Appendix E2. a – Restoration Plans and TMDLs (Impervious Area Assessment)

Impervious Area Assessment

Harford County, MD Department of Public Works

Watershed Protection and Restoration

Watershed Restoration Status (MS4 Permit 11-DP-3310)

Complete Projects (pre-2009)

Barry Glassman
County Executive

Stormwater and stream restoration - inspections FY2020

Total 176.68

Wpid	Wpname	Wpcomplete (FY)	Total Credits (IA)	Last Inspection	Pass / Fail
WP000040	Pumphrey Property Demolition	2010	0.51	N/A	N/A
WP000003	Laurel Valley Stream Restoration	2009	40.2	11/11/2019	Pass
WP000065	Gilley Property Demolition	2008	0.43	N/A	N/A
WP000002	Laurel Valley SWM Retrofit[1]	2005	19.74	2/14/2018	Fail
WP000001	Laurel Valley Bioretention	2005	1.27	12/21/2018	Pass
WP000007	Harford Center Water Quality Improvments	2005	0.94	6/7/2017	Pass
WP000009	Winters Run at Route 7 Stream Restoration	2004	43.5	11/11/2019	Pass
WP000004	Box Hill South Tributary Stream Restoration	2004	24.3	11/11/2019	Pass
WP000066	Logana Property Demolition	2002	0.46	N/A	N/A
WP000067	Leyko Property Demolition	2002	0.43	N/A	N/A
WP000006	Mt Royal Project SWM Facility[2]	2002	35.56	7/25/2017	Fail
WP000011	Foster Branch Tributary at Haverhill Stream Restoration	2004	9.34	11/11/2019	Pass

[1] HOA maintained, needed repaired not related to retrofit

[2] Dredging pending

Watershed Restoration Projects

Barry Glassman
County Executive

Bynum at St Andrews Way Stream Restoration (WP000029)

Design Initated - Jul 2009 Construction Completed - May 2019

Near intersection of Mac Phail Road and St Andrews Way (ADC (2012) 42B6)

Stream restoration

Design	Construction	Total Cost	Grant	Credits	Cost per Impervious Acre
$318,869 (15%)	$1,764,720 (85%)	$2,083,589	$1,600,000 (77%)	92.52 acres	$22,520

CIPid	Credits Type	Drainage (acres) / Impervious	Project Size	Credits (acres)	Credit Value
CIP0029	Stream Restoration (piedmont)		3084 feet	92.52	0.03 ac imp per liner foot

Costs do not include County salaries for inspections or project management
Impervious Credits calculated based on "Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated", August 2014
RR = Runoff Reduction, ST = Stormwater Treatment (Source: 2000 Design Manual, MDE)

Barry Glassman
County Executive

Stormwater Retrofit at Homestead Elementary (WP000088)

Design Initated - Jun 2017 Construction Completed - Jun 2019

900 South Main Street (ADC (2012) 4351F6)

New bioretention

Design	Construction	Total Cost	Grant	Credits	Cost per Impervious Acre
$25,811 (20%)	$105,563 (80%)	$131,374	$0 (0%)	1.57 acres	$83,678

CIPid	Credits Type	Drainage (acres) / Impervious	Project Size	Credits (acres)	Credit Value
CIP0104	SWM Facility (RR)	7.04 (41%)	0.54 " rainfall treated	1.57	1 ac imp per 1" rainfall treated

Costs do not include County salaries for inspections or project management
Impervious Credits calculated based on "Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated", August 2014
RR = Runoff Reduction, ST = Stormwater Treatment (Source: 2000 Design Manual, MDE)

Harford County, MD Department of Public Works
Watershed Protection and Restoration
Watershed Restoration Status (MS4 Permit 11-DP-3310)

Construction completed after 7/1/2019
Under construction as of 12/30/2019
Construction contract awarded as of 12/30/2019

Total	876.4

Active Projects

Project	Restoration Type	Complete (FY)	Credits (IA)
Annie's Playground	Stream Restoration, Tree Planting	2020	98.47
Tributary to Plumtree Run at Wakefield Manor	Stream Restoration	2020	8.85
Courthouse (Green Infrastructure Plan)	Bioretention	2020	0.46
Willoughby Beach	Stormwater Wetlands, Stream Restoration	2020	53.63
Mariner Point Park (Green Infrastructure Plan)	Tree Planting	2020	0.2
Barrington	Bioretention, RSC, Stormwater Wetland, Stream Restoration	2021	74.27
Magnolia Middle (aka Emmord)	Stream Restoration	2021	19.5
Sunnyview	Stream Restoration	2021	90
Stillmeadow	Stream Restoration	2021	31.44
Northwest Branch Declaration Run	RSC, Stream Restoration	2021	38.8
Church Creek Elementary	Submerged Gravel Wetland, Stream Restoration	2021	45.92
C Milton Wright High	Bioretention, Rainwater Harvest, Bioswale, Stream Restoration	2021	35
Heavenly	Wetland Creation, Stream Restoration	2021	24
Fallston Library	SWM Retrofit	2021	2.0
Fallston Firehouse	SWM Retrofit	2021	2.6

Watervale	Stream Restoration	2021	100
Woodland	Stream Restoration	2021	54
175 (Hickory Vet)	SWM Retrofit - Submerged Gravel Wetland	2021	0.8
191 (Spenceola)	SWM Retrofit - Sandfilter	2021	2.5
31 (Cmart - Gavigans)	SWM Retrofit - Bioretention	2021	1.0
Fallston MS, Fallston HS	Tree Planting, Bioretention, Stream Restoration	2022	193.0

Harford County, MD Department of Public Works

Watershed Protection and Restoration

Watershed Restoration Status (MS4 Permit 11-DP-3310)

Barry Glassman
County Executive

Complete Projects

Tree planting - inspections FY2020
Stormwater and stream restoration - inspections FY2020
Repairs needed

Total 612.44

Wpid	Wpname	Wpcomplete (FY)	Total Credits (IA)	Last Inspection	Pass / Fail
WP000088	Stormwater Retrofit at Homestead Elementary	2019	1.57	7/10/2019	Pass
WP000029	Bynum at St. Andrews Way Stream Restoration	2019	92.52	4/24/2019	Pass
WP000027	Lower Wheel Creek SWM Retrofit & Stream Restoration	2018	139.52	4/22/2017	Pass
WP000027	Lower Wheel Creek SWM Retrofit & Stream Restoration	2018	-15	4/9/2019	Fail
WP000046	Leight Center Parking Lot Green Infrastructure	2018	0.41	11/17/2017	Pass
WP000070	Abingdon Library Water Quality Improvements	2018	3.72	10/19/2017	Pass
WP000070	Abingdon Library Water Quality Improvements	2018	-3	2/19/2019	Fail
WP000074	Bear Cabin Branch Wetland and Stream Restoration	2018	110.25	5/9/2018	Pass
WP000035	Ring Factory ES SWM Retrofit & Stream Restoration	2018	41.33	7/27/2018	Pass
WP000025	Wheel Creek at Country Walk 1B SWM Retrofit	2017	3.66	10/23/2019	Pass
WP000036	Foster Branch at Dembytown Stream Restoration	2017	42.10	10/3/2018	Pass
WP000024	Wheel Creek at Country Walk 1A SWM Retrofit	2016	8.66	9/21/2017	Pass
WP000026	Wheel Creek at Festival at Bel Air SWM Retrofit	2016	12.00	1/10/2018	Pass
WP000095	Willoughby Beach Road Tree Planting	2016	0.57		
WP000096	Trappe Church Road Tree Planting	2016	0.27		

WP000073	Hickory Elementary Retrofit	2016	0.75	8/16/2017	Pass
WP000031	Norrisville Elementary Bioretention	2015	0.63	12/5/2019	Pass
WP000020	Woodbridge Stream Restoration	2015	24.6	4/5/2018	Pass
WP000051	Amoss Mill Road Tree Planting II	2015	0.21		
WP000052	Edwards Lane Tree Planting II	2015	1.7		
WP000055	Patterson Mill High School Tree Planting II	2015	1.22		
WP000063	Rider Lane Tree Planting	2015	0.76		
WP000064	Oakmont Road Tree Planting	2015	0.44		
WP000093	Red Pump Elementary School Tree Planting II	2015	0.66		
WP000094	Magnolia Middle School Tree Planting II	2015	0.47		
WP000060	Edwards Lane Tree Planting	2015	0.97		
WP000061	Amoss Mill Road Tree Planting	2015	0.18		
WP000062	Harford Christian School Tree Planting	2015	0.62		
WP000032	Foster Branch at Trimble Road Stream Restoration	2014	24.26	11/11/2019	Pass
WP000054	Mt Soma Property Tree Planting	2014	0.97		
WP000056	Magnolia Middle School Tree Planting	2014	0.23		
WP000058	North Harford High School Tree Planting	2014	0.15		
WP000059	Perryman Wellfield Tree Planting	2014	1.81		
WP000019	Woodbridge SWM Retrofit	2014	3.80	11/30/2016	Pass
WP000048	Heaven Waters Boulton Street Tree Planting	2014	0.20		
WP000049	Churchville Recreation Complex Tree Planting	2014	0.24		
WP000050	Walters Mill Tree Planting	2014	1.09		
WP000053	Harford Center Tree Planting	2014	0.22		

WP000022	Wheel Creek at Gardens of Bel Air SWM Retrofit	2014	4.79	12/21/2018	Pass
WP000030	Wheel Creek at Calvert Walks Stream Restoration	2013	21.75	11/6/2019	Pass
WP000057	Patterson Mill High School Tree Planting	2013	0.82		
WP000068	Cedarwood Pump Station Demolition	2013	0.05	N/A	N/A
WP000018	Friends Pond SWM Retrofit	2012	11.70	6/6/2018	Pass
WP000012	Bynum Ridge Stream Stablization	2012	13.95	11/6/2019	Pass
WP000016	Forest Hill Elementary School Bioretention	2011	0.91	12/21/2018	Pass
WP000017	Hickory Elementary School Bioretention	2011	0.60	8/16/2017	Pass
WP000013	Plumtree Run at Tollgate Stream Restoration	2011	50.40	11/6/2019	Pass
WP000042	Washington Court Demolition	2011	2.11	N/A	N/A
WP000015	Abingdon Library Bioretention	2011	0.60	12/21/2018	Pass

Memorandum

Date: April 30, 2019

To: Maryland's Municipal Separate Storm Sewer System (MS4) Community

From: Maryland Department of the Environment (Department), Sediment, Stormwater, and Dam Safety Program

Re: Stream Restoration Crediting Clarification for MS4 Permitting Purposes

Introduction

The Department recognizes and accepts the Chesapeake Bay Program's (CBP) Urban Stormwater Work Group's revised stream restoration pollutant load reduction rates, *Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects, Schueler and Stack, 2014,* for use in crediting projects to support MS4 permit restoration requirements. The Department's *Municipal Separate Storm Sewer System Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, (Guidance), August 2014,* provided instructions for transitioning to these pollutant load reduction rates for total maximum daily load (TMDL) analysis. More recently in December 2017 and October 2018, the Department provided guidance on how to use these revised pollutant load reduction rates for calculating equivalent impervious acres toward completing MS4 permit restoration requirements. This memorandum provides further clarification on the use of pollutant load reduction planning rates and individual site monitoring for calculating MS4 equivalent impervious acre permit restoration credit. These clarifications are for use in coordination with the CBP Phase 5 model calibration and applicable to Maryland's MS4 jurisdictions.

Stream Restoration Pollutant Load Reduction Planning Rates

In *Schueler and Stack, 2014,* the CBP established pollutant load reduction planning rates for stream restoration projects for use in the CBP's Phase 5 watershed model. These planning rates may be used by Maryland's MS4 community for calculating MS4 equivalent impervious acre permit restoration credit. The MS4 equivalent impervious acre permit restoration credit may be applied uncapped in relation to the actual impervious acres in the stream restoration project's watershed. Table 1 below provides the CBP pollutant load reduction planning rates for stream restoration projects and the equivalent impervious acre credit in accordance with the Department's *Guidance, August 2014.*

Table 1. Planning Rates for Stream Restoration and Impervious Acre Equivalents

Geography	TN[1] (lbs./ft.)	TP[1] (lbs./ft.)	TSS[1] (lbs./ft.)	Equivalent Impervious Acres[2] EIA (acres/ft.)
Coastal Plain	0.075	0.068	15	0.02
Non-Coastal Plain	0.075	0.068	45	0.03

[1] *Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects, Schueler and Stack, 2014*

[2] *Municipal Separate Storm Sewer System Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated, (Guidance), August 2014*

Site Specific Monitoring of Stream Restoration Projects

The Department also supports the use of site specific stream restoration monitoring data combined with the protocols approved by the CBP for calculating pollutant load reductions for TMDLs. The stream restoration protocols, and specifically the pollutant load reductions associated with the monitoring of individual stream restoration projects, are currently being re-evaluated by the CBP's Urban Stormwater Work Group. For this reason, the equivalent impervious acre MS4 permit restoration credit for site specific stream restoration monitoring is capped at the actual impervious acres draining to the most downstream point of the stream restoration project. Once the CBP completes its reevaluation of the stream restoration protocols and provides updates, the Department will determine how to incorporate them into future MS4 permits in coordination with the Phase 6 CBP model calibration and will reconsider the impervious acre cap applied to the use of site specific monitoring data.

Stream Restoration Inspection Protocol
Technical Memorandum

Prepared for

Harford County Department of Public Works
Division of Construction Management
Watershed Protection and Restoration Office
212 S. Bond Street
Bel Air, Maryland 21014

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
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December 2019
Version: FINAL
EA Project No. 1535706

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Table of Contents

Page

1.0 Introduction and Background 1
1.1 Purpose 1
2.0 Inspection Parameters 1
2.1 Rated Stream Parameter Terminology 2
2.2 Non-Rated Stream Parameter Terminology 2
3.0 Inspection Process 3
3.1 Pre-Field Preparation 3
3.2 Field Inspection 4
3.3 Post-Field Summary 5

List of Figures

Page

Figure 1. Bank Erosion Hazard Index 2
Figure 2. Georeferenced Plans in ArcGIS Webmap 4

Stream Restoration Inspection Protocol Technical Memorandum

1.0 Introduction and Background

Harford County's (the County's) National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System (MS4) Permit (Permit Number 11-DP-3310, effective 30 December 2014 through 29 December 2019) requires the County to conduct preventative maintenance inspections of all environmental site design treatment systems and structural stormwater best management practices (BMPs) on a triennial basis. The County is required to report annually to the Maryland Department of the Environment (MDE) documentation identifying the stormwater management practices inspected, the inspection results (pass/fail), the number of maintenance inspections, the number of follow-up inspections, the enforcement actions used to ensure compliance, and the maintenance inspection schedule. According to the *Accounting for Stormwater Wasteload Allocation and Impervious Acres Treated (*August 2014), "A "failed" designation assigned to any BMP indicates the facility is not functioning as designed."

Stream restoration projects are a type of stormwater BMP installed to restore function and stability of a stream to the site's potential. Most stream restoration projects are required to have 3-year or 5-year monitoring plans and inspections as part of the authorization and associated permit conditions from the U.S. Army Corps of Engineers/MDE. This Stream Restoration Inspection Protocol will be used by the County for projects that have completed their required monitoring and are entering the triennial BMP inspection cycle.

1.1 Purpose

The MS4 Office contracted EA Engineering, Science, and Technology, Inc., PBC. to develop this Stream Restoration Inspection Protocol for the Stream Restoration projects that have completed their required monitoring plan and inspections as part of the authorization and associated permit conditions for the U.S. Army Corps of Engineers/MDE, and that have entered the triennial inspection cycle.

This Stream Restoration Inspection Protocol documents the conditions and parameters the County used to designate a Stream Restoration project as "functioning as designed" or not. The inspection relies upon visual characterizations of various parameters to make this determination.

2.0 Inspection Parameters

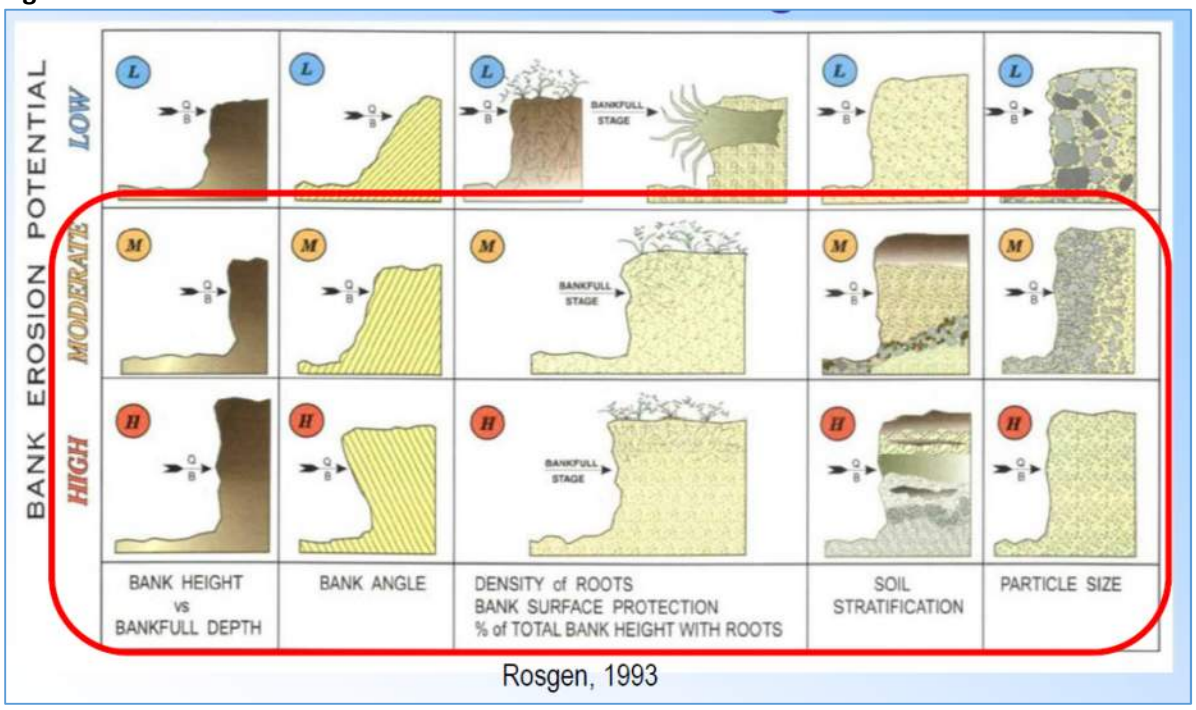
The Restoration Project Inspection Protocol includes the assessment of stream reach-scale morphological parameters and structural stability to ensure MS4 permit compliance. As MS4 permits are directly tied to a reduction in Total Maximum Daily Loads, the primary indicator of success is the reduction of sediment-producing banks. This is quantified for each stream restoration project through the establishment of critical locations, which document in-stream structure and bank stability. Length and severity of bank instability is noted, as well as functionality and stability of each structure and channel bed instability.

Pass/Fail Rating is determined by the percentage of stable banks within the project limits of disturbance. Majority stable banks (≥75% stable) pass the site ("Functional"), while majority unstable banks (<75% stable) fail the site ("Not Functional"). Non-rated parameters are assessed to identify any potential future impairments or negative impacts to the design.

2.1 Rated Stream Parameter Terminology

For bank stability, a visual assessment of Bank Erosion Hazard Index (BEHI) is used to identify banks with moderate or high erosion potential (**Figure 1**). Steep banks and undercut banks are more likely to experience high rates of erosion than gently sloping banks with protection, whether vegetative or structural. If a bank is categorized as moderate or high BEHI, the length, severity, and start and stop station is recorded. This assessment is performed for the right and left banks separately.

Figure 1. Bank Erosion Hazard Index



2.2 Non-Rated Stream Parameter Terminology

These parameters will be assessed during the inspection but are not necessarily indicators of the stream restoration project MS4 crediting. These parameters are important to capture during the inspection for the County's records, as they may indicate maintenance needs or potential future failures.

1. Channel Bed Stability (Aggradation/Degradation)—Look for the presence of sediment deposition, bed scour, head-cut, and the changes that have occurred to the stream bed because of sediment movement. High levels of sediment movement (erosion or deposition) are symptoms of an unstable and continually changing stream system.

2. Placed Instream Structure Stability—Assess for the stability of any placed instream structures (log, rock, or combined) including riffle, run, pools, and steps. If instability is noted, evaluate if isolated or potential impact to additional structures.

3. Design Channel Alteration/Anthropogenic Evidence—This is a measure of large-scale changes in the shape and stability of the designed stream channel due to direct anthropogenic impacts into the restored channel. Channel alteration may include creation of embankments, channel shaping, addition of structures, riprap or artificial bank stabilization, dams, channel crossings, etc.

4. Property/Structure/Utilities Damage—Assess damage or imminent potential for damage to properties, structures, road, or utilities due to flooding, erosion, transportation of excessive sediment, high flow, etc.

5. Riparian Vegetation Zone Width—The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream. Mowing of riparian vegetation, dumping of trash and debris, and unauthorized discharges into the channel will be assessed and noted.

6. Encroachment of Invasive Plant Species within Project Area—Assessment and identification of invasive plant species impacting the project area.

7. Channel Obstruction—Identification of debris accumulation disrupting existing drainage patterns or causing channel instability.

8. Water Quality—A visual/olfactory assessment of water quality. Any suspected water quality issues will be immediately reported to the County.

3.0 Inspection Process

Stream Restoration inspections should occur in the spring or fall to allow for good line of sight, as well as identification of any invasive species that may be impacting the project area.

3.1 Pre-Field Preparation

All stream restoration projects are unique and will require site-specific preparation. Prior to performing the inspections, the inspector should review available documents, consulting with the County if necessary, to verify location, access, project area extent, and location/type of design elements. Available plans should be georeferenced into an ArcGIS webmap for use in the field (**Figure 2**). A project geodatabase was created to host critical location points, notes, and photographs for the Fall 2019 inspections. This information will be made available through the County for future inspections.

Figure 2. Georeferenced Plans in ArcGIS Webmap

For up to 3 days prior to field inspections, weather and precipitation information must be observed and recorded.

The following field equipment is recommended:

- Tablet with global positioning system (GPS) capabilities
- Design and as-built plans
- Pencils or waterproof pens
- GPS-enabled digital camera
- Measuring tape
- Survey rod.

3.2 Field Inspection

During the baseline inspection for each project site critical locations will be developed. Critical locations will be placed at the upstream extent of each in-stream structure or every 100 feet along the proposed alignment, whichever creates a higher density of points. Additional locations may be added to ensure all project areas of concern are documented. Critical locations are saved in the webmap application, to ensure ease of replication for future monitoring efforts.

Note: Photos should include a person for perspective.

For each critical location, notes will be taken either in the tablet or on the hardcopies of the plans and a photograph will be taken to fully document the condition of the parameter. To the greatest extent possible, photographs should include surrounding site elements for context.

3.3 Post-Field Summary

At the conclusion of the field monitoring effort, total length of moderate and high BEHI banks will be summed and divided by the total length of both left and right banks, measured along the proposed alignment. If the total percentage of unstable banks is greater than 25%, then the entire stream restoration project will be considered as "not functioning as designed" and will receive a failed rating for MDE annual reporting. Conversely, if the total percentage of stable banks is greater than or equal to 75%, the entire stream restoration project will be considered "functioning as designed" and will receive a passing rating. This will be summarized in a Restoration Project Inspection Report for each site, including notes, maintenance considerations, and photographs. The inspections completed for Fall 2019 are available in Appendix A.

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Appendix A
Fall 2019 Inspection Reports

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Box Hill Stream Restoration			
Restoration Project Inspection Status	Pass		
Date of Field Inspection	November 11, 2019	**Precipitation past 24 hrs**	None
Investigator(s)	N.Williamson & M.Johnson	**Flow Condition**	Baseflow

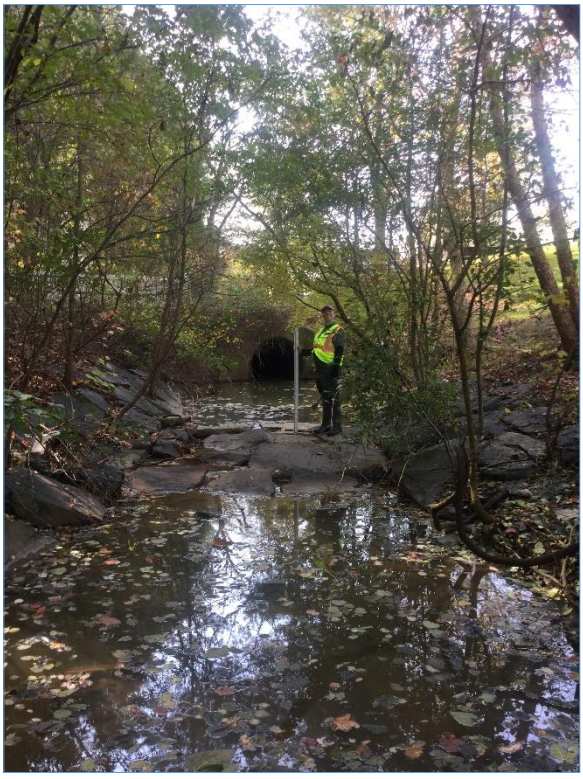
Inspection Notes

- Surface water in the upstream-most 400 ft of the channel is a milky color, with no foul odor.
- Overall, a majority of restoration structures are stable. Minor instabilities include:
  - One scour hole along left bank of step pool channel at Station 10+40, likely due to stormwater flow from Kensington Parkway. Structure is functioning as intended, but scour extends to full depth of channel bank and may threaten stability if it progresses.
  - Erosion along left bank of cross vane weir at Station 6+00. Structure is functioning as intended, although there is minor instability at downstream extent.
  - Erosion along right bank of boulder bank stabilization at Station 1+30. Structure is functioning as intended, although there is minor instability at upstream extent.
- 94% of the channel banks within the project limits are stable.

Maintenance Considerations

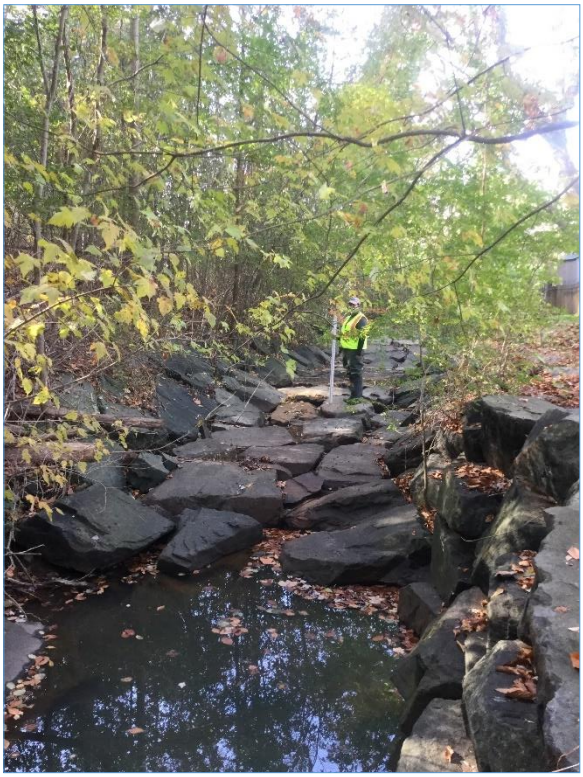
- Evaluate watershed for illicit discharge.
- Assess need for stormwater dissipation feature on Kensington Parkway and/or placement of stone backfill behind step pool channel at Station 10+40.

Photographs



Upstream extent storm drain outfall

Scour hole left bank of step pool channel Sta. 10+40



Milky color of water in channel

Minor instability downstream left bank Sta. 6+00

Minor instability upstream right bank Sta. 1+30

Bynum Ridge Stream Restoration			
Restoration Project Inspection Status	Pass		
Date of Field Inspection	November 6, 2019	**Precipitation past 24 hrs**	None
Investigator(s)	N.Williamson & M.Johnson	**Flow Condition**	Baseflow

Inspection Notes

- Overall, all restoration structures are stable. Minor instabilities, not associated with the restoration project include:
  - Concrete outfall apron undermined and detached on left bank at Station 12+25.
  - Common bamboo (*Bambusa vulgaris*) on right bank at Station 16+00.
  - Wooden fence across the stream channel at Bynum Road culvert.
  - Exposed sanitary sewer line crossing channel at Station 0+60.
- 98% of the channel banks within the project limits are stable.

Maintenance Considerations

- Evaluate outfall structure at Station 12+25 for maintenance.
- Assess need for bamboo treatment at Station 16+00.
- Assess need for removal of wooden fence at Bynum Road culvert.

Photographs

Concrete outfall apron detached Sta. 12+25

Wooden fence crossing channel at Bynum Road

Calvert's Walk Stream Restoration			
Restoration Project Inspection Status	Pass		
Date of Field Inspection	November 6, 2019	**Precipitation past 24 hrs**	None
Investigator(s)	N.Williamson & M.Johnson	**Flow Condition**	Baseflow

Inspection Notes

- Overall, all restoration structures are stable. One minor instability includes:
  - Headcut downstream of existing gabion at Station 16+10. Downstream riffle structure is holding grade and functioning as intended. No maintenance required.
- 94% of the channel banks within the project limits are stable. Most erosion is minor and not associated with implemented structures.

Maintenance Considerations

- None at this time.

Photographs

Upstream extent of project

Headcut downstream of existing gabion Sta. 16+10

Foster Branch at Haverhill Stream Restoration			
Restoration Project Inspection Status	Pass		
Date of Field Inspection	November 11, 2019	**Precipitation past 24 hrs**	None
Investigator(s)	N.Williamson & M.Johnson	**Flow Condition**	Baseflow

Inspection Notes

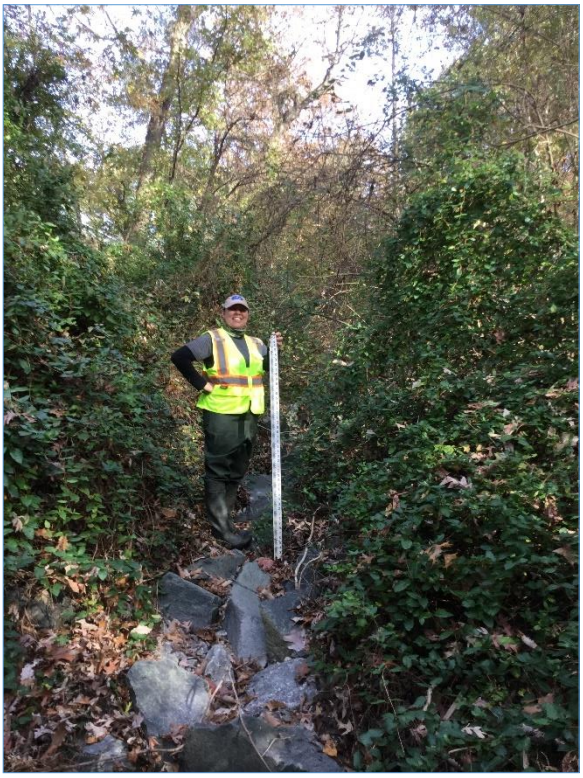
- Overall, all restoration structures are stable. Minor instabilities include:
  - Headcut downstream of existing gabion at Station 1+90. All upstream restoration structures are functioning as intended. No maintenance required.
  - Heavy invasive vine coverage, including Japanese Honeysuckle (*Lonicera japonica*), in floodplain and channel from Station 2+00 to 4+00.
  - Common bamboo (*Bambusa vulgaris*) on right bank at Station 6+75.
- 98% of the channel banks within the project limits are stable.

Maintenance Considerations

- Assess need for invasive vine treatment from Station 2+00 to 4+00.
- Assess need for bamboo treatment at Station 6+75.

Photographs

Headcut downstream of gabion structure Sta. 1+90



Heavy invasive vine coverage Sta. 2+75

Foster Branch at Trimble Stream Restoration			
Restoration Project Inspection Status	Pass		
Date of Field Inspection	November 11, 2019	**Precipitation past 24 hrs**	None
Investigator(s)	N.Williamson & M.Johnson	**Flow Condition**	Baseflow

Inspection Notes

- Overall, the majority of restoration structures are stable. One minor instability includes:
  - Displacement of Outfall #1 class II riprap from upstream plunge pool. Pool is functioning as intended and all downstream restoration structures appear stable. No maintenance required.
- High quantity of fine sediment deposition throughout upstream extent of restoration project.
- 98% of the channel banks within the project limits are stable.

Maintenance Considerations

- None at this time.

Photographs

Displacement of Outfall #1 class 2 riprap

Stable channel Sta. 6+50

Laurel Valley Stream Restoration			
Restoration Project Inspection Status	Pass		
Date of Field Inspection	November 11, 2019	**Precipitation past 24 hrs**	None
Investigator(s)	N.Williamson & M.Johnson	**Flow Condition**	Baseflow

Inspection Notes

- A majority of the restoration structures are stable, although several instabilities occur, including:
  - Minor scour behind existing outfall endwall and behind stone toe protection along both banks from Station 6+45 to 6+50 and right bank from Station 7+40 to 7+50, 9+10 to 9+20, 10+35 to 10+65, and 12+40 to 12+63. Structures in these areas appear stable.
  - Severe erosion behind right bank stone toe protection from Station 4+00 to 4+40, with 10 ft of stone displacement exposing bank. Mowing to top of bank exacerbates erosion.
  - Severe bank migration and stone displacement from Station 9+30 to 9+50.
  - Flow under log weir at Station 10+65. Structure is no longer holding channel grade.
  - Porcelainberry (*Ampelopsis brevipedunculata*) in floodplain from Station 2+75 to 3+25, 3+50 to 4+50, and 6+25 to 6+50. Common bamboo (*Bambusa vulgaris*) from 11+00 to 12+00.
- 89% of the channel banks within the project limits are stable.

Maintenance Considerations

- Educate homeowners on importance of stream buffer to prevent stream and lawn erosion.
- Evaluate need for addition of stone to right bank from Station 4+00 to 4+40 and 9+30 to 9+50.
- Assess need for porcelainberry and bamboo treatment throughout project.

Photographs

Scour behind existing outfall endwall

Erosion and stone migration Sta. 4+00 to 4+40

Scour behind stone toe protection Sta. 7+50

Bank migration and stone toe displacement Sta. 9+40

Flow under log weir and right bank scour at Station 10+65

Scour behind stone toe protection at Station 12+40

Mt. Royal Stream Restoration			
Restoration Project Inspection Status	Pass		
Date of Field Inspection	November 6, 2019	**Precipitation past 24 hrs**	None
Investigator(s)	N.Williamson & M.Johnson	**Flow Condition**	Baseflow

Inspection Notes

- A majority of the restoration structures are stable. Minor instabilities include:
  - Two-foot scour hole behind boulder spur on left bank at Station 5+19. The structure is functioning as intended.
  - Scour behind boulder spur on right bank at Station 4+28. The structure is functioning as intended.
  - Scour behind boulder spur with grade control on right bank at Station 0+80. The structure is functioning as intended.
- 81% of the channel banks within the project limits are stable. Most erosion is moderate in severity and occurs in areas without structure installation.

Maintenance Considerations

- None at this time.

Photographs

Two-foot scour hole behind weir Sta. 5+15

Erosion on left bank between structures Sta. 3+85 to 5+15

Scour behind boulder spur Sta. 4+28

Erosion on left bank between Sta. 0+50 and 2+10

Scour behind boulder spur with grade control Sta. 0+80

Plumtree Run at Tollgate Road Stream Restoration			
Restoration Project Inspection Status	Pass		
Date of Field Inspection	November 6, 2019	**Precipitation past 24 hrs**	None
Investigator(s)	N.Williamson & M.Johnson	**Flow Condition**	Baseflow

Inspection Notes

- A majority of the restoration structures are stable. Instabilities include:
  - Mainstem erosion at upstream extent of boulder bank stabilization on left bank at Station 9+80. The structure is currently functioning as intended.
  - Mainstem erosion and bank migration on left bank behind rock toe protection from Station 15+75 to 16+25 and boulder bank stabilization from Station 19+75 to 21+25.
  - Tributary erosion and displaced rock on left bank from Station 4+73 to 5+15.
  - Tributary erosion in right bank live stake area from Station 1+25 to 2+25 and 3+50 to 4+00.
- 81% of the channel banks within the project limits are stable. Most erosion is severe, particularly where associated with structure failure.

Maintenance Considerations

- Educate homeowners on importance of stream buffer to prevent stream and lawn erosion.
- Evaluate need for relocation of boulders against migrated bank surface with addition of rock backfill at mainstem Station 15+75 to 16+25 and 19+75 to 21+25.
- Evaluate need for addition of shrub and live stake material to tributary erosion.
- Assess success of Japanese knotweed (*Fallopia japonica*) management in the spring.

Photographs

Mainstem

Severe erosion upstream of boulder bank Sta. 9+80

Severe erosion and bank migration behind rock Sta. 16+25

Severe erosion on left bank Sta. 18+50

Severe erosion and bank migration behind rock Sta. 20+00

Tributary

Severe erosion and displaced structure Sta. 5+00

Severe erosion Sta.1+50

Winters Run Stream Restoration			
Restoration Project Inspection Status	Pass		
Date of Field Inspection	November 11, 2019	**Precipitation past 24 hrs**	None
Investigator(s)	N.Williamson & M.Johnson	**Flow Condition**	Baseflow

Inspection Notes

- A majority of the restoration structures are stable. Instabilities include:
  - Minor erosion between vane structures on the right bank from Station 1+25 to 1+75. The structures are currently functioning as intended.
  - Minor scour behind outfall endwall structure. Outfall endwall and channel remain stable.
  - Right bank migration behind stone toe protection, riffle grade control structure, and cross vane from Station 4+25 to 6+75.
- 90% of the channel banks within the project limits are stable. Most erosion is associated with bank migration from Station 4+25 to 6+75, which appears to have reached a state of equilibrium.

Maintenance Considerations

- None at this time.

Photographs

Minor erosion between vanes Sta.1+25

Scour behind outfall endwall structure

Right bank migration Sta. 4+25

Right bank migration Sta. 6+50

Stable cross vane Sta. 6+25

Watershed Restoration Projects - Permit Monitoring

Woodbridge Stream Restoration
Dembytown Stream Restoration
Ring Factory Elementary School Stream Restoration
Bear Cabin Branch Stream Restoration
Bynum Run and St. Andrew's Way Stream Restoration
Emmord Branch Stream Restoration
Willoughby Beach Stream Restoration

Woodbridge Year 4 Post-construction Monitoring

Pre-construction

Post-construction

Prepared for:
The Harford County Department of Public Works

November 2019

Prepared by:
KCI Technologies Inc.
936 Ridgebrook Road
Sparks, MD
21152

KCI Job Number:
17170458.11

KCI TECHNOLOGIES

1. INTRODUCTION 1

1.1 Restoration Design Description 1

2. METHODOLOGY 3

2.1 Monitoring Schedule 3

2.2 Structural Assessment 3

2.3 Physical Habitat Evaluation 5

2.4 Biological Monitoring 6

3. MONITORING YEAR 4: RESULTS AND DISCUSSION 7

3.1 Structural Assessment 7

3.1.1 Evaluation of Channel and Bank Stabilization Structures 7

3.1.2 Reach 1 Tributary 9

3.2 Physical Habitat Evaluation 9

3.3 Biological Monitoring 13

4 CONCLUSIONS 17

5 REFERENCES 18

FIGURES

Figure 1 Vicinity Map 2
Figure 2 Site Assessment Location Map 4
Figure 3 Comparison with Pre-Construction (2005-2007) and Post-Construction (2016-2019) PHI Scores 11
Figure 4 Comparison of Post-Construction (2016-2019) RBP Scores 12
Figure 5 Comparison of Post-Construction (2016-2019) data with Pre-Construction (2005-2007) 16
Figure 6 Comparison of BIBI Scores at the MBSS Reference Site (2009-2018) 17

TABLES

Table 1 RBP Low Gradient Habitat Parameters 5
Table 2 RBP Habitat Score and Ratings 5
Table 3 PHI Coastal Plain Parameters 6
Table 4 PHI Scores and Ratings 6
Table 5 Biological Condition Scoring for the Coastal Plain Benthic Macroinvertebrates 7
Table 6 BIBI Scoring and Rating 7
Table 7 Physical Habitat Assessment Results 2015-2019 11
Table 8 Benthic Index of Biotic Integrity (BIBI) Summary Data 2016-2019 14
Table 9 MBSS Reference Site LWIN-108 BIBI Summary Data 15

APPENDICES

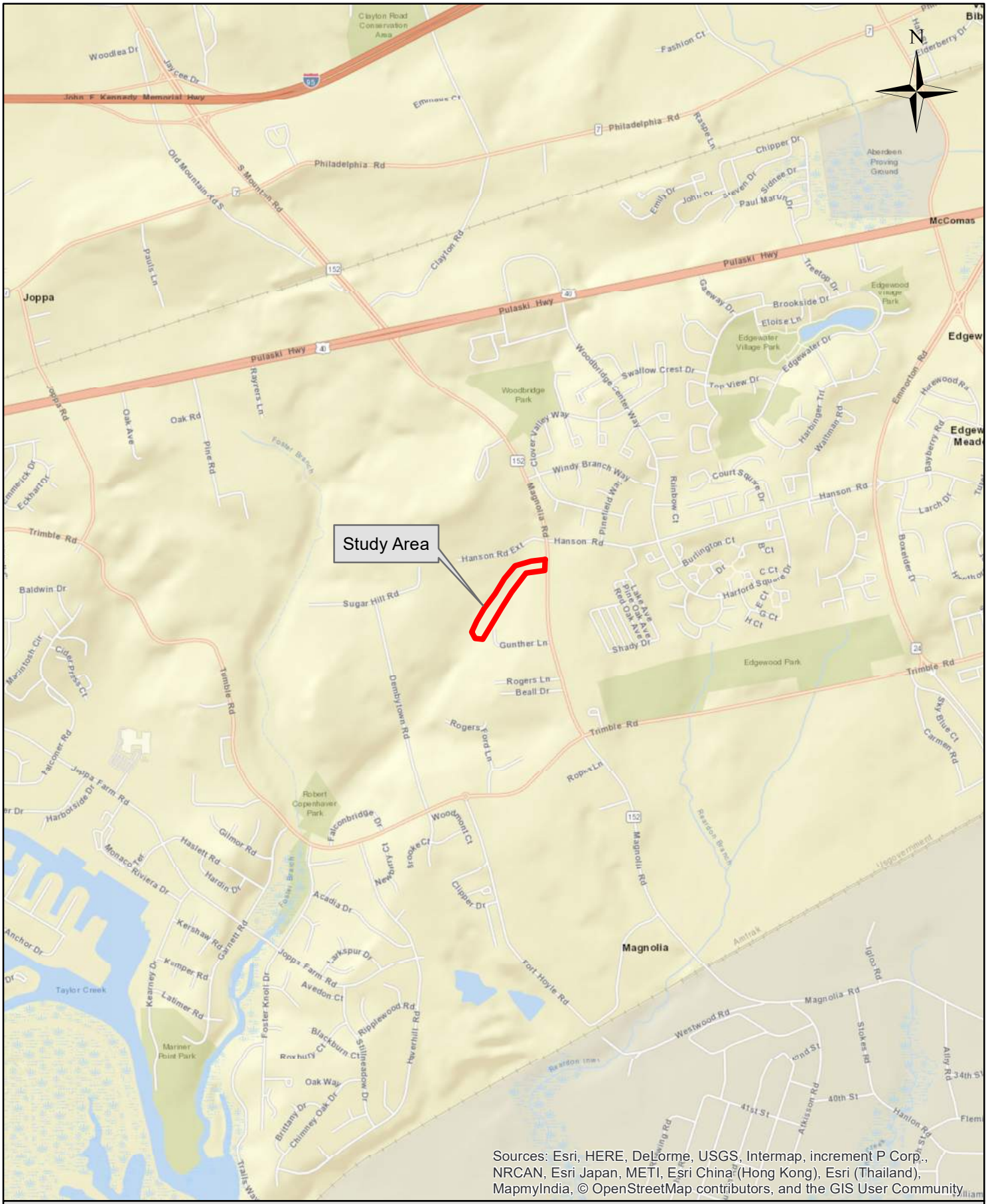
Appendix A. Site Photographs
Appendix B. Physical Habitat Data
Appendix C. Biological Assessment Data

1. INTRODUCTION

This report documents the monitoring services required under item 8 and item 10 of the joint permit (CENAB-OP-RMN (HA DPW/Woodbridge/Stream Restoration) 2011-60634-M24) issued February 5, 2013. This is the fourth year post-construction monitoring study, which follows the monitoring activities completed under task assignment 3 for monitoring year 1-3. The project area is located in Joppatowne in southern Harford County, Maryland, and is situated southwest of the intersection of Magnolia Road (MD 152) and Hanson Road (see Figure 1, Project Vicinity Map). Post-construction monitoring for years 1-3 included geomorphic, physical habitat, riparian buffer planting, biological assessments, and structure inspections see (KCI 2018 Report) Year 4 and 5 only includes physical habitat, biological assessments, and visual structure assessment with photo documentation. The Harford County Department of Public Works requested these services from KCI Technologies, Inc. (KCI) in order to assist with documenting the success of the restoration project implemented that was completed in April 2015. The Year 4 geomorphic monitoring survey was conducted in June 2019 and the biological monitoring survey was conducted in April 2019.

1.1 Restoration Design Description

The Woodbridge Stream Restoration project is a 1,200 linear feet (LF) of stream with a variety of geomorphic stabilizing structures. Reach 1, prior to restoration, was highly degraded with 10-12 feet high banks. Private property adjacent to the extents of channel erosion made avoidance of impacts a challenge to design. The result is the Stepped Riffle Complex (SRC) system that retains up to the 10-year discharge within the channel and drops over a steep gradient in a controlled manner for approximately 300 LF. The SRC morphology consists of an in-line pattern of riffle, weir, pool with very low sinuosity. Reach 2 was several tortuous meanders that had too tight of radius of curvature, mature trees along both banks, and nearby adjacent private property. Restoration in this segment consisted of 500 LF of riffle-pool sequence that was stabilized with riffle grade controls and stone toe protection. The last 50 LF consisted of a set of three step pools to bring the channel down to the elevation of the driveway culverts dictating channel elevation. The lower segment begins 30 LF downstream of the driveway culvert and contains 320 LF of minimal restoration efforts. The site conditions at the time of assessment and the general wish of the private property owner, though which the channel traverses, was to leave the channel bed and left bank unrestored after the grade control immediately downstream of the driveway culvert. Only bank grading and stabilization with natural fiber matting and live stakes was to be conducted on the right bank for approximately 100 LF. Approximately 200 LF downstream and near the end of the private property a stone sill was placed to mitigate any downstream initiated disturbance from migrating up into the restoration area.



Woodbridge Stream Restoration
Post-Construction Monitoring
Figure 1. Vicinity Map
Harford County, Maryland
KCI Job No. 171700458.11

0 1,000 2,000 4,000 Feet

1" = 2000'

Legend

Study Area

2. METHODOLOGY

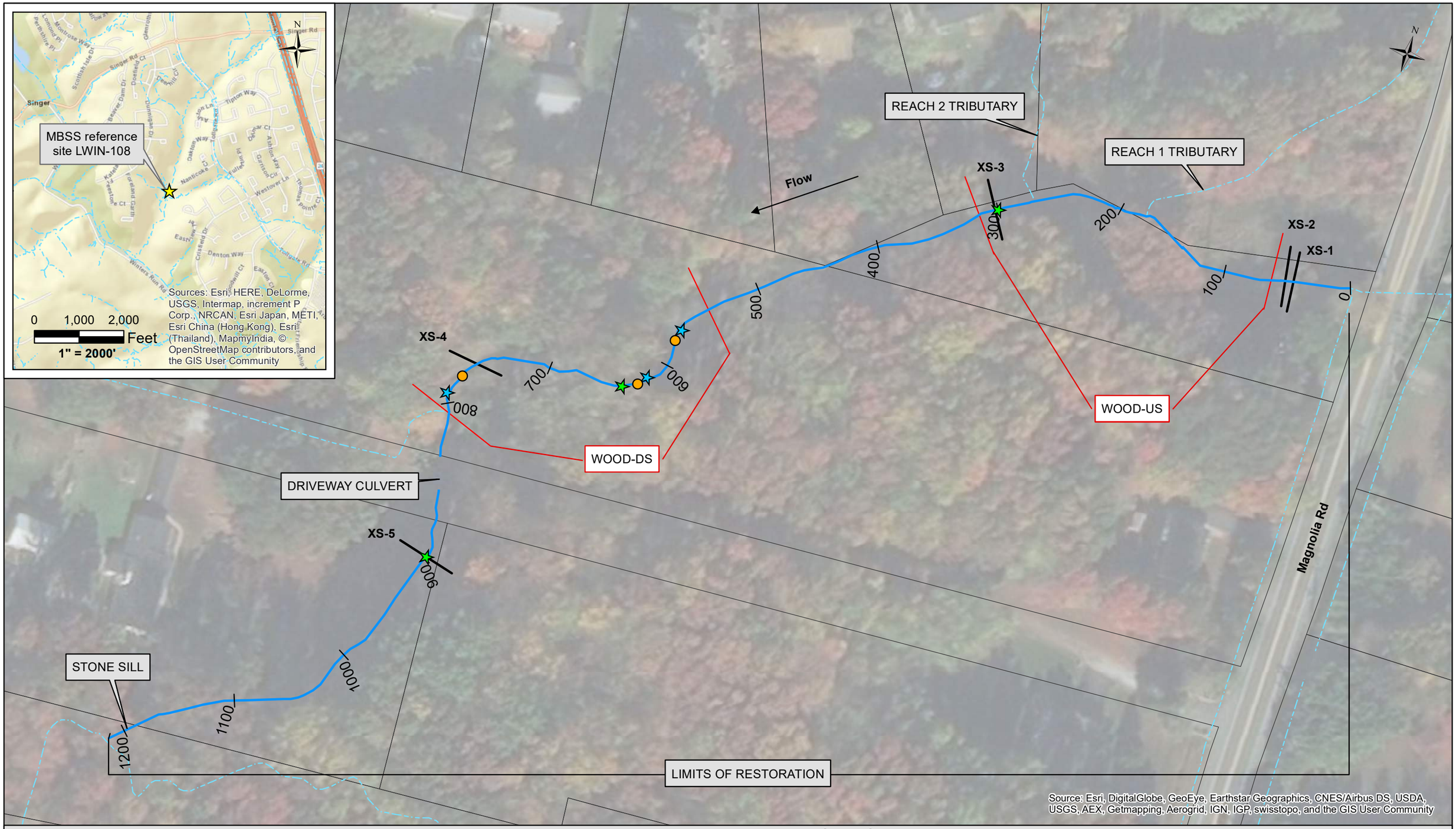
2.1 Monitoring Schedule

The Woodbridge site is being assessed annually for a period of five years around the same time each year. Data collected during Year 1 (2016) monitoring efforts shall serve as the baseline data to which future monitoring events are compared. The monitoring assessment year 1-3 includes evaluations of riparian plantings, geomorphic assessments, physical habitat evaluation, biological monitoring, and structure inspections. Years 4 and 5 only consist of physical habitat evaluations, biological monitoring, and visual structure assessments with photo documentation. Geomorphic and biological assessment locations can be seen in Figure 2, Site Assessment Location Map. Photographic documentation was collected during assessments for comparison of observations and can be referenced in Appendix A.

Stationing described in this report was coordinated with the design plan baseline, running from upstream to downstream, and will be referred to as the survey station. All assessments of bank and vegetation are approximate to the survey stationing. Right and left banks are designated facing downstream.

2.2 Structural Assessment

Monitoring year 1-3 geomorphic assessments included a longitudinal profile survey for the entire project length, 5 cross-sectional surveys, radius of curvature measurements, bank profile monitoring, evaluation of sediment characteristics, and inspection of structures see (KCI 2018 Report). The locations of these assessments have been included on Figure 2 for reference. Year 4 only includes a structural assessment as a visual qualitative evaluation of the condition of the bank and bed stabilization techniques. A visual assessment of the SRC structure, riffle grade control, stone sill, cascade crest, and stone toe protection was completed to evaluate the success of these stabilization structures. The assessment focused on observed structural integrity of the stabilization techniques noting evidence of deterioration, dislodgement, etc. Typical areas of concern include locations where shifting, scouring, and undercutting compromises the stability of the structures. Photos from the previous monitoring year 1-3 will be used to compare to the year 4 conditions and document any changes to the structural integrity of the stabilization techniques and function of each structure within the restoration reach. The specific photographic documentation for geomorphic assessments is included in Appendix A.



Woodbridge Stream Restoration
Post-Construction Monitoring
Figure 2. Site Assessment Location Map
Harford County, Maryland
KCI Job No. 171700458.11

0 35 70 140
Feet
1" = 70'

Legend

- Other Streams
- Stream
- Pebble Count Location
- Radius of Curvature Location
- Bank Pin
- Cross Section
- Biological Sampling Reach Limits
- Parcels

2.3 Physical Habitat Evaluation

Physical habitat was evaluated at two (2) biological monitoring sites within the restoration (see Figure 2) and at one local urban reference site. The biological monitoring sites were characterized based on visual observations of physical characteristics and various habitat parameters. The EPA's Rapid Bioassessment Protocol (RBP) habitat assessment for low gradient streams (Barbour et al., 1999) and the Maryland Biological Stream Survey's (MBSS) Physical Habitat Index (PHI; Paul et al., 2003) were used to assess the physical habitat at each restoration site. The local urban reference site is monitored by Maryland Department of Natural Resources' (MDNR) MBSS which only collects PHI habitat metrics. The PHI habitat assessment was added to the restoration sites post restoration to allow for comparison with the MBSS local reference site.

The RBP habitat assessment consists of a review of ten biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health (Table 1). Each parameter is given a numerical score from 0-20 (20 = best, 0 = worst), or 0-10 for individual bank parameters (i.e., bank stability, vegetative protection, and riparian vegetative zone width), and a categorical rating of optimal, suboptimal, marginal or poor. Overall habitat quality typically increases as the total score for each site increases.

Table 1 RBP Low Gradient Habitat Parameters

Low Gradient Stream Parameters	
Epifaunal substrate/available cover	Channel alteration
Pool substrate characterization	Channel sinuosity
Pool variability	Bank stability
Sediment deposition	Vegetative protection
Channel flow status	Riparian Vegetative Zone Width

The RBP habitat parameters for each reach are summed, with a total possible score of 200. The total score is then placed into one of four narrative categories (Table 2) based on the percent comparability to reference conditions.

Table 2 RBP Habitat Score and Ratings

Score	**Percent of Reference**	**Narrative Rating**
≥180	≥90%	Comparable to Reference
150-179	75% - 89%	Supporting
120-149	60% - 74%	Partially Supporting
≤119	≤60%	Non-Supporting

Additionally, indicators of site conditions and instream and riparian habitat were assessed at each site during the spring sampling visit following MBSS procedures (MDNR, 2019). The PHI incorporates the results of a series of habitat parameters selected for Coastal Plain, Piedmont and Highlands regions. While all parameters are rated during the field assessment, the Coastal Plain parameters are used to develop the PHI score. In developing the PHI, MBSS identified six parameters that have the most discriminatory power for coastal plain streams. These parameters

are used in calculating the PHI (Table 3). Several of the parameters have been found to be drainage area dependent and are scaled accordingly.

Table 3 PHI Coastal Plain Parameters

Coastal Plain Stream Parameters	
Remoteness	Instream Habitat
Shading	Woody Debris and Rootwads
Epifaunal Substrate	Bank Stability

Each habitat parameter is given an assessment score ranging from 0-20, with the exception of shading (percentage) and woody debris and rootwads (total count). A prepared score and scaled score (0-100) are then calculated. The average of these scores yields the final PHI score. The final scores are then ranked according to the ranges shown in Table 4 and assigned corresponding narrative ratings, which allows for a score that can be compared to habitat assessments performed statewide.

Table 4 PHI Scores and Ratings

PHI Score	**Narrative Rating**
81.0 – 100.0	Minimally Degraded
66.0 – 80.9	Partially Degraded
51.0 – 65.9	Degraded
0.0 – 50.9	Severely Degraded

To reduce individual sampler bias, both assessments were completed as a team with discussion and agreement of the scoring for each parameter. In addition to the visual assessments, photographs were taken from three locations within each sampling reach (downstream end, mid-point, and upstream end) facing in the upstream and downstream direction, for a total of six (6) photographs per site (Appendix A-4).

2.4 Biological Monitoring

Benthic macroinvertebrate sampling was conducted at the two established biological monitoring sites located within the restoration reach: Wood-US and Wood-DS (see Figure 2). Samples were collected following MBSS protocols (MDNR, 2019) by field personnel certified by MDNR in MBSS sample collection procedures. Benthic macroinvertebrate samples were processed and identified according to methods described in MBSS Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy (Boward and Friedman, 2011) by Aquatic Resource Center. Identification of the specimens is conducted to the genus level for most organisms. Groups including Oligochaeta and Nematomorpha were identified to the family level while Nematoda was left at the phylum. Individuals of early instars or those that may be damaged are identified to the lowest possible level, which could be phylum or order, but in most cases they are identified to the family level.

Benthic macroinvertebrate data were analyzed using methods developed by MBSS as outlined in the New Biological Indicators to Better Assess the Condition of Maryland Streams (Southerland

et al., 2005). The Benthic Index of Biotic Integrity (BIBI) approach involves statistical analysis using metrics that have a predictable response to water quality and/or habitat impairment. The metrics selected fall into five major groups including taxa richness, composition measures, tolerance to perturbation, trophic classification, and habit measures. The current study area is located within the coastal plain physiographic region; therefore, the coastal plain BIBI was calculated for data analysis. Raw values from each metric are given a score of 1, 3 or 5 based on ranges of values developed for each metric as shown in Table 5. The results are combined into a scaled BIBI score ranging from 1 to 5 and a corresponding narrative rating is assigned (Table 6).

Table 5 Biological Condition Scoring for the Coastal Plain Benthic Macroinvertebrates

Metric	**Score**		
	5	**3**	**1**
Total Number of Taxa	≥22	14-21	<14
Number of EPT Taxa	≥5	2-4	<2
Number of Ephemeroptera Taxa	≥2.0	1-1	<1.0
Percent Intolerant Urban Taxa	≥28	10-27	<10.0
Percent Ephemeroptera Taxa	≥11	0.8-10.9	<0.8
Number Scraper Taxa	≥2	1-1	<1.0
Percent Climber Taxa	≥8.0	0.9-7.9	<0.9

Table 6 BIBI Scoring and Rating

BIBI Score	**Narrative Rating**
4.0 – 5.0	Good
3.0 – 3.9	Fair
2.0 – 2.9	Poor
1.0 – 1.9	Very Poor

3. MONITORING YEAR 4: RESULTS AND DISCUSSION

3.1 Structural Assessment

3.1.1 Evaluation of Channel and Bank Stabilization Structures

Stepped Riffle Complex

The SRC was constructed from station 0+00 to 3+10, and includes a sequence of 16 pool, riffle-weir complexes. The entire SRC was inspected as a complete structure. SRC weirs are composed of boulders and appear stable throughout the system. SRC pools were composed of a riffle grade control material. Overall, the SRC pools are stable, though it seems that some shifting of material has occurred throughout. Movement of material has not created any areas of instability, so the shifting is not of concern.

Riffle Grade Control

The riffle grade control (RGC) uses sediments that were sized to resist a greater critical shear stress than boundary shear stress of the 10-year flow event. This would therefore stabilize the channel bed and maintain its grades up to the designed flow event. The riffle grade controls were

constructed between stations 3+12 and 3+40; 4+25 and 4+45; 5+00 and 5+25; 5+60 and 5+75; 6+50 and 6+80; 8+00 and 8+18; and 8+89 and 9+14.6. Upon inspection, all RGC structures appeared stable. During the Year 1 survey the downstream tie-in to existing grade at station 9+25 was observed as slightly elevated making a sharp drop from the RGC to the existing channel bed. This has the potential to produce scour in the channel bed and should continue to be monitored, though the Year 2, 3, and 4 surveys were noted as the same condition without downstream deterioration.

Stone Sill

Stone sills were constructed at stations 9+00 and 12+00. The sill at 9+00 is stable and the scour pool directly downstream is also stable. The sill at 12+00 is located at the downstream extent of the restoration project. Year 1 observations of this weir indicated there had been some minor movement of the weir stones and the development of a downstream scour hole and bed lowering. At that time the structure was not failing. In Year 2 it is apparent the structure was beginning to fail after further deterioration downstream and flanking at the left bank. Year 3 observations clearly show the structure failing, with further deterioration and flanking at the left bank. Year 4 the left bank of the sill continues to deteriorate. KCI recommends a remedial action. A possible approach could be to push the top stones of the weir into the scour hole, repair the flanking with riprap and direct flow through the middle of the structure, thus decreasing the need for the water to scour around the stone along the left and right banks. See photos on page 43 and 44 of Appendix A of the failing stone sill.

Step Pools

A series of three step pools were placed from 8+18 to 8+51 with crests at stations 8+18, 8+26, 8+34, 8+42, and 8+51. Each crest was observed to be stable, however, most of the pools were partially or fully filled with fine sediments or leaf litter. This is not anticipated to affect the stability as this material will be easily mobilized during a high flow event when the pools are scoured and needed for energy dissipation.

Stone Toe Protection

Stone toe protection was placed in the mainstem along the outer bends of meanders, along some of the riffle grade control structures, and where a drainage enters the stream. On the left bank, this includes stations 5+92 to 6+80. On the right bank, this includes stations 4+65 to 5+75; and 7+25 to 8+20. The stone toe protection is designed to harden the banks and prevent erosion and lateral migration of the channel. The majority of stone toe protection materials are sufficiently large with no indication of dislodging.

In Year 1 in two locations the up or downstream key-in to a non-stone bank was of minor concern. The upstream key-in at 4+65 on the right bank showed some scour and the downstream tie-in at 5+75 was elevated in such way that it has a high potential for inducing scour under high flow conditions. In Year 2 the key-in at 4+65 was obscured from view due to a debris jam caused by large cut branches, potentially placed in the channel, blocking flow. KCI staff removed the cut debris to allow better flow but did not fully remove the material from the near-bank region or even the channel due to the size of the material. Once removed the accumulated debris still obscured

much of the channel view but what could be seen did not indicate any further change in the key-in stability. During year 4 survey no debris jam was present, and no signs of scour was noted.

The second location, at 5+75, did not appear to be elevated as was noted in Year 1 in any subsequent observations. The transition from the stone toe to smaller bank material was filled with minor deposition and vegetation has helped fill the spacing making the elevated stone only minutely visible. Thus far, all stone toe protection is functioning as designed.

3.1.2 Reach 1 Tributary

During construction approximately 25 LF of the Reach 1 tributary was stabilized with the addition of cobble material and slight channel formation. The banks were stabilized with natural fiber matting above the cobble material. This channel was walked in the Year 2 structure assessment and the upstream limits appear to have been excavated of material which was placed on the top of banks. Two headcuts now form the upper limits of the Reach 1 Tributary. No note of such condition was made in Year 1 though photos indicate this was present at the time. It is likely this excavation was completed by a nearby resident after construction. During Year 3, two locations in the channel were filled with debris. During year 4 the debris had been washed downstream and is no longer present. Two headcuts at the upper limits of the Reach 1 Tributary observed in Year 2 were also observed during Year 3 and Year 4 monitoring. The headcut is within a minor swale and potential wetland and should be mitigated.

3.2 Physical Habitat Evaluation

Physical habitat evaluations were conducted at the two (2) biological monitoring sites on April 10, 2019, concurrently with biological sampling. The summary results of the RBP and PHI habitat assessments are presented in Table 7. Complete habitat assessment results are presented in Appendix B.

In 2019, the percent comparability to RBP reference scores was 60.0 percent and a narrative rating of 'Partially Supporting' at WOOD-US and 61.0 percent and a narrative rating of 'Partially Supporting' at site WOOD-DS. The current RBP scores represent an improvement when compared to all previous surveys. The better habitat scores seen in Year 4 are due to slight improvements in multiple parameters, including epifaunal substrate/available cover, velocity depth diversity frequency of riffles, and vegetative protection. As vegetation grows, bank protection, shading, and woody debris/rootwad scores will continue to improve.

Similar assessment results were observed using the PHI index, where site WOOD-US received the lower score of 58.78 and a narrative rating of 'Degraded', and site WOOD-DS received the higher score of 60.63 and a rating of 'Degraded.' The PHI results are consistent with the RBP final scores for Year 4, showing incremental improvement in habitat quality for both sites every post-construction year. Slight improvements in instream habitat, epifaunal substrate, velocity depth diversity, shading, trash, woody debris/rootwads, and maximum depth in Year 4 resulted in higher scores when compared to Year 3.

The initially selected pre-construction reference site was not able to be sampled due to issues with property owner permissions, therefore a nearby MBSS urban reference site, LWIN-108, has been

used as the reference site. As previously explained, the MBSS urban reference site (LWIN-108) was not evaluated using the RBP method. Furthermore, although the reference site is located within the Piedmont physiographic region while the monitoring sites WOOD-US and WOOD-DS are located in the Coastal Plain, LWIN-108 was selected because it represents a more appropriate reference site since it does not have any restoration projects located in its upstream watershed as is the case for other reference sites found nearby the project area and within the Coastal Plain region. For that reason, any changes observed in the data produced in this reference site can be considered fully attributable to natural variability and/or climatic influences.

The MBSS reference site (LWIN-108) habitat has been also rated as 'Degraded' in all monitoring years from 2015 through 2018. The PHI score has ranged from 57.1 in 2017 to 64.9 in 2015.

Table 7 Physical Habitat Assessment Results 2015-2019

Year	RBP Index			PHI Index	
	Total RBP	RBP % of Reference	RBP Classification	PHI Score	PHI Narrative Rating
WOOD-US					
Year 1-2016	104	52.0	Non-Supporting	55.18	Degraded
Year 2-2017	88	44.0	Non-Supporting	55.18	Degraded
Year 3-2018	109	54.5	Non-Supporting	55.92	Degraded
Year 4-2019	120	60.0	Partially Supporting	58.78	Degraded
WOOD-DS					
Year 1-2016	115	57.5	Non-Supporting	60.32	Degraded
Year 2-2017	113	56.5	Non-Supporting	57.46	Degraded
Year 3-2018	122	61.0	Partially Supporting	59.77	Degraded
Year 4-2019	122	61.0	Partially Supporting	60.63	Degraded
LWIN-108 Reference Site					
2015	n/a	n/a	n/a	64.9	Degraded
Year 1-2016	n/a	n/a	n/a	59.1	Degraded
Year 2-2017	n/a	n/a	n/a	57.1	Degraded
Year 3-2018	n/a	n/a	n/a	62.4	Degraded

A comparison of post-construction PHI results from 2016 to 2019, to pre-construction data from 2005 – 2007 is presented below in Figure 3. Regarding the PHI scores, both sites remain relatively stable when compared with pre-construction conditions, with most years within the 'Degraded' category. However, habitat scores continued to improve slightly between the 2018 and 2019 surveys. It is likely that the PHI scores will improve once the vegetation becomes established, improving shading and woody input to the stream channel, however this process will take several more years. Both sites have shown improvements in regard to habitat conditions when comparing the post-construction assessment results with the 2007 pre-construction data (Figure 3). Habitat data sheets can be found in Appendix B

Figure 3 Comparison with Pre-Construction (2005-2007) and Post-Construction (2016-2019) PHI Scores

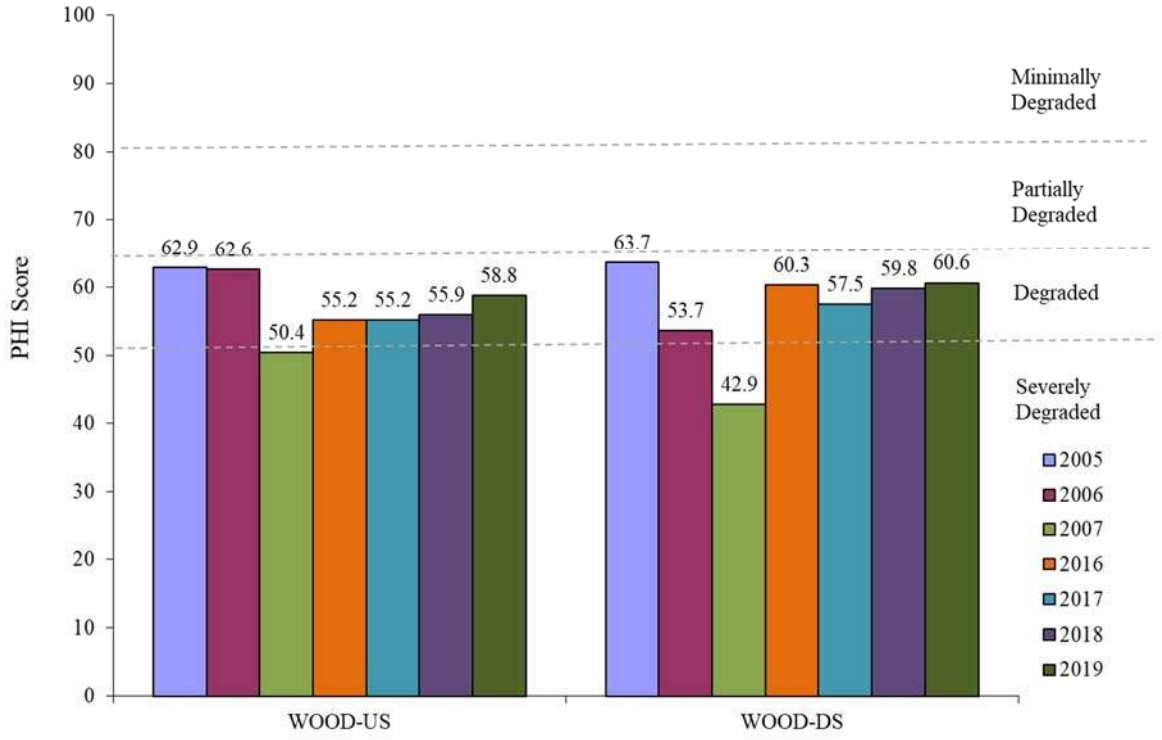
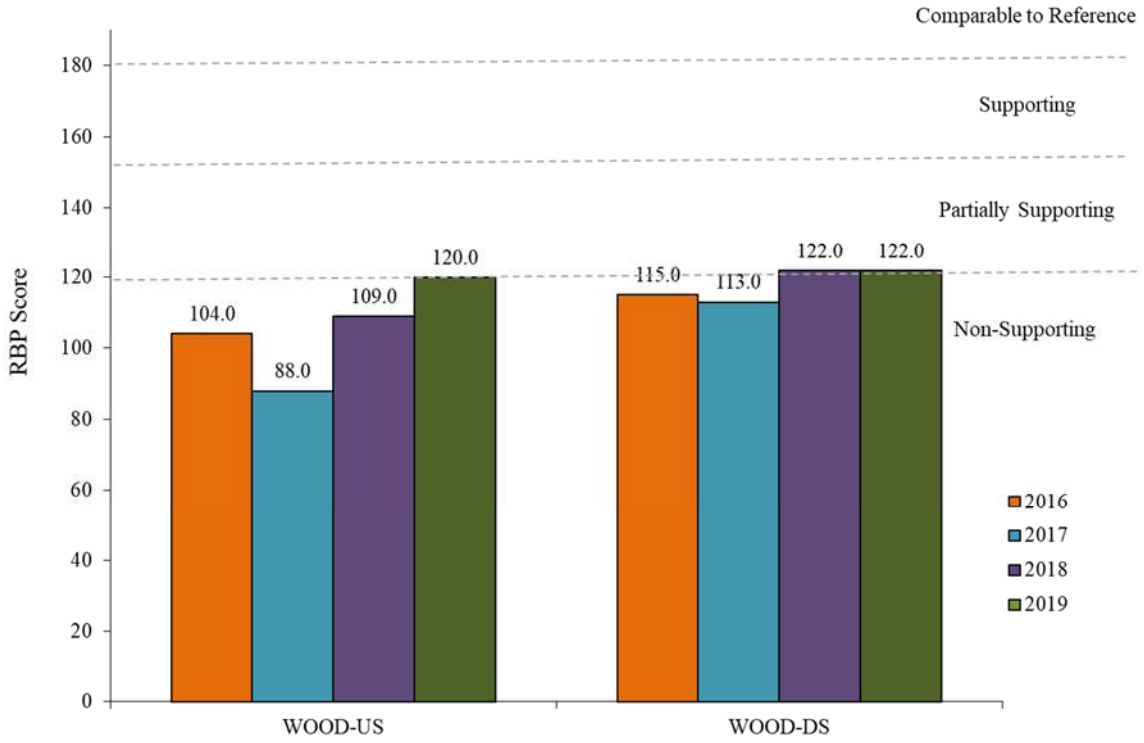


Figure 4 Comparison of Post-Construction (2016-2019) RBP Scores



3.3 Biological Monitoring

Benthic macroinvertebrate sampling was conducted at the two (2) biological monitoring sites on April 10, 2019. Both WOOD-DS and WOOD-US received 'Very Poor' biological condition ratings and BIBI scores of 1.57, which represents a decline in conditions at both sites. The BIBI score at WOOD-US in 2019 was the second lowest ever found in both pre- and post-construction monitoring. In 2019, WOOD-DS had the lowest BIBI score ever recorded.

At the downstream restoration reach, WOOD-DS, there were 106 individuals identified in the sample, comprising 12 taxa. In the previous two years, the sample at this site was dominated by Naididae (Tolerance Value [TV] = 8.5), a family of pollution tolerant oligochaete worms. During the Year 3 and 4 monitoring events, the samples were dominated by Cricotopus/ Orthocladius, which includes species of midges with a Tolerance Value of 7.7. There were only 2 EPT Taxa present and no Ephemeroptera taxa. No scraper taxa or intolerant individuals were present, and climbers were present in low amounts (1.9%).

WOOD-US, the upstream restoration reach, had 11 taxa present in the 112-organism subsample. During 2016 and 2017 sampling, EPT and scraper taxa were both absent. In the 2018 sample, there were 5 EPT taxa and 3 scraper taxa present, but no Ephemeroptera taxa present. In the 2019 sample, there were 2 EPT taxa, but no Ephemeroptera, scraper taxa, or intolerant taxa present, and only 0.89% climber taxa. The sample was dominated by midges similar to WOOD-DS, as well as pollution tolerant oligochaete worms.

Table 8 Benthic Index of Biotic Integrity (BIBI) Summary Data 2016-2019

Metric	2016		2017		2018		2019	
	WOOD-DS	WOOD-US	WOOD-DS	WOOD-US	WOOD-DS	WOOD-US	WOOD-DS	WOOD-US
Metric Values								
Total Number of Taxa	11	11	18	16	19	25	12	11
Number of EPT Taxa	2	1	2	0	3	5	2	2
No. of Ephemeroptera Taxa	0	0	0	0	0	0	0	0
Percent Intolerant Urban	2.4	0.0	6.2	1.5	1.6	1.9	0	0
Percent Ephemeroptera	0	0	0	0	0	0	0	0
Number Scraper Taxa	1	0	4	3	2	3	0	1
Percent Climbers	3.2	0.0	13.3	3.1	1.6	6.7	1.9	0.9
Metric Scores								
Total Number of Taxa	1	1	3	3	3	5	1	1
Number of EPT Taxa	3	1	3	1	3	5	3	3
No. of Ephemeroptera Taxa	1	1	1	1	1	1	1	1
Percent Intolerant Urban	1	1	1	1	1	1	1	1
Percent Ephemeroptera	1	1	1	1	1	1	1	1
Number Scraper Taxa	3	1	5	5	5	5	1	3
Percent Climbers	3	1	5	3	3	3	3	1
BIBI Score	**1.86**	**1.00**	**2.71**	**2.14**	**2.43**	**3.00**	**1.57**	**1.57**
Narrative Rating	**Very Poor**	**Very Poor**	**Poor**	**Poor**	**Poor**	**Fair**	**Very Poor**	**Very Poor**

Results from the MBSS reference site (LWIN-108) are presented in Table 9. MDNR sampled this site during the spring 2019 index period, however 2019 data will not be available until early 2020, so 2016 through 2018 data are presented. This site is located in the adjacent Winters Run watershed; however, it is within the Piedmont Physiographic Region. Subsequently, the MBSS Piedmont were used to calculate the BIBI score. Overall, the site received a BIBI score of 1.33 and a corresponding narrative rating of "Very Poor". The 120-organism subsample was represented by 21 taxa, four (4) of which were EPT taxa. No Ephemeroptera taxa were present in the sample. Intolerant individuals comprised 3% of the sample, and clingers comprised 90%, which represent an overall decline when compared to 2016 and 2017 BIBI results.

Table 9 MBSS Reference Site LWIN-108 BIBI Summary Data

Metric	2016	2017	2018
Metric Values			
Total Number of Taxa	12	21	21
Number of EPT Taxa	8	5	4
Number of Ephemeroptera Taxa	1	1	0
Percent Intolerant Urban	29	23	3
Percent Chironomidae	44	71	90
Percent Clingers	69	28	22
Metric Scores			
Total Number of Taxa	5	3	3
Number of EPT Taxa	3	3	1
Number of Ephemeroptera Taxa	1	1	1
Percent Intolerant Urban	3	3	1
Percent Chironomidae	3	1	1
Percent Clingers	3	1	1
BIBI Score	**3.00**	**2.00**	**1.33**
Narrative Rating	**Fair**	**Poor**	**Very Poor**

A comparison of post-construction results from 2016 and 2019, to pre-construction data from 2005–2007 is presented below in Figure 5. It is important to note that the upstream site (WOOD-US) was shifted from above Magnolia Road in the pre-restoration phase to immediately below Magnolia Road in the post-restoration phase because the pre-restoration location did not allow for the monitoring site to be fully within the restoration reach. Therefore, comparisons in BIBI scores between pre- and post-construction periods need to account for this difference. WOOD-DS shows fairly consistent BIBI scores from pre- to post-construction conditions from 2005 through 2018, with improving scores in 2017 and 2018, but a substantial decline in the BIBI score in 2019. The 2018 score was in the 'Poor' category, but was the highest score of all monitoring years. Then in 2019, the site received the lowest score of 1.67 and was in the 'Very Poor' category. WOOD-US shows more variability between the years. There was a drastic improvement over the Year 1 post-construction BIBI score in both 2017 and 2018. Similar to WOOD-US, in 2019 the site received the second lowest score of 1.67 and was in the 'Very Poor' category again. However, even at the reference site, deviations occur in the BIBI scores from year-to-year resulting from natural

variation (see Figure 6). In the past three years, BIBI scores at the reference site have declined, similarly to monitoring sites. Biological data and photographs can be found in Appendix C.

Figure 5 Comparison of Post-Construction (2016-2019) data with Pre-Construction (2005-2007) BIBI Scores

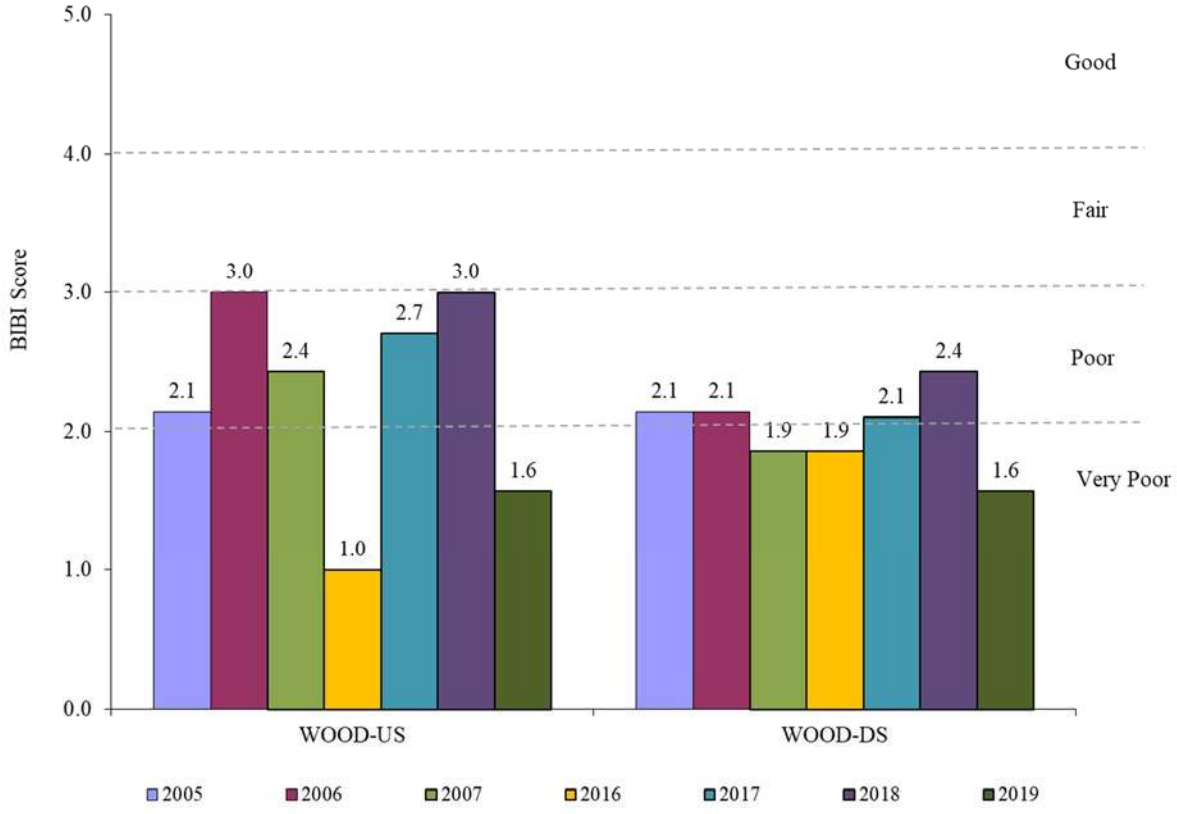
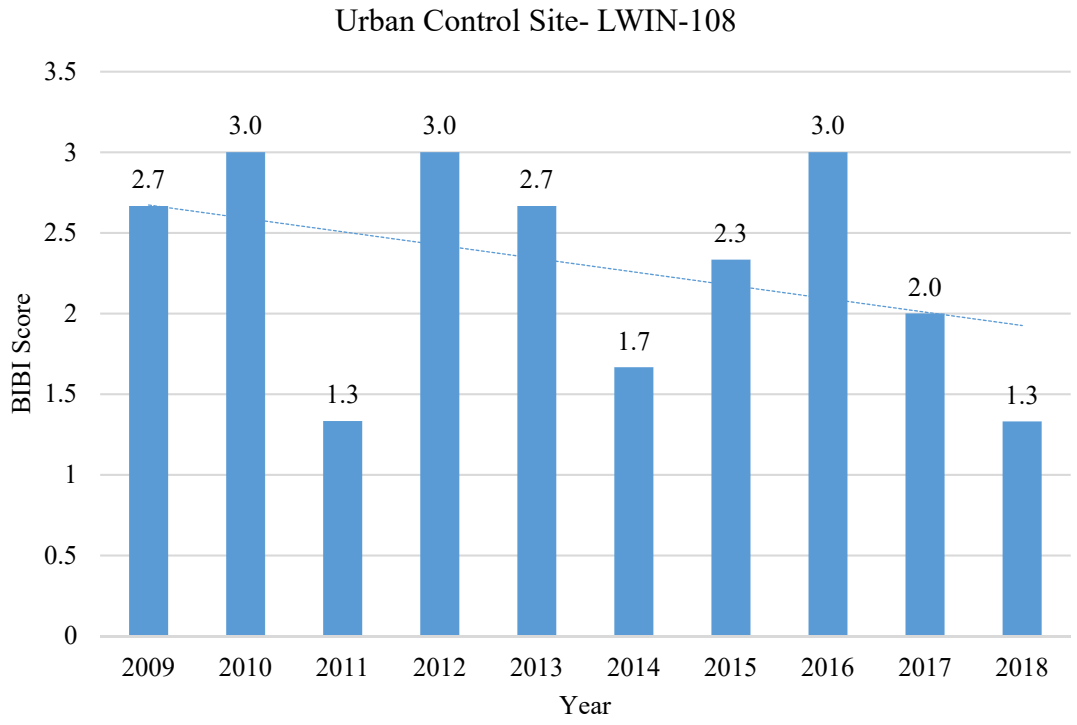


Figure 6 Comparison of BIBI Scores at the MBSS Reference Site (2009-2018)



4 CONCLUSIONS

The Year 4 (2019) structure assessment show a stream channel that is overall stable and functioning as designed with the exception of one area of concern. This exception being the downstream sill near 12+00. Bank erosion upstream of the failed sill is likely related to upstream headcut migration from the sill location. The bank erosion could worsen if the sill structure continues to degrade. Reach 1 Tributary headcut is recommended to be stabilized before further development of an incised channel occurs through headcut migration.

Riparian observations were not included in the year 4 scope of services However, conditions are largely similar to Year 3. Previously stated recommendations are still relative:

- The princess trees under the power lines should be removed.
- It is recommended that the area downstream of the culvert on the right bank from 9+50 to 10+00 be replanted with live stakes.
- The dead white oak tree on the right bank at station 1+00 should be removed.

MDE permit conditions require 85% survival of planted vegetation for 5 years. At the time of the Year 3 inspection, all zones met this requirement.

Impacted biological and physical habitat conditions are still present at the stream restoration project. Improvements in the benthic macroinvertebrate community were observed at both sites

with their BIBI ratings improving from a 'Very Poor' to 'Poor' between post-construction Year 1 and Year 3, however scores declined in the Year 4 sample at both sites back to 'Very Poor' conditions. Decline in BIBI scores were also observed in the reference site, LWIN-108, from 2016 to 2018. The slow improvement in the physical habitat conditions is expected since it often takes time for vegetation to recover following a substantial disturbance, such as construction of a new stream channel. Furthermore, as the habitat conditions improve and vegetation progresses in its recolonization of both sites, we expect to find improved biological conditions at the two target segments during future assessments. Biological potential is limited by the quality of the physical habitat, which forms the template upon which biological communities develop (Southwood, 1977).

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APPENDIX A

Site Photographs

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 0+00 facing downstream; culvert invert

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 0+09 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 0+43 at cross section 1 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 0+43 at cross section 1 facing left bank

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 0+43 at cross section 1 facing right bank

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 0+47 at cross section 2 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 0+47 at cross section 2 facing left bank

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 0+47 at cross section 2 facing right bank

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 0+55 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 0+70 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 1+40 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 1+71 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 1+90 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 2+25 facing downstream; pool and downstream riffle are dry

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 2+60 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 2+87 facing downstream; tributary confluence on right bank

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 2+92 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

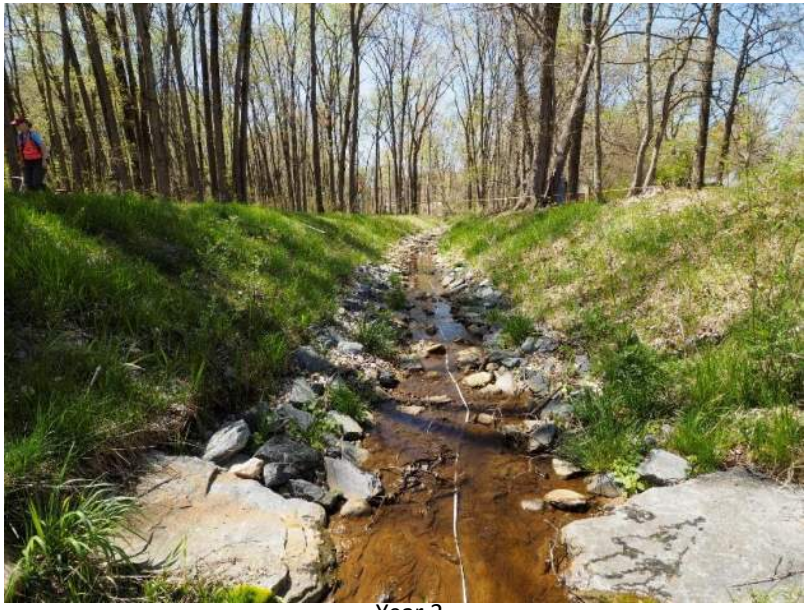
Year 3

Year 4

Station 3+28 at cross section 3 facing downstream

Right and left banks are determined facing downstream

Year 1



Year 2

Year 3

Year 4

Station 3+28 at cross section 3 facing left bank

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 3+28 at cross section 3 facing right bank

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 3+46 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 3+72 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 4+65 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 5+05 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 5+50 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 5+81 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 6+10 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 6+55 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 7+32 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 8+00 at cross section 4 facing right bank

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 8+00 at cross section 4 facing left bank

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 8+25 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 8+40 facing downstream towards driveway culvert

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 8+85 at downstream end of driveway culvert facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 8+95 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 9+38 at cross section 5 facing left bank

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 9+38 at cross section 5 facing right bank

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 9+38 at cross section 5 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 9+70 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 10+00 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 10+40 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 11+40 facing downstream

Right and left banks are determined facing downstream

Year 1

Year 2

Year 3

Year 4

Station 12+00 at weir facing downstream

Right and left banks are determined facing downstream

Facing right bank erosions at station 11+30

Additional pictures Year 4

Facing right bank erosion at stations 11+40

Facing right bank scour at weir from station 12+10

APPENDIX B

Physical Habitat Data

Project Name: Woodbridge Post-Construction Biomonitoring
Project Number: 171700458.11
Prepared by: JM Checked by: SKB
Prepared date: 6/18/19 Checked date: 7/19/19

RBP_Woodbridge_High_Gradient_v1_Yr 4.xlsx
Version: 1
Site Name: Woodbridge

STATION ID	DATE	ESC	E	VD	SD	CF	CA	FR	BSL	BSR	VPL	VPR	RZL	RZR	TOTAL	PERCENT	CLASSIFICATION
Wood US	4/10/2019	5	15	13	17	12	0	15	10	10	8	8	2	5	120	60.00	Partially Supporting
Wood DS	4/10/2019	7	15	7	11	16	0	16	10	10	7	7	8	8	122	61.00	Partially Supporting

BSL - Bank Stability (left)
BSR - Bank Stability (right)
CA - Channel alteration
CF - Channel Flow Status
E - Embeddeddness
ESC - Epifaunal substrate / available co
FR - Frequency of riffles
RZL - Riparian Zone (left)
RZR - Riparian Zone (right)
SD - Sediment /deposition
VD - Velocity /depth
VPL - Vegetative Protection (left)
VPR - Vegetative Protection (right)
Total - Total Score
Total possible score = 200
Percent - Total/200*100

Classification Scoring	
>90%	Comparable to Reference
75.1-89.9%	Supporting
60.1-75.0%	Partially Supporting
<60%	Non-Supporting

Project Name: Woodbridge Post-Construction Biomonitoring
Project Number: 171700458.11 PHI_Coastal_Plain_v2_Woody_Yr4.xlsx
Prepared by: JM Checked by: SKB Version: 1
Prepared date: 6/18/19 Checked date: 7/19/19 Site Name: Woodbridge

		Raw Data											Scaled Metrics						Rating	
Site	Subshed Area (acres)	Instream Habitat	Epibenthic Substrate	Velocity Depth Diversity	Pool Glide Eddy Quality	Bank Stab (0-20)	Embeddedness	Percent Shading	Aesthetics (Trash)	Remoteness Score	# Woody Debris/ Rootwads	Max Depth	Instream Habitat	Epibenthic Substrate	Bank Stability	Shading	Remoteness	# Woody Debris/ Rootwads	PHI	PHI Rating
Wood US	35	3	6	11	6	20	30	30	14	2	0	54	60.95	67.91	100.00	31.57	10.77	81.46	58.78	Degraded
Wood DS	70	6	6	7	6	20	20	45	14	2	0	25	70.50	63.39	100.00	45.47	10.77	73.61	60.63	Degraded

Score	Narrative Rating
81-100	Minimally Degraded
66.0-80.9	Partially Degraded
51.0-65.9	Degraded
0-50.9	Severely Degraded

Project Name: Woodbridge Post-Construction Biomonitoring
Project Number: 171700458.11
Prepared by: JM Checked by: SKB
Prepared date: 6/18/19 Checked date: 7/19/19

RBP_Woodbridge_High_Gradient_v1_Yr 4.xlsx
Version: 1
Site Name: Woodbridge

STATION ID	DATE	ESC	E	VD	SD	CF	CA	FR	BSL	BSR	VPL	VPR	RZL	RZR	TOTAL	PERCENT	CLASSIFICATION
Wood US	4/10/2019	5	15	13	17	12	0	15	10	10	8	8	2	5	120	60.00	Partially Supporting
Wood DS	4/10/2019	7	15	7	11	16	0	16	10	10	7	7	8	8	122	61.00	Partially Supporting

BSL - Bank Stability (left)
BSR - Bank Stability (right)
CA - Channel alteration
CF - Channel Flow Status
E - Embeddeddness
ESC - Epifaunal substrate / available co
FR - Frequency of riffles
RZL - Riparian Zone (left)
RZR - Riparian Zone (right)
SD - Sediment /deposition
VD - Velocity /depth
VPL - Vegetative Protection (left)
VPR - Vegetative Protection (right)
Total - Total Score
Total possible score = 200
Percent - Total/200*100

Classification Scoring	
>90%	Comparable to Reference
75.1-89.9%	Supporting
60.1-75.0%	Partially Supporting
<60%	Non-Supporting

APPENDIX C

Biological Assessment Data

WOOD-US Facing Upstream at 0 meters

WOOD-US Facing Downstream at 0 meters

WOOD-US Facing Upstream at midpoint

WOOD-US Facing Downstream at midpoint

WOOD-US Facing Upstream at 75 meters

WOOD-US Facing Downstream at 75 meters

WOOD-DS Facing Upstream at 0 meters

WOOD-DS Facing Downstream at 0 meters

WOOD-DS Facing Upstream at midpoint

WOOD-DS Facing Downstream at midpoint

WOOD-DS Facing Upstream at 75 meters

WOOD-DS Facing Downstream at 75 meters

Project Name: Woodbridge Year 4 Post-Construction Monitoring
Project Number: 171700458.11
Prepared by: JSM Checked by: SKB
Prepared date: 6/18/2019 Checked date: 7/22/2019

BIBI_Coastal_Plain_v4_Woodbridge.xlsx
Version: 4
Site Name: WOOD DS

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Odonata	Calopterygidae	Calopteryx	Calopteryx	L	1	Predator	cb	8.3
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	L	1	Filterer	cn	6.5
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	L	18	Filterer	cn	7.5
Insecta	Trichoptera	Hydropsychidae	not identified	Hydropsychidae	P	2	Filterer	cn	5.7
Insecta	Diptera	Empididae	Hemerodromia	Hemerodromia	L	5	Predator	sp, bu	7.9
Insecta	Diptera	Tipulidae	Antocha	Antocha	L	1	Collector	cn	8
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	A	16	Collector	bu	8.5
Insecta	Diptera	Chironomidae	Cricotopus/Orthocladius	Cricotopus/Orthocladius	34 larva, 9 pupa	43	Shredder	0	7.7
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	L	2	Collector	sp	8.5
Insecta	Diptera	Chironomidae	Microtendipes	Microtendipes	L	7	Filterer	cn	4.9
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	1 larva, 3 pupa	4	Collector	sp	6.2
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	L	5	Shredder	cn, bu	9.6
Insecta	Diptera	Chironomidae	Tanytarsus	Tanytarsus	L	1	Filterer	cb, cn	4.9

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Project Name: Woodbridge Year 4 Post-Construction Monitoring
Project Number: 171700458.11
Prepared by: JSM Checked by: SKB
Prepared date: 6/18/2019 Checked date: 7/22/2019

BIBI_Coastal_Plain_v4_Woodbridge.xlsx
Version: 4
Site Name: WOOD US

Subphylum/ Class	Order	Family	Genus	Final ID	Note[1]	# of Org	FFG[2]	Habit[3]	Tolerance Value[4]
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	L	2	Filterer	cn	6.5
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	L	3	Filterer	cn	7.5
Insecta	Coleoptera	Elmidae	Stenelmis	Stenelmis	L	1	Scraper	cn	7.1
Insecta	Diptera	Simuliidae	Simulium	Simulium	L	1	Filterer	cn	5.7
Insecta	Diptera	Empididae	Hemerodromia	Hemerodromia	L	1	Predator	sp, bu	7.9
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	A	35	Collector	bu	8.5
Insecta	Diptera	Chironomidae	Cricotopus/Orthoclad	Cricotopus/Orthocladius	39 larva, 6 pupa	45	Shredder	0	7.7
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	L	19	Collector	sp	8.5
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	L	3	Collector	sp	6.1
Insecta	Diptera	Chironomidae	Cricotopus	Cricotopus	L	1	Shredder	cn, bu	9.6
Insecta	Diptera	Chironomidae	Polypedilum	Polypedilum	L	1	Shredder	cb, cn	6.3

1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Dembytown Stream Restoration Project
Post-Restoration
Monitoring – Year 3
2019

December 2019

PREPARED FOR:

Harford County

Department of Public Works

Watershed Protection and Restoration Office

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Sparks, Maryland 21152

TABLE OF CONTENTS

1 INTRODUCTION 2

2 METHODS 5

2.1 VISUAL HYDROLOGY ASSESSMENT 5
2.2 GEOMORPHIC ASSESSMENT 5
2.3 INVASIVE PLANT AND VEGETATION ASSESSMENT 8

3 RESULTS AND CONCLUSIONS 9

3.1 VISUAL HYDROLOGY ASSESSMENT 9
3.2 GEOMORPHIC ASSESSMENT 9
3.3 INVASIVE PLANT AND VEGETATION ASSESSMENT 15
3.4 CONCLUSIONS 16

4 REFERENCES 17

LIST OF TABLES

Table 1 – Parameters, Measurements, and Success Criteria for Dembytown Stream Restoration Project 2
Table 2 – Monitoring Timeline 3
Table 3 – Select Visual Hydrology Parameters, Measurements, and Success Criteria 5
Table 4 – Select Geomorphic Assessment Parameters, Measurements, and Success Criteria 5
Table 5 - RBP High Gradient parameters 8
Table 6 - RBP Physical Habitat condition ratings 8
Table 7 – Select Invasive Plant and Vegetation Assessment Parameters, Measurements, and Success Criteria 8
Table 8 – Slope of longitudinal profile survey- 2017 (As-built), 2019 (Year 3) 10
Table 9 - Results of cross-sectional survey analysis- 2017 (As-built), 2019 (Year 3) 10
Table 10 Summary of RBP High Gradient habitat assessment results 14

LIST OF FIGURES

Figure 1 - Stream Survey Limits, Cross-Section and Photo Locations 4
Figure 2 - Longitudinal Profile Overlay – 2017, 2019 11
Figure 3 - Cross Section Survey – 2017 (As-built), 2019 (Yr 3) 12
Figure 4 – BEHI analysis 13
Figure 5 - Particle Distribution Analysis – 2019 (Year 3) 14

LIST OF APPENDICES

Appendix A SITE PHOTOGRAPHS

Appendix B GEOMORPHIC DATA

Appendix C RBP HABITAT DATA

Appendix D INVASIVE PLANT SURVEY PHOTOS

1 INTRODUCTION

Harford County Department of Public Works completed a stream restoration project during 2017 along a portion of Foster Branch in the vicinity of the Dembytown Road stream crossing in Joppa, Harford County, Maryland. The Baltimore District, Army Corps of Engineers authorized the stream restoration under nationwide permit 2015-60530-M37 and is requiring monitoring as a condition of the permit. Information and data collected during the required monitoring activities will be used to assess various success criteria which will be used to evaluate the success of the Dembytown stream restoration project. The Army Corps of Engineers outlined the success criteria and years when monitoring activities should occur in the authorization letter sent to Harford County dated January 19, 2016. The parameters, measurements, and success criteria outlined in the permit are as follows:

Table 1 – Parameters, Measurements, and Success Criteria for Dembytown Stream Restoration Project

Level and Category	Parameter	Measurement	Success Criteria	Monitoring Years[1]
1-Hydrology	Flow	Visual hydrology assessment	Exceeds baseline (intermittent or perennial)	PC, 5
2-Hydraulics	Floodplain Connectivity	Bank height Ratio	<1.2	AB, 5
3-Geomorphology	Vertical Stability	Longpro/riffle crest elevations	<0.5 ft thalweg degradation from as-built	AB, 3
	Lateral Stability	BEHI	Moderate or Better	3
	Habitat Assessment	RBP-High Gradient	Greater than Baseline	PC, 3, 5
	Vegetative Cover	% cover	>80% cover in LOD	5
	Rosgen Stream Classification	X-section from riffle crests	Does not classify as G or F stream type	PC, 3, 5
4-Water Quality	NA	NA	NA	NA
5-Biology	Invasive Plant Reduction	% cover invasive species in LOD	Less than Baseline	PC, 5

[1] PC = pre-construction, AB = as-built

Assessment techniques include an annual visual hydrology assessment, annual geomorphological assessment, and annual invasive plant assessment. The monitoring timeline used for the Dembytown mandated monitoring is presented below in Table 2. In 2017, an assessment was conducted to establish the as-built or post-construction baseline conditions. Assessment methods are described in more detail below. Methods, data, and results from the

current 2019 monitoring period are detailed in this report and will be compared with future assessments to investigate changes in flow, channel geometry, stability, and vegetative success over time.

Table 2 – Monitoring Timeline

Permit Monitoring Year	Calendar Year Monitoring Completed
As-Built (AB)	2017
Year 1	2017
Year 2	2018
Year 3	2019
Year 4	2020
Year 5	2021

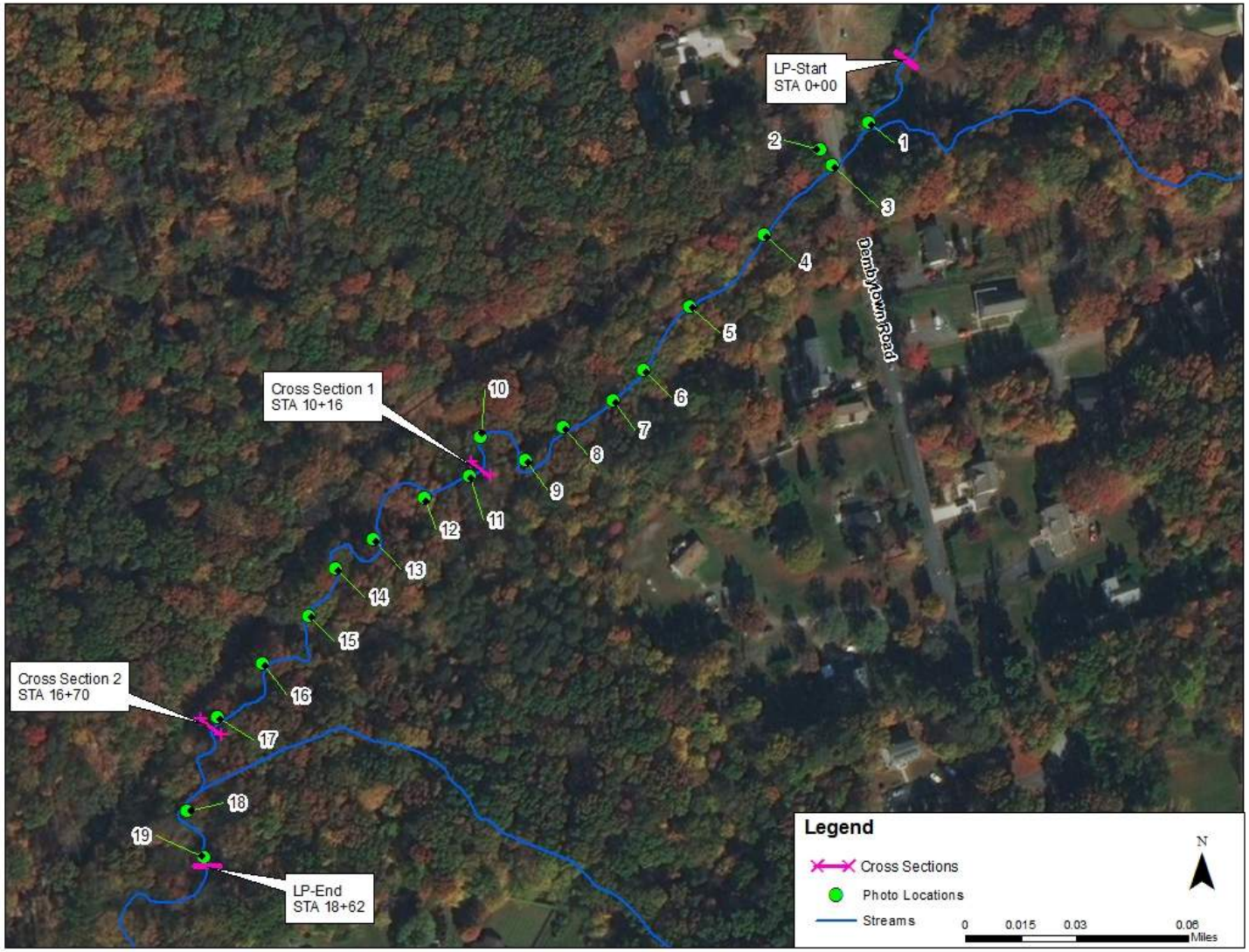

Figure 1 - Stream Survey Limits, Cross-Section and Photo Locations

2 METHODS

2.1 VISUAL HYDROLOGY ASSESSMENT

Table 3 – Select Visual Hydrology Parameters, Measurements, and Success Criteria

Level and Category	Parameter	Measurement	Success Criteria	Monitoring Years[1]
1-Hydrology	Flow	Visual hydrology assessment	Exceeds baseline (intermittent or perennial)	PC, 5

[1] PC = pre-construction, AB = as-built

A visual assessment of hydrology will be completed by annual observation and photo-documentation taken at set locations along the restoration reach. Photographic monument stations were selected in the field after construction with input from Harford County DPW staff and locations recorded with a sub-meter accuracy GPS receiver. Figure 1 presents a map showing the locations of the photographic monument station locations relative to the Dembytown stream restoration project area. Photographs were taken at each station looking both upstream and downstream.

For each annual visual hydrology assessment staff will return to the restoration reach with a tablet PC, a sub-meter accuracy GPS receiver, and a digital camera. The tablet will contain GIS data for the established photographic monument stations and previously taken pictures from each monument station. Staff will navigate to the photographic monument location using the GPS and GIS data, and the photos will be taken to ensure that the same orientation of previous photos is maintained.

The visual hydrology assessment was conducted during the 2017 and 2019 (As-built; Year 1 and Year 3) geomorphic assessments. Appendix A contains photographs taken during the 2017 and 2019 assessments.

2.2 GEOMORPHIC ASSESSMENT

Table 4 – Select Geomorphic Assessment Parameters, Measurements, and Success Criteria

Level and Category	Parameter	Measurement	Success Criteria	Monitoring Years[1]
2-Hydraulics	Floodplain Connectivity	Bank height Ratio	<1.2	AB, 5
3-Geomorphology	Vertical Stability	Longpro/riffle crest elevations	<0.5 ft thalweg degradation from as-built	AB, 3
	Lateral Stability	BEHI	Moderate or Better	3

Level and Category	Parameter	Measurement	Success Criteria	Monitoring Years[1]
	Habitat Assessment	RBP-High Gradient	Greater than Baseline	PC, 3, 5
	Vegetative Cover	% cover	>80% cover in LOD	5
	Rosgen Stream Classification	X-section from riffle crests	Does not classify as G or F stream type	PC, 3, 5

[1] PC = pre-construction, AB = as-built

A longitudinal profile of the assessment reach was surveyed on December 18 and 19, 2017 (As-built) and December 3 and 4, 2019 (Year 3) using a laser level, calibrated stadia rod, and 300-foot measuring tape. The profile was established along the thalweg of the channel and included a survey of breakpoints in and between bed features and delineation of riffles, runs, pools, and glides. A survey of the bankfull elevation (where discernible), top of bank, and water surface was also performed. Profile data can be found in Appendix B.

To establish locations where fluvial geomorphic characteristics of the channel could be measured and compared over time for assessing bed and bank stability, permanent cross-sections were established during the 2017 (As-built) monitoring effort at two riffle crest locations within the assessment reach (Figure 1). Rebar monuments were established on either side of the channel to mark the cross-section locations and to maintain repeatable elevation controls. The cross- sectional surveys captured features of the floodplain, monuments, and all pertinent channel features including:

- Top of bank
- Bankfull elevation
- Edge of water
- Limits of point bar and instream depositional features
- Thalweg
- Floodprone elevation

Longitudinal profile and cross-section data were entered into The Reference Reach Spreadsheet version 4.3L (Mecklenberg 2006) for data analysis and graphical interpretation.

Bankfull elevations were selected based upon field observed bankfull indicators and used to calculated measures of channel geometry. Because bankfull indicators are not always easily discernible from year to year and best professional judgment is often required to determine bankfull elevations in incised or constructed channels, top of bank features were also measured. Top of low bank cross-sectional areas were also calculated and used to generate values that are directly comparable between each monitoring effort.

An analysis of the Bank Erosion Hazard Index (BEHI) is required during Year 3 and was conducted on December 4, 2019 under low flow conditions using the BEHI methods described by Rosgen (2001). The primary goal of the BEHI assessment is to determine erosion potential rate predictions through the entire study area, but without the NBS ratings an erosion rate cannot be determined. BEHI measures the sensitivity of a particular bank to erosion processes. BEHI scores were attributed based on vegetation and/or geomorphic characteristics such as bank height, root depth, root density, bank angle, surface protection, and bank material. The BEHI assessment was conducted on right and left banks. A reach length was established by identifying apparent changes in the bank characteristic and based on the measured characteristics of each reach, a numerical score is calculated and a category is assigned based on the following category ranges:

- 0.0 – 9.5: Very Low
- 10 – 19.5: Low
- 20– 29.5: Moderate
- 30 – 39.5: High
- 40 – 45: Very High
- 46 – 50: Extreme

Channel substrate composition (e.g., gravel, sand, silt) is an important aspect of a stream's biological and geomorphic character. The substrate size and complexity affects the stream's available habitat for benthic fauna and determines a channel's roughness, which influences the channel flow characteristics. To quantify the distribution of channel substrate particle sizes within the study area, modified Wolman pebble counts (Wolman 1954) were performed. A weighted (proportional) pebble count was conducted at 10 transects positioned throughout the entire reach based on the proportion of bed features, and 10 particles (spaced as evenly as possible) were measured across the bankfull channel of each transect for a total of 100 particles. Particles were chosen without visual bias by reaching forth with an extended finger into the stream bed while looking away and choosing the first particle that came in contact with the sampler's finger. All particles were then measured (to the nearest millimeter) across the intermediate axis using a ruler. The results of each pebble count were used to determine the median particle size (i.e., D50) of the specific reach. Additionally, the D84 was calculated to determine the particle size that 84% of the sample is of the same size or smaller. The D84 particle is used in calculating channel velocity and discharge.

The restoration reach was characterized based on physical characteristics and various habitat parameters following the Environmental Protection Agency's Rapid Bioassessment Protocol (RBP) habitat assessment for high gradient streams (Barbour et al., 1999).

The RBP habitat assessment consists of a review of ten biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health. Each parameter was given a numerical score from 0-20 (20=best, 0=worst), or 0-10 (10=best, 0=worst) for individual bank parameters, and a categorical rating of optimal, suboptimal, marginal or poor. Overall habitat quality typically increases as the total score for each site increases. The RBP parameters assessed for high gradient streams are presented in Table 5.

Table 5 - RBP High Gradient parameters

Parameters Assessed	
Epifaunal substrate/available cover	Channel alteration
Embeddedness	Frequency of riffles/bends
Velocity/depth regime	Bank stability
Sediment deposition	Vegetative protection
Channel flow status	Riparian vegetative zone width

The 10 individual RBP habitat parameters for each reach were summed to obtain an overall RBP assessment score. The total score, with a maximum possible score of 200, was then placed into one of four narrative categories based on their percent comparability to reference conditions (Table 6; Plafkin et al. 1989).

Table 6 - RBP Physical Habitat condition ratings

Score	Narrative
>90%	Comparable
75.1 – 89.9%	Supporting
60.1 – 75.0%	Partially Supporting
<60%	Non Supporting

2.3 INVASIVE PLANT AND VEGETATION ASSESSMENT

Table 7 – Select Invasive Plant and Vegetation Assessment Parameters, Measurements, and Success Criteria

Level and Category	Parameter	Measurement	Success Criteria	Monitoring Years[1]
3-Geomorphology	Vegetative Cover	% cover	>80% cover in LOD	5
5-Biology	Invasive Plant Reduction	% cover invasive species in LOD	Less than Baseline	PC, 5

[1] PC = pre-construction, AB = as-built

The vegetation assessments were conducted on August 4, 2017 (Year 1), August 3, 2018 (Year 2), and July 23, 2019 (Year 3) to document the presence of invasive plant species within the project limit of disturbance (LOD) and to estimate the percent cover of any observed invasive plant species. Overall species presence and invasive plant density was recorded.

Photographs were taken to document the vegetative composition of the site during the inspections. A photolog of representative site photos and notes from the invasive plant assessments are presented in Appendix D. While invasive plant and vegetation assessment monitoring is only required during the Year 5 inspection, this inspection will be conducted

annually for the five years of monitoring to allow the County to be pro-active in remedying any serious issues observed. Observations are compared to previous monitoring data in order to document any changes in coverage of invasive plant species within the project LOD.

3 RESULTS AND CONCLUSIONS

3.1 VISUAL HYDROLOGY ASSESSMENT

The as-built visual hydrology assessment occurred in 2017 coincident with the as-built geomorphic assessment and the Year 3 assessment was conducted on December 3 and December 4, 2019 (see section 3.2 below). Water was found in the stream channel throughout the majority of the restoration project during each visit (Figure 2). In 2017, within the second half of the reach, from STA 9+95 to STA 13+35, five of eleven riffle crests were dry. These occurred at STA 10+25 (photo station 11a – upstream), 11+20 (photo station 12b – downstream), 12+20 (photo station 13a and 13b), 13+20 (photo station 14a), and 15+40 (photo station 16a and 16b). In 2019, only one riffle crest was dry, STA 13+20 (photo station 14a). Within the riffle crests that were dry, there was visible flow towards the bottom of the downstream side of each riffle. This suggest that there is subterranean flow through the pore space between the bed materials of the riffle.

Harford County has collected biological data from summer of 2015 through spring of 2019 at a site approximately 150m downstream of the end of the Dembytown restoration reach. Field visits to this biological motoring site during the summers of 2015 and 2016 found the stream reduced to standing pools where the stream was flowing during summer visits in 2017 and 2019. These observations suggest that the standing pool condition on this portion of Fosters Branch is likely a normal condition during low-flow times of the year or during dry periods.

3.2 GEOMORPHIC ASSESSMENT

The first year of post restoration longitudinal profile and cross-sectional surveys was completed on December 18 and December 19, 2017. The Year 3 post restoration geomorphic survey was conducted on December 3 and December 4, 2019. Photographs depicting visual hydrology and overall site conditions are presented in Appendix A. The longitudinal profile data was analyzed to calculate the water surface slope for the channel (Table 8) and can be found in Appendix B along with a graphical overlay of 2017 and 2019 data in Figure 2. The longitudinal profile begins at STA 0+00 approximately 180 feet upstream of Dembytown Road bridge and ends at STA 18+62 at the bottom of a riffle. There has been no change in slope between the As-built and Year 3 surveys, indicating that the stream restoration is vertically stable (Level 3 performance measure).

Table 8 – Slope of longitudinal profile survey- 2017 (As-built), 2019 (Year 3)

Reach	Slope	
	2017	2019
Dembytown; 0+00 to 18+62	0.80%	0.80%

Cross-sectional surveys were analyzed at each of the two permanent monitoring locations to determine the vertical and lateral stability of the stream. Bankfull width, mean depth, width/depth ratio, overall cross-sectional area were measured and BEHI analysis was conducted at each cross-section to determine the vertical and lateral stability at each riffle. Assessments conducted during 2017 (As-built) represented the as-built condition or Year 1 post restoration channel conditions. The assessment conducted in 2019 represented the Year 3 post restoration channel conditions. Results of the cross-sectional measurements are included inThalweg depths changed less than the performance criteria of 0.5' of thalweg degradation between as-built and Year 3, showing that the vertical stability of the project is performing as expected.

Table 9. Overall, the monitored cross-sections have remained stable with very minor changes occurring between 2017 and 2019. Appendix B presents the 2017 and 2019 cross section data. Future cross section surveys will be superimposed on the current data to show any trends. Graphical depictions of the cross sections are in Figure 3. Thalweg depths changed less than the performance criteria of 0.5' of thalweg degradation between as-built and Year 3, showing that the vertical stability of the project is performing as expected.

Table 9 - Results of cross-sectional survey analysis- 2017 (As-built), 2019 (Year 3)

Year	Bankfull Width (ft)	Mean Depth (ft)	Width/ Depth Ratio	Entrench -ment ratio	Bankfull Velocity (ft/s)	Bankfull Discharge (cfs)	Bank Height Ratio	Flood Prone Area (ft^2)	Bank- full Area (ft^2)	Top of Bank Area (ft^2)
Cross-section 1										
2017	19.0	0.5	35.3	2.0	1.2	12.6	1.9	38.6	10.3	29.3
2019	18.7	0.5	39.2	1.3	1.1	9.9	2.3	25.2	8.9	33.0
Cross-section 2										
2017	14.1	0.7	19.2	9.8	1.5	15.4	1.6	138.1	10.4	40.6
2019	14.9	0.7	22.2	9.2	1.4	14.0	1.8	123.0	10.0	34.5

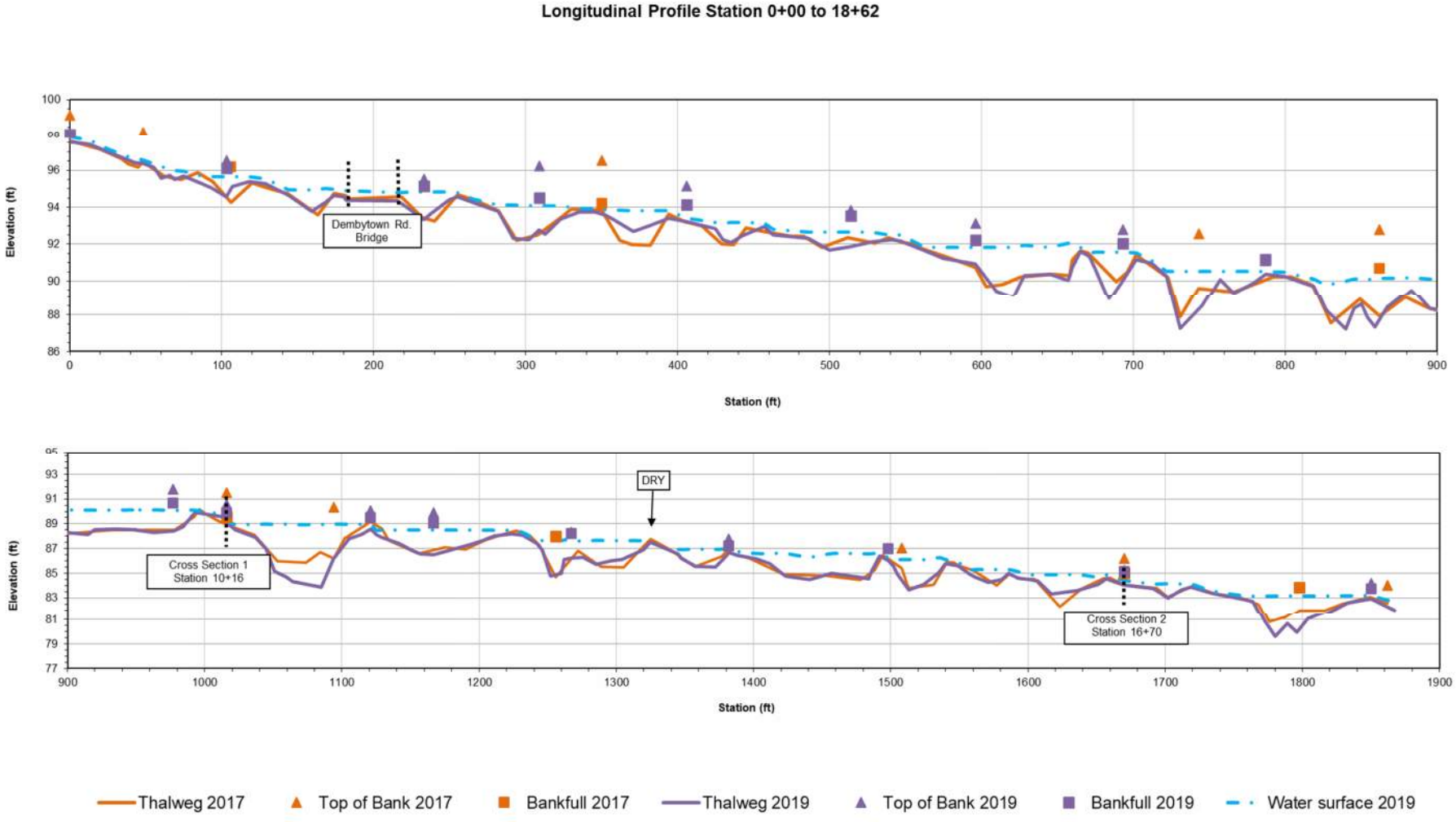

Figure 2 - Longitudinal Profile Overlay – 2017, 2019

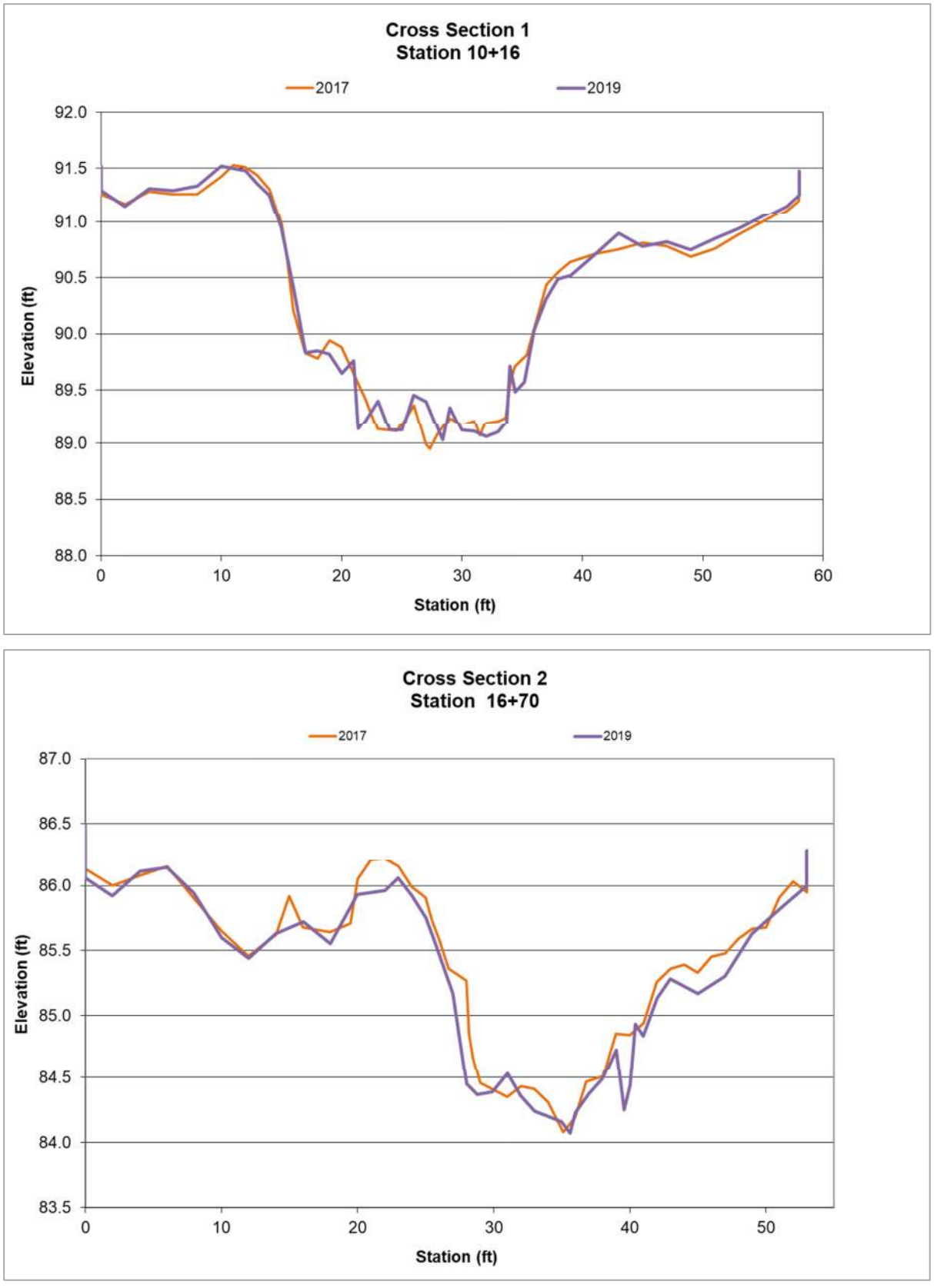

Figure 3 - Cross Section Survey – 2017 (As-built), 2019 (Yr 3)

The BEHI analysis demonstrates that the study area is not highly susceptible to lateral erosion. A BEHI score of 'Moderate or Better' is required and the majority of the site resulted in a rating of 'Low' or 'Very Low'. Figure 4 shows a map of the BEHI scores along the entire restoration length. Two short reaches in the middle of the restoration rated 'Moderate,' primarily due to the lack of a top of bank (the stream flowed against the edge of the valley). In addition, one short reach near the downstream extent of the restoration rated 'High' due to a newly fallen tree creating a raw bank without vegetation. This isolated section is very short compared to the overall length of restoration and overtime the bank will likely self-heal and vegetation will grow in and reduce the erosion potential. Overall this restoration site is laterally stable, thus resulting in 'Low' or 'Very Low' BEHI Ratings.

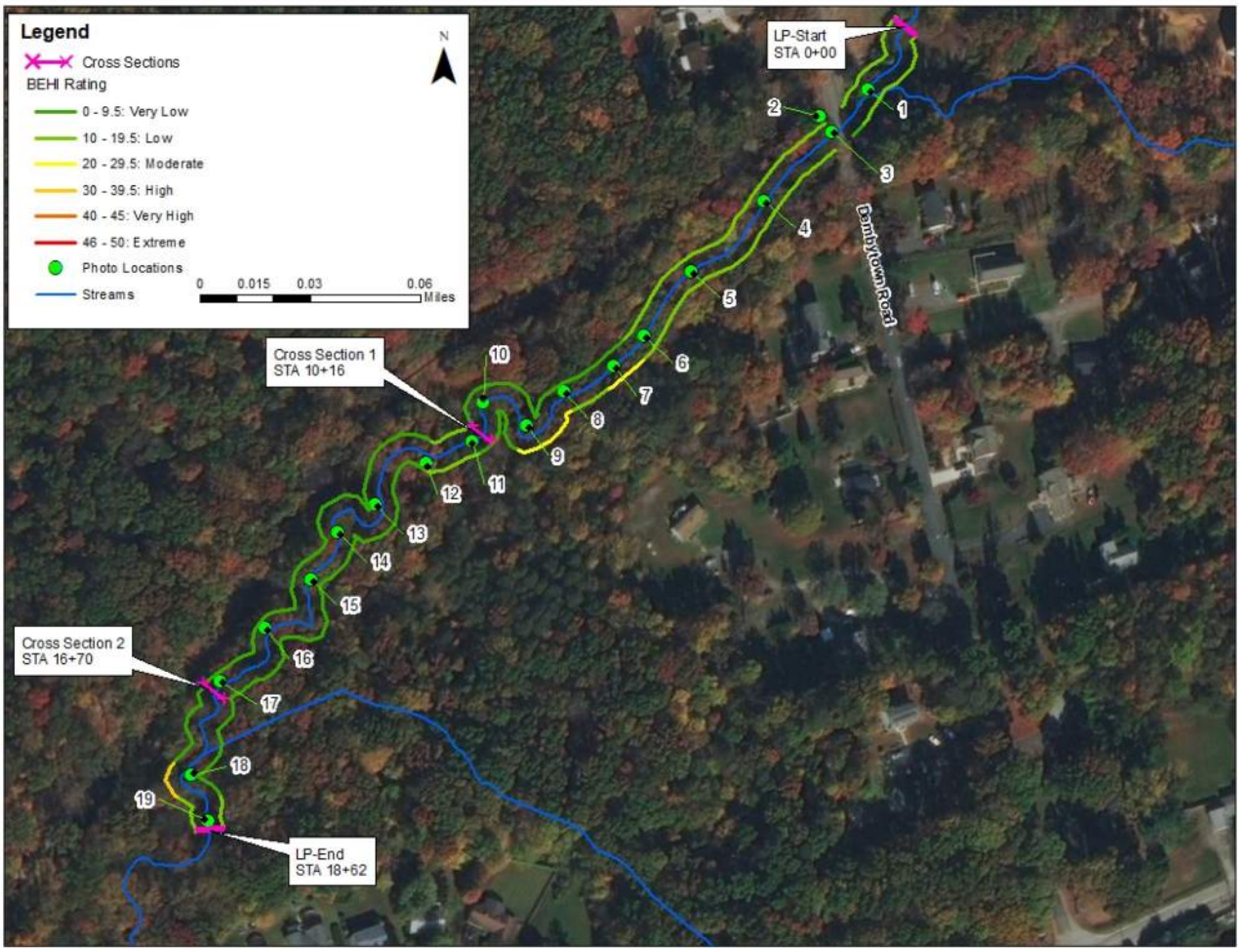

Figure 4 – BEHI analysis

The weighted pebble count transect breakdown in 2019 was 60 percent pools to 40 percent riffles. Figure 5 gives a visualization of the weighted counts by bed features. The median particle size, or D50, was 20mm while in 2017 the D50 was 69mm. The D84, which is the particle size that 84 percent of the sample is of the same size or smaller, was 110mm while in 2017, the D84 was 160mm. The D50 between 2017 and 2019 changed from small cobble to coarse gravel particle size. The D84 during that same time period changed from large cobble to medium cobble. The decrease in particle size occurred mostly in the pools where silt/clay and fine sand was commonly encountered.

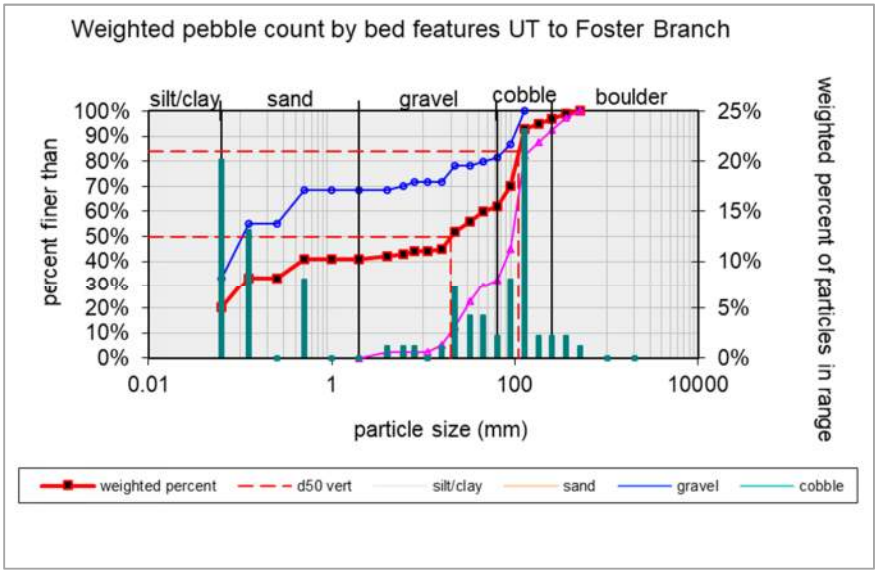

Figure 5 - Particle Distribution Analysis – 2019 (Year 3)

The EPA RBP High-Gradient habitat assessment was conducted Year 3 of post-restoration to determine if the restoration project has increased the biological habitat of the stream. A summary of RBP physical habitat assessment data is presented in Table 10. Optimal scores were given in the categories of 'Sediment Deposition', 'Bank Stability' on both banks, 'Vegetative Protection' on both banks and 'Riparian Zone Width' on the left bank. The full data set indicating individual scores for specific parameters is included in Appendix C.

Table 10 Summary of RBP High Gradient habitat assessment results

Year	RBP Total	RBP Percent	RBP Narrative Rating
Year 3	134	64.00	Partially Supporting

Results of the geomorphic assessments indicate a Rosgen C type stream classification, which meets the Level 3 Geomorphology target for Rosgen Stream Classification. Although the Level 2 Hydraulics success criteria for floodplain connectivity (bank height ratio <1.2) was not achieved at the two surveyed cross sections, it should be noted that these sections were constructed as designed and were not intended to achieve a bank height ratio of less than 1.2. There are other sections of the stream that were designed with a lower bank height ratio;

however, these sections were not surveyed during Year 1 or 3. Cross-section analyses indicate that very little change has occurred at each riffle-cross section and that the riffles surveyed are both vertically and laterally stable. It is recommended that additional supplemental cross sections be surveyed in future monitoring efforts to demonstrate whether areas that have been designed to have greater floodplain access achieved the success criteria for hydraulics. The long-pro overlay indicates a few pools have increased in depth. This depth increase can be beneficial in creating more habitat for pool specialist benthic macroinvertebrate and fish species.

3.3 INVASIVE PLANT AND VEGETATION ASSESSMENT

Overall, the invasive species density throughout the restoration was found to be moderate during all assessments. During the assessments, species presence and overall invasive plant density was noted, and very little change was observed between the years. Average invasive plant density throughout the site was calculated to be 35% in both 2017 and 2018, and decreased slightly to an estimated 32% in 2019. Species present at the site during the 2017 (Year 1) assessment included oriental bittersweet (*Celastrus orbiculatus*), multiflora rose (*Rosa multiflora*), American burnweed (*Erechtites hieracifolius*), mile-a-minute (*Persicaria perfoliata*), silk tree (*Albizia julibrissin*), white mulberry (*Morus alba*), Japanese honeysuckle (*Lonicera japonica*), Japanese stiltgrass (*Microstegium vimineum*), ground ivy (*Glechoma hederacea*), Japanese barberry (*Berberis thunbergii*), common ragweed (*Ambrosia artemisiifolia*), and privet (*Ligustrum* sp.). In addition to the species found during the 2017 (Year 1) assessment, a small amount of garlic mustard (*Alliaria petiolata*) was found during the 2018 (Year 2) assessment. The only new species found in the 2019 (Year 3) assessment was Asiatic dayflower (*Commelina communis*) at the upstream end of the restoration. Japanese stiltgrass continues to be the invasive species with the highest density across the site.

Native species such as New York fern (*Thelypteris noveboracensis*) and various sedge species (*Carex* sp.) were found at increasing densities during the 2019 assessment, and are beginning to outcompete Japanese stiltgrass in some locations, which has helped reduce the overall invasive species density estimated during the 2019 assessment.

Most of these species were also found outside the LOD, within the adjacent forest, and were likely present prior to restoration activities, so their continued presence is expected. The LOD contains many existing mature trees that were saved during construction and the areas within the critical root zones of these trees were largely not disturbed by construction activities. Invasive species were found primarily in these areas around existing mature trees. These areas of invasive species were present prior to construction. No invasive species were found to be in direct competition with planted vegetation. Invasive vines, such as oriental bittersweet and mile-a-minute often climb up newly planted trees, resulting in mortality. Fortunately, this was not observed at the time of either inspections, but this potential issue will be monitored in the future.

3.4 CONCLUSIONS

The results of monitoring data from 2017 (As-built; Year 1) established a baseline on which the 2019 (Year 3) survey can be compared to. The abundance of cobble throughout the reach with few signs of sedimentation occurring between monitoring years indicates a stable channel post restoration. Of the five dry riffles in 2017, only one remained dry in 2019 with subsurface flow visible. This riffle should continue to be investigated to determine if the subsurface flow is seasonal or if the riffle elevation is too high. The bottom half of the reach, station 11+00 to 18+62, has much greater access to the floodplain, which is evident in the difference between the flood prone area of cross-section 1 and cross-section 2. In Year 3 of post-restoration monitoring, there is no discernable difference in the geomorphologic stability between cross-section 1 with less access to the floodplain and cross-section 2 that has a much larger floodplain. Both cross-sections have remained vertically and laterally stable. Thalweg depths at the two measured cross sections changed by less than 0.5'. The vertical stability performance measure is required in Year 3, and based on these results the project is performing as expected for this performance criteria (Table 11). Overall, the project results in mainly 'Low' or 'Very Low' BEHI scores, meaning that the entire restoration length is also laterally stable. The lateral stability performance measure is required in Year 3, and based on these results the project is performing as expected for this performance criteria (Table 11). Only one short, isolated reach resulted in a high BEHI score, which is not affecting the overall stability of the project. Performing annual invasive plant assessments will allow the County to stay ahead of potential invasive strongholds and also allow for visual assessments of the stream to note any major changes. The visual hydrology assessment will continue each year to assess whether the stream in this area is perennial or ephemeral and how that compares to pre-construction conditions.

Table 11 – Year 3 Required Performance Criteria

Level and Category	Parameter	Measurement	Success Criteria	Monitoring Years	Criteria Met
3-Geomorphology	Vertical Stability	Longpro/riffle crest elevations	<0.5 ft thalweg degradation from as-built	AB, 3	Yes – thalweg riffle crest elevation changes <0.5'
	Lateral Stability	BEHI	Moderate or Better	3	Yes – All BEHI ratings Low or Very Low

4 REFERENCES

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Year-1 Monitoring Memo for Ring Factory Elementary School TMDL Outfall Repair and Stream Stabilization

EVALUATION DATE: May 29, 2019

SITE LOCATION: Bel Air, Harford County, MD DPW

Background

This memo describes Year-1 conditions at the Ring Factory Elementary School TMDL Outfall Repair and Stream Stabilization project conducted in compliance with the U.S. Army Corps of Engineers 2016-60581-M37 (HA DPW / Ring Factory Elementary / Outfall Construction / TMDL) dated March 16, 2016, for Department of Army (DA). No specific MDE monitoring requirements were indicated in the permitting.

The site is located in Harford County, Maryland, originating at Ring Factory Elementary School. The Tributary, which drains to Plumtree Run is a Use IV-P waterway within the Atkisson Reservoir Sub-Watershed (02130703) and is ultimately within the Bush River watershed (021307). The design limits of the project encompass a total of 1,078 linear feet. The Mainstem originates at a seep upstream of the project limits and flows downstream into a 42" CMP that conveys the Tributary through a residential community. Two pre-existing stormwater management ponds on the school property were retrofitted as part of the project referenced in this memo. The site also contains a stormwater management outfall channel that connects the second storm water management pond to the mainstem stream channel. This outfall channel was repaired and stabilized also as part of the project referenced in this memo.

The project goals defined in the permit focused on reducing in-stream erosion, improve habitat and bedform diversity by constructing a stream with more frequent access to the floodplain, improving vertical stability and providing cover for aquatic fauna. All stream and wetland impacts were to be remediated onsite, and the project proposes to provide a net gain in stream and wetland functions.

The following monitoring tasks were to be performed during the Year1 monitoring:

- Visual Assessment and Field Walk evaluating stability and noting the condition of the channel, floodplain, natural resources and any potential areas of concern.
- Visual assessment of riffle crest and wetland areas.
- Assess species richness and cover by conducting a visual assessment of mortality and natural recruitment to determine vegetative cover.
- Photographic records of vegetation, areas of concern, and overall project.

Visual Assessment

A visual evaluation of the stream was completed to assess post-construction conditions. The proposed plans were used as a base for taking notes. Notes from this assessment are included on the proposed plans in **Appendix A**.

The Year-1 visual assessment of the stream indicated that the stream restoration has significantly reduced bank erosion along the mainstem while maintaining wetland functions throughout the floodplain. The project has been effective by reducing bank height ratio and creating lateral and vertical stability. The site showed little erosion and all soil stabilization matting remains keyed in, tight, functioning and intact. The mainstem, SWM outfall channel as well as the four small outlet channels along the left bank of the mainstem remain stable and functioning.

There are a few minor areas of concern noted in the visual assessment that include:

- Mid-channel bar at approximate station 0+50
- Appears to be missing a few proposed imbricated boulders at the confluence of the outfall channel at approximate station 2+60
- Mid channel bar at approximate station 2+50
- A tree is laying over the channel at station 3+00, however, it is not disrupting flow but will need to continue to be monitored
- Clay lense is exposed in channel and minor bank erosion is occurring at approximate station 5+05
- A large debris jam at station 5+50 is causing a backwater from approximately station 5+50 to 6+15
- Larger rocks approximately Class I in size have piled up creating a dam at approximate station 8+90
- Subsurface flow between the first and second step pool at approximate station 10+35
- The footbridge at station 4+30 that was supposed to be removed is still present

These areas of potential concern are photographed and included in **Appendix B**.

Riffle Crests and Wetland Areas

A visual assessment of all riffles and wetlands area was completed for documentation. Riffles were all seen to be stable per the proposed design and wetlands appear functioning based on visual observation. Photos and photos locations are included in **Appendix C.**

Vegetation Assessment and Species Richness

The herbaceous coverage is not meeting the project goal of 85% coverage. The herbaceous coverage has improved from 50% in As-built conditions to 75% in Year 1 monitoring. Bare spots are frequent troughout the floodplain, especially where the haul road was during construction. Bare spots are noted in the visual assessment mapping included in **Appendix D**.

Woody tree planting survival was not strong during the visual assessment of vegetation. Many trees were dead, lost all branches, had been broken or were completely gone with only a planting pit and mulch remaining. Deer presence was evident during the monitoring, and deer browse and rubs on tree plantings was evident throughout the project. Of the 234 trees planted within the project boundaries only 67 have survived past year 1. This is a success rate for planted trees of 29%. Including pre-existing trees there are a total of 110 trees located within the project area.

Invasive Species Assessment

Invasive species are not prevalent within the LOD of the site. A majority of invasive species observed were at the footbridge that was supposed to be removed, per the stream stabilization plan sheets. On the right bank side of the footbridge English Ivy (*Hedera helix*) and Multiflora Rose (*Rosa multiflora)* were observed attached the existing foot bridge. In addition, small patches of Multiflora Rose and Mile-a-minute (*Persicaria perfoliate)* were found within the floodplain. Locations and photos of invasive species is included in **Appendix E**.

Year-2 monitoring will be completed and reported on in 2020.

Sincerely,

WHITNEY BAILEY COX & MAGNANI, LLC

Matthew Hubbard
Project Manager, *Environmental Water Resources*

APPENDIX A

VISUAL ASSESSMENT

Year 1 (2019) Monitoring -
VISUAL ASSESSMENT MAPPING

HARFORD COUNTY, MARYLAND

DEPARTMENT OF PUBLIC WORKS
BID NO.

RING FACTORY ELEMENTARY SCHOOL SWM POND RETROFIT, OUTFALL REPAIR, AND STREAM STABILIZATION

INDEX OF SHEETS

SHEET NO.	DESCRIPTION
1	TITLE SHEET
2	STORMWATER MANAGEMENT GEOMETRIC LAYOUT
3	STORMWATER MANAGEMENT PLAN
4-5	STORMWATER MANAGEMENT PROFILES
6	STORMWATER MANAGEMENT OUTFALL PROFILE
7-9	STORMWATER MANAGEMENT DETAILS
10-11	STORMWATER MANAGEMENT STAKEOUT PLANS
12	STORMWATER MANAGEMENT SPECIFICATIONS
13-14	STREAM STABILIZATION GEOMETRIC LAYOUT
15-16	STREAM STABILIZATION PLANS
17-18	STREAM STABILIZATION DETAILS
19	STREAM STABILIZATION PROFILE
20-25	STREAM STABILIZATION CROSS SECTIONS
26-27	EROSION AND SEDIMENT CONTROL NOTES
28-29	EROSION AND SEDIMENT CONTROL DETAILS
30-31	EROSION AND SEDIMENT CONTROL PLANS
32	EROSION AND SEDIMENT CONTROL PROFILE
33-35	LANDSCAPE PLANS
36	LANDSCAPE DETAILS
37	DRAINAGE AREA MAP

Legend:

Red Lettering = Stability Notes
Green Lettering = Vegetation Notes
Purple Lettering = Invasive Species Notes

DEVELOPER'S CERTIFICATION

I/WE HEREBY CERTIFY THAT ALL PROPOSED WORK SHOWN ON THESE CONSTRUCTION DRAWING(S) WILL BE ACCOMPLISHED PURSUANT TO THESE PLANS. I/WE ALSO UNDERSTAND THAT IT IS MY/OUR RESPONSIBILITY TO HAVE THE CONSTRUCTION SUPERVISED AND CERTIFIED, INCLUDING THE SUBMITTAL OF "AS-BUILT" PLANS WITHIN 30 DAYS OF COMPLETION, BY A REGISTERED PROFESSIONAL ENGINEER.

SIGNED: _____

PRINT NAME: _____

DATE: _____

ENGINEER'S CERTIFICATION

I HEREBY CERTIFY THAT THIS PLAN HAS BEEN PREPARED BY ME, OR UNDER MY SUPERVISION, AND MEETS THE MINIMUM STANDARDS OF THE HARFORD COUNTY DEPARTMENT OF PUBLIC WORKS AND/OR THE UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, AND/OR THE MARYLAND DEPARTMENT OF THE ENVIRONMENT, WATER MANAGEMENT ADMINISTRATION.

SIGNED: _____

PRINT NAME: _____

DATE: _____

P.E. NO.: _____

AS-BUILT CERTIFICATION

I HEREBY CERTIFY THAT THE FACILITIES SHOWN ON THIS PLAN WERE CONSTRUCTED AS SHOWN ON THE "AS-BUILT" PLANS AND MEETS THE APPROVED PLANS AND SPECIFICATIONS.

SIGNED: _____

PRINT NAME: _____

DATE: _____

P.E. NO.: _____

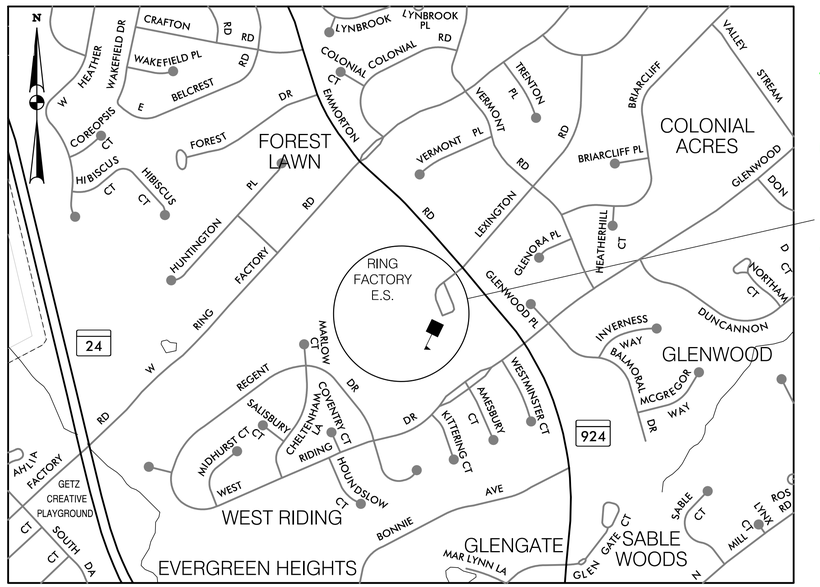
FIELD VERIFICATION CERTIFICATION

I HEREBY CERTIFY THAT I COMPLETED A FIELD VERIFICATION TO THE INFORMATION SHOWN ON THE PLANS ON _____ AND THAT THE INFORMATION SHOWN ON THE PLANS IS IN AGREEMENT WITH THE ACTUAL FIELD CONDITIONS.

SIGNED: _____

PRINT NAME: _____

DATE: _____



HARFORD COUNTY

LOCATION MAP

SCALE 1" = 600'

Herbaceous Vegetation Cover Project-wide: 75%

S/C PLAN #59823
GRA 2757-2015

OWNER:
HARFORD COUNTY BOARD OF EDUCATION

DEVELOPER/APPLICANT:
HARFORD COUNTY DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS AND STORMWATER MANAGEMENT
212 SOUTH BOND STREET, 3RD FLOOR
BEL AIR, MD 21014
410-638-3545
CONTACT: NAVEED SHAH

GENERAL NOTES

1. SPECIFICATIONS: ALL WORK IS TO BE PERFORMED IN ACCORDANCE MARYLAND STATE HIGHWAY ADMINISTRATIONS STANDARD SPECIFICATIONS FOR CONSTRUCTION AND MATERIALS DATED JULY 2008 AND THE MOST RECENT REVISIONS THEREOF AND ADDITIONS THERETO.

2. UTILITIES: UTILITY LOCATIONS SHOWN ON THE PLANS ARE BASED ON LIMITED INFORMATION AVAILABLE. HOWEVER, IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY THE ACCURACY OF THIS INFORMATION. THE COST OF REPAIR OR REPLACEMENT OF ANY SUCH FACILITIES DAMAGED BY THE CONTRACTOR'S OPERATIONS SHALL BE BORNE BY HIM.

   CONTACT "MISS UTILITY" AT 1-800-257-7777 AT LEAST FIVE (5) DAYS PRIOR TO THE START OF WORK. THERE SHOULD BE NO EXCAVATION UNTIL THE LOCATIONS OF UNDERGROUND UTILITIES HAVE BEEN DETERMINED.

3. STANDARD DETAILS: REFERENCE MADE TO STANDARDS ARE TAKEN FROM THE HARFORD COUNTY ROAD CODE "BOOK OF STANDARD DETAILS" AND FROM "THE MARYLAND STATE HIGHWAY ADMINISTRATION'S BOOK OF STANDARDS-HIGHWAY AND INCIDENTAL STRUCTURES", IT WILL BE THE CONTRACTOR'S RESPONSIBILITY THAT THE STANDARD DRAWINGS IN HIS POSSESSION ARE THE LATEST REVISED STANDARDS UP TO AND INCLUDING THE DATE OF THE ADVERTISEMENT OF THIS CONTRACT.

4. RIGHT-OF-WAY LINES: RIGHT-OF-WAY LINES SHOWN ON THESE PLANS DO NOT INCLUDE EASEMENTS. THEY ARE FOR ASSISTANCE IN INTERPRETING THE PLANS ONLY. THESE LINES DO NOT REPRESENT THE OFFICIAL PROPERTY ACQUISITION LINES. FOR OFFICIAL FEE RIGHT-OF-WAY AND EASEMENT INFORMATION, SEE THE APPROPRIATE RIGHT-OF-WAY PLATS.

5. SOIL CONSERVATION: THE CONTRACTOR SHALL NOT DISTURB THE EXISTING VEGETATION OUTSIDE THE LIMITS OF DISTURBANCE. STAGING AND STOCKPILING WILL BE ALLOWED WHERE INDICATED ON THE PLANS. SOIL STABILIZATION WILL CONFORM TO 2011 MARYLAND STANDARDS AND SPECIFICATIONS FOR SOIL EROSION AND SEDIMENT CONTROL. WASTE EXCAVATION SHALL BE DISPOSED OF AT A SITE WITH AN APPROVED SEDIMENT CONTROL PLAN AND PERMIT.

6. THE CONTRACTOR IS RESPONSIBLE FOR RESTORING, REPAIRING, OR RECONSTRUCTING EXISTING SITE FEATURES (I.E. SIDEWALKS, CURB/GUTTER, FENCING, PAVING, LIGHTING, UTILITIES, ETC.) THAT ARE DAMAGED AS A RESULT OF THE PROJECT WORK.

7. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PRESERVING EXISTING PROPERTY MARKERS. EXISTING PROPERTY MARKERS THAT ARE DISTURBED AS A RESULT OF THE CONTRACTOR'S OPERATIONS SHALL BE RESET BY A REGISTERED LAND SURVEYOR AT THE CONTRACTOR'S SOLE EXPENSE.

8. SURVEYS:

   COORDINATES AND BEARINGS SHOWN HEREON ARE REFERENCE TO THE MARYLAND COORDINATE SYSTEM (NAD 83/91) AND ARE BASED ON THE FOLLOWING NATIONAL GEODETIC SURVEY CONTROL MONUMENTS:

JV6313 TT7/21 AZMK	667735.97	1502895.74
JB6280 RING	673440.68	1497878.62

   ELEVATIONS SHOWN HEREON ARE REFERRED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD'88) WITH LOCAL REFERENCE TO THE FOLLOWING NATIONAL GEODETIC SURVEY CONTROL MONUMENTS:

JV6313 TT7/21 AZMK	324.88
JV6280 RING	290.23

   ONLY THOSE CONTROL POINTS SHOWN ON THESE PLANS ARE TO BE USED FOR THE CONSTRUCTION OF THIS PROJECT.

9. MARYLAND DEPARTMENT OF THE ENVIRONMENT CONSIDERS THIS STREAM AS A USE IV-P STREAM PURSUANT TO WHICH IN-STREAM WORK IS PROHIBITED FROM MARCH 1 TO MAY 31.

HARFORD COUNTY STORMWATER MANAGEMENT BILLING # 99975

THESE PLANS HAVE BEEN REVIEWED BY HARFORD COUNTY AND MEET THE TECHNICAL REQUIREMENTS FOR STORMWATER QUANTITY AND/OR QUALITY MANAGEMENT ONLY.

REVIEWED FOR TECHNICAL SUFFICIENCY:	REVIEWED AND APPROVAL RECOMMENDED:
STORMWATER MANAGEMENT	PROJECT ENGINEER
REVIEWED AND APPROVAL RECOMMENDED:	REVIEWED AND APPROVAL RECOMMENDED:
CHIEF ENGINEER	CHIEF ENGINEER
APPROVAL RECOMMENDED:	APPROVAL RECOMMENDED:
DEPUTY DIRECTOR OF PUBLIC WORKS	DEPUTY DIRECTOR OF PUBLIC WORKS
APPROVED:	APPROVED:
DIRECTOR OF PUBLIC WORKS	DIRECTOR OF PUBLIC WORKS

WALLACE MONTGOMERY
ENGINEERS·PLANNERS·SURVEYORS·CONSTRUCTION MANAGERS
10150 York Road, Suite 200
Hunt Valley, Maryland 21030
410.494.9093 Tel / 410.667.0925 Fax
www.WallaceMontgomery.com A Limited Liability Partnership

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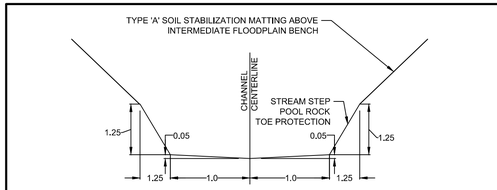
Fax: (410) 893-9380
E-mail: info@cemscience.com

PROFESSIONAL CERTIFICATION

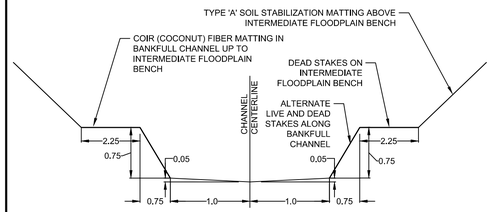
I HEREBY CERITFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND, LICENSE NO. 16142, EXPIRATION DATE: 8/17/2018.

ADC MAP :
TAX MAP :
HCG BILLING ID No.:
HCG DWG ID No.:
SCALE 1" = 1 INCH



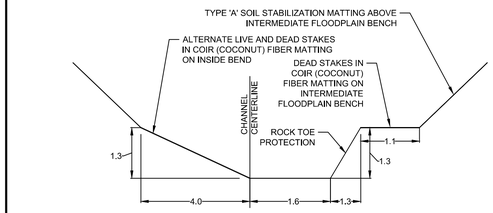
STEP POOL - UPPER TRIBUTARY

STANDARD SECTION
(NOT TO SCALE)



RIFFLE - UPPER TRIBUTARY

STANDARD SECTION
(NOT TO SCALE)



POOL - UPPER TRIBUTARY

STANDARD SECTION
(NOT TO SCALE)

SITE NOTES:

1. ALL SURVEY DATA, GPS DATA INCLUDING WETLAND DELINEATIONS AND OBSERVED WATERS OF THE US, AND ADDITIONAL BASE GIS DATA OFFSITE PROVIDED BY WALLACE MONTGOMERY.
   SURVEY CONTROL INFORMATION: HORIZONTAL-NAD83 US FEET, VERTICAL-NVGD88 US FEET.
2. ALL DELINEATED STREAMS ARE USE 1V-P STREAMS, WITHIN THE ATKISSON RESERVOIR WATERSHED (02130703). ALL IN-STREAM WORK SHALL NOT BE CONDUCTED DURING THE CLOSURE PERIOD OF MARCH 1 THROUGH MAY 31, INCLUSIVE, DURING ANY YEAR.
3. SOILS ON SITE INCLUDE A MIX OF CcB2 & CcC2 (CHESTER SILT LOAM), GcC2 & GcC3 (GLENELG LOAM) AND GnB (GLENVILLE SILT LOAM). CHESTER AND GLENELG SOILS ARE IN HYDROLOGIC GROUP B. GLENVILLE SOILS ARE IN HYDROLOGIC GROUP C.
4. SLOPES GREATER THAN 25% EXIST ALONG THE STREAM WITHIN ALL OF THE SOIL TYPES.
5. THE SITE IS NOT LOCATED WITHIN THE ESTABLISHED FEMA 100-YEAR FLOODPLAIN.
6. THE SITE IS NOT LOCATED WITHIN THE CRITICAL AREA.
7. SEE SHEETS 2 THROUGH 12 FOR POND RETROFIT WORK.
8. SEE SHEETS 26 THROUGH 32 FOR COMPLETE LIMITS OF DISTURBANCE, ACCESS PATHS, AND EROSION AND SEDIMENT CONTROL MEASURES FOR THE POND RETROFIT WORK. COORDINATE CONSTRUCTION SCHEDULES AND ACCESS FOR ALL WORK AS NECESSARY.
9. CONTRACTOR TO UTILIZE STAGING AND STOCKPILE AREAS FOR THE STREAM STABILIZATION WORK AS WILL BE USED FOR THE POND #2 RETROFIT WORK.
10. MINIMIZE TREE REMOVAL AS MUCH AS POSSIBLE WITHIN THE LOD. ALL DISTURBED AREAS SHALL BE REPLANTED IN ACCORDANCE WITH THE PLANTING PLANS (SEE SHEETS 33 THROUGH 36).

E:1500300
N:637900

MATCHLINE - SEE SHEET 16 OF 37

ADC MAP :

TAX MAP :

HCG BILLING ID No.:

HCG DWG ID No.:

SCALE: 1"=20'

EXISTING 75' HARFORD COUNTY STREAM BUFFER

EXISTING WOODS LINE

EXISTING 75' HARFORD COUNTY WETLAND BUFFER

EXISTING TREE

Herb. Vegetation weak

Large debris jam causing back-watering upstream

Back-watering from large debris jam

NED WITH GEOTEXTILE A 60:40 MIX OF CLASS I RIPRAP AND GRAVEL/COBBLE MIX DOWN TO THE PROPOSED STREAM CHANNEL

Haul Road herb. Vegetation weak

PROPOSED THALWEG ALIGNMENT

Invasive Multiflora rose present

Herb. Vegetation strong

Stable

UPPER TRIBUTARY STREAM FLOW

SWALE TO BE LINED WITH GEOTEXTILE FABRIC AND A 60:40 MIX OF CLASS I RIPRAP AND GRAVEL/COBBLE MIX DOWN TO THE PROPOSED STREAM CHANNEL

PROPOSED STREAM STEP POOL SECTION (SEE DETAIL SHEET 18)

Invasive Mile-a-minute and multiflora present

PROPOSED COIR (COCONUT) FIBER MATTING TO STABILIZE BANKS WITH ALTERNATING LIVE AND DEAD STAKES (SEE STANDARD CROSS SECTIONS THIS SHEET AND DETAIL SHEET 18)

STREAM FLOW

PROPOSED ROCK TOE PROTECTION TYPICAL AS SHOWN (SEE DETAIL SHEET 17)

PROPOSED RIFFLE GRADE CONTROL STRUCTURES INSTALLED AT DOWNSTREAM LIMIT OF RIFFLE SEGMENTS (SEE DETAIL SHEET 17)

PROPOSED STREAM STEP POOL GRADE CONTROL STRUCTURE (SEE DETAIL SHEET 18)

PROPOSED STREAM STEP POOL ROCK TOE PROTECTION (SEE DETAIL SHEET 18)

IIT OF LAND

EXISTING 25' MARYLAND WETLAND BUFFER

Fallen trees outside LOD laying over channel

Subsurface flow in-between first and second step pool

Invasive Mile-a-minute present

Larger rocks (Class I - II) piled up creating small dam

Planted trees have heavy evidence of deer browse. Many are in poor condition

LEGEND

EXISTING CONTOURS		PROPOSED RIFFLE GRADE CONTROL STONE	
PROPOSED CONTOURS			
WETLAND	W W	PROPOSED ROCK TOE PROTECTION STONE	
WATERS OF THE U.S.	WUS WUS		
WETLAND BUFFER	WB WB	EX. THALWEG	
STREAM BUFFER	SB SB	PROPOSED THALWEG	
WOODS LINE			

0 20 40 60

DATUM: NAD 83/91 Horizontal
NAVD 88 Vertical

PROFESSIONAL CERTIFICATION

I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND.

LICENSE NO.: 32519
EXPIRATION DATE: 06/10/2017

STATE OF MARYLAND · SCOTT A. MURRAY · 32519 · LICENSED PROFESSIONAL ENGINEER

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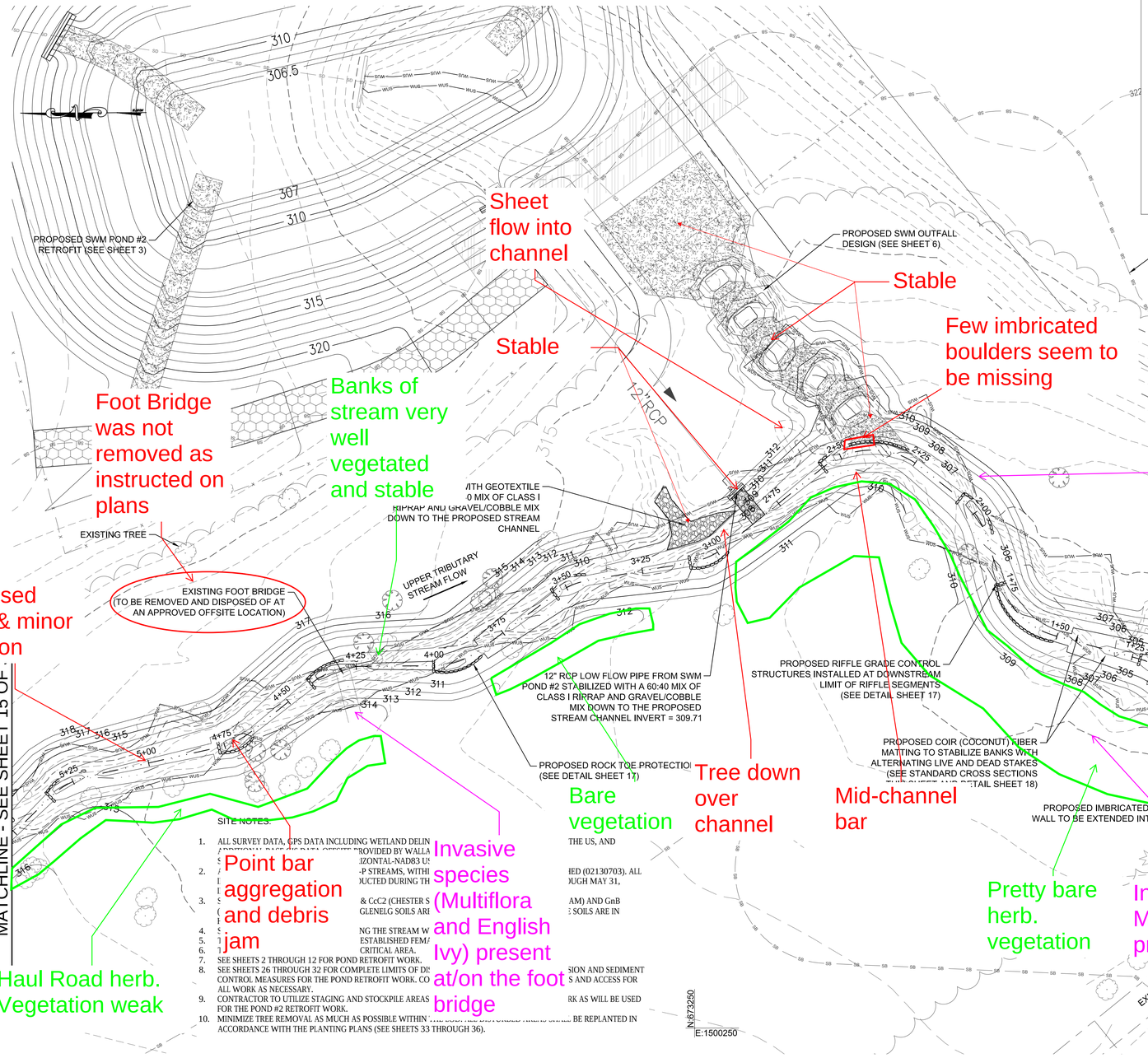
Revisions

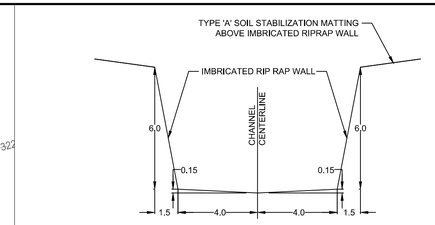
HARFORD COUNTY, MARYLAND

RING FACTORY ELEMENTARY SCHOOL TMDL
SWM POND RETROFIT, OUTFALL REPAIR, AND STREAM STABILIZATION
STREAM STABILIZATION PLAN

Drawn By : NML
Designed By : SAM
Reviewed By : SAM

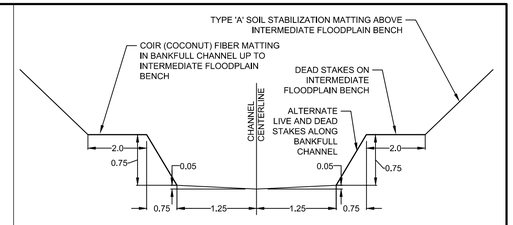
Contract No :
Scale : 1"=20'
Sheet 15 Of 37
Date : NOVEMBER 2016





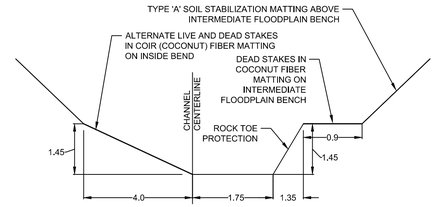
IMBRICATED RIPRAP WALL - LOWER TRIBUTARY

STANDARD SECTION
(NOT TO SCALE)



RIFFLE - LOWER TRIBUTARY

STANDARD SECTION
(NOT TO SCALE)



POOL - LOWER TRIBUTARY

STANDARD SECTION
(NOT TO SCALE)

SITE NOTES:

1. ALL SURVEY DATA, GPS DATA INCLUDING WETLAND DELIN… PROVIDED BY WALLA… IZONTAL-NAD83 US…
2. …-P STREAMS, WITH… UCTED DURING TH…
3. …& CcC2 (CHESTER S… AM) AND GnB… GLENELG SOILS ARI… : SOILS ARE IN…
4. …NG THE STREAM W…
5. … ESTABLISHED FEM…
6. … CRITICAL AREA.
7. SEE SHEETS 2 THROUGH 12 FOR POND RETROFIT WORK.
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10. MINIMIZE TREE REMOVAL AS MUCH AS POSSIBLE WITHIN … …BE REPLANTED IN ACCORDANCE WITH THE PLANTING PLANS (SEE SHEETS 33 THROUGH 36).

LEGEND

EXISTING CONTOURS	PROPOSED RIFFLE GRADE CONTROL
PROPOSED CONTOURS	STONE
WETLAND	PROPOSED ROCK TOE PROTECTION
WATERS OF THE U.S.	STONE
WETLAND BUFFER	EX. THALWEG
STREAM BUFFER	PROPOSED THALWEG
WOODS LINE	

0 20 40 60

DATUM: NAD 83/91 Horizontal
NAVD 88 Vertical

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Revisions

HARFORD COUNTY, MARYLAND

RING FACTORY ELEMENTARY SCHOOL TMDL
SWM POND RETROFIT, OUTFALL REPAIR, AND STREAM STABILIZATION
STREAM STABILIZATION PLAN

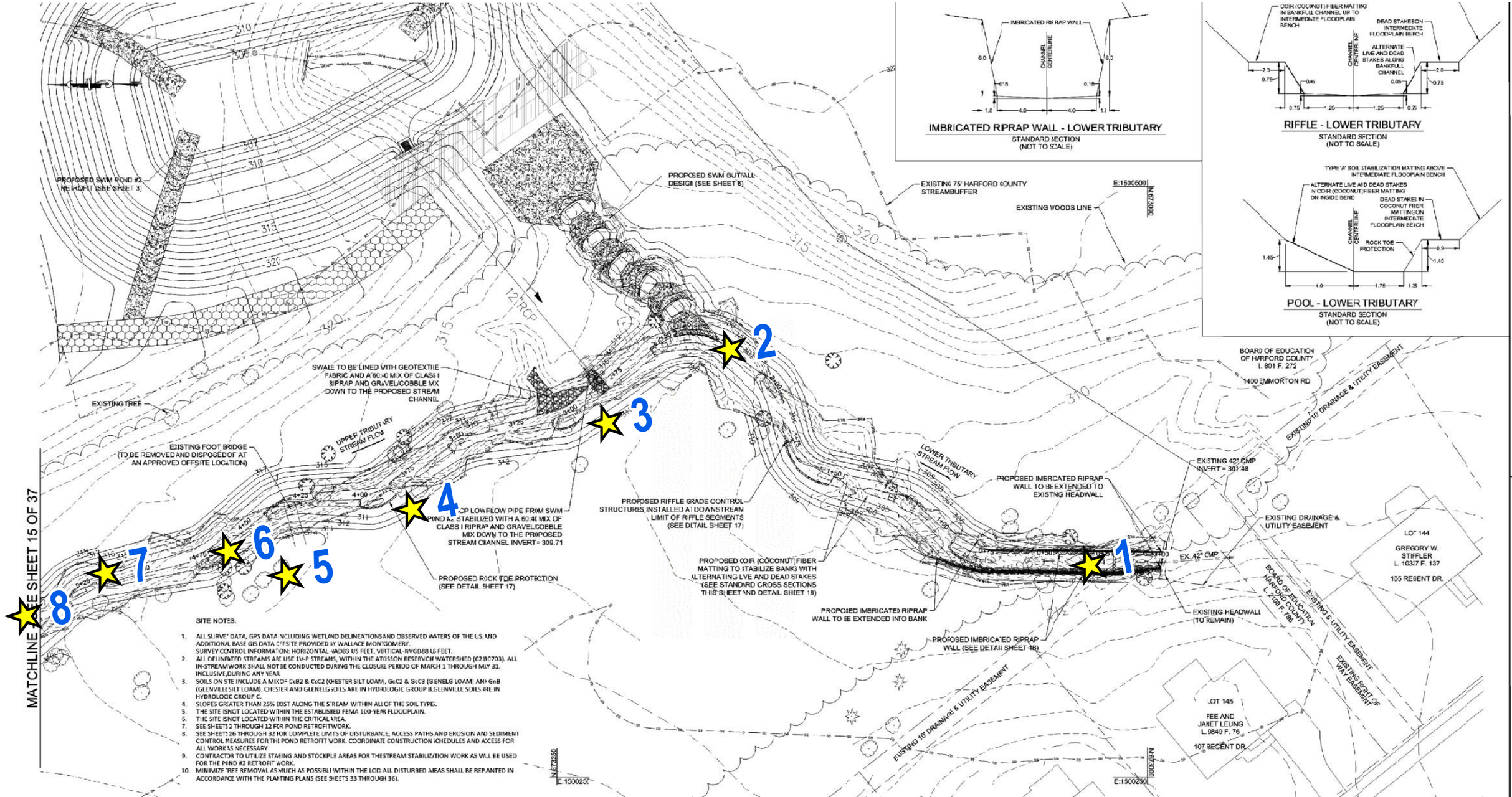
Drawn By : NML
Designed By : SAM
Reviewed By : SAM

Contract No :
Scale : 1"=20'
Sheet 16 Of 37
Date : NOVEMBER 2016

APPENDIX B

AREAS OF CONCERN PHOTOS

Year 1 (2019) Monitoring - Areas of Concern Photo Log Location Mapping



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LEGEND

- EXISTING CONTOURS
- PROPOSED CONTOURS
- WETLAND
- WATERS OF THE U.S.
- WETLAND BUFFER
- STREAM BUFFER
- WOODS LINE
- PROPOSED RIFFLE GRADE CONTROL STONE
- PROPOSED ROCK TOE PROTECTION STONE
- EX. THALWEG
- PROPOSED THALWEG

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LICENSE NO.: 3519

DATUM: NAD 83/91 Horizontal
NAVD 88 Vertical

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HARFORD COUNTY, MARYLAND

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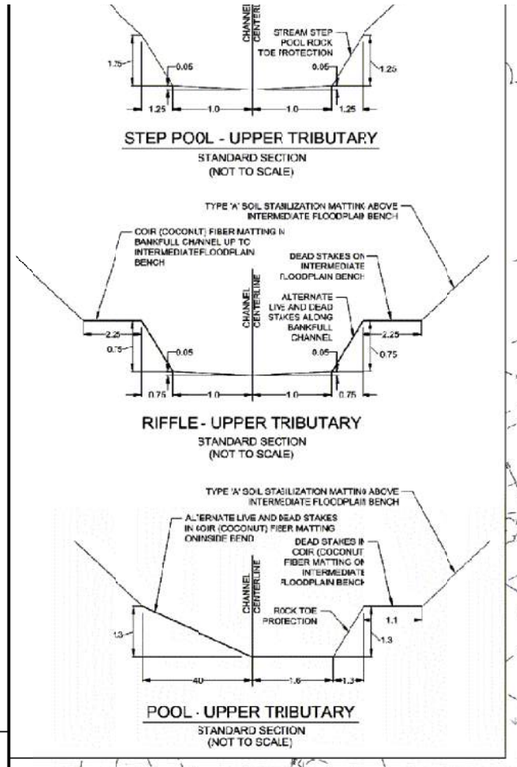
STREAM STABILIZATION PLAN

Drawn By :	NML	Contract No :	
Designed By	SAM	Scale :	1"=20'
Reviewed By :	SAM	Sheet	16 Of 37

TAX MAP :
ADC MAP :
HGG BILLING ID NO.:
HGG DWG ID NO.:

Year 1 (2019) Monitoring - Areas of Concern Photo Log Location Mapping



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MATCHLINE - SEE SHEET 16 OF 37

E:1500300
N:672900
E:1500700
N:672900
EXISTING 75' HARFORD COUNTY STREAM BUFFER
EXISTING WOODS LINE
EXISTING 75'-HARFORD COUNTY WETLAND BUFFER
EXISTING TREE
SWALE TO BE LINED WITH GEOTEXTILE FABRIC AND A 60:40 MIX OF CLASS I RIPRAP AND GRAVEL/COBBLE MIX DOWN TO THE PROPOSEE STREAM CHANNEL
UPPER TRIBUTARY STREAM FLOW
PROPOSED THALWEG ALIGNMENT
SWALE TO BE LINED WITH GEOTEXTILE FABRIC AND A 60:40 MIX OF CLASS I RIPRAP AND GRAVEL/COBBLE MIX DOWN TO THE PROPOSED STREAM CHANNEL
PROPOSED STREAM STEP POOL SECTION SEE DETAIL SHEET 18)
STREAM FLOW
PROPOSEE COIR (COCONUT) FIBER MATTING TO STABILIZE BANKS WITH ALTERNATNG LIVE AND DEAD STAKES (SEE STANDARD CROSS SECTIONS THIS SHEET AND DETAIL SHEET 18)
PROPOSED ROCK TOE PROTECTION TYPICALAS SHOWN (SEE DETAIL SHEET 17)
PROPOSED RIFFLE GRADE CONTROL STRUCTURES INSTALLED AT DOWNSTREAM LIMIT OF RIFFLE SEGMENTS (SEE DETAIL SHEET 17)
PROPOSED STREAM STEP POOL GRADE-CONTROL STRUCTURE (SEE DETAIL SHEET 18)
PROPOSED STREAM STEP POOL-ROCK TOE PROTECTION (SEE DETAIL SHEET 18)
LIMIT OF EXISTING WETLAND
EXISTING 25' MARYLAND WETLAND BUFFER
N:672980
E:1500100

9
10

LEGEND

EXISTING CONTOURS		PROPOSED RIFFLE GRADE CONTRL STONE	
PROPOSED CONTOURS			
WETLAND		PROPOSED ROCK TOE PROTECTION STONE	
WATERS OF THE U.S.	WUS WUS		
WETLAND BUFFER		EX. THALWEG	
STREAM BUFFER		PROPOSED THALWEG	
WOODS LINE			

0 20 40 60

DATUM: NAD 83/91 Horizontal
NAVD 88 Vertical

PROFESSIONAL CERTIFICATION

I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BYME, AND THAT I AM A DULY LICENSED PROFESIONAL ENGINEER UNDIR THE LAWS OF THE STATE OF MARYLAND.

LICENSE NO.: 32510
EXPIRATION DATE: 09/10/2017

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Revisions

HARFORD COUNTY, MARYLAND

RING FACTORY ELEMENTARY SCHOOL TMDL
SWM POND RETROFIT, OUTFALL REPAIR, AND STREAM STABILIZATION
STREAM STABILIZATION PLAN

Drawn By :	NML	Contract No :	
Designed By :	SAM	Scale :	1"=20'
Reviewed By :	SAM	Sheet : 15 Of 37	
		Date :	NOVEMBER 2016

Ring Factory Elementary School Stream and Outfall Restoration Monitoring: YEAR 1
Areas of Concern Photo Log

Photo 1 - Mid channel bar at station 0+50 – Minor Concern

Photo 2 - Bar forming and imbricated boulders missing at station 2+45 – Moderate Concern

Photo 3 - Tree down across channel at station 3+00 – Minor Concern

Photo 4 - Minor erosion at station 3+80 – Moderate Concern

Ring Factory Elementary School Stream and Outfall Restoration Monitoring: YEAR 1
Areas of Concern Photo Log

Photo 5 - Bridge to be removed per plans is not removed and covered in invasive species at station 4+30 – Moderate Concern

Photo 6 - Small bar forming at station 4+75 – Minor Concern

Photo 7 - Erosion under matting exposing clay layer at station 5+00 – Minor Concern

Photo 8 - Very large debris jam causing backwater at station 5+50 – Moderate Concern

Ring Factory Elementary School Stream and Outfall Restoration Monitoring: YEAR 1
Areas of Concern Photo Log

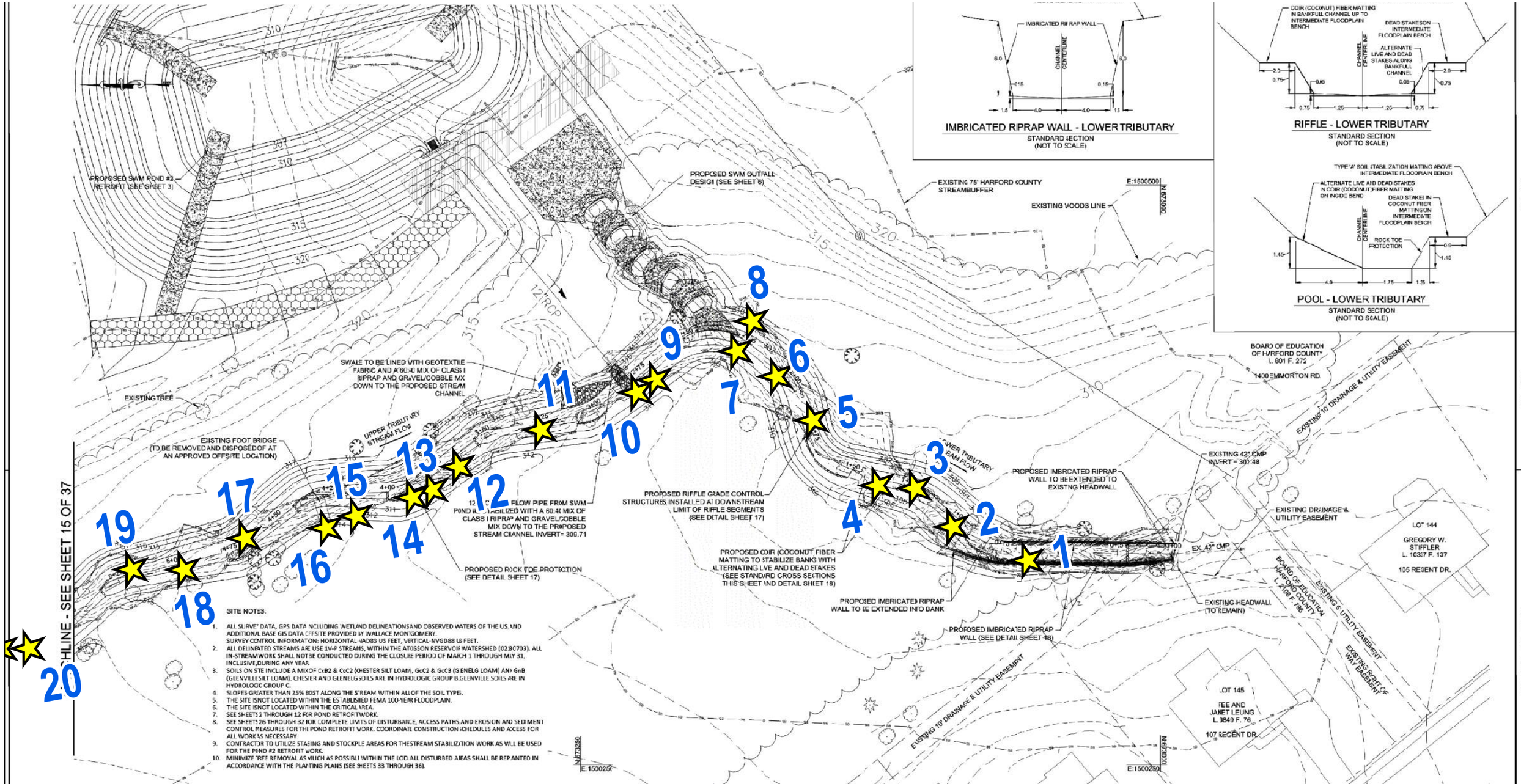
Photo 9 - Rocks piled up creating small dam at station 9+00 – Minor Concern

Photo 10 - Subsurface flow at station 10+25 – Minor Concern

APPENDIX C

RIFFLE CREST AND WETLAND PHOTOS

Year 1 (2019) Monitoring - Riffle Crest and Wetland Photo Log Location Mapping



SHEET 15 OF 37

SITE NOTES.

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3. SOILS ON STE INCLUDE A MIXOF CeB2 & CcC2 (CHESTER SILT LOAM), GcC2 & GcC3 (GLENELG LOAM) AND GnB (GLENVILLESILT LOAM). CHESTER AND GLENELG SOILS ARE IN HYDROLOGIC GROUP B.GLENVILLE SOILS ARE IN HYDROLOGIC GROUP C.
4. SLOPES GREATER THAN 25% EXIST ALONG THE STREAM WITHIN ALL OF THE SOIL TYPES.
5. THE SITE ISNOT LOCATED WITHIN THE ESTABLISHED FEMA 100-YEAR FLOODPLAIN.
6. THE SITE ISNOT LOCATED WITHIN THE CRITICAL AREA.
7. SEE SHEETS 2 THROUGH 12 FOR POND RETROFITWORK.
8. SEE SHEETS 26 THROUGH 32 FOR COMPLETE LIMITS OF DISTURBANCE, ACCESS PATHS AND EROSION AND SEDIMENT CONTROL MEASURES FOR THI POND RETROFIT WORK. COORDINATE CONSTRUCTION SCHEDULES AND ACCESS FOR ALL WORK AS NECESSARY
9. CONTRACTOR TO UTILIZE STAGING AND STOCKPILE AREAS FOR THESTREAM STABILIZTION WORK AS WLL BE USED FOR THE POND #2 RETROFIT WORK.
10. MINIMIZE TREE REMOVAL AS MUCH AS POSSIBLI WITHIN THE LOD. ALL DISTURBED AREAS SHALL BE REPANTED IN ACCORDANCE WITH THE PLANTING PLANS (SEE SHEETS 33 THROUGH 36).

LEGEND

EXISTING CONTOURS		PROPOSED RIFFLE GRADE CONTROL STONE	
PROPOSED CONTOURS		PROPOSED ROCK TOE PROTECTION STONE	
WETLAND		EX. THALWEG	
WATERS OF THE U.S.	WUS WUS	PROPOSED THALWEG	
WETLAND BUFFER	WB WB		
STREAM BUFFER	SB SB		
WOODS LINE			

0 20 40 80

DATUM: NAD 83/91 Horizontal
NAVD 88 Vertical

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HARFORD COUNTY, MARYLAND

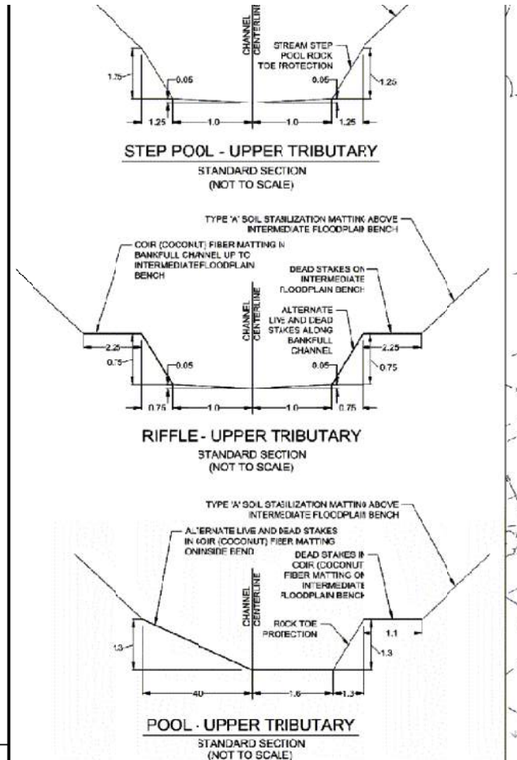
RING FACTORY ELEMENTARY SCHOOL TMDL
SWM POND RETROFIT, OUTFALL REPAIR, AND STREAM STABILIZATION
STREAM STABILIZATION PLAN

Drawn By : NML
Designed By : SAN
Reviewed By : SAN

Contract No :
Scale : 1"=20'
Sheet 16 Of 37

TAX MAP :
ADC MAP :
HCG BILLING ID NO.:
HCG DWG ID NO.:

Year 1 (2019) Monitoring - Riffle Crest and Wetland Photo Log Location Mapping



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PROPOSED CONTOURS			
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WATERS OF THE U.S.	WA WB		
WETLAND BUFFER		EX. THALWEG	
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Designed By :	SAM	Scale :	1"=20'
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Ring Factory Elementary School Stream and Outfall Restoration Monitoring
Riffle Crest and Existing Wetlands Photo Log

Photo 1 - Riffle crest at station 0+60

Photo 2 - Riffle crest at station 0+90

Photo 3 - Riffle crest at station 1+20

Photo 4 - Riffle crest at station 1+50

Ring Factory Elementary School Stream and Outfall Restoration Monitoring
Riffle Crest and Existing Wetlands Photo Log

Photo 5 - Riffle crest at station 1+80

Photo 6 - Riffle crest at station 2+25

Photo 7 - Riffle crest at station 2+55

Photo 8 - RSC weir crests in the RSC channel from stormwater pond

Ring Factory Elementary School Stream and Outfall Restoration Monitoring
Riffle Crest and Existing Wetlands Photo Log

Photo 9 - Riffle crest at station 2+75

Photo 10 - Riffle crest at station 2+85

Photo 11 - Riffle crest at station 3+35

Photo 12 - Riffle crest at station 3+60

Ring Factory Elementary School Stream and Outfall Restoration Monitoring
Riffle Crest and Existing Wetlands Photo Log

Photo 13 - Riffle crest at station 3+75

Photo 14 - Riffle crest at station 3+80

Photo 15 - Riffle crest at station 4+20

Photo 16 - Riffle crest at footbridge

Ring Factory Elementary School Stream and Outfall Restoration Monitoring
Riffle Crest and Existing Wetlands Photo Log

Photo 17 - Riffle crest at station 4+70 with small bar forming

Photo 18 - Riffle crest at station 4+85

Photo 19 - Riffle crest at station 5+10

Photo 20 - Riffle crest at station 5+65

Ring Factory Elementary School Stream and Outfall Restoration Monitoring
Riffle Crest and Existing Wetlands Photo Log

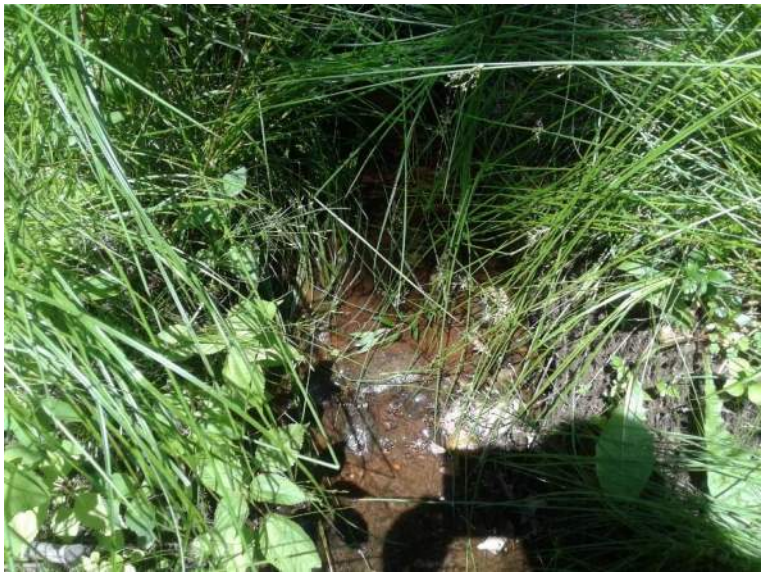


Photo 21 - Riffle crest at station 5+90

Photo 22 - Riffle crest at station 6+15

Photo 23 - Riffle crest at station 6+30

Photo 24 - Riffle crest at station 7+00

Ring Factory Elementary School Stream and Outfall Restoration Monitoring
Riffle Crest and Existing Wetlands Photo Log

Photo 25 - Riffle crest at station 7+65

Photo 26 - Riffle crest at station 8+00

Photo 27 - Riffle crest at station 8+25

Photo 28 - Riffle crest at station 8+60

Ring Factory Elementary School Stream and Outfall Restoration Monitoring
Riffle Crest and Existing Wetlands Photo Log

Photo 29 - Riffle crest at station 9+30

Photo 30 - Riffle crest at station 9+50

Photo 31 - Riffle crest at station 9+60

Photo 32 - Riffle crest at station 9+75

Ring Factory Elementary School Stream and Outfall Restoration Monitoring
Riffle Crest and Existing Wetlands Photo Log

Photo 33 - Riffle crest at station 10+60

Photo 34 - Existing wetland

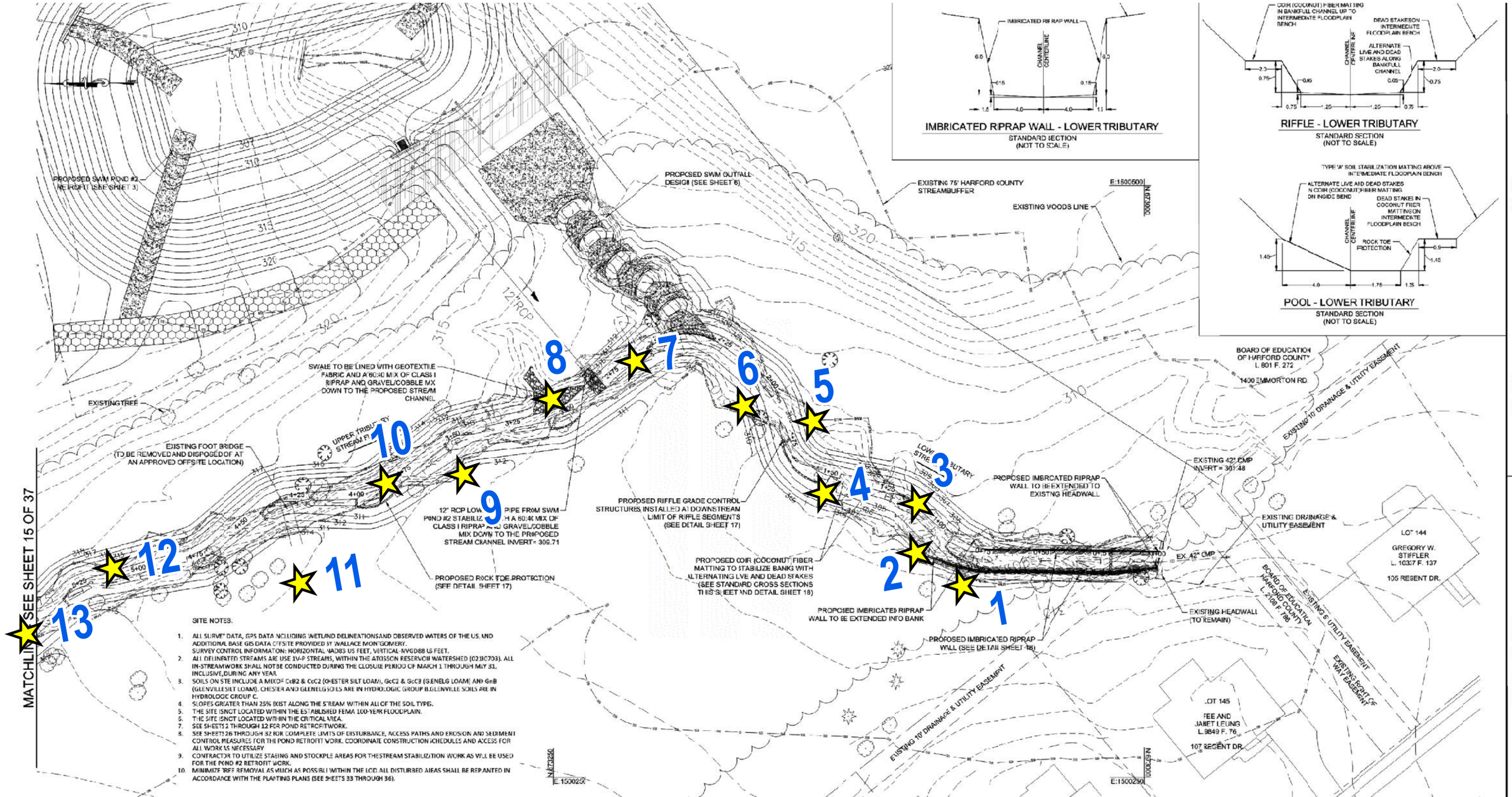
Photo 35 - Existing wetland

Photo 36 - Existing wetland

APPENDIX D

VEGETATION PHOTOS

Year 1 (2019) Monitoring - Vegetation Photo Log Location Mapping



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LEGEND

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PROPOSED CONTOURS		PROPOSED ROCK TOE PROTECTION STONE	
WETLAND		EX. THALWEG	
WATERS OF THE U.S.	WUS WUS	PROPOSED THALWEG	
WETLAND BUFFER	WB WB		
STREAM BUFFER	SB SB		
WOODS LINE			

0 20 40 80

DATUM: NAD 83/91 Horizontal
NAVD 88 Vertical

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NOVEMBER 2016

ADC MAP :
TAX MAP :
HGG BILLING ID NO.:
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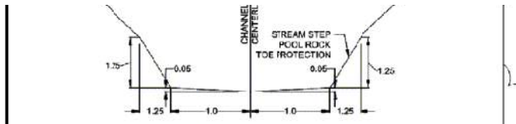
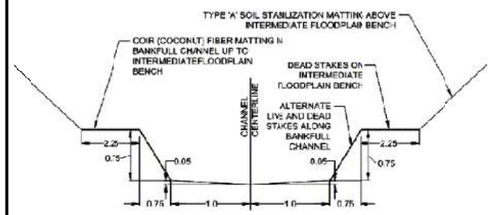
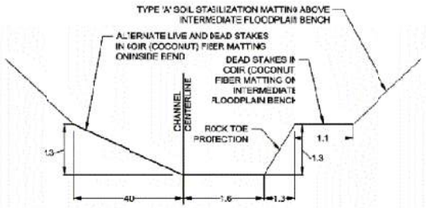
Year 1 (2019) Monitoring - Vegetation Photo Log Location Mapping



STEP POOL - UPPER TRIBUTARY
STANDARD SECTION
(NOT TO SCALE)



RIFFLE - UPPER TRIBUTARY
STANDARD SECTION
(NOT TO SCALE)



POOL - UPPER TRIBUTARY
STANDARD SECTION
(NOT TO SCALE)

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PROPOSED CONTOURS			
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WATERS OF THE U.S.	WB WG		
WETLAND BUFFER	WB WG	EX. THALWEG	
STREAM BUFFER	SB SB	PROPOSED THALWEG	
WOODS LINE			

0 20 40 60

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Reviewed By :	SAM	Sheet	15 Of 37
		Date :	NOVEMBER 2016

Ring Factory Elementary School Stream and Outfall Restoration Monitoring: YEAR 1 Vegetation Photo Log

Photo 1 – Representative - Ground cover has improved from As Built Monitoring

Photo 2 - Bare spot

Photo 3 - Bare spot

Photo 4 - Bare spot – Most bare spots are located at the downstream extents of the project

Ring Factory Elementary School Stream and Outfall Restoration Monitoring: YEAR 1
Vegetation Photo Log

Photo 5 - Bare spots

Photo 6 - Bare spot

Photo 7 - Bare spots

Photo 8 - Bare spot

Ring Factory Elementary School Stream and Outfall Restoration Monitoring: YEAR 1 Vegetation Photo Log

Photo 9 - Bare spots

Photo 10 - Bare spots with minor erosion

Photo 11 - Bare spot extending through most of right bank where the access road was located

Photo 12 - Bare spot

Ring Factory Elementary School Stream and Outfall Restoration Monitoring: YEAR 1
Vegetation Photo Log

Photo 13 - Bare spot and dying planted trees

Photo 14 – Representative ground cover and healthy existing trees

Photo 15 - Representative ground cover with healthy planted trees

Photo 16 – Small bare spots

Ring Factory Elementary School Stream and Outfall Restoration Monitoring: YEAR 1 Vegetation Photo Log

Photo 17- Representative - Good ground cover but some planted trees are dying in the photographed area

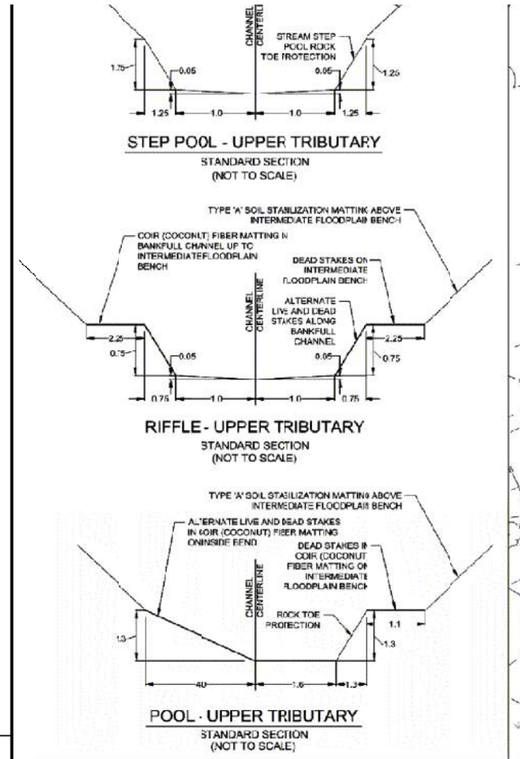
Photo 18 - Bare spot

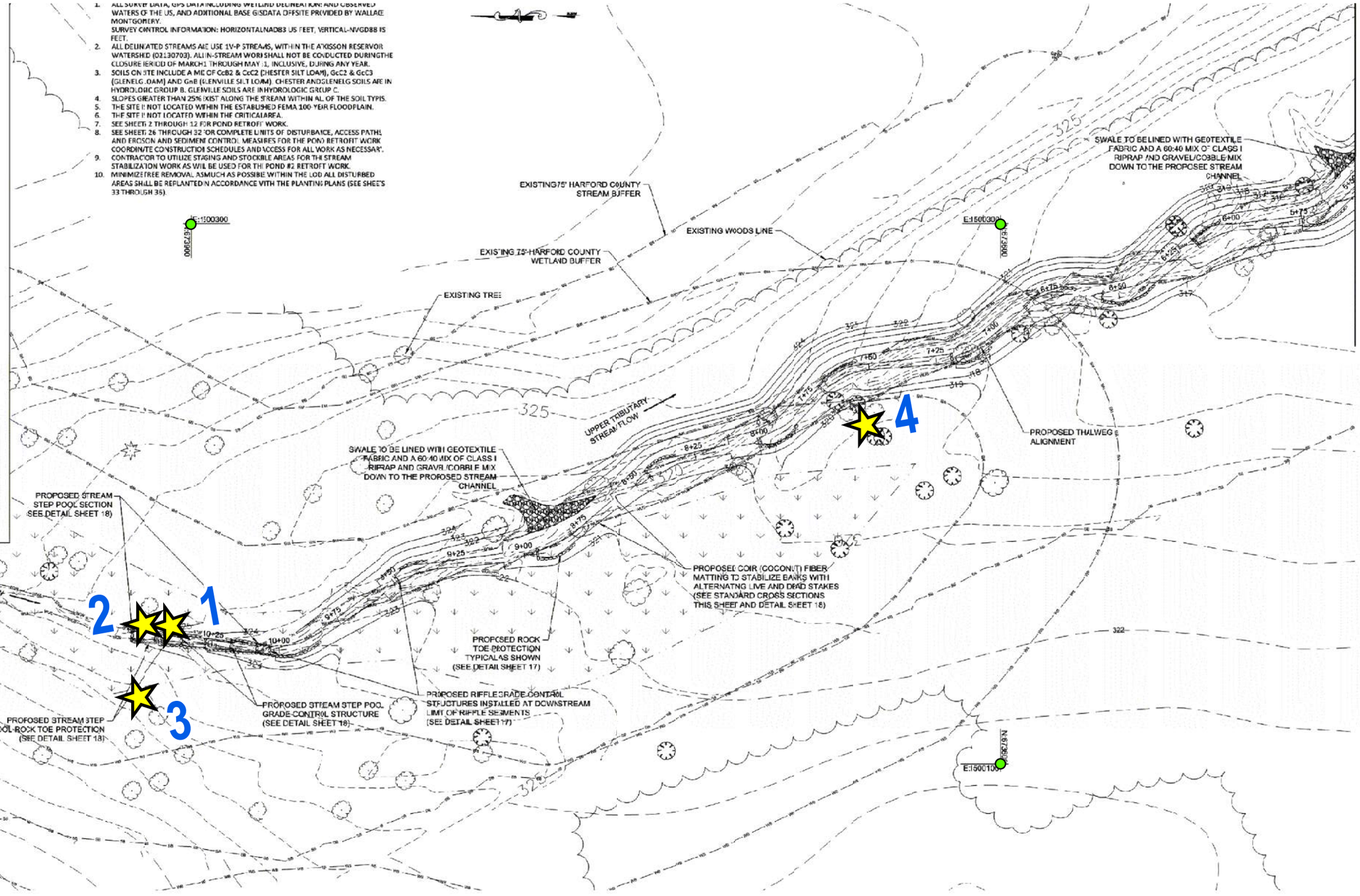
Photo 19 – Representative – Good ground cover with healthy existing and planted trees towards upstream extents of project

APPENDIX E

INVASIVE SPECIES PHOTOS

Year 1 (2019) Monitoring - Invasive Species Photo Log Location Mapping





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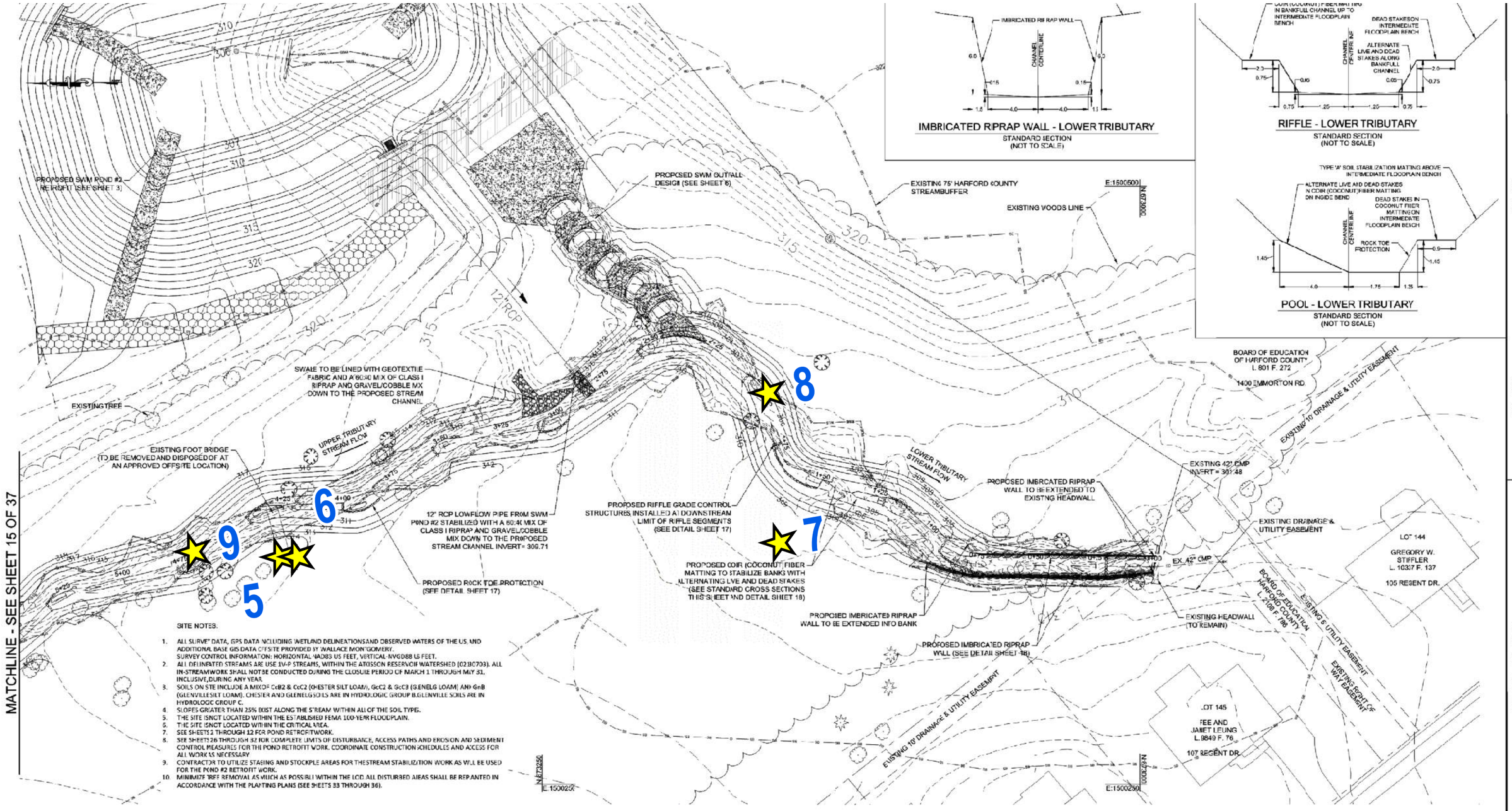
Drawn By :	NML	Contract No :	
Designed By :	SAM	Scale :	1"=20'
Reviewed By :	SAM	Sheet	15 Of 37
		Date :	NOVEMBER 2016

Year 1 (2019) Monitoring - Invasive Species Photo Log Location Mapping



SITE NOTES:

1. ALL SURVEY DATA, GPS DATA INCLUDING WETLAND DELINEATIONS AND OBSERVED WATERS OF THE US, AND ADDITIONAL BASE GIS DATA OFFSITE PROVIDED BY WALLACE MONTGOMERY.
   SURVEY CONTROL INFORMATION: HORIZONTAL-NAD83 US FEET, VERTICAL-NVGD88 US FEET.
2. ALL DELINEATED STREAMS ARE USE IV-P STREAMS, WITHIN THE ATQUSSON RESERVOIR WATERSHED (02130703). ALL IN-STREAM WORK SHALL NOT BE CONDUCTED DURING THE CLOSURE PERIOD OF MARCH 1 THROUGH MAY 31, INCLUSIVE, DURING ANY YEAR.
3. SOILS ON SITE INCLUDE A MIX OF CeB2 & CcC2 (CHESTER SILT LOAM), GeC2 & GeC3 (GLENELG LOAM) AND GnB (GLENVILLE SILT LOAM). CHESTER AND GLENELG SOILS ARE IN HYDROLOGIC GROUP B. GLENVILLE SOILS ARE IN HYDROLOGIC GROUP C.
4. SLOPES GREATER THAN 25% EXIST ALONG THE STREAM WITHIN ALL OF THE SOIL TYPES.
5. THE SITE IS NOT LOCATED WITHIN THE ESTABLISHED FEMA 100-YEAR FLOODPLAIN.
6. THE SITE IS NOT LOCATED WITHIN THE CRITICAL AREA.
7. SEE SHEETS 2 THROUGH 12 FOR POND RETROFIT WORK.
8. SEE SHEETS 26 THROUGH 32 FOR COMPLETE LIMITS OF DISTURBANCE, ACCESS PATHS AND EROSION AND SEDIMENT CONTROL MEASURES FOR THE POND RETROFIT WORK. COORDINATE CONSTRUCTION SCHEDULES AND ACCESS FOR ALL WORK AS NECESSARY
9. CONTRACTOR TO UTILIZE STAGING AND STOCKPILE AREAS FOR THE STREAM STABILIZTION WORK AS WILL BE USED FOR THE POND #2 RETROFIT WORK.
10. MINIMIZE TREE REMOVAL AS MUCH AS POSSIBLE WITHIN THE LOD. ALL DISTURBED AREAS SHALL BE REPLANTED IN ACCORDANCE WITH THE PLANTING PLANS (SEE SHEETS 33 THROUGH 36).

LEGEND

EXISTING CONTOURS		PROPOSED RIFFLE GRADE CONTROL STONE	
PROPOSED CONTOURS			
WETLAND		PROPOSED ROCK TOE PROTECTION STONE	
WATERS OF THE U.S.	WUS WUS		
WETLAND BUFFER	WB WB	EX. THALWEG	
STREAM BUFFER	SB SB	PROPOSED THALWEG	
WOODS LINE			

PROFESSIONAL CERTIFICATION

I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND.

LICENSE NO.: 25519
EXPIRATION DATE: 04/09/2019

DATUM: NAD 83/91 Horizontal
NAVD 88 Vertical

CHESAPEAKE ENVIRONMENTAL MANAGEMENT INC.
41 N. Main Street
Bel Air, MD 21014
Phone: (410) 893-9010
Fax: (410) 893-9380
E-mail: info@cemscience.com

WALLACE MONTGOMERY
ENGINEERS · PLANNERS · SURVEYORS · CONSTRUCTION MANAGERS
10150 York Road, Suite 200
Hunt Valley, Maryland 21030
410.494.9093 Tel / 410.667.0925 Fax

Revisions

HARFORD COUNTY, MARYLAND

RING FACTORY ELEMENTARY SCHOOL TMDL
SWM POND RETROFIT, OUTFALL REPAIR, AND STREAM STABILIZATION
STREAM STABILIZATION PLAN

Drawn By : NML
Designed By : SAM
Reviewed By : SAM

Contract No :
Scale : 1"=20'
Sheet 16 Of 37

TAX MAP :
ADC MAP :
HCG BILLING ID NO.:
HCG DWG ID NO.:

Ring Factory Elementary School Stream and Outfall Restoration Monitoring: YEAR 1
Invasive Species Photo Log

Photo 1 - Mile a minute

Photo 2 - Multiflora rose

Photo 3 - Mile a minute

Photo 4 - Multiflora rose and mile a minute

Ring Factory Elementary School Stream and Outfall Restoration Monitoring: YEAR 1
Invasive Species Photo Log

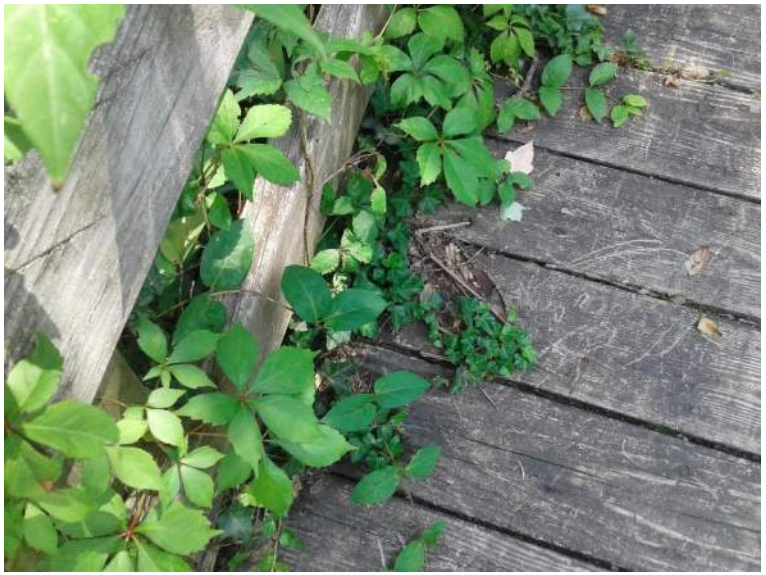


Photo 5 - English Ivy on existing footbridge that should be removed per plans

Photo 6 - Multiflora rose next to existing footbridge

Photo 7 - Mile a minute

Photo 8 - Multiflora rose

Ring Factory Elementary School Stream and Outfall Restoration Monitoring: YEAR 1
Invasive Species Photo Log

Photo 9 - Mile a minute near and in the stream channel

ecotone
ecological restoration

Ecotone, Inc.
410.420.2600 (P)
410.420.6983 (F)

August 26, 2019

Nick Ozburn
U.S. Army Corps of Engineers
Baltimore District Office
2 Hopkins Plaza
Baltimore, MD 21201

RE: Bear Cabin Branch Stream Restoration - Permit: 2017-60285
Year Two Monitoring Report

Dear Mr. Ozburn,

Ecotone Inc. has completed Year Two monitoring of the Bear Cabin Branch Stream Restoration project located on Grafton Shop Road in Bel Air in Harford County. Based on the survey conducted May 3, 2019, it is concluded that the goals of the stream restoration are being met.

Background

Prior to construction, Bear Cabin Branch (Use IV) was suffering from accelerated bank erosion and meander migration. The banks were exhibiting high to extreme bank erodibility with very little rooting depth or density, bank angles were greater than seventy degrees, and they were devoid of any effective surface protection. This stream restoration project focused on remedying these problems by reconnecting the channel to the floodplain to decrease shear stress on the banks and reduce sediment loads. The creation of non-tidal wetlands, establishment of a riparian buffer, and improvement of water quality and habitat through stream re-alignment within the Atkisson Reservoir watershed were also goals of the project. In-stream woody structures, such as log vanes and toe wood, were used in the design to introduce woody material to the system. Log vanes were used to assist in grade control within the stream, and toe wood was used to increase roughness and streambank stability along meander bends. Woody structures were also placed in the stream buffer to increase habitat and provide roughness in the floodplain. Streambanks were graded to provide floodplain connectivity while the floodplain features extensive microtopography to allow the stream to dissipate energy during high flows and provide habitat. To further assist with streambank stability, sod and coir matting were used. Oxbow and non-tidal wetlands were created to provide habitat and promote diversity within the reach. Post-construction, this project reestablished approximately 2,970 linear feet of perennial stream and 12.6 acres of wetlands. The stream flow classification for Bear Cabin Branch, before and after construction, is perennial.

Vegetation Survey

Grass seed and coir matting were used in conjunction to provide immediate stability while the seed germinated. The project area was also planted with trees, shrubs, live stakes, and warm season grasses. A variety of volunteer sedges and grasses have established themselves along the banks and in the floodplain. Common species on site include red maple seedlings (*Acer rubrum*), garden yellowrocket (*Barbera vulgaris*), red clover (*Trifolium pratense*), jewelweed (*Impatiens capensis*), soft rush (*Juncus effusus*), sedge species (*Carex* spp.), and fescue (*Festuca*). At the time of the Year Two survey,

vegetative cover was estimated to be 100%. Invasive species presence is less than 5% and will continue to be monitored in future years.

Photo Exhibit
A photo exhibit for Year Two monitoring survey is included with this report.

Thank you for your attention to this project. Please feel free to contact Ecotone with any comments.

Sincerely,

Haley Kelly
Environmental Scientist

Enclosures

CC: Christine Buckley, Harford County Department of Public Works

Bear Cabin Branch Stream Restoration
Photo Exhibit – Photos Taken May 3, 2019
Year Two Monitoring

Photo 1: View of riffle crest at station 1+38.

Photo 2: View of riffle crest at station 3+19.

Photo 3: View of riffle crest at station 6+34.

Photo 4: View of riffle crest at station 9+35.

Photo 5: View of riffle crest at station 11+60.

Photo 6: View of riffle crest at station 13+24.

Photo 7: View of riffle crest at station 15+40.

Photo 8: View of riffle crest at station 16+94.

Photo 9: View of riffle crest at station 18+56.

Photo 10: View of riffle crest at station 20+77.

Photo 11: View of riffle crest at station 22+12.

Photo 12: View of riffle crest at station 23+43.

Photo 13: View of riffle crest at station 25+05.

Photo 14: View of riffle crest at station 27+38.

Photo 15: View of riffle crest at station 29+10.

Photo 16: View of oxbow wetland adjacent to approximate stations 1+50-3+00.

Photo 17: View of oxbow wetland adjacent to approximate stations 5+25-6+25.

Photo 18: View of oxbow wetland adjacent to approximate stations 6+25-7+00.

Photo 19: View of oxbow wetland adjacent to approximate stations 7+00-9+25.

Photo 20: View of oxbow wetland adjacent to approximate stations 12+00-13+75.

Photo 21: View of oxbow wetland adjacent to approximate stations 13+25-15+25.

Photo 22: View of oxbow wetland adjacent to approximate stations 17+00-18+50.

Photo 23: View of oxbow wetland adjacent to approximate stations 19+00-22+50.

Photo 24: View of oxbow wetland adjacent to approximate stations 22+00-24+00.

Photo 25: View of oxbow wetland adjacent to approximate stations 25+50-27+50.

Photo 26: View of toe wood providing bank stability and habitat.

Photo 27: View of log vane at station 16+20.

Photo 28: View of log vane with rock sill at station 28+40.

ecotone
ecological restoration

Ecotone, Inc.
410.420.2600 (P)
410.420.6983 (F)

May 10, 2019

Nick Ozburn
U.S. Army Corps of Engineers
Baltimore District Office
2 Hopkins Place
Baltimore, MD 21201

RE: Bynum Run/HA DPW Stream Restoration - Permit: 2014-60352
As-Built Report

Dear Mr. Ozburn,

Ecotone Inc. has completed As-Built monitoring of the Bynum Run and unnamed tributaries/HA DPW Property Stream Restoration project located on MacPhail Road in Bel Air, Harford County. Based on the survey conducted February 25, 2019, it is concluded that the goals of the stream restoration are being met and no corrective measures are necessary. The survey revealed that in-stream structures are functioning as intended and native vegetation is establishing at the site.

Background

Prior to construction, Bynum Run and unnamed tributaries (Stream Use III) were exhibiting signs of degradation evident by bank slough, highly erodible vertical banks, entrenchment and down-cutting, and eroding meander bends. Potential causes of channel degradation most likely originated from land use changes and a high amount of land development including a large percentage of impervious surfaces created throughout the watershed. The restoration measures implemented included significant amounts of grade control and bank grading to achieve the goal of floodplain connectivity and stability. Restoration design grade control measures included the installation of stone riffle grade control, log-stone j-hook structures and stone cross vane structures as well as bank grading and bioengineering. Boulder toe increases streambank stability along meander bends. J-hooks and cross vanes assist in grade control within the stream. Streambanks were graded to provide floodplain connectivity while floodplain benches allow the stream to dissipate energy during high flows. To further assist with streambank stability, coir matting and bioengineering with native species was used.
Post-construction, this project restored approximately 3,345 linear feet of perennial stream.

Baseline Conditions

Construction was completed in January 2019 and an As-Built survey was conducted on February 25, 2019. During the As-Built survey, detailed notes were taken to evaluate the structures and conditions of the stream restoration. Longitudinal profile and cross sections were surveyed to serve as the basis for evaluating structural and lateral stability of the stream restoration in future monitoring. The As-Built cross sections were surveyed at 22 stations along the longitudinal profile of Bynum Run and five stations along the unnamed tributaries. Two riffle cross sections were monumented with rebar and cap and will be surveyed per permit monitoring requirements to monitor lateral stability. The first cross section is monumented at 39°31'31.51"N, 76°18'57.35"W and 39°31'32.14"N, 76°18'56.64"W. The second cross section is monumented at 39°31'28.91"N,

76°18'56.72"W and 39°31'29.26"N, 76°18'54.79"W. The stream flow classification for Bynum Run and the unnamed tributaries, before and after construction, is perennial.

The realignment of the stream is currently allowing the stream to distribute energy across the floodplain during high flows. Boulder toe along with streambank and floodplain vegetation help minimize high erosive forces present before restoration. Coir matting is providing stability to the stream while planted warm season grasses, trees and shrubs become established.

Vertical and Lateral Stability

The As-Built survey confirms that the restoration project is exhibiting vertical and lateral stability. Minor changes occurred between proposed conditions and the As-Built. Boulder toe along Bynum Run silted over and was not surveyed during the As-Built survey from station 5+00 to station 6+75. Class III slope protection was added around the existing sewer vault on the left bank near station 14+35. A section of boulder toe was added per designer request from approximately stations 19+55 to 19+75. Cross vane 2 at proposed station 20+26 was shifted downstream to station 20+33 to account for the sewer line. An imbricated wall was added per the engineer's request from the end of the arm of j-hook 12, located at proposed station 22+67, to station 24+20. When building j-hook 13 at proposed station 23+60, existing bedrock was encountered. The log j-hook was changed to a stone j-hook and was shifted downstream to station 23+71. The boulder toe from approximately station 26+70 to 27+75 was not installed; the existing riprap at this location was left in place. Cross vane 4 was shifted from proposed station 27+42 to 27+61 to account for the sewer and better transition into the existing bridge. While constructing pools around station 22+87, existing bedrock was encountered, and pools could not be dug to proposed elevations. Unless specified, pools along Bynum Run were built to proposed elevations. Some pools experienced aggradation from storm events. In the cart crossing section of Bynum Run, the two cross vane elevations were raised 0.5-0.7' to account for the existing riffle downstream. On Tributary 3, locations and elevations of step pools changed in the field per the designer's request. The second pool on Tributary 4 was built to the proposed elevation, however, aggradation occurred after a storm event.

All proposed structures, except for those previously noted, were installed and are working as designed. A more detailed view of the As-Built survey can be observed on the attached As-Built plan set.

Habitat Assessment

A Rapid Bioassessment Protocol (RBP) evaluated current site conditions including embeddedness, channel alteration, channel flow, riffle frequency, bank stability, and riparian vegetative zone width at two locations: Location 1 (station 17+00) and Location 2 (station 26+00).

The pre-construction assessment was completed in August 2018; RBP scores were 52 and 46, respectively. Overall, the site scored 165 at Location 1 and 158 at Location 2. Both scores are in an optimal range and show improvement improved from the pre-construction assessment scores. These results demonstrate functional uplift and we expect further improvement as the vegetative buffer continues to establish and in-stream habitat improves. A copy of each RBP is included with this report.

Vegetation Survey

At the time of the As-Built survey, vegetative cover was estimated to be 50%. Though this is lower than the goal of 85% cover, the survey was conducted shortly after completion of construction. We expect that after a full growing season, the site will be fully vegetated. Grass seed and coir matting were used in conjunction to provide immediate stability while the seed germinated. Herbaceous species at the site are currently sprouting, including field peppercress (*Lepidum campestre*) and common wintercress (*Barbarea vulgaris*). Live stakes at the site are beginning to grow. Vegetative stability is expected to increase in subsequent years. Invasive species presence during the As-Built survey was minimal. The vegetation will continue to be monitored over the remaining monitoring years.

Photo Exhibit

A photo exhibit for As-Built monitoring is included with this report.

Necessary Corrective Measures

There are no corrective measures necessary at this time.

Thank you for your attention to this project. Please feel free to contact Ecotone with any comments.

Sincerely,

Haley Kelly
Environmental Scientist

Bynum Run Stream Restoration
Photo Exhibit – Photos Taken April 30, 2019
As-Built/Year One Monitoring

Photo 1: Top of riffle at station 7+75. J-hook #1 at station 8+00.

Photo 2: Top of riffle at station 9+10. J-hook #2 at station 9+50.

Photo 3: Top of riffle at station 11+10. J-hook #3 at station 11+60

Photo 4: Looking upstream at Tributary #3.

Photo 5: J-hook #4 at station 12+28.

Photo 6: Top of riffle at station 12+83. J-hook #5 at station 13+08.

Photo 7: J-hook #6 at station 13+70.

Photo 8: Top of riffle at station 14+25. Cross vane #1 at station 14+75.

Photo 9: J-hook #7 at station 15+30.

Photo 10: Top of riffle at station 16+05. J-hook #8 at station 16+35.

Photo 11: Top of riffle at station 17+00.

Photo 12: Top of riffle at station 17+90. J-hook #9 at station 18+20.

Photo 13: J-hook #10 at station 18+77.

Photo 14: Top of riffle at station 19+63 and concrete ford crossing.

Photo 15: Downstream view of cross vane #2 at 20+26 after concrete ford crossing.

Photo 16: Top of riffle at station 20+81. Cross vane #3 at station 21+20.

Photo 17: Top of riffle at station 21+75. J-hook #11 at station 22+05.

Photo 18: J-hook #12 at station 22+67.

Photo 19: J-hook #13 at station 23+71.

Photo 20: Upstream view of Tributary #4 from confluence.

Photo 21: Top of riffle at station 24+50.

Photo 22: J-hook #14 at station 25+50.

Photo 23: J-hook #15 at station 26+30.

Photo 24: Top of riffle at station 27+05. Cross vane #4 at station 27+42.

Photo 25: Cross vane #5 at cart crossing station 0+88.5.

Photo 26: Cross vane #6 at cart crossing station 1+44.5 and confluence with Tributary #5.

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME Bynum Run	LOCATION (1)	
STATION # 17400 RIVERMILE	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY JK | GC	DATE 8/29/18 TIME 9 (AM) PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 (2) 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 (8) 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE 4	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 (4) 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 (2) 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 9	20 19 18 17 16	15 14 13 12 11	10 (9) 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 (6)	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of>25.
SCORE 8	20 19 18 17 16	15 14 13 12 11	10 9 (8) 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 1 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 (1) 0
SCORE 3 (RB)	Right Bank 10 9	8 7 6	5 4 (3)	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 1 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 (1) 0
SCORE 3 (RB)	Right Bank 10 9	8 7 6	5 4 (3)	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 1 (LB)	Left Bank 10 9	8 7 6	5 4 3	2 (1) 0
SCORE 4 (RB)	Right Bank 10 9	8 7 6	5 (4) 3	2 1 0

Total Score 52

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME Byrum Run	LOCATION (2)	
STATION # 26130 RIVERMILE	STREAM CLASS	
LAT LONG	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY JK/GC	DATE 8/29/18 TIME 9 (AM) PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE 1	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 (1) 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE 5	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	(5) 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 (6)	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 (6)	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE 7	20 19 18 17 16	15 14 13 12 11	10 9 8 (7) 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE 2	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 (2) 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the widtb of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of tbe stream is a ratio of>25.
SCORE 6	20 19 18 17 16	15 14 13 12 11	10 9 8 7 (6)	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 3 (LB)	Left Bank 10 9	8 7 6	5 4 (3)	2 1 0
SCORE 2 (RB)	Right Bank 10 9	8 7 6	5 4 3	(2) 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more tban one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 2 (LB)	Left Bank 10 9	8 7 6	5 4 3	(2) 1 0
SCORE 2 (RB)	Right Bank 10 9	8 7 6	5 4 3	(2) 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 2 (LB)	Left Bank 10 9	8 7 6	5 4 3	(2) 1 0
SCORE 2 (RB)	Right Bank 10 9	8 7 6	5 4 3	(2) 1 0

Total Score 46

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME Byrum Run	LOCATION Byrum Run @ St Andrew's Way	
STATION # 17+00 RIVERMILE	STREAM CLASS	
LAT LONG	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY HK, SER, MVB	DATE 4/30/2019 TIME (AM) PM	REASON FOR SURVEY As Built

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 (18) 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/deptb regimes present (slow-deep, slow-sballow, fast-deep, fast-sballow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 babitat regimes present (if fast-sballow or slow-sballow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less tban 5% of tbe bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reacbes base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of tbe available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Cbannelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past cbannelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on botb banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	(20) 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or otber large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by tbe width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 (7) 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 (7) 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-balf of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very bigh; vegetation has been removed to 5 centimeters or less in average stubble beigbt.
SCORE ___ (LB)	Left Bank 10 9	(8) 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 (7) 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities bave impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities bave impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0

Total Score 165

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME Bynum Run	LOCATION Bynum Run @ St Andrew's Way 2	
STATION # 26+00 RIVERMILE	STREAM CLASS	
LAT LONG	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY HK, SER, MVB	DATE 4/30/2019 TIME AM PM	REASON FOR SURVEY As Built

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 (14) 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 (18) 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	(20) 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 (19) 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 (6)	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 (6)	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 (6)	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 (6)	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 (9)	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 (9)	8 7 6	5 4 3	2 1 0

Total Score 158

May 7, 2019

Ms. Christine Buckley
Harford County DPW
Watershed Protection and Restoration
212 South Bond Street, 1st Floor
Bel Air, MD 21014

RE: Post- Construction Monitoring Unnamed Tributary to Emmord Branch Stormwater Treatment Bar and Stream Restoration

Attn: Ms. Dobson:

WBCM is submitting this proposal for the post-construction permit monitoring at the Unnamed Tributary to Emmord Branch Stormwater Treatment Bar and Stream Restoration project.

Please feel free to contact me at 410.512.4559 or via email at mhubbard@wbcm.com with any questions or comments regarding the scope of services and fee. Thank you for your time and consideration and we look forward to working with Harford County on this project.

WBCM will complete the Technical Scope of Services in accordance with Contract No. 16-153 Task 6, for a total fee of **Thirty-Four Thousand, Eight-hundred and twenty-three Dollars and seventy cents ($34,820.70).**

Sincerely,

Matt Hubbard, PWS
Project Manager, Environmental and Water Resources

Attachments:

- Attachment 1: Technical Scope of Services
- Attachment 2: Hour Estimate

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ATTACHMENT 1

TECHNICAL SCOPE OF SERVICES

Technical Scope of Services

Introduction

The Harford County Department of Public Works (DPW) has requested WBCM to develop a scope of services and associated fee for the post-construction permit monitoring of the Unnamed Tributary to Emmord Branch Stormwater Treatment Bar and Stream Restoration (CENAB-OPR-MN-2016-61811-M37 (HA DPW/UT Emmord /TMDL)) project, which included approximately 1,100 linear feet of stream restoration, and re-establishment of 899 square feet of non-tidal wetlands that are being temporarily impacted.

The WBCM Team appreciates this opportunity to work with DPW and has developed the following scope of services to achieve the post-construction monitoring permit requirements required by the ACOE Nationwide Permit Ref. 2016-61811-M37 Special Conditions.

Phase 1 – Post-Construction Monitoring Physical and Vegetation Monitoring

Task 1.1 – Visual Assessment and Field Walk

Once during each monitoring year (four years total including year as built), the entire stream reach will be walked, and a qualitative evaluation of stability will be evaluated and documented for inclusion in the four (4) annual monitoring reports. Reports will be provided in Years As-built, 1, 2 and 3 for a total of four reports. During this visual site assessment, specific notes will be made in reference to the condition of the channel, noting any potential areas of concern or conversion of natural resources. Any areas of concern will be noted on the as-built planview sheets and appropriate photos will be taken to document the conditions. During the annual field walk for the visual assessment, any invasive species will be noted in order for WBCM to recommend an invasive species management approach, so the County can take the necessary steps to meet the permit requirements and establishment of plantings and native vegetation. No formal invasive survey will be completed until Year-3 monitoring, further information on invasive monitoring and control is included in *Task 1.3* below.

Task 1.2– Riffle Crest Profile and Resource Classification

Field – The team will evaluate structural stability by performing a rapid longitudinal profile survey of the riffle crests to document thalweg and water surface elevations for the Year-As-Built and Year-3 monitoring periods. Notes will be made on the profile to classify the stream as perennial, intermittent, or ephemeral in Year-3. The profile will be used to document riffle crest elevations.

Office - The team will create a graphical display showing the as-built condition. In Year-3, the riffle crest profile will be overlaid on the Year-As-Built data in accordance with the required monitoring frequency/schedule. Successful criteria for vertical stability shall be a change of less than a 0.5 ft. in elevation in Year-3 when compared to Year-As-Built. Mapping of resource

classification will be included in the Year-3 report for comparison with the pre-construction condition.

Task 1.3 – Vegetation Assessment/Species Richness and Invasive Species Assessment

The team will assess species richness and cover for the Year-3 monitoring period. The team will complete a visual assessment of mortality and natural recruitment to determine if the overall vegetative cover goal of 85% has been met. A photographic record will be taken for documentation of areas of interest or concern that demonstrate the survivability and overall conditions of the plantings and vegetative cover. Representative photos will also be taken of any major areas of mortality or bare soils. In Year-3, overall survivability will be estimated for the project close-out.

To determine 80% survivability for the plant warranty, the total stems per acre will be evaluated from the as-built plans for each planting area and compared that to the actual stems per acre for the site. This work will be completed prior to the end of the warranty period, so the County can coordinate replacements with the contractor during the established warranty period of 1-year.

Invasive species coverage will be evaluated during Year-3 monitoring. In Year-1 and Year-2 it will be described in the annual report based on visual observation. In Year-3, field evaluations will be completed to document coverage and a photo map that shows the locations of the most dominant invasive species will be included with the monitoring report. Following the annual field investigations, results of the evaluations will be communicated to the County Project Manager, so that the County can take appropriate invasive species management or control practices as they deem necessary. Communication will be by email with a follow up phone call for discussion as needed. Based on coordination with the County following our recommendation, an invasive species eradication and maintenance plan will be developed and submitted to the ACOE as part of the annual monitoring report.

Task 1.4 - Stream Habitat Assessment

Field Investigation - The team will complete the Environmental Protection Agency (EPA) Rapid Bio-assessment Protocol (RBP) habitat form for low gradient streams during Year-3 monitoring. The pre-construction data will be compared to the Year-3 data in the final annual monitoring report.

Task 1.5 - Photo Documentation

The team will photo document all riffle locations and created wetlands annually for the as-built and three-year monitoring period as indicated in the permit conditions.

Task 1.6 - Wetland Delineation & Hydric Soil Monitoring

A wetland delineation of the site will be completed once in Year-3 using the same methodology applied in the original wetland delineation (1987 Corps of Engineers Wetland Delineation Manual and the 2010 Atlantic and Gulf Coastal Plain Regional Supplement) to determine if there is the

re-establishment of 899 square feet of wetlands to account for the temporary impacts. Wetland boundaries will be GPS located with a sub-meter GPS unit. A wetland delineation memorandum, datasheets and a GIS wetland map will be developed and included with the final monitoring report. Wetland hydrology and wetland vegetation will be recorded within the wetland delineation datasheets as part of the delineation. The wetland delineation will take place during the Harford County growing season, which shall be based on above-ground growth and development of vascular plants and soil temperature as an indicator of soil microbial activity.

Wetland hydrology is defined as 14 consecutive days of flooding or ponding, or a water table 12 inches or less below the soil surface, during the growing season. Wetland vegetation dominance is defined as a vegetation community where more than 50% of all dominant plant species across all strata are rated obligate, facultative wet or facultative, using the vegetation sampling procedures described in the 1987 Corps of Engineers Wetland Delineation Manual and the 2010 Eastern Mountains and Piedmont Regional Supplement.

Hydric soil monitoring will be completed using alpha-alpha dipyridyl strips in accordance with MDE mitigation monitoring protocols which requires a minimum of 3 field observations to verify hydric soils. Results of the hydric soils monitoring will be included in the final monitoring report.

Task 1.7 - Annual Post-Construction Monitoring Report

The Team will prepare an annual monitoring report describing the methods and results for the monitoring tasks that occur in that year and provide a comprehensive interpretative discussion of the findings. The final annual monitoring reports and memos will be submitted annually by December 31st of each year. It is anticipated that the team will provide a complete report for County review by November 1 annually, and will receive one inclusive round of County comments by December 10th annually. A total of four reports including the as-built report will be provided.

Assumptions and Exclusions

The following items assumptions/exclusions were taken into consideration in developing this scope of services.

- No cross sections are included in this scope.
- Scope is for 3-years of annual monitoring. Survey equipment will not provide X, Y coordinates. A laser level or similar equipment will be utilized.
- Maintenance is excluded from the current scope.
- Remediation design is excluded from the current scope.
- Two copies of the ACOE report will be provided.
- One round of complete comments will be provided by the County and addressed annually for the monitoring report. If additional comments are received it will be considered out of scope work.
- If the ACOE determines the project to be successful and stable prior to Year-3, monitoring may be abbreviated.

Schedule and Fee

The WBCM team will complete the services outlined above in accordance with Contract No. 16-153, for a total fee of $34,820.70.

WBCM appreciates this opportunity to assist Harford County DPW with the monitoring requirements.

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ATTACHMENT 2

HOUR ESTIMATE

Stream Restoration Monitoring - UT Emmord Branch				
WBCM				
Manhour Estimate - April 29, 2019				
	Project Manager	**Senior Natural Resource Specialist**	**Natural Resource Specialist**	**Task Totals**
Task 1.1 Visual Assessment and Field Walk	12	0	16	28
Task 1.2 Riffle Crest Profile and Res. Classification	8	0	8	16
Task 1.3 Vegetation Assessment, Species Rich. and Invasive Sp. Assessment	8	24	60	92
Task 1.4 Stream Habitat Assessment RBP	4	0	4	8
Task 1.5 Photo Documentation	8	0	24	32
Task 1.6 Wetland Delineation and Hydric Soil	8	4	24	36
Task 1.7 Annual Post-Construction Monitoring Report	24	32	80	136
Total				**348**
RATES	$ 140.00	$ 120.00	$ 78.00	
TOTALS BY CLASSIFICATION	**72**	**60**	**216**	**348**
LABOR TOTAL	**$ 10,080.00**	**$ 7,200.00**	**$ 16,848.00**	**$ 34,128.00**

NOTES:

Direct Costs	Unit Description	Cost/Unit
Mileage	Mile	$ 362.70
Reproduction	Each	$ 250.00
Field Supplies	Each	$ 80.00

LABOR TOTAL	**$**	**34,128.00**
DIRECT COSTS	**$**	**692.700**
TOTAL COST	**$**	**34,820.70**

ISO 9001:2008 CERTIFIED
ENGINEERS • PLANNERS • SCIENTISTS • CONSTRUCTION MANAGERS
936 Ridgebrook Road • Sparks, MD 21152 • Phone 410-316-7800 • Fax 410-316-7885

May 24, 2019

Ms. Michele G. Dobson
Harford County Department of Public Works
212 South Bond St, 1st Floor
Bel Air, MD 21014

RE: Scope of Work and Cost Proposal: Willoughby Beach Road Stream Restoration Project Monitoring
Harford County Consultant Contract No. 16-073
Open-End Environmental Monitoring
KCI Job No. 161602035.04

Dear Ms. Dobson:

KCI Technologies, Inc. (KCI) is pleased to present our Scope of Work and Cost Proposal to perform five years of monitoring in and around the Willoughby Road stream restoration project on Sam's Branch tributary to Otter Point Creek in Edgewood, Harford County, Maryland. This proposal is based on the phone conversation on May 21, 2019, subsequent discussions, and the monitoring requirements laid out by the Baltimore District of the Army Corps of Engineers in a letter dated October 9, 2018. A detailed scope of work and fee derivation with man-hour breakdown are attached for your review. Our proposed fee for this work is **$54,986.30**.

Thank you for the opportunity to submit our Scope of Work. We look forward to working with you on this project. Should you have any questions about the enclosed material please do not hesitate to contact me.

Very truly yours,
KCI TECHNOLOGIES, INC.

James E. Deriu
Vice President – Natural Resources

Direct Dial: (410) 316-7865
Email: james.deriu@kci.com

Attachments

Willoughby Beach Road Stream Restoration Monitoring

Scope of Work

Background

Harford County Department of Public Works recently put out for bid, construction of a stream restoration project including 3,000 linear feet of stream restoration of unnamed tributaries to Otter Point Creek in the vicinity of Willoughby Beach Road. The Baltimore District, Army Corps of Engineers authorized the stream restoration under Nationwide Permit #27 and is requiring monitoring as a condition of the permit. Construction is anticipated to begin in early August, 2019 and conclude during the spring of 2020. Information and data collected during the required monitoring activities will be used to assess various success criteria which will be used to evaluate the success of the Willoughby Beach Road stream restoration project. The Army Corps of Engineers outlined the success criteria and years when monitoring activities should occur in the authorization letter sent to Harford County received on October 9, 2018. The required monitoring from the authorization letter is as follows:

Table 1 – Success Criteria for Stream Restoration

Level and Category	Parameter	Measurement	Success Criteria	Monitoring Years
1-Hydrology	Flow	Visual	Meets or exceeds baseline (intermittent or perennial)	PC, 1
2-Hydraulics	NA	NA	NA	NA
3-Geomorphology	Vertical Stability	Longpro/riffle crest elevations	<0.5 ft thalweg degradation from as-built	AB, 3
	Lateral Stability	NA	NA	NA
	Habitat Assessment	RBP-High Gradient	Exceeds Baseline	PC, 3
	Vegetative Cover	% cover	>85% cover in LOD	3
4-Water Quality	NA	NA	NA	NA
5-Biology	Invasive Plant Reduction	% cover invasive species in LOD	Less than Baseline	PC, 3
	Fish (perennial streams only)	IBI MBSS Protocol	Reported	PC, 3

Table 1 showing performance standards for stream restoration. AB=As-built, PC=Pre-construction, 1-3 corresponds to the monitoring year following construction, NA=Not applicable.

Table 2 – Success Criteria for Wetlands

Category	Parameter	Measurement	Success Criteria	Monitoring Years
Hydrology	Hydrology indicators present (Condition 13)	Delineation Form	Wetland Hydrology	By year 3
Soil	Hydric Soils (Condition 14)	Alpha-alpha dipyridyl test or hydric soils classification	Hydric soils present or positive reaction with Alpha-alpha dipyridyl	By year 3
Vegetation	Wetland vegetation dominance (Condition 15)	Delineation Form	Greater than 50% are either OBL, FACW, and/or FAC	By year 3

Table 2 showing performance standards for restored and remediated wetlands. 1-3 corresponds to the monitoring year following construction, NA=Not applicable.

Harford County has requested a scope and fee for KCI to perform monitoring which fulfills the requirements placed on the Willoughby Beach Road stream restoration project. Also, KCI will produce annual monitoring reports to the County which may be submitted to the Army Corps of Engineers to fulfill the annual reporting requirement.

Schedule

The anticipated schedule for completion of this Scope of Work is as follows:

Early-June 2019	Project kick-off meeting
Previous to August, 2019	Pre-construction monitoring activities
October 15, 2019	Draft Pre-construction Monitoring Report
November 15, 2019	Final Pre-construction Monitoring Report
Previous to September 30, 2020	As-built and Year 1 monitoring activities
October 15, 2020	Draft As-built and Year 1 Monitoring Report
November 15, 2020	Final As-built and Year 1 Monitoring Report
Previous to September 30, 2021	Year 2 monitoring activities
October 15, 2021	Draft Year 2 Monitoring Report
November 15, 2021	Final Year 2 Monitoring Report
Previous to September 30, 2022	Year 3 monitoring activities
October 15, 2022	Draft Year 3 Monitoring Report
November 15, 2022	Final Year 3 Monitoring Report

Project Tasks

Task 1: Project Initiation, Coordination

Subtask 1.1: Project Initiation

Within two weeks of receiving the Notice to Proceed, KCI Technologies, Inc. will hold a project kick-off meeting with the County Project Manager and designated County staff to discuss project coordination efforts and schedule of activities. The meeting will last no longer than two (2) hours. Results of the meeting will include a documented meeting summary.

Subtask 1.2: Project Coordination

Project coordination with County staff will be important throughout the course of the work effort. In addition to the project kick-off meeting described above, KCI proposes three meetings to coincide with the completion of substantial draft monitoring reports. Meetings will not be planned for the end of years 1 and 2 as those years have minimal monitoring occurring. These sessions will be necessary to ensure that project work and data collection results meet the County goals and objectives as well as the monitoring requirements set forth by the Army Corps of Engineers. The proposed milestone meetings are:

- At the completion of the Pre-construction Monitoring Report (approx. Oct 15, 2019),
- At the completion of the Year 3 Final Monitoring Report (approx. Oct 15, 2022),

KCI will prepare an agenda and e-mail it to the Project Manager for input two days prior to the milestone meeting date. Additionally, KCI will prepare meeting minutes to be reviewed first by the County Project Manager, and then distributed by KCI to appropriate Harford County DPW staff.

KCI's project manager will maintain communication with the County's Project Manager, prepare and submit monthly invoices with progress reports, and schedule and direct the performance of the work. The monthly progress reports will be short, bulleted documents providing status updates on the monitoring efforts described above. Such reports will include summaries of any technical problems or issues associated with the monitoring efforts, any interesting or unusual conditions observed in the field, and will document actions planned for the upcoming month. KCI's project manager will be responsible for timely submission of all deliverables for this work effort.

Task 1 Deliverables

- KCI will prepare meeting agendas and meeting minutes for all coordination meetings for the duration of the project.

Task 2: Monitoring

KCI will perform monitoring in and around the Willoughby Beach Road stream restoration project that fulfills the monitoring requirements as outlined in the Baltimore District, Army Corps of Engineers letter received October 9, 2018. The following table outlines the monitoring components and in which year those components will be completed.

Table 3 – Schedule of Completion of Monitoring Components

Category	Parameter	Pre-construction (2019)	As-built and Year 1 (2020)	Year 2 (2021)	Year 3 (2022)
Hydrology	Visual Flow	X	X	X	X
Geomorphology	Vertical Stability - profile		X		X
	RBP Habitat Assessment	X			X
	Vegetative Cover				X
Biology	Invasive Plant Reduction	X	X	X	X
	Fish	X			X
Wetland	Hydrology indicators present (Condition 13)				X
	Hydric Soils (Condition 14)				X
	Wetland vegetation dominance (Condition 15)				X

Hydrology Visual Assessment

During all years (PC, AB/Yr1, Yr2, Yr3) KCI will perform a visual assessment of flow and determine if the stream throughout the Willoughby Beach Road restoration project is perennial, intermittent, or ephemeral. The visual assessment will take place during the same visit as the invasive plant and vegetative assessment in summer of each year. This will allow the hydrology to be assessed during the natural low-flow period. Hydrological conditions will be photodocumented at the time of the assessment. This assessment of hydrology will be used to assess the success of the project when compared against the preconstruction hydrological condition of the site (see Table 1). Visual assessments of hydrology will also be performed during other monitoring activities throughout the three years of post-construction monitoring. These additional assessments may prove useful if year 1 falls during a drought year, where the required assessment of hydrology may not reflect the actual hydrological conditions during an average year.

Geomorphology Assessments

KCI will perform geomorphic monitoring to assess vertical stability in the Willoughby Beach Road project area. The Army Corps of Engineers monitoring requirements specify that this geomorphological monitoring be performed at the as-built stage, and in year 3. After construction, KCI will establish permanent monuments on each bank at the top and bottom of the longitudinal profile. These monuments will be used as benchmarks to compare elevations of the profile across years. Standard

stream surveying techniques will be used to survey a longitudinal profile at the Willoughby Beach Road restoration reach.

The longitudinal profile of the restoration reach will be surveyed along the thalweg thread and include riffles, pools, water surface, and (where discernable) bankfull and terrace features. Longitudinal profile surveys are completed to determine riffle/pool sequencing patterns and to determine any changes in channel slope and the extent of any degradation or aggradation that may occur in subsequent surveys. Photographs will be taken along the profile to document site conditions. The station along the longitudinal profile for each picture will be recorded during the first As-Built/Year 1 monitoring event and used during Year 3 to match up picture locations for comparison over time.

At four representative riffle crests within the restored reach, KCI will install additional monuments, one monument on each bank perpendicular to the riffle crest. These monuments will help tie-in the riffle crests to the longitudinal profile over time to help assess and vertical change of the restoration. Four photographs of each monumented riffle crest will be taken; looking upstream at the riffle crest, looking downstream at the riffle crest, looking from the right bank to the left bank, and looking from the left bank to the right bank.

Physical Habitat Assessment

The Willoughby Beach Road restoration site will be visually-assessed based on physical characteristics and various habitat parameters following the Environmental Protection Agency's Rapid Bioassessment Protocol (RBP) habitat assessment for high gradient streams (Barbour et. al, 1999). Physical habitat assessments will be performed during the geomorphology assessment visits during the as-built and year 3 surveys.

The RBP habitat assessment consists of a review of ten biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health. Each parameter is given a numerical score from 0-20 (20=best, 0=worst), or 0-10 (10=best, 0=worst) for individual bank parameters, and a categorical rating of optimal, suboptimal, marginal or poor. Overall habitat quality typically increases as the total score for each site increases. The RBP parameters assessed for high gradient streams are as follows.

RBP High Gradient Parameters

Epifaunal substrate/available cover	Channel alteration
Embeddedness	Frequency of riffles/bends
Velocity/depth regime	Bank stability
Sediment deposition	Vegetative protection
Channel flow status	Riparian vegetative zone width

Stream physical habitat data will be used to assess success of the project when compared against habitat scores from before construction (see Table 1).

Invasive Plant and Vegetation Assessments

KCI proposes an annual visual inspection and assessment of the project inside the LOD for the presence of invasive plant species. The Army Corps of Engineers monitoring requirements only specify that this invasive plant inspection be performed in year 3. Performing this inspection annually allows the County to respond quickly to remove any invasive species observed in the project LOD. Waiting until

year 3 allows the potential for invasive plants to overrun the project area, making removal at that point more difficult and costly.

The annual invasive plant assessment will document the presence of any invasive plant species within the project LOD and estimate the percent cover of any observed invasive plant species. Photographs will be taken to document the vegetative composition of the site during each annual inspection. Observations made during the current inspection will be compared to previous monitoring data in order to document any changes in coverage of invasive plant species within the project LOD. If invasive plants are observed, KCI will immediately notify Harford County DPW of the species observed the estimated percent coverage. This scope does not cover the development of an invasive species eradication and maintenance plan if annual site visits document their presence. The development of an eradication and maintenance plan would be performed under a separate task order.

During year 3 a final visual inspection of the riparian buffer plantings along the restored channel will be completed to assess the re-establishment and viability of the riparian buffer plantings per the intent of the design. If identified, specific problem areas will be noted on the landscape plans and KCI will document evidence of invasive species, infestation, disease, browsing, mortality, and/or establishment of volunteer species that may have contributed to the problem. This vegetative assessment will produce an estimate of the percent cover of vegetation within the LOD, providing the information needed to assess the success criteria for vegetative cover.

Fish Community Assessment

The fish community will be sampled at two sites, one within the Willoughby Beach Road stream restoration and one site downstream of the restoration. Both sites will be sampled during the Summer Index Period used by the Maryland Biological Stream Survey (MBSS). In general, the sampling will follow the MBSS Round Four protocols. The approach uses electrofishing of the entire 75-meter study reach. Block nets are placed at the upstream and downstream ends of the reach to obstruct fish movement into or out of the study reach. Two passes are completed along the reach to ensure the segment is adequately sampled. The time in seconds for each pass is recorded and the level of effort for each pass should be similar.

All captured fish will be identified to species and enumerated. A total fish biomass for each pass is measured. Unusual anomalies such as fin erosion, tumors etc., are recorded. In lieu of voucher specimens, photographs of each species identified will be taken.

Wetland Assessment

Before the end of year 3, KCI will conduct a site investigation to identify waters of the United States (WUS) and jurisdictional wetlands within the study area in accordance with the “Routine” method outlined in the U.S. Army Corps of Engineers (USACE) Wetland Delineation Manual (Environmental Laboratory, 1987) and the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (Environmental Laboratory, 2010). Wetland and WUS boundaries will be marked with flagging tape. A GPS will be used to capture the locations of placed flags and markers. A field map will be developed illustrating wetlands and waterway(s) locations and associated flag numbers. Total acres of existing wetlands will be calculated and can be used to document that the project offset any wetlands lost during project construction. The wetlands assessment will be used to assess three success criteria for the restoration project (see Table 2).

Task 3: Data Entry and Analysis

Field data and observations will be managed, and analyzed using appropriate scientific methodology.

Subtask 3.1: Geomorphic Data

The stream longitudinal profile data will be partially analyzed using the Ohio Department of Natural Resources Reference Reach Spreadsheet Version 4.3L (Mecklenburg, 2006). The following values and ratios will be calculated, compared to previous monitoring, and included in the report.

Sinuosity	Entrenchment ratio	Bankfull cross-section area
Slope	Bankfull height	Velocity
Floodprone width	Bankfull width	Discharge
Width / depth ratio	Mean depth	Sheer stress

These data will be used detect changes in channel geometry over time in this restoration reach. Special emphasis will be placed on vertical stability.

Subtask 3.2: Physical Habitat Data

Physical habitat data will be entered into an Excel spreadsheet. The 10 individual RBP habitat parameters are summed to obtain an overall RBP assessment score. The total score, with a maximum possible score of 200, is then placed into one of four narrative categories based on their percent comparability to reference conditions (Plafkin et al., 1989).

RBP Physical Habitat Condition Ratings

RBP Score	Narrative Rating
>151	Comparable to Reference
126 – 150	Supporting
101 – 125	Partially Supporting
<100	Non-supporting

Subtask 3.3: Invasive Plant and Vegetation Data

Invasive plant data will be entered into spreadsheets which will contain any species observed and the percent cover of the site.

Subtask 3.4: Fish Community Data

Fish data will also be analyzed by KCI using methods developed by MBSS as outlined in the *New Biological Indicators to Better Assess the Condition of Maryland Streams* (Southerland et al., 2005). The IBI approach involves statistical analysis using metrics that have a predictable response to water quality and/or habitat impairment. One metric performs best when adjusted by catchment size. The catchment drainage area for each site will be calculated, as above for the PHI. Raw values from each metric are given a score of 1, 3 or 5 based on ranges of values developed for each metric. The results are combined into a scaled FIBI score from 1.0 to 5.0 and a narrative rating is applied.

Four sets of metric calculations have been developed for Maryland streams based on broad eco-physiographic regions and stream type strata. These include the Coastal Plain, Eastern Piedmont and warmwater and coldwater Highlands. The Willoughby Beach Road stream restoration is located in the Coastal Plain region therefore the following Coastal Plain metrics and FIBI scoring will be used for the analysis.

Fish Index of Biotic Integrity Scoring for the Coastal Plain

Metric	Score		
	5	3	1
Abundance per Square Meter	≥ 0.72	0.45 – 0.71	< 0.45
Number of Benthic Species*	≥ 0.22	0.01 – 0.21	0
% Tolerant	≤ 68	69 – 97	> 97
% Generalist, Omnivores, Invertivores	≤ 92	93 – 99	100
% Round-bodied Suckers	≥ 2	1	0
% Abundance Dominant Taxa	≤ 40	41 – 69	> 69

*adjusted for watershed area

FIBI Condition Ratings

FIBI Score	Narrative Rating
4.0 – 5.0	Good
3.0 – 3.9	Fair
2.0 – 2.9	Poor
1.0 – 1.9	Very Poor

Subtask 3.5: Wetland Assessment Data

Wetland assessment data will be recorded on data sheets and digitally using GPS-enabled tablets or hand held GPS units. Data will be entered into standard spreadsheets and GIS databases and or shapefiles. GIS data will be used to produce maps of the wetland delineation for use in the year 5 report.

Task 4: Reporting

KCI will prepare an annual monitoring technical memorandum for monitoring activities completed each year of this scope of work. This technical memorandum may serve as the County's annual monitoring report to the Army Corps of Engineers. A draft technical memo will be emailed to the Harford County DPW Project Manager by October 15th of each monitoring year. Comments will be incorporated into a final technical memo and delivered to Harford County DPW on or before November 15th of each monitoring year.

Annual Monitoring Technical Memo – Pre-Construction Year will cover monitoring activities from the summer of 2019 prior to construction and will contain the results of geomorphology, habitat assessment, invasive plant monitoring, and fish community assessment.

Annual Monitoring Technical Memo – Year 1 will cover monitoring activities from 2020 of the as-built and post-construction Year 1 condition and will contain the results of geomorphology, annual invasive plant, and the required visual hydrology assessments.

Annual Monitoring Technical Memo – Year 2 will cover monitoring activities from 2021 and include monitoring results for invasive plant, and the visual hydrology assessments.

Annual Monitoring Technical Memo – Year 3 will cover monitoring activities from 2022 and include monitoring results for geomorphology, physical habitat, invasive plant, fish community, and wetland assessments. The Year 3 tech memo will compare geomorphology results from preconstruction, the as-built survey, and Year 3 where appropriate. The Year 3 memo will also compare the physical habitat and fish community assessments from pre-construction and Year 3. This memo will include the final project assessment of vegetative cover and identify any invasive plant species located within the project LOD and quantify the percent cover. This memo will also include the results of the hydrology visual assessment and compare those results to the preconstruction condition. The Year 3 memo will also compile the wetlands information gathered in the field into a Natural Resources Inventory section that can be utilized for waterway permitting requirements as described below. The description of wetland/stream systems within the project area will include information required by USACE, as specified in their most recent guidance documents and jurisdictional determination checklists at the time of the investigation. Information to be included in the report may include results of the delineation, field data sheets of wetland systems, representative photographs of site conditions and a NRI Map with surveyed wetland boundaries overlain. Data sheets and site photographs will be appended to the text.

Task 5 Deliverables

- Draft Annual Monitoring Technical Memorandum; Pre-construction, Years 1, 2, and 3 (digital copy for review)
- Final Annual Monitoring Technical Memorandum; Pre-construction, Years 1, 2, and 3 (digital copy)
- Excel Spreadsheets containing all invasive plant, geomorphic, habitat assessment, fish IBI, and wetland assessment raw data, calculations, and results.

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.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440-4-89-001.

Rosgen, D.L. 2001. A Practical Method of Computing Streambank Erosion Rate. Proceedings of the 7th Federal Interagency Sedimentation Conference, Vol. 2, pp. 9-15, March 25, 2001, Reno, NV. Available on the Wildland Hydrology website at: http://www.wildlandhydrology.com/html/references_.html

Rosgen D. 1996. Applied Fluvial Morphology. Wildland Hydrology. Pagosa Springs, CO.

Harford County Open-End Environmental Monitoring

TASK 4 - Willoughby Beach Road Monitoring - Years Pre-construction through 3
May 24, 2019

		KCI								
Task	**Task Description**	**Principal**	**PM**	**Environmental Engineer**	**Water Quality Specialist**	**Aquatic Ecologist**	**Environmental Scientist**	**Wetland Scientist**	**KCI Hours**	**Fee**
1	**Project Initiation and Coordination**									
1.1	Project Initiation and Kick-off Meeting		8			3			11	$ 1,603.78
	Progress Meetings (2 total, years PC, and 3)		8			8			16	$ 2,194.08
1.2	General Coordination		32			12			44	$ 6,415.12
	subtotal hours	*0*	*48*	*0*	*0*	*23*	*0*	*0*	*71*	**$ 10,212.98**
	subtotal labor	*$ -*	*$ 7,497.60*	*$ -*	*$ -*	*$ 2,715.38*	*$ -*	*$ -*		
2	**Monitoring**									
2.1	**Pre-construction Year**									
	Invasive Plant and Visual Flow Assessment				10				10	$ 862.80
	Fish Community and Habitat Assessment		1		10	12	12		35	$ 3,164.36
	subtotal hours	*0*	*1*	*0*	*20*	*12*	*12*	*0*	*45*	**$ 4,027.16**
	subtotal labor	*$ -*	*$ 156.20*	*$ -*	*$ 1,725.60*	*$ 1,416.72*	*$ 728.64*	*$ -*		
2.2	**As-built and Year 1**									
	Geomorphology		1	20	22				43	$ 4,692.76
	Invasive Plant and Visual Flow Assessment				8				8	$ 690.24
	subtotal hours	*0*	*1*	*20*	*30*	*0*	*0*	*0*	*51*	**$ 5,383.00**
	subtotal labor	*$ -*	*$ 156.20*	*$ 2,638.40*	*$ 2,588.40*	*$ -*	*$ -*	*$ -*		
2.3	**Year 2**									
	Invasive Plant and Visual Flow Assessment				8				8	$ 690.24
	subtotal hours	*0*	*0*	*0*	*8*	*0*	*0*	*0*	*8*	**$ 690.24**
	subtotal labor	*$ -*	*$ -*	*$ -*	*$ 690.24*	*$ -*	*$ -*	*$ -*		
2.3	**Year 3**									
	Geomorphology		1	20	22				43	$ 4,692.76
	Invasive Plant, Vegetative Cover and Visual Flow Assessment				8				8	$ 690.24
	Fish Community and Habitat Assessment		1		10	12	12		35	$ 3,164.36
	Wetland Assessment		1					30	31	$ 3,011.30
	subtotal hours	*0*	*3*	*20*	*40*	*12*	*12*	*30*	*117*	**$ 11,558.66**
	subtotal labor	*$ -*	*$ 468.60*	*$ 2,638.40*	*$ 3,451.20*	*$ 1,416.72*	*$ 728.64*	*$ 2,855.10*		
3	**Data Entry and Analysis**									
3.1	**Geomorphic (As-built, Year 3)**		1		6				7	$ 673.88
3.2	**Habitat Assessment (PC, Year 3)**		1				2		3	$ 277.64
3.3	**Invasive Plant (years PC, Years 1-3)**		1		8				9	$ 846.44
3.4	**Fish Community Assessment (PC, Year 3)**		1			2	4		7	$ 635.20
3.5	**Wetland Assessment (Year 3)**		1		4			26	31	$ 2,975.74
	subtotal hours	*0*	*5*	*0*	*18*	*2*	*6*	*26*	*57*	**$ 5,408.90**
	subtotal labor	*$ -*	*$ 781.00*	*$ -*	*$ 1,553.04*	*$ 236.12*	*$ 364.32*	*$ 2,474.42*		
4	**Task Report**									
4.1	**Pre-construction Year**									
	Draft Report		2		16	8			26	$ 2,637.36
	Final Report		1	2	2	2			7	$ 828.72
	subtotal hours	*0*	*3*	*2*	*18*	*10*	*0*	*0*	*33*	**$ 3,466.08**
	subtotal labor	*$ -*	*$ 468.60*	*$ 263.84*	*$ 1,553.04*	*$ 1,180.60*	*$ -*	*$ -*		
4.2	**As-built and Year 1**									
	Draft Report		2	4	12	8			26	$ 2,819.92
	Final Report		1	1	2	2			6	$ 696.80
	subtotal hours	*0*	*3*	*5*	*14*	*10*	*0*	*0*	*32*	**$ 3,516.72**
	subtotal labor	*$ -*	*$ 468.60*	*$ 659.60*	*$ 1,207.92*	*$ 1,180.60*	*$ -*	*$ -*		
4.3	**Year 2**									
	Draft Report		2		8				10	$ 1,002.64
	Final Report		1		2				3	$ 328.76
	subtotal hours	*0*	*3*	*0*	*10*	*0*	*0*	*0*	*13*	**$ 1,331.40**
	subtotal labor	*$ -*	*$ 468.60*	*$ -*	*$ 862.80*	*$ -*	*$ -*	*$ -*		
4.4	**Year 3**									
	Draft Report		2	4	24	8		32	70	$ 6,900.72
	Final Report		1	2	4	2		8	17	$ 1,762.64
	subtotal hours	*0*	*3*	*6*	*28*	*10*	*0*	*40*	*87*	**$ 8,663.36**
	subtotal labor	*$ -*	*$ 468.60*	*$ 791.52*	*$ 2,415.84*	*$ 1,180.60*	*$ -*	*$ 3,806.80*		
	Subtotal Task - Hours	0	70	53	186	79	30	96	514	
	Hourly Rate	$ 168.89	$ 156.20	$ 131.92	$ 86.28	$ 118.06	$ 60.72	$ 95.17		
	Labor Subtotal	$ -	$ 10,934.00	$ 6,991.76	$ 16,048.08	$ 9,326.74	$ 1,821.60	$ 9,136.32		$ 54,258.50
	Summary									
	KCI Labor Fee									$ 54,258.50
	KCI Direct Expenses									$ 727.80
	TOTAL									**$ 54,986.30**

MEMORANDUM

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Phone 410.728.2900
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Date: 11/27/19
Topic: Harford County Sewer Manifest Database – Assumptions Made During Analysis

This document is a brief overview compiled after the review of the Harford County Sewer Manifests for the 2019 Fiscal Year (July 2018 – June 2019) and their input into the Harford County Septic Hauler Manifests Database.

The total volume that was recorded as Septic: **9,088,603 gallons (US)**.

The Septic totals broken down by month:

Date	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
US Gal.	777,029	770,746	679,844	837,887	849,755	833,808
Date	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19
US Gal.	658,486	508,151	756,255	858,064	773,774	784,804
		Exclusion Total (US Gal):		804,986	**Sum (US Gal)**	9,088,603
		Sum, with exclusion (US Gal):		9,893,589		

These totals exclude various tickets identified as "Excluded" for the purposes of MS4 wastewater crediting; these are discussed under "Exclusion Assumptions" (see below).

Furthermore, Holding Tank and Commercial volumes were not reviewed in-depth. Continuing coordination could be done to identify outstanding tickets that could potentially be included for Septic totaling purposes.

	Volumes in (US Gal)		
Type	Total, without Exclusion	Exclusion Total	Total with Exclusion
Holding Tank	11,610,009	2,134,909	13,744,918
Commercial	1,004,852	25,719	1,030,571

Exclusion Assumptions

- Several identifiers were used to designate which volumes would not be included in the totaling process, listed below:
  - Assumed Commercial – with tickets that had multiple waste types checked, assumed volume was commercial
  - Assumed Holding Tank – with tickets that had multiple waste types checked, assumed volume was holding tank
  - Empty Ticket – ticket had no generator, no street number, and no road name recorded
  - Landfill Leachate – tickets identified as relating to the Harford Co Landfill Leachate
    - Includes tickets relating to "SWM", "MDE", and "MES Harford Co Landfill" all at *Scarboro Rd*
    - Process was only completed for July and August 2018
    - All volumes in July and August 2018 appeared to be Holding Tanks, but excluded to be cautious
  - No Address – tickets where generator was recorded, but no address could be identified through an internet search
  - No Road Name – tickets where a street number was recorded, but no generator or road name identified
  - No Street # – tickets where road name was recorded, but no generator or street number to use to identify
  - Not in HarCo – tickets where the address was found to be outside of Harford County's jurisdiction
  - Pappy's Landfill – tickets listed as "Pappy's Landfill", large volumes, likely leachate, placed inconsistently
  - Port a Pots – tickets recorded as "Port a Pots"
  - Post-It Note Ticket – a post-it note with a date, a hauler, and a volume, but no address or further identifying information. These were attached to a physical ticket.
  - No MS4 – tickets analyzed and, based on patterns identified through names, addresses, and type of waste, were determined to be unreliable and therefore, not included in the totaling process

Address Assumptions

- Further coordination is needed to parse the addresses recorded in the database to ensure successful GIS translation.
- Added road names of state roads for future ease of recording since most haulers used the physical road name. For example: instead of "STATE HWY 7", added the road name "PHILADELPHIA RD".
- In conjunction with the above, added a handful of cardinal direction (N/S/E/W) designations as new roads (the basic road was kept as well). For example, "WHEEL RD", now has: "E WHEEL RD", "W WHEEL RD", and "WHEEL RD". Examples of each were identified on physical manifests.
- Several roads were added or renamed that were missing from the provided Road Database.
- Modified several road names that were listed as "DR" to "RD", "RD" to "LN", etc. in the Road Database to coincide with either internet or SDAT data.
- Modified generator name and street number of tickets if analysis showed locations should coincide; made note of these changes under "Ticket_Notes" field.

Ticket Assumptions

- Truck #'s and Hauling Companies seemed to have changed from the pre-2018 and 2018/2019 databases.
- Not all tickets were recorded on the Manifest Log Sheet.
- Across FY2019, several cases of recycled manifest #'s with different addresses/dates/loads.
- Some physical tickets had a post-it note attached as discussed under "Exclusion Assumptions". These were separated out and listed under the Manifest # 111111. These tickets were excluded from totaling purposes as they were lacking an address.
- Tickets labeled as "Port a Pots" often did not have an associated address. As such, Port a Pots were also excluded.
- Tickets labeled as "SWM" or "MES Harford Co Landfill" were generally separated from the other tickets in the ticket stack. These were discussed to likely come from the landfill leachate from the Scarboro Landfill – these were excluded from totaling purposes.
- In some cases, on one physical manifest ticket, multiple addresses were recorded without a clearly distinguishable way to allocate the total deposited load. Recorded these as "Multiple Generator" and split the total load in half into two separate tickets (with the same date and Manifest #).
- In some cases, a ticket would have multiple waste types checked (Septic and Holding Tank, Septic and Commercial, Holding Tank and Commercial) - or no waste type checked at all.
    - These tickets were recorded with identifiers in the "Waste_Type" field. (12 implies Septic and Holding Tank, 13 implies Septic and Commercial, 23 Holding Tank and Commercial, while 123 implies that no waste type was checked).
    - A waste type of 0 indicates that the ticket was not physically reviewed.
- In some cases, locations and businesses would seem inconsistently listed: sometimes septic, sometimes holding tank, other times commercial. This could be due to businesses that have both commercial tanks (like grease traps) and septic/holding tanks. However, the volume of the load generally remained consistent across the months for the same location.
    - Facilities like "Pappy's Landfill" with upwards of 20,000 gal that seem arbitrarily placed in Septic or Holding Tank. These ended up being excluded from totaling purposes (see Exclusion Assumptions).
    - "Swan Harbor Dell", "Father Martin's Ashley", "Intercon Trucking" are some other examples.
    - Note that not all of these "Inconsistent" locations where excluded from totaling purposes.
    - Labeled "Inconsistent" in cases where a location would always have multiple waste types checked. Further coordination could be performed to analyze these locations.

Harford County Open-End Environmental Monitoring

TASK 4 - Willoughby Beach Road Monitoring - Years Pre-construction through 3
May 24, 2019

Description	Number	Type	Unit Cost	Extended Cost
Sediment Sampling				
Misc Equipment	1	lump sum	$200.00	$200.00
Travel				
Mileage (15 trips at 55 miles)	825	miles	$0.58	$478.50
Field maps	10	color 11X17 copies	$0.98	$9.80
Draft and Final Report		digital submission		
Misc copies/prints	300	bw 8.5x11 copies	$0.05	$15.00
	10	color 11X17 copies	$0.98	$9.80
	30	color 8.5x11copies	$0.49	$14.70
			TOTAL	$727.80

FY2019 Septic Manifests

Volume	Count	Properties	%	Cumulative	%	Volume	%	Cumulative	%
< 500	49	45	1%	45	1%	16,239	0%	16,239	0%
>= 500 and < 1,000	852	805	16%	850	17%	667,831	10%	684,070	10%
>= 1,000 and < 1,200	2085	1921	39%	2771	56%	1,973,517	29%	2,657,587	39%
>= 1,200 and < 1,500	790	643	13%	3414	69%	862,763	13%	3,520,350	52%
>= 1,500 and < 2,000	1088	821	17%	4235	85%	1,345,703	20%	4,866,053	72%
>= 2,000 and < 3,000	948	562	11%	4797	96%	1,332,108	20%	6,198,161	91%
>= 3,000	284	175	4%	4972	100%	601,141	9%	6,799,302	100%
Total	6096	4972				6,799,302			

	Count	Properties	Volume	Adjusted Volume
Single pumps	4,596	4,596	6,148,301	6,148,301
Multiple pumps	1,500	376	2,934,047	651,001
Total	6,096	4,972	9,082,348	6,799,302

Notes
Adjusted volume = (sum per address) / (number of pumps)
Percent reduction of volume = (volume - adjusted volume) / volume = 25%
Average tank volume = adjusted volume / adjusted count = 1, 368 gallons

Credits for Septic Pump Out

Fiscal Year	Actual	Less Exclusions[1]	Less Multi-pumps[2]	Average Tank[3]	# of Tanks	IA per Tank	IA
FY2019	9,893,589	9,088,603	6,799,302	1,368	4,972	0.03	149.2
FY2018	10,011,344	9,196,777	6,880,228	1,368	5,031	0.03	150.9
FY2017	9,888,895	9,084,291	6,796,076	1,368	4,970	0.03	149.1
FY2016	10,298,771	9,460,818	7,077,760	1,368	5,176	0.03	155.3
FY2015	9,388,424	8,624,540	6,452,131	1,368	4,718	0.03	141.5
FY2014	10,055,116	9,236,987	6,910,310	1,368	5,053	0.03	151.6
FY2013	9,485,500	8,713,718	6,518,845	1,368	4,767	0.03	143.0
FY2012	10,450,050	9,599,788	7,181,726	1,368	5,252	0.03	157.5
FY2011	12,785,400	11,745,124	8,786,679	1,368	6,425	0.03	192.8
FY2010	12,536,375	11,516,360	8,615,539	1,368	6,300	0.03	189.0
FY2009	8,397,330	7,714,086	5,771,008	1,368	4,220	0.03	126.6

1 - Calculated for FY2019 as less exclusions / actual = 92%

2 - Calculated for FY2019 as less multi-pumps / less exclusions = 75%

3 - Calculated for FY2019 as less multi-pumps / addresses; addresses = 4,972

Harford County, MD Department of Public Works
Watershed Protection and Restoration
Watershed Restoration Status (MS4 Permit 11-DP-3310)

Barry Glassman
County Executive

	Thru FY2015	FY2016	FY2017	FY2018	FY2019	FY2020 [1]	Total
Septic Pump Out [2]	162.6	155.3	149.1	150.9	149.2		153.4
Connections to WWTP	17.6	3.5	3.1	3.5	2.3	2.0	32.0
Septic BAT Installation	25.2	17.9	10.7	4.7	4.7	2.0	65.2
Restoration	173.1	22.3	45.8	277.2	94.1	107.3	719.8
Total	378.5	199.0	208.6	436.4	250.3	111.3	970.4

Note: All values are impervious acres calculated using methods outlines in the "Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated", MDE 2014

[1] Estimated through permit expiration 12/29/2019

[2] A value for FY2020 has not been included since the credits are averaged over the year

Target = 20%	2,218.0
Balance	1,247.6
Under construction	127
Construction contract signed	20
Balance	1,100.6

Harford County, MD Department of Public Works

Watershed Protection and Restoration

Watershed Restoration Status (MS4 Permit 11-DP-3310)

Pending Projects Total 51.5 $2,890,850

Project	Restoration Type	Complete (FY)	Credits (IA)	Total
Jarrettsville Elementary	Submerged Gravel Wetland	2021	3	$225,000
Jarrettsville Shlop	Bioswale	2021	3	$225,000
Hopkins Property (Joint SC)	Tree and Meadow Planting	2021	5.0	$200,000
Rose Property (Joint SCD)	Stream Restoration	2022	20.0	$1,100,000
Lily Run (Joint HDG)	Stream Restoration	2022	11	$620,000
165 (Amyclae)	SWM Retrofit - Sandfilter	2022	1.7	$92,950
166 (Amyclae)	SWM Retrofit - Sandfilter	2022	3.8	$206,250
167 (Amyclae)	SWM Retrofit - Sandfilter	2022	3.2	$174,900
168 (Amyclae)	SWM Retrofit - Sandfilter	2022	0.9	$46,750

Identified Projects Total 1552.1 $85,364,607

Project	Restoration Type	Complete (FY)	Credits (IA)	Total
Aberdeen MS	Tree Planting and Bioretention	TBD	3.4	$187,186
Abingdon ES	Bioretention, Stream Restoration	TBD	2.7	$147,948
Alice & William Longley Park	Tree Planting, Stream Stabilization	TBD	2.0	$110,000
Bel Air ES	Tree Planting and Bioretention	TBD	1.2	$66,672
Bus Storage Place	Bioretention	TBD	2.5	$136,711
Churchville Recreation Complex	Tree Planting and Bioretention	TBD	2.5	$134,780
Dublin ES	Tree Planting and Bioretention	TBD	1.4	$76,417
Edgeley Grove Farm	Tree Planting and Bioretention	TBD	3.0	$165,170
Edgewater Village Park	Tree Planting	TBD	0.5	$25,105
Edgewood ES	Tree Planting and Bioretention	TBD	3.1	$171,979
Flying Point Park	Tree Planting and Bioretention	TBD	1.6	$87,418
Forest Hill Recreation Complex	Bioretention	TBD	2.0	$109,655
Forest Lakes ES	Tree Planting and Bioretention	TBD	2.4	$131,387
Fountain Green ES	Tree Planting	TBD	3.0	$162,556
George D.Lisby ES at Hillsdale	Tree Planting and Bioretention	TBD	1.7	$95,021
Halls Cross Road ES	Tree Planting and Bioretention	TBD	2.0	$112,739
Harford County Detention Center	Bioretention	TBD	2.3	$128,652

Harford Glen	Tree Planting and Bioretention	TBD	2.2	$121,837
Havre de Grace ES	Bioretention, Stream Restoration	TBD	1.5	$84,873
Hickory ES	Tree Planting and Bioretention	TBD	4.3	$236,172
Jarrettsville Library	Bioretention	TBD	1.7	$96,123
John Archer Sp Ed, Prospect Mill ES, Harford Technical HS	Tree Planting and Bioretention	TBD	10.3	$566,529
Joppatowne ES	Tree Planting and Bioretention	TBD	2.4	$132,479
Joppatowne HS	Tree planting, stream restoration, bioretention	TBD	20.0	$1,100,000
North Bend ES	Tree Planting and Bioretention	TBD	2.5	$138,226
North Harford ES, North Harford MS	Tree Planting and Bioretention	TBD	6.2	$339,043
North Harford HS	Bioretention, Stream/Wetland Restoration	TBD	6.7	$367,417
Patterson MS, Patterson HS	Tree Planting	TBD	8.4	$460,300
Riverside ES	Tree Planting and Bioretention	TBD	1.7	$94,555
Roye-Williams ES	Tree Planting and Bioretention	TBD	2.1	$118,159
Southampton MS	Tree Planting and Bioretention	TBD	3.0	$167,141
Swan Harbor Farm	Tree Planting	TBD	3.8	$208,759
Whiteford Library	Tree Planting and Bioretention	TBD	0.4	$20,088
William S.James ES	Tree Planting and Bioretention	TBD	1.7	$95,613
Aldino Rd County Property	Tree Planting	TBD	7.5	$411,950
Darlington Rt1 Park-and-Ride	Tree Planting	TBD	2.4	$131,450
Dublin County Property A	Tree Planting	TBD	3.8	$209,000
Dublin County Property B	Tree Planting	TBD	0.8	$46,200
Dublin County Property C	Tree Planting	TBD	4.5	$248,600
Dublin County Property D	Tree Planting	TBD	3.9	$215,050
Eden Mill Big Branch	Tree Planting	TBD	0.8	$44,000
Eden Mill Hilltop	Tree Planting	TBD	1.1	$62,700

Norrisville Rec	Tree Planting	TBD	11.7	$643,500
OS1	Step Pool Stormwater Conveyance	TBD	1.9	$106,150
OS2	Step Pool Stormwater Conveyance	TBD	1.0	$52,250
R1	SWM Retrofit - Stormwater Wetland	TBD	2.1	$115,500
R2	SWM Retrofit - Stormwater Wetland	TBD	2.4	$134,200
R3	SWM Retrofit - Stormwater Wetland	TBD	6.4	$350,350
R4	SWM Retrofit - Stormwater Wetland	TBD	4.6	$255,200
R5	SWM Retrofit - Stormwater Wetland	TBD	6.1	$335,500
Rt1 Re-Planting	Tree Planting	TBD	1.8	$98,450
Sandy Hook	Tree Planting	TBD	11.6	$637,450
Sandy Hook UT	Stream Restoration	TBD	4.5	$247,500
Scarboro	Tree Planting	TBD	7.0	$382,250
ST1	Stream Restoration	TBD	20.5	$1,127,500
ST2	Stream Restoration	TBD	4.5	$247,500
ST3	Stream Restoration	TBD	48.0	$2,637,250
ST4	Stream Restoration	TBD	5.5	$302,500
ST5	Stream Restoration	TBD	12.0	$660,000
ST6	Stream Restoration	TBD	7.0	$385,000
Thomas Run A	Stream Restoration	TBD	18.5	$1,017,500
Thomas Run B	Stream Restoration	TBD	49.2	$2,706,000
Walters Mill	Tree Planting	TBD	1.0	$56,650
Walters Mill UT	Stream Restoration	TBD	7.6	$415,250
WR1	Wetland Restoration	TBD	1.0	$55,000
WR2	Wetland Restoration	TBD	1.0	$55,000
SR-1	Stream Restoration	TBD	51.3	$2,821,500

SR-10	Stream Restoration	TBD	18.7	$1,028,500
SR-2	Stream Restoration	TBD	12.5	$687,500
SR-3	Stream Restoration	TBD	51.6	$2,838,000
SR-4	Stream Restoration	TBD	23.8	$1,309,000
SR-5	Stream Restoration	TBD	12.0	$660,000
SR-6	Stream Restoration	TBD	9.5	$522,500
SR-8	Stream Restoration	TBD	18.7	$1,028,500
SR-9	Stream Restoration	TBD	12.7	$698,500
SWM-1	SWM Retrofit - Stormwater Wetland	TBD	15.4	$847,000
SWM-2	SWM Retrofit - Stormwater Wetland	TBD	22.7	$1,248,500
SWM-3	SWM Retrofit - Sandfilter	TBD	6.0	$330,000
SWM-4	Step Pool Stormwater Conveyance	TBD	7.0	$385,000
SWM-5	Step Pool Stormwater Conveyance	TBD	2.1	$115,500
Fairmont	Stream Restoration	TBD	15.0	$825,000
Macphail, Brosvenor, Brook Hill	Stream Restoration and Outfall Stabilization	TBD	55.0	$3,025,000
Ring Factory	Stream Restoration	TBD	22.0	$1,210,000
Victory	Stream Restoration and Outfall Stabilization	TBD	26.0	$1,430,000
SR 1-4 & SR 1-3 & SR 1-2	Stream Restoration	TBD	8.0	$440,000
SR 3-1 & SR 3-2	Stream Restoration	TBD	4.0	$220,000
SR 6-1	Stream Restoration	TBD	8.0	$440,000
SR 7-1 & SR 8-1	Stream Restoration	TBD	19.0	$1,045,000
6	Stream Restoration	TBD	19.0	$1,045,000
9	Stream Restoration	TBD	14.0	$770,000
1b	Stream Restoration	TBD	12.0	$660,000
3a	Stream Restoration	TBD	18.0	$990,000

7 & 5b	Stream Restoration	TBD	23.0	$1,265,000
Declaration - D-ES-2	WQ Trap Retrofit - Stormwater Wetland	TBD	5.0	$275,000
Declaration - Reach 2	Outfall Stabilization	TBD	4.0	$220,000
Declaration D-ES-12	SWM Retrofit - Stormwater Wetland	TBD	1.0	$55,000
Declaration D-ES-6	WQ Trap Retrofit - Bioretention	TBD	2.0	$110,000
Declaration -D-ES-7	Bioswale and Bioretention	TBD	2.0	$110,000
Declaration D-NS-7	Step Pool Stormwater Conveyance	TBD	2.0	$110,000
Riverside - R-ES-1	SWM Retrofit - Stormwater Wetland	TBD	40.0	$2,200,000
Riverside - R-NS-1	Bioretention	TBD	2.0	$110,000
Riverside - R-NS-5	Tree Planting	TBD	1.0	$55,000
Riverside - R-NS-7&8	Bioswale	TBD	4.0	$220,000
SR-1	Stream Restoration	TBD	18.4	$1,012,000
SR-2	Stream Restoration	TBD	18.4	$1,012,000
SR-3	Stream Restoration	TBD	5.0	$275,000
SR-4	Stream Restoration	TBD	20.5	$1,127,500
SR-5	Stream Restoration	TBD	24.7	$1,358,500
SWM-1	Sand Filter	TBD	13.2	$726,000
SWM-2	SWM Retrofit - Submerged Gravel Wetland	TBD	1.9	$104,500
SWM-3	Submerged Gravel Wetland	TBD	1.9	$104,500
SWM-4	SWM Retrofit - Stormwater Wetland	TBD	2.5	$137,500
SWM-5	Bioretention	TBD	1.9	$104,500
SWM-6	SWM Retrofit - Stormwater Wetland	TBD	1.2	$66,000
SWM-7	SWM Retrofit - Stormwater Wetland	TBD	0.9	$49,500
23	SWM Retrofit - Bioretention	TBD	0.3	$18,700
33	SWM Retrofit to Stormwater Wetland	TBD	7.4	$405,350

34	SWM Retrofit - Bioretention	TBD	0.5	$25,300
35	SWM Retrofit - Bioretention	TBD	0.9	$49,500
38	SWM Retrofit - Stormwater Wetland	TBD	0.4	$21,450
52	Bioretention	TBD	1.4	$78,650
112	SWM Retrofit - Stormwater Wetland	TBD	1.6	$90,200
113	SWM Retrofit - Stormwater Wetland	TBD	2.5	$135,850
114	SWM Retrofit - Stormwater Wetland	TBD	6.2	$339,900
144	SWM Retrofit - Stormwater Wetland	TBD	7.9	$433,950
145	SWM Retrofit - Stormwater Wetland	TBD	6.7	$366,300
156	SWM Retrofit - Bioretention	TBD	1.2	$63,800
157	SWM Retrofit - Bioretention	TBD	2.6	$145,200
158	SWM Retrofit - Stormwater Wetland	TBD	1.0	$52,800
159	SWM Retrofit - Bioretention	TBD	1.2	$68,200
162	SWM Retrofit - Stormwater Wetland	TBD	1.1	$59,950
163	SWM Retrofit - Stormwater Wetland	TBD	4.8	$262,900
164	SWM Retrofit - Stormwater Wetland	TBD	1.3	$69,850
169	SWM Retrofit - Stormwater Wetland	TBD	4.1	$227,700
170	SWM Retrofit - Stormwater Wetland	TBD	12.9	$709,500
171	SWM Retrofit - Stormwater Wetland	TBD	14.8	$812,900
172	SWM Retrofit - Bioretention	TBD	5.2	$285,450
173	SWM Retrofit - Stormwater Wetland	TBD	6.6	$364,650
174	SWM Retrofit - Submerged Gravel Wetland	TBD	0.4	$19,800
176	SWM Retrofit - Stormwater Wetland	TBD	4.4	$243,100
179	SWM Retrofit - Stormwater Wetland	TBD	7.6	$420,200
180	SWM Retrofit - Sandfilter	TBD	1.8	$97,900

181	SWM Retrofit - Stormwater Wetland	TBD	1.4	$74,800
184	SWM Retrofit - Stormwater Wetland	TBD	14.0	$767,250
190	SWM Retrofit - Stormwater Wetland	TBD	1.5	$84,700
194	SWM Retrofit - Bioretention	TBD	0.9	$51,150
195	SWM Retrofit - Bioretention	TBD	0.1	$6,050
202	SWM Retrofit - Stormwater Wetland	TBD	1.9	$106,700
Bynum Run@ Blake's Venture Park	Stream Restoration	TBD	25.0	$1,375,000
Bynum Run@ Harford Detention Center	Stream Restoration	TBD	8.0	$440,000
Bynum Run@ MD-23	Stream Restoration	TBD	21.0	$1,155,000
Bynum Run@ Moores Mill Road	Stream Restoration	TBD	23.0	$1,265,000
Bynum Run@ Newport Drive	Stream Restoration	TBD	5.0	$275,000
N101	Bioretention	TBD	0.5	$25,300
N102	Bioswale	TBD	4.2	$228,250
N103	Stormwater Wetland	TBD	2.0	$107,800
N104	Stormwater Wetland	TBD	3.9	$216,700
N105	Bioretention	TBD	1.0	$56,100
N106	Stormwater Wetland	TBD	1.0	$56,100
N107	Bioswale	TBD	1.9	$104,500
N108	Stormwater Wetland	TBD	7.3	$403,700
N109	Bioswale	TBD	0.8	$42,900
N110	Step Pool Stormwater Conveyance	TBD	4.8	$261,250
N112	Bioretention	TBD	0.4	$21,450
N113	Bioswale	TBD	1.2	$67,650
N114	Bioswale	TBD	1.8	$100,650
N115	Bioretention	TBD	1.3	$68,750

N116	Bioretention	TBD	0.9	$48,400
N117	Bioretention	TBD	1.2	$64,900
N118	Stormwater Wetland	TBD	23.3	$1,278,750
N119	Bioretention	TBD	0.2	$11,550
N120	Stormwater Wetland	TBD	1.7	$91,300
N121	Stormwater Wetland	TBD	3.6	$199,100
N123	Bioretention	TBD	3.0	$164,450
N124	Stormwater Wetland	TBD	3.9	$216,700
N125	Stormwater Wetland	TBD	7.4	$405,350
N126	Stormwater Wetland	TBD	1.8	$101,200
N127	Stormwater Wetland	TBD	6.1	$337,700
N128	Bioretention	TBD	0.5	$29,150
N129	Stormwater Wetland	TBD	1.8	$97,900
N130	Bioretention	TBD	0.9	$49,500
N131	Stormwater Wetland	TBD	4.1	$226,050
N132	Bioretention	TBD	1.4	$77,000
N137	Stormwater Wetland	TBD	3.5	$193,600
N138	Bioretention	TBD	0.9	$47,850
N141	Bioretention	TBD	0.3	$18,150
N142	Bioretention	TBD	0.5	$29,700
N143	Bioretention	TBD	1.0	$53,900
Unnamed Trbutary@ Switchman Drive	Stream Restoration	TBD	4.0	$220,000
Unnamed Triburtay@ MD 543	Stream Restoration	TBD	37.0	$2,035,000
Unnamed Tributary@ Bel Air Bypass	Stream Restoration	TBD	23.0	$1,265,000
Unnamed Tributary@ Broadway	Stream Restoration	TBD	23.0	$1,265,000

Unnamed Tributary@ Centreville Way	Stream Restoration	TBD	20.0	$1,100,000
Unnamed Tributary@ Frogleap Way	Stream Restoration	TBD	8.0	$440,000
Unnamed Tributary@ MD-22	Stream Restoration	TBD	12.0	$660,000
Unnamed Tributary@ Melrose Lane	Stream Restoration	TBD	22.0	$1,210,000
Unnamed Tributary@ Pipercove Way	Stream Restoration	TBD	11.0	$605,000
Unnamed Tributary@ Rockfield Park	Stream Restoration	TBD	25.0	$1,375,000

Watershed Assessment	Credits (IA)
County-owned properties	97.2
Deer Creek (2018)	261.7
Emmord Branch (2018)	264.0
Taylors Creek (2018)	110.5
Upper Bynum Run (2018)	507.4
Farnandis Branch (2017)	118.0
Declaration Run / Riverside Area (2014)	66.0
Foster Branch (2012)	39.0
Plumtree Run (2011)	86.0
Other	2.3
Total	1,552.1