considerations for Swale Retrofits

Swale retrofits are normally accepted by communities if they are properly designed and maintained, but require approval by multiple landowners to secure additional right of way. The main concerns of adjacent residents are perceptions that swale retrofits will create nuisance conditions or will be hard to maintain. Common concerns include the continued ability to mow grass, landscape preferences, weeds, standing water, and mosquitoes. For these reasons, wet swales are not recommended in residential settings - the shallow, standing water in the swale is often viewed as a potential nuisance by homeowners. Dry swales are a much better alternative.

Key Design Issues for Swale Retrofits

Several design elements can ensure the swale retrofit performs effectively over the long run:

Pretreatment: Adequate pretreatment is needed to trap sediments before they reach the main treatment cell of the swale retrofit. A small sediment forebay located at the upstream end of the swale often works best. A pea gravel flow spreader along the top of each bank can pretreat lateral runoff from the road shoulder to the swale.

Swale Dimensions: Swales should have a bottom width ranging from two to eight feet to ensure an adequate surface area exists along the bottom of the swale for filtering. If a swale will be wider than eight feet, designers should incorporate berms, check dams, level spreaders or multi-level cross sections to prevent braiding and erosion within the swale bottom. Swale retrofits should be designed with a parabolic or trapezoidal cross section and have side slopes no steeper than 3:1 (h:v). Designers should seek side slopes much less than 3:1 to promote more treatment of lateral sheet flow, if space is available.

Ponding Depth: Drop structures or check dams can be used to create ponding cells along the length of the swale. The maximum ponding depth in a swale should not exceed 18 inches at the most downstream point. The average ponding depth throughout the swale should be 12 inches.

Drawdown: Dry swale retrofits should be designed so that the desired WQv is completely filtered within six hours or less. This drawdown time can be achieved by using a sandy soil mix or an underdrain along the bottom of the swale. No minimum drawdown time is required for wet swale retrofits.

Swale Media: Dry swales require replacement of native soils with a prepared soil media. The soil media provides adequate drainage, supports plant growth and facilitates pollutant removal within the dry swale. The soil media should have an infiltration rate of at least one foot per day and be comprised of a mix of native soil, sand and organic compost similar to bioretention design recommendations presented in ST-4. At least 18 inches of soil media should be mixed into the swale bottom.

Underdrain: Underdrains are provided in dry swale retrofits to ensure they drain properly after storms. The underdrain should have a minimum diameter of 6 inches and be encased in a foot deep gravel bed. Underdrains are not needed in wet swales or grass channels.

Swale Maintenance Requirements

Swale maintenance often fits within normal turf management operations that are already being performed. Swale retrofits are often located near landowners that have real or perceived concerns on how the swale may affect their front yards and property value. Therefore, designers should consider how to:

- Minimize standing water
- Minimize interference of check dams with regular mowing
- Manage vegetative growth in the future
- Educate residents on how to properly maintain the swale over time

Regular inspections should be conducted on the swale retrofit to schedule maintenance operations such as sediment removal, spot revegetation and inlet stabilization. Maintenance crews may need to be educated on the purpose and maintenance needs of swale retrofits installed along streets or highway right-of-way.

Adapting Swales for Special Climates and Terrain

Swale retrofits can be applied in most climates and terrain with some design modifications:

Cold Climates: Swales can store snow and treat snowmelt runoff. If roadway salt is applied, swales should be planted with salt-tolerant and non-woody plant species. Consult the Minnesota Stormwater Manual for a list of salt-tolerant grass species (MSSC, 2005). The dry swale underdrain pipe should extend below the frost line and be oversized by one pipe size to reduce the chances of freeze-up.

Arid Climates: It is extremely hard to maintain a wet swale retrofit in arid and semi-arid climates. Swales should be planted with drought-tolerant vegetation and the planting plan should specify fewer broad-leaved plants to minimize the need for supplemental irrigation. A xeriscaping approach is preferred for any swale in arid or semi-arid regions since irrigation makes little sense and is expensive in these regions.

Karst Terrain: Swale retrofits should utilize impermeable liners and underdrains to prevent sinkhole formation in active karst areas.

Swale Installation Costs

Only limited cost data has been published on swale construction costs. Equations to estimate swale costs for new construction are outlined in Appendix E. The projected cost for swales at new development sites is estimated to be $18,150 per impervious acre treated (range: $10,900 to $36,300). Few retrofit sites will meet the construction conditions for new development sites; most swale retrofits will cost about twice as much, particularly if they involve off-channel treatment.

Swale Design Tools

New York State Stormwater Management Design Manual
http://www.dec.state.ny.us/website/dow/toolbox/swmanual/index.html

Vermont Stormwater Management Manual
http://www.anr.state.vt.us/dec/waterq/cfm/ref/Ref_Stormwater.cfm

Stormwater Management Manual for Western Washington
http://www.ecy.wa.gov/programs/wq/stormwater/manual.html#How_to_Find_the_Stormwater_Manual_on_the

CNMI and Guam Stormwater Management Manual
http://www.guamepa.govguam.net/programs/water/index.html

Appendix B

Stream Adoption and Stream Clean-up

C-2

Stream Cleanups

STREAM ADOPTION

Description

A stream adoption program encourages individual citizens to become involved in the assessment, monitoring and stewardship for specific urban stream reaches. Stream adoption is normally organized as a volunteer program, in which participants "adopt" an urban stream segment to routinely clean up trash, perform monitoring, report water quality violations and implement smaller stream repair and stewardship projects (Figure 1). Volunteers become the eyes and ears for the stream and act as the primary caretaker of an individual stream segment within a subwatershed. The goal is to walk and assess the stream segment during every season of the year.

Stream adoption is best done in impacted and non-supporting watersheds. The extensive enclosure and interruption that occurs in urban drainage subwatersheds makes them very difficult to adopt. Stream adopters play a very important role in reporting problems in the subwatersheds, including dumping, sanitary sewer overflows, fish kills, erosion and sediment control violations, spills, and illegal discharges. In addition, they can play a valuable role in providing direct retail homeowner education.

Feasibility

Stream adoption programs can be difficult to implement in urban watersheds if access is poor to the stream network. Access may be restricted by fences, commercial and industrial uses, overgrown vegetation, or because streams are enclosed or culverted. Urban stream adoption has unique cleanup and safety issues and is typically more complex compared to rural streams.

Figure 1: Advertising of a local adopt-a-stream program

Implementation

Implementing a stream adoption program involves many tasks to recruit, train and retain a large number of volunteers across a subwatershed. These tasks include identifying viable stream reaches to adopt, recruiting and training volunteers, and providing incentives for those volunteers to continue their stewardship activities.

Watershed Delineation and Stream Selection – Watershed delineation is used to find stream reaches that are practical for volunteers to adopt and manage. This is usually done after the stream network in a subwatershed has been systematically walked using the Unified Stream Assessment (USA) technique (Manual 10). Generally, all "walkable" streams in a subwatershed are open for adoption, but these should be divided into smaller, more manageable units for actual adoption. According to Zielinski (2004), "adopted" reaches should meet the following criteria:

- Be about 1,000 to 2,000 feet long
- Have at least one easy access point to the stream from a road or open area
- Be located between major road crossings or major land use changes (include culvert with downstream section)
- Major confluences should be used as breaks between reaches
- Have public access along at least one side of the floodplain

Once streams reaches are identified, it is helpful to give each one a unique subwatershed address. Using a simple stream address system allows organizers to create less cluttered maps and reduces potential confusion among volunteers.

Once all adoptable reaches have been identified, a map of the stream reach should be generated, depicting watershed boundaries, roads, structures, streams, parks, neighborhoods, landmarks and adoption sections. This map can be printed in brochure format and distributed throughout the watershed (map on one side, program details on the other). The watershed address should also be posted on the watershed organization's website. Volunteers can then choose which reaches they would like to adopt by looking at the maps.

Designing the Program and Recruiting Volunteers – Zielinski (2004) interviewed adopt-a-stream programs around the country and presents some tips to design effective programs in Table 1. The critical element of any program is to recruit, train and retain volunteers. While individuals choose to volunteer for many reasons, it seems that satisfaction goes hand-in-hand with recognition as the motivation to practice stewardship. Incentives are benefits that entice individuals to participate in an activity and may include, but are not limited to:

- Improve the quality of life in the community
- Have fun
- Take the first steps of environmental activism
- Acquire new skills
- Fulfill the community service requirements for a club, school, church
- Make new friends and network
- Contribute to a cause that is important to them

Table 1: Tips on Developing an Effective Stream Adoption Program (from Zielinski, 2004)
• Provide progressive levels of stream adoption to meet the different skills and interests of the volunteer pool. For example, one stream watch program has five different levels of adoption: s*tream cleaners* that monitor trash levels in the corridor, *stream walkers* that perform a visual survey of stream problems, *stream watchers* that regularly conduct the USA on each reach, *bug pickers* that collect aquatic insect data at fixed stations, and *snapshot samplers* that collect regular grab samples to characterize water quality. • Educate potential volunteers about water quality issues to get them interested in volunteering. • Recruit volunteers through newsletters, newspaper ads, websites, flyers, and word-of-mouth • Make adoption fun, educational and family-oriented • Continuously recruit and train new volunteers, and develop an updated contact database. Try to outreach to volunteers at least five times a year • Conduct regular "hands on" training workshops for both new and existing volunteers • Choose previously tested and standardized monitoring methods and develop quality control plans • Assign some local technical staff to support field activities and be liaison to the volunteers • Continuously monitor volunteer satisfaction and modify program to maintain it at a high level • Provide direct and timely response when volunteers discover water quality problems • Work with volunteers to implement small-scale stream repair projects within adopted stream segments • Address potential liability issues with standard waiver forms and safety training • Use a newsletter or website to regularly communicate with volunteers and get data out to the public

Since many other volunteer opportunities exist, and residents have many other competing demands on their time, it is important to recognize the meaningful contribution that volunteers make in the community. Many low-cost options to encourage and recognize volunteers include:

- A recognition event: dinner, lunch, or other gathering
- Awards
- Certificates
- Drawings for prizes
- Gift Certificates to restaurants
- Gifts of photos of the watershed
- Most hours of service
- Number of years of service
- Outstanding service
- Recognition at regularly scheduled events
- Thank you letters and other acknowledgements
- T-shirts
- Volunteer of the month/year

The selection of incentives and recognition should reflect the nature of the expected volunteers or organizations. For example, volunteer groups composed of college students will be motivated by different incentives and benefits than one comprised mostly of elderly or adolescent volunteers.

Monitoring the Adopted Stream - Stream adoption programs can collect volunteer monitoring data. Monitoring may include water quality testing, habitat and aquatic insect sampling, pH, outfall testing, and physical stream assessments (Figure 2). The monitoring frequency for stream assessments can range from one to five times per year, depending on the type of assessment. This data should be incorporated into a database so that trends in the stream can be tracked. This information helps the stream managers and volunteers better understand the state of the streams and subwatershed.

Reporting Water Quality Violations – A major role of a stream adopter is to act as the eyes and ears or the stream and report problems. The stream adopter should be trained to identify, document, and quickly report any of the following: dumping, fish kills, erosion and sediment control violations, suspicious outfalls, sanitary sewer overflows, buffer encroachment, illicit discharges, or other water quality violations.

Other Roles – Stream adopters can play many roles in other stewardship activities. They can monitor trash levels along the stream and its corridor and arrange regular stream cleanups (Profile Sheet C-1). In addition, they can be the "retail" watershed education distributor in the subwatershed to civic groups, garden clubs, and neighborhood associations.

Cost – The costs to organize and implement a stream adoption program is typically moderate, depending on whether or not paid staff are needed to administer the program. According to Zielinski (2004), the annual cost to adopt a mile of stream ranges from $200 to $1,000. If paid staff are needed, annual costs can run from $5,000 to $10,000 per subwatershed, not including plans to secure sponsors, assemble outreach materials, or acquire monitoring and cleanup equipment and database systems. It is important to note that much of the monitoring and cleanup equipment can be donated by local businesses and institutions.

Figure 2: Aquatic insect sampling

Further Resources

Many states, communities or watershed organizations have developed stream adoption or citizen monitoring program to involve citizens in stream assessment. The goals and methods of adoption programs can differ considerably (Zielinski, 2004). The following list of resources is not meant to be exhaustive, but provides good examples of national organizations and regional programs that may be helpful.

Adopt-a-Stream http://www.adopt-a-stream.org, including a Teachers guide: http://www.adopt-a-stream.org/about_the_teachers_guides.html

Izaak Walton League http://www.iwla.org/

Streamkeepers
http://www.streamkeeper.org/tools

Assabet River Stream Watch Program (MA)
http://assabetriver.org/streamwatch/

Delaware Stream Watch
http://www.delawarenaturesociety.org/streamwatch.htm

Huron River Watershed Council Adopt-a-Stream (MI)
http://comnet.org/local/orgs/hrwc/adopt/adopt.htm

Maryland Stream Waders
http://www.dnr.state.md.us/streams/mbss/waders2.html
This also has excellent volunteer stream monitoring manual:
http://dnrweb.dnr.state.md.us/download/bays/streams/2002waders.pdf

North Carolina Stream Watch
http://www.ee.enr/state.nc.us/

Adopt-a-Stream Programs
http://www.fws.gov/r5cneafp/adopt2.htm (Atlantic)

http://www.wdfw.wa.gov/outreach/education/salclass.htm (Pacific)

C-1	Stream Cleanups
	STREAM CLEANUPS

Description

Stream cleanups are a simple practice to enhance the appearance of a stream corridor by removing unsightly trash, litter and debris. In some cases, mechanical equipment is needed to remove large quantities of rubble, appliance and trash that have been illegally dumped in the stream or its corridor. Cleanups make the stream a more attractive place for anglers, canoers, hikers and landowners. In some cases, stream cleanups can prevent pollutants from being released, if drums, tires, appliances, medical waste or other potentially hazardous materials are present (Figure 1).

Typically, stream cleanups are accomplished using volunteers from the community or schools that are led by a local watershed group and/or supported by municipal agencies. Stream cleanups have great value in educating volunteers and increasing community awareness about watershed restoration, and are also an effective recruiting tool for local watershed groups. Repeated stream cleanups can often make a real difference in the appearance of impacted and non-supporting streams, but may not always be able to keep up with the severe trash and debris loads experienced in urban drainage streams. In addition, the volume of illegal dumping in the corridor of urban drainage subwatersheds tends to be much higher.

Feasibility

The Trash and Debris (TR) form of the Unified Stream Assessment is an excellent tool to use when choosing potential cleanup sites in a subwatershed, as it pinpoints locations of greatest trash accumulation along the entire stream corridor, and evaluates accessibility and other factors (Manual 10). Several feasibility factors should be considered when scouting potential stream cleanup sites. The first factor is access, which usually means finding a bridge, road crossing or easement that makes it possible to reach the stream. Next, safety should be considered. Stream corridors with steep slopes, steep eroding banks, or overgrown thorny vegetation can all pose access problems. Third, an adjacent trash stockpiling area is needed to temporarily store trash and debris collected until it can be removed a few days later. This usually means finding a nearby parking lot or roadside area accessible by a dump or garbage truck. The fourth factor is the water quality of the stream itself. The main concern here is skin contact with bacteria and pathogens. It can generally be assumed that if the cleanup site is located in a non-supporting or urban drainage subwatershed, dry weather stream flows may contain bacteria. In these situations, plastic gloves, waterproof waders and other protective equipment should always be worn (Figure 2). Stream cleanups can be done in all kinds of urban subwatersheds, but are most effective in impacted and non-supporting streams.

Figure 1: Example of potentially hazardous materials and conditions in an urban stream

Figure 2: Stream cleanup effort in an urban Maryland stream

Implementation

Implementing a cleanup entails three steps: planning and organizing, conducting the cleanup, and performing follow-up activities.

Planning a Cleanup - Planning and organizing are the most time-consuming component of a successful stream cleanups, and several details should be considered for a smooth effort, including:

- Selecting an appropriate site(s)
- Choosing the cleanup date, and a rain date
- Assessing safety needs at the site
- Recruiting volunteers and organizing teams
- Acquiring landowner permission
- Arranging for trash hauling
- Buying supplies
- Publicizing the cleanup event

Choosing and publicizing the stream cleanup date should be done months in advance to provide ample time for volunteers and workers to include it in their busy schedules. Stream cleanups should be scheduled to avoid poor weather conditions, such as extreme heat or cold, rainy periods that might cause flooding, and snow. Good scheduling can reduce the risk of a low turnout or cancellation of the cleanup due to poor weather. Typically late spring or early fall is the best season to schedule stream cleanups in most regions of the country.

Safety is an essential responsibility for the cleanup organizer, and potential risks should be thoroughly evaluated. Since volunteers will be handling trash and debris and be in and around water, they may be susceptible to injury. The following safety factors should be evaluated:

Clothing – Advise volunteers to wear thick pants, sturdy shoes/boots, and gloves

First Aid Kit – A good first aid kit should be provided, along with someone who has training in its use. The kit should contain items to address common outdoor injuries (e.g., bee stings, cuts, poison ivy, and ankle sprains)

Stockpile Sites – These sites should be marked with orange warning cones or flags to alert pedestrians and traffic

Daily weather reports - Forecasts should be consulted to be aware of potentially threatening weather events, such as thunderstorms

Safety plan – This plan should show the nearest phone and list important emergency phone numbers and the closest medical center

Water – Stream cleanups can be strenuous, so make sure ample water is available to volunteers to prevent dehydration

Liability Waiver – Make sure volunteers sign liability forms and provide medical information about allergies and medications

Cleanup organizers should organize recruits into teams of six to eight to work in specific areas of the stream. Each team should be assigned a team leader that has scouted the stream reach and knows where debris should be stockpiled.

Parents or guardians must give written permission if minors wish to participate in the stream cleanup. This should include an emergency phone contact and permission to administer medical care. Organizers should consider requiring a minimum age for volunteers.

Arrangements for removing trash and debris should be made in advance with the local public works department. It is also helpful to coordinate with local recycling centers on how to recycle materials collected during the cleanup (e.g., plastics, aluminum, glass).

The length of the stream cleanup determines how many supplies are needed. For example, a small project may only require a borrowed truck, while a larger project may require use of a large dump truck. Typical supplies needed for a stream cleanup include: trash bags, waders, plastic gloves, refreshments, shovels, wheelbarrows, t-shirts, first aid kits, and other equipment (Kumble and Bernstein, 1991). For larger projects, the cost of trash removal and hauling debris should be taken into consideration.

Organizers should notify local newspapers, and radio and television stations about the cleanup, with an emphasis on progress made, the watershed restoration effort, and recognition of volunteers.

The Cleanup - Cleanups are typically done in a single day. All trash and debris collected during the cleanup should be organized into piles of recyclables (e.g., plastic, glass, aluminum, etc.) and non-recyclable garbage. Municipal recycling and trash removal agencies should coordinate trash hauling. It is helpful to track the amount and type of garbage collected during the cleanup. Also, try to plan some kind of stream education event to educate volunteers on the larger watershed restoration effort. Before and after photographs help document how much was accomplished (Figure 3). Finally, thank all who participated in the cleanup effort or contributed in some way to the project.

After the cleanup, the site should be monitored to determine the source of the trash, and efforts to continue trash pick-up should be made. Summaries of the type and volume of trash collected should be reported to the press and local agencies.

Figure 3: Trash removed during a stream cleanup

Costs - The overall cost of a stream cleanup is highly dependent on the amount of donated supplies and services. Trash and debris hauling and landfill disposal fees can be significant, although most municipal agencies are usually happy to provide them for free. Donation of services, corporate sponsors, waiving of fees, and the use of publicly-owned equipment can reduce cleanup costs. Most cleanups use volunteer labor, but organizers must supply equipment, such as hand tools, waders and safety equipment (e.g., gloves, goggles, etc.). Efforts should be made to obtain these materials as donations or at a reduced cost. Additional costs include volunteer appreciation materials, disposable cameras, film and developing, refreshments for volunteers, promotional materials, printing costs, and educational materials.

Further Resources

Stream cleanup guidance from U.S. Environmental Protection Agency http://www.epa.gov/adopt/patch/html/streambeach.html

Water Action Volunteers. *Stream and River Cleanup*. http://clean-water.uwex.edu/wav/river/cleanup.pdf

National River Cleanup http://www.nationalrivercleanup.com

Appendix C

Hot Spot Profile Sheets, Residential Profile Sheets and Rooftop Retrofits

H-1	Hotspot Source Area: Vehicles	
	VEHICLE MAINTENANCE AND REPAIR	

Description

Vehicle maintenance and repair operations can exert a significant impact on water quality by generating toxins such as solvents, waste oil, antifreeze, and other fluids. Often, vehicles that are wrecked or awaiting repair can be a storm water hotspot if leaking fluids are exposed to storm water runoff (Figure 1). Vehicle maintenance and repair can generate oil and grease, trace metals, hydrocarbons, and other toxic organic compounds. Table 1 summarizes a series of simple pollution prevention techniques for vehicle maintenance and repair operations that can prevent storm water contamination. You are encouraged to consult the Resources section of this sheet to get a more comprehensive review of pollution prevention practices for vehicle maintenance and repair operations.

Figure 1: Junkyard and Potential Source of Storm Water Pollution

Application

Pollution prevention practices should be applied to any facility that maintains or repairs vehicles in a subwatershed. Examples include car dealerships, body shops, service stations, quick lubes, school bus depots, trucking companies, and fleet maintenance operations at larger industrial, institutional, municipal or transport-related operations. Repair facilities are often clustered together, and are a major priority for subwatershed pollution prevention.

Table 1: Pollution Prevention Practices for Vehicle Maintenance and Repair Activities
• Avoid hosing down work or fueling areas
• Clean all spills immediately using dry cleaning techniques
• Collect used antifreeze, oil, grease, oil filters, cleaning solutions, solvents, batteries, hydraulic and transmission fluids and recycle with appropriate agencies
• Conduct all vehicle and equipment repairs indoors or under a cover (if done outdoors)
• Connect outdoor vehicle storage areas to a separate storm water collection system with an oil/grit separator that discharges to a dead holding tank, the sanitary sewer or a storm water treatment practice
• Designate a specific location for outdoor maintenance activities that is designed to prevent storm water pollution (paved, away from storm drains, and with storm water containment measures)
• Inspect the condition of all vehicles and equipment stored outdoors frequently
• Use a tarp, ground cloth, or drip pans beneath vehicles or equipment being repaired outdoors to capture all spills and drips
• Seal service bay concrete floors with an impervious material so cleanup can be done without using solvents. Do not wash service bays to outdoor storm drains
• Store cracked batteries in a covered secondary containment area until they can be disposed of properly
• Wash parts in a self-contained solvent sink rather than outdoors

Primary Training Targets

Owners, fleet operation managers, service managers, maintenance supervisors, mechanics and other employees are key targets for training.

Feasibility

Pollution prevention techniques for vehicle repair facilities broadly apply to all regions and climates. These techniques generally rely on changes to basic operating procedures, after an initial inspection of facility operations. The inspection relies on a standard operations checklist that can be completed in a few hours.

Implementation Considerations

Employee training is essential to successfully implement vehicle repair pollution prevention practices. The connection between the storm drain system and local streams should be emphasized so that employees understand why any fluids need to be properly disposed of. It is also important to understand the demographics of the work force; in some communities, it may require a multilingual education program.

Cost - Employee training is generally inexpensive, since training can be done using posters, pamphlets, or videos. Structural practices can vary based on what equipment is required. For instance, solvent sinks to clean parts can cost from $1,500 to $15,000, while spray cabinets may cost more than $50,000. In addition, proper recycling/disposal of used or spilled fluids usually requires outside contractors that may increase costs.

Resources

Stormwater Management Manual for Western Washington: Volume IV -- Source Control BMPs.
http://www.ecy.wa.gov/biblio/9914.html

California Stormwater Quality Association. 2003 California Stormwater BMP Handbook: Industrial and Commercial.
http://www.cabmphandbooks.com/

Coordinating Committee For Automotive Repair (CCAR) Source: US EPA CCAR-*Green*Link®, the National Automotive Environmental Compliance Assistance Center CCAR-*Green*Link® Virtual Shop http://www.ccar-greenlink.org/

Auto Body Shops Pollution Prevention Guide. Peaks to Prairies Pollution Prevention Information Center.
http://peakstoprairies.org/p2bande/autobody/abguide/index.cfm

Massachusetts Office of Technical Assistance for Toxics Use Reduction (OTA). Crash Course for Compliance and Pollution Prevention Toolbox
http://www.state.ma.us/ota/pubs/toolfull.pdf

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities.
http://www.swrcb.ca.gov/stormwtr/murp.html

US EPA. Virtual Facility Regulatory Tour: Vehicle Maintenance. FedSite Federal Facilities Compliance Assistance Center.
http://permanent.access.gpo.gov/websites/epagov/www.epa.gov/fedsite/virtual.html

City of Santa Cruz. Best Management Practices for Vehicle Service Facilities (in English and Spanish).
http://www.ci.santa-cruz.ca.us/pw/pdf/vehiclebmp.pdf

City of Los Angeles Bilingual Poster of BMPs for Auto Repair Industry
http://www.lastormwater.org/downloads/PDFs/autopstr.pdf

H-2	Hotspot Source Area: Vehicles	
	VEHICLE FUELING	

Description

Spills at vehicle fueling operations have the potential to directly contribute oil, grease, and gasoline to storm water, and can be a significant source of lead, copper and zinc, and petroleum hydrocarbons. Delivery of pollutants to the storm drain can be sharply reduced by well-designed fueling areas and improved operational procedures. The risk of spills depends on whether the fueling area is covered and has secondary containment. The type, condition, and exposure of the fueling surface can also be important. Table 1 describes common pollution prevention practices for fueling operations.

Application

These practices can be applied to any facility that dispenses fuel. Examples include retail gas stations, bus depots, marinas, and fleet maintenance operations (Figure 1). In addition, these practices also apply to temporary above-ground fueling areas for construction and earthmoving equipment. Many fueling areas are usually present in urban subwatersheds, and they tend to be clustered along commercial and highway corridors. These hotspots are often a priority for subwatershed source control.

Figure 1: Covered Retail Gas Operation Without Containment for Potential Spills

Table 1: Pollution Prevention Practices For Fueling Operation Areas
• Maintain an updated spill prevention and response plan on premises of all fueling facilities (see Profile Sheet H-7) • Cover fueling stations with a canopy or roof to prevent direct contact with rainfall • Design fueling pads for large mobile equipment to prevent the run-on of storm water and collect any runoff in a dead-end sump • Retrofit underground storage tanks with spill containment and overfill prevention systems • Keep suitable cleanup materials on the premises to promptly clean up spills • Install slotted inlets along the perimeter of the “downhill” side of fueling stations to collect fluids and connect the drain to a waste tank or storm water treatment practice. The collection system should have a shutoff valve to contain a large fuel spill event • Locate storm drain inlets away from the immediate vicinity of the fueling area • Clean fuel-dispensing areas with dry cleanup methods. Never wash down areas before dry clean up has been done. Ensure that wash water is collected and disposed of in the sanitary sewer system or approved storm water treatment practice • Pave fueling stations with concrete rather than asphalt • Protect above ground fuel tanks using a containment berm with an impervious floor of Portland cement. The containment berm should have enough capacity to contain 110% of the total tank volume • Use fuel-dispensing nozzles with automatic shutoffs, if allowed • Consider installing a perimeter sand filter to capture and treat any runoff produced by the station

Primary Training Targets

Training efforts should be targeted to owners, operators, attendants, and petroleum wholesalers.

Feasibility

Vehicle fueling pollution prevention practices apply to all geographic and climatic regions. The practices are relatively low-cost, except for structural measures that are installed during new construction or station remodeling.

Implementation Considerations

Fueling Area Covers - Fueling areas can be covered by installing an overhanging roof or canopy. Covers prevent exposure to rainfall and are a desirable amenity for retail fueling station customers. The area of the fueling cover should exceed the area where fuel is dispensed. All downspouts draining the cover or roof should be routed to prevent discharge across the fueling area. If large equipment makes it difficult to install covers or roofs, fueling islands should be designed to prevent storm water run-on through grading, and any runoff from the fueling area should be directed to a dead-end sump.

Surfaces - Fuel dispensing areas should be paved with concrete; the use of asphalt should be avoided, unless the surface is sealed with an impervious sealant. Concrete pads used in fuel dispensing areas should extend to the full length that the hose and nozzle assembly can be pulled, plus an additional foot.

Grading - Fuel dispensing areas should be graded with a slope that prevents ponding, and separated from the rest of the site by berms, dikes or other grade breaks that prevent run-on of urban runoff. The recommended grade for fuel dispensing areas is 2 - 4% (CSWQTF, 1997).

Cost - Costs to implement pollution prevention practices at fueling stations will vary, with many of the costs coming upfront during the design of a new fueling facility. Once a facility has implemented the recommended source control measures, ongoing maintenance costs should be low.

Resources

Best Management Practice Guide – Retail Gasoline Outlets. Prepared by Retail Gasoline Outlet Work Group.
http://www.swrcb.ca.gov/rwqcb4/html/programs/stormwater/la_ms4_tentative/RGO BMP Guide_03-97_.pdf

Stormwater Management Manual for Western Washington: Volume IV -- Source Control BMPs.
http://www.ecy.wa.gov/biblio/9914.html

California Stormwater Quality Association. 2003 California Stormwater BMP Handbook: New Development and Redevelopment.
http://www.cabmphandbooks.com/

City of Los Angeles, CA Best Management Practices for Gas Stations
http://www.lacity.org/SAN/wpd/downloads/PDFs/gasstation.pdf

City of Dana Point Stormwater Best Management Practices (BMPs) For Automotive Maintenance And Car Care
http://www.danapoint.org/water/WC-AUTOMOTIVE.pdf

Alachua County, FL Best Management Practices for Controlling Runoff from Gas Stations
http://environment.alachua-county.org/Natural_Resources/Water_Quality/Documents/Gas%20Stations.pdf

California Stormwater Regional Control Board Retail Gasoline Outlets: New Development Design Standards For Mitigation Of Storm Water Impacts
http://www.swrcb.ca.gov/rwqcb4/html/programs/stormwater/la_ms4_tentative/RGOpaper.pdf
http://www.swrcb.ca.gov/rwqcb4/html/programs/stormwater/la_ms4_tentative/RGOPaperSupplement_12-01_.pdf

Canadian Petroleum Products Institute Best Management Practices Stormwater Runoff from Petroleum Facilities
http://www.cppi.ca/tech/BMPstormwater.pdf

City of Monterey (CA). Posters of Gas Station BMPs.
http://www.monterey.org/publicworks/stormeduc.html

Pinole County, CA Typical Stormwater Violations Observed in Auto Facilities and Recommended Best Management Practices (BMPs)
http://www.ci.pinole.ca.us/publicworks/downloads/AutoStormwater.pdf

H-3

Hotspot Source Area: Vehicles

VEHICLE WASHING

Description

Vehicle washing pollution prevention practices apply to many commercial, industrial, institutional, municipal and transport-related operations. Vehicle wash water may contain sediments, phosphorus, metals, oil and grease, and other pollutants that can degrade water quality. When vehicles are washed on impervious surfaces such as parking lots or industrial areas, dirty wash water can contaminate storm water that ends up in streams.

Application

Improved washing practices can be used at any facility that routinely washes vehicles. Examples include commercial car washes, bus depots, car dealerships, rental car companies, trucking companies, and fleet operations. In addition, washing dump trucks and other construction equipment can be a problem. Washing operations tend to be unevenly distributed within urban subwatersheds. Vehicle washing also occurs in neighborhoods, and techniques to keep wash water out of the storm drain system are discussed in the car washing profile sheet (N-11). Table 1 reviews some of the pollution prevention techniques available for hotspot vehicle washing operations.

Primary Training Targets

Owners, fleet managers, and employees of operations that include car washes are the primary training target.

Feasibility

Vehicle washing practices can be applied to all regions and climates. Vehicle washing tends to occur more frequently in summer months and in drier regions of the country. Sound vehicle washing practices are not always used at many sites because operators are reluctant to change traditional cleaning methods. In addition, the cost of specialized equipment to manage high volumes of wash water can be too expensive for small businesses.

Improved vehicle washing practices are relatively simple to implement and are very effective at preventing storm water contamination. Training is essential to get owners and employees to adopt these practices, and should be designed to overcome cultural and social barriers to improved washing practices.

Table 1: Pollution Prevention Practices for Vehicle Washing
• Wash vehicles at indoor car washes that recycle, treat or convey wash water to the sanitary sewer system • Use biodegradable, phosphate-free, water-based soaps • Use flow-restricted hose nozzles that automatically turn off when left unattended • Wash vehicles on a permeable surface or a washpad that has a containment system • Prohibit discharge of wash water into the storm drain system or ground by using temporary berms, storm drain covers, drain plugs or other containment system • Label storm drains with “No Dumping” signs to deter disposal of wash water in the storm drain system • Pressure and steam clean off-site to avoid runoff with high pollutant concentrations • Obtain permission from sewage treatment facilities to discharge to the sanitary sewer

Implementation Considerations

The ideal practice is to wash all vehicles at commercial car washes or indoor facilities that are specially designed for washing operations. Table 2 offers some tips for indoor car wash sites. When washing operations are conducted outside, a designated wash area should having the following characteristics:

- Paved with an impervious surface, such as Portland cement concrete
- Bermed to contain wash water
- Sloped so that wash water is collected and discharged to the sanitary sewer system, holding tank or dead-end sump
- Operated by trained workers to confine washing operations to the designated wash area

Outdoor vehicle washing facilities should use pressurized hoses without detergents to remove most dirt and grime. If detergents are used, they should be phosphate-free to reduce nutrient loading. If acids, bases, metal brighteners, or degreasing agents are used, wash water should be discharged to a treatment facility, sanitary sewer, or a sump. In addition, waters from the pressure washing of engines and vehicle undercarriages must be disposed of using the same options.

Table 2: Tips for Indoor Car Wash Sites *(Adapted from U.S. EPA, 2003)*
• Facilities should have designated areas for indoor vehicle washing where no other activities are performed (e.g. fluid changes or repair services)
• Indoor vehicle wash areas should have floor drains that receive only vehicle washing wastewater (not floor washdown or spill removal wash waters) and be connected to a holding tank with a gravity discharge pipe, to a sump that pumps to a holding tank, or to an oil/grit separator that discharges to a municipal sanitary sewer
• The floor of indoor vehicle wash bays should be completely bermed to collect wash water
• Aromatic and chlorinated hydrocarbon solvents should be eliminated from vehicle-washing operations
• Vehicle-washing operations should use vehicle rinsewater to create new wash water through the use of recycling systems that filter and remove grit.

Discharge to pervious areas may be an option for washing operations that generate small amounts of relatively clean wash water (water only - no soaps, no steam cleaning). The clean wash water should be directed as sheet flow across a vegetated area to infiltrate or evaporate before it enters the storm drain system. This option should be exercised with caution, especially in environmentally sensitive areas or protected groundwater recharge areas.

The best way to avoid stormwater contamination during washing operations is to drain the wash water to the sanitary sewer system. Operations that produce high volumes of wash water should consider installing systems that connect to the sewer. Other options for large and small operations include containment units to capture the wash water prior to transport away for proper disposal (Figure 1). If vehicles must be washed on an impervious surface, a storm drain filter should be used to capture solid contaminants.

Cost - The cost of using vehicle-washing practices can vary greatly and depends on the size of the operation (Table 3). The cost of constructing a commercial grade system connected to the sanitary sewer can exceed $100,000. Disposal fees and frequency of washing can also influence the cost. Training costs can be minimized by using educational

Figure 1: Containment System Preventing Wash Water from Entering the Storm Drain

materials available from local governments, professional associations or EPA's National Compliance Assistance Centers (http://www.assistancecenters.net/). Temporary, portable containment systems can be shared by several companies that cannot afford specialized equipment independently.

Table 3: Sample Equipment Costs for Vehicle Washing Practices	
Item	**Cost**
Bubble Buster	$2,000 –2,500*
Catch basin insert	$65*
Containment mat	$480-5,840**
Storm drain cover (24" drain)	$120.00 **
Water dike/ berm (20 ft)	$100.00 **
Pump	$75-3,000**
Wastewater storage container	$50-1,000+**
*Source: *U.S. EPA, 1992 **Robinson, 2003*	

Resources

EPA FedSite Virtual Facility Regulatory Tour, Vehicle Maintenance Facility Tour. Vehicle Washing - P2 Opportunities http://permanent.access.gpo.gov/websites/epagov/www.epa.gov/fedsite/virtual.html

Alachua County Pollution Prevention Fact Sheet: Best Management Practices for Controlling Runoff from Commercial Outdoor Car Washing. http://environment.alachua-county.org/Natural_Resources/Water_Quality/Documents/Commercial Outdoor Car Wash.pdf.

Kitsap County Sound Car Wash Program. http://www.kitsapgov.com/sswm/carwash.htm.

Washington Department of Ecology. 1995. Vehicle and Equipment Wash Water Discharges: Best Management Practices Manual. Olympia, Washington. http://www.ecy.wa.gov/pubs/95056.pdf

U.S. Environmental Protection Agency. Pollution Prevention/Good Housekeeping for Municipal Operations. http://cfpub2.epa.gov/npdes/stormwater/menuofbmps/poll_18.cfm

California Stormwater Quality Association. 2003 California Stormwater BMP Handbook: Industrial and Commercial. http://www.cabmphandbooks.com/

H-4	Hotspot Source Area: Vehicles	
	VEHICLE STORAGE	

Description

Parking lots and vehicle storage areas can introduce sediment, metals, oil and grease, and trash into storm water runoff. Simple pavement sweeping, litter control, and storm water treatment practices can minimize pollutant export from these hotspots. Table 1 provides a list of simple pollution prevention practices intended to prevent or reduce the discharge of pollutants from parking and vehicle storage areas.

Application

Pollution prevention practices can be used at larger parking lots located within a subwatershed. Examples include regional malls, stadium lots, big box retail, airport parking, car dealerships, rental car companies, trucking companies, and fleet operations (Figure 1). The largest, most heavily used parking lots with vehicles in the poorest condition (e.g., older cars or wrecked vehicles) should be targeted first. This practice is also closely related to parking lot maintenance source controls, which are discussed in greater detail in profile sheet H-11.

Primary Training Targets

Owners, fleet operation managers, and property managers that maintain parking lots are key training targets.

Figure 1: Retail Parking Lot

Table 1: Pollution Prevention Practices for Parking Lot and Vehicle Storage Areas

Parking Lots

- Post signs to control litter and prevent patrons from changing automobile fluids in the parking lot (e.g., changing oil, adding transmission fluid, etc.)
- Pick up litter daily and provide trash receptacles to discourage littering
- Stencil or mark storm drain inlets with "No Dumping, Drains to ______" message
- Direct runoff to bioretention areas, vegetated swales, or sand filters
- Design landscape islands in parking areas to function as bioretention areas
- Disconnect rooftop drains that discharge to paved surfaces
- Use permeable pavement options for spillover parking (Profile sheet OS-11 in Manual 3)
- Inspect catch basins twice a year and remove accumulated sediments, as needed
- Vacuum or sweep large parking lots on a monthly basis, or more frequently
- Install parking lot retrofits such as bioretention, swales, infiltration trenches, and storm water filters (Profile sheets OS-7 through OS-10 in Manual 3)

Vehicle Storage Areas

- Do not store wrecked vehicles on lots unless runoff containment and treatment are provided
- Use drip pans or other spill containment measures for vehicles that will be parked for extended periods of time
- Use absorbent material to clean up automotive fluids from parking lots

Feasibility

Sweeping can be employed for parking lots that empty out on a regular basis. Mechanical sweepers can be used to remove small quantities of solids. Vacuum sweepers should be used on larger parking lot storage areas, since they are superior in picking up deposited pollutants (See Manual 9). Constraints for sweeping large parking lots include high annual costs, difficulty in controlling parking, and the inability of current sweeper technology to remove oil and grease. Proper disposal of swept materials might also represent a limitation.

Implementation Considerations

The design of parking lots and vehicle storage areas can greatly influence the ability to treat storm water runoff. Many parking areas are landscaped with small vegetative areas between parking rows for aesthetic reasons or to create a visual pattern for traffic flow. These landscaped areas can be modified to provide storm water treatment in the form of bioretention (Figure 2).

Figure 2: Parking Lot Island Turned Bioretention Area

Catch basin cleanouts are also an important practice in parking areas. Catch basins within the parking lot should be inspected at least twice a year and cleaned as necessary. Cleanouts can be done manually or by vacuum truck. The cleanout method selected depends on the number and size of the inlets present (see Manual 9).

Most communities have contractors that can be hired to clean out catch basins and vacuum sweep lots. Mechanical sweeping services are available, although the cost to purchase a new sweeper can exceed $200,000. Employee training regarding spill prevention for parking areas is generally low-cost and requires limited staff time.

Resources

California Stormwater Quality Association. 2003 California Stormwater BMP Handbook: Industrial and Commercial
http://www.cabmphandbooks.com/

Stormwater Management Manual for Western Washington: Volume IV -- Source Control BMPs. WA Dept. of Ecology
http://www.ecy.wa.gov/biblio/9914.html

H-6

Hotspot Source Area: Outdoor Materials

OUTDOOR STORAGE

Description

Protecting outdoor storage areas is a simple and effective pollution prevention practice for many commercial, industrial, institutional, municipal, and transport-related operations. The underlying concept is to prevent runoff contamination by avoiding contact between outdoor materials and rainfall (or runoff). Unprotected outdoor storage areas can generate a wide range of storm water pollutants, such as sediment, nutrients, toxic materials, and oil and grease (Figure 1).

Materials can be protected by installing covers, secondary containment, and other structures to prevent accidental release. Outdoor storage areas can be protected on a temporary basis (tarps or plastic sheeting) or permanently through structural containment measures (such as roofs, buildings, or concrete berms). Table 1 summarizes pollution prevention practices available for outdoor storage areas.

Figure 1: Mulch Stored Outdoors at a Garden Center

Application

Many businesses store materials or products outdoors. The risk of storm water pollution is greatest for operations that store large quantities of liquids or bulk materials at sites that are connected to the storm drain system. Several notable operations include nurseries and garden centers, boat building/repair, auto recyclers/body shops, building supply outlets, landfills, ports, recycling centers, solid waste and composting facilities, highway maintenance depots, and power plants. Attention should also be paid to industrial operations that process bulk materials, which are often regulated under industrial storm water NPDES permits.

Primary Training Targets

Owners, site managers, facility engineers, supervisors, and employees of operations with loading/unloading facilities are the primary training target.

Feasibility

Outdoor storage protection can be widely applied in all regions and climate zones, and requires routine monitoring by employees. Most operations have used covering as the major practice to handle outdoor storage protection (U.S. EPA, 1999). The strategy is to design and maintain outdoor material storage areas so that they:

- Reduce exposure to storm water and prevent runon
- Use secondary containment to capture spills
- Can be regularly inspected
- Have an adequate spill response plan and cleanup equipment

Table 1: Pollution Prevention Practices for Protecting Outdoor Storage Areas
• Emphasize employee education regarding storage area maintenance • Keep an up-to-date inventory of materials stored outdoors, and try to minimize them • Store liquids in designated areas on an impervious surface with secondary containment • Inspect outdoor storage containers regularly to ensure that they are in good condition • Minimize storm water run-on by enclosing storage areas or building a berm around them • Slope containment areas to a drain with a positive control (lock, valve, or plug) that leads to the sanitary sewer (if permitted) or to a holding tank • Schedule regular pumping of holding tanks containing storm water collected from secondary containment areas

Implementation Considerations

Covers - The use of impermeable covers is an effective pollution prevention practice for non-hazardous materials. Covers can be as simple as plastic sheeting or tarps, or more elaborate roofs and canopies. Site layout, available space, affordability, and compatibility with the covered material all dictate the type of cover needed for a site. In addition, the cover should be compatible with local fire and building codes and OSHA workplace safety standards. Care should be taken to ensure that the cover fully protects the storage site and is firmly anchored into place.

Secondary Containment - Secondary containment is designed to contain possible spills of liquids and prevent storm water run-on from entering outdoor storage areas. Secondary containment structures vary in design, ranging from berms and drum holding areas to specially-designed solvent storage rooms (Figure 2).

Figure 2: Secondary Containment of Storage Drums Behind a Car Repair Shop

Secondary containment can be constructed from a variety of materials, such as concrete curbs, earthen berms, plastic tubs, or fiberglass or metal containers. The type of material used depends on the substance contained and its resistance to weathering. In general, secondary containment areas should be sized to hold 110% of the volume of the storage tank or container unless other containment sizing regulations apply (e.g., fire codes).

If secondary containment areas are uncovered, any water that accumulates must be collected in a sanitary sewer, a storm water treatment system, or a licensed disposal facility. Water quality monitoring may be needed to determine whether the water is contaminated and dictate the method of disposal. If the storm water is clean, or an on-site storm water treatment practice is used, a valve should be installed in the containment dike so that excess storm water can be drained out of the storage area and directed either to the storm drain (if clean) or into the storm water treatment system (if contaminated). The valve should always be kept closed except when storm water is drained, so that any spills that occur can be effectively contained. Local sewer authorities may not allow discharges from a large containment area into the sewer system, and permission must be obtained prior to discharge. If discharges to the sanitary sewer system are prohibited, containment should be provided, such as a holding tank that is regularly pumped out.

Employee training on outdoor storage pollution prevention should focus on the activities and site areas with the potential to pollute storm water and the proper techniques to manage material storage areas to prevent runoff contamination.

Training can be conducted through safety meetings and the posting of on-site informational signs. Employees should also know the on-site person who is trained in spill response.

Cost - Many storage protection practices are relatively inexpensive to install (Table 2). Actual costs depend on the size of the storage area and the nature of the pollution prevention practices. Other factors are whether practices are temporary or permanent and the type of materials used for covers and containment. Employee training can be done in connection with other safety training to reduce program costs. Training costs can also be reduced by using existing educational materials from local governments, professional associations or from EPA's National Compliance Assistance Centers (http://www.assistancecenters.net).

Table 2: Sample Equipment Costs for Outdoor Storage Protection

Storage Protection Device	Cost
Concrete Slab (6")	\$3.50 to \$5.00 per ft^2
Containment Pallets	\$50 to \$350 based on size and # of barrels to be stored
Storage buildings	\$6 to \$11 per ft^2
Tarps & Canopies	\$25 to \$500 depending on size of area to cover
Sources: Costs were derived from a review of Ferguson et al.*, 1997 and numerous websites that handle proprietary spill control or hazardous material control products*	

Resources

California Stormwater Quality Association. 2003 California Stormwater BMP Handbook: Industrial and Commercial. http://www.cabmphandbooks.com/

Rouge River National Wet Weather Demonstration Project. Wayne County, MI. http://www.rougeriver.com/geninfo/rougeproj.html

Storm Water Management Fact Sheet: Coverings. USEPA, Office of Water, http://www.epa.gov/owm/mtb/covs.pdf.

EPA Office of Wastewater Management Storm Water Management Fact Sheet: Coverings http://www.epa.gov/owm/mtb/covs.pdf

California Stormwater Quality Association Factsheet: Outdoor Storage of Raw Materials http://www.cabmphandbooks.com/Documents/Municipal/SC-33.pdf

Alameda Countywide Clean Water Program Outdoor Storage of Liquid Materials http://www.cleanwaterprogram.com/outdoor_stor_liquid_fact_sht.pdf

Washtenaw County, MI Community Partners for Clean Streams Fact Sheet Series #1: Housekeeping Practices http://www.ewashtenaw.org/content/dc_drnbmp1.pdf

H-8

Hotspot Source Area: Waste Management

DUMPSTER MANAGEMENT

Description

Dumpsters provide temporary storage of solid wastes at many businesses. Most dumpsters are unregulated hotspots that can be a significant pollution source in many subwatersheds. Many dumpsters are open, which allows rainfall to mix with the wastes, creating a potent brew affectionately known as “dumpster juice.” When combined with the inevitable spillage, dumpsters can be a source of trash, oil and grease, metals, bacteria, organic material, nutrients, and sediments. Poor dumpster management can make a site unsightly, create unpleasant odors, and attract rodents (Figure 1). Table 1 lists some common pollution prevention practices for dumpsters.

Application

Every business generates waste as a part of its daily operations and temporarily stores it pending disposal by an independent contractor. Nearly every hotspot site has a ubiquitous dumpster located somewhere behind the building. Several factors should be evaluated to determine whether an individual dumpster could be a pollution source. The first is whether the dumpster pad is directly connected to the storm drain system. The second factor is how frequently the dumpster is emptied. Frequently emptied dumpsters usually have more spillage and are open more often and exposed to rainfall. The last factor is the type and moisture content of wastes thrown in the dumpster, which can include trash, yard waste, building rubble, food, or other waste products.

Figure 1: Dumpster Site with Typical Signs of Poor Management (trash accumulation, dumpster without lid, dumpster near storm drain)

Good dumpster management is particularly important to reduce trash loadings to a stream. Several kinds of hotspots deserve scrutiny if they exist in a subwatershed, including dumpsters serving convenience stores, fast food restaurants, shopping centers, recycling centers, solid waste collection areas and hospitals. It may useful to target waste haulers as well, since the placement of temporary open dumpsters for demolition, remodeling and other construction purposes can be a problem in some subwatersheds.

Primary Training Targets

Key education targets are the managers and employees that use the dumpster.

Feasibility

Dumpster pollution prevention practices can be applied in all regions and climate zones.

Table 1: Pollution Prevention Practices for Dumpsters
• Locate dumpsters on a flat concrete surface that does not slope or drain to the storm drain system
• Install a secondary containment system such as a berm or curb around the dumpster if it is connected to the storm drain
• Install protective covers or lids to keep rainfall from accumulating in the dumpster or secondary containment area
• Close lids at dumpsters located at vehicle service areas, fast food restaurants, and convenience stores
• Install an oil and grease separator or sump pit for dumpsters that receive waste with a high moisture content
• Place clear and visible signs on dumpsters indicating what kind of waste can be accepted
• Never throw oil and grease or other liquids into a dumpster - provide alternative disposal locations for impermissible substances
• Close and secure lids properly when the dumpster is not being loaded or unloaded
• Empty dumpsters on a frequent basis to prevent overfilling or storage outside the dumpster
• Repair leaking or damaged dumpsters immediately
• Never use bleach and soap to clean the container unless the wash water is sent to the sanitary sewer system
• Pick up and sweep trash and litter from around the dumpster regularly

Implementation Considerations

Dumpster pollution prevention practices can be hard to implement. Perhaps the greatest challenge is changing the mindset of employees about proper disposal techniques. Since dumpster practices require additional effort, owners need to train staff and inspect dumpsters more frequently. Lastly, dumpster practices that require liquids/oil and grease separation or secondary containment may be costly for many small businesses.

Target Areas for Education and Enforcement- Education and enforcement should be targeted to specific types of dumpsters that are known hotspots and/or have high potential for environmental contamination. These include:

- Foodservice dumpsters that produce waste with high moisture content and oil and grease that can be easily carried by storm water runoff (Figure 2)
- Automobile service dumpsters that can potentially produce a high volume of wastes, such as oil and grease, cleaning fluids, used parts, filters, and rags
- Industrial dumpsters that produce a high volume and variety of wastes
- Dumpsters with multiple contributors, such as multi-family units, and institutional facilities
- Temporary dumpster locations at small construction sites, demolition projects, and redevelopment projects

Figure 2: Restaurant Waste Barrels Without Secondary Containment

Routine Inspection - Dumpsters should be routinely inspected for the following problems:

- Cracks or dents in the dumpster that may permit storm water run-on
- Poorly functioning lids that cannot be closed or secured
- Hydraulic hoses with cracks or leaks (if applicable)
- Presence of impermissible substances in the container
- Liquid leaking from the container and/or signs of previous leakage, which are often indicated by stains or deposits on ground or storm drain inlets

Working with Solid Waste Disposal Contractor - Choosing a reliable and environmentally-conscious waste disposal contractor is important to prevent storm water contamination. Routine maintenance and emptying of the dumpster by the solid waste disposal contractor should be performed on a regular basis. If concerns about the condition of the dumpster or collection process arise (e.g. dumpster put in wrong location, dented corners, infrequent dumping, etc.), the service should be contacted immediately.

Cost - Proper dumpster management is a relatively inexpensive storm water pollution prevention practice and avoids the liability for spills and/or containment. Operational costs depend on the volume and type of waste, frequency of maintenance (e.g., replacing damaged containers), and whether additional protective measures need to be installed, such as secondary containment systems, canopies, and signs.

Operational costs are primarily related to training workers on proper dumpster management. Frequent training is needed to maintain compliance by workers, particularly in high turnover businesses.

Resources

California Stormwater BMP Handbook: Industrial and Commercial
http://www.cabmphandbooks.com/

Storm Water BMP #4. Solid Waste Containers (Dumpsters/Compactors)
http://www.cleancharles.org/stormwater_bmp4.shtml

North Central Texas Council of Governments (NCTCOG) Building Maintenance BMP Fact Sheet
http://www.dfwstormwater.com/P2/PDF/p2bldg_bmps.pdf

San Mateo Countywide Storm Water Pollution Prevention Program: Storm Water Best Management Practices for Supermarkets and Grocery Stores
http://www.flowstobay.org/pdfs/bmp/Food/grocery.pdf

Harvard University Stormwater Bmp: Solid Waste Container
http://www.uos.harvard.edu/ehs/env_sbmp4.shtml

California Stormwater Quality Association Factsheet: Waste Handling and Disposal
http://www.cabmphandbooks.com/Documents/Municipal/SC-75.pdf

City of Rancho Santa Margarita Waste Handling and Disposal
http://www.cityofrsm.org/civica/filebank/blobdload.asp?BlobID=1772

Stanford University SLAC Stormwater BMP Factsheet: Waste Handling and Disposal
http://www.slac.stanford.edu/esh/epr/Stormwater/BMP9.html

H-12

Hotspot Source Area: Turf and Landscaping

TURF MANAGEMENT

Description

Many non-residential areas in a subwatershed have significant areas of intensively managed turf. Examples include road and utility rights-of-way, schools, ball fields, parks, corporate office parks and the grounds of large institutions, each of which has a different turf management regime (Figure 1). Turf management involves mowing, fertilization, pesticide application, and supplemental irrigation, where needed. These services are generally performed by a lawn care/landscaping contractor or an in-house maintenance crew. Poor turf management practices have the potential to create storm water pollution, particularly in urban areas where soils are compacted. Potential pollutants generated by poor turf management include nutrients, herbicides, organic carbon and sediment. In addition, poor irrigation practices can produce nuisance water in some subwatersheds.

Table 1 summarizes a series of simple pollution prevention practices for turf management to reduce this potential pollution source. Turf management practices are implemented by educating, training and certifying workers in the lawn care industry.

Figure 1: Extensive Turf Areas Commonly Found in Schoolyards

Application

The typical distribution of turf cover in three Mid-Atlantic states is shown in Table 2. As can be seen, home lawns constitute 67% of the total turf cover. Pollution prevention practices for residential lawns are described in profile sheets N-1 through N-8. Non-residential turf comprises about a third of the total turf cover (although the exact percentage will vary from subwatershed to subwatershed).

Municipal turf accounts for about two-thirds of non-residential turf, and includes roadside rights-of-way, public open space, parks and schools. Institutional turf, commercial turf and golf courses each represent about 10% of non-residential turf. With the exception of airports and sod farms, turf cover is generally rare at most industrial sites.

In terms of the intensity of turf management, golf courses, institutions, and corporate office parks usually receive the highest inputs of water, fertilizer, and pesticides. Turf management on municipal lands tends to be fairly modest, with the exception of athletic fields at schools and some park settings. Highway and power line rights-of-way are seldom fertilized or irrigated, although they are increasingly sprayed with herbicides to limit vegetative growth in places that cannot be safely or conveniently mowed. Recent research has linked roadway and utility herbicide use to the presence of atrazine and simazine in urban streams. These herbicides were detected in streams where they were used to control vegetation in rights-of-way, but were not available to residential homeowners for retail sale (USGS, 1999).

Table 1: Pollution Prevention for Turf Management
• Evaluate whether some or all of the turf area can be managed as meadow or forest. If so, consider watershed reforestation techniques (see Manual 7) • Sweep any grass clippings away from paved surfaces after mowing • Use mulching type mowers to return grass clippings to the lawn • Never apply fertilizers or pesticides within five feet of pavement, 25 feet of a storm drain inlet, or 50 feet of a stream or water body • Consider a low or no fertilizer approach to maintain turf • Select a reputable lawn care or landscape service that uses organic fertilizers and natural pest management techniques • Perform a soil test to determine actual fertilization need and set application rates • Calibrate fertilizer spreaders to avoid excessive application. Do not apply fertilizer just prior to predicted rainfall events or on wet turf • Do not prepare herbicides or pesticides for application near storm drains • Minimize off-target application of fertilizers, and leave a no-application zone for fertilizer and pesticides around streams and lakes • Work fertilizers into the soil rather than just applying onto the surface • Reduce water needs during the hot summer months by adjusting grass to an increased height • Consider turf alternatives, such as native or low-water, cool-season turf grasses • Select grass species that will best meet the requirements and purposes of the lawn area • Use synthetic turf for small, lightly used and inaccessible areas that require no watering, chemicals, or mowing

Primary Training Targets

The training targets for this practice include property managers; landscaping contractors; golf course managers; and road, park, and utility maintenance crews and supervisors.

Table 2: Distribution of Turf Cover by Sector in Three Mid-Atlantic States	
Sector	**% of Total Turf Cover**
Home Lawns	67
Roadside Rights-of-Way	10
Municipal Open Space	7
Parks	3.5
Schools	3
Commercial/Corporate	3
Institutions	3
Golf Courses	2.5
Airports/Sod Farms	1
Source: Schueler, 2003	

Feasibility

Turf grass management practices vary regionally, in response to different growing seasons, rainfall amounts and soil types. As Swann (1999) notes, arid and semi-arid areas rely heavily on supplemental irrigation, whereas the practice is less common in humid regions. Herbicide use tends to be greater in northern regions, while outdoor insecticide use is greatest in southern regions. To reduce the quantity of products used to manage turf, consult the local cooperative extension service for advice on the most appropriate grass species depending on its intended use.

A second key feasibility factor is the nature of the local lawn care industry. In many regions, it tends to be a low-wage, seasonal industry that employs young workers. These workers often have limited education, may not speak English, and have high turnover rates. As a result, education programs targeted toward the industry need to be simple, multi-lingual, and frequently repeated.

Implementation Considerations

In general, healthy and attractive turf is produced by good pollution prevention practices. A number of factors influence turf health, which can be stressed by mowing activity. Mowing grass too short causes turf to become less tolerant of environmental stresses, more disease-prone and more reliant on pesticides, fertilizers and irrigation. Mowing only a third of the grass blade height during cooler times of the day can minimize turf stress. Areas where soil is compacted may require aeration or soil amendments in order to increase permeability.

Equipment modifications may also be necessary to reduce environmental impacts. Fertilizer application equipment should be calibrated frequently (see the Resources section for more tips). Granular spreaders need to be calibrated for each product, since each fertilizer requires a different spreader setting to provide the desired rate of fertilizer. Liquid fertilizers should be applied using coarse droplet nozzles with a close/tight spray pattern at the lowest pumping pressure to avoid drift onto non-turf areas.

Professional training is extremely important to successfully implement turf management practices. Lawn care company employees can be trained on the proper calibration, use, and application techniques for the equipment they will use. Local governments have found that certification classes and promotional tie-ins can promote changes in the practice of professional landscape and lawn care companies. Examples include training, certification, and recognition programs for environmentally sensitive golf course management (See Profile Sheet H-15 for resources designed specifically for golf course managers).

Educating lawn care professionals on turf pollution prevention practices is an excellent way to improve local water quality. Messages to highlight in any education program include:

- Local information on proper timing and application rates for fertilizers and pesticides
- Registration and permit requirements for professional landscaping and lawn care service companies
- Recommended management practices and guidelines for reducing maintained turf area

Cost - Costs consist largely of program efforts for training and education, with only small operational costs to implement turf management practices. It is often reasonable to assume that operational savings from reduced fertilizer and herbicide inputs will offset any increased costs for more intensive practices, such as manual weed removal. Replacement of turf areas should also reduce mowing costs. A study in North Marin County, CA compared traditionally landscaped projects to projects that met specific design criteria for water conservation. The study found that when costs for water, labor, fertilizer, fuel, and herbicide were considered, annual savings of $75 per dwelling unit were realized for the water-conserving projects (Iwata, 1994). Water-conserving landscapes averaged 55% less turf area; used 54% less water; and saved 25% in labor costs, 61% in fertilizer, 44% in fuel, and 22% in herbicides, with a overall total of 10% less landscaped area.

Resources

California Stormwater BMP Handbook: Industrial and Commercial.
http://www.cabmphandbooks.com/

Xeriscape: Winning the Turf War Over Water
http://hem.dis.anl.gov/eehem/94/940711.html

University of Florida Cooperative Extension How to Calibrate a Fertilizer Spreader
http://turf.ufl.edu/residential/fertspreader.htm

Turf and Landscape Irrigation Best Management Practices. Prepared by the Water Management Committee of The Irrigation Association
http://www.irrigation.org/gov/default.aspx?r=1&pg=bmps.htm

Health Dangers of Urban Use of Pesticides Working Group. Sustainable Municipal Turf Management. Region of Ottawa-Carleton, Ontario Canada
http://www.sankey.ws/ipm.html

US EPA. Integrated Pest Management (IPM) in Schools
http://www.epa.gov/pesticides/ipm/

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities.
http://www.swrcb.ca.gov/stormwtr/murp.html

Stormwater Management Manual for Western Washington: Volume IV -- Source Control BMPs. WA Dept. of Ecology, Olympia, WA.
http://www.ecy.wa.gov/biblio/9914.html

Landscaping for Stormwater Management
http://www.dep.state.fl.us/law/Documents/Grants/CMP/pdf/stormwatermems.pdf

St. Johns River Water Management District Florida Landscaping to Promote Water Conservation Using the Principles of Xeriscape
http://sjr.state.fl.us/programs/outreach/conservation/landscape/toc.html

N-1	Neighborhood Source Area: Yard	
	REDUCED FERTILIZER USE	

Description

The ideal behavior is to not apply fertilizer to lawns. The next best thing for homeowners who feel they must fertilize is to practice natural lawn care: using low inputs of organic or slow release fertilizers that are based on actual needs as determined by a soil test. The obvious negative watershed behavior is improper fertilization, whether in terms of the timing, frequency or rate of fertilizer applications, or a combination of all three. The other important variable to define is who is applying fertilizer in the neighborhood. Nationally, about 75% of lawn fertilization is done by homeowners, with the remaining 25% applied by lawn care companies (Figure 1). This split, however, tends to be highly variable within individual neighborhoods, depending on its income and demographics.

How Fertilizer Influences Water Quality

Recent research has demonstrated that lawn over-fertilization produces nutrient runoff with the potential to cause downstream eutrophication in streams, lakes, and estuaries (Barth, 1995a and 1995b). Scientists have also discovered that nitrogen and phosphorus levels in lawn runoff are about two to 10 times higher than any other part of the urban landscape such as streets, rooftops, driveways or parking lots (Bannerman *et al.*, 1993; Steuer *et al.*, 1997; Waschbusch *et al.*, 2000; Garn, 2002).

Figure 1: Lawn Care Company Truck

Percentage of People Engaging in Fertilizer Use

Lawn fertilization is among the most widespread watershed behaviors in which residents engage. A survey of lawn care practices in the Chesapeake Bay indicated that 89% of citizens owned a yard, and of these, 50% applied fertilizer every year (Swann, 1999). The average rate of fertilization in 10 other regional lawn care surveys was even higher (78%), although this may reflect the fact that these surveys were biased towards predominantly suburban neighborhoods and excluded non-lawn owners. Several studies have measured the frequency of lawn fertilization, and have found that lawns are fertilized about twice a year, with spring and fall being the most common season for applications (Swann, 1999).

A significant fraction of homeowners can be classified as "over-fertilizers" who apply fertilizers above recommended rates. Surveys indicate the number of over-fertilizers at 50% to 70% of all fertilizers (Morris and Traxler, 1996; Swann, 1999; Knox *et al.*, 1995). Clearly, many homeowners, in a quest for quick results or a bright green lawn, are applying more nutrients to their lawns than they actually need.

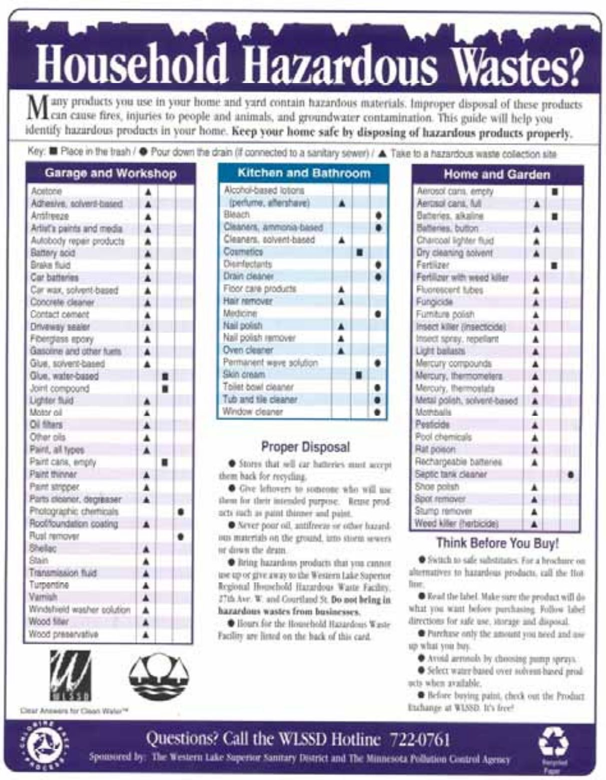
Variation in Fertilization Behavior

Many regional and neighborhood factors influence local fertilization behavior. From a regional standpoint, climate is a very important factor, as it determines the length of the growing season, type of grass, and the irrigation needed to maintain a lawn. A detailed discussion of the role these factors play in fertilization can be

N-14	Neighborhood Source Area: Garage
	HOUSEHOLD HAZARDOUS WASTE COLLECTION

Description

The average garage contains many products that are classified as hazardous waste, including paints, stains, solvents, used motor oil, excess pesticides, and cleaning products. The ideal watershed behavior is to regularly participate in household hazardous waste (HHW) collection days, and to be careful when rinsing paintbrushes, cleaning pesticide applicators and fertilizer spreaders, and fueling outdoor power equipment (Figure 1). The negative watershed behavior is continued storage, improper disposal or illegal dumping of household hazardous wastes, and poor cleaning, refueling and rinsing practices.



Household Hazardous Wastes?

Many products you use in your home and yard contain hazardous materials. Improper disposal of these products can cause fires, injuries to people and animals, and groundwater contamination. This guide will help you identify hazardous products in your home. **Keep your home safe by disposing of hazardous products properly.**

Key: ■ Place in the trash / ● Pour down the drain (if connected to a sanitary sewer) / ▲ Take to a hazardous waste collection site

Garage and Workshop			
Acetone	▲		
Adhesive, solvent-based	▲		
Antifreeze	▲		
Artist's paints and media	▲		
Autobody repair products	▲		
Battery acid	▲		
Brake fluid	▲		
Car batteries	▲		
Car wax, solvent-based	▲		
Concrete cleaner	▲		
Contact cement	▲		
Driveway sealer	▲		
Fiberglass epoxy	▲		
Gasoline and other fuels	▲		
Glue, solvent-based	▲		
Glue, water-based		■	
Joint compound		■	
Lighter fluid	▲		
Motor oil	▲		
Oil filters	▲		
Other oils	▲		
Paint, all types	▲		
Paint cans, empty		■	
Paint thinner	▲		
Paint stripper	▲		
Parts cleaner, degreaser	▲		
Photographic chemicals			●
Roof/foundation coating	▲		
Rust remover			●
Shellac	▲		
Stain	▲		
Transmission fluid	▲		
Turpentine	▲		
Varnish	▲		
Windshield washer solution	▲		
Wood filler	▲		
Wood preservative	▲		

Kitchen and Bathroom			
Alcohol-based lotions (perfume, aftershave)	▲		
Bleach			●
Cleaners, ammonia-based			●
Cleaners, solvent-based	▲		
Cosmetics		■	
Disinfectants			●
Drain cleaner			●
Floor care products	▲		
Hair remover	▲		
Medicine			●
Nail polish	▲		
Nail polish remover	▲		
Oven cleaner	▲		
Permanent wave solution			●
Skin cream		■	
Toilet bowl cleaner			●
Tub and tile cleaner			●
Window cleaner			●

Home and Garden			
Aerosol cans, empty		■	
Aerosol cans, full	▲		
Batteries, alkaline		■	
Batteries, button	▲		
Charcoal lighter fluid	▲		
Dry cleaning solvent	▲		
Fertilizer		■	
Fertilizer with weed killer	▲		
Fluorescent tubes	▲		
Fungicide	▲		
Furniture polish	▲		
Insect killer (insecticide)	▲		
Insect spray, repellant	▲		
Light ballasts	▲		
Mercury compounds	▲		
Mercury, thermometers	▲		
Mercury, thermostats	▲		
Metal polish, solvent-based	▲		
Mothballs	▲		
Pesticide	▲		
Pool chemicals	▲		
Rat poison	▲		
Rechargeable batteries	▲		
Septic tank cleaner			●
Shoe polish	▲		
Spot remover	▲		
Stump remover	▲		
Weed killer (herbicide)	▲		

Proper Disposal

- Stores that sell car batteries must accept them back for recycling.
- Give leftovers to someone who will use them for their intended purpose. Reuse products such as paint thinner and paint.
- Never pour oil, antifreeze or other hazardous materials on the ground, into storm sewers or down the drain.
- Bring hazardous products that you cannot use up or give away to the Western Lake Superior Regional Household Hazardous Waste Facility, 27th Ave. W. and Courtland St. **Do not bring in hazardous wastes from businesses.**
- Hours for the Household Hazardous Waste Facility are listed on the back of this card.

Think Before You Buy!

- Switch to safe substitutes. For a brochure on alternatives to hazardous products, call the Hot line.
- Read the label. Make sure the product will do what you want before purchasing. Follow label directions for safe use, storage and disposal.
- Purchase only the amount you need and use up what you buy.
- Avoid aerosols by choosing pump sprays.
- Select water-based over solvent-based products when available.
- Before buying paint, check out the Product Exchange at WLSSD. It's free!

Clear Answers for Clean Water™

Questions? Call the WLSSD Hotline 722-0761

Sponsored by: The Western Lake Superior Sanitary District and The Minnesota Pollution Control Agency

Figure 1: Household Hazardous Waste Disposal Guidelines

Source: http://www.duluthstreams.org/understanding/impact_oil.html

How It Influences Water Quality

According to EPA, the average home/garage accumulates as much as 100 pounds of household hazardous waste per year**.** Nationally, households are collectively estimated to generate more than 1.6 million tons of household hazardous wastes annually. The proportion of HHW that reaches the storm drain system is not well known. Most HHW appears to be stored indefinitely, thrown out with the trash, or flushed down the sink/toilet, which is not environmentally acceptable. The key unknown is what fraction of HHW is illegally dumped into the storm drain. It is probable that most HHW enters the storm drain system during outdoor rinsing of pesticide applicators and outdoor painting cleanup. HHW that reaches the storm drain system can potentially be toxic to downstream aquatic life.

Percentage of Residents Engaging in HHW Collection

Homeowner participation in HHW collection programs is usually quite low, with several studies indicating participation rates of one to 5% (HGAC, 2004).

Variation in Participation

Convenience and awareness appear to be critical factors influencing participation in household hazardous waste collection programs. Participation is inversely related to the distance homeowners must travel to recycle waste, restrictions on what can be accepted and the number of days each year that collection events are held.

Techniques to Increase Participation

Communities continue to experiment with improved techniques to make HHW collection more convenient for residents, including:

- Mass media campaigns to educate residents on proper outdoor cleaning/rinsing
- Conventional outreach to notify residents about HHW collection days
- More frequent HHW collection days
- Providing curbside disposal options for certain HHW
- Establishing permanent collection facilities at solid waste facilities
- Providing mobile HHW pickup
- Waiving disposal fees at landfills
- Storm drain marking (see N-21)

Good Examples

The City of Denver Pilot Door-to-Door HHW Collection Program. This unique program assists residents in proper disposal and recycling of household hazardous wastes. Residents are permitted one HHW collection annually and receive a collection date and an HHW Kit that can hold up to 75 pounds. The program not only provides a curbside pick-up program for household hazardous waste, but also educates citizens on how to prevent the accumulation of chemicals in the garage.
http://www.denvergov.org/admin/template3/forms/INSERT1.pdf

King County Wastemobile. The Wastemobile is a traveling collection program that goes to two sites in the county per month to accept HHW and provide information about alternatives to hazardous products. The Wastemobile is funded through a surcharge on solid waste disposal and wastewater discharge, and residents utilizing the Wastemobile are not charged a fee on site.
http://www.govlink.org/hazwaste/house/disposal/wastemobile/

Top Resources

EPA Household Hazardous Waste Website
http://www.epa.gov/epaoswer/non-hw/muncpl/hhw.htm

Guide to Household Hazardous Wastes
http://www.epa.gov/grtlakes/seahome/housewaste/house/products.htm

Household Hazardous Waste: Steps to Safe Management
A guide for residential homeowners that describes household hazardous waste and the dangers of improper disposal.
http://www.epa.gov/epaoswer/non-hw/househld/hhw.htm

Household Hazardous Waste (HHW) Management: A Manual for One Day Community Collection Programs
A manual that helps communities plan for one-day, drop-off HHW collection programs. Provides community leaders with guidance on all aspects of planning, organizing, and publicizing a HHW collection program.
http://www.epa.gov/epaoswer/non-hw/househld/hhw/cov_toc.pdf

Department of Defense - Household Hazardous Waste Topic Hub
http://wrrc.p2pays.org/p2rx/toc.cfm?hub=16&subsec=7&nav=7&CFID=23448&CFTOKEN=55325833

Household/Small Business Hazardous Waste: A Manual for Sponsoring a Collection Event
http://www.dep.state.pa.us/dep/deputate/airwaste/wm/Hhw/Documents/TechMan.pdf

N-15	Neighborhood Source Area: Driveway	
	CAR FLUID RECYCLING	

Description

The ideal watershed behavior is to have automotive fluids changed at a commercial operation where stringent pollution source controls and fluid recycling practices are in place. The next best alternative is to perform car maintenance under cover within the garage, and carefully dispose of all oil, antifreeze and other fluids at approved recycling facilities. The negative behavior is to improperly store, dump or otherwise dispose of car fluids into the storm drain system.

How Fluid Changing Influences Water Quality

Dumping automotive fluids down storm drains can be a major water quality problem, since only a few quarts of oil or a few gallons of antifreeze can have a major impact on small streams. Dumping can be a major source of hydrocarbons, oil/grease, metals, xylene and other pollutants to a stream, and are potentially toxic if dumped during dry-weather conditions when existing flow cannot dilute these discharges. The major culprit has been the backyard mechanic who changes his or her own automotive fluids (Figure 1). It has been estimated that do-it-yourself mechanics improperly dispose of 192 million gallons of used oil into the environment each year (University of Missouri, 1994). It remains unclear what fraction of the improper disposal of motor oil occurs within the storm drain system.

Figure 1: Fluid Changing on Driveway

Percentage of People Engaging in Improper Disposal

The number of backyard mechanics who change their own oil and antifreeze has been dropping steadily in recent decades. With the advent of the $20 oil change, only about 30% of car owners still change their own oil or antifreeze (Swann, 2001). Backyard mechanics have traditionally been the target of community oil recycling and storm drain marking programs. These programs appear to have been quite effective, since more than 80% of backyard mechanics claim to dispose of or recycle these fluids properly (Smith, 1996; PRG, 1998; Assing, 1994). Most backyard mechanics were more prone to recycle oil than antifreeze. Backyard mechanics that indicated they had improperly disposed of automotive fluids reported that they dumped it into trashcans rather than the storm drain system. Oil and antifreeze dumping is considered socially unacceptable in many communities, and, according to Swann (2001), less than 5% of backyard mechanics report that they illegally dump oil.

Variation in Car Fluid Disposal

Neighborhood demographic and income levels appear to be important factors governing the number of "do-it-yourselfers" in a given subwatershed. As with other residential behaviors, proper disposal of oil and anti-freeze is primarily influenced by the ease, convenience and costs for accepting these fluids at local service stations or municipal collection stations.

Techniques to Change Car Fluid Disposal

While used oil collection has been a common municipal service for many years, some communities are continuously refining their programs to increase participation (Figure 2). These techniques include:

- Conventional outreach materials provided at point of sale (e.g., auto parts stores, service stations)
- Multilingual outreach materials
- Community oil recycling
- Directories of used oil collection stations
- Free or discounted oil disposal containers
- Storm drain marking

Figure 2: Frisbee Advertising Oil Recycling

Good Examples

King County Kiosks (Washington). Thirty interactive kiosks on oil recycling were placed in King County licensing offices, county buildings and other locations. In addition, a direct mail campaign to 6,000 households and three newspaper ads were used to distribute coupons good for product or service discounts that could be used when dropping off oil at participating sites.

California's Used Oil Recycling Program Incentive Program. Residents can receive incentives from certified centers that recycle used oil. Certified centers must accept used oil from the public at no charge during business hours and offer a $0.16 per gallon recycling incentive. In turn, only certified used oil collection centers can file a claim for recovery of the $0.16 per gallon it pays out. Certified centers can also claim the recycling incentive for all used oil generated on site from their business as an inducement to take oil from the public. http://www.ciwmb.ca.gov/BoardInfo/ProgramResp/SpecialWaste/HHW.htm - Public%20Info

Top Resources

Car Care for Do-It-Yourselfers
http://www.monterey.org/publicworks/carcare.html

Car Care for Cleaner Water
http://clean-water.uwex.edu/pubs/stormie/carcare.pdf

Motor Vehicle Maintenance
http://www2.ctahr.hawaii.edu/oc/freepubs/pdf/HH-15.pdf

How To Set Up a Local Program to Recycle Used Oil - Explains the organization, design, implementation, and promotion of a used oil program, as well as administrative issues. Includes sample brochures and letters. http://www.epa.gov/epaoswer/non-hw/recycle/89039a.pdf

N-16	Neighborhood Source Area: Rooftop
	DOWNSPOUT DISCONNECTION

Description

Downspout disconnection spreads rooftop runoff from individual downspouts across the lawn or yard where it filters or infiltrates into the ground. While some disconnections are simple, most require the installation of an on-site storm water retrofit practice. These simple practices capture, store and infiltrate storm water runoff from residential lots, and include rain barrels, rain gardens, French drains or dry wells. *Rain barrels* capture runoff from rooftops and are typically installed on individual roof leaders. Runoff captured in the barrel is stored for later use as supplemental irrigation. *Rain gardens* are shallow, landscaped depressions in the yard used to store and infiltrate runoff from rooftops and other impervious surfaces on the lot. *French drains and dry wells* are shallow small stone trenches used to infiltrate rooftop runoff into the ground, where soils are permeable. More details about on-site retrofit practices can be found in Profile Sheets 0S-15 through 0S-17 in Manual 3.

The ideal watershed behavior is to disconnect all downspouts so individual rooftops deliver no runoff to the storm drain system or stream. The negative watershed behavior is to pipe downspouts across the yard and into the curb or street in order to promote positive drainage (Figure 1).

How Downspout Disconnection Influences Subwatershed Quality

Downspout disconnection reduces the amount of impervious cover on a developed lot that can generate stormwater runoff. In addition to reducing the volume of runoff, downspout disconnection promotes groundwater recharge, reduces storm water runoff volumes, and filters out pollutants through the lawn soil. Since each individual retrofit for downspout disconnection treats only a few hundred or thousand square feet of impervious cover, dozens or hundreds are needed to make a measurable difference at the subwatershed level. Consequently, an intensive campaign to target education, technical assistance, and financial resources within a neighborhood or subwatershed to encourage widespread adoption of disconnection is needed.

Percentage of Residents Engaging in Downspout Disconnection

Data is not currently available to estimate the rate at which homeowners voluntarily disconnect downspouts. The frequency of this behavior is thought to be extremely low in most neighborhoods unless a community aggressively promotes and subsidizes disconnections. If this occurs, homeowner participation rates of 20 to 30% have been reported in pilot projects (Environment Canada, 2001).

Figure 1: Downspout Intentionally Bypassing Landscaped Area and Draining onto Driveway

Variation in Downspout Disconnection

The potential to disconnect downspouts is normally evaluated as part of the Neighborhood Source Assessment component of the USSR survey (see Manual 11). The most important neighborhood factor is the proportion of existing homes directly connected to the storm drain system. Negative neighborhood factors include the presence of basements, compacted soils, and poor neighborhood awareness or involvement. Positive factors are large rooftop areas that are directly connected to the storm drain system, lots with extensive tree canopy, and good neighborhood housekeeping. In general, large residential lots are most suitable for most disconnection retrofits (1/4 acre lots and larger), although rain barrels can be used on lots as small as 4,000 square feet (Figure 2).

To date, the impetus for most disconnection retrofit programs has been to separate residential storm water from sewer flows in older neighborhoods in order to minimize basement sewer backups or combined sewer overflows.

Figure 2: Rain Barrel Used on a Back, Second Floor Balcony

Techniques to Promote Downspout Disconnection

Communities are experimenting with many different carrots to promote disconnection retrofits, including:

- Conventional outreach materials (flyers, brochures, posters)
- Free or discounted rain barrel distribution
- Municipal or schoolyard demonstration projects
- Credits or subsidies for disconnection retrofits
- Direct technical assistance
- Provision of discounted mulch, piping or plant materials
- Modification of sewer and storm water ordinances to promote disconnection
- Mandatory disconnection for targeted subwatersheds

Good Examples

Downspout Disconnection Program (Portland, OR). The City offers residents a credit of $53 per disconnection in the form of a check or a one-time lump sum credit toward their sewer bill after inspection and approval of the work. In addition, neighborhood associations and other civic groups (churches, schools, etc.) can earn $13 for every downspout they disconnect. http://www.portlandonline.com/bes/index.cfm?c=32144

Rain Blocker Program (*City of Chicago)*. The Rain Blocker pilot program is specifically designed to eliminate or greatly reduce the amount of basement flooding caused by sewer surcharge. The program works by restricting the rate of storm water flow into the city sewer system, via installing vortex restrictors within the catch basins of city streets and through downspout disconnection from buildings. http://www.cityofchicago.org/WaterManagement/blocker.html

Neighborhood Rain Gardens (Minneapolis, MN). This program works with neighborhood associations to encourage landscaping for rainwater management. The Fulton Neighborhood Association has worked with eight homeowners to install rain gardens, rain barrels, gutter downspout redirection, and infiltration systems that reduce runoff delivered from individual properties to streets, alleys and sidewalks.
http://www.fultonneighborhood.org/lfrwm.htm

Top Resources

How to Disconnect Your Downspouts (Portland Oregon)
http://www.portlandonline.com/bes/index.cfm?c=32144

Milwaukee Downspout Disconnection Program
http://www.mmsd.com/projects/downspout.cfm

Boston Water and Sewer Commission's Downspout Disconnection Program
http://www.bwsc.org/Customer_Service/Programs/downspout.htm

RainGardens.org
http://www.raingardens.org/

Rain Gardens: A how-to manual for homeowners
http://www.dnr.state.wi.us/org/water/wm/dsfm/shore/documents/rgmanual.pdf

Rain Garden Applications and Simple Calculations
http://www.cwp.org/Community_Watersheds/Rain_Garden.htm

How to Build and Install a Rain Barrel
http://www.cwp.org/Community_Watersheds/brochure.pdf

Skills for Protecting Your Stream: Retrofitting Your Own Backyard
http://www.cwp.org/Community_Watersheds/Retrofitting_Backyard.pdf

N-18	Neighborhood Source Area: Common Areas
	PET WASTE PICKUP

Description

The ideal watershed behavior is to pick up and properly dispose of pet waste (Figure 1). The negative watershed behavior is to leave pet waste in common areas and the yard, where it can be washed off in storm water runoff.

How Pet Waste Influences Subwatershed Quality

Pet waste has been found to be a major source of fecal coliform bacteria and pathogens in many urban subwatersheds (Schueler, 1999). A typical dog poop contains more than three billion fecal coliform bacteria and as many as 10% of dogs are also infected with either *giardia* or salmonella*,* which is not surprising considering they drink urban creek water. Fecal coliform bacteria are frequently detected in urban streams and rivers after storms, with levels as high 5,000 fecal coliform per tablespoon. Thus, it is not uncommon for urban and suburban creeks to frequently violate bacteria standards for swimming and water contact recreation after larger rainstorms.

Percentage of Residents that Pick Up After Pets

Surveys indicate that about 40% of all households own one or more dogs (Swann, 1999). Not all dog owners, however, are dog walkers. Only about half of dogs are walked regularly. About 60% of dog walkers claim to pick up after their dog some or all of the time (Swann, 1999; HGIC, 1998; and Hardwick, 1997). The primary disposal method reported by residents for pet waste is the trash can, with toilets coming in distant second. Dog walkers that do not pick up after their dogs are highly resistant to change; nearly half would not pick up even if confronted with fines or complaints from neighbors (Swann, 1999). Men are also prone to pick up after their dogs less often than women (Swann, 1999).

Figure 1: Pet Waste Pickup Station

Techniques to Promote Pet Waste Pickup

The key technique is to educate residents on sanitary and convenient options for retrieving and disposing of pet waste. Several communities have used both carrots and sticks to get more owners to pick up after their pets, including:

- Mass media campaigns of the water quality impacts of pet waste
- Conventional outreach materials (brochures, flyers, posters)
- Pooper bag stations in parks, greenways and common areas
- Educational signs in same areas
- "Pooper scooper" ordinances and enforcement
- Banning dogs from beaches and waterfront areas
- Providing designated "dog parks"

Good Examples

Water Quality Consortium Nonpoint Source Education Materials
The Water Quality Consortium implemented an ad campaign focused on four themes: a man pushing a fertilizer spreader, a car driving on water leaking oil, a man washing his car, and man walking his dog. Each ad explains how the behavior leads to water pollution and provides specific tips outlining what residents can do to protect water quality.
http://www.psat.wa.gov/Programs/Pie_Ed/Water_Ed_Materials.htm

Pick It Up - It's Your Doodie Campaign (Gwinnett County Parks & Recreation Department) - The county park agency provides plastic grocery bags for pet owners to use to clean up after their pets as part of a pilot program. The baggies are attached to a wooden post at a local park. Underneath a sign explains their purpose. Pet owners are also encouraged to bring replacement bags when they visit the park.
http://www.gwinnettcitizen.com/0203/doodie.html

Top Resources

Public Open Space and Dogs: A Design and Management Guide for Open Space Professionals and Government
http://www.petnet.com.au/openspace/frontis.html

Considerations for the Selection and Use of Pet Waste Collection Systems in Public Areas
http://www.ecy.wa.gov/programs/wq/nonpoint/pet_waste/petwaste_station.pdf

Properly Disposing of Pet Waste
http://www.cleanwatercampaign.com/what_can_i_do/pet_waste_home.html

Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water
U.S. EPA Source Water Protection Practices Bulletin.
http://www.epa.gov/safewater/protect/pdfs/petwaste.pdf

N-20	Neighborhood Source Area: Common Areas
	BUFFERSCAPING

Description

Many neighborhoods built in the last few decades still have a decent stream corridor protected by buffers, flood plain setbacks or wetland protection requirements. The stream corridor that remains is often in common or private ownership. The ideal watershed behavior is to respect the boundaries of the stream corridor and expand it where possible through "bufferscaping" and backyard planting of native plants and trees. The negative watershed behavior is stream corridor encroachment, through clearing, dumping, allowing invasive plant species to spread from private yards, and erecting structures (Figure 1).

How Bufferscaping Influences Subwatershed Quality

A forested stream corridor is an essential ingredient of a healthy stream, except in certain arid and semi-arid regions. Bufferscaping can add to the total area of the stream corridor, provide wildlife habitat and enhance the structure and function of the buffer. By contrast, encroachment activities diminish the quality, function and attractiveness of the stream buffer.

Percentage of People Encroaching on/Expanding the Stream Corridor

Data is not currently available to estimate the rate at which homeowners add to the stream corridor, but several troubling studies have examined the degree of residential buffer encroachment. Many residents perceive buffers as an extension of their backyard, and think little of removing trees, dumping yard wastes or erecting structures on their land. A major reason is that nearly 60% of residents are ignorant of the boundaries and intended purpose of stream buffers (Heraty, 1993). Studies of wetland buffer encroachment in Washington residential areas found that 95% of buffers were visibly altered, 40% to such a degree that their functional value was eliminated (Cooke, 1991). Other studies of Maryland buffers indicate encroachment rates of as much as 1% of area buffer per year. Clearly, residential awareness and behaviors in regard to the stream corridor need to be improved in many subwatersheds.

Neighborhood Factors that Contribute to Buffer Stewardship

Several factors play a role in how buffers are managed within a neighborhood: the age of the development, lot size, activism of homeowner association, boundary signs, and the prior existence of stream buffer or flood plain regulations.

Figure 1: A New Subdivision Encroaching on the Stream Buffer

Techniques to Encourage Buffer Stewardship

Protecting or expanding stream buffers requires direct education and interaction with individual property owners that back up to the buffer. Some useful techniques include:

- Bufferscaping assistance and guides
- Community buffer walks
- Buffer boundary inspections
- Boundary signs (Figure 2)
- Defining unallowed uses in local stream buffer ordinances
- Presentations to community associations
- Adopt-a-stream program
- Financial incentives for bufferscaping

Figure 2: Sign Identifying a Buffer Boundary

Good Examples

Burnett County, WI Natural Shoreline Incentives. The county pays homeowners to enroll in a program to maintain shorelines in their natural state. The program asks for a voluntary commitment by placing a covenant on a homeowner's property stating that the shoreline will remain natural. Program members receive a payment of $250 after an initial inspection that certifies the property meets program standards, and the shoreline covenant is recorded. Participants also receive an annual deduction from their tax statement as a thank you.
http://www.burnettcounty.com/burnett/lwcd/preserve.html

Tennessee Valley Authority Banks and Buffers Software: A Guide to Selecting Native Plants for Streambanks and Shorelines includes software application to help homeowners select plants for bufferscaping. It also contains selected characteristics and environmental tolerances of 117 plants and more than 400 color photographs illustrating habitat and growth form.
http://www.tva.gov/river/landandshore/stabilization/websites.htm

Top Resources

The Architecture of Urban Stream Buffers
http://www.stormwatercenter.net/Library/Practice/39.pdf

Chesapeake Bay Riparian Handbook: A Guide for Establishing and Maintaining Riparian Forest Buffers
http://www.chesapeakebay.net/pubs/subcommittee/nsc/forest/riphbk.pdf

Riparian Forest Buffer Design, Establishment, and Maintenance
http://www.agnr.umd.edu/MCE/Publications/Publication.cfm?ID=13

Riparian Area Management: A Citizen's Guide
http://www.co.lake.il.us/elibrary/publications/smc/riparian.pdf

Backyard Buffers for the South Carolina Lowcountry
http://www.scdhec.net/ocrm/pubs/backyard.pdf

Alliance for the Chesapeake Bay – Backyard Buffers
http://www.acb-online.org/pubs/projects/deliverables-158-1-2003.pdf

Cayuga County, NY – Green Thumbs for Blue Water Workshops
http://www.co.cayuga.ny.us/wqma/greenthumbs

Tree-mendous Maryland
http://www.dnr.state.md.us/forests/treemendous/

N-21

Neighborhood Source Area: Common Areas

STORM DRAIN MARKING

Description

The ideal watershed behavior is to get residents to fully understand the connection between storm drains and downstream waters and avoid any activity that discharges pollutants. This awareness is most often created by marking or stenciling storm drain inlets with a “Don’t dump, drains to...” message (Figure 1). The negative watershed behavior is to use storm drains as a means of disposal for trash, yard waste and household products.

How Storm Drain Marking Influences Water Quality

Storm drain marking sends a clear message to keep trash and debris, leaf litter and organic matter out of the storm drain system. Stencils may also reduce residential spills and illicit discharges. Marking is also a direct and local way to increase watershed awareness and practice neighborhood stewardship. The actual water quality benefits of storm drain marking have yet to be demonstrated through field research or monitoring. Still, marking is always a sign of good neighborhood housekeeping. Santa Monica, CA also marks the hotline phone number on storm drains to report water quality problems and illegal dumping.

Percentage of Residents Engaging in Storm Drain Marking

This behavior does not require extensive resident participation; only a few trained volunteers are needed to thoroughly mark storm drains within a neighborhood. Volunteers can include scouts, service groups, high school students, neighborhood associations, and other volunteers. Normally, marking is “sanctioned” by the local public works authority or environmental agency, so it is important to coordinate closely with them (Figure 2). Table 1 provides guidance for marking storm drains.

Factors to Consider in Storm Drain Marking

The only significant impediment to storm drain marking is when a neighborhood is primarily served by open channels or grassed channels, rather than enclosed storm drains.

Figure 1: Storm Drain Marking

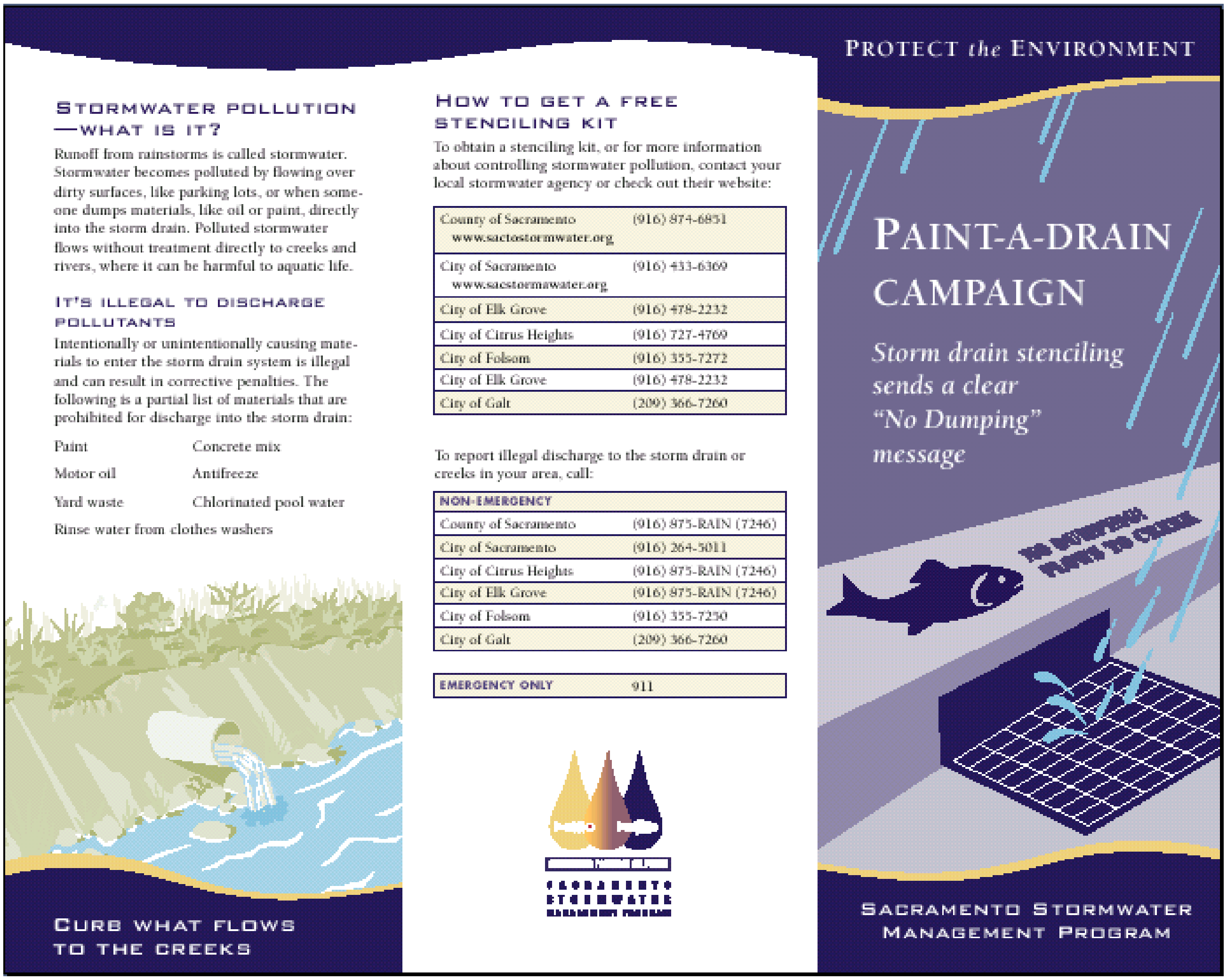


Figure 2: Educational Brochure on Storm Drain Marking/Stenciling
Source: http://www.sactostormwater.org/documents/stencil_brochure_03.pdf

Table 1: Storm Drain Marking Guidance

- Enlist one person to serve as the team leader, and make sure he/she knows all marking rules and safety procedures.
- Review all safety procedures before marking.
- Marking should be performed by at least two people, so one can be on the lookout for oncoming vehicles. Safety vests and traffic cones can be used to alert vehicles.
- Remember to wear old cloths and shoes.
- Bring paper towels or a rag to wipe up and two trash bags – one for the wet stencil (when necessary), which is not garbage, and one to pick-up garbage along the way.
- Keep track of all storm drain stencils and turn this information over to the team leader or the appropriate local government agency.
- Do not mark any storm drains with vehicles parked nearby.
- Record the locations of any storm drains that have leaves, grass clippings, oil, or other pollutants.
- Properly dispose of all trash at the end of the day, and return all empty paint cans and supplies to the team leader.

Information adapted from the following sources:
http://www.deq.state.la.us/assistance/litter/stormdrain.htm
Storm Drain Stenciling: A Manual for Communities (GI-212) *developed by the Texas Natural Resource Conservation Commission*

Top Resources

Texas Natural Resource Conservation Commission's Storm Drain Stenciling: A Guide for Communities. This extensive guide includes information on how to get volunteers involved, guidelines and materials for marking, reviews of five marking programs, and sample recognition certificates, press releases, door hangers, and public service announcements.
http://www.tnrcc.state.tx.us/exec/sbea/education.html

The Urban Dweller's Guide To Watersheds
http://www.museumca.org/creeks/umbrella.html

University of Wisconsin-Extension Water Resources Program Storm Drain Stenciling Web Page
http://clean-water.uwex.edu/wav/stormdrain/index.htm

Earthwater Stencils Home Page
http://www.earthwater-stencils.com/

Storm Drain Stenciling Project Guidelines
http://www.epa.gov/adopt/patch/html/guidelines.html

The Ocean Conservancy's Storm Drain Sentries
http://www.oceanconservancy.org/site/PageServer?pagename=op_sentries

South Carolina Department of Health and Environmental Control's Water Watch Campaign: Conducting a Storm Drain Tagging Project
http://www.scdhec.net/water/pubs/wwtag2.pdf

Multilingual Storm Drain Stenciling GreenSpace Partners worked with local watershed groups and volunteers to stencil storm drains with messages in English, Somali and Spanish.
http://www.greeninstitute.org/GSP/programs/stormwater/stencils/stencils.html

North Carolina's Storm Drain Stenciling Project This project was piloted in 1994 along coastal NC watersheds and has received support from many state and national organizations and has received the "Take Pride in North Carolina" Award.
http://www.bae.ncsu.edu/bae/programs/extension/wqg/smp-18/stormdrain/

N-10	Neighborhood Source Area: Yard
	SAFE POOL DISCHARGES

Description

Routine and end-of-season pool maintenance can cause chlorinated water or filter back flush water to be discharged into the storm drain system or the stream. The ideal watershed behavior is to discharge chlorinated pool water to the sanitary sewer system, or hold it for a week or more before spreading over a suitable pervious surface. The negative watershed behavior is to drain pool water directly into the storm drain system or stream where it may be toxic to aquatic life (Figure 1). Public and community pools can also be a subwatershed hotspot; details on controlling these pollution sources can be found in Profile Sheet H-14.

How Swimming Pool Maintenance Influences Subwatershed Water Quality

Pool water typically contains two to four parts per million of chlorine, as well as other chemicals to reduce bacteria and algae, and control pH. Consequently, the direct discharge of pool water can be toxic to aquatic life in small streams. Not much research has been done to characterize the precise impact of pool discharges on aquatic systems, but there is anecdotal evidence of fish kills and other problems. Part of the problem is the size of pool discharges: the average in-ground pool is estimated to have a capacity of nearly 20,000 gallons.

Percentage of Homeowners Engaging in Pool Maintenance

The density of swimming pools in a subwatershed is extremely variable, but can be determined through inspection of low-altitude aerial photographs or the USSR survey (Figure 2). The number of in-ground or above-ground swimming pools in the United States is estimated at 7.5 million (Pool and Spa Marketing, 2003), or about 7% of all households. The actual operational and discharge behaviors of pool owners remains poorly understood, so it is difficult to characterize the magnitude of the pool discharge problem.

Figure 1: Swimming Pool Discharging to Street and into Storm Drain

Figure 2: Aerial Photo Showing High Density of Swimming Pools (~30%) in a Neighborhood

Variation in Pool Discharge

While the greatest pool density is found in warmer regions, the actual discharge problem may be more acute in northern regions where pools must be drained before the onset of winter. Key neighborhood factors include local plumbing codes that govern how discharge water is handled, the overall density of pools in the subwatershed, and their age.

Techniques to Change the Behavior

Most pool owners understand that regular maintenance is essential to keep a pool safe and clean, and they probably conduct more water quality monitoring as a group than any other segment of society. Therefore, they may be more receptive to changing discharge behaviors with proper education. Some techniques include:

- Conventional outreach techniques on proper discharge (pamphlets, water bill inserts, posters)
- Educational kiosks at the retail outlets where they purchase pool chemicals
- Changes in local plumbing codes to require discharge to sanitary sewer systems
- Adoption of water quality ordinances that allow for fines/enforcement for unsafe pool discharges
- Inspections (done in conjunction with regular local health and safety inspections)

Good Examples

State of Maryland Pool Permit. The State has developed a general permit to govern pool discharges. The general discharge permit, developed by the Maryland Department of the Environment, addresses discharges from both swimming pools and spas. It can be found at: http://www.mde.state.md.us/assets/document/permit/MDE-WMA-PER070-SI.pdf

Top Resources

Guidelines for Swimming Pool and Spa Owners and Operators
http://www.montgomerycountymd.gov/mc/services/dep/Enforcement/pools.htm

Oregon Department of Environmental Quality (ODEQ). 1997. Water Quality Permit Program: Guidance for Swimming Pool and Hot Tub Discharges.
http://www.deq.state.or.us/wq/wqpermit/swimpools.pdf

US EPA National Menu of Best Management Practices for Storm Water Phase II: Alternative Discharge Options for Chlorinated Water. Office of Wastewater Management
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/poll_1.cfm

N-11	Neighborhood Source Area: Driveway
	SAFE CAR WASHING

Description

The ideal watershed behavior is to wash cars less often, wash them on grassy areas, and use phosphorus-free detergents and non-toxic cleaning products. Alternatively, residents can use commercial car washes that treat or recycle wash water. The negative behavior is to wash cars in a manner where dirty wash water frequently flows into the street, storm drain system, or the stream. This behavior applies not only to individuals, but to community groups that organize outdoor car washes for charitable purposes (Figure 1).

How Car Washing Influences Subwatershed Quality

Outdoor car washing has the potential to generate high nutrient, sediment, metal, and hydrocarbon loads in many subwatersheds. Detergent-rich water used to wash the grime off cars can flow down the driveway and into the storm drain, where it can be an episodic pollution source during dry weather. Not much is currently known about the quality of car wash water, but local water quality sampling can easily characterize it. Car wash water can also be a significant flow source to streams during dry weather. As an example, a typical hose flowing at normal pressure produces between 630 and 1,020 gallons of water per hour, depending on its diameter. These flows can be sharply reduced if the hose is equipped with a shut-off nozzle.

Figure 1: Poor Practices at a Charity Car Wash Event at a Local Gas Station

Percentage of Residents Engaging in Car Washing

Car washing is one of the most common watershed behaviors in which residents engage. According to surveys, about 55 to 70% of homeowners wash their own cars, with the remainder utilizing commercial car washes (Schueler, 2000b). Of these, 60% of homeowners can be classified as "chronic car-washers," in that they wash their car at least once a month (Smith, 1996; PRG, 1998; and Hardwick, 1997). Between 70 and 90% of residents reported that their car wash-water drained directly to the street, and presumably, to the nearest stream.

Variation in Car Washing

Regional and climatic factors play a strong role in determining the frequency of residential car washing. In colder climates, many residents utilize commercial car washes during the winter months, and then wash their cars themselves during the summer. In warmer climates, residential car washing is often a year-round phenomenon. Neighborhood factors that influence car washing include the number of vehicles per household, lot size, driveway surfaces, income and demographics. Another key factor is the nature of the storm water conveyance system. If a neighborhood has open section roads with grass swales, the impact of car wash water will be less.

Difficulty in Changing Car Washing Behaviors

Residential car washing is a hard watershed behavior to change, since the alternative of using commercial car washes costs more money. In addition, many residents are not aware of the water quality consequences of car washing, nor do they understand the chemical content of the soaps and detergents they use. Lastly, many residents do not understand that their driveway is often directly connected to the storm drain system and the urban stream. Consequently, many communities will need to educate homeowners about the water quality implications of car washing.

Techniques to Change Car Washing Behavior

Several communities have developed effective techniques to promote safer car washing, including:

- Media campaigns to increase awareness about water quality impacts of car washing (billboards, posters, etc.)
- Conventional outreach materials (brochures, posters, water bill inserts)
- Promote use of nozzles with shut-off valves
- Provide information on environmentally safe car washing products at point of sale
- Provide storm drain plugs and wet vacs for charity carwash events
- Provide discounted tickets for use at commercial car washes
- Modify sewer bylaws or plumbing codes to prevent storm drain discharges
- Storm drain marking (see N-21)

Good Examples

Puget Sound Car Wash Association - This charity car wash program allows qualifying nonprofit organizations to raise money for their group by selling tickets that can be redeemed at participating commercial car wash facilities.
http://www.charitycarwash.com/

Drain Plugs and Bubble Busters (Kitsap County) – This program provides drain plugs to contain car wash water from charitable car wash events, as well as "bubble busters" to pump out and safely dispose of wash water.
http://www.kitsapgov.com/sswm/carwash.htm

Top Resources

RiverSafe Carwash Campaign
http://www.riversides.org/riversafe/

The Dirty Secret of Washing Your Car at Home
http://www.forester.net/sw_0106_trenches.html

Best Management Practices for Controlling Runoff from Commercial Outdoor Car Washing
http://environment.alachua-county.org/Natural_Resources/Water_Quality/Documents/Commercial Outdoor Car Wash.pdf

How to Run a Successful Carwash fundraiser
http://www.carwashguys.com/fundraisers/LASchools.html

Make Your Next Car Wash "Environmentally Smart"
http://www.ci.eugene.or.us/PW/storm/Publications/Carwash fundraiser.pdf

found in Barth (1995a). A host of factors also comes into play at the individual neighborhood scale. Some of the more important variables include average income, market value of houses, soil quality, and the age of the development (Law *et al.*, 2004). Higher rates of fertilization appear to be very common in new suburban neighborhoods where residents seek to establish lawns and landscaping. Also, lawn irrigation systems and fertilization are strongly associated.

Difficulty in Changing Behavior

Changing fertilization behaviors can be hard since the desire for green lawns is deeply rooted in our culture (Jenkins, 1994; Teyssott, 1999). For example, the primary fertilizer is a man in the 45 to 54 year age group (BHI, 1997) who feels that "a green attractive lawn is an important asset in a neighborhood" (De Young, 1997). According to surveys, less than 10% of lawn owners take the trouble to take soil tests to determine whether fertilization is even needed (Swann, 1999; Law *et al.*, 2004). Most lawn owners are ignorant of the phosphorus or nitrogen content of the fertilizer they apply (Morris and Traxler, 1996), and are unaware that grass-cycling can sharply reduce fertilizer needs.

Most residents rely on commercial sources of information when making their fertilization decisions. The average consumer relies on product labels, store attendants, and lawn care companies as their primary, and often exclusive, sources of lawn care information. Consumers are also influenced by direct mail and word of mouth when they choose a lawn care company (Swann, 1999 and AMR, 1997).

Two approaches have shown promise in changing fertilization behaviors within a neighborhood, and both involve direct contact with individual homeowners. The first relies on using neighbors to spread the message to other residents, through master gardening programs. Individuals tend to be very receptive to advice from their peers, particularly if it relates to a common interest in healthy lawns. The second approach is similar in that it involves direct assistance to individuals at their homes (e.g., soil tests and lawn advice) or at the point of sale.

Techniques to Change Behavior

Most communities have primarily relied on carrots to change fertilization behaviors, although sticks are occasionally used in phosphorus-sensitive areas. The following are some of the most common techniques for changing fertilization behaviors:

- Seasonal media awareness campaigns
- Distribution of lawn care outreach materials (brochures, newsletters, posters, etc.; Figure 2)
- Direct homeowner assistance and training
- Master gardener program
- Exhibits and demonstration at point-of-sale retail outlets
- Free or reduced cost for soil testing
- Training and/or certification of lawn care professionals
- Lawn and garden shows on radio
- Local restrictions on phosphorus content in fertilizer

Good Examples

King County, Washington- Northwest Natural Yard Days. This month-long program offers discounts on natural yard care products and educational information about natural yard care in local stores throughout King County and Tacoma. Education specialists came to Saturday and Sunday events at some stores and spent time with buyers to help them make good choices and learn about natural yard care, including the use of organic fertilizers that don't wash off into streams and lakes as easily as "quick release" chemical fertilizers. For more details, consult: http://dnr.metrokc.gov/swd/ResRecy/events/naturalyard.shtml

North Carolina Department of Agriculture Free Residential Lawn Soil Testing. Residents can get a free soil test to determine the exact fertilizer and lime needs for their lawn, as well as for the garden, landscape plants and fruit trees. Information sheets and soil boxes are available from various government agencies, or local garden shops and other businesses. For more information, consult: http://www.ncagr.com/agronomi/stfaqs.htm

Minnesota Department of Agriculture Phosphorus Lawn Fertilizer Use Restrictions. Starting in 2004, these restrictions limit the concentration of phosphorus in lawn care products and restrict its application at higher rates to specific situations based on need. http://www.mda.state.mn.us/appd/ace/lawncwaterq.htm

Top Resources

Cornell Cooperative Extension. The Homeowner's Lawn Care Water Quality Almanac.
http://www.gardening.cornell.edu/lawn/almanac/index.html

University of Rhode Island Cooperative Extension Home*A*Syst Healthy Landscapes Program
http://www.healthylandscapes.org/

University of Maryland Cooperative Extension - Home and Garden Information Center.
http://www.agnr.umd.edu/users/hgic/

Turf and Landscape Best Management Practices. South Florida Water Management District and the Broward County Extension Education Division
http://www.sfwmd.gov/org/exo/broward/c11bmp/fertmgt.html

Florida Yards and Neighborhoods Handbook: A Guide to Environmentally Friendly Landscaping
http://hort.ufl.edu/fyn/hand.htm

University of Minnesota Extension Service Low-Input Lawn Care (LILaC)
http://www.extension.umn.edu/distribution/horticulture/DG7552.html

Austin TX, Stillhouse Spring Cleaning
http://www.ci.austin.tx.us/growgreen/stillhouse.htm

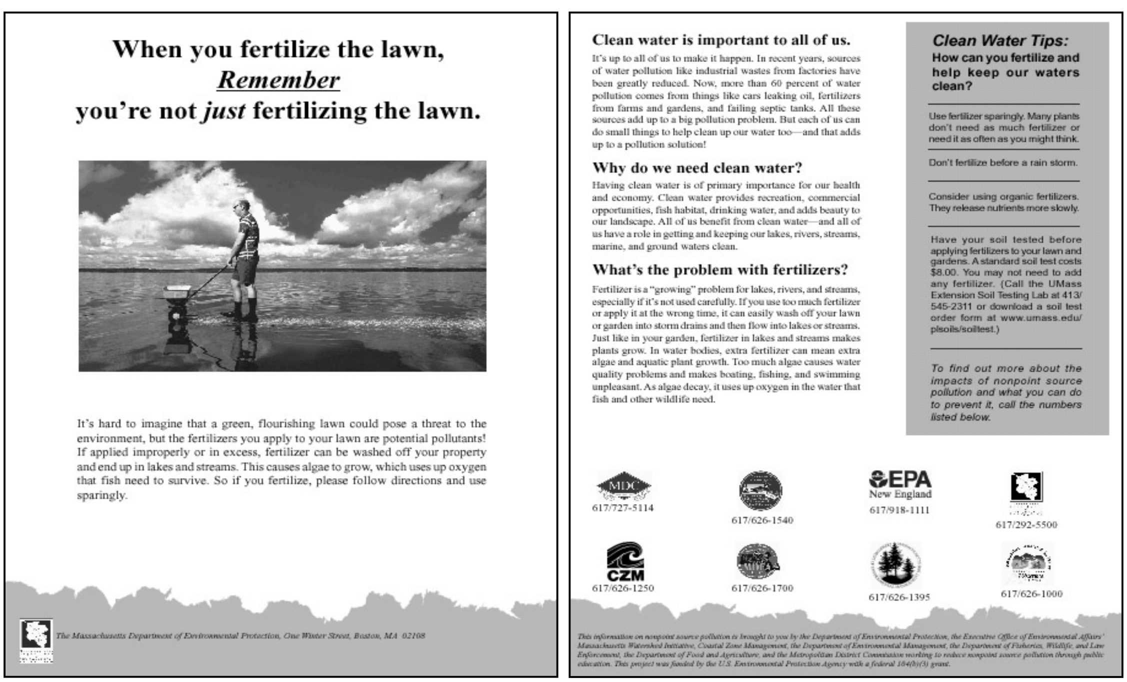


Figure 2: Educational Brochure on Fertilizer
Source: http://www.state.ma.us/dep/brp/wm/files/fertiliz.pdf

N-2

Neighborhood Source Area: Yard

REDUCED PESTICIDE USE

Description

The ideal watershed behavior is to not apply any insecticides or herbicides to the lawn or garden. Many residents, however, still want to control pests and weeds, so the next best behavior is a natural approach that emphasizes limited use of safer chemicals, proper timing and targeted application methods. The negative residential behavior is over-use or improper application of insecticides and herbicides that are known to have an adverse impact on aquatic life.

How Pesticide Use Influences Subwatershed Quality

The leading source of pesticides to urban streams is homeowner applications in the lawn and garden to kill insects and weeds. The pesticides of greatest concern are insecticides, such as diazinon and chloropyrifos, and a large group of herbicides (CWP, 2003; USGS, 2001; Schueler, 1995; Figure 1). Very low levels of these pesticides can be harmful to aquatic life. According to a national monitoring study, one or more pesticides were detected in 99% of urban streams sampled (USGS, 2001). Pesticide levels in urban streams exceeded national water quality standards to protect aquatic life in one out of every five samples. Even more troubling was the finding that 100% of fish in urban streams had detectable levels of pesticide in their tissues, with 20% exceeding recommended guidelines for fish-eating wildlife (such as racoons, kingfishers, ospreys and eagles).

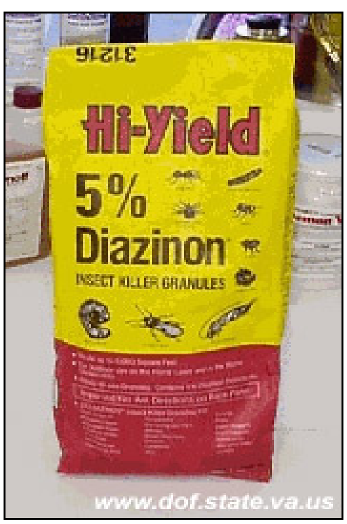


Figure 1: Bag of Pesticide Granules

Percentage of People Engaging in Pesticide Use

About half of Chesapeake Bay residents reported that they had applied pesticides to their lawn or garden (Swann, 1999). Surveys on residential pesticide use for other regions of the country indicate that home pesticide use varies greatly, ranging from a low of 17% to a high of 87% of households (Swann, 1999). According to EPA, the average acre of maintained suburban lawn receives five to seven pounds of pesticides each year.

Variation in Pesticide Use

Many regional and neighborhood factors influence the degree of local pesticide use. From a regional standpoint, climate is an extremely important factor. For example, insecticides are applied more widely in warmer climates where insect control is a year round problem (e.g., 50 to 90% of warm-weather residents report using them). This can be compared to 20 to 50% of insecticide use reported for colder regions where hard winters help keep insects in check (Schueler, 2000b). By contrast, herbicide application rates tend to be higher in colder climates in order to kill weeds that arrive with the onset of spring (e.g., 60 to 75% of cold weather residents report use).

Many neighborhood factors can play a strong role in the degree of pesticide use. These include lot or lawn size, presence of gardens, condition of turf, presence or absence of irrigation and neighborhood age. The average income and demographics within a neighborhood are also thought to play a strong role, particularly if residents rely on lawn care and landscaping companies to maintain their lawns.

Difficulty in Changing the Behavior

Pesticide use is a difficult behavior to change for several reasons. First, many residents want a quick and effective solution to their pest problems. Second, many residents lack awareness about the link between their pesticide use and stream quality. Lastly, many residents rely on commercial sources of information when choosing pesticides, and lack understanding of safer alternatives and practices. As with fertilizers, product labels are the primary source of information about pesticides. Nearly 90% of homeowners rely on them to guide their pesticide use (Swann, 1999). In addition, many residents are unaware of the pesticide application practices that their lawn care company applies to their yard and prefer to rely on professional know-how (Knox *et al*., 1995).

Confusion also stems from the recent growth of "weed and feed" lawn care products that combine weed control and fertilizer in a single bag. In one Minnesota study, 63% of residents reported that they used weed and feed lawn products, but only 24% understood that they were applying herbicides to their lawn (Morris and Traxler, 1996).

Techniques to Change the Behavior

Most communities rely on the same basic combination of carrots to change pesticide use as they do for fertilizer use, since they are so interrelated. The following are some of the most common techniques to change pesticide use:

- Seasonal media awareness campaigns
- Distribution of lawn care outreach materials (brochures, newsletters, posters, etc.)
- Direct homeowner assistance and training
- Master gardener program
- Exhibits and demonstration at point of sale at retail outlets
- Pest advice hotlines
- Training, certification and/or licensing of lawn care professionals and pesticide applicators
- Radio lawn and garden advice shows


4 If You Must Use Pesticides ...

- **Use a pesticide that is specifically designed to control your pest.** The insect should be listed on the label. Approximately 90% of the insects on your lawn and garden are not harmful.
- **Read labels!** Use only as directed. In their zeal to control the problem, many gardeners use pesticides at over *20 times the rate* that farmers do.

5 Pesticide Disposal

- Household toxics–such as pesticides, cleansers and motor oil–can pollute the ocean and poison groundwater if disposed of in storm drains or gutters.
- Rinse empty pesticide containers and use rinse water as you would the product. Dispose of empty rinsed containers in the trash.
- City of Los Angeles residents should dispose of unused household toxics at a HazMobile instead of into the sink.

Call 1(800) 98 TOXIC (8-6942) for the location nearest you.

Dumping toxics into the street, gutter or storm drain is illegal!

- Gardeners, landscapers and residents outside the City of Los Angeles can call the reference numbers listed in this pamphlet to learn where they can properly dispose of household toxics.

Spill Response Agencies

City of Los Angeles
Department of Public Works, Bureau of Engineering
Stormwater Management Division
1 (800) 974-9794

City of Los Angeles
Police Department, Hazardous Materials Unit
(213) 237-2793 or (213) 485-4011

Los Angeles Fire Department
Health/Hazardous Materials Program
City: (213) 485-8080 County: (213) 890-4045

Recycling & Hazardous Waste Disposal

City of Los Angeles
Small Business Hazardous Waste Hotline
(800) 98-TOXIC/ 988-6942

Solid Resources Citywide Recycling Division
(213) 847-1444

Los Angeles County
Department of Public Works
Recycling & Household Hazardous Waste Hotline
1 (800) 552-5218

To Report Illegal Dumping

City of Los Angeles
Department of Public Works, Bureau of Engineering
Stormwater Management Division
1 (800) 974-9794

Los Angeles County
Department of Public Works
1 (800) 303-0003

To Report a Clogged Catch Basin

City of Los Angeles
Department of Public Works, Bureau of Engineering
Stormwater Management Division
1 (800) 974-9794

Los Angeles County
Department of Public Works
(818) 458-HELP or (888) CLEAN-LA

This is one in a series of pamphlets describing storm drain protection measures. Other pamphlets include:

Automotive Maintenance & Car Care
Food Service Industry
Fresh Concrete & Mortar Application
General Construction & Site Supervision
Heavy Equipment & Earthmoving Activities
Home Repair & Remodeling
Horse Owners & Equine Industry
Painting
Swimming Pool, Jacuzzi & Fountain Maintenance
Roadwork & Paving

For more information about storm drain protection or additional pamphlets, call:

1 (800) 974-9794
Bureau of Sanitation
Department of Public Works
City of Los Angeles

Stormwater Best Management Practices (BMPs)

Landscaping Gardening & Pest Control

Safe Environmental Habits and Procedures for:

Gardeners
Homeowners
Landscapers

Figure 2: Educational Pesticide Brochure
Source: http://www.lacity.org/SAN/wpd/index.htm

Good Examples

Perdue Pesticide Program - Web-based program to help comply with the State of Indiana regulations that help homeowners use pesticides effectively and safely. According to Indiana law and recently enacted regulations, all retail establishments in the state that sell gardening and pest control products and offer recommendations on their use must be licensed as consultants, while their sales associates must be trained to knowledgeably disseminate product information.
http://www.btny.purdue.edu/PPP/

Green Communities Association's Pesticide Free Naturally: A Campaign to Reduce the Cosmetic Use of Pesticides - The campaign includes an Action Kit that includes pesticide-free lawn signs, fact sheets on health impacts, tips on how to engage neighbors in discussions about pesticide use, a children's activity pack, and information on effective alternatives to pesticides, including home recipes.
http://www.gca.ca/indexcms/index.php?pfn

Top Resources

Tips for Homeowners on Hiring a Pesticide Applicator
http://www.epa.gov/oppfead1/Publications/Cit_Guide/citguide.pdf

Try Pesticide Alternatives
http://www.mda.state.md.us/pdf/Tip1.pdf

Washington State University - Pesticide Safety Programs
http://pep.wsu.edu/psp/

National Pesticide Information Center Site - Provides objective, science-based information about a variety of pesticide-related subjects, including pesticide products, toxicology, and environmental chemistry.
http://npic.orst.edu/

IPM Practitioners Association IPM ACCESS Webpage
http://www.efn.org/~ipmpa/

Our Water, Our World
http://sfwater.org/detail.cfm/MC_ID/4/MSC_ID/78/MTO_ID/NULL/C_ID/1402

Grow Green: Landscaping for Clean Water
http://www.ci.austin.tx.us/growgreen/default.htm

N-4	Neighborhood Source Area: Yard	
	NATURAL LANDSCAPING	

Description

The ideal watershed behavior is to replace existing turf cover with native species of annuals, perennials, shrub and forest cover in mulched beds that produce less runoff and create backyard habitat. The negative watershed behavior is exclusive reliance on turf cover in the yard and/or use of non-native invasive species that can spread from the yard into adjacent stream corridors or natural area remnants.

How Natural Landscaping Influences Subwatershed Quality

The cumulative effect of natural landscaping practices on subwatershed quality are hard to quantify, but can provide some clear benefits. First, reduced turf area produces more natural hydrologic conditions in the yard, since mulched beds intercept and adsorb rainfall and can produce less runoff (Figure 1). Natural landscaping also creates native habitats, increases forest cover, and creates a natural seed bank of native plant species in subwatersheds. Natural landscaping can also prevent the spread of invasive non-native plant species into the stream corridor, which is an increasing problem in many urban subwatersheds. English ivy, bamboo, and other fast-spreading non-native species can quickly dominate the plant community of the urban stream corridor.

Percentage of Homeowners Engaging in Natural Landscaping

The proportion of homeowners that engage in natural landscaping is poorly understood at both the national and neighborhood level. About half of Americans report that home gardening and landscaping is one of their major hobbies (Figure 1), but the proportion using native plants or landscape for wildlife or watershed appears to constitute a much smaller niche market.

Variation in Landscaping Behavior

Native plant species are adapted to local differences in soil, rainfall and temperature conditions. Neighborhood factors such as neighborhood age, lot size, income level and watershed awareness appear to influence the promotion of natural landscaping.

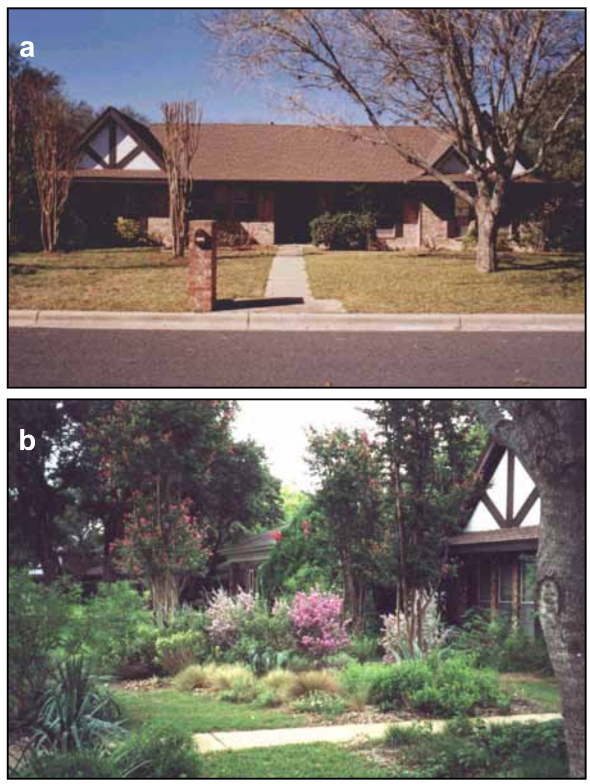


Figure 1: Before (a) and After (b) Natural Landscaping

Difficulty in Changing Landscaping Behavior

While natural landscaping practices have been growing in recent years, there are a number of barriers to more widespread implementation. The first barrier is that many homeowners are not aware of which plant species are native or non-native, and they do not know the benefits of natural landscaping. Second, native plant materials are not always widely available at garden centers and nurseries. Third, some communities still have weed and vegetation control ordinances that discourage natural landscaping.

Techniques to Promote Natural Landscaping

A range of carrots and sticks can help promote more widespread use of natural landscaping in a subwatershed, including:

- Conventional outreach on natural landscaping (brochures, newsletters, plant guides)
- Backyard habitat programs
- Free or reduced mulch
- Distribution of free or discounted native plant material
- Repeal of local weed ordinances with natural landscaping criteria
- Support of garden clubs and native plant societies
- Demonstration gardens (e.g. Bayscapes)
- Invasive species alerts
- Promotion of native plant nurseries
- Homeowner award/recognition programs
- Xeriscaping rebates

Good Examples

City of Austin, TX - WaterWise Program. Owners of new and existing homes may qualify for rebates up to $500 for Water Wise plantings of trees and shrubs. The goal of this program is to install a quality, low water use, low maintenance native landscape.
http://www.ci.austin.tx.us/watercon/wwlandscape.htm

Village of Long Grove, IL - Village Code. Natural landscaping is encouraged in the city code, which states "impervious surfaces, shall not exceed forty percent (40%) of the total lot area. The remaining minimum sixty percent (60%) of the lot area shall be maintained as a 'green area' and shall consist of native wild areas, grass, trees, ponds or other natural vegetation." The code also does not limit residential vegetation height, which in other communities can limit use of natural plant species.
http://www.longgrove.net/

Top Resources

National Wildlife Federation - Natural Back Yard Habitat Program. The Backyard Wildlife Habitat program educates people about the benefits and techniques of creating and restoring natural landscapes. Through a backyard wildlife "certification" process, guided efforts of homeowners and other community members to improve wildlife habitat where they live and work are formally acknowledged.
http://www.nwf.org/backyardwildlifehabitat/

Alliance for the Chesapeake Bay - Bayscapes. This website provides practical guidance on how to design a "Bayscape," which is a watershed friendly form of natural landscaping.
http://alliancechesbay.org/bayscapes.cfm

Wild-Ones- Native Plants, Natural Landscaping Publications and Model Ordinances. Website contains a wealth of information on natural landscaping, including the *Wild Ones Handbook* - a compendium of useful information for the native plant landscaper and wildflower gardener, appropriate for all bioregions. The site also provides vegetation and weed control model municipal ordinances that encourage the use of native plant communities as an alternative in urban landscape design. http://www.for-wild.org/

N-5	Neighborhood Source Area: Yard	
	TREE PLANTING	

Description

The ideal watershed behavior is to ultimately achieve a mature tree canopy that covers more than 50% of residential lots within a neighborhood through tree planting and care (Figure 1a). The negative watershed behavior is tree clearing that reduces existing tree canopy on a residential lot and in neighborhoods (Figure 1b).

How Tree Planting Influences Subwatershed Quality

Forested neighborhoods have a distinctly different hydrological profile than non-forested neighborhoods. For operational purposes, American Forests defines forested neighborhoods as having at least 50% forest canopy covering the residential lot. The branches and leaves of the forest canopy help intercept and slowdown rainfall. For example, a large oak tree can intercept and retain more than 500 to 1,000 gallons of rainfall in a given year, which is roughly equivalent to a rain barrel in terms of runoff reduction (Cappiella, 2004). According to American Forests (1999), a healthy forest canopy can reduce storm water runoff by as much as 7% in a neighborhood.

Figure 1: Lots with Extensive Tree Cover (a) and Less Tree Cover (b)

A healthy residential forest canopy provides many additional environmental and economic benefits within a neighborhood. These include savings on home heating and cooling costs, higher property values, shading, removal of air pollutants, and noise reduction (Cappiella, 2004).

Percentage of Homeowners Engaging in Tree Planting

Regional GIS analyses of urban areas conducted by American Forests (2001) reveal that about 60% of neighborhoods have less than 50% forest canopy cover. The actual rate of tree planting is a poorly understood residential behavior. The actual rate of tree planting is a poorly understood residential behavior. A survey in the Chesapeake Bay watershed indicated that 71% of residents had planted a tree within the last five years (CBP, 2002). Tree planting rates by homeowners of around 50% were reported in urban metropolitan areas such as Baltimore, MD and Washington, D.C.; however, more research is needed to determine the frequency and impact of tree planting in urban subwatersheds.

Variation in Tree Planting Behavior

Trees may not be part of the native plant community in some regions of the country, and specific tree or prairie species will be determined by local climate and soils. Also, concerns about fire safety may make the 50% forest canopy goal impractical in regions that experience wildfires. At the neighborhood level, several factors influence the extent of forest canopy that can be attained. Probably the most important factor is the neighborhood age, as recently constructed neighborhoods generally lack established forest cover (Figure 2). Other factors include the existing forest canopy, lot subsidies or rebates for energy conservation plantings, size and soil depth.

Difficulty in Increasing Tree Planting Behavior

Generally, tree planting is a relatively easy behavior to encourage, although it may take decades to grow a mature canopy on a residential lot. Perhaps the biggest barrier to overcome is to find the best locations in the yard to plant trees that can grow to maturity (e.g., away from overhead powerlines, underground utilities, septic systems, etc.). The second concern is proper planting and care techniques to ensure that trees can survive and flourish in the critical first few years after they are planted. Third, some localities may discourage tree planting in the right-of-way due to maintenance concerns and pavement cracking.

Techniques for Increasing Residential Forest Canopy Cover

A series of techniques can promote tree planting and discourage tree clearing:

- Distribution of outreach materials on tree planting (brochures, newsletters, plant guides)
- Tree clearing ordinances and permits
- Direct forestry assistance
- Free seedlings or other native tree stocks
- Native tree planting guidebooks

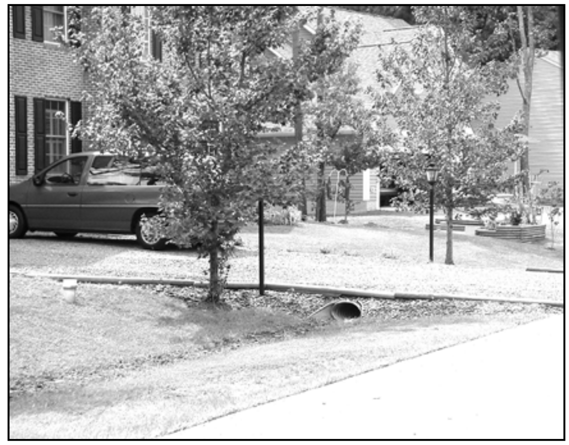


Figure 2: Newly Planted Trees in a New Neighborhood

Good Examples

Slinger, WI -Residential Tree Power Incentive Program. The electric utility in this community offers cash incentives for planting deciduous trees that conserve energy by providing significant shading of an air conditioning unit or the south or west exposure of a home upon tree maturity.
http://www.slinger-wi-usa.org/utilityprograms.htm

Tucson Electric Power (TEP) Tree Planting Incentives for Residents. TEP, working with the Trees for Tucson program, offers residents up to two five-gallon size trees at $3.00 per tree for planting on the west, east or south side of their homes. The program has distributed more than 22,000 trees since its inception, and also provides information to homeowners, neighborhood groups, and schools on low-water species appropriate to the local environment, and optimum placement of trees for energy and water conservation.
http://swenergy.org/programs/arizona/utility.htm

Banks and Buffers: A Guide to Selecting Native Plants for Streambanks and Shorelines. Produced by the Tennessee Valley Authority, this guide includes a software application to assist in plant selection. It also contains selected characteristics and environmental tolerances of 117 native plants and over 400 color photographs illustrating habitat and growth form.
http://www.tva.gov/river/landandshore/stabilization/index.htm

National Arbor Day Foundation Awards
This award recognition program honors the achievements of citizens, communities, the media, and schools whose work in the cause of tree planting, care, and conservation have set an example of excellence. Applications are submitted through the Department of Natural Resources to the National Arbor Day Foundation. Contact: DNR - Forest Service regional office or The National Arbor Day Foundation, 100 Arbor Avenue, Nebraska City, NE 68410. http://www.arborday.org/

Top Resources

American Forests - CityGreen GIS software
http://www.americanforests.org./

Center for Urban Forest Research
http://wcufre.ucdavis.edu/

Guidelines for Developing and Evaluating Tree Ordinances
http://www.isa-arbor.com/publications/ordinance.aspx

Treelink
http://www.treelink.org/

National Tree Trust
http://www.nationaltreetrust.org/

Treepeople
http://www.treepeople.org/

Society of Municipal Arborists
http://www.urban-forestry.com/

Urban Forest Ecosystems Institute
http://www.ufei.calpoly.edu/

USDA Forest Service, Northeastern Research Station
http://www.fs.fed.us/ne/

USDA Forest Service, Southern Region
http://www.urbanforestrysouth.org/

USDA Forest Service, Pacific Northwest Research Station
http://www.fs.fed.us/pnw/

USDA Forest Service, Pacific Southwest Research Station
http://www.fs.fed.us/psw/

RR-4	Rooftop Retrofit Design Sheets	
	RAIN BARRELS	

Description

Rain barrels are used to capture, store and reuse residential rooftop runoff. They consist of a simple stormwater collection device that stores rainwater from individual rooftop downspouts. Stored water can be used as a source of outdoor water for car washing or lawn or garden watering. The rooftop runoff stored in a rain barrel would normally flow onto a paved surface and eventually into a storm drain. Rain barrels typically have a capacity of 50 to 100 gallons of water (Figure 1).

Rain barrels can be applied to new and existing residential developments. They are most applicable for single family residential and townhouse uses. Rain barrels can have benefits on both a site level and subwatershed wide basis. Rain barrels promote water conservation, reduce water demand, and lower irrigation costs and demand (a rain barrel can save homeowners about 1,300 gallons of water during the peak summer months). Rain barrels are inexpensive and easy to build and install and create stronger watershed awareness.

Feasibility

Rain barrels are a common on-site retrofit practice to treat rooftop runoff from individual homes. Because each rain barrel retrofit treats such a small area, dozens or hundreds are needed to make a measurable difference at the subwatershed level. Consequently, widespread homeowner implementation of rain barrels requires targeted education, technical assistance and financial subsidies.

The potential to retrofit with rain barrels is normally evaluated as part of the neighborhood source assessment of the USSR. The most important factor is the proportion of existing homes that are directly connected to the storm drain system. In general, neighborhoods with residential lot sizes as small as 4000 square feet can be effectively retrofit with rain barrels (Figure 2). Negative neighborhood factors include the presence of basements, limited space for barrel de-watering, and lack of active homeowner association.

Regional and Climatic Considerations - Several issues pertaining to water quality, climate, and algae and mosquito control

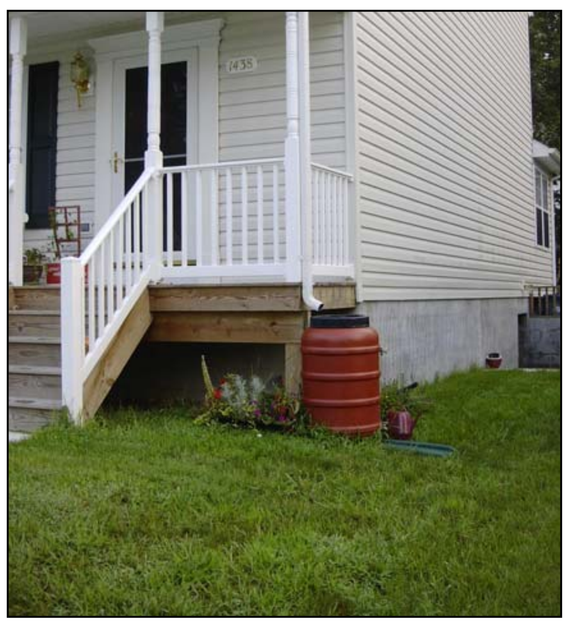


Figure 1: Installed Rain Barrel

should be taken into account in design. Water quality is usually not a major issue unless the stored water will be used for drinking water, which is not recommended without additional filtering and treatment. Rooftop runoff contains trace metals, such as zinc, copper and lead. The presence of these metals, however, should not adversely affect the use of rooftop runoff for supplemental lawn and garden irrigation.

Rain barrels require modification in regions with cold winters. Rain barrels do not function if temperatures regularly reach the freezing mark during winter months. Consequently, rain barrels should be drained and disconnected during winter months to ensure that frozen water does not damage the rain barrel, to back up into downspouts or overflow into a building foundation. Alternatively, rain barrels can be installed inside a building or garage.

Figure 2: Rain barrel installed on a balcony due to space constraints on a small lot.

It is important to reduce the amount of organic matter entering the barrel to prevent algae from growing in a rain barrel. This can be a problem for rain barrels serving a downspout whose gutters fill with leaves and other debris.

Since rain barrels have standing water, there is some risk that they may become mosquito-breeding sites. Simple solutions to reduce mosquito breeding include routine emptying of the barrel on a five day cycle to interfere with breeding time required by mosquitoes or screening the rainwater inlet so mosquitoes cannot enter the rain barrel (USWG, 2003).

Site Constraints and Permits - Rain barrels may not be appropriate in high-density urban settings where there is little or no green space to irrigate using the collected water. Similarly, neighborhoods where homes are close together may not have adequate surface area to safely discharge rain barrel overflow. Lastly, installation of rain barrels in neighborhoods where downspouts are already disconnected provides little or no retrofit benefit.

Implementation

Design - Rain barrels are much easier to design compared to other on-site retrofit practices. Still, the rain barrel should always incorporate the same basic design elements of any good stormwater practice, such as pretreatment (clean gutters), adequate storage capacity, and safe conveyance of flooding with rain barrel overflows).

Construction - Rain barrels can be purchased or custom made from large plastic drums (typically 55-gallon drums). They are relatively easy to construct using a few basic components available from hardware stores. Installation of a typical rain barrel involves disconnecting individual downspouts and redirecting it into the top of the rain barrel.

Rain barrels have an overflow pipe that redirects the rainwater back into the downspout or onto the lawn or other pervious surface when the rain barrel is full. Other rain barrel components may include spigots, connector barrels, mosquito proofing, and even water filters (CWP, 2003).

Maintenance – The maintenance required for rain barrels involves regular dewatering of the barrel to preserve capacity for the next storm event. Roof gutters should be inspected to ensure that leaves and organic matter are not entering the downspout to the rain barrel. In addition, the rain barrel, gutters, and downspouts need to be checked for leaks or obstructions. Lastly, the overflow pipe should be checked to ensure that overflow is draining in a non-erosive manner

Cost - Although costs vary across manufacturers, the average cost of a single rain barrel ranges from about $50 to $300, with an average of about $150 The cost per cubic foot treated is about $25 per cubic foot treated (ranging from $7 to $40) Costs can be reduced if volunteers or watershed groups perform the instillation. Consult Profile Sheet 0S-10 for some helpful resources on rain barrel delivery.

Further Resources

The following internet resources are recommended for a detailed description on how to build and install a rain barrel.

How to Build and Install a Rain Barrel
http://www.cwp.org/Community_Watersheds/brochure.pdf

Rain Barrels for Dummies: Unofficial Guidance for Backyard Retrofitters.
http://www.cwp.org/Community_Watersheds/Rain_Barrel.htm

King County, WA. Rain Barrel Information and Sources for the Pacific Northwest.
http://dnr.metrokc.gov/wlr/PI/rainbarrels.htm

Low Impact Development Center (LID). Rain Barrels and Cisterns.
http://www.lid-stormwater.net/raincist/raincist_maintain.htm

Maryland Green Building Program: Building a Simple Rain Barrel.
http://www.dnr.state.md.us/ed/rainbarrel.html

City of Bremerton. Rain Barrel Program: A Modern Spin On An Old Idea.
http://www.cityofbremerton.com/content/sw_makeyourownrainbarrel.html

Portland, OR Downspout Disconnection Program
http://www.portlandonline.com/bes/index.cfm?c=43081

RR-5	Rooftop Retrofit Design Sheets	
	RAIN GARDENS	

Rain gardens capture, filter and infiltrate residential rooftop runoff, and consist of small, landscaped depressions that are usually 6 to 18 inches deep. A sand/soil mixture below the depression is planted with native shrubs, grasses or flowering plants (Figure 1). Rooftop runoff is detained in the depression for no more than a day until it either infiltrates or evapotranspires. Rain gardens can replenish groundwater, reduce stormwater volumes, and remove pollutants. A rain garden allows at least 30% more water to infiltrate into the ground compared to a conventional lawn (UWEO, 2002).

Rain gardens can be applied to existing single-family homes within targeted neighborhoods. Rain gardens have many benefits including increased watershed awareness and personal stewardship, improved neighborhood appearance, and creation of habitat for birds and butterflies. Rain gardens must be properly maintained; otherwise they may create basement flooding and standing water, and become an eyesore. For this reason, implementation of rain gardens requires a dedicated homeowner and community buy-in.

Feasibility

Rain gardens are essentially a non-engineered form of bioretention that treats rooftop runoff from individual roof leader. (see Profile Sheet ST-4). Because each rain garden treats a rather small area, dozens or hundreds are needed to make a measurable difference at the subwatershed level. Consequently, widespread homeowner implementation of rain gardens requires targeted education, technical assistance and financial subsidies.

The potential to retrofit rain gardens is normally evaluated as part of the neighborhood source assessment of the USSR. The most

Figure 1: Rain Garden

important factor is the proportion of existing homes that are directly connected to storm drain system. In general, neighborhoods with large residential lot sizes are most suitable (1/4 acre lots and larger). Negative neighborhood factors include the presence of basements, compacted soils, and poor neighborhood awareness. Positive factors are large rooftop areas that are directly connected to the storm drain system, lots with extensive tree canopy and good neighborhood housekeeping.

Regional and Climatic Considerations - One common misperception associated with rain gardens is that they provide a breeding ground for mosquitoes. Mosquitoes need three to seven days to breed, and standing water in the rain garden should last for only a few hours after most storms USWG, 2003).

Plant selection is also an important element of a successful rain garden. Considerations should include drought-tolerant plants that will not require much watering, but can withstand wet soils for up to 24 hours. Plant selection also depends on the amount of sun the garden receives. Xeriscaping (the practice of landscaping to conserve water) is recommended in arid climates (Figure 2). For a listing of the native plants in your region, visit: http://plants.usda.gov/ (USDA NRCS). This database allows the user to search for plants by name (common or scientific) or by state or county.

Site Constraints and Permits - The site constraints for rain gardens include soils and proximity to the house. The garden should be located a minimum of 10 feet away from the house to prevent basement seepage. Rain gardens work best in areas with well-drained soils. However, performance can be enhanced in poorly draining soils by providing an underdrain system or soil amendments.

Implementation

Design - The surface area of a rain garden should be between 20% and 30% of the roof area it drains to it to ensure it can temporarily hold water from a 1-inch rainstorm. Further guidance on sizing a rain garden is provided in Table 1.

To ensure that the water flows from the impervious surface to the garden, maintain at least a 1% slope from the lawn down to the rain garden (a shallow swale can be used). A downspout extension can be used to direct rooftop flow into the garden.

Construction - Construction of rain gardens is simple but requires physical labor to dig the garden, prepare the soil, and plant desired species. Select plants that have a well-established root system and plant them approximately one foot apart (UWEO, 2002). More information on how to install rain gardens can be found online in the Further Resources section.

Figure 2: Xeriscaped Garden

Table 1: Rain Garden Sizing Example
30' x 30' house footprint
¼ of this area drains to one downspout
15' x 15' = 225 sf
20% of 225sf = 45sf
30% of 225sf = 67.5 sf
The rain garden area should be between 45 and 67.5 square feet, depending on the soil type (use 20% for sandier soils in Soil Group A)

Maintenance - Maintenance of rain gardens is essential to ensure public acceptance and proper performance, and reduce nuisance problems. Typical maintenance includes periodic watering and weeding. The use of native plants can significantly reduce overall yard maintenance needs since they require less mowing, watering and fertilizer than conventional lawns.

Cost - The cost to construct a rain garden includes labor for construction and design, plants, and soil mixture. Design and construction costs can vary widely depending on the complexity of the project. Rain gardens typically cost about $4.00 per cubic foot of runoff treated (ranging from $3 to $5). Do-it-yourselfers can create beautiful rain gardens for a fraction of this cost.

Further Resources

Center for Watershed Protection *How to Install a Rain Garden*. http://www.cwp.org/Community_Watersheds/brochure.pdf

UWEO (University of Wisconsin Extension Office). Rain Gardens: http://clean-water.uwex.edu/pubs/pdf/home.gardens.pdf

Bannerman, R. and E. Considine. 2003. Rain Gardens: A how-to manual for homeowners http://www.dnr.state.wi.us/org/water/wm/dsfm/shore/documents/rgmanual.pdf

Center for Watershed Protection . *Rain Garden Applications and Simple Calculations*. http://www.cwp.org/Community_Watersheds/Rain_Garden.htm

Friends of Bassett Creek. 2000. *Rain Gardens: Gardening with Water Quality in Mind*. http://www.mninter.net/~stack/bassett/gardens.html.

Minneapolis, MN Neighborhood Rain Gardens http://www.fultonneighborhood.org/lfrwm.htm

Portland, OR Downspout Disconnection Program http://www.portlandonline.com/bes/index.cfm?c=43081

Rain Gardens for Stormwater Bioretention and Ecological Restoration.. http://www.nwf.org/campusecology/files/reillyprop.pdf

"Plotting to Infiltrate? Try Rain Gardens." *Yard and Garden Line News* 3(6). http://www.extension.umn.edu/yardandgarden/YGLNews/YGLN-May0101.html

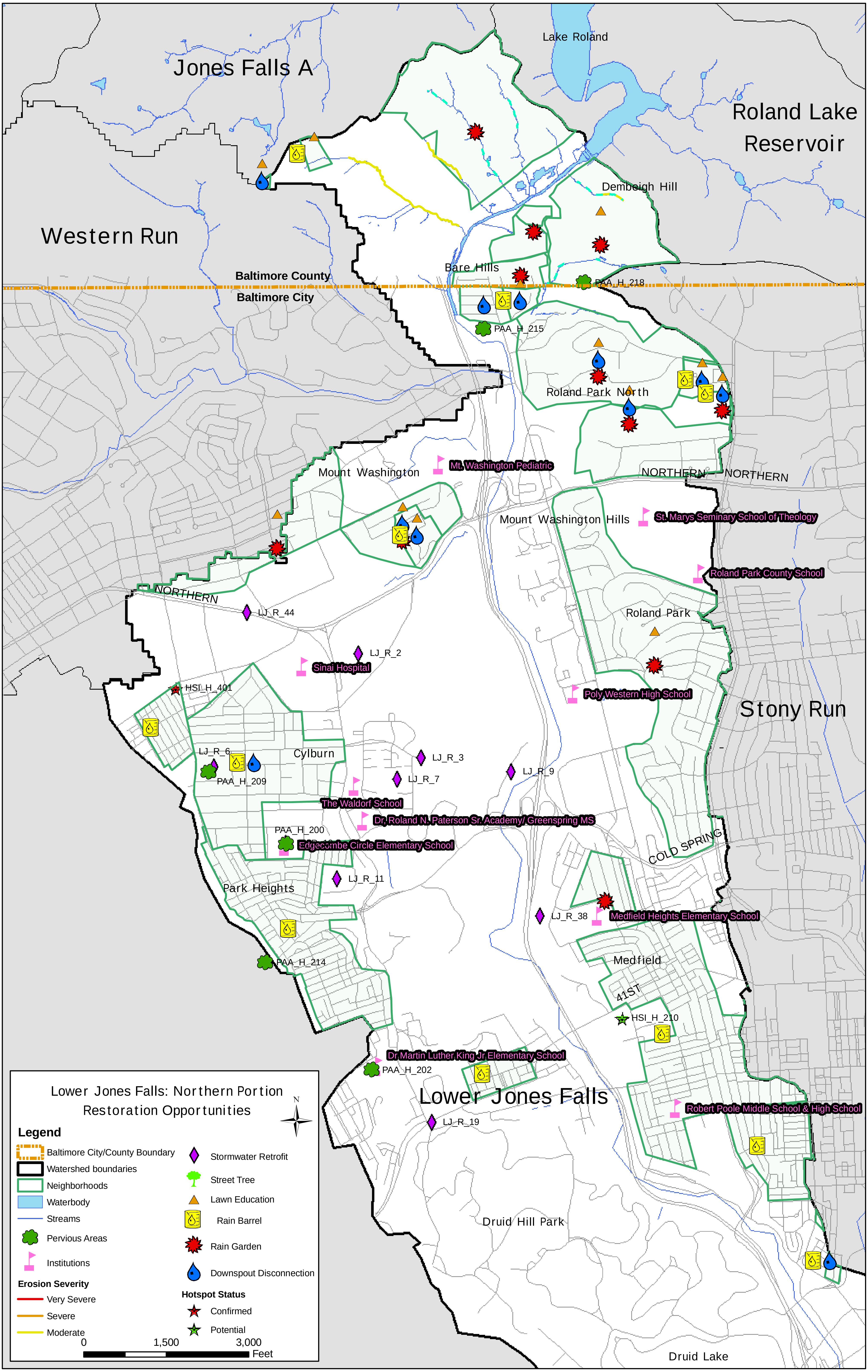
West Michigan Environmental Action Council and the City of Grand Rapids RainGardens.org. http://www.raingardens.org

Appendix D

Subwatershed Restoration Opportunity Maps

Appendix D

Subwatershed Restoration Opportunity Maps


Lower Jones Falls: Northern Portion
Restoration Opportunities
Legend
Baltimore City/County Boundary
Watershed boundaries
Neighborhoods
Waterbody
Streams
Pervious Areas
Institutions
Erosion Severity
Very Severe
Severe
Moderate
Stormwater Retrofit
Street Tree
Lawn Education
Rain Barrel
Rain Garden
Downspout Disconnection
Hotspot Status
Confirmed
Potential
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Jones Falls A
Roland Lake Reservoir
Western Run
Dembeigh Hill
Bare Hills
Baltimore County
Baltimore City
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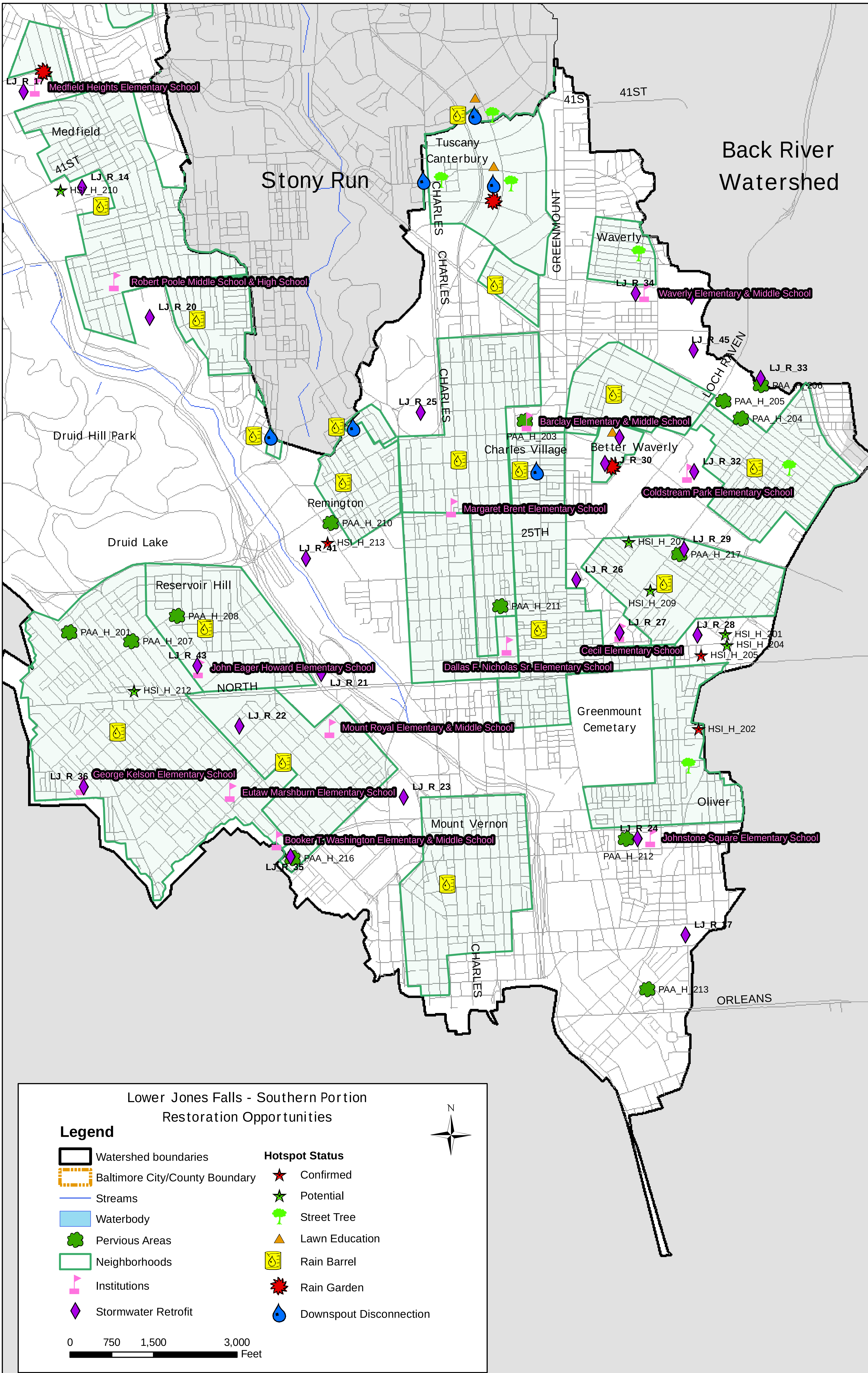
PAA_H_215
Roland Park North
Mt. Washington Pediatric
Mount Washington
NORTHERN
Mount Washington Hills
St. Marys Seminary School of Theology
Roland Park County School
Roland Park
LJ_R_44
LJ_R_2
Sinai Hospital
HSI_H_401
Poly Western High School
Stony Run
LJ_R_6
Cylburn
LJ_R_3
LJ_R_7
LJ_R_9
PAA_H_209
The Waldorf School
Dr. Roland N. Paterson Sr. Academy/ Greenspring MS
PAA_H_200
Edgecombe Circle Elementary School
COLD SPRING
Park Heights
LJ_R_11
LJ_R_38
Medfield Heights Elementary School
Medfield
PAA_H_214
41ST
HSI_H_210
Dr Martin Luther King Jr Elementary School
PAA_H_202
Lower Jones Falls
LJ_R_19
Robert Poole Middle School & High School
Druid Hill Park
Druid Lake


Lower Jones Falls - Southern Portion
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Downspout Disconnection
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1,500
3,000
Feet
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Stony Run
Back River Watershed
Medfield
Tuscany Canterbury
Waverly
Druid Hill Park
Druid Lake
Remington
Charles Village
Better Waverly
Reservoir Hill
Greenmount Cemetary
Mount Vernon
Oliver
41ST
CHARLES
GREENMOUNT
LOCH RAVEN
25TH
NORTH
ORLEANS
Medfield Heights Elementary School
Robert Poole Middle School & High School
Waverly Elementary & Middle School
Barclay Elementary & Middle School
Coldstream Park Elementary School
Margaret Brent Elementary School
Cecil Elementary School
Dallas F. Nicholas Sr. Elementary School
John Eager Howard Elementary School
Mount Royal Elementary & Middle School
George Kelson Elementary School
Eutaw Marshburn Elementary School
Booker T. Washington Elementary & Middle School
Johnstone Square Elementary School
LJ_R_17
LJ_R_14
HSI_H_210
LJ_R_20
LJ_R_34
LJ_R_45
LJ_R_33
PAA_H_205
PAA_H_204
LJ_R_25
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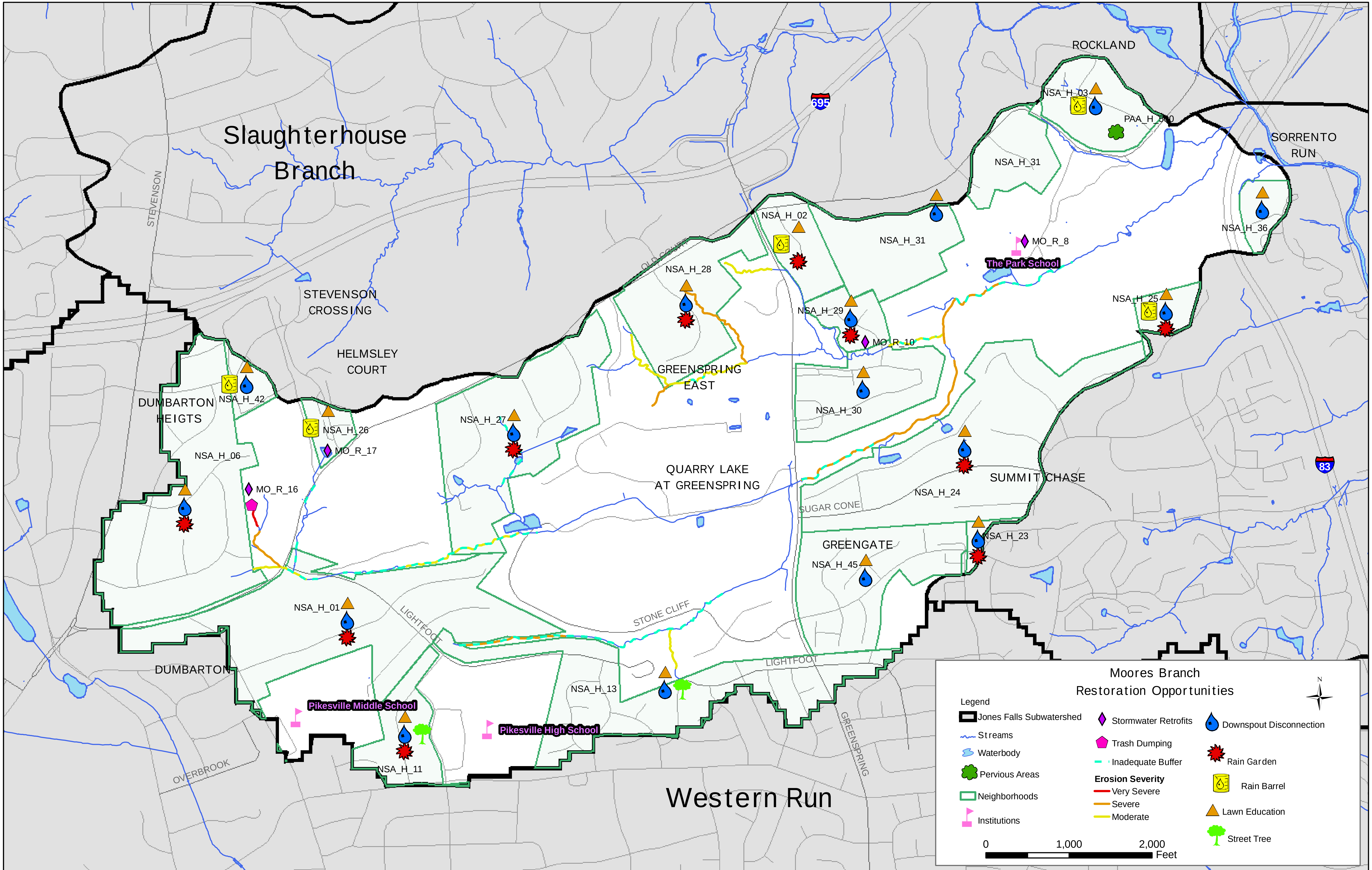

Slaughterhouse Branch
STEVENSON CROSSING
HELMSLEY COURT
DUMBARTON HEIGTS
ROCKLAND
SORRENTO RUN
GREENSPRING EAST
QUARRY LAKE AT GREENSPRING
SUMMIT CHASE
GREENGATE
DUMBARTON
Western Run
STEVENSON
OLD COURT
SUGAR CONE
STONE CLIFF
LIGHTFOOT
GREENSPRING
OVERBROOK
695
83
NSA_H_03
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MO_R_8
The Park School
NSA_H_28
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Pikesville High School
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Moores Branch
Restoration Opportunities
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Legend
Jones Falls Subwatershed
Streams
Waterbody
Pervious Areas
Neighborhoods
Institutions
Stormwater Retrofits
Trash Dumping
Inadequate Buffer
Erosion Severity
Very Severe
Severe
Moderate
Downspout Disconnection
Rain Garden
Rain Barrel
Lawn Education
Street Tree
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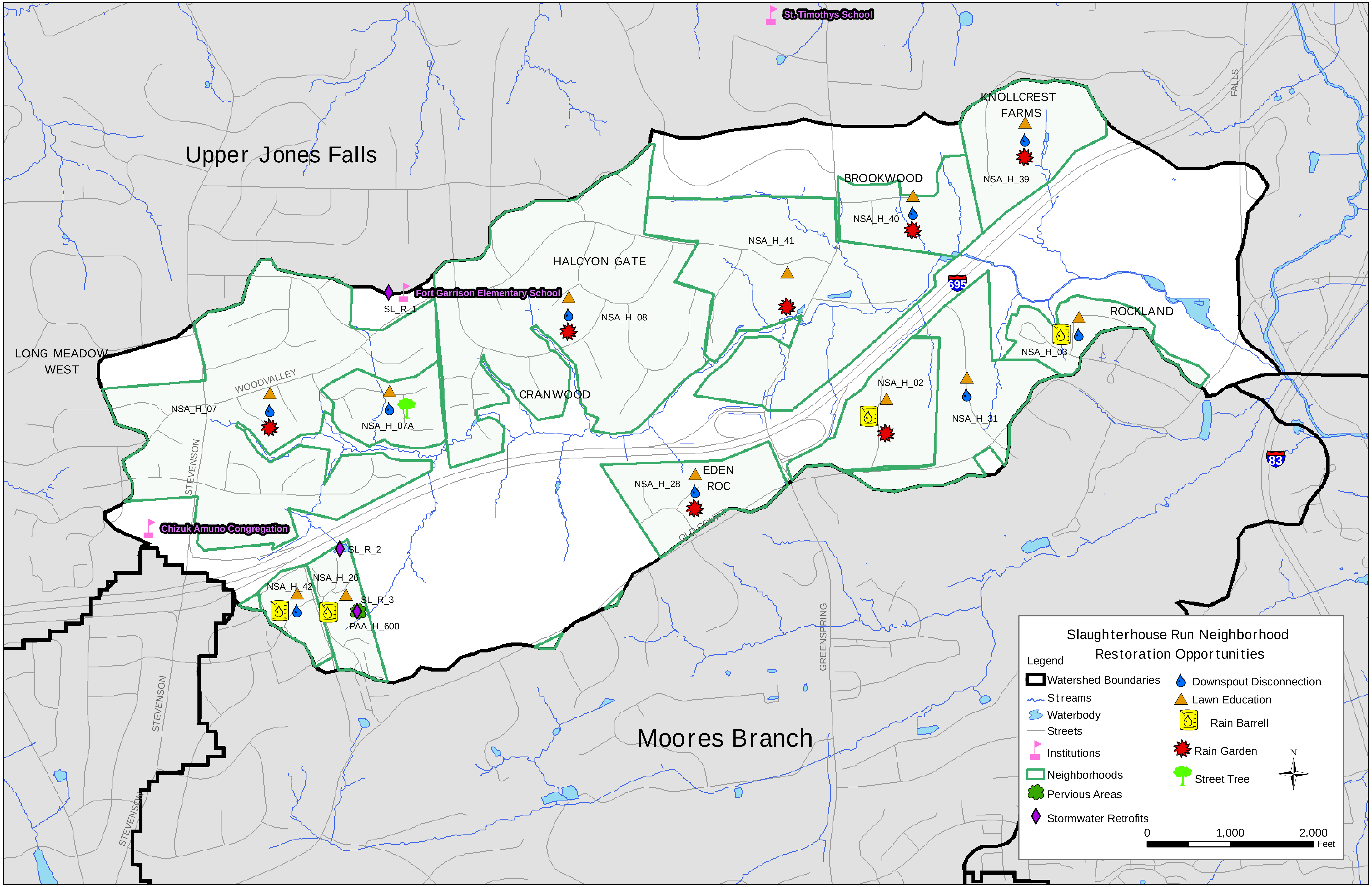

Slaughterhouse Run Neighborhood Restoration Opportunities
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BROOKWOOD
HALCYON GATE
CRANWOOD
ROCKLAND
EDEN ROC
LONG MEADOW WEST
WOODVALLEY
STEVENSON
GREENSPRING
FALLS
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SL_R_2
SL_R_3
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83
Legend
Watershed Boundaries
Streams
Waterbody
Streets
Institutions
Neighborhoods
Pervious Areas
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Lawn Education
Rain Barrell
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Street Tree
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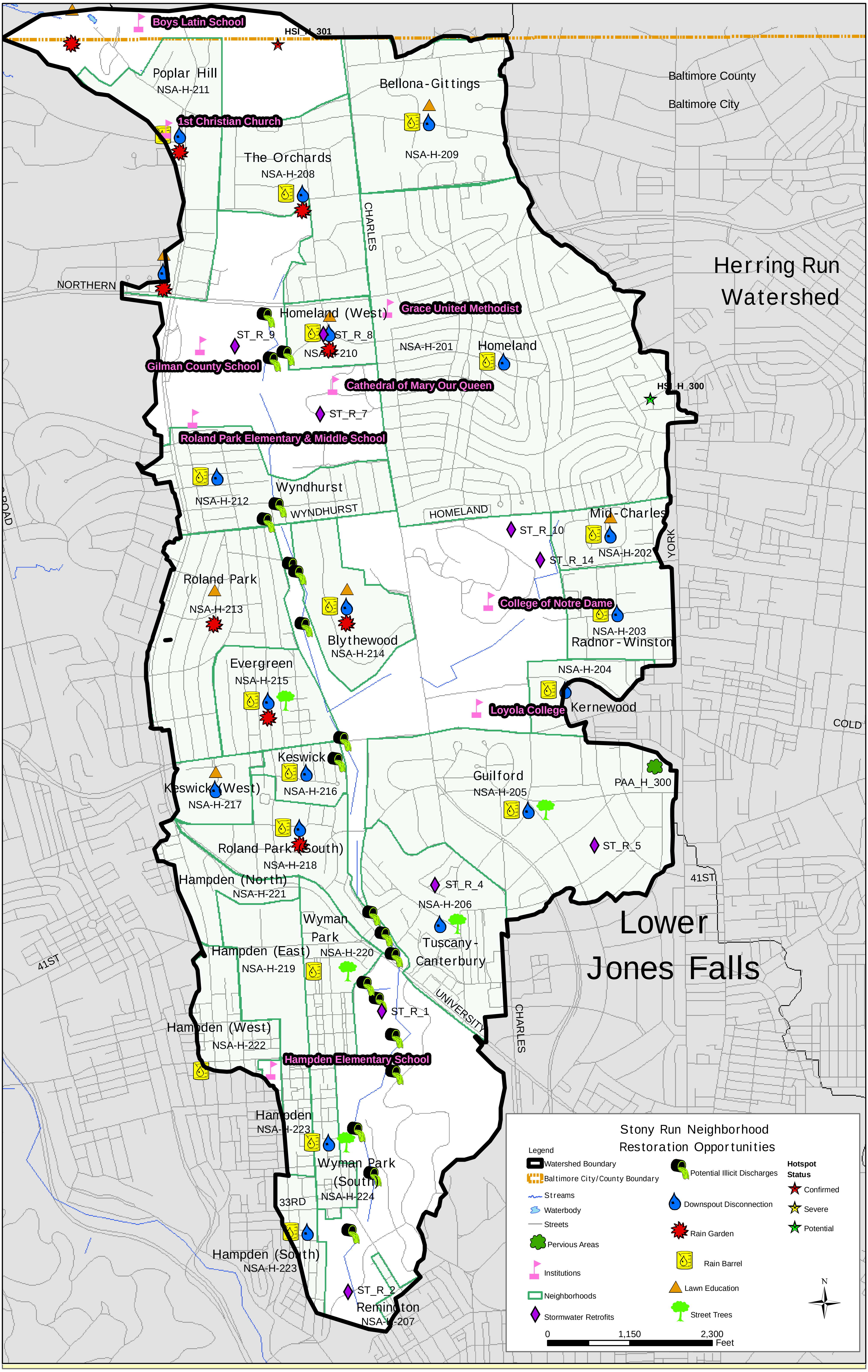
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Stormwater Retrofits
Potential Illicit Discharges
Downspout Disconnection
Rain Garden
Rain Barrel
Lawn Education
Street Trees
Hotspot Status
Confirmed
Severe
Potential
0
1,150
2,300
Feet
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Baltimore County
Baltimore City
Herring Run Watershed
Lower Jones Falls
HSI_H_301
HSI_H_300
PAA_H_300
Boys Latin School
1st Christian Church
Grace United Methodist
Gilman County School
Cathedral of Mary Our Queen
Roland Park Elementary & Middle School
College of Notre Dame
Loyola College
Hampden Elementary School
Poplar Hill
NSA-H-211
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The Orchards
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Blythewood
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Radnor-Winston
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Evergreen
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Hampden (East)
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Wyman Park (South)
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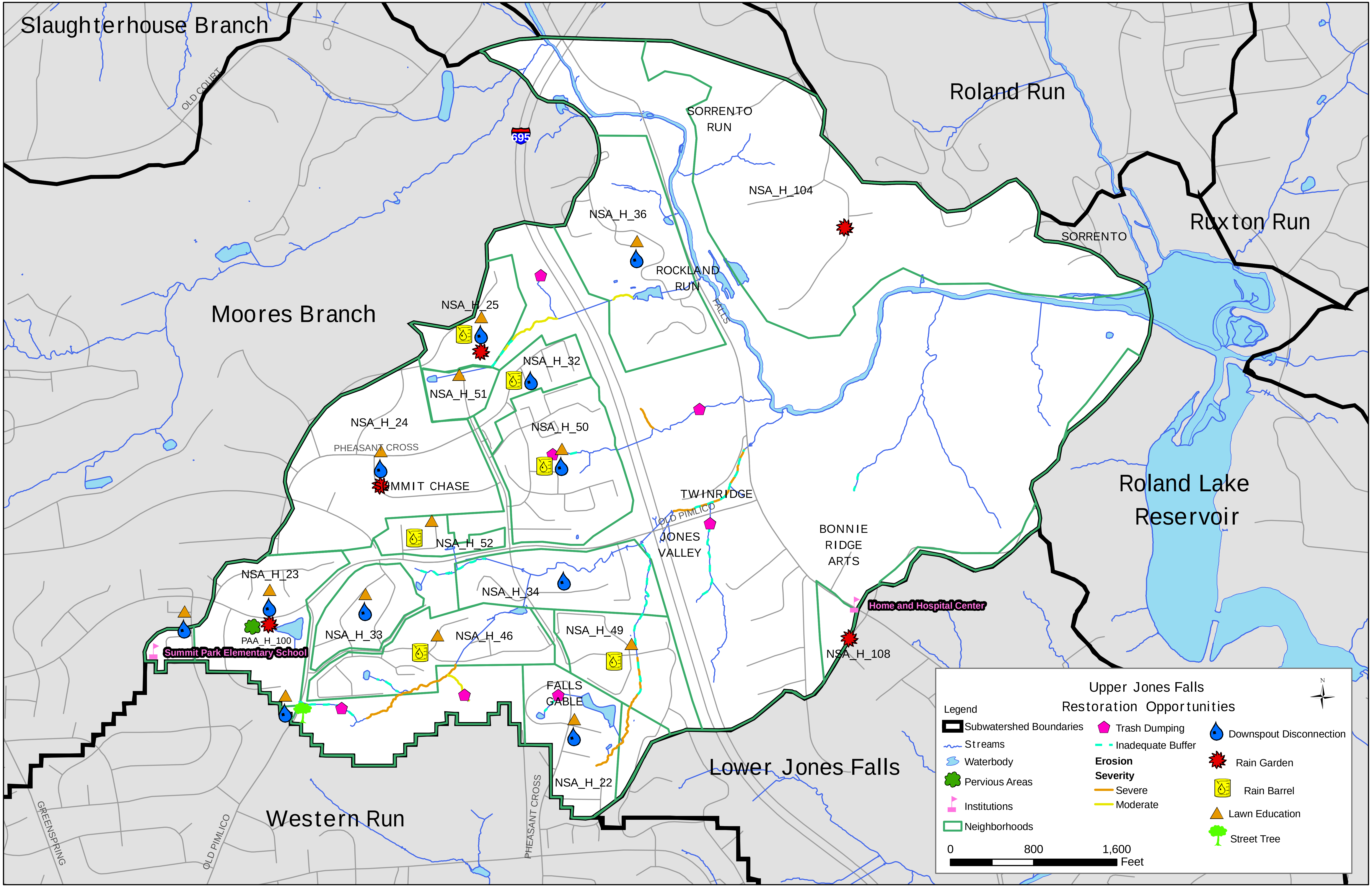
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ROCKLAND
RUN
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SUMMIT CHASE
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OLD PIMLICO
JONES
VALLEY
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RIDGE
ARTS
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NSA_H_46
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Home and Hospital Center
NSA_H_108
FALLS
GABLE
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OLD COURT
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GREENSPRING
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Neighborhoods
Trash Dumping
Inadequate Buffer
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Severity
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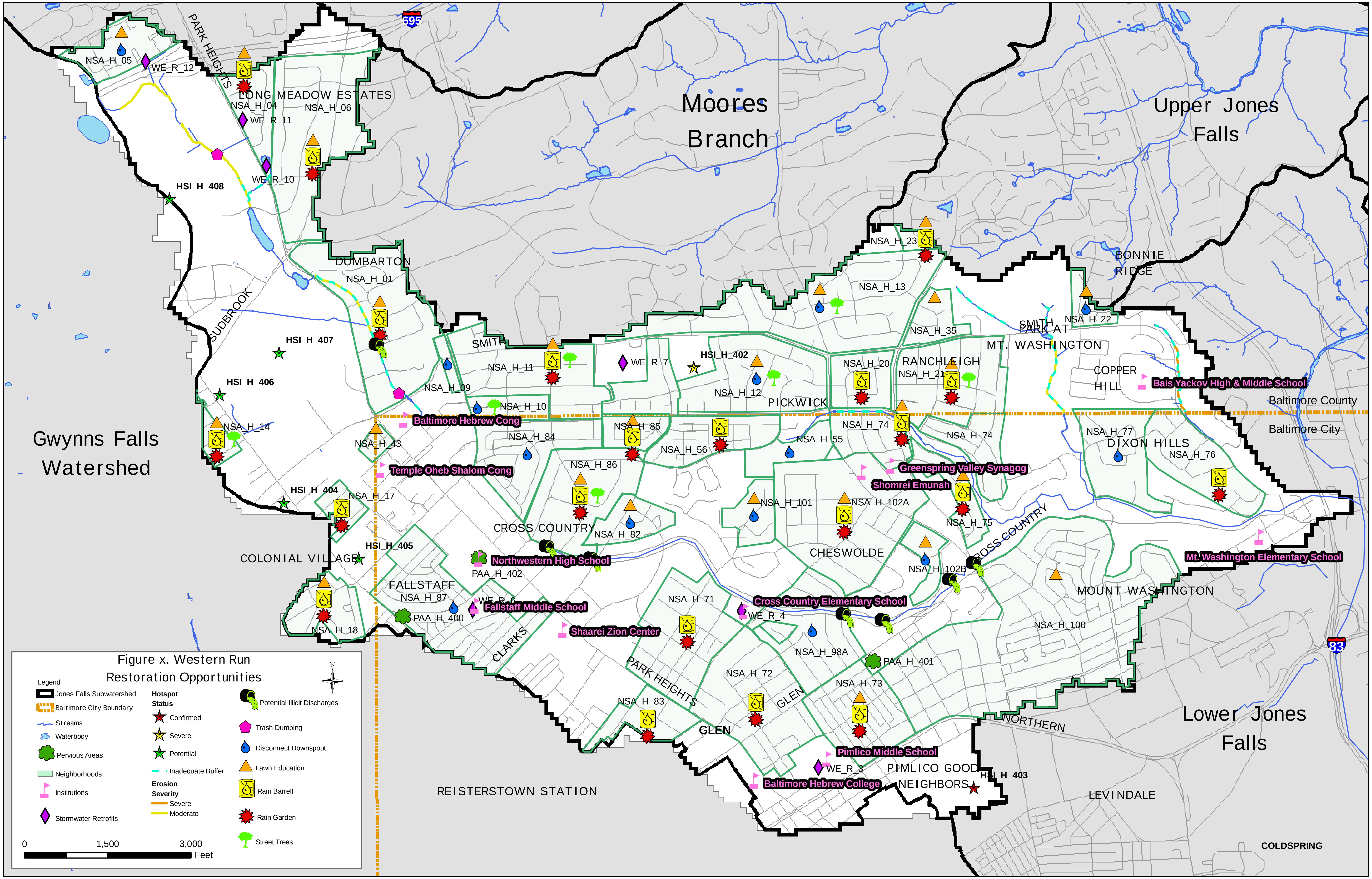
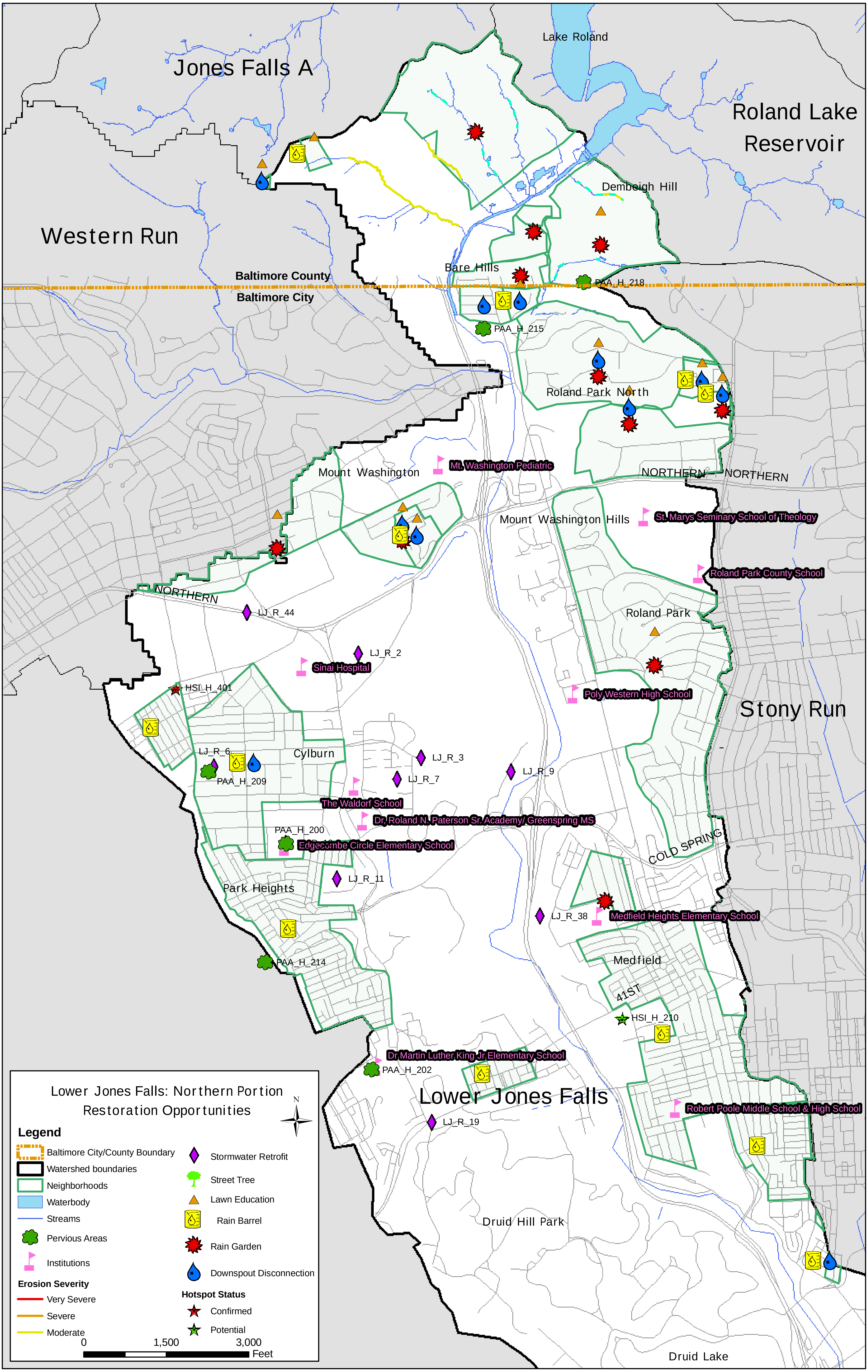


Figure x. Western Run Restoration Opportunities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Waterbody
Streams
Pervious Areas
Institutions
Erosion Severity
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Severe
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Stormwater Retrofit
Street Tree
Lawn Education
Rain Barrel
Rain Garden
Downspout Disconnection
Hotspot Status
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Reservoir
Western Run
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Bare Hills
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Mt. Washington Pediatric
Mount Washington
Mount Washington Hills
St. Marys Seminary School of Theology
Roland Park County School
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Sinai Hospital
HSI_H_401
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Stony Run
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Cylburn
LJ_R_3
LJ_R_9
LJ_R_7
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Dr. Roland N. Paterson Sr. Academy/ Greenspring MS
PAA_H_200
Edgecombe Circle Elementary School
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Park Heights
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Medfield
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41ST
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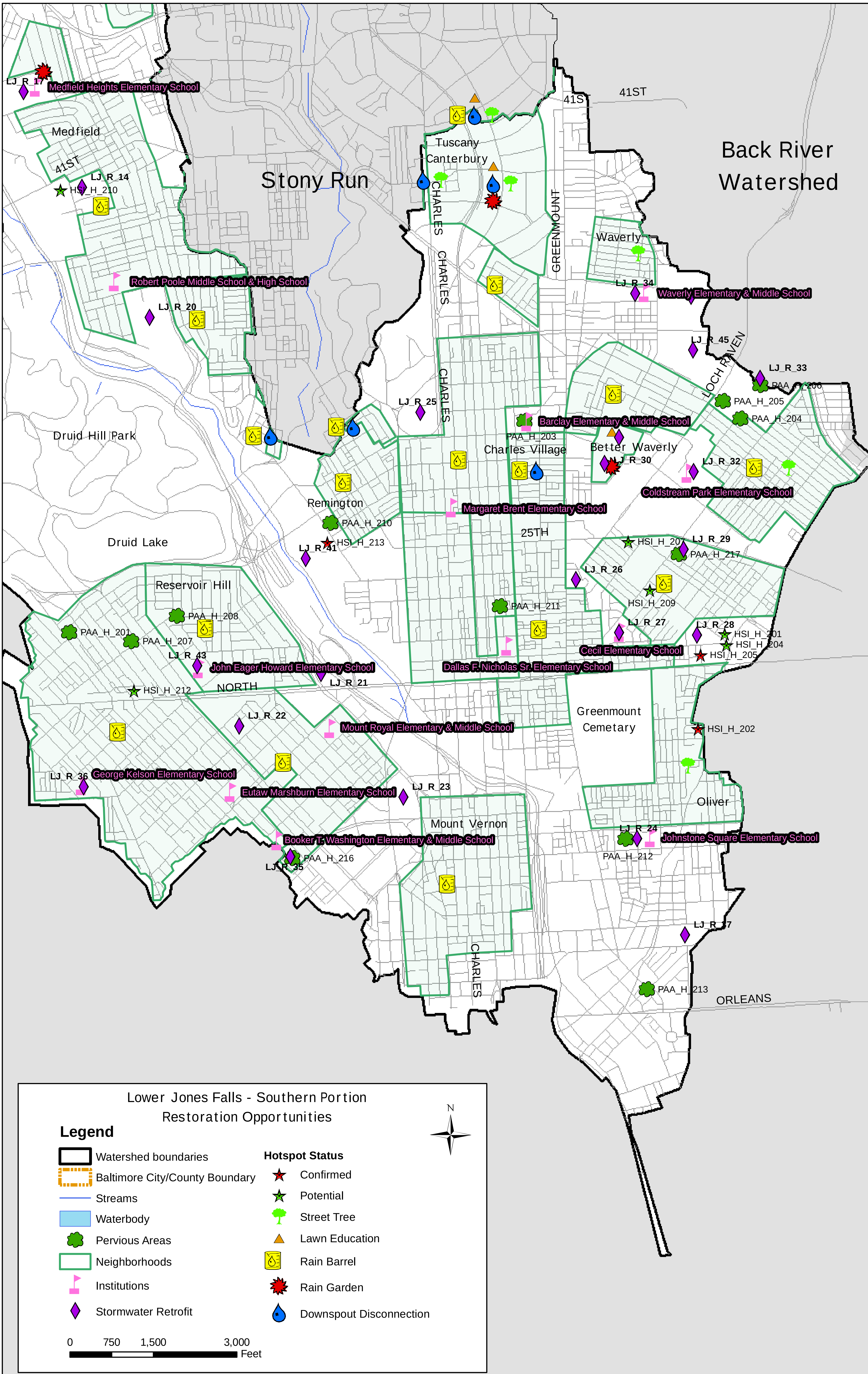
LJ_R_19
Robert Poole Middle School & High School
Druid Hill Park
Druid Lake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Pervious Areas
Neighborhoods
Institutions
Stormwater Retrofit
Hotspot Status
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Street Tree
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Rain Barrel
Rain Garden
Downspout Disconnection
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Back River Watershed
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Tuscany Canterbury
Waverly
Druid Hill Park
Druid Lake
Remington
Charles Village
Better Waverly
Reservoir Hill
Greenmount Cemetary
Mount Vernon
Oliver
41ST
CHARLES
GREENMOUNT
LOCH RAVEN
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NORTH
ORLEANS
Medfield Heights Elementary School
Robert Poole Middle School & High School
Waverly Elementary & Middle School
Barclay Elementary & Middle School
Coldstream Park Elementary School
Margaret Brent Elementary School
Cecil Elementary School
Dallas F. Nicholas Sr. Elementary School
John Eager Howard Elementary School
Mount Royal Elementary & Middle School
George Kelson Elementary School
Eutaw Marshburn Elementary School
Booker T. Washington Elementary & Middle School
Johnstone Square Elementary School
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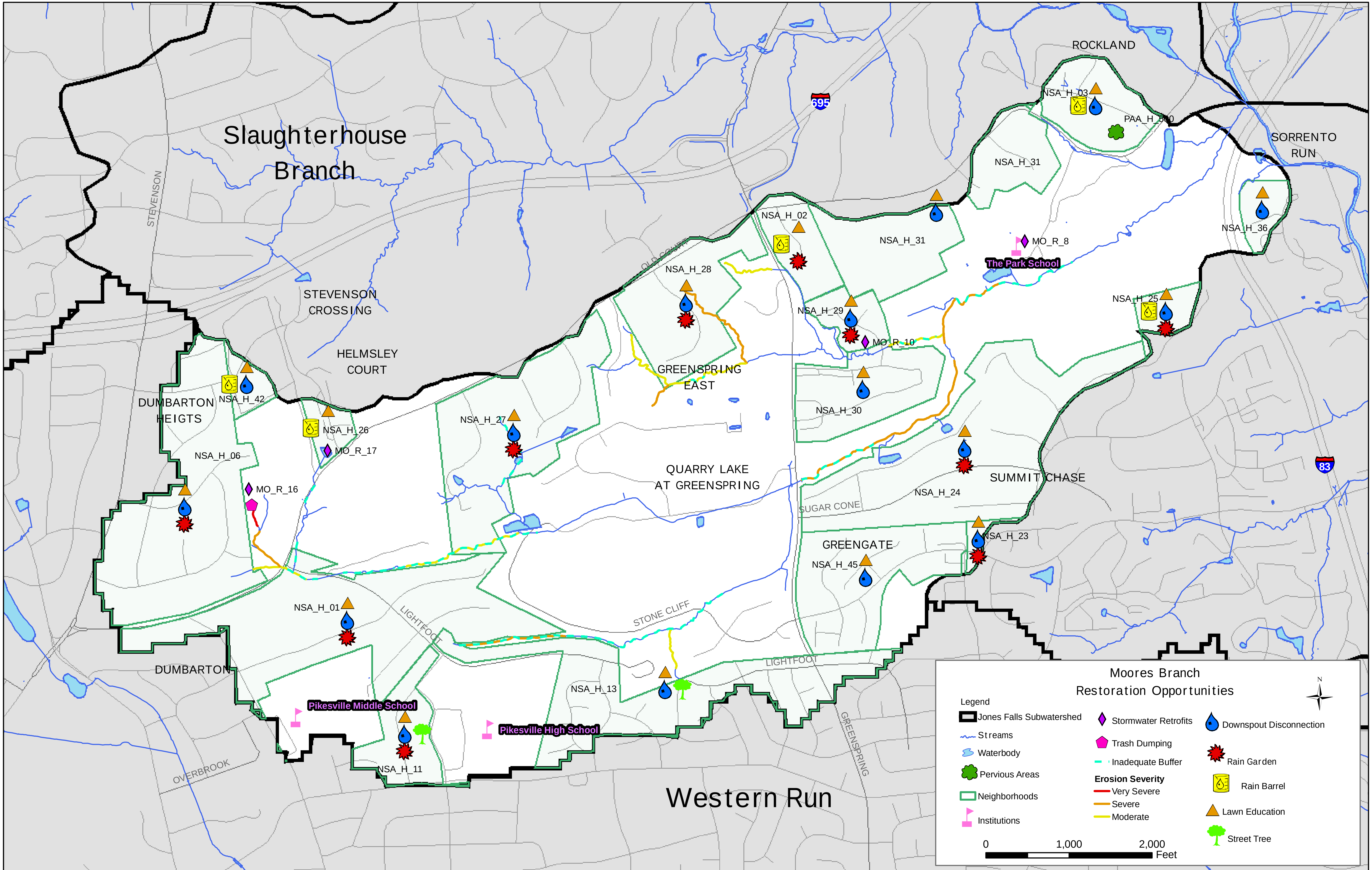

Moores Branch
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Legend
Jones Falls Subwatershed
Streams
Waterbody
Pervious Areas
Neighborhoods
Institutions
Stormwater Retrofits
Trash Dumping
Inadequate Buffer
Erosion Severity
Very Severe
Severe
Moderate
Downspout Disconnection
Rain Garden
Rain Barrel
Lawn Education
Street Tree
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Slaughterhouse Branch
Western Run
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SORRENTO RUN
STEVENSON CROSSING
HELMSLEY COURT
DUMBARTON HEIGTS
DUMBARTON
GREENSPRING EAST
QUARRY LAKE AT GREENSPRING
SUMMIT CHASE
GREENGATE
The Park School
Pikesville Middle School
Pikesville High School
STEVENSON
OLD COURT
LIGHTFOOT
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SUGAR CONE
GREENSPRING
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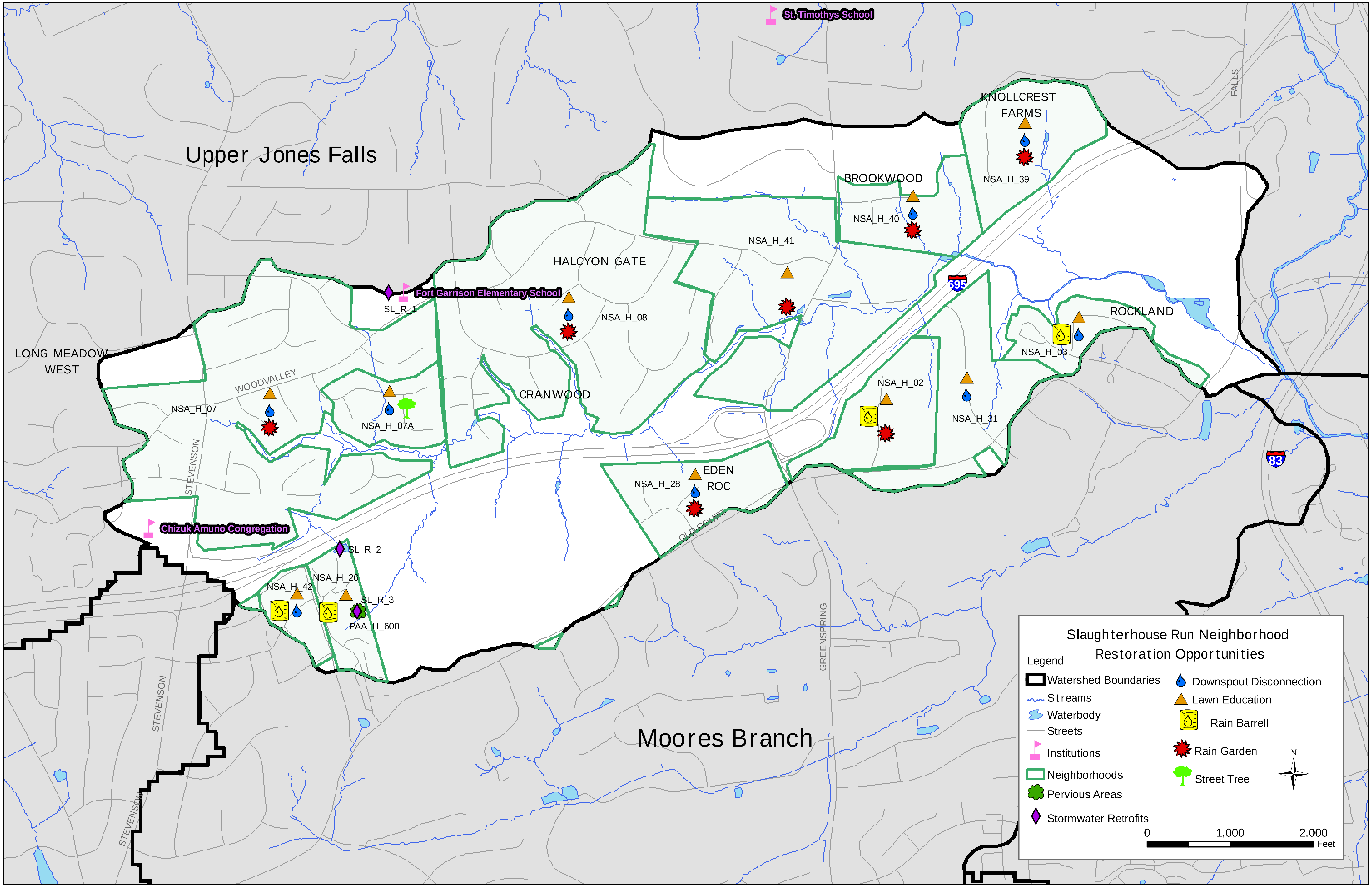

St. Timothys School
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HALCYON GATE
Fort Garrison Elementary School
SL_R_1
NSA_H_08
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ROCKLAND
NSA_H_03
LONG MEADOW
WEST
WOODVALLEY
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EDEN
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OLD COURT
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STEVENSON
STEVENSON
Moores Branch
Slaughterhouse Run Neighborhood
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Waterbody
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Neighborhoods
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Downspout Disconnection
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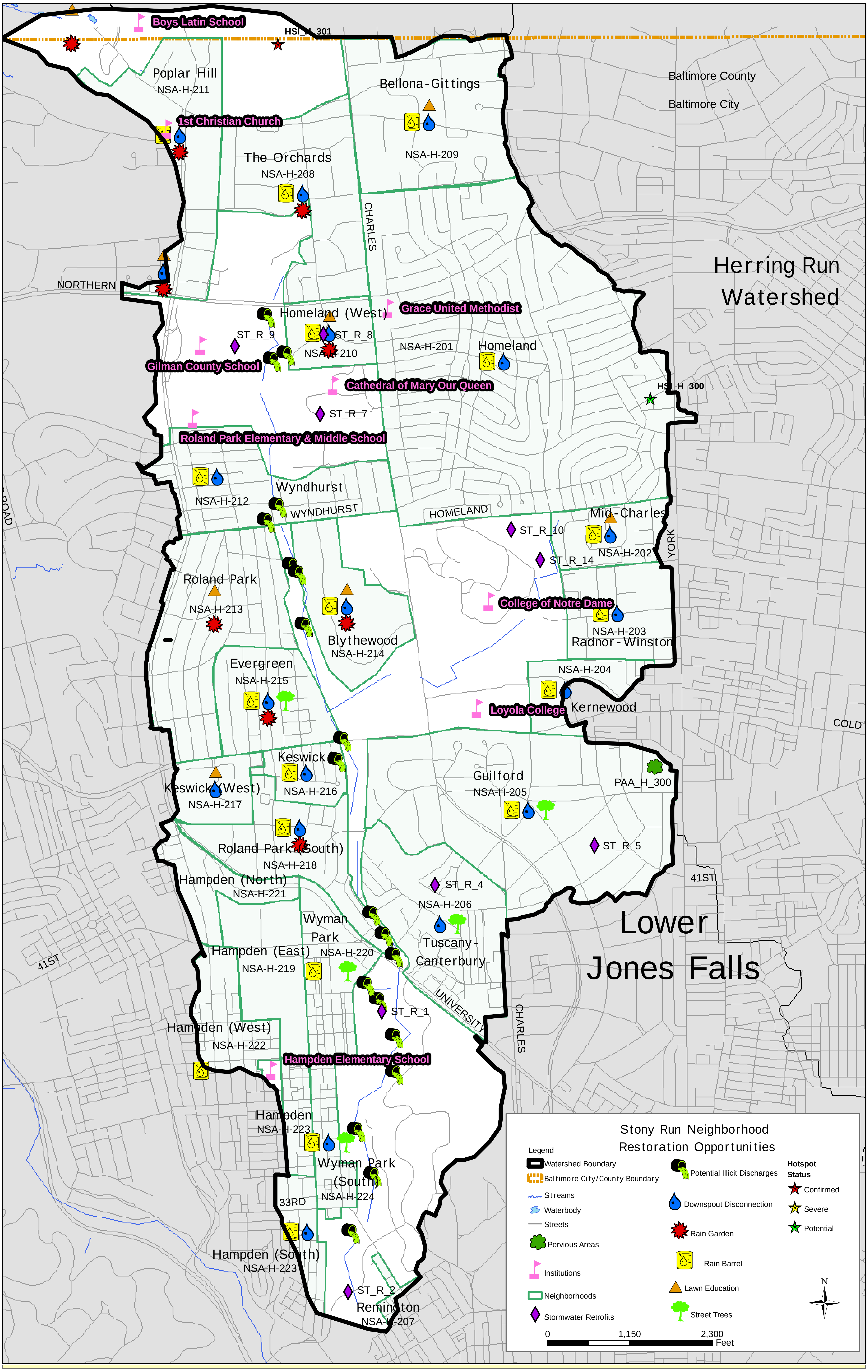

Stony Run Neighborhood
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Legend
Watershed Boundary
Baltimore City/County Boundary
Streams
Waterbody
Streets
Pervious Areas
Institutions
Neighborhoods
Stormwater Retrofits
Potential Illicit Discharges
Downspout Disconnection
Rain Garden
Rain Barrel
Lawn Education
Street Trees
Hotspot Status
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Bellona-Gittings
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The Orchards
NSA-H-208
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NORTHERN
Homeland (West)
Grace United Methodist
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WYNDHURST
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Blythewood
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Evergreen
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Loyola College
Kernewood
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Wyman Park
Tuscany-Canterbury
Hampden (East)
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ST_R_1
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CHARLES
Hampden (West)
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Hampden Elementary School
Hampden
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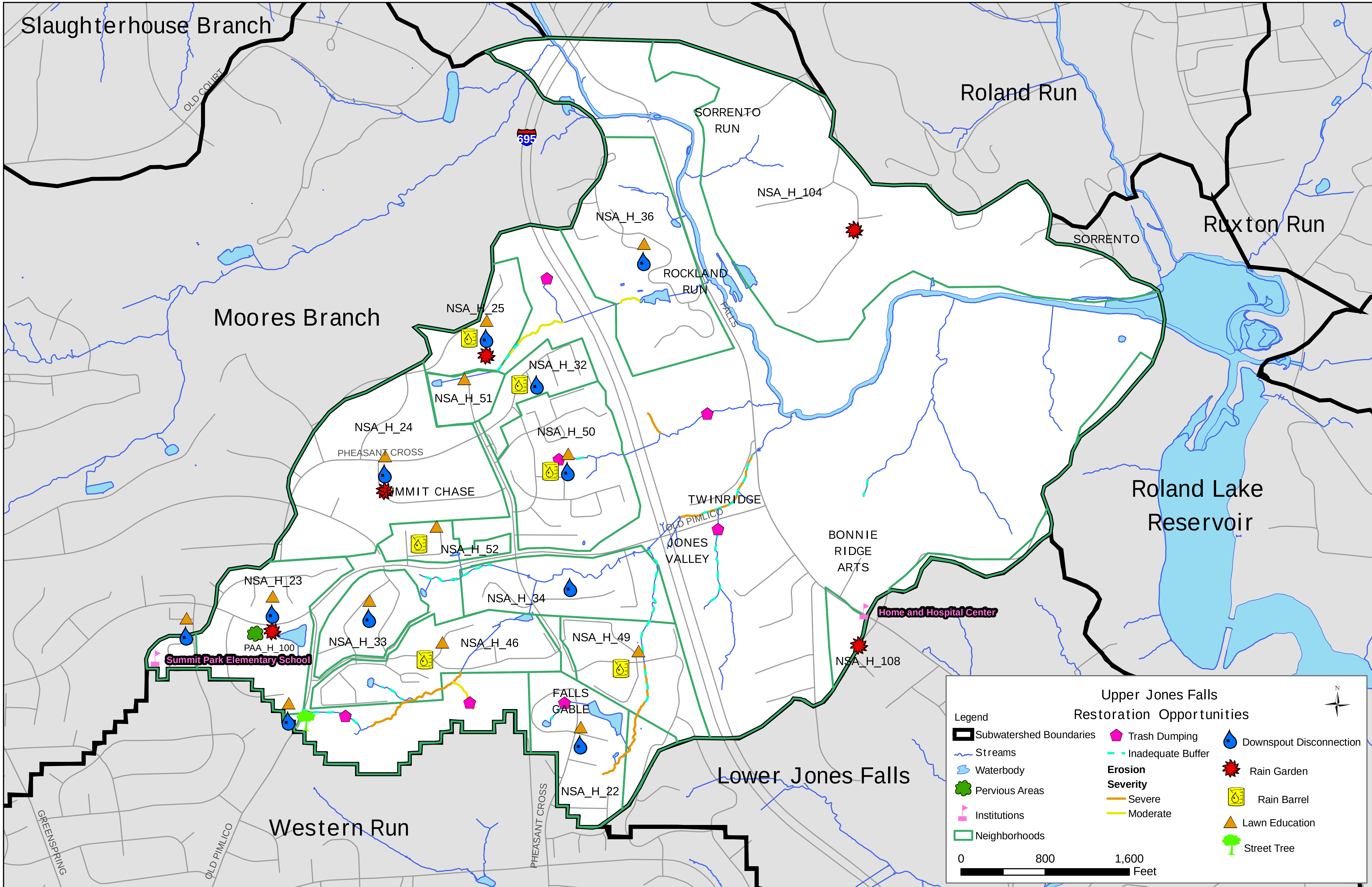

Upper Jones Falls
Restoration Opportunities
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Subwatershed Boundaries
Streams
Waterbody
Pervious Areas
Institutions
Neighborhoods
Trash Dumping
Inadequate Buffer
Erosion Severity
Severe
Moderate
Downspout Disconnection
Rain Garden
Rain Barrel
Lawn Education
Street Tree
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Feet
Slaughterhouse Branch
Roland Run
Ruxton Run
Moores Branch
Roland Lake Reservoir
Lower Jones Falls
Western Run
SORRENTO RUN
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SORRENTO
ROCKLAND RUN
FALLS
NSA_H_25
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SUMMIT CHASE
TWINRIDGE
OLD PIMLICO
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BONNIE RIDGE ARTS
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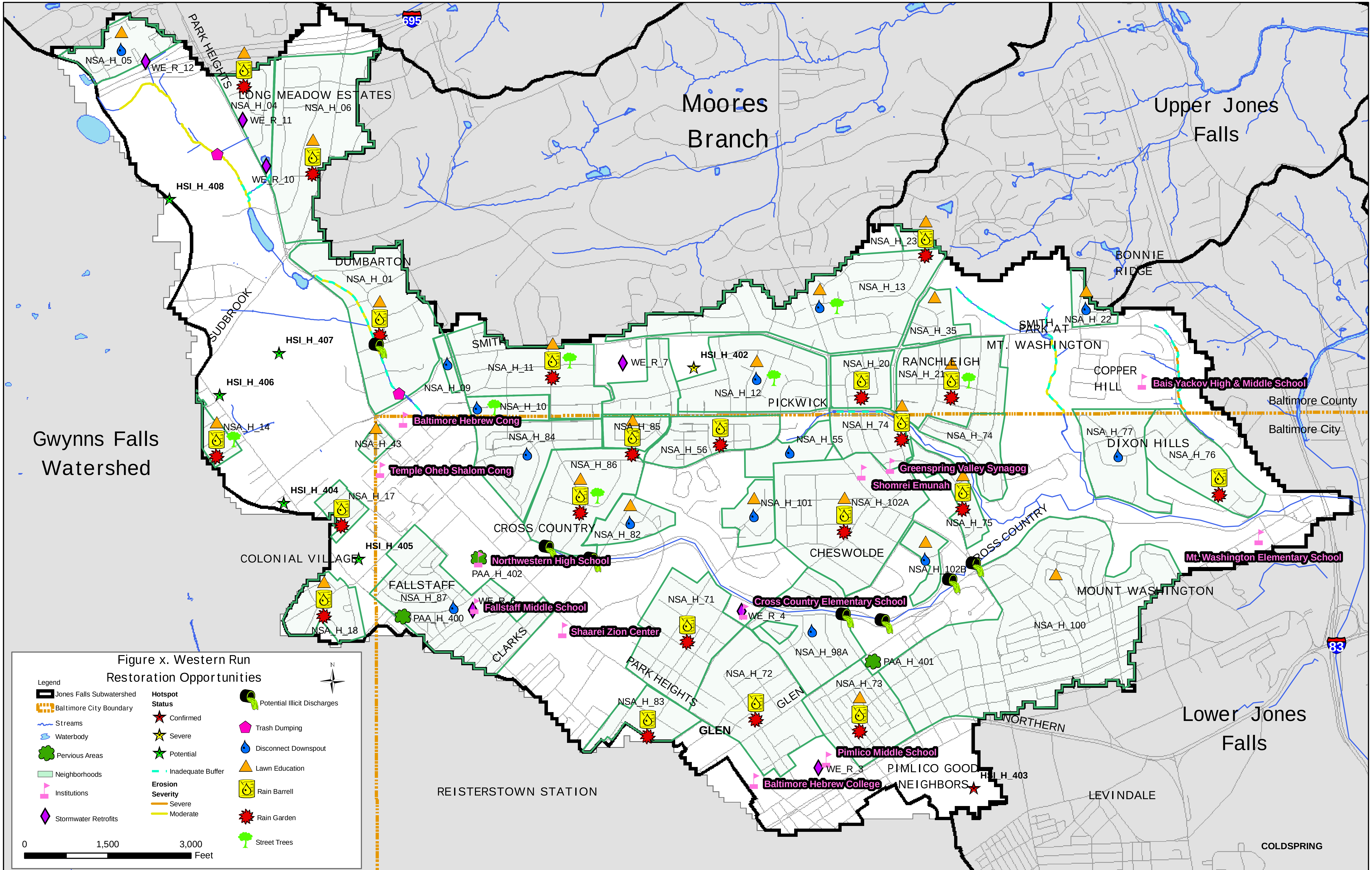
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SMITH
PICKWICK
RANCHLEIGH
MT. WASHINGTON
SMITH PARK AT
COPPER HILL
BONNIE RIDGE
DIXON HILLS
CROSS COUNTRY
COLONIAL VILLAGE
FALLSTAFF
CHESWOLDE
MOUNT WASHINGTON
CLARKS
GLEN
NORTHERN
PIMLICO GOOD NEIGHBORS
REISTERSTOWN STATION
LEVINDALE
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Temple Oheb Shalom Cong
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Fallstaff Middle School
Shaarei Zion Center
Cross Country Elementary School
Greenspring Valley Synagog
Shomrei Emunah
Bais Yaakov High & Middle School
Mt. Washington Elementary School
Pimlico Middle School
Baltimore Hebrew College
Figure x. Western Run Restoration Opportunities
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Neighborhoods
Institutions
Stormwater Retrofits
Hotspot Status
Confirmed
Severe
Potential
Inadequate Buffer
Erosion Severity
Severe
Moderate
Potential Illicit Discharges
Trash Dumping
Disconnect Downspout
Lawn Education
Rain Barrell
Rain Garden
Street Trees
N
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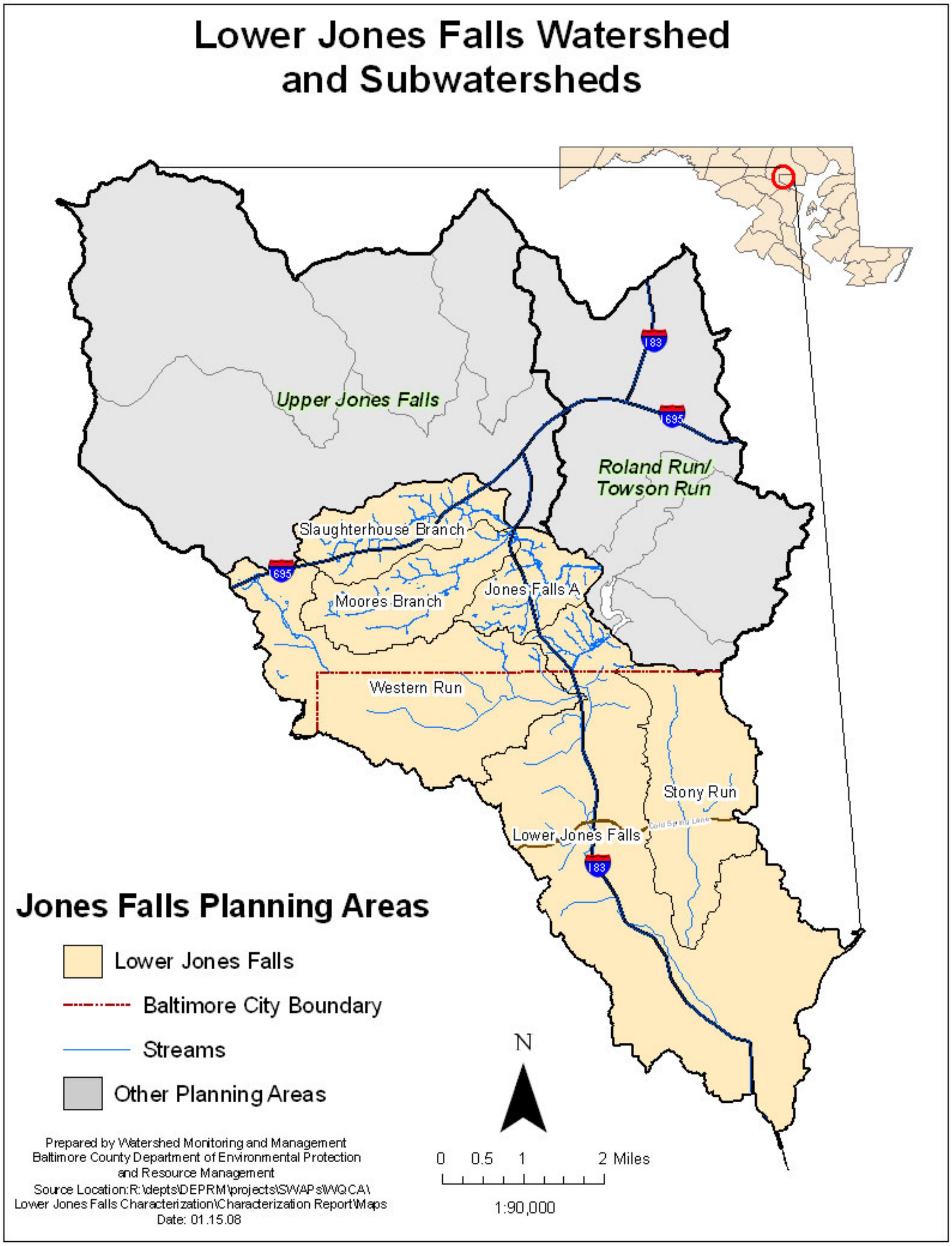
3,000
Feet
695
83

Appendix E

Lower Jones Falls Characterization Report

November 21, 2008

Lower Jones Falls
Watershed Characterization Report



Final

November 21, 2008

LOWER JONES FALLS CHARACTERIZATION REPORT
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CHAPTER 1

INTRODUCTION

1.1 Purpose of the Characterization

The Lower Jones Falls 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 the 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 the Baltimore County Lower Jones Falls Stream Corridor Assessment, the Baltimore City Western Run Stream Corridor Assessment, and the Slaughterhouse Branch Stream Stability Assessment will be used as the basis for the formulation of the Lower Jones Falls 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 Lower Jones Falls watershed is located in the Jones Falls River Basin in the Piedmont and Coastal Plain regions of Maryland. The watershed contains the mouth of the Jones Falls 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, while Figure 1-2 depicts the location of the subwatersheds within the Lower Jones Falls watershed.

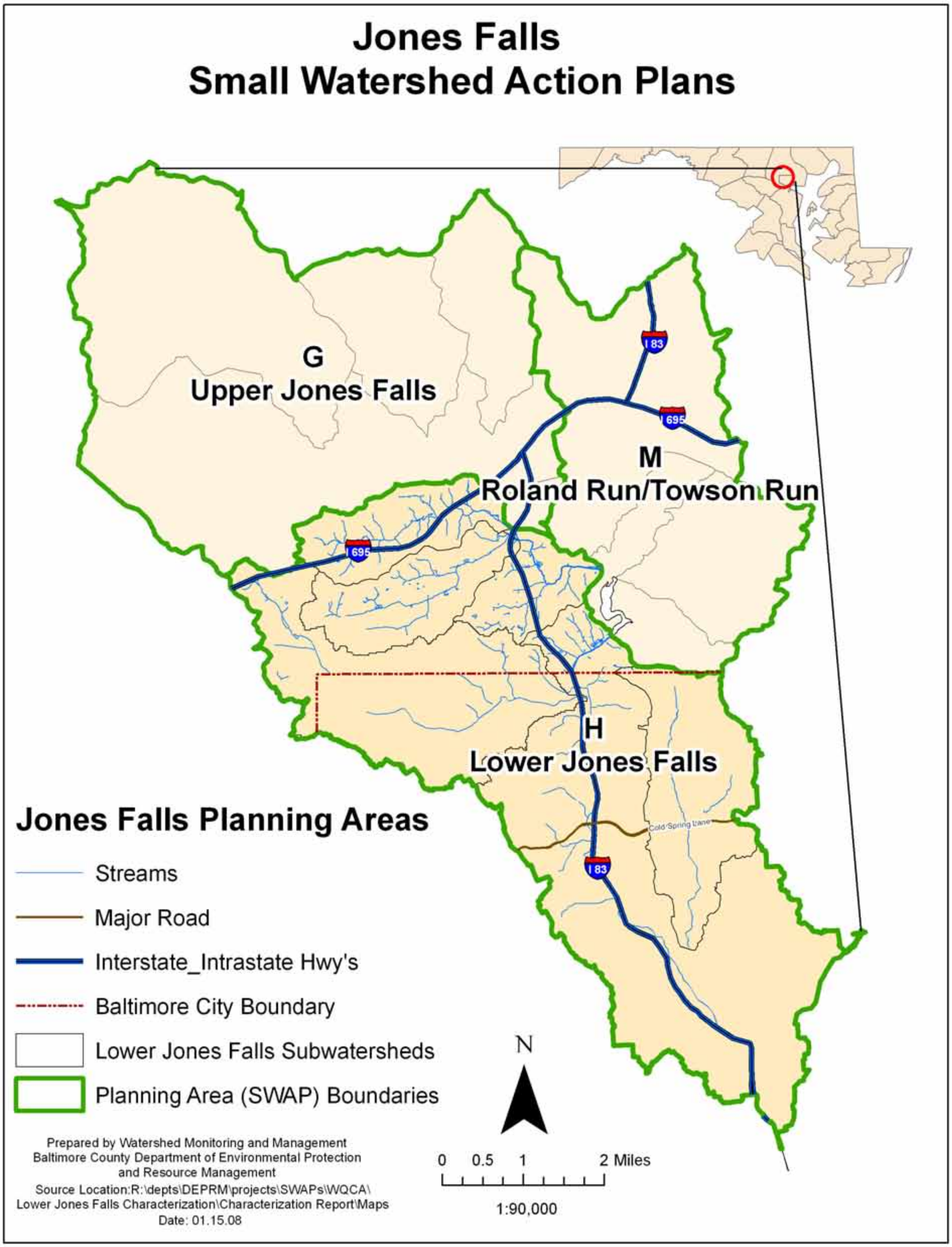

Figure 1-1: Lower Jones Falls Watershed in Relation to Other Small Watershed Action Planning Areas

Table 1-1: Distribution of Lower Jones Falls Watershed Acreage

Jurisdiction	Land	
	Acres	%
Baltimore County	5,485	33.1
Baltimore City	11,062	66.9
Watershed Total	**16,547**	**100**

The analysis presented in this report was conducted at the subwatershed scale in addition to an analysis of the entire Lower Jones Falls watershed. The subwatershed scale provides information on smaller drainage areas that are often the focus of intense restoration and preservation efforts, and 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: Lower Jones Falls Subwatershed Acreages

Subwatershed Scale	Acres
Slaughterhouse Branch	1,272
Moore's Branch	1,396
Western Run	3,487
Jones Falls A	862
Lower Jones Falls	7,287
Stony Run	2,243
Total	**16,547**

As Table 1-2 indicates, there are six separate subwatersheds identified for this report.

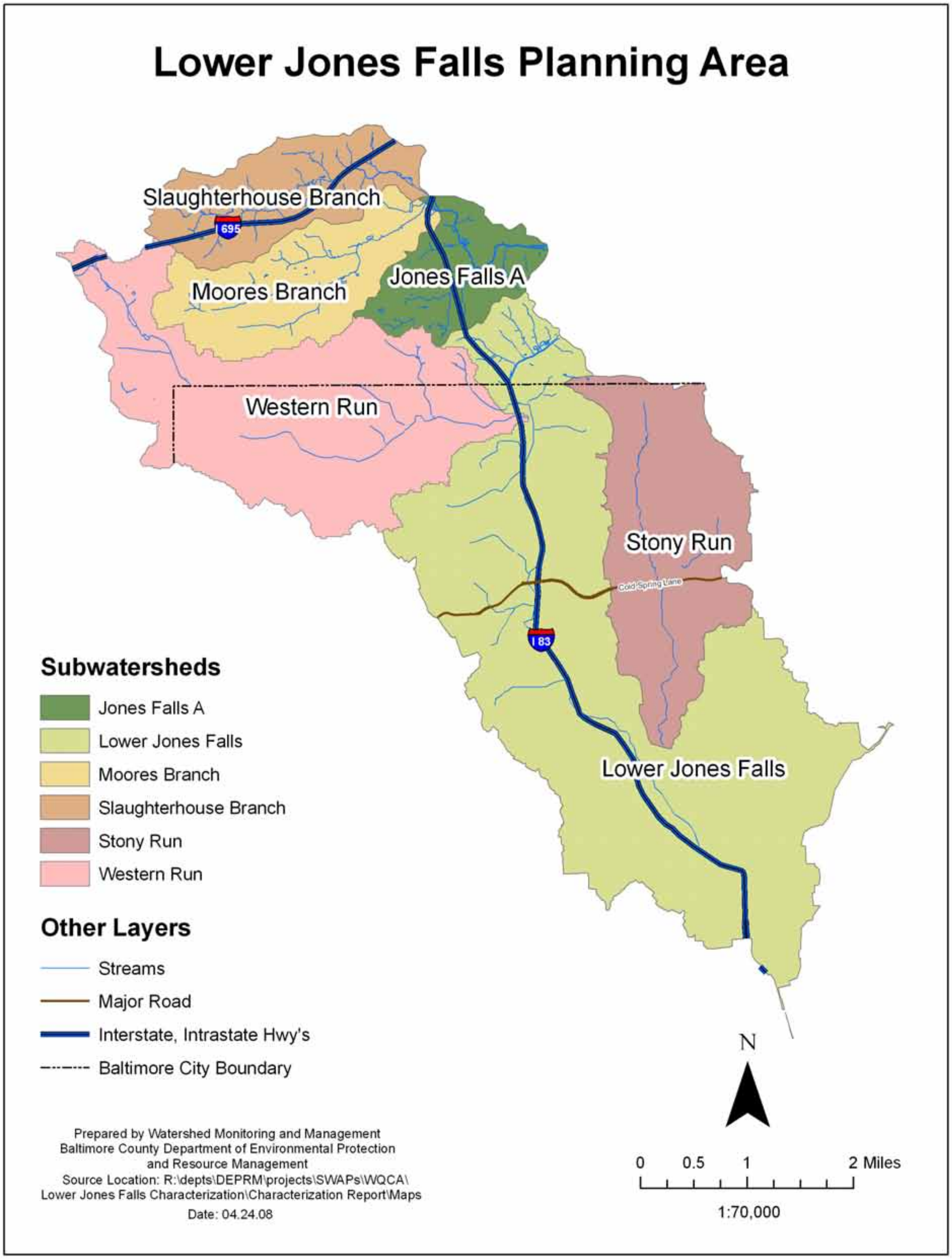

Figure 1-2: Lower Jones Falls subwatersheds.

1.3 Report Organization

This report is organized into five chapters. Chapter 1 presents an overview of the characterization report and general locations and acreage distributions of the study area.

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, and it relates the landscape characteristics to 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 Lower Jones Falls 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 Lower Jones Falls watershed. This will provide the basis for later chapters on water quality, living resources, restoration, and management.

The Lower Jones Falls watershed (16,550 acres) represents a portion (45%) of the larger Jones Falls watershed. It is one of three planning areas within the Jones Falls watershed. It was selected based on the similarity of land use and its geographical position to the west and south of Lake Roland. The other two planning areas will be addressed in future Small Watershed Action Plans.

The Lower Jones Falls watershed lies mostly within the Piedmont Region (74%) of Maryland with a small portion in the Coastal Plain (26%). 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 Lower Jones Falls 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 Lower Jones Falls 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 the factors are the physiographic province, the underlying geology and the surface soils, the climate that effects 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 drain 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 Lower Jones Falls watershed lies mostly within the Piedmont Physiographic Province with a small portion within the Western Coastal Plain located adjacent to Baltimore Harbor. The highest point of the planning area is located at 550 feet in elevation in the Slaughterhouse Branch. The lowest point in the watershed is located where the Jones Falls flows into the Inner Harbor at sea level. 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 Jones Falls watershed is a below average-sized 8-digit watershed that contains about 37,000 acres, or 57.82 square miles. The Lower Jones Falls planning area is 16,550 acres or 25.9 square miles in extent. For development of this Small Watershed Action Plan the Lower Jones Falls has been further divided into six subwatersheds (Figure 2-1). All data will be presented on the basis of these six subwatersheds.

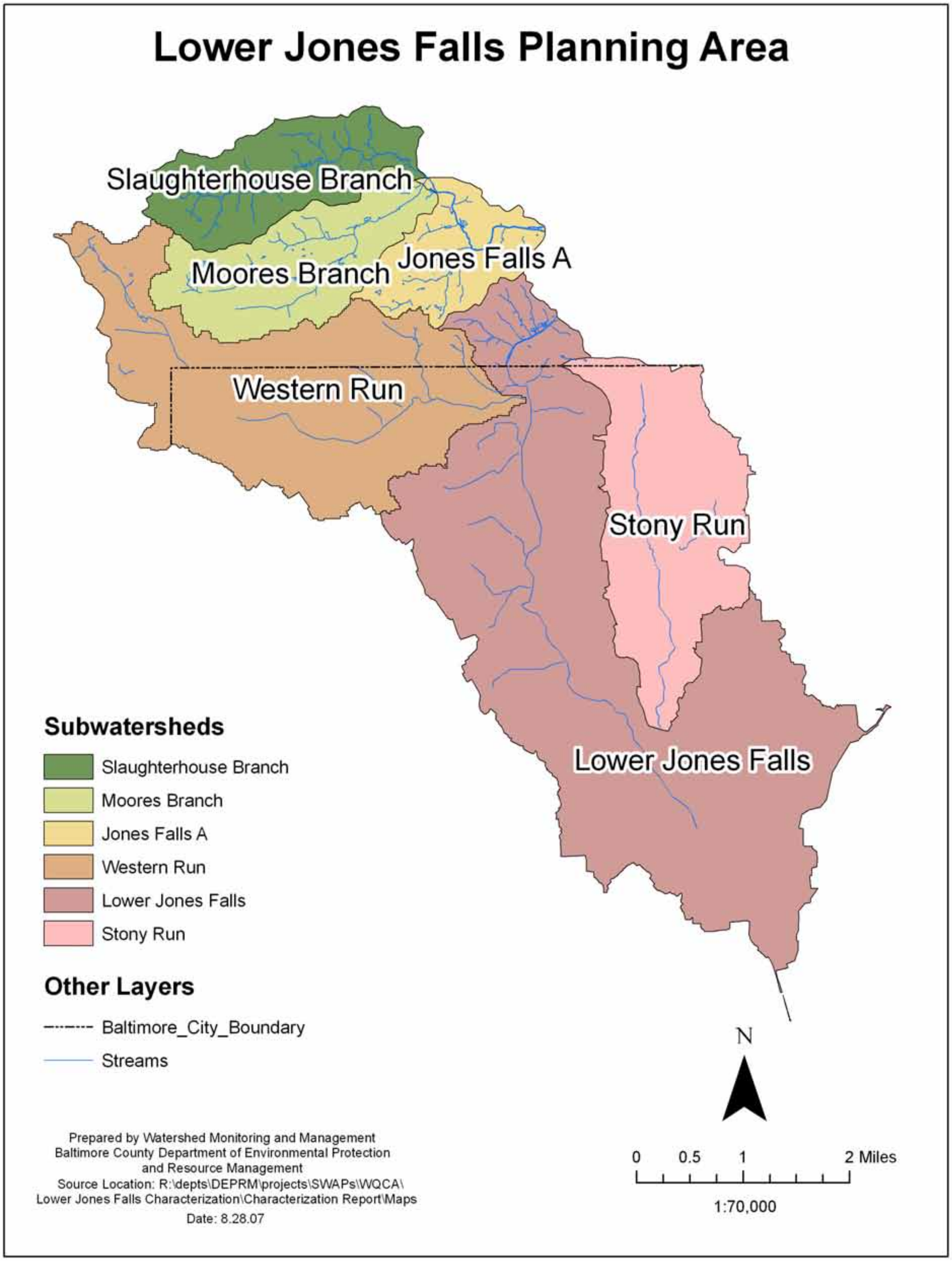

Figure 2-1: Lower Jones Falls Planning Area Subwatersheds

2.2.2.2 Topography

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: Lower Jones Falls Subwatershed Slope Categories (%)

Subwatershed	Slope Category				
	Low	Low-Medium	Medium	Steep	Extremely Steep
Slaughterhouse Run	10.3	57.4	14.1	16.7	1.5
Moores Run	14.7	39.1	20.9	13.2	12.1
Jones Falls A	15.7	17.6	25.5	14.3	26.9
Western Run	13.0	67.3	13.9	1.2	4.6
Stony Run	4.4	64.0	25.6	0.3	5.7
Lower Jones Falls	5.5	38.6	39.4	1.7	14.8
Total	**8.6**	**48.6**	**27.9**	**4.2**	**10.7**

The two subwatersheds with the highest proportion of steep and extremely steep slopes are the Jones Falls A subwatershed (41% of the area), and Moore's Run (25%). These subwatersheds contain relatively broken topography, making them more prone to erosion, depending on soil type and land cover. Conversely, Stony Run and Lower Jones Falls 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 Lower Jones Falls Planning Area.

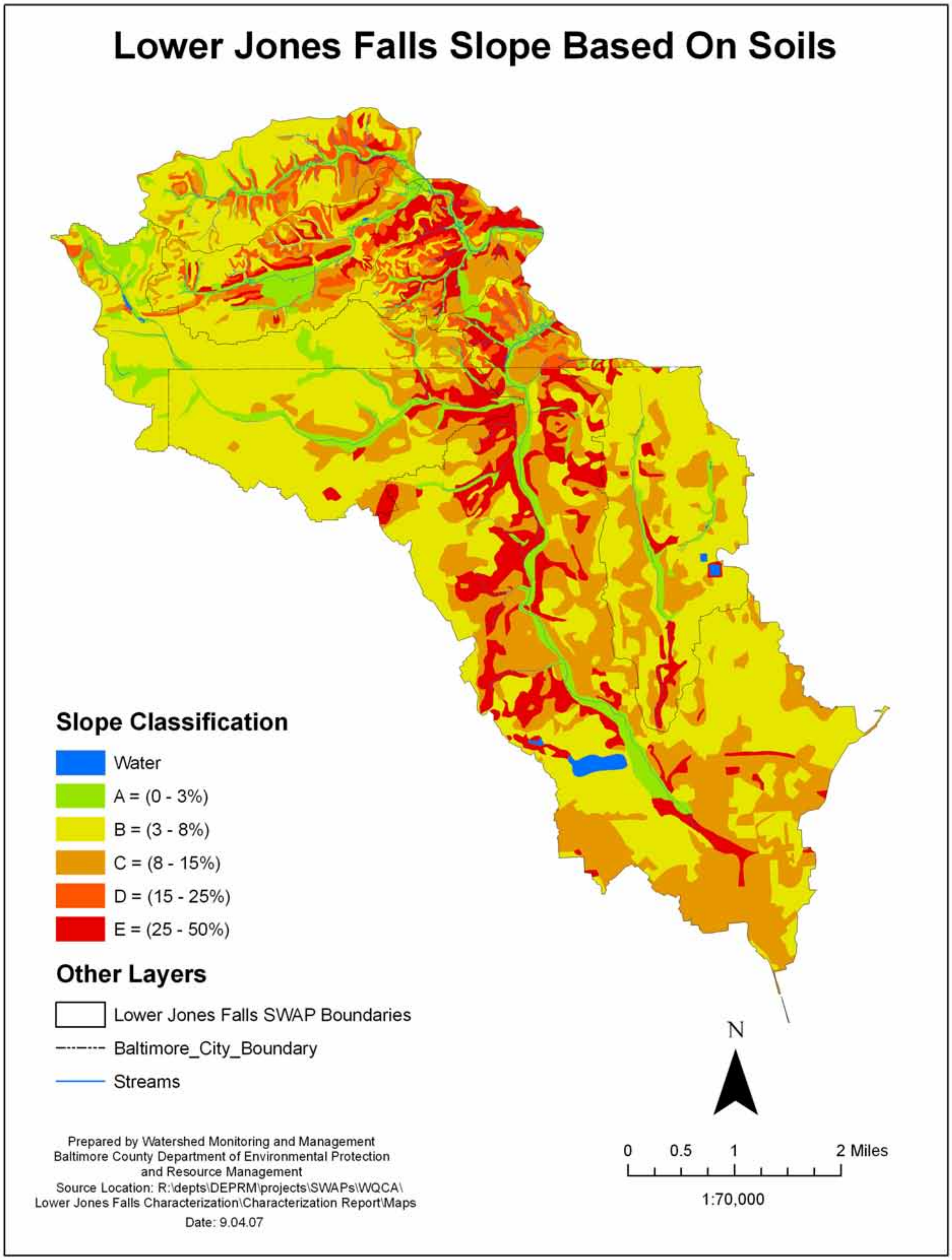

Figure 2-2. Lower Jones Falls Watershed Topography

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 northern portion of the Lower Jones Falls watershed and much of the Piedmont consists mainly of crystalline schists 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 southern portion of Lower Jones Falls.

The geological formations of the Lower Jones Falls 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: Lower Jones Falls Geological Composition by Subwatershed (%)

Geology	Type	Moores Run	Slaughter-house Run	Lower Jones Falls A	Western Run	Stony Run	Lower Jones Falls
Baltimore Gneiss	Metamorphic	30.8	63.7	0.0	9.5	31.2	4.9
Cockeysville Marble	Metamorphic	18.1	3.4	1.1	0.0	0.0	0.0
Loch Raven Schist	Metamorphic	35.5	0.0	32.8	5.2	4.1	0.3
Mount Washington Amphibolite	Metamorphic	0.9	0.0	0.0	75.6	17.3	6.1
Oella Formation	Metamorphic	0.0	0.0	66.1	8.4	7.5	6.7
Setters Gneiss	Metamorphic	12.2	0.8	0.0	1.0	4.1	1.0
Slaughterhouse Gneiss	Metamorphic	2.5	32.1	0.0	0.0	0.0	0.0
Patuxent Formation	Unconlidated	0.0	0.0	0.0	0.0	9.2	24.6
Sykesville Formation	Unconlidated	0.0	0.0	0.0	0.1	0.0	1.4
Artificial Fill	Unconlidated	0.0	0.0	0.0	0.2	2.8	2.8
James Run – Carroll Gneiss Member	Metamorphic	0.0	0.0	0.0	0.0	13.6	14.9
James Run – Druid Hill Amphibolite	Metamorphic	0.0	0.0	0.0	0.0	0.0	10.7
Jones Falls Schist	Metamorphic	0.0	0.0	0.0	0.0	5.4	2.6
Potomac Group	Unconlidated	0.0	0.0	0.0	0.0	7.6	4.4
Arundel Formation	Unconlidated	0.0	0.0	0.0	0.0	0.0	2.3
Coldspring Gneiss	Metamorphic	0.0	0.0	0.0	0.0	0.0	1.6
Hollofield Layered Ultramafite	Metamorphic	0.0	0.0	0.0	0.0	0.0	12.3
Raspeburg Amphilbolite	Metamorphic	0.0	0.0	0.0	0.0	0.0	3.5

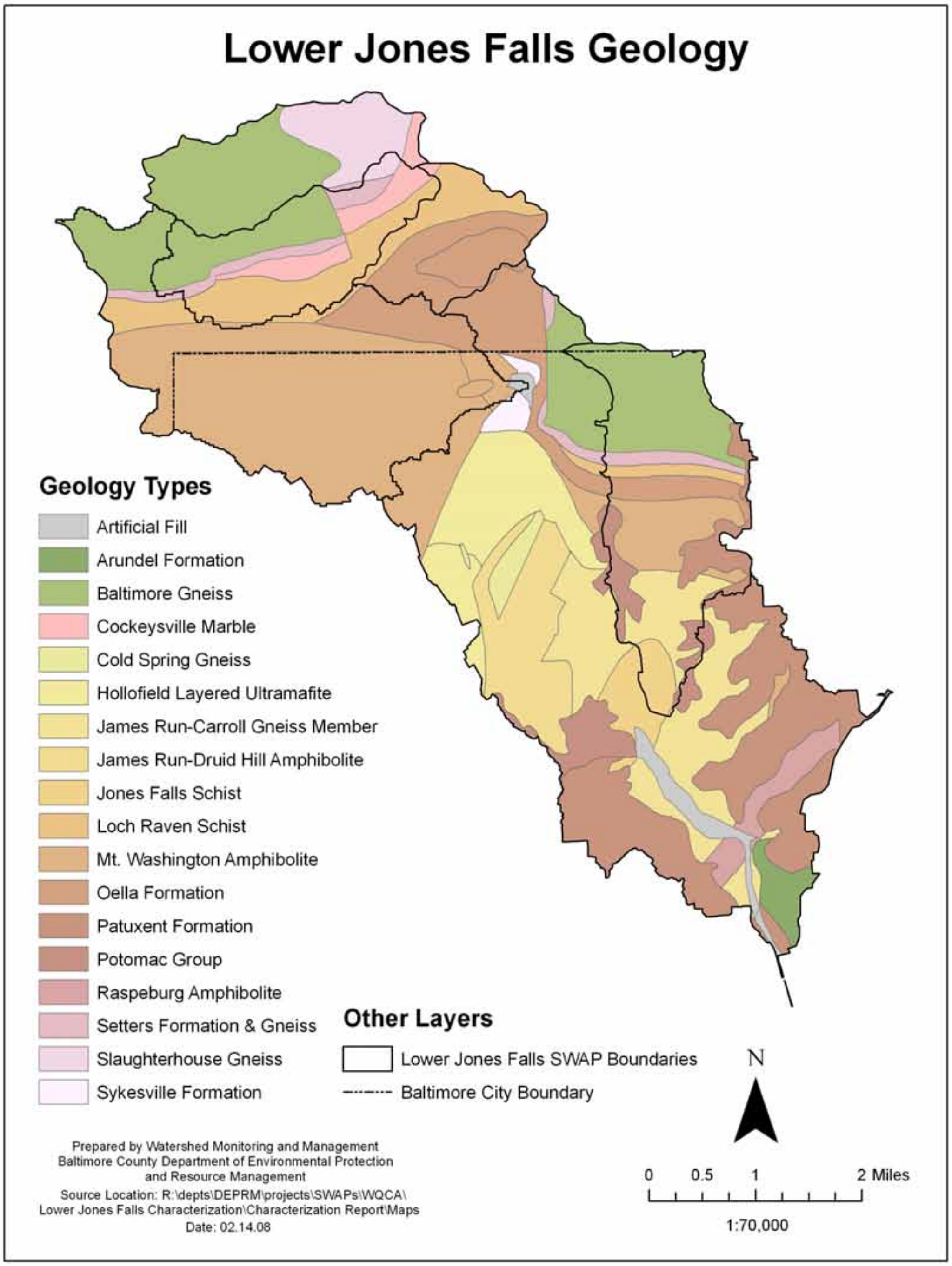

Figure 2-3. Lower Jones Falls Watershed Geology

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: Lower Jones Falls Subwatershed Hydrologic Soil Categories (%)

Subwatershed Scale	Hydrologic Soil Group %			
	A	B	C	D
Slaughterhouse Run	0.0	82.9	7.7	9.3
Moores Run	0.0	74.5	9.8	15.7
Jones Falls A	0.0	61.8	5.1	33.1
Western Run	0.0	22.4	14.5	63.2
Stony Run	1.3	14.6	5.0	79.1
Lower Jones Falls	1.7	19.0	5.5	73.8
Total	**0.9**	**31.0**	**7.9**	**60.2**

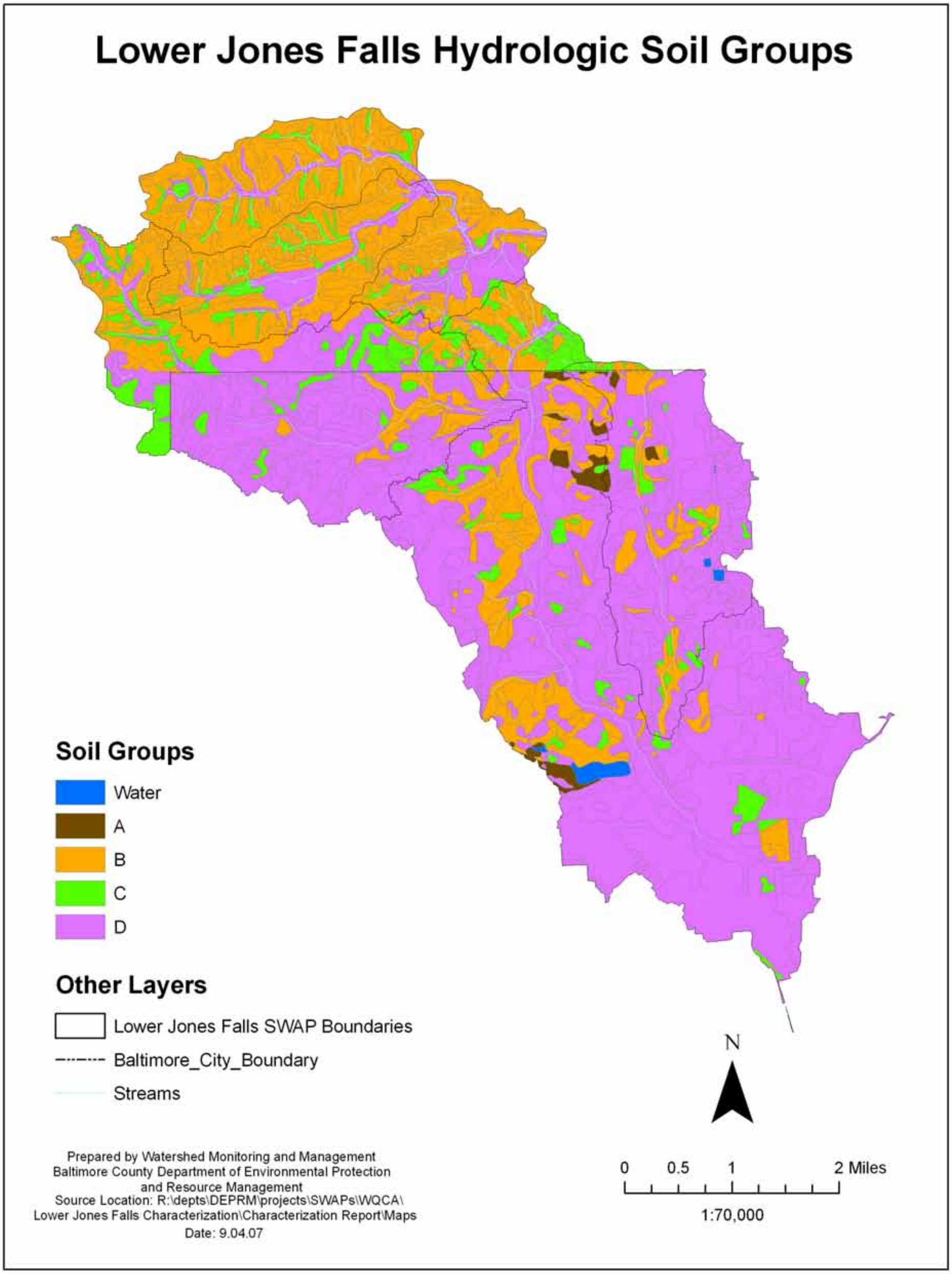

Figure 2-4. Lower Jones Falls Watershed - Hydrological Soil Groups

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 Lower Jones Falls 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 the Conservation Reserve Enhancement Program and 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 Lower Jones Falls 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 Jones Falls A subwatershed has over 50% highly erodible soils. This would rate as a priority subwatershed for maintaining protective land cover.

Table 2-4: Lower Jones Falls Subwatershed Soil Erodibility Categories (%)

Subwatershed Scale	Soil Erodibility Category %		
	Low	Medium	High
Slaughterhouse Run	1.1	62.6	36.4
Moores Run	14.5	47.7	37.8
Jones Falls A	31.0	13.5	55.5
Western Run	6.5	61.7	31.8
Stony Run	17.2	55.0	27.8
Lower Jones Falls	40.7	32.9	26.4
Total	**24.5**	**44.6**	**31.0**

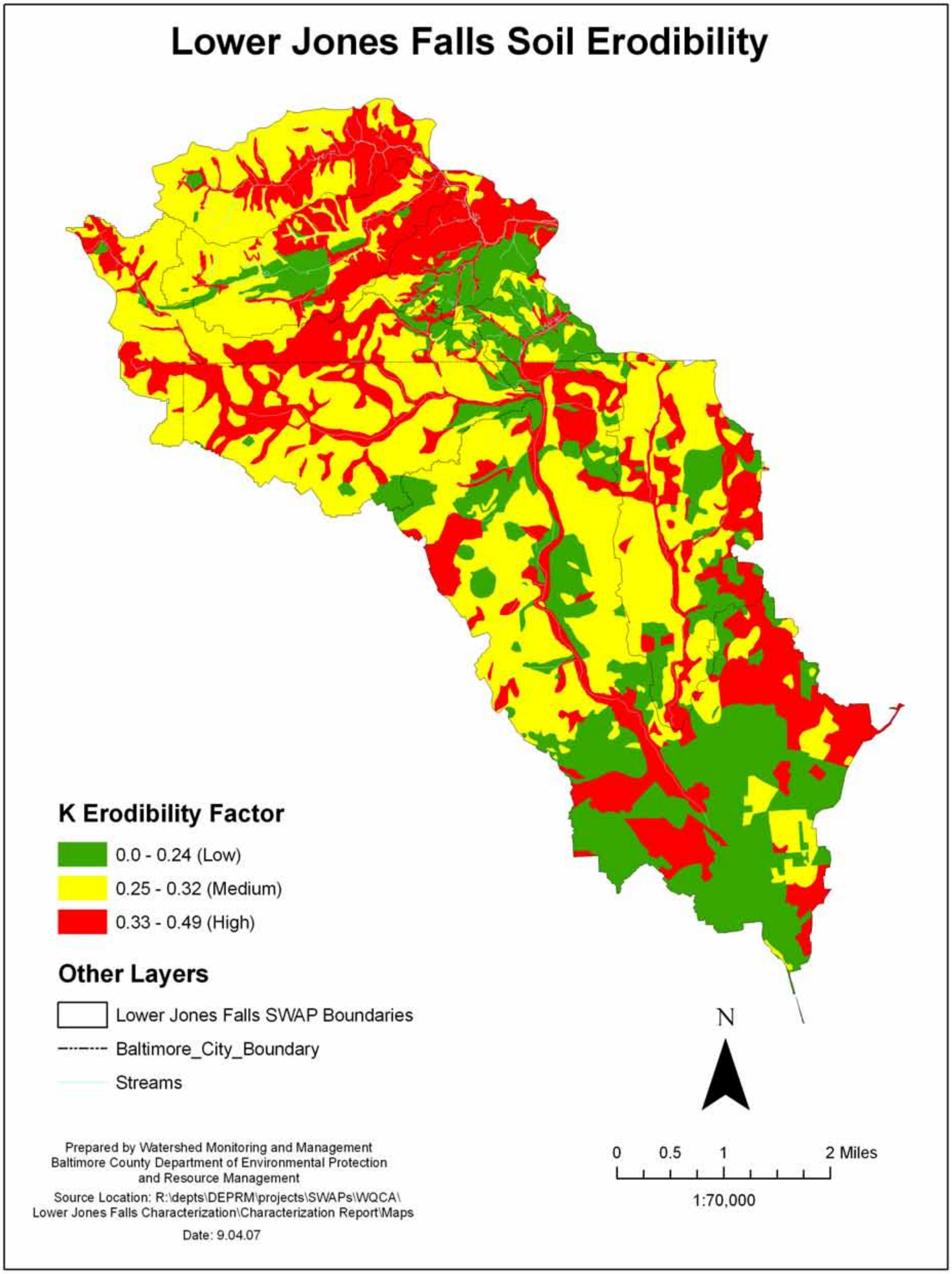

Figure 2-5. Soil Erodibility Based on the K factor

2.2.5 Forest

The entire Chesapeake Bay watershed, including the Lower Jones Falls 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 Lower Jones Falls 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 Lower Jones Falls watershed contains 2,252 acres of forest. The subwatersheds with the most forested acres are Lower Jones Falls and Moore's Branch. These areas are a potential priority for preservation. Portions of The Robert E. Lee Park exist in the Jones Falls A and Lower Jones Falls subwatersheds. There is a Natural Heritage Area (NHA #09) located within the park that supports populations of the state-listed endangered Serpentine Aster (*Symphyotrichum depauperatum)* and state-listed threatened Fameflower (*Talinum teretifolium)*.

Table 2-5: Lower Jones Falls Subwatershed Forested Area

Subwatershed	Total Acres	Forested Acres	% Forested
Slaughterhouse Run	1,272	305	24
Moores Branch	1,396	389	28
Jones Falls A	862	375	44
Western Run	3,487	179	5
Stony Run	2,243	109	5
Lower Jones Falls	7,288	895	12
Total	**16,548**	**2252**	**13.6**

With the exception of Jones Falls A, all of the subwatersheds contain less than 30% forest cover, with Western and Stony Run the lowest, both at 5%. These areas 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 Lower Jones Falls watershed contains approximately 54 miles of streams, all of which drain into the Baltimore Harbor. Slaughterhouse Branch, Moore's Branch and Jones Falls A all flow into Lake Roland which empties to the Jones Falls. Lake Roland was created in 1861 as part of the municipal drinking water system, taken offline in 1915 and refilled in June 1994.

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

Table 2-6: Lower Jones Falls Stream Mileage and Density

Subwatershed	County Stream Miles	City Stream Miles	Total Stream Miles	Stream Miles/Sq. Mile
Slaughterhouse Branch	10.2	0.0	10.2	5.13
Moores Run	8.1	0.0	8.1	3.71
Jones Falls A	6.9	0.0	6.9	5.12
Western Run	4.5	4.7	9.2	1.69
Stony Run	0.0	4.5	4.5	1.28
Lower Jones Falls	4.5	10.6	15.1	1.33
Total	**34.2**	**19.8**	**54.0**	**2.09**

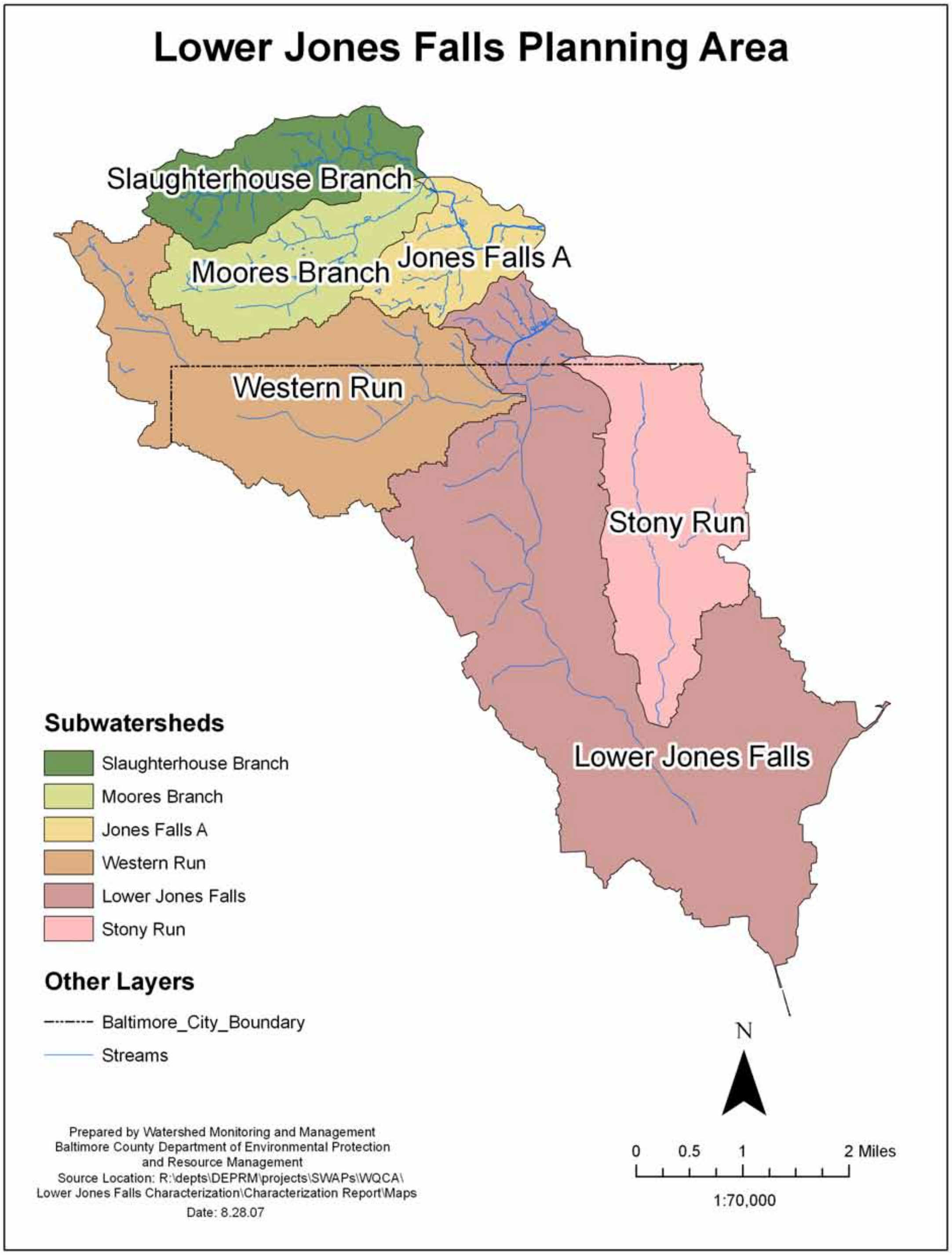

Figure 2-6. Lower Jones Falls Planning Area & Subwatersheds

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 to 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 2-7 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
Slaughterhouse Branch	147.9 (66)	65.9 (30)	9.6 (4)	**223.4 (16)**
Moores Branch	98.8 (53)	80.6 (43)	8.8 (4)	**188.2 (13)**
Western Run	83 (25)	213 (63)	39.7 (12)	**335.7 (24)**
Stony Run	69.1 (59)	37.4 (32)	10.7 (9)	**117.2 (8)**
Lower Jones Falls	130.4 (34)	193.5 (50)	59.4 (16)	**383.3 (27)**
Jones Falls A	75.6 (44)	85.2 (50)	9.4 (6)	**170.2 (12)**
Total	**604.8 (43)**	**675.6 (48)**	**137.6 (9)**	**1,418 (100)**

The percentage of the riparian buffer that is forested ranges from a high of 66% (Slaughterhouse Run) to a low of 34% (Lower Jones Falls). The areas to the north generally had higher percentages of forested buffer, while the areas to the south had lower percentages of forested buffer. The open pervious condition, covering 48% (675 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.

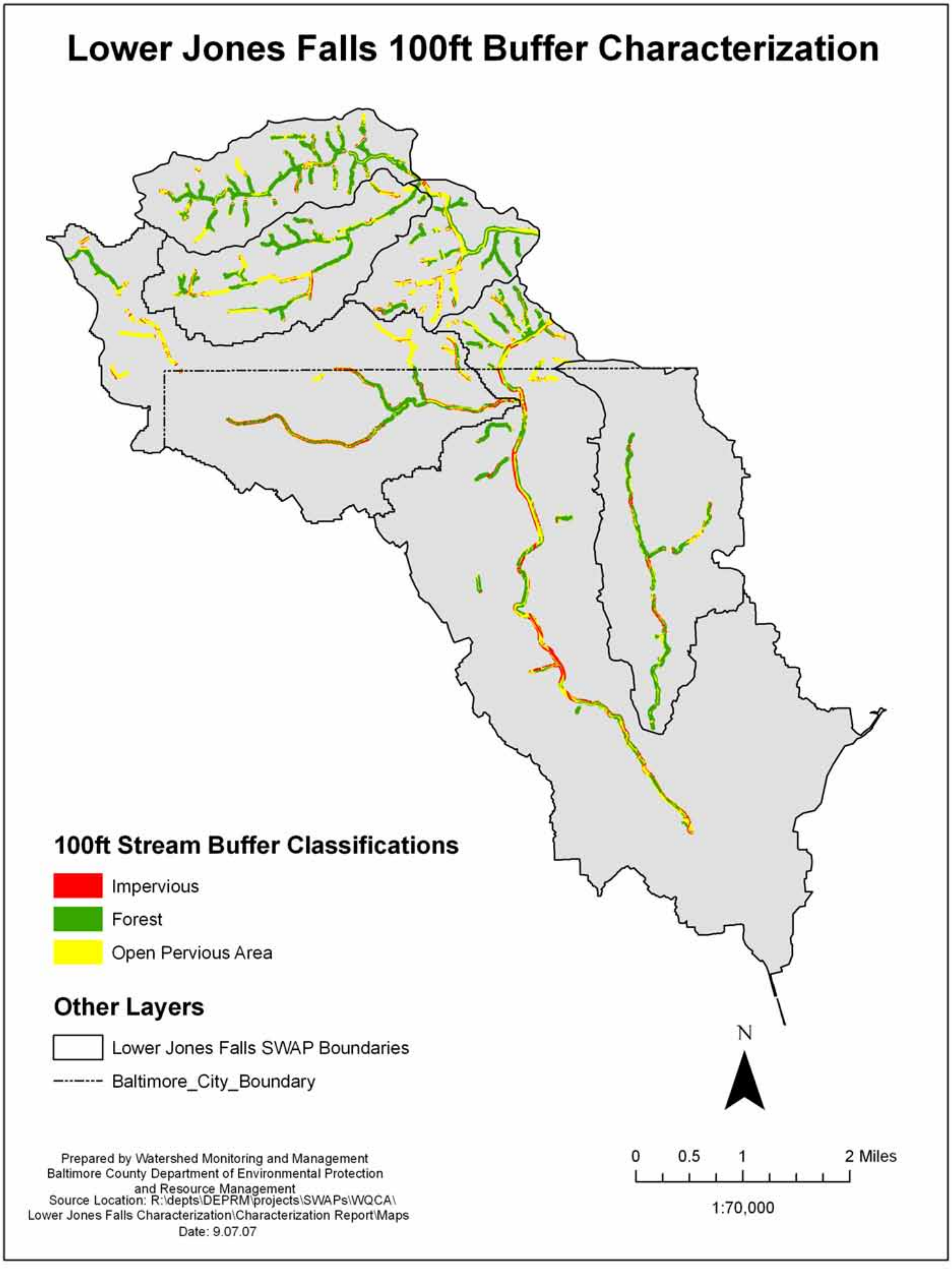

Figure 2-7. Riparian Buffer Condition

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 Lower Jones Falls watershed has 16,547 acres of land. The dominating land use types are: urban/residential 9,248 acres (56%), forest 2,252 acres (14%) and institutional land 1,731 acres (11%).

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 2-8. 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. Lower Jones Falls Watershed Land Use

Subwatershed Scale	Slaughter-house Branch %	Moores Branch %	Jones Falls A %	Western Run %	Stony Run %	Lower Jones Falls %	Total %
Forest	24.0	27.9	43.5	5.1	4.9	12.3	**13.6**
Commercial	0.0	0.9	2.4	5.6	2.3	11.8	**6.9**
Agricultural	14.1	2.3	0.0	0.0	0.0	0.0	**1.3**
Industry	0.0	7.3	5.3	0.0	0.0	4.7	**2.4**
Institutional	2.1	11.0	0.2	5.5	20.6	12.2	**10.5**
Low Density Residential	47.9	21.0	11.3	7.6	5.0	6.0	**11.1**
Medium Density Residential	8.8	21.6	8.6	46.8	50.2	8.6	**23.7**
High Density Residential	7.4	13.3	18.3	17.9	11.1	32.3	**21.1**
Highway	0.0	0.0	0.0	0.3	1.8	3.6	**1.9**
Open Urban	0.0	0.0	2.2	11.1	3.8	7.1	**6.1**
Bare Ground	0.0	2.3	0.8	0.0	0.0	0.8	**0.6**
Extractive	0.0	7.3	0.0	0.0	0.0	0.0	**0.6**
Water	0.0	0.0	0.0	0.0	0.3	0.7	**0.3**

A limited amount of agriculture is still present in the Lower Jones Falls planning area, located in the northern subwatersheds of Slaughterhouse Branch and Moore's Branch. Forest cover accounts for only 13.6% of the land cover, again mainly located in the northern subwatersheds. This is indicative of the greater intensity of development in the Baltimore City urban core. Urban/suburban residential development accounts for 56% of the land use in Lower Jones Falls watershed, with the majority (45%) in medium and high-density residential land use (<1 acre per dwelling unit). The extractive land use indicated in Moores Run is currently undergoing development as medium and high-density residential land use with a small amount of commercial. The old quarry will serve as a stormwater management facility for the development and provide water quality for downstream portions of Moores Run.

Institutional land use, consisting mainly, but not exclusively of schools, represents a large percentage (10.5%) of the land use within the Lower Jones Falls. Many of these institutions are private universities and colleges, and represent an opportunity to initiate environmentally sensitive management of the grounds.

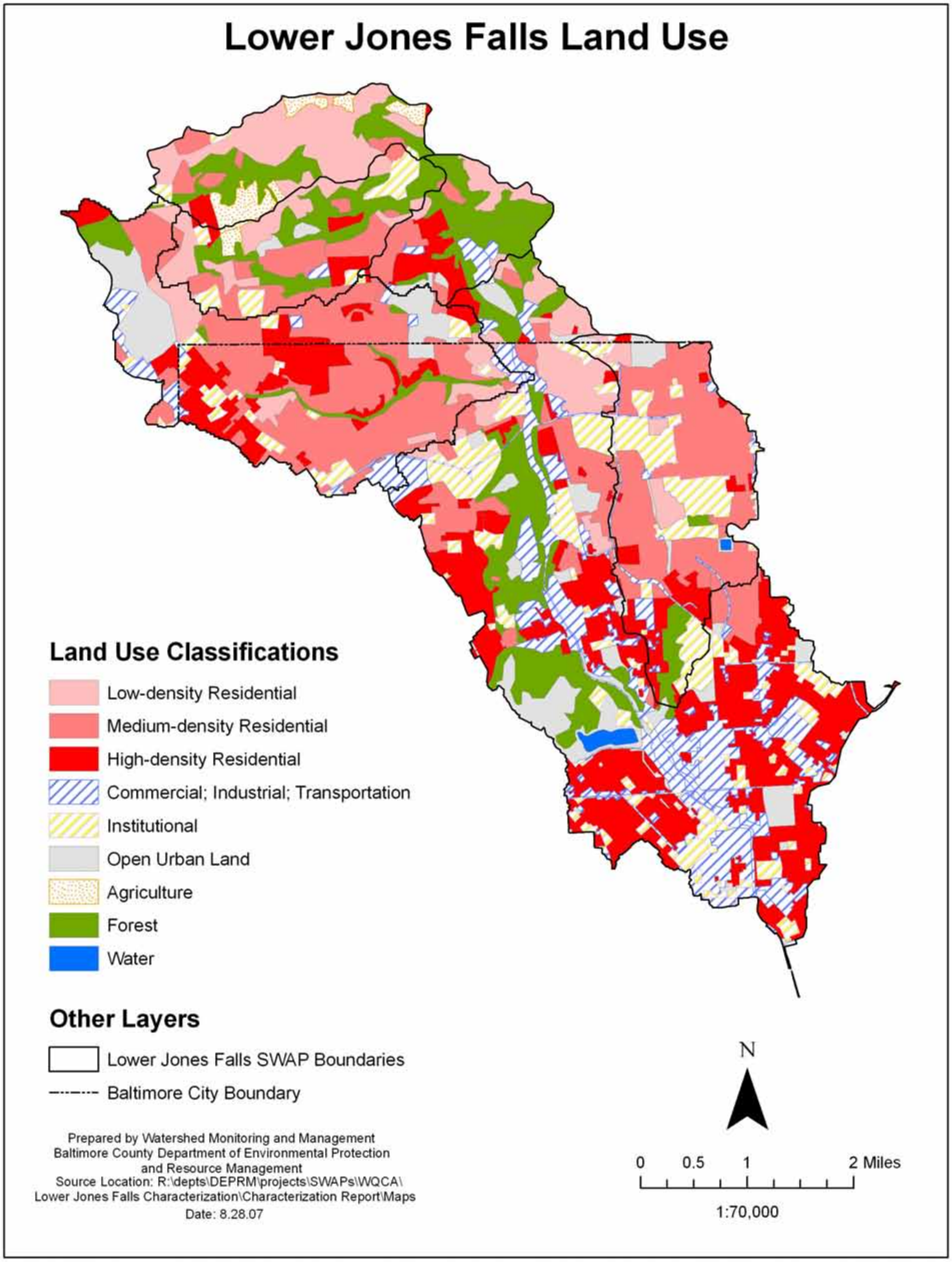

Figure 2-8. Land Use in the Lower Jones Falls Watershed.

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: Lower Jones Falls Subwatershed Population Data

Subwatershed	Total Population (2000 census)	SWAP Area (acres)	Population Density (per acre)	Population Density (per impervious acre)
Slaughterhouse Run	1,967	1,272	1.5	12.2
Moores Branch	4,515	1,395	3.2	21.3
Jones Falls A	4,244	862	4.9	24.6
Western Run	31,745	3,488	9.1	29.4
Stony Run	23,087	2,242	10.3	31.9
Lower Jones Falls	110,663	7,287	15.2	38.1
Total	**178,221**	**16,546**	**10.8**	**33.9**

A trend of increasing density from the northern subwatersheds to the southern 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 adjacent to Baltimore Harbor northward to the northern suburban subwatersheds. Within the high population density Lower Jones Falls subwatershed the residential population is clustered towards the harbor and along major thoroughfares with intervening areas of lower density population.

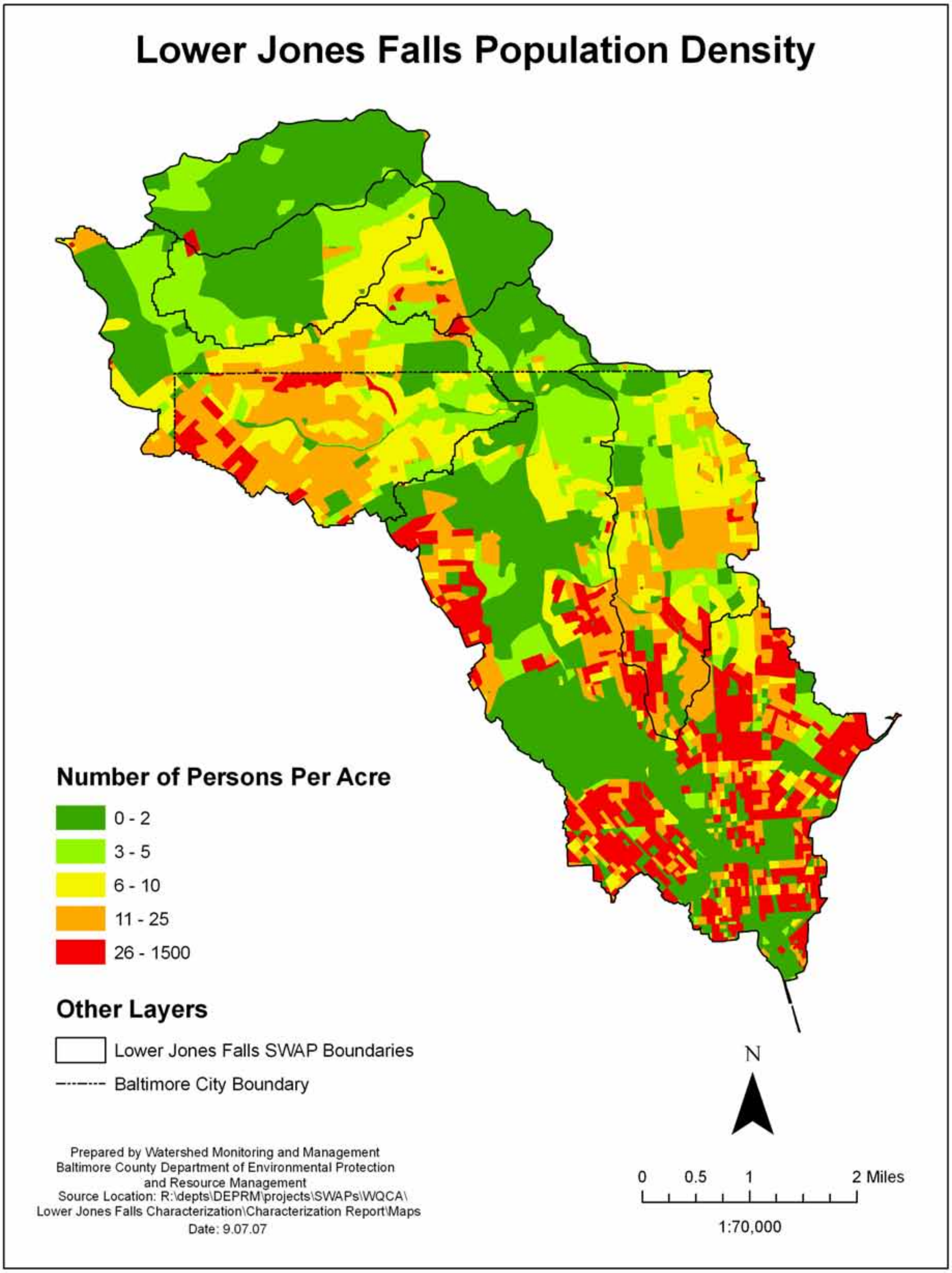

Figure 2-9 Population in the Lower Jones Falls Watershed

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.

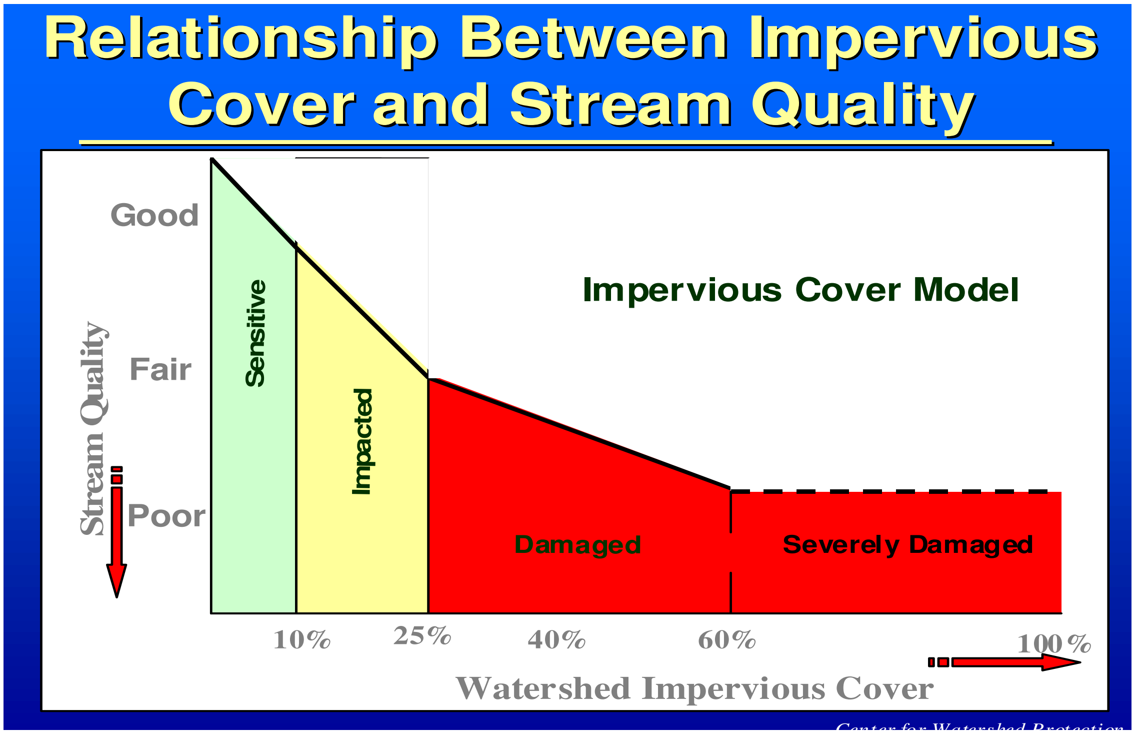

Figure 2-10. Impervious Cover Model

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 Lower Jones Falls watershed. The total amount of impervious surface in the watershed is estimated to be 5,258 acres or 31.8% of the watershed area. Compared to less urbanized watersheds in Baltimore County, this is a relatively high level of imperviousness. Figure 2-11 shows impervious cover data by subwatershed.

Table 2-10. Impervious Surface in the Lower Jones Falls Watershed

Subwatershed	Acres Car Habitat		Acres Buildings		% Impervious	
	City	County	City	County	City	County
Slaughterhouse Branch	NA	100.6	NA	61.0	NA	12.7
Moores Branch	NA	126.0	NA	87.7	NA	15.3
Jones Falls A	NA	110.6	NA	61.7	NA	20.0
Western Run	404.9	252.8	260.2	163.7	19.1	11.9
Stony Run	413.7	10.3	293.2	6.1	31.6	0.8
Lower Jones Falls	1,658.2	47.0	1,175.9	24.3	38.9	0.9
Total	**2,476.8**	**647.3**	**1,729.3**	**404.5**	**38.0**	**19.2**
Combined Total	***3124.1***		***2133.8***		***31.8***	

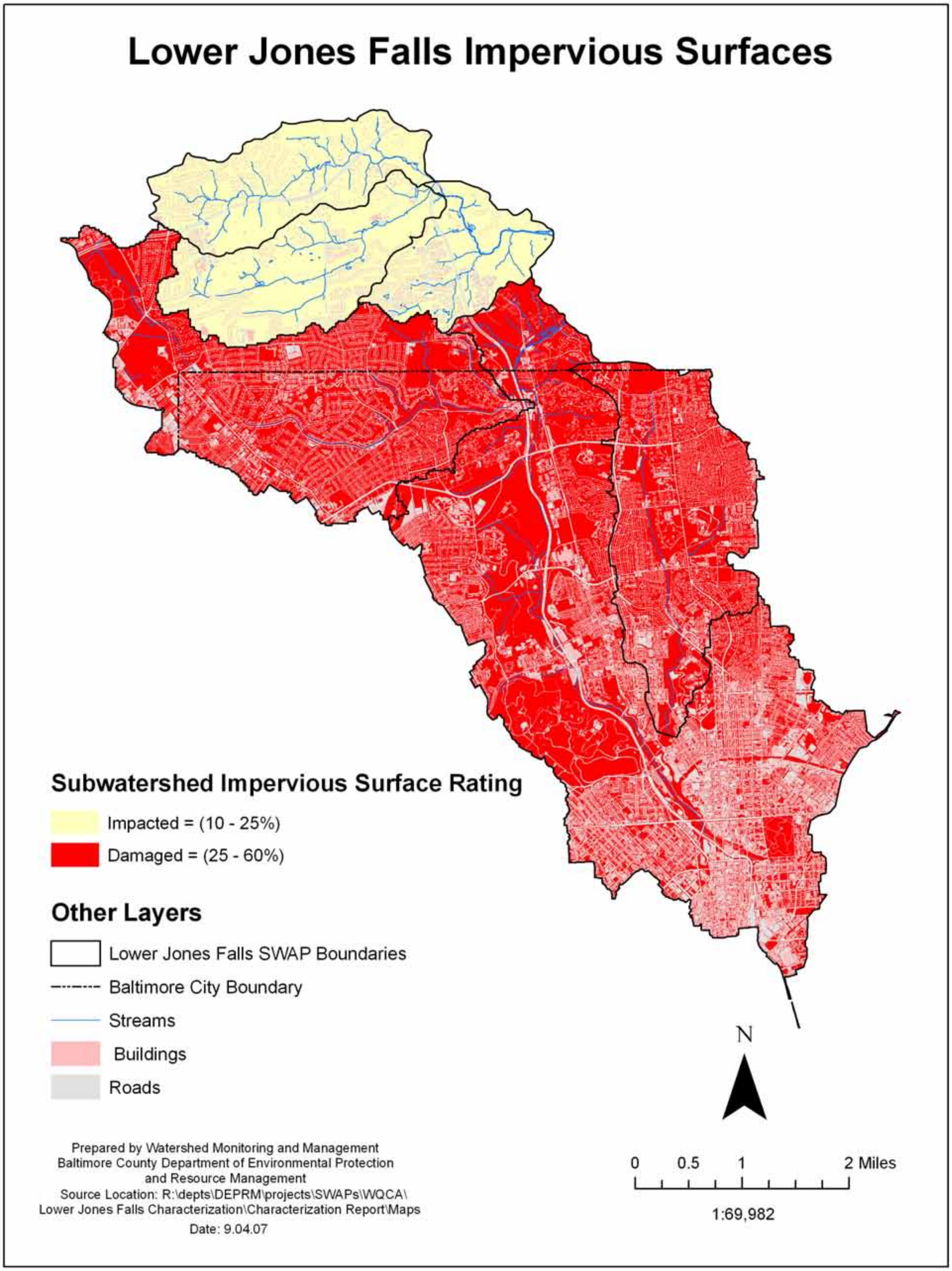

Figure 2-11. Impervious Cover Ratings by Subwatershed

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 Lower Jones Falls planning area is served by public water.

2.3.3.1 Public Water Supply

After 1915, when the Lake Roland Reservoir (originally called Swann Lake) was taken offline from the municipal drinking water system, the Jones Falls ceased to be part of Baltimore's municipal drinking water supply. Only The Gunpowder Falls, Patapsco River and, in times of drought, the Susquehanna River, feed the water supply system today. Although there are storage reservoirs at Druid Hill and in Stony Run, this water is pumped from outside the Jones Falls watershed.

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.

2.3.4 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.

2.3.4.1 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.

2.3.4.2 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. Tables 2-11 & 2-12 show sewer piping data. 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.

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
Moore’s Branch	2,125	821	95,189	65	0	**98,200**
Western Run (county)	0	453	143,222	349	0	**144,024**
Western Run (city)	0	0	300,385	0	91,586	**391,971**
Jones Falls A	0	0	52,057	0	0	**52,057**
Lower Jones Falls(county)	335	0	20,779	0	0	**21,114**
Lower Jones Falls (city)	0	0	1,080,742	0	551,672	**1,632,414**
Stony Run (county)	0	0	859	0	0	**859**
Stony Run (city)	0	0	304,296	0	112,092	**416,388**
Slaughterhouse Branch	512	0	66,264	0	0	**66,776**
Total	**2,972**	**1,274**	**2,063,793**	**414**	**755,350**	**2,823,802**

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)
Moore’s Branch	974	43,652	0
Western Run	0	198,355	16,810
Jones Falls A	0	38,650	0
Lower Jones Falls	30	96,737	48,449
Stony Run	0	87,090	31,991
Slaughterhouse Branch	257	33,341	0

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 environmental impacts themselves include high Biological Oxygen Demand, bacterial contamination, high nutrient loadings, and toxic materials. See Section 3.4 for an analysis of the sewage overflows in the Lower Jones Falls planning area.

2.3.4.3 Waste Water Treatment Facilities

There are no wastewater treatment facilities located within the Lower Jones Falls planning area.

2.3.5 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 runoffs, as well as, the amount and intensity of rainfall. Stormwater can carry pollutants from imperious 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.

2.3.5.1 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 outlines data on the existing strom drain system in the Lower Jones Falls watershed.

Table 2-13: Lower Jones Falls Storm Drain System

Subwatershed	Storm Drain Outfalls (#)	Storm Drain Inlets (#)	Strom Drain Piping (ft)
Moore's Branch	43	192	47,468
Western Run (county)	23	128	75,354
Western Run (city)	77	1,521	149,678
Jones Falls A	28	157	26,276
Lower Jones Falls (county)	4	13	2,631
Lower Jones Falls (city)	220	7,952	918,604
Stony Run (county)	0	0	194
Stony Run (city)	94	1,801	225,278
Slaughterhouse	29	95	24,965
Total	**518**	**11,859**	**1,470,447**

2.3.5.2 Stormwater Management Facilities

Starting in the 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 Table 2-14 and Figure 2-12 illustrate the stormwater management facilities in the Baltimore County portion of the Lower Jones Falls watershed. The facility type and drainage area to the facility are listed by subwatershed in Table 2-14.

Table 2-14. Lower Jones Falls Stormwater Management Facilities

Subwatershed	Slaughter-house Branch	Moores Branch	Western Run	Stony Run	Lower Jones Falls	Jones Falls A	Totals
Dry Pond Hydro (#) Drainage Area (acres)	2 18.9	4 299.5	5 30.1	0 0.0	1 4.9	5 98.6	**17** **452.1**
Wet Ponds (#) Drainage Area (acres)	0 0.0	2 785.3	1 8.5	0 0.0	0 0.0	1 54.6	**4** **848.4**
Infiltration (#) Drainage Area (acres)	0 0.0	0 0.0	1 0.62	0 0.0	1 3.6	1 0.1	**3** **4.3**
Filtration (#) Drainage Area (acres)	2 17.6	1 3.21	4 0.61	0 0.0	0 0.0	1 0.2	**8** **21.6**
Extended Detention (#) Drainage Area (acres)	0 0.0	3 104.5	6 46.6	0 0.0	1 16.1	5 68.1	**15** **235.4**
Other (#) Drainage Area (acres)	0 0.0	3 10.4	0 0.0	0 0.0	0 0.0	0 0.0	**3** **10.39**
Total (#) **Total (acres)**	**4** **36.5**	**13** **1,202.9**	**17** **86.5**	**0** **0.0**	**3** **24.6**	**13** **221.7**	**50** **1,572.3**

Table 2-14 reveals that the dry pond is the best-represented storm water management design in terms of number of facilities. Being that the dry pond has the lowest pollution removal efficiency, these types present the best opportunities for conversion to a more efficient design.

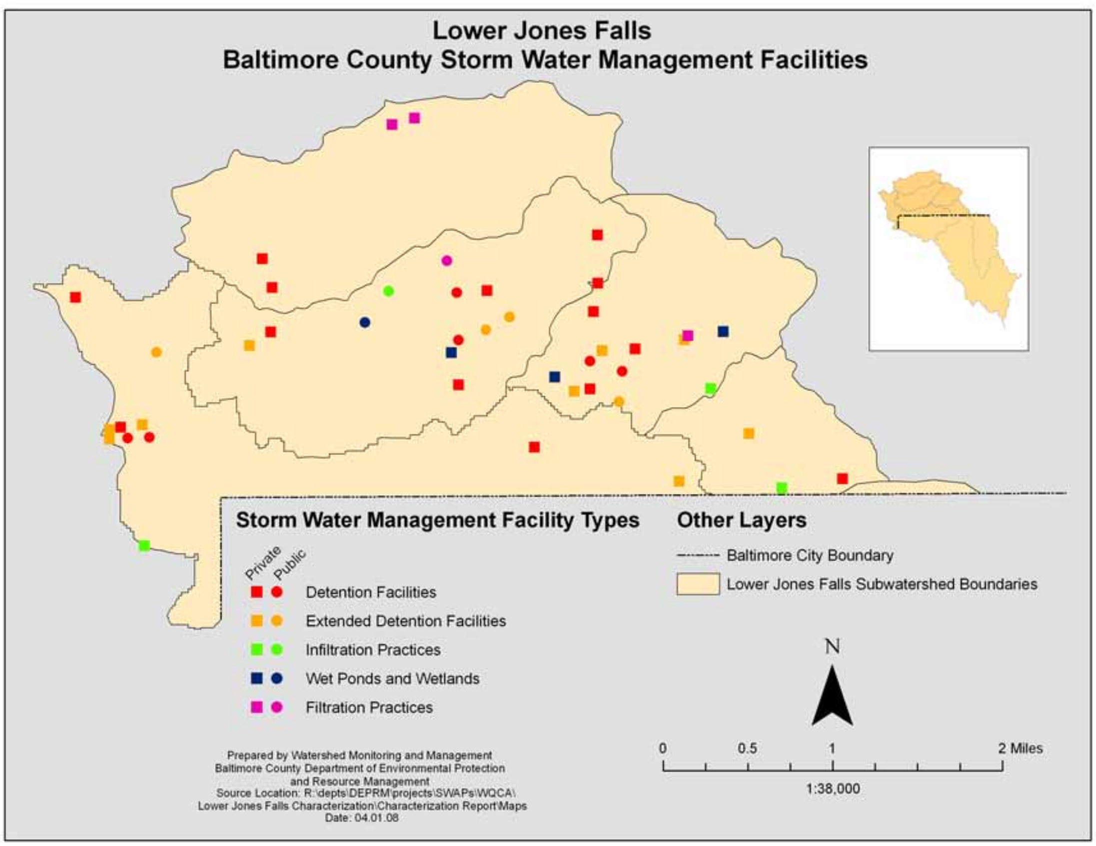

Figure 2-12. Stormwater Management

Figure 2-12 shows that the stormwater management facilities in the county portion of the Lower Jones Falls are fairly well scattered throughout the watershed. A total of 50 facilities are represented.

Table 2-15 shows the percentage of urban land use areas in the county portion of the Lower Jones Falls that are treated by stormwater management.

Table 2-15. Lower Jones Falls 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 (%)
Slaughterhouse Branch	1,272.0	787.5	36.5	5
Moores Branch	1,395.6	942.1	1,202.9	128
Western Run	1,474.0	1,382.5	86.5	6
Stony Run	36.4	36.4	0.0	0
Lower Jones Falls	445.8	263.9	24.7	84
Jones Falls A	862	479.4	221.7	46

2.3.6 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 swimming pool discharges.

Table 2-16: NPDES Permits in the Lower Jones Falls Watershed

Subwatershed	# Industrial	#General	# Pools	# Of Permits
Slaughterhouse Branch	0	1	0	1
Moore's Branch	0	3	1	4
Jones Falls A	1	2	1	4
Western Run	0	4	6	10
Lower Jones Falls	11	5	3	19
Stony Run	0	2	4	6
Total	**12**	**17**	**15**	**44**

2.3.7 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 Figures 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, 18, & 19 show how the various zoning types are distributed throughout the Lower Jones Falls.

The entire Lower Jones Falls watershed is located within a priority funding area.

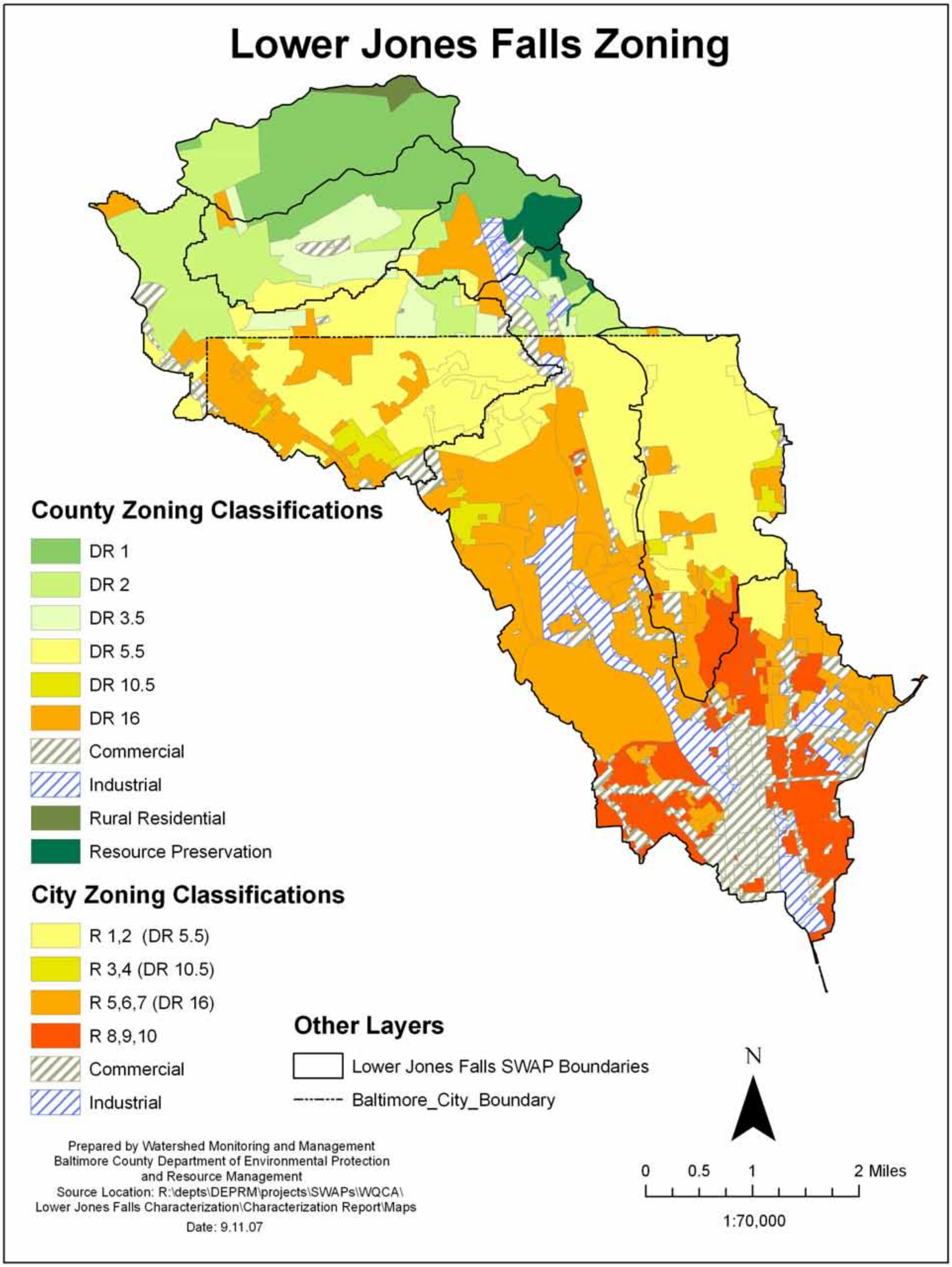

Figure 2-13. Zoning in the Lower Jones Falls Watershed

Table 2-17: Lower Jones Falls County Zoning

Zoning Code (county)	Zoning Description	Allowed Units/Acre	Total (acres)	Total (%)
RC-5	Rural Residential	-	74.9	1.4
RC-6	Rural Conservation/Residential	-	0.0	0.0
RC-7	Resource Preservation	-	195.5	3.6
DR-1	Density Residential	1	1,686.4	30.7
DR-2	Density Residential	2	1,613.7	29.4
DR-3.5	Density Residential	3.5	646.8	11.8
DR-5.5	Density Residential	5.5	538.4	9.8
DR-10.5	Density Residential	10.5	0.4	0.0
DR-16	Density Residential	16	382.9	7.0
RAE-1	Residential Apartment	40	0.0	0.0
RAE-2	Residential Apartment	80	0.0	0.0
Commercial	Offices/Businesses	-	214.9	3.9
Manufacturing	Industrial	-	132.2	2.4
Total			**5,486.1**	**100**

Table 2-18: Lower Jones Falls 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	-	-	-	216.8	2.0
R-1A	Single Family Residential	3	-	-	-	0.0	0.0
R-1	Single Family Residential	5.9	-	-	-	3,272.6	29.6
R-2	General Residential	5.9	5.9	5.9	-	184.5	1.7
R-3	Single Family Residential	8.7	-	-	-	196.6	1.8
R-4	General Residential	5.9	8.7	8.7	-	91.1	0.8
R-5	General Residential	5.9	14.5	17.4	17.4	1,476.2	13.3
R-6	General Residential	5.9	14.5	29	29	982.2	8.9
R-7	General Residential	5.9	17.4	39.6	39.6	1,319.0	11.9
R-8	General Residential	5.9	21.7	58	58	833.4	7.5
R-9	General Residential	5.9	21.7	79.2	58	368.7	3.3
R-10	General Residential	5.9	21.7	217.8	58	70.6	0.6
Commercial	Offices/Businesses	-	-	-	-	1,246.2	11.3
Manufacturing	Industrial	-	-	-	-	802.1	7.3
Total						**11,059.9**	**100.0**

Table 2-19: Lower Jones Falls Zoning Combined

Zoning Code (county)	Zoning Code (city)	Zoning Description	Total (acres)	Total (%)
RC-5	-	Rural Residential	74.9	0.5
RC-7	-	Resource Preservation	195.5	1.2
DR-1	-	Density Residential	1,686.4	10.2
DR-2	R-1B	Density Residential	1,830.5	11.1
DR-3.5	-	Density Residential	646.8	3.9
DR-5.5	R-1, 2	Density Residential	3,995.5	24.1
DR-10.5	R-3, 4	Density Residential	288.1	1.7
DR-16	R-5, 6, 7	Density Residential	4,160.3	25.1
RAE-1	R-8, 9, 10	General residence	1,272.6	7.7
Commercial	Commercial	Offices/Businesses	1,461.1	8.8
Manufacturing	Manufacturing	Industrial	934.3	5.6
Total			**16,546**	**100**

The Lower Jones Falls watershed has 13,955 acres of residentially zoned area, the predominant assessment class at 84% of the watershed area. There is a fair amount (14%) of commercial and manufacturing totaling 2,395 acres throughout the Lower Jones Falls watershed. Resource preservation or RC-7 zoning accounts for only 1% of the land area in the watershed. This zoning category has a very low density of one residential unit per 25 acres. As shown in Figure 2-13, most of the RC-7 zoned land is in the Jones Falls A subwatershed in the Robert E. Lee Park area bordering Lake Roland. 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 Lower Jones Falls 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 Lower Jones Falls 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 Jones Falls Watershed Association conducts an annual synoptic survey within the Jones Falls watershed. The locations of these sites are also displayed in Figure 3-1.

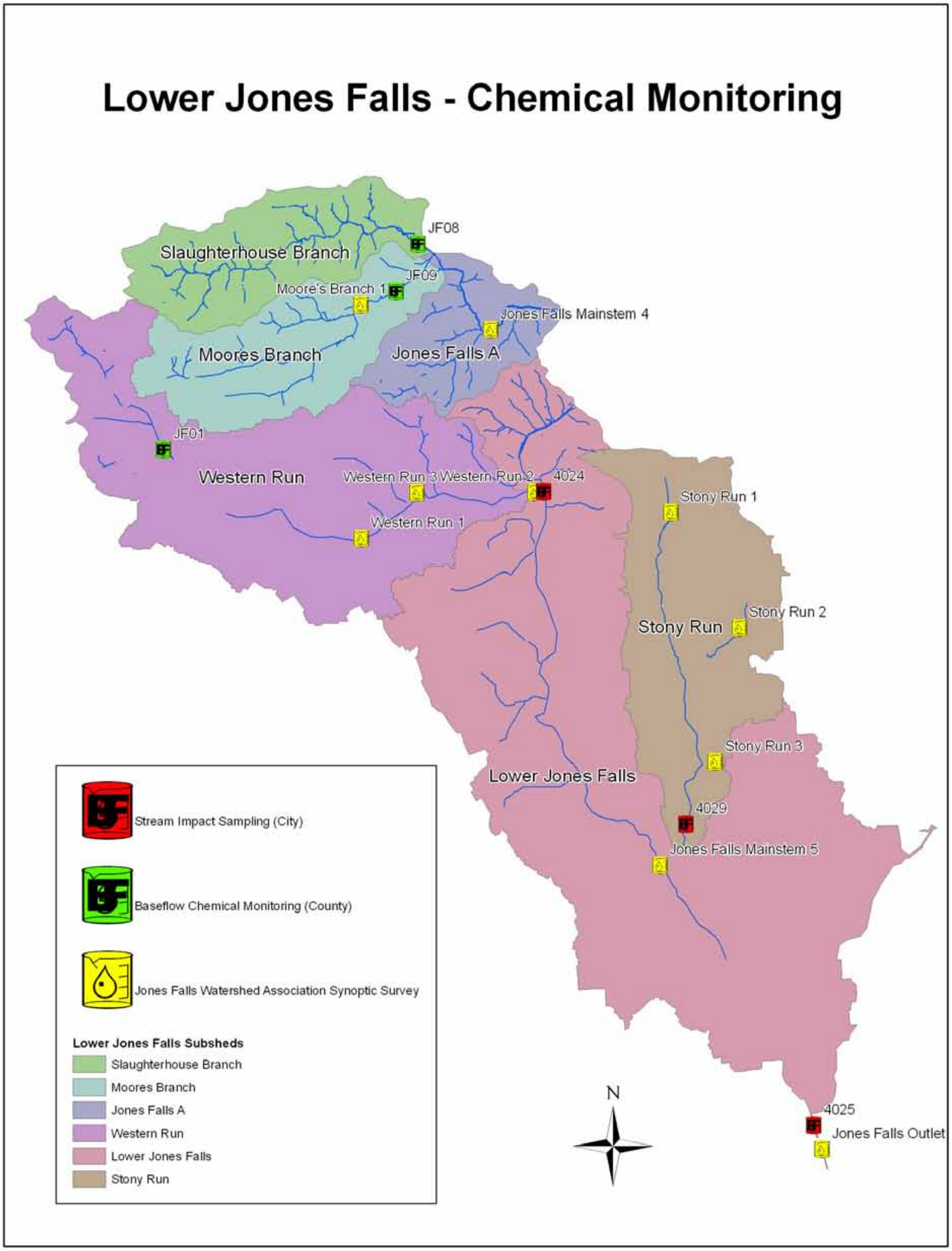

Figure 3-1. Chemical Monitoring in the Lower Jones Falls Watershed

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 1. The key parameters were evaluated because of their importance to Total Maximum Daily Loads (TMDLs) and Bay Program Tributary Strategy goals.

Table 3-1: Lower Jones Falls Planning Area Subwatershed Abbreviations

Subwatershed	Subwatershed Abbreviation
Slaughterhouse Branch	SB
Moores Branch	MB
Western Run	WR
Lower Jones Falls	LJF
Stony Run	SR

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 criteria 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 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).

<u>*3.2.1.1* Baltimore City Data</u>

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 three sites located within the Lower Jones Falls planning area are displayed in Table 3-3.

Table 3-3: Jones Falls Watershed – Baltimore City Water Quality Data

Parameter (mg/l)		Site		
		4024*	4025*	4029*
		1997-2006	1997-2007	1997-2007
Subwatershed		LJF	LJF	SR
Chloride	Max	1,040.00	3,500.00	720.00
	Min	16.50	55.00	24.30
	Median	65.00	350.00	57.60
Total Nitrogen	Max	6.80	7.00	6.68
	Min	0.85	0.91	0.30
	Median	1.85	2.19	2.54
Suspended Solids	Max	26.00	96.50	29.00
	Min	0.50	1.00	0.00
	Median	5.20	5.00	2.00
Total Phosphorus	Max	1.39	0.49	0.53
	Min	0.00	0.03	0.00
	Median	0.06	0.10	0.06
Total Coliform (colonies/100ml)	Median	230	17,000	5000
	75^{th} percentile	500	30,000	11,000

The Baltimore City water quality data set is reported from 1997 to 2007. Site 4025 in Lower Jones Falls, reported high levels of median chloride at 350 mg/l, moderate level of total nitrogen at 2.19 mg/l and exhibited an high level of median total phosphorus at 0.10 mg/l. Site (4029), in Stoney Run, exhibited moderate levels of median total nitrogen at 2.54 mg/l. There are no reported elevated levels of median suspended solids, which is not surprising given that sediment primarily moves during storm events.

The total coliform concentrations for Lower Jones Falls and Stony Run are very elevated. Site 4024 is the only site with total coliform concentrations that look relatively normal when compared to the 200 colonies/100ml standard for water contact recreation. It would be efficient and useful to start from site 4024 and work downstream to resolve the high concentrations of coliform in the Jones Falls watershed.

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 three sites located within the Lower Jones Falls planning area.

Table 3-4: Lower Jones Falls Watershed – Baltimore County Data

Parameter (mg/l)		JF01*	JF08*	JF09*
Subwatershed		WR	SB	MB
Chloride	Max	375.47	195.66	100.63
	Min	69.14	108.09	55.68
	Median	122.85	156.15	73.83
Total Nitrogen	Max	1.81	3.37	1.63
	Min	0.94	1.84	0.82
	Median	1.40	2.45	1.16
Suspended Solids	Max	7.00	20.00	8.00
	Min	0.50	0.50	0.50
	Median	0.50	0.50	0.50
Total Phosphorus	Max	1.36	0.12	0.06
	Min	0.01	0.01	0.01
	Median	0.05	0.05	0.03

Of the three sites within the planning area, one site in Slaughterhouse Branch (JF08) shows high levels of median total nitrogen at 3.37 mg/l. Two of the sites, JF01 and JF08 in Western Run and Slaughterhouse, respectively, had slightly elevated phosphorus.

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.

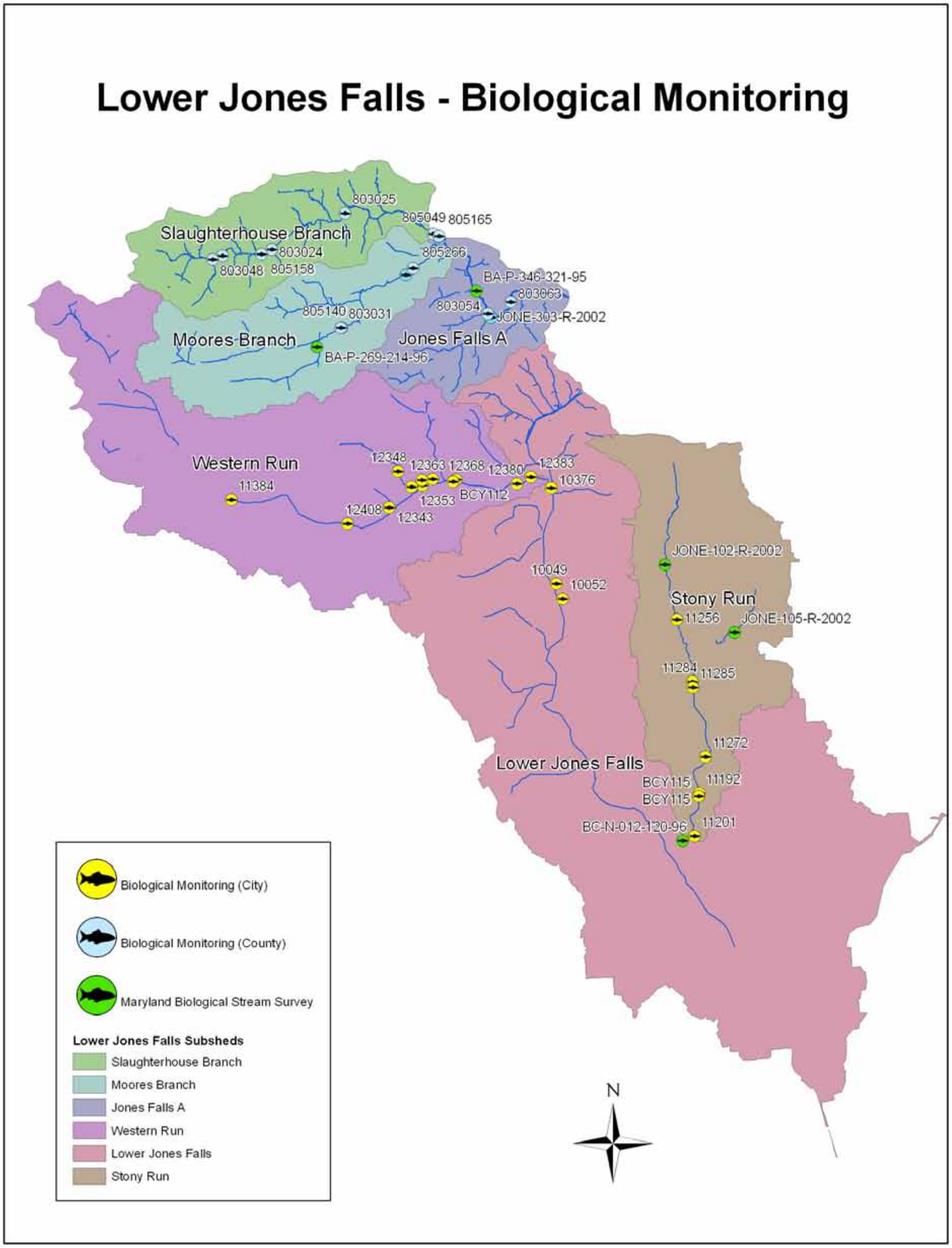

Figure 3-2. Lower Jones Falls Biological Monitoring

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	Median Values				
				Benthic IBI		Fish IBI		EPT Score
				Score	Rating	Score	Rating	
BCY112**	Western Run	39.3673	-76.6643	1.70	Very Poor	1.35	Very Poor	1
BCY114***	Stony Run	39.3528	-76.6292	2.06	Poor	N/A	N/A	2
BCY115**	Stony Run	39.3280	-76.6251	2.00	Poor	1	Very Poor	1
10021*	Lower Jones Falls	39.3711	-76.6522	2.33	Poor	N/A	N/A	1
10024*	Lower Jones Falls	39.3695	-76.6507	2.22	Poor	N/A	N/A	1
10025*	Lower Jones Falls	39.3692	-76.6499	1.89	Very Poor	N/A	N/A	1
10032*	Lower Jones Falls	39.3653	-76.6482	1.67	Very Poor	N/A	N/A	0
10039*	Lower Jones Falls	39.3608	-76.6500	1.33	Very Poor	N/A	N/A	2
10045*	Lower Jones Falls	39.3568	-76.6495	2.22	Poor	N/A	N/A	2
10048*	Lower Jones Falls	39.3550	-76.6483	1.22	Very Poor	N/A	N/A	0
10049*	Lower Jones Falls	39.3545	-76.6478	1.67	Very Poor	2.1	Poor	0
10052*	Lower Jones Falls	39.3527	-76.6468	1.56	Very Poor	1.7	Very Poor	1
10092*	Lower Jones Falls	39.3310	-76.6421	1.56	Very Poor	N/A	N/A	1
10376*	Lower Jones Falls	39.3665	-76.6485	1.78	Very Poor	2.6	Poor	2
11192*	Stony Run	39.3283	-76.6250	2.11	Poor	1	Very Poor	2
11201*	Stony Run	39.3230	-76.6258	1.56	Very Poor	0.6	Very Poor	1
11248*	Stony Run	39.3551	-76.6295	2.00	Poor	N/A	N/A	1
11256*	Stony Run	39.3500	-76.6284	1.56	Very Poor	N/A	N/A	2
11272*	Stony Run	39.3329	-76.6239	1.33	Very Poor	0.4	Very Poor	2
11284*	Stony Run	39.3422	-76.6260	1.78	Very Poor	N/A	N/A	2
11285*	Stony Run	39.3416	-76.6259	2.22	Poor	N/A	N/A	1
12322*	Western Run	39.3669	-76.6691	2.44	Poor	N/A	N/A	3
12338*	Western Run	39.3721	-76.6797	2.22	Poor	N/A	N/A	0
12343*	Western Run	39.3704	-76.6762	2.11	Poor	N/A	N/A	4
12348*	Western Run	39.3687	-76.6731	1.89	Very Poor	N/A	N/A	3
12353*	Western Run	39.3667	-76.6709	3.00	**Fair**	N/A	N/A	5
12356*	Western Run	39.3676	-76.6693	1.67	Very Poor	N/A	N/A	0
12363*	Western Run	39.3677	-76.6675	2.22	Poor	N/A	N/A	2
12368*	Western Run	39.3676	-76.6638	2.78	Poor	N/A	N/A	6

12380*	Western Run	39.3671	-76.6540	2.00	Poor	1.4	Very Poor	5
12383*	Western Run	39.3679	-76.6518	2.00	Poor	2.6	Poor	2
12384*	Western Run	39.3651	-76.6998	2.56	Poor	N/A	N/A	2
12408*	Western Run	39.3621	-76.6812	1.89	Very Poor	N/A	N/A	2

** Data based on sampling in 2002*
*** Data based on sampling in 2002-2005*
**** Data based on sampling in 2002-2003*

There are 32 biological sites within Baltimore City. The Benthic IBI scores of these sites include sixteen sites rated as very poor, one site rated a fair and sixteen sites rated as poor. Of the fish IBI sites, seven are rated very poor, three are rated poor and the rest of the sites (23) do not have data. The EPT scores in Baltimore City range from 0-6 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).

Table 3-6: Baltimore County Biological Monitoring Results

Station ID	Subwatershed	Longitude	Latitude	Sample Year	Benthic IBI	
					Score	Rating
803054	Jones Falls - A	-76.6586	39.3883	2003	3.33	Fair
803063	Jones Falls - A	-76.6549	39.3898	2003	2.33	Poor
807017	Jones Falls - A	-76.6581	39.3878	2007	1.67	Very Poor
803024	Slaughterhouse Branch	-76.6932	39.3964	2003	1.33	Very Poor
803023	Slaughterhouse Branch	-76.7012	39.3956	2003	1.00	Very Poor
803025*	Slaughterhouse Branch	-76.6814	39.4008	2003	2.00	Poor
803048	Slaughterhouse Branch	-76.7027	39.3951	2003	1.33	Very Poor
805049	Slaughterhouse Branch	-76.6673	39.3983	2005	2.67	Poor
805158	Slaughterhouse Branch	-76.6949	39.3958	2005	3.00	Fair
807066	Slaughterhouse Branch	-76.6665	39.3979	2007	1.67	Very Poor
803031*	Moores Branch	-76.6820	39.3865	2003	1.00	Very Poor
805140	Moores Branch	-76.6822	39.3866	2005	2.00	Poor
805266	Moores Branch	-76.6706	39.3940	2005	1.67	Very Poor
807014	Moores Branch	-76.6717	39.3931	2007	1.33	Very Poor
807065	Moores Branch	-76.6662	39.3976	2007	1.67	Very Poor

* Indicates a Sentinel Station

Baltimore County has 15 biological sites within the Lower Jones Falls Planning area. The benthic IBI ratings include nine very poor sites, four poor sites, and two fair sites. There are two sentinel sites in the Lower Jones Falls planning area in Baltimore County.

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 (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

Site	Subwatershed	Ammonia (mg/l)		
		Median	Maximum	Minimum
5000	LJF	0.05	0.36	0.00
5001	WR	0.08	1.70	0.00
5021	LJF	0.21	0.71	0.00
5024	WR	0.05	0.30	0.00
5027	LJF	0.14	1.07	0.00
5036	LJF	0.07	1.30	0.00
5037	SR	0.04	1.63	0.00
5039	SR	0.08	3.00	0.00
5045	SR	0.13	3.00	0.00
5047	LJF	1.00	24.00	0.00

The Baltimore City ammonia dataset is reported from 1998 to 2007. There are two sites out of ten that show excessive levels of median ammonia. The two values are 0.21 and 1.00 mg/l at sites 5021 and 5047 respectively.

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 (two or more times) and properly prioritized. A Microsoft Access Query based on the prioritization scheme generates the list of outfalls to be screened.

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

- *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.

The Lower Jones Falls planning area within Baltimore County has 24 major outfalls of which three are classified as priority 1, seven as priority 2, eleven as priority 3, and three remain unclassified. Table 3-8 displays the results.

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

	Slaughterhouse Branch	Moores Branch	Jones Falls A	Western Run	Lower Jones Falls	Total
Priority 0	0	0	0	1	2	**3**
Priority 1	0	3	0	0	0	**3**
Priority 2	0	3	1	1	2	**7**
Priority 3	2	2	0	2	5	**11**
Total	**2**	**8**	**1**	**4**	**9**	**24**

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 Lower Jones Falls 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
Slaughterhouse Branch	High	Medium	Very Poor	N/A	N/A	N/A
Moores Branch	Medium	Low	Very Poor	Low	Low	N/A
Jones Falls A	N/A	N/A	N/A	N/A	N/A	N/A
Western Run	Medium	Medium	Poor	N/A	N/A	Low
Lower Jones Falls	Medium	Low	Very Poor	N/A	N/A	High
Stony Run	High	Low	Poor	N/A	N/A	Low

N/A =no data available

Water quality data reported two subwatersheds (Slaughterhouse Branch and Stony Run) with high values for total nitrogen with the rest reported as medium values. Water quality values for total phosphorus include one subwatershed with a high value (Upper Jones Falls), two medium (Slaughterhouse Branch and Western Run) and three low values (Moores Branch, Lower Jones Falls and Stony Run). Biological IBI scores were reported as very poor in three subwatersheds (Moores Branch, Slaughterhouse Branch and Lower Jones Falls). Outfall data in only one subwatershed (Moores Branch) was sampled in the county with low total nitrogen and total phosphorus reported. In the city, three subwatersheds were sampled for ammonia with one subwatershed (Lower Jones Falls) reported with high levels of ammonia.

3.3 Stream Assessments

Two types of stream assessment were performed: Stream Stability Assessments, and Stream Corridor Assessments. All stream assessments were conducted in Baltimore County. It was felt by the Steering Committee that the streams in Baltimore City were not in need of additional assessment, as the stream restoration project on Stony Run had been recently completed and the City portion of Western Run will be undergoing an assessment through a city contract. The functions of stream assessments are an identification of potential stream problem areas, and an identification of potential restoration projects.

3.3.1 Stream Stability Assessment

Baltimore County contracted with Parsons, Brinkerhoff, Inc. to conduct a Stream Stability Assessment (SSA) in the Slaughterhouse Branch subwatershed. 8.8 miles of stream were assessed broken down into 68 reaches. The stream stability assessment was conducted in the summer of 2007. The report will be an Appendix of Volume 2 of the Small Watershed Action Plan where it will provide part of the supporting data for the restoration actions. The data is summarized below.

39 percent of the stream reaches have high, very high or extreme erosion potential. 3.4 miles were recommended for buffer enhancement. Buffer enhancement was recommended when the

buffer consisted of grass, was less than 50 ft., or was identified during the field assessment. 55.9 percent of the reaches had some type of fish blockage.

3.3.2 Stream Corridor Assessment

The Stream Corridor Assessments were conducted in the fall and winter of 2007 by Baltimore County Department of Environmental Protection and Resource Management staff.

3.3.2.1 Assessment Protocol

The Stream Corridor Assessment, or SCA, provides descriptive and positional data for potential environmental problems along a watershed's non-tidal stream network. Developed by DNR's Watershed Services, the survey is a watershed management tool used to identify environmental problems and to help prioritize restoration opportunities on a watershed basis. The assessment follows protocols set forth in *SCA Survey Protocols* (Yetman, 2001). As part of the survey, specially trained personnel walk a watershed's streams and record data for several potential environmental problems that can be easily observed within the stream corridor. Each potential problem site is ranked on a scale of one to five for its severity, correctability, and ease of access for restoration work.

Using a grid system, the county portion of the Lower Jones Falls study was divided into 10 sections and a GIS map created for each section. Each map contained aerial photography and hydrology data and was laminated for field use. The maps were used as a guide for locating and walking the streams. All potential problems were indicated directly on the map using Sharpie markers showing locations and/or distances.

3.3.3.2 Summary of Sites Investigated

The subwatersheds focused on for the SCAs were Moore's Branch, Jones Falls A and the county portions of Western Run and Lower Jones Falls. The main stem of the Jones Falls was not assessed, as it is more feasible to control pollution sources in headwaters and tributaries. Slaughterhouse Branch was assessed in the aforementioned SSA so this area was not assessed. The quarry area of Moore's Branch was under heavy construction at the time of the assessment so this area was also avoided.

Baltimore City has completed stream assessments for Stony Run and the city portion of Western Run. The upper section of Stony Run has undergone a restoration and there are further efforts planned by the city for sections of Western Run. Therefore the city portion of the Lower Jones Falls watershed was not included in the SCA.

Figure 3-3 shows the stream reaches assessed during the survey.

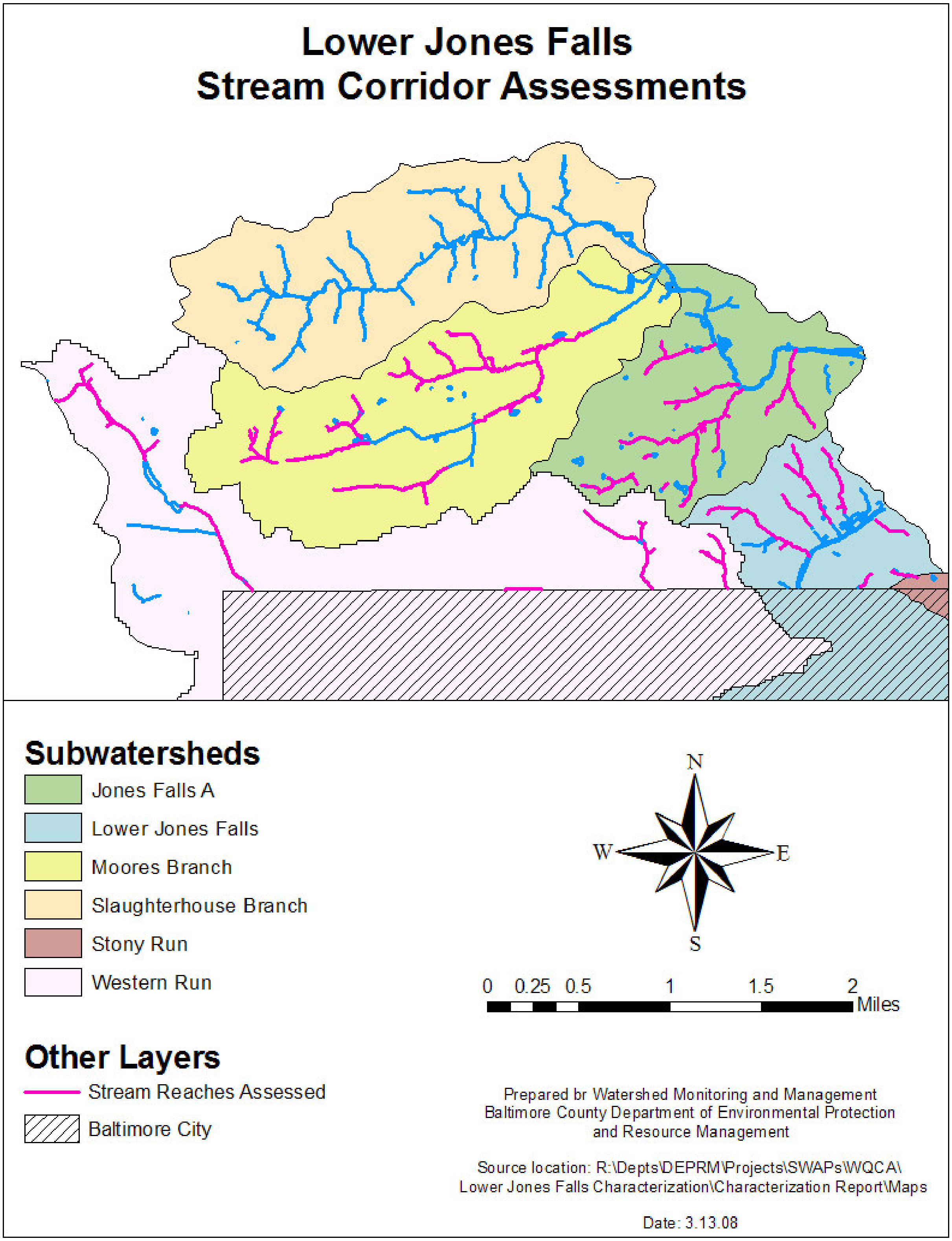

Figure 3-3 Stream Reaches Assessed for SCA in the Lower Jones Falls

3.3.2.3 General Findings

Table 3-9 summarizes the results of the stream corridor assessment. The most common problem discovered through the stream corridor assessment was pipe outfalls (91), however only 3 were rated severe or very severe. Erosion sites and inadequate buffers were also numerous. A total of 6 miles (37.4%) of the 16.2 miles assessed were found to have an inadequate buffer, with approximately 33% rated very severe or severe. Erosion was identified as a problem for 8.3 miles (51.3 %) of the streams assessed, with approximately 29% in the severe or very severe category. Due to the urban nature of the watershed, problems associated with channel alterations and trash dumping were numerous. Table 3-10 presents the results for each subwatershed assessed by problem category. Table 3-11 presents the linear feet of inadequate buffer and stream erosion by subwatershed.

Table 3-10. Summary of SCA Results

	#	Estimated Length (ft)	# Very Severe	# Severe	# Moderate	# Low Severity	# Minor
Pipe Outfall	91		0	3	8	36	44
Erosion Site	54	43,945	1	13	16	20	4
Inadequate Buffer	39	32,070	2	11	13	11	2
Fish Barrier	35		11	2	5	7	10
Unusual Condition	18		1	1	6	4	6
Exposed Pipe	15		-	2	8	3	2
Channel Alteration	12	7,318	1	7	2	2	-
Trash Dumping	10		-	4	1	3	2
In-Stream Construction	2		-	2	-	-	-
TOTAL	276		17	45	59	87	68
Representative Sites	30						

Table 3-11: Baltimore County Stream Corridor Survey Results – Number of Problems

Stream Segment	Channel Alteration	Erosion	Fish Barrier	Inadequate Buffer	Pipe Outfall	Exposed Pipe	In Stream Construction	Trash Dumping	Total
Moore's Branch	3	20	7	11	26	8	1	1	**77**
Western Run	5	11	11	11	27	6	1	2	**74**
Jones Falls A	3	16	11	11	28	0	0	7	**76**
Lower Jones Falls	1	8	4	6	10	1	0	0	**30**
Total	**12**	**55**	**33**	**39**	**91**	**15**	**2**	**10**	**257**

Table 3-12: Baltimore County Stream Corridor Survey Results – Linear Feet of Inadequate Buffer and Stream Erosion

Stream Segment	Erosion	Inadequate Buffer
Moore's Branch	17,025	11,828
Western Run	9,785	10,718
Jones Falls A	8640	5802
Lower Jones Falls	8495	3722
Total	**43,945 (51.3%)**	**32,070 (37.4%)**

The most impacted subwatershed based on stream erosion and inadequate buffer is Moore's Branch.

Stream Bank Erosion

Stream bank erosion is actually a natural process necessary for maintaining a good aquatic habitat. Very often in human impacted environments, however, the natural erosion process is drastically accelerated resulting in habitat destruction and sediment pollution problems. This often occurs below a specific alteration, such as a pipe outfall or road crossing, or when land use in a watershed changes. For example, as a watershed becomes more urbanized, forest and agricultural fields are converted to impervious surfaces where rainwater cannot seep naturally into the ground. This results in a much greater in-stream flow rate during storm events and leads to eroded streambeds and banks. Although streams in forested areas may have adequate 50 ft. forest buffers, they can also experience erosion problems due to these high flows.

The erosion sites were defined by vertical stream banks with exposed soil and overall instability. Severity ratings were based on height and length of the exposed bank.

There were 55 total sites marked for erosion problems with lengths ranging from 16 ft. up to 2700 ft. As shown in Table 3-6, erosion exists in over 50 percent of the stream reaches assessed. Figure 3-2 shows the erosion problem areas discovered during the SCA in the Lower Jones Falls watershed and the rated severity of the problem. Figure 3-4 confirms that erosion exists consistently throughout the watershed.

Inadequate Buffers

Forest buffers along streams provide a natural element essential to maintaining stream health and water quality. Tree roots capture and remove excess nutrients and pollutants from shallow flowing water and help stabilize stream banks reducing sedimentation. Shade from tree canopies facilitates the cooler stream temperatures necessary for most stream life, especially cold-water species like trout. Maintaining adequate forest buffers and maintaining healthy streams are important parts of reducing nutrient and sediment loads in the Chesapeake Bay.

While there is no single minimum standard for how wide a stream buffer should be in Maryland, for the purposes of this study, all buffers measured less than 50 ft. from the edge of the stream were considered inadequate. Severity ratings were based on the lengths and widths of the buffer on each side of the stream.

Survey crews identified 39 inadequate buffer sites with a total length of 32,070 ft (6.07 miles), approximately 37 percent of the stream miles surveyed. Figure 3-5 shows the inadequate buffer locations and severity ratings.

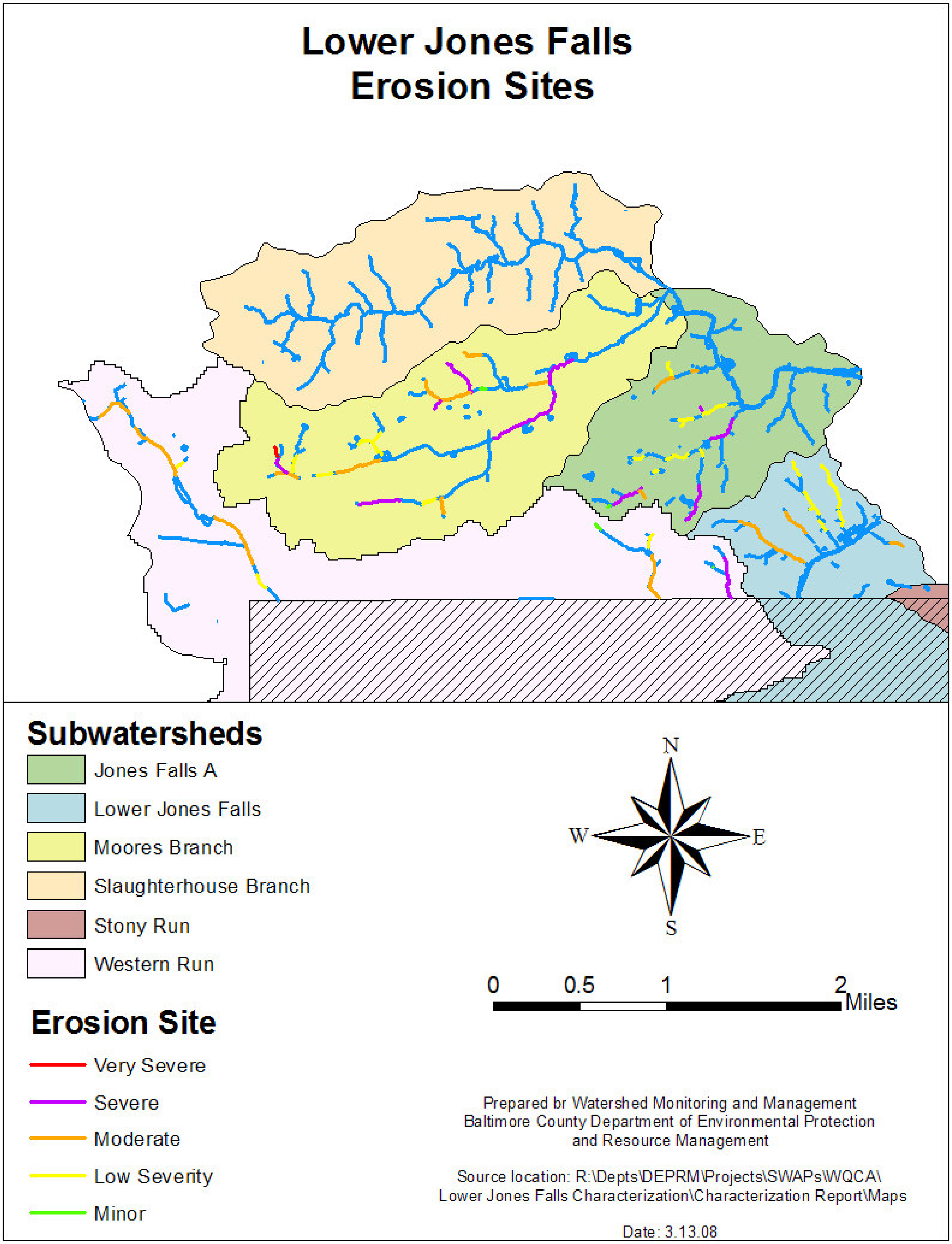

Figure 3-4: Erosion Site Locations and Severities

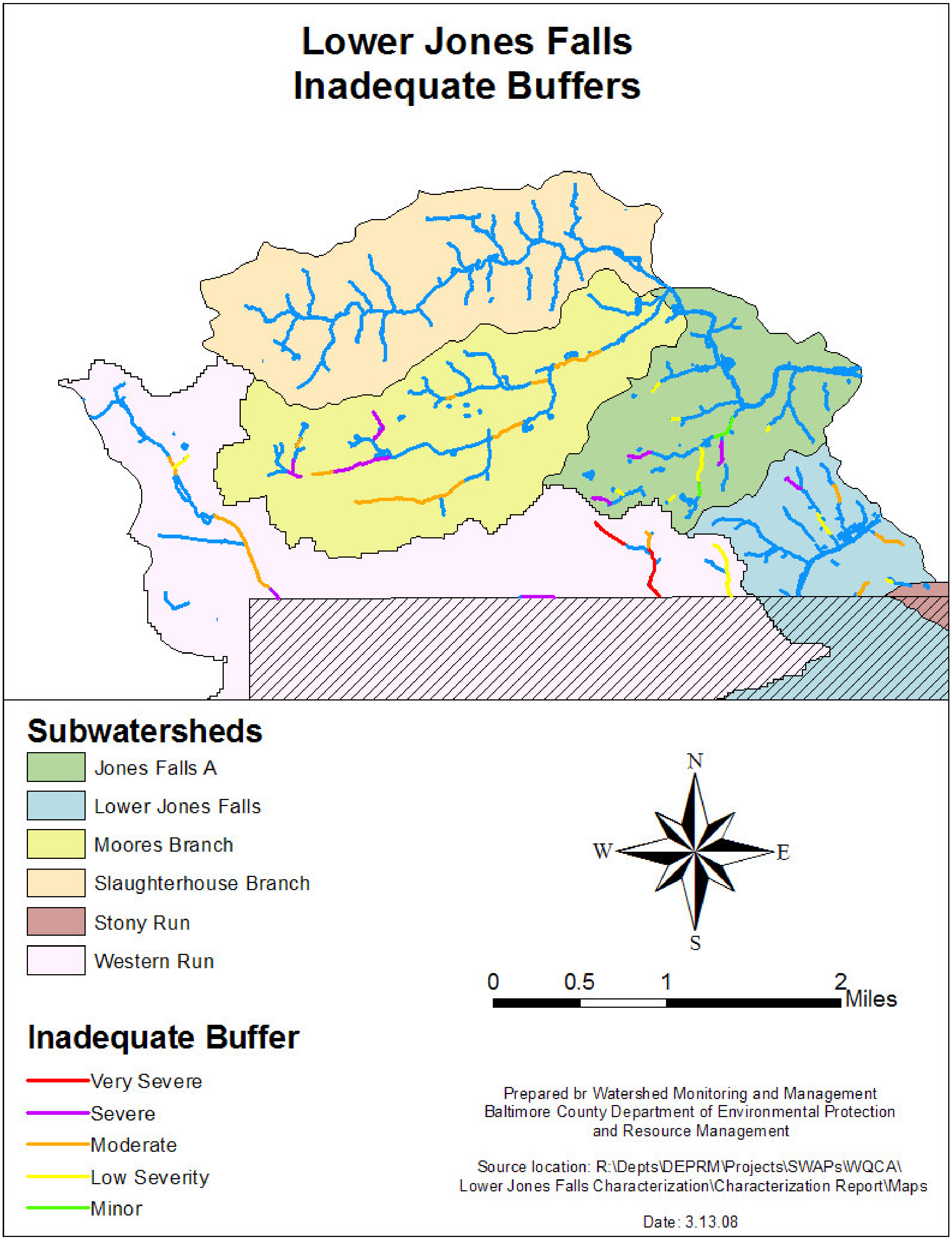

Figure 3-5: Inadequate Buffer Locations and Severities

Trash Dumping

Trash dumping sites are areas where large amounts of trash have either been dumped or have accumulated from wind or storm drainage. Severity ratings were based on the type of trash, the area trash covers and the potential impact on the stream.

There were a total of 10 sites noted for trash dumping, four rated as severe. Two of these four (69A346 and 69A356) have been referred to Baltimore County's Environmental Impact Review for investigation, as it appeared to be a single perpetrator at each site, facilitating possible enforcement measures. Figure 3-6 shows the locations of all trash dumping sites.

Exposed Pipes

Any pipes or sewer stacks that are located in the stream or along the stream's immediate banks that could be damaged by a high flow event are recorded as exposed pipes in the SCA survey. An exposed pipe can be vulnerable to puncture by debris in stream, especially during periods of high flow. A punctured pipe is likely to discharge fluid into the stream causing a serious water quality problem and potential health hazard.

Field crews observed 15 exposed pipes during the survey. Sites 68C313 and 68C314 were rated as severe due to their lengths and locations of exposures. These were both located in Moore's Branch subwatershed within 400 feet of each other. Figure 3-6 shows the locations of all exposed pipes.

Fish Barriers

Fish migration barriers include any condition in the stream that significantly interferes with the free upstream movement of fish. Unimpeded fish passage is especially important for anadromous fish that live most of their lives in tidal waters but must migrate into non-tidal rivers and streams to spawn. In addition, blockages can isolate sections of the stream making it difficult for fish to avoid a pollution disturbance and then harder still to re-populate the area after the disturbance has passed.

33 fish barriers were discovered during the SCA with ten rated as very severe. More than half were due to road crossings (11) or debris dams (6). Figure 3-6 shows the locations of all fish barriers recorded during the survey.

Site 68C312, a fish barrier downstream of a road crossing

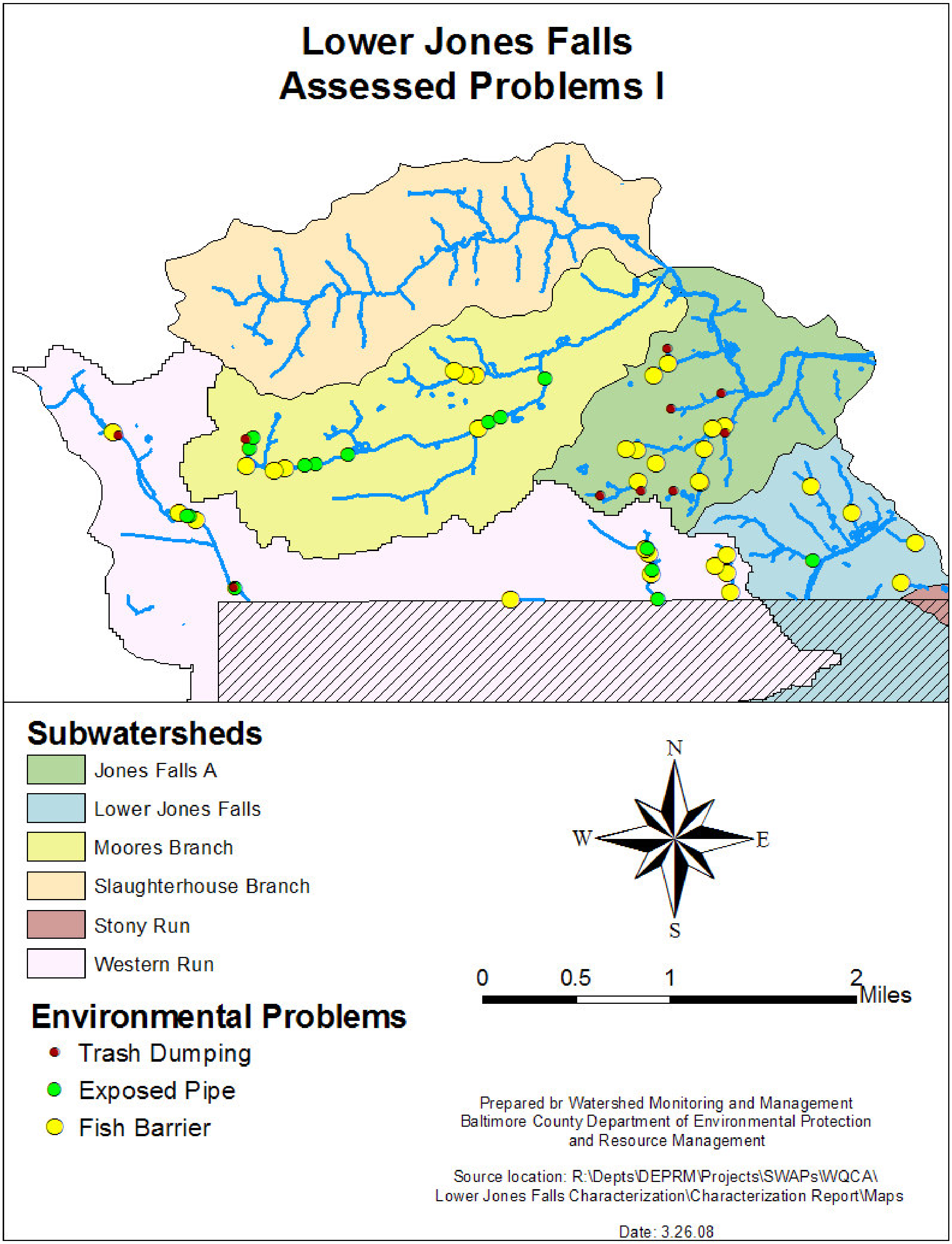

Figure 3-6: Trash Dumping, Exposed Pipe and Fish Barrier Locations

Pipe Outfalls

Pipe outfalls included any pipe or constructed channel that could potentially discharge into the stream. Pipe outfalls are considered a potential environmental problem in the survey because they can carry uncontrolled runoff and pollutants such as oil, heavy metals, and nutrients to a stream system.

A total of 91 outfalls were identified during the SCA, making it the most common of the problems assessed. Of these 91, however, 79 were classified as having a minor or low severity rating and only four were considered severe or very severe. These four were referred to Baltimore County's Illicit Discharge Detection and Elimination program for follow up inspection. Figure 3-7 shows the locations of all pipe outfalls.

In/Near Stream Construction

If in or near stream construction projects cause major disturbances inside or near the stream corridor at the time of the survey, field teams note their location and record any effect on the steam corridor.

Two construction sites were observed during the survey and each was given a severe rating due to the large scale of the projects and the apparent impact on the stream. Site 79A122 was located where the old Bonnie View golf course is now being converted into a housing development in Western Run. Site 78C112 is located at the quarry housing development in Moore's Branch. Figure 3-7 shows their locations.

Unusual Conditions or Comments

Survey teams record unusual conditions or comments to note the location of anything of environmental interest beyond the scope of the existing parameters of the SCA.

Survey crews identified 9 unusual conditions and 9 comments. The two severely rated items involve serious structural damage to stormwater drainage outfall areas. Locations of comments and conditions are shown in figure 3-7.

Channel Alterations

Stream channel alterations are areas of the stream that have been modified from their naturally occurring structure or condition. Typically this involves the use of a concrete channel to control the flow of the stream near roadways or developments. This increases flow rates and decreases habitat and can decrease nutrient uptake in the waterway. Stream channels can also be straightened by hardening the banks with gabion baskets, concrete or even stone or wooden walls.

12 sites exhibited characteristics of channel alterations during the course of the survey totaling 7,318 ft or 1.4 miles. Eight of the 12 sites qualified as severe or very severe. Severity ratings were based on length of the alteration, water depth, and presence of natural sediments

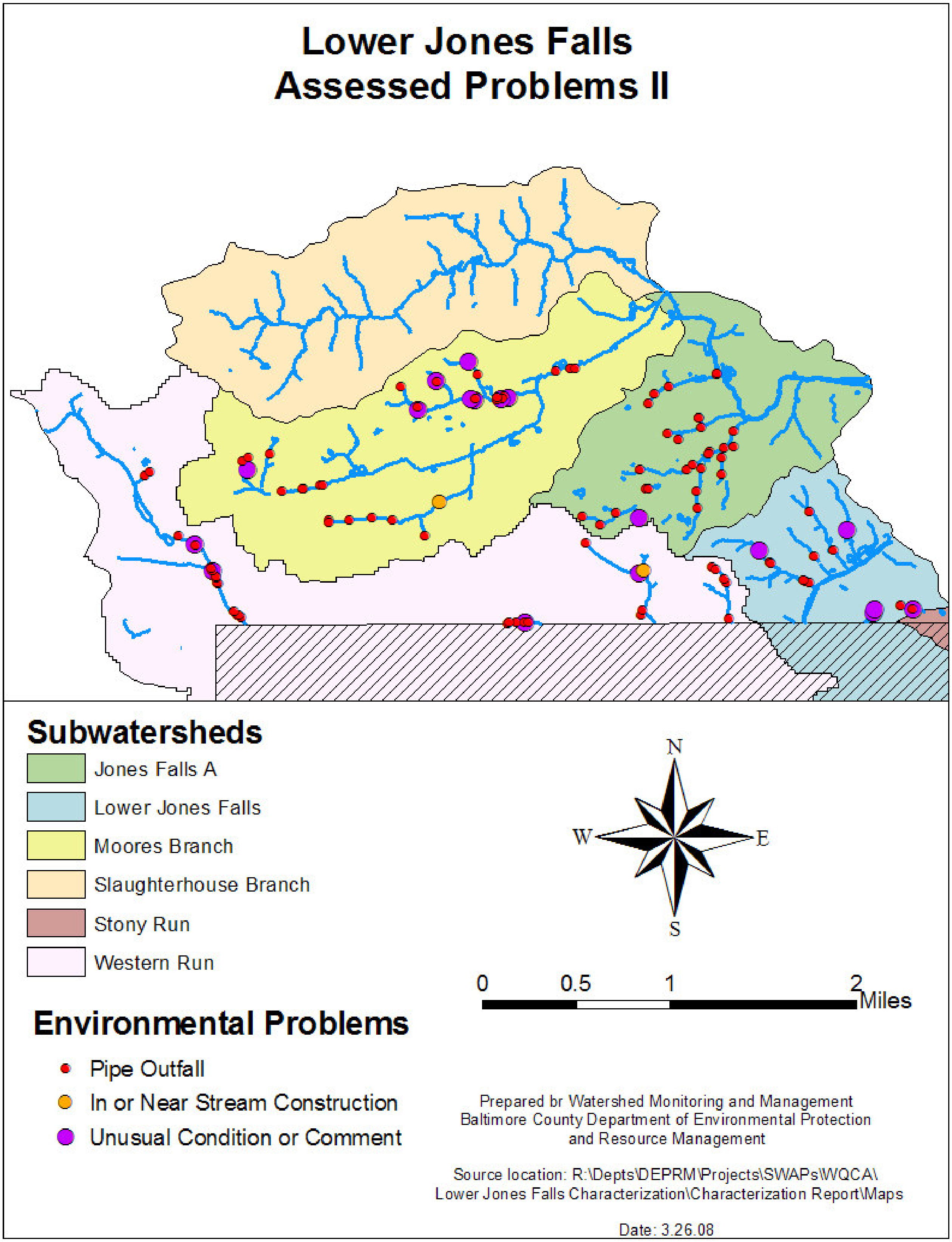

Figure 3-7: Pipe Outfall, Stream Construction and Unusual Condition Locations

Representative Sites

Representative sites are used in the SCA to document the general condition of both in-stream habitat and the adjacent riparian corridor. At each representative site, the following 10 categories are evaluated to qualify the health of the stream habitat.

- Attachment Sites for Macroinvertebrates
- Shelter for Fish
- Sediment Deposition
- Channel Flow Status
- Condition of Banks
- Embeddedness
- Channel Alteration
- Velocity and Depth Regime
- Bank Vegetation Protection
- Riparian Vegetative Zone Width

Under each category, field crews base a rating of optimal, suboptimal, marginal or poor on established grading criteria developed to reflect ideal wildlife habitat for rocky bottom streams. In addition to habitat ratings, teams collect data on the steam's wetted width and pool depths at both runs and riffles at each representative site. Depth measurements are taken at the streams thalweg (main flow channel). Field crews also indicate whether the bottom sediments are primarily silt, sand, gravel, cobble, boulder or bedrock. Survey crews evaluated 28 representative sites during the SCA.

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 3-12 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, the EPA and MDE issued a consent decree to Baltimore County to help reduce and eventually eliminate sanitary sewer overflows.

Table 3-13: Baltimore Sewer Overflows in the Lower Jones Falls, 2001-2007

Year	City Volume	County Volume	Total Volume
2001	65,359	3,360	70,720
2002	105,662	2,050	109,714
2003	561,870	0	563,873
2004	284,013	700	286,717
2005	127,232	120	129,357
2006	6,489,890	122,970	6,614,866
2007	338,930	10,220	351,157
Total	**7,972,956**	**139,420**	**8,112,376**

Table 3-13 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 3-14: Baltimore Sewer Overflows by Subwatershed, 2001-2007

Subwatershed	City Volume (gal)	County Volume (gal)	TN (lbs)	TP (lbs)	TSS (lbs)	FC (MPN)
Slaughterhouse	NA	0	0	0	0	0
Moores	NA	4,270	1.07	0.36	7.99	1.0×10^{12}
Jones Falls A	NA	2,600	0.65	0.22	4.87	6.2×10^{11}
Western	65,891	128,150	48.43	16.1	363.24	4.7×10^{13}
Lower Jones	1,896,903	3,950	474.45	158.2	3,558.4	4.6×10^{14}
Stony Run	6,010,162	0	1,500.13	500.0	11,251.02	1.4×10^{15}
Total	**7,972,956**	**138,970**	**2,024.73**	**674.88**	**15,185.52**	$\mathbf{1.9 \times 10^{15}}$

Figure 3-8 shows the volume and location of sanitary sewer overflows through the years 2000-2007.

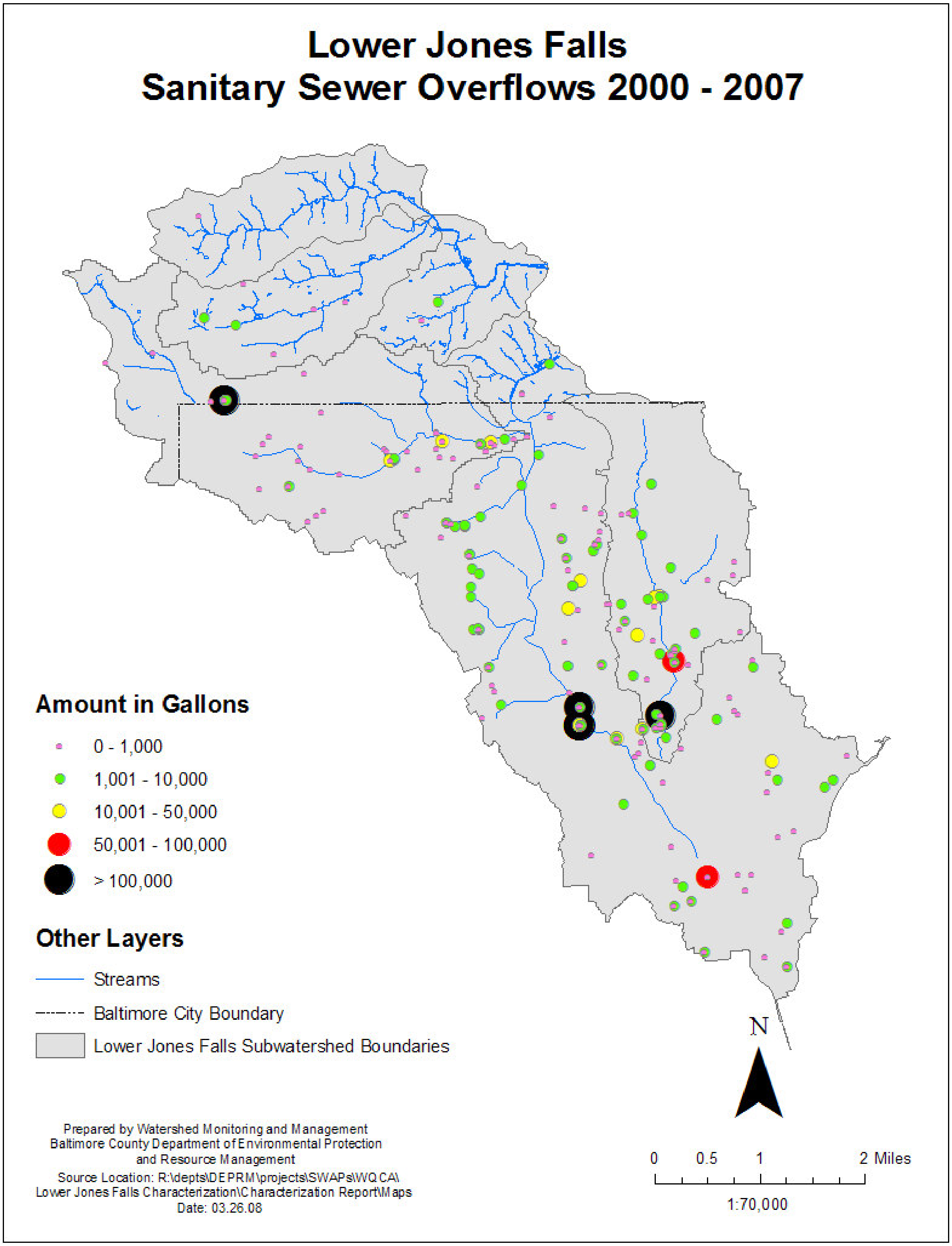

Figure 3-8: Sanitary Sewer Overflows 2000-2007

3.5 303(d) Listings and Total Maximum Daily Loads

The Jones Falls 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. Jones Falls drains to the Baltimore Harbor 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 found that the pollutant is not impairing the receiving waters than a report documenting the findings is submitted to EPA for concurrence. Table 3-14 displays the status of the impairment listings.

Table 3-15: Water Quality Impairment Listings and Status

Impairment	Applicable Segment	Status	Approval Date
Stream Biological Community	02130904	Impaired	
PCB in Fish Tissue	02130904 – Lake Roland	TMDL development within two years	
Total Suspended Solids - TSS	02130904	Impaired	
Phosphorus	02130904	Impaired	
Chlordane	02130904 – Lake Roland	TMDL Complete	March 2001
Nutrients	Baltimore Harbor	TMDL Complete	December 2007
Fecal Coliform	02130904	TMDL Complete	February 2008
Zinc	02130904	Water Quality Assessment	February 2003
Copper and Lead	02130904	Water Quality Assessment	December 2004

The Jones Falls watershed has nine impairment listings (for purposes of this report the separate listings for nitrogen and phosphorus for Baltimore Harbor have been combined as nutrients, but the phosphorus listing for the watershed is kept separate). Three TMDLs and two Water Quality Assessment have been completed. The *Draft 2008 Integrated Report of Surface Water Quality in Maryland* indicated that a TMDL for PCBs would be developed within two years. Three additional listings, TSS, Stream Biological Impairment, and phosphorus (watershed impairment, not tidal waters), 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_jonesfalls_zinc_final.asp , while the Water Quality Assessment for lead and copper can be found at http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/ApprovedFinalTMDL/WQA_final_jonesfalls_Cu_Pb.asp. Both of these documents can be found in Volume 2 - Appendix J of the Lower Jones Falls 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 December 2007. Based on the analysis, the bulk of the nitrogen and phosphorus reductions needed to meet water quality standards in the tidal segment of the Baltimore Harbor will come from improvements in the Patapsco Waste Water Treatment Plant (WWTP). The Patapsco River WWTP is scheduled for completion of an upgrade to Enhanced Nutrient Removal in 2011, as well as, an expansion from 73 mgd to 81 mgd. Upon completion the discharge of nitrogen will be reduced to 3 mg/L and phosphorus will be reduced to 0.2 mg/L.

The Baltimore Harbor receives drainage from the Jones Falls, the Gwynns Falls, and the Patapsco River watersheds. In order to meet water quality standards within Baltimore Harbor a reduction of 15% nitrogen and 15% phosphorus from urban non-point sources will have to achieved in each of the three watersheds draining to Baltimore Harbor.

The document entitled *Total Maximum Daily Loads of Nitrogen and Phosphorus for the Baltimore Harbor in Anne Arundel, Baltimore, Carroll, and Howard Counties and Baltimore City, 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_baltimoreharbor_nutrient.asp

The document can also be found in Volume 2 - Appendix G of the Lower Jones Falls Small Watershed Action Plan.

The Jones Falls is also listed as being impaired by phosphorus. This impairment listing is related to Lake Roland. Fresh water receiving water bodies are often impaired by phosphorus and not nitrogen. This is related to the nutrient dynamics within the watersheds with phosphorus typically being the limiting nutrient for algal growth.

3.5.2 Bacteria

The entire Jones Falls watershed is listed as impaired by bacteria. Using a combination of monthly samples at five locations and an analysis methodology know as Bacterial Source Tracking (BST), MDE was able to identify the sources of the bacteria. They found that ~52% - 80% of the bacteria could be attributed to human sources, ~14% - 27% to domestic pets, ~1% - 5% to wildlife, and ~5% - 16% to lifestock; depending on the subwatershed. The reductions needed to meet water quality standards range from ~92 % - 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 Non-Tidal Jones Falls 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_JonesFalls_fc.asp

The document can also be found in Volume 2 - Appendix H of the Lower Jones Falls Small Watershed Action Plan.

3.5.3 Chlordane

The impairment listing for chlordane was limited to Lake Roland. 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 sources 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 lake Roland* can be found on the MDE website at:

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

The document can also be found in Volume 2 - Appendix I of the Lower Jones Falls Small Watershed Action Plan.

3.6 Pollutant Loading Analysis

3.6.1 Watershed Treatment Model

The pollutant load assessment for the Jones Falls watershed in both Baltimore City and Baltimore County was 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 are 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.

<u>*3.6.1.2 Input Data and Assumptions*</u>

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 3-15. 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 3-16. Land Use Summary for Back River and Jones Falls Watersheds
Source: (Baltimore County GIS, 2002 and Baltimore City GIS, date unknown)

Land Use Category	Impervious Cover (%)	Acres		
		Back River	Jones Falls (upper)	Jones Falls (lower)
Agriculture	1.9%	1108	2863	72
Water	2%	446	6	140
Roads*	2%	418	0	354
Railroads*	5%	217	0	134
Open Urban Land	8.6%	3936	5390	3197
2 Acre Lot Residential	10.6%	2	0	4
1 Acre Lot Residential	14.3%	3838	6481	1751
1/4 Acre Lot Residential	27.8%	7421	743	2772
1/8 Acre Lot Residential	32.6%	4260	0	3681
Townhome Residential	40.9%	1952	0	1696
Multifamily Residential	44.4%	4924	580	1685
Institutional	34.4%	3005	533	2330

Light Industrial	53.4%	2786	58	610
Commercial	72.2%	3419	168	1597
*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 3-16. 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 3-17: 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. 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 3-17 presents information on secondary sources.

Table 3-18. 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 3-18) included in the WTM are based on data provided in Baltimore County's 2005 NPDES report and Baltimore City's 2006 NPDES report.

Table 3-19: 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 3-19.

Table 3-20: Urban BMP Efficiencies

	Efficiency			
BMP Type	**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 for the Upper and Lower watersheds, are summarized in Table 3-20 and Table 3-21, respectively. Total loads for TN, TP, TSS and fecal coliform are reported in Table 3-22.

Table 3-21: Jones Falls Upper Watershed Annual Load

Loads	TN lb/year	TP lb/year	TSS lb/year	FC # billion/year
Primary loads	31,766	3,988	2,745,812	1,313,806
Secondary loads	63,993	4,021	4,086,941	2,844,213
Total	95,760	8,009	6,832,753	4,158,018
Load reduction existing practices	-16,745	-2,390	-1,786,120	-342,597
Total current load	**79,015**	**5,619**	**5,046,633**	**3,815,421**
Assumptions: 42 inches annual runoff, 26.28 mi^2 or 16,822 acres				

Table 3-22: Jones Falls Lower Watershed Annual Load

Loads	TN lb/year	TP lb/year	TSS lb/year	FC # billion/year
Primary loads	98,749	13,606	4,234,569	4,503,989
Secondary loads	34,892	3,061	2,844,318	4,039,216
Total	133,640	16,667	7,078,887	8,543,206
Load reduction existing practices	19,838	2,811	1,072,023	392,291
Total current load	**153,478**	**19,478**	**8,150,910**	**8,935,497**
Assumptions: 42 inches annual runoff, 31.3 mi^2 or 20,023 acres				

Table 3-23: Jones Falls Annual Load

Loads	TN lb/year	TP lb/year	TSS lb/year	FC # billion/year
Total current load	**232,493**	**25,097**	**13,197,543**	**12,750,918**
Assumptions: 42 inches annual runoff, 57.58 mi^2 or 36,846acres				

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 (Table 3-23). The TMDL and CBP goals are the two primary goals that load reduction strategies are attempting to fulfill.

Table 3-24: Jones Falls Loading Estimates from Several Sources

				% difference from WTM	
Source	**TN**	**TP**	**TSS**	**TN**	**TP**
WTM	232,493	25,097		NA	NA
TMDL	??	20,834		NA	-17.0%
CBP	278,767	23,166		+19.9%	-7.7%
Baltimore County	187,295	18,289		-19.4%	-27.1%
WQMP*	69,385*	5,742*	2,607,934*		
* Water Quality Management Plan Baltimore County portion only					

3.6.1.5 Discussion

In Table 3-23 the loading estimates from the TMDL, Bay Program (CBP), Baltimore County and the WTM compare favorably with one another. 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 6 subwatersheds within the Lower Jones Falls 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 480-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 3-24 presents the per-acre loadings for nitrogen and phosphorus used in this analysis.

Table 3-25: Land Use per Acre Nitrogen and Phosphorus Loadings (pounds/acre/year)

Land Use	Nitrogen Load per Acre	Phosphorus Load per Acre
Urban Pervious	14.86	2.11
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 3-25 and 3-26 for nitrogen and phosphorus respectively.

Table 3-26: 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)
Slaughterhouse Branch	10,603	2,669	430	13,702	10.8
Moores Branch	12,779	307	549	13,636	9.8
Jones Falls A	6,005	0	530	6,535	7.6
Western Run	41,799	0	253	42,052	12.1
Lower Jones Falls	74,078	0	1,749	75,827	10.4
Stoney Run	26,693	0	216	26,909	12.0
Total	**171,957**	**2,976**	**3,727**	**178,661**	**10.8**

Table 3-27: 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)
Slaughterhouse Branch	1,403	130	6	1,539	1.2
Moores Branch	1,646	24	8	1,677	1.2
Jones Falls A	736	0	8	743	0.9
Western Run	5,249	0	4	5,253	1.5
Lower Jones Falls	8,613	0	46	8,659	1.2
Stoney Run	3,331	0	6	3,337	1.5
Total	**20,978**	**154**	**78**	**21,208**	**1.3**

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 Facility Assessments

3.8.1 Stormwater Management Facility Conversion Assessment

The existing stormwater management facilities located within the Lower Jones Falls 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 43 stormwater management facilities have been built in the planning area. Of these facilities 12 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 to first if any conversion potential existed and secondly 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 it was not possible to determine the pond type in the field no further consider 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.
- Accessiblity – 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 12 stormwater management facilities assessed, only 10 were found to have conversion potential and ranked for conversion. Two of the facilities were found to be of the wrong type when investigated in the field; one was a wet pond and one was an extended detention pond.

The results of the application of the ranking methodology described above are presented in Table 3-27. The table presents the ownership, drainage area to the facility, the total score and the subwatershed that the pond is in.

Table 3-28: Potential Conversions of Dry Ponds to Improve Water Quality

Pond Number	Ownership	Acres	Total Score	Rank	Subwatershed
899	Private	12.0	32	High	Slaughterhouse Branch
912	Public	11.0	27	High	Jones Falls A
900	Private	6.9	27	High	Slaughterhouse Branch
939	Private	7.3	26	High	Western Run
898	Private	8.6	22	High	Moores Branch
945	Private	20.7	13	Medium	Jones Falls A
913	Public	64.3	13	Medium	Jones Falls A
1472	Private	189.6	12	Medium	Moores Branch
445	Private	4.9	9	Medium	Lower Jones Falls
910	Private	37.8	8	Medium	Moores Branch

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 3-24. The amount of reduction is dependant on the type of facility that receives the stormwater. Table 3-28 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 3-29: 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 3-29.

Table 3-30: 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
Slaughterhouse Branch	Detention	20.6	2	258.1	12.9	32.2	3.2
	Filtration	19.1	1	22.4	9.0	14.3	8.6
	Subwatershed Total	**39.7**	**3**	**280.5**	**21.9**	**46.5**	**11.8**
Moores Branch	Detention	388.1	5	3,447.5	172.4	678.6	67.9
	Extended Detention	86.7	3	1,134.0	340.2	148.1	29.6
	Filtration	9.0	2	76.6	30.6	10.4	6.2
	Wet Ponds	502.8	2	4,792.8	2,396.4	685.8	342.9
	Subwatershed Total	**986.6**	**12**	**9,450.9**	**2,939.6**	**1,522.9**	**446.6**
Jones Falls A	Detention	95.1	6	1,079.8	54.0	137.9	13.8
	Extended Detention	38.7	4	430.9	129.3	54.1	10.8
	Filtration	0.1	1	0.0	0.0	0.0	0.0
	Infiltration	0.2	1	0.0	0.0	0.0	0.0
	Subwatershed Total	**134.1**	**12**	**1,510.7**	**183.3**	**192.0**	**24.6**
Western Run	Detention	50.0	5	558.7	27.9	62.2	6.2
	Extended Detention	42.0	2	574.8	172.4	77.1	15.4
	Subwatershed Total	**92.0**	**7**	**1,133.5**	**200.3**	**139.3**	**21.6**
Lower Jones Falls	Detention	60.3	1	847.3	42.4	115.8	11.6
	Infiltration	0.2	1	0.0	0.0	0.0	0.0
	Subwatershed Total	**60.5**	**2**	**847.3**	**42.4**	**115.8**	**11.6**
All Subsheds	***Grand Total***	***1,130.2***	***36***	***12,035.8***	***3,328.1***	***1,632.5***	***447.8***

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 3-28 above. Nitrogen removal would improve from 5% to 50% and phosphorus removal would improve from 10% to 50%. Table 3-30 presents the summary results by subwatershed.

Table 3-31: Conversion of Dry Detention Ponds – Nutrient Removal Calculations

Subshed	# of Facilities	Acres	Nitrogen (pounds)			Phosphorus (pounds)		
			Load to Facility	Current Removal	Converted Removal	Load to Facility	Current Removal	Converted Removal
Slaughterhouse Branch	2	20.6	258.1	12.9	129.1	32.2	3.2	16.1
Moores Branch	3	264.5	2,125.1	106.3	2,062.6	505.4	50.5	252.7
Jones Falls A	3	89.2	1,030.0	51.5	515.0	132.0	13.2	66.0
Western Run	1	7.9	91.2	4.6	45.6	10.6	1.1	5.3
Lower Jones Falls	1	60.3	847.3	42.4	423.7	115.8	11.6	57.9
Total	**10**	**442.5**	**4,351.7**	**217.7**	**3,176.0**	**796.0**	**79.6**	**398.0**

The conversion of all 10 dry ponds would result in an increase in the removal of nitrogen from ~218 pounds to ~3,176 pounds, and for phosphorus from ~80 pounds to ~398 pounds.

References

Baltimore County Department of Environmental Protection (DEPRM), 2005. *2005 Annual NPDES Report*. Available Online. http://www.baltimorecountyonline.info/Agencies/environment/watersheds/epnpdesmain.html

Baltimore DPW and Baltimore County DEPRM, 2005. *State of Our Watersheds. The 2005 Conference for the Baltimore Region.*

Brown, E., D. Caraco and R. Pitt. 2004. *Illicit discharge detection and elimination: a guidance manual for program development and technical assessments.* Prepared for the U.S.

Cappiella and Brown. 2001. Impervious Cover and Land Use in the Chesapeake Bay Watershed. Ellicott City, MD.

Caraco, D. 2002. The Watershed Treatment Model. Version 3.1. Center for Watershed Protection. Ellicott City, MD.

Center for Watershed Protection, 2005. A User's Guide to Watershed Planning in Maryland. Prepared for MD Department of Natural Resources. Annapolis, MD.

Chesapeake Bay Program (CBP), 2005. Chesapeake Bay Program *Watershed Model Phase 4.3*. Annapolis, MD.

City of Baltimore. *2006 Annual NPDES Report*.

COMAR, 2005. Code of Maryland Regulations Title 26: Department of the Environment, Subtitle 08: Water Pollution, Chapter 2: Water Quality

Environmental Protection Agency Office of Wastewater Management. Center for Watershed Protection. Ellicott City, MD.

EA Engineering, Science, & Technology, Inc. March 2001. *Framework For Biomonitoring Programs: Fish and Macroinvertebrates. City of Baltimore*.

http://www.epa.gov/waterscience/standards/wqslibrary/md/index.html

Frink C.R. 1991. *Estimating nutrient exports to estuaries*. Journal of Environmental Quality 20: 717–724.

Horsley & Witten, Inc., 2000. On-site Sewage Disposal Systems Pollutant Loading Evaluation, Test and Validation of Indian River Lagoon Nitrogen Model, Melbourne, FL, January 2000.

MD DNR, 2005. Report on Nutrient Synoptic Surveys in the Anacostia River Watershed, Prince George's County, Maryland, April, 2004 as part of a Watershed Restoration Action Strategy. Watershed Services Division, Annapolis, MD.

Pitt, R., Maestre A., and R. Morquecho. 2003. The National Stormwater Quality Database (NSQD), Version 1.0. Water Environment Federation Technical Exposition and Conference, Los Angeles. October 2003.

Schueler, T. 1987. Controlling Urban Runoff. MWCOG. Washington, D.C.
Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices: 2nd Edition. Center for Watershed Protection. Ellicott City, MD.

United States Environmental Protection Agency (EPA), 2002. *Onsite Wastewater Treatment Systems Manual.* EPA/625/R-00/008. Office of Water. Cincinnati, OH.

United States Environmental Protection Agency (EPA), 1988. Ambient Water Quality Criteria for Chloride – 1988. Office of Water, Regulations and Standards Criteria and Standards Division, Washington, DC 20460.

United States Environmental Protection Agency (EPA). 1980. *Onsite Wastewater Treatment Systems Manual.* Office of Water. Cincinnati, OH.

United States Geological Survey (USGS), 1999. *Monitoring Nutrients in the Major Rivers Draining to the Chesapeake Bay.* Water-Resources Investigations Report 99-4238. http://va.water.usgs.gov/online_pubs/WRIR/99-4238/wrir_99_4238_text.pdf

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 investigations used to conduct the survey is one in 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 the 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 Lower Jones Falls watershed: the Neighborhood Source Assessment, Hot Spot Investigation, Institutional Site Investigation and Pervious Area Assessment.

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 Jones Falls watershed is an older and highly 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 was called the Neighborhood Source Assessment Junior (NSA Jr.) and was used in less than 2% of neighborhoods.

Prior to the fieldwork, neighborhood units were designated 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 than 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. If a different action was identified during the field visit, than it was noted as a separate comment

- 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 retrofit

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". PSI rates the degree 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 or behavior changes based on the NSA.

4.2.2 Summary of Sites Investigated

A total of 130 neighborhoods were identified and assessed. Of these 130, 39 were considered to have a "high" Pollution Severity Index (PSI) and/or a "high" Restoration Opportunity Index (ROI). Note that of these 39, six had a high rank for both PSI & ROI.

4.2.3 General Findings

Below is a description of the methodologies associated with evaluating potential for recommended actions along with 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 from the associated assessment.

4.2.3.1 Downspout Disconnection

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 rooftop runoff from impervious areas or from a direct connection to a nearby lawn or garden 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 available for infiltration to occur.

Rain barrels and rain gardens are other disconnection options that were sometimes recommended instead of redirection based on specific conditions. When there is limited space or limited impervious 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 either directly connected to the system or drain to an impervious surface that feeds into a storm drain inlet, will score for downspout redirection as a recommended action, given there is 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.

Typical rain barrel installation with overflow hose

Directly connected downspouts in NSA-H-98A

Table 4-1 Acres Addressed by Downspout Redirection

Subwatershed	Number of Neighborhoods with Downspout Redirection Recommended	Impervious Rooftop Acres Addressed by Downspout Disconnection
Jones Falls A	11	30.7
Lower Jones Falls	18	70.1
Moores Branch	17	67.0
Slaughterhouse	12	50.5
Stony Run	25	204.2
Western Run	31	212.4

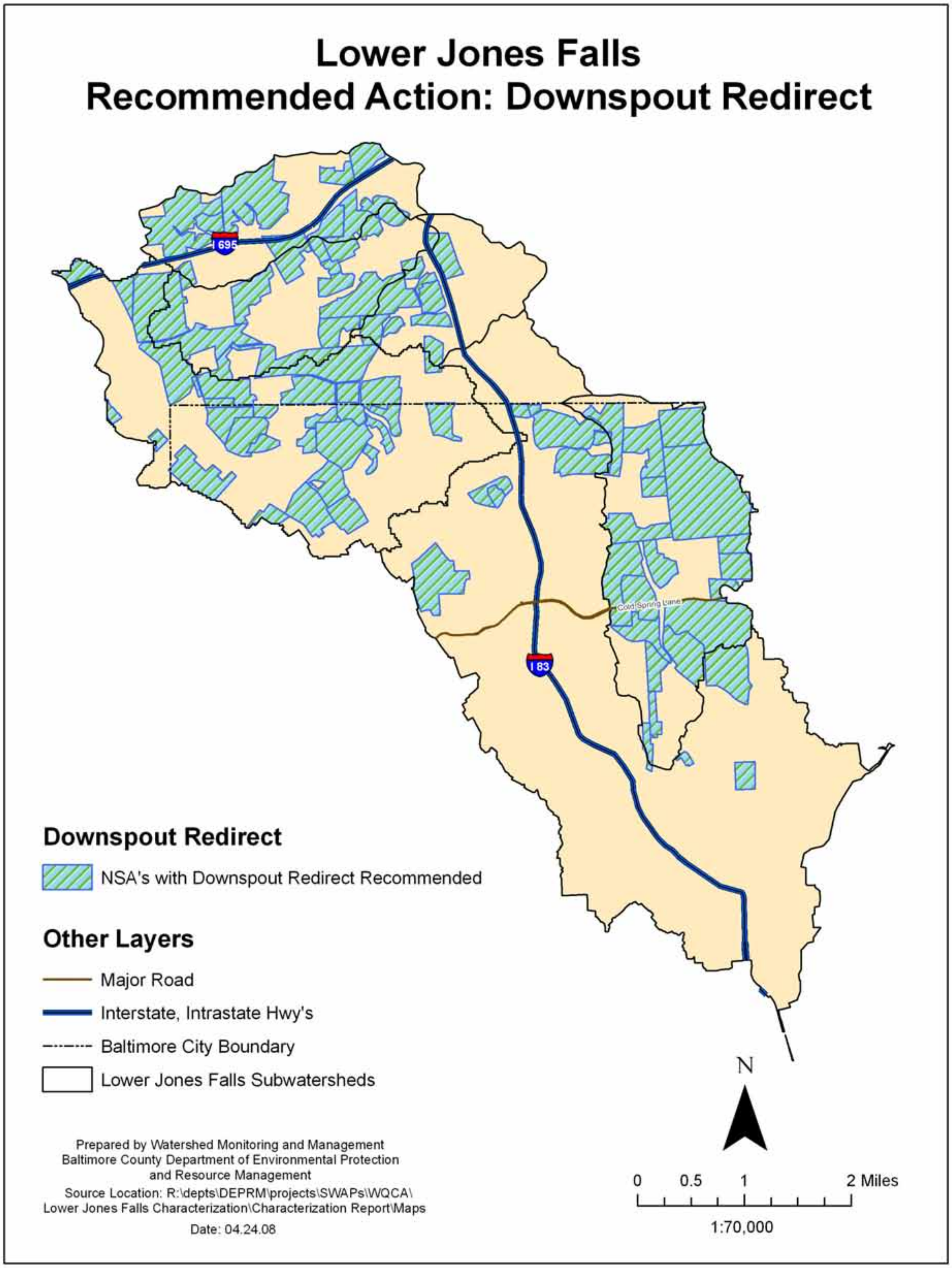

Figure 4-1. Neighborhoods with Downspout Redirection Recommended

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 nearby streams. This helps reduce the clogging of the stream with excess material and the decay of excess organic matter that can rob the stream of essential oxygen.

Neighborhoods exhibiting 20% or more of their curbs/gutters with excessive trash, sediment and/or organic matter were 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. Figure 4-2 shows the locations of neighborhoods recommended for street sweeping. Table 4-2 lists these 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

Street sweeping can help reduce sediment in streams

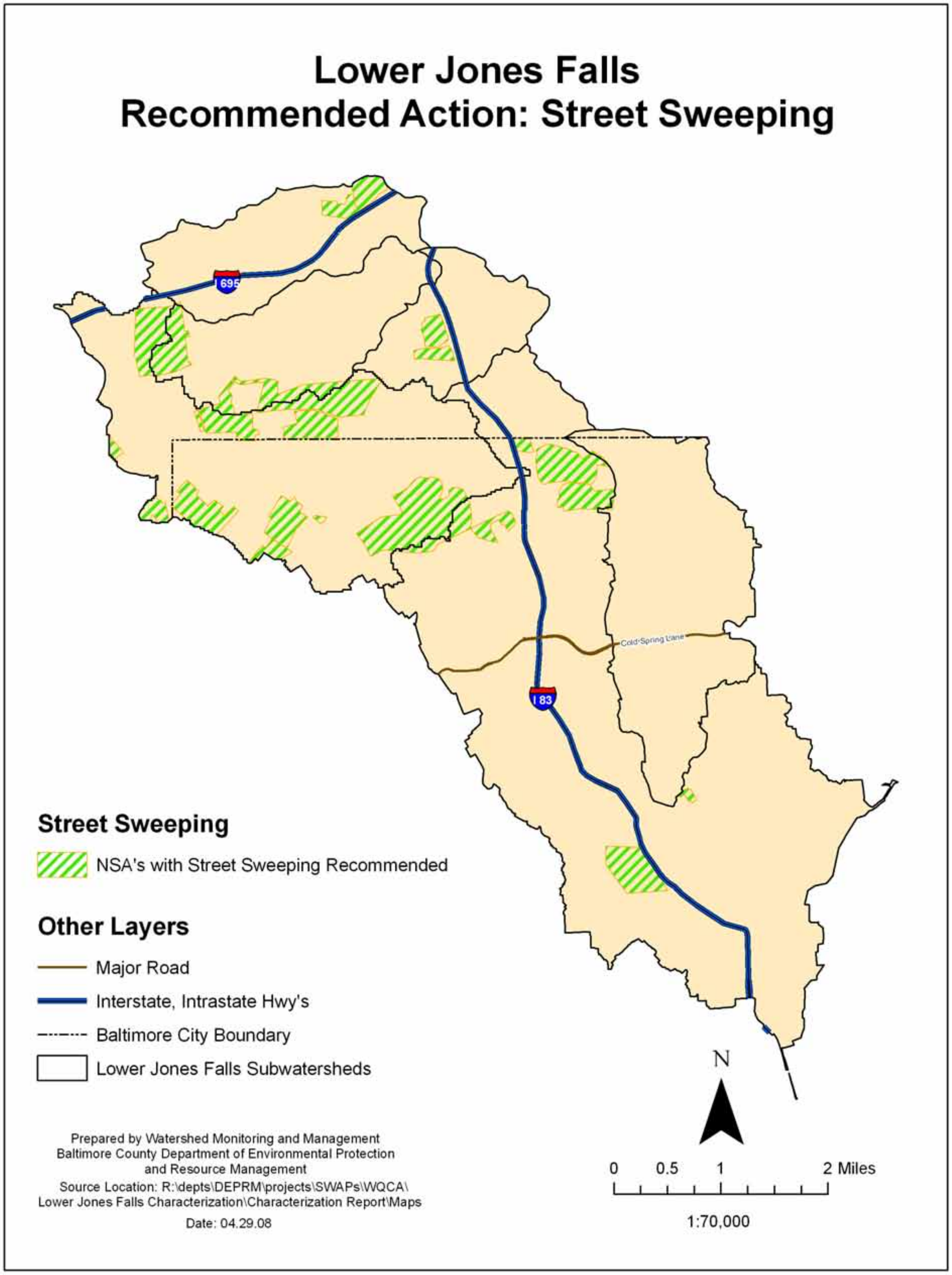

Figure 4-2 Neighborhoods with Street Sweeping Recommended

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
Jones Falls A	3	5.2
Lower Jones Falls	7	16.1
Moore's Branch	3	8.8
Slaughterhouse	2	4.0
Stony Run	1	.03
Western Run	12	46.7

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

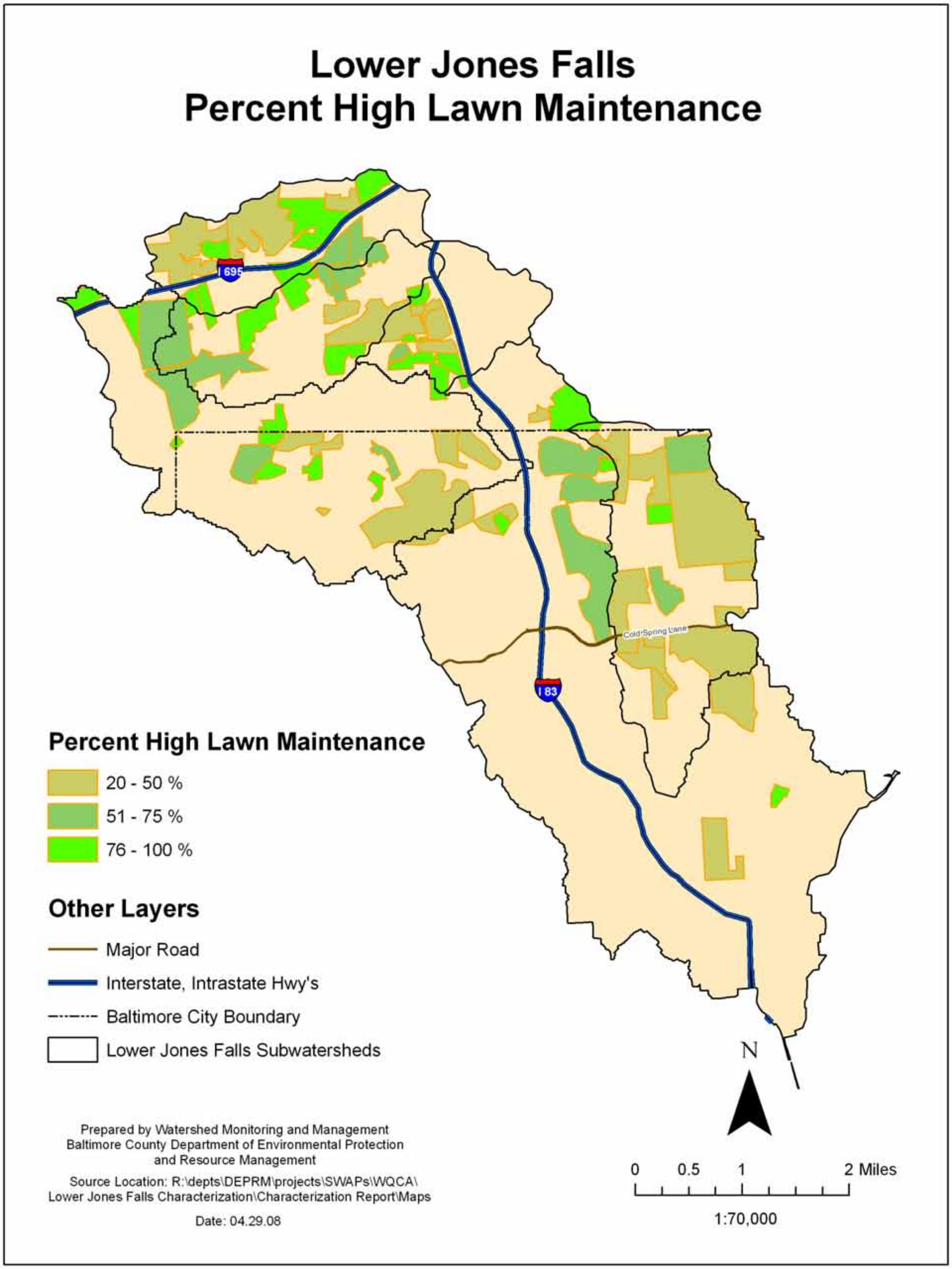

Figure 4-3 Neighborhoods with 20-100% High Maintenance Lawns

Table 4-3 Acres of Lawn Addressed by Fertilizer Reduction

Subwatershed	Number of Neighborhoods with Fertilizer Reduction Recommended	Acres of Lawn Addressed by Fertilizer Reduction	% of Subwatershed Addressed by Fertilizer Reduction
Jones Falls A	12	156.7	18
Lower Jones Falls	16	445.7	6
Moores Branch	13	412.4	30
Slaughterhouse	13	428.0	34
Stony Run	20	460.5	21
Western Run	16	462.9	13

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, and can enhance wildlife benefits. Implementing new bayscaped areas on a property also reduces lawn maintenance requirements, which reduces fuel consumption and exhaust from mowing equipment and also reduces the need for lawn chemicals.

Every neighborhood could use more bayscaping. In this case, however, bayscaping education and implementation was recommended in neighborhoods where the typical lot was less then 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

This bayscaped area helps reduce the need to maintain a large area of lawn

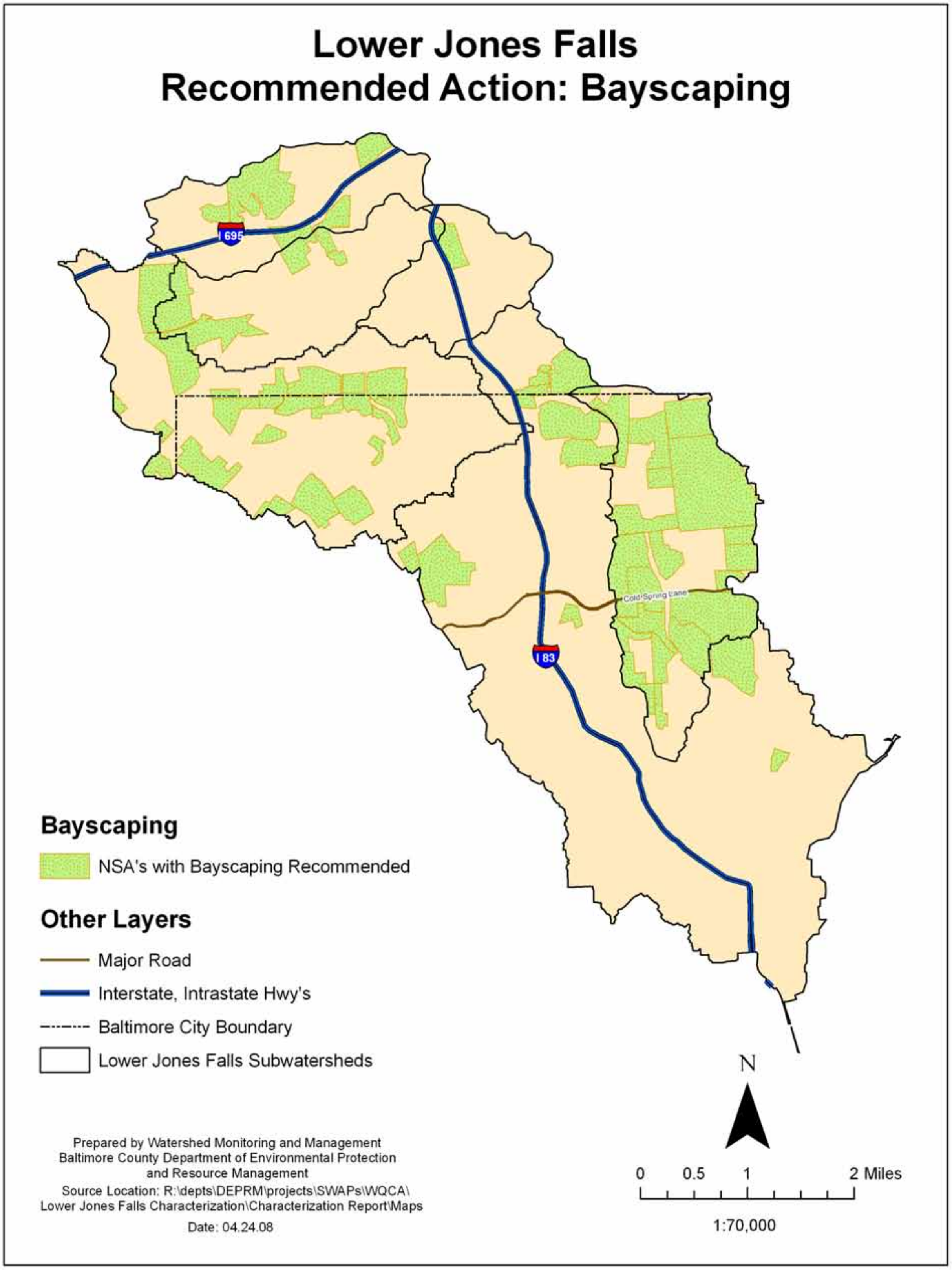

Figure 4-4 Neighborhoods with Bayscaping recommended

Table 4-4 Neighborhoods and Acres of Land Addressed by Bayscaping

Subwatershed	Number of Neighborhoods with Bayscaping Recommended	Acres of Land Addressed with Bayscaping
Jones Falls A	1	43.7
Lower Jones Falls	18	441.6
Moore's Branch	6	224.0
Slaughterhouse	6	281.4
Stony Run	26	1,012.8
Western Run	22	588.8

4.2.3.5 Street Trees

Street trees improve air quality, catch precipitation with their leaves and absorb precipitation 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 suitable distance between the sidewalk and road

Real estate values increase when a neighborhood is beautified with trees

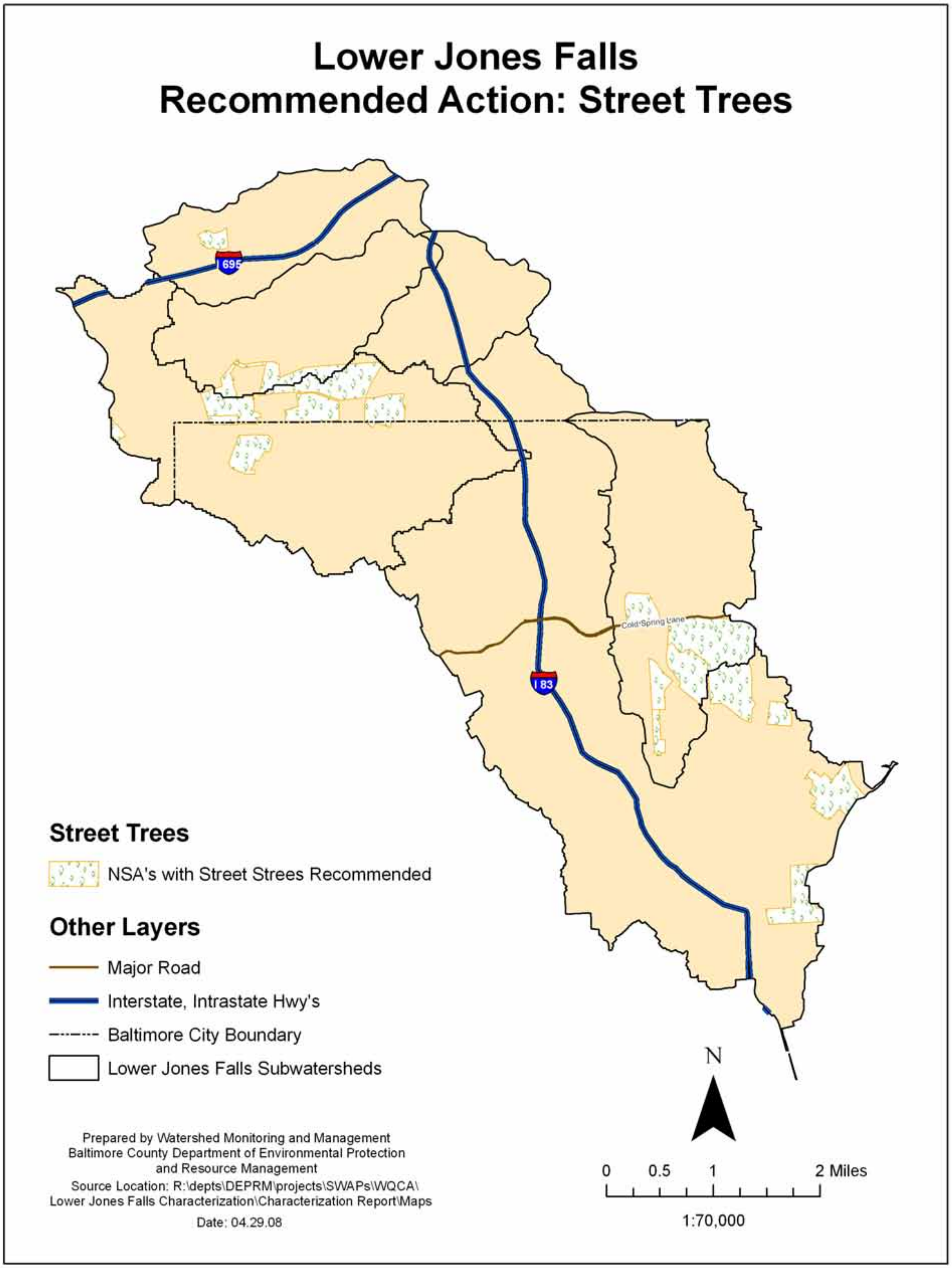

Figure 4-5 Neighborhoods with Street Tree Planting Recommended

Table 4-5 Number of Street Trees to be Planted.

Subwatershed	Number of Neighborhoods with Street Trees Recommended	Number of Trees That Could be Planted
Jones Falls A	0	0
Lower Jones Falls	4	139
Moores Branch	2	49
Slaughterhouse	1	75
Stony Run	5	170
Western Run	7	375

See appendix 4-1 for a comprehensive summary of NSA results

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 observation 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.

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 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 to drain to storm system.

F. Storm Water Infrastructure: Any on-site storm water management practices were indicated here along with gutter conditions if there were 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 25 hotspot candidates were investigated, 21 of which were commercial establishments. Of these 25, the initial hotspot statuses were designated as follows: one severe, six confirmed and 12 potential hotspots. The remaining six were found 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
Jones Falls A	0	0	0	0
Lower Jones Falls	0	3	6	5
Moores Branch	0	0	0	0
Slaughterhouse	0	0	0	0
Stony Run	0	1	1	0
Western Run	1	2	5	1

Table 4-7 Hotspot Site Type of Facility

Subwatershed	# Commercial	# Industrial	# Municipal	# Transportation Related
Jones Falls A	0	0	0	0
Lower Jones Falls	10	0	2	2
Moores Branch	0	0	0	0
Slaughterhouse	0	0	0	0
Stony Run	2	0	0	0
Western Run	9	0	0	0

Table 4-8 Hotspot Site Source of Pollution

Subwatershed	Outdoor Storage	Waste Management	Physical Plant	Turf/ Landscaping
Jones Falls A	0	0	0	0
Lower Jones Falls	10	7	2	0
Moores Branch	0	0	0	0
Slaughterhouse	0	0	0	0
Stony Run	0	1	0	0
Western Run	5	5	5	3

Dumpster juice" has direct access to the storm drain

HSI site H-401, an auto shop where vehicles are repaired and stored outside

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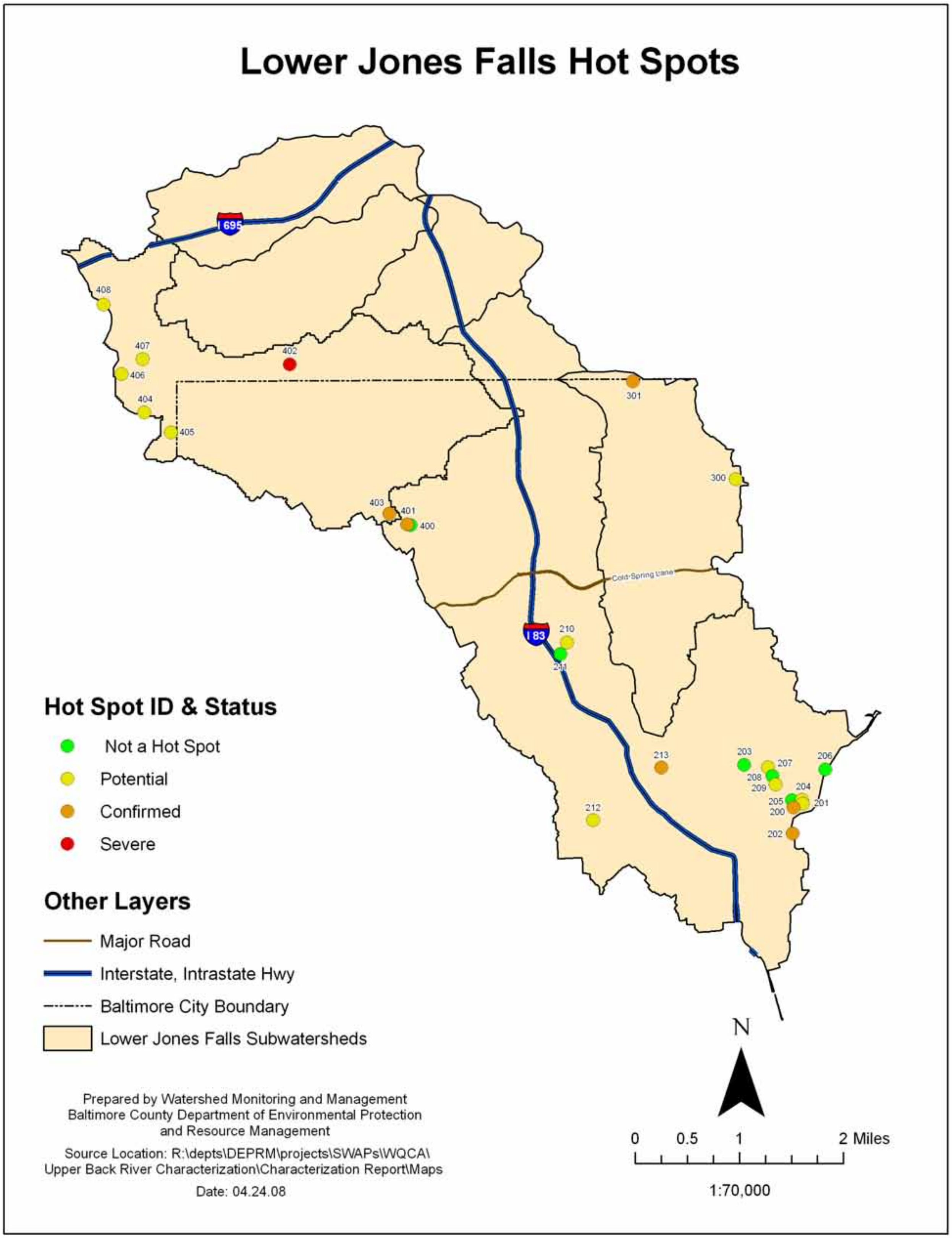
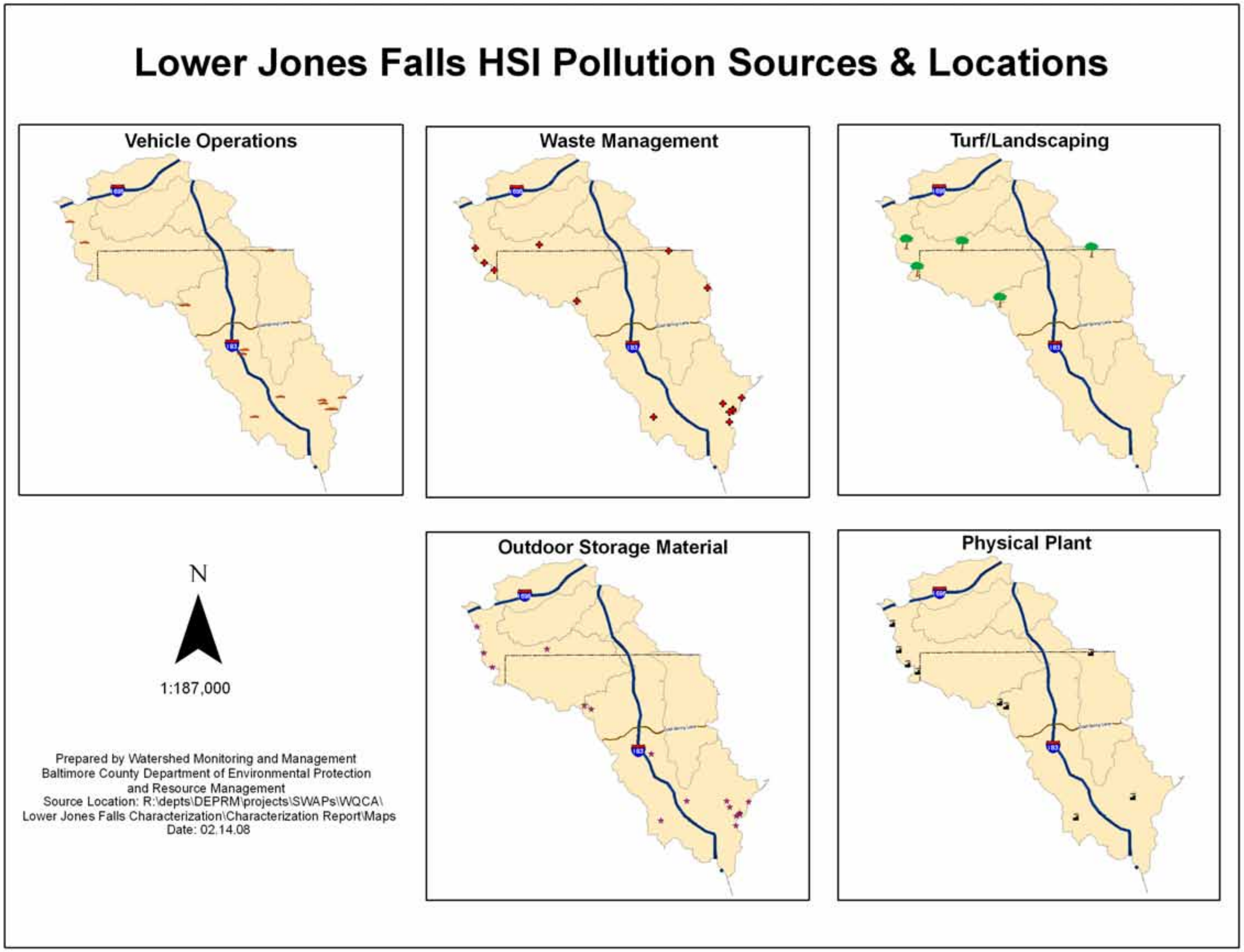


Figure 4-6 Hot Spot Investigation Locations

Figure 4-7 Hot Spot Investigation Pollution Sources and Locations



4.3.3 General Findings

See Appendix 4-2

Categorically, the auto repair shops were the biggest offenders, 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.

Site 402, the only "severe" rated site, was reported to Baltimore Country DEPRM for a follow-up site visit and possible enforcement measures.

Also worthy of note is the Pimlico racecourse, located in the city portion of Western Run. Although it scored as a confirmed hot spot rather than severe, the scope of its pollution potential, based on its large drainage area and the problems observed, qualify it as one of the best operations to target for education and implementation of better stormwater management practices.

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 Lower Jones Falls 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 Jones Falls watershed has an abundance of Institutional facilities that occupy a significant amount, more than 15%, 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

The ownership, if known, is also indicated. This is important 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.

Also included was whether the site 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 10 acres of land or more. Several of the Institutions in the study area potentially qualify and these will be forwarded to staff at the 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.

Parts D. (vehicle operations) and **E. (outdoor materials)** were not applicable in any institutions during these investigations.

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 institutions 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. 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 54 ISI sites were identified 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 Schools	Colleges	Hospitals	Public Schools
Jones Falls A	0	0	0	0	1
Lower Jones Falls	0	2	0	2	19
Moores Branch	0	1	0	0	3
Slaughterhouse	1	1	0	0	1
Stony Run	3	2	2	0	3
Western Run	5	1	1	0	6

Staining from dumpster leading to storm drain at ISI site H-207

Direct connected downspouts suitable for disconnection at ISI site H-216

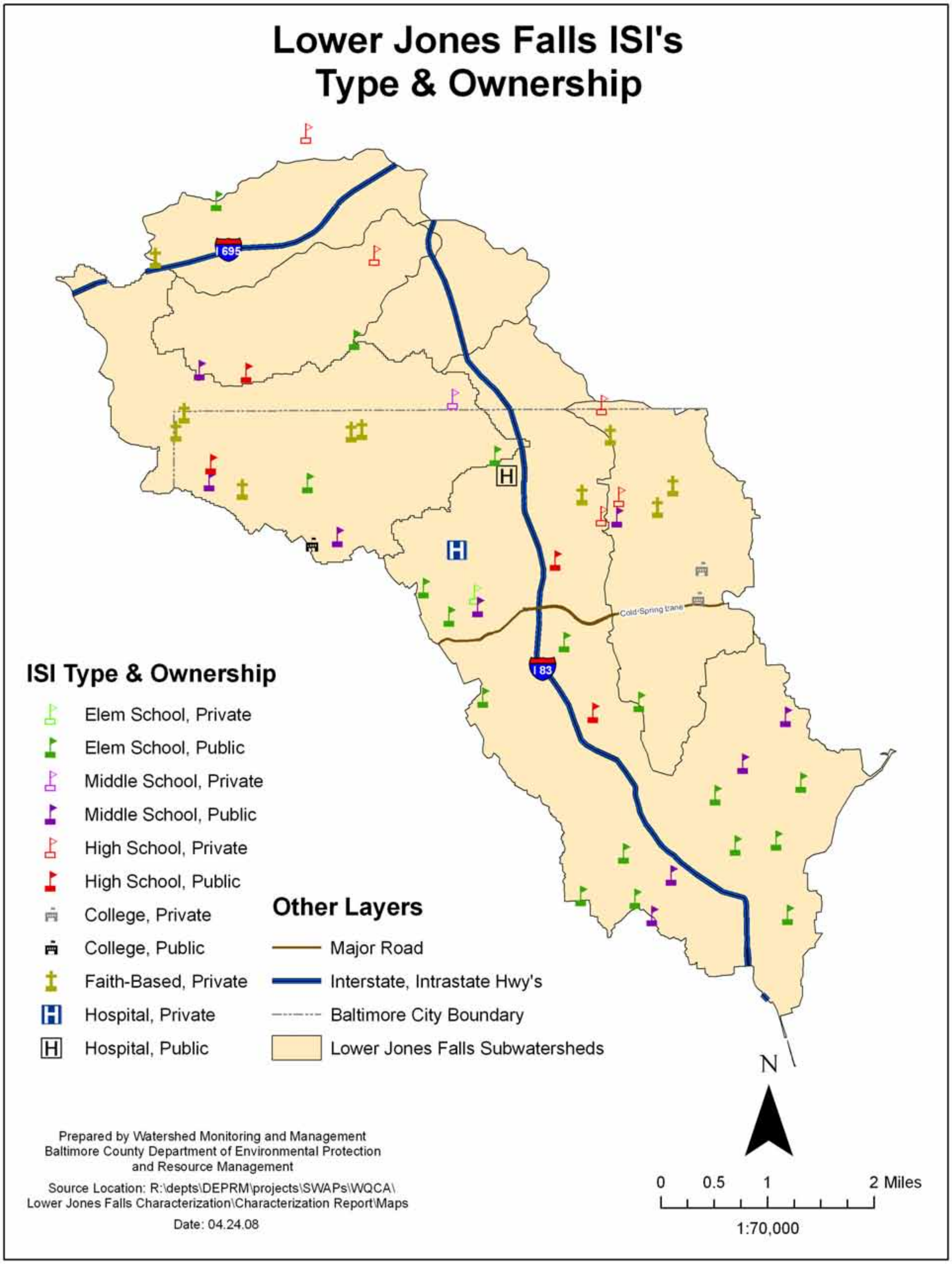


Figure 4-8 Institutional Site Investigation Locations

4.4.3 General Findings

See Appendix 4-3

Waste management proved to be the most frequent area in need of improvement with over 50% of the sites exhibiting this as a potential pollution source. 18 sites had areas of impervious cover that could be removed, 14 sites showed downspout disconnection possibilities and 16 sites had storm water retrofit potential.

It was estimated that 4633 total trees could be planted throughout 39 of the 54 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.
Jones Falls A	250	0	0	0	0
Lower Jones Falls	2,423	11	6	13	18
Moores Branch	675	2	1	0	0
Slaughterhouse	250	1	1	1	1
Stony Run	505	1	5	1	3
Western Run	530	1	1	3	6

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 any 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 26 pervious areas were assessed within the study area totaling 58.75 acres. Parcel sizes ranged from .25 acres to 10 acres with an average of 2.25 acres. All but site 401, a natural area remnant, 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-H-202	2.0	Lower Jones Falls	Minimal
PAA-H-204	1.0	Lower Jones Falls	Minimal
PAA-H-205	1.0	Lower Jones Falls	Minimal
PAA-H-206	7.0	Lower Jones Falls	Minimal
PAA-H-211	1.0	Lower Jones Falls	Minimal
PAA-H-216	1.0	Lower Jones Falls	Minimal
PAA-H-217	1.5	Lower Jones Falls	Minimal
PAA-H-300	1.0	Stony Run	Minimal
PAA-H-400	0.50	Western Run	Minimal
PAA-H-401	5.50	Western Run	None

PAA site H-400 off of Reisterstown Rd.

PAA site H-216 at Madison & W. Lanvale

4.5.3 General Findings

See Appendix 4-4

The most likely candidates for a successful pervious area restoration effort are those on public lands with minimal site preparation required. There were 9 such sites identified in the study with areas ranging from .5 to 7 acres. Sites 206 and 202 were the largest of these sites, both on public school property and good starting points for pervious area restoration efforts.

Site 218 is a ten-acre open pervious area spanning the city/county border in the Lower Jones Falls subwatershed. Ownership of this land is unknown, however, considering the size and apparent lack of usage, it is worthy of a follow-up investigation.

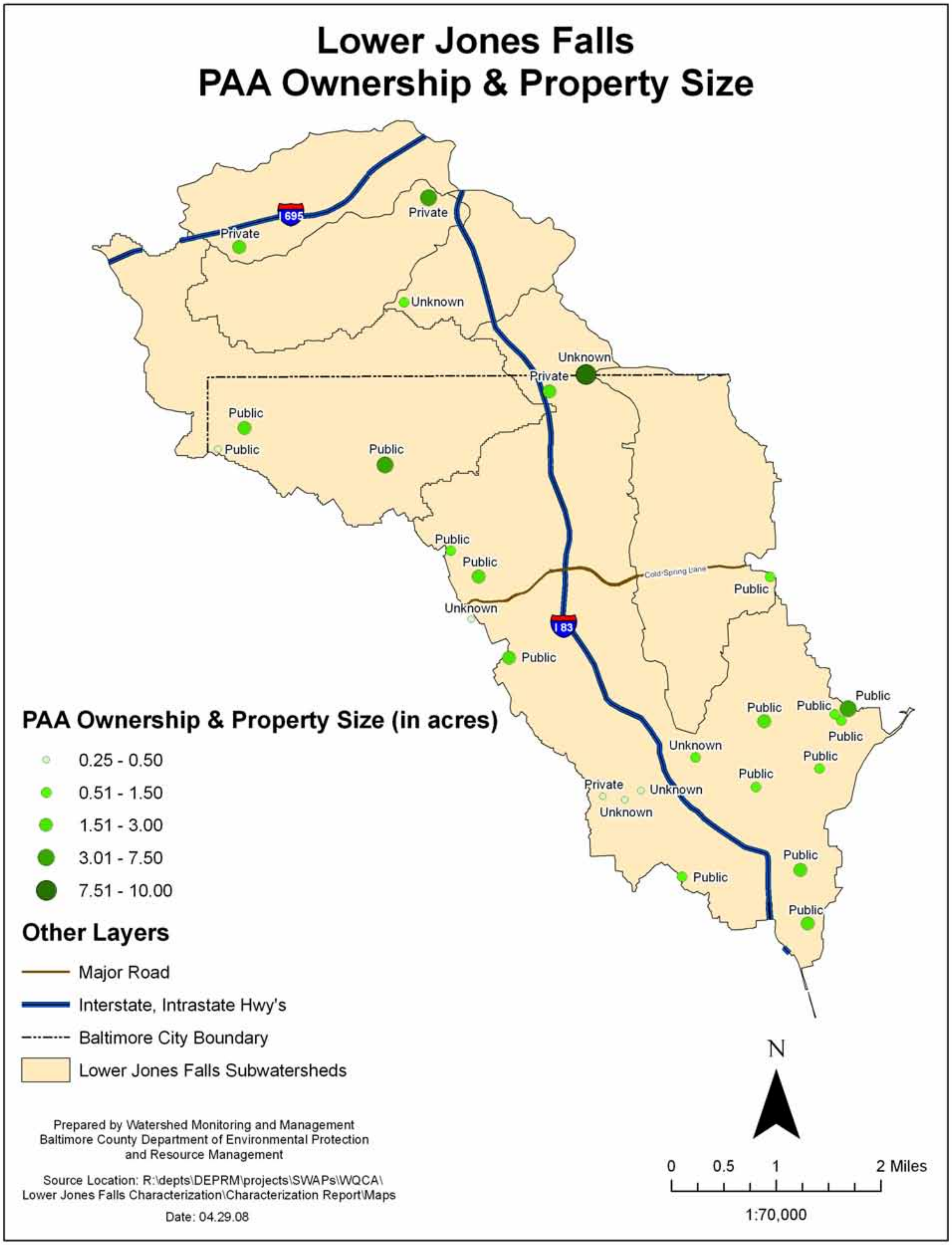


Figure 4-9 Pervious Area Assessment Locations

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 (%)	Pet waste
NSA_H_01	Moderate	Moderate	X		X	X	X	X	X	60	
NSA_H_02	Moderate	Moderate		X	X	X	X	X	X	70	
NSA_H_03	Moderate	Low	X	X		X			X	90	
NSA_H_04	High	High	X		X	X		X	X	95	
NSA_H_05	Moderate	Moderate	X	X		X		X	X	100	
NSA_H_06	High	High	X		X	X	X	X	X	75	
NSA_H_07	High	Moderate	X		X	X			X	50	
NSA_H_07A	Moderate	High	X			X	X	X	X	90	
NSA_H_08	Moderate	Low	X		X	X	X		X	30	
NSA_H_09	Moderate	Moderate	X	X		X		X		10	
NSA_H_10	Moderate	Moderate	X	X		X	X	X		15	
NSA_H_11	Moderate	High	X		X	X		X	X	40	
NSA_H_12	Moderate	High	X			X	X	X	X	50	
NSA_H_13	Moderate	High	X					X	X	35	
NSA_H_14	High	High	X		X	X	X	X	X	25	
NSA_H_17	Moderate	Moderate	X		X		X	X		20	
NSA_H_18	High	Moderate			X	X	X	X		20	X
NSA_H_20	Moderate	Moderate	X		X	X	X			10	
NSA_H_21	Moderate	Moderate	X		X		X		X	40	
NSA_H_22	Moderate	Moderate	X			X			X	90	
NSA_H_23	Moderate	Moderate	X		X	X		X	X	70	
NSA_H_24	Moderate	Moderate	X		X	X		X	X	50	
NSA_H_25	Moderate	Low	X	X	X	X			X	90	
NSA_H_26	Moderate	High		X		X			X	100	
NSA_H_27	Moderate	Moderate	X		X	X		X	X	100	
NSA_H_28	High	Moderate	X		X	X	X		X	80	
NSA_H_29	Moderate	Moderate	X		X	X	X	X	X	75	
NSA_H_30	Moderate	Moderate	X			X		X	X	50	
NSA_H_31	Moderate	Low	X			X			X	60	
NSA_H_32	Moderate	Low	X	X		X				20	
NSA_H_33	Moderate	Moderate	X			X		X	X	60	
NSA_H_34	Moderate	Moderate	X			X				25	
NSA_H_35	Moderate	Moderate				X			X	50	
NSA_H_36	Moderate	Moderate	X			X	X	X	X	100	
NSA_H_39	High	High	X		X	X	X	X	X	90	
NSA_H_40	Moderate	Moderate	X		X	X			X	40	
NSA_H_41	Moderate	Low			X				X	80	
NSA_H_42	Moderate	Moderate	X	X		X		X	X	100	
NSA_H_43	Moderate	Moderate		X		X		X	X	100	
NSA_H_44	Moderate	Moderate			X	X		X	X	100	
NSA_H_45	High	Moderate	X			X		X	X	100	
NSA_H_46	Moderate	Moderate		X		X		X	X	100	
NSA_H_49	Moderate	Moderate		X		X		X	X	100	
NSA_H_50	Moderate	Moderate	X	X		X			X	50	
NSA_H_51	Moderate	Moderate				X			X	40	
NSA_H_52	Moderate	Moderate		X		X			X	100	
NSA_H_55	Moderate	Moderate	X			X	X			0	
NSA_H_56	Moderate	Moderate		X		X	X			0	
NSA_H_57	High	Moderate	X	X						0	
NSA_H_58	Moderate	Low		X		X				0	
NSA_H_59	None	Low								0	
NSA_H_60	Moderate	High			X		X		X	100	X
NSA_H_61	High	Low	X		X		X		X	30	
NSA_H_62	Moderate	Low		X						0	
NSA_H_63	None	Low								0	
NSA_H_64	High	Moderate		X						0	X
NSA_H_65	Moderate	Moderate	X	X		X				10	

Neighborhood ID	PSI	ROI	Downspout Redirect	Rain Barrel	Rain Garden	Storm drain Stenciling	Bayscaping	Lot Canopy	Fertilizer Reduction	High Maintenance Lawns (%)	Pet waste
NSA_H_66	Severe	Moderate								0	
NSA_H_67	High	Moderate	X	X		X	X			0	X
NSA_H_68	Moderate	Moderate		X		X	X	X		0	
NSA_H_69	Moderate	Moderate		X						0	
NSA_H_70	High	Moderate		X		X				0	
NSA_H_71	Moderate	Moderate			X	X				10	
NSA_H_72	Moderate	Moderate	X		X	X	X			0	
NSA_H_73	Moderate	High	X		X	X	X	X	X	30	
NSA_H_74	Moderate	High	X		X	X	X	X	X	25	
NSA_H_75	Moderate	High	X		X	X	X	X	X	60	
NSA_H_76	Moderate	Low			X	X				20	
NSA_H_77	Moderate	Moderate	X			X				20	
NSA_H_78	Moderate	Low			X				X	70	
NSA_H_79	Moderate	Moderate			X		X	X		0	
NSA_H_80	None	Moderate		X		X				0	
NSA_H_81	Moderate	Moderate		X		X				0	
NSA_H_82	Moderate	Moderate	X			X	X	X	X	80	
NSA_H_83	High	High	X		X	X	X	X		20	
NSA_H_84	Moderate	Moderate	X			X	X	X		25	
NSA_H_87	High	High	X			X	X	X		15	X
NSA_H_88A	High	Moderate	X		X	X			X	50	
NSA_H_88B	Moderate	Low	X	X		X			X	100	
NSA_H_89	Moderate	Moderate	X		X	X	X		X	60	
NSA_H_90A	Moderate	Moderate	X	X		X		X	X	100	
NSA_H_90B	Moderate	Moderate	X				X	X		10	
NSA_H_91	Moderate	Moderate	X	X		X			X	100	
NSA_H_92	High	Moderate	X		X	X	X		X	65	
NSA_H_93	Moderate	Moderate		X		X				5	
NSA_H_94A	None	High		X						0	
NSA_H_94B	None	Moderate		X						0	
NSA_H_95	Moderate	Moderate		X		X				0	
NSA_H_96	Moderate	Moderate		X		X				0	
NSA_H_97	Moderate	Moderate		X		X				0	
NSA_H_98A	Moderate	Moderate	X			X				20	
NSA_H_98B	None	Moderate								0	
NSA_H_100	Moderate	Moderate			X	X			X	40	
NSA_H_101	Moderate	Moderate	X	X		X			X	100	
NSA_H_102A	High	Moderate	X		X	X			X	50	
NSA_H_102B	Moderate	Moderate	X			X	X	X	X	100	
NSA_H_103	High	High		X		X				0	
NSA_H_104	Moderate	Low			X					0	
NSA_H_105	Moderate	Moderate			X	X	X	X	X	80	
NSA_H_106	Moderate	Low					X	X		0	
NSA_H_107	Moderate	Moderate			X	X	X	X		0	
NSA_H_108	High	Low			X					0	
NSA_H_109	Moderate	Moderate			X	X	X	X		50	X
NSA_H_201	Moderate	Moderate	X	X			X		X	35	
NSA_H_202	Moderate	Moderate	X	X		X	X		X	50	
NSA_H_203	Moderate	Moderate	X	X		X	X			0	
NSA_H_204	High	Moderate	X	X		X	X		X	40	
NSA_H_205	High	Moderate	X	X			X		X	35	X
NSA_H_206	Moderate	High	X			X	X			15	
NSA_H_207	Moderate	Low								0	X
NSA_H_208	High	Moderate	X	X	X	X	X		X	30	X
NSA_H_209	Moderate	Moderate	X	X			X		X	65	X
NSA_H_210	Moderate	Moderate	X	X	X		X		X	100	
NSA_H_211	Moderate	High	X	X	X	X	X		X	25	
NSA_H_212	High	Moderate	X	X			X			15	X

Neighborhood ID	PSI	ROI	Downspout Redirect	Rain Barrel	Rain Garden	Storm drain Stenciling	Bayscaping	Lot Canopy	Fertilizer Reduction	High Maintenance Lawns (%)	Pet waste
NSA_H_213	Moderate	Moderate	X	X	X	X	X		X	25	
NSA_H_214	Moderate	Moderate	X	X	X		X		X	70	
NSA_H_215	Moderate	High	X	X	X		X			15	X
NSA_H_216	High	Moderate	X	X			X		X	25	X
NSA_H_217	Moderate	Moderate	X			X	X		X	50	
NSA_H_218	Moderate	High	X	X	X	X	X		X	30	
NSA_H_220	Moderate	Moderate		X			X			20	X
NSA_H_221	Moderate	Moderate				X	X			5	X
NSA_H_222	Moderate	Low					X			5	X
NSA_H_223	Moderate	Moderate	X	X		X				0	X
NSA_H_224	Moderate	Moderate	X	X			X			0	X
NSA_H_225	Moderate	High				X	X			0	X

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
NSA_H_01		X	0	0					192	30
NSA_H_02		X	0	0					54	4
NSA_H_03			0	0		X			48	10
NSA_H_04			0	0					31	4
NSA_H_05			0	30		X			49	12
NSA_H_06			0	0				X	187	40
NSA_H_07			0	0					229	33
NSA_H_07A		X	75	0					25	5
NSA_H_08			0	0					197	26
NSA_H_09			0	0				X	5	1
NSA_H_10			100	0					15	8
NSA_H_11			50	0				X	89	25
NSA_H_12			100	0				X	69	24
NSA_H_13		X	100	0				X	187	51
NSA_H_14			7	0				X	16	3
NSA_H_17			0	0					12	2
NSA_H_18			0	20				X	50	8
NSA_H_20			0	0					25	8
NSA_H_21			40	0					62	19
NSA_H_22			0	0		X			34	10
NSA_H_23			0	0					37	10
NSA_H_24		X	0	0					152	28
NSA_H_25			0	0					22	3
NSA_H_26			0	0					26	8
NSA_H_27			0	0					69	6
NSA_H_28			0	0					78	9
NSA_H_29			0	0					11	3
NSA_H_30			0	30		X			33	10
NSA_H_31			0	0					100	10
NSA_H_32			0	0		X			11	5
NSA_H_33			0	0					14	6
NSA_H_34			0	15		X		X	25	7
NSA_H_35			0	25					16	3
NSA_H_36		X	0	0					55	2
NSA_H_39			0	0				X	79	4
NSA_H_40		X	0	0				X	31	3

Neighborhood ID	Trash Management	Buffer Impact	Street Trees	Open Space Trees	Park Creation	Parking Lot Retrofit	Alley Retrofit	Street Sweeping	Total Acres	Impervious Acres
NSA_H_41		X	0	0					122	8
NSA_H_42			0	50		X			20	11
NSA_H_43			0	0					5	5
NSA_H_44			0	50					26	13
NSA_H_45			0	100	X	X			48	13
NSA_H_46			0	75		X			27	10
NSA_H_49		X	0	75		X			28	10
NSA_H_50			0	15				X	36	14
NSA_H_51			0	30		X			7	3
NSA_H_52			0	0					7	2
NSA_H_55			0	0					18	7
NSA_H_56			0	0					35	25
NSA_H_57			0	0	X		X		30	20
NSA_H_58			0	0	X		X		166	106
NSA_H_59			0	0		X			96	73
NSA_H_60			0	50		X			14	5
NSA_H_61			15	0					110	34
NSA_H_62			0	0					18	9
NSA_H_63			50	0					28	16
NSA_H_64	X		0	0	X		X		53	36
NSA_H_65			0	0				X	7	3
NSA_H_66	X		50	0	X				99	52
NSA_H_67	X		0	0					129	44
NSA_H_68			0	0					22	12
NSA_H_69	X		30	0	X		X		105	55
NSA_H_70	X		0	0					139	57
NSA_H_71			0	0				X	69	20
NSA_H_72			0	0					81	26
NSA_H_73			0	0			X		51	17
NSA_H_74		X	0	0					56	30
NSA_H_75		X	0	0					20	7
NSA_H_76			0	0					47	13
NSA_H_77			0	0					45	15
NSA_H_78		X	0	0					216	53
NSA_H_79			0	0					18	6
NSA_H_80			0	0			X		48	30
NSA_H_81			0	0					172	90
NSA_H_82			0	100					21	6
NSA_H_83			0	0				X	29	8
NSA_H_84			0	0			X		52	24
NSA_H_85			0	35		X			16	11
NSA_H_86			30	0					63	16
NSA_H_87			0	10			X	X	92	32
NSA_H_88A			0	0				X	45	6
NSA_H_88B			0	0		X			13	4
NSA_H_89			0	0				X	113	19
NSA_H_90A		X	0	10					18	1
NSA_H_90B			0	30			X	X	12	6
NSA_H_91			0	20					11	5
NSA_H_92			0	0			X	X	70	10
NSA_H_93	X		0	0			X		17	8
NSA_H_94A			0	0			X		124	67
NSA_H_94B			0	20	X		X		360	197
NSA_H_95			0	0			X		143	109
NSA_H_96	X		0	0	X				120	73
NSA_H_97	X		0	0			X		103	69
NSA_H_98A		X	0	0					57	18
NSA_H_98B			0	0		X		X	4	1

Neighborhood ID	Trash Management	Buffer Impact	Street Trees	Open Space Trees	Park Creation	Parking Lot Retrofit	Alley Retrofit	Street Sweeping	Total Acres	Impervious Acres
NSA_H_100			0	0				X	301	82
NSA_H_101			0	0		X			9	7
NSA_H_102A			0	0					111	30
NSA_H_102B		X	0	40					13	3
NSA_H_103	X		0	0	X		X	X	110	57
NSA_H_104		X	0	0					364	8
NSA_H_105			0	0					164	14
NSA_H_106			0	0					17	7
NSA_H_107			0	1					4	1
NSA_H_108			0	0					196	12
NSA_H_109			0	1					12	2
NSA_H_201			0	0					370	113
NSA_H_202			0	0					31	15
NSA_H_203			0	0					46	18
NSA_H_204			0	0					32	5
NSA_H_205			75	0					193	54
NSA_H_206			20	0					86	41
NSA_H_207			0	0					4	2
NSA_H_208			0	0					86	25
NSA_H_209			0	0					90	30
NSA_H_210			0	0					26	6
NSA_H_211			0	0					69	24
NSA_H_212			0	0					73	26
NSA_H_213			0	0					95	31
NSA_H_214			0	0					51	7
NSA_H_215			50	0					48	16
NSA_H_216			0	0					20	7
NSA_H_217			0	0					23	9
NSA_H_218			0	0					55	18
NSA_H_220			15	0					39	18
NSA_H_221			0	0					28	11
NSA_H_222			0	0					32	17
NSA_H_223			0	0					18	11
NSA_H_224			10	0					21	13
NSA_H_225			0	0					17	11

Appendix 4-2a Hot Spot Category and Status

		HSI Category			HSI Status			
Hotspot ID	**Description**	Commercial	Municipal	Transport-Related	Not a Hotspot	Potential	Confirmed	Severe
HSI_H_200	City School Bus Facility		X		X			
HSI_H_201	Banquet & Meeting Hall	X				X		
HSI_H_202	Stop Shop Save	X					X	
HSI_H_203	BP Gasoline	X			X			
HSI_H_204	Soul Food	X				X		
HSI_H_205	Ironworks/car repair/food	X					X	
HSI_H_206	Tires/Car Repair	X			X			
HSI_H_207	Car Repair	X				X		
HSI_H_208	MTA Bus		X		X			
HSI_H_209	Car Repair	X				X		
HSI_H_210	Carroll Fuels			X		X		
HSI_H_211	Pepsi Distributing			X	X			
HSI_H_212	North Ave Car Wash	X				X		
HSI_H_213	Car Repair/Transportation	X					X	
HSI_H_300	Homeland Auto Body	X				X		
HIS_H_301	Elkridge Country Club	X					X	
HSI_H_400	Small's Garage	X			X			
HSI_H_401	Mjs Collision Shop	X					X	
HSI_H_402	Grnspring Shopping Center	X						X
HSI_H_403	Pimlico Race Course	X					X	
HSI_H_404	Strip Mall	X				X		
HSI_H_405	7 Mile Market	X				X		
HSI_H_406	Pikes Diner	X				X		
HSI_H_407	Suburban Country Club	X				X		
HSI_H_408	Druid Ridge Cemetary	X				X		
Total		**21**	**2**	**2**	**6**	**12**	**6**	**1**

Appendix 4-2b Hot Spot Facility Operations

Hotspot ID	Description	Vehicle Operations	Outdoor Storage Materials	Waste Management	Physical Plant	Turf/Land-scaping	Stormwater
HSI_H_200	School Bus Facility	X					
HSI_H_201	Banquet & Meeting Hall	X	X	X			
HSI_H_202	Stop Shop Save		X	X			
HSI_H_203	BP Gasoline				X		X
HSI_H_204	Soul Food		X	X			
HSI_H_205	Ironworks/car repair/food		X	X			
HSI_H_206	Tires/Car Repair	X	X	X			
HSI_H_207	Car Repair		X				
HSI_H_208	MTA Bus	X					
HSI_H_209	Car Repair	X	X	X			
HSI_H_210	Carroll Fuels	X	X				
HSI_H_211	Pepsi Distributing	X					X
HSI_H_212	North Ave Car Wash	X	X	X	X		X
HSI_H_213	Car Repair/Transportation	X	X				
HSI_H_300	Homeland Auto Body			X			X
HSI_H_301	Elkridge Country Club	X		X	X	X	
HSI_H_400	Small's Garage	X					
HSI_H_401	Mjs Collision Shop	X	X		X		X
HSI_H_402	Grnspring Shopping Center		X	X		X	X
HSI_H_403	Pimlico Race Course		X	X	X	X	X
HSI_H_404	Strip Mall		X	X	X		X
HSI_H_405	7 Mile Market			X	X	X	X
HSI_H_406	Pikes Diner		X	X	X		X
HSI_H_407	Suburban Country Club	X			X	X	X
HSI_H_408	Druid Ridge Cemetary	X	X		X		X
Total		**14**	**16**	**14**	**10**	**5**	**12**

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_H_101	Home & Hospital Center	school	public	N	250			
ISI_H_200	Sinai Hospital	hospital	private	N	500			
ISI_H_201	Poly Western HS	school	public	Y	500	X		X
ISI_H_202	Pimlico ES	school	public	N	20		X	
ISI_H_203	Edgecombe Circle ES	school	public	N	0	X	X	
ISI_H_204	Waldorf School	school	private	N	50	X	X	
ISI_H_205	MLK ES	school	public	N	50			X
ISI_H_206	Robert Poole MS/HS	school	public	N	0	X	X	
ISI_H_207	Waverly MS	school	public	N	100		X	X
ISI_H_209	Johnstone Sq ES	school	public	N	50	X	X	
ISI_H_210	St. Mary’s Seminary	faith-based	private	Y	500		X	X
ISI_H_211	Roland Park Country School	school	private	N	50			
ISI_H_212	Coldstream ES	school	public	N	100		X	X
ISI_H_213	Cecil ES	school	public	N	43		X	X
ISI_H_214	Dallas F Nichols ES	school	public	N	15			X
ISI_H_215	George G Kelson ES	school	public	N	60			X
ISI_H_216	Mt Washington Pediatric	hospital	public	N	45	X		
ISI_H_217	Medfield Heights ES	school	public	N	40		X	X
ISI_H_218	Booker T Washington ES/MS	school	public	N	50			X
ISI_H_219	Eutaw Mashburn ES	school	public	N	40		X	X
ISI_H_220	John Eager Howard ES	school	public	N	30		X	X
ISI_H_221	Mt. Royal ES/MS	school	public	N	0		X	X
ISI_H_222	Barclay ES/MS	school	public	N	30			X
ISI_H_223	Margaret Blent ES	school	public	N	0			X
ISI_H_224	Ujima Village Academy	school	public	N	150			X
ISI_H_300	Boys Latin	school	private	N	50	X		
ISI_H_301	College of Notre Dame	college	private	Y	100			
ISI_H_303	Loyola	college	private	N	200			X

Institution ID	Description	Type	Public or Private?	Nutrient Mgmt. Plan Req?	Tree Planting (#)	Downspout Disconnect	Impervious Cover Removal	Trash Mgmt.
ISI_H_304	Hampden ES	school	public	N	10		X	X
ISI_H_305	Gilman	school	private	Y	0	X		
ISI_H_306	Grace United Methodist	faith-based	private	N	20			
ISI_H_307	Cathedral Of Mary Our Quenn	faith-based	private	N	75	X		
ISI_H_308	Roland Park MS	school	public	N	0	X		X
ISI_H_309	1st Christian Church	faith-based	private	N	50	X		
ISI_H_400	Wellwood Int. ES	school	public	Y	200			
ISI_H_401	Fallstaff MS	school	public	N	50	X	X	
ISI_H_402	Cross Country ES	school	public	N	0			X
ISI_H_403	Pimlico MS	school	public	Y	200		X	
ISI_H_404	Temple Oheb Shalom Cong	faith-based	private	N	0			
ISI_H_405	Baltimore Hebrew Cong	faith-based	private	N	0			
ISI_H_406	Bais Yaakov	school	private	N	0			
ISI_H_407	Mt Washington ES	school	public	N	15		X	X
ISI_H_408	Greenspring Valley Synagogue	faith-based	private	N	0			X
ISI_H_409	Shomrei Emunah	faith-based	private	N	0			
ISI_H_410	Northwestern HS	school	public	N	60			X
ISI_H_411	Shaarei Zion	faith-based	private	N	5			X
ISI_H_212	Baltimore Hebrew Univ	college	public	N	0			X
ISI_H_500	The Park School	school	private	Y	50	X		
ISI_H_501	Pikesville MS	school	public	Y	225			
ISI_H_502	Pikesville HS	school	public	Y	150			
ISI_H_503	Summit Park ES	school	public	Y	250			
ISI_H_600	St. Timothy's	school	private	Y	0	X		
ISI_H_601	Chizuk Amuno	school	private	Y	0	X		
ISI_H_602	Fort Garrison	school	public	N	75			

Appendix 4-4 PAA Data

Site ID	Ownership	Acres	Subwatershed	Site Prep	% Turf
PAA-H-100	Unknown	1.0	Jones Falls A	Minimal	95
PAA-H-200	Public	2.0	Lower Jones Falls	Extensive	85
PAA-H-201	Private	0.5	Lower Jones Falls	Excessive	100
PAA-H-202	Public	2.0	Lower Jones Falls	Minimal	80
PAA-H-203	Public	2.0	Lower Jones Falls	Extensive	10
PAA-H-204	Public	1.0	Lower Jones Falls	Minimal	95
PAA-H-205	Public	1.0	Lower Jones Falls	Minimal	75
PAA-H-206	Public	7.0	Lower Jones Falls	Minimal	90
PAA-H-207	Unknown	0.25	Lower Jones Falls	Minimal	100
PAA-H-208	Unknown	0.25	Lower Jones Falls	Minimal	95
PAA-H-209	Public	1.0	Lower Jones Falls	Extensive	65
PAA-H-210	Unknown	0.75	Lower Jones Falls	Extensive	90
PAA-H-211	Public	1.0	Lower Jones Falls	Minimal	95
PAA-H-212	Public	2.5	Lower Jones Falls	Extensive	100
PAA-H-213	Public	2.0	Lower Jones Falls	Extensive	50
PAA-H-214	Unknown	0.5	Lower Jones Falls	Minimal	90
PAA-H-215	Private	3.0	Lower Jones Falls	Minimal	60
PAA-H-216	Public	1.0	Lower Jones Falls	Minimal	90
PAA-H-217	Public	1.5	Lower Jones Falls	Minimal	90
PAA-H-218	Unknown	10.0	Lower Jones Falls	Minimal	100
PAA-H-300	Public	1.0	Stony Run	Minimal	90
PAA-H-400	Public	0.50	Western Run	Minimal	100
PAA-H-401	Public	5.50	Western Run	None	0
PAA-H-402	Private	2.0	Western Run	Minimal	50
PAA-H-500	Private	7.50	Moore's Branch	Minimal	99
PAA-H-600	Private	2.0	Slaughterhouse	Minimal	99

CHAPTER 5

RESTORATION & PRESERVATION OPTIONS

5.1 Introduction

This section of the plan presents an overview of the key management practice recommendations for the Lower Jones Falls 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 Management Practices Recommended in the Lower Jones Falls 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 Appendix A for more detail and guidance ** See Appendix B for more detail on stream repair practices *** See Appendix C for more detail on residential and hotspot source control practices		

5.2 Stormwater Retrofits

The Center 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 this 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.

The developed nature of the watershed provides limited potential for implementing new storage projects other than retrofitting existing stormwater ponds (Figure 4-1). 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).

On-site residential practices provide a great potential in both neighborhoods and institutions in the watershed. These opportunities include simple disconnection of downspouts in neighborhoods and schools where storm drains are directly connected to the street or stormdrains (Figure 5-2). In addition, impervious cover removal and bioretention are good options to help treat and reduce stormwater at schools.

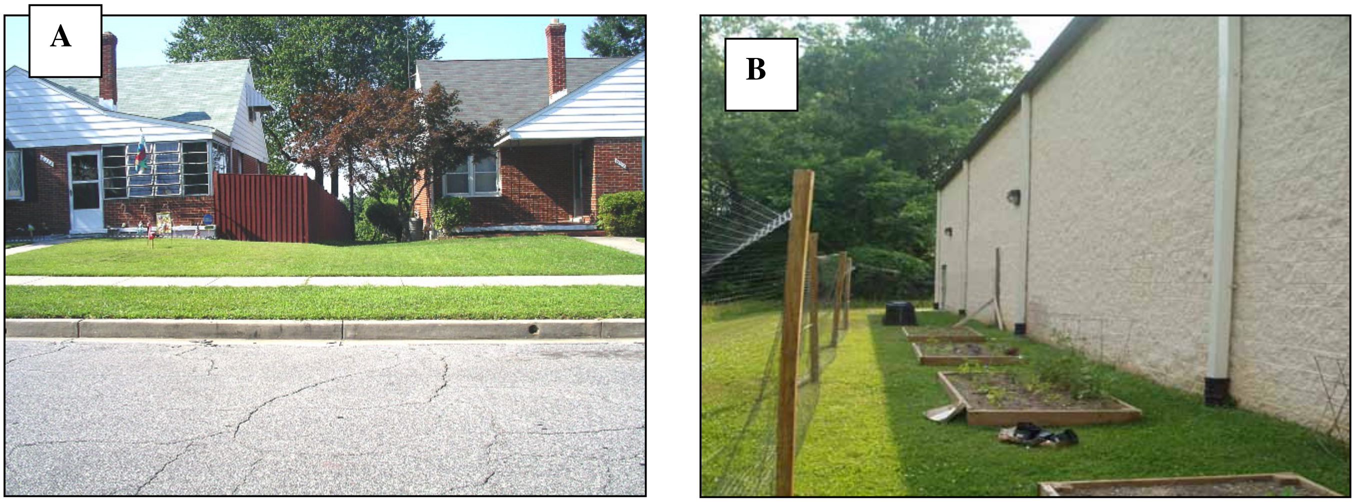


Figure 5-2. Downspout Disconnection Opportunities in a Neighborhood (A) and at a School (B).

5.3 Stream Corridor Restoration

Stream corridor restoration practices are used to enhance the appearance, stability, and aquatic function of urban stream corridors. 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. Stream repair practices are often combined with stormwater retrofits and riparian management practices to meet subwatershed restoration objectives. Primary practices for use in the Lower Jones Falls 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 Lower Jones Falls, 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 Lower Jones Falls 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 field work. 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 turfgrass. 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 4-4), 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.

References

Brown, E., D. Caraco and R. Pitt. 2004. *Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments*. Center for Watershed Protection and University of Alabama. EPA X-82907801-0. U.S. EPA. Office of Water and Wastewater. Washington, DC.

Kaushal, S.S., P. Groffman, P. Mayer, E. Striz and A. Gold. 2008. "Effects of Stream Restoration on Denitrification in an Urbanizing Watershed*." Ecological Applications* 18 (3): 789-804.

MacRae C. and A. Rowney, 1992. The Role of Moderate Flow Events and Bank Structure in the Determination of Channel Response to Urbanization. 45th Annual Conference. Resolving Conflicts and Uncertainty in Water Management. Proceeding of the Canadian Water Resources Association, Kingston, Ontario.

Wenger, S. 1999. *A Review of the Scientific Literature on Riparian Buffer Width, Extent and Vegetation.* Office of Public Service & Outreach Institute of Ecology University of Georgia. http://www.agecon.lsu.edu/WaterEconomics/pdf/buffer_litreview.pdf