Sam's Branch Tributary Watershed Assessment and Baseline Stream Monitoring

Final Report

August 2012

Prepared for:

Harford County

Department of Public Works
212 South Bond Street
3rd Floor
Bel Air, Maryland 21014

Prepared by:

BIOHABITATS, INC.

The Stables Building
2081 Clipper Park Road
Baltimore, Maryland 21211

TABLE OF CONTENTS

7.0 APPENDICES

7.1 Appendix A – Soils Map, FEMA Map and Photographs

7.2 Appendix B – Unified Subwatershed and Site Reconnaissance (USSR) Data Sheets

7.3 Appendix C – Community Awareness Survey

7.4 Appendix D - Surveyed Cross Sections, Particle Size Measurements, Thalweg Surveys and BEHI Data Sheets

7.5 Appendix E – Benthic Macroinvertebrate, Fish Survey and Habitat Assessment Data Sheets

7.6 Appendix F – Water Quantity and Water Quality Sampling

TABLE OF TABLES

TABLE OF FIGURES

1.0 PROJECT INTRODUCTION

1.1 Project Background

Biohabitats, under contract with Harford County Department of Public Works, has conducted upland assessment, baseline stream monitoring and analysis services for the Sam's Branch tributary and the surrounding drainage area from April of 2008 through December 2011. The purpose of this assessment was to determine baseline watershed conditions from this predominantly medium density residential watershed. In addition, the watershed assessment resulted in the identification of restoration opportunities that could result in improvement of water quality from nonpoint source runoff and enhancement of habitat in the Sam's Branch watershed. The anticipated benefits of implementation and associated costs of the restoration opportunities have been evaluated.

The study limits include the drainage area to Sam's Branch at Otter Point Creek and the stream channel extending from the headwaters to the confluence with Otter Point Creek. Assessment and monitoring activities have included a community awareness survey, an upland assessment including the identification of stormwater retrofit opportunities and nonpoint source best management practices, physical/geomorphic condition survey, riparian condition survey, baseline water quantity and quality levels, in-stream biological condition surveys and natural resource restoration opportunities.

This report covers the assessment and monitoring activities performed and includes descriptions of the assessment methodology and baseline condition summary results. Included in the appendices, are all the monitoring data collected to date including Appendix A-Soils Map, FEMA Map and Photographs; Appendix B-Unified Subwatershed and Site Reconnaissance (USSR) Data Sheets; Appendix C-Community Awareness Survey, Appendix D-Surveyed Cross Sections, Particle Size Measurements, Thalweg Surveys and BEHI Data Sheets; Appendix E-Benthic Macroinvertebrate, Fish Survey and Habitat Assessments Data Sheets; Appendix F-Water Quantity and Water Quality Sampling.

1.2 Project Location and Description

Figure 1-1 Project vicinity map depicts the location of the drainage area of Sam's Branch relative to other Edgewood landmarks. Figure 1-2 Project site map shows the drainage area and the Sam's Branch stream channel on aerial photography. The drainage area boundary delineates the limits of the study area. The stream channel study limits extend from the headwaters to the confluence with Otter Point Creek, a total study length of approximately 5,000 linear feet. The study area along the Sam's Branch stream channel was divided into four discrete study reaches with the primary reach boundaries including culverted road crossings of the Sam's Branch stream channel (Figure 1-3). Reach 1 extends from the upstream limit to Edgewood Road. Reach 2 extends between Edgewood Road and Hornbeam Road. Reach 3 includes the portion of the channel between Hornbeam Road and Perry Avenue. Reach 4, the downstream-most reach, is bounded by Perry Avenue and Otter Point Creek downstream.

1.3 Project Goals and Objectives

Sam's Branch baseline assessment and monitoring goals and objectives include the documentation of drainage area conditions through the collection of stream monitoring data and upland field observations throughout the drainage area. Through data analysis and processing of field observations, several retrofit and restoration opportunities have been identified with the intent of improving water quality conditions of Sam's Branch. The goal of proposed restoration opportunities included improvement of water quality from nonpoint source runoff and enhancement of habitat in the Sam's Branch watershed. The anticipated load reduction benefits from implementation and associated costs of implementation of the restoration opportunities were determined. Following the implementation of select retrofit and restoration opportunities identified through this study, post-implementation conditions will be established and compared to the baseline (pre-implementation) conditions. In summary, this study will assess watershed conditions and monitor stream health with the goal of demonstrating improvement in water quality of runoff and habitat conditions in the Sam's Branch watershed.

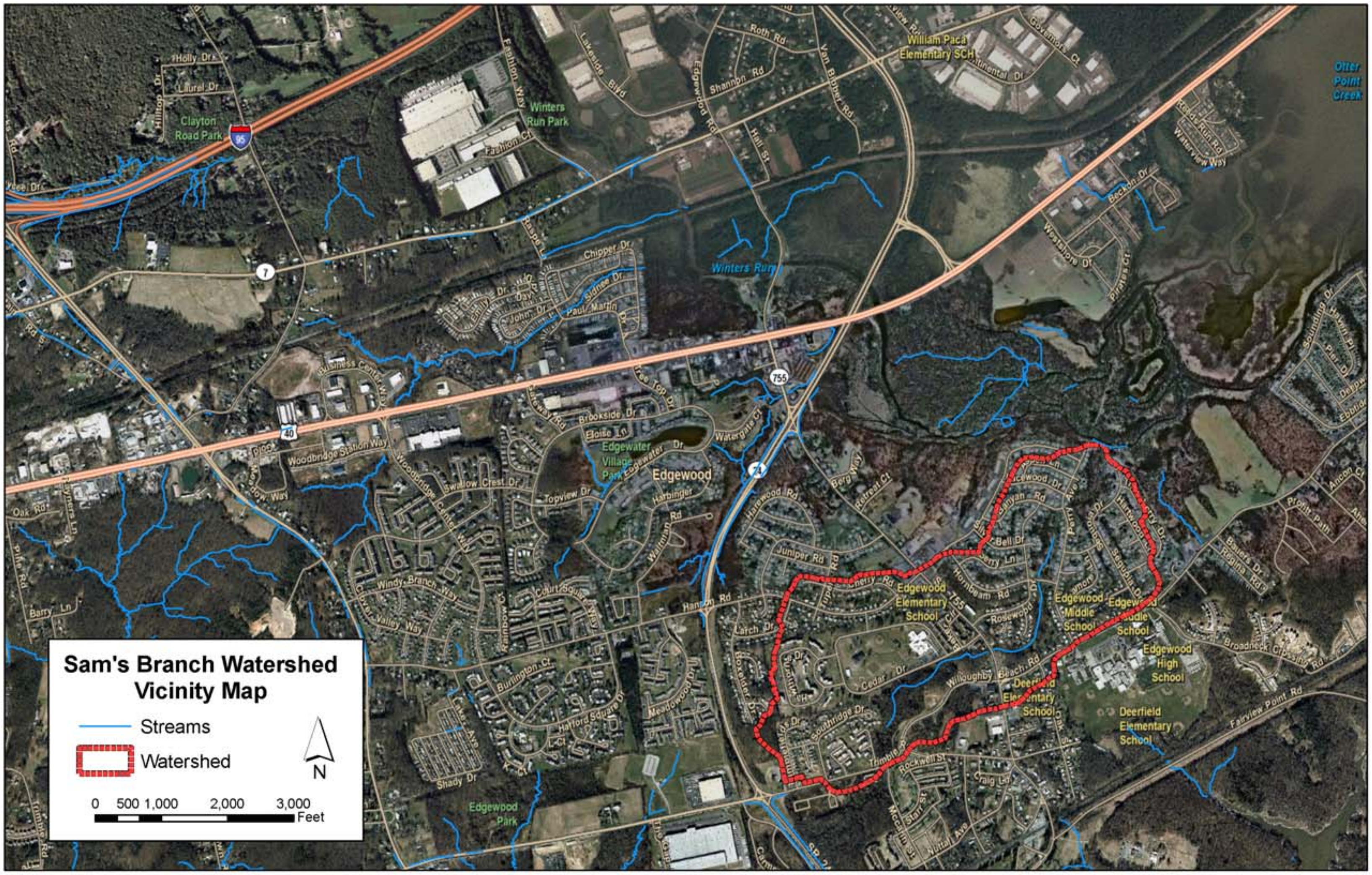


Figure 1-1. Project Vicinity Map

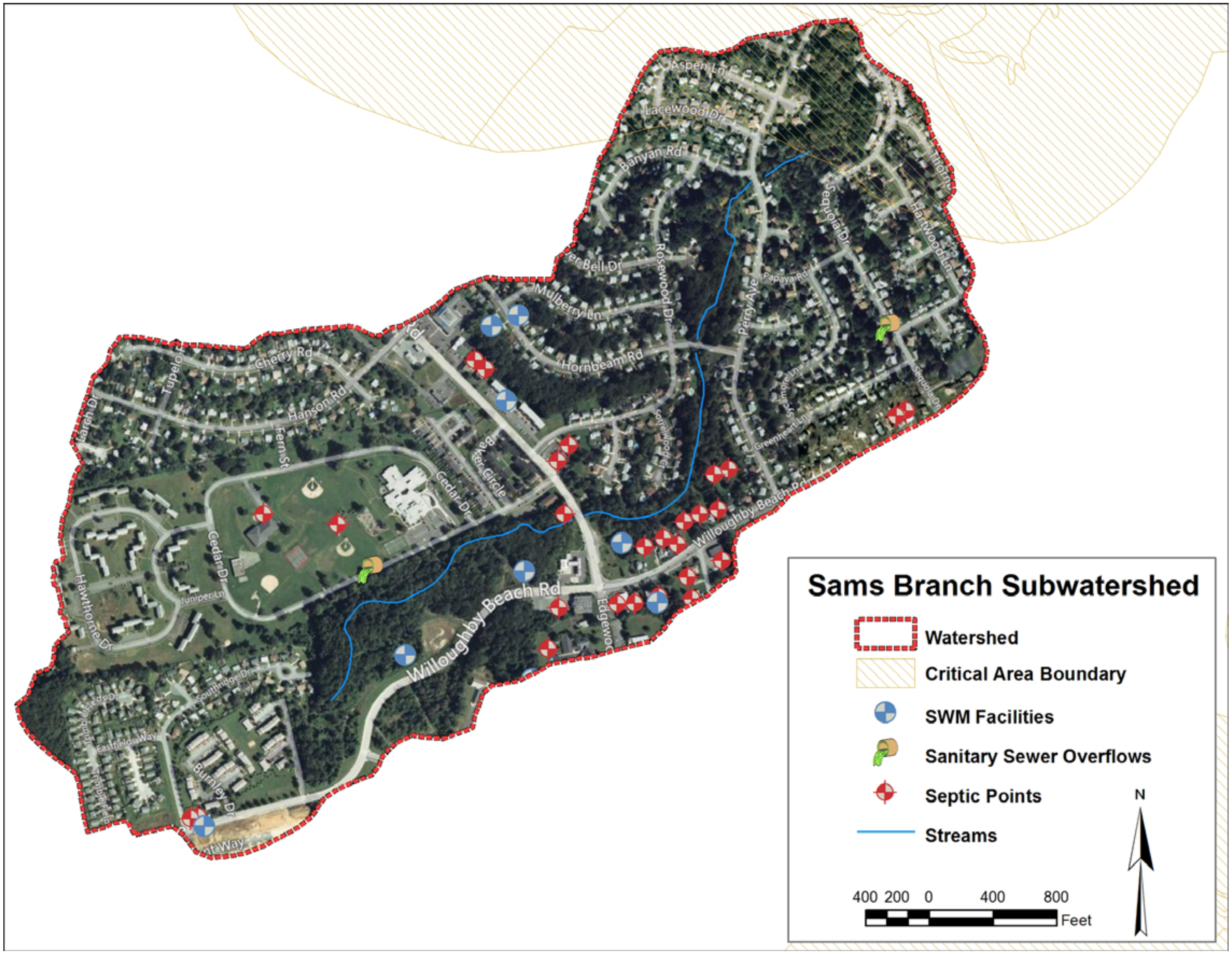


Figure 1-2. Project Drainage Area and Site Map (note – sanitary serwer overflows are infrequent, and limited in size and duration in this watershed)

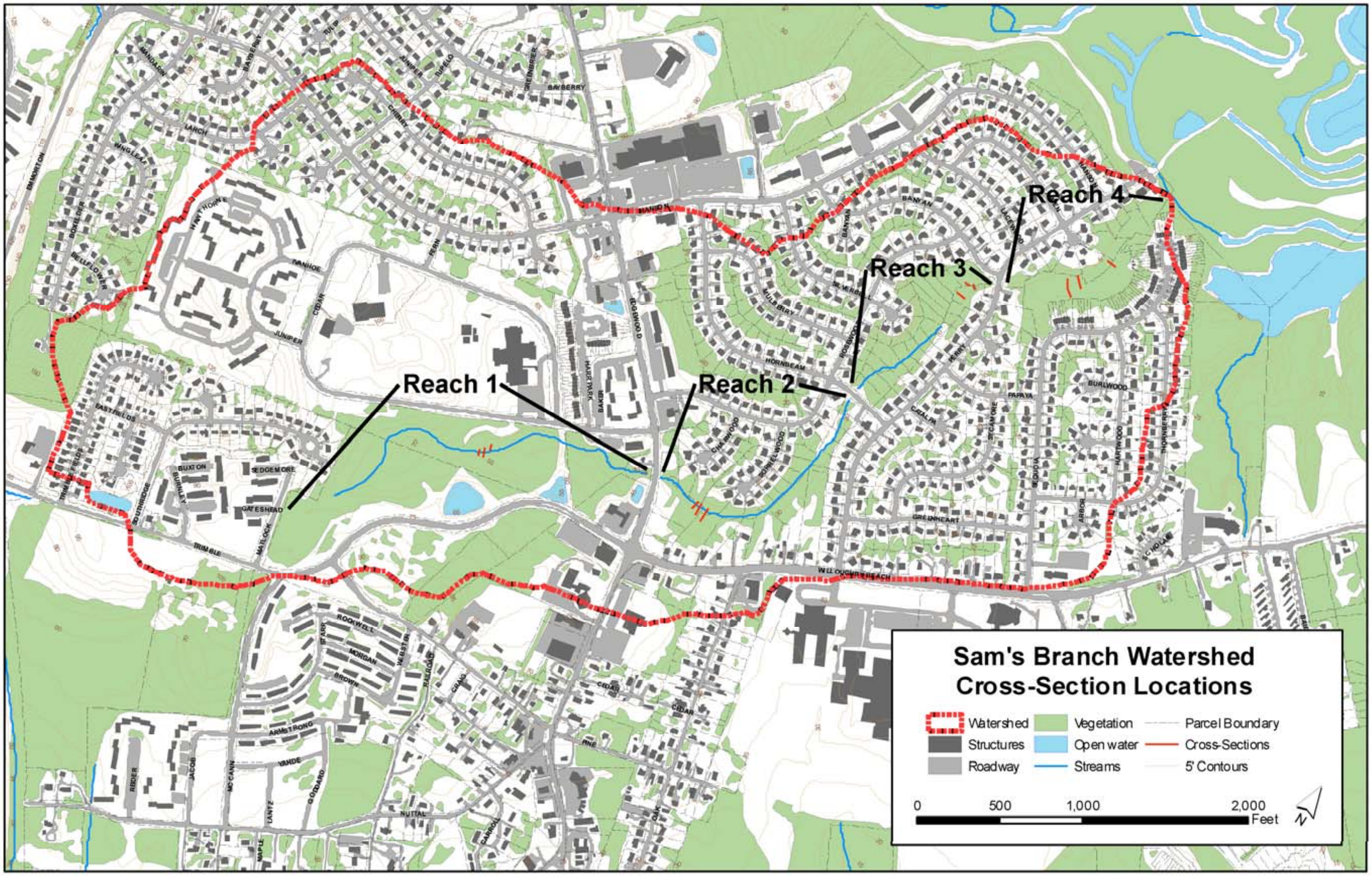


Figure 1-3. Stream Reach Map

1.4 U.S. EPA Watershed Planning "a-i Criteria"

Beginning 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 be supported by a watershed plan that includes the following nine minimum elements, known as a-i criteria. The criteria include a) indication of causes and sources, b) estimate of the load reductions expected, c) description of NPS management measures, d) estimate of the amounts of technical and financial assistance needed, e) information and education component, f) schedule for implementing the NPS management measures, g) description of interim, measurable milestones, h) set of criteria that can be used to determine whether loading reductions are being achieved, and i) monitoring component to evaluate the effectiveness.

This watershed assessment and restoration recommendations addresses the a-i criteria, and Table 1-1 shows where these criteria are addressed throughout this report.

Table 1-1. U.S. EPA Watershed Planning Criteria

Section of Report	Criteria								
	a	b	c	d	e	f	g	h	i
Project Introduction									
Watershed Characterization	X								
Upland Condition and Retrofit Survey	X		X		X				
Community Awareness Survey					X				
Riparian Condition Survey	X								
Stream Morphology	X								
Stream Biological Survey	X								X
Stream Water Quantity and Quality Monitoring	X								X
Restoration Opportunities			X						
Pollutant Load Reduction Analyses and Costs		X		X	X			X	
Prioritization									
Monitoring Plan								X	X
Schedule				X		X	X		

2.0 WATERSHED CHARACTERIZATION

2.1 Description of Physiographic Province

The project site is located within the Western Shore Lowlands Region of the Coastal Plain physiographic province. This province is underlain by fluviomarine sediments including gravel, sand, silt and clay, deposited in proximity to the Chesapeake Bay (Maryland Geologic Survey, 2009).

2.2 Topography

The Sam's Branch Watershed is divided by Sam's Branch Tributary. From east to west, there is an approximate 100 foot change in elevation from the downstream to upstream extent of the watershed. The elevation is approximately 20 feet at the downstream-most location of Sam's Branch near the confluence with Otter Point Creek. The elevation is approximately 120 feet at Hawthorne Drive in the western portion of the watershed (Maryland Department of Natural Resources, 2011). The slopes throughout the watershed are gradual, which have been conducive to the development of this watershed.

2.3 Geology and Soil

The project site, located within the Western Shore Lowlands Region of the Coastal Plain Province, is underlain by unconsolidated sediments (Maryland Geological Survey, 2009). According to the Natural Resources Conservation Service Web Soil Survey, several soil map units were mapped within the Sam's Branch watershed (Table 2-1, Appendix A). The soil map units covering the most area included Av, BeB, En, Fs, JpC, KpB, LyB, MkB, MIA, MIB, ShB2, and SsD (Soil Survey Staff, 2011).

Alluvial land (Av), Elkton silt loam (En), and Fallsington loam (Fs) are mapped along Sam's Branch tributary and the riparian area, extending East of Southridge Drive to the confluence with Otter Point Creek. Av, mapped along the downstream portion of the tributary floodplain, is a poorly drained soil derived from sand and silty alluvium. En and Fs are mapped along the upstream portion of the tributary mostly West of Edgewood Road. Both soils are mapped in depressions, drainages, and swales, are poorly drained, and derived from fluviomarine deposits (Soil Survey Staff, 2011).

Beltsville silt loam, 2 to 5 percent slopes (BeB), mapped along the Edgewood Road corridor, is moderately well drain and has formed from silty eolian deposits (Soil Survey Staff, 2011).

Matapeake silt loam, 2 to 5 percent slopes (MkB) is a well drained soil primarily mapped to the west of Edgewood Road on flats, depressions, and swales. The Matapeake soil series has formed from silty eolian deposits over fluviomarine sediments. Similar to MkB, Mattapex silt loam, 0 to 2 percent slopes (MIA) and Mattapex silt loam, 2 to 5 percent slopes (MIB) is mapped in depressions and swales east of Edgewood Road. Both MIA and MIB are moderately well drained and derived from silty eolian deposits over fluviomarine sediments (Soil Survey Staff, 2011).

Sassafras sandy loam, 2 to 5 percent slopes, moderately eroded (ShB2) and Sassafras and Joppa soils, 10 to 15 percent slopes (SsD) are mapped to the west of Edgewood Road on convex knolls and hills. Both soil map units are well drained. However, ShB2 is derived from loamy fluviomarine sediments, while SsD is derived from sandy and gravelly fluviomarine sediments (Soil Survey Staff, 2011).

Each soil series within a soil map unit is assigned a hydrologic soil group (HSG). This classification is based on the soil's ability to intake and transmit water under "conditions of maximum yearly wetness" or thoroughly wet conditions. Soils are classified as A, B, C, or D. Soils denoted as A have a low runoff potential when thoroughly wet and transmit water freely through the soil, D soils has a high runoff potential when thoroughly wet and restricted to very restricted water movement through the soil. Table 2-1 present the HSGs for the soil map units mapped within Sam's Branch Watershed. When two or more HSGs were provided for a soil map unit because there is more than one soil series component to the map unit, the HSG characterizing the majority of the soil map unit was listed in Table 2-1. Sometimes a dual HSG is designated if the soil can be adequately drained to permit favorable water transmission. In those situations, the first letter applies to the drained condition and the second letter applies to the undrained condition.

Table 2-1. Soil Map Units within the Sam's Branch Watershed

Map Unit Symbol	Map Unit Name	Hydrologic Soil Group (HSG)
Av	Alluvial land	D
BeB	Beltsville silt loam, 2 to 5 percent slopes	C
BeC	Beltsville silt loam, 5 to 10 percent slopes	C
En	Elkton silt loam	C/D
EvC	Evesboro loamy sand, 5 to 15 percent slopes	A
Fs	Fallsington loam	B/D
Hb	Hatboro silt loam	D
JpB	Joppa gravelly sandy loam, 2 to 5 percent slopes	B
JpC	Joppa gravelly sandy loam, 5 to 10 percent slopes	B
KpA	Keyport silt loam, 0 to 2 percent slopes	C
KpB	Keyport silt loam, 2 to 5 percent slopes	C
Lr	Leonardtown silt loam	D
LyB	Loamy and clayey land 0 to 5 percent slopes	B
LyD	Loamy and clayey land 5 to 15 percent slopes	B
LyE	Loamy and clayey land 15 to 30 percent slopes	B
MkA	Matapeake silt loam, 0 to 2 percent slopes	B
MkB	Matapeake silt loam, 2 to 5 percent slopes	B
MIA	Mattapex silt loam, 0 to 2 percent slopes	C

Map Unit Symbol	Map Unit Name	Hydrologic Soil Group (HSG)
MIB	Mattapex silt loam, 2 to 5 percent slopes	C
Ot	Othello silt loam	C/D
ShB2	Sassafras sandy loam, 2 to 5 percent slopes, moderately eroded	B
ShC2	Sassafras sandy loam, 5 to 10 percent slopes, moderately eroded	B
SIB2	Sassafras loam, 2 to 5 percent slopes, moderately eroded	B
SIC2	Sassafras loam, 5 to 10 percent slopes, moderately eroded	B
SsD	Sassafras and Joppa soils, 10 to 15 percent slopes	B
SsE	Sassafras and Joppa soils, 15 to 30 percent slopes	B
WoB	Woodstown loam, 0 to 5 percent slopes	B

2.4 Water Resources

A portion of the Sam's Branch Watershed is located within the Chesapeake Bay Critical Area (1,000 feet of the Bay or Bay tributary). The Chesapeake Bay Critical Area boundary overlaps the watershed's northern-most portion near the confluence with Otter Point Creek by approximately 700 feet (Maryland Department of Natural Resources, 2011).

<u>Surface Waters</u>
The Sam's Branch tributary, a perennial stream, is divided into four representative reaches within the watershed (Figure 1-3). Reach 1 extends from the upstream limit to Edgewood Road. Reach 2 extends between Edgewood Road and Hornbeam Road. Reach 3 includes the portion of the channel between Hornbeam Road and Perry Avenue. Reach 4, the downstream-most reach, is bounded by Perry Avenue and Otter Point Creek downstream. Based on the initial survey in late 2008 an early 20 09, the following baseline geomorphic characterization was completed. These survey results are included in Appendix D and discussed in section 6.0.

<u>Wetlands</u>
National Wetland Inventory (NWI) and Maryland Department of Natural Resources (MD DNR) Wetland Inventory indicated no presence of wetlands or wetlands of special concern within the Sam's Branch watershed. However, north of the watershed near the confluence with Otter Point Creek, NWI and MD DNR Wetland Inventory indicated there is a network of wetlands along Otter Point Creek. NWI identified palustrine forested wetlands, palustrine emergent wetlands, and palustrine scrub shrubs wetlands, while MD DNR identified only palustrine forested wetlands (US Fish and Wildlife Service, 2011; Maryland Department of Natural Resources, 2011).

Both the NWI and DNR wetland maps are intended for regional and watershed data display and general guidance purposes. Field investigation is recommended to confirm the absence and/or presence of wetlands as identified by NWI and DNR within the watershed.

FEMA Floodplain

According to the FEMA Flood Insurance Rate Map (Appendix A), a portion of Sam's Branch Watershed is designated as Areas of Special Flood Hazard (100-year flood). The 100-year flood zone borders approximately 1,600 linear feet of Sam's Branch tributary, extending from the confluence with Otter Point Creek upstream to the Perry Avenue road crossing. This portion of the 100-year flood zone is confined between Perry Avenue to the west and Sequoia Drive to the east. Upstream of the road crossing, the 100-year zone borders another 700 linear feet of Sam's Branch tributary and is confined between Rosewood Drive to the west and Perry Avenue to the east. The rest of the watershed is identified as "Zone X" or "areas determined to be outside 500-year floodplain (FEMA, 2011).

2.5 Land Use Summary

Sam's Branch watershed is approximately 373 acres and located in the Winters Run/Otter Point Creek watershed. The watershed's land use is predominantly residential. At 64.6% of the watershed, the residential category is composed of 54.3% medium density residential, defined as 1 to 4 dwelling per acre, and 10.3% high density residential, defined as greater than 4 dwellings per acre. The remaining 35.4% of the watershed's land use is characterized as forest (15.1%), institutional (9.8%), commercial (9.5%), bare ground (1%), and open water (0.03%), in descending order.

2.6 Existing Condition Watershed Treatment Model

2.6.1 Sam's Branch Watershed Modeling

The Watershed Treatment Model (CWP, 2010) was used as an indicator of causes and sources of pollution in the Sams Branch Watershed, and to estimate the load reductions expected from the upland retrofit and watershed restoration measures proposed. The Watershed Treatment Model (WTM) was used to estimate the existing pollutant loads from the watershed using information derived from Harford County GIS data. The WTM uses the Simple Method (Schueler, 1987) to calculate loads from urban stormwater runoff, and area loading factors to calculate loads from non-urban areas:

$$L = 0.226*R*C*A$$

Where L = annual load (lbs); R = annual runoff (inches); C = pollutant concentration (mg/L); A = area (acres); and 0.226 = conversion factor.

The Sam's Branch watershed encompasses 373 acres of Eastern Harford County in the Winters Run/Otter Point Creek watershed. The Simple Method relies on accurate land use-based loading rates in order to determine the primary non-point sources of pollution. Pollutant concentrations were derived from the Chesapeake Bay Program Model values for loading rates, as shown in Table 2-2 and published in Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated (MDE, 2011), as recommended by the Maryland Department of the Environment

(MDE). Since no guidance has been given for bacteria loading rates, the default value was used in the WTM. After an initial estimate was calculated using the WTM, the annual loading rates were compared to grab samples collected at Sam's Branch for verification, as discussed in Section 2.6.3.

Table 2-2. Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated

Parameter	Urban Impervious	Urban Pervious	Forest
TN (lbs/acre/year)	10.85	9.43	3.16
TP (lbs/acre/year)	2.04	0.57	0.13
TSS (tons/acre/year)	0.46	0.07	0.03

Adapted from CBP Model, Version 5.3.0, 2011

2.6.2 Existing Conditions Model

Primary Sources

The WTM calculated the primary sources of pollutant loads based on land use. Land Use/Land Cover data from 2007 was summarized for the watershed using GIS, and the results are shown in the following table (Table 2-3). The default percentages for impervious cover per land use classification were slightly adjusted to match the impervious cover area for Sam's Branch.

Table 2-3. Land Use/Land Cover for Sam's Branch Watershed

PRIMARY SOURCES - Land Use		Area (Acres)	Impervious Cover (%)*	Turf Cover (%)**
Category	**Detailed Description**			
Residential	**MDR (1-4 du/acre)**	202.44	22%	63%
	HDR (>4 du/acre)	38.48	35%	54%
Commercial	**Commercial**	35.43	76%	22%
Institutional	**Institutional**	36.39	14%	70%
Forest	**Forest**	56.31		
Open Water	**Open Water**	0.11		
Bare Ground	**Active Construction**	3.72		
Total	**Total Acres**	**373**	**90 acres**	**182 acres**

*Uniformly increased from default WTM values to derive GIS-based acres of impervious cover
**Default WTM values

Annual runoff is dependent on the percentage of impervious surface, turf, forest, and rural area within the watershed, as well as the hydrologic soil groups. Runoff is calculated according to the following equation:

R = P*Pj*Rv

Where R = annual runoff; P = annual precipitation; Pj = fraction of annual rainfall events that produce runoff (default is 0.9); and Rv = runoff coefficient. The average annual rainfall according to the NOAA long-term monitoring station at BWI is 42 inches. The data record for BWI is 140 years, which is longer than the more local USGS gaging stations at Fallston, MD and Atkisson Reservoir, which have only been reporting data since 2012.

The runoff coefficient is dependent on the fraction of impervious, turf, forest, and rural land cover, as well as the hydrologic soil groups within the watershed. Soils data was derived from NRCS mapping of the County, and used to estimate the percentage of each hydrologic soil group (HSG) within the watershed (Table 2-4). HSG is an important parameter for determining the volume of runoff. The hydric soils determination was also used to classify the average depth to groundwater in the watershed. Depth to groundwater is used by the model to calculate losses of pollutants to the shallow groundwater table rather than as runoff to surface waters. The model does not estimate the delivery of pollutants from groundwater to surface waters.

Table 2-4. Percentage of each Hydrologic Soil Group (HSG) within the Watershed

Soils Information	Soil Fraction (%)	Runoff Coefficients*				
		Impervious	Turf	Forest	Rural	Active Construction
HYDROLOGIC SOIL GROUP						
A Soils	0.2%	0.95	0.15	0.02	0.02	0.5
B Soils	37%	0.95	0.20	0.03	0.03	0.5
C Soils	38%	0.95	0.22	0.04	0.04	0.5
D Soils	24%	0.95	0.25	0.05	0.05	0.5
Watershed Average		**0.95**	**0.22**	**0.04**	**0.04**	**0.5**
DEPTH TO GROUNDWATER*						
<3 Feet	28%					
3-5 Feet	36%					
>5 Feet	36%					

*Default WTM values
**Assumptions based on hydric (<3-ft), partially hydric (3-5 ft), and not hydric (>5 ft) classifications

Secondary Sources

The WTM also accounts for a number of secondary sources of pollutants in the watershed, which include sanitary sewer overflows (SSOs), septic systems, and channel erosion. The model calculates the pollutant loading from these sources using a combination of watershed-based characteristics and research values of unit loads from historical studies, as shown in Table 2-5. Based on the building footprints within residential land cover, there are approximately 729 dwelling units within Sam's Branch watershed. The GIS data for Harford County also indicated the presence of SSOs and septic systems within the watershed (Figure 1-2). Data from these points were entered into the WTM. The default values within the WTM were used for general sewage use, and the information regarding SSOs was entered into the model. Approximately 11.7 miles of sanitary sewer were measured from GIS, with an estimated 2 overflows per year indicated by the SSO data. These overflows had an average volume of 1,816 gallons. Three percent of the dwelling units had unsewered septic systems, and of these 3% only one was within 100-feet of the stream. The default values for management and delivery were assumed in the model.

Another secondary source of sediment for Sam's Branch is urban channel erosion. The length of stream within the watershed was measured as 0.85 miles from GIS. Based on field observations and BEHI measurements (see Section 8.4), we assumed a low assessment of channel erosion, described as channels largely armored or stable. The model calculates a channel erosion-based load as 25% of the total edge-of-field-based sediment load for low erosion rate channels. While the upper reach certainly shows moderate to high erosion, much of the other reaches are either armored or stable, which supported the assumption.

Table 2-5. Pollutant Loads from Secondary Sources

Secondary Source	Watershed Metric	WTM Application
SSOs	11.7 miles of sewer, 2 overflows per year, 1816 gallons per overflow	Average wastewater characteristics, point source
Onsite Sewage Disposal (Septic Systems)	729 dwelling units, 3% on septic, 3% of septic within 100-ft stream buffer	Average sewage characteristics, conventional removal efficiencies, point source
Channel Erosion	Average BEHI Score = 33, High index	Low Assessment of Erosion, 25% of watershed sediment load

Existing Management Practices

Three existing stormwater management (SWM) practice types were recognized in the watershed: erosion and sediment control program, structural stormwater facilities, and a riparian buffer. The WTM uses program efficiency, fraction of permits regulated and a maintenance discount factor to calculate the reduction in sediment from an erosion and sediment control program. The default program efficiency of 70% and an assumption that 100% of permits were regulated in Sam's Branch were used. The maintenance discount was assumed to be 0.9, which is defined as a program which requires inspectors to visit construction sites weekly, and pre-construction meetings and contractor education for most sites.

The structural SWM practices are shown in Figure 1.2 and listed in Table 2-6. For removal efficiency, the default WTM values were overridden by the values given in the MDE guidance (2011).

Table 2-6. Structural BMP Practices in the Sam's Branch Watershed

Site	Date	Type*	Acres
Trimble Fields	6/8/1989	Dry Pond	19.39
Edgewood Library	10/30/01	Underground Storage	1.67
Willoughby Beach Rd Extended – Pond 1	7/2/96	Dry Extended Detention Structure	19.42
Willoughby Beach Rd. Extended – Pond 2	7/2/96	Dry Extended Detention Structure	12.99
Edgewood Library	n/a	Infiltration Trench, Complete Exfiltration	0.45
7-11 Edgewood	3/1/1999	Dry Extended Detention Structure	2.7
Splash And Dash	8/5/2002	Dry Extended Detention Structure	3.41
423 Edgewood Road	5/7/2004	Sand Filter	0.09

*Type assigned according to the MDE Glossary of Stormwater BMP Structure Types (http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/stormprint/Documents/BMP_Glossary2.pdf).

Analysis of the vegetative cover at Sam's Branch using GIS revealed that 0.83 of the 0.85 miles in stream length were buffered by at least 100-feet of riparian forest. Since there are no ordinances or restrictions on activities within the buffer, a low maintenance factor was used to model the pollutant removal efficiency within the WTM.

The total reduction in loading according to the WTM as a result of the existing management practices is shown in Table 2-7. The current erosion and sediment control program has the most benefit to reducing sediment delivery to surface waters, while riparian buffers account for the best reduction in nutrients, bacteria, and runoff volume. Structural SWM practices also provide a significant reduction in loading across all pollutants.

Table 2-7. Load Reduction from Existing Practices (lbs/year)

	N (lbs/year)	P (lbs/year)	TSS (lbs/year)	Bacteria (billion/year)	Volume Reduction (acre-feet)
Erosion and Sediment Control	10	2	6,793	0	0
Structural Stormwater Management Practices	94	10	4,013	1,641	4
Riparian Buffers	110	11	2,393	4,997	14
Total Reduction in Storm Loading	214	23	13,199	6,638	18

Results of the existing conditions model using the WTM are presented in Table 2-8. The analysis includes a breakdown of pollutant loads according to source and a summary of the total load due to both stormwater and non-stormwater inputs. The model assumes a certain percentage of urban pollutants are transported as shallow groundwater flow, shown as the total non-storm load. Also of note are the lack of nutrients derived from channel erosion. Since the nutrient concentrations of the bank sediments are not known, and can vary widely from region-to-region, the fraction of nutrients derived from eroded streambank material was not modeled.

Table 2-8. Existing Loads to Surface Waters

Source	TN	TP	TSS	Fecal Coliform	Runoff Volume
	lb/year	lb/year	lb/year	billion/year	acre-feet/year
Urban Land	2,873	289.17	50,596	181,556	520
Active Construction	6	1	3,990	-	6
SSOs	2	0	12	1,373	-
Channel Erosion	-	-	23,108	-	-
Forest	178	7	1,689	676	5
Septic Systems	39	7	261	351	-
Open Water	1	0	17	-	-
Total Storm Load	2,971	296	79,243	183,605	531
Total Non-Storm Load	128	9	430	351	-
Total Load to Surface Waters	**3,099**	**305**	**79,674**	**183,956**	**531**

The three primary pollutants of concern in terms of the broader water quality goals for the Chesapeake Bay and the State of Maryland are nitrogen, phosphorus, and sediment. Urban land is clearly the major source for nitrogen (93%) and phosphorus (95%) for Sam's Branch, with minor contributions from forest (3-6%), septic systems (1-2%), active construction (<1%), SSOs (<1%), and open water (<1%, atmospheric deposition).

Bacteria impacts Sam's Branch and downstream receiving bodies' ability to meet their use designation for human contact. The indicator species Fecal Coliform is modeled by the WTM. Similar to nutrients and sediment, urban land is the major source of bacteria (99%), followed by SSOs (1%), forest (<1%), and septic systems (<1%). As shown in Table 2-8, based on the results from bacteria, sediment, and nutrients, clearly effective treatment of urban runoff or greater source abatement (fertilizer bans or controls, pet waste pickup, turf conversion) would target the greatest load to the watershed.

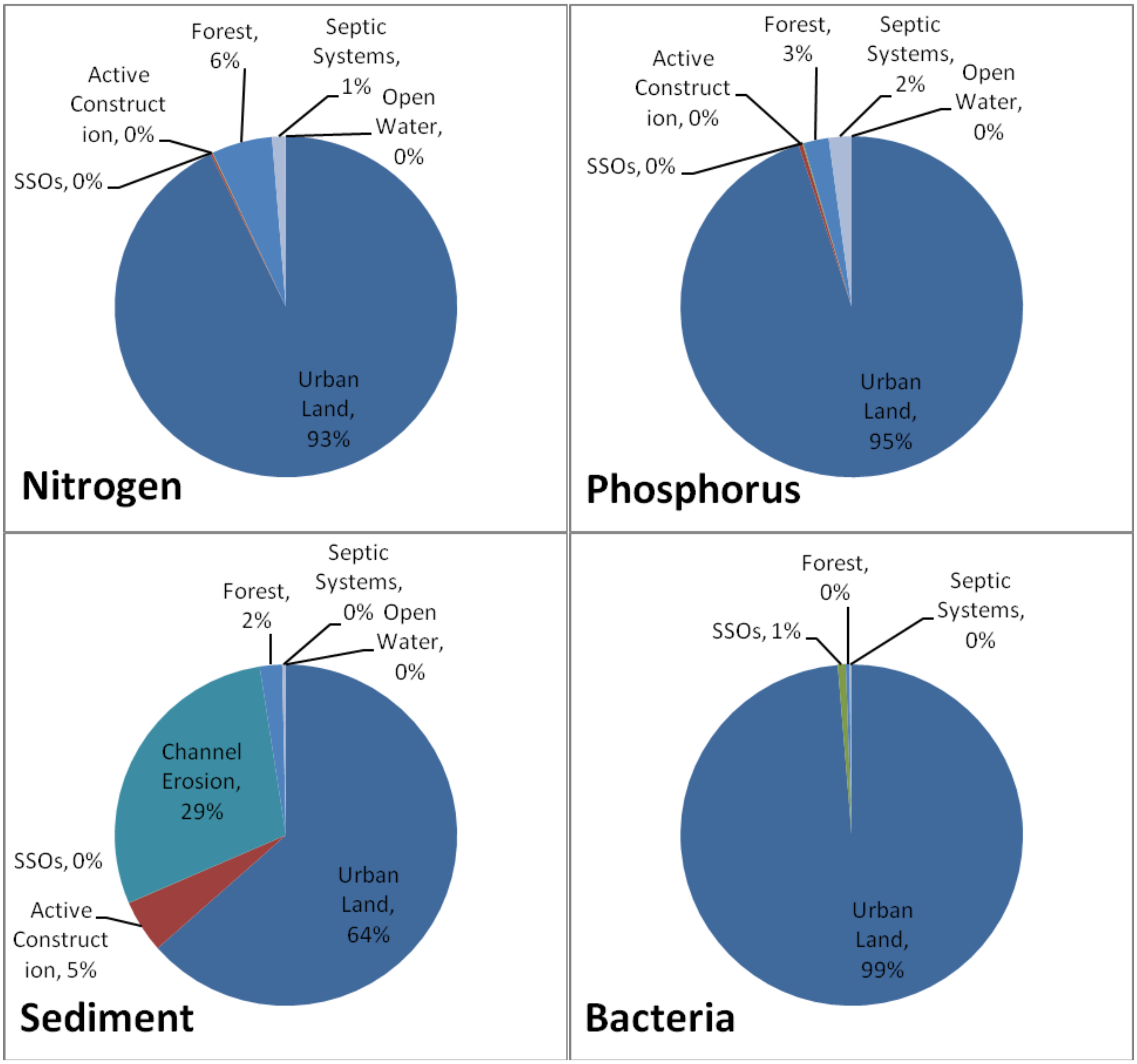


Figure 2-1. Existing nutrient, sediment, and bacteria loads in the Sam's Branch Watershed

2.6.3 Model Verification

Harford County has collected in-stream chemical and physical data including nutrient, sediment, and bacteria data at Sam's Branch during storm events. For comparison with the in-stream monitoring data, the WTM output for existing loads were converted to concentrations. This was done using the Simple Method to back calculate the overall watershed pollutant concentration, C, using the following equation:

L = 0.226*R*C*A
Where: L = annual load (lbs)
R = annual runoff (inches)
C = pollutant concentration (mg/L)
A = area (acres)
0.226 = unit conversion factor

For Bacteria, the unit conversion factor is $1.03*10^{-3}$ to calculate the annual load in billion colonies using pollutant concentration in MPN/100 mL.

Table 2-9 shows that the two data sets deviate between 8% (TSS) and 24% (TP) for sediment and nutrients. While it is difficult to compare single storm grab sample results with annual loading rates, the results indicate that the WTM model results are a close approximation of the measured Sam's Branch monitoring concentrations. Other secondary sources not modeled by the WTM include commercial/industrial hotspots, illegal cross-connections, nutrients bound to the in-stream sediment and released during erosion, or other wildlife loads such as water fowl in stormwater management facilities. The Fecal Coliform load was actually fitted to the monitoring results by changing the urban land use EMC from 20,000 to 28,271 MPN/100 mL. Changing the EMC for bacteria is certainly within reason given the large variation in research data collected to date (Figure 2-3; National Stormwater Quality Database, v3, 2008).

Table 2-9. Current In-stream Monitoring Data and WTM Output for Existing Event Mean Concentrations

	TN	**TP**	**TSS**	**Fecal Coliform**
	mg/L	**mg/L**	**mg/L**	**MPN/100 mL**
WTM Total Load	2.15	0.21	55.32	28,025
Monitoring (N)	2.64 (4)	0.17 (7)	51.23 (8)	28,025 (4)

N = number of samples collected

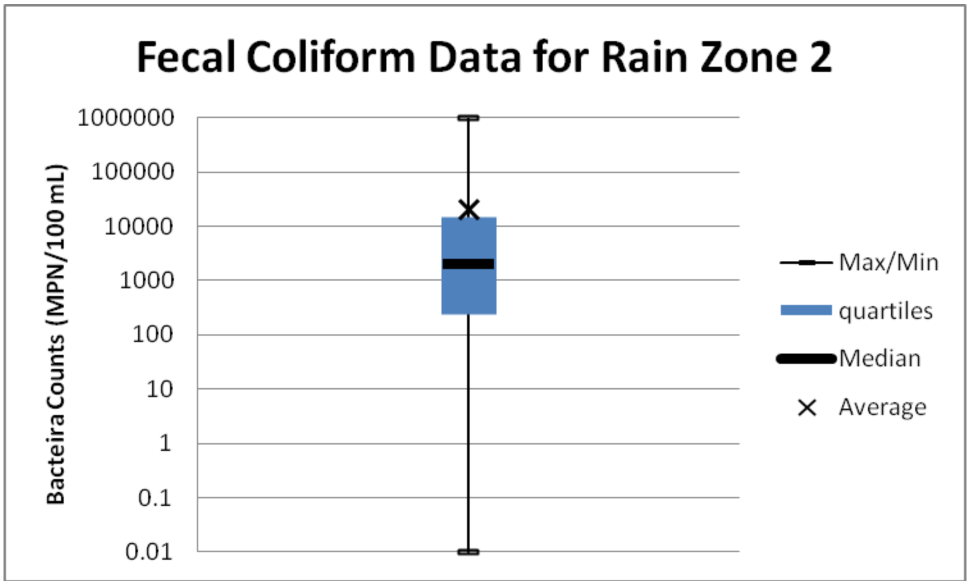


Figure 2-2. Example of Variability of Bacteria EMC values, adapted from National Stormwater Quality Database v3, 2008

2.6.4 Causes or Sources of Pollution

The land use summary and the existing condition modeling of the Sam's Branch watershed, and observed during field reconnaissance, indicate two primary causes or sources of pollution. Using the categorizes under Section 319 (criteria a) reporting requirements, the two primary sources of pollution are 4000 Urban Runoff/Stormwater including municipal, commercial and residential; and 7100 Channelization – channel erosion/incision.

3.0 UPLAND CONDITION AND RETROFIT SURVEY

3.1 Unified Subwatershed and Site Reconnaissance (USSR) and Stormwater Management Retrofit Survey

A suite of upland assessments were carried out over the time period of May of 2008 through April of 2009. These efforts resulted in the identification of simple and cost effective stormwater retrofit opportunities throughout the Sam's Branch drainage area. Some of these observations and recommendations include source reduction such as downspout disconnection (i.e., directing downspouts to pervious areas to promote recharge and runoff volume reduction) and bioretention installation opportunities, and impervious cover reduction (opportunities for alternative paving material, etc.). Other observations were used toward recommendations of public outreach efforts for improving community watershed behaviors, and programmatic opportunities for Harford County Government to pursue toward improved water quality.

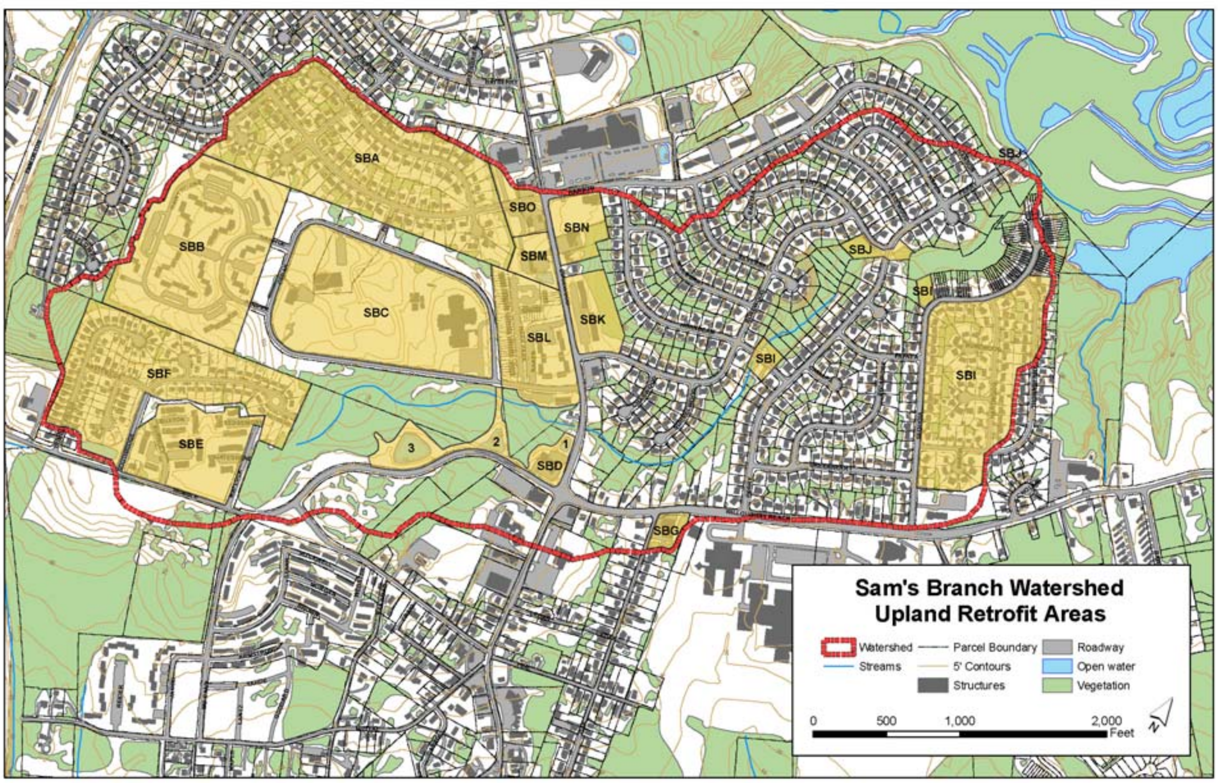


Figure 3-1. Upland Retrofit Study Areas (yellow highlighted areas indicate locations of retrofit opportunities)

3.1.1 Methods

A map of the site was generated using GIS digital mapping data. The upland areas of the watershed were grouped by land use and assigned letter codes with Sam's Branch (SB) SBA through SBO as shown in Figure 3-1. Biohabitats conducted a survey of these upland areas over three field days to determine stormwater retrofit opportunities using Retrofit Reconnaissance Investigation (RRI) data forms from the Unified Subwatershed and Site Reconnaissance (USSR) Manual (CWP, 2004) with accompanying photo documentation. Retrofit recommendations were prioritized by cost, level of benefit, and land ownership. Appendix B contains the USSR data sheets that were completed during this upland assessment survey.

Other upland assessments included inspection of existing stormwater management facilities for conditions leading to poor performance. Conditions such as excessive sedimentation, waterfowl presence, and lack of littoral zone vegetation were assessed looking at potential stormwater and restoration opportunities such as new facilities, retrofit of existing facilities, reforestation opportunities, and maintenance measures. Additional retrofitting opportunities were explored such as providing treatment to parking lots in the high density residential areas.

3.1.2 Summary of Baseline Upland Conditions and Retrofit Opportunities

The majority of the watershed area is medium density (single family home) residential neighborhoods with some high density (apartment) neighborhoods. Edgewood Elementary School occupies a significant portion of the western subwatershed with a corridor of commercial uses including three gas stations, a public library, and various other commercial uses along Edgewood Road. The delineated upland areas include:

SBA – Medium density residential neighborhood
SBB – Abandoned high density residential
SBC – Edgewood Elementary School and sports field
SBD – Gas station and three stormwater detention basins
SBE – Harford Commons high density residential neighborhood
SBF – Medium density residential neighborhood
SBG – Commercial/retail single detached building and parking lot
SBH – Edgewood High School and Deerfield Elementary School (determined to be outside of watershed limits)
SBI – Medium density residential
SBJ – Culvert under Perry Road with surrounding wetland and buffer potential
SBK – Commercial/retail single detached building and parking lot
SBL – High Density Residential
SBM – Car wash and stormwater detention basin
SBN – Public library and commercial/retail building with hair salon, restaurant, and mini-mart
SBO – Two corner gas stations

Within these upland areas, sixteen specific locations are recommended for retrofits to improve the quality and reduce quantity of stormwater runoff impacting Sam's Branch. Where applicable, Figures 3-2 through 3-20 show drainage areas and retrofit areas are delineated on an aerial plan with a photo from the survey showing a view of the site. Issues, strategies, and expected benefits are listed on these sheets for each site. The retrofit sites include:

SBA – Bioretention along the medium density residential Hanson Road: This lengthy residential road is directly draining to Sam's Branch through several large curb inlet drains. Lawn clippings were visible in the gutter from the lawns on either side of the sidewalks. Replacing the lawn areas between the road and sidewalk with vegetated bioswales could intercept road runoff before it reaches the curb inlets. The expected benefits of this strategy include enhanced quality and quantity control for frequently-occurring storms as well as educational benefit as a demonstration project for residents.

SBB - Abandoned high density residential**:** Existing abandoned/unused impervious surface on Hawthorne Drive are currently in poor condition. Strategies for improvement include removal of unused impervious surface (24,630 ft^2), and stabilization of area with soil amendment and native vegetation. Depending on the approach toward removal or rehabilitation of the buildings at this site, additional pavement area could also be stabilized with soil amendments and native vegetation. The benefits of this strategy would be to reduce the volume of stormwater runoff and promote infiltration.

SBC – Bioretention and revegetation along Cedar Dr. at Edgewood Elementary School: The parking lot of Edgewood Elementary School drains through large drain inlets directly under Cedar Drive and into Sam's Branch. The two drainage areas in the parking lot could be redirected into proposed bioretention cells in the existing lawn area between the parking lot and Cedar Drive. A swale which runs through the large lawn area to the southwest of the school building is another major source of drainage into Sam's Branch from the SBC site. This channel had standing water in portions during the survey. This swale could be vegetated with native vegetation and engineered media could be selectively added to create a bioswale. Through these strategies, the stormwater runoff from this edge of the SBC site, adjacent to Sam's Branch, could have improved water quality and quantity control for frequently occurring storms, enhanced habitat and aesthetic appeal, and educational benefit as a demonstration project for students and residents.

SBD – Gas station and three stormwater detention basins: This site includes a gas station and 3 existing stormwater basins. Basin #1 lacks vegetation aside from grass and water quality benefit based on the existing stormwater treatment. Recommendations at this site include replacement of the pond bottom with engineered media and an underdrain, and plant with native vegetation. The expected benefits include alleviation of minor standing water problem, improvement of water quality leaving the existing basin and enhanced aesthetic appeal.

The outfall channel downstream of Basin #2 has eroded banks and is actively head-cutting, contributing accelerated sediment loading to Sam's Branch and Otter Creek. Restoration strategies include stabilizing the channel using regenerative stormwater conveyance, as a stepped outfall system. The expected benefits of this approach include reduced sediment yield from channel erosion, improved hydrologic behavior (increasing groundwater recharge), and habitat improvement.

At Basin #3, a lack of vegetation, bare and eroded soils, trash deposition and lack of maximized water quality benefit were noted. Retrofit strategies include stabilization of bare and eroded soil, and native vegetation installation, construction of a water quality forebay, and a modified mowing program for any portion that remains grassy. Expected benefits include improved trash management and water quality, as well as, enhanced habitat and aesthetic appeal.

***SBE – Harford Commons high density residential neighborhood*:** Along the headwater portion of the stream corridor near Harford Commons, a high density residential neighborhood, there is significant debris accumulation and impaired water quality. Strategies for improvement and restoration of this area include moving a residing dumpster away from the drainage network and the creation of a sand seepage wetland with native vegetation. This wetland area would encompass approximately 0.8 acres and capture approximately 9 acres of drainage area. This strategy would result in improved water quality and hydrologic conditions in this critical headwater area of Sam's Branch, increasing habitat and aesthetic appeal.

SBF – Bioretention along the medium density residential Southridge Drive turn-around island: Southridge Drive has asphalt in poor condition, direct drainage to the headwaters of Sam's Branch, and is highly visible to residents who live on this street as a potential educational opportunity. There is currently a lack of water quality control for the runoff on this street. By lowering the grade of the raised turn-around island, cutting the curbs, and constructing a bioretention cell to capture road runoff, there is the potential to enhance the quality and quantity control for frequently-occurring storms as well as use this project for demonstration for residents.

***SBG - Commercial/retail single detached building and parking lot*:** This commercial area houses a basement waterproofing company and did not exhibit much available area or opportunity in the way of significant stormwater management opportunities.

SBH – Edgewood High School and Deerfield Elementary School: Much of the drainage area at these locations drains to another tributary. Further investigation of the stormdrain network will be conducted; however, no current recommendations are included in this report.

SBI – Sequoia Drive Cul-de-sac Parking Lot: Sequoia Drive Cul-de-sac parking lot is currently in fair condition, but results in directly connected drainage that lacks any water quality treatment. A retrofit strategy would include replacing existing pavement with permeable pavement covering an area approximately 13,570 ft^2. The expected benefits would include quality and quantity control for more frequent storms, and enhanced aesthetic appeal.

SBJ – Culvert under Perry Road with surrounding wetland and buffer potential: This area captures roadway surface along Rosewood Drive, Banyan Road, and Perry Avenue that currently runs directly into two concrete channels into Sam's Branch. Retrofit opportunities include a terraced bioretention facility in a grassy area adjacent to the roadway near the intersection of Banyon Road and Perry Avenue. Benefits of this retrofit would include enhanced water quality and quantity treatment.

SBK – Bioretention for the parking lot for two high density apartment buildings: The parking lot for the two apartment buildings on the corner of Edgewood Road and Rosewood Drive has no visible drain inlets but has a steady grade towards Rosewood Drive. The area of lawn to the north of the entry road into the parking lot could be used to construct a bioretention cell adjacent to the entrance. This bioretention could solve the issues of the directly connected drainage, lack of water quality control, and low vegetation diversity. Expected benefits include enhanced quality and quantity control for frequently-occurring storms, enhanced aesthetic appeal, and educational benefit as a demonstration project for residents.

***SBL – High Density Residential*:** At this high density residential site, the asphalt is in poor condition and much of the existing soil is compact, barren and in some areas, there is evidence of erosion. In addition, the drainage is directly connected and lacks any water quality treatment. Strategies for water quality enhancement include replacement of the entire paved area, including the pavement between the buildings, with permeable pavement. Soil amendment or augmentation is also recommended at this location, with native revegetation. Benefits gained by the implementation of these measures include enhanced water quality and quantity control, enhanced habitat and aesthetic appeal, and the alleviation of erosion and standing water. In addition, at this location there is an opportunity for regenerative stormwater conveyance replacing an existing rip-rap channel, and capturing parking lot drainage prior to discharging into Sam's Branch.

***SBM – Car wash and stormwater detention basin*:** No recommendations have been made at this time, additional evaluation of the stormwater pond as-built drawings and modeling information are necessary to determine if retrofit of the existing stormwater detention basin would be recommended.

***SBN1 – Pollution/trash prevention strategies for the commercial site*:** This commercial site contains a mini mart store in the southeast portion of the building. A drainage channel runs along the entire length of the southeast edge of the property line. Significant amounts of trash were seen on this site along the fence between the building and the ditch as well as in the ditch. Oil from road runoff can also be seen in the water within the channel. This channel and the trash it carries flow into a tributary to Sam's Branch. By providing more trash cans, repairing holes in the fence, and other trash control methods, this trash may be prevented from entering the waterways within this watershed.

SBN2 – Bioretention and outreach opportunities at Public Library: Existing rooftop drainage drains through downspouts and that are either directly connected to the stormdrain system or drain directly into a grass swale and enters an inlet draining to the storm drain. Water quality benefit is not maximized by the portion of the rooftop drainage that currently runs through the grassy swale area. A bioretention facility could be built near the entrance to the public library to capture a portion of the rooftop runoff by disconnecting the connected downspouts and redirecting the existing drainage into the facility. Educational signage could be established near the entrance to the library to educate the community on watersheds, stormwater management and the health of their local water resources. Benefits include enhanced water quality and quantity control for frequently-occurring storms and educational outreach opportunities.

SBO – Bioretention opportunity at Commercial Center: Existing parking lot drainage enters an inlet and the stormdrain system along the east corner. No water quality treatment of this drainage is currently provided. Strategies for improvement include the use of adjacent down gradient lawn area for a bioretention facility. Educational signage could be established near the entrance to the library to educate the community on watersheds, stormwater management and the health of their local water resources. Benefits include enhanced water quality and quantity control for frequently-occurring storms and educational outreach opportunities.

Figure 3-2. SBA – Bioretention along the medium density residential Hanson Road

Bioretention - Residential - SBA - Hanson Rd.

Low point along Hanson Rd.; Flooding in road has been alleviated by the curb inlets according to resident

Typical shoulder configuration; turf clippings flowing into curb inlet

Issues:
- Directly connected drainage
- Lack of water quality control
- Lawn clippings in gutter

Strategies:
- Replace lawn in areas between sidewalks and roads with vegetated bioswales to intercept road runoff before reaching curb inlets

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Educational benefit as demonstration project for residents

Figure 3-3. SBB – Hawthorne Drive - abandoned high density residential

Remove Impervious Surfaces - SBB - Hawthorne Drive

Proposed Impervious Surface Removal
Area: 24,630 sq. ft.

0 400

Existing pavement on Hawthorne Drive

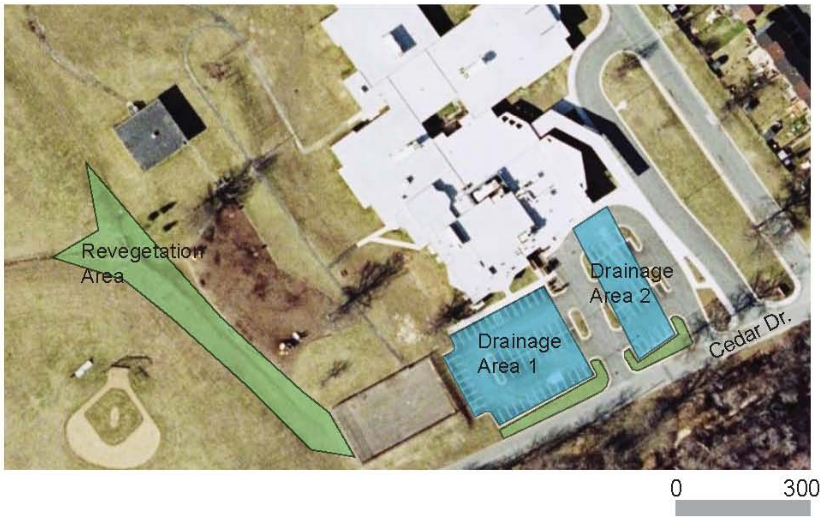
Issues:
- Abandoned/unused impervious surfaces in poor condition

Strategies:
- Remove unused impervious surfaces in the delineated area
- Stabilize area with soil amendment and native vegetation
- Depending on the approach to building demolition, additional driveways, parking areas, or roads could also be removed

Expected Benefits:
- Reduced stormwater runoff volume
- Infiltration is promoted

Figure 3-4. SBC - Edgewood Elementary School – Bioretention and Revegetation

Bioretention & Revegetation - Public/Educational - SBC - Edgewood Elementary School



Drainage Area 1: 15,880 sq. ft.

Drainage Area 2: 7,981 sq. ft.

Proposed Bioretention Cell Area 1: 1,850 sq. ft.

Proposed Bioretention Cell Area 2: 1,041 sq. ft.

Revegetation Area: 14,370 sq. ft.

Issues:
- Directly connected drainage
- Lack of water quality control
- Some standing water in existing swale

Strategies:
- Replace lawn areas with bioretention cells and redirect parking lot drainage into cells
- Plant existing lawn swale with native vege-tationand selectively add engineered media

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Enhanced habitat and aesthetic appeal
- Educational benefit as demonstration proj-ect for students and residents

Portion of existing swale

Proposed bioretention location, Drainage Area 1

Figure 3-5. SBD – Basin 1

Retrofit Existing Stormwater Basins - SBD - Basin 1

Outflow riser with de-watering device

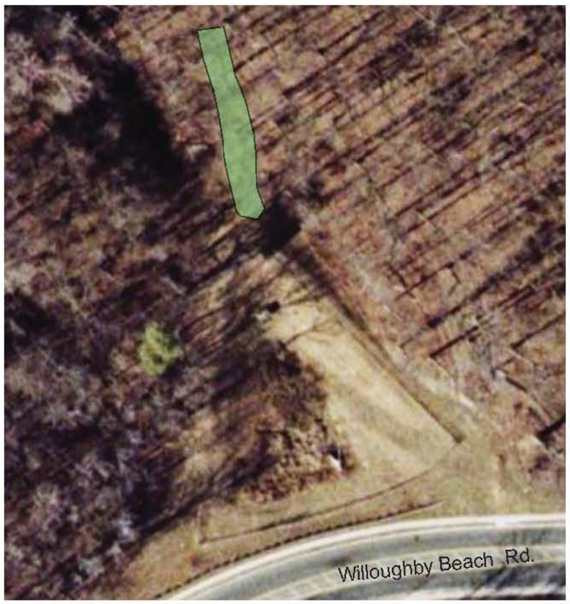
Issues:
- Lack of vegetation besides grass
- Water quality benefit not maximized

Strategies:
- Replace pond bottom with engineered media and underdrain
- Plant with native vegetation

Expected Benefits:
- Alleviate minor standing water problem
- Improved water quality leaving basin
- Enhanced aesthetic appeal

Figure 3-6. SBD – Basin 2

Regenerative Stormwater Conveyance - SBD - Basin 2 Outfall



Proposed Regenerative Stormwater Conveyance Channel

0 150

Eroded outfall channel

Issues:
- Channel connection basin outfall to Sam's Branch has eroded banks, and active head-cut, and is deeply incised

Strategies:
- Stabilize channel using regenerative storm-water conveyance (step pool system)

Expected Benefits:
- Reduced sedimentation from channel ero-sion
- Improved hydrologic behavior
- Habitat enhancement

Figure 3-7. SBD – Basin 3

Retrofit Existing Stormwater Basins - SBD - Basin 3

Proposed Revegetation Area: 1.3 acres

0 150

Partial view of eroded areas

Issues:
- Lack of vegetation
- Bare/eroded areas
- Trash deposition
- Water quality benefit not maximized

Strategies:
- Stabilize bare/eroded areas
- Plant with native vegetation
- Construct water quality forebay
- Modify mowing practices to avoid exacer-bating erosion

Expected Benefits:
- Improved trash managment
- Improved water quality leaving basin
- Enhanced habitat and aesthetic appeal

Figure 3-8. SBE – Harford Commons

Sand Seepage Wetland - SBE - Harford Commons High Density Residential

Drainage Area: 9 acres

Proposed Sand Seepage Wetland Area: 0.8 acre

0 400

Existing channel

Trash deposition

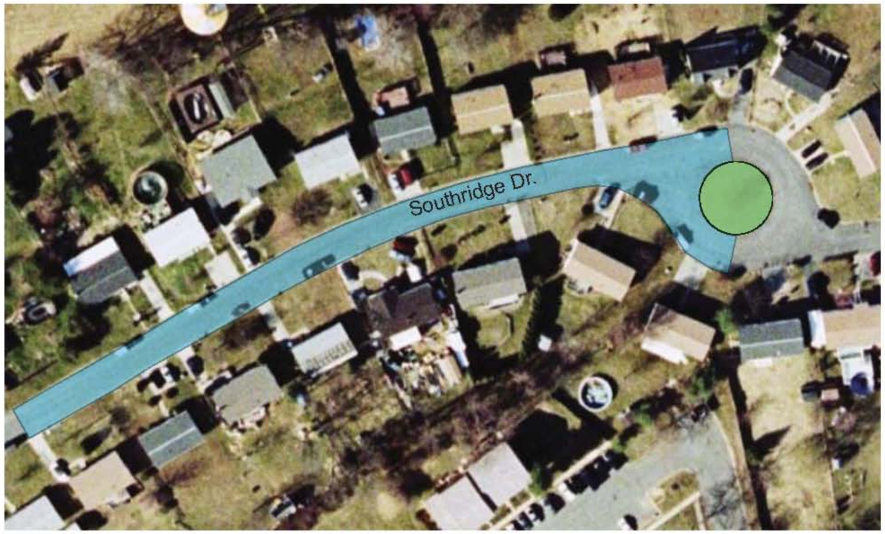
Issues:
- Impaired water quality and severe trash deposition in headwater area below Harford Commons

Strategies:
- Move dumpster away from drainage culvert
- Create sand seepage wetland with native vegetation

Expected Benefits:
- Improved water quality and hydrologic behavior in critical headwaters area of Sam's Branch
- Enhanced habitat and aesthetic appeal

Figure 3-9. SBF – Southridge Drive Turn-around

Bioretention - Residential - SBF - Southridge Dr. Turn Around Island



Drainage Area: 18,150 sq. ft.

Proposed Bioretention Cell Area: 2,376 sq. ft.

0 150

Turn-around island

Issues:
- Directly connected drainage
- Lack of water quality control

Strategies:
- Lower grade of raised turn around island, cut curbs, and construct bioretention cell to capture road runoff

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Educational benefit as demonstration project for residents

Figure 3-10. SBI – Sequoia Drive Cul-de-sac

Permeable Paving and/or Biofiltration - SBI - Sequoia Drive Cul-de-sac Parking

Parking in center of cul-de-sac on Sequoia Dr.

Issues:

- Pavement in fair condition
- Directly connected drainage
- Lack of water quality control

Strategies:

- Replace existing pavement with permeable pavement

Expected Benefits:

- Enhanced quality and quantity control for frequently-occuring storms
- Enhanced aesthetic appeal

Figure 3-11. SBJ - Bioretention

Bioretention - SBJ

One of two existing channels from road into Sam's Branch

Issues:
- Directly connected road drainage into Sam's Branch via two concrete channels
- Lack of water quality control

Strategies:
- Terraced bioretention in existing grass area

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms

Figure 3-12. SBK - Biorention

Bioretention - Residential - SBK

Drainage Area: 22,210 sq. ft.

Proposed Bioretention Cell Area: 1,691 sq. ft.

0 150

Proposed bioretention location

Issues:
- Directly connected drainage
- Lack of water quality control
- Low vegetation diversity

Strategies:
- Construct bioretention cell adjacent to entrance

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Enhanced aesthetic appeal
- Educational benefit as demonstration project for residents

Figure 3-13. SBL High Density Residential

Permeable Pavement + Soil Amendment & Revegetation - SBL - High Density Residential

Existing Pavement

Existing inlet at east corner of lot

Proposed Permeable Pavement Area: 33,250 sq. ft.

Proposed Soil Amendment and Revegetation Area: 5,000 sq. ft. (could be expanded to the whole internal lawn area)

0 200

Issues:
- Asphalt paving in poor condition
- Bare, compacted and eroded common area
- Directly connected drainage
- Lack of water quality control

Strategies:
- Replace entire paved area (including pavement between buildings) with permeable pavement.
- Amend or replace soil in common area and revegetate

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Enhanced aesthetic appeal
- Alleviate erosion and standing water

Figure 3-14. SBL – Regenerative Stormwater Conveyance

Regenerative Stormwater Conveyance - SBL - High Density Residential

Drainage Area: 10,000 sq. ft.

Proposed RSC Area

0 150

Riprap channel at southwest corner of parking lot

Issues:
- Parking lot runoff drains into small riprap channel flowing directly to Sam's Branch
- Trash deposition

Strategies:
- Replace existing channel with Regenerative Stormwater Conveyance (step pool system)

Expected Benefits:
- Improved hydrologic behavior
- Improved runoff water quality
- Enhanced habitat and aesthetic appeal

Figure 3-15. SBN – Library - Bioretention

Bioretention - Public/Educational - SBN - Library


Existing swale and downspouts

Issues:
- Water quality benefit not maximized

Strategies:
- Construct bioswale
- Disconnect downspouts into bioswale
- Add educational signage

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms
- Excellent educational opportunity

Figure 3-16. SBN – Commercial Site

Pollution Prevention Strategies - SBN Commercial Site

Trash accumulation along fence

Trash deposition and poor water quality in channel

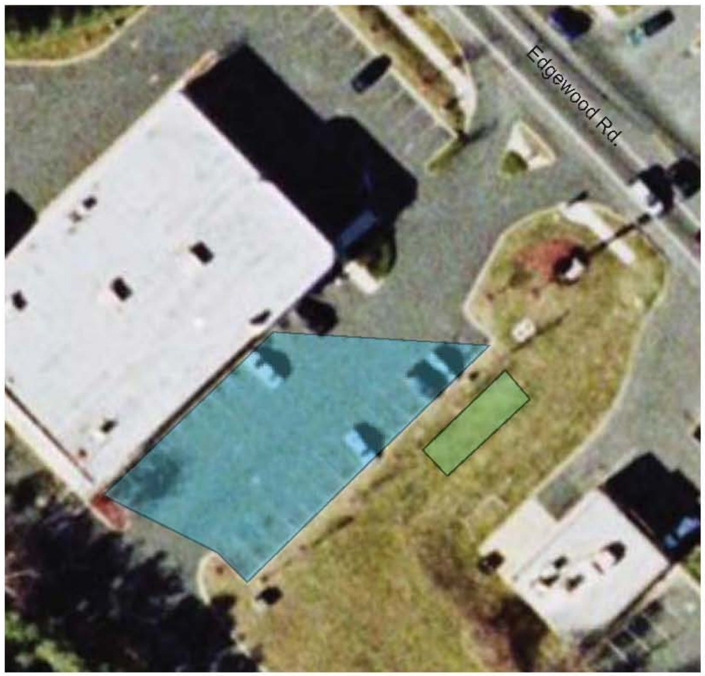
Issues:
- Drainage channel conveys trash from parking lot into tributary of Sam's Branch

Strategies:
- Provide more trash cans, repair holes in fence, and employ other trash control methods to prevent trash from entering drainage channel

Expected Benefits:
- Reduced trash in tributary

Figure 3-17. SBO – Commercial Bioretention

Bioretention - Commercial - SBO



Drainage Area:
7,000 sq. ft.

Proposed Bioretention Cell Area:
525 sq. ft.

0 100

Lawn area below parking lot

Existing inlet at east corner of lot

Issues:
- Directly connected drainage
- Lack of water quality control

Strategies:
- Use adjacent lawn area for bioretention

Expected Benefits:
- Enhanced quality and quantity control for frequently-occuring storms

Figure 3-18. Typical Bioretention Section

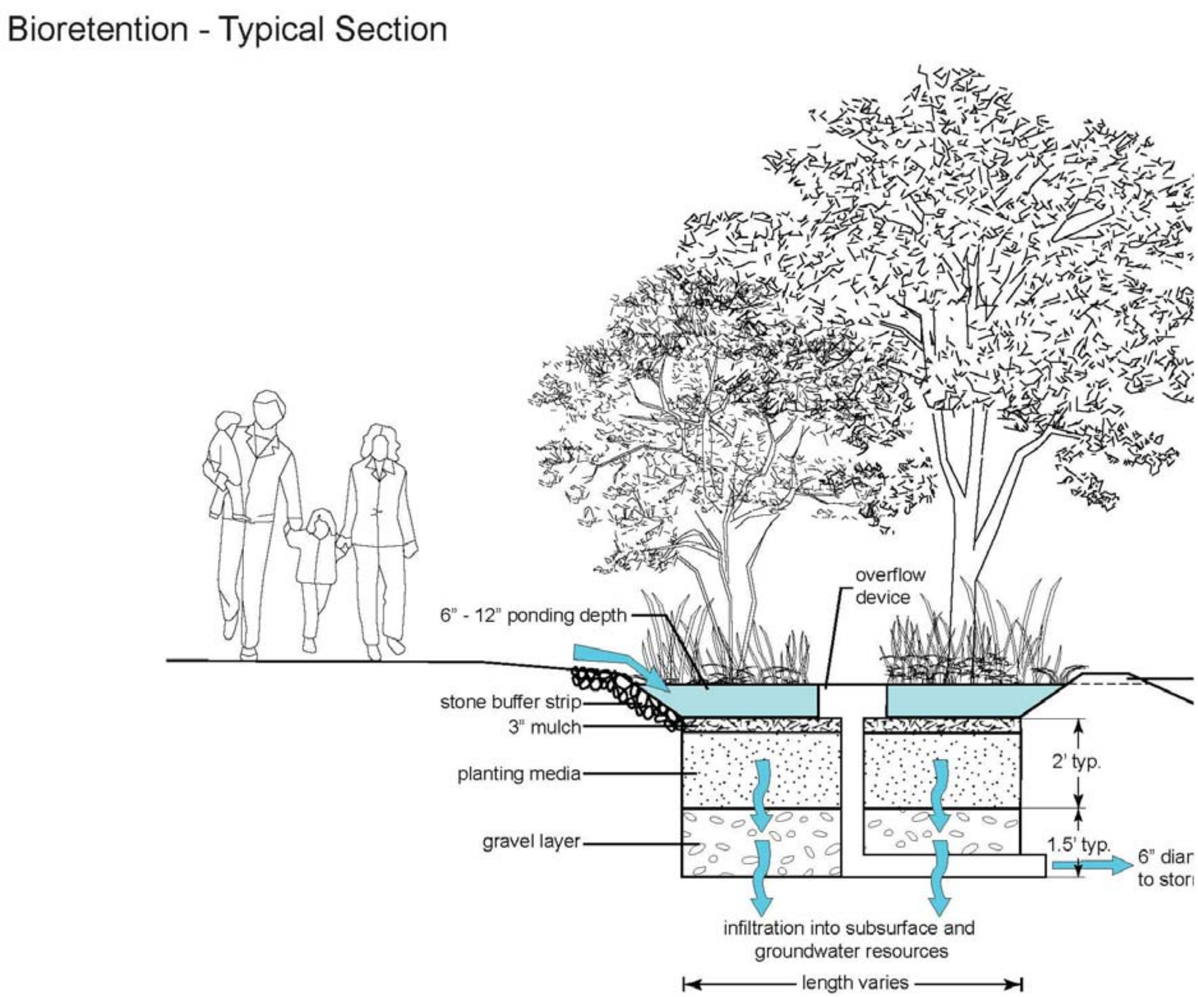


Figure 3-19. Typical Regenerative Stormwater Conveyance Section

Regenerative Stormwater Conveyance - Typical Section

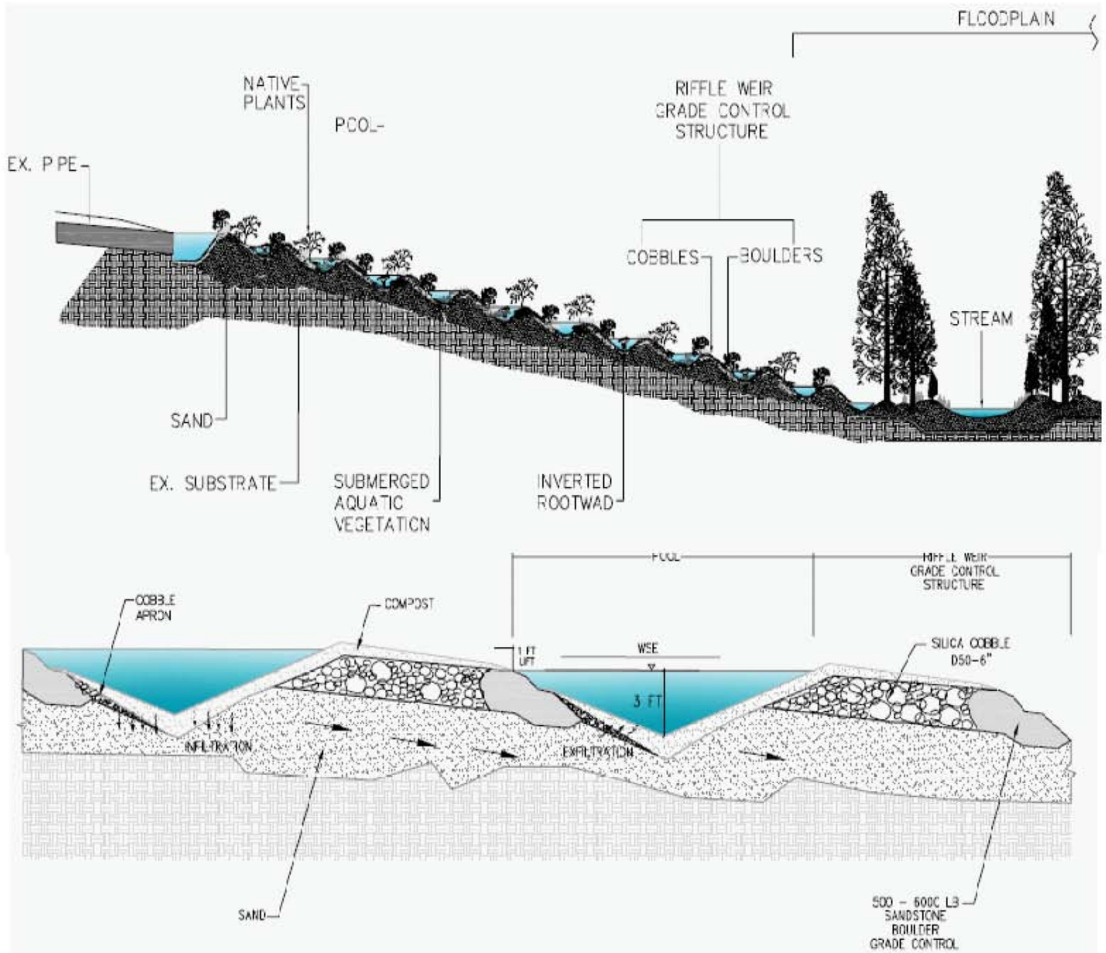
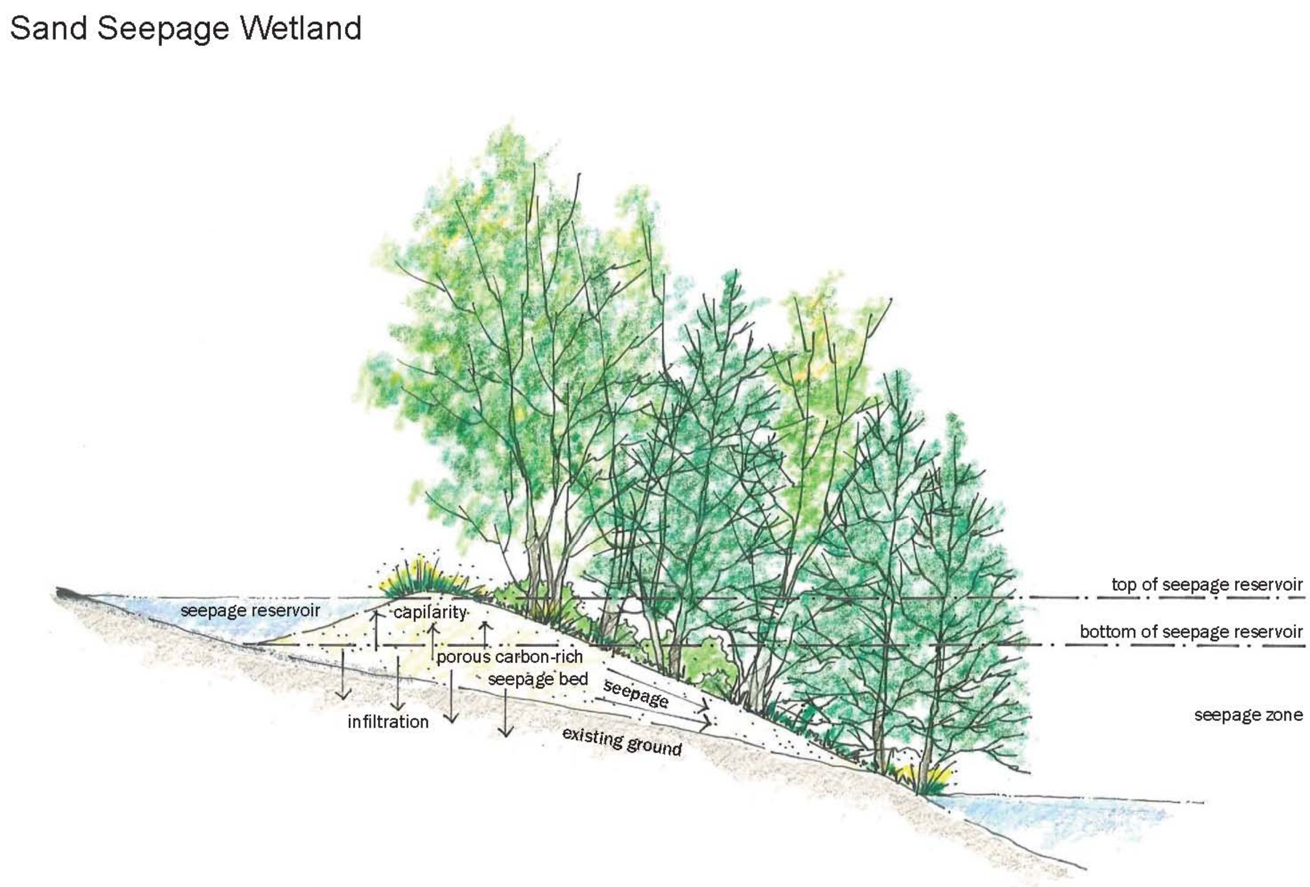


Figure 3-20. Typical Sand Seepage Wetland Schematic Section



4.0 COMMUNITY AWARENESS SURVEY

A key approach to truly assessing the health of a watershed requires information and input from the inhabitants of the watershed. Establishing a dialogue with the communities helps to understand watershed behaviors and to seek input early on the development of management approaches and restoration/implementation strategies.

4.1.1 Methods

A residential survey was developed for Harford County to supplement the windshield survey carried out during the upland survey. The purpose of the residential survey was to seek input from the residents to characterize current watershed awareness and to gather information on relevant watersheds behaviors. The survey was distributed by Harford County to all the residents within the Sam's Branch drainage area. In part, the survey results serve as an indicator of the willingness to change behaviors that could contribute to degraded in-stream conditions. The findings of the community awareness survey have been summarized below. Preliminary recommendations are presented to address certain behaviors documented and to follow-up on response provided by the survey. Biohabitats will continue this effort working with County staff and community stakeholders to explore incentives to promote and increase the amount of participation in better "watershed" behaviors, foster stewardship and initiate volunteer efforts.

4.1.2 Summary of Baseline Community Awareness Survey

A copy of the blank survey that was distributed is included in Appendix C along with a spreadsheet of the survey results. Thirty eight (38) responses were received by Harford County of the 778 postcards that were distributed to the residents of the Sam's Branch watershed serving as notification of the survey effort, representing just under a 5 % response rate. Single family homes represented 97% of the responses with one response from a townhome property. Ninety five percent (95%) of the respondents that indicated they have lawn area that requires mowing also apply fertilizer to their lawn. The number of times per year a resident fertilized their lawn varied, 34% apply fertilizer twice a year or more with the predominant application time of early spring and early fall. The application rate/amount per fertilization varied with 4 respondents using 8 pounds, 6 respondents using 16 pounds, 4 respondents using 50 pounds and one respondent using 100 pounds per application. Twenty four percent (24%) of respondents indicated that they apply pesticides or herbicides to their lawns, while only one respondent applied to their garden as well. Sixty eight percent (68%) of respondents have a garden and 77% of those with gardens apply fertilizer or compost to their gardens. The majority of the residents who responded indicated they maintain their own lawns and gardens. Product labels were the predominant source used as information on application rates.

The vast majority of respondents (95%) have not had soil tests within the last 3 years, but 71% of respondents indicated they would have a soil test performed and that for no fee or a small fee they would provide a soil sample to the County for analysis.

Over 50% leave the clippings on their lawns after mowing, others mulched, and 9 property owners bagged and disposed of the bags. For leaf litter collection, 26% of respondents indicated that they take leaf litter to a recycling center, 26% mulched leaf litter, and 18% do not collect leaf litter, with a small percentage composting or dumping in the woods or near Sam's Branch.

Sixteen (16) of the 38 respondents indicated they have a dog representing about 42% of the total respondents. Approximately 70% of those dog owners walking their dogs are cleaning up after them.

Ninety five percent (95%) of residents have personal vehicles and 58% do not perform any maintenance on those vehicles, while 36% change oil and replace fluids. Most residents recognized potentially hazardous materials and either dispose of at a landfill or a designated recycling center.

Eighteen percent (18%) of respondents indicated their downspouts are currently connected to impervious surfaces and only 2 of those indicated that they would be interested in disconnecting the downspouts. Yet, many respondents (12 yes and 9 undecided) indicated that they would or may be willing to attend a workshop to learn more about downspout disconnection and 23 respondents indicated that they have an interest in establishing a rain garden.

4.1.3 Preliminary Recommendations from Baseline Community Awareness Survey

Preliminary recommendations to follow-up with the community based on the survey results include holding a ½ day workshop to disseminate information to the community on downspout disconnection, turf conversion, rain gardens, rain barrels and garden watering using rain barrel captured rainwater, organic gardening, pet waste management, reduction in use of hazardous materials, recycling of unused potentially hazardous materials including paints and batteries. Fertilizer could be discussed with residents, who could be encouraged to bring soil samples to the meeting and the County could have the analysis done and provide the results and recommendations back to the community by mail.

Additional ideas for presentation to the community might include the benefits of the use of native plants in landscaping, potential community outreach efforts within the Sam's Branch watershed including volunteer involvement in proposed retrofit and restoration projects.

5.0 RIPARIAN CONDITION SURVEY

5.1 Establish Baseline Riparian Condition

Biohabitats walked the entire length of each restoration reach photographing and noting existing condition of the stream corridor including a riparian condition survey and mapping outfall locations. A GPS point location was also recorded for each baseline condition photograph taken for comparison to future conditions. These photographs are included in Appendix A. In addition, outfall locations were also GPS located along each reach (Figure 6-2). Plant community types were identified with the dominant plant species recorded and impacts (i.e., invasive species) to those communities noted.

5.1.1 Methods

On April 25, 2008 Biohabitats, Inc. staff performed a visual assessment of the forested areas immediately adjacent to the stream channel along the length of the study area. Biohabitats conducted a riparian condition survey along the entire length of the study area. The riparian condition survey consisted of mapping invasive species, plant community types, riparian widths, and areas of encroachment, locating yard waste dumping, and documenting the general health of the plant community along the length of the study area.

5.1.2 Summary of Baseline Riparian Conditions

The upper reaches of Sam's Branch originate in a highly degraded forested wetland fed by stormwater outfalls. Much of the overstory here is composed of black willow and silver maple.

Progressing further downstream Sam's Branch cuts its way through a mixed hardwood forest dominated by tulip poplar, red maple and black cherry with an occasional beech, black locust and pin oak. The understory in this area is dominated by seeps and depressions. The forested area to the south of Sam's Branch is vegetated with sweet gum, sycamore, holly, sweet bay, spicebush, highbush blueberry and various ferns.

The lower portions of Sam's Branch pass through a forest floodplain wetland that is dominated by green ash with other floodplain tree species found in this association such as sycamore, black walnut, silver maple, river birch, red maple and willow oak. This information will be used during the design of stream restoration along Sam's Branch including stream corridor riparian enhancement zones.

Riparian vegetation species are listed below:

Common Name (*Latin Name*)

Tulip poplar (*Liriodendron tulipifera*)
Red maple (*Acer rubrum*)

Black cherry (*Prunus serotina*)
Locust (*Robinia* sp)
Southern magnolia (*Magnolia grandiflora*)
Sweet bay (*Magnolia virginiana*)
American beech (*Fagus americana*)
Pin oak (*Quercus palustris*)
Red oak (*Quercus falcata*)
Sweet gum (*Liquidambar styraciflua*)
Sycamore (*Platanus occidentalis*)
Poison ivy (*Toxicodendron radicans*)
Virgins bower (*Clematis virginiana*)
Virginia creeper (*Parthenocissus cinquefolia*)
Skunk cabbage (*Symplocarpus foetidus*)
Sensitive fern (*Onoclea sensibilis*)
Mayapple (*Podophyllum peltatum*)
Grape (*Vitis* sp)
Violet (*Viola* sp)
Greenbriar (*Smilax* sp)
Chickweed (*Stellaria* sp)
Red-osier dogwood (*Cornus sericea*)
Highbush blueberry (*Vaccinium corymbosum*)
Arrowwood (*Viburnum dentatum*)
Flowering dogwood (*Cornus florida*)
Spicebush (*Lindera benzoin*)
Blackhaw (*Viburnum prunifolium*)
Holly (*Ilex opaca*)
Sweetpepperbush (*Clethra alnifolia*)
Rubus
Elderberry (*Sambucus canadensis*)
Sassafras (*Sassafras albidum*)
Willow oak (*Quercus phellos*)
Black willow (*Salix nigra*)
Silver maple (*Acer saccharinum*)
Black walnut (*Juglans nigra*)
Jewelweed (*Impatiens capensis*)
Cinnamon fern (*Osmunda cinnamomea*)
Mulberry (*Morus* sp)
Hobblebush (*Viburnum lantanoides*)
Bittersweet (*Celastrus* sp)
Multiflora rose (*Rosa multiflora*)
Japanese honeysuckle (*Lonicera japonica*)
Japanese knotweed (*Polygonum cuspidatum*)
Winged euonymus (*Euonymus alatus*)
English ivy (*Hedera helix*)
Privet (*Ligustrum* sp)
Wisteria (*Wisteria* sp)
Garlic mustard (*Alliaria petiolata*)
Wineberry (*Rubus phoenicolasius*)

6.0 STREAM MORPHOLOGY

A geomorphic survey of four reaches was conducted within the study area to document a range of representative conditions and establish baseline conditions. Field measurements and observations focused on the survey of monumented cross sections and longitudinal profile; measurement of bed material size; and assessment and photo documentation of overall site conditions and channel stability.

6.1 Monumented Cross Sections and Longitudinal Profiles

Initial measurements of stream cross sections and longitudinal profiles were taken to provide baseline information regarding stream shape and elevation during late 2008 and early 2009, additional measurements were taken during the 2010 – 2011 monitoring period. Overlays of the cross sections and profiles between these two sampling periods are provided in Appendix D. Future adjustments to the channel bed and banks can be identified when contrasted with these baseline data. In addition this information will be used during the design development of stream restoration along Sam's Branch.

Baseline measurements and observations were stratified within the context of four representative reaches within the project area (Figure 6-1 and Figure 6-2). Reach 1 extends from upstream limit to Edgewood Road. Reach 2 extends between Edgewood Road and Hornbeam Road. Reach 3 includes the portion of the channel between Hornbeam Road and Perry Avenue. Reach 4, the downstream-most reach, is bounded by Perry Avenue and Otter Point Creek downstream.

6.1.1 Methods

Biohabitats used a laser level instrument and rod to survey stream cross sections within the four restoration reaches using standard geomorphic techniques (Harrelson et al., 1994). Within each of the four reaches, Biohabitats surveyed two riffle cross sections and one pool cross section, for a total of twelve cross sections. Photographs were taken of the upstream, downstream, left bank and right bank of each surveyed cross section. Cross-sectional characteristics were recorded including top of bank, bankfull elevation, water surface elevation, thalweg and other notable features. Rebar pins were used to monument the left and right ends of the cross sections approximately 20 feet from top of bank. GPS coordinates of the rebar monuments were recorded. A stream longitudinal profile was also surveyed along the full extent of each of the four reaches. Longitudinal profiles extended approximately 20 channel widths or greater to best characterize topographical variation. Top of riffle, bottom of riffle, run, maximum pool depth, and glide features were recorded along the channel thalweg. Bankfull features, top of bank, and water surface elevation also were surveyed along the longitudinal profile. Relative elevations were recorded based onan arbitrary benchmark of 100 feet. The relative starting elevations from the 2010/2011 survey were used for the cross section overlays. During the overlay process, the 2008/2009 cross sections were overlain and adjusted to the 2010/2011 benchmark elevations. For each reach we also developed a geomorphic sketch, which identified key features and noted general channel stability. Appendix D contains data from these surveys.

6.1.2 Summary of Baseline Stream Morphology Conditions

Photographs of the monumented cross sections are presented in Appendix A. Cross section and profile survey results and reach geomorphic sketches for each reach survey for the data collected during the 2008 and 2009 monitoring period are presented in Appendix D. In general, the upstream reaches were more incised and unstable due to tall, nearly vertical bank slopes, and poor floodplain access. Stream hydraulics (e.g., discharge) and associated channel morphology (e.g., bank slopes) appear to be strongly controlled by three road crossings: Edgewood Road, Hornbeam Road, and Perry Avenue. Additionally, water surface elevations in Reach 4 are controlled by backwater conditions in Otter Creek.

The Reach 1 longitudinal profile demonstrates pool-riffle morphology with an average pool-to-pool spacing of 21 ft. The reach has an overall thalweg slope of 1%. The surveyed cross sections document the deep incision of the channel into floodplain sediments, with entrenchment ratios of 1.2 and 1.4. Bankfull discharge is estimated between 49 and 55 cfs based on measurements at the riffle cross sections.

Reach 2 extends between Edgewood Road and Hornbeam Road. The reach exhibits pool-riffle morphology, with relatively less variability than other reaches in riffle and pool spacing and depth (pool-to-pool spacing is 58 feet). The surveyed longitudinal profile has an average slope of 1.5%. The reach cross sections are moderately incised with entrenchment ratios between 1.7 and 2.6. Bankfull discharge is estimated between 68 and 72 cfs.

Reach 3 shows the most variability in the longitudinal profile with pool-to-pool spacing ranging from 22 to 172.5 ft. The variability is attributed to the transition between the relatively straight upstream portions (with little riffle-pool morphology) to the downstream meandering reach (with more developed, deeper pools). Appendix D includes a geomorphic sketch of the reach illustrating the transition. Overall channel slope is 0.5%. The reach is moderately incised with entrenchment ratios between 1.7 and 2.4. The bankfull discharge is estimated to be between 47 and 49 cfs.

Reach 4, the downstream-most reach, is bounded by Perry Avenue and Otter Creek downstream. Average pool-to-pool spacing is 46 feet. The overall profile slope is 0.4%. The channel was generally stable with good floodplain access and entrenchment ratios greater than 2.2. The bankfull discharge is estimated between 125 and 157 cfs.

6.2 Particle Size Measurements at Cross Section Locations

Biohabitats characterized the particle-size distribution of stream bed on a reach basis and at selected riffle cross sections. These baseline data can be used to identify future textural changes in the channel bed material, as well as characterize channel competency as it may relate to overall channel stability.

6.2.1 Methods

Particle size distribution of bed material was completed using a modified Wolman pebble count procedure during 2008-2009 and 2010-2011 monitoring periods. Pebble counts at the four reaches were collected during the 2008-2009 monitoring year on the following dates: December

18, 2008, December 23, 2008, December 30, 2008, and January 8, 2009. Pebble counts at the four reaches were collected during the 2010-2011 monitoring year on the following dates: May 27, 2010, July 29, 2010, August 4, 2010, and September 2, 2010. Within each reach, stream bed particle-size distribution was characterized using a Wolman pebble count of 100 particles within the wetted-width of the best representative riffle cross section. A reach-wide 100-particle pebble count was also performed by selecting particles from riffles and pools based on these features' relative abundance (Rosgen, 1996). Particles were taken from the wetted-width, except one particle from every other transect was taken outside the wetted-width but within the bankfull width along the stream bank. The competency of the channel (i.e., the ability of the channel to entrain a particle of a given size) was estimated by comparing the D_{84} (the particle size for which 84% of the grain-size distribution is equal or finer) to the threshold particle size according to the Shield's equation (as presented in Mecklenburg, 2006):

$$D_s = T / ((R_s - R)* g* 0.06)* (304.8)$$

D_s = diameter of sediment particle (mm or ft)

T = shear stress (lb/ft^2 or N/m^2)
R_s = density of sediment (5.15 slugs/ft^3 or 2560 kg/m^3)
R = density of water (1.94 slugs/ft^3 or 1000 kg/m^3)
g = gravitational acceleration (32.2 ft/s^2 or 9.81 m/s^2)
0.06 = Shield's parameter
Conversion Constant 304.8 mm/ft or 1000 mm/m

6.2.2 Summary 2008-2009 Monitoring Year Baseline Particle Size Measurement

Particle size distributions from selected riffle cross sections and reach-wide pebble counts are included in Appendix D. Photographs of the bed material are included with the cross section photographs in Appendix A.

Reach 1 has a median riffle particle size of 10 mm (medium gravel). The median particle size of the reach-wide pebble count is 3 mm (very fine gravel). Given that the threshold particle size estimated as 30 mm is larger than the D_{84} (24 mm), the potential for entrainment of bed materials is high.

Reach 2 has a median riffle particle size of 21 mm (coarse gravel). The reach-wide median particle is 16 mm (medium gravel). Threshold particle size is between 44 and 46 mm, similar to the D_{84} of 43 mm. In the absence of any quantified sediment supply rates, the results suggest that channel bed material would be generally stable with a moderate erosion risk. This is consistent with field observations suggesting that the reach is largely stable.

Reach 3 has a median riffle particle size of 11 mm (medium gravel). The reach-wide median particle is 6 mm (fine gravel). The threshold particle size is estimated at 15 mm, which is smaller than the measured D_{84} of 24 mm. This is corroborated by observations of a generally reach stability and an apparent low potential for bed erosion.

Reach 4 has a median riffle particle size of 3 mm (very fine gravel) and reach-wide median particle of 0.2 mm (fine sand). The threshold particle size is estimated between 15 to 17 mm. Due to the smaller D_{84} (10 mm), the reach has a high potential for erosion. However, given the hydraulic control of Otter Point Creek downstream, the stream bed is generally considered stable. Backwater from Otter Point Creek during elevated stages would generally protect Reach 4 from excessive sediment transport.

6.2.3 Summary 2010-2011 Monitoring Year Baseline Particle Size Measurement

Particle size distributions from selected riffle cross sections and reach-wide pebble counts are included in Appendix D. Photographs of the bed material are included with the cross section photographs in Appendix A.

Reach 1 has a median riffle particle size of 11.6 mm (medium gravel). The median particle size of the reach-wide pebble count is 3.8 mm (very fine gravel).

Reach 2 has a median riffle particle size of 13.2 mm (medium gravel). The reach-wide median particle is 3.5 mm (very fine gravel).

Reach 3 has a median riffle particle size of 13 mm (medium gravel). The reach-wide median particle is 2.7 mm (very fine gravel).

Reach 4 has a median riffle particle size of 1.3 mm (very coarse sand) and reach-wide median particle of 1.6 mm (very coarse sand).

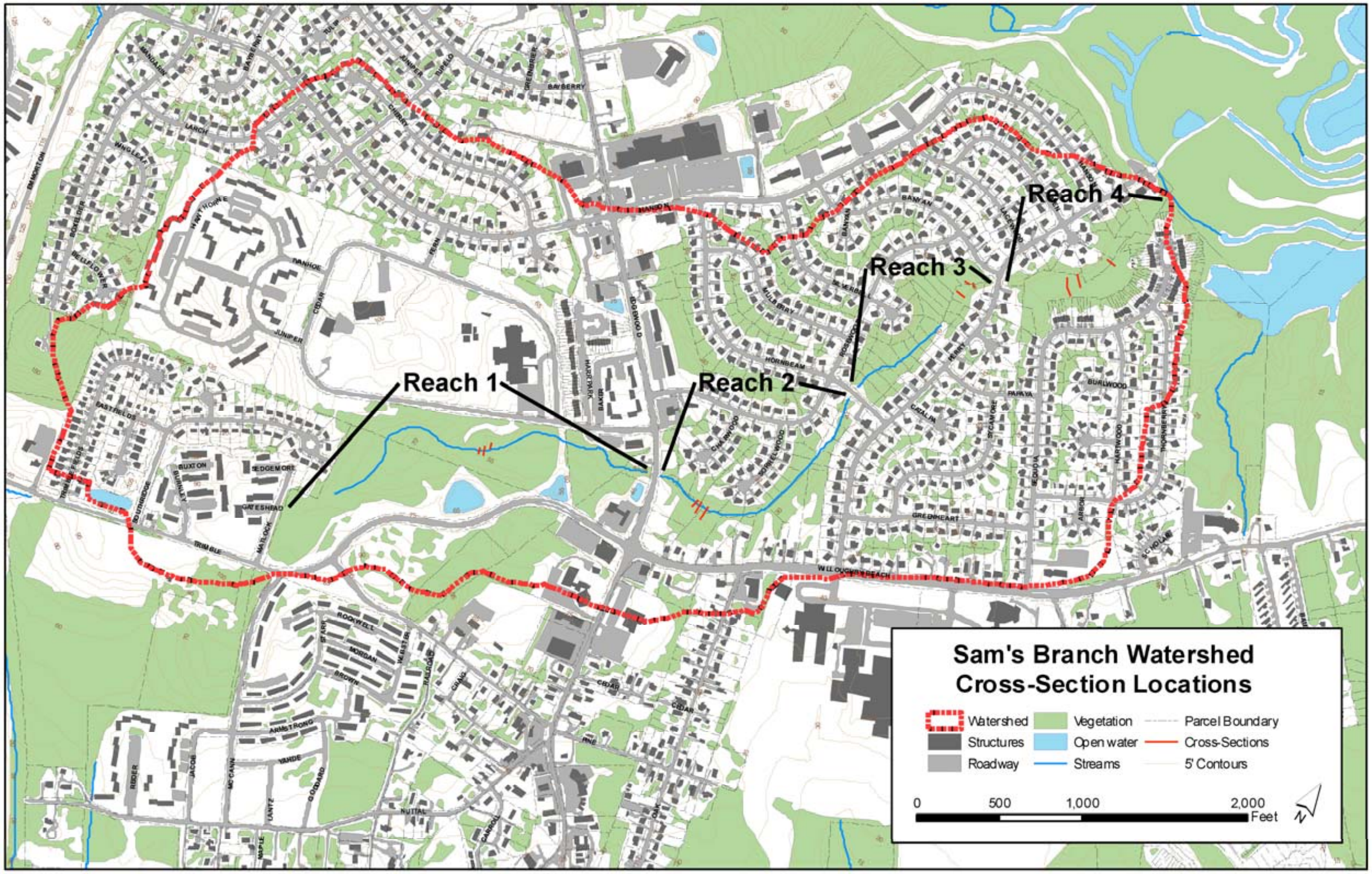


Figure 6-1. Reach Boundaries and Cross Sections Locations for Sam's Branch Tributary

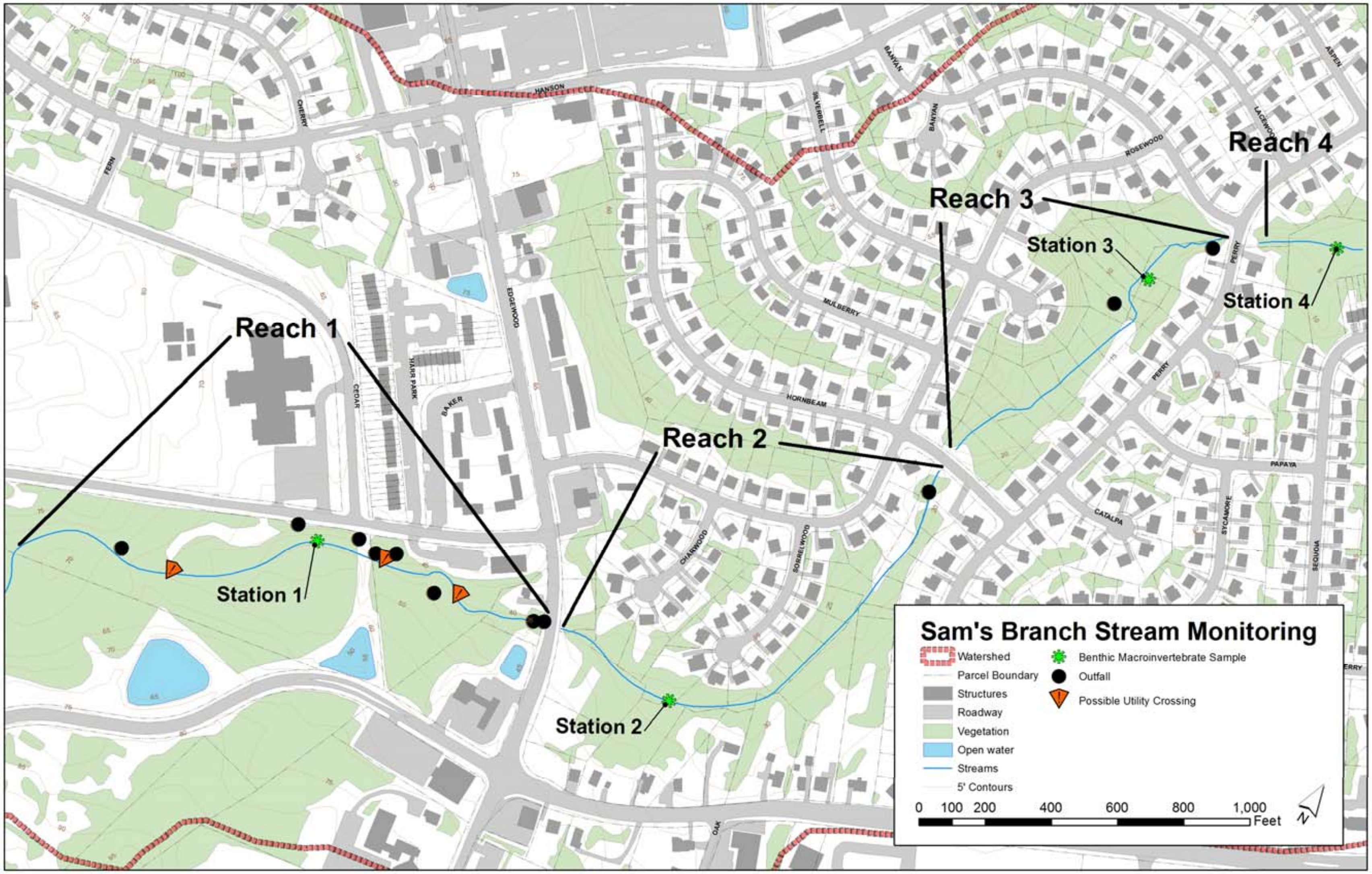


Figure 6-2. Reach Boundaries and Monitoring Locations for Sam's Branch Tributary

7.0 STREAM BIOLOGICAL SURVEY

7.1 Benthic Macroinvertebrates

7.1.1 Methods

During April 2008, Biohabitats collected benthic invertebrate samples at each of the four (4) sampling stations, shown in Figure 6-2, using a D frame net in riffle areas. Collected organisms were identified to the lowest taxon possible and their relative abundance was tabulated.

Station 1 is located approximately 800ft upstream of Edgewood Road parallel to Cedar Drive. Station 2 is approximately 400ft downstream of Edgewood Road. Station 3 is approximately 300ft upstream of Perry Ave and Station 4 is approximately 300ft downstream of Perry Ave. Appendix E contains the field data sheets from the benthic sampling.

7.1.2 Summary 2008-2009 Monitoring Year Baseline Benthic Conditions

On April 24, 2008 the benthic macroinvertebrate community was sampled at each of the four monitoring stations. Invertebrates were sampled in 20 square feet of the best suitable habitat utilizing Maryland Biological Stream Survey protocols (DNR, 2009). Gravel and cobble substrate as well as riparian vegetation root matter and aquatic vegetation was thoroughly disturbed to dislodge invertebrates which were then washed into the net by water current. The contents of the net were washed into a sample jar and preserved with isopropyl alcohol. Samples were evaluated under a microscope with 10X to 30X magnification. Invertebrates were identified to the lowest positive taxonomic level (generally, family or genus) and their relative abundance was noted.

Station 1 yielded 29 organisms comprised of just 4 taxa. Two taxa included chironomid midges (Tanypodinae, and Orthocladiinae), while the other two included a crane fly (*Tipula* sp.) and an aquatic beetle (*Stenelmis* sp.).

Station 2 contained 168 individual organisms from 6 taxa. This included four dipteran taxa and one caddisfly (*Cheumatopsyche* sp.). Of the 115 total organisms collected, 109 were from the family Chironomidae.

Station 3 yielded 69 individual organisms representing 4 taxa. One oligocheate and 68 chironomidae (orthocladiinae and chironomini) were identified.

Station 4 contained only 2 organisms from 2 taxa. This included one chironomid midge (orhocladiinae) and one oligocheate worm.

Based on the dominance by Oligocheate and Chironomidae larvae, the invertebrate community is clearly not representative of a diverse healthy aquatic community. Generally, the dipterans have a short life cycle to take advantage of ephemeral and undesirable habitats. Excess sediment, lack of riffle habitat, and a poor riparian corridor would appear to be the primary factors that influence the poor species composition within the study area.

7.1.3 Summary 2010 – 2011 Monitoring Year Baseline Benthic Conditions

On May 13, 2010 the benthic macroinvertebrate community was sampled at each of the four monitoring stations. Invertebrates were sampled in 20 square feet of the best suitable habitat utilizing Maryland Biological Stream Survey protocols. Gravel and cobble substrate as well as riparian vegetation root matter and aquatic vegetation was thoroughly disturbed to dislodge invertebrates which were then washed into the net by water current. The contents of the net were washed into a sample jar and preserved with isopropyl alcohol. Samples were evaluated under a microscope with 10X to 30X magnification. Invertebrates were identified to the lowest positive taxonomic level (generally, family or genus) and their relative abundance was noted.

Station 1 yielded 127 organisms comprised of just 4 identified taxa, including 123 chironomid midge larvae, 1 crane fly larvae (*Tipula* sp.), 1 black fly larvae (*Simulium* sp.) and 2 unknown adult flies. Of the 127 total organisms collected, 123 were from the family Chironomidae.

Station 2 contained 120 individual organisms from 6 identified taxa, including 90 chironomid midge larvae, 10 black fly larvae (*Simulium* sp.), 9 isopods, 5 oligochaete worms, 3 earthworms, 2 crane fly larvae (*Tipula* sp.), and 1 Trichopteran, 1 Hydropsychid. This included 4 dipteran taxa and 1 caddisfly (*Cheumatopsyche* sp.). Of the 120 total organisms collected, 90 were from the family Chironomidae.

Station 3 yielded 125 individual organisms representing 5 identified taxa, including 117 chironomid midge larvae, 2 black fly larvae (*Simulium* sp.), 3 oligochaete worms, 2 earthworms, and 1 leech. Of the 125 total organisms collected, 117 were from the family Chironomidae.

Station 4 provided 136 organisms from 5 identified taxa. This included 126 chironomid midge larvae, 6 amphipods, 1 black fly larvae (*Simulium* sp.), 2 oligochaete worms and 1 leech (Hirudinea). Of the 136 total organisms collected, 126 were from the family Chironomidae.

Based on the dominance by Chironomidae larvae, with minor contributions of other tolerant taxon, the invertebrate community is clearly not representative of a diverse healthy aquatic community. Generally, the dipterans have a short life cycle to take advantage of ephemeral and undesirable habitats and these sites were sampled just outside the optimal sampling timeframe of March 1 – April 30th.. The numbers of toxics tolerant midge larvae would suggest impacts from road runoff affecting the invertebrate community. Excess sediment, lack of riffle habitat, and a poor riparian corridor would also appear to be factors that influence the poor species composition within the study area.

7.2 Fish Survey

7.2.1 Methods

On July 10th and 17th, 2008, and again on July 22nd and 30th, 2010, Biohabitats sampled a 75-m section of stream for fish at each of the four (4) stream sampling stations (Figure 6-2). Block nets were erected at the ends of each sampling reach and the reach was sampled with a Smith-Root electro-fishing apparatus. Fish were identified by species at the site.

Station 1 is located approximately 800ft upstream of Edgewood Road parallel to Cedar Drive. Station 2 is approximately 400ft downstream of Edgewood Road. Station 3 is approximately 300ft upstream of Perry Ave and Station 4 is approximately 300ft downstream of Perry Ave. Appendix E contains the data sheets from the fish survey.

7.2.2 Summary 2008-2009 Monitoring Year Baseline Fish Survey Conditions

At Station 1, 75 blacknose dace *(Rhinichthys atratulus)* and 66 creek chub *(Semotilus atromaculatus)* were collected. This sampling reach appears to be at the uppermost headwaters of the stream. The entire channel had discernible flow and was sample able, however; no fish were collected from above a significant (>1.5') head-cut in the final 10 meters of the 75m reach.

At Station 2, 191 blacknose dace and 88 creek chub were captured over the 75 m length. Fish mortality was 0% and no anomalies were noted on any of the individuals that were captured.

At Station 3, six species of fish were collected. These included 122 blacknose dace, 185 creek chub, 5 white sucker (*Catostomus commersoni*), 2 creek chubsucker (*Erimyzon oblongus*), 2 American eel (*Anguilla rostrata*) and 1 rosyside dace (*Clinostomus funduloides*).

At Station 4, nine species of fish were collected. These included 76 blacknose dace, 125 creek chub, 23 white sucker, 4 creek chubsucker, 9 American eel, 6 pumpkinseed sunfish (*Lepomis gibbosus*), 2 redbreast sunfish (*Lepomis* auritus), 1 yellow bullhead (*Ameiurus nebulosus*) catfish, and 2 tesselated darter (*Etheostoma* olmstedi). The higher number of species at this station is likely due to the combination of improved instream habitat along this reach including well formed riffle pool complexes, adequate riparian buffer, and the proximity and exchange with Otter Point Creek. Along this reach, there are no obstructions such as roads or culverts and fish can migrate freely between the two streams.

7.2.3 Summary 2010-2011 Monitoring Year Baseline Fish Survey Conditions

On July 22 and 30, 2010, the Sam's Branch fish community composition was evaluated using a Smith Root Model 12 B Battery Operated Backpack Electrofisher. The voltage on the electrofishing equipment for all stations was adjusted to 200 and 300 volts with the output waveform set to J-6.

At Station 1, 57 blacknose dace *(Rhinichthys atratulus)* and 38 creek chub *(Semotilus atromaculatus)* were collected. This sampling reach appears to be at the uppermost headwaters of the stream. The entire channel had discernible flow of 1 to 3 inches in depth and was sample able.

At Station 2, 196 creek chub, 144 blacknose dace, and 4 longnose dace (*Rhinichthys cataractae*) were captured over the 75 m length. Within the 75 m length, the channel depth ranged between 2 to 7 inches.

At Station 3, seven species of fish were collected. These included 420 creek chub, 68 blacknose dace, 5 white sucker (*Catostomus commersoni*), 5 green sunfish (*Lepomis cyanellus*), 4 American eel (*Anguilla rostrata*), 2 creek chubsucker (*Erimyzon oblongus*), and 1 eastern mudminnow (*Umbra pygmaea*). The channel depth ranged between 2 to 8 inches along the 75 m length.

At Station 4, seventeen species of fish were collected. These included 313 creek chub, 44 blacknose dace, 77 white sucker (*Catostomus commersoni*), 19 brown bullhead catfish (*Ameiurus nebulosus*), 13 American eel, 13 pumpkinseed sunfish (*Lepomis gibbosus*), 12 creek chubsucker, 6 bluntnose minnow (*Pimephales notatus*), 3 green sunfish, 3 largemouth bass (*Micropterus salmoides*), 3 spottail shiner (*Notropis hudsonius*), 3 eastern mudminnow, 2 redbreast sunfish (*Lepomis* auritus), 2 tesselated darter (*Etheostoma* olmstedi), 2 smallmouth bass (*Micropterus dolomieu*), 2 Eastern mosquitofish (*Gambusia holbrooki*), and 2 banded killifish (*Fundulus diaphanus*). The higher number of species at this station compared to the other three stations may be due to its close proximity to the confluence with Otter Point Creek, a larger stream, and the lack of obstructions such as roads or culverts which enables fish to migrate feely between the two streams. Within the 75 m length, the channel depth ranged between 2 to 10 inches.

Overall, fish mortality was 0% and no anomalies were noted on any of the individuals that were captured.

7.2.4 Overall Summary Fish Survey Conditions

While the number of species sampled increased from the 2008-2009 monitoring year to the 2010-2011 monitoring year at stations 2, 3, and 4, the fish community composition is generally poor. Several factors can be seen as contributing to the generally poor fish community composition in the sampling reaches. Excessive sedimentation in the lower reaches would reduce reproductive success, while a poor macroinvertebrate community would force fish to populate other stream reaches where food resources are more plentiful. Fish barriers throughout the project site include vertical drops in the stream elevation, most notably at the Edgewood Road and Perry Avenue culverts which limit fish passage between Stations 1 through 4.

Limited physiochemical parameters (dissolved oxygen, pH, water temperature, and conductivity) were observed during the 2008-2009 and 2010-2011 fish survey sampling events. The preliminary indication is that water quality is not a significant limiting factor to the fish and macroinvertebrate communities. The chemical parameters were within accepted ranges during both monitoring years.

These initial results indicate that habitat, fish blockages, and reduced baseflow due to watershed development are limiting the fish and macroinvertebrate communities in the Sam's Branch tributary.

8.0 STREAM WATER QUANTITY AND QUALITY MONITORING

8.1 Water Quantity Monitoring

Biohabitats installed and maintained two (2) Solinst © stage loggers (shown in Figures 8-1 and 8-2) with temperature measurement, and one (1) Solinst © barometric pressure logger with air temperature recorder at an upstream and downstream location along the length of the study area for establishing baseline water quantity conditions. Biohabitats also established and maintained an Infinity © rain gauge at the site. Throughout the monitoring period (November 2008 – October 2011), Biohabitats monitored and maintained the equipment to ensure reliable and consistent results. The flow logger with temperature measurement, the barometric pressure logger with air temperature, and the rain gage monitor continuously and were downloaded approximately every 80 days.

Rain gage data has been recorded and downloaded from the site from through November of 2008 through October 2011. The rainfall record is displayed in graphs representing 30- minute rainfall intensities in Appendix F. Raw data was analyzed for larger storm events to determine cumulative totals for discussion purposes in the summary below. Gaps in data occurred on two occasions from 12/18/08-1/9/09 and 4/30/10 – 5/10/10 over the monitoring period.

Biohabitats established a stage discharge rating curve using the stage data collected over the course of the monitoring period. A combination of hand held weir for low flow measurements and Pygmy current velocity meter for higher flow were used to measure flow during a series of dry-weather and storm events at two, pre-established cross sections. An established rating curve for the cross sections was used to calculate discharge from the continuous stage recordings.

8.1.1 Methods

The stage loggers were employed to monitor the stage height continuously over time. Since these loggers use absolute pressure transducers to monitor stage, the results were corrected for barometric pressure. Figures 6-1 and 6-2 illustrate the location of the stage loggers. Manual measurements were used to establish a relationship between stage and discharge for the specific cross sections using the USGS cross section method (USGS, 1982). Approximately 99 total discharge points were taken at two cross sections during 7 different flow conditions to establish the curve. A power curve regression equation was fitted to the data (see Appendix F).

Figure 8-1. Photo from the Reach 2 stage logger (April 09, 2009). The photo shows field personnel during water quality sampling using the handheld meter.

Figure 8-2. Photo from the Reach 4 stage logger. The photo shows the Reach 4 cross section with some debris build-up after the August 28, 2009 event (September 09, 2009).

8.1.2 Summary of Water Quantity Baseline Conditions

Appendix F contains rain gage data as cumulative total in inches over each year of record and 30-minute rainfall intensities in inches for each year of record. In summary, the total recorded rainfall for 2009 beginning January 5, 2009 through December 31, 2009 was 39.92 inches of rainfall. The total recorded rainfall for 2010 beginning January 1, 2010 through December 31, 2010 (with a loss of data from 4/30/10 through 5/10/10) was 39.93 inches of rainfall. The total recorded rainfall for 2011 beginning January 1, 2011 through October 21, 2011 was 41.96 inches of rainfall.

Individual significant rainfall totals and intensities were calculated directly from raw data. During 2011, on August 27 through 28th for a duration of 20.5 hours a total of 5.51" of rainfall was recorded, and from March 9 – 11, for a duration of 26.5 hours a total of 2.4" of rainfall was recorded. During 2010, on September 30 - October 1 for a duration of 25.5 hours a total of 9.03" of rainfall was recorded, and on March 13 for a duration of 16 hours a total of 1.6" of rainfall was recorded. During 2009, on December 8 – 9 for a duration of 9.5 hours a total of 1.92" of rainfall was recorded.

The rating curve analysis resulted in best-fit lines with coefficients of determination (R^2) of 0.80 and 0.83 for the Reach 2 and Reach 4 stage loggers, respectively. These regression equations should yield accurate measurements of flow between baseflow and the maximum discharge recorded which occurred at 0.9-foot and 2.9-foot for Reach 2 and Reach 4 cross sections, respectively. Discharge calculated at stages greater than these maximum measurements are approximations only based on the extrapolated curves.

Recorded discharge is shown in Appendix F on Streamflow Monitoring Graphs. Observation of the discharge hydrograph illustrates a flashy hydrologic system, where by the discharge quickly rises in response to rainfall, but quickly diminishes to baseflow conditions. Peak discharges were recorded of over 100 cfs at both stations on September 30 through October 1, 2010 with a cumulative rainfall intensity of 9.03 inches of rainfall over 25.5 hours, and a peak, 30-minute rainfall intensity of 1.66 in/hr and August 27th and 28th , 2011 with a cumulative rainfall intensity of 5.51 inches of rainfall over 20.5 hours, and a peak rainfall intensity of 0.35 in/hr.

8.2 Water Quality Monitoring

During the monitoring period, Biohabitats collected water quality samples at two (2) locations along the length of the study area. Monitoring of the stream included one (1) base flow and two (2) flow-weighted stormwater samples seasonally at each of the two (2) locations resulting in a total of 12 successful samples, for the following parameters:

- Total suspended solids (TSS)
- Alkalinity, SO4, chloride and hardness
- Total Kjedahl Nitrogen, Nitrate
- Total Phosphorus, Ortho Phosphorus
- Metals (Cu, Zn, Pb, Ca, Cd, Ni, Hg)

- Biochemical Oxygen Demand (BOD_5)
- Petroleum Hydrocarbons
- Herbicides/Pesticides
- Fecal Coliform/ E. Coli

Water samples were collected manually at each of the two (2) monitoring stations. The water samples were sent to a qualified laboratory for analysis. During the baseflow sample collection we also measured the physicochemical conditions (conductivity, pH, and dissolved oxygen) of the water using a hand held instrument.

8.2.1 Methods

Manual water samples were taken at the two monitoring cross sections facing upstream, at the area of maximum flow, within the middle of the water column, being careful to kick up as little sediment as possible from the stream bottom. A table of lab methods and detection limits is included in the water quality results presented in Appendix F. Depending on the analyte, different sampling techniques were employed:

Fecal and total coliform and E. coli samples were collected by opening the sample bottle below the water surface to allow some water to flow in. The amount of water in the bottle was checked by closing the bottle and raising it above the water surface in order to see the approximate volume. Exposure to ambient air was limited as much as possible. After 100 ml was collected, leaving a small headspace in the bottle, the bottle was capped and locked.

For TPH or Oil and grease samples were collected in glass, wide-mouth 1-liter bottle . The sample bottle was held 1/2 in and 1/2 out to maximize the surface floating material that enters the bottle. Since oil and grease and TPH tend to float on water surfaces, the bottle mouth should be immersed just halfway into the water, so that the maximum surface area of the stream (on which floats the analyte) enters the bottle.

The remaining analytes ("general water quality parameters") were collected by immersing the open bottle in the water until the container is filled.

Baseflow sampling resulted in one sample at one time per cross section. For storm events, we collected one flow-weighted sample (rising, peak and receding limb of the hydrograph) at each of the 2 logger locations. Samples were composited at the end of the storm, with the volume of sample weighted by the discharge measured at the time of sampling.

8.2.2 Summary of Water Quality Baseline Conditions

Sam's Branch Tributary is designated as Use I, Water Contact Recreation and Protection of Aquatic Life as outlined in Code of Maryland Regulations 26.08.02 Water Quality. As presented in Tables 8-1 through 8-5 below, the water quality parameters of alkalinity, BOD, nutrients, sulfate, hardness, and TSS did not result in abnormal levels. The pH and dissolved oxygen data collected in-situ with a handheld device during the dry and wet weather water quality sampling, and the benthic and fisheries data collection during dry weather are presented in Table 8-6. This data showed dissolved oxygen concentrations exceeding the state minimum standard of 5 mg/l for aquatic life for all measurements taken and in some cases far exceeding the minimum standard (e.g., 12.2 mg/l at Reach 4 on 5/13/10 and 11.3 mg/l at Reach 1 on 5/13/10). High concentrations of dissolved solids can cause water balance problems for aquatic organisms and decrease dissolved oxygen levels. Along Sam's Branch conductivity was measured during sampling efforts. Currently, there are no specific numeric criteria in Maryland that quantify the impact of chlorides and conductivity on the aquatic health of non-tidal stream systems. However, the levels measured along Sam's Branch are normal with a range from 108 to 347 ppm (e.g., 347 ppm at Reach 4 on 5/13/10 and 212 ppm at Reach 1) when compared to other streams with similar geology and land use, and not considered to be levels for aquatic life in other systems. Slightly acidic pH levels were measured during sampling in late winter and early spring (e.g., 5.96 at Reach 2 on 5/13/10 and 5.83 at Reach 3 on 5/13/10) when compared with the state standard range of pH values falling between 6.5 and 8.5 for protection of aquatic life. Generally, TSS was higher upstream at Reach 2 on average than downstream at Reach 4. The only elevated levels of TSS occurred during the 4/20/09 storm flows. This is in part due to road culvert construction at Edgewood Road, directly upstream of the Reach 2 sample location and the channel instability along the upstream portion of the study area.

The results from the bacterial analysis show elevated levels of total coliforms at both sampling locations. Low levels of E. coli were also found at each location. This could be a result of natural background due to wildlife, or anthropogenic input due to sewer main leaks or failing septic systems. Further source tracking of bacteria is the only method to determine if the bacteria in the stream resulted from natural or anthropogenic inputs.

Elevated levels of diesel range organics were found at both sample locations. One sample during dry weather at Reach 2 also revealed gasoline range organics. Diesel range organics include automotive diesel, kerosene, jet fuel, light oil and home heating oil. Gasoline range organics include automotive gasoline and mineral spirits and Stoddard solvents. Based on the land use, the source is most likely due to road runoff during storm events. However, the dry weather sample also revealed diesel range organics, which may be associated with the road culvert construction at Edgewood Road, and heavy equipment access to the stream. See Appendix F for additional graphical summary of water quality results.

No pesticides were detected during either the baseflow or storm sampling.

Copper and nickel levels are evident on the 3/10/11 sampling date at both Reach 2 and Reach 4, and zinc was evident at both stations on several sampling dates. Cadmium, copper, cobalt, iron, nickel, lead and zinc are deposited into the environment by vehicle exhaust, brake linings, and tire and engine wear. Accumulation on roads is washed into storm drains during rainfall events. Some copper comes from architectural uses and treated wood, and a primary source is brake pads. Accumulation of these heavy metals on the roadway during the relative dry periods in the months preceding this sampling event are the likely source of the high concentration of these metals during this sampling event. Galvanized metal rooftops, gutters and downspouts, and use of moss killer may also be a source of the zinc in the water quality samples taken along Sam's Branch.

Table 8-1. General Water Chemistry, TSS, Nutrients and Bacteria Results

			Alkalinity, Total (CaCO3)	Total Hardness	TSS	Nitrate	Nitrogen, Kjeldahl	Phosphate, Ortho	Phosphorus, Total	BOD, 5 day	Total Coliforms	E-Coli	Fecal Coliforms	Sulfate (gravimetric) In Water
Date/Time	Site	Condition	mg/L	mg/L	mg/L	mg/L as N	mg/L	mg/L	mg/L	mg/L	MPN/ 100mL	MPN/ 100mL		mg/L
3/26/2009 17:00	Reach 2	Stormflow	28	63	28	**	**	**	**	3.4	900	280		18
4/9/2009 11:00	Reach 2	Baseflow	26	62	**	**	**	**	**	**	30	4		2.4
4/20/2009 15:50	Reach 2	Stormflow	16	25	167.6	**	1.3	**	0.21	41*	1600	34		**
6/1/2010 13:00	Reach 2	Baseflow	23	64	**	1.6	**	**	**	**	16000	230		23
8/18/2010 9:30	Reach 2	Stormflow	32	44	5.2	1.3	0.75	19	0.1	4.6		1700	16000	14
10/14/2010 0:00	Reach 2	Stormflow	27	44	36	2.2	55	0.05	0.08	14		50000		13
3/10/2011 9:30	Reach 2	Stormflow	19	30	27.6	**	**	**	0.1	**		5000		**
3/26/2009 17:30	Reach 4	Stormflow	38	55	31	**	**	**	0.12	5.9	1600*	14		12
4/9/2009 11:00	Reach 4	Baseflow	48	80	**	**	**	**	**	**	30	11		3.7
4/20/2009 15:50	Reach 4	Stormflow	21	26	117.6	**	**	**	0.33	3.9	1600*	17		**
6/1/2010 12:00	Reach 4	Baseflow	36	66	**	1.2	**	**	0.1	**	16000*	800		24
8/18/2010 9:30	Reach 4	Stormflow	33	48	8.8	1.2	1.9	0.06	**	5.1		5000	90000	11
10/14/2010 0:00	Reach 4	Stormflow	28	45	37.5	1.7	16	0.05	0.07	8.9		160000		10**
3/10/2011 9:30	Reach 4	Stormflow	18	28	24	**	**	0.07	0.2	**		1100		**

*Exceeds maximum detection limit
**Below minimum detection limit

Table 8-2. Petroleum and Metals Content Results

			Diesel Range Organics	Gasoline Range Organics	Tot.Petroleum Hydrocarbons	Cadmium	Chromium	Copper	Lead	Nickel	Silver	Zinc
Date/Time	Site	Condition	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
3/26/2009 17:00	Reach 2	Stormflow	0.26	**	**	**	**	**	**	**	**	**
4/9/2009 11:00	Reach 2	Baseflow	0.87	0.05	**	**	**	**	**	**	**	**
4/20/2009 15:50	Reach 2	Stormflow	1.66	**	**	**	**	**	**	**	**	**
6/1/2010 13:00	Reach 2	Baseflow	8.23	**	**	**	**	**	**	**	**	0.031
8/18/2010 9:30	Reach 2	Stormflow	3.34	**	**	**	**	**	**	**	**	0.045
3/10/2011 9:30	Reach 2	Stormflow	**	**	11	**	**	0.37	**	0.29	**	0.024
3/26/2009 17:30	Reach 4	Stormflow	0.17	**	**	**	**	**	**	**	**	**
4/9/2009 11:00	Reach 4	Baseflow	0.91	**	**	**	**	**	**	**	**	**
4/20/2009 15:50	Reach 4	Stormflow	**	**	**	**	**	**	**	**	**	0.056
6/1/2010 12:00	Reach 4	Baseflow	8.16	**	**	**	**	**	**	**	**	0.039
8/18/2010 9:30	Reach 4	Stormflow	4.27	**	5	**	**	**	**	**	**	0.035
3/10/2011 9:30	Reach 4	Stormflow	**	**	**	**	**	0.41	**	0.26	**	0.017

*Exceeds maximum detection limit

Table 8-3. Pesticide Testing Results

			4,4'-DDD	4,4'-DDE	4,4'-DDT	Aldrin	Alpha-BHC	Beta-BHC	Chlordane	Delta-BHC	Dieldrin	Endosulfan I	Endosulfan II	Endosulfan Sulfate	Endrin	Endrin Aldehyde
Date/Time	Site	Condition	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
3/26/2009 17:00	Reach 2	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**	**	**
4/9/2009 11:00	Reach 2	Baseflow	**	**	**	**	**	**	**	**	**	**	**	**	**	**
4/20/2009 15:50	Reach 2	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**	**	**
6/1/2010 13:00	Reach 2	Baseflow	**	**	**	**	**	**	**	**	**	**	**	**	**	**
8/18/2010 9:30	Reach 2	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**	**	**
3/10/2011 9:30	Reach 2	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**	**	**
3/26/2009 17:30	Reach 4	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**	**	**
4/9/2009 11:00	Reach 4	Baseflow	**	**	**	**	**	**	**	**	**	**	**	**	**	**
4/20/2009 15:50	Reach 4	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**	**	**
6/1/2010 12:00	Reach 4	Baseflow	**	**	**	**	**	**	**	**	**	**	**	**	**	**
8/18/2010 9:30	Reach 4	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**	**	**
3/10/2011 9:30	Reach 4	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**	**	**

*Exceeds maximum detection limit
**Below minimum detection limit

Table 8-4. Pesticide Testing Results (cont'd)

			Gamma-BHC	Heptachlor	Heptachlor Epoxide	Metjhoxychlor	PCB-1016	PCB-1221	PCB-1232	PCB-1242	PCB-1248	PCB-1254	PCB-1260	Toxaphene
Date/Time	Site	Condition	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
3/26/2009 17:00	Reach 2	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**
4/9/2009 11:00	Reach 2	Baseflow	**	**	**	**	**	**	**	**	**	**	**	**
4/20/2009 15:50	Reach 2	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**
6/1/2010 13:00	Reach 2	Baseflow	**	**	**	**	***	***	***	***	***	***	***	**
8/18/2010 9:30	Reach 2	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**
3/10/2011 9:30	Reach 2	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**
3/26/2009 17:30	Reach 4	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**
4/9/2009 11:00	Reach 4	Baseflow	**	**	**	**	**	**	**	**	**	**	**	**
4/20/2009 15:50	Reach 4	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**
6/1/2010 12:00	Reach 4	Baseflow	**	**	**	**	***	***	***	***	***	***	***	**
8/18/2010 9:30	Reach 4	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**
3/10/2011 9:30	Reach 4	Stormflow	**	**	**	**	**	**	**	**	**	**	**	**

*Exceeds maximum detection limit
**Below minimum detection limit
*** No PCBs were analyzed for the 6/1/10 samples

Table 8-5. Herbicide and Surrogate Testing Results

			2,4,5-TP	2,4-D	DCAA (Surr)	DCB (Surr)	TCMX (Surr)	C-28 Surrogate Standard (Surr)
Date/Time	Site	Condition	ug/L	ug/L	%	%	%	%
3/26/2009 17:00	Reach 2	Stormflow	**	**	76.4	88.7	115	93
4/9/2009 11:00	Reach 2	Baseflow	**	**	91.1	69.5	87.6	90
4/20/2009 15:50	Reach 2	Stormflow	**	**	104	93.3	95.8	110
6/1/2010 13:00	Reach 2	Baseflow	**	**	85.6	98.1	104	92
8/18/2010 9:30	Reach 2	Stormflow	**	**	104	94.4	99.8	93
3/10/2011 9:30	Reach 2	Stormflow	**	**	131	97.5	99.6	110
3/26/2009 17:30	Reach 4	Stormflow	**	**	82.9	100	110	91
4/9/2009 11:00	Reach 4	Baseflow	**	**	77.4	74.3	91.9	88
4/20/2009 15:50	Reach 4	Stormflow	**	**	85.1	101	107	**
6/1/2010 12:00	Reach 4	Baseflow	**	**	89.6	101	110	96
8/18/2010 9:30	Reach 4	Stormflow	**	**	96.8	89.1	96.5	100
3/10/2011 9:30	Reach 4	Stormflow	**	**	131	98.1	102	100

*Exceeds maximum detection limit
**Below minimum detection limit

Table 8-6. In-stream Parameters Measured with Handheld Device

DATE	LOCATION	CONDITION	FLOW	pH	DO	DO	TEMP	CONDUCTIVITY
xx/xx/xxxx	XS	baseflow/storm	cfs	pH	ppm	% Sat	deg C	uS
7/17/2008	XS 1	storm	11.17	7.29	8.02	81.1	15	115
7/17/2008	XS 2	storm	2.59	7.12	7.47	71.7	13	297
7/17/2008	XS 3	storm	1.45	7.32	7.68	76.2	14.6	141
7/17/2008	XS 4	storm	1.05	7.02	8.92	88.5	14.9	147
4/9/2009	XS 2	storm	1.02	7.06	9.14	91.4	15.1	157
4/9/2009	XS 4	storm	0.72	7.01	9.43	92.3	13.9	275
5/13/2010	XS 1	baseflow	0.44	6.84	11.31	105	12.1	212
5/13/2010	XS 2	baseflow	0.41	5.96	6.95	78.7	21.5	327
5/13/2010	XS 3	baseflow	0.29	5.83	8.24	89.4	19.6	295
5/13/2010	XS 4	baseflow	0.28	6.79	12.18	108	11.2	347
6/1/2010	XS 2	benthic/fish		6.58	9.8	91	12.4	273
6/1/2010	XS 4	benthic/fish		7.18	10.1	97	13.2	291
10/14/2010	XS 2	benthic/fish		7.28	9.68	93.4	13.7	309
10/14/2010	XS 2	benthic/fish		7.12	8.94	86.9	14.1	313
10/14/2010	XS 2	benthic/fish		6.75	7.4		21.1	212
10/14/2010	XS 4	benthic/fish		7.66	9.5		21.4	262
10/14/2010	XS 4	benthic/fish		7.4	6.76		23.5	268
10/14/2010	XS 4	benthic/fish		7.5	7.2		23.6	269
3/10/2011	XS 2	storm	14.65	5.58	12.28	102.6	7.7	120
3/10/2011	XS 2	storm	16.5	5.81	13.02	111.2	8.5	114
3/10/2011	XS 4	storm	32.47	5.85	11.62	100.3	9	108
3/10/2011	XS 4	storm	9.73	5.72	13.41	113.3	7.8	127
3/10/2011	XS 4	storm	7.09	5.55	13.11	111.7	8.6	133

8.3 Habitat Assessment

8.3.1 Methods

Biohabitats conducted a habitat assessment of each reach for the 2010-2011monitoring year during May 2010, a visual assessment of in-stream and riparian habitat quality was conducted for each reach. The results were recorded on the Habitat Assessment Field Data Sheet for low gradient streams. The assessment was performed as described in the Rapid Bioassessment Protocols (RBP) for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, Second Edition (Barbour et.al, 1999). In July 2010 during the Summer Index Period, a habitat assessment of the stream's physical variables was conducted in accordance to the Maryland Biological Stream Survey (MBSS) Sampling Manual (DNR,2009). This data was also collected in May 2010 during the benthic sampling. The results were recorded on the MBSS Summer Habitat Data Sheet. All data and data sheets collected are include in Appendix E . Both habitat assessments were conducted within the along the entire length of the long profile survey for reaches 1 thru 4.

8.3.2 Summary of Habitat Assessment

The results of the habitats assessment for low gradient stream concluded that overall habitat value decreased in the following order: Reach 4, Reach 1, and Reach 3, to Reach 2. In comparison to the other three reaches, reach 4 has moderately stable banks with 80-90% of the streambanks covered by vegetation and a minimally human-impacted riparian zone. These in-stream and riparian habitat qualities of reach 4 contribute to its relatively high total score (99). Similar to reach 4, reach 1 has also experienced minimal human impact; however, it has a slightly lower total score due to moderately unstable banks and 60% vegetation protection on the banks. Reaches 3 and 2 have the lowest total scores, respectively, due to channel alteration by past activities to straighten the stream and human activities within riparian vegetative zone. Overall, human impacts to both the in-stream and riparian habitats had the greatest negative effect on the overall habitat value.

Table 8-7. RBP Habitat Assessment Results for Sam's Branch by Reach (May 2010)

Habitat Assessment - Low Gradient Streams	Reach 1	Reach 2	Reach 3	Reach 4
Epifaunal Substrate/Available Cover	6 Marginal	8 Marginal	8 Marginal	7 Marginal
Pool Substrate Characterization	9 Marginal	2 Poor	7 Marginal	6 Marginal
Pool Variability	5 Poor	1 Poor	7 Marginal	7 Marginal
Sediment Deposition	8 Marginal	8 Marginal	6 Marginal	4 Poor
Channel Flow	6	15	10	7

Habitat Assessment - Low Gradient Streams	Reach 1	Reach 2	Reach 3	Reach 4
Status	Marginal	Suboptimal	Marginal	Marginal
Channel Alteration	18 Optimal	5 Poor	11 Suboptimal	16 Optimal
Channel Sinuosity	11 Suboptimal	5 Poor	7 Marginal	8 Marginal
Bank Stabilization - Left Bank	3 Poor	6 Marginal	5 Poor	8 Marginal
Bank Stabilization - Right Bank	3 Poor	6 Marginal	6 Marginal	8 Marginal
Vegetative Protection - Left Bank	4 Poor	6 Marginal	5 Poor	8 Marginal
Vegetative Protection - Right Bank	4 Poor	6 Marginal	4 Poor	7 Marginal
Riparian Vegetative Zone Width - Left Bank	10 Marginal	1 Poor	4 Poor	8 Marginal
Riparian Vegetative Zone Width - Right Bank	10 Marginal	3 Poor	1 Poor	5 Poor
Total Score	**97**	**72**	**81**	**99**

8.4 Bank Erosion Hazard Index (BEHI)

8.4.1 Methods

For the 2010-2011 monitoring year, Biohabitats evaluated the BEHI on the left bank and the right bank along the entire length of the longitudinal profile survey for reaches 1 thru 4. The BEHI was conducted as described in Rosgen's River Stability Field Guide (2008). BEHI evaluates the susceptibility of stream banks to erosion based on multiple variables that relate to erosional processes. There are seven categories used to calculate the erosion prediction model or BEHI. These categories include: study bank height-bankfull height ratio, root depth/study bank height (root depth ratio), weighted root density, bank angle, surface protection, bank material, and stratification of bank material. Each of these categories were measured or estimated in the field. The field measurements were then used to calculate a value. The values for each category were then assigned an index value or BEHI score. Finally, a total BEHI score was calculated by adding all the categories together and a BEHI adjective rating was assigned. Linear lengths of bank with similar measurements or estimates for a BEHI category were grouped together.

8.4.2 Summary of BEHI

The susceptibility that a bank has to erosion is evaluated using the BEHI model. The model uses several variables to relate multiple erosional processes to ultimately obtain an overall BEHI rating of erosional risk for the stream bank. The individual BEHI rating for each variable and overall BEHI rating can range from very low to extreme.

The left bank (facing downstream) at Reach 1 has an average overall BEHI rating of high. The left bank can be characterized as having a high bank height to bankfull height ratio, and bank stratified and dominated by sandy textures. These characteristics contributed to the extreme and high individual BEHI ratings for study bank height/bankfull height and the bank material adjustment which ultimately resulted in a high overall BEHI rating. In comparison to the left bank, the majority of the right bank was more unstable with an overall BEHI rating of extreme. This is largely a result of the right bank having a higher bank heights and sandy material.

The left bank at Reach 2 has an average overall BEHI rating of high. The left bank can be characterized as having a high bank height to bankfull height ratio, a low root density, and a bank dominated by sandy textures. These characteristics contributed to the extreme and very high individual BEHI ratings for study bank height/bankfull height and weighted root density and the bank material adjustment which ultimately resulted in a high overall BEHI rating. In comparison to the left bank, the right bank was relatively more stable with an overall BEHI rating of moderate. This is largely a result of the right bank having a higher weighted root density.

Reach 3 has an average overall BEHI rating ranging from moderate to high on the left bank and high on the right bank. The rating range assigned to the left bank reflects the high bank height to bankfull height ratio and presence of stratification observed throughout the reach and the low root density, 80% bank angle, and sandy bank material present in only a portion of the reach. The high BEHI rating for the right bank is a result of a high bank height to bankfull height ratio, 80-90% bank angles, and the presence of sand and stratified layers in the bank.

Both the left and right bank at Reach 4 has an overall BEHI rating of high. The rating is contributed by the high bank height to bankfull height ratio, 75-80% bank angles, and the presence of a gravel or composite matrix and stratified layers in the banks.

Table 8-8. Bank Erosion Hazard Index (BEHI) Results for Sam's Branch by Reach

Reach	1	1	1	2	2	2	2	2	2
Stationing (ft)	0 to 195	0 to 30	30 - 195	0 to 18	18 to 50	50 to 227	0 to 36	36 to 158	158 to 227
Left Bank/Right Bank	Left Bank	Right Bank	Right Bank	Left Bank	Left Bank	Left Bank	Right Bank	Right Bank	Right Bank
	BEHI Score	BEHI Score	BEHI Score	BEHI Score	BEHI Score	BEHI Score	BEHI Score	BEHI Score	BEHI Score
Study Bank Height/ Bankfull Height	8.5	10	10	10	10	8.6	8.6	10	10
Root Depth/Study Bank Height	2	4	6	5.9	10	3.5	1	1.7	2.7
Weighted Root Density	5	8.5	9	8.5	10	5.2	1.9	3.4	3.8
Bank Angle	8	4	3	3	3.3	3	3.8	2.5	3
Surface Protection	4.5	7.5	7	5.2	1	1.8	1.9	1.9	1.9
Bank Material Adjustment	5	0	10	10	0	10	10	10	10
Stratification Adjustment	5	0	5	0	0	0	0	0	0
Total BEHI Score	38	34	50	42.6	34.3	32.1	27.2	29.5	31.4
Adjective Rating	High	High	Extreme	Very High	High	High	Moderate	Moderate	High

Reach	3	3	3	3	3	4	4	4
Stationing (ft)	0 to 153	153 to 275	0 to 145	145 to 211	211 to 275	0 to 330	0 to 160	160 to 330
Left Bank/Right Bank	Left Bank	Left Bank	Right Bank	Right Bank	Right Bank	Left Bank	Right Bank	Right Bank
	BEHI Score	BEHI Score	BEHI Score	BEHI Score	BEHI Score	BEHI Score	BEHI Score	BEHI Score
Study Bank Height/ Bankfull Height	10	10	10	10	10	10	10	10
Root Depth/Study Bank Height	3	1	1	1	2.2	1	1	1
Weighted Root Density	6.1	3	1.7	1.5	1.7	1.5	1.7	3.5
Bank Angle	3.5	5.9	5.9	3	7.9	5.9	5.9	5.5
Surface Protection	1.5	3.5	1.5	1	1	1	2.7	2.7
Bank Material Adjustment	0	5	0	10	10	8	5	8
Stratification Adjustment	5	5	5	5	5	5	5	5
Total BEHI Score	29.1	33.4	25.1	31.5	37.8	32.4	31.3	35.7
Adjective Rating	Moderate	High	Moderate	High	High	High	High	High

Adjective Rating	Very Low	Low	Moderate	High	Very High	Extreme
Total Score	5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

9.0 STREAM CORRIDOR RESTORATION OPPORTUNITES

Biohabitats conducted a field walk of the entire site in May 2010 and in February of 2011 to identify restoration opportunities along each of the four reaches of the Sam's Branch study area. Presented below is a description of potential restoration opportunities found along each of the four reaches of Sam's Branch from the headwater area downstream of Southridge Drive to the confluence with Otter Point Creek. Figures 9-1 through 9-9 Restoration Opportunities Maps provides a graphical depiction of the approximate locations, lengths and spatial coverage of the potential restoration opportunities identified through field investigation.

Restoration recommendations were given a level of priority based on assumptions regarding cost, level of benefit, and land ownership. The prioritization was qualitative and based on a relative comparison across the range of opportunities recommended within the study area. For example, the cost of Riparian Buffer Enhancement would be low in cost when compared to the cost for the design and installation of Regenerative Stream Channel (high cost). The assumptions surrounding the level of benefit include the overall pollutant reduction benefits to the subwatershed gained by the implementation of the opportunity. Land ownership is based on the source of ownership for the actual area of implementation. This determination is a consideration in the overall ranking based on the assumption that public lands should be a higher priority because of factors including the lack of necessity and expense associated with easements, access relates issues, potential disagreement on behalf of landowners with proposed implementation activities, and complications with long-term maintenance on private landowners. The overall priority was a subjective determination when considering the priority ranking across the cost, level of benefit and land ownership.

9.1 Proposed Restoration Alternatives

9.1.1 Sand Seepage Wetlands

The proposed Sand Seepage Wetland consists of a combination of sand berms, shallow aquatic pools and cobble weirs that hold water surfaces at different elevations and create a diversity of broad pools and wet areas that would function to detain and treat stormwater.

Using the pools as vegetated stilling basins, stormflow velocities would be reduced and energy dissipated. Stormwater would be treated through the filtration of it through the sand berms. The sand seepage berms, with 20%-by-volume green mulch, support microbes, fungi, soil invertebrates, and processes which remove nutrients and contaminants as they pass through the sand bed while maintaining porosity. The many roots present in the sand take up nutrients and provide sites for microbial attachment, contaminant adsorption, and long-term sequestration in the peat forming layer resulting from annual root formation of the fibric root mat. The entire system would be heavily vegetated to provide long-term stability continue to sustain porosity throughout the system to maintain filtration through the sand.

The expected benefits would include storm water quality and quantity control over a range of storm flows, enhanced habitat, and enhanced aesthetic appeal.

9.1.2 Regenerative Stream Channel

The proposed Regenerative Stream Channel (Baseflow Channel Design) consists of riffle weirs, native vegetation and fill material that raise the baseflow water surface of the perennial stream in close proximity to the floodplain elevation.

Due to uncontrolled stormwater, typical urban streams such as Sam's Branch have down cut and become deep gullies with increased in-channel shear stresses; causing channel erosion, entrainment, and export of sediment downstream. The stream has become disconnected from the adjacent floodplain, which also lowers groundwater elevations and negatively impacts riparian wetlands and vegetation.

The baseflow stream channel conveys the 'normal' flow in a channel with a high surface area to volume ratio, a physical relationship associated with effective material processing. During storm flows, the increased water surface elevation spills out of the baseflow channel and into the adjacent floodplain. This results in a loss of energy due to a slower, broad, shallow flow with a comparable reduction in the channel adjustment and sediment entrainment.

Reconnecting the channel to the floodplain to deliver frequent flows to these vegetated systems capitalizes on natural floodplain functions critical to ecosystem health, including sediment trapping, material processing, reduction in flood water surface elevation, and increase in concentration time of floodwaters, reduction in volumes through infiltration, evaporative losses, and depression storage. Furthermore, channel overflow contributes to groundwater recharge and maintenance of stream baseflow during periods of summer low flow; providing support for wetland and vernal pool hydrology and ecology, suppression of non-native invasive plant species, and increased micro-habitat diversity.

The riffle weirs also result in the formation of backwatered sections of the channel. This can be of significant value to aquatic life in small streams as the larger, deeper pools are important habitat, serving as summer low-flow refugia habitat.

The expected benefits would include improved connectivity between the stream and its adjacent riparian/floodplain area, a connection known to provide many benefits for water quality, water quantity control (e.g., increased time of concentration, reduced velocity and shear stresses), improved wetland hydrology, and a variety of aquatic and terrestrial habitat values.

9.1.3 Regenerative Stormwater Conveyance

The proposed Regenerative Stormwater Conveyance (Outfall Channel Design) consists of a series of riffle weirs and shallow aquatic pools, native vegetation and an underlying sand layer that treats and safely attenuates and conveys storm flow, and converts stormwater to groundwater through infiltration and below ground seepage. This practice is suitable for drainage ditches or stormdrain outfalls with no baseflow.

Starting at a location of concentrated stormwater, such as a storm drain or stormwater pond outfall, the riffle weirs set the surface water elevations and establishes the hydraulic head necessary to drive the sand seepage system and support the plants. The sand seepage bed, with 20%-by-volume green mulch, supports microbes, fungi, soil invertebrates, and processes which remove nutrients and contaminants as they pass through the sand bed while maintaining porosity. The many roots present in the sand take up nutrients and provide sites for microbial attachment, contaminant adsorption, and long-term sequestration in the peat forming layer resulting from annual root formation of the fibric root mat.

The systems are effective at flow attenuation and can be designed as zero surface discharge systems in some situations; converting all surface flow inputs into shallow groundwater flows that discharge as seeps at the receiving stream or wetland. A full range of typical stormwater management criteria, including: groundwater recharge, volume reduction, water quality, channel protection, and flood control can be achieved by the systems, yet are also designed to be stable enough to convey flows associated with events up to and including the extreme floods (i.e., 100-year storm) in a non-erosive manner, which results in reduced channel erosion impacts commonly associated with stormwater practice outfalls and receiving waters. Because of the integration of vegetation and rock structures, the system is mostly self-maintaining.
The expected benefits would include storm water quality and quantity control over a range of storm flows, enhanced habitat, and enhanced aesthetic appeal.

9.1.4 Realignment of Stream Channel

The proposed realignment of stream channel consists of the creation of a new channel in a new location within the stream valley and at a higher elevation. Historic anthropogenic impacts to stream valleys in Maryland included physical straightening and deepening of the channel to improve drainage for agriculture and/or use of hydropower for mills. This led to a legacy of deep floodplain sediments, and overly incised and straightened stream channels. Raising the channel invert to re-connect the hydrology with the floodplain while increasing the sinuosity of the system would reduce stream power, increase floodplain storage, provide variable riffle-pool morphology and habitat, and increase retention time for nutrient cycling.

The expected benefits of this type of construction include working in the dry such that an expensive pump-around and time restrictions are avoided, balancing cut and fill by using the old stream alignment for cut material and reducing the required volume of fill, and flexibility in the alignment to avoid utilities and property restraints.

9.1.5 Riparian Buffer Enhancement/Reforestation

Restoring a healthy riparian plant community along portions of Sam's Branch will support a healthy stream ecosystem and increase biodiversity by creating habitat and enhancing connectivity with the wildlife corridor along Otter Point Creek. Riparian enhancement will include augmenting the existing vegetation communities by introducing non-regenerating native canopy and understory species, and eliminating invasive species.

The expected benefits would include increased connectivity, increased canopy cover over the stream channel resulting in in-stream habitat enhancement, increased biodiversity and reduction of invasive species, increased bank stability along Sam's Branch.

9.1.6 Bank Protection

Stream bed erosion results when the stream begins to cut downward into the substrate. This creates an incised condition with high eroding banks and head cuts within the channel. Bank erosion can result from a number of factors including changes in the flow regime, changes in the riparian vegetative cover, and human alteration of the bank slope. It can be stopped by using three direct, in-stream approaches: 1) armoring channel banks, 2) creating stable cross section, plan, and profile geometry including raising the channel invert, minimizing bank height, and establishing a stable bank angle through cross section design, and 3) re-establishing a densely vegetated bank in areas where vegetation has been cleared. In many cases a combination of these approaches is used to stabilize an eroding bank.

There are three different methods that could be applied to modify the channel banks:
Structural – application of materials such as boulder banks, or boulder toe protection to hold the bank in place. These methods are suitable for addressing full bank erosion along steep banks (>2:1 slope) where inadequate right-of-way or extensive tree removal at the top of bank prohibits re-grading of the banks.
Non-structural – bank grading to adjust the bank angle and native vegetation to stabilize the bank slopes. This method works best on moderately sloping banks (maximum 2:1 slope) or conditions where surficial or top of bank erosion occurs.
Soil Bioengineering – a hybrid approach that combines native plant material and rock/wood to control erosion and stabilize slopes. This approach is suitable for treating toe, top of bank, and full bank erosion situations. Specific techniques include the use of rootwads, soil lifts, live branch layering, brush mattresses and crib walls, coconut fiber rolls, and coir fabric.

In many cases, native materials such as log toe and large boulders will be used as part of the proposed bank stabilization. Some large boulders are prevalent throughout the study area. They may be used during construction if they meet the requirements of the contract specifications. Appropriate sizes and types of materials will be specified in the design.

The expected benefits would include stabilization of the stream channel banks, reduction of sediment yield and accompanying TSS delivered to downstream areas.

9.1.7 Stormwater Interception and Treatment of Roadway Runoff

The proposed stormwater interception and treatment of roadway runoff consists of capturing untreated stormwater runoff from adjacent roadways and providing water quality enhancement through treatment options like bioretention/bioflitration.

The expected benefits would include reduction of roadway pollutants entering the waterway.

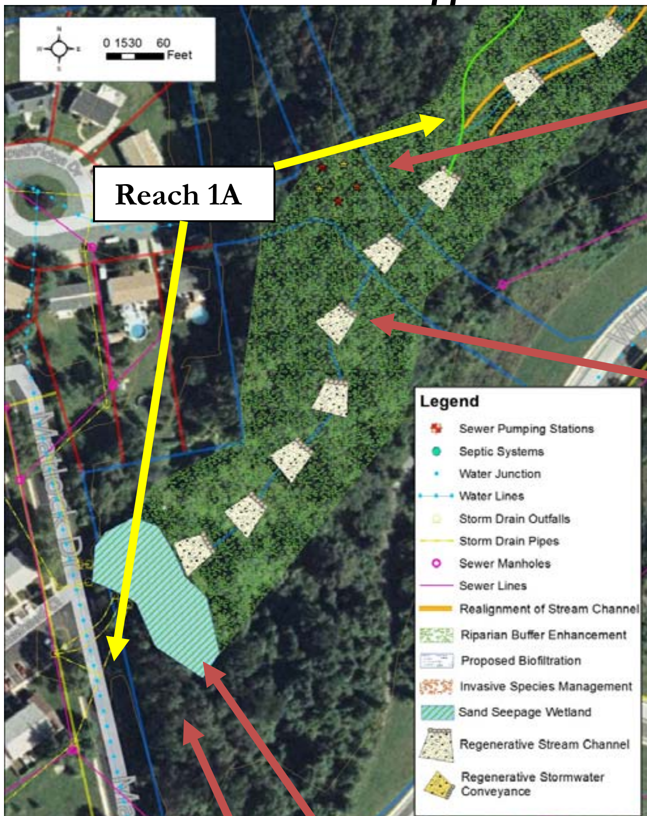
9.1.8 Invasive Species Management

Throughout portions of the study area and recommended stream corridor restoration areas, management of invasive plant species is necessary to control the further spread of invasive plant species and to ensure that new planting thrive and survive and are not out competed.

9.1.9 Homeowner Education

Homeowner education and stewardship opportunities include riparian tree planting, rain garden and rain barrel workshops, and septic tank maintenance.

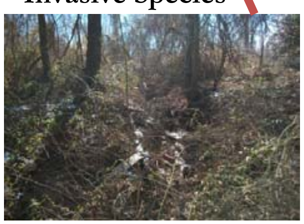
9.2 Reach 1 Restoration Opportunities:



Trash in Floodplain

Head-cut

Invasive Species



Proposed Sand Seepage Wetland

Figure 9-1. Existing Conditions and Restoration Opportunities Map - Reach 1A

Existing Conditions

The upper reaches of Sam's Branch originate at Matlock Drive fed from a series of stormwater outfalls. The forested wetland is highly degraded, and the stream experiences a series of head-cuts to become highly entrenched. Much of the overstory here is composed of black willow and silver maple.

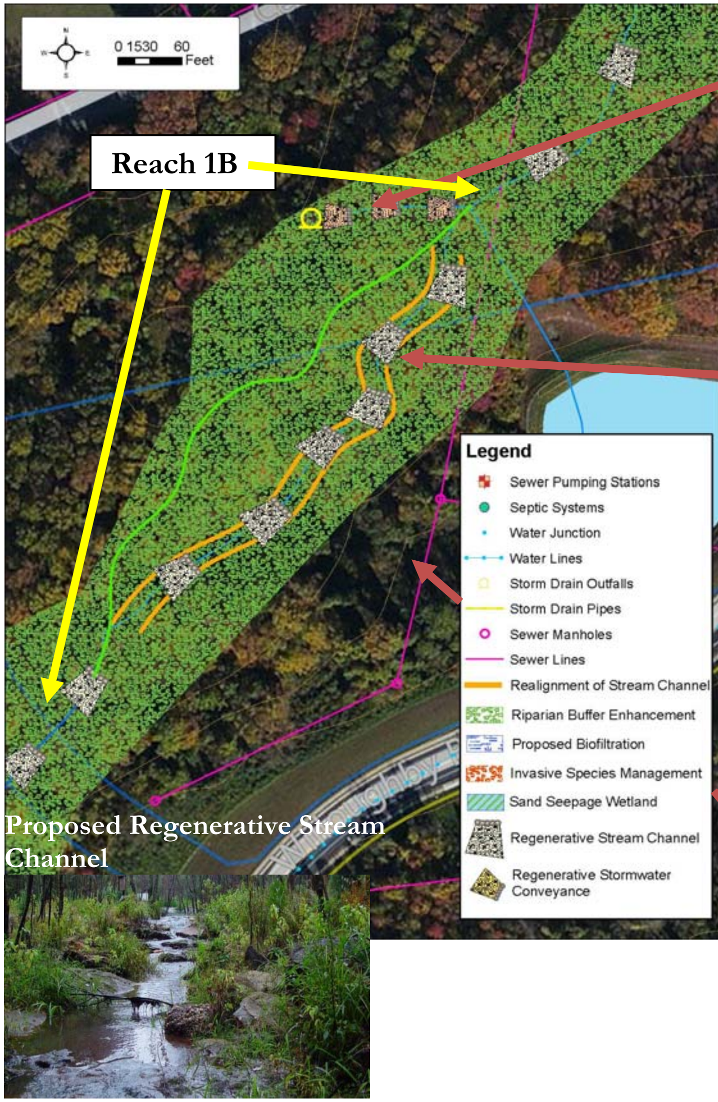
Proposed Alternatives

A. Sand Seepage Wetland
B. Regenerative Stream Channel
C. Riparian Buffer Enhancement

Expected Benefits

The sand seepage wetland will provide water quality and channel protection benefits to the receiving reaches downstream of the stormwater outfalls. A regenerative stream channel system would raise the channel invert and reconnect the surrounding floodplain to groundwater. Riparian buffer enhancement would include planting of native species and management to control the spread of invasive species in the forested wetland.

Alternative	A	B	C
Cost	Medium	High	Low
Level of Benefit	High	High	Medium
Land Ownership	Public	Public	Public
Level of Priority	High	High	High



Eroded Outfall

Channel Incision

Existing Wetland

Figure 9-2. Existing Conditions and Restoration Opportunities Map - Reach 1B

Existing Conditions

The **upper** reaches of Sam's Branch originate at Matlock Drive fed from a series of stormwater outfalls. The forested wetland is highly degraded, and the stream experiences a series of head-cuts to become highly entrenched. Much of the overstory here is composed of black willow and silver maple.

Proposed Alternatives

A. Regenerative Stormwater Conveyance
B. Regenerative and Realignment of Stream Channel
C. Riparian Buffer Enhancement

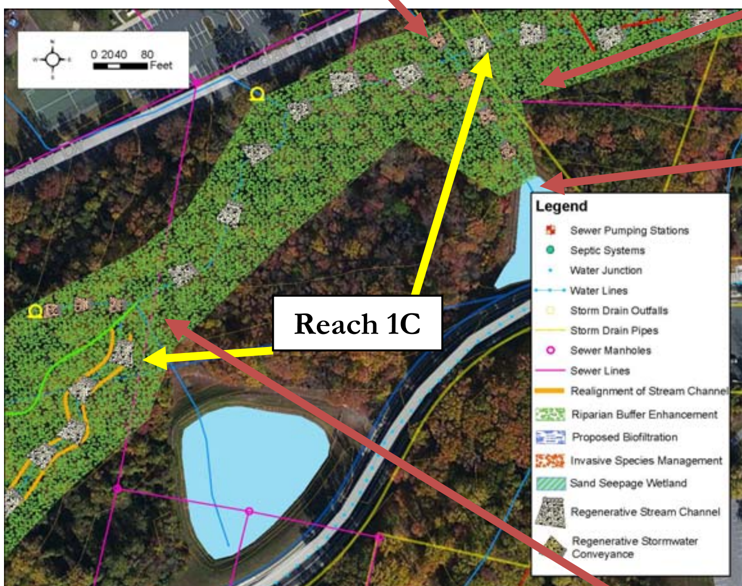
Expected Benefits

A realigned and regenerative stream channel system with a higher channel invert will reconnect the channel to the surrounding floodplain to groundwater. Regenerative stormwater conveyance along the outfall channel will treat stormwater runoff through infiltration and filtering of runoff, and provide stable conveyance. Riparian buffer enhancement would include planting of native species and management to control the spread of invasive species in the forested wetland.

Alternative	A	B	C
Cost	Medium	High	Low
Level of Benefit	High	High	Medium
Land Ownership	Public	Public	Public
Level of Priority	High	High	High

Trash and Debris in Stream, Failed Headwall

Proposed Regenerative Stormwater Conveyance



Existing Stormwater Pond

Severe Bank Erosion

Figure 9-3. Existing Conditions and Restoration Opportunities Map - Reach 1C

Existing Conditions

The upper reaches of Sam's Branch originate at Matlock Drive fed from a series of stormwater outfalls. The forested wetland is highly degraded, and the stream experiences a series of head-cuts to become highly entrenched. Much of the overstory here is composed of black willow and silver maple.

Proposed Alternatives

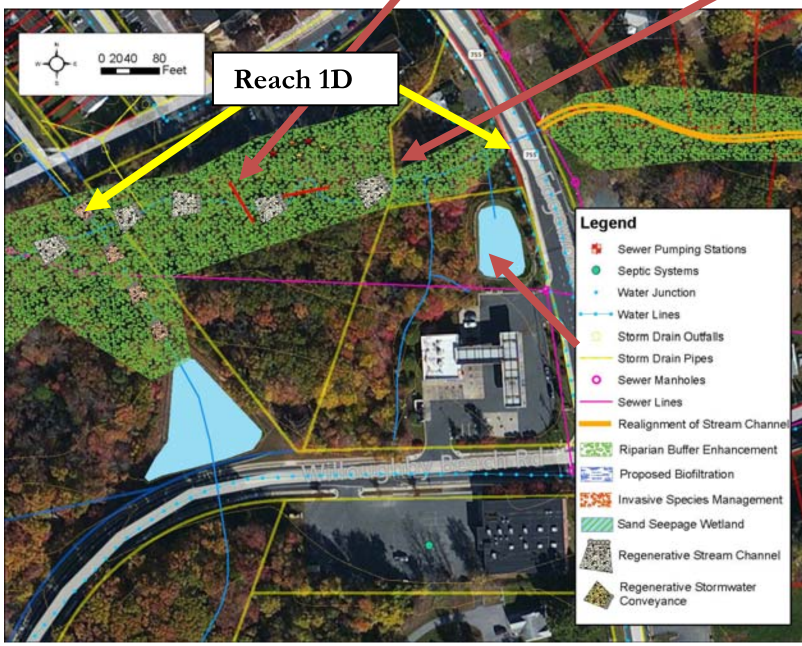
A. Regenerative Stormwater Conveyance
B. Regenerative Stream Channel
C. Riparian Buffer Enhancement

Expected Benefits

Regenerative stormwater conveyance along the outfall channels will treat stormwater runoff through infiltration and filtering of runoff, and provide stable conveyance. A regenerative stream channel system would raise the channel invert and reconnect the surrounding floodplain to groundwater. Riparian buffer enhancement would include planting of native species and management to control the spread of invasive species in the forested wetland.

Alternative	A	B	C
Cost	Medium	High	Low
Level of Benefit	High	High	Medium
Land Ownership	Public	Public	Public
Level of Priority	High	High	High

Exposed Pipes in Stream



Existing: Over-widened Channe

Proposed: Regenerative Stream Channel

Existing Stormwater Pond at 7Eleven

Existing Conditions

The upper reaches of Sam's Branch originate at Matlock Drive fed from a series of stormwater outfalls. The forested wetland is highly degraded, and the stream experiences a series of head-cuts to become highly entrenched. Much of the overstory here is composed of black willow and silver maple.

Proposed Alternatives

A. Regenerative Stormwater Conveyance
B. Regenerative Stream Channel
C. Riparian Buffer Enhancement

Expected Benefits

The sand seepage wetland will provide water quality and channel protection benefits to the receiving reaches downstream of the stormwater outfalls. A regenerative stream channel system would raise the channel invert and reconnect the surrounding floodplain to groundwater. Riparian buffer enhancement would include planting of native species and management to control the spread of invasive species in the forested wetland.

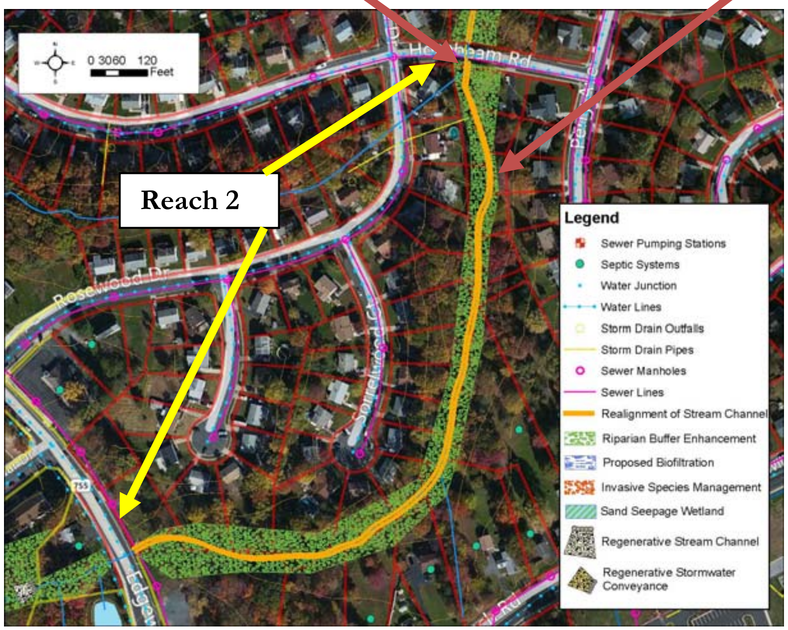
Alternative	A	B	C
Cost	Medium	High	Low
Level of Benefit	High	High	Medium
Land Ownership	Public	Public	Public
Level of Priority	High	High	High

Figure 9-4. Existing Conditions and Restoration Opportunities Map - Reach 1D

9.3 Reach 2 Restoration Opportunities:

Poor Water Quality from tributary; Erosion near Hornbeam Road

Poor Riparian Buffer



Proposed Enhanced Buffer:

Photo Credit USDA NRCS

Direct Rooftop Connections

Figure 9-5. Existing Conditions and Restoration Opportunities Map – Reach 2

Existing Conditions

Reach 2 extends between Edgewood Road and Hornbeam Road, cutting its way through a mixed hardwood forest dominated by tulip poplar, red maple and black cherry with an occasional beech, black locust and pin oak. GIS data indicated that the southern properties have septic drain fields, which may be contributing to poor water quality. The reach morphology exhibits less pool-riffle variability than other reaches, but is relatively stable.

Proposed Alternatives

A. Realignment of Stream Channel
B. Riparian Buffer Enhancement
C. Homeowner Education

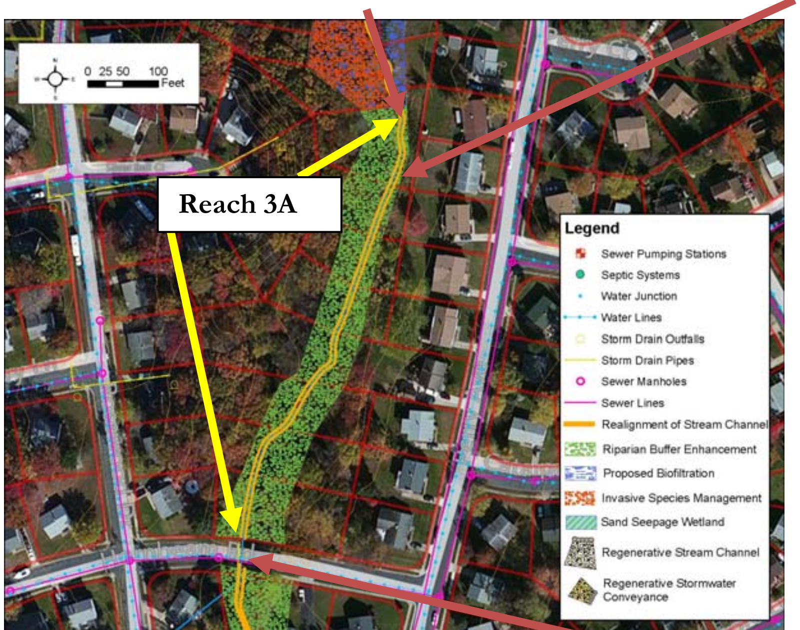
Expected Benefits

Through informal discussions with residents, Sam's Branch historically meandered further south in the floodplain. Realignment of the stream channel would restore historic morphology, and reduce bank erosion and include riparian buffer enhancement. However, private land ownership would make this option difficult. Homeowner education and stewardship opportunities include riparian tree planting, rain garden and rain barrel workshops, and septic tank maintenance.

Alternative	A	B	C
Cost	High	Low	Low
Level of Benefit	High	Medium	High
Land Ownership	Private	Private	Private
Level of Priority	Low	High	High

9.4 Reach 3 Restoration Opportunities:

Invasive species (bamboo) and bank erosion/stream channel migration



Homeowner concrete bank protection:

Failed homeowner footbridge:

Existing bank erosion:

Hornbeam Road Culvert:

Figure 9-6. Existing Conditions and Restoration Opportunities Map – Reach 3A

Existing Conditions

Reach 3A extends downstream Hornbeam Road, cutting its way through a mixed hardwood forest dominated by tulip poplar, red maple and black cherry with an occasional beech, black locust and pin oak. The property ownership is all private residential. Individual homeowners have taken various measures that have impacted the stream, including concrete and rubble bank protection and home-made footbridge crossings.

Proposed Alternatives

A. Homeowner Education
B. Bank Stabilization and Riparian Buffer Reforestation
C. Riparian Buffer Enhancement

Expected Benefits

Many of the home-made bank protection and footbridge structures are failing and causing erosion. Bioengineered bank stabilization and riparian buffer enhancement is recommended. However, private land ownership would make this option difficult. Homeowner education to increase stream stewardship could be a lower cost alternative.

Alternative	A	B	C
Cost	Low	High	Low
Level of Benefit	High	Medium	Medium
Land Ownership	Private	Private	Private
Level of Priority	High	Medium	Medium

Sam's Branch Tributary
Watershed Assessment and Baseline Stream Monitoring
Assessment and Baseline Report

Invasive species (bamboo) and bank erosion/stream channel migration

Poor Riparian Buffer and concrete swale at Perry Avenue

Stormwater outfall channel at Perry Aveune:

Proposed bank protection:

Figure 9-7. Existing Conditions and Restoration Opportunities Map – Reach 3B

Existing Conditions

Reach 3B terminates at Perry Avenue, cutting its way through a mixed hardwood forest. The floodplain is entirely privately owned residential yards, and as such, management differs between property owners. Mowed and/or reaches dominated by invasive bamboo exhibit extensive bank erosion and channel migration. The forested reaches are relatively stable.

Proposed Alternatives

A. Bank stabilization and riparian buffer reforestation
B. Homeowner education
C. Outfall stabilization

Invasive Species Management

Expected Benefits

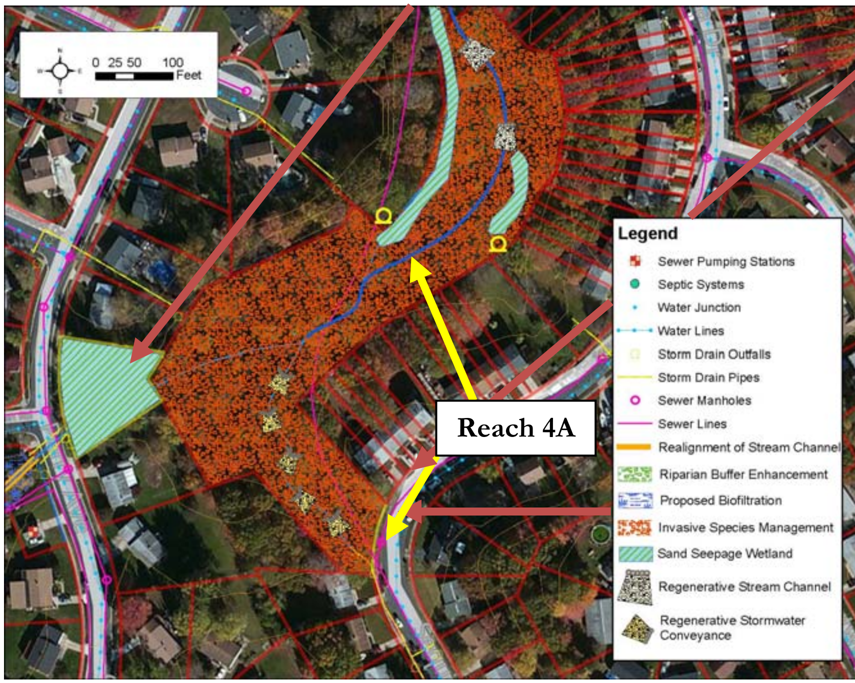
Bioengineered bank protection and invasive species management would improve in-stream habitat, reduce erosion, and prevent excessive channel migration. However, due to the private landownership, education and stewardship may be a more cost effective option. The stormwater outfall channel upstream of the Perry Avenue Culvert offers a good opportunity for regenerative stormwater conveyance.

Alternative	A	B	C
Cost	High	Low	Medium
Level of Benefit	High	Medium	Medium
Land Ownership	Private	Private	Private
Level of Priority	Low	High	Medium

9.5 Reach 4 Restoration Opportunities:

Existing stormwater runoff:

Proposed bioinfiltration:



Representative reach photo, showing sandy stream bed:

Tributary for potential woody structure grade control:

Example of natural woody grade control:

Figure 9-8. Existing Conditions and Restoration Opportunities Map – Reach 4A

Existing Conditions

Reach 4A begins at the Perry Avenue culvert, passing through a forest floodplain wetland that is dominated by green ash, with other floodplain tree species such as sycamore, black walnut, silver maple, river birch, red maple and willow oak. Land is privately owned by the Isaac Walton League. The channel was generally stable with good floodplain access and entrenchment ratios greater than 2.2.

Proposed Alternatives

A. Stormwater Bioinfiltration Practice
B. Tributary stabilization
C. Invasive Species Management

Expected Benefits

Capturing the untreated stormwater from Perry Avenue would improve the water quality to the stream and stabilize the culvert. A small tributary to Sams Branch offers a good opportunity for low impact restoration using woody grade control, which would also improve nutrient cycling and in-stream habitat. Management is necessary to control the spread of invasive species in the forested wetland.

Alternative	A	B	C
Cost	Medium	Medium	Low
Level of Benefit	High	Medium	Medium
Land Ownership	Private	Private	Private
Level of Priority	High	Medium	Medium

Existing typical reach:

Proposed grade control for better floodplain connection:

Understory invasive species:

Clogged stormdrains. Potential for stormwater treatment:

Proposed vernal pool / stormwater treatment

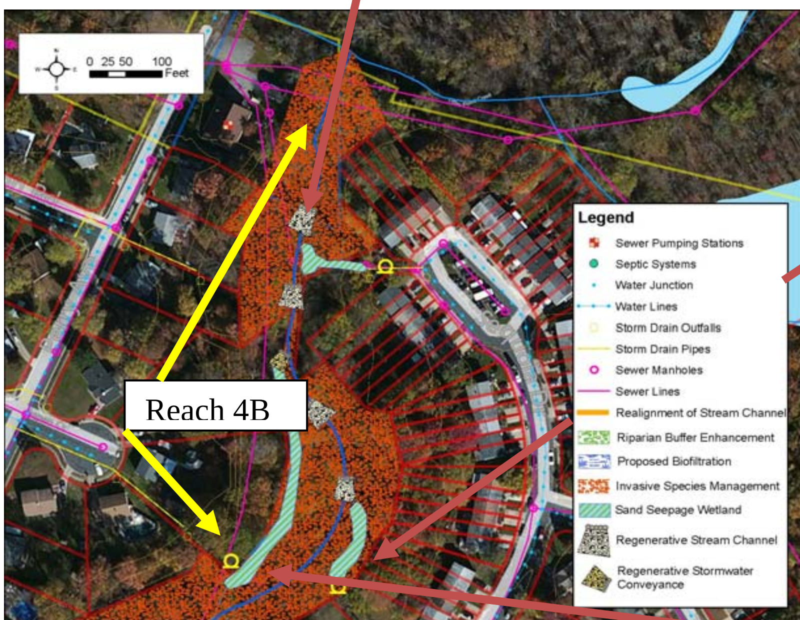


Figure 9-9. Existing Conditions and Restoration Opportunities Map – Reach 4B

Existing Conditions

Reach 4B begins downstream of 4A and ends at the confluence with Otter Creek. The floodplain is a forested wetland that is dominated by green ash with other floodplain tree species found in this association such as sycamore, black walnut, silver maple, river birch, red maple and willow oak. The floodplain is privately owned by the Isaac Walton League, which could offer a good partnership opportunity for the county. The channel was generally stable with good floodplain access and entrenchment ratios greater than 2.2.

Proposed Alternatives

A. Regenerative Stream Channel
B. Invasive Species Management
C. Sand Seepage Wetland

Expected Benefits

A regenerative stream channel including re-connection of baseflow with the floodplain would improve existting wetland quality and extent, while passively controlling the spread of invasive species. The stormwater outfalls in this reach were clogged with sediment and trash. The existing floodplain slough features offer a good opportunity for stormwater capture and attenuation via sand seepage wetlands. Management is necessary to control the spread of invasive species in the forested wetland.

Alternative	A	B	C
Cost	High	Low	Medium
Level of Benefit	High	Medium	Medium
Land Ownership	Private	Private	Private
Level of Priority	Low	High	Medium

10.0 POLLUTANT LOAD REDUCTION ANALYSES AND COSTS

10.1 Proposed Conditions Model

Nineteen upland retrofit opportunities were identified during the Unified Subwatershed and Site Reconnaissance (USSR) and Stormwater Management Retrofit Survey. The results from the survey including drainage area, impervious area treated, practice area, practice type and construction costs are summarized in Tables 10-1 and 10-2. The WTM was used to model the affects of implementing the suite of upland retrofits and restoration opportunities on reducing pollutant loads in the Sam's Branch Watershed.

Table 10-1. Upland Retrofit Opportunities

ID	DA (acre)	IA (acre)	Practice Area (sq ft)	Practice Length (lf)	Practice Type	Cost
SBA	1.60	0.80	5239		Bioretention	$57,600
SBB	0.57	0.57	24630		Impervious Surface Removal	$54,000
SBC	0.36	0.36	1850		Bioretention	$50,400
SBC	0.18	0.18	1041		Bioretention	$25,200
SBC	0.33	0.00	14370		Revegetation	$8,700
SBD	19.42	7.38		120	Regenerative SW Conveyance	$48,000
SBD	2.70	1.35	5768		Retrofit Existing Basin	$90,068
SBD	12.99	4.94	56628		Retrofit Existing Basin	$135,000
SBE	9.00	3.42	34848		Sand Seepage Wetland	$60,000
SBF	0.42	0.42	2376		Bioretention	$50,400
SBI	0.31	0.31	13570		Permeable Paving	$151,200
SBJ	1.07	1.07	3600		Bioretention	$138,600
SBK	0.51	0.51	1691		Bioretention	$63,000
SBL	0.76	0.76	33250		Permeable Paving	$403,200
SBL	0.23	0.23		100	Regenerative SW Conveyance	$40,000
SBL	0.11	0.00	5000		Revegetation	$6,000
SBN	0.07	0.07	300		Bioretention	$11,760
SBN					Pollution Prevention Strategies	$2,000
SBO	0.16	0.16	525		Bioretention	$33,600

The structural stormwater retrofits resulted in varied pollutant reduction, based on their removal efficiency. The following table (Table 10-3) summarizes the results of the WTM model of the proposed structural stormwater retrofits.

Table 10-2. Retrofit Opportunities Costs, Sources and Assumptions

Delineated Upland Area	Stormwater Retrofits	Retrofit Description	Strategies	Unit of Retrofit	Drainage Area	Impervious Area (ac.)	Source of Cost Estimate	Cost	Notes
SBA	Bioretention	Bioretention along medium density residential Hanson Road	- Replace lawn in areas between sidewalks and roads with vegetated bioswales to intercept road unoff before reaching curb inlets.	5239 sq. ft.	69850 sq. ft. OR 1.6 ac.	0.8	USRM Cost Spreadsheet	$57,600.00	Assume "Large Bioretention Retrofits" because several cells are proposed along Hanson Road. Use High Value ($72,000/imp ac). Assume 50% of drainage area is impervious.
SBB	Remove Impervious Surfaces	Remove impervious surfaces on Hawthorne Drive at adbandoned high density residential	- Remove unused impervious surfaces - Stabilize area with soil admendment and native vegetation	24630 sq. ft.	NA	0.6	USRM Cost Spreadsheet	$54,000.00	Assume "Impervious Cover Conversion". Use High Value ($90000/imp ac.) or Mean ($84000/imp ac.). Impervious area is the entire lot proposed for retrofit.
SBC	Bioretention Cell 1	Edgewood Elementary	- Replace lawn with bioretention cells.	1850 sq. ft.	15880 sq.ft.	0.4 ac.	USRM Cost Spreadsheet	$50,400.00	Assume "Small Bioretention Retrofits." Use Mean Value ($126000/imp ac.). Assume 100% of the drainage area is impervious (a parking lot).
	Bioretention Cell 2	Edgewood Elementary	- Replace lawn with bioretention cells.	1041 sq. ft.	7981 sq. ft.	0.2 ac.	USRM Cost Spreadsheet	$25,200.00	Assume "Small Bioretention Retrofits." Use Mean Value ($126000/imp ac.). Assume 100% of the drainage area is impervious (a parking lot).
	Revegetation	Edgewood Elementary	- Plant existing lawn swale with native vegetation and selectively add engineered media.	14370 sq. ft. OR 0.3 ac.	NA	NA	USRM Cost Spreadsheet	$8,700.00	Use "Impervious Cover Conversion" values to calculate revegetation. Subtract out the asphalt/concrete removal ($/CF) from the Impervious Cover Conversion cost. Use Mean Value ($29/imp ac). Assume planting with prarie/meadow mix.
SBD	Retrofit Existing Stormwater Basin 1		-Replace pond bottom with engineered media and underdrain. - plant with native vegetation.	5768 sq. ft.	2.7 ac.	NA	TO 14 bioretention cost calculator	$90,068.00	Biotention Cost Calculator to be appriate for our project. Major changes: No bump out, no trees, no utility relocation, no clearing and grubbing, no traffic control, assume 1.5ft excavation and placement of bioretention media. Used a 25% contingency.
	Regeneratice Stormwater Conveyance (RSC) at Basin 2 Outfall		- Stabilize channel using regenerative stormwater conveyance (step pool system).	120 LF	NA	NA	Recent Bids/Estimates	$48,000.00	Steeper gradients generally cost more. We're using numbers in the ~$400 per ft range as average, but it can be twice this price with steeper sloped streams. Design cost is on the order of $50/lf, not assuming extra needs (e.g., survey, lots of public meetings, etc.). Estimated linear feet from Google Earth and was conservative on the length.
	Retrofit Existing Stormwater Basin 3		- Stabilize bare/eroded soil - Plant native vegetation - Construct water quality forebay - modify mowing practices	56628 sq. ft.OR 1.3 ac	12.99 ac.	NA	TO 14 bioretention cost calculator	$135,000.00	Biotention Cost Calculator to be appriate for our project. Major changes: No bump out, no trees, no utility relocation, no clearing and grubbing, no traffic control, minor excavation, no bioretention media, added Class I Riprap, changed quart grasses to native seed. Assume 15% of area will be the water quality forebay. Used a 25% contingency.
SBE	Sand Seepage Wetland	Sand seepage wetland in Harford Commons High Density Residential	-Create sand seepage wetland with native vegetation.	0.8 ac.			Recent Bids/Estimates	$60,000.00	$50-$100K/AC for wetland restoration from recent bid tabs. Use Mean Value of $75000/AC.
SBF	Bioretention	Bioretention on Southridge Dr. turn around island	- Lower grade of raised turn around island, cut curbs, and construct biorentention.	2376 sq. ft.	18150 sq. ft.	0.4 ac.	USRM Cost Spreadsheet	$50,400.00	Assume "Small Bioretention Retrofits." Use Mean Value ($126000/imp ac.). Assume 100% of the drainage area is impervious (a parking lot).
SBI	Permeable Paving and/or Biofiltratior	Permeable Paving and/or Biofiltration on Sequoia D	- Replace existing pavement with permeable pavement.	13570 sq. ft.	NA	0.3 ac.	USRM Cost Spreadsheet	$151,200.00	Assume "Permeable Pavers." Use Mean Value ($504000/imp ac.). Assume 100% of existing parking lot is impervious.
SBJ	Bioretention		-Terraced bioretention in existing grass area.	3600 sq. ft.	46650 sq. ft.	1.1 ac.	USRM Cost Spreadsheet	$138,600.00	Assume "Small Bioretention Retrofits." Use Mean Value ($126000/imp ac.). Assume 100% of the drainage area is impervious (secondary roads).

Delineated Upland Area	Stormwater Retrofits	Retrofit Description	Strategies	Unit of Retrofit	Drainage Area	Impervious Area (ac.)	Source of Cost Estimate	Cost	Notes
SBK	Bioretention		- Construct bioretention cell adjacent to entrance.	1691 sq. ft.	22210 sq. ft.	0.5 ac.	USRM Cost Spreadsheet	$63,000.00	Assume "Small Bioretention Retrofits." Use Mean Value ($126000/imp ac.). Assume 100% of the drainage area is impervious (parking lot).
SBL	Permeable Pavement		-Replace entire paved area (incl. pavement between buildings) with permeable pavement.	33250 sq. ft.	NA	0.8 ac.	USRM Cost Spreadsheet	$403,200.00	Assume "Permeable Pavers." Use Mean Value ($504000/imp ac.). Assume 100% of existing parking lot is impervious.
	Soil Amendment and Revegetation		-Amend or replace soil in common area and revegetate.	5000 sq. ft.	NA	0.1 ac.	USRM Cost Spreadsheet	$6,000.00	Use "Impervious Cover Conversion" values to calculate revegetation. Subtract out the asphalt/concrete removal ($/CF) from the Impervious Cover Conversion cost. Use Mean Value ($29/imp ac). Assume planting with prarie/meadow mix. Use Soil Compost Amendment described in USRM to calculate amendment portion.
	Regeneratice Stormwater Conveyance (RSC)		- Replace existing channel with RSC (step pool system).	100 LF	NA	NA	Recent Bids/Estimates	$40,000.00	Steeper gradients generally cost more. We're using numbers in the ~$400 per ft range as average, but it can be twice this price with steeper sloped streams. Design cost is on the order of $50/lf, not assuming extra needs (e.g., survey, lots of public meetings, etc.). Estimated linear feet from Google Earth and was conservative on the length.
SBN	Bioretention	Bioretention at Public Library	- Construct bioswale. - Disconnect downspouts into bioswale. - add educational signage.	300 sq. ft.	2859 sq. ft.	0.07 ac.	USRM Cost Spreadsheet	$11,760.00	Assume "Small Bioretention Retrofits." Use High Value ($168000/imp ac.) because extremely small bioretention in comparison to other proposed projects. High value also allows for educational signage. Assume 100% of the drainage area is impervious (roof).
	Pollution Prevention Strategies	Pollution Prevention Strategies at commercial site	- Provide more trash cans, repair holes in fence, etc.	Lump Sum	NA	NA	Lowes Website & Angler Engineering Cost Estimate	$2,000.00	"Ultra Play 32-gallon Thermoplastic Coating Outdoor Garbage Can" at Lowes costs $330/EA. Assume 2 trash cans. Permanent Chain Link Fence according to Angler Engineering for Mongomery Co. is $11/SF. Assume ~100SF of fence needs mended. Total = 1760.00
SBO	Bioretention	Bioretention at commercial site	- Use adjacent lawn area for bioretention.	525 sq. ft.	7000 sq. ft.	0.2 ac.	USRM Cost Spreadsheet	$33,600.00	Assume "Small Bioretention Retrofits." Use High Value ($168000/imp ac.) because extremely small bioretention in comparison to other proposed projects. Assume 100% of the drainage area is impervious (parking lot).
USRM -	Retrofit construction costs from Urban Subwatershed Restoration Manual v3, Appendix E, Table E.4							**$1,428,728.00**	

Table 10-3. Structural Retrofit Pollutant Reduction

Structural BMP Type	Pollutant Reduction(lb/year)			Fecal Coliform Reduction (billion/year)	Runoff Reduction (ac-ft/year)
	TN	TP	TSS		
Regenerative SW Conveyance	89	10	896	9550	15
Retrofit Existing Basin (Soil Amendments)	83	8	611	5577	16
Bioretention	43	5	1075	3548	4
Sand Seepage Wetland	15	3	855	3763	0
Permeable Pavement	12	1	292	460	1
Total	**243**	**28**	**3729**	**22899**	**36**

When the revegetation and impervious surface removal practices are included, the total net reduction in surface loads is as shown in Table 10-4. Revegetation was modeled as a land use conversion or "urban downsizing", while impervious surface removal was modeled as redevelopment with improvements using the WTM. The model illustrates that the current riparian buffers reduce less pollutants with the proposed retrofits, due to a reduced load flowing to the buffer. Also, the retrofits result in an increase in nitrogen discharge to groundwater due to increased infiltration.

Table 10-4. Load Reductions for Future Management Practices

Practice Type	Pollutant Reductions (lbs/year)			Fecal Coliform Reduction (billion/year)	Runoff Reduction (acre-ft/yr)
	TN	TP	TSS		
Structural Stormwater Retrofits	243	28	3,729	22,899	36
Retrofits – Discharge to GW	-83	0	0	0	0
Impervious Surface Removal (Redevelopment)	10	1	272	635	2
Revegetation (Urban Downsizing)	4	0	52	233	1
Riparian Buffers	0	0	-14	-23	0
Riparian Buffers – Infiltration	0	0	0	3	0
Total Net Reduction	**173**	**29**	**4,040**	**23,747**	**39**

The result of the reduced load in pollutants from urban lands is reflected in an overall total loads and load reductions to surface waters, as summarized in Table 10-5 and Table 10.6. Reductions of total loads to surface waters for proposed conditions for TN are 8%, TP are 10%, TSS are 5%, and Bacteria are 13% are expected based on the modeling. All reductions were accounted in the urban land source. An overall runoff volume reduction of 7% has been modeled under the proposed conditions.

Table 10-5. Proposed Loads to Surface Waters

Land Use	TN	TP	TSS	Fecal Coliform	Runoff Volume
	lb/year	lb/year	lb/year	billion/year	acre-feet/year
Urban Land	2,617	259.25	46,505	157,812	481
Active Construction	6	1	3,990	-	6
SSOs	2	0	12	1,373	-
Channel Erosion	-	-	23,108	-	-
Forest	178	7	1,689	676	5
Septic Systems	39	7	261	351	-
Open Water	1	0	17	-	-
Total Storm Load	2,715	266	75,152	159,861	492
Total Non-Storm Load	128	9	430	351	-
Total Load to Surface Waters	**2,843**	**275**	**75,582**	**160,212**	**492**

Table 10-6. Comparison of Overall and Urban Existing Loads to Surface Waters and Proposed Loads to Surface Waters

Urban Land	Load Reduction from Existing Practices	Existing Load from Urban Land	Proposed Load from Urban Land	Total Existing Load to Surface Waters	Total Proposed Load to Surface Waters	% Reduction in Total Load to Surface Waters
TN lb/year	214	2,873	2,617	3,099	2,843	8
TP lb/year	23	289.17	259.25	305	275	10
TSS lb/year	13,199	50,596	46,505	79,674	75,582	5
Fecal Coliform billion/year	6,638	181,556	157,812	183,956	160,212	13
Runoff Volume acre-feet/year	**18**	**520**	**481**	**531**	**492**	**7**

Analysis of the pollutant load reduction in terms of cost effectiveness reveals some interesting results as shown in Table 10-7. Regenerative SW Conveyance has significantly better nitrogen, phosphorus, and bacterial reduction cost efficiency. The sand seepage wetland had the highest sediment reduction cost efficiency. Permeable pavement had a relatively low cost efficiency, but this analysis does not account for the multiple beneficial uses of permeable pavement, such as transportation and parking.

Table 10-7. Cost Effectiveness Comparison of Pollutant Load Reduction Measures

Practice Type	TN Thousand $/lbs	TP Thousand $/lbs	TSS Thousand $/lbs	Fecal Coliform Thousand $/lbs
Regenerative SW Conveyance	1	9	200	9
Retrofit Existing Basin (Soil Amendments)	3	27	1,000	40
Sand Seepage Wetland	4	17	143	16
Revegetation (Urban Downsizing)	4	43	500	63
Impervious Surface Removal (Redevelopment)	5	42	333	83
Bioretention	10	91	1,000	125
Permeable Pavement	45	500	3,333	1,000
Overall Average	6	48	1,000	59

11.0 PRIORITIZATION

Qualitative implementation rankings have been developed for upland retrofit and restoration opportunities. The qualitative prioritization for the stream corridor restoration opportunities are described in Section 9.0. Ranking parameters for the upland retrofit opportunities include cost and level of benefit with ranking levels of low, medium or high; land ownership determination of public versus private; and an overall priority based on the combination of ranking parameters as described in section 3.

For the upland retrofit opportunities, the prioritization was qualitative and based on a relative comparison across the range of opportunities recommended within the study area. For example, the cost of educational outreach with the community would be low in cost when compared to the cost for the design and installation of biofiltration facilities (medium cost). The assumptions surrounding the level of benefit include the overall benefits including the pollutant reduction benefits to the subwatershed gained by the implementation of the opportunity. Land ownership is based on the source of ownership for the actual area of implementation. This determination is a consideration in the overall ranking based on the assumption that public lands should be a higher priority because of factors including the lack of necessity and expense associated with easements, access relates issues, potential disagreement on behalf of landowners with proposed implementation activities, and complications with long-term maintenance on private landowners.

Presented in Table 11-1 is a summary of the upland retrofit opportunities and restoration opportunities presented with an overall prioritization using the priority ranking level of high to low priority with the cost effectiveness comparison results also taken into account (Table11-1).

Table 11-1. Summary of Retrofit Opportunities and Restoration Opportunities by Initial Ranking Category with Priority ID

Overall Priority	ID	DA (acre)	IA (acre)	Practice Area (sq ft)	Priority Ranking	Practice Type	Cost
1	**SBD**	19.42	7.38	120 LF	High	Regenerative SW Conveyance	$48,000
2	**SBD**	12.99	4.94	56628	High	Retrofit Existing Basin	$135,000
3	**SBD**	2.7	1.35	5768	High	Retrofit Existing Basin	$90,068
4	**SBE**	9	3.42	34848	High	Sand Seepage Wetland	$60,000
5	**SBN**				High	Pollution Prevention Strategies	$2,000
6	**SBA**	1.6	0.8	5239	High	Bioretention	$57,600
7	**SBC**	0.36	0.36	1850	High	Bioretention	$50,400
8	**SBC**	0.33	0	14370	High	Revegetation	$8,700

Overall Priority	ID	DA (acre)	IA (acre)	Practice Area (sq ft)	Priority Ranking	Practice Type	Cost
9	**SBC**	0.18	0.18	1041	High	Bioretention	$25,200
10	**SBN**	0.07	0.07	300	High	Bioretention	$11,760
11	**SBL**	0.23	0.23	100 LF	Medium	Regenerative SW Conveyance	$40,000
12	**SBL**	0.11	0	5000	Medium	Revegetation	$6,000
13	**SBB**	0.57	0.57	24630	Medium	Impervious Surface Removal	$54,000
14	**SBJ**	1.07	1.07	3600	Medium	Bioretention	$138,600
15	**SBK**	0.51	0.51	1691	Medium	Bioretention	$63,000
16	**SBF**	0.42	0.42	2376	Low	Bioretention	$50,400
17	**SBO**	0.16	0.16	525	Low	Bioretention	$33,600
18	**SBL**	0.76	0.76	33250	Medium	Permeable Paving	$403,200
19	**SBI**	0.31	0.31	13570	Medium	Permeable Paving	$151,200

12.0 MONITORING PLAN

Harford County along with other stakeholders including funding organizations have vested interest in measuring the success of implemented upland retrofit and restoration projects. Measurement of success can be done in different ways including direct measurements of pollutant reduction and improved habitat quality to indirect benefits such as increased public awareness of the benefits of natural resources and number of volunteer efforts. The monitoring approach for demonstrating success in the Sam's Branch watershed and improved health in the Sam's Branch tributary will include the continuation of the sentinel monitoring stations along Sam's Branch at the locations that the baseline monitoring has occurred measuring trends of key indicators. These key indicators will include improved water quality through chemical water quality sampling and improved habitat conditions through continued biological sampling.

Tracking implementation progress and managing the data from a monitoring plan is an important aspect of the long-term monitoring efforts. GIS will be employed to track the progress of implementation from design, permitting construction and monitoring stage. Regular reporting will be employed as a means of documenting progress and presenting the results of retrofit and restoration implementation and monitoring results related to project success.

13.0 SCHEDULE

An implementation schedule has been established with overall timeframes for key implementation phases and milestones of the proposed upland projects including design, construction and monitoring as shown in Table 13-1. High priority upland projects are scheduled first with medium and low priority projects phased in over the next subsequent years and likely concurrently, with the proposed stream corridor restoration projects.

Table 13-1. Implementation Schedule

Prioirity	Project Name	Project Type	2013				2014				2015				2016				2017				2018				2019				2020	
			1-Jan-13	1-Apr-13	1-Jul-13	1-Oct-13	1-Jan-14	1-Apr-14	1-Jul-14	1-Oct-14	1-Jan-15	1-Apr-15	1-Jul-15	1-Oct-15	1-Jan-16	1-Apr-16	1-Jul-16	1-Oct-16	1-Jan-17	1-Apr-17	1-Jul-17	1-Oct-17	1-Jan-18	1-Apr-18	1-Jul-18	1-Oct-18	1-Jan-19	1-Apr-19	1-Jul-19	1-Oct-19	1-Jan-20	1-Apr-20
1	SBD	Regenerative SW Conveyance	♦																											
2	SBD	Retrofit Existing Basin	♦																											
3	SBD	Retrofit Existing Basin	♦																											
	Reach 1	Stream Corridor Restoration	♦																											
4	SBE	Sand Seepage Wetland				♦																								
5	SBN	Pollution Prevention Strategies				♦																								
6	SBA	Bioretention				♦																								
7	SBC	Bioretention				♦																								
8	SBC	Revegetation				♦																								
9	SBC	Bioretention				♦																								
10	SBN	Bioretention				♦																								
	Reach 2	Stream Corridor Restoration																												
11	SBL	Regenerative SW Conveyance								♦																				
12	SBL	Revegetation								♦																				
13	SBB	Impervious Surface Removal								♦																				
14	SBJ	Bioretention								♦																				
15	SBK	Bioretention																												
	Reaches 3 and 4	Stream Corridor Restoration								♦																				
16	SBF	Bioretention												♦																
17	SBO	Bioretention												♦																
18	SBL	Permeable Paving																♦												
19	SBI	Permeable Paving																♦												

LEGEND:
- Design
- Permitting
- Construction

14.0 REFERENCES

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington , D.C.

Center for Watershed Protection (CWP). March 2010. Watershed Treatment Model. Ellicott City, Maryland.

Center for Watershed Protection (CWP). 2004. Unified Subwatershed and Site Reconnaissance: A User's Manual, Version 1.0, Manual 11, Ellicott City, Maryland.

Department of Natural Resources (DNR). 2009. Maryland Biological Stream Survey (MBSS) Sampling Manual .

Federal Emergency Management Agency (FEMA). U.S. Department of Homeland Security. Map Service Center. Available online at http://msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1&userType=G. Accessed September 12, 2011.

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream channel reference sites: An illustrated guide to field technique. General Technical Report RM-245. Fort Collins, CO: US Department of Agricultutre, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

Maryland Department of Environment (MDE). 2011. *Draft* Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated; Baltimore, Maryland.

Maryland Department of Natural Resources. Merlin Online. Anne Arundel County, Maryland. Available online at http://www.mdmerlin.net/mapper.html. Accessed [09/12/2011].

Maryland Geological Survey, Maryland Department of Natural Resources, State of Maryland. A Brief Description of the Geology of Maryland. Available online at http://www.mgs.md.gov/esic/brochures/mdgeology.html. Accessed [09/12/2011]. Last updated January 22, 2009.

Mecklenburg, D. 2006. "The Reference Reach Spreadsheet for Channel Survey Data Management, version 4.2L," Ohio Department of Natural Resources.

National Stormwater Quality Database, v3, 2008.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology; Pagosa Springs, CO.

Rosgen, D. 2008. River Stability Field Guide. Wildland Hydrology; Fort Collins, CO.

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Harford County, Maryland. Available online at http://websoilsurvey.nrcs.usda.gov/. Accessed [09/12/2011].

USGS. 1982. USGS Cross-sectional method, manual technique, USGS Water-Supply Paper 2175, "Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge", U.S. Government Printing Office.

U.S. Fish and Wildlife Service. Wetlands Mapper. Harford County, Maryland. Available online at http://www.fws.gov/wetlands/data/index.html. Accessed September 12, 2011.