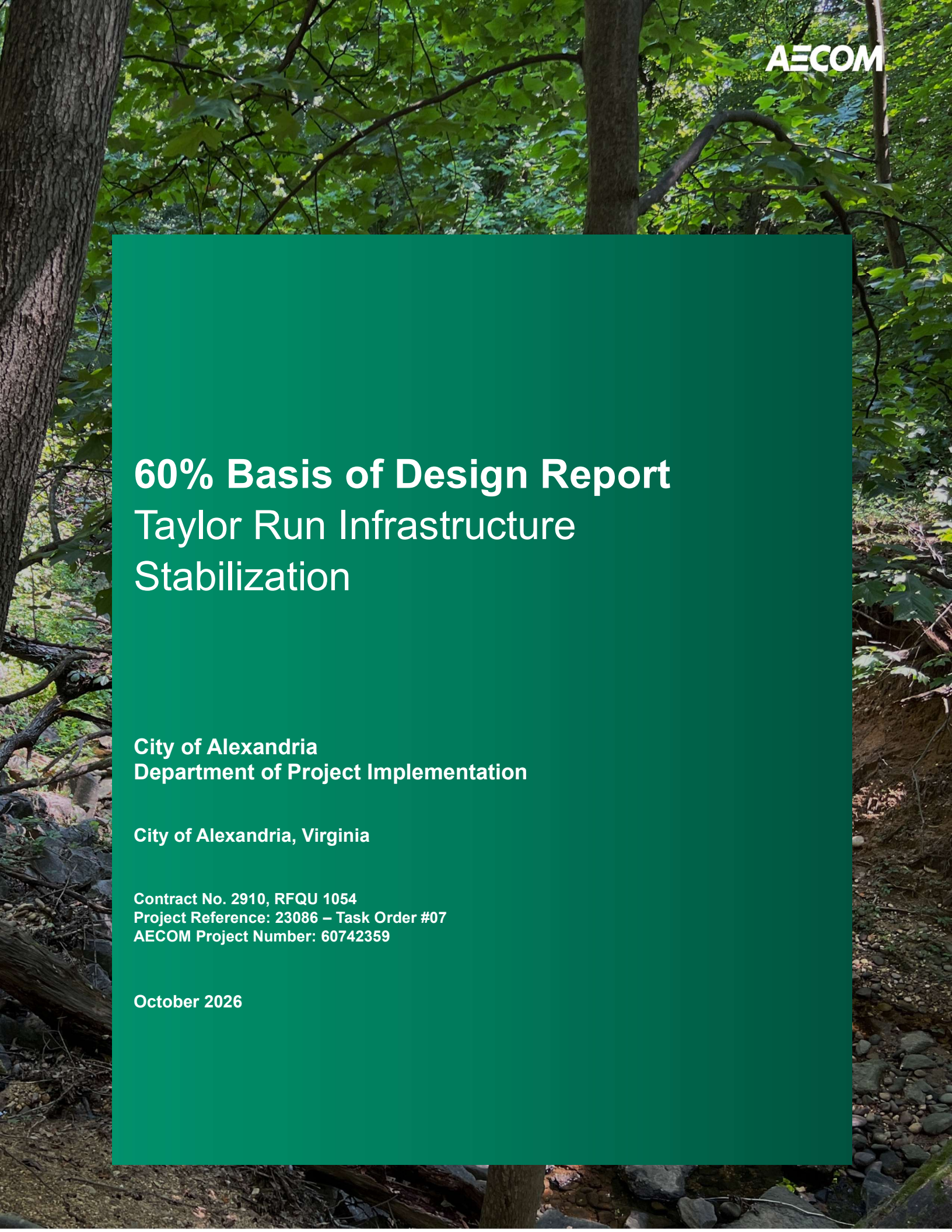


60% Basis of Design Report
Taylor Run Infrastructure Stabilization

City of Alexandria
Department of Project Implementation

City of Alexandria, Virginia

Contract No. 2910, RFQU 1054
Project Reference: 23086 – Task Order #07
AECOM Project Number: 60742359

October 2026

Table of Contents

Executive Summary **1**

1 Introduction **2**

1.1 Project Site Overview 2

1.2 Project Goals and Objectives 5

1.2.1 Project Goals 5

1.2.2 Project Objectives 5

2 Data Collection and Review **6**

2.1 Topographic Survey and LiDAR 6

2.2 Soils 6

2.3 FEMA Effective Data 7

2.4 Tree Inventory 8

2.5 CCTV Condition Assessment 11

2.6 Geotechnical Investigation 12

2.7 Landscape Architect Site Assessment 12

2.8 Wetland Delineation 12

3 Existing Stream Assessment **13**

3.1 Project Area Descriptions 13

3.1.1 Project Area 1 13

3.1.2 Project Area 2 14

3.1.3 Project Area 3 15

3.1.4 Project Area 4 16

3.2 Permitting Considerations 16

4 Hydrology and Hydraulics **17**

5 Proposed Minimal Intervention **23**

5.1 Outfall Stabilization 24

5.2 Channel Bank Stabilization 24

5.3 Stream Bed Stabilization 24

5.4 Sanitary Sewer Infrastructure Protection 25

5.5 Cost Estimate 25

5.6 Construction Access and Scheduling 26

6 Conclusion **26**

Figures

Figure 1: Taylor Run Project Location Map and LOD 4

Figure 2: Effective FIRM of Taylor Run 8

Tables

Table 1: Project Hydrologic Soil Group Summary 7
Table 2: Tree Inventory Summary 9
Table 3: Project Area Name and Lengths 13
Table 4: Existing Conditions Peak Discharge 17
Table 5: HEC-RAS Models Water Surface Elevation Comparison 18
Table 6: HEC-RAS Models Shear Stress Comparison 20
Table 7: HEC-RAS Models Velocity Comparison 21

Appendices

Appendix A Tree Inventory
Appendix B CCTV Assessment Report
Appendix C Geotechnical Assessment Report
Appendix D Wetland Delineation Report
Appendix E Site Photographs
Appendix F Hydrology and Hydraulics
Appendix G Joint Permit Application Package
Appendix H Stormwater Pollution Prevention Plan
Appendix I Adverse Impact Verification Memorandum
Appendix J Construction Specifications
Appendix K Cost Estimate
Appendix L 60% Stream Design Plans

Executive Summary

The Taylor Run Infrastructure Stabilization Design Project (Project) is located in the City of Alexandira, Virginia. The goal of the project is to implement a 'minimal stabilization' approach to protect at-risk infrastructure and provide stream stabilization along approximately 265 linear feet of non-continuous stream necessary to provide long-term infrastructure protection.

The project has been divided into four distinct areas, each addressing specific infrastructure vulnerabilities:

1. **Upstream Stormwater Outfall:** Currently in disrepair, surrounding stream banks are actively eroding, and outfall discharges into an undersized plunge pool causing excessive bed scour.
2. **Sanitary Sewer Crossing 1 and Stormwater Outfall:** Sanitary sewer crossing is at-risk of structural damage, adjacent stormwater outfall in deteriorating, contributing to eroding stream bed and banks.
3. **Exposed Sanitary Sewer Manhole:** Exposed sanitary sewer manhole is exposed and vulnerable to damage from storm flows or debris.
4. **Sanitary Sewer Crossing 2 and Retaining Wall:** Stream bank and bed erosion has exposed an existing sanitary sewer crossing risking structural damage, and a nearby retaining wall is failing.

Updated topographic and tree surveys were completed to ensure the most current site data was used in the design process. The project areas were evaluated during site visits, and items of note included erosion undermining trees, destabilizing stream banks, and threatening City infrastructure. Debris blockages occur throughout the stream and consist primarily of woody debris and concrete rubble. Stormwater and sanitary sewer infrastructure, including two stormwater outfalls, two exposed pipe crossings and an exposed sanitary sewer manhole, is susceptible to damage. To proceed with construction, a Nationwide Permit will be required for activities related to maintenance, bank stabilization, and utility line protection.

Taylor Run has a FEMA designated Zone AE floodplain, necessitating that proposed solutions do not result in adverse impacts, such as increases downstream water surface elevations. A hydraulic analysis using FEMA effective flows has been completed to establish existing conditions. Proposed conditions will be modeled and submitted for review in future design phases.

Proposed stabilization measures include streambank grading and rip rap placement to stabilize stream banks and protect the exposed sanitary infrastructure, replacement or improvement of deteriorated outfall headwalls, encasement of exposed sanitary sewer pipes, and install boulder cascades to dissipate energy through the project areas supporting long term stability and reduced project grading extents.

The engineer's Opinion of Probable Construction Cost (OPCC) at the 60% design phase is approximately $650,000. This estimate includes a 20% contingency to account for design uncertainties

and a 4.3% escalation factor to reflect anticipated inflation between now and the mid-point to construction.

1 Introduction

The Taylor Run Stream Restoration Project, conducted during 2019–2020 under Task Order No. 22 of Contract No. 0000292, was initiated to stabilize the stream while generating nutrient and sediment reduction credits to support the City of Alexandria's compliance with Chesapeake Bay cleanup mandates.

Following stakeholder engagement and evaluation of project goals, the decision was made to pursue a more 'minimal stabilization' approach, focusing primarily on the protection of at-risk infrastructure rather than broader ecological restoration goals and objectives. Further engagement following the initial 60% design resulted in removal of certain design elements. The design presented within this report is the revised 60% design.

AECOM, in collaboration with the City of Alexandria Department of Project Implementation and Transportation and Environmental Services, has prepared this revised 60% Design Report to document the development of the Taylor Run Infrastructure Stabilization Design Project. The project focuses on implementing a minimal stabilization approach to protect at-risk infrastructure along Taylor Run. Designs for four key project areas emphasize targeted interventions to address exposed sanitary sewer infrastructure, deteriorating stormwater outfalls, and eroding stream bed and banks.

Construction access and site disturbance will be carefully planned to minimize tree impacts and reduce disruption to the surrounding community. This minimal approach was selected over a more extensive stream restoration strategy based on stakeholder input favoring reduced environmental and community impacts.

The report and accompanying design documents outline recommended strategies to provide long-term stability to vulnerable infrastructure, maintain existing systems, and guide further design development and regulatory review.

1.1 Project Site Overview

Taylor Run is within the Mid-Atlantic Region within the Middle Potomac-Anacostia-Occoquan (HUC8: 02070010), Cameron Run-Potomac River (HUC10:0207001003), and Cameron Run (HUC12: 020700100302) watersheds. The stream discharges into Holmes Run, which ultimately flows into the Potomac River and then the Chesapeake Bay.

The project is situated in a developed urban area across two parcels owned by the City of Alexandria. The contributing drainage area encompasses approximately 333 acres of densely developed land. Surrounding the limits of disturbance (LOD) are residential neighborhoods, a community center, a school, open space, and forested buffers. The total watershed imperviousness is estimated at approximately 38%, contributing to increased runoff and deteriorating infrastructure conditions.

Four distinct project areas (**Figure 1**) were identified for necessary stabilization of at-risk infrastructure:

5. **Upstream Stormwater Outfall:** Currently in disrepair, surrounding stream banks are actively eroding, and outfall discharges into an undersized plunge pool causing excessive bed scour.
6. **Sanitary Sewer Crossing 1 and Stormwater Outfall:** Sanitary sewer crossing is at-risk of structural damage, adjacent stormwater outfall in deteriorating, contributing to eroding stream bed and banks.
7. **Exposed Sanitary Sewer Manhole:** Exposed sanitary sewer manhole is exposed and vulnerable to damage from storm flows or debris.
8. **Sanitary Sewer Crossing 2 and Retaining Wall:** Stream bank and bed erosion has exposed an existing sanitary sewer crossing risking structural damage, and a nearby retaining wall is failing.

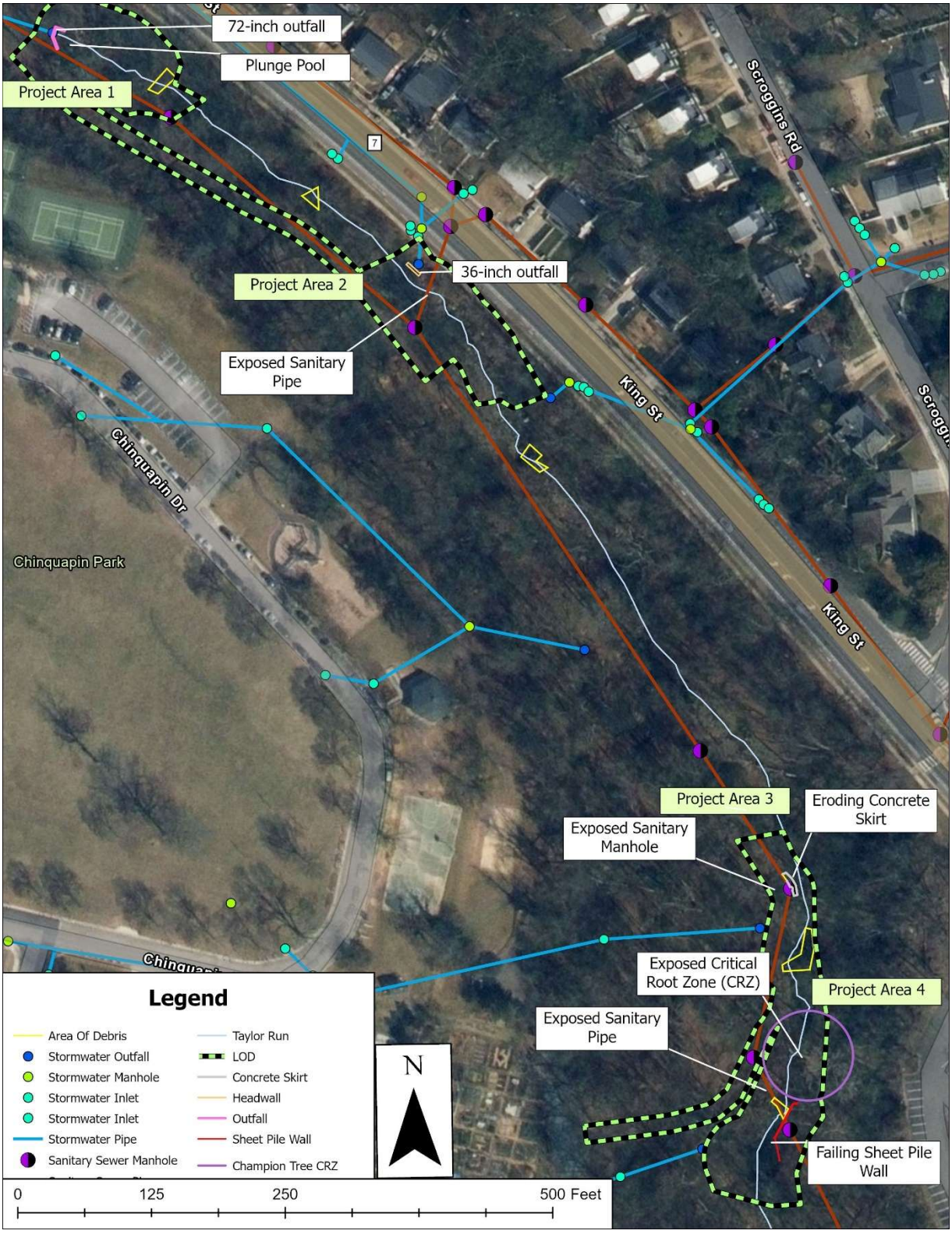


Figure 1: Taylor Run Project Location Map and LOD

1.2 Project Goals and Objectives

The Project is guided by a set of clearly defined goals and supporting objectives. These elements shape the conceptual design and ensure alignment with the City of Alexandria's priorities, as outlined in the Request for Qualifications (RFQ). The goals represent the overarching outcomes the project seeks to achieve, while the objectives define the specific actions and deliverables that support those goals.

1.2.1 Project Goals

The primary goals of the project are to:

1. Protect critical at-risk infrastructure from erosion and damage, including exposed sanitary sewer lines and stormwater outfalls.
2. Preserve and protect ecological features, such as the existing wetlands and mature trees within the park.
3. Stabilize streambanks to reduce excessive sedimentation and improve hydraulic function.
4. Minimize environmental and community impacts during construction and implementation.
5. Ensure cost-effective design and construction, aligned with budgetary and regulatory requirements.

1.2.2 Project Objectives

To achieve these goals, the project will:

- Develop fully engineered plans that meet all applicable regulatory and technical standards.
- Ensure design and construction costs remain within the awarded budget, maintaining fiscal responsibility throughout the project lifecycle.
- Create a phased construction plan that minimizes disruption to surrounding residential neighborhoods, schools, and public spaces.
- Design with minimal limits of disturbance, including access routes, to reduce vegetation removal and preserve site integrity.
- Implement stabilization measures that provide long-term protection for exposed infrastructure and sensitive ecological features.

The final design will deliver a balanced and sustainable solution that stabilizes the hydraulic function of Taylor Run, protects vulnerable infrastructure, and preserves the ecological integrity of the site. These goals and objectives collectively support the City's environmental, fiscal, and community engagement priorities.

2 Data Collection and Review

2.1 Topographic Survey and LiDAR

Rice Associates conducted a detailed topographic survey of approximately 1,450 linear feet of stream within an approximate 1.84-acre investigation area. The survey data was processed using Autodesk Civil 3D to generate 1-foot contour intervals, providing a high-resolution representation of existing site conditions.

The horizontal datum used for the survey is the Virginia State Plane Coordinate System (NAD83) in U.S. Survey Feet, and the vertical datum is the North American Vertical Datum of 1988 (NAVD88), also in U.S. Survey Feet.

To supplement the field-collected data and support the Hydrologic and Hydraulic (H&H) analysis, previously surveyed data from 2019 and Light Detection and Ranging (LiDAR) data was obtained from the U.S. Geological Survey (USGS). This additional data provided broader topographic context and enhanced the accuracy of watershed delineation and hydraulic modeling.

2.2 Soils

To characterize the soil conditions within the Project and contributing watershed, AECOM utilized data from the NRCS Web Soil Survey, developed by the U.S. Department of Agriculture Natural Resources Conservation Service (USDA NRCS).

Within the immediate project area, the dominant soil type is the Sassafras-Neabsco complex, which accounts for 100% of the surveyed area. These soils are typically well-drained and are commonly found on slopes, shoulders, and summits of marine terraces, making them suitable for stabilization efforts with minimal concern for poor drainage or high runoff.

To evaluate the broader drainage area, soils were classified into Hydrologic Soil Groups (HSGs), which provide an index of runoff potential based on infiltration characteristics:

- Group A soils (e.g., sand, loamy sand, sandy loam) have low runoff potential and high infiltration rates.
- Group D soils (e.g., clay, clay loam, silty clay) have high runoff potential and low infiltration rates.

The Taylor Run watershed is predominantly composed of Group B soils, which have moderate infiltration rates and low runoff potential, indicating favorable conditions for infiltration and reduced stormwater impacts.

The percent composition for each hydrologic soil group within the limits of disturbance is summarized in **Table 1** below. The results show that soils within the Project area are predominantly classified as hydrologic soil group B, or soils with a low runoff potential.

Table 1: Project Hydrologic Soil Group Summary

Percent Composition (%)			
HSG A	**HSG B**	**HSG C**	**HSG D**
0%	99.8%	0.2%	0%

2.3 FEMA Effective Data

Taylor Run is designated as a regulatory Zone AE stream, originally studied as part of the Cameron Run watershed analysis conducted by the Federal Emergency Management Agency (FEMA) in 2014. The most recent FEMA Flood Insurance Study (FIS) for the area was published on January 11, 2024, incorporating updated hydrologic and hydraulic data.

To support the design and regulatory compliance of the Project, a comprehensive hydrologic and hydraulic (H&H) assessment was performed. The hydrologic analysis was conducted using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) version 3.1.1, while the hydraulic modeling was completed using HEC-River Analysis System (HEC-RAS) version 3.1.1.

As part of the 2024 FIS update, flood hazard boundaries were re-delineated in 2020, reflecting changes in land use, hydrology, and topography. These updates are critical to ensure that proposed stabilization measures do not result in adverse impacts, such as increased water surface elevations downstream.

The effective Flood Insurance Rate Map (FIRM), illustrating the Taylor Run floodplain and regulatory boundaries, is provided in **Figure 2**.

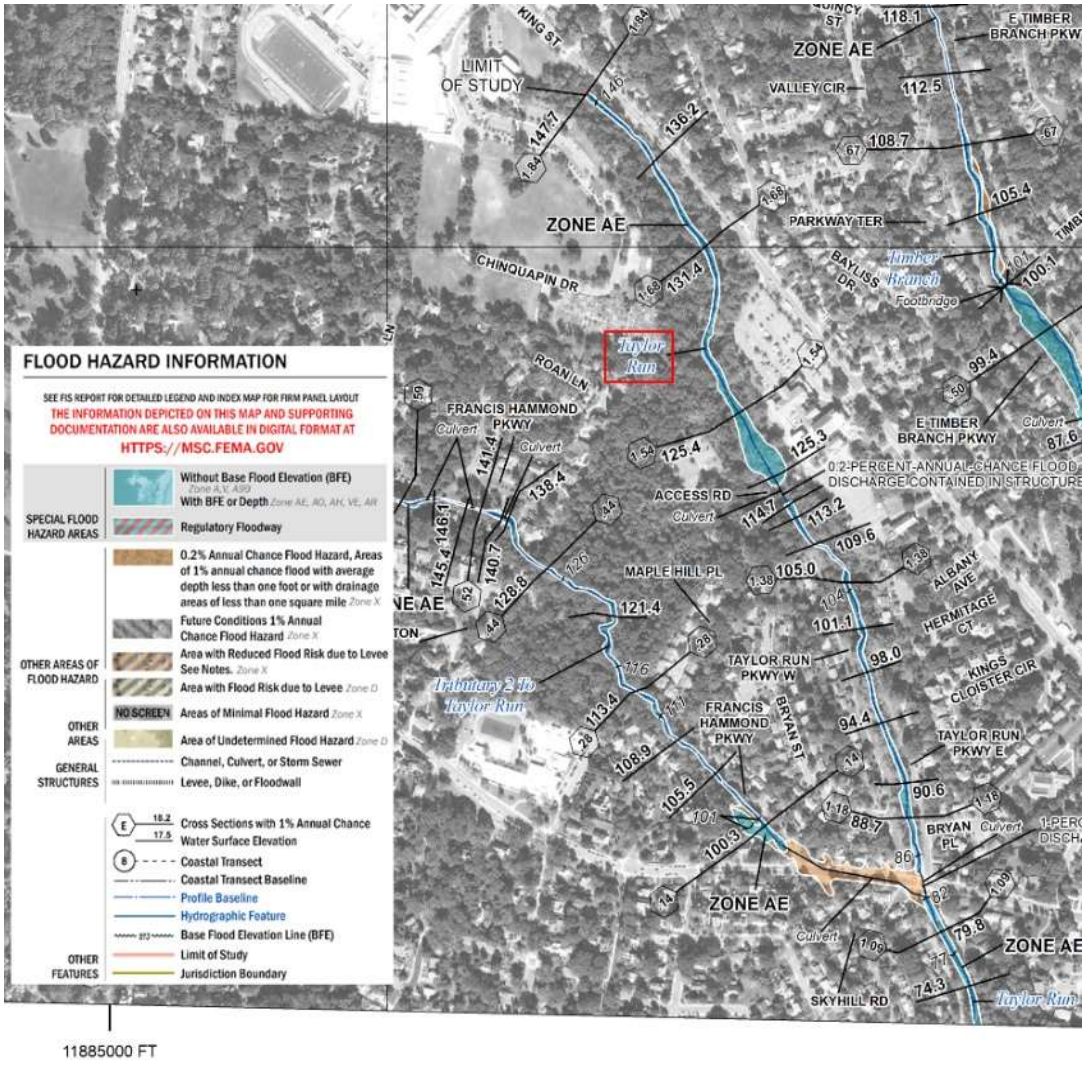


Figure 2: Effective FIRM of Taylor Run

2.4 Tree Inventory

Between May and July 2025, AECOM conducted field investigations to update and verify the existing tree inventory within the Project. The purpose of this effort was to identify any changes since the previous survey, including trees that had grown to significant size, fallen or died, and to ensure accurate documentation of current site conditions.

During the field survey, AECOM confirmed species identification, diameter at breast height (DBH) measurements, and health conditions of existing trees. Any new trees with a DBH of 12 inches or greater that were not included in the previous inventory were assigned unique identification numbers and geolocated using GPS technology.

A total of 749 trees were documented, of which 629 (approximately 84%) were living and 120 (approximately 16%) were dead. The most common species was Red Maple, with 152 trees recorded — 145 living and 7 dead. Other dominant species included Tulip tree (123 trees), Black Locust (80

trees), and Slippery Elm (54 trees), all of which contribute significantly to the canopy cover and ecological function of the stream corridor.

While the overall health of the tree population appears stable, certain species exhibited higher mortality rates. Notably, Black Locust had a mortality rate of approximately 32.5%. Additionally, 63 trees were classified as either Unknown Snag (24) or Unknown Tree (39), all of which were dead and in too poor of a condition to accurately identify. Although they may be outside the removal areas of any project impacts these trees may pose safety risks to the public while using the park and future considerations should be made to investigate if removal of these trees would improve park safety.

The inventory reflects a high diversity of tree species, with over 40 distinct types identified. This diversity enhances the ecological resilience of the area and contributes to the overall environmental value of the stream corridor.

The updated tree inventory provides critical data to inform design decisions, particularly in minimizing vegetation disturbance and protecting significant ecological features. Results from the survey are summarized in **Table 2** and further discussed in the Tree Inventory Memo (**Appendix A**).

Table 2: Tree Inventory Summary

Tree Type (Common Name)	Number of Trees	Status (Living | Dead)
American Beech	3	3 | 0
American Elm	31	30 | 1
American Holly	4	4 | 0
American Sycamore	4	4 | 0
Black Cherry	56	51 | 5
Black Locust	80	54 | 26
Black Oak	1	1 | 0
Black Walnut	10	10 | 0
Black gum	9	9 | 0
Boxelder	3	3 | 0
Chestnut Oak	6	6 | 0
Common Hackberry	1	1 | 0
Common Persimmon	3	3 | 0
Eastern Cottonwood	2	2 | 0

Tree Type (Common Name)	Number of Trees	Status (Living | Dead)
Green Ash	10	10 | 0
Hickory Species	2	2 | 0
Honey locust	1	1 | 0
Littleleaf Linden	1	1 | 0
Mimosa	1	1 | 0
Norway Maple	5	5 | 0
Pin Oak	1	1 | 0
Red Maple	152	145 | 7
Red Mulberry	2	1 | 1
Royal Paulownia	4	4 | 0
Sassafras	14	12 | 2
Scarlet Oak	1	1 | 0
Silver Maple	27	27 | 0
Slippery Elm	54	54 | 0
Southern Red Oak	3	3 | 0
Sugar Maple	2	2 | 0
Sweet Cherry	3	2 | 1
Sweet Gum	3	3 | 0
Tree of Heaven	25	21 | 4
Tuliptree	123	117 | 6
Unknown Snag	24	0 | 24
Unknown Tree	39	0 | 39
Virginia Pine	2	2 | 0
While Mulberry	25	25 | 0

Tree Type (Common Name)	Number of Trees	Status (Living | Dead)
White Oak	10	7 | 3
Willow Oak	2	1 | 1
Total	**749**	**629 | 120**

2.5 CCTV Condition Assessment

In July 2025 AECOM performed a CCTV inspection of the exposed sanitary sewer crossings in Project Area 2 and 4. Closed circuit video recording equipment was utilized to inspect the interior condition and generally, both pipe sections are in fair condition. The 12-inch, circular Ductile Iron Pipe (DIP) sanitary sewage pipe in Project Area 2 was assessed for approximately 97 linear feet between manhole ID 00047 and ID 00041. Sediment and rocks were present throughout the pipe and light cleaning is recommended. Observations of note include delaminating and discoloration of lining feature, and surface damage from spalling.

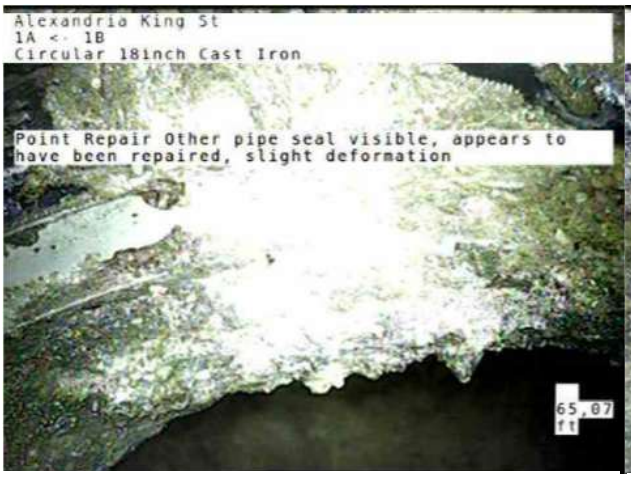


Spalling damage of pipe surface



Sediment and rock obstructions and discoloration of pipe lining.

The 18-inch circular DIP sanitary sewage pipe in Project Area 4 was assessed for approximately 67 linear feet from manhole ID 007531 to ID 006571. There was evidence of a crown repair within the first foot of the upstream manhole (007531). The area shows minor deformation but there was no active infiltration observed during investigation. Additionally, medium joint separation and surface damage corrosion were noted. The CCTV Inspection reports can be found in **Appendix B**.



Point repair of pipe crown but has slight deformation



Pipe joint separation

2.6 Geotechnical Investigation

Between September and October 2025, AECOM conducted a geotechnical subsurface investigation. Four geotechnical soil borings were collected using the Standard Penetration Test (SPT). The surface fill (extending approximately 6 feet deep) is characterized as medium stiff to sandy clay and sandy silt with varying amounts of gravel. The underlying native soil (extending the maximum depth of the borings of 45 feet deep), consists of predominantly medium stiff to very stiff Potomac clay and thin embedded layers of well-graded sands. Very stiff Potomac clay soils are known to be susceptible to slope instability issues and are also known to have high shrink-swell properties. Collected materials from the borings were sent for laboratory testing to define material properties. Refer to **Appendix C** for the Geotechnical Investigation Memo.

2.7 Landscape Architect Site Assessment

In February 2026, AECOM Landscape Architects conducted field investigations along approximately 1,500 linear feet of Taylor Run to assess existing site vegetation. Observed plant species and their relative abundance were documented and used to inform the development of the planting schedule in coordination with stakeholder input. Refer to **Appendix L** for the 60% Design Plans which include the planting plan and schedule.

2.8 Wetland Delineation

AECOM conducted a field delineation of wetlands and waters of the United States (WUS) within the Taylor Run study area on April 6 of 2026 at the direction of the USACE to confirm previously delineation resource boundaries. This delineation provided confirmation of wetland and WUS boundaries from the previous delineation. During previous review, the USACE-Norfolk District determined WETA and WETC are regulated wetlands and Taylor Run, INT1, EPH3 and EPH 6 are regulated waters. At this time the USACE considered WET B to be disturbed and did not satisfy hydric soil parameters. Investigations in 2026 revealed WET B soils to exhibit hydric conditions. Confirmation from the USACE

will be required prior to a change in regulatory boundaries. Proposed access to the site, limits of disturbance, and identified construction staging areas are able to avoid impacts to identified resources. Refer to **Appendix D** for the Wetland Delineation Report.

3 Existing Stream Assessment

In May and August 2025, AECOM stream specialists conducted field investigations along approximately 1,500 linear feet of Taylor Run, with a focused assessment of approximately 590 linear feet within the four designated project areas. The purpose of these investigations was to evaluate previously identified impairments and determine appropriate minimal stabilization remedies for each area. Photographs documenting existing site conditions and photo descriptions can be found in **Appendix D.**

3.1 Project Area Descriptions

Four distinct project areas were identified for stabilization along Taylor Run. For clarity and consistency, each area has been assigned a unique identifier (Project Areas 1–4), ordered sequentially from upstream to downstream. The approximate stream length within these areas is summarized in **Table 3**.

Table 3: Project Area Name and Lengths

	Length (ft)
Project Area 1	30
Project Area 2	95
Project Area 3	70
Project Area 4	70
Total Length	265

3.1.1 Project Area 1

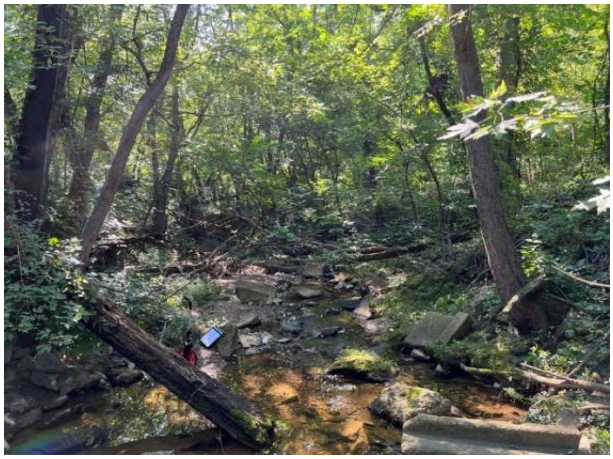
Project Area 1 originates from a 72-inch reinforced concrete pipe (RCP) outfall that conveys flow from Chinquapin Park, Alexandria City High School, surrounding residential neighborhoods, and a portion of Braddock Road.

Bank erosion has undermined many trees along the streambank slopes, causing them to fall into the channel and producing debris blockages. Evidence of stream head cut was noted next to the outfall right wingwall (looking upstream) where a gully has developed, contributing to the outfall being unstable. The plunge pool does not meet the most recent Virginia Department of Transportation

(VDOT) standards. Large concrete debris was observed in the plunge pool and the immediate downstream section of stream.



Recently downed trees on the left bank, immediately downstream of the outfall



Debris accumulation obstructing flow downstream of the outfall



Erosion observed behind the right wingwall of the outfall (viewed looking upstream)



Deteriorating outfall and concrete debris in plunge pool

3.1.2 Project Area 2

Project Area 2 originates approximately 290 linear feet downstream of Project Area 1. Vertical and lateral erosion has lowered the streambed elevation, exposing an existing sanitary sewer putting the existing City infrastructure at-risk of damage. The exposed sanitary sewer line has no concrete encasement and acts as an inline weir for the upstream plunge pool. The exterior of the sewer line is undamaged, but with no concrete encasement it is susceptible to damage as debris has already accumulated on the crossing from fallen limbs and trees. Refer to **Section 2.5** for details on interior conditions.

Immediately downstream of the rock cascade, the left bank shows signs of significant erosion, including raw, vertical banks that exceed 6 feet in height. Lateral erosion of the left bank has exposed a dense clay layer and tree roots, which will cause the trees to fall into the channel and produce debris

blockages. The erosion extends upstream where a 36-inch RCP outfall has an approximate 18-inch undercut that is eroding the headwall. Extensive concrete and woody debris were noted in the channel, contributing to the development of mid-channel bars, increasing near bank stress and accelerating stream bank erosion rates.



Exposed sanitary sewer line vulnerable to erosion and structural damage



Severely eroded streambank with visible tree root exposure



36-inch stormwater outfall showing significant undercutting and headwall deterioration



Accumulation of woody debris contributing to channel instability and bank erosion

3.1.3 Project Area 3

Project Area 3 originates approximately 520 feet downstream of Project Area 2. On the right stream bank there is an exposed sanitary sewer manhole that sits on a concrete skirt. The concrete skirt has an undercut of approximately 24 inches. A large accumulation of woody debris in the channel has contributed to channel migration, bank stress and erosion which can cause root erosion and more trees to fall into the channel and compromise the park's trail network as a portion of the trail has collapsed into the stream.



Exposed sanitary sewer manhole with undercut concrete base, indicating potential structural vulnerability



Significant accumulation of woody debris contributing to channel migration and increased streambank erosion

3.1.4 Project Area 4

Project Area 4 originates approximately 25 feet downstream of the large accumulation of woody debris within Project Area 3. An undercut on the left bank has exposed the root mass of a large tulip poplar tree putting it at risk of falling. Mid-channel bars are evident as the main flow path has migrated directly under the exposed roots.

Directly downstream, the existing sheet pile retaining wall is failing from erosion and hydrostatic pressure. A sanitary sewer manhole behind the sheet pile wall risks damage once the wall collapses. The distance of the center of the manhole to the top of the wall is approximately 3 feet and the edge of the manhole is approximately 10 inches. The exposed sewer pipe crossing the channel has no concrete encasement, making it susceptible to damage. The exterior of the sanitary sewer pipe is intact and has accumulated leafy and woody debris behind the structure, acting as a channel blockage. Refer to **Section 2.5** for details on interior conditions.



Exposed sanitary pipe adjacent to a deteriorating sheet pile wall (left), with a riprap-lined channel bank providing erosion control on the right.

Lateral and vertical erosion of the channel banks is evident, exposing tree roots, causing them to fall into the channel and producing debris. There is evidence of bank stabilization efforts on the right bank, downstream of the sanitary sewer pipe.



Sanitary sewer manhole behind failing sheet pile wall

3.2 Permitting Considerations

A pre-application meeting was had on December 12, 2025 to verify permitting considerations with the U.S. Army Corps of

Engineers (USACE). For wetlands and streams, the project is expected to meet the General and Regional Conditions of the U.S. Army Corps of Engineers (USACE).

- Nationwide Permit (NWP) 3 for maintenance of sewer crossings, and
- NWP 13 for bank stabilization, and
- NWP 18 for minor discharges related to the boulder cascades.

The USACE indicated that the sewer crossings, associated encasements, and boulder cascades should be permitted under separate NWPs as they are in distinct maintenance areas. The bank stabilization efforts are to be permitted under one NWP 13.



Exposed roots of large tulip poplar tree, looking upstream

4 Hydrology and Hydraulics

Effective FEMA hydrologic flows were utilized for the conditions for the 10-, 25-, 50-, and 100 -year, 24-hour storm events. Flows to be applied are provided in **Table 4**.

Table 4: Existing Conditions Peak Discharge

Starting Cross Sections	Scenario	Peak Discharge (cfs)
3972	10-year	252
	25-year	356
	50-year	445
	100-year	540
2485	10-year	283
	25-year	379
	50-year	463
	100-year	580
1008	10-year	343
	25-year	444
	50-year	538
	100-year	672

The FEMA Effective Model was reviewed and updated with recent survey data (Refer to **Section 2.1**). Obstructions were added to the channel in areas of observed debris blockages with survey elevations

and field measurements. The existing conditions hydraulic analysis was performed to analyze changes in water surface elevations and shear stresses for the 10-, 25-, 50-, and 100 -year, 24-hour storm events using HEC River Analysis System (RAS) version 6.5. One-dimensional steady-state models were developed.

The HEC-RAS model includes areas outside of our Project. Stations 3996-3487 encompass the upstream portion of study (Project Area 1 and Project Area 2) and stations 2935-2622 encompass the downstream portion of our study (Project Area 3 and Project Area 4). A comparison of results between the existing conditions and proposed conditions models at relevant cross sections are shown in **Table 5**, **6**, and **7** for each storm event.

Table 5: HEC-RAS Models Water Surface Elevation Comparison

Existing Station	Proposed Station	Existing Water Surface Elevation (ft)				Proposed Water Surface Elevation (ft)			
		10-year	25-year	50-year	100-year	10-year	25-year	50-year	100-year
3996	3972	149.64	150.36	150.91	151.48	150.25	150.95	151.52	152.05
3993	3969	148.30	148.71	149.02	149.33	148.56	148.86	149.10	149.33
3984	3961	149.58	149.99	148.55	148.73	148.66	148.88	149.04	149.19
3976	3953	149.12	149.51	149.29	149.34	149.14	149.18	149.28	149.38
3968	3945	147.17	147.51	147.72	147.88	147.11	147.43	147.64	147.82
3962	3939	148.58	149.10	149.48	149.86	148.55	149.07	149.47	149.85
3955	3932	148.46	148.93	149.26	149.59	148.37	148.83	149.15	149.47
3950	3927	148.36	148.81	149.13	149.44	148.38	148.86	149.21	149.56
3939	3916	148.55	149.07	149.47	149.85	147.82	148.25	148.58	148.91
3926	3903	147.12	147.43	147.67	147.89	147.09	147.39	147.63	147.86
3894	3871	146.49	146.98	147.39	147.75	146.51	147.03	147.38	147.76
3866	3843	145.69	146.12	146.43	146.77	145.60	146.06	146.41	146.75
3805	3782	143.79	144.38	144.86	145.39	144.05	144.75	145.40	146.07
3738	3717	143.60	144.11	144.49	144.85	144.24	144.74	144.97	145.20
3678	3658	143.26	143.78	144.18	144.55	144.19	144.69	144.91	145.12
3634	3615	143.06	143.62	144.04	144.45	144.16	144.67	144.90	145.12
3564	3545	141.14	141.55	141.84	142.16	144.02	144.54	144.75	144.96
3550	3535	138.70	139.30	139.71	140.08	143.41	143.73	144.31	144.53
3533	3520	137.61	137.99	138.28	138.57	139.62	139.93	140.16	140.43
3518	3504	137.30	137.65	137.98	138.31	137.36	137.72	138.01	138.32
3502	3488	137.41	137.90	138.18	138.48	136.69	136.96	137.18	137.41
3487	3471	135.08	135.58	135.98	136.37	135.40	135.90	136.28	136.66
3475	3461	135.02	135.37	135.66	135.97	134.89	135.26	135.55	135.84

Existing Station	Proposed Station	Existing Water Surface Elevation (ft)				Proposed Water Surface Elevation (ft)			
		10-year	25-year	50-year	100-year	10-year	25-year	50-year	100-year
3463	3449	134.40	134.81	135.13	135.47	134.15	134.48	134.74	135.00
3448	3434	133.39	133.74	134.01	134.28	133.22	133.53	133.77	134.02
3406	3392	132.55	132.86	133.09	133.33	132.51	132.79	133.01	133.22
3320	3307	130.60	131.07	131.43	131.76	130.73	131.26	131.65	132.02
3214	3200	130.20	130.76	131.23	131.72	130.23	130.82	131.27	131.72
3125	3112	129.61	130.06	130.38	130.70	129.45	129.93	130.34	130.86
3031	3018	128.87	129.54	130.02	130.48	128.93	129.65	130.27	130.95
2935	2922	128.19	128.78	129.22	129.69	128.34	129.27	129.94	130.64
2915	2903	128.12	128.63	128.98	129.38	128.07	129.04	129.69	130.41
2902	2890	128.15	128.63	128.96	129.27	127.92	128.50	128.77	129.13
2890	2878	127.92	128.50	128.77	129.13	128.06	128.70	129.06	129.45
2878	2866	128.06	128.70	129.06	129.45	127.93	128.53	128.79	129.01
2857	2844	128.05	128.47	128.72	128.91	127.16	128.05	128.47	128.89
2838	2828	128.28	128.82	129.19	129.54	127.33	127.95	128.41	128.93
2824	2814	128.28	128.82	129.19	129.53	127.33	127.95	128.40	128.91
2812	2807	127.53	127.96	128.27	128.69	127.33	127.94	128.38	128.88
2806	2798	126.12	126.73	127.19	127.63	127.34	127.96	128.41	128.92
2782	2777	126.10	126.74	127.21	127.67	127.34	127.97	128.42	128.94
2749	2745	125.94	126.55	127.01	127.45	127.30	127.91	128.36	128.87
2714	2716	125.79	126.32	126.71	127.07	127.25	127.83	128.25	128.73
2683	2681	125.84	126.41	126.82	127.21	127.09	127.65	128.04	128.54
2671	2667	124.31	125.00	125.51	126.51	126.34	126.83	127.20	128.14
2658	2657	123.80	124.37	124.76	126.09	124.01	124.50	124.92	125.37
2651	2650	123.42	123.85	124.25	126.10	122.91	123.37	123.76	124.17
2635	2634	123.20	123.54	123.85	126.12	122.89	123.07	123.22	126.14
2622	2622	122.72	122.94	123.10	126.16	122.72	122.94	123.10	126.16

Table 6: HEC-RAS Models Shear Stress Comparison

Existing Station	Proposed Station	Existing Shear Stress (lb/sq ft)				Proposed Shear Stress (lb/sq ft)			
		10-year	25-year	50-year	100-year	10-year	25-year	50-year	100-year
3996	3972	3.15	3.70	4.15	4.52	3.19	3.74	4.12	4.53
3993	3969	6.50	7.73	8.66	9.54	7.81	9.16	10.17	11.14
3984	3961	0.95	1.35	9.15	10.65	5.12	7.11	8.71	10.35
3976	3953	1.93	2.25	4.66	6.40	2.16	4.03	5.48	6.94
3968	3945	6.51	6.68	7.43	8.56	6.80	7.34	8.20	9.23
3962	3939	0.74	0.99	1.20	1.41	0.78	1.04	1.26	1.47
3955	3932	0.85	1.17	1.44	1.70	1.00	1.36	1.67	1.98
3950	3927	1.03	1.37	1.66	1.96	0.88	1.14	1.35	1.56
3939	3916	0.78	1.04	1.26	1.47	2.03	2.36	2.59	2.81
3926	3903	3.23	3.87	4.35	4.80	3.19	3.83	4.29	4.74
3894	3871	2.33	2.68	2.86	3.13	2.29	2.57	2.89	3.13
3866	3843	2.86	3.37	3.82	4.11	1.85	2.10	2.26	2.43
3805	3782	2.42	2.61	2.71	2.71	2.83	2.96	2.87	2.78
3738	3717	1.18	1.50	1.75	2.02	0.68	0.95	1.27	1.62
3678	3658	1.03	1.29	1.49	1.71	0.47	0.67	0.92	1.20
3634	3615	0.93	1.13	1.29	1.43	0.38	0.54	0.74	0.96
3564	3545	2.11	2.42	2.71	2.91	0.62	0.79	1.05	1.31
3550	3535	6.25	6.07	6.15	6.37	2.80	3.68	2.90	3.34
3533	3520	7.03	8.03	8.66	9.18	13.27	13.44	14.09	13.81
3518	3504	4.63	5.69	6.11	6.44	9.27	10.24	10.89	11.08
3502	3488	2.58	3.07	3.73	4.29	6.07	7.82	9.05	10.02
3487	3471	4.04	4.12	4.18	4.29	4.48	5.23	5.81	6.28
3475	3461	3.21	3.86	4.24	4.51	4.22	4.97	5.51	5.96
3463	3449	3.38	3.95	4.31	4.59	4.57	5.38	5.94	6.40
3448	3434	4.07	4.76	5.23	5.61	4.64	5.55	6.19	6.76
3406	3392	2.63	3.44	4.04	4.61	2.59	3.48	4.17	4.84
3320	3307	2.51	2.94	3.28	3.66	2.48	2.84	3.17	3.52
3214	3200	1.01	1.13	1.18	1.21	0.91	0.98	1.05	1.11
3125	3112	0.89	1.17	1.41	1.66	1.02	1.28	1.43	1.45
3031	3018	0.82	0.78	0.79	0.80	0.78	0.77	0.73	0.68
2935	2922	0.73	0.78	0.84	0.87	0.82	0.75	0.75	0.73
2915	2903	0.63	0.81	0.97	1.08	1.01	0.93	0.96	0.94

Existing Station	Proposed Station	Existing Shear Stress (lb/sq ft)				Proposed Shear Stress (lb/sq ft)			
		10-year	25-year	50-year	100-year	10-year	25-year	50-year	100-year
2902	2890	0.46	0.67	0.87	1.07	1.13	1.53	2.02	2.43
2890	2878	1.13	1.53	2.02	2.43	0.89	1.23	1.59	1.93
2878	2866	0.89	1.23	1.59	1.93	0.98	1.34	1.81	2.36
2857	2844	0.47	0.73	0.97	1.28	2.13	2.15	2.48	2.78
2838	2828	0.07	0.10	0.13	0.16	0.19	0.25	0.30	0.33
2824	2814	0.06	0.10	0.13	0.17	0.16	0.22	0.27	0.32
2812	2807	6.94	7.78	8.26	7.79	0.15	0.22	0.28	0.33
2806	2798	0.30	0.39	0.45	0.52	0.13	0.19	0.24	0.28
2782	2777	0.28	0.33	0.37	0.41	0.11	0.16	0.19	0.22
2749	2745	0.39	0.46	0.52	0.58	0.14	0.19	0.24	0.27
2714	2716	0.44	0.59	0.71	0.84	0.16	0.24	0.31	0.37
2683	2681	0.22	0.31	0.38	0.46	0.54	0.71	0.86	0.93
2671	2667	0.22	0.30	0.37	0.36	2.77	3.06	3.28	2.18
2658	2657	0.73	0.91	1.06	0.70	7.61	7.84	7.82	7.69
2651	2650	1.19	1.52	1.66	0.68	7.19	7.48	7.59	7.56
2635	2634	1.24	1.66	1.88	0.57	2.09	3.17	4.03	0.58
2622	2622	1.91	2.76	3.49	0.47	1.91	2.76	3.49	0.47

Table 7: HEC-RAS Models Velocity Comparison

Existing Station	Proposed Station	Existing Velocity (ft/s)				Proposed Velocity (ft/s)			
		10-year	25-year	50-year	100-year	10-year	25-year	50-year	100-year
3996	3972	9.91	11.15	12.08	12.88	9.91	11.16	12.00	12.86
3993	3969	13.14	14.84	16.06	17.19	13.47	15.16	16.36	17.49
3984	3961	5.51	6.70	15.94	17.45	11.32	13.67	15.36	16.96
3976	3953	7.08	7.93	11.20	13.19	7.48	10.26	12.08	13.73
3968	3945	12.07	12.81	13.83	15.09	12.46	13.49	14.59	15.76
3962	3939	4.84	5.77	6.46	7.10	4.98	5.92	6.61	7.27
3955	3932	5.14	6.17	6.95	7.69	5.53	6.63	7.46	8.25
3950	3927	5.56	6.59	7.38	8.13	5.11	5.99	6.65	7.26
3939	3916	4.98	5.92	6.61	7.27	7.35	8.21	8.82	9.37
3926	3903	8.86	10.04	10.88	11.65	8.77	9.95	10.77	11.54
3894	3871	8.12	9.03	9.55	10.17	8.06	8.84	9.57	10.15

Existing Station	Proposed Station	Existing Velocity (ft/s)				Proposed Velocity (ft/s)			
		10-year	25-year	50-year	100-year	10-year	25-year	50-year	100-year
3866	3843	8.84	9.93	10.79	11.41	9.41	10.39	11.05	11.69
3805	3782	11.06	11.96	12.51	12.84	12.29	13.09	13.29	13.45
3738	3717	7.96	9.26	10.20	11.12	6.28	7.58	8.86	10.12
3678	3658	7.42	8.58	9.41	10.24	5.29	6.47	7.64	8.79
3634	3615	7.09	8.08	8.80	9.44	4.80	5.87	6.90	7.92
3564	3545	7.16	7.96	8.63	9.13	4.36	5.05	5.87	6.64
3550	3535	12.94	13.36	13.79	14.32	7.79	9.15	8.44	9.17
3533	3520	13.49	14.90	15.80	16.58	15.29	16.08	16.89	17.17
3518	3504	10.93	12.52	13.32	13.98	14.98	16.40	17.35	17.94
3502	3488	8.59	9.69	10.86	11.84	12.21	14.28	15.67	16.81
3487	3471	13.50	14.29	14.83	15.39	15.13	16.92	18.22	19.32
3475	3461	11.91	13.53	14.53	15.34	13.77	15.50	16.70	17.73
3463	3449	12.42	13.94	14.92	15.74	13.89	15.65	16.85	17.88
3448	3434	13.32	14.94	16.05	16.97	14.08	15.97	17.25	18.40
3406	3392	10.94	12.88	14.24	15.47	10.89	12.96	14.45	15.83
3320	3307	11.13	12.47	13.48	14.50	11.22	12.46	13.46	14.43
3214	3200	7.08	7.79	8.18	8.52	6.69	7.27	7.70	8.12
3125	3112	6.75	7.98	8.92	9.81	7.16	8.30	8.96	9.26
3031	3018	6.35	6.46	6.65	6.84	6.21	6.42	6.47	6.46
2935	2922	5.98	6.46	6.87	7.16	6.63	6.65	6.84	6.96
2915	2903	5.81	6.77	7.53	8.13	7.48	7.54	7.86	7.99
2902	2890	5.23	6.43	7.39	8.30	8.22	9.83	11.41	12.65
2890	2878	8.22	9.83	11.41	12.65	7.54	9.06	10.41	11.62
2878	2866	7.54	9.06	10.41	11.62	7.82	9.37	10.96	12.63
2857	2844	5.50	6.91	8.07	9.32	11.37	11.82	12.88	13.83
2838	2828	2.06	2.59	3.00	3.41	3.30	3.87	4.30	4.62
2824	2814	2.05	2.61	3.05	3.50	3.12	3.79	4.29	4.68
2812	2807	7.09	7.82	8.26	8.25	3.12	3.83	4.37	4.81
2806	2798	4.12	4.82	5.33	5.81	2.88	3.52	4.01	4.40
2782	2777	3.84	4.35	4.72	5.08	2.61	3.15	3.55	3.87
2749	2745	4.57	5.18	5.62	6.05	2.90	3.52	3.98	4.34
2714	2716	4.89	5.81	6.52	7.21	3.18	3.93	4.50	4.98
2683	2681	3.51	4.24	4.79	5.31	4.18	4.93	5.49	5.83

Existing Station	Proposed Station	Existing Velocity (ft/s)				Proposed Velocity (ft/s)			
		10-year	25-year	50-year	100-year	10-year	25-year	50-year	100-year
2671	2667	3.72	4.45	5.00	5.04	7.81	8.51	9.01	7.71
2658	2657	6.08	6.94	7.64	6.56	12.45	13.21	13.60	13.87
2651	2650	7.52	8.69	9.23	6.37	13.49	14.39	14.92	15.30
2635	2634	7.75	9.21	10.02	6.12	9.69	12.16	13.90	6.17
2622	2622	9.14	11.23	12.80	5.56	9.14	11.23	12.80	5.56

Results from the existing condition model reflect observations made during site investigations. As shown in **Table 5** the stream experiences high shear stress throughout the reach, with average calculated shear stresses of 2.04, 2.87, and 3.03 lb/sq ft for the 10-, 50- and 100-year storm events respectively. Increases in shear stress occur at both sewer sanitary sewer crossings within Project Area 2 (Stations 3572-3533) and Project Area 4 (Stations 2683-2658). The results coincide with observed eroded stream banks and highlight the risk to the sanitary sewer infrastructure.

Comparison between existing and proposed conditions results in an average increase in velocity of 0.47 feet per second across the project reach for all storm events. Localized increases can be noted in the proposed boulder cascades. This is expected as the grade is much steeper than existing, however these forces are not erosive as the imbricated rock that comprises the cascade can withstand these velocities. A water surface elevation rise is noted at all storm events, with an average rise of 0.41 feet across the project reach during the 100-year storm. A maximum rise of 4.64 feet was noted at proposed cross section 3535, located within design area 2, due to the proposed grade being 5 feet higher than existing grade. This rise is located entirely on City of Alexandria property and does not affect adjoining properties. Hydraulic conditions downstream of the project area remain the same in the existing and proposed conditions. See **Appendix F** for current model parameters and detailed results.

5 Proposed Minimal Intervention

The proposed design was guided by the Project goals and objectives, including long-term stream and bank stability, and protecting compromised infrastructure. The design implements a ‘minimal stabilization’ approach to reduce disturbance to the trees and community.

5.1 Outfall Stabilization

Project Areas 1 and 2 exhibit signs of outfall instability due to erosion. In Project Area 1, riprap will be installed behind the right wingwall (looking upstream) and within the existing scour hole to protect the structure during storm events. In Project Area 2, the existing 36-inch RCP outfall will be replaced with a new precast endwall constructed in accordance with Virginia Department of Transportation (VDOT) standards. To mitigate future erosion during high-flow events, VDOT Class II riprap will be installed around the headwall perimeter. The outfalls will feature a rock façade finish to blend with the natural environment.



Example of rock façade finish for outfalls

5.2 Channel Bank Stabilization

In Project Areas 1 and 2, VDOT Class II riprap will be installed along each streambank where grading has occurred to protect the bank from future erosion. Existing riprap along the streambanks will be left in place or salvaged for re-use after grading has been completed.

In Project Area 3, following the removal of large woody debris, the banks will be regraded and stabilized using native plantings and soil stabilization matting.

In Project Area 4, the existing sheet pile wall will remain. The existing wall will be reinforced by a deadman anchoring system, which consists of a tieback buried behind the retaining wall to resist the outward force of the soil. This will improve wall stability and improve the longevity of the existing wall.

5.3 Stream Bed Stabilization

Channel blockages, consisting mostly of woody and concrete debris, occur throughout the stream and were created from erosion of the City infrastructure and channel banks. Removal of the large debris blockages in Project Areas 2 through 4 will require the realignment of the thalweg towards the center of the channel and performing grading to stabilize the channel.



Example of boulder cascade following Regenerative Step Pool Convevance Desian Guidelines

Downstream of the 36-inch outfall and sanitary sewer pipe crossing in Project Area 2, a boulder cascade will be implemented over approximately 30 linear feet. The stream elevation will rapidly drop 4 feet to tie into the existing stream elevation at 136'. A second boulder cascade will be installed in Project Area 4, downstream of the sanitary sewer pipe crossing. The cascade will extend approximately 20 feet and will lower the stream elevation 3 feet to tie into existing ground at elevation 120.94'. Boulder cascades will be constructed of strategically placed imbricated rocks, following Regenerative Step Pool Conveyance Design Guidelines, developed for the Anne Arundel County, Maryland Public Works Department.

5.4 Sanitary Sewer Infrastructure Protection

Portions of sanitary sewer pipes cross Taylor Run in Project 2 and Project 4. Both pipes will be encased in concrete. The boulder cascades, described in **Section 5.3**, will provide protection. The VDOT Class II riprap, described in **Section 5.2,** will provide protection against future scour near the concrete encasement.



Example of sanitary sewer manhole protection

Grouted VDOT Class III riprap will be used to protect the exposed sanitary sewer manhole in Project Area 3. The riprap will tie into existing bank grade at elevation 129' for approximately 38.5 linear feet.

5.5 Cost Estimate

The estimated total cost for the Project is approximately $650,000. This figure reflects the scope and complexity of the stream stabilization work, including anticipated grading, material requirements, and site-specific conditions. The estimate incorporates a 20% contingency to account for unforeseen conditions and design refinements. Additionally, a 4.3% escalation factor has been applied to account for inflation between the present and the projected midpoint of construction.

It is important to note that stream stabilization project costs can vary significantly based on factors such as project length, location, access constraints, and design complexity. The detailed cost breakdown is provided in **Appendix F**.

5.6 Construction Access and Scheduling

Multiple access points will be required for the project as the project areas span over 1,500 linear feet of stream. The Project will not be creating new paths for construction access to limit vegetation clear and disturbance to the community and park. Project Area 1 has access from the existing earthen park trail at most upstream extent of Taylor Run, at the 72-inch outfall. Minimal clearing will be required as many trees in this area have already died and fallen due to bank erosion or storm damage. Within Project Area 1 a total of 3 living trees will be impacted. Project Area 2 has access from the existing park trail and King Street with some moderate clearing of vegetation required. Within Project Area 2 a total of 3 living trees will be impacted. Project Areas 3 and 4 have access from the trail entrance near the community garden. Moderate clearing of vegetation will be required, for both of these areas a total of 2 living trees will be impacted.

The Virginia Department of Wildlife Resources (DWR) has designated no instream work between March 1 – June 30 due to general cold water species time of year restrictions. for DWR. Existing open areas adjacent to the stream have been identified for contractor stockpiling and staging to reduce vegetation impacts.

Although stream stabilization requires detail-oriented construction, implementation costs may be kept low by having contractors who specialize in stream stabilization construct the Project. Experienced construction contractors can avoid mistakes that may compromise project function and extend the Project schedule. AECOM recommends that the City requires contractors to have an appropriate amount of experience in stream stabilization, wall construction, and utility protection for bid qualification or to be deemed the responsible bidder. AECOM also recommends that a stream restoration professional or engineer of record is also recommended to be on site during construction (full time or at minimum during Project critical times) to provide supervision and timely oversite to ensure a quality product.

6 Conclusion

The Project is designed to protect vulnerable infrastructure long-term while minimizing disturbance to surrounding trees and the local community. The project encompasses four distinct areas, each targeting specific stabilization needs, including exposed sanitary sewer infrastructure, deteriorating stormwater outfalls, and actively eroding stream banks. The total estimated cost for the stabilization effort is $650,000, which includes a 20% contingency and a 4.3% inflation escalation factor.