Carsins Runs
I-95 Section 200
Stream Mitigation

PS&E Design Report

Prepared for
MDTA

REDLINE REVISION NO. 1, June 2020
Modifies Reaches 1 & 3 of the tributary to:
-lower the riffle top of bank and pool inverts by 0.5’,
-reduce the proposed BHR to < 1.2, and
-revise grading in the floodplain.
Incorporates Special Conditions and Performance Standards per USACE authorization.
Incorporates updates reflecting the results of the revised proposed HEC RAS model of the redline revisions (See Appendix I.2.).

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April 2020 updates incorporate Special Conditions and Performance Standards per the USACE authorization CENAB-OPR-MN (MDTA//I-95 - Stage II/ETL NORTHBOUND EXTENTION) 2019-60846-M48 *approved April 2, 2020 (USACE Permit), and clarify that MDTA is not seeking wetland mitigation credit from this project. Design Report and appendices also updated to reflect spring 2020 Redline 1 revisions to lower top of banks in Tributary Reaches 1 and 3 by 0.5 feet.*

May 2021 update is to revise the report to reflect that wetland credits will be sought after all, and wetland performance standards have been incorporated per MDE and USACE direction.

1.0 INTRODUCTION / MITIGATION COMPONENTS

The Maryland Transportation Authority (MDTA) proposes to construct the Express Toll Lanes (ETL) Northbound Extension Project along I-95 from north of MD 43 in Baltimore County to MD 24 in Harford County (I-95 Section 200 Project) to address safety and congestion concerns.

During development of the NEPA Environmental Assessment (EA), MDTA determined that despite significant avoidance and minimization efforts during design, the I-95 Section 200 project would have unavoidable impacts to wetlands and waterways, requiring mitigation. To mitigate for these unavoidable impacts, MDTA is using a combination of on-site, in-kind, and off-site, out of kind approaches. One of the projects proposed in the EA includes restoration of portions of the Carsins Run Mainstem upstream of Interstate 95 (I-95).

Carsins Run is a stream located within MDTA right-of-way just north of the I-95/MD 22 interchange and west of I-95, within the Swan Creek watershed (Figure 1). It is located within Section 200, although outside of the I-95 ETL Northbound Extension project area. At the time that I-95 was built, Carsins Run was channelized and given a concrete substrate. Since that time, the bottom of the concrete channel has been washed out, and portions of the concrete bank have failed. In addition, an intermittent unnamed tributary to Carsins Run, referred to as the Tributary, is actively eroding both vertically and laterally, likely due to altered hydrology resulting from the nearby Ripken Stadium development.

MDTA is the applicant for the U.S. Army Corps of Engineers (USACE) and Maryland Department of the Environment (MDE) permits and will be the responsible party for providing compensatory mitigation for unavoidable impacts to wetlands and streams associated with the proposed project. This report has been prepared in accordance with the *Maryland Compensatory Mitigation Guidance* (Interagency Mitigation Task Force (IMTF), 1994) and the *Compensatory Mitigation for Losses of Aquatic Resources; Final Rule* date April 10, 2008. This report will document and address the twelve elements required for mitigation plans per the Final Rule which include the following:

- Objectives
- Site Selection Criteria
- Site Protection Instruments
- Baseline Information
- Credit Determination Methodology
- Mitigation Work Plan
- Maintenance Plan
- Ecological Performance Standards
- Monitoring Requirements
- Long-Term Management Plan
- Adaptive Management Plan
- Financial Assurances

Figure 1. Project Site Map (not to scale)

1.1 Objectives

The following objectives are from the I-95 ETL Northbound Extension Maryland Transportation Authority (MdTA) Compensatory Mitigation Plan (JMT, 2018):

"The objectives of the compensatory mitigation include stream stabilization, enhanced stream and riparian habitat, reduced concentrations of sediment, nitrogen and phosphorus, create wetlands, and provide stable conveyance of flows through the stream channel. To meet these objections, the proposed stream restoration activities within Carsins Run include removing the existing concrete substrate, adding weir structures and riffle grade controls, planting native trees and shrubs along the banks, and replacing a failed storm drain. Within the Tributary, MDTA proposes to realign the stream, reconnect it to its floodplain at more frequent flows, create riffles and deep pools, create wetlands, and enhance riparian vegetation.

The proposed restoration activities will improve overall water quality within Carsins Run, the Ripken Tributary, and the Swan Creek watershed by decreasing the transport of sediment through bed and bank stabilization in areas exhibiting significant and continued degradation, and by increasing the volume of flood storage (which in turn decreases the velocities of high flow events and further reduces potential for erosion).

Coordination with the Maryland Department of Natural Resources (DNR) returned a record for the state listed threatened logperch (Percina bimaculata) downstream of the mitigation site, in Swan Creek. DNR indicated that all appropriate best management practices for sediment and erosion control should be stringently adhered to, to reduce likelihood of adverse impacts to the logperch.

MDTA proposed that a mitigation credit ratio of 1:1 be utilized for the stream site, as the impacted zero order stream and mainstem, matches closely in function and value with those proposed to be restored. The restoration aims to restore two channels (a tributary to Carsins Run and a portion of Carsins Run mainstem), by reducing sediment and nutrients delivered from eroding banks, provide more frequent flooding of the tributary floodplain, improving habitat and riparian vegetation, as well as improving public safety." (JMT, 2018)

The project provides up to 960 linear feet (LF) of stream restoration credit and 3,992 SF of wetland mitigation credits. These totals are based on the refined restoration design, which are slightly greater than those presented in the approved Phase II Mitigation plan (MDE 2018). The stream restoration credits include 160 LF along perennial Carsins Run and 800 LF along the intermittent Tributary. MDTA is not seeking mitigation credit for the 40 LF of proposed stream restoration on City of Aberdeen property in the upstream most portion of the Tributary nor portions of Carsins Run beyond where concrete is being removed and replaced with more natural structures. Permanent wetland impacts (3,019 SF) caused by the Carsins Run stream restoration will be replaced on-site in-kind using some of the 7,011 SF of proposed wetland creation; leaving approximately 3,992 SF of creation "to be reserved to provide mitigation credit for the Section 200 ultimate build-out." (MDE, October 10, 2018). (See Figure 1, Project Site Map, and Appendix J, Project Location Map).

The objectives for each channel are outlined below.

1.1.1 Unnamed tributary to Carsins Run (Tributary) Objectives

- Reduce excess sediment delivered downstream through bed and bank stabilization.
- Restore channel geometry to provide long term stability to minimize future maintenance.
- Reduce nutrients by reducing sediment delivered downstream and allowing the channel to access the floodplain more frequently and create or enhance hyporheic exchange.
- Improve habitat by introducing a variety of velocity / flow regimes through realignment, creating riffles and deep pools, and introducing woody material.
- Create wetlands by raising the water table, leaving slight depressions in abandoned and adjacent portions of the channel, planted with native wetland plants, and allowing flow to the access the floodplain more frequently.
- Enhance the riparian vegetation through a robust native planting plan.

1.1.2 Carsins Run Mainstem Objectives

- Improve habitat and water chemistry by removing concrete and introducing riffle grade control and w-weir structures.
- Improve public safety by replacing failed 21” stormdrain at Randolph Drive and introducing a drop structure.
- Improve bank stability and reduce potential sediment from bank erosion by replacing failed 21” stormdrain, addressing the unstable tributary inflows, and installing native plants along portions of the stream banks.

1.1.3 Wetland Creation Area Objectives

- Create wetland hydrology/hydroperiod, topography, vegetative structure and overall function.
- Create a forested wetland system that will meet the hydrophytic and diversity composition required under the standard IRT monitoring protocols for forested wetland sites.
- Reduce invasive/non-native species from colonization.

1.2 Site Selection

The following site selection efforts are from the I-95 ETL Northbound Extension Maryland Transportation Authority (MdTA) Compensatory Mitigation Plan (JMT, 2018):

“A mitigation plan was previously created in 2012 for the Section 200 ultimate build-out. A mitigation site search was conducted using GIS, aerial imagery, and field reviews. MDTA also coordinated with multiple agencies for aid in identification of existing opportunities, field reconnaissance, and assessment of sites; those agencies included USACE, MDE, the Environmental Protection Agency (EPA), the US Department of Agriculture, and the Harford County Department of Planning and Public Works. Potential on-site mitigation was identified and prioritized. This consisted of replacement of perennial and intermittent concrete-lined systems with naturalized channels, as well as replacement of impacted ephemeral ditches in-kind. However, due to the reduction in scope of the current roadway project, none of these previously identified channels are within the project area. The previous mitigation plan also included stream mitigation at Carsins Run, Grays Run, and Winters Run, all of which were considered on-site mitigation due to their locations within Section 200. Of these sites, only Carsins Run remains feasible" (JMT, 2018).

Carsins Run crosses I-95 just north of the I-95/MD 22 interchange and west of I-95 within the Swan Creek watershed. It is located within Section 200, although outside of the I-95 ETL Northbound Extension project area. This stream was channelized beneath I-95 in the 1960s. The existing stream now flows through a concrete channel and portions of the concrete bank and bed revetment have failed (See Appendix A page 16).

Based on site visits performed in February 2018, the proposed restoration area also includes an unnamed tributary originating from Ripken Stadium (Tributary) northwest of I-95 (see Appendix J for an annotated aerial image showing the existing conditions within the mitigation project area). The Stadium was constructed in 2002 primarily on what had been farmland. The Tributary is actively eroding, both vertically and laterally, likely due to the altered hydrology resulting from the Stadium development (See Appendix A, pages 2 through 13).

After a visual assessment of the area downstream of I-95, KCI determined that the impacts associated with accessing the site outweighed the benefit in potential restoration. The reach downstream of I-95 appears relatively stable and connected to the floodplain, which is forested and contains wetlands (see Appendix A, page 17).

Review of the State Department of Assessments and Taxation (SDAT) website as well as other mapping provided for the study indicates that the restoration site is located within I-95 right of way, property owned by the Maryland State Highway Administration (SHA), and property owned by the City of Aberdeen. Along the left bank of the Mainstem where the stormdrain repairs and some minor grading are proposed are privately owned and will require easements (See Appendix A page 14).

KCI performed a topographic survey, boundary survey and easement plat, utility investigation, existing conditions hydrologic and hydraulic analyses, geomorphic assessment, natural resource inventory (NRI), and restoration design, which are summarized below. Constellation Design Group (CDG) prepared the proposed conditions hydraulic analysis. The hydrologic and hydraulic (H&H) report and the Natural Resource Inventory Forest Stand Delineation Report are standalone documents included in Appendix I and Appendix E respectively.

The restoration design offers a total of approximately 960 linear feet of stream restoration and 3,992 square feet of created wetlands toward mitigation requirements for the Express Toll Lanes (ETL) project (See Section 3.0 for Determination of Credits).

This design report is part of the submittal which includes the restoration plans, construction cost estimate, construction specifications, forest conservation plan, and impact plates associated with the proposed Carsins Run restoration.

1.3 Site Protection Instrument

The Tributary portion and some of the mainstem of the Carsins Run stream restoration site is located on land owned primarily by MDTA and the City of Aberdeen. A Right of Entry Agreement will be secured with the City of Aberdeen and Ripken Baseball Academy, LLC (RBA) and the

Maryland Transportation Authority. The Agreement is a legal document that provides access to the property for construction, monitoring, and maintenance for 13 years beginning July 2020 and ending July 2033.

On the left bank of the Mainstem around the Randolph Drive stormdrain, two private property temporary construction easements will be secured. The mitigation credit total does not include any length near the storm drain, thus no protective mechanism is required. A declaration of restrictive covenants (DRC) will be placed on the MdTA ROW. Special Condition #~~14~~13 of the USACE permit requires submission of draft restrictive covenants (DRC) by June 1, 2021. Special Condition #~~15~~14 requires a completed fully executed DRC to be submitted to USACE by January 1, 2022 (USACE Permit, April, 2020).

2.0 BASELINE INFORMATION

2.1 Watershed Description

The mitigation project area is located within the Swan Creek watershed (02130706) and the nearest named waterway is Carsins Run. The drainage area to the project area is forested. The Maryland Surface Water Use Designation for Carsins Run and all its tributaries in this area is “Use I”, pursuant to which they are protected for “water contact recreation and protection of nontidal, warmwater, aquatic life” (COMAR 26.08.02.08). Per the Special Condition #15 of the USACE permit, in-stream work may not be conducted during the period of ~~March 1~~ February 15 through June 15, inclusive, during any year (USACE Permit, April 2020). Additionally, KCI reviewed Maryland’s High Quality Waters (Tier II) list to identify any Tier II waters within the mitigation project area. No Tier II waters were identified (MDE, 2010). According to the Maryland 303(d) list of impaired waterways, the Swan Creek watershed is listed as Category 5 – impaired for phosphorus and total suspended solids.

The Maryland Department of Planning, Land Use/Land Cover geographic information systems (GIS, 2011) indicated the majority of the mitigation project area, and its immediate surroundings, is classified as “Forest” (Code 41), “Low Density Residential” (Code 11), “Commercial” (Code 14), and Transportation (80).

The mitigation project area is located within the Piedmont Physiographic Province. According to a review of the *Aberdeen, Maryland 7.5’ Topographic Quadrangle* (United States Geological Survey, 2016) and other sources, the topography within the project area is moderately sloping to the east and south. Elevations range from approximately 180 feet above mean sea level (MSL) at the southern end of the project limits to 210 feet above MSL at the western end.

The Carsins Run drainage area to the upstream side of I-95 is 2,735 acres or 4.27 square miles. The drainage area to the Tributary is approximately 11.6 acres. Both the Carsins Run Mainstem and the Tributary drainage areas have minimal percent impervious (5.2% and 4.2% respectively), with forested cover of 57% and 47% respectively. While the Tributary drainage area is zoned for additional development, the presence of the Ripken Stadium deems the ultimate build out scenario unlikely.

2.2 Utilities Investigation

KCI has investigated the existing utility information for the following owners who are potentially impacted by the project: 1) City of Aberdeen, 2) Harford County, 3) Baltimore Gas & Electric (BGE), 4) Level 3 Communication, and 5) Maryland State Highway Administration (SHA). As-Builts for Ripken Stadium were provided by the City of Aberdeen, and shows the basic existing on-site utilities, including water, sewer, and stormwater management infrastructure near the Long Drive cul-de-sac circle. KCI contacted BGE for gas and electric utilities within and near the project site. Besides secondary electric at the Randolph Drive properties, additional underground electric transmission was identified at the Long Drive circle and extending to the Ripken Stadium and Marriott Hotel parking lots. The Harford County as-built plan shows a storm drain inlet between 842 & 843 Randolph Drive and a 21-inch storm drain pipe discharging at the top of Carsins Run's left bank. In addition, private septic and well records for properties 842 & 843 were obtained thru the Harford County Health Department. Information obtained from CenturyLink (Level 3 Network) only revealed underground conduits along the JFK Memorial Highway (I-95) and thus is outside the scope of the project. Review of the highway bridge as-built Contract No. NE 106 (plan sheet 25) showed a 60 foot right-of-way and the City of Baltimore's 108" raw water transmission main along the southeast side of the highway and the bridge. However, we do not anticipate conflict with this water main since the work will occur on the northwest side of the highway and the bridge. Lastly, Verizon has not responded to requests for utility information to date. Based on these available information, the existing utility locations in the plans were updated.

2.3 Natural Resources Inventory Summary

KCI performed a Natural Resources Inventory of the mitigation project area corridor in February 2018. The Natural Resources Inventory Report is contained in Appendix E and includes methodology and results of the wetland delineations and forest stand delineations, Natural Resource, Historic and Cultural Review correspondence, and literature review results including watershed and land use, topography, soils, National Wetlands Inventory (NWI) and FEMA floodplains. Mapping and supporting documentation is provided in the NRI Report Appendices.

Carsins Run, a perennial stream, flows generally southeast through the mitigation project area, through a box culvert beneath I-95, and continues outside the mitigation project area to its eventual confluence with Swan Creek (see Appendix E).

The mitigation project area also includes an intermittent tributary to Carsins Run (Tributary) as well as three ephemeral channels. The intermittent tributary originates at a headwater wetland near Ripken Stadium.

Two forest stands were identified within the original mitigation project area. A mixed hardwood forest was identified north of I-95, dominated by tulip poplar, sweetgum, white oak, pignut hickory, American beech, and red maple in the 12 to 29.9-inch size classes. Ironwood, common greenbrier, fox grape, northern spicebush, American beech, Japanese barberry, and hawthorn species are the dominant understory and shrub species. The herbaceous layer is dominated by Japanese honeysuckle, meadow garlic, multiflora rose, and Japanese stilt grass. Nineteen specimen trees were found during the field survey.

The second stand was identified south of I-95 and is a Tulip Poplar-Red Maple forest dominated by tulip poplar, red maple, sweetgum, black gum, and American beech, in the 12 to 19.9-inch size class. American beech, ironwood, fox grape, red maple, and common greenbrier are the dominant understory and shrub species. The herbaceous layer is dominated by Japanese honeysuckle, meadow garlic, multiflora rose, ironwood, Japanese stilt grass, common greenbrier, Christmas fern, and sedge species. One specimen tree was found during the field survey.

2.4 Geology

This area is underlain by Lowland Deposits. The Lowland Deposits are described as, "Medium- to coarse- grained sand and gravel; cobbles and boulders near base; commonly contains reworked Eocene glauconite; varicolored silts and clays; brown to dark gray lignitic silty clay; contains estuarine to marine fauna in some areas; thickness 0 to 150 feet." (MGS, 1968).

2.5 Habitat Assessment

KCI personnel conducted habitat assessments in the Mainstem upstream of I-95, and in all three Reaches of the Tributary following the Environmental Protection Agency's Rapid Bioassessment Protocol (RBP) as described by Barbour et al., 1999. The scoring categories are optimal (160-200), suboptimal (110-159), marginal (60-109), and poor (<60). Scores range from 108 (high end of marginal) at the downstream end of the Tributary (Reach 3), 154 (optimal) at Reach 2 in the Tributary, which is characterized by a step-pool system, and 127 (suboptimal) at the upstream section of the Tributary (Reach 1). Should the headcut move through Reach 1, its score would likely drop to marginal. The Mainstem received a score of 133 (suboptimal). The field forms are included in Appendix D.1.

All reaches scored in the suboptimal range for epifaunal substrate/available cover with the presence of woody debris and cobble. The channel flow status and frequency of riffles scored in the suboptimal range for both Tributary Reach 1 and Reach 3. Reach 1 and 3 also scored in the high suboptimal / low optimal range for channel alteration and riparian vegetative zone width, with wide forested floodplains with little observed alterations in the last 20 years.

The Mainstem scored in the optimal range for velocity/depth regime, channel flow status, frequency of riffles, and the right bank vegetative zone width. Bank stability for the right bank, vegetative protection, and riparian vegetative zone width for the left bank, scored in the marginal range.

The scores indicate that the structure of the surrounding physical habitat that influences the quality of the resident aquatic community can only partially support a viable aquatic community. The entire mitigation project area is impacted by invasive species, which limits the vegetative protection scores. The Mainstem also has residential encroachment to the left side of the floodplain (e.g. mowed lawns, culverts, etc.).

The habitat assessment points towards possibilities for successful habitat *uplift* with the restoration in Tributary Reaches 1 and 3. Specifically, improvements in: sediment deposition (by reducing fine excess sediments generated from eroding banks and mobilized bed); bank stability and vegetative protection (by stabilizing the banks and introducing native plantings); and velocity/ depth regime (by introducing stable riffles and deep pools).

2.6 Maryland Biological Stream Survey (MBSS) Data

Biological monitoring was previously conducted in the Carsins Run and Swan Creek watersheds by Maryland Department of Natural Resources (MDNR) Maryland Biological Stream Survey (MBSS) at five sites between 1996 and 2014. MBSS results are presented in Appendix D.2. Results of the MBSS monitoring in this area show a relatively healthy fish community, most sites are in the 'Good' or 'Fair' category for the Fish Index of Biotic Integrity (FIBI), and mixed results for the Benthic Index of Biotic Integrity (BIBI) with half the sites in 'Good' or 'Fair' category and the remaining half in the 'Poor' category. Fish species observed at these sites are generally pollution tolerant or species without an assigned pollution tolerance. The fish species collected most often and in the highest abundances were American Eel, Blacknose Dace, Common Shiner, Creek Chub, Rosyside Dace, and Swallowtail Shiner.

The monitoring sites on Carsins Run and Swan Creek closest to the restoration site (Carsins Run -SWAN-105-R; Swan Creek – HA-N-036-206-96) are approximately 1.5 miles upstream from and 1.0 miles downstream of the restoration site. The upstream site was sampled in 2000 and 2014 while the downstream site was sampled in 1996. Ecological condition at these two sites are in the 'Good' category for fish and mixed results for benthic macroinvertebrates. The upstream site rated 'Poor' in 2000 and 'Fair' in 2014 and the downstream site rated 'Poor' for the condition of the benthic macroinvertebrate community. Instream habitat quality assessed for fish (on a scale of 0-20; ratings of Poor, Marginal, Sub-Optimal, Optimal) was in the 'Sub-Optimal' category for the upstream site and 'Marginal' for the downstream site. Epifaunal substrate habitat quality assessed for the benthic macroinvertebrates was rated 'Sub-Optimal' at both sites.

MBSS records of Chesapeake Logperch (*Percina bimaculata*) were obtained from MD DNR and reviewed for potential impacts from this project (see map in Appendix D.2). The nearest record of Chesapeake Logperch is for the mainstem of Swan Creek downstream of Old Post Road, approximately 3.5 river miles downstream of the project area (Kilian et al, 2011; Kilian and Raesly, 2012). Chesapeake Logperch habitat is larger streams and the lowest portions of tributaries to those streams (Sauffer et al, 2016); in Maryland that is the mainstem of Susquehanna River, and the lower portions of Broad Creek, Deer Creek, Mill Creek, Octoraro Creek, and Swan Creek. In Pennsylvania, mean stream widths measured at sites with Cheapeake Logperch were 18.9 m (62.0 ft) and 15.3 m (50.2 ft), and Chesapeake Logperch were absent at upstream sites with mean widths of 14.0 m (45.9 ft) and 13.1 m (43.0 ft) (PFBC, 2015; Stauffer et al, 2016). Mean width at bankfull at the Carsins Run project is 10.4 m (34.0 ft); it is unlikely that this stream is large enough for the habitat requirements of the Chesapeake Logperch. This is supported by the absence of Chesapeake Logperch in MBSS sites between the project area and the Old Post Road site (see map in Appendix D.2).

2.7 BANCs Study

An assessment of the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) was conducted on February 14, and February 19, 2018, under flow conditions that are assumed to be slightly higher than normal following runoff events and snow melt. These assessments were performed using the BEHI and NBS methods described by Rosgen (2001). The primary goal of the BEHI and NBS assessments is to determine erosion rate predictions through the entire mitigation project area. The BANCs analysis included the Mainstem upstream of I-95 and the Tributary. The mitigation project area was divided into discrete bank reaches distinguished by an apparent change in vegetative and/or geomorphic characteristics such as bank height, root depth, root density, bank angle, surface protection, bank material, near-bank maximum depth, and mean depth. BEHI and NBS assessments were conducted on right and left banks.

The BEHI and NBS evaluations apply the U.S. Fish and Wildlife Service (USFWS) Bank Erodibility Curve as supplemented with the North Carolina Stream Bank Erodibility Curve to determine total bank erosion rates in cubic feet per year (Rosgen, 2001). A table summarizing the streambank erosion estimates and BEHI computations for the typical conditions are contained in Appendix C. See Appendix B.4. for the plan view depiction of BEHI Ratings.

Tributary Reaches 1 and 3 have 3-foot high steep banks with little surface protection and rooting depth. The bank erosion alternates with BEHI ratings of very high on the outside bends to high on the inside bends. NBS scores are estimated to be low or very low. The result is an estimated 348 cubic feet per year generated from Reach 1, and 572 cubic feet per year generated from Reach 3.

Banks on Carsins Run are typically 7 feet high and relatively steep. BEHI ratings for the left bank are mostly low due to the extensive point bar, with sections of high and extreme upstream of the point bar and at the Randolph Drive stormdrain outfall (see photos in Appendix A sheet 14). The right bank has a BEHI rating of very high upstream and high downstream. The entire Mainstem has NBS ratings of low or very low. The BANCs analysis predicts 432 cubic feet per year generated from the left bank, and 870 cubic feet per year from the right bank.

2.8 Existing Conditions Hydrology

KCI prepared the existing GIS-Hydro hydrologic model developed to represent the field verified drainage boundary of the Carsins Run watershed. A sub-drainage area and associated TR-55 analysis is also included for the Tributary to facilitate the design. The Existing Conditions Hydrologic and Hydraulics Memorandum (see Appendix I.1), documents the procedures and results of the modeling. Discharges were developed for existing and ultimate (zoning) land use conditions for the 1-, 2-, 10-, and 100-year storm events. Tables 1 and 2 summarize discharges for the Tributary and Mainstem. While the Tributary drainage area is zoned for additional development, which results in significantly increased discharges, the presence of the Ripken Stadium deems the ultimate build out scenario unlikely.

Hydraulic modeling was performed using HEC-RAS for the main stem as well as the Tributary. The modeling included an analysis of existing conditions. The study included an analysis of the existing culverts under I-95 (See Appendix I.1).

Table 1. Summary of TR-55 Discharges to Tributary

Storm	**Discharge (cfs)**	
	Existing	**Ultimate Land Use**
1-year	6.4 cfs	24.9 cfs
2-year	10.9 cfs	32.7 cfs
10-year	28.1 cfs	57.8 cfs
100-year	73.2 cfs	111.5 cfs

Table 2. Summary of TR-20 Discharges to Mainstem at I-95

Storm	**Discharge (cfs)**	
	Existing	**Ultimate Land Use**
1-year	387 cfs	391 cfs
2-year	612 cfs	617 cfs
10-year	1,366 cfs	1,374 cfs
100-year	3,207 cfs	3,215 cfs

2.9 Geomorphic Assessment

The geomorphic assessment includes visual observation, survey of representative reaches (profile, cross sections), and pebble counts. KCI stream restoration specialists conducted detailed fluvial geomorphic assessments within two sub-reaches of the Tributary and the Mainstem, according to the methods described in Stream Channel Reference Sites: An Illustrated Guide to Field Technique (Harrelson et al., 1994). Note that a number of runoff events (rain and snowmelt) resulted in relatively saturated and wet conditions while on site performing the assessments. Appendix A contains existing conditions site photographs and Appendix B contains the existing conditions geomorphic survey output including the cross sections and pebble count output for Reaches 2a, 3, and Carsins Run Mainstem, and profiles for the Tributary Reaches 2a and 3. Reach 3 is representative of Reach 1 and Reach 2a is representative of Reach 2b. Appendix B also contains an *Assessment & Geomorphic Features Reference Map*, indicating the location of the cross sections, reach breaks, BEHI reaches with ratings, and mainstem features including the point bar, observed concrete lining, and failed stormdrain outfall.

2.9.1 Tributary

The Tributary is a zero order intermittent channel. The channel is unstable due to relatively steep valley slopes along with altered hydrology (due to development in the headwaters). Multiple waves of headcuts have moved through the system, resulting in an incised, unstable, actively eroding channel (see Appendix A, pages 2 through 13). The Tributary was divided into three reaches for geomorphic assessment.

Reach 1, the upstream most reach, begins at a knick point just downstream of a confluence of two shallow riprapped channels (see Appendix A, pages 12 and 13). The reach continues downstream for approximately 220 linear feet to a debris jam and 2-foot deep headcut. Reach 1 classifies as a Rosgen F4b channel. Rosgen F4b channels are considered unstable. The channel is completely disconnected from the surrounding floodplain and has moderately eroding banks. The anticipated upstream movement of the headcut through the reach would result in further bed and bank erosion.

Reach 2 is a 200-linear foot step pool reach at a nearly 6% slope that appears stable with good habitat (see Appendix A, pages 9 through 11). This reach classifies as a Rosgen A4. Reach 2 is further subdivided for assessment into Reach 2a (upstream) and 2b (downstream). Reach 2a is very stable and will be used as a reference reach for the steeper Tributary reaches proposed for restoration (proposed Reaches 2a, 2b, and 4). This reach will be preserved rather than restored. *Note, that in the proposed design, the naming is modified such that Reach 2a represents an* *upstream proposed step pool reach that transitions into Reach 2-no action (stable reach), then to Reach 2b, proposed step pools.* The largest particles measured in this reach are less than 19 inch intermediate diameter and were observed to have moss growing on them. This suggests that the small boulders appear to be stationary and withstand the shears and velocities under a range of flows. The downstream end of Reach 2, Reach 2b, shows minor bank erosion and aggradation and will be restored as part of the mitigation work (see Appendix A, page 8).

The surveyed reach within Reach 3 has a bankfull discharge based on the geomorphic survey of 6 cfs. This correlates to the discharges determined by the regional regression equations discussed in Section 2.8.3. The full channel to the existing top of bank conveys approximately 200 cfs, which is more than the existing 100-year discharge and nearly 10 times the predicted ultimate 1-year discharge. Reach 3 classifies as a Rosgen F4b with a 2.2% slope, and a width to depth ratio (w/d) of 25. Reach 3 is vertically and laterally unstable with multiple observed headcuts and actively eroding raw banks (see Appendix A, pages 2 through 7). This reach has tortuous meander geometry, with radii of curvatures (Rc) between 1 and 1.5 times the bankfull width (where stable channels in this region typically have Rc between 2 and 3 times bankfull width). The channel is no longer connected to the surrounding floodplain with a high bank height ratio (BHR) of almost 6. The BHR is the low bank height divided by the bankfull maximum depth and is a measure of floodplain connectivity and potential for hyporheic exchange.

2.9.2 Carsins Run Mainstem

The geomorphic evaluation for the Mainstem includes the approximately 400 linear feet upstream of the I-95 crossing. Carsins Run classifies as a Rosgen B3c/F3 channel with a slope less than 1%, a width to depth ratio of 35 and an entrenchment ratio of 1.6. Field run topographic survey gathered the cross section and longitudinal profile data including flagged geomorphic features. Representative existing condition photographs are included in Appendix A, pages 13 through 17.

There are various areas where broken slabs of concrete still exist in the channel (see Appendix A, page 16). A number of unstable inflows discharge into the Carsins Run study Reach: the severely eroded outfall from Randolph Drive on the left, the Tributary *forks* on the right, and the roadside drainage ditches adjacent to I-95 upstream and downstream – left and right.

The upstream extent of the Mainstem Reach is just upstream of the Randolph Drive cul-de-sac. Here, a deteriorated 21” stormdrain pipe with large sinkholes discharges on the left bank causing significant scour and bank erosion (see Appendix A, page 14). There is a patch of bamboo on the left terrace behind a residence upstream of the stormdrain pipe.

Downstream of the stormdrain outfall, a well-defined point bar established on the left provides good bankfull stage indicators. The point bar extends downstream and likely covers portions of existing concrete lining the channel.

The survey indicates presence of more than 4,000 square feet of concrete-lined bed and banks. However, the observed depositional features (i.e. point bar) suggest that the concrete could extend beyond the area surveyed. KCI obtained the December 10, 1963 as-builts for the Northeastern Expressway (File H-X856C.pdf, contract No. NE 106). The plans indicate that Carsins Run was relocated upstream of I-95. The as-builts indicate 185 linear feet of channel restoration and 200 linear feet ‘stream bed paving’ (width 31 feet). Based on field measurements of observable concrete, the depth is approximately 3 to 5 inches. It is assumed that the streambed paving is the concrete lined portion of channel. Based on the plan dimensions and field observations, an estimated 80 cubic yards of concrete lines the bottom of Carsins Run upstream of I-95 within the limits of the proposed work. The as-builts do not depict cross sections to reflect the side slope or bank portions of the concrete lined channel. The roadside concrete ditches (type I and type II) noted on the plans, are not being addressed as part of this mitigation project. No test pitting is being performed under the design contract. Verifying and computing the extents and quantities of concrete will be the responsibility of the Contractor.

Geomorphic Survey Summary

The following tables provide summaries of the geomorphic assessment as described above. The geomorphic parameters of the Tributary Reach 3 are representative of those observed in Tributary Reach 1. Table 3 provides geomorphic parameters and Rosgen Stream Classification. Tables 4 and 5 provide select hydraulic parameters including shear stress, velocity, and Froude number reflecting bankfull and top of bank conditions respectively. Table 6 summarizes the material distributions for each representative reach. The Tributary Reach 2a and the Mainstem sections are used as templates for proposed conditions. Reach 3 is an unstable section.

Table 3. Rosgen Classification and Bankfull Dimensions

Reach	Width (ft)	Mean Depth (ft)	Max Depth	Area (ft^2)	W/D	Ent. Ratio	Slope (%)	BHR	Stream Type
Trib Reach 2a	3.9	0.4	0.6	1.5	9.8	1.4	5.6	3.4	A4
Trib Reach 3	7.6	0.3	0.5	2.3	24.7	1.1	2.2	5.9	F4b
Mainstem	38.9	1.1	2.3	44	34.5	1.6	0.87	4	B3c/F3

Table 4. Select Hydraulic Parameters at Bankfull Stage

Reach	Est. Bankfull Q (cfs)	Shear Stress (lb/ft2)	Threshold Grain Size (mm)	Velocity (ft/s)	Froude No.
Trib Reach 2a	6.1	1.26	62	4	1.17
Trib Reach 3	6.1	0.41	20	2.6	0.84
Mainstem	172.3	0.6	30	3.9	0.66

Table 5. Select Hydraulic Parameters at Top of Bank (TOB)

Reach	Q TOB(cfs)	Max. Depth (ft)	Shear Stress (lb/ft2)	Threshold Grain Size (mm)	Velocity (ft/s)	Froude No.
Trib Reach 2a	94.5	2	3.89	191	9.2	1.66
Trib Reach 3	205	2.9	2.08	102	7.7	1.1
Mainstem	5494	9.2	2.9	143	11.2	0.85

Table 6. Material Distribution for Riffles

Reach	D50 (mm)	D84 (mm)	D95 (mm)
Trib Reach 2a	34	86	150
Trib Reach 3	25	70	90
Mainstem	73	170	250

2.9.3 Design Discharge (bankfull) Determination

Bankfull discharge characterizes the flow that is effective in shaping and maintaining a stream. Over time, geomorphic processes adjust the stream capacity and shape to accommodate the bankfull discharge within the stream. Bankfull discharge is a critical piece of data used for several assessment parameters. Bankfull discharge is also used in natural channel design procedures as a scale factor to convert morphological parameters from a stable reach of one size to a disturbed reach of another size. It is broadly accepted within stream restoration science that the bankfull condition typically occurs between the 1- to 2-year recurrence intervals in non-urban watersheds, and that urbanization causes recurrence intervals to shorten to values close to 1 year, and sometimes less than 1 year.

Calibration of field determined bankfull stage and discharge is especially important in actively eroding channels with little to no identifiable bankfull indicator, such as the Tributary Reach 3. In addition to the TR-55 and TR-20 hydrologic analyses, KCI also used the Maryland Hydrology Panel regional regression equations (MSHA, 2016) to calibrate the geomorphic survey. The drainage areas and their percent forest and impervious cover were input into the Maryland Piedmont Blue Ridge 2016 regression equations. The table below summarizes the regression equations input and output for both the Mainstem and Tributary. Note that the Tributary drainage area falls outside of the statistically valid range for the regression equation (the drainage area, which is only 11.6 acres, is smaller than those used in the data set).

For the Tributary, design discharges were selected based on the TR-55 1-year discharge estimates, which are corroborated by the field determined bankfull discharge and the 1.5-year discharge estimated using the Hydrology Panel regression equations (see Tables 1 & 7). The Mainstem bankfull design discharge is based on the field run survey of a cross section (see Table 4 and Appendix B) which is most similar to the 1.25-year discharge estimate from the Hydrologic Panel (Table 7). Table 8 summarizes the design discharges used to establish proposed channel dimensions.

Table 7. Regional Regression Discharge Summary

Location	Impervious Acre (%)	Forest Cover (%)	Lime (%)	Drainage Area (mi^2)	Q1.25 (cfs)	Q1.5 (cfs)	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
Tributary	4.22	47.18	0	0.02	4.0	6.0	9.6	44	177
Mainstem	5.18	57.02	0	4.27	197.5	269.5	381.4	1236	3790

Table 8. Summary of Design Discharges

Frequency	Tributary	Mainstem
'Bankfull'	6.4 cfs	187 cfs
2-year	11 cfs	612 cfs
10-year	28 cfs	1,366 cfs
100-year	73 cfs	3,207 cfs

3.0 DETERMINATION OF CREDITS

The Carsins Run Mainstem provides 160 LF of perennial stream mitigation credit and the tributary provides 800 LF of intermittent stream mitigation credits at a 1:1 ratio as documented in the Approved Phase II Compensatory Mitigation Plan for the I-95 ETL Northbound Extension, nontidal Wetlands Permit #18-NT-0086/201860368, (JMT, 2018). The total length (960 LF) has increased from the original total length documented in the Approved Phase II Compensatory Mitigation Plan (840 LF) due to the additional work proposed on the Mainstem and changes to the restoration plan along the Tributary. The 800 LF of intermittent stream mitigation and 160 LF of perennial stream mitigation does not include the upper portion of the Tributary on City of Aberdeen property, or a middle segment of the Tributary that will not be restored due to its good existing condition. Similarly, the perennial stream mitigation credits only reflect the portion of channel where the concrete is being removed and the riffle grade control and W-Weir are being added, but does not include the isolated portions upstream where improvements include creation of a scour pool, replacement of stormdrain, and upstream placement of riffle grade control.

Up to 7,011 SF of incidental wetland creation is also proposed. Temporary wetland impacts caused by the Carsins Run stream mitigation will be replaced on-site in-kind using this wetland creation; after subtracting that amount (3,019 SF), approximately 3,992 SF of creation is anticipated to be available for mitigation credit.

MITIGATION WORK PLAN

The accompanying plan set depicts the existing and proposed conditions including, but not limited to: plan and profile, typical sections and details, erosion and sediment control plan, sequence of construction, and landscaping plan with planting notes, sections and details.

3.1 Tributary

The proposed Tributary is divided into four segments. The reaches follow the division applied in the assessment with Reach 4 added for the proposed step pool reach at the downstream end of the Tributary. Reach 2 is split into three segments: an upstream reach (Reach 2a), a middle stable reach, and a downstream reach (Reach 2b). The middle reach corresponds to the stable portion of Reach 2 in the assessment phase where no restoration is planned. The proposed restoration uses modified natural channel design methodology to reconnect the Tributary Reach 1 and Reach 3 channels with the floodplain at more frequent flow events by raising the channel invert. A Rosgen B3(C3) channel is proposed to produce a stable channel through the relatively steep valley topography. The proposed design, raises the channel invert and proposed water table, while protecting the steep valley from rill or gully formations by providing rough grading, and protecting the steep valley from rill or gully formations by providing rough grading, and strategically placing clay and woody debris plugs. The channel will be realigned to provide a stable sustainable system. This approach provides opportunities for wetland creation in oxbows left from the abandoned meander bends. Reaches 2 & 4, with steeper average slopes (6 to 6.5%) will be stabilized using rock step pools. The stable step pool reach (existing Reach 2a and proposed Reach 2), is used as a reference reach to apply to the steep Tributary restoration reaches (Reaches 2a, 2b, & 4). In order to ensure stability of the channel bed and banks throughout the project, various treatments have been designed and include: riffle grade control with sills; woody toe protection; toe boulders with bioengineering; step pools; and, proposed landscaping. Table 9 below defines the reaches by proposed baseline (centerline) stationing and summarizes the general design approach for each.

Table 9. Tributary Reach Summary

Reach Name	Channel Type	Beginning Station	Ending Station
Reach 1	Riffle-Pool; B3	20+00	21+95
Reach 2a	Step Pool System	21+95	22+27
No Action, Stable	Step Pool System	22+27	23+23
Reach 2b	Step Pool System	23+23	24+28
Reach 3	Riffle-Pool; B3	24+28	27+37
Reach 4	Step Pool System	27+37	29+37

4.1.1 Tributary Cross Section

Proposed cross section templates were developed using Mecklenburg (Mecklenburg, 2006) to evaluate geomorphic dimensions, relationships and evaluate hydraulic parameters. These are presented in Appendix F and are summarized below in Tables 10a through 10c. For Reaches 1 & 3, meandering B3 Riffle – Pool Systems, the proposed channel dimensions were developed based on the range of common design dimensionless ratios for stable C4/B4 streams as summarized in Harman et. al, 2012. The B3 system is designed to be moderately entrenched. For the Reaches 2 & 4 Step Pool System, the proposed channel dimensions are based on the surveyed reference reach (Reach 2a). Pools are designed to have cross sectional areas at least 30% larger than the riffles to help dissipate energy. Tables 10a through 10c below summarize the Tributary design cross section parameters and select hydraulic parameters for the bankfull stage and at the design top of bank (TOB).

Table 10a. Proposed Tributary Cross Section Parameters at Bankfull Stage

Reach	Width (ft)	Mean Depth (ft)	Max Depth (ft)	Area (ft^2)	W/D	Slope (%)
Reach 1 and 3	6.0	0.3	0.5	2.0	18.0	3.1 to 3.5
Reach 2a, 2b, and 4	5	0.5	0.8	2.7	9.5	6.5

Table 10b. Proposed Tributary Hydraulic Parameters at Bankfull Stage

Reach	Discharge (cfs)	Shear Stress (lbs/ft^2)	Threshold Grain Size (mm)	Velocity (ft/s)	Froude Number
Reach 1 and 3	6.2 to 6.4	0.63	31	3.1	0.96
Reach 2a, 2b, and 4		2.01	99	2.4	0.6

Table 10c. Proposed Tributary Hydraulic Parameters at Top of Bank

Reach	Feature/ Location	Discharge (cfs)	Width (ft)	Max Depth (ft)	Shear Stress (lbs/ft^2)	Threshold Grain Size (mm)	Velocity (ft/s)	Froude Numbe r
Reach 1 and 3	Riffle	6.2	6.0	0.5	0.63	31	3.1	0.96
	Pool	-	8.5	2	0.82	40	-	-
Reach 2a, 2b, and 4	Crest	11	6	1	2.51	123	2.8	0.6
	Pool	-	7	2	1.47	72	-	-

4.1.2 Tributary Profile and Planform

The planform alignment particularly for Reach 1 and Reach 3 was designed to provide a stable plan form geometry with radii of curvature and pool to pool spacing based on acceptable ranges for B4/C4 channel types relative to the proposed bankfull width (Harman et. al, 2012). The average slope through Reaches 1 & 3 is approximately 3.1 to 3.5%. Rc is typically 18’ or three times the bankfull width. The riffles are short and steep. The proposed alignment avoids the existing wetlands and specimen trees (except for Ash trees, and a red oak that will be removed within the LOD), and minimizes grading impacts to saved trees.

4.1.3 Proposed Hydraulic Analyses

To assess the 100-year water surface elevations in the Tributary and Mainstem, and evaluate hydraulics of the proposed condition, a HEC-RAS model was developed using the proposed surface. As previously mentioned, the ultimate build out scenario is unlikely, therefore the existing conditions hydrology is used to evaluate shears and velocities for the proposed design to determine specified rock sizing and other bed and bank treatments. The ultimate build out hydrology was used to compare the 100-year water surface elevations in the Tributary and Mainstem. Appendix I.2 contains the proposed HEC-RAS model and report, which summarizes results, compares existing to proposed conditions, and describes the modeling approach, boundary conditions, and assumptions.

The results of the model indicate that the proposed condition will not increase water surface elevations of the 100-year on private properties. Proposed velocities for the 2-, and 10-year modeled flows generally decreases. Shear stress decreases and increases in sections. The proposed bed and bank treatments have been specified to resist the proposed velocities and shear stresses as discussed below.

4.1.4 Stone Sizing

The HEC-RAS model results along with professional judgement and existing reference reach conditions were used for sizing the material. Generally, the highest shears and velocities for a given reach are evaluated over a range of flows (bankfull, 2-, 10-, 100-yr existing discharges) to determine minimum stone sizes to provide stability and resist predicted velocities and shear stresses. A summary of proposed stone sizes are presented in Table 11a and 11b. Equations, distribution calculations, and stone size computations can be found in Appendix G. In addition to the treatments listed below, graded banks not receiving other treatments and the surrounding area outside of the channel will receive natural fiber matting and temporary seeding for immediate stabilization. Natural fiber matting can withstand shear stresses up to 2 lb/ft^2 and velocities of up to 8 ft/s. All stone shall be in accordance with MSHA 901.02.01 and as noted below and in the Contract Documents.

Stone Sizing by Shear Stress and Velocity

Shear stress and velocity over a range of flows are evaluated to determine the type of treatment and size rocks for long term stability. For each reach the 1-, 2- and 10- and 100-year shear stress and velocity values as computed using HEC-RAS are examined to determine the minimum stone size to withstand the maximum shears and velocities. The shear stresses are used to size the boulders for the step pool crests and sill grade control structures, and the bed material mixes used in the riffles. The velocities are used to evaluate bank treatments and size the toe boulders. The Riffle Grade Control Material (RGC Mix) is determined to be well-graded and resist the calculated shear stress for the channel reach using the Colorado Curve from Figure 11-11 of the Part 654 Stream Restoration Design National Engineering Handbook (USDA, 2007). The D_{max} determined using the Colorado Curve, is set as the D_{84} and then a well graded mix is developed around this value. A description of the protection measures and restoration features are described below.

Table 11a. Summary of Computed Stone Sizes

Material	Location	Application	Computation Method	Computed Value
Type I Boulder	Tributary Reach 1 and 3	RGC Sills, Toe Boulders	Maximum Channel Shear / Maximum Channel Velocity	4.72 lb/ft^2 9.08 ft/s
Type II Boulder	Tributary Reach 2 and 4	Step Pool Crests	Maximum Channel Shear	9.0 lb/ft^2
Key Stone Type III Boulder	Tributary Reach 2 and 4	Step Pool Crests	Maximum Channel Shear	9.0 lb/ft^2
Imbricated Class III	Mainstem	W-Weir	2 year Shear to Approximate Bankfull (USDA, 2007)	4.58 lb/ft^2
RGC Mix	Tributary, Mainstem	RGC with Sill, RGC Mainstem, Pool Pavement	Maximum Channel Shear**	3.86 lb/ft^2

**10-year maximum shear in Tributary

Table 11b. Summary of Specified Stone Sizes

Material	**Location**	**Application**	**Required Rock Size (ft)**	**Specification**
Type I Boulder	Tributary Reach 1 and 3	RGC Sills, Toe Boulders	1.3, 1.6*	Select Class II Riprap with Min. Intermediate (B) Axis of 1.5’ to 2.0'
Type II Boulder	Tributary Reach 2 and 4	Step Pool Crests	2.1	Select Class II/III Riprap with Min. Intermediate (B) Axis of 1.9' to 2.4’
Key Stone Type III Boulder	Tributary Reach 2 and 4	Key Stone Boulder in Step Pool Crests	2.8	Select Class III Riprap with Min. Intermediate (B) Axis of 2.5’ to 3.0'
Imbricated Class III	Mainstem	W-Weir	3.5	Imbricated Class III blocky in shape with Int. (B) Axis of 3.5’ to 4.5’; Minor (C) Axis 1.5’ to 2.2’; Major (A) Axis 4.5’ to 6.0'
RGC Mix	Tributary & Mainstem	RGC with Sill, RGC Mainstem, Pool Pavement	D_{84}=16”	D_{50}= 9.5”; D100= 18”. May be comprised of 80% Class I Riprap; 20% Class II Riprap; chinked with Class 0; Depth 19”

*1.6 is resulting size with 1.2 factor of safety for the 100 year. Specified Rock sizes deemed sufficient.

Tributary Reach 1 & 3

To ensure stability a combination of bed and bank treatments is proposed. The bed material mixes will provide additional substrate for potential habitat colonization, as well as protecting the channel from erosion. Bed material mixes include Channel Sand and Gravel for the pool material and RGC Mix for the riffles. The outer banks in the pools will be revetted with woody toe protection or toe boulders with bioengineering. This will improve the RBP categories of velocity/depth regime, channel flow status, frequency of riffle, and bank stability to closer to the optimal range. The boulders used in the sills are sized such that the specified D_{50} withstands shear stresses and velocities up to the existing 100-year discharge to ensure long-term stability. The riffle grade control mix is sized such that the materials larger than the D_{84} will withstand shear stresses and velocities up to the exiting 100-year discharge.

Riffle Grade Control with Sill

Riffle grade control (RGC) structures with a boulder sill are placed in each riffle throughout Reaches 1 & 3. Except for the 100-year shear stress at HEC RAS Section 896.36 baseline station 20+50 in Reach 1, all shear stresses in Tributary Reaches 1 and 3 are less than 4.0 lb/ft^2 such that a boulder with an intermediate diameter of 1.5 feet would remain stationary. The maximum existing 100-yr shear stress at HEC RAS Section 896.36 baseline station 20+50 in Reach 1, is 4.72 lb/ft^2 resulting in a minimum D_{50} of 1.6 feet given a critical shear stress of 0.03 and a 1.2 factor of safety. The boulders used to create the downstream sill at each riffle shall be select Type I Boulders with a minimum intermediate diameter of 1.5 feet. The RGC Mix is sized to withstand the next highest maximum shear stress found in Reach 1 and 3, 3.86 lb/ ft^2. The RGC Mix will be placed upstream of the sills throughout the bed and along the banks of the riffle. The RGC Mix for the Tributary has a D_{84} of 16 inches and D_{100} of 18 inches (see Appendix G and Contract Documents). This can be comprised of approximately 80% Class I Riprap and 20% Class II riprap. Chinking with Class 0 riprap and a channel sand and gravel washed into each RGC structure will help fill the interstitial voids and seal the bed.

Pool Material – Channel Sand & Gravel

The Pools in Reaches 1 & 3 will be backfilled with the Channel Sand and Gravel Mix (see Contract Documents) to provide substrate diversity for improved species composition. The same material will be used as the wash-in for the riffle grade control structures to fill interstitial voids and prevent subsurface flow.

Woody Toe Protection

Woody Toe Protection (TW) consists of stacked trunks, limbs, and other large woody material placed at a 30 degree angle to the flow at the pool's outer bank toe of slope. The woody material is placed to a depth at which it will remain wet to avoid rotting of the material. A reinforced natural fiber matting soil lift is placed on top of each woody material lift until the desired bank height is achieved. The lift is planted with live stakes. The dead woody material will provide bank stability through the submerged bank during base flow, and the live branches will re-sprout to provide an adaptable, living form of bank protection during storm flows and replenish materials that may break down over time in the upper layers of woody material. The entire structure also promotes aquatic organism habitat and carbon uptake, which will increase the RBP epifaunal substrate score of the Tributary from suboptimal to optimal. Based on performance monitoring for various projects, the woody toe protection appears to be stable over time and over a range of flows, including 500-yr plus events. Woody Toe Protection is proposed in all outer meander bends in Reaches 1 & 3, except for those where cut needs to be minimized to protect specimen trees or other natural resources.

Toe Boulder with Bioengineering

Toe boulders are used in outer bends where cut needs to be minimized to protect specimen trees or other natural resources. Boulders sized to withstand maximum velocities are placed below grade and along the toe of the outer bends. Bioengineering stabilizes the banks above the toe boulders through the use of reinforced soil lifts, and live stakes. Reaches 1 & 3 have a maximum velocity of 9.99 ft/s estimated to occur during the 100-year storm event at HEC-RAS station 896.36 (baseline station 20+50 in Reach 1). According to the Ishbash equation, the minimum stone toe diameter equates to a 1.42 feet diameter stone (Appendix G). The Type I Boulder with an intermediate diameter of 1.5 feet will be stable. Type I Boulders have been designated for use in all Toe Boulder structures as indicated on the plans. Toe Boulders shall be selected to have minimum dimensions as shown on the plans.

Tributary Reach 2&4

Step Pool System

Step pools are used to provide energy dissipation and channel stability over steep slopes. They consist of a series of crests, each followed by an inline pool lined with appropriately sized riprap (pool pavement), with another crest at the downstream extent to provide grade control. Step pools are proposed in Reaches 2 & 4 where proposed average slopes are between 6% and 7%. Rather than using Imbricated Riprap, Select Type II Boulders and Keystone Type III Boulders are placed to mimic the reference step pool reach. The highest shear stress found in Reach 4 for the 100-year discharge is 8.95 lbs/ft^2. The resulting minimum stone size based on a critical shear stress of 0.05 range is 1.8 feet. If the critical shear stress of 0.05 is applied to the reference step pool reach, where at HEC RAS section 713.14 the 100-year shear stress is 8.21 lb/ft^2, the resulting minimum stone size is determined to be 1.7 feet or 20 inches. The stable reference reach was observed to have 15 to 19 inch intermediate diameter stones with moss growing on them. This suggests that the small boulders in the step pool reach will remain stationary and withstand the existing shears and velocities under a range of flows. The Type II Boulder is specified to have an intermediate axis dimension ranging from 1.9' to 2.4'. The Key Stone Type III Boulders will be sized with intermediate axis dimension ranging from 2.5' to 3.0'.

Between the crests, the pools are lined with the RGC Mix extending to the top of bank. Based on the reference reach, this size material should be stable under the proposed conditions.

4.1.5 Created Wetlands

The Tributary channel realignment and raised invert provides opportunities for wetland creation in oxbows left from the abandoned meander bends. Rather than filling these channels evenly with the proposed surrounding grades, the channels will be only slightly graded to create very rough undulating topography (microtopography). Microtopography features create mounds or berms outside of the belt width of the proposed channel to add roughness and low elevation diversity to the floodplain area. The created wetlands are proposed in Reaches 1 and 3 where the channel and surrounding topography is relatively flat. Though the Tributary is classified as intermittent, there are significant groundwater inputs to supplement the surface water hydrology.

The upstream created wetland areas within Reach 1 are planned in the DcB soil mapping unit, which is dominantly covered by the Delanco soil series. Typical pedons in this series have thirteen inches of silt loam textured soil underlain by silty clay loam and clay loam. These finer textures lower in the soil restrict water movement through the lower layers, which is conducive to creating wetland hydrology and hydric soils. Grading this soil down 6 inches and giving more hydrologic inputs from the stream will provide this soil the conditions necessary to form hydric conditions. There is an existing large wetland in the headwaters of Reach 1 in an area within the same soil mapping unit indicating a strong likelihood that created wetlands will be successfully supported.

The other created wetland areas are proposed in Reach 3 in the AdB soil mapping unit, which is dominantly covered by the Aldino soil series. This series typically has fourteen inches of silt loam underlain by silty clay loam and a fragipan. Fragipans are extremely water restrictive, so they can locally perch the water table if the surface soil is fed by surface runoff or flooding from streams. Grading this soil down by an average of 6 inches, adding hydrologic inputs from the stream, and microtopography to prolong the residence time of surface runoff will contribute to creating hydric soil conditions. The clay enriched layer and the fragipan will make the proposed hydrologic inputs and microtopography more effective.

The proposed grading within the created wetlands will allow for the water table to be within 10 inches (25 cm) of the ground surface at a minimum frequency of 5 years in 10.

4.2 Carsins Run Mainstem

The proposed mitigation approach for the Mainstem is to remove the concrete within the channel and replace with structures that are more natural to provide long term stability and improved habitat conditions.

Just upstream of the culvert under I-95, a W-Weir will be constructed. This will direct flow to the center of each culvert, while also protecting the bed and banks from erosion. Other areas where broken concrete is providing grade control, riffle grade control structures will be used. The proposed structures will provide grade control and bank protection for long-term stability. The W-Weir will improve habitat by creating scour holes and eddies to improve the velocity / depth regime. The riffle grade control structures provide habitat and grade control. The structures are sized to the bankfull elevation as determined through the geomorphic survey.

Realignment is not proposed in the Mainstem as there are too many surrounding constraints with not enough benefit to do mass grading. There are two inflows into the right bank, where the Tributary currently forks and traverses over the steep existing Mainstem right bank. These 'forks' are both unstable. The upstream fork will be abandoned and the downstream fork will be stabilized with rock step pools (proposed Reach 4). Grading on the right bank is proposed in two areas where the Tributary inflows are being modified (abandoned upstream and step pools downstream). However, due to the amount of earthwork and disturbance to existing trees required to reduce the bank angle, the remainder of the right bank will be left in its current condition.

4.2.1 Proposed Drop Structure to Replace Stormdrain

There is an existing 21" reinforced concrete pipe (RCP) conveying storm water from the inlet at the Randolph Drive cul-de-sac to the Carsins Run Mainstem. The RCP pipe is approximately 192-feet long at 6% slope. The invert of the stormdrain hangs approximately nine feet above the stream channel without any end section or headwall, which is causing significant bank erosion (see photo page 14 of Appendix A). There is an existing sink hole developed near the downstream end of the pipe. The cause of the sinkhole was found to be leaking at the connections. The pipe is comprised of multiple 12-foot long pipe sections, and the leaking is occurring 12 feet upstream of the last section of pipe. The rest of the pipe is in good condition based on the visual inspection.

To prevent further bank erosion and sink hole development, the last section (12 feet) of the pipe is proposed to be removed and replaced by a drop manhole and a 24-foot long RCP pipe at 0.5% slope. The drop manhole will apply the Maryland Department of Transportation State Highway Administration Standard Drop Manhole MD 383.11 detail with modifications to the top slob. Specifically, the top of the drop manhole is proposed to be modified with a flat concrete slab to accommodate the adjacent existing ground and reduce protrusion. Approximately 36-foot long of the existing 21" RCP pipe upstream of the proposed manhole will be removed for the installation of the drop structure. Structural sheeting will be used for assisting the installation to protect the adjacent private properties. This standard drop manhole was designed to accommodate water drop up to 24 feet. The 24-foot level RCP pipe is proposed to convey water from the drop manhole to the pool downstream proposed at the Carsins Run Mainstem. A standard type C endwall for a 24" pipe is proposed at the downstream end of the pipe to protect the stream bank. The endwall will be using the detail of Maryland Department of Transportation State Highway Administration Standard Type C Endwall Concrete Round Pipe MD 354.01. The outlet of the pipe and the flow path to the pool will be stabilized using riprap. See Appendix K for storm drain computations.

4.2.2 Mainstem Cross Section

The Mainstem cross sections blend to existing grades, with minor grading to shift the thalweg to reduce bank erosion where appropriate. Proposed grades and existing/proposed cross sections are presented in the Contract Plans. Table 12 below summarizes the approximate Mainstem design cross section parameters reflecting a bankfull discharge of 187 cfs (see Appendix F for proposed section as determined in Mecklenburg and Contract Documents for actual proposed grades and dimensions).

Table 12. Mainstem Design Cross Sections

Reach	**Feature/ Location**	**Slope (%)**	**Width (ft)**	**Mean Depth (ft)**	**W/D**	**Max Depth (ft)**	**Cross Section Area (ft^2)**	**Froude Number**	**Shear Stress (lbs/ft^2)**	**Velocity (ft/s)**
Mainstem	Riffle	0.87	32.0	1.4	23.3	2.0	44.0	0.64	0.73	4.2
	Pool	2.2	36.0	2.0	17.9	3.0	72.5	-	2.71	-

4.2.3 Mainstem Profile and Planform

The proposed design does not change the existing longitudinal slope nor the plan form for the Mainstem. The existing and proposed average slope is approximately 0.87%. Some minor channel grading is proposed to enhance the pool and riffle features. The enhanced pool and riffle grading and structures comply with the typical stable ranges for C4/B4c type channels (e.g. pool-pool spacing, max depth of pools relative to average bankfull depth). Mainstem enhancements include: deepening of the pool between Station 10+50 and 10+90; minor channel grading and introduction of structures between station 12+69, and the existing box culverts at station 14+33.

4.2.4 Stone Sizing – Mainstem

Riffle Grade Control Mainstem

Riffle grade control (RGC) structures in the Mainstem are sized to mimic the existing stable riffle material distribution, rather than oversizing the material based on the HEC-RAS results. The maximum shear stress of 4.58 lb/ft^2, estimated to occur during the 2-year discharge at HEC RAS Section 922 at baseline station 13+41, is the location of the proposed RGC just upstream of the W-Weir. This shear stress results in a D_{84} of 18 inches, D_{50} of 11 inches, and D_{100} of 22 inches. The existing Mainstem riffle has a D_{84} of 7 inches, D_{50} of 3 inches, and D_{100} of 14 inches. The RGC Mix specified for the Tributary is larger than the existing stable riffle material. Therefore, the Tributary mix will be applied to the Mainstem. See Appendix G, which reflects the computed mix based on the HEC-RAS predictions, the existing Mainstem riffle material mix, and the proposed Tributary mix.

W-Weir Stone

W-Weirs are effective in “maintaining grade control, transporting excessive course bed load, reducing bank erosion, buying time for riparian vegetation colonization, and providing trout habitat” (USDA, 2007). The proposed W-Weir is located just upstream of the I-95 culvert. The W-Weir will discourage aggradation by directing flows toward the center of each culvert opening rather than allowing them to spread across the section. The vanes will tie into the existing wing walls. Stone size for W-Weir was estimated using the Figure 11-43 from Part 654 Stream Restoration Design National Engineering Handbook (USDA, 2007). The 4.58 lb/ft2 shear stress, which occurs just upstream of the proposed W-Weir at the 2-year discharge, is an approximation for the bankfull discharge. This is also the maximum shear stress found in the mainstem. The resulting minimum diameter is 3.8 feet, as shown in the Appendix G and indicated in the stone sizing table on the plans.

The RGC mix with Channel Sand & Gravel will be used to backfill the trench and channel bed to the proposed grades.

4.3 Scour Analysis

A scour depth analysis was performed to inform how deep the footer rocks should be placed beneath the channel bed. While the proposed HEC-RAS model and resulting critical shear stress and velocity stone sizing help determine the minimum rock size required to prevent bed and bank material movement, the additional scour analysis determines the vertical stability throughout the channel, and the depth at which the material needs to be placed to prevent issues such as headcutting. The analysis utilized the PBS&J spreadsheet (Kreymborg, 2008), which computes scour depth using various methodologies based on user input parameters. The spreadsheet includes Blench and Lacey for general scour, and Maynord for bend scour of armored channels (ASCE, 2005), where both methodologies are presented in the Technical Supplement 14-B—Scour Calculations (USDA, 2007). “Pemberton and Lara (1984) suggested that regime equations provided by Blench (1970) and Lacey (1931) could be used to predict general scour in natural channels. A designer may compute scour depth using both formulas, and average the outcome or take the largest value”. (USDA, 2007) Both general scour and bend scour were computed for the highest velocity of each type of stone sizing and for design bankfull conditions. The spreadsheet tool utilized proposed HEC-RAS conditions for user inputs (though minor changes in the HEC-RAS model subsequent to the Scour Analysis are not reflected). The Summary Table in Appendix H presents the Blench / Lacey general Scour and Meynard bend scour results with the full output sheets for each reach.

The resulting scour estimates for the Tributary are 0.7 feet for general and 0.5 feet for bend scour in Reaches 1 and 3, and 1.5 feet general scour in Reaches 2 & 4 (bend scour is not applicable in the step pool reaches). The specified footer depths exceed this in all locations where scour could be a concern (sills, crests, toe boulders). For the Mainstem just upstream of I-95, where the velocities are the greatest, the specified footer depths for the W-Weir exceeds the maximum scour estimate of 2.5 feet. The minimum footer depths are shown on the detail sheets in the plans along and in Appendix H.

4.4 Landscaping

Four inches of topsoil covered by natural fiber matting is proposed for all graded areas outside of the channel. This material application will provide suitable growing medium and stabilize the denuded soil against erosion until the establishment of vegetation. The natural fiber matting will be keyed into the various bank treatments and cover the extent of any bank grading or disturbed existing soil noted as Highly Erodible in the Contract Drawings.

The landscaping plan has been developed to permit native vegetation to become reestablished in the disturbed areas through the planting of herbaceous seeding, live stakes, trees, and shrubs. Each vegetation zone will be planted with species according to the landscape plan following the matting placement. Several landscape zones (Live Stakes, PFO Wetland / Lowland Riparian, Riparian, and Turf Grass) and two bank treatment areas (Toe Boulder and Woody Toe) have been defined where bioengineering is part of bank stabilization. Each zone or area has vegetative species that have been selected according to soil, water, and light tolerances that are available. This landscaping will help improve the vegetative protection score of the RBP closer to the optimal range.

Live Stakes and permanent seeding will be installed in the Live Stakes Zone, a narrow zone of approximately 4 feet immediately adjacent to woody toe and toe boulders. Live stakes are proposed at a 2 foot spacing rate.

Understory trees, canopy trees, and permanent seeding will be planted in the PFO Wetland / Lowland Riparian Zone and Riparian Zone. Shrubs and canopy trees are proposed in this zone to be placed at 15 foot and 9 foot spacing rates respectively. A permanent SHA seeding mix is proposed in each zone, consisting of herbaceous species native to lower midland areas in Maryland.

The created wetland areas where the existing channel is abandoned for the proposed alignment, will be planted with FACW species and will be tolerant of the anticipated anaerobic conditions of wetlands.

Permanent seeding will apply the SHA Wet Meadow Mix to the created wetland areas, PFO Wetland and Lowland Riparian Zones and areas closest to the channel including the live stake zone, the woody toe, and toe boulder structures. The SHA Upland Meadow Mix will be applied in the Riparian Zone areas.

Turf grass seeding is proposed along the access for the project where there is currently turf.

5.0 RESTORATION UPLIFT

Through the restoration of the Tributary and the portion of Carsins Run mainstem, hydraulic, geomorphic, and physiochemical, uplift will occur, which should result in improved habitat. Lateral stability will be achieved through the use of bank grading, in-stream structures and riparian plantings. Physicochemical improvements will be achieved through nutrient and sediment load reduction that will occur from the proposed streambank stabilization. Habitat uplift for Tributary Reaches 1 and 3 are expected by addressing sediment deposition (by reducing fine excess sediments generated from eroding banks and mobilized bed); bank stability and vegetative protection (by stabilizing the banks and introducing native plantings); and velocity/ depth regime (by introducing stable riffles and deep pools). All of which will improve instream habitat. Additionally, by stabilizing active headcuts, the restoration will protect existing wetlands and stable reaches, which would otherwise degrade (e.g. Tributary Reach 2a, wetlands upstream of Tributary Reach 1). Table 13 below provides a summary of the uplift provided by the mitigation.

Table 13. Restoration Uplift Summary Table

Category	**Parameters**	**Design Objectives**
Hydraulics	**1.** Floodplain Connectivity	**1.** Reduce BHR from over 5.0 to less than 1.2
Geomorphology	**1.** Lateral Stability **2.** Sediment/Reduction and Trapping **3.** Riparian Buffer	**1.** Reduce stream bank erosion rates (Tributary) **2.** Decrease sediment loads **3.** Enhance native forested riparian buffer habitat
Physiochemical	**1.** Sediment Supply **2.** Nutrient Levels	**1.** Decrease sediment loads entering the Mainstem. **2.** Reduce nutrient levels compared to existing conditions by creating or enhancing hyporheic exchange.
Habitat	**1.** Sediment Deposition **2.** Bank Stability & Vegetative protection; **3.** Velocity/depth regime **4.** Riparian Vegetation	**1.** Reduce stream bank erosion rates (Tributary) **2**. Reduce stream bank erosion rates and introduce native plantings **3.** Introduce variety and deeper pools; improve riffle spacing **4**. Removal of invasive; native plantings.

5.1 Hydraulic Uplift

While this restoration will not alter the land use of the project area (hydrology is largely driven by land use), several hydraulic improvements will occur. By adding meander bends in Tributary Reaches 1 and 3 (typical radius of curvature of 18’) and creating pools in the existing channel location where the proposed alignment is changing, the flashy response to runoff will be dampened. Water is more likely to attenuate on the floodplain and in the created pools. By creating a bankfull channel, the Tributary will be less incised and will be able to access the floodplain on a more frequent basis, which causes an overall decrease of the shear stress and velocity. The proposed BHR is reduced to less than 1.2.

In the Mainstem, the drop structure that will be installed to convey the stormwater from the 21” RCP from the Randolph Drive cul-de-sac will cause the local velocity to decrease and will stabilize the confluence between the stormdrain outfall and the Mainstem.

5.2 Geomorphic Uplift

The incised F4b/A4 channel will be replaced by a B3 channel in Tributary Reaches 1 and 3 and step pools in Reaches 2 and 4. The geomorphic conditions of the proposed design is based on the stable parameters of a B3 channel and the step pool reaches are designed to mimic the reference reach located within the project area. The existing sediment supply from upstream of the Tributary is minimal and the d50 of the material used in the design will allow the channel bed and banks to remain stable throughout higher flow events. The step pool reaches provide grade control that will prevent the Tributary from headcutting upstream. The proposed design adds vertical and lateral stability to the Tributary, creating a stable and sustainable geomorphic condition.

The geomorphic conditions of the Mainstem will be improved through the addition of the drop structure and W-Weir. The W-Weir will provide grade control and streambank protection, improve bed-load transport, and protect the central pier and approach section of the I-95 bridge (USDA, 2007). Proposed riffle grade control and minor grading of the channel bed will ensure areas where concrete is removed are replaced with appropriate cobble bed material to a grade to maintain hydraulic grade line continuity over a range of flows. The pool at the confluence with new drop structure will allow for energy dissipation and local bank stabilization and protection.

5.3 Physiochemical Uplift

The combination of riparian and wetland planting and the increased floodplain connection in the Tributary will enhance nutrient cycling in the hyporheic zone. In addition, these factors may decrease the overall water temperature, promoting a higher dissolved oxygen concentration, enhancing the biological community. The use of woody toe in the design will promote denitrification and will trap fine sediment, thus reducing the turbidity.

In the Mainstem, the removal of concrete will allow for a hyporheic zone to be created, which will promote additional denitrification and potentially lower water temperature.

5.4 Habitat Uplift

Tributary Reaches 1 & 3 (riffle-pool sequences) will introduce woody material into the pools and cobble sized bed material to provide cover and colonization opportunities for aquatic organisms, and provide a variety of velocity and depth regimes. The frequency of riffles and plan form should also improve habitat, with key boulder placement, providing beneficial irregularities. The step pool reaches in the Tributary provide an alternative habitat from the riffle-pool sequences. Wetland habitat is improved or created through floodplain grading, and native wetland plantings. Existing wetlands are protected from future anticipated degradation. The riparian habitat uplift will be improved by monitoring and elimination of invasive species, and introduction of native trees, and shrubs and seed mixes.

The Mainstem improvements include removal of the concrete and introduction of the W-Weir, which will improve velocity / depth regime by creating scour holes and eddies for improved fish habitat relative to the broken concrete. The riparian habitat will be enhanced through removal of invasive and introduced native plantings along the banks.

6 MAINTENANCE PLAN

As stated in the Approved Phase II Compensatory Mitigation Plan for the I-95 ETL Northbound Extension, nontidal Wetlands Permit #18-NT-0086/201860368, (JMT, 2018), MDTA will be the responsible party for the maintenance of the site in perpetuity. “[The site] is designed to be self-sustaining after the monitoring period is over and performance standards have been met. Until then, MDTA anticipated the need to control invasive species within created wetlands, control deer browse, and repair stream restoration structures/features. Invasive species will be monitored and treated as necessary within created wetlands, up to twice per year" (JMT, 2018). Deer browse of riparian plantings will be monitored and managed using tree shelters. "Locations of specific stream restoration structures/features will be visited after major storm events to determine if the restoration structures/features are performing according to the design and performance standards." (JMT, 2018) "Any anomalies in either vegetation or stream stability within restoration areas will be brought to the attention of both USACE and MDE to determine if remedial measures are warranted. In the event remedial measures are implemented at the mitigation site, the monitoring period may be extended. The extension will be determined on a case-by-case basis" (JMT, 2018).

7 MONITORING REQUIREMENTS AND PERFORMANCE STANDARDS

The following language outlines the performance standards and reporting requirements as stated in the MDE and USACE authorizations. MDTA proposes that, for all performance standard criteria, Year 1 begins the year the mitigation construction and planting is complete, unless this occurs after April 15, in which case Year 1 will not begin until the following year. As-built surveys would also be considered part of Year 1 provided construction and planting is complete before April 15.

Created Wetland Monitoring Requirements and Performance Standards:

The created wetland areas proposed to result from the stream restoration project will be monitored and evaluated in accordance with the *Ecological Performance Standards and Monitoring Protocol for Permittee-responsible Nontidal Wetland Mitigation Sites in Maryland* (revised October 30, 2020). Monitoring of the created wetlands must be conducted a minimum of once per year during the years that monitoring reports are required for the project.

Stream Restoration Monitoring Requirements and Performance Standards:

MDE Phase II Approval Letter (December 30, 2019):

The Permittee or their successors or designees are required to monitor the mitigation sites and submit monitoring reports for the mitigation projects to the Wetlands and Waterways Program, Mitigation and Technical Assistance Section. Permittee shall monitor the stream restoration projects for a period of ten years following completion of construction of the mitigation project to verify that the site is meeting all performance standards. The Permittee will follow specific stream and wetland monitoring and performance standards included in Appendix G of their Compensatory Mitigation Plan, dated October 2019. Permittee shall coordinate with the regulatory agencies concerning applicable remedial measures for any identified project failures and shall correct any project failures within one year of their identification. All proposed remedial measures must be reviewed and approved prior to implementation.

Permittee shall coordinate with the regulatory agencies concerning applicable remedial measures for any identified project failures and shall correct any project failures within one year of their identification. All proposed remedial measures must be reviewed and approved prior to implementation. Permittee shall submit reports for years 2, 3, 5, 7, and 10 on the results of the monitoring efforts at the mitigation sites to the Department by December 31 of each year. The monitoring shall identify and evaluate changes in 1) channel cross-section, pattern and profile; 2) bed materials; 3) channel stability; 4) structure stability and condition; and 5) vegetation viability. The monitoring effort may include topographic surveys of monumented cross-sections within the realigned channel segment, visual field observations, photographic documentation, vegetation viability measurements, and identify any necessary corrective measures.

MDE Wetlands and Waterways Permit (February 21, 2020):

Permittee shall monitor the stream restoration projects for a period of ten years following completion of construction of the mitigation project to verify that the site is meeting all performance standards. The Permittee must propose specific monitoring and performance standards based on the goals of the mitigation project for the Administration's *approval. Permittee shall coordinate with the regulatory agencies concerning applicable remedial measures for any identified project failures and shall correct any project failures within one year of their identification. All proposed remedial measures must be reviewed and approved prior to implementation. In the event of discrepancy with the stream monitoring requirements found in this Condition, the standards and requirements set forth in the Phase II Approval Letter ("Approval Letter"), the Approval Letter shall govern. Permittee shall submit reports as specified in their monitoring plan and approved by the Administration.*

USACE Individual Permit (April 2, 2020):

The permittee must monitor the stream restoration project components for a minimum of ten (10) years following the completion of the project and prepare monitoring reports. Monitoring requirements are listed below. Monitoring frequency and success criteria are outlined in Table 1. Table 1 shows performance standards for stream restoration. AB=As-built, PC=Preconstruction, 1-5 corresponds to the monitoring year following construction. Any alternative metric assessing stream habitat must be approved by Corps project manager.

The permittee must prepare and provide the Corps with as-built plans of the mitigation site within six months following the completion of the mitigation site. The as-built plans will include, among other items, grading, planting, structures, pool elevations, and key spot elevations.

Monitoring reports must be submitted by December 31 of the year following completion of the mitigation site (Year 2) and then on years 3, 5, 7, and 10. The following standards will be used to assess project success and must be achieved each monitoring year:

At a minimum, the monitoring reports must:

a. *Classify stream flow before and after construction for each stream (perennial, intermittent, and ephemeral).*
b. *Evaluate channel stability by documenting changes in cross-sections across three riffles. The representative riffle cross-sections must be monumented and shown in a graphical display which overlays previous cross-sections in annual reports.*
c. *Evaluate vertical stability by performing a longitudinal profile survey to document thalweg and water surface elevations. Longitudinal profiles must be shown in a graphical display which overlays previous profiles in annual reports.*
d. *Report vegetation species richness and cover.*
e. *Evaluate stream habitat quality using an assessment method such as EPA's Rapid Bioassessment Protocol (RBP) high gradient stream habitat form. Results of stream habitat assessment must be shown for all monitoring years assessed at the time the report is submitted, including preconstruction in each monitoring report.*
f. *Photograph site conditions annually along the entire stream relocated project area. Photos of each grade control structure and riffle crest are required.*
g. *Identify any necessary corrective measures.*
h. *Delineate temporary wetland impact areas and relocated wetland areas after construction to demonstrate that the wetlands have been restored after disturbance from construction and quantify acreage.*

Table 1. USACE Success Criteria for Stream Restoration

Parameter	***Measurement***	***Success Criteria***	***Monitoring Year***
Flow	*Visual Characterization (Perennial, Intermittent, or Ephemeral)*	*Meets or exceeds baseline*	*PC, 3, 5, 7, 10*
Floodplain Connectivity	*Bank height ratio*	*<1.2*	*AB, 5, 7, 10*
	Documented or modeled at discretion of consultant	*Demonstrate substantial increase in floodplain connection following construction*	*By Year 3*
Vertical Stability	*Longitudinal profile/riffle crest and vertical control elevations*	*<0.5 ft thalweg degradation from as-built.*	*AB, 3, 5, 7, 10*
Lateral Stability	*BEHI*	*Moderate or better after construction*	*PC, 3, 5*
Habitat Assessment	*RBP- High gradient (or Corps-approved alternative metric)*	*Exceeds baseline*	*PC, 3, 5, 7, 10*
Vegetative Cover	*% cover*	*>80% cover in LOD*	*5, 7, 10*
Invasive Plant Reduction	*% cover invasive species in LOD*	*Less than baseline*	*PC, 3, 5*

Proposed Monitoring and Reporting to Meet MDE and USACE Requirements.

It is anticipated that all construction and planting will be completed prior to April 15, 2021 and therefore the As-built survey and certification and Year 1monitoring will occur in 2021, with Year 2 monitoring and reporting of all previous monitoring to be completed by December 31, 2022 and so forth. Baseline data from the design and assessment shall meet the requirements for preconstruction monitoring. To meet the requirements as stated by both MDE and USACE, MDTA has amended the USACE Table 1 as presented in Table 2 below.

Table 2. MDTA Success Criteria for Stream Restoration

Parameter	**Measurement**	**Success Criteria**	**Monitoring Year**						
			PC	AB /1	2	3	5	7	10
Flow	Visual Characterization (Perennial, Intermittent, or Ephemeral)	Meets or exceeds baseline	X			X	X	X	X
Floodplain Connectivity	Bank height ratio	<1.2		X	X	X	X	X	X
	Documented or modeled at discretion of consultant	Demonstrate substantial increase in floodplain connection following construction				X			
Vertical Stability	Photos of all grade control structures, survey of 3 Cross Sections and Long. Profile*	<0.5 ft thalweg degradation from as-built.		X	X	X	X	X	X
Lateral Stability	BEHI	Moderate or better after construction	X		X	X	X	X	X
Bed Materials	Pebble Count	Same or less fines (particles less than 6 mm in size) compared to baseline	X	X	X	X	X	X	X
Habitat Assessment	RBP- High gradient (or Corps-approved alternative metric)	Exceeds baseline	X	X	X	X	X	X	X
Vegetative Richness & Cover	Species and % cover	>80% cover in LOD			X	X	X	X	X
Invasive Plant Reduction	% cover invasive species in LOD	Less than baseline	X			X	X	X	X
Wetland Delineation	Acreage	Temporary impacts and relocated wetlands restored		X		X	X		X

*There will be inherent discrepancies with the longitudinal profile due to the difficulty in reproducing survey from one year to the next (i.e. the channel length due to tape layout, or elevations due to rod placement may be slightly different from year to year).

8 LONGTERM MANAGEMENT PLAN

As stated in the Approved Phase II Compensatory Mitigation Plan for the I-95 ETL Northbound Extension, nontidal Wetlands Permit #18-NT-0086/201860368, (JMT, 2018), MDTA will be the responsible party for the long-term management of the sites in perpetuity. MDTA is committed to providing successful compensatory mitigation for impacts associated with the proposed improvements and will continue to monitor and manage the sites until they have not only met performance standards but also has been deemed to be self-sustaining.

9 ADAPTIVE MANAGEMENT

Should unforeseen issues threaten the success of the mitigation sites, MDTA will implement adaptive management strategies. Potential issues could include erosion damage from extreme storm events during the vegetative establishment period and/or colonization of sites by invasive species triggering the need for adaptive management either during or after the required monitoring period. Monitoring reports comparing site-specific data with performance standards, in conjunction with observations made during data collection, will indicate the need to consider implementation of adaptive management. MDTA will follow the following steps if monitoring data or observations indicate adaptive management is necessary:

- Notify USACE and MDE of the issues, potential causes and proposed solutions;
- Work with USACE and MDE to agree upon corrective measures and establish a timeframe for implementation;
- Implement corrective measures according to the established schedule; and
- Continue to implement corrective measures and monitoring until performance standards have been met.

10 FINANCIAL ASSURANCES

As stated in the Approved Phase II Compensatory Mitigation Plan (JMT, 2018), MDTA operates on a 5-year Transportation Improvement Program (TIP) cycle and has allocated $115,160,000 as a specific line item in its TIP budget to construct the I-95 ETL Northbound Extension Project. The funding allocated for the project is inclusive of any compensatory mitigation, including required construction, monitoring, and long-term maintenance activities, for unavoidable impacts associated with the proposed improvements.

11 SUMMARY & CONCLUSIONS

The Carsins Run Mainstem upstream of I-95 along with the unnamed tributary from Ripken Stadium (Tributary) offer excellent opportunities for stream restoration and wetland mitigation. By removing the deteriorated concrete and providing natural structures sized to withstand shear stresses and velocities over a range of flows, the Mainstem will be restored to a more stable system with improved habitat features. Addressing the unstable outfall will arrest bank erosion and eliminate safety concerns associated with the sink hole. The Tributary mitigation will restore the unstable reaches to reduce bank erosion, provide stable natural channel plan form and geometry, raise the channel to provide access to the surrounding floodplain at more frequent flows, create wetlands, enhance the riparian corridor with a robust native planting plan, and provide habitat uplift.

The Carsins Run Mainstem provides 160 LF of Perennial stream mitigation credit and the tributary provides 800 LF of Intermittent stream mitigation credits at a 1:1 ratio. In addition to the stream mitigation credit, 3,992 SF of wetland creation is anticipated to be available for mitigation credit.

The work in the Mainstem will require development of two (2) easements to install the drop manhole structure and regrade the surrounding failing bank. Draft easement plats and negotiations are currently underway.

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APPENDIX

APPENDIX

APPENDIX

APPENDIX A

EXISTING PHOTOS

Carsins Run Stream Mitigation

Existing Conditions Site Photographs

Note: References to right and left bank are noted facing downstream.

Facing mainstem from top of right bank at upstream confluence of tributary with mainstem.

Facing upstream at knick point on northwest tributary fork near confluence with mainstem.

Facing downstream at mainstem from northwest tributary fork.

Facing upstream at the fork in the tributary.

Note: References to right and left bank are noted facing downstream.

Facing upstream from upstream of tributary fork (~Sta. 8+50).

Facing downstream from tributary fork (~Sta. 8+50).

Facing upstream at knick point/headcut. Note, the fines and right bank erosion (~Sta. 7+75).

Facing upstream at buttress trees in left floodplain from Sta. 7+75.

Note: References to right and left bank are noted facing downstream.

Facing upstream from station 7+75. Photo shows alternating point bars, right bank erosion, and boulder knick point.

Close-up view upstream at boulder knick point (~Sta. 6+90).

Facing upstream at typical Reach 3 from left floodplain near Sta. 6+65

Facing downstream from left floodplain near Sta. 6+50.

Note: References to right and left bank are noted facing downstream.

Facing right bank at typical outer bend bank erosion in Reach 3 (from Sta. 6+30)

Facing upstream from Sta. 6+30 at surveyed cross section. (point bar feature to the right of the tape in the photo associated with bankfull stage).

Facing downstream from Sta. 6+20 at typical Reach 3 bank erosion and point bars.

Facing upstream from Sta. 6+10

Ripken Trib Reach 3

Note: References to right and left bank are noted facing downstream.

Reach 3 geomorphic cross section facing right bank.

Reach 3 geomorphic cross section facing upstream.

Reach 3 geomorphic cross section facing downstream.

Reach 3 geomorphic cross section facing left bank.

Note: References to right and left bank are noted facing downstream.

Facing downstream at undercut bank just upstream of surveyed cross section.

Facing upstream from near 5+50 at typical bank erosion.

Facing downstream from just downstream of 2 foot knick point (Sta. 5+50).

Facing upstream at 2 foot knick point between Reaches 2 & 3.

Ripken Trib Reach 3

Note: References to right and left bank are noted facing downstream.

Facing downstream toward Reach 3 from just upstream of knick point.

Facing upstream at the downstream end of the step pool reach where there is aggradation and deposition of fines.

Facing upstream into Reach 2b (minor bank erosion)

Facing downstream at the downstream end of the Reach 2b step pools where there is minor right bank erosion.

Ripken Trib Reach 3 / Downstream end of Reach 2b

Note: References to right and left bank are noted facing downstream.

Facing upstream from middle of Reach 2 Sta. 3+80 (step pool reach)

Facing downstream from middle of Reach 2 Sta. 3+80 (step pool reach). Optimal habitat.

Facing upstream from downstream end of step pool surveyed reference reach (Sta. 3+00)

Facing downstream from downstream end of step pool surveyed reference reach (Sta. 3+00)

Ripken Trib Reach 2a

Note: References to right and left bank are noted facing downstream.

Facing downstream at step and pool geomorphic cross sections.

Facing the left bank at step and pool geomorphic cross sections.

Facing the right bank at step and pool geomorphic cross sections.

Facing upstream at step and pool geomorphic cross sections.

Note: References to right and left bank are noted facing downstream.

Facing downstream from upstream end of step pool surveyed reference reach (Sta. 2+10)

Facing downstream from upstream end of step pool surveyed reference reach (Sta. 2+10)

Facing downstream at side channel on right (not hydraulically connected to tributary, source not overserved)

Facing upstream at the side channel that enters from the right near Sta. 2+10 in the middle of the surveyed Reach 2 reference reach.

Ripken Trib Reach 2a

Note: References to right and left bank are noted facing downstream.

Facing upstream at debris jam / knick point (break between Reach 1&2)

Facing upstream at typical Reach 1, just upstream of the debris jam / knick point (~Sta. 2+00).

Facing downstream at typical Reach 1 from Sta. 2+00

Facing upstream at upstream most knick point (~Sta. 0+25)

Note: References to right and left bank are noted facing downstream.

Facing downstream at upstream most knick point (~Sta. 0+25)

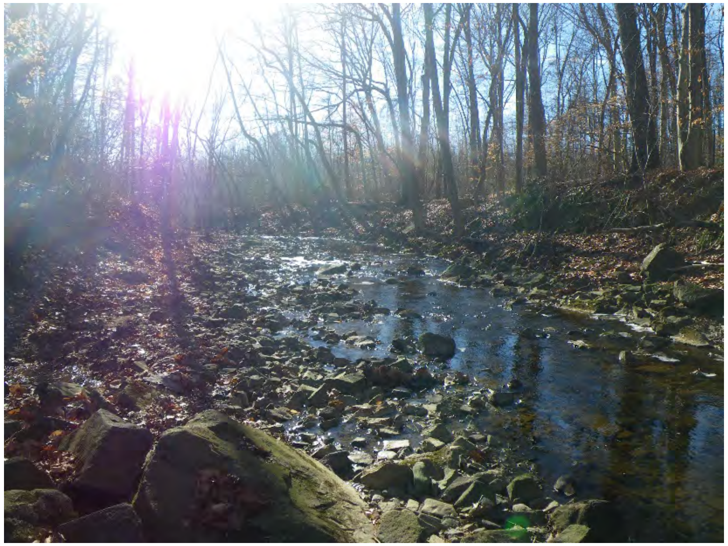
Facing southeast at riprap stabilization toward stormwater pond (does not discharge into study area).

Facing west at existing swale at upstream end of study reach.

Facing upstream toward stormdrain pipe from Ripken Stadium.

Note: References to right and left bank are noted facing downstream.

Facing upstream at upstream end of the study reach (~Sta. 10+00)



Facing downstream from near stormdrain outfall.

Facing left bank at severe erosion at 21” stormdrain outfall off of Randolph.

Facing left bank from right terrace (note bamboo stand on left bank upstream of stormdrain outfall).

Mainstem

Note: References to right and left bank are noted facing downstream.

Facing right bank at cross section Sta. 12+03

Facing downstream at cross section Sta. 12+03 (note flagged bankfull stage along point bar)

Facing upstream at cross section Sta. 12+03

Facing left bank cross section Sta. 12+03

Note: References to right and left bank are noted facing downstream.

Facing downstream at upstream face of I-95 culvert and concrete lined channel (proposed W-Weir location)

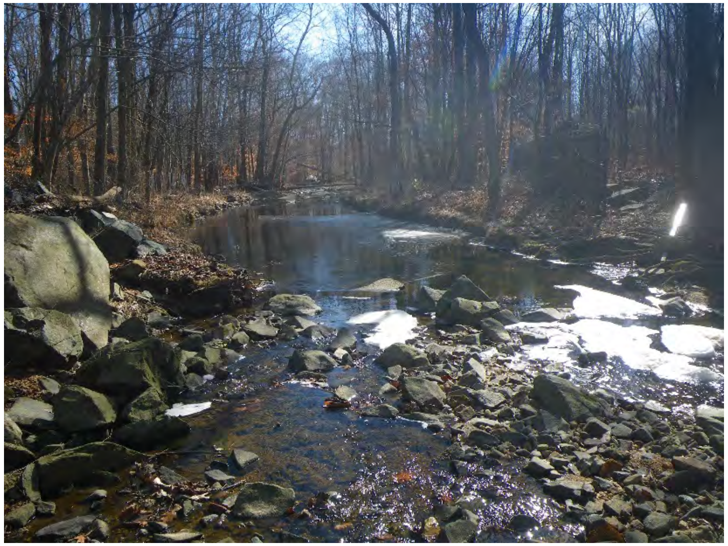
Facing upstream from Sta. 13+90 (proposed location of W-Weir invert)

Facing upstream from Sta. 14+44 (invert of upstream end I-95 culvert) showing broken concrete lining to be removed).

Facing upstream at the downstream face of the I-95 culvert (downstream of I-95), no fish blockages observed.

Mainstem

Note: References to right and left bank are noted facing downstream.



Facing downstream from I-95 culvert.

Facing downstream toward well connected left bank.

Facing upstream at Carsins Run downstream of I-95 (note broken slabs of concrete).

Facing left bank close up of broken concrete slabs.

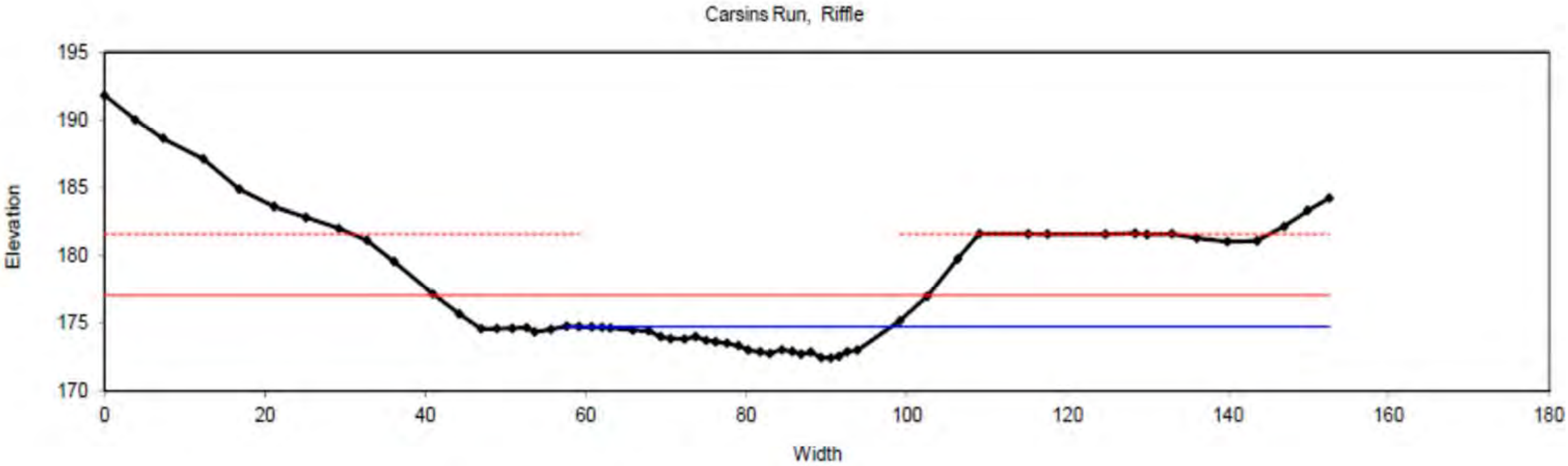
Mainstem Downstream of I95

APPENDIX B

EXISTING GEOMORPHIC OUTPUT SUMMARY

APPENDIX B.1
GEOMORPHIC CROSS SECTIONS

APPENDIX B.1. GEOMORPHIC CROSS SECTIONS



Bankfull Dimensions

44.0	x-section area (ft.sq.)
38.9	width (ft)
1.1	mean depth (ft)
2.3	max depth (ft)
39.6	wetted parimeter (ft)
1.1	hyd radi (ft)
34.5	width-depth ratio

Flood Dimensions

61.5	W flood prone area (ft)
1.6	entrenchment ratio
9.2	low bank height (ft)
4.0	low bank height ratio

Materials

---	D50 (mm)
---	D84 (mm)
30	threshold grain size (mm):

Bankfull Flow

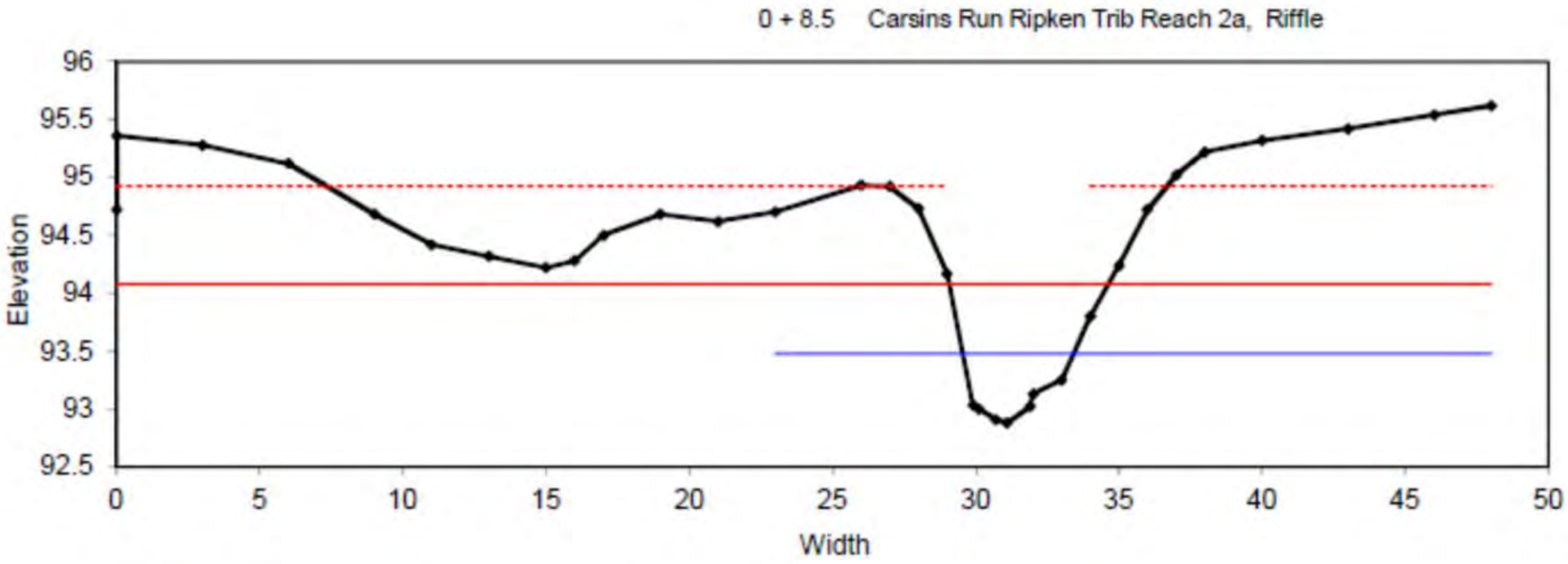
3.9	velocity (ft/s)
172.3	discharge rate (cfs)
0.66	Froude number

Flow Resistance

0.038	Manning's roughness
0.16	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power

0.87	channel slope (%)
0.60	shear stress (lb/sq.ft.)
0.56	shear velocity (ft/s)
2.4	unit strm power (lb/ft/s)



Bankfull Dimensions

1.5	x-section area (ft.sq.)
3.9	width (ft)
0.4	mean depth (ft)
0.6	max depth (ft)
4.2	wetted parimeter (ft)
0.4	hyd radi (ft)
9.8	width-depth ratio

Flood Dimensions

5.6	W flood prone area (ft)
1.4	entrenchment ratio
2.0	low bank height (ft)
3.4	low bank height ratio

Materials

34	D50 Riffle (mm)
86	D84 Riffle (mm)
62	threshold grain size (mm):

Bankfull Flow

4.0	velocity (ft/s)
6.1	discharge rate (cfs)
1.17	Froude number

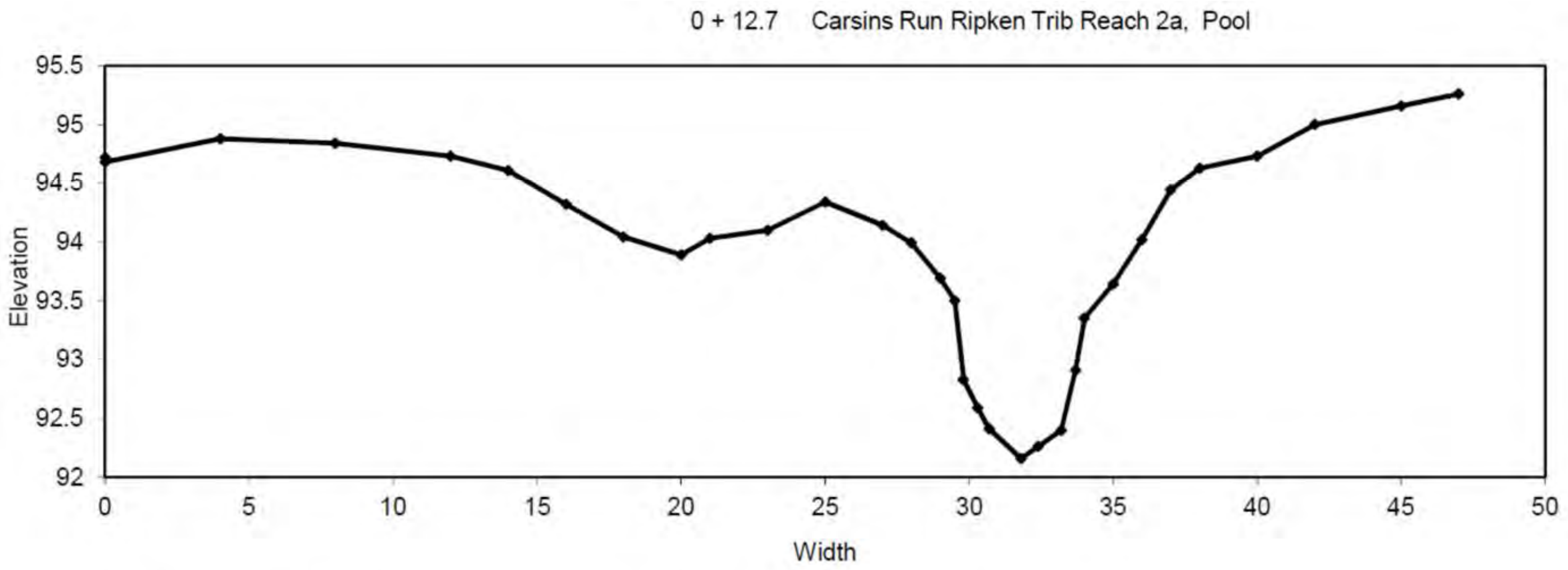
TOB W=9.7; dmax=2;
Q=79.5

Flow Resistance

0.045	Manning's roughness
0.33	D'Arcy-Weisbach fric.
3.9	resistance factor u/u*
1.4	relative roughness

Forces & Power

5.6	channel slope (%)
1.26	shear stress (lb/sq.ft.)
0.81	shear velocity (ft/s)
5.5	unit strm power (lb/ft/s)



0 + 12.7 Carsins Run Ripken Trib Reach 2a, Pool

Bankfull Dimensions

0.0	x-section area (ft.sq.)
0.0	width (ft)
0.0	mean depth (ft)
0.0	max depth (ft)
0.0	wetted parimeter (ft)
0.0	hyd radi (ft)
0.0	width-depth ratio

Flood Dimensions

---	W flood prone area (ft)
---	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Materials

34	D50 Riffle (mm)
86	D84 Riffle (mm)
---	threshold grain size (mm):

Bankfull Flow

---	velocity (ft/s)
---	discharge rate (cfs)
---	Froude number

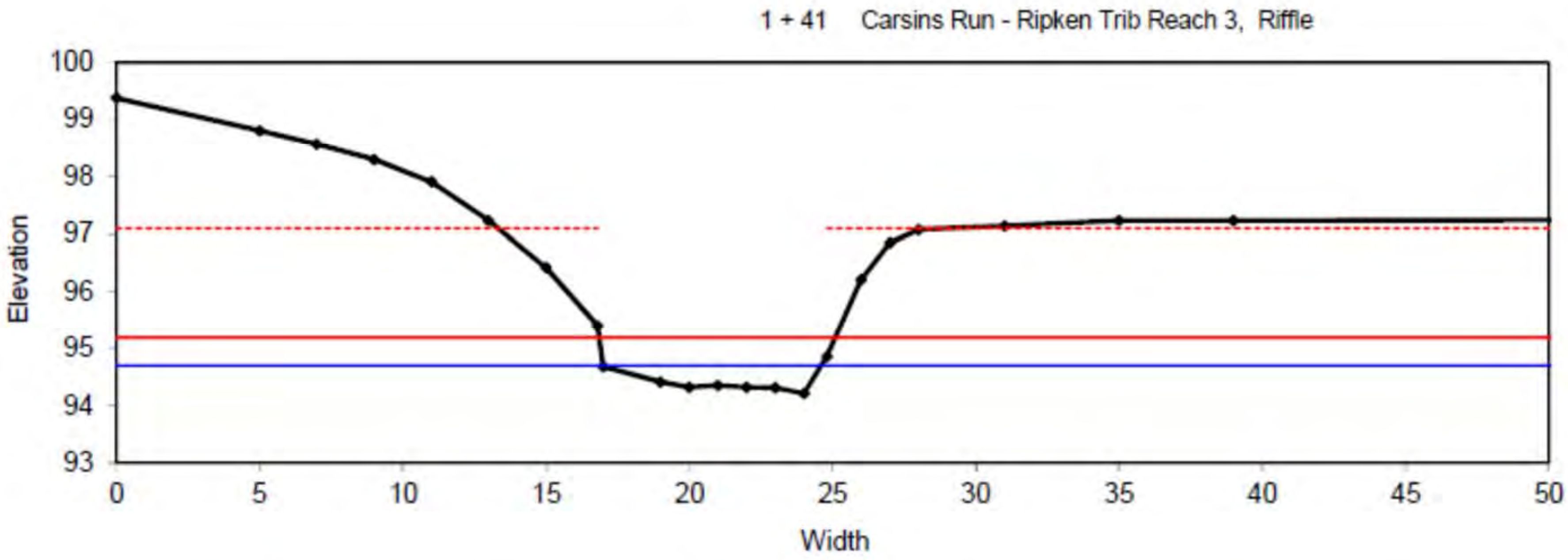
Flow Resistance

0.023	Manning's roughness
---	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power

5.6	channel slope (%)
---	shear stress (lb/sq.ft.)
---	shear velocity (ft/s)
---	unit strm power (lb/ft/s)

Hydraulic computations ommited for pool section. As Mannings equation is valid only for turbulent uniform flow.



Bankfull Dimensions	
2.3	x-section area (ft.sq.)
7.6	width (ft)
0.3	mean depth (ft)
0.5	max depth (ft)
7.8	wetted parimeter (ft)
0.3	hyd radi (ft)
24.7	width-depth ratio

Flood Dimensions	
8.2	W flood prone area (ft)
1.1	entrenchment ratio
2.9	low bank height (ft)
5.9	low bank height ratio

Materials	
25	D50 Riffle (mm)
70	D84 Riffle (mm)
20	threshold grain size (mm):

Bankfull Flow	
2.6	velocity (ft/s)
6.1	discharge rate (cfs)
0.84	Froude number

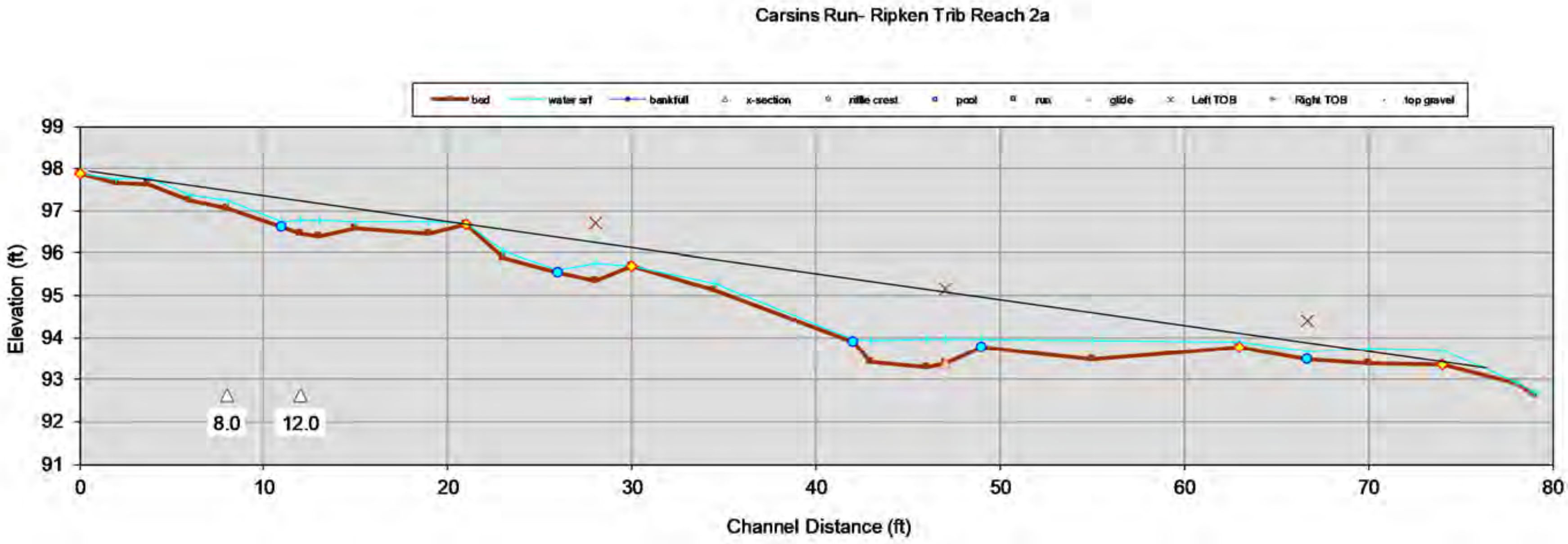
Flow Resistance	
0.038	Manning's roughness
0.25	D'Arcy-Weisbach fric.
3.9	resistance factor u/u*
1.3	relative roughness

Forces & Power	
2.2	channel slope (%)
0.41	shear stress (lb/sq.ft.)
0.46	shear velocity (ft/s)
1.1	unit strm power (lb/ft/s)

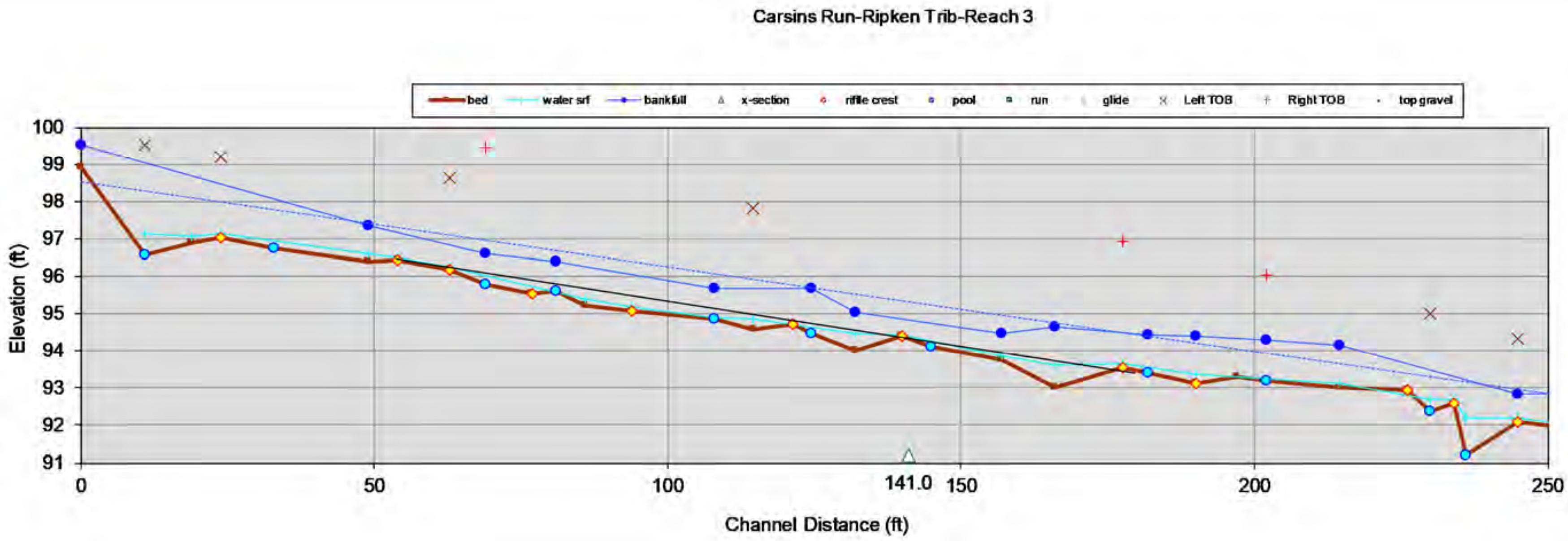
APPENDIX B.2

GEOMORPHIC LONGITUDINAL PROFILES

APPENDIX B.2. GEOMORPHIC LONGITUDINAL PROFILES



	slope (%)	slope ratio	length (ft)	length ratio	pool-pool spacing (ft)	p-p ratio
reach	5.6	---	79.0 (20.4 channel widths	---	---	---
riffle	13 (5.4 - 22)	2.3 (1 - 3.9)	7.9 (3.7 - 12)	2 (1 - 3.1)	---	---
pool	0 (0 - 0.5)	0 (0 - 0.1)	8.1 (4 - 14)	2.1 (1 - 3.6)	13.9 (7 - 17.7)	3.6 (1.8 - 4.6)
	---	---	---	---	---	---
glide	0.5	0.1	2.0	0.5	---	---



	slope (%)	slope ratio	length (ft)	length ratio	pool-pool spacing (ft)	p-p ratio
reach	2.2	—	294.3 (38.7 channel widths	—	—	—
riffle	#DIV/0!	—	9.4 (0 - 49.3)	1.2 (— - 6.5)	—	—
pool	1.5 (0 - 4)	0.7 (0 - 1.8)	14.7 (4 - 32.5)	1.9 (0.5 - 4.3)	22.5 (6 - 37)	3 (0.8 - 4.9)
	—	—	—	—	—	—
	—	—	—	—	—	—

Note: The existing conditions mainstem longitudinal profile is from field run topography and is included in the plan set.

APPENDIX B.3

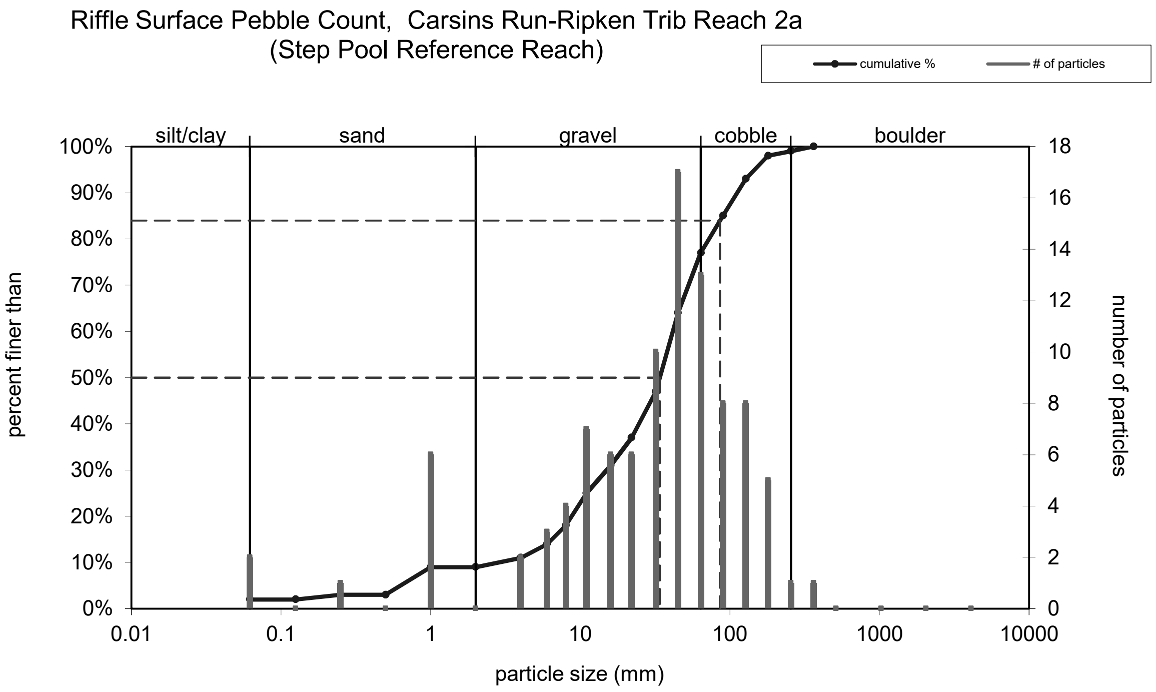
PEBBLE COUNT / MATERIAL DISTRIBUTION SUMMARY

APPENDIX B.3. PEBBLE COUNT / MATERIAL DISTRIBUTION SUMMARY

Riffle Surface ▼

Material	Size Range (mm	Count
silt/clay	0 - 0.062	**2**
very fine sand	0.062 - 0.125	**0**
fine sand	0.125 - 0.25	**1**
medium sand	0.25 - 0.5	**0**
coarse sand	0.5 - 1	**6**
very coarse sand	1 - 2	**0**
very fine gravel	2 - 4	**2**
fine gravel	4 - 6	**3**
fine gravel	6 - 8	**4**
medium gravel	8 - 11	**7**
medium gravel	11 - 16	**6**
coarse gravel	16 - 22	**6**
coarse gravel	22 - 32	**10**
very coarse gravel	32 - 45	**17**
very coarse gravel	45 - 64	**13**
small cobble	64 - 90	**8**
medium cobble	90 - 128	**8**
large cobble	128 - 180	**5**
very large cobble	180 - 256	**1**
small boulder	256 - 362	**1**
small boulder	362 - 512	**0**
medium boulder	512 - 1024	**0**
large boulder	1024 - 2048	**0**
very large boulder	2048 - 4096	**0**
total particle count:		100
bedrock	-------------	
clay hardpan	-------------	
detritus/wood	-------------	
artificial	-------------	
total count:		100

Note:



Riffle Surface Pebble Count, Carsins Run-Ripken Trib Reach 2a
(Step Pool Reference Reach)

Size (mm)	
D16	6.9
D35	20
D50	34
D65	46
D84	86
D95	150

Size Distribution	
mean	24.4
dispersion	3.7
skewness	-0.14

Type	
silt/clay	2%
sand	7%
gravel	68%
cobble	22%
boulder	1%

D100~17 to 19 inches

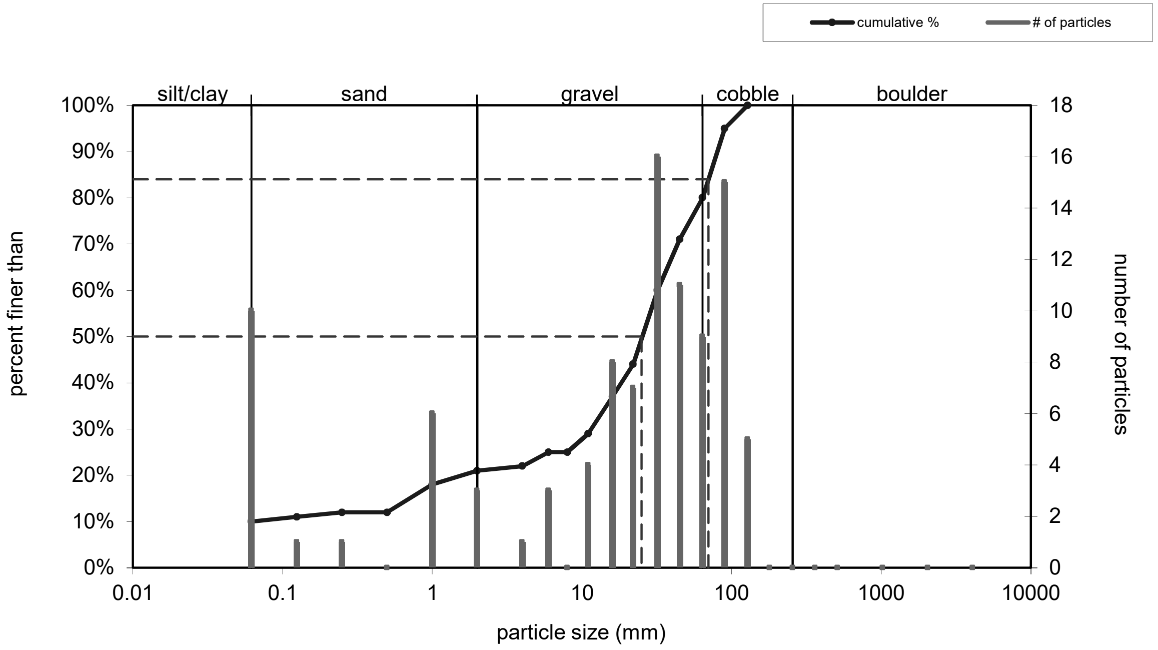
Riffle Surface ▼

Material	Size Range (mm			Count
silt/clay	0	-	0.062	**10**
very fine sand	0.062	-	0.125	**1**
fine sand	0.125	-	0.25	**1**
medium sand	0.25	-	0.5	**0**
coarse sand	0.5	-	1	**6**
very coarse sand	1	-	2	**3**
very fine gravel	2	-	4	**1**
fine gravel	4	-	6	**3**
fine gravel	6	-	8	**0**
medium gravel	8	-	11	**4**
medium gravel	11	-	16	**8**
coarse gravel	16	-	22	**7**
coarse gravel	22	-	32	**16**
very coarse gravel	32	-	45	**11**
very coarse gravel	45	-	64	**9**
small cobble	64	-	90	**15**
medium cobble	90	-	128	**5**
large cobble	128	-	180	**0**
very large cobble	180	-	256	**0**
small boulder	256	-	362	**0**
small boulder	362	-	512	**0**
medium boulder	512	-	1024	**0**
large boulder	1024	-	2048	**0**
very large boulder	2048	-	4096	**0**

total particle count:		100
bedrock	-------------	
clay hardpan	-------------	
detritus/wood	-------------	
artificial	-------------	
total count:		100

Note:

Riffle Surface Pebble Count, Riipken Trib - Reach 3



Size (mm)	
D16	0.79
D35	15
D50	25
D65	37
D84	70
D95	90

Size Distribution	
mean	7.4
dispersion	17.2
skewness	-0.38

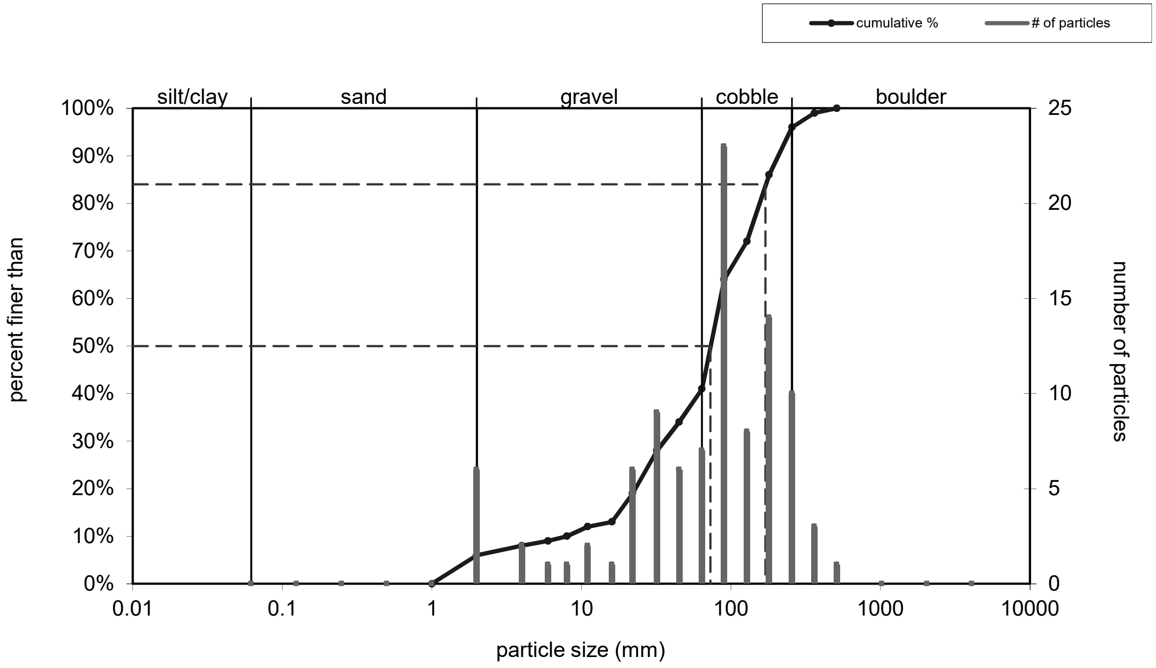
Type	
silt/clay	10%
sand	11%
gravel	59%
cobble	20%
boulder	0%

Riffle Surface ▼

Material	Size Range (mm			Count
silt/clay	0	-	0.062	**0**
very fine sand	0.062	-	0.125	**0**
fine sand	0.125	-	0.25	**0**
medium sand	0.25	-	0.5	**0**
coarse sand	0.5	-	1	**0**
very coarse sand	1	-	2	**6**
very fine gravel	2	-	4	**2**
fine gravel	4	-	6	**1**
fine gravel	6	-	8	**1**
medium gravel	8	-	11	**2**
medium gravel	11	-	16	**1**
coarse gravel	16	-	22	**6**
coarse gravel	22	-	32	**9**
very coarse gravel	32	-	45	**6**
very coarse gravel	45	-	64	**7**
small cobble	64	-	90	**23**
medium cobble	90	-	128	**8**
large cobble	128	-	180	**14**
very large cobble	180	-	256	**10**
small boulder	256	-	362	**3**
small boulder	362	-	512	**1**
medium boulder	512	-	1024	**0**
large boulder	1024	-	2048	**0**
very large boulder	2048	-	4096	**0**
total particle count:				100
bedrock	-------------			
clay hardpan	-------------			
detritus/wood	-------------			
artificial	-------------			
total count:				100

Note:

Riffle Surface Pebble Count, Carsins Run-Mainstem



Size (mm)	
D16	19
D35	47
D50	73
D65	94
D84	170
D95	250

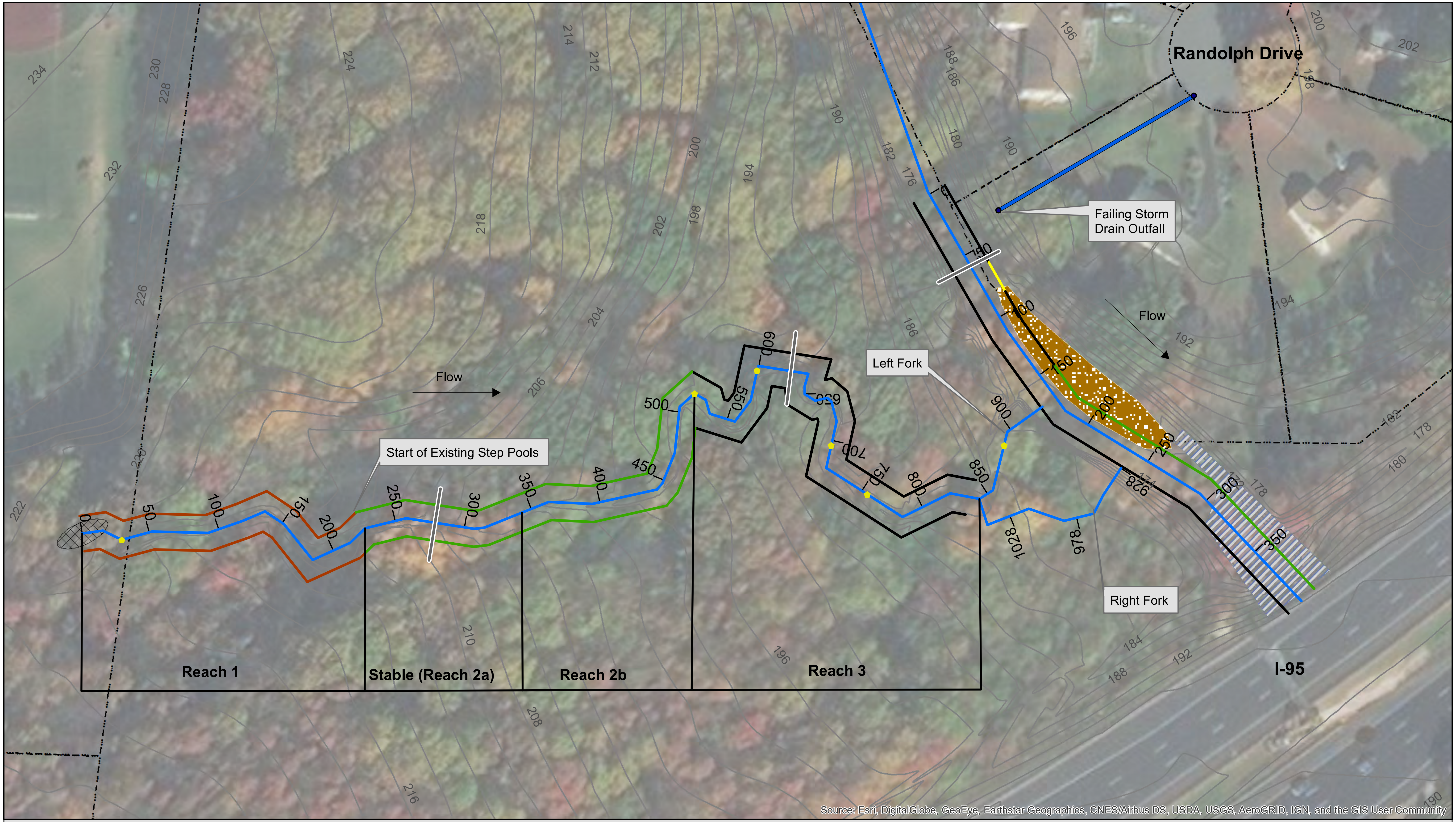
Size Distribution	
mean	56.8
dispersion	3.1
skewness	-0.11

Type	
silt/clay	0%
sand	6%
gravel	35%
cobble	55%
boulder	4%

D100~11 to 14 inches

APPENDIX B.4

GEOMORPHIC FEATURES REFERENCE MAP



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Carsins Run Stream Restoration
Appendix B.4.
Assessment & Geomorphic Features Reference Map

Legend

APPENDIX C

EXISTING BANCs SUMMARY – CARSINS RUN

Project: **Carsins Run Stream Restoration**
Date: **2/14/2018, 2/19/2018**
Field Crew: **SL+BD, BD+LK**
Data Entered **BD**
QC by: **SL**

REACH	Left Reach ID	Starting Station	Ending Station	Left Bank Length (ft)	Left Bank BEHI	Left Bank NBS	Left Bank Height (ft)	Left Bank Erosion Rate*	LB_ Erosion Potential (cu ft/yr)	Right Reach ID	Starting Station	Ending Station	Right Bank Length (ft)	Right Bank BEHI	Right Bank NBS	Right Bank Height (ft)	Right Bank Erosion Rate*	RB_Erosion Potential (cu ft/yr)	BANK EROSION ADDRESSED THROUGH RESTORATION (cu ft/yr)**
TRIB REACH 1	0	0	221	221	MODERATE	LOW	3	**0.13**	**82.88**	0	0	221	221	VERY HIGH	LOW	3	0.4	**265.20**	**348**
TRIB REACH 3	L1	15	53	38	VERY HIGH	LOW	3	**0.40**	**45.60**	R1	15	53	38	HIGH	VERY LOW	2	0.25	**19.00**	**65**
	L2	53	123	70	HIGH	VERY LOW	3	**0.25**	**52.50**	R2	53	123	70	VERY HIGH	LOW	3.5	0.4	**98.00**	**151**
	L3	123	141	18	VERY HIGH	LOW	3.5	**0.40**	**25.20**	R3	123	141	18	HIGH	VERY LOW	3.5	0.25	**15.75**	**41**
	L4	141	159	18	HIGH	VERY LOW	3	**0.25**	**13.50**	R4	141	159	18	VERY HIGH	LOW	3	0.4	**21.60**	**35**
	L5	159	176	17	VERY HIGH	LOW	2	**0.40**	**13.60**	R5	159	176	17	VERY HIGH	LOW	2	0.4	**13.60**	**27**
	L6	176	195	19	HIGH	VERY LOW	2	**0.25**	**9.50**	R6	176	195	19	VERY HIGH	LOW	2	0.4	**15.20**	**25**
	L7	195	253	58	VERY HIGH	LOW	2.5	**0.40**	**58.00**	R7	195	253	58	HIGH	VERY LOW	2.5	0.25	**36.25**	**94**
	L8	259	294	35	HIGH	VERY LOW	2	**0.25**	**17.50**	R8	259	269	10	VERY HIGH	LOW	3	0.4	**12.00**	**30**
	L9	294	314	20	VERY HIGH	LOW	3	**0.40**	**24.00**	R9	269	294	25	HIGH	VERY LOW	1.5	0.25	**9.38**	**33**
										R10	294	345	51	VERY HIGH	LOW	3.5	0.4	**71.40**	**71**
CARSINS RUN UPSTREAM OF I95	L1***	0	60	60	HIGH	LOW	7	0.4	**168.00**	R1***	0	225	130	VERY HIGH	MODERATE	7	0.64	**582.40**	
	L2	60	80	20	EXTREME	LOW	7	1.3	**182.00**	R2***	225	395	90	HIGH	LOW	8	0.4	**288.00**	**182**
	L3***	80	150	40	HIGH	VERY LOW	7	0.25	**70.00**										
	L4***	150	390	240	LOW	VERY LOW	3.5	0.015	**12.60**										
																			1102

* USFW CURVE AS SUPPLIMENTED WITH NC CURVE
** NOT ADJUSTED FOR DELIVERY RATIO OR RESTORATION EFFICIENCY (RE PROTOCOL 1 FOR TMDL).
*** BANK TREATMENTS NOT PROPOSED

CARSINS RUN - RIPKEN TRIB
REACH 1 TYPICAL

BANK EROSION HAZARD INDEX

Stream:	Ripken Trib	**Observer(s):**	SL/BD	**Data:**		**QA/QC:**	
Reach:	Reach 1	**Comments:**					
Location:	left bank	**Bank Length**					
Date:	2/14/2018						

Total Score:	**29.08**					
	Moderate					
Total Score Values:	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
	5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potential	Notes
3.00	1.00	3.00	10.00	Extreme	
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potential	Notes
1.00	3.00	0.33	5.57	Moderate	
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potential	Notes
30.00	0.33	10.00	8.44	Very High	
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potential	Notes
45.00			3.17	Low	
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potential	Notes
80.00			1.90	Very Low	
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**29.08**		

Bank Erosion Potential								
			Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables	**Bank Height / Bankfull Height**	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments		
Bank Material	**Bedrock**	Bedrock banks have a very low erosion potential.
	Boulders	Boulder banks have a low erosion potential.
	Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
	Clay/Silt Loam	Add 5 points.
	Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
	Sand	Add 10 points.
	Silt / Clay	No adjustment.
Stratification		
	Add 5-10 points depending on position of unstable layers in relation to bankfull stage.	

See Appendix A pages 12 and 13 for typical photos

CARSINS RUN - RIPKEN TRIB
REACH 3 TYPICAL

BANK EROSION HAZARD INDEX

Stream:	Ripken Trib	**Observer(s):**	SL/BD	**Data:**		**QA/QC:**	
Reach:	Reach 3	**Comments:**	alternating bank erosion				
Location:	Eroding Banks	**Bank Length**					
Date:	2/14/2018						

Total Score:	**43.53**					
	Very High					
Total Score Values:	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
	5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potential	Notes
3.00	0.50	6.00	10.00	Extreme	
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potential	Notes
0.25	3.00	0.08	8.63	Very High	
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potential	Notes
20.00	0.08	1.67	10.00	Extreme	
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potential	Notes
80.00			5.90	Moderate	
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potential	Notes
10.00			9.00	Very High	
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**43.53**		

Bank Erosion Potential								
			Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables	**Bank Height / Bankfull Height**	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

	Adjustments	
Bank Material	**Bedrock**	Bedrock banks have a very low erosion potential.
	Boulders	Boulder banks have a low erosion potential.
	Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
	Clay/Silt Loam	Add 5 points.
	Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
	Sand	Add 10 points.
	Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

See Appendix A pages 3 through 8 for typical photos

CARSINS RUN - MAINSTEM
MAINSTEM TYPICAL

BANK EROSION HAZARD INDEX

Stream:	CARSINS RUN	**Observer(s):**		**Data:**		**QA/QC:**		**Total Score:**	**31.24**					
Reach:	L1	**Comments:**							**High**					
Location:		**Bank Length**	60					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	2/19/2018								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
7.00	0.50	14.00	10.00	Extreme	
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
3.50	7.00	0.50	3.90	Low	
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
20.00	0.50	10.00	8.44	Very High	
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
70.00			4.90	Moderate	
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
10.00			9.00	Very High	
			Adjustment		Notes
Bank Materials			(5.00)		
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**31.24**		

Bank Erosion Potential

Erodibility Variables			Very Low	Low	Moderate	High	Very High	Extreme
	Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

Bank Material	**Bedrock**	Bedrock banks have a very low erosion potential.
	Boulders	Boulder banks have a low erosion potential.
	Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
	Clay/Silt Loam	Add 5 points.
	Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
	Sand	Add 10 points.
	Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

See Appendix A pages 14 through 16 for typical photos

APPENDIX D
EXISTING BIOLOGICAL DATA

APPENDIX D.1

HABITAT ASSESSMENT FIELD DATA SHEETS

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

STREAM NAME Reach 1	LOCATION TRIB	
STATION # ________ RIVERMILE ________	STREAM CLASS	
LAT ____________ LONG ____________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS BD, LWK		
FORM COMPLETED BY BD	DATE ______ TIME ______ 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 <u>not</u> new fall and <u>not</u> 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 12	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 15	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 7	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 17	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 14	20 19 18 17 16	15 [✓ 14] 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Reach 1 Cont.

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 14	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 12	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 6 (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 5 (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 9 (LB)	Left Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0

Total Score 127

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

STREAM NAME

LOCATION Reach 2a

STATION #________ RIVERMILE________

STREAM CLASS

LAT ________ LONG ________

RIVER BASIN

STORET #

AGENCY

INVESTIGATORS BD, LWK

FORM COMPLETED BY LWK

DATE 2/19/18
TIME 11:30 [✓ 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 <u>not</u> new fall and <u>not</u> 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 12	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 18	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 8	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 18	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 14	20 19 18 17 16	15 [✓ 14] 13 12 11	10 9 8 7 6	5 4 3

Reach 2a Cont.

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 16	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 16	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 9 (LB)	Left Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0
SCORE 9 (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 7 (LB)	Left Bank 10 9	8 [✓ 7] 6	5 4 3	2 1 0
SCORE 7 (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 10 (LB)	Left Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0

Total Score 154

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

STREAM NAME Reach 3
LOCATION TRIB
STATION # ________ RIVERMILE ________
STREAM CLASS
LAT ____________ LONG ____________
RIVER BASIN
STORET #
AGENCY
INVESTIGATORS BD, LWK
FORM COMPLETED BY BD
DATE ______ TIME ______ AM PM
REASON FOR SURVEY

	Habitat Parameter	Condition Category			
		Optimal	**Suboptimal**	**Marginal**	**Poor**
Parameters to be evaluated in sampling reach	**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 14	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 11	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 11	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 8	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 13	20 19 18 17 16	15 14 [✓ 13] 12 11	10 9 8 7 6	5 4 3 2 1 0

Reach 3 Cont.

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	[✓ 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 12	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 1 (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 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 10 (LB)	Left Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank [✓ 10] 9	8 7 6	5 4 3	2 1 0

Total Score 115

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

STREAM NAME Carsins Run	LOCATION Mainstem
STATION # ________ RIVERMILE ________	STREAM CLASS
LAT ____________ LONG ____________	RIVER BASIN
STORET #	AGENCY
INVESTIGATORS BD, LWK	
FORM COMPLETED BY BD	DATE 2/19/18 TIME ________ 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 11	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 13	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 17	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 12	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 16	20 19 18 17 [✓ 16]	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Mainstem Cont.

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 14	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 17	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 6 (LB)	Left Bank 10 9	8 7 [✓ 6]	5 4 3	2 1 0
SCORE 5 (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 5 (LB)	Left Bank 10 9	8 7 6	[✓ 5] 4 3	2 1 0
SCORE 5 (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 3 (LB)	Left Bank 10 9	8 7 6	5 4 [✓ 3]	2 1 0
SCORE 9 (RB)	Right Bank 10 [✓ 9]	8 7 6	5 4 3	2 1 0

Total Score 133

APPENDIX D.2

MBSS SITE DATA

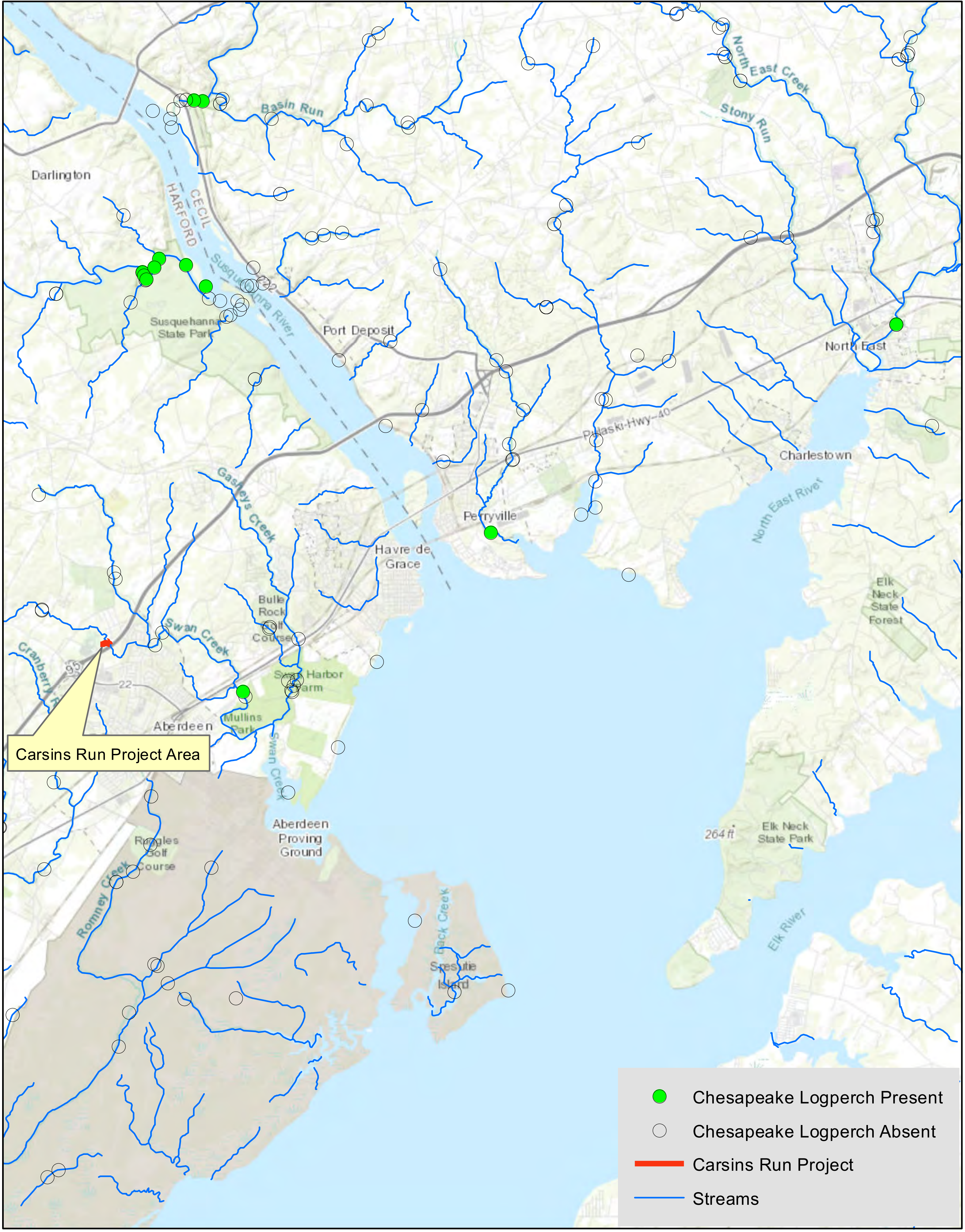
Table D.2a – MBSS IBI Scores For Sites Near Carsins Run

Site ID	Year	BIBI Score	BIBI Rating	FIBI Score	FIBI Rating
HA-N-036-206-96	1996	2.00	Poor	4.00	Good
SWAN-104-R-2000	2000	4.67	Good	4.00	Good
SWAN-105-R-2000	2000	2.67	Poor	4.33	Good
SWAN-106-R-2000	2000	2.00	Poor	1.67	Very Poor
SWAN-204-B-2008	2008	4.00	Good	3.00	Fair
SWAN-105-R-2014	2014	3.67	Fair	4.00	Good

Table D.2b – Fish Species Observed at MBSS Sites

Species	Tolerance to Urbanization	Native or Non-native	Sites					
			HA-N-036-206-96	SWAN-104-R-2000	SWAN-105-R-2000	SWAN-106-R-2000	SWAN-204-B-2008	SWAN-105-R-2014
American Eel	No Type	Native	62	19	41		81	59
Blacknose Dace	Tolerant	Native	1	96	248		17	414
Bluegill	Tolerant	Non-native			9			95
Common Shiner	Intolerant	Native	28	4	112		19	103
Creek Chub	Tolerant	Native	37	79	63	1	41	40
Cutlip Minnow	No Type	Native	94	2	24		24	58
Green Sunfish	Tolerant	Non-native					3	47
Largemouth Bass	Tolerant	Non-native	5					13
Margined Madtom	Intolerant	Native	4				26	7
Pumpkinseed	Tolerant	Native	14		2			
Redbreast Sunfish	No Type	Native	13		21		7	57
River Chub	Intolerant	Native	1				1	
Rosyside Dace	No Type	Native	43	122	156		35	77
Satinfin Shiner	Intolerant	Native					37	
Swallowtail Shiner	No Type	Native	106	2	152		15	215
Tessellated Darter	Tolerant	Native	56	2	22		63	69
White Sucker	Tolerant	Native	88	31	56		42	50

Chesapeake Logperch Records in the Vicinity of Carsins Run, MD, Harford County



APPENDIX E

NATURAL RESOURCES INVENTORY REPORT

Carsins Runs
I-95 Section 200
Stream Restoration Site

Natural Resources Inventory

Prepared for
MDTA

Maryland Transportation Authority
2310 Broening Highway
Baltimore, Maryland 21224

KCI Technologies, Inc.
February 2018
KCI Project No. 22145228.36

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1 INTRODUCTION

1.1 Project Description

The Maryland Transportation Authority is proposing stream restoration along approximately 1,500 linear feet of Carsins Run in Harford County, Maryland. As part of this effort, KCI Technologies, Inc. (KCI) developed this Natural Resources Inventory (NRI), including a forest stand delineation (FSD) and wetland delineation, to identify and characterize environmental resources that could potentially be impacted within the study area. KCI conducted a wetland investigation to determine the presence of wetlands and other "waters of the United States" (WUS) systems within the study area in accordance with the methodologies outlined in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987), the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Eastern Mountains and Piedmont Region (Version 2.0)* (Environmental Laboratory, 2012), and other relevant guidance documents. Additionally, KCI conducted an FSD to summarize forest species composition, apparent seral stage, degree of structural complexity, environmental condition, and ecosystem function of forest stands that could potentially be impacted within the study area. Forest stands throughout the study area were identified and delineated in accordance with the methodologies outlined in the *State Forest Conservation Technical Manual, Third Edition* (MDNR, 1997) and *Harford County Forest Cover Conservation and Replacement Manual* (Harford County Department of Planning and Zoning [HCDPZ], 1992).

Prior to the commencement of field activities, KCI reviewed readily available primary source materials to determine the presence or absence of natural resources within the study area. Relevant information found during this search is described in detail below and references utilized during the literature review are included as Appendix A to this report.

1.2 Study Area Description

The project study area extends along a 600-linear foot (LF) forested stream corridor that crosses Interstate 95 (I-95) north of the MD Route 22 interchange, and adjacent to Ripken Stadium. Carsins Run flows generally southeast through the study area, through a box culvert beneath I-95, and continues outside the study area to its eventual confluence with Swan Creek. The study area also includes an approximately 700-LF segment of an intermittent tributary to Carsins Run that originates at a wetland southeast of Ripken Stadium. The study area is surrounded by residential property and forested land. A Site Location Map depicting the study area is enclosed as Attachment 1 to this report.

2 METHODOLOGY

2.1 Review of Existing Data / Literature Review

Prior to conducting field activities, KCI reviewed readily available primary source materials including USGS maps, National Wetland Inventory (NWI) maps, Federal Emergency Management Agency (FEMA) floodplain data, and the city/county soil survey to determine the presence or absence of regulated natural resources (wetlands and streams) within the study area.

2.2 Wetland Delineation Methodology

KCI performed a field reconnaissance for the entire study area to determine the presence or absence of wetland areas during February 2018. Based upon this review, KCI determined that normal conditions were present on the site and that the “Routine Determination" method would be appropriate in order to identify wetland boundaries within the study area. In the field, wetland delineations were conducted using the criteria outlined in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987) and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Eastern Mountains and Piedmont Region (Version 2.0)* (Environmental Laboratory, 2012).

During the course of the field investigation, dominant plant species within suspected wetland areas were identified and recorded for each stratum present. The United States Army Corps of Engineers (USACE) *2016 National Wetland Plant List* (Lichvar, 2016) was used to determine the indicator status of the vegetation found within each community. KCI then characterized the plant community as hydrophytic or upland based upon the results of the Dominance Test and the Prevalence Index worksheets within the *Wetland Determination Data Form – Eastern Mountains and Piedmont Region*.

KCI assessed wetland hydrology within the study area based on the presence of one primary or two or more secondary hydrology indicators. Surface water inundation, depth to soil saturation, drift lines, water marks, and sediment deposits are some of the primary indicators listed in the *Wetland Determination Data Form – Eastern Mountains and Piedmont Region*. Secondary indicators include surface soil cracks, a sparsely vegetated concave surface, drainage patterns, and moss trim lines, as well as other less commonly found indicators.

Soil pits were typically excavated to a depth of approximately 18-24 inches, barring refusal, or immediately below the A-horizon. KCI recorded soil texture and the color of the matrix and any concretions or soft masses within a representative soil sample were assigned hue, value, and chroma utilizing the *Munsell Soil Color Charts* (Munsell, 2000). All soil samples were thoroughly investigated for the presence of redoximorphic features and/or hydric soil indicators included in *Field Indicators of Hydric Soils* (NRCS, 2016) and the *Wetland Determination Data Form – Eastern Mountains and Piedmont Region*. KCI then classified soils as hydric or non-hydric based upon the presence or absence of hydric soil characteristics and indicators.

KCI determined areas to be wetlands once all three wetland parameters (vegetation, hydrology, and soils), as described above, were identified (Environmental Laboratory, 1987 and 2012). When wetlands and streams were identified in the field, their boundaries were flagged along the wetland/upland interface or along the ordinary high water mark, respectively. Closed wetland systems were identified with a "WP" in the system name, while open or linear systems that extended outside of the study area were identified with a "WL" in the system name. Boundaries were marked in the field using consecutively numbered flagging tape, and flag locations were subsequently field located utilizing a total station survey apparatus. A map showing delineated wetlands and waterways is included as Appendix B to this report.

Vegetation, hydrologic, and soils data collected in the field, as well as information derived from the pre-fieldwork data review, were transferred to *Wetland Determination Data Forms - Eastern Mountains and Piedmont Region* in accordance with USACE protocols (1987 and 2012). Appendix C includes the Wetland Determination Data Forms for the upland and wetland sample plot locations and Stream Features Datasheets for WUS systems throughout the study area.

Representative photographs were taken throughout the study area and specifically of wetlands and stream systems in order to document field conditions at the time of the delineation. These photos have been included as Appendix E to this report.

2.3 Forest Stand Delineation Methodology

KCI identified and delineated forest stands throughout the study area in accordance with the methodologies outlined in the *State Forest Conservation Technical Manual, Third Edition* (MDNR, 1997) and the Harford County *Harford County Forest Cover Conservation and Replacement Manual (HCDPZ, 1992)*.

Preliminary field maps were generated in house for the entire subject property. These maps (Environmental Features and Forest Survey Maps) were prepared showing approximate boundaries of the forest stands delineated from aerial photographs, topography (steep slopes between 15 and 25% and greater than 25% are indicated), streams (intermittent and perennial), and wetlands and their buffers. The Environmental Features map marked with soils, steep slopes, forest buffers, land uses, critical habitat areas, and 100-year floodplains was used to assess any major forest stands present. Sample plot locations, individual specimen trees (trees with a diameter at breast height (DBH) over 30", or having 75% of the DBH of current State champion of that species), champion trees, and forest structure data were marked on the Forest Survey Map with critical habitats, historic areas, net tract area, and forest circumference line. These field maps were used for later development of the FSD map.

KCI assessed the entire forested section of the project corridor to confirm the boundaries of the forest stands and to document stand condition. Forest stands under one acre in size were included in larger adjacent stands unless it was apparent that some unique characteristic (such as rare, threatened, or endangered species present) would make it critical to evaluate the stand as a separate entity.

A 1/10-acre fixed-plot method was used to document stand condition. The sample plots were determined based on size, topography, contiguity, and forest community features. Sample plots within stands were delineated by tying white and orange flagging to trees. After plots were delineated, the number and species of dominant and co-dominant trees, the percent canopy cover, the percent of understory cover, percent herbaceous ground cover, presence of exotic or invasive species, basal area, size of specimen trees, condition and health of stand, and understory species composition were recorded on the Forest Sampling Data Forms. A map showing delineated forest stands is included as Appendix B. Completed Forest Sampling Data Forms are included in Appendix C.

Priority retention areas were identified and labeled on the FSD map. Priority retention of stands is based on raking of high to low as described below.

- **High Priority** – includes areas within critical habitats for RTE species; areas associated within intermittent and perennial streams, slopes over 25%, hydric soils, highly erodible soils with a K value greater than 0.35 on slopes of 15% or more, and 100-year floodplain areas; stands with high structural diversity; contiguous forested areas of 100 acre that connect larger forests; forests within a corridor 300 feet wide between two larger forested tracts; forest stands that include specimen or champion trees or associated with a historic site.
- **Moderate Priority** – includes forests with good structural diversity, contiguous forests of 20 acre or more that connect to larger forests, forested stream buffers, and forest areas that provide a landscaping or buffer function.
- **Low Priority** – includes forest stands with poor structural diversity and areas with none of the characteristics listed above.
- **Disturbed** – includes forest stands with a high percentage of land cover with exotic or invasive species and none of the characteristic listed above.

Specimen trees within stands throughout the entire study corridor were identified in the field with white and orange flagging. Specimen trees and sample plot locations were documented using Global Positional System (GPS) with submeter accuracy. Specimen tree health was characterized using the following criteria:

Health	Characteristics
Excellent	Tree form normal for the species Full crown/no vines in crown No major branches dead Leaves normal size and color for the species, with no spotting or insect infestation No cracks in bark that expose the inner layers No weak branch union, cankers, decay No root severing, exposed roots, roots compacted from foot traffic, decay, dieback No invasive vines on tree (bittersweet, wild grape, poison ivy, English ivy)
Good	Competition from adjacent tree species but otherwise normal tree form for the

Health	Characteristics
	species 80-90% full crown/no vines in crown, <10% smaller branches dead >80% leaves normal size and color for the species, <10% spotting, less than 5% insect infestation > 10% of tree has cracks in bark that are 4" in diameter No weak branch union, cankers, decay No root severing, exposed roots, roots compacted from foot traffic, decay, dieback No invasive vines on tree (bittersweet, wild grape, poison ivy, English ivy)
Fair	Tree has lost a major limb or is leaning to one side <75% full crown/vines may be present in crown <30% of branches may have dead wood >60% leaves normal size and color for the species, >20% spotting on leaves >30% of tree has cracks in bark that are 4" or greater in diameter Weak branch union is present, cankers present, decay, present One or more root problem is present but does not appear to be causing tree dieback One or more invasive vines (bittersweet, wild grape, poison ivy, English ivy) are present and competing with crown growth Presence of Insect infestation appears to be causing tree dieback
Poor	Tree has lost major limbs and is leaning to one side <50% full crown/vines are dominant in crown >50% of branches may have dead wood <50% leaves normal size and color for the species, >40% spotting on leaves >50% of tree has cracks in bark that are 4" or greater in diameter Weak branch union is present, cankers present, decay, present One or more root problems are present and appears to be causing tree dieback Invasive vines on tree (bittersweet, wild grape, poison ivy, English ivy) are present and are dominating over crown growth Presence of Insect infestation appears to be causing tree dieback

Note: Trees may have one or more of the characteristics listed under each category.

Representative site photographs were taken throughout the study area and of each sample plot within the forest stands. These photos have been included as Appendix E to this report.

MDTA submitted inquiries requesting information regarding the possibility of rare, threatened, and endangered species within or adjacent to the study area to the United States Fish and Wildlife Service (USFWS) and Maryland Department of Natural Resources (MDNR) in February 2018. An inquiry letter has also been sent to the Maryland Historical Trust (MHT) in regards to possible historical areas within the limits of the study area and adjacent land. USFWS did not identify RTE species within the project area. The responses from MDNR and MHT are currently pending. Copies of the correspondence with MHT, MDNR, and USFWS are included as Appendix F.

3 RESULTS

3.1 Literature Review Results

3.1.1 Watershed and Land Use

The study area is located within the Swan Creek watershed (02130706). Carsins Run flows through the study area. The Maryland Surface Water Use Designation for Carsins Run and all its tributaries in this area is "Use I", pursuant to which they are protected for "water contact recreation and protection of nontidal, warmwater, aquatic life" (COMAR 26.08.02.08). Due to this designation, in-stream work may not be conducted during the period of March 1 through June 15, inclusive, during any year (COMAR 26.08.02.11). Additionally, KCI reviewed Maryland's High Quality Waters (Tier II) list to identify any Tier II waters within the study area. No Tier II waters were identified in the study area (MDE, 2010). According to the Maryland 303(d) list of impaired waterways, the Swan Creek watershed is listed as Category 5 – impaired for phosphorus and total suspended solids.

The Maryland Department of Planning, Land Use/Land Cover geographic information systems (GIS, 2011) indicated the majority of the study area, and its immediate surroundings, is classified as "Forest" (Code 41), "Low Density Residential" (Code 11), "Commercial" (Code 14), and Transportation (80).

3.1.2 Topography

The study area is located within the Piedmont Physiographic Province. According to a review of the *Aberdeen, Maryland 7.5' Topographic Quadrangle* (United States Geological Survey, 2016) and other sources, the topography within the study area is moderately sloping to the east and south. Elevations range from approximately 180 feet above mean sea level (MSL) at the southern end of the study area to 210 feet above MSL at the western end of the study area. A copy of the relevant USGS quadrangle map for the study area is included as Attachment 2 to this report.

3.1.3 Soils

According to the *Soil Survey of Harford County, Maryland* (United States Department of Agriculture-Soil Conservation Service [USDA-SCS], 1975) and more recently available digital Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) soils data for the County (NRCS Web Soil Survey, 2018), the predominant soil association found within the vicinity of the study area is the Codorus-Hatboro-Alluvial Land Association. Soils in this association are described as deep, nearly level, moderately well drained to very poorly drained soils that are underlain by stratified alluvial sediment on floodplains. Within this association, six distinct soil units are present within the study area:

- Aldino silt loam, 3-8% slopes (AdB)
- Alluvial land (Av)
- Codorus silt loam (Cu)

- Delanco silt loam, 3-8% slopes (DcB)
- Elsinboro loam, 2-5% slopes, moderately eroded (EsB2)
- Montalto silt loam, 8-15% slopes, moderately eroded (MsC2)

Mapped soil units are classified hydric based upon their listing on the National Hydric Soils List by State (USDA-NRCS, continuously updated) and the State and County lists in the web soil survey (NRCS Web Soil Survey, 2018). Hydric soils are defined as those soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part of the soil profile. The table below summarizes hydric components of soils within the study area as listed in either the National Hydric Soils List by State or the web soil survey.

Soil Series	**Hydric (Y/N)**	**Hydric Component**	**Percent of map unit**
Aldino silt loam, 3-8% slopes (AdB)	No	Watchung	5%
Alluvial land (Av)	Yes	Alluvial Land	100%
Codorus silt loam (Cu)	No	Hatboro	15%
Delanco silt loam (DcB)	No	N/A	N/A
Elsinboro loam, 2-5% slopes, moderately eroded (EsB2)	No	N/A	N/A
Montalto silt loam, 8-15% slopes, moderately eroded (MsC2)	No	N/A	N/A

A copy of the soil survey map for the study area is included as Attachment 3 to this report.

3.14 National Wetlands Inventory

The *National Wetlands Inventory (NWI) Map for Aberdeen, Maryland* (U.S. Fish and Wildlife Service [USFWS], 1981-2016) identifies Carsins Run and an adjacent wetland as palustrine, forested, broad-leaved deciduous, temporarily flooded (PFO1A) systems within the study area. Attachment 4 shows the locations of NWI-classified wetlands in the vicinity of the study area.

3.1.5 FEMA-Designated Floodplains

According to a review of Federal Emergency Management Agency (FEMA) Q3 Flood Data, the study area is within the 100-year floodplain associated with Carsins Run (*FEMA Panel No. 24025C0191E*) and (*FEMA Panel No. 24025C0193E*). Attachment 5 shows the locations of FEMA-designated floodplains in the vicinity of the study area.

3.2 Wetland and Waters of the U.S. Field Investigation Results

The field investigation performed during February 2018 located two nontidal wetland systems, two perennial streams, and one intermittent stream, classified as "waters of the U.S." Additionally, three ephemeral channels were identified within the study area. Information concerning these wetlands and streams is outlined below and included in the appendices to this report.

3.2.1 Waters of the U.S.

WUS WL001 (Perennial)

WUS WL001 (Flags WL001-001 to WL001-017A/B), Carsins Run, is a nontidal, perennial stream that enters the study area from the northwest, flows generally southeast, beneath I-95 through a box culvert, and continues outside of the study area to its confluence with Swan Creek. Approximately 1,197 LF of this stream is within the study area. This perennial stream had an approximate bankfull width of 12 feet with an average bankfull depth of 12 inches and an observed water depth of 6 inches at the time of the site investigation. WUS WL001 is identified on the *National Wetland Inventory Map for Aberdeen, Maryland* (USFWS, 1981-2016) as a palustrine, forested, broad-leaved deciduous, temporarily flooded (PFO1A) wetland system. Based on the field investigation, the Cowardin Classification for Carsins Run is riverine, lower perennial, unconsolidated bottom, cobble-gravel/sand (R2UB1/2).

More information regarding WUS WL001 can be found in the appendices of this report.

Waterway WL002 (Ephemeral)

Waterway WL002 (Flags WL002-001 to WL002-002A/B) is a nontidal, ephemeral channel west of Randolph Drive in the northern extents of the study area. Waterway WL002 originates at a stormwater outfall and conveys flow southwest to its confluence with WUS WL001. Approximately 13 LF of this stream is within the study area. This ephemeral channel had an approximate bankfull width of 4 feet with an average bankfull depth of 4 inches and an observed water depth of 1 inch at the time of the site investigation. Waterway WL002 is not identified on the *National Wetland Inventory Map for Aberdeen, Maryland* (USFWS, 1981-2016).

More information regarding Waterway WL002 can be found in the appendices of this report.

WUS WL003 (Intermittent)

WUS WL003 (Flags WL003-001 to WL003-039A/B) is a nontidal, intermittent stream that originates at a wetland northwest of I-95, west of WUS WL001 and Waterway WL004, and flows generally northeast to its confluence with WUS WL001. Approximately 928 LF of this stream is within the study area. This intermittent stream had an approximate bankfull width of 2 feet with an average bankfull depth of 12 inches and an observed water depth of 2 inches at the time of the site investigation. WUS WL003 is not identified on the *National Wetland Inventory Map for Aberdeen, Maryland* (USFWS, 1981-2016). Based on the field investigation, the Cowardin Classification for this system is riverine, intermittent, streambed, cobble-gravel/sand (R4SB3/4).

More information regarding WUS WL003 can be found in the appendices of this report.

Waterway WL004 (Ephemeral)

Waterway WL004 (Flags WL004-001 to WL004-008A/B) is a nontidal, ephemeral channel that originates as overflow from WUS WL003, northwest of I-95, and flows generally northeast to its confluence with WUS WL001. Approximately 136 LF of this channel is within the study area. This ephemeral channel had an approximate bankfull width of 1.5 feet with an average bankfull depth of 4 inches and an observed water depth of less than 0.5 inch at the time of the site investigation. Waterway WL004 is not identified on the *National Wetland Inventory Map for Aberdeen, Maryland* (USFWS, 1981-2016).

More information regarding Waterway WL004 can be found in the appendices of this report.

WUS WL005 (Perennial)

WUS WL005 (Flags WL005-001 to WL005-005A/B) is a nontidal, perennial stream that originates at Carsins Run at a split with WL001, flows generally south, and continues outside of the project area. This channel appears to convey the majority of the Carsins Run flow into a large wetland system (WL008), although the mapped Carsins Run takes a southwest turn. Approximately 47 LF of this stream is within the study area. This perennial stream had an approximate bankfull width of 15 feet with an average bankfull depth of 10 inches and an observed water depth of 8 inches at the time of the site investigation. WUS WL005 is identified on the *National Wetland Inventory Map for Aberdeen, Maryland* (USFWS, 1981-2016) as part of a palustrine, forested, broad-leaved deciduous, temporarily flooded (PFO1A) wetland system. Based on the field investigation, the Cowardin Classification for this system is riverine, lower perennial, unconsolidated bottom, cobble-gravel/sand (R2UB1/2).

More information regarding WUS WL005 can be found in the appendices of this report.

Waterway WL006 (Ephemeral)

Waterway WL006 (Flags WL006-001 to WL006-005A/B) is a nontidal, ephemeral channel that originates within Wetland WL008, southeast of I-95, and conveys flow generally south to its confluence with Carsins Run. Approximately 138 LF of this stream is within the study area. This ephemeral channel had an approximate bankfull width of 2 feet with an average bankfull depth of 4 inches and an observed water depth of less than 1 inch at the time of the site investigation. Waterway WL006 is not identified on the *National Wetland Inventory Map for Aberdeen, Maryland* (USFWS, 1981-2016).

More information regarding Waterway WL006 can be found in the appendices of this report.

3.2.2 Nontidal Wetlands

Wetland WL007 (Flags WL007-001 to WL007-018)

Wetland WL007 is a palustrine, forested, broad-leaved deciduous, temporarily flooded (PFO1A) wetland at the headwaters of WUS WL003, generally east of Ripken Stadium. Approximately 0.365 acre of this wetland is within the study area. Wetland WL007 receives hydrology from overland flow from and outlets in an easterly direction to WUS WL003. This wetland is not identified on the *National Wetland Inventory Map for Aberdeen, Maryland* (USFWS, 1981-2016).

KCI collected information from a sample plot within Wetland WL007 (Plot WL007-WET) in order to properly classify the predominant vegetation, soil characteristics, and hydrologic indicators. Vegetative cover in close proximity to the sample plot is dominated by red maple (*Acer rubrum*), green ash (*Fraxinus pennsylvanica*), Japanese stilt grass (*Microstegium vimineum*), multiflora rose (*Rosa multiflora*), and poison ivy (*Toxicodendron radicans*). Sweet gum (*Liquidambar styraciflua*) is also noted within the plot; therefore, sample plot WL007-WET satisfies the hydrophytic vegetation criterion. Hydrologic indicators in the wetland include saturation, water-stained leaves, oxidized rhizospheres on living roots, and drainage patterns.

Soil characteristics within Wetland WL007 are summarized in the following table:

Depth (inches)	Texture	Matrix	Redox Features
0-8	Silt clay loam	10YR 4/2	10YR 2/1, depletions in the matrix 7.5YR 4/4, concentrations in the matrix/pore linings
8-20	Silt clay loam	2.5Y 6/1	10YR 5/2, concentrations in the matrix 10YR 5/8, concentrations in the matrix 10YR 3/2, concentrations in the matrix 7.5YR 4/4, concentrations in the matrix/pore linings
20-24	Clay loam	2.5Y 6/1	10YR 6/8, concentrations in the matrix 10YR 3/2, concentrations in the matrix 10YR 4/4, concentrations in the matrix

Hydric soil indicators were identified within the soil profile; therefore, sample plot WL007-WET satisfies the hydric soils criterion.

In addition to a sample plot within the wetland, one upland data point (UPL-1) was taken in close proximity to Wetland WL007 to classify the surrounding upland area.

Vegetation at UPL-1 consists primarily of white oak (*Quercus alba*), American beech (*Fagus grandifolia*), ironwood (*Carpinus caroliniana*), northern spicebush (*Lindera benzoin*), Japanese honeysuckle (*Lonicera japonica*), poison ivy, and fox grape (*Vitis labrusca*). Other vegetation identified within the sample plot included sweetgum (*Liquidambar styraciflua*), eastern red cedar (*Juniperus virginiana*), black gum (*Nyssa sylvatica*), tulip poplar (*Liriodendron tulipifera*), meadow garlic (*Allium canadense*), and Japanese stilt grass. Sample plot UPL-1 does not satisfy the hydrophytic vegetation criterion.

Soil characteristics at UPL-1 are summarized in the following table:

Depth (inches)	Texture	Matrix	Redox Features
0-10	Silt loam	10YR 4/4	7.5YR 4/4, concentrations in the matrix
10-24	Silt loam	7.5YR 4/6	10YR 3/3, concentrations in the matrix

Hydric soil indicators were not identified within the soil profile; therefore, sample plot UPL-1 does not satisfy the hydric soils criterion. No wetland hydrologic indicators were present in close proximity to upland sample plot UPL-1. Sample Plot UPL-1 does not satisfy the three mandatory wetland criteria; therefore, this area was classified as upland.

More information regarding the soils, vegetation, and hydrology found within Wetland WL007 and the adjacent upland can be found in the appendices to this report.

Wetland WL008 (Flags WL008-001 to WL008-010)

Wetland WL008 is a palustrine, forested, broad-leaved deciduous, temporarily flooded (PFO1A) southeast of I-95, northeast of WUS WL001. Approximately 0.017 acre of this wetland is within the study area. Wetland WL008 receives hydrology from groundwater and overland flow and outlets in a southerly direction towards Carsins Run. This wetland is identified on the *National Wetland Inventory Map for Aberdeen Maryland* (USFWS, 1981-2016) as a palustrine, forested, broad-leaved deciduous, temporarily flooded (PFO1A) wetland.

KCI collected information from a sample plot within Wetland WL008 (Plot WL008-WET) in order to properly classify the predominant vegetation, soil characteristics, and hydrologic indicators. Vegetative cover in close proximity to the sample plot is dominated by red maple, black gum, American beech, and sedge species (*Carex* species). Other vegetation identified within the sample plot included sweetgum, ironwood, and white oak. Hydrologic indicators in the wetland include saturation and oxidized rhizospheres on living roots.

Soil characteristics within Wetland WL008 are summarized in the following table:

Depth (inches)	Texture	Matrix	Redox Features
0-8	Silt clay loam	10YR 4/1	10YR 4/4, concentrations in the matrix/pore linings 10YR 6/1, concentrations in the matrix
8-12	Silt clay loam	10YR 5/1	10YR 4/1, concentrations in the matrix 10YR 5/6, concentrations in the matrix/pore linings 10YR 6/6, concentrations in the matrix
12+	Refusal due to rock		

Hydric soil indicators were identified within the soil profile; therefore, sample plot WL008-WET satisfies the hydric soils criterion.

In addition to a sample plot within the wetland, one upland data point (UPL-2) was taken in close proximity to Wetland WL008 in order to classify the surrounding upland area. Vegetation at UPL-2 consists primarily of red maple, American beech, sedge species, and Japanese stilt grass. Other vegetation identified within the sample plot included eastern red cedar, black gum, and sweetgum. Sample Plot UPL-2 satisfies the hydrophytic vegetation criterion.

Soil characteristics at UPL-2 are summarized in the following table:

Depth (inches)	Texture	Matrix	Redox Features
0-6	Medium sand	10YR 3/3	10YR 4/4, concentrations in the matrix
6-12	Silt loam	10YR 4/3	N/A
12-20	Silt clay loam	2.5Y 5/4	2.5Y 5/3, concentrations in the matrix 10YR 5/6, concentrations in the matrix 10YR 6/6, concentrations in the matrix 10Y 3/2, concentrations in the matrix

Hydric soil indicators were not identified within the soil profile; therefore, sample plot UPL-2 does not satisfy the hydric soils criterion. Hydrologic indicators identified within the upland plot include saturation. The sample plot satisfies the hydrology criterion. Sample plot UPL-2 satisfies only two of the three mandatory wetland criteria; therefore, this area was classified as upland.

More information regarding the soils, vegetation, and hydrology found within Wetland WL008 and the adjacent upland can be found in the appendices to this report.

3.3 Forest Stand Delineation Results

This section documents forest stand conditions as field delineated on February 6, 2018, within the vicinity of the proposed Carsins Run Stream Restoration project. As part of this effort, KCI reviewed readily available information regarding environmental resources within the study area and conducted an FSD to determine the potential for impacts to forest resources within the study area.

The field investigation performed on February 6, 2018, generally confirmed the information gathered from the literature review performed prior to commencement of fieldwork activities. Specifically, existing land uses, topography, soils, and floodplain locations were generally similar to what is recorded on existing, readily available information for the study area. Additional information concerning the forest stands and natural resources is outlined below and in the appendices to this report.

3.3.1 Forest Stands

Two forest stands were identified onsite. A 1/10 acre fixed plot sampling technique was used to sample forest stand conditions at five points onsite (see Forest Sampling Data Forms in Appendix D). Sample points were chosen randomly within the two identified stands.

Overall, the health of the forest stands was determined to be good with no significant sign of disease or widespread colonization of exotic plant species observed. No rare, threatened, or endangered species were observed.

Forest Stand A

Stand A (Mixed Hardwood) occupies approximately 2.59 acres within the study area and is located northeast of I-95. This early-mid successional deciduous stand is bounded by I-95 to the south, Gilbert Road to the north, Ripken Stadium to the west, and Randolph Drive to the east.

Stand A is dominated by tulip poplar, sweetgum, white oak, pignut hickory (*Carya glabra*), American beech, and red maple in the 12 to 29.9-inch size classes. Ironwood, common greenbrier (*Smilax rotundifolia*), fox grape, northern spicebush, American beech, Japanese barberry (*Berberis thunbergii*), and hawthorn species (*Crataegus* species) are the dominant understory and shrub species. The herbaceous layer is dominated by Japanese honeysuckle, meadow garlic, multiflora rose, and Japanese stilt grass.

Nineteen specimen trees were found during the field survey and are listed in the table below. Each tree was assessed and the health of the trees is listed in the table below.

Specimen Trees			
ID	**Species**	**Size**	**Condition**
SP-2	*Quercus rubra*	30.0	Good
SP-3	*Liriodendron tulipifera*	33.0	Good
SP-4	*Quercus alba*	31.0	Fair
SP-5	*Fraxinus pennsylvanica*	31.0	Fair
SP-6	*Fraxinus pennsylvanica*	30.0	Fair
SP-7	*Fraxinus pennsylvanica*	36.0	Fair
SP-8	*Liriodendron tulipifera*	30.0	Good
SP-9	*Liriodendron tulipifera*	31.0	Good
SP-10	*Quercus velutina*	33.0	Good
SP-11	*Quercus rubra*	32.0	Good
SP-12	*Quercus rubra*	33.0	Good
SP-13	*Liriodendron tulipifera*	31.0	Good
SP-14	*Liriodendron tulipifera*	32.0	Good
SP-15	*Quercus alba*	30.0	Fair
SP-16	*Fagus grandifolia*	30.0	Good
SP-17	*Liquidambar styraciflua*	33.0	Good
SP-18	*Quercus alba*	38.0	Poor
SP-19	*Liriodendron tulipifera*	32.0	Poor
SP-20	*Liriodendron tulipifera*	46.0	Far

Canopy closure within the stand was estimated at approximately 80% and basal area was determined to be 115 square feet per acre. There was a moderate amount of downed woody debris and no standing dead trees greater than 20 inches DBH were identified. Litter depth was less than a half inch.

The topography in the stand is moderately sloping to the east and west. Forest Stand A is a high priority retention forest because of its proximity to floodplains, wetlands, and streams, and due to the presence of specimen trees. This is an early-mid successional stand with a low amount of invasive species coverage.

Forest Stand B

Stand B (Tulip Poplar-Maple Forest) occupies approximately 0.60 acre within the study area and is located southeast of I-95. This early successional deciduous stand is bounded by I-95 to the north, Beards Hill Road to the south, Maxa Road to the east, and commercial property to the west.

Stand B is dominated by sweetgum, red maple, black gum, American beech, and tulip poplar in the 12 to 19.9-inch size class. American beech, ironwood, fox grape, red maple, and common greenbrier are the dominant understory and shrub species. The herbaceous layer is dominated by Japanese honeysuckle, meadow garlic, multiflora rose, ironwood, Japanese stilt grass, common greenbrier, Christmas fern (*Polystichum acrostichoides*), and sedge species.

One specimen tree was found during the field survey and is listed in the table below. The tree was assessed and the health of the tree is listed in the table below.

Specimen Trees			
ID	**Species**	**Size**	**Condition**
SP-1	*Liriodendron tulipifera*	31.0	Good

Canopy closure within the stand was estimated at approximately 80% and basal area was determined to be 100 square feet per acre. There was a moderate amount of downed woody debris and no standing dead trees greater than 12 inches DBH were identified. Litter depth was less than a half inch.

The topography in the stand is gently sloping to the southeast. Forest Stand B is a high priority retention forest because of its proximity to floodplains, wetlands, and streams, and the presence of specimen trees. This is an early successional stand with a low amount of invasive species coverage.

4 CONCLUSIONS

4.1 Wetlands and Waters of the U.S.

The study area contains two wetlands. Information concerning these wetlands is summarized below, in tabular form and included in the appendices to this report. Refer to Appendix B: Natural Resources Inventory/Forest Stand Delineation Map for the locations of natural resources within the study area.

Wetland System	Cowardin Classification*	Approximate Wetland Area within the Study Area (AC)
Wetland WL007	PFO1A	0.365
Wetland WL008	PFO1A	0.017

** Based on National Wetland Inventory Classification System (Cowardin, et al. 1979).*

In addition, six waterways were identified during the field investigation. Information regarding these waterways is summarized below, in tabular form. Refer to Appendix B: Natural Resources Inventory/Forest Stand Delineation Map for the locations of natural resources within the study area.

WUS System	Cowardin Classification*	Approximate Length within Study Area (LF)
WUS WL001	R2UB1/2	1,197
Waterway WL002	Ephemeral	13
WUS WL003	R4SB3/4	928
Waterway WL004	Ephemeral	136
WUS WL005	R2UB1/2	47
Waterway WL006	Ephemeral	138

** Based on National Wetland Inventory Classification System (Cowardin, et al. 1979).*

This investigation represents a study of the wetland and waterway resources as observed within the study area during February 2018. Investigations of this type reflect the current state of temporal and variable conditions and require individual professional judgment. This is, therefore, a professional estimate of the wetlands and “waters of the U.S.” located in the study area based on the delineation methodology utilized and the most recent and best-available information for the above mentioned sites. Wetland boundaries, as currently defined for regulatory purposes, can only be verified through a review by the U.S. Army Corps of Engineers and/or the Maryland Department of the Environment in consultation with the U.S. Environmental Protection Agency and U.S. Fish and Wildlife Service.

4.2 Forests

The study area contains two distinct forest stands. Stands A and B are high priority retention stands because of their proximity to floodplains, wetlands, streams, and specimen trees.

This investigation represents a study of the forested areas within the study area as observed during February 2018. Forest Stand Delineations of this type reflect the current state and require individual professional judgment. This is, therefore, a professional estimate of the forests located in the study area based on the delineation methodology utilized and the most recent and best-available information for the above mentioned site.

4.3 Discussion

The Maryland Transportation Authority is proposing stream restoration of approximately 1,500 LF along Carsins Run. Impacts to wetlands or waterways within the proposed project area will require a *Joint Federal/State Application for the Alteration of Any Floodplain, Waterway, Tidal, or Nontidal Wetland in Maryland*. Additionally, forest disturbance will require a forest conservation plan (FCP). Clearing above the established threshold will require forest mitigation in the form of reforestation onsite or off-site or through a fee-in-lieu.

Qualifications of Preparer

Ms. Jennifer Bird, Senior Project Manager with KCI’s Natural Resources Management Practice, prepared the Forest Stand Delineation included in this Natural Resources Inventory. Enclosed in Appendix G is a copy of Ms. Bird’s confirmation letter from MDNR stating she is a Qualified Professional under Maryland State Forest Conservation regulations, to conduct forest stand delineations and develop forest conservation plans.

5 REFERENCES

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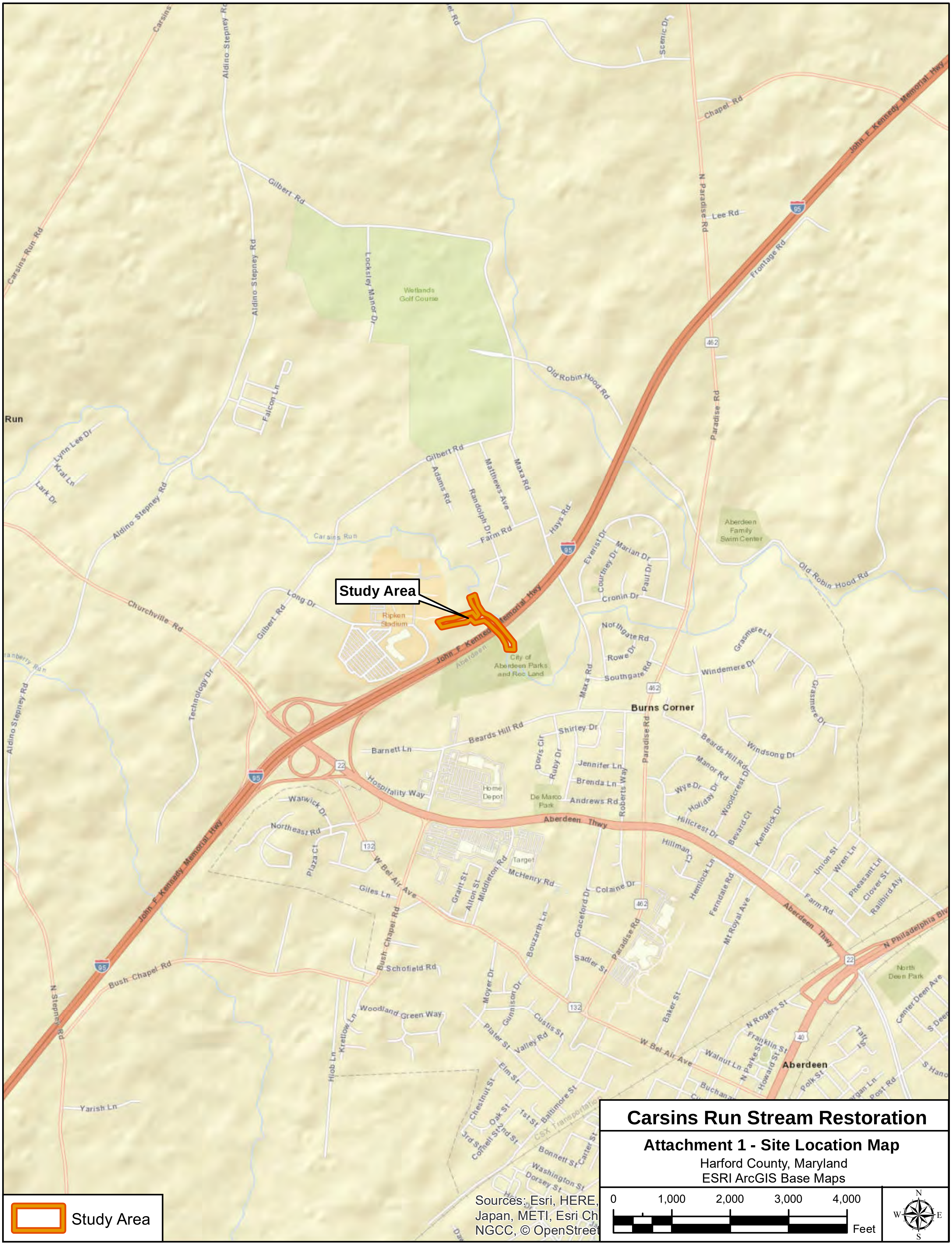
ATTACHMENT 1

Site Location Map



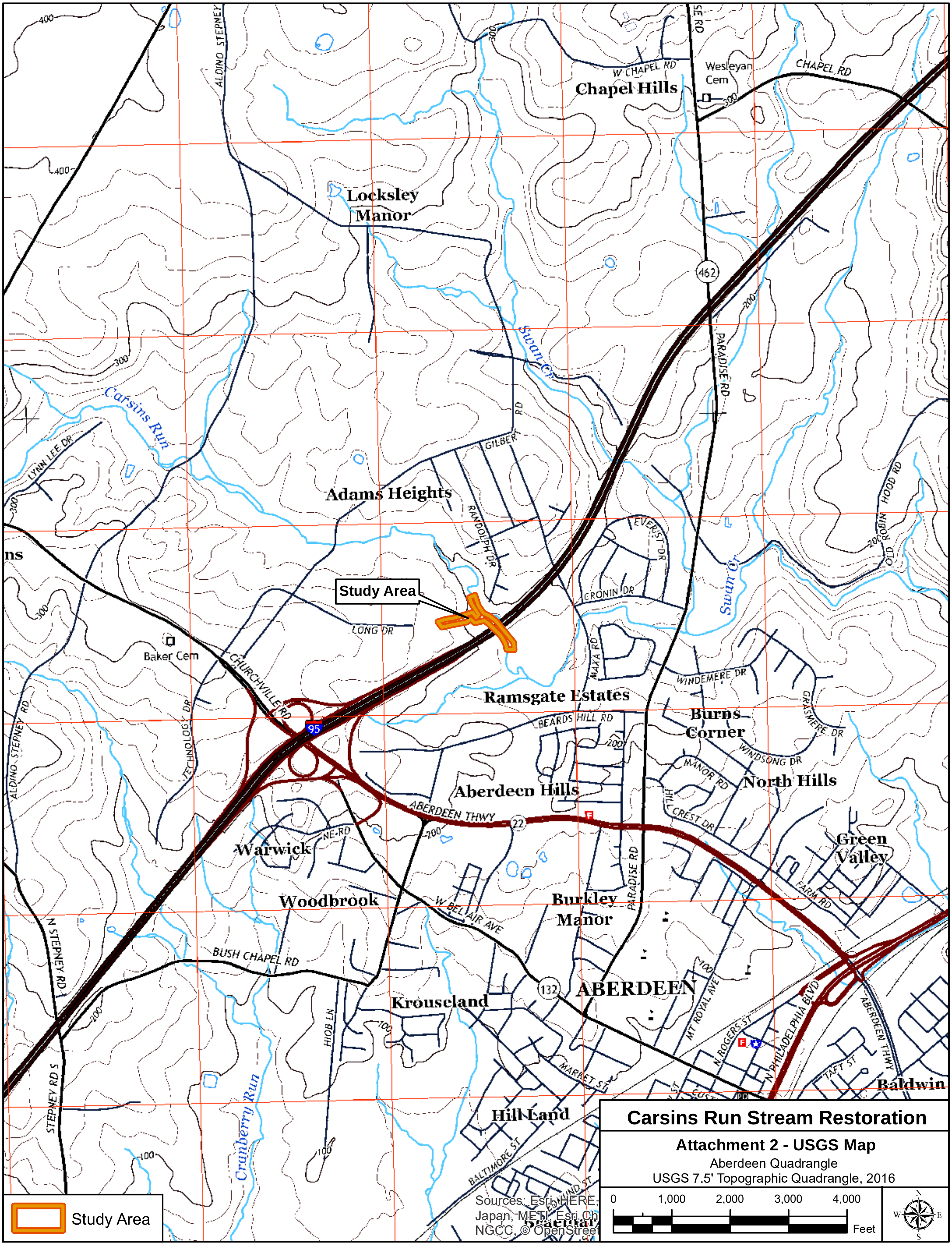
Carsins Run Stream Restoration

Attachment 1 - Site Location Map

Harford County, Maryland
ESRI ArcGIS Base Maps

ATTACHMENT 2

USGS 7.5’ Topographic Map



Carsins Run Stream Restoration

Attachment 2 - USGS Map

Aberdeen Quadrangle
USGS 7.5' Topographic Quadrangle, 2016

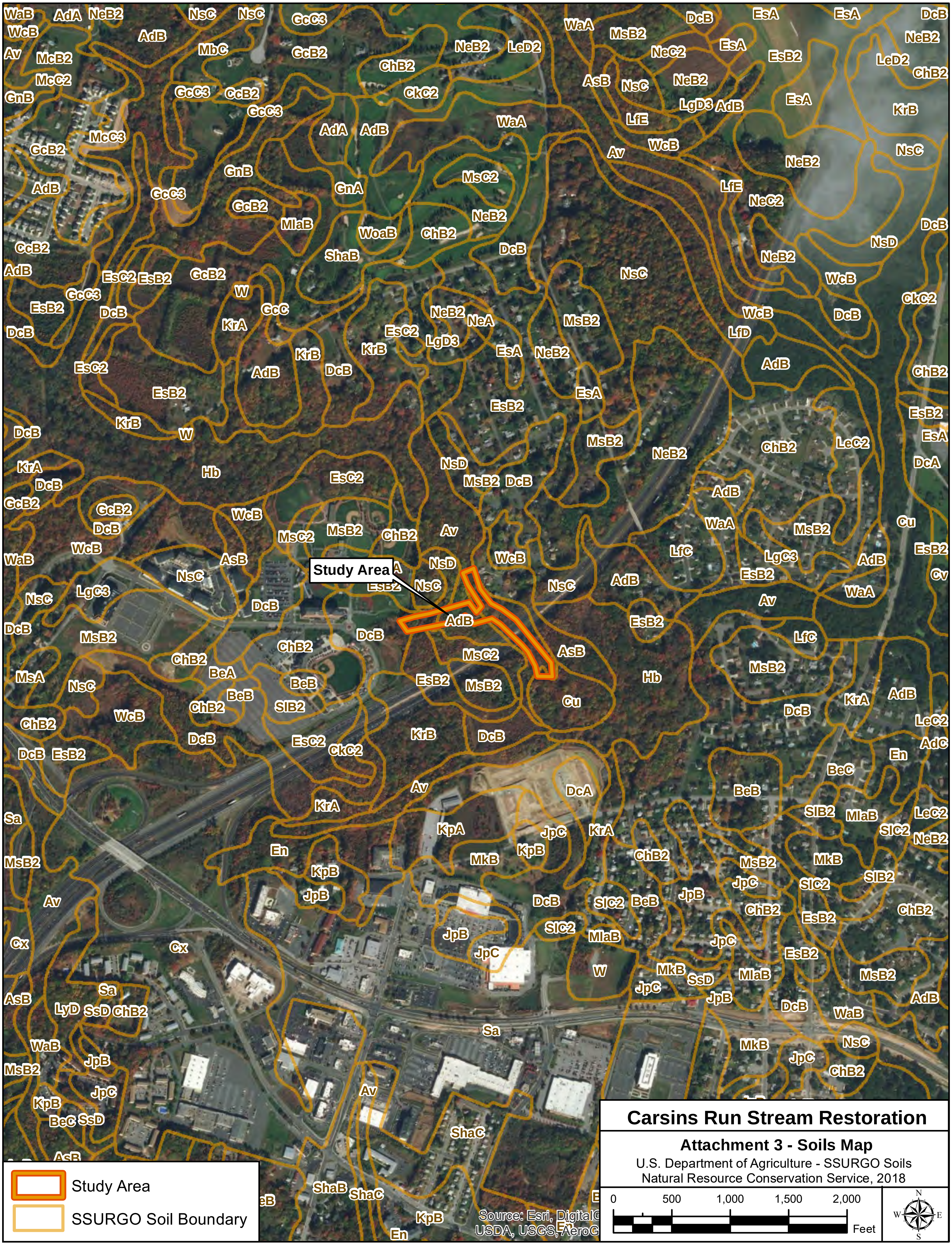
0 1,000 2,000 3,000 4,000
Feet

Sources: Esri, HERE,
Japan, METI, Esri Ch
NGCC, © OpenStreet

▭ Study Area

ATTACHMENT 3

Soils Map



Carsins Run Stream Restoration

Attachment 3 - Soils Map

U.S. Department of Agriculture - SSURGO Soils
Natural Resource Conservation Service, 2018

ATTACHMENT 4

National Wetlands Inventory (NWI) Map

Carsins Run Stream Restoration

Attachment 4 - NWI Map

U.S. Fish & Wildlife Service
National Wetlands Inventory, 1981-2017

ATTACHMENT 5

Q3 Flood Map

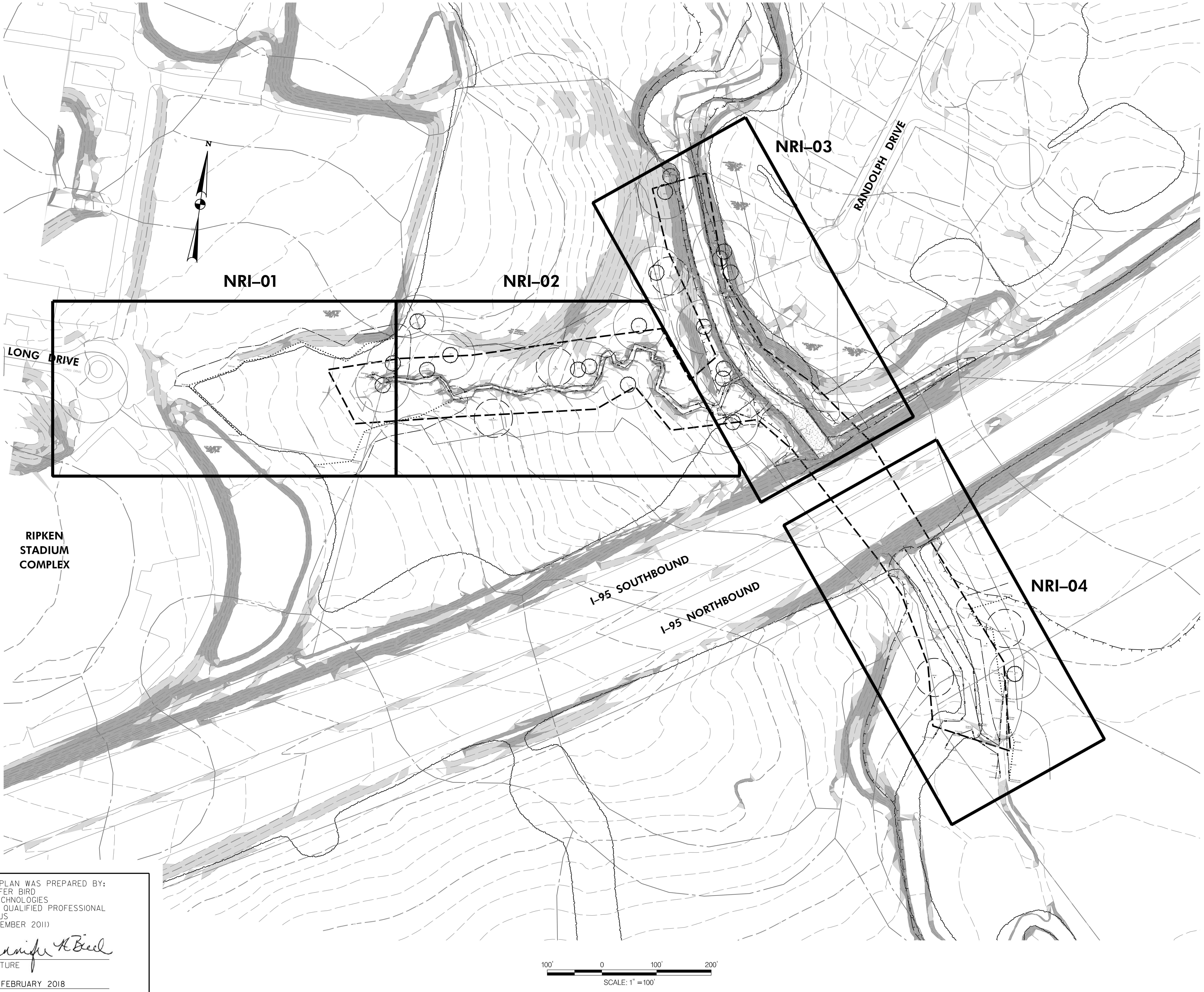
Carsins Run Stream Restoration

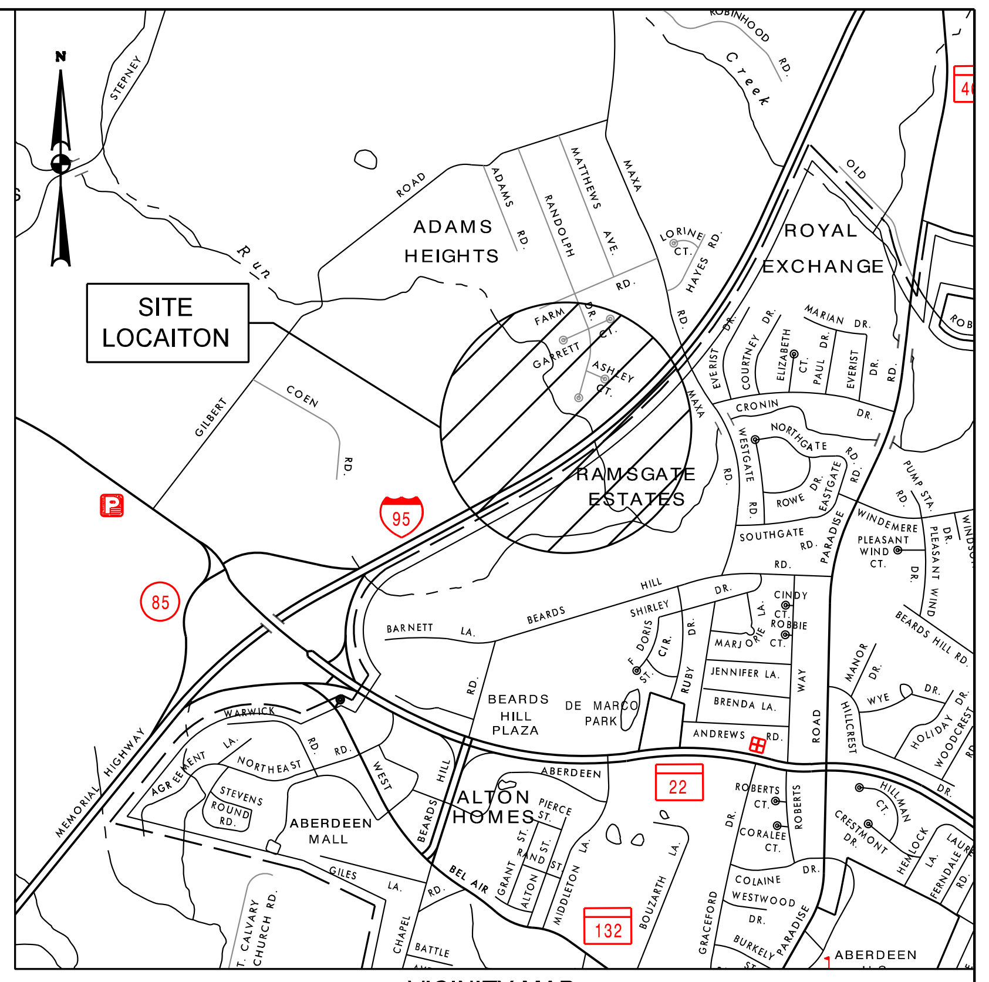
Attachment 5 - Q3 Flood Map

Federal Emergency Management Agency
Q3 Flood Data for Harford County, Maryland

APPENDIX A

Natural Resources Inventory/Forest Stand Delineation Map





VICINITY MAP
SCALE: 1"=2,000'

NOTES:

1. WETLANDS AND WATERWAYS WERE DELINEATED BY KCI TECHNOLOGIES, INC IN FEBRUARY 2018.
2. TOPOGRAPHICAL SURVEY WAS COMPLETED BY KCI TECHNOLOGIES, INC IN FEBRUARY 2018.
3. TOPOGRAPHICAL SURVEY IS SUPPLEMENTED WITH ADDITIONAL TWO FOOT CONTOURS FROM HARFORD COUNTY GIS DATA.
4. ALL BUILDINGS, PROPERTY LINES, EDGE OF PAVEMENT, AND PARKING LOTS ARE FROM HARFORD COUNTY GIS DATA.
5. NO RARE, THREATENED, OR ENDANGERED SPECIES (RTES) WERE IDENTIFIED DURING FIELD INVESTIGATIONS.
6. INQUIRIES WERE SENT TO MARYLAND DEPARTMENT OF NATURAL RESOURCES (MDNR) AND U.S. FISH AND WILDLIFE SERVICE (USFWS) REGARDING RTES. USFWS RESPONDED THAT THERE ARE NO RTES OR CRITICAL HABITATS WITHIN THE STUDY AREA. A RESPONSE IS PENDING FROM MDNR. AN INQUIRY WAS SENT TO MARYLAND HISTORICAL SOCIETY REGARDING ANY HISTORICAL RESOURCES. A RESPONSE IS PENDING.
7. FOREST STANDS WERE DELINEATED BY KCI TECHNOLOGIES, INC IN FEBRUARY 2018.
8. TWO FOREST STANDS WERE IDENTIFIED WITHIN THE STUDY AREA.
9. TWENTY SPECIMEN TREES WERE IDENTIFIED WITHIN THE STUDY AREA.
10. * DENOTES RESOURCE EXTENDS BEYOND THE STUDY AREA.

SOILS TABLE

Soil Symbol	Soil Unit Name	Percent Slope	K_f value	Hydric (Y/N)
AdB	Aldino silt loam	3-8	0.49	No
Av	Alluvial land	–	0.43	Yes
Cu	Codorus silt loam	–	0.32	No
DcB	Delanco silt loam	3-8	0.37	No
EsB2	Elsinboro loam, moderately eroded	2-5	0.49	No
MsC2	Montalto silt loam, moderately eroded	8-15	0.37	No

SPECIMEN TREE TABLE

Number	Species	Common Name	Size, DBH (in)	Condition	Notes
SP-1	*Liriodendron tulipifera*	Tulip Poplar	31.0	Good	Splits at DBH
SP-2	*Quercus rubra*	Northern Red Oak	30.0	Good	
SP-3	*Liriodendron tulipifera*	Tulip Poplar	33.0	Good	
SP-4	*Quercus alba*	White Oak	31.0	Fair	Vine coverage, dead branches
SP-5	*Fraxinus pennsylvanica*	Green Ash	31.0	Fair	Dead branches
SP-6	*Fraxinus pennsylvanica*	Green Ash	30.0	Fair	Vine coverage, dead branches
SP-7	*Fraxinus pennsylvanica*	Green Ash	36.0	Fair	Vine coverage, Large cavity at base
SP-8	*Liriodendron tulipifera*	Tulip Poplar	30.0	Good	
SP-9	*Liriodendron tulipifera*	Tulip Poplar	31.0	Good	
SP-10	*Quercus velutina*	Black Oak	33.0	Good	
SP-11	*Quercus rubra*	Northern Red Oak	32.0	Good	Barbed wire in the tree
SP-12	*Quercus rubra*	Northern Red Oak	33.0	Good	
SP-13	*Liriodendron tulipifera*	Tulip Poplar	31.0	Good	
SP-14	*Liriodendron tulipifera*	Tulip Poplar	32.0	Good	Located on stream bank, splits above DBH
SP-15	*Quercus alba*	White Oak	30.0	Fair	Vine coverage, barbed wire in tree, fungus on trunk
SP-16	*Fagus grandifolia*	America Beech	30.0	Good	Barbed wire in the tree
SP-17	*Liquidambar styraciflua*	Sweetgum	33.0	Good	Located at the outlet pipe of Waterway WL002
SP-18	*Quercus alba*	White Oak	38.0	Poor	Heavy vine coverage, Lots of dead/broken branches
SP-19	*Liriodendron tulipifera*	Tulip Poplar	32.0	Poor	Heavy vine coverage, Narrow Crown
SP-20	*Liriodendron tulipifera*	Tulip Poplar	46.0	Fair	Vine coverage, Missing branches

LEGEND

------ 430 ------	EX. CONTOUR	▨	SLOPES 15-25%
X——X——X	EX. FENCE	■	SLOPES 25% OR GREATER
	EX. WOODS LINE	GhB / GuB	SOILS LINE
	EX. TREE	x UPL-1	WETLAND/UPLAND SAMPLE PLOT
SS SD	EX. MANHOLE	x A-2	FOREST STAND SAMPLE PLOT
	EX. UTILITY POLE	SP-1 CRZ	SPECIMEN TREE
	PROPERTY LINE		EX. FEMA 100 YEAR FLOODPLAIN
	STUDY AREA BOUNDARY		
—— WUS ——	WATERS OF THE U.S.		
—— WUSE ——	WATERS OF THE U.S. EPHEMERAL		
● ● ● ● ● ● ● ●	EX. NON-TIDAL WETLAND		
—— B ——	25' WETLAND BUFFER		
—— SB ——	75' STREAM BUFFER		

HORIZONTAL DATUM NAD 83/91
VERTICAL DATUM NAVD 88

THIS PLAN WAS PREPARED BY:
JENNIFER BIRD
KCI TECHNOLOGIES
MDNR QUALIFIED PROFESSIONAL
STATUS
(SEPTEMBER 2011)

Jennifer A. Bird
SIGNATURE

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Maryland Transportation Authority
Engineering Division

ADDENDUMS & REVISIONS

NO.	DESCRIPTION	BY	DATE

JOHN F. KENNEDY MEMORIAL HIGHWAY
I-95 ETL NORTHBOUND EXTENSION
CARSINS RUN STREAM MITIGATION PLANS
APPENDIX A: NATURAL RESOURCES INVENTORY - FOREST STAND DELINEATION MAP

DESIGNED BY .
DRAWN BY .
CHECKED BY .
CONST. REVIEW BY .
DATE FEBRUARY 2018
SCALE 1" = 20'

CONTRACT NO. AE 2796-000-001/6
DRAWING NO. NRI–00
SHEET NO. 1 OF 5