Carsins Runs
I-95 Section 200
Stream Mitigation

PS&E Design Report

Prepared for
MDTA




MDTA
Maryland
Transportation
Authority

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TECHNOLOGIES

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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. MDTA intends to pursue mitigation for these unavoidable impacts using on-site, in-kind, and within the same watershed and off-site, out of kind, and within the same watershed 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 flows 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 easements will be secured. For these properties, MDTA will establish restrictive covenants or deed restrictions using the USACE conservation easement template, over the restoration reach as required by MDE to protect the mitigation project in perpetuity. A restrictive covenant is a provision in a deed that limits the use of the property and prohibits certain uses. A deed restriction is a limitation on the deed, limiting the use of the property. A conservation easement is a written agreement between the owner of the land and an entity with an interest in the land that conserves that land and limits its use. Special Condition #14 of the USACE permit requires submission of draft restrictive covenants (DRC) within 90 days prior to the start of construction of mitigation sites. Special Condition #15 requires a completed fully executed DRC to be submitted to USACE prior to the start of construction.

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). 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 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.

4.0 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.

4.1 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 channel is proposed to produce a moderately entrenched channel through the relatively steep valley topography. The proposed moderately entrenched design, raises the channel invert and proposed water table, while also protecting the steep valley from rill or gully formations, which could undermine the mitigation by end cutting around the stabilized channel and producing significant amounts of sediment. 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 (6.5%) 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). To provide for additional floodplain access, the top of banks within Reaches 1 & 3 adjacent to proposed created wetland areas may be lowered up to 0.5 feet from design elevations at the direction of the Engineer.

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	5.6	0.3	0.5	1.9	16.5	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	6.4	0.72	35	3.3	1.0
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	26.2	7	1	1.45	71	5.3	1.1
	Pool	-	8.5	2	1.28	63	-	-
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 3.5%. 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	3.71 lb/ft^2 9.08 ft/s
Type II Boulder	Tributary Reach 2 and 4	Step Pool Crests	Maximum Channel Shear	10.4 lb/ft^2
Key Stone Type III Boulder	Tributary Reach 2 and 4	Step Pool Crests	Maximum Channel Shear	13.6 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	3.71 lb/ft^2

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	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”

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. Shear stresses up to the ultimate 100-year storm 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 in Reaches 1 and 3 is 3.71 lb/ft^2 found at HEC RAS Section 896.36 baseline station 20+50 in Reach 1, resulting in a minimum D_{50} of 1.3 feet. for the Sill Boulders, given a critical shear stress of 0.03. 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 same maximum 100-year shear stress. 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 9.08 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 1.2 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 stresses are found in Reach 4 for the

100-year discharge and are 10.4 and 13.6 lbs/ft^2. The resulting minimum stone sizes based on a critical shear stress of 0.05 range from 2.1 to 2.8 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 2.0 for the Tributary Reaches 1 & 3.
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 by design (moderately entrenched) may be 1.9 in some cases which exceeds the success criteria as established in the USACE permit. However the proposed BHR is greatly reduced from the existing condition and is consistent with Rosgen Stream Types within these steeper valley settings. Provisions in the Contract Documents (plans and special provisions) allow for the Engineer to direct the contractor to reduce top of bank elevations in Reaches 1 & 3 to provide more floodplain connection and reduce the BHR to 1.

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

Monitoring and success criteria for the wetland and stream restoration mitigation will follow the special conditions as outlined in the USACE Permit CENAB-OPR-MN (MDTA//I-95-Stage I/ETL NORTHBOUND EXTENTION) 2018-60368-M12 issued January 7, 2019, attached as Appendix L. The 10 year monitoring period will begin the growing season following completion of construction and the year 1 monitoring report will include as-built plans. Annual monitoring will be conducted with monitoring reports submitted in years 2, 3, 5, 7, and 10 for MDE and USACE review at the end of each calendar year.

Monitoring reports will substantiate success or challenges of the project and contain the elements as stated on pages 8 and 9 of the permit (see Appendix L) including but not limited to: surveyed cross sections overlays and longitudinal profile, BEHI, RBP, observed and reported richness and abundance of fishes and amphibians, photo documentation, vegetation data, and wetland soils, hydrology. Additionally, the report will include maps and plans including a location map and topographic plans showing data points, photo stations, and other pertinent features of the project site and conclusions discussing, but not limited to, the progress of the mitigation site, and whether performance standards are being met. As results of the monitoring show a need for adjustments to the project, MDTA will develop an adaptive management plan. The plan including remedial measures will be prepared and submitted to the regulatory agencies for review and approval prior to implementation.

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 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.

Ripken Trib Reach 3

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).

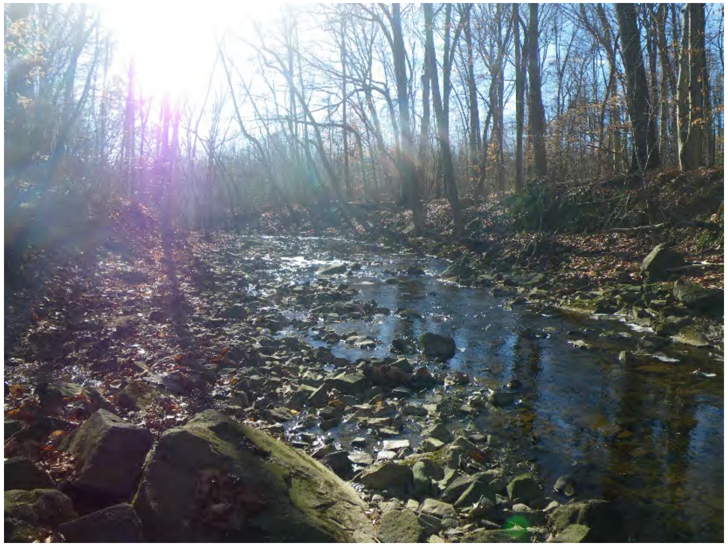

Facing west at existing swale at upstream end of study reach.


Facing upstream toward stormdrain pipe from Ripken Stadium.

Ripken Trib Reach 1

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).

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.

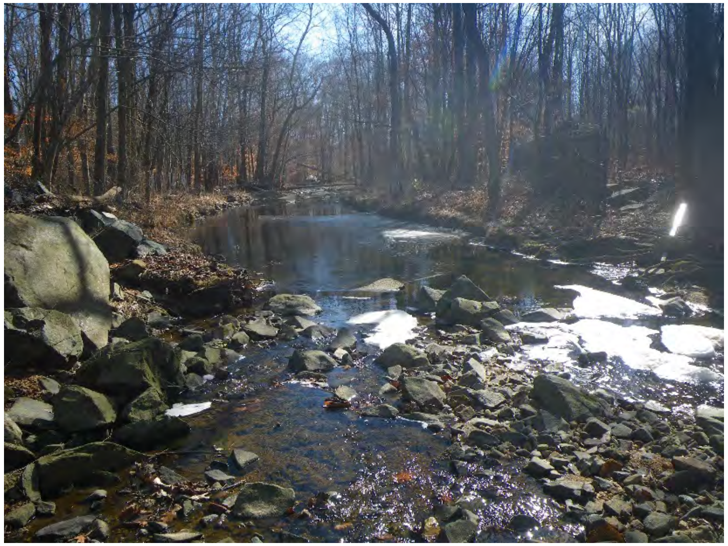
Facing downstream at upstream face of I-95 culvert and concrete lined channel (proposed W-Weir location)

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.

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).

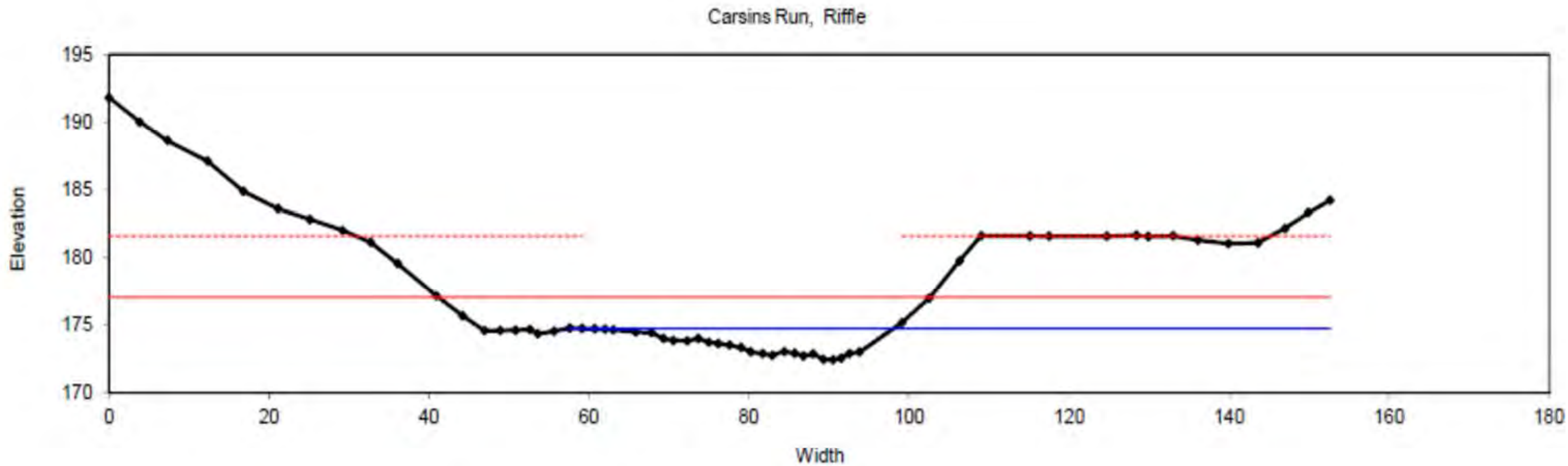
Facing left bank close up of broken concrete slabs.

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

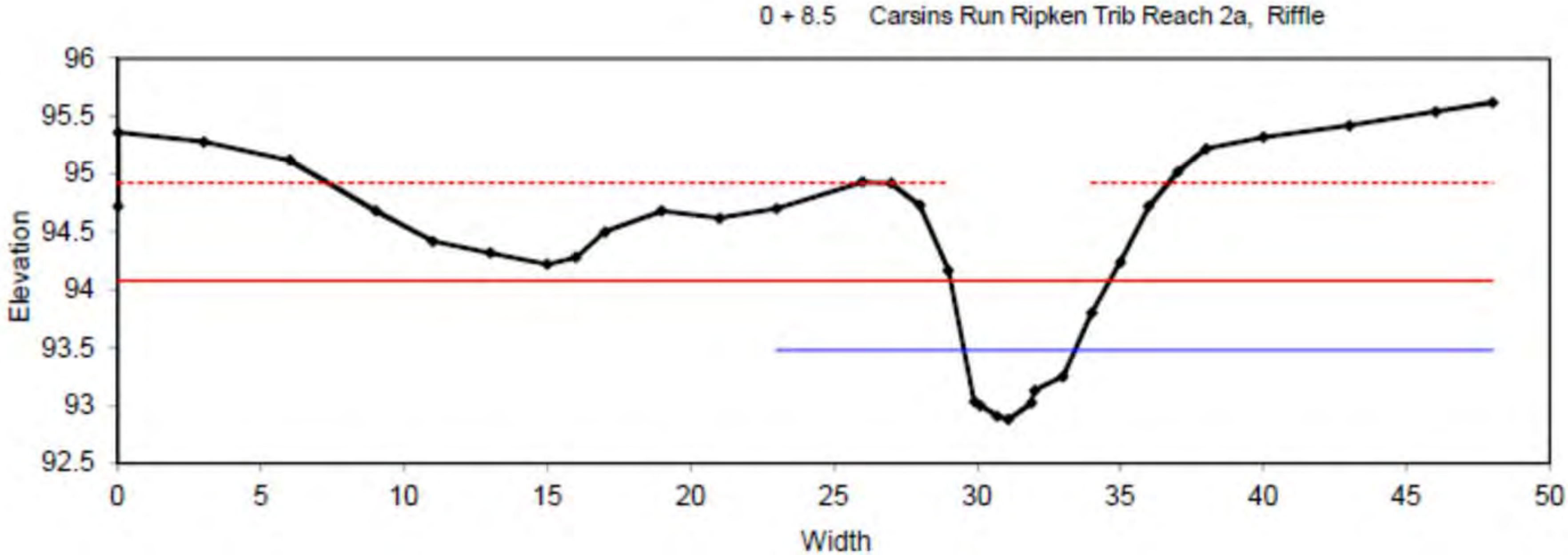
3.9	velocity (ft/s)
172.3	discharge rate (cfs)
0.66	Froude number

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

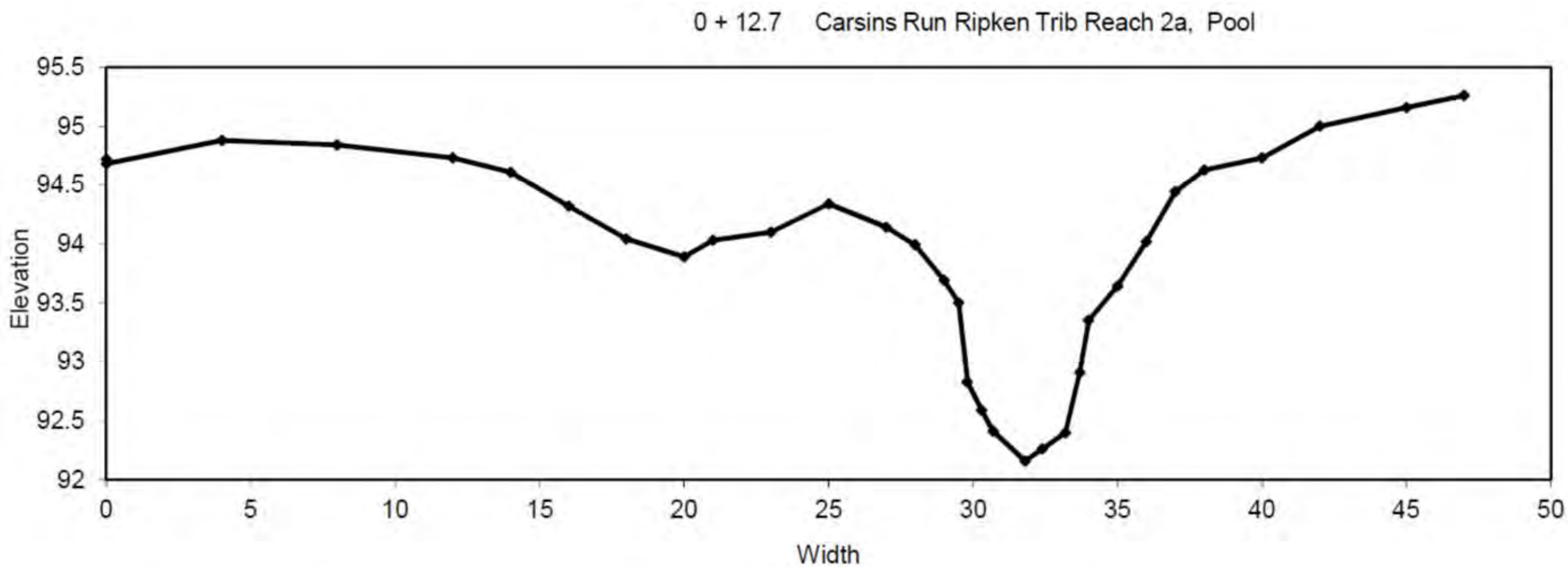
Materials	
34	D50 Riffle (mm)
86	D84 Riffle (mm)
62	threshold grain size (mm):

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

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)

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



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

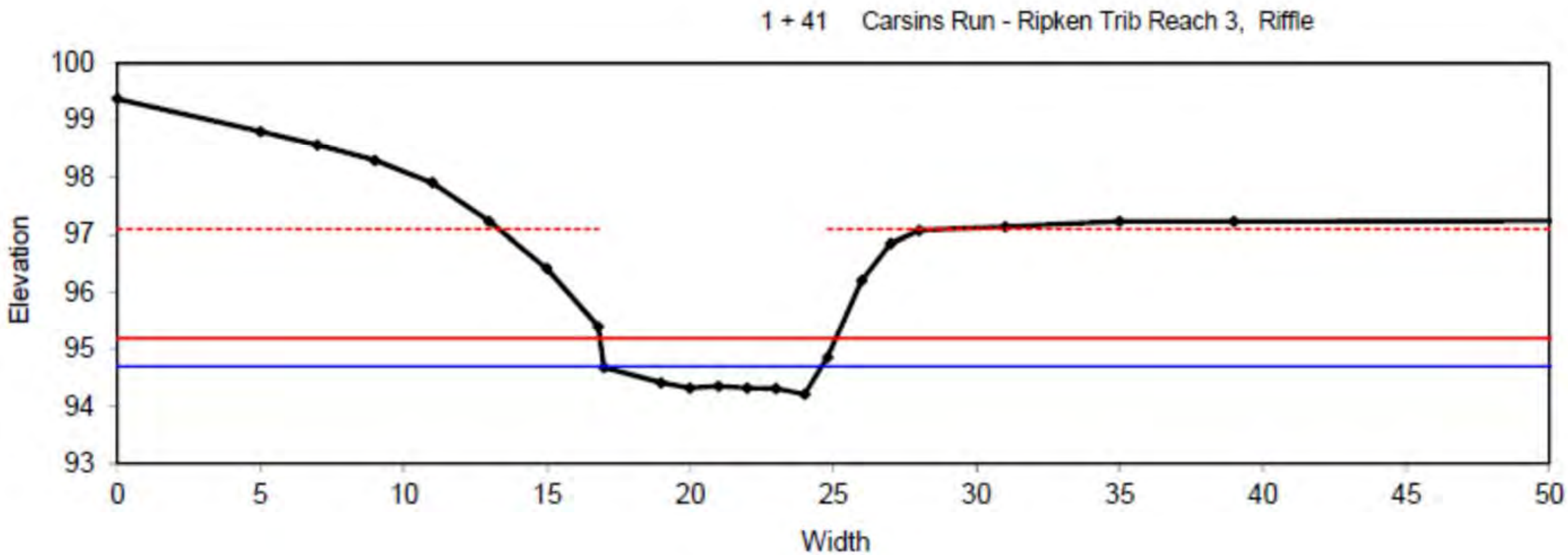
Materials	
34	D50 Riffle (mm)
86	D84 Riffle (mm)
---	threshold grain size (mm):

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):

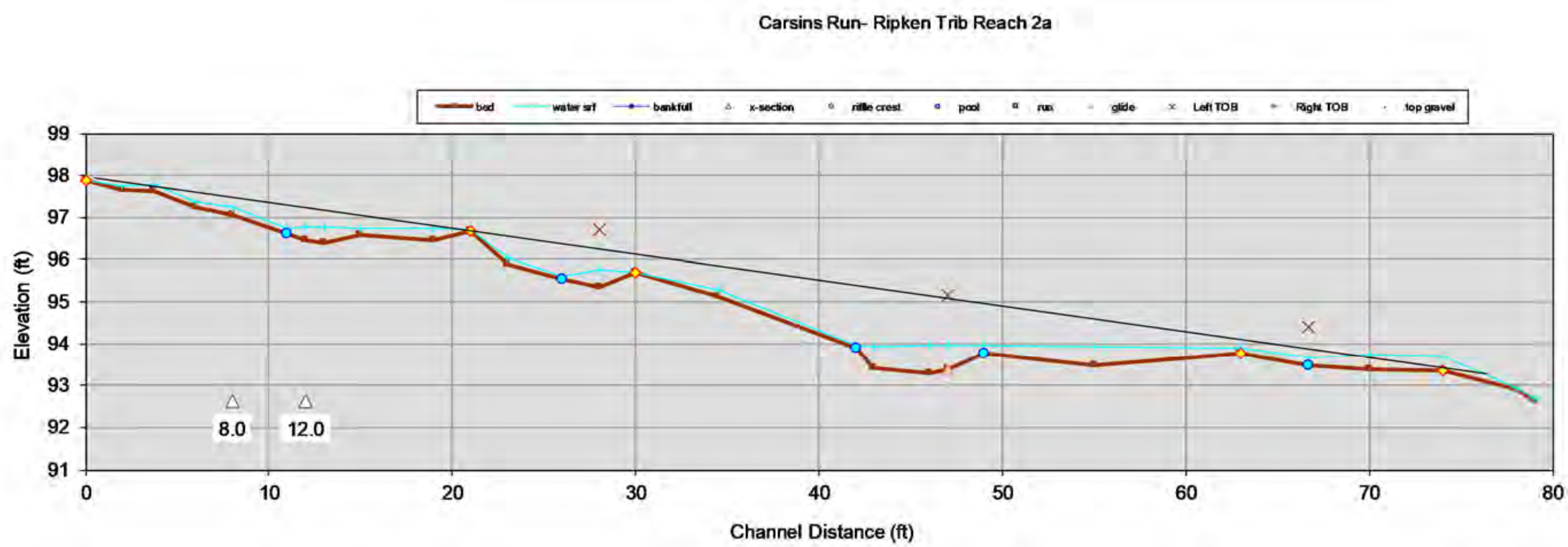
Bankfull Flow	
2.6	velocity (ft/s)
6.1	discharge rate (cfs)
0.84	Froude number

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

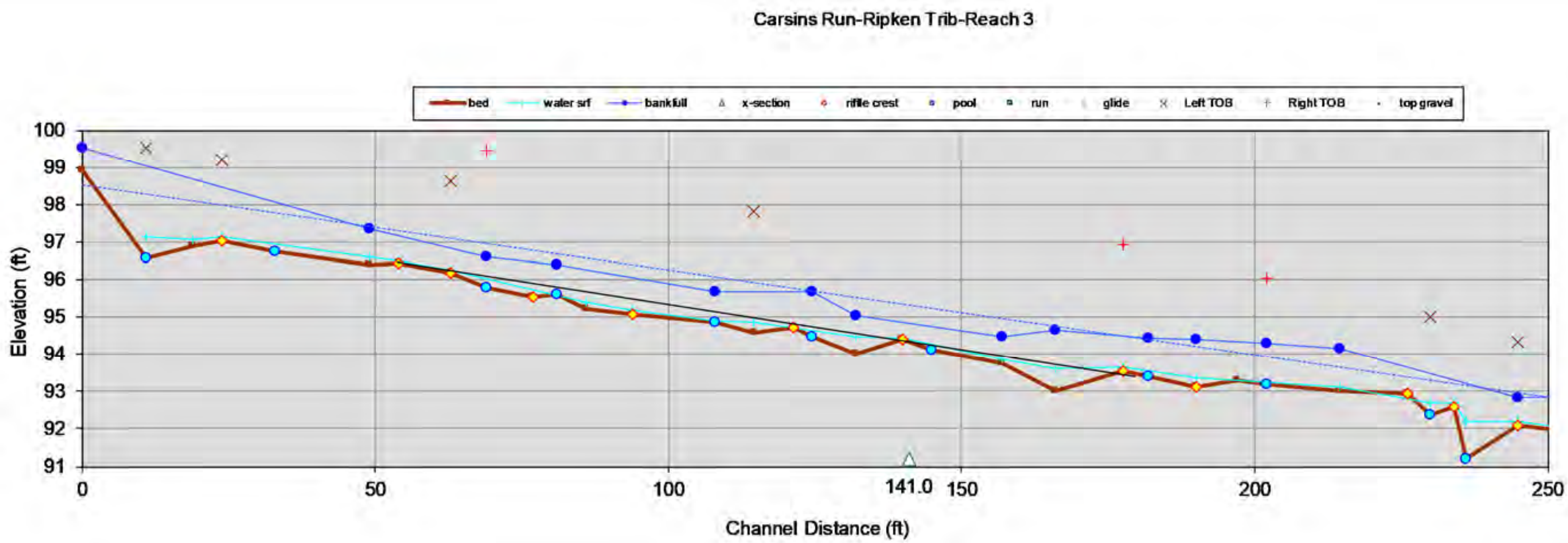
Forces & Power	
2.2	channel slope (%)
0.41	shear stress (lb/sq.ft.)
0.46	shear velocity (ft/s)
1.1	unit strm power (lb/ft/s)

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

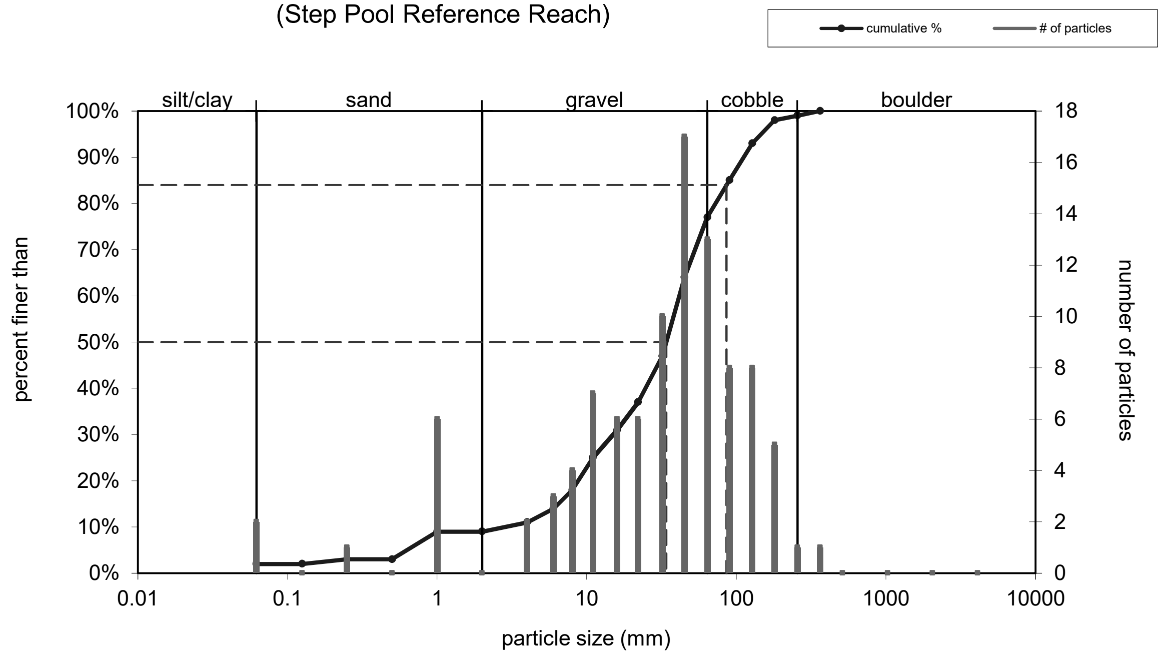
APPENDIX B.3. PEBBLE COUNT / MATERIAL DISTRIBUTION SUMMARY

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%

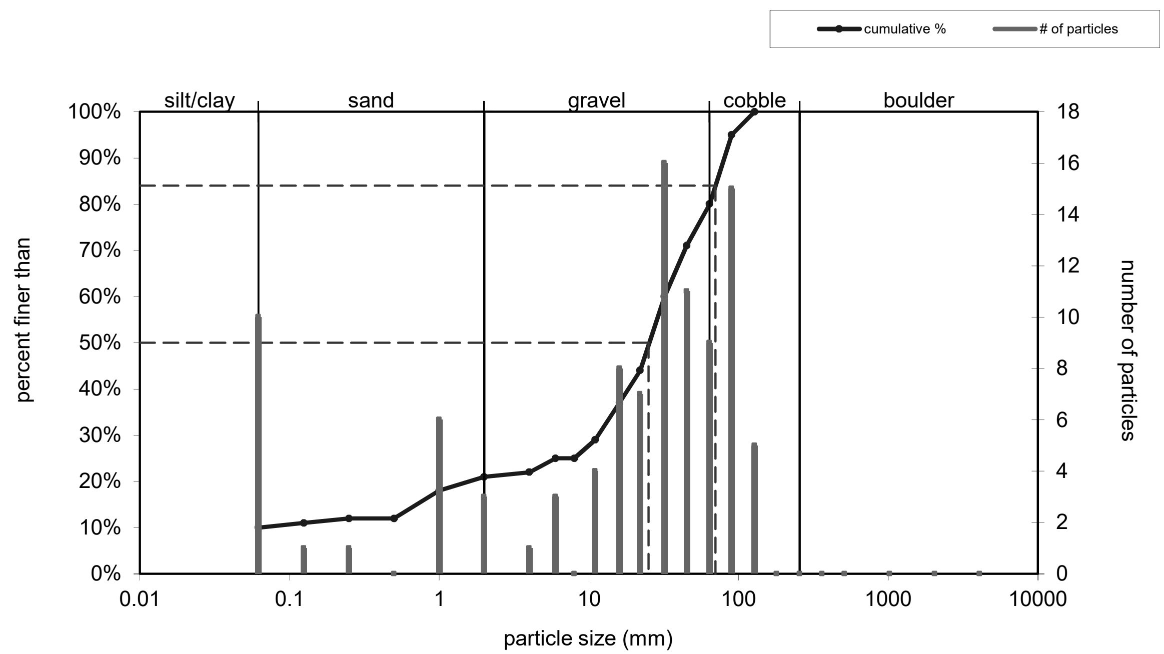
D100~17 to 19 inches

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

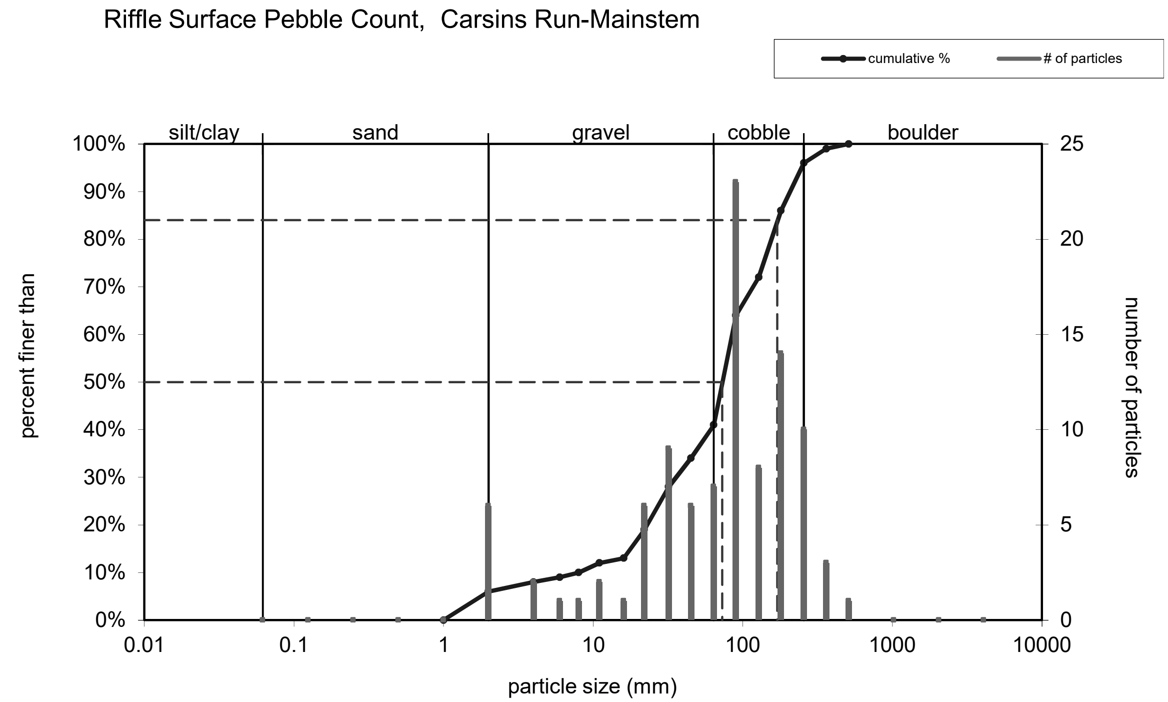
Size Distribution	
mean	7.4
dispersion	17.2
skewness	-0.38

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:



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

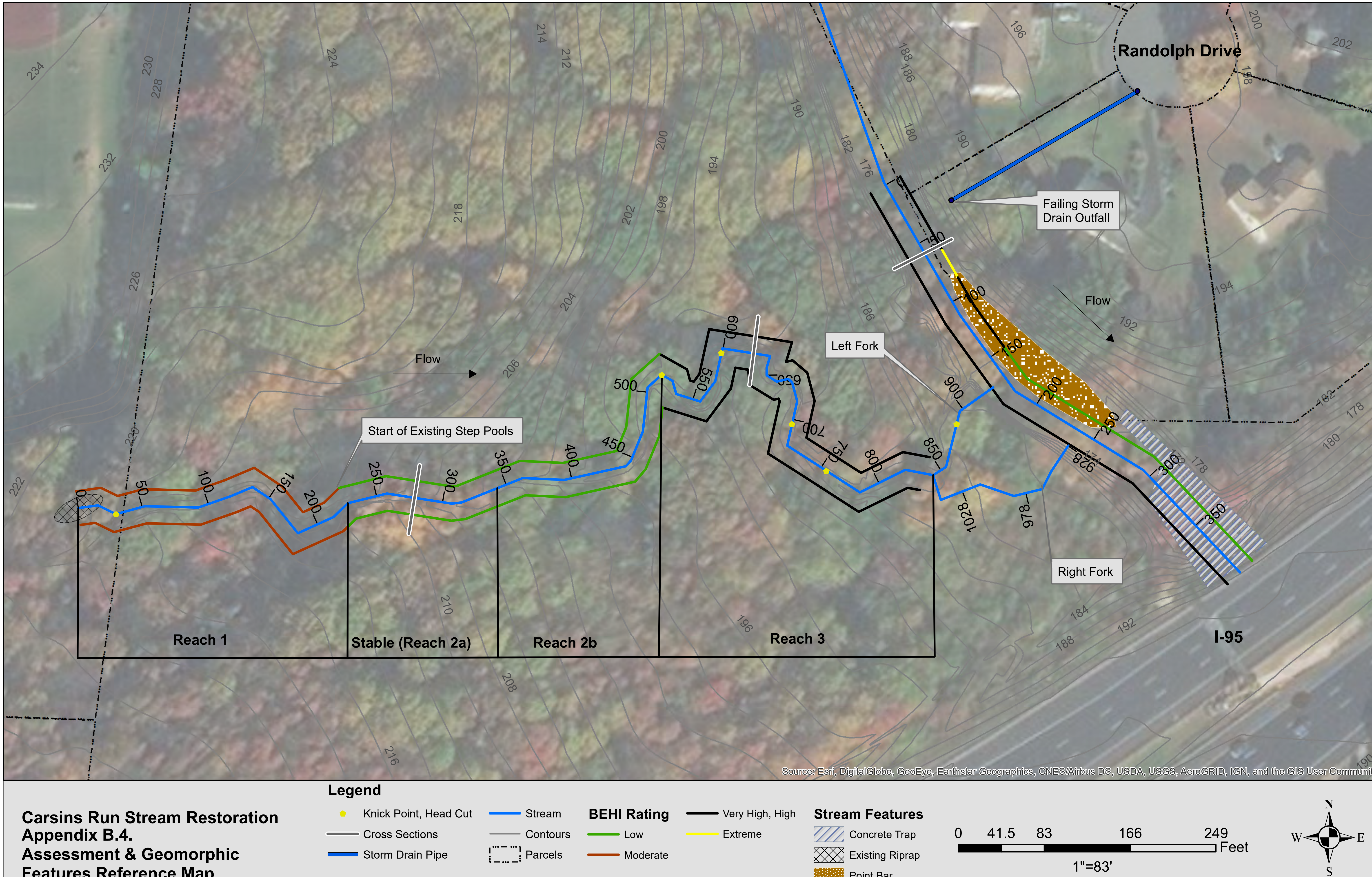
Size Distribution	
mean	56.8
dispersion	3.1
skewness	-0.11

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

D100~11 to 14 inches

APPENDIX B.4

GEOMORPHIC FEATURES REFERENCE MAP



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

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:**		**Total Score:**		**29.08**			
Reach:	Reach 1	**Comments:**								**Moderate**			
Location:	left bank	**Bank Length**						**Total Score**	**Very Low**	**Low**	**Moderate**	**High**	**Very High** / **Extreme**
Date:	2/14/2018							**Values:**	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
3.00	1.00	3.00	10.00	Extreme	
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
1.00	3.00	0.33	5.57	Moderate	
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
30.00	0.33	10.00	8.44	Very High	
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
45.00			3.17	Low	
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
80.00			1.90	Very Low	
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**29.08**		

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 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:**		**Total Score:**	43.53				
Reach:	Reach 3	**Comments:**	alternating bank erosion						Very High				
Location:	Eroding Banks	**Bank Length**						**Total Score**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	2/14/2018							**Values:**	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
3.00	0.50	6.00	10.00	Extreme	
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
0.25	3.00	0.08	8.63	Very High	
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
20.00	0.08	1.67	10.00	Extreme	
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
80.00			5.90	Moderate	
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	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								
			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 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 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 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 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 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

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 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

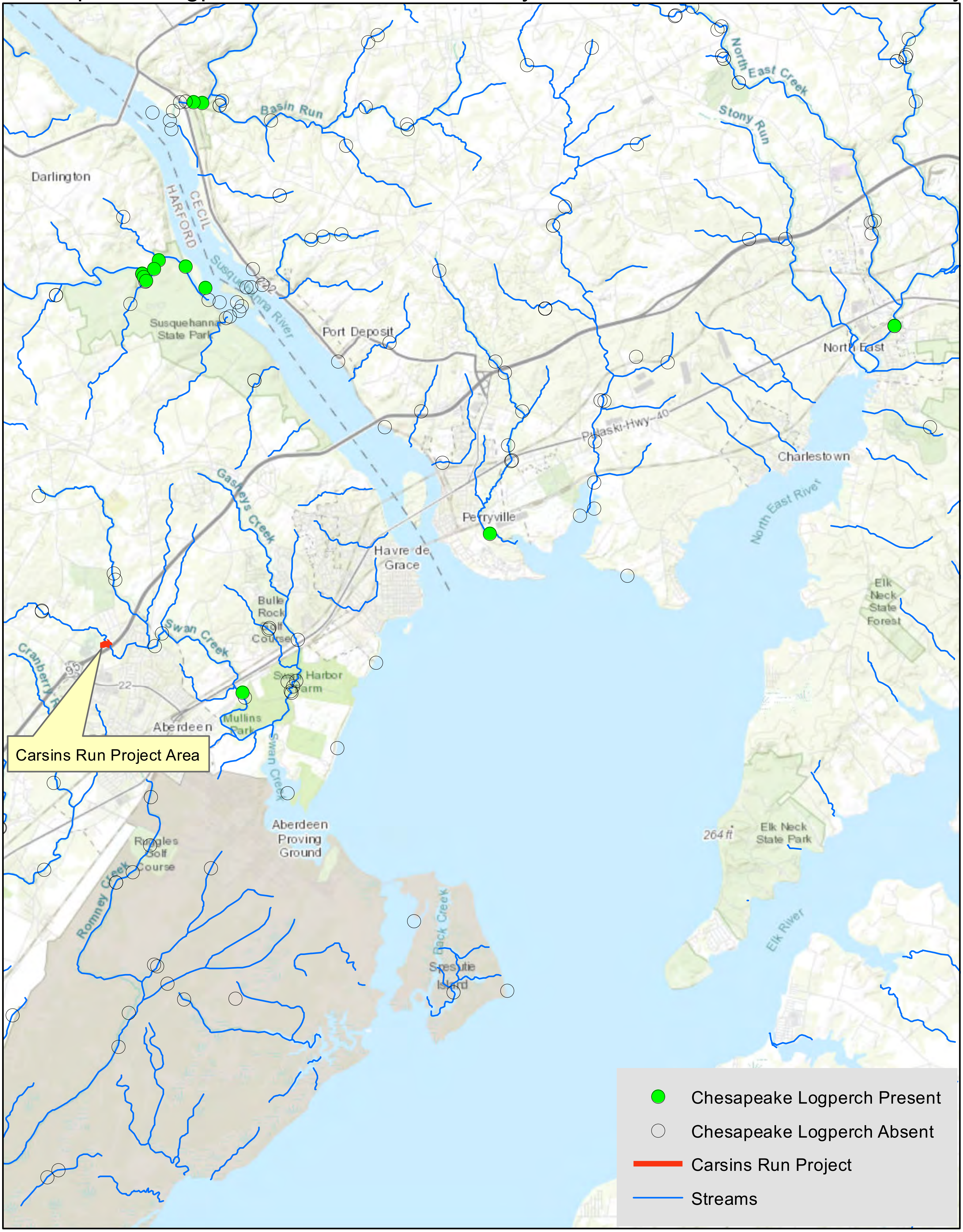
Table D.2a – MBSS IBI Scores For Sites Near Carsins Run

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

MDTA
Maryland
Transportation
Authority

Maryland Transportation Authority
2310 Broening Highway
Baltimore, Maryland 21224

KCI
TECHNOLOGIES

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

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ATTACHMENTS

APPENDICES

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.

<u>Wetland WL008 (Flags WL008-001 to WL008-010)</u>

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.

<u>Forest Stand B</u>

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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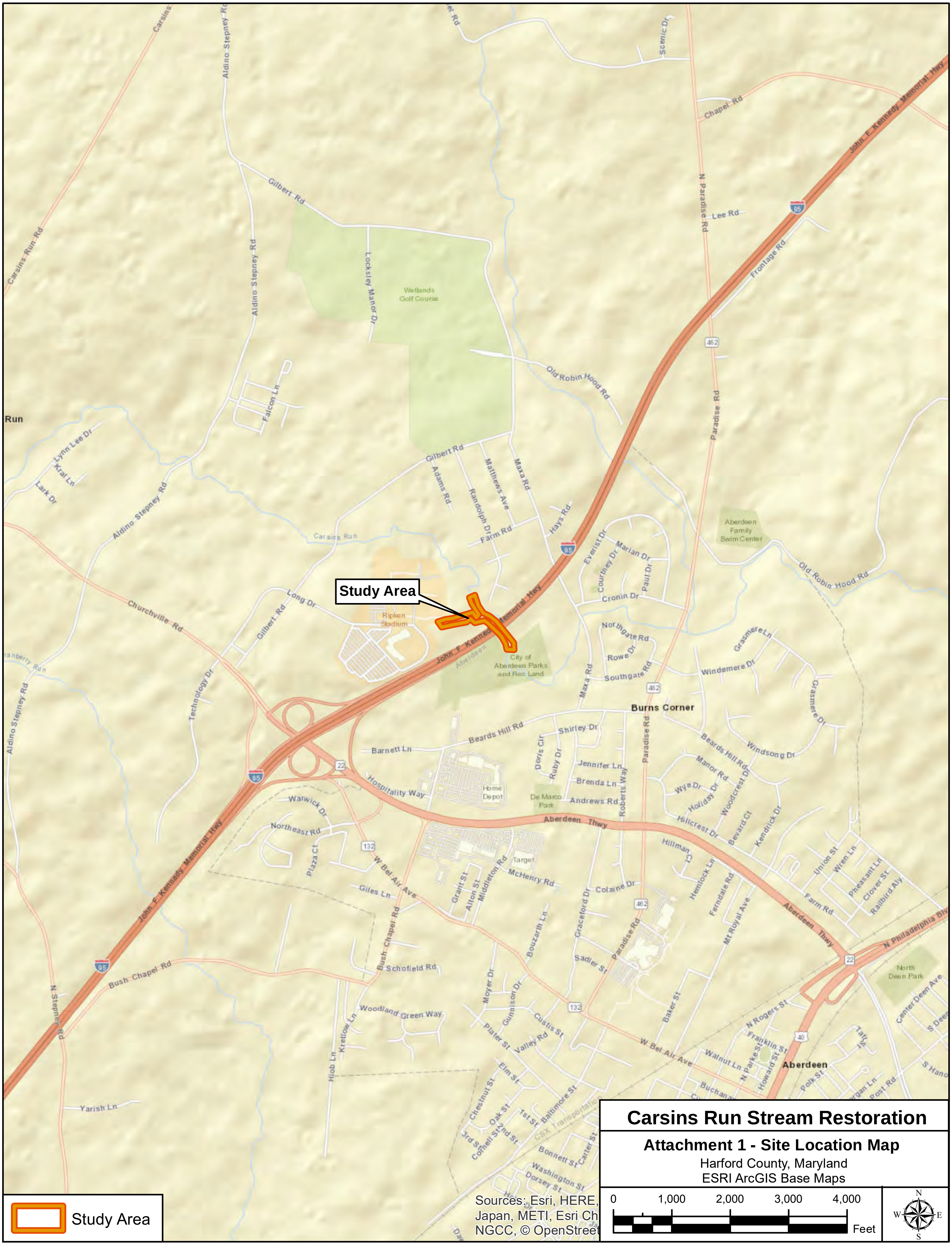
ATTACHMENT 1

Site Location Map



Carsins Run Stream Restoration

Attachment 1 - Site Location Map

Harford County, Maryland
ESRI ArcGIS Base Maps

Study Area

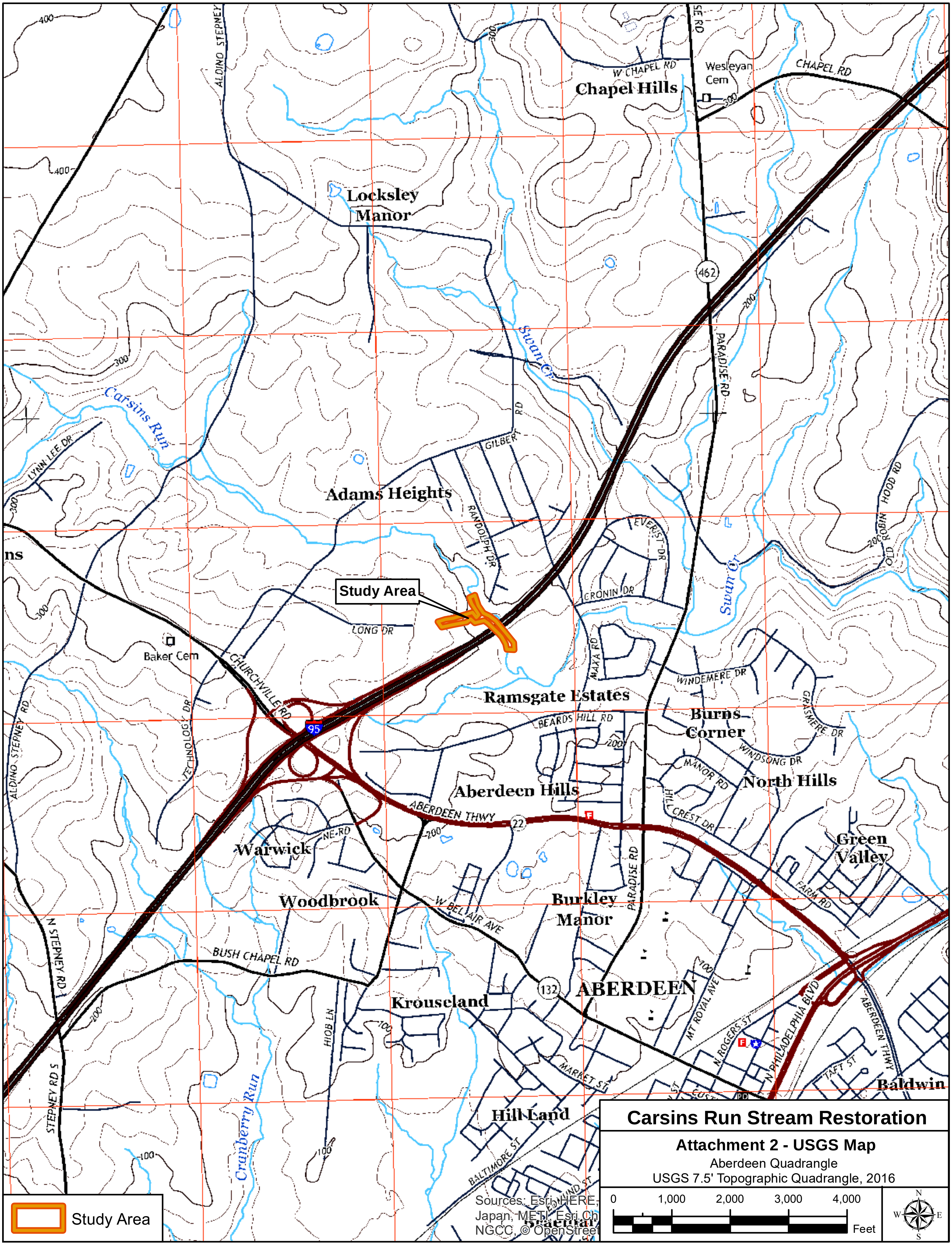
Sources: Esri, HERE, Japan, METI, Esri Ch NGCC, © OpenStreet

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

N W E S

ATTACHMENT 2

USGS 7.5' Topographic Map



Carsins Run Stream Restoration

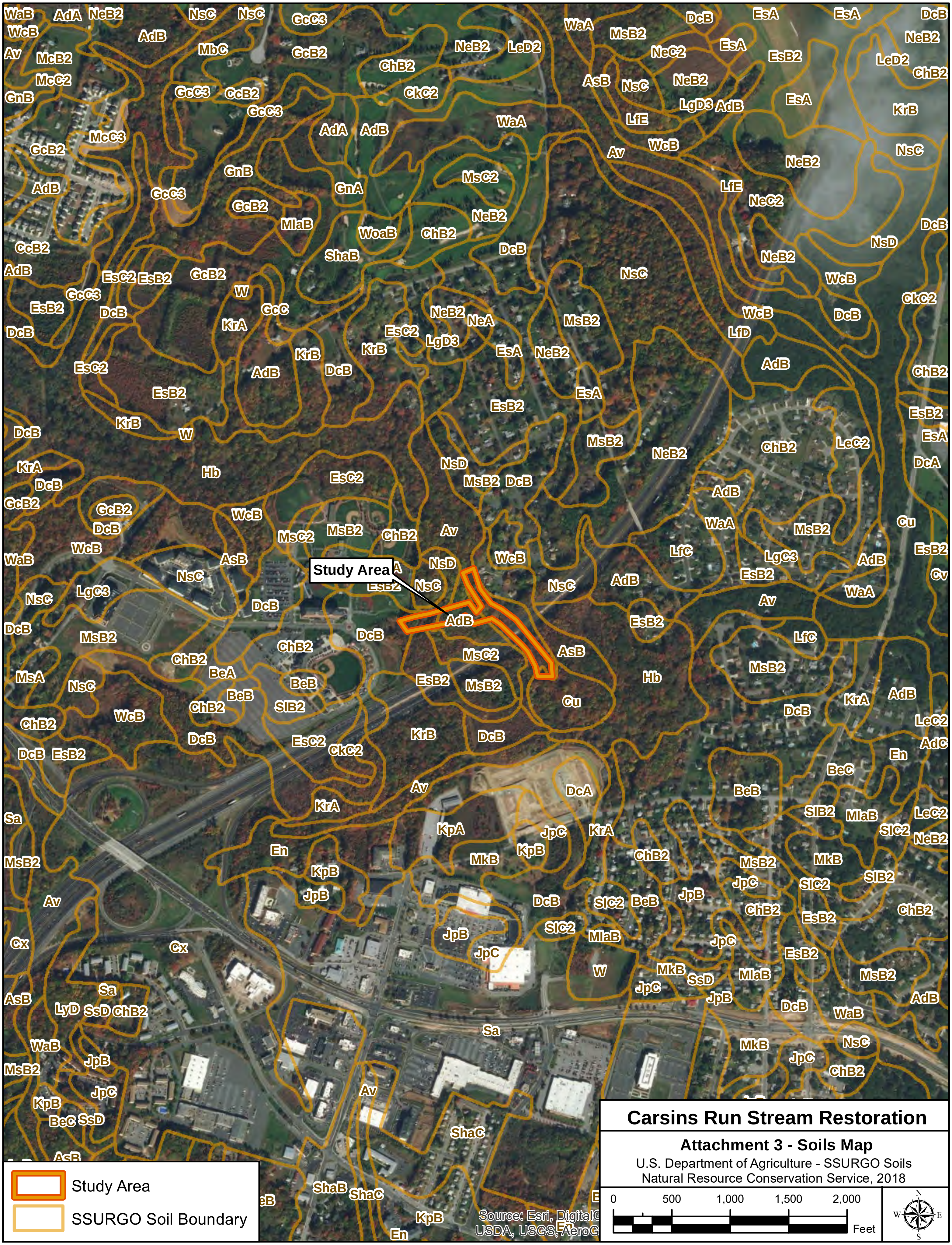
Attachment 2 - USGS Map

Aberdeen Quadrangle

USGS 7.5' Topographic Quadrangle, 2016

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

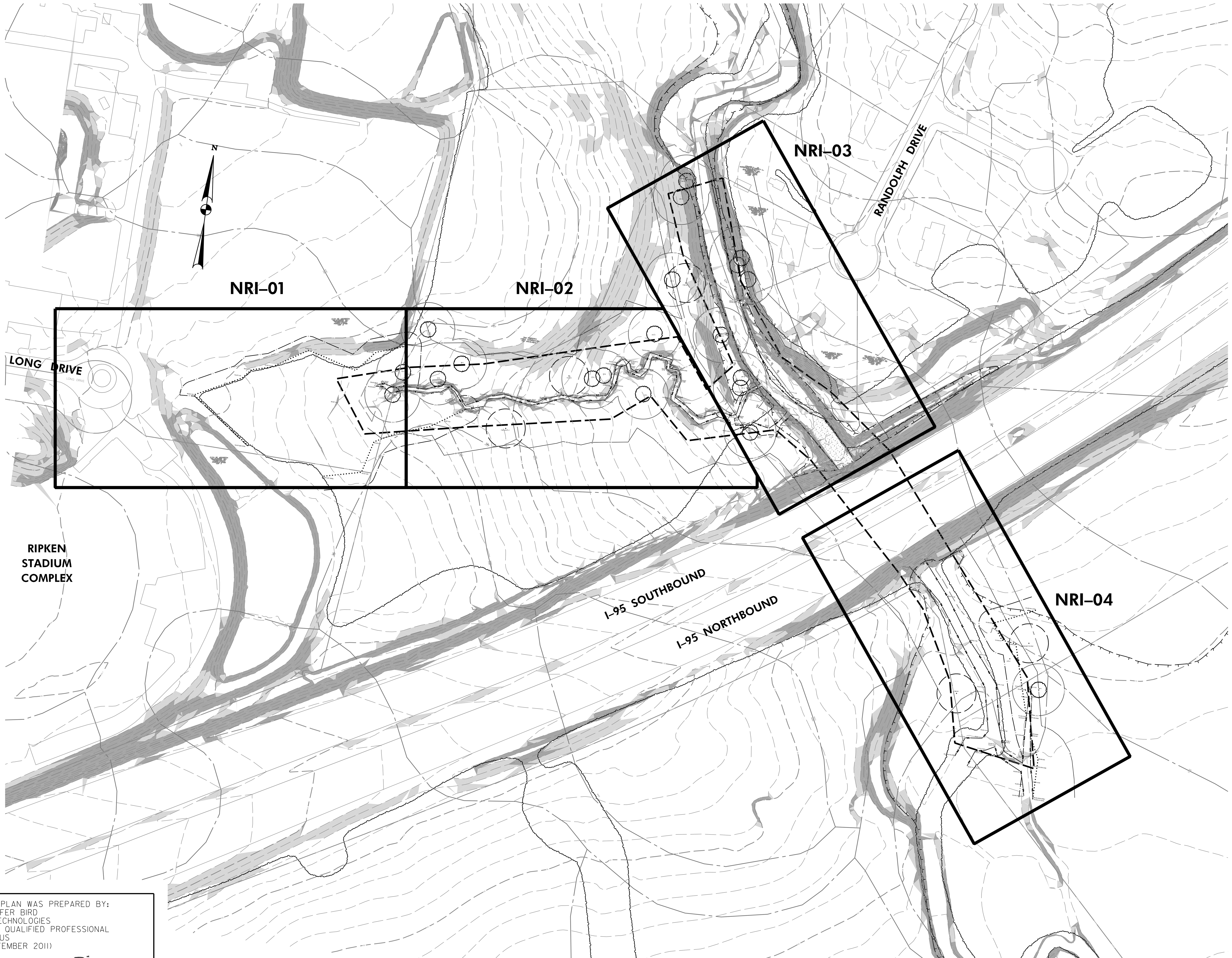
ATTACHMENT 5

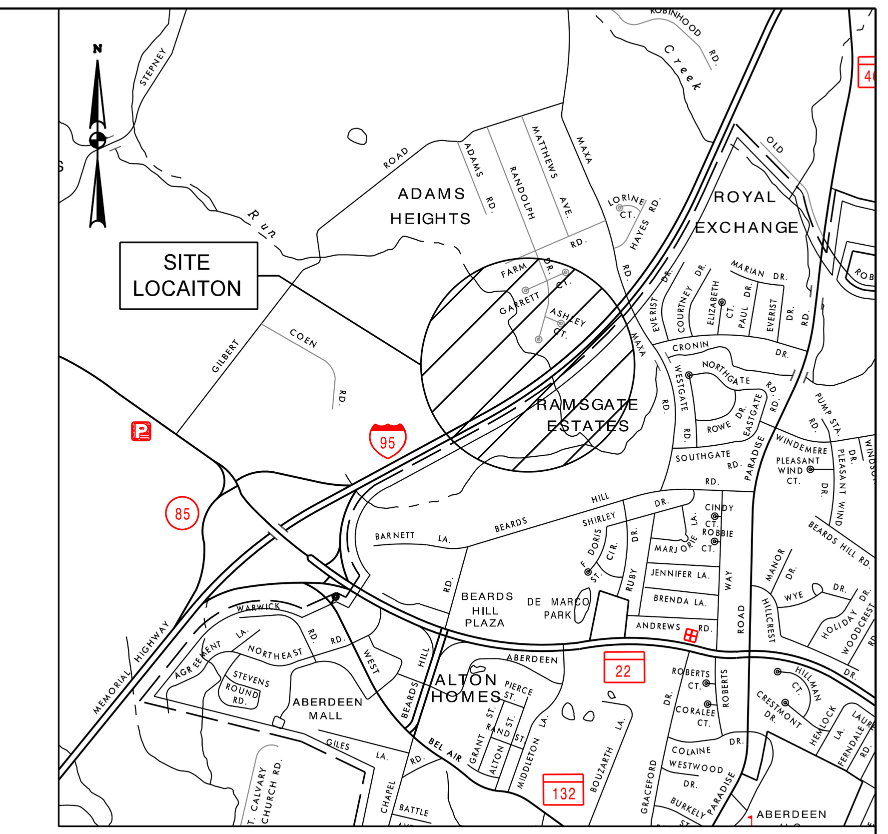
Q3 Flood Map


Study Area
Carsins Run Stream Restoration
Attachment 5 - Q3 Flood Map
Federal Emergency Management Agency
Q3 Flood Data for Harford County, Maryland
0
500
1,000
1,500
2,000
Feet
N
E
S
W
Study Area
FEMA 100-Year Floodplain

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
EX. FENCE
EX. WOODS LINE
EX. TREE
SS SD EX. MANHOLE
EX. UTILITY POLE
PROPERTY LINE
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
SLOPES 15-25%
SLOPES 25% OR GREATER
GhB GuB SOILS LINE
UPL-1 WETLAND/UPLAND SAMPLE PLOT
A-2 FOREST STAND SAMPLE PLOT
CRZ SP-1 SPECIMEN TREE
EX. FEMA 100 YEAR FLOODPLAIN

HORIZONTAL DATUM NAD 83/91
VERTICAL DATUM NAVD 88

100' 0 100' 200'
SCALE: 1" =100'

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

Jennifer A. Bird
SIGNATURE

FEBRUARY 2018
DATE

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KCI TECHNOLOGIES

P.E. STAMP HERE

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

FILE: M:\2014\22145228.36\Drawings\pNRI-P000_Carsins_NRI.dgn
DATE: Friday, February 23, 2018 AT 02:54 PM

LEGEND

········ 430 ········	EX. CONTOUR
—×—×—	EX. FENCE
	EX. WOODS LINE
	EX. TREE
SS SD	EX. MANHOLE
	EX. UTILITY POLE
	PROPERTY LINE
	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
	SLOPES 15-25%
	SLOPES 25% OR GREATER
GhB / GuB	SOILS LINE
x UPL-1	WETLAND/UPLAND SAMPLE PLOT
x A-2	FOREST STAND SAMPLE PLOT
CRZ SP-1	SPECIMEN TREE
	EX. FEMA 100 YEAR FLOODPLAIN

20' 0 20' 40'
SCALE: 1" = 20'

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

SIGNATURE

FEBRUARY 2018
DATE

HORIZONTAL DATUM NAD 83/91
VERTICAL DATUM NAVD 88

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WWW.JMT.COM 410-329-3100

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PLANNERS
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Maryland Transportation Authority
Engineering Division

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NO.	DESCRIPTION	BY	DATE

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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-01
SHEET NO. 2 OF 5

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LEGEND

430	EX. CONTOUR
—×—×—	EX. FENCE
	EX. WOODS LINE
	EX. TREE
SS SD	EX. MANHOLE
	EX. UTILITY POLE
	PROPERTY LINE
	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
	SLOPES 15-25%
	SLOPES 25% OR GREATER
GhB / GuB	SOILS LINE
x UPL-1	WETLAND/UPLAND SAMPLE PLOT
x A-2	FOREST STAND SAMPLE PLOT
CRZ SP-1	SPECIMEN TREE
	EX. FEMA 100 YEAR FLOODPLAIN

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

Jennifer A. Bird
SIGNATURE

FEBRUARY 2018
DATE

SCALE: 1" = 20'

HORIZONTAL DATUM NAD 83/91
VERTICAL DATUM NAVD 88

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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-02
SHEET NO. 3 OF 5

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DATE: Friday, February 23, 2018 AT 02:56 PM

LEGEND

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	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	CRZ SP-1	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		

MATCH LINE – SEE NRI–02

SCALE: 1" = 20'

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

SIGNATURE

FEBRUARY 2018
DATE

HORIZONTAL DATUM NAD 83/91
VERTICAL DATUM NAVD 88

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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–03
SHEET NO. 4 OF 5

FILE: M:\2014\22145228.36\Drawings\pNRI-P003_Carsins_NRI.dgn
DATE: Friday, February 23, 2018 AT 02:57 PM

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

SIGNATURE

FEBRUARY 2018

DATE

HORIZONTAL DATUM NAD 83/91
VERTICAL DATUM NAVD 88

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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-04
SHEET NO. 5 OF 5

FILE: M:\2014\22145228.36\Drawings\pNRI-P004_Carsins_NRI.dgn
DATE: Friday, February 23, 2018 AT 02:58 PM

APPENDIX B

Data Point Forms: Wetland Determination and Stream Features

Stream Features
Field Sheet

Date: 2/5/18 **Project Site:** Carsins Run Stream Restoration **Stream #** WL001
Observers: KM, AW

Stream Flow: X Perennial ___ Intermittent ___ Ephemeral
Gradient: 2%

Morphology:

Average Bankful Width 12' Average Bankfull Depth 1' Average Water Depth: 6"

Has stream morphometry been altered? Describe type and degree: The channel is culverted under I-95, and is concrete lined directly upstream of the I-95 culvert.

Habitat and Pollutants:

Substrate:

___ Bedrock X Gravel/Sand X Silt

X Sand X Cobble/Gravel ___ Clay

Habitat Complexity:

X Riffle/Pools ___ Undercut banks

X Tree Roots X Woody Debris

Bank Erosion: ___ Severe X Moderate ___ Minor

Describe: Some banks are sheer with close to a 90 degree drop in some areas

Silt Deposition: ___ Severe ___ Moderate X Minor

Riparian Zone:

Right Bank: X Forested ___ Vegetated ___ Developed ___ Maintained

Notes: Adjacent to upland riparian forest.

Slope: 2%

Left Bank. X Forested ___ Vegetated ___ Developed ___ Maintained

Notes: Adjacent to upland riparian forest.

Slope: 5%

Cowardin (1979) Stream Classification: R2UB1/2

Stream Features
Field Sheet

Date: 2/5/18 **Project Site:** Carsins Run Stream Restoration **Stream #** WL002
Observers: AW, KM

Stream Flow: ____ Perennial ____ Intermittent __X__ Ephemeral
Gradient: 1%

Morphology:

Average Bankful Width 4' Average Bankfull Depth 4" Average Water Depth: 1"

Has stream morphometry been altered? Describe type and degree: A stormwater outfall outlets into the channel.

Habitat and Pollutants:

Substrate:

____ Bedrock __X__ Gravel/Sand __X__ Silt

__X__ Sand ____ Cobble/Gravel ____ Clay

Habitat Complexity:

__X__ Riffle/Pools ____ Undercut banks

__X__ Tree Roots ____ Woody Debris

Bank Erosion: ____ Severe ____ Moderate __X__ Minor

Describe: A low gradient channel, with minimal erosion, that is fed by an upstream outfall.

Silt Deposition: ____ Severe ____ Moderate __X__ Minor

Riparian Zone:

Right Bank: __X__ Forested ____ Vegetated ____ Developed ____ Maintained

Notes: Adjacent to upland riparian forest.

Slope: 2%

Left Bank. __X__ Forested ____ Vegetated ____ Developed ____ Maintained

Notes: Adjacent to upland riparian forest.

Slope: 2%

Cowardin (1979) Stream Classification: N/A

Stream Features
Field Sheet

Date: 2/5/18 **Project Site:** Carsins Run Stream Restoration **Stream #** WL003
Observers: AW, KM

Stream Flow: ____ Perennial __X__ Intermittent ____ Ephemeral

Gradient: __4%__

Morphology:

Average Bankful Width __2'__ Average Bankfull Depth __1'__ Average Water Depth: __2"__

Has stream morphometry been altered? Describe type and degree: Not within project area. WUS WL003 originates at Wetland WL007.

Habitat and Pollutants:

Substrate:

____ Bedrock __X__ Gravel/Sand __X__ Silt

__X__ Sand __X__ Cobble/Gravel ____ Clay

Habitat Complexity:

__X__ Riffle/Pools ____ Undercut banks

____ Tree Roots __X__ Woody Debris

Bank Erosion: ____ Severe __X__ Moderate ____ Minor

Describe: Some sheer banks and areas of incision.

Silt Deposition: ____ Severe ____ Moderate __X__ Minor

Riparian Zone:

Right Bank: __X__ Forested ____ Vegetated ____ Developed ____ Maintained

Notes: Adjacent to upland riparian forest.

Slope: __3%__

Left Bank. __X__ Forested ____ Vegetated ____ Developed ____ Maintained

Notes: Adjacent to upland riparian forest.

Slope: __3%__

Cowardin (1979) Stream Classification: R4SB3/4

Stream Features
Field Sheet

Date: 2/5/18 **Project Site:** Carsins Run Stream Restoration **Stream #** WL004
Observers: AW, KM

Stream Flow: ____ Perennial ____ Intermittent X Ephemeral
Gradient: 1%

Morphology:

Average Bankful Width 1.5' Average Bankfull Depth 4" Average Water Depth: <0.5"

Has stream morphometry been altered? Describe type and degree: Not within project area. The channel originates as overflow from WUS WL003, and outlets into WUS WL001.

Habitat and Pollutants:

Substrate:
____ Bedrock X Gravel/Sand X Silt

X Sand ____ Cobble/Gravel ____ Clay

Habitat Complexity:
X Riffle/Pools ____ Undercut banks

____ Tree Roots X Woody Debris

Bank Erosion: ____ Severe ____ Moderate X Minor

Describe: This is a low gradient overflow channel from WUS WL003.

Silt Deposition: ____ Severe ____ Moderate X Minor

Riparian Zone:

Right Bank: X Forested ____ Vegetated ____ Developed ____ Maintained

Notes: Adjacent to upland riparian forest.

Slope: 2%

Left Bank. X Forested ____ Vegetated ____ Developed ____ Maintained

Notes: Adjacent to upland riparian forest and WUS WL003.

Slope: 1%

Cowardin (1979) Stream Classification: N/A

Stream Features
Field Sheet

Date: 2/5/18 **Project Site:** Carsins Run Stream Restoration **Stream #** WL005
Observers: AW, KM

Stream Flow: ___ Perennial __X__ Intermittent ___ Ephemeral
Gradient: __2%__

Morphology:

Average Bankful Width __15'__ Average Bankfull Depth __10"__ Average Water Depth: __8"__

Has stream morphometry been altered? Describe type and degree: Not within the project area.
The originates at its confluence with WUS WL001 and flows outside of the project area.

Habitat and Pollutants:

Substrate:

	Bedrock	X	Gravel/Sand		Silt
X	Sand	X	Cobble/Gravel		Clay

Habitat Complexity:

X	Riffle/Pools	X	Undercut banks
X	Tree Roots	X	Woody Debris

Bank Erosion: ___ Severe __X__ Moderate ___ Minor

Describe: Some banks are undercut and beginning to erode.

Silt Deposition: ___ Severe ___ Moderate __X__ Minor

Riparian Zone:

Right Bank: __X__ Forested ___ Vegetated ___ Developed ___ Maintained

Notes: Adjacent to upland riparian forest

Slope: __3%__

Left Bank. __X__ Forested ___ Vegetated ___ Developed ___ Maintained

Notes: Adjacent to upland riparian forest

Slope: __1%__

Cowardin (1979) Stream Classification: R4SB3/4

Stream Features
Field Sheet

Date: 2/5/18 **Project Site:** Carsins Run **Stream #** WL006
Observers: AW, KM

Stream Flow: ____ Perennial ____ Intermittent __X__ Ephemeral
Gradient: __1%__

Morphology:

Average Bankful Width __2'__ Average Bankfull Depth __4"__ Average Water Depth: __<1"__

Has stream morphometry been altered? Describe type and degree: Not within the project area.
WUS WL006 originates at Wetland WL008, and outlets into WUS WL005.

Habitat and Pollutants:

Substrate:

____ Bedrock __X__ Gravel/Sand ____ Silt

__X__ Sand ____ Cobble/Gravel ____ Clay

Habitat Complexity:

____ Riffle/Pools ____ Undercut banks

____ Tree Roots ____ Woody Debris

Bank Erosion: ____ Severe ____ Moderate __X__ Minor

Describe: This is a natural channel that has formed in Wetland WL008.

Silt Deposition: ____ Severe ____ Moderate __X__ Minor

Riparian Zone:

Right Bank: __X__ Forested ____ Vegetated ____ Developed ____ Maintained

Notes: Adjacent to upland riparian forest.

Slope: __1%__

Left Bank. __X__ Forested __X__ Vegetated ____ Developed ____ Maintained

Notes: Adjacent to Wetland WL008

Slope: __1%__

Cowardin (1979) Stream Classification: N/A

WETLAND DETERMINATION DATA FORM – Eastern Mountains and Piedmont Region

Project/Site: Carsins Run Stream Restoration City/County: Harford Sampling Date: 2/6/18

Applicant/Owner: Maryland Transportation Authority State: MD Sampling Point: WL007-W

Investigator(s): AW, BD Section, Township, Range: Aberdeen

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): none Slope (%): 1

Subregion (LRR or MLRA): MLRA 148 Lat: 39.531739 Long: -76.183367 Datum: NAD 83

Soil Map Unit Name: Delanco silt loam, 3-8% slopes (DcB) NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ☐ (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ☐

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓	No ☐
Hydric Soil Present?	Yes ✓	No ☐
Wetland Hydrology Present?	Yes ✓	No ☐

Is the Sampled Area within a Wetland? **Yes** ✓ **No** ☐

Remarks:

The sample plot satisfies the three mandatory wetland criteria; therefore, this area is classified as a palustrine, forested, broad-leaved deciduous, temporarily flooded (PFO1A) wetland. The wetland is located adjacent to the Ripken Stadium complex and outlets into WUS WL003. A stormwater management (SWM) pond is located above the wetland. Standing water is present throughout the wetland. Rain has occurred within the past 48 hours.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ✓ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ✓ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ✓ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ✓ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ Microtopographic Relief (D4)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ☐	No ✓	Depth (inches): N/A
Water Table Present?	Yes ✓	No ☐	Depth (inches): 1"
Saturation Present? (includes capillary fringe)	Yes ✓	No ☐	Depth (inches): surfa

Wetland Hydrology Present? Yes ✓ **No** ☐

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

The sample plot satisfies the wetland hydrology criterion. Surface water is present throughout the wetland; however, no surface water was present near the wetland sample plot.

VEGETATION (Five Strata) – Use scientific names of plants. Sampling Point: WL007-WET

Tree Stratum (Plot size: 30ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. Acer rubrum	50	Y	FAC
2. Fraxinus pennsylvanica	20	Y	FAC
3. Liquidambar styraciflua	10	N	FAC
4.			
5.			
6.			
	80	= Total Cover	
50% of total cover: 40	20% of total cover: 16		

Sapling Stratum (Plot size: 15ft radius)			
1.			
2.			
3.			
4.			
5.			
6.			
	0	= Total Cover	
50% of total cover: 0	20% of total cover: 0		

Shrub Stratum (Plot size: 15ft radius)			
1. Rosa multiflora	15	Y	FACU
2.			
3.			
4.			
5.			
6.			
	15	= Total Cover	
50% of total cover: 7.5	20% of total cover: 3		

Herb Stratum (Plot size: 5ft radius)			
1. Microstegium vimineum	40	Y	FAC
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	40	= Total Cover	
50% of total cover: 20	20% of total cover: 8		

Woody Vine Stratum (Plot size: 30ft radius)			
1. Toxicodendron radicans	2	Y	FAC
2.			
3.			
4.			
5.			
	2	= Total Cover	
50% of total cover: 1	20% of total cover: 0.4		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 80 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Five Vegetation Strata:

Tree – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in diameter at breast height (DBH).

Sapling – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and less than 3 in. (7.6 cm) DBH.

Shrub – Woody plants, excluding woody vines, approximately 3 to 20 ft (1 to 6 m) in height.

Herb – All herbaceous (non-woody) plants, including herbaceous vines, regardless of size, and woody plants, except woody vines, less than approximately 3 ft (1 m) in height.

Woody vine – All woody vines, regardless of height.

Hydrophytic Vegetation Present? Yes ☑ No ☐

Remarks: (Include photo numbers here or on a separate sheet.)

The sample plot satisfies the hydrophytic vegetation criterion.

SOIL

Sampling Point: WL007

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-8	10YR 4/2	70	10YR 2/1	10	D	M	sicl	organic matter
			7.5YR 4/4	20	C	M/PL		
8-20	2.5Y 6/1	40	10YR 5/2	25	C	M	sicl	
			10YR 5/8	15	C	M		
			10YR 3/2	5	C	M		
			7.5YR 4/4	15	C	M/PL		
20-24	2.5Y 6/1	50	10YR 6/8	25	C	M	cl	
			10YR 3/2	10	C	M		
			10YR 4/4	15	C	M		

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10) **(LRR N)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1) **(LRR N, MLRA 147, 148)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7)
- ☐ Polyvalue Below Surface (S8) **(MLRA 147, 148)**
- ☐ Thin Dark Surface (S9) **(MLRA 147, 148)**
- ☐ Loamy Gleyed Matrix (F2)
- ☑ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Iron-Manganese Masses (F12) **(LRR N, MLRA 136)**
- ☐ Umbric Surface (F13) **(MLRA 136, 122)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 148)**
- ☐ Red Parent Material (F21) **(MLRA 127, 147)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 2 cm Muck (A10) **(MLRA 147)**
- ☐ Coast Prairie Redox (A16) **(MLRA 147, 148)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 136, 147)**
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: N/A

Depth (inches):

Hydric Soil Present? Yes ☑ No ☐

Remarks: The sample plot satisfies the hydric soils criterion.

WETLAND DETERMINATION DATA FORM – Eastern Mountains and Piedmont Region

Project/Site: Carsins Run Stream Restoration City/County: Harford Sampling Date: 2/6/18

Applicant/Owner: Maryland Transportation Authority State: MD Sampling Point: WL008-W

Investigator(s): AW/BD Section, Township, Range: Aberdeen

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): none Slope (%): 1

Subregion (LRR or MLRA): MLRA 148 Lat: 39.531255 Long: -76.178877 Datum: NAD 83

Soil Map Unit Name: Aldino very stony silt loam, 0-8% slopes (AsB) NWI classification: PFO1A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ☐ (If no, explain in Remarks.)

Are Vegetation ☐, Soil ✓, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ☐ No ✓

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓	No ☐	Is the Sampled Area within a Wetland? Yes ✓ No ☐
Hydric Soil Present?	Yes ✓	No ☐	
Wetland Hydrology Present?	Yes ✓	No ☐	

Remarks:

The sample plot satisfies all three mandatory wetland criteria; therefore, this areas is classified as a palustrine, forested, broad-leaved deciduous, temporarily flooded (PFO1A) wetland. The sample plot is located downstream of Interstate 95 on the left bank of WUS WL001. Rock and cobble are present throughout the wetland.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ✓ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ✓ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ Microtopographic Relief (D4)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ☐	No ✓	Depth (inches):
Water Table Present?	Yes ✓	No ☐	Depth (inches): 10"
Saturation Present? (includes capillary fringe)	Yes ✓	No ☐	Depth (inches): Surfa

Wetland Hydrology Present? Yes ✓ No ☐

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

The sample plot satisfies the wetland hydrology criterion.

VEGETATION (Five Strata) – Use scientific names of plants.

Sampling Point: WL008-WET

Tree Stratum (Plot size: 30ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. Liquidambar styraciflua	10	N	FAC
2. Carpinus caroliniana	5	N	FAC
3. Fagus grandifolia	10	N	FACU
4. Acer rubrum	35	Y	FAC
5. Nyssa sylvatica	20	Y	FAC
6. Quercus alba	15	N	FACU
	95 = Total Cover		
50% of total cover: 47.5	20% of total cover: 19		

Sapling Stratum (Plot size: 15ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. Fagus grandifolia	10	Y	FACU
2.			
3.			
4.			
5.			
6.			
	10 = Total Cover		
50% of total cover: 5	20% of total cover: 2		

Shrub Stratum (Plot size: 15ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
	0 = Total Cover		
50% of total cover: 0	20% of total cover: 0		

Herb Stratum (Plot size: 5ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. Carex species	10	Y	NI
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	10 = Total Cover		
50% of total cover: 5	20% of total cover: 2		

Woody Vine Stratum (Plot size: 30ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
50% of total cover: 0	20% of total cover: 0		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 67 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Five Vegetation Strata:

Tree – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in diameter at breast height (DBH).

Sapling – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and less than 3 in. (7.6 cm) DBH.

Shrub – Woody plants, excluding woody vines, approximately 3 to 20 ft (1 to 6 m) in height.

Herb – All herbaceous (non-woody) plants, including herbaceous vines, regardless of size, and woody plants, except woody vines, less than approximately 3 ft (1 m) in height.

Woody vine – All woody vines, regardless of height.

Hydrophytic Vegetation Present? Yes ☑ No ☐

Remarks: (Include photo numbers here or on a separate sheet.)

The sample plot satisfies the hydrophytic vegetation.

SOIL Sampling Point: WL008

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-8	10YR 4/1	85	10YR 4/4	10	C	M/PL	sicl	
			10YR 6/1	5	C	M		
8-12	10YR 5/1	55	10YR 4/1	10	D	M	sicl	
			10YR 5/6	15	C	M/PL		
			10YR 6/6	20	C	M		
12+	---	--	---	--	--	--	--	Refusal

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10) **(LRR N)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1) **(LRR N, MLRA 147, 148)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7)
- ☐ Polyvalue Below Surface (S8) **(MLRA 147, 148)**
- ☐ Thin Dark Surface (S9) **(MLRA 147, 148)**
- ☐ Loamy Gleyed Matrix (F2)
- ☑ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Iron-Manganese Masses (F12) **(LRR N, MLRA 136)**
- ☐ Umbric Surface (F13) **(MLRA 136, 122)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 148)**
- ☐ Red Parent Material (F21) **(MLRA 127, 147)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 2 cm Muck (A10) **(MLRA 147)**
- ☐ Coast Prairie Redox (A16) **(MLRA 147, 148)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 136, 147)**
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: Rock

Depth (inches): 12+

Hydric Soil Present? Yes ☑ No ☐

Remarks: The sample plot satisfies the hyrdric soils criterion. Refusal occurred at 12 inches due to the presence of rock and cobble throughout the wetland.

WETLAND DETERMINATION DATA FORM – Eastern Mountains and Piedmont Region

Project/Site: Carsins Run Stream Restoration City/County: Harford Sampling Date: 2/6/18

Applicant/Owner: Maryland Transportation Authority State: MD Sampling Point: UPL-1

Investigator(s): AW, BD Section, Township, Range: Aberdeen

Landform (hillslope, terrace, etc.): hillslope Local relief (concave, convex, none): none Slope (%): 1

Subregion (LRR or MLRA): MLRA 148 Lat: 39.531805 Long: -76.181951 Datum: NAD 83

Soil Map Unit Name: Aldino silt loam, 3-8% slopes (AdB) NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ☐ (If no, explain in Remarks.)

Are Vegetation ☐ Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ☐

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

	Yes	No
Hydrophytic Vegetation Present?	☐	✓
Hydric Soil Present?	☐	✓
Wetland Hydrology Present?	☐	✓

Is the Sampled Area within a Wetland? **Yes** ☐ **No** ✓

Remarks:

The sample plot does not satisfy the three mandatory wetland criteria; therefore, this area is classified as upland. The sample plot is located on a hillslope within Forest Stand Delineation Sample Plot FSD A-3. Rain has occurred within the past 48 hours.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ Microtopographic Relief (D4)
- ☐ FAC-Neutral Test (D5)

Field Observations:

	Yes	No	Depth (inches)
Surface Water Present?	☐	✓	
Water Table Present?	☐	✓	
Saturation Present? (includes capillary fringe)	☐	✓	

Wetland Hydrology Present? **Yes** ☐ **No** ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

The sample plot does not satisfy the hydrology criterion.

VEGETATION (Five Strata) – Use scientific names of plants.

Sampling Point: UPL-1

Tree Stratum (Plot size: 30ft radius)

	Absolute % Cover	Dominant Species?	Indicator Status
1. Liquidambar styraciflua	15	N	FAC
2. Quercus alba	40	Y	FACU
3. Fagus grandifolia	20	Y	FACU
4. Juniperus virginiana	5	N	FACU
5. Nyssa sylvatica	5	N	FAC
6. Liriodendron tulipifera	10	N	FACU
= Total Cover	95		

50% of total cover: 47.5 20% of total cover: 19

Sapling Stratum (Plot size: 15ft radius)

	Absolute % Cover	Dominant Species?	Indicator Status
1. Carpinus caroliniana	5	Y	FAC
2.			
3.			
4.			
5.			
6.			
= Total Cover	5		

50% of total cover: 2.5 20% of total cover: 1

Shrub Stratum (Plot size: 15ft radius)

	Absolute % Cover	Dominant Species?	Indicator Status
1. Lindera benzoin	15	Y	FAC
2.			
3.			
4.			
5.			
6.			
= Total Cover	15		

50% of total cover: 7.5 20% of total cover: 3

Herb Stratum (Plot size: 5ft radius)

	Absolute % Cover	Dominant Species?	Indicator Status
1. Lonicera japonica	10	Y	FACU
2. Allium canadense	2	N	FACU
3. Microstegium vimineum	5	N	FAC
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
= Total Cover	17		

50% of total cover: 8.5 20% of total cover: 3.4

Woody Vine Stratum (Plot size: 30ft radius)

	Absolute % Cover	Dominant Species?	Indicator Status
1. Toxicodendron radicans	5	Y	FAC
2. Vitis labrusca	5	Y	FACU
3.			
4.			
5.			
= Total Cover	10		

50% of total cover: 5 20% of total cover: 2

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 7 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 43 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	0	x 1 = 0
FACW species	0	x 2 = 0
FAC species	50	x 3 = 150
FACU species	92	x 4 = 368
UPL species	0	x 5 = 0
Column Totals:	142 (A)	518 (B)

Prevalence Index = B/A = 3.65

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☐ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Five Vegetation Strata:

Tree – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in diameter at breast height (DBH).

Sapling – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and less than 3 in. (7.6 cm) DBH.

Shrub – Woody plants, excluding woody vines, approximately 3 to 20 ft (1 to 6 m) in height.

Herb – All herbaceous (non-woody) plants, including herbaceous vines, regardless of size, and woody plants, except woody vines, less than approximately 3 ft (1 m) in height.

Woody vine – All woody vines, regardless of height.

Hydrophytic Vegetation Present? Yes ☐ No ☑

Remarks: (Include photo numbers here or on a separate sheet.)

The sample plot does not satisfy the hydrophytic vegetation criterion.

SOIL

Sampling Point: UPL-1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-10	10YR 4/4	70	7.5YR 4/4	30	C	M	sil	
10-24	7.5YR 4/6	70	10YR 3/3	30	C	M	sil	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10) **(LRR N)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1) **(LRR N, MLRA 147, 148)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7)
- ☐ Polyvalue Below Surface (S8) **(MLRA 147, 148)**
- ☐ Thin Dark Surface (S9) **(MLRA 147, 148)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Iron-Manganese Masses (F12) **(LRR N, MLRA 136)**
- ☐ Umbric Surface (F13) **(MLRA 136, 122)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 148)**
- ☐ Red Parent Material (F21) **(MLRA 127, 147)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 2 cm Muck (A10) **(MLRA 147)**
- ☐ Coast Prairie Redox (A16) **(MLRA 147, 148)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 136, 147)**
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: N/A

Depth (inches):

Hydric Soil Present? Yes ☐ No ☑

Remarks:
The sample plot does not satisfy the hydric soils criterion.

WETLAND DETERMINATION DATA FORM – Eastern Mountains and Piedmont Region

Project/Site: Carsins Run Stream Restoration City/County: Harford Sampling Date: 2/6/18
Applicant/Owner: Maryland Transportation Authority State: MD Sampling Point: UPL-2
Investigator(s): AW, BD Section, Township, Range: Aberdeen
Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): none Slope (%): 1
Subregion (LRR or MLRA): MLRA 148 Lat: 39.531114 Long: -76.179001 Datum: NAD 83
Soil Map Unit Name: Aldino very stony silt loam, 0-8% slopes (AsB) NWI classification: N/A
Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ☐ (If no, explain in Remarks.)
Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ☐
Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓	No ☐
Hydric Soil Present?	Yes ☐	No ✓
Wetland Hydrology Present?	Yes ✓	No ☐

Is the Sampled Area within a Wetland? **Yes** ☐ **No** ✓

Remarks:

The sample plot satisfies only two of the three mandatory wetland criteria; therefore, the area is classified as upland. The sample plot is located on the floodplain adjacent to WUS WL001, Wetland WL008, and a fence line. Rain has occurred within the past 48 hours.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ✓ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ Microtopographic Relief (D4)
- ☐ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ☐	No ✓	Depth (inches):
Water Table Present?	Yes ☐	No ✓	Depth (inches):
Saturation Present? (includes capillary fringe)	Yes ✓	No ☐	Depth (inches): 8"

Wetland Hydrology Present? **Yes** ✓ **No** ☐

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

The sample plot satisfies the hydrology criterion. No water table is associated with the zone of saturation.

VEGETATION (Five Strata) – Use scientific names of plants. Sampling Point: UPL-2

Tree Stratum (Plot size: 30ft radius)

	Absolute % Cover	Dominant Species?	Indicator Status
1. Acer rubrum	40	Y	FAC
2. Juniperus virginiana	5	N	FACU
3. Nyssa sylvatica	5	N	FAC
4. Liquidambar styraciflua	35	N	FAC
5. Fagus grandifolia	10	N	FACU
6.			
	95 = Total Cover		
50% of total cover: 47.5	20% of total cover: 19		

Sapling Stratum (Plot size: 15ft radius)

	Absolute % Cover	Dominant Species?	Indicator Status
1. Fagus grandifolia	10	Y	FACU
2.			
3.			
4.			
5.			
6.			
	10 = Total Cover		
50% of total cover: 5	20% of total cover: 2		

Shrub Stratum (Plot size: 15ft radius)

	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
	0 = Total Cover		
50% of total cover: 0	20% of total cover: 0		

Herb Stratum (Plot size: 5ft radius)

	Absolute % Cover	Dominant Species?	Indicator Status
1. Carex species	15	Y	NI
2. Microstegium vimineum	5	Y	FAC
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	20 = Total Cover		
50% of total cover: 10	20% of total cover: 4		

Woody Vine Stratum (Plot size: 30ft radius)

	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
50% of total cover: 0	20% of total cover: 0		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 67 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Five Vegetation Strata:

Tree – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and 3 in. (7.6 cm) or larger in diameter at breast height (DBH).

Sapling – Woody plants, excluding woody vines, approximately 20 ft (6 m) or more in height and less than 3 in. (7.6 cm) DBH.

Shrub – Woody plants, excluding woody vines, approximately 3 to 20 ft (1 to 6 m) in height.

Herb – All herbaceous (non-woody) plants, including herbaceous vines, regardless of size, and woody plants, except woody vines, less than approximately 3 ft (1 m) in height.

Woody vine – All woody vines, regardless of height.

Hydrophytic Vegetation Present? Yes ☑ No ☐

Remarks: (Include photo numbers here or on a separate sheet.)

The sample plot satisfies the hydrophytic vegetation criterion.

SOIL

Sampling Point: UPL-2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-6	10YR 3/3	80	10YR 4/4	20	C	M	ms	
6-12	10YR 4/3	100	---	--	C	M	sil	with fine sand
12-20	2.5Y 5/4	45	2.5Y 5/3	20	C	M	sicl	
			10YR 5/6	15	C	M		
			10YR 6/6	15	C	M		
			10YR 3/2	5	D	M		

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10) **(LRR N)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1) **(LRR N, MLRA 147, 148)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7)
- ☐ Polyvalue Below Surface (S8) **(MLRA 147, 148)**
- ☐ Thin Dark Surface (S9) **(MLRA 147, 148)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Iron-Manganese Masses (F12) **(LRR N, MLRA 136)**
- ☐ Umbric Surface (F13) **(MLRA 136, 122)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 148)**
- ☐ Red Parent Material (F21) **(MLRA 127, 147)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 2 cm Muck (A10) **(MLRA 147)**
- ☐ Coast Prairie Redox (A16) **(MLRA 147, 148)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 136, 147)**
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: N/A

Depth (inches):

Hydric Soil Present? Yes ☐ No ☑

Remarks: The sample plot does not satisfy the hydric soils criterion.

APPENDIX C

Forest Sampling Data Sheets and Forest Summary Datasheets

Property: Carsins Run Stream Restoration **Prepared By:** AW, BD

Stand #: A **Plot #:** 1 **Plot Size:** 1/10 Acre **Date:** 2/6/2018

Basal Area in sf/acre: 120

Size Class of trees >20' height within sample plot

Tree Species	# of Trees 2-5.9" dbh			# of Trees 6-11.9" dbh			# of Trees 12-19.9" dbh			# of Trees 20-29.9" dbh			# of Trees > 30" dbh			
Crown Position	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Total**
Fagus grandifolia										1						1
Liriodendron tulipifera							1			2						3
Acer rubrum							1			1						2
																0
																0
																0
																0
																0
																0
																0
																0
																0
Total Number of Trees per Size Class	0			0			2			4			0			6
Number & Size of Standing Dead Trees	1						1									2

List of Common Understory Species 3' - 20':
Berberis thunbergii, Fagus grandifolia, Lindera benzoin

% of Canopy Closure

C	*N*	*E*	*S*	*W*	*Total*
95	90	90	95	85	91

% Understory Cover 3' - 20'

C	*N*	*E*	*S*	*W*	*Total*
5	15	10	15	15	12

Percent of Invasive Cover per Plot (All Layers): 10%

Plot Successional Stage: Early-Mid

List of Herbaceous Species 0' - 3':
Lonicera japonica

% of Herbaceous Cover 0' - 3'

C	*N*	*E*	*S*	*W*	*Total*
2	0	0	0	2	0.8

Comments
The sample plot is located at the upstream end of the project area on the right bank, and is located generally northwest of I-95. A moderate amount of downed woody debris is present. There is a minimal amount of understory and herbaceous coverage within the sample plot. Approximately 1/2" of leaf litter is present within the forest stand sample plot.

Property: Carsins Run Stream Restoration **Prepared By:** AW, BD

Stand #: A **Plot #:** 2 **Plot Size:** 1/10 Acre **Date:** 2/6/2018

Basal Area in sf/acre: 105

Size Class of trees >20' height within sample plot

Tree Species	# of Trees 2-5.9" dbh			# of Trees 6-11.9" dbh			# of Trees 12-19.9" dbh			# of Trees 20-29.9" dbh			# of Trees > 30" dbh			
Crown Position	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Total**
Carpinus caroliniana			2													2
Prunus serotina			1													1
Liriodendron tulipifera										1						1
Liquidambar styraciflua							2									2
Celtis occidentalis			1													1
Carya glabra							1									1
Quercus alba						1				1						2
																0
																0
																0
																0
																0
Total Number of Trees per Size Class	4			1			3			2			0			10
Number & Size of Standing Dead Trees																0

List of Common Understory Species 3' - 20':
Crataegus species, *Fagus grandifolia, Lindera benzoin*

% of Canopy Closure

C	*N*	*E*	*S*	*W*	*Total*
80	90	85	90	95	88

% Understory Cover 3' - 20'

C	*N*	*E*	*S*	*W*	*Total*
20	5	25	30	10	18

Percent of Invasive Cover per Plot (All Layers): 5%

Plot Successional Stage: Early-Mid

List of Herbaceous Species 0' - 3':
Allium canadensis, Lonicera japonica

% of Herbaceous Cover 0' - 3'

C	*N*	*E*	*S*	*W*	*Total*
2	2	5	2	0	2.2

Comments
The sample plot is located generally northwest of I-95 and is located on the left bank of WUS WL003. Rock is present within the sample plot, and there is a minimal amount of downed woody debris present. Approximately 1/2" of leaf litter is present within the forest stand sample plot.

Property: Carsins Run Stream Restoration **Prepared By:** AW, BD

Stand #: A **Plot #:** 3 **Plot Size:** 1/10 Acre **Date:** 2/6/2018

Basal Area in sf/acre: 120

Size Class of trees >20' height within sample plot

Tree Species	# of Trees 2-5.9" dbh			# of Trees 6-11.9" dbh			# of Trees 12-19.9" dbh			# of Trees 20-29.9" dbh			# of Trees > 30" dbh			
Crown Position	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Total**
Liriodendron tulipifera			1			1	2									4
Fagus grandifolia			3													3
Liquidambar styraciflua							3									3
Prunus serotina			1													1
Quercus alba							2									2
Juniperus virginiana			1													1
Carya glabra										1						1
Nyssa sylvatica			2													2
Carpinus caroliniana			2													2
																0
																0
																0
Total Number of Trees per Size Class	10			1			7			1			0			19
Number & Size of Standing Dead Trees	1			1												2

List of Common Understory Species 3' - 20':
Carpinus caroliniana, Lindera benzoin, Smilax rotundifolia, Vitis labrusca

% of Canopy Closure

C	*N*	*E*	*S*	*W*	*Total*
80	60	60	60	80	68

% Understory Cover 3' - 20'

C	*N*	*E*	*S*	*W*	*Total*
0	10	15	15	10	10

Percent of Invasive Cover per Plot (All Layers): 15%

Plot Successional Stage: Early

List of Herbaceous Species 0' - 3':
Allium canadense, Lonicera japonica, Microstegium vimineum, Rosa multiflora

% of Herbaceous Cover 0' - 3'

C	*N*	*E*	*S*	*W*	*Total*
2	5	2	10	10	5.8

Comments
The forest stand sample plot is located generally northwest of I-95, and is on the right bank of WUS WL003. The forest stand plot is surrounded by upland riparian forest. There is approximately 1/2" of leaf litter, and a moderate amount of downed woody debris present within the plot. There is a minimal amount of understory and herbaceous coverage within the sample plot.

Property: Carsins Run Stream Restoration **Prepared By:** AW, BD

Stand #: B **Plot #:** 1 **Plot Size:** 1/10 Acre **Date:** 2/6/2018

Basal Area in sf/acre: 130	Size Class of trees >20' height within sample plot														
Tree Species	# of Trees 2-5.9" dbh			# of Trees 6-11.9" dbh			# of Trees 12-19.9" dbh			# of Trees 20-29.9" dbh			# of Trees > 30" dbh		
Crown Position	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Total**
Liriodendron tulipifera			1		1		6			1						9
Liquidambar styraciflua			1	2	3											6
Fagus grandifolia			9													9
Acer rubrum					2											2
Nyssa sylvatica			5													5
Carpinus caroliniana			5													5
Ulmus rubra			1													1
																0
																0
																0
																0
																0
Total Number of Trees per Size Class	22			8			6			1			0			37
Number & Size of Standing Dead Trees	1			1												2

List of Common Understory Species 3' - 20':
Carpinus caroliniana, Fagus grandifolia, Vitis labrusca

% of Canopy Closure

C	*N*	*E*	*S*	*W*	*Total*
85	90	0	90	95	72

% Understory Cover 3' - 20'

C	*N*	*E*	*S*	*W*	*Total*
2	0	5	0	0	1.4

Percent of Invasive Cover per Plot (All Layers): 20%

Plot Successional Stage: Early

List of Herbaceous Species 0' - 3':
Allium canadense, Carex species, *Lonicera japonica, Polystichum acrostichoides, Rosa multiflora, Smilax rotundifolia*

% of Herbaceous Cover 0' - 3'

C	*N*	*E*	*S*	*W*	*Total*
10	2	45	5	30	18.4

Comments
The sample plot is located generally southeast of I-95, and is located on the right bank of WUS WL001 and WUS WL005. Rock and a moderate amount of downed woody debris and herbaceous cover is present within the sample plot. There is an approximately 1/2" of leaf litter present within the sample plot.

Property: Carsins Run Stream Restoration **Prepared By:** AW, BD

Stand #: B **Plot #:** 2 **Plot Size:** 1/10 Acre **Date:** 2/6/2018

Basal Area in sf/acre: 70

Size Class of trees >20' height within sample plot																
Tree Species	# of Trees 2-5.9" dbh			# of Trees 6-11.9" dbh			# of Trees 12-19.9" dbh			# of Trees 20-29.9" dbh			# of Trees > 30" dbh			
Crown Position	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Dom**	**CoD**	**Other**	**Total**
Fagus grandifolia		1	4													5
Liquidambar styraciflua				3												3
Acer rubrum			3	2	2		1									8
Quercus alba			1													1
Nyssa sylvatica			3	1												4
Carpinus caroliniana			5													5
																0
																0
																0
																0
																0
																0
Total Number of Trees per Size Class	17			8			1			0			0			26
Number & Size of Standing Dead Trees																0

List of Common Understory Species 3' - 20':
Acer rubrum, Carpinus caroliniana, Fagus grandifolia, Smilax rotundifolia

% of Canopy Closure

C	*N*	*E*	*S*	*W*	*Total*
95	90	90	95	95	93

% Understory Cover 3' - 20'

C	*N*	*E*	*S*	*W*	*Total*
0	5	2	0	0	1.4

Percent of Invasive Cover per Plot (All Layers): 10%

Plot Successional Stage: Early

List of Herbaceous Species 0' - 3':
Carex species, *Microstegium vimineum, Smilax rotundifolia*

% of Herbaceous Cover 0' - 3'

C	*N*	*E*	*S*	*W*	*Total*
20	2	2	20	10	10.8

Comments
The sample plot is located southeast of I-95, on the left bank of WUS WL001, and within Wetland WL008. The sample plot is located within the existing fence line. A moderate amount of downed woody debris is present. There is a minimal amount of understory and herbaceous cover present within the sample plot. Approximatly 1/2" of leaf litter is present within the sample plot.

Property Name: Carsins Run Stream Restoration	
Location: Aberdeen, Harford County, MD	
Prepared By: AW, BD	**Date: 2/6/18**
Stand Variable	**Stand A**
1. Dominant/Codominant species	**Dominant:** *Acer rubrum, Carya glabra, Fagus grandifolia, Liriodendron tulipifera, Liquidambar styraciflua, Quercus alba*
2. Successional stage	Early-Mid
3. Basal area in square feet per acre	115
4. Size class of dominant species	12-19.9", 20-29.9"
5. Percent of canopy closure	82.3%
6. Number of tree species per acre	11
7. Common understory species per acre	*Berberis thumbergii, Carpinus caroliniana, Crataegus* species, *Fagus grandifolia, Lindera benzoin, Smilax rotundifolia, Vitis labrusca*
8. Percent of understory cover 3' to 10' tall	13.3%
9. Number of woody plants species 3' to 20' tall	7
10. Common herbaceous species 0' to 3' tall	*Allium canadense, Lonicera japonica, Microstegium viminuem, Rosa multiflora*
11. Percent of herbaceous and woody plant cover 0' to 3' tall	2.9%
12. List of major invasive plant species and percent cover	*Berberis thunbergii, Lonicera japonica, Microstegium vimineum, Rosa multiflora* - 10%
13. Number of standing dead trees 6" dbh or greater	2
14. Comments	The forest stand is located generally northwest of I-95. There is a moderate amount of downed woody debris present. A majority of the specimen trees are located within this forest stand. There is a moderate amount of understory and invasive species coverage. Additionally, there is a minimal amount of herbaceous coverage.
Forest Stand Summary Worksheet	Sheet 4 of 7

Property Name: Carsins Run Stream Restoration	
Location: Aberdeen, Harford County, MD	
Prepared By: AW, BD	**Date: 2/6/18**

Stand Variable	**Stand B**
1. Dominant/Codominant species	**Dominant:** *Acer rubrum, Liquidambar styraciflua, Liriodendron tulipifera, Nyssa sylvatica* **CoDomiant:** *Fagus grandifolia*
2. Successional stage	Early
3. Basal area in square feet per acre	100
4. Size class of dominant species	6-11.9”, 12-19.9”, 20-29.9”
5. Percent of canopy closure	82.5%
6. Number of tree species per acre	8
7. Common understory species per acre	*Acer rubrum, Carpinus caroliniana, Fagus grandifolia, Smilax rotundifolia, Vitis labrusca*
8. Percent of understory cover 3’ to 10’ tall	1.4%
9. Number of woody plants species 3’ to 20’ tall	5
10. Common herbaceous species 0’ to 3’ tall	*Allium canadense, Carex* species, *Carpinus caroliniana, Lonicera japonica, Microstegium vimineum, Polystichum acrostichoides, Rosa multiflora, Smilax rotundifolia*
11. Percent of herbaceous and woody plant cover 0’ to 3’ tall	14.6%
12. List of major invasive plant species and percent cover	*Lonicera japonica, Microstegium vimineum, Rosa multiflora,*– 15%
13. Number of standing dead trees 6” dbh or greater	1
14. Comments	Forest Stand B is located southeast of I-95. This early successional stand has a moderate amount of herbaceous and invasive species coverage. There is a minimal amount of understory coverage present. There is a moderate amount of downed woody debris present.

APPENDIX D

Representative Site Photographs

Photographic Record

KCI Technologies, Inc.

Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: K. Myers
Date: 2/5/18
Frame No. 1
Direction: North
Comments: View of WUS WL001 facing upstream from flag WL001-002

Photographer: K. Myers
Date: 2/5/18
Frame No. 2
Direction: North
Comments: View of WUS WL001 facing upstream between flags WL001-008 and WL001-009.

Photographic Record

KCI Technologies, Inc.

Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: K. Myers
Date: 2/5/18
Frame No. 3
Direction: North
Comments: View of WUS WL001 facing upstream from flag WL001-011.

Photographer: K. Myers
Date: 2/5/18
Frame No. 4
Direction: Southeast
Comments: View of WUS WL001 facing downstream from flag WL001-011.

Photographic Record

KCI Technologies, Inc.
Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: K. Myers
Date: 2/5/18
Frame No. 5
Direction: Northeast
Comments: View of Waterway WL002 facing upstream from flag WL002-002.

Photographer: K. Myers
Date: 2/5/18
Frame No. 6
Direction: West
Comments: View of WUS WL003 facing upstream from flag WL003-003.

Photographic Record

KCI Technologies, Inc.

Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: K. Myers
Date: 2/5/18
Frame No. 7
Direction: West
Comments: View of Waterway WL003 facing upstream from flag WL003-007.

Photographer: K. Myers
Date: 2/5/18
Frame No. 8
Direction: East
Comments: View of WUS WL003 facing downstream from flag WL003-032.

Photographic Record

KCI Technologies, Inc.
Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: K. Myers
Date: 2/5/18
Frame No. 9
Direction: East
Comments: View of Waterway WL003 facing downstream from flag WL003-037.

Photographer: K. Myers
Date: 2/5/18
Frame No. 10
Direction: West
Comments: View of WUS WL003 facing upstream from flag WL003-038.

Photographic Record

KCI Technologies, Inc.
Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: K. Myers
Date: 2/5/18
Frame No. 11
Direction: Northwest
Comments: View of Waterway WL004 facing upstream from flag WL004-002.

Photographer: K. Myers
Date: 2/5/18
Frame No. 12
Direction: Southeast
Comments: View of Waterway WL004 facing downstream from flag WL004-002.

Photographic Record

KCI Technologies, Inc.
Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: K. Myers
Date: 2/5/18
Frame No. 13
Direction: South
Comments: View of WUS WL001 facing upstream from flag WL001-017.

Photographer: K. Myers
Date: 2/5/18
Frame No. 14
Direction: North
Comments: View of WUS WL005 facing downstream from flag WL005-004.

Photographic Record

KCI Technologies, Inc.
Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: K. Myers
Date: 2/5/18
Frame No. 15
Direction: South
Comments: View of WUS WL001 facing upstream from flag WL001-017.

Photographer: K. Myers
Date: 2/5/18
Frame No. 16
Direction: North
Comments: View of Waterway WL006 facing upstream from flag WL006-003.

Photographic Record

KCI Technologies, Inc.
Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: K. Myers
Date: 2/5/18
Frame No. 17
Direction: South
Comments: View of Waterway WL006 facing downstream from flag WL006-006.

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 18
Direction: Northwest
Comments: View of Wetland Sample Plot WL007-WET towards Ripken Stadium complex

Photographic Record

KCI Technologies, Inc.
Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 19
Direction: N/A
Comments: View of Wetland Sample Plot WL007-WET soils.

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 20
Direction: South
Comments: View of Wetland Sample Plot WL008-WET.

Photographic Record

KCI Technologies, Inc.
Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 21
Direction: N/A
Comments: View of Wetland Sample Plot WL008-WET soils.

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 22
Direction: North
Comments: View of Upland Sample Plot UPL-1.

Photographic Record

KCI Technologies, Inc.
Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 23
Direction: N/A
Comments: View of Upland Sample Plot UPL-1 soils.

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 24
Direction: Southwest
Comments: View of Upland Sample Plot UPL-2.

Photographic Record

KCI Technologies, Inc.
Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 25
Direction: N/A
Comments: View of Upland Sample Plot UPL-2 soils.

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 26
Direction: West
Comments: View of Forest Stand Delineation Sample Plot FSD A-1 from center.

Photographic Record

KCI Technologies, Inc.
Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 27
Direction: East
Comments: View of Forest Stand Delineation Sample Plot FSD A-2 from center.

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 28
Direction: East
Comments: View of Forest Stand Delineation Sample Plot FSD A-3 from center.

Photographic Record

KCI Technologies, Inc.

Agency: Maryland Transportation Authority
Project: Carsins Run Stream Restoration
Project No. – 22145228.36

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 29
Direction: North
Comments: View of Forest Stand Delineation Sample Plot FSD B-1 from center.

Photographer: A. Wagoner
Date: 2/6/18
Frame No. 30
Direction: North
Comments: View of Forest Stand Delineation Sample Plot FSD B-2 from center.

APPENDIX E

Natural Resource, Historic and Cultural Review Correspondence

United States Department of the Interior
U.S. Fish & Wildlife Service
Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401
410/573 4575

Online Certification Letter

Today's date: 2/7/2018

Project: Carsins Run Stream Restoration

Dear Applicant for online certification:

Thank you for using the U.S. Fish and Wildlife Service (Service) Chesapeake Bay Field Office online project review process. By printing this letter in conjunction with your project review package, you are certifying that you have completed the online project review process for the referenced project in accordance with all instructions provided, using the best available information to reach your conclusions. This letter, and the enclosed project review package, completes the review of your project in accordance with the Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884), as amended (ESA).This letter also provides information for your project review under the National Environmental Policy Act of 1969 (P.L. 91-190, 42 U.S.C. 4321-4347, 83 Stat. 852), as amended. A copy of this letter and the project review package must be submitted to this office for this certification to be valid. This letter and the project review package will be maintained in our records.

Based on this information and in accordance with section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.), we certify that except for occasional transient individuals, no federally proposed or listed endangered or threatened species are known to exist within the project area. Therefore, no Biological Assessment or further section 7 consultation with the U.S. Fish and Wildlife Service is required. Should project plans change, or if additional information on the distribution of listed or proposed species becomes available, this determination may be reconsidered.

This response relates only to federally protected threatened or endangered species under our jurisdiction. For additional information on threatened or endangered species in Maryland, you should contact the Maryland Wildlife and Heritage Division at (410) 260-8573. For information in Delaware you should contact the Delaware Division of Fish and Wildlife, Wildlife Species Conservation and Research Program at (302) 735-8658. For information in the District of Columbia, you should contact the National Park Service at (202) 339-8309.

The U.S. Fish and Wildlife Service also works with other Federal agencies and states to minimize loss of wetlands, reduce impacts to fish and migratory birds, including bald eagles, and restore habitat for wildlife. Information on these conservation issues and how development projects can avoid affecting these resources can be found on our website (www.fws.gov/chesapeakebay)

We appreciate the opportunity to provide information relative to fish and wildlife issues, and thank you for your interest in these resources. If you have any questions or need further assistance, please contact Chesapeake Bay Field Office Threatened and Endangered Species program at (410) 573-4527.

Sincerely,

Genevieve LaRouche
Field Supervisor

Maryland Transportation Authority

Larry Hogan
Governor

Boyd K. Rutherford
Lt. Governor

Pete K. Rahn
Chairman

Kevin C. Reigrut
Executive Director

300 Authority Drive
Baltimore MD 21222-2200
410-537-7500
410-537-7803 (fax)
711 (MD Relay)
1-888-754-0098

e-mail: mdta@
mdta.maryland.gov

www.mdta.maryland.gov

February 8, 2018

Mr. Tony Redman
Maryland Department of Natural Resources
Environmental Review Program, ERP
Tawes State Office Building C-3
580 Taylor Avenue
Annapolis, Maryland 21401

RE: Maryland Transportation Authority (MDTA)
I-95 Express Toll Lanes Northbound Extension
Carsins Run Stream Restoration
MDTA Tracking # KH-3009
Aberdeen, Harford County, Maryland
Fisheries Information Request

Dear Mr. Redman:

The Maryland Transportation Authority is considering stream restoration along an approximately 500 linear foot segment of Carsins Run (upstream and downstream of I-95) and an intermittent tributary to Carsins Run that originates at a wetland, upstream of I-95 and northeast of Ripken Stadium. Stream restoration efforts would serve as compensatory mitigation for unavoidable impacts incurred during construction of the I-95 Express Toll Lanes Northbound Extension project. A map of the project location has been included for your reference.

We request any information concerning resident fish and anadromous fish or additional water quality considerations within the study area. Please include the MDTA tracking information listed in the subject line above in all future correspondence. If you have questions regarding this request or require additional information to complete your review, please contact me at wpines@mdta.state.md.us or (410) 931-0808.

Sincerely,

William N. Pines, P.E.
Director of Project Development

Enclosure

Cc:
JMT: Leyla Lange, Michael Rothenheber
KCI: Jennifer Bird
CDM Smith: David Greenwood

MDTA
Maryland Transportation Authority

300 Authority Drive
Baltimore MD 21222-2200
410-537-7500
410-537-7803 (fax)
711 (MD Relay)
1-888-754-0098

e-mail: mdta@
mdta.maryland.gov

www.mdta.maryland.gov

February 8, 2018

Ms. Lori Byrne, Environmental Review Division
Maryland Department of Natural Resources
Wildlife and Heritage Service
Tawes State Office Building E-1
580 Taylor Avenue
Annapolis, Maryland 21401

RE: Maryland Transportation Authority (MDTA)
I-95 Express Toll Lanes Northbound Extension
Carsins Run Stream Restoration
MDTA Tracking # KH-3009
Aberdeen, Harford County, Maryland
Threatened and Endangered Species and Unique Habitat Information Request

Dear Ms. Byrne:

The Maryland Transportation Authority is considering stream restoration along an approximately 500 linear foot segment of Carsins Run (upstream and downstream of I-95) and an intermittent tributary to Carsins Run that originates at a wetland, upstream of I-95 and northeast of Ripken Stadium. Stream restoration efforts would serve as compensatory mitigation for unavoidable impacts incurred during construction of the I-95 Express Toll Lanes Northbound Extension project. A map of the project location has been included for your reference.

We request any information concerning federally or state-listed rare, threatened or endangered species and unique habitat that may occur in the study area. Please include the MDTA tracking information listed in the subject line above in all future correspondence. If you have questions regarding this request or require additional information to complete your review, please contact me at wpines@mdta.state.md.us or (410) 931-0808.

Sincerely,

William N. Pines, P.E.
Director of Project Development

Enclosure

Cc:
JMT: Leyla Lange, Michael Rothenheber
KCI: Jennifer Bird
CDM Smith: David Greenwood

300 Authority Drive
Baltimore MD 21222-2200
410-537-7500
410-537-7803 (fax)
711 (MD Relay)
1-888-754-0098

e-mail: mdta@mdta.maryland.gov

www.mdta.maryland.gov

February 8, 2018

Ms. Elizabeth Hughes
State Historic Preservation Officer
Maryland Historic Trust
100 Community Place, 3rd floor
Crownsville, MD 21032-2023

Attention: Ms. Beth Cole

RE: Maryland Transportation Authority (MDTA)
I-95 Express Toll Lanes Northbound Extension
Carsins Run Stream Restoration
MDTA Tracking # KH-3009
Aberdeen, Harford County, Maryland
Historic Properties and Archeological Resources Information Request

Dear Ms. Hughes:

The Maryland Transportation Authority is considering stream restoration along an approximately 500 linear foot segment of Carsins Run (upstream and downstream of I-95) and an intermittent tributary to Carsins Run that originates at a wetland, upstream of I-95 and northeast of Ripken Stadium. Stream restoration efforts would serve as compensatory mitigation for unavoidable impacts incurred during construction of the I-95 Express Toll Lanes Northbound Extension project. A map of the project location has been included for your reference.

We request any information concerning historic or archeological resources within the vicinity of the study area. Please include the MDTA tracking information listed in the subject line above in all future correspondence. If you have questions regarding this request or require additional information to complete your review, please contact me at wpines@mdta.state.md.us or (410) 931-0808.

Sincerely,

William N. Pines, P.E.
Director of Project Development

Enclosure

Cc:
JMT: Leyla Lange, Michael Rothenheber
KCI: Jennifer Bird
CDM Smith: David Greenwood

APPENDIX F

Qualification of Preparer

September 6, 2011

Jennifer Bird
1717 Dogwood Dr.
Frederick, MD 21701

Dear Ms. Bird:

The Maryland Department of Natural Resources has reviewed your application for qualified professional status for the purpose of developing Forest Stand Delineations and Forest Conservation Plans. We are happy to inform you that you meet the requirements of COMAR 08.19.06.01 for qualified professional status.

Your name will be included on a list of qualified professionals to be sent to the jurisdictions with authority to review Forest Stand Delineations and Forest Conservation Plans.

Participation by professionals like you is key to successful implementation of the Forest Conservation Act. Thank you for submitting your application.

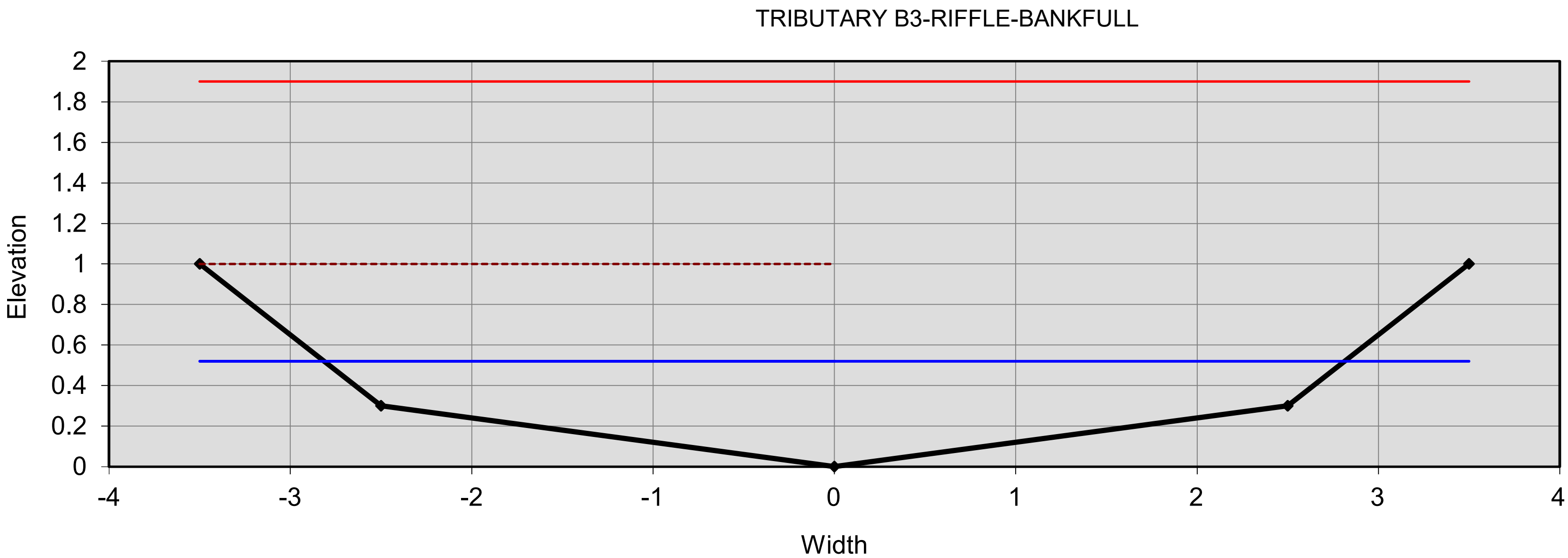
Sincerely,

Steven W. Koehn

Steven W. Koehn
Director/State Forester

APPENDIX F
PROPOSED SECTIONS

Cross Section



Bankfull Dimensions

1.9	x-section area (ft.sq.)
5.6	width (ft)
0.3	mean depth (ft)
0.5	max depth (ft)
5.8	wetted parimeter (ft)
0.3	hyd radi (ft)
16.5	width-depth ratio

Flood Dimensions

7.0	W flood prone area (ft)
1.2	entrenchment ratio
1.0	low bank height (ft)
1.9	low bank height ratio

Materials

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

Bankfull Flow

3.3	velocity (ft/s)
6.4	discharge rate (cfs)
1.02	Froude number

Flow Resistance

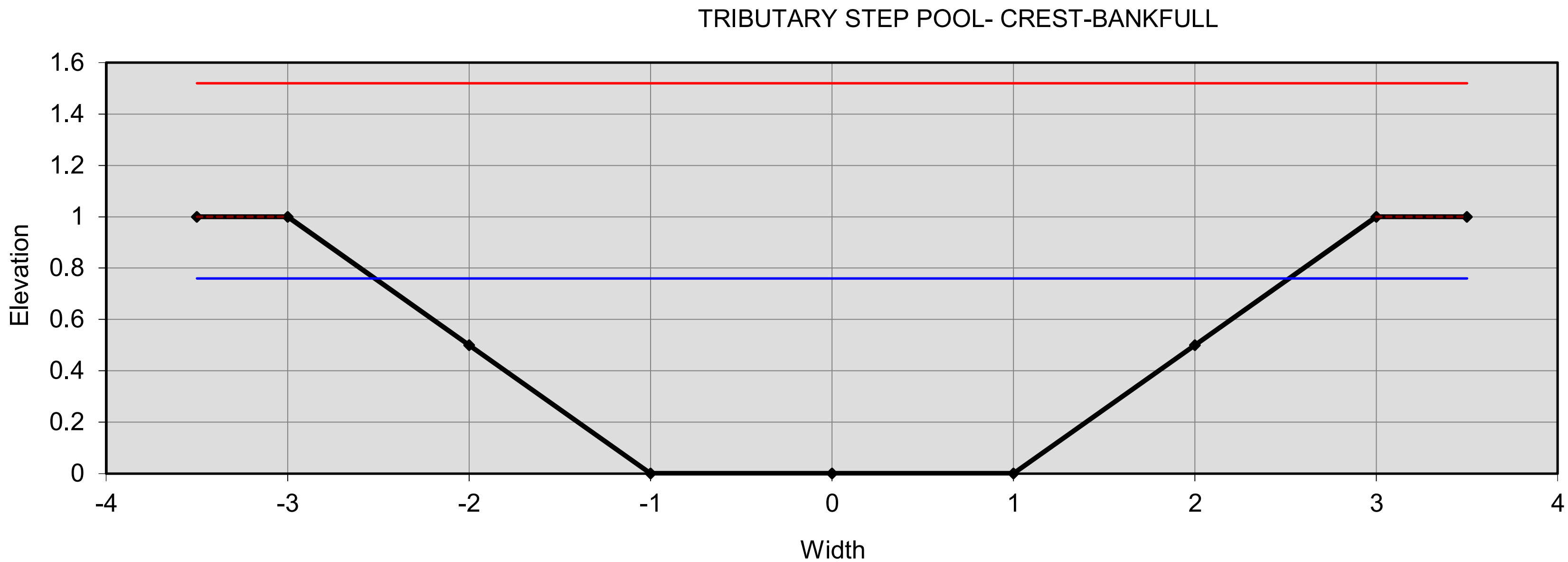
0.040	Manning's roughness
0.27	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power

3.5	channel slope (%)
0.72	shear stress (lb/sq.ft.)
0.61	shear velocity (ft/s)
2.5	unit strm power (lb/ft/s)

Contract documents allow for the top of bank to be lowered up to 0.5' to provide additional floodplain access at the direction of the Engineer.

Cross Section Crest



Bankfull Dimensions

2.7	x-section area (ft.sq.)
5.0	width (ft)
0.5	mean depth (ft)
0.8	max depth (ft)
5.4	wetted parimeter (ft)
0.5	hyd radi (ft)
9.5	width-depth ratio

Flood Dimensions

10.2	W flood prone area (ft)
2.0	entrenchment ratio
1.0	low bank height (ft)
1.3	low bank height ratio

Materials

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

Bankfull Flow

2.4	velocity (ft/s)
6.4	discharge rate (cfs)
0.60	Froude number

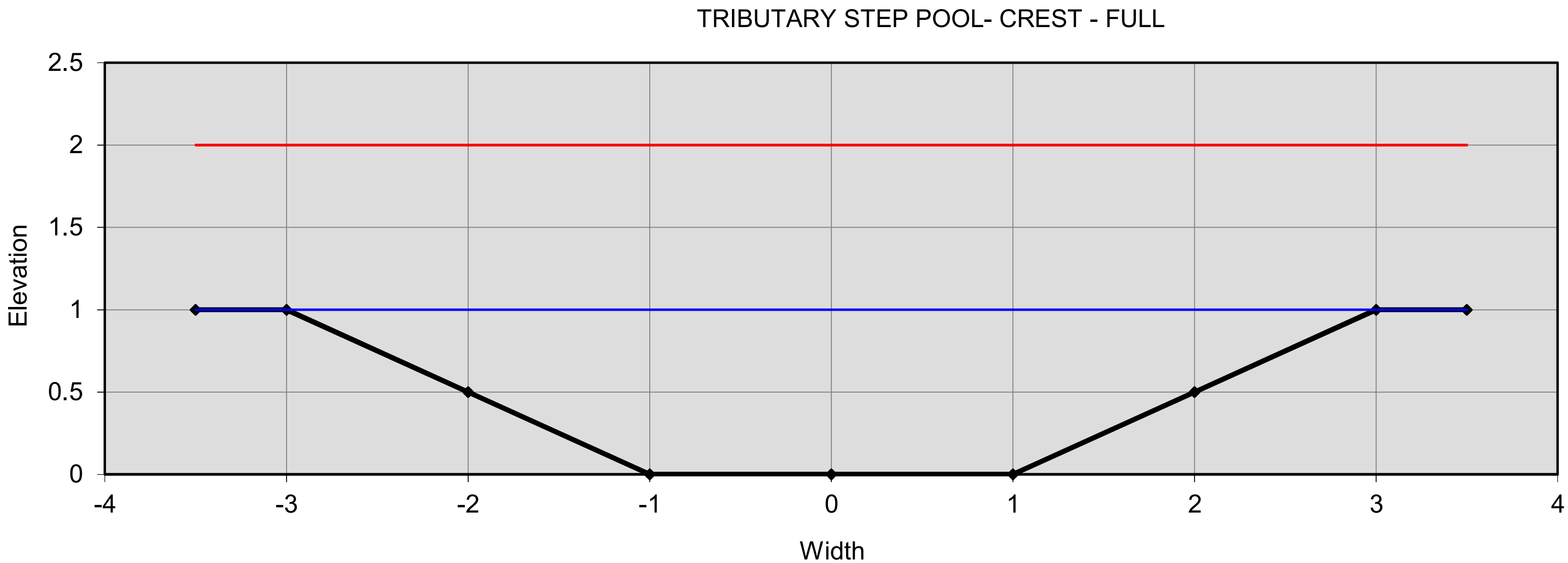
Flow Resistance

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

Forces & Power

6.5	channel slope (%)
2.01	shear stress (lb/sq.ft.)
1.02	shear velocity (ft/s)
5.1	unit strm power (lb/ft/s)

Cross Section Crest



Bankfull Dimensions	
4.0	x-section area (ft.sq.)
6.0	width (ft)
0.7	mean depth (ft)
1.0	max depth (ft)
6.5	wetted parimeter (ft)
0.6	hyd radi (ft)
9.0	width-depth ratio

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

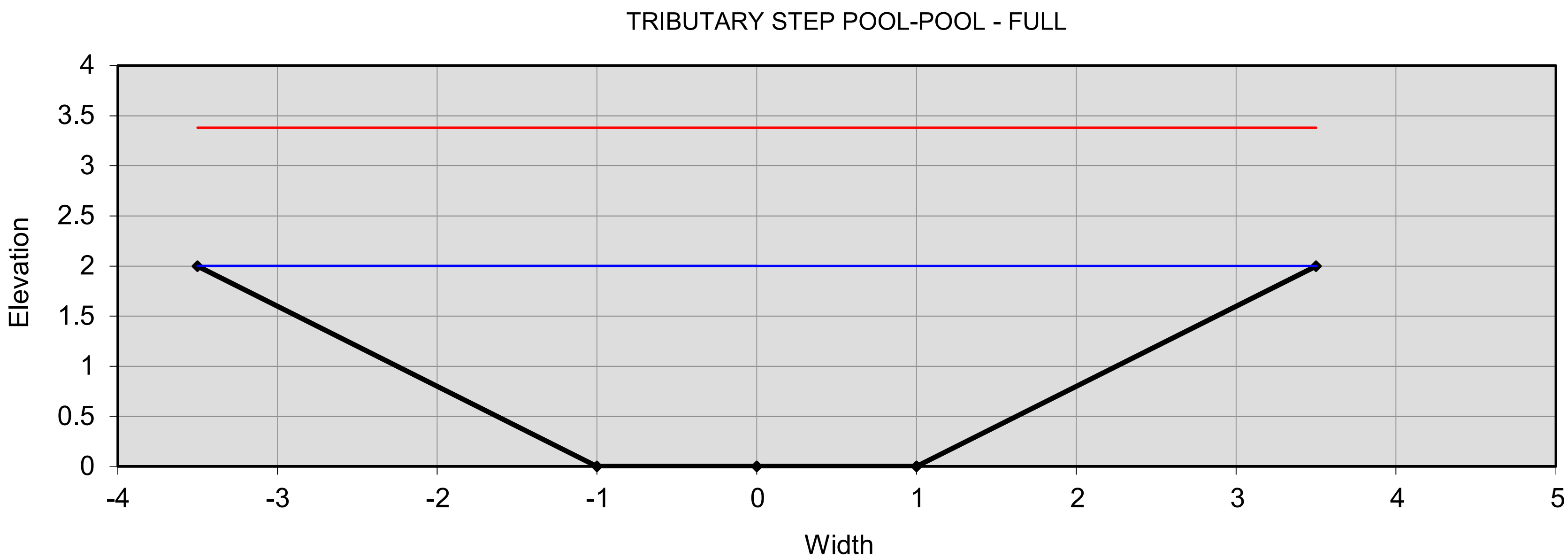
Materials	
---	D50 (mm)
---	D84 (mm)
123	threshold grain size (mm):

Bankfull Flow	
2.8	velocity (ft/s)
11.0	discharge rate (cfs)
0.62	Froude number

Flow Resistance	
0.100	Manning's roughness
1.36	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
6.5	channel slope (%)
2.51	shear stress (lb/sq.ft.)
1.14	shear velocity (ft/s)
7.5	unit strm power (lb/ft/s)

Cross Section



Bankfull Dimensions

9.0	x-section area (ft.sq.)
7.0	width (ft)
1.3	mean depth (ft)
2.0	max depth (ft)
8.4	wetted parimeter (ft)
1.1	hyd radi (ft)
5.4	width-depth ratio

Flood Dimensions

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

Materials

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

Bankfull Flow

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

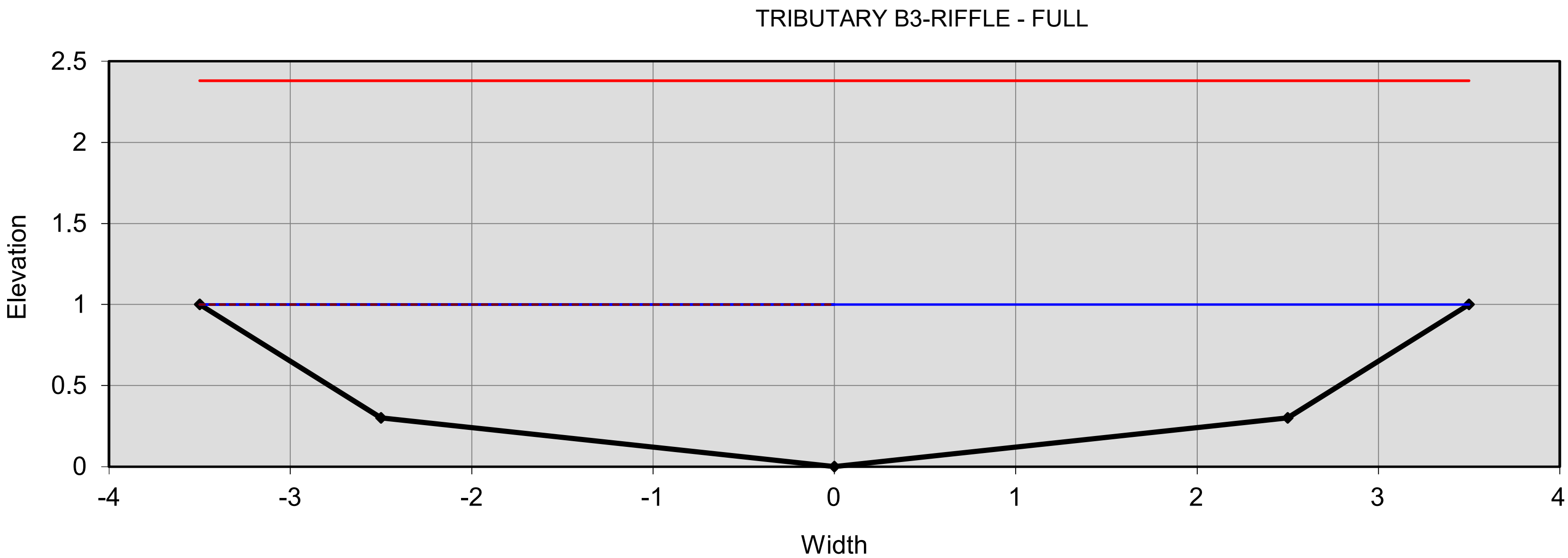
Flow Resistance

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

Forces & Power

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

Cross Section



Bankfull Dimensions

5.0	x-section area (ft.sq.)
7.0	width (ft)
0.7	mean depth (ft)
1.0	max depth (ft)
7.5	wetted parimeter (ft)
0.7	hyd radi (ft)
9.9	width-depth ratio

Flood Dimensions

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

Materials

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

Bankfull Flow

5.3	velocity (ft/s)
26.2	discharge rate (cfs)
1.15	Froude number

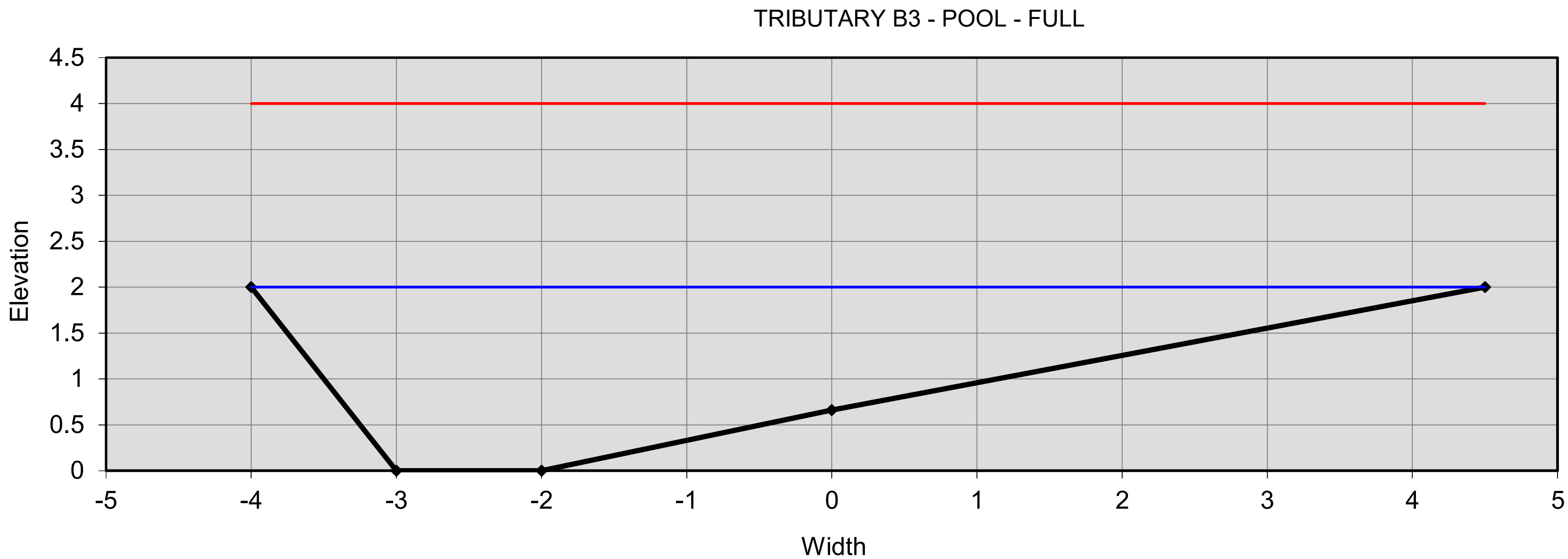
Flow Resistance

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

Forces & Power

3.5	channel slope (%)
1.45	shear stress (lb/sq.ft.)
0.86	shear velocity (ft/s)
8.2	unit strm power (lb/ft/s)

Cross Section



Bankfull Dimensions

9.4	x-section area (ft.sq.)
8.5	width (ft)
1.1	mean depth (ft)
2.00	max depth (ft)
10.0	wetted parimeter (ft)
0.9	hyd radi (ft)
7.7	width-depth ratio

Flood Dimensions

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

Materials

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

Bankfull Flow

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

Flow Resistance

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

Forces & Power

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

Contract documents allow for the top of bank to be lowered up to 0.5' to provide additional floodplain access at the direction of the Engineer.

Cross Section

Bankfull Dimensions

44.0	x-section area (ft.sq.)
32.0	width (ft)
1.4	mean depth (ft)
2.0	max depth (ft)
32.5	wetted parimeter (ft)
1.4	hyd radi (ft)
23.3	width-depth ratio

Flood Dimensions

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

Materials

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

Bankfull Flow

4.2	velocity (ft/s)
186.9	discharge rate (cfs)
0.64	Froude number

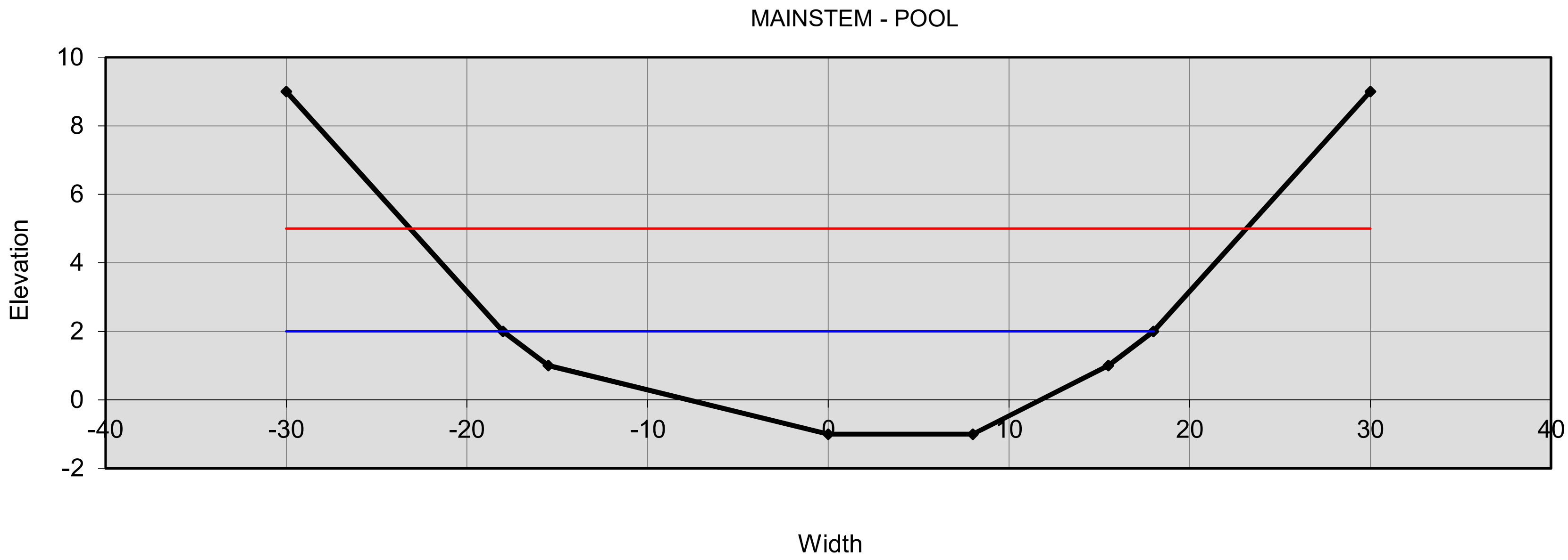
Flow Resistance

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

Forces & Power

0.87	channel slope (%)
0.73	shear stress (lb/sq.ft.)
0.62	shear velocity (ft/s)
3.2	unit strm power (lb/ft/s)

Cross Section



Bankfull Dimensions

72.5	x-section area (ft.sq.)
36.0	width (ft)
2.0	mean depth (ft)
3.0	max depth (ft)
36.8	wetted parimeter (ft)
2.0	hyd radi (ft)
17.9	width-depth ratio

Flood Dimensions

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

Materials

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

Bankfull Flow

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

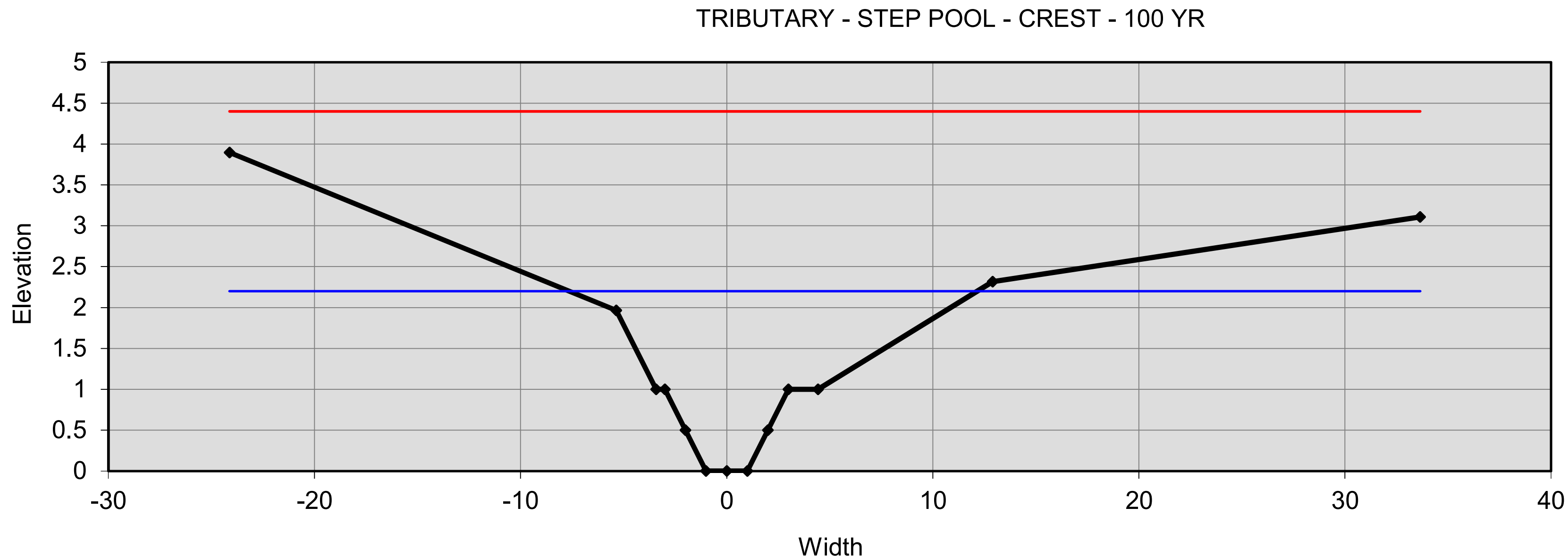
Flow Resistance

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

Forces & Power

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

Cross Section Crest



Bankfull Dimensions

19.7	x-section area (ft.sq.)
19.8	width (ft)
1.0	mean depth (ft)
2.2	max depth (ft)
20.6	wetted parimeter (ft)
1.0	hyd radi (ft)
19.9	width-depth ratio

Flood Dimensions

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

Materials

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

Bankfull Flow

3.7	velocity (ft/s)
72.7	discharge rate (cfs)
0.66	Froude number

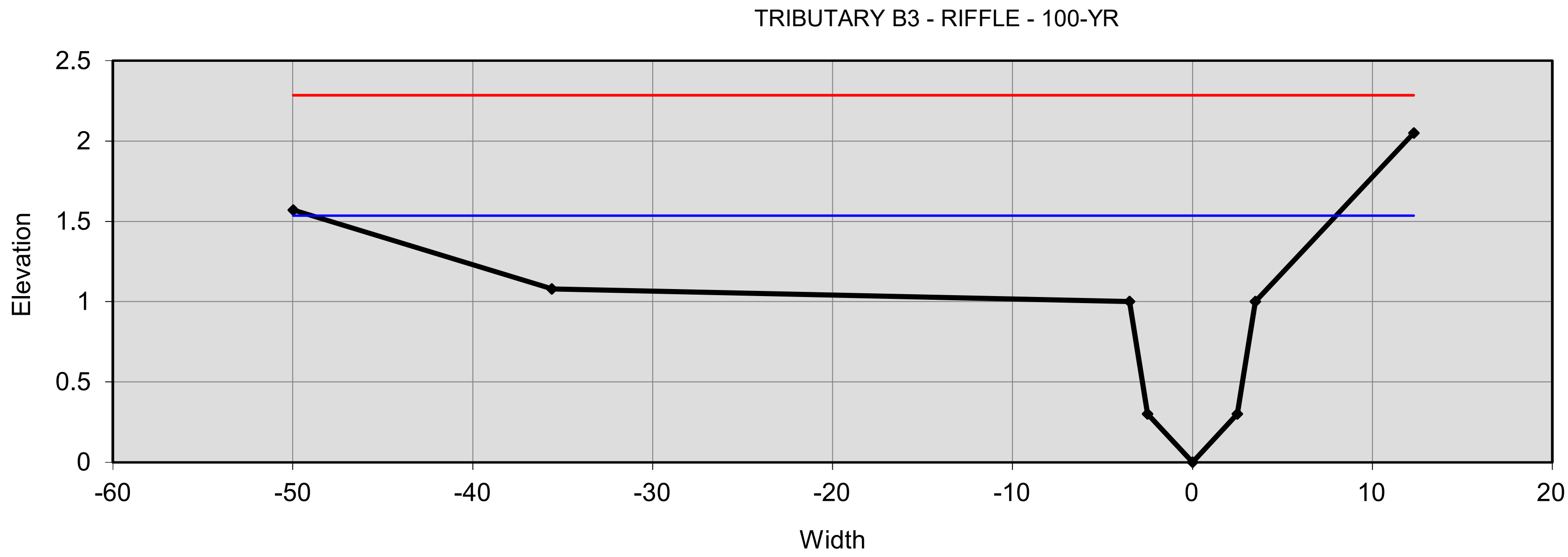
Flow Resistance

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

Forces & Power

6.5	channel slope (%)
3.88	shear stress (lb/sq.ft.)
1.42	shear velocity (ft/s)
14.9	unit strm power (lb/ft/s)

Cross Section



Bankfull Dimensions	
28.8	x-section area (ft.sq.)
56.9	width (ft)
0.5	mean depth (ft)
1.5	max depth (ft)
57.5	wetted parimeter (ft)
0.5	hyd radi (ft)
112.5	width-depth ratio

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

Materials	
---	D50 (mm)
---	D84 (mm)
54	threshold grain size (mm):

Bankfull Flow	
2.5	velocity (ft/s)
72.5	discharge rate (cfs)
0.63	Froude number

Flow Resistance	
0.070	Manning's roughness
0.72	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
3.5	channel slope (%)
1.10	shear stress (lb/sq.ft.)
0.75	shear velocity (ft/s)
2.8	unit strm power (lb/ft/s)

APPENDIX G
PROPOSED STONE SIZING COMPUTATIONS

Bed Boulder Material Sizing by Critical Shear Stress

Project Name: Carsin's Run Stream Mitigation
Project Number: 22145228.47
Designed: HS **Checked: SL**
River: Tributary to Carsin's Run

KCI TECHNOLOGIES

Maximum Channel Shear:

Sta.	Sub-Reach	Feature Type	HEC-RAS Station	Channel Shear	Storm Event
28+79***	Reach 4	Step Pool Crests	64.76	7.14	10yr Existing
28+79***	Reach 4	Step Pool Crests	64.76	10.40	100yr Existing
27+53	Reach 4	Step Pool Crests	193.16	6.86	10yr Existing
27+53	Reach 4	Step Pool Crests	193.16	13.60	100yr Existing
25+53	Reach 3	RGC Sill	393.08	1.91	10yr Existing
25+53	Reach 3	RGC Sill	393.08	3.56	100yr Existing
23+94	Reach 2b	Step Pool Crests	552.49	6.07	2yr Existing**
23+94	Reach 2b	Step Pool Crests	552.49	8.77	100yr Existing
22+33	No Restoration	N/A	713.14	3.81	10yr Existing
22+33	No Restoration	N/A	713.14	8.21	100yr Existing
22+27	Reach 2a/No Restoration	Tie in	719.16	2.08	10yr Existing
22+27	Reach 2a/No Restoration	Tie in	719.16	3.98	100yr Existing
20+50	Reach 1	RGC Sill	896.36	3.52	10yr Existing
20+50	Reach 1	RGC Sill	896.36	3.71	100yr Existing
10+90	Mainstem	Outfall Confluence	1180	3.11	10yr Existing
10+90	Mainstem	Outfall Confluence	1180	3.12	100yr Existing

Requires Input

(1) Enter identifying data of each design feature and max shear at each feature HEC-RAS station based on storm event

*- This section is the transistion between 2b and 3

**- Note that they 2 year shear is greater than the 10 year shear

*** Section is not included in revised HEC-RAS model, Appednix I.2. No design changes necessary.

Critical Shear Stress (t_c) Equation:

$$\tau_c = \tau_{ci}^*(\rho_s - \rho_w) g D$$

Therefore,

$$D = \frac{\tau_c}{\tau_{ci}^*(\rho_s - \rho_w) g}$$

Where,

ρ_s = 5.15 slugs/ft^3 (quartz sediment)
ρ_w = 1.94 slugs/ft^3
g = 32.2 ft/sec^2
D = threshold grain size (ft)
t^*_{ci} = dimensionless critical shear stress; 0.03 for Reaches 1 & 3 & Mainstem; and 0.05 for Reaches 2 & 4 that are steep. For steeper step-pool streams with little sediment supply, studies find that a critical shear stress of 0.17 to 0.67 better relates to measured bed material mobilized at bankfull (Bunte, 2010). The 0.05 critical shear stress predictions still predict mimum diameters that exceed observed particles that have remained stable within the reference step pool reach.

References: Shields 1936
Bunte, 2010, 2013

Minimum Stone Size:

Sta.	Sub-Reach	Feature Type	Dimensionless Critical Shear Stress	Threshold Grain Size (ft)	Equivalent Stone Weight (assume 160 lbs/ft³)	Safety Factor	Minimum Stone Weight (lbs)	Minimum Stone Size (ft)
28+79	Reach 4	Step Pool Crests	0.05	1.38	221	1.2	265	**1.5 ft**
28+79	Reach 4	Step Pool Crests	0.05	2.01	682	1.2	819	**2.1 ft**
27+53	Reach 4	Step Pool Crests	0.05	1.33	196	1.2	235	**1.4 ft**
27+53	Reach 4	Step Pool Crests	0.05	2.63	1526	1.2	1831	**2.8 ft**
25+53	Reach 3	RGC Sill	0.03	0.62	20	1.2	23	**0.7 ft**
25+53	Reach 3	RGC Sill	0.03	1.15	127	1.2	152	**1.2 ft**
23+94	Reach 2b	Step Pool Crests	0.05	1.17	136	1.2	163	**1.2 ft**
23+94	Reach 2b	Step Pool Crests	0.05	1.70	409	1.2	491	**1.8 ft**
22+33	No Restoration	N/A	0.05	0.74	34	1.2	40	**0.8 ft**
22+33	No Restoration	N/A	0.05	1.59	336	1.2	403	**1.7 ft**
22+27	Reach 2a/No Restoration	Tie in	0.05	0.40	5	1.2	7	**0.4 ft**
22+27	Reach 2a/No Restoration	Tie in	0.05	0.77	38	1.2	46	**0.8 ft**
20+50	Reach 1	RGC Sill	0.03	1.14	122	1.2	147	**1.2 ft**
20+50	Reach 1	RGC Sill	0.03	1.20	143	1.2	172	**1.3 ft**
9+22	Mainstem	RGCM	0.03	1.00	84	1.2	101	**1.1 ft**
9+22	Mainstem	RGCM	0.03	1.01	85	1.2	102	**1.1 ft**

Bank Material Sizing by Velocity

Project Name: Carsin's Run
Project Number: 22145228.47
Designed: HS **Checked:** SL
River: Tributary to Carsin's Run

Maximum Channel Velocity:

Sta.	Reach	Feature Type	HEC-RAS Station	Channel Velocity (ft/s)	Storm Event
28+78	Reach 4	Pool Pavement	64.76	4.89	10 yr existing
28+78	Reach 4	Pool Pavement	64.76	6.46	100 yr existing
25+53	Reach 3	Toe Boulder	393.08	6.03	10 yr existing
25+53	Reach 3	Toe Boulder	393.08	8.89	100 yr existing
23+94	Reach 2b	Pool Pavement	552.49	4.44	10 yr existing
23+94	Reach 2b	Pool Pavement	552.49	5.84	100 yr existing
22+33	Reach 2a/No Restoration	Pool Pavement	713.14	3.69	10 yr existing
22+33	Reach 2a/No Restoration	Pool Pavement	713.14	5.74	100 yr existing
20+50	Reach 1	Toe Boulder	896.36	7.93	10 yr existing
20+50	Reach 1	Toe Boulder	896.36	9.08	100 yr existing
13+41	Mainstem	RGCM	922	7.77	1 yr existing
13+41	Mainstem	RGCM	922	9.37	2 yr existing

Requires Input

(1) Enter identifying data of each design feature and max velocity at each feature HEC-RAS station based on storm event

Note: HEC-RAS Section 64.76 is not included in revised HEC-RAS model, Appednix I.2. No design changes necessary.

Isbash Equation:

$$v = c * \sqrt{2g * \frac{\rho_s - \rho_w}{\rho_w}} * D^{1/2}$$

Therefore,

$$D = \left(\frac{v}{c * \sqrt{2g * \frac{\rho_s - \rho_w}{\rho_w}}} \right)^2$$

Where,

D = threshold grain size (ft), spherical diameter of stone
v = Velocity (ft/s)
c = Isbash constant (0.86 for high turbulence level flow)
g = Acceleration of gravity, 32.2 ft/s^2
ρ_s = Specific stone weight, 160 lbs/ft^3
ρ_w = Specific weight of water, 62.4 lbs/ft^3

References: Isbash 1936, USACE 1970, USACE 1991, USDA 2007 TS14C
https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17812.wba

Minimum Stone Size:

Sta.	Channel Location	Feature Type	Threshold Grain Size (ft)	Equivalent Stone Weight (assume 160	Safety Factor	Minimum Stone Weight (lbs)	Minimum Stone Size (ft)
28+78	Reach 4	Pool Pavement	0.32	3	1.2	3	**0.34 ft**
28+78	Reach 4	Pool Pavement	0.56	15	1.2	18	**0.60 ft**
25+53	Reach 3	Toe Boulder	0.49	10	1.2	12	**0.52 ft**
25+53	Reach 3	Toe Boulder	1.06	100	1.2	120	**1.13 ft**
23+94	Reach 2b	Pool Pavement	0.26	2	1.2	2	**0.28 ft**
23+94	Reach 2b	Pool Pavement	0.46	8	1.2	10	**0.49 ft**
22+33	Reach 2a/No Restoration	Pool Pavement	0.18	1	1.2	1	**0.19 ft**
22+33	Reach 2a/No Restoration	Pool Pavement	0.44	7	1.2	9	**0.47 ft**
20+50	Reach 1	Toe Boulder	0.84	50	1.2	60	**0.90 ft**
20+50	Reach 1	Toe Boulder	1.11	113	1.2	136	**1.18 ft**
13+41	Mainstem	RGCM	0.81	45	1.2	53	**0.86 ft**
13+41	Mainstem	RGCM	1.18	137	1.2	164	**1.25 ft**

Bed Material Mix Based on Colorado Curve

Project Name: **Carsins Run**
Project Number: **22145228.47**
Designed: **Checked: SL**
River: Carsins Run & Tributary to Carsins Run

KCI TECHNOLOGIES

Where:

Rosgen Colorado Curve data (tau in lbs/ft2)
dmax (mm) = 152.02tau^(0.7355)

	RGC		RGC	
Channel	**Mainstem**		**Trib**	Requires Input
tau (lb/ft^2)	4.58		3.71	(1) Enter max shear at channel location
dmax (mm)	465.6		398.7	(2) dmax (mm) computed by Rosgen Curve
dmax (in)	18.3		15.7	(3) dmax (mm) converted to dmax (in)

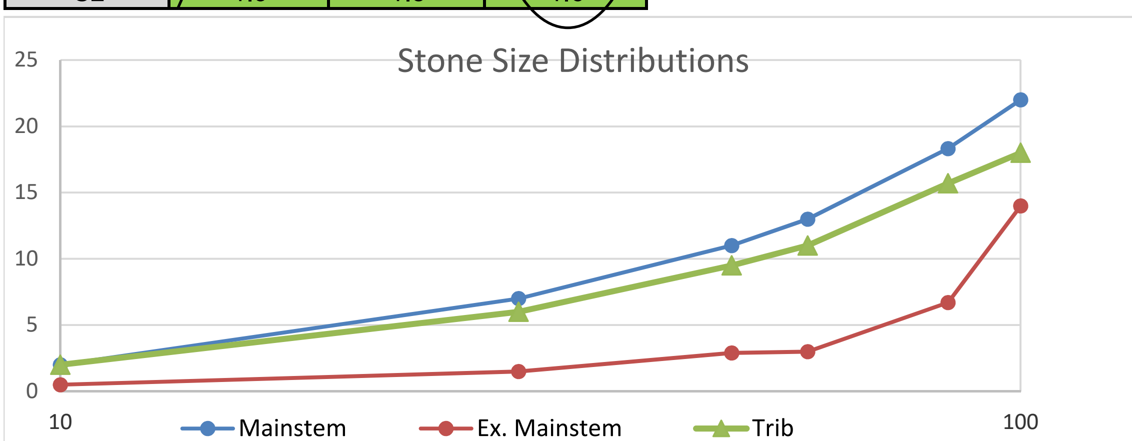
Mix Gradations:

Where:

Coefficient of Curvature: $Cz = d30^2 / (d60*d10)$ (Craig 1993)
The Cz of a well mixed bed ranges between 1 and 3

% less than	Mainstem	Ex. Mainstem	Trib	
10	2.0	0.5	2.0	
30	7.0	1.5	6.0	
50	11.0	2.9	9.5	
60	13.0	3.0	11.0	
84	18.3	6.7	15.7	(4) dmax (in) set to equal D84
100	22.0	14.0	18.0	(5) manually
Cz	1.9	1.5	1.6	

The specified RGC Mix will be sufficient to withstand predicted shear stress in the Trib, and is larger than the existing Mainstem riffle material, which appears stable.



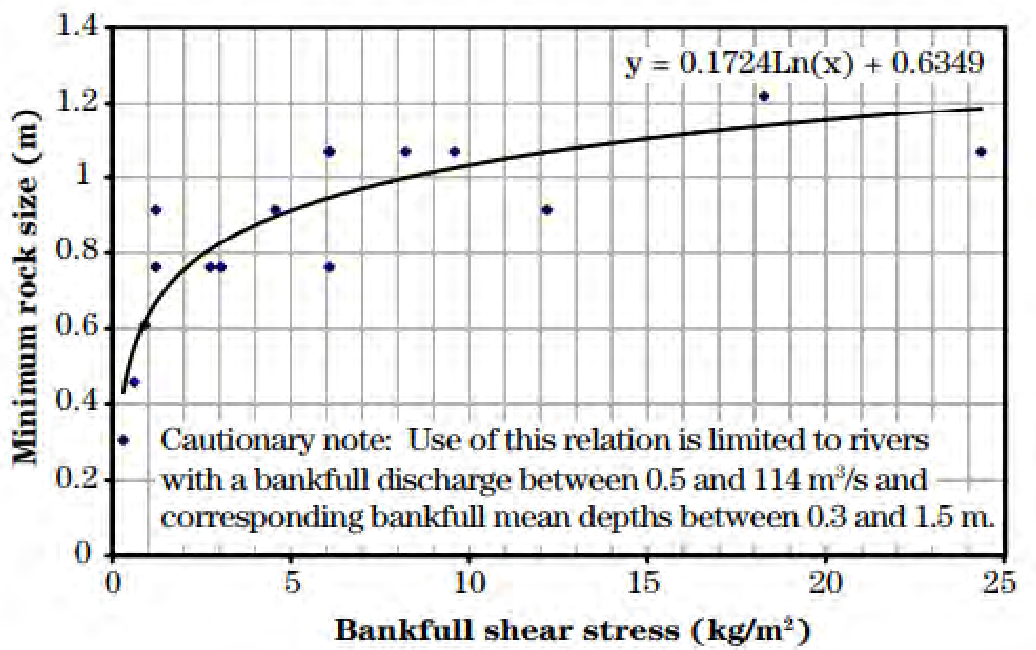
W-Weir Stone Sizing by Shear Stress

Project Name: **CARSINS**
Project Number: **22145228.470**
Designed: HS **Checked: SL**
River: Tributary to Carsin's Run

Where:

Based on Part 654 Chapter 11 Figure 11-43 Rock Size
https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17771.wba

Figure 11–43 Rock size



Sub-Reach	Feature Type	Maximum Channel 2-year Shear (lb/sf)	Maximum Channel Shear (kg/sm)	Minimum Rock Size (m)	Minimum Rock Size (ft):
MAINSTEM	WWEIR	4.58	22.36	1.17	**3.54**

APPENDIX H
PROPOSED SCOUR COMPUTATIONS

Footer Scour Analysis by Maximum Velocity

Project Name: Carsin's Run

Project Number: 22145228.47

Designed: HS **Checked: SL**

River: **Tributary to Carsin's Run/Carsin's Run**

KCI TECHNOLOGIES

Summary of Estimated Scour Depths

Location	Baseline Station	HECRAS Station	Riprap Class	Applicable Stationing	Storm Event	Velocity (ft/s)	Blench/ Lacey Scour (Largest Value) (ft)	Bend Scour Meynard (ft)	Proposed Footer Depth (ft)
Tributary Reach 1	20+50	896.36	I Boulders	Reach 1	100	6.6	0.71	0.37	Riffle Sill: 3.0 Toe Boulder: 1.3
Tributary Reach 2b	23+94	552.49	II/III Boulders	Reach 2a, 2b, 4	100	5.84	0.88	NA	Step Pool Crest: 3.0
Tributary Reach end 2b	24+28	518.16	II/III Boulders	Reach 2a, 2b, 4	100	8.29	1.48	0.61	Step Pool Crest: 3.0
Tributary Reach 3	25+53	393.08	I Boulders	Reach 3	100	8.89	0.71	0.45	Riffle Sill: 3.0 Toe Boulder: 1.3
Mainstem	13+41	922	Imbricated III	14+02 to 14+33	1-yr	7.77	1.41	NA	W-Weir: 3.0
Mainstem	13+41	922	Imbricated III	14+02 to 14+33	10-yr	5.27	2.46	NA	

Input Assumptions for PBSJ spreadhseet:

1. D50/D90 are existing bed material
2. Bend radius conservatively estimated as 3 times the width of the channel
3. Manning's 'n' is the designed 'n' value for the given reach
4. Minor adjustment to HEC-RAS subsequent to scour analysis.

Tributary Reach 1, HEC-RAS Section 896.36, 100-YR

GENERAL SCOUR

Zeller General Scour	Value	Description
Reference: Simons Li & Associates, 1985		
y_{max}	1.39	feet. Maximum depth of flow
V_m	9.08	ft/s. Average velocity of flow
Y_h	0.35	feet. Hydraulic or mean depth of flow
S_e	0.058	Energy slope (or bed slope or uniform slope)
$y_{gs,\ calculated}$	0.598467214	feet. $=y_{max}$ [(0.0685 $V_m^{0.8}$) / ($y_h^{0.4}$ $S_e^{0.3}$) -1]. Zeller equation general scour depth.
$y_{gs,}$ (minimum 0)	**0.598467214**	feet. Zeller General Scour (greater of 0 or Zeller equation).

Neill Incised	**Value**	**Description**
Reference: Neill, 1973		
y_i	0.49	feet. average depth at bankfull discharge in incised reach
q_f	2.218844985	(ft3/s/ft). Design flood discharge per unit width
$Q_{bankfull}$	6.4	cfs. Bankfull or channel forming discharge
$W_{bankfull}$	5.5	feet. Bankfull width.
q_i	1.163636364	(ft^3/s/ft). Bankfull discharge in incised reach per unit width
m	0.85	exponent varying from 0.67 for sand to 0.85 for coarse gravel
y_f	0.848123908	feet. Scoured depth (general scour) below design floodwater level
Z	0.7	Neill Incised Z
		$=Z * y_f$
y_s	**0.593686736**	Neill general scour below streambed.

Blench Zero Bed Factor	Value	Description
Reference: Pemberton & Lara, 1984		
q_f	2.218844985	cfs/ft. Design discharge per unit width.
D_{50}	25	mm.
F_{b0}	4.11116356	ft^2/s. Blench's "zero bed factor," (interpolated)
		feet. Water depth for zero bed sediment transport
y_{f0}	1.061931222	$= q_f^{2/3} / F_{b0}^{1/3}$
Degree of bend	severe	
Z	0.6	Blench Z
		feet. $=Z * y_{f0}$
y_s	**0.637158733**	Blench general scour below streambed.

Lacey	Value	Description
Reference: ASCE, Predicting Bed Scour, 2005		
Q	73	design discharge, (ft^3/s)
d_m	25	mean grain size of bed material (mm)
f	8.8	Lacey's silt factor = 1.76 $(D_m)^{1/2}$
Use Laceys regime equation for mean depth?	yes	
Mean depth using Lacey's regime eq.	0.951432365	feet.
Mean depth from inputs	0.35	feet.
y_m	0.951432365	feet. Mean water depth for Lacey scour equation.
Z	0.75	Lacey Z
y_s	**0.713574273**	feet. $=Z * y_m$. Scour depth below streambed

Neill Competent Velocity	**Value**	Description
Reference: Pemberton & Lara, 1984		
D_{50}	25	mm
y_m	0.35	mean depth, (ft)
V_c	#N/A	ft/sec. Competent mean velocity (interpolated)
V_m	9.08	mean velocity, (ft/s)
		$=y_m (V_m / V_c - 1)$
y_s	**#N/A**	scour depth below streambed, (ft)

USBR Envelope Curve	Value	Description
Reference: Pemberton & Lara, 1984		
q	2.218844985	Unit discharge, cfs per foot width
ds	**2.966446739**	Scour depth, feet below streambed, from curve.
Within valid slope range	FALSE	
Within valid D_{50} range	FALSE	

USBR Mean Velocity Method	Value	Description
Reference: Pemberton & Lara, 1984		
Z	0.75	Lacey Z from Lacey's method
d_m	0.35	feet. Mean depth
d_s	**0.2625**	feet. Scour depth below streambed. $d_s = Z\ d_m$

Tributary Reach 1, HEC-RAS Section 896.36, 100-YR

BEND SCOUR

Zeller Bend Scour	Value	
Reference: Simons Li & Associates, 1985 (page 5.105-5.106)		
y_{max}	1.54	feet. Maximum Depth of upstream flow
V	6.6	fps. Mean velocity of upstream flow
y_h	0.38	feet. Hydraulic Depth of upstream flow
S_e	0.031	Upstream energy slope
W	90.5	feet. Channel topwidth of upstream flow
r_c	18	feet. Radius of curvature to centerline of channel
$\sin^2(\alpha/2)/\cos(\alpha)$	1.256944	Used in Zeller Bend Scour Equation
$y_{bs,}$ prelimiinary	2.388262	feet. Zeller Bend Scour, initial calculation
$\mathbf{y_{bs}}$	**2.388262**	feet. Zeller Bend Scour, final (disallowing negative values)
Manning n-value	0.04	to calculate Chezy coefficient
Hydraulic Radius	0.35	feet.
Chezy coefficient	31.18675	
b	32.9	feet. Design discharge top width in the bend.
Superelevation	6.807896	feet. $= V_z^2\, b\ / (g\, r_c)$ (Equation 16-11, Chow) (based on top width, velocity, and radius of curvature, where b=W=topwidth)
Maximum depth of flow	1.39	feet.
y	8.197896	feet. Max depth of flow including superelevation on outside of bend
X	***103.6752***	feet. $= 2.3\ (C\ g^{1/2})\ y$. Distance downstream of end of curvature to where downstream currents have dissipated

Maynord Bend Scour	Value	Note: Not recommended where overbank depth exceeds 20% channel depth
Reference: Maynord, 1996 via ASCE, 2005		Comment
y_u	0.38	feet. Average water depth in crossing upstream of bend.
r_c	18	feet. Centerline radius of bend.
W_u	11.7	feet. Water surface width at upstream end of bend (active or bankfull width)
nominal r_c / W_u	1.538462	Equation limited to $r_c / W_u < 10$, ratio in equation set to 1.5 if less
r_c / W_u for equation	1.538462	dimensionless.
r_c / W_u within range	TRUE	
nominal W_u / y_u	30.78947	Equation limited to $W_u / y_u < 125$, ratio in equation set to 20 if less
nominal W_u / y_u for equation	30.78947	dimensionless.
W_u / y_u within range	TRUE	
y_{mxb}	0.752465	feet. $= y_u * (1.8 - 0.051\ (r_c / W_u) + 0.0084\ (W_u / y_u))$. Maximum water depth in bend.
$\mathbf{y_{bs}}$	**0.372465**	feet. $= y_{mxb} - y_u$ = Below thalweg.

Thorne Bend Scour	Value	
Reference: Thorne et. al, 1995 via ASCE, 2005		
y_u	0.38	feet. Average water depth in crossing upstream of bend.
r_c	18	feet. Centerline radius of bend.
W_u	90.5	feet. Water surface width at upstream end of bend.
y_{max} / y_u	#NUM!	$=2.07-0.19*\log_{10}(r_c / W_u-2)$. Thorne bend scour equation
y_{max}	#NUM!	$= (y_{max} / y_{u)})\ * y_{u.}$ Thorne bend scour below water surface.
r_c / W_u	0.198895	dimensionless.
r_c / W_u within range	FALSE	Equation limited to $r_c / W_u > 2$
y_{bs} (below thalweg)	**#NUM!**	feet. $= y_{max} - y_u$. Scour below thalweg

Bend Scour Design Curves, Corps of Engineers	Value	
Reference: Corps of Engrs. EM 1110-2-1601 Plate B41		
r_b	18	feet. Centerline radius of bend
W	32.9	feet. Water surface width
r_b / W	0.547112	x-axis of design curve
Mean depth in the approach section	0.38	feet.
Maximum depth in the bend	1.39	feet
Max depth bend / mean depth approach (Sand Bed Channels)	3.765504	y-axis of design curve, sand-bed channels
Max depth bend / mean depth approach (Gravel Bed Channels)	3.801157	y-axis of design curve, gravel-bed channels
Bend Scour Depth, sand-bed channels	**0.040892**	feet. Below minimum channel elevation (no bend scour if negative).
Bend Scour Depth, gravel-bed channels	**0.05444**	feet. Below minimum channel elevation (no bend scour if negative).

Tributary Reach 2/3, HEC-RAS Section 518.16, 100-YR

GENERAL SCOUR

Zeller General Scour	Value	Description
Reference: Simons Li & Associates, 1985		
y_{max}	1.54	feet. Maximum depth of flow
V_m	8.29	ft/s. Average velocity of flow
Y_h	1	feet. Hydraulic or mean depth of flow
S_e	0.04	Energy slope (or bed slope or uniform slope)
$y_{gs,\ calculated}$	-0.035345046	feet. $=y_{max}\ [(0.0685\ V_m^{0.8}) / (y_h^{0.4}\ S_e^{0.3}) - 1]$. Zeller equation general scour depth.
$y_{gs,}$ (minimum 0)	**0**	feet. Zeller General Scour (greater of 0 or Zeller equation).

Neill Incised	**Value**	**Description**
Reference: Neill, 1973		
y_i	0.51	feet. average depth at bankfull discharge in incised reach
q_f	7.832618026	(ft3/s/ft). Design flood discharge per unit width
$Q_{bankfull}$	6.4	cfs. Bankfull or channel forming discharge
$W_{bankfull}$	5.59	feet. Bankfull width.
q_i	1.14490161	(ft^3/s/ft). Bankfull discharge in incised reach per unit width
m	0.85	exponent varying from 0.67 for sand to 0.85 for coarse gravel
y_f	2.614797978	feet. Scoured depth (general scour) <u>below design floodwater level</u>
Z	0.7	Neill Incised Z
		$=Z * y_f$
y_s	**1.830358585**	Neill general scour below streambed.

Blench Zero Bed Factor	Value	Description
Reference: Pemberton & Lara, 1984		
q_f	7.832618026	cfs/ft. Design discharge per unit width.
D_{50}	25	mm.
F_{b0}	4.11116356	$ft^{2/}s$. Blench's "zero bed factor," (interpolated)
		feet. Water depth for zero bed sediment transport
y_{f0}	2.461971645	$= q_f^{2/3} / F_{b0}^{1/3}$
Degree of bend	severe	
Z	0.6	Blench Z
		feet. $=Z * y_{f0}$
y_s	**1.477182987**	Blench general scour below streambed.

Lacey	Value	Description
Reference: ASCE, Predicting Bed Scour, 2005		
Q	73	design discharge, (ft^3/s)
d_m	25	mean grain size of bed material (mm)
f	8.8	Lacey's silt factor = $1.76\ (D_m)^{1/2}$
Use Laceys regime equation for mean depth?	yes	
Mean depth using Lacey's regime eq.	0.951432365	feet.
Mean depth from inputs	1	feet.
y_m	0.951432365	feet. Mean water depth for Lacey scour equation.
Z	0.75	Lacey Z
y_s	**0.713574273**	feet. $=Z * y_m$. Scour depth below streambed

Neill Competent Velocity	**Value**	Description
Reference: Pemberton & Lara, 1984		
D_{50}	25	mm
y_m	1	mean depth, (ft)
V_c	#N/A	ft/sec. Competent mean velocity (interpolated)
V_m	8.29	mean velocity, (ft/s)
		$=y_m\ (V_m / V_c - 1)$
y_s	**#N/A**	scour depth below streambed, (ft)

USBR Envelope Curve	Value	Description
Reference: Pemberton & Lara, 1984		
q	7.832618026	Unit discharge, cfs per foot width
ds	**4.015168281**	Scour depth, feet below streambed, from curve.
Within valid slope range	FALSE	
Within valid D_{50} range	FALSE	

USBR Mean Velocity Method	Value	Description
Reference: Pemberton & Lara, 1984		
Z	0.75	Lacey Z from Lacey's method
d_m	1	feet. Mean depth
d_s	**0.75**	feet. Scour depth below streambed. $d_s = Z\ d_m$

Tributary Reach 2/3, HEC-RAS Section 518.16, 100-YR

BEND SCOUR

Zeller Bend Scour	Value	
Reference: Simons Li & Associates, 1985 (page 5.105-5.106)		
y_{max}	1.76	feet. Maximum Depth of upstream flow
V	5.84	fps. Mean velocity of upstream flow
y_h	0.81	feet. Hydraulic Depth of upstream flow
S_e	0.106	Upstream energy slope
W	19.64	feet. Channel topwidth of upstream flow
r_c	18	feet. Radius of curvature to centerline of channel
$\sin^2(\alpha/2)/\cos(\alpha)$	0.272778	Used in Zeller Bend Scour Equation
$y_{bs,}$ prelimiinary	0.653716	feet. Zeller Bend Scour, initial calculation
$\mathbf{y_{bs}}$	**0.653716**	feet. Zeller Bend Scour, final (disallowing negative values)
Manning n-value	0.04	to calculate Chezy coefficient
Hydraulic Radius	0.93	feet.
Chezy coefficient	36.70337	
b	9.32	feet. Design discharge top width in the bend.
Superelevation	1.156761	feet. $= V_z^2\ b\ /\ (g\ r_c)$ (Equation 16-11, Chow) (based on top width, velocity, and radius of curvature, where b=W=topwidth)
Maximum depth of flow	1.54	feet.
y	2.696761	feet. Max depth of flow including superelevation on outside of bend
X	***40.13754***	feet. $= 2.3\ (C\ g^{1/2})\ y$. Distance downstream of end of curvature to where downstream currents have dissipated

Maynord Bend Scour	Value	Note: Not recommended where overbank depth exceeds 20% channel depth
Reference: Maynord, 1996 via ASCE, 2005		Comment
y_u	0.81	feet. Average water depth in crossing upstream of bend.
r_c	18	feet. Centerline radius of bend.
W_u	4.24	feet. Water surface width at upstream end of bend (active or bankfull width)
nominal r_c / W_u	4.245283	Equation limited to $r_c / W_u < 10$, ratio in equation set to 1.5 if less
r_c / W_u for equation	4.245283	dimensionless.
r_c / W_u within range	TRUE	
nominal W_u / y_u	5.234568	Equation limited to $W_u / y_u < 125$, ratio in equation set to 20 if less
nominal W_u / y_u for equation	20	dimensionless.
W_u / y_u within range	TRUE	
y_{mxb}	1.418707	feet. $= y_u * (1.8 - 0.051\ (r_c / W_u) + 0.0084\ (W_u / y_u))$. Maximum water depth in bend.
$\mathbf{y_{bs}}$	**0.608707**	feet. $= y_{mxb} - y_u$ = Below thalweg.

Thorne Bend Scour	Value	
Reference: Thorne et. al, 1995 via ASCE, 2005		
y_u	0.81	feet. Average water depth in crossing upstream of bend.
r_c	18	feet. Centerline radius of bend.
W_u	19.64	feet. Water surface width at upstream end of bend.
y_{max} / y_u	#NUM!	$=2.07-0.19*\log_{10}(r_c / W_u-2)$. Thorne bend scour equation
y_{max}	#NUM!	$= (y_{max} / y_{u)}\ * y_{u.}$ Thorne bend scour below water surface.
r_c / W_u	0.916497	dimensionless.
r_c / W_u within range	FALSE	Equation limited to $r_c / W_u > 2$
y_{bs} (below thalweg)	**#NUM!**	feet. $= y_{max} - y_u$. Scour below thalweg

Bend Scour Design Curves, Corps of Engineers	Value	
Reference: Corps of Engrs. EM 1110-2-1601 Plate B41		
r_b	18	feet. Centerline radius of bend
W	9.32	feet. Water surface width
r_b / W	1.93133	x-axis of design curve
Mean depth in the approach section	0.81	feet.
Maximum depth in the bend	1.54	feet
Max depth bend / mean depth approach (Sand Bed Channels)	2.938357	y-axis of design curve, sand-bed channels
Max depth bend / mean depth approach (Gravel Bed Channels)	2.909903	y-axis of design curve, gravel-bed channels
Bend Scour Depth, sand-bed channels	**0.840069**	feet. Below minimum channel elevation (no bend scour if negative).
Bend Scour Depth, gravel-bed channels	**0.817021**	feet. Below minimum channel elevation (no bend scour if negative).

Tributary Reach 2, HEC-RAS Section 552.49, 100-YR

GENERAL SCOUR

Zeller General Scour	Value	Description
Reference: Simons Li & Associates, 1985		
y_{max}	1.76	feet. Maximum depth of flow
V_m	5.84	ft/s. Average velocity of flow
Y_h	0.81	feet. Hydraulic or mean depth of flow
S_e	0.106	Energy slope (or bed slope or uniform slope)
$y_{gs,\ calculated}$	-0.704768493	feet. $=y_{max}\ [(0.0685\ V_m^{0.8}) / (y_h^{0.4}\ S_e^{0.3}) - 1]$. Zeller equation general scour depth.
$y_{gs,}$ (minimum 0)	**0**	feet. Zeller General Scour (greater of 0 or Zeller equation).

Neill Incised	**Value**	**Description**
Reference: Neill, 1973		
y_i	0.56	feet. average depth at bankfull discharge in incised reach
q_f	3.716904277	(ft3/s/ft). Design flood discharge per unit width
$Q_{bankfull}$	6.4	cfs. Bankfull or channel forming discharge
$W_{bankfull}$	4.24	feet. Bankfull width.
q_i	1.509433962	($ft^3/s/ft$). Bankfull discharge in incised reach per unit width
m	0.85	exponent varying from 0.67 for sand to 0.85 for coarse gravel
y_f	1.204620355	feet. Scoured depth (general scour) below design floodwater level
Z	0.5	Neill Incised Z
		$=Z * y_f$
y_s	**0.602310178**	Neill general scour below streambed.

Blench Zero Bed Factor	Value	Description
Reference: Pemberton & Lara, 1984		
q_f	3.716904277	cfs/ft. Design discharge per unit width.
D_{50}	34	mm.
F_{b0}	4.431909207	$ft^{2/}s$. Blench's "zero bed factor," (interpolated)
		feet. Water depth for zero bed sediment transport
y_{f0}	1.460799572	$= q_f^{2/3} / F_{b0}^{1/3}$
Degree of bend	straight	
Z	0.6	Blench Z
		feet. $=Z * y_{f0}$
y_s	**0.876479743**	Blench general scour below streambed.

Lacey	Value	Description
Reference: ASCE, Predicting Bed Scour, 2005		
Q	73	design discharge, (ft^3/s)
d_m	34	mean grain size of bed material (mm)
f	10.26247533	Lacey's silt factor = $1.76\ (D_m)^{1/2}$
Use Laceys regime equation for mean depth?	yes	
Mean depth using Lacey's regime eq.	0.903902184	feet.
Mean depth from inputs	0.81	feet.
y_m	0.903902184	feet. Mean water depth for Lacey scour equation.
Z	0.25	Lacey Z
y_s	**0.225975546**	feet. $=Z * y_m$. Scour depth below streambed

Neill Competent Velocity	**Value**	Description
Reference: Pemberton & Lara, 1984		
D_{50}	34	mm
y_m	0.81	mean depth, (ft)
V_c	#N/A	ft/sec. Competent mean velocity (interpolated)
V_m	5.84	mean velocity, (ft/s)
		$=y_m\ (V_m / V_c - 1)$
y_s	**#N/A**	scour depth below streambed, (ft)

USBR Envelope Curve	Value	Description
Reference: Pemberton & Lara, 1984		
q	3.716904277	Unit discharge, cfs per foot width
ds	**3.357450472**	Scour depth, feet below streambed, from curve.
Within valid slope range	FALSE	
Within valid D_{50} range	FALSE	

USBR Mean Velocity Method	Value	Description
Reference: Pemberton & Lara, 1984		
Z	0.25	Lacey Z from Lacey's method
d_m	0.81	feet. Mean depth
d_s	**0.2025**	feet. Scour depth below streambed. $d_s = Z\ d_m$

Tributary Reach 3, HEC-RAS Section 393.08, 100-YR

GENERAL SCOUR

Zeller General Scour	Value	Description
Reference: Simons Li & Associates, 1985		
y_{max}	1.38	feet. Maximum depth of flow
V_m	8.89	ft/s. Average velocity of flow
Y_h	0.38	feet. Hydraulic or mean depth of flow
S_e	0.056	Energy slope (or bed slope or uniform slope)
$y_{gs,\ calculated}$	0.518109313	feet. $=y_{max}\ [(0.0685\ V_m^{0.8})\ /\ (y_h^{0.4}\ S_e^{0.3})\ -1]$. Zeller equation general scour depth.
$y_{gs,}$ (minimum 0)	**0.518109313**	feet. Zeller General Scour (greater of 0 or Zeller equation).

Neill Incised	**Value**	**Description**
Reference: Neill, 1973		
y_i	0.51	feet. average depth at bankfull discharge in incised reach
q_f	2.183014354	(ft3/s/ft). Design flood discharge per unit width
$Q_{bankfull}$	6.4	cfs. Bankfull or channel forming discharge
$W_{bankfull}$	5.59	feet. Bankfull width.
q_i	1.14490161	(ft^3/s/ft). Bankfull discharge in incised reach per unit width
m	0.85	exponent varying from 0.67 for sand to 0.85 for coarse gravel
y_f	0.882704494	feet. Scoured depth (general scour) below design floodwater level
Z	0.7	Neill Incised Z
		$=Z * y_f$
y_s	**0.617893146**	Neill general scour below streambed.

Blench Zero Bed Factor	Value	Description
Reference: Pemberton & Lara, 1984		
q_f	2.183014354	cfs/ft. Design discharge per unit width.
D_{50}	25	mm.
F_{b0}	4.11116356	$ft^{2/}$s. Blench's "zero bed factor," (interpolated)
		feet. Water depth for zero bed sediment transport
y_{f0}	1.050467956	$= q_f^{2/3}\ /\ F_{b0}^{1/3}$
Degree of bend	severe	
Z	0.6	Blench Z
		feet. $=Z * y_{f0}$
y_s	**0.630280774**	Blench general scour below streambed.

Lacey	Value	Description
Reference: ASCE, Predicting Bed Scour, 2005		
Q	73	design discharge, (ft^3/s)
d_m	25	mean grain size of bed material (mm)
f	8.8	Lacey's silt factor = $1.76\ (D_m)^{1/2}$
Use Laceys regime equation for mean depth?	yes	
Mean depth using Lacey's regime eq.	0.951432365	feet.
Mean depth from inputs	0.38	feet.
y_m	0.951432365	feet. Mean water depth for Lacey scour equation.
Z	0.75	Lacey Z
y_s	**0.713574273**	feet. $=Z * y_m$. Scour depth below streambed

Neill Competent Velocity	**Value**	Description
Reference: Pemberton & Lara, 1984		
D_{50}	25	mm
y_m	0.38	mean depth, (ft)
V_c	#N/A	ft/sec. Competent mean velocity (interpolated)
V_m	8.89	mean velocity, (ft/s)
		$=y_m\ (V_m\ /\ V_c\ -\ 1)$
y_s	**#N/A**	scour depth below streambed, (ft)

USBR Envelope Curve	Value	Description
Reference: Pemberton & Lara, 1984		
q	2.183014354	Unit discharge, cfs per foot width
ds	**2.95487876**	Scour depth, feet below streambed, from curve.
Within valid slope range	FALSE	
Within valid D_{50} range	FALSE	

USBR Mean Velocity Method	Value	Description
Reference: Pemberton & Lara, 1984		
Z	0.75	Lacey Z from Lacey's method
d_m	0.38	feet. Mean depth
d_s	**0.285**	feet. Scour depth below streambed. $d_s = Z\ d_m$

Tributary Reach 3, HEC-RAS Section 393.08, 100-YR

BEND SCOUR

Zeller Bend Scour	Value	
Reference: Simons Li & Associates, 1985 (page 5.105-5.106)		
y_{max}	1.84	feet. Maximum Depth of upstream flow
V	5.2	fps. Mean velocity of upstream flow
y_h	0.56	feet. Hydraulic Depth of upstream flow
S_e	0.012	Upstream energy slope
W	52.89	feet. Channel topwidth of upstream flow
r_c	18	feet. Radius of curvature to centerline of channel
$\sin^2(\alpha/2)/\cos(\alpha)$	0.734583	Used in Zeller Bend Scour Equation
$y_{bs,}$ prelimiinary	2.182746	feet. Zeller Bend Scour, initial calculation
$\mathbf{y_{bs}}$	**2.182746**	feet. Zeller Bend Scour, final (disallowing negative values)
Manning n-value	0.04	to calculate Chezy coefficient
Hydraulic Radius	0.37	feet.
Chezy coefficient	31.47694	
b	33.44	feet. Design discharge top width in the bend.
Superelevation	2.469771	feet. = V_z^2 b / (g r_c) (Equation 16-11, Chow) (based on top width, velocity, and radius of curvature, where b=W=topwidth)
Maximum depth of flow	1.38	feet.
y	3.849771	feet. Max depth of flow including superelevation on outside of bend
X	***49.13938***	feet. = 2.3 (C $g^{1/2}$) y. Distance downstream of end of curvature to where downstream currents have dissipated

Maynord Bend Scour	Value	Note: Not recommended where overbank depth exceeds 20% channel depth
Reference: Maynord, 1996 via ASCE, 2005		Comment
y_u	0.56	feet. Average water depth in crossing upstream of bend.
r_c	18	feet. Centerline radius of bend.
W_u	5.63	feet. Water surface width at upstream end of bend (active or bankfull width)
nominal r_c / W_u	3.197158	Equation limited to r_c / W_u < 10, ratio in equation set to 1.5 if less
r_c / W_u for equation	3.197158	dimensionless.
r_c / W_u within range	TRUE	
nominal W_u / y_u	10.05357	Equation limited to W_u / y_u < 125, ratio in equation set to 20 if less
nominal W_u / y_u for equation	20	dimensionless.
W_u / y_u within range	TRUE	
y_{mxb}	1.010769	feet. = y_u * (1.8 - 0.051 (r_c / W_u) + 0.0084 (W_u / y_u). Maximum water depth in bend.
$\mathbf{y_{bs}}$	**0.450769**	feet. = y_{mxb} - y_u = Below thalweg.

Thorne Bend Scour	Value	
Reference: Thorne et. al, 1995 via ASCE, 2005		
y_u	0.56	feet. Average water depth in crossing upstream of bend.
r_c	18	feet. Centerline radius of bend.
W_u	52.89	feet. Water surface width at upstream end of bend.
y_{max} / y_u	#NUM!	=2.07-0.19*$\log_{10}$(r_c / W_u-2). Thorne bend scour equation
y_{max}	#NUM!	= (y_{max} / $y_{u)}$ * $y_{u.}$ Thorne bend scour below water surface.
r_c / W_u	0.340329	dimensionless.
r_c / W_u within range	FALSE	Equation limited to r_c / W_u>2
y_{bs} (below thalweg)	**#NUM!**	feet. = y_{max} - y_u. Scour below thalweg

Bend Scour Design Curves, Corps of Engineers	Value	
Reference: Corps of Engrs. EM 1110-2-1601 Plate B41		
r_b	18	feet. Centerline radius of bend
W	33.44	feet. Water surface width
r_b / W	0.538278	x-axis of design curve
Mean depth in the approach section	0.56	feet.
Maximum depth in the bend	1.38	feet
Max depth bend / mean depth approach (Sand Bed Channels)	3.776181	y-axis of design curve, sand-bed channels
Max depth bend / mean depth approach (Gravel Bed Channels)	3.812661	y-axis of design curve, gravel-bed channels
Bend Scour Depth, sand-bed channels	**0.734661**	feet. Below minimum channel elevation (no bend scour if negative).
Bend Scour Depth, gravel-bed channels	**0.75509**	feet. Below minimum channel elevation (no bend scour if negative).

Mainstem, HEC-RAS Section 922, 1-YR

GENERAL SCOUR

Zeller General Scour	Value	Description
Reference: Simons Li & Associates, 1985		
y_{max}	1.54	feet. Maximum depth of flow
V_m	7.77	ft/s. Average velocity of flow
Y_h	1.05	feet. Hydraulic or mean depth of flow
S_e	0.0531	Energy slope (or bed slope or uniform slope)
$y_{gs, calculated}$	-0.25310228	feet. $=y_{max}$ [(0.0685 $V_m^{0.8}$) / ($y_h^{0.4}$ $S_e^{0.3}$) -1]. Zeller equation general scour depth.
$y_{gs,}$ (minimum 0)	**0**	feet. Zeller General Scour (greater of 0 or Zeller equation).

Neill Incised	**Value**	**Description**
Reference: Neill, 1973		
y_i	1.54	feet. average depth at bankfull discharge in incised reach
q_f	8.164556962	(ft3/s/ft). Design flood discharge per unit width
$Q_{bankfull}$	387	cfs. Bankfull or channel forming discharge
$W_{bankfull}$	47.4	feet. Bankfull width.
q_i	8.164556962	(ft^3/s/ft). Bankfull discharge in incised reach per unit width
m	0.85	exponent varying from 0.67 for sand to 0.85 for coarse gravel
y_f	1.54	feet. Scoured depth (general scour) below design floodwater level
Z	0.5	Neill Incised Z
		$=Z * y_f$
y_s	**0.77**	Neill general scour below streambed.

Blench Zero Bed Factor	Value	Description
Reference: Pemberton & Lara, 1984		
q_f	8.164556962	cfs/ft. Design discharge per unit width.
D_{50}	60	mm.
F_{b0}	5.091639011	$ft^{2/}$s. Blench's "zero bed factor," (interpolated)
		feet. Water depth for zero bed sediment transport
y_{f0}	2.356871368	$= q_f^{2/3} / F_{b0}^{1/3}$
Degree of bend	straight	
Z	0.6	Blench Z
		feet. $=Z * y_{f0}$
y_s	**1.414122821**	Blench general scour below streambed.

Lacey	Value	Description
Reference: ASCE, Predicting Bed Scour, 2005		
Q	387	design discharge, (ft^3/s)
d_m	60	mean grain size of bed material (mm)
f	13.63290138	Lacey's silt factor = 1.76 $(D_m)^{1/2}$
Use Laceys regime equation for mean depth?	no	
Mean depth using Lacey's regime eq.	1.433745547	feet.
Mean depth from inputs	1.05	feet.
y_m	1.05	feet. Mean water depth for Lacey scour equation.
Z	0.25	Lacey Z
y_s	**0.2625**	feet. $=Z * y_m$. Scour depth below streambed

Neill Competent Velocity	**Value**	Description
Reference: Pemberton & Lara, 1984		
D_{50}	60	mm
y_m	1.05	mean depth, (ft)
V_c	#N/A	ft/sec. Competent mean velocity (interpolated)
V_m	7.77	mean velocity, (ft/s)
		$=y_m (V_m / V_c - 1)$
y_s	**#N/A**	scour depth below streambed, (ft)

USBR Envelope Curve	Value	Description
Reference: Pemberton & Lara, 1984		
q	8.164556962	Unit discharge, cfs per foot width
ds	**4.055364676**	Scour depth, feet below streambed, from curve.
Within valid slope range	FALSE	
Within valid D_{50} range	FALSE	

USBR Mean Velocity Method	Value	Description
Reference: Pemberton & Lara, 1984		
Z	0.25	Lacey Z from Lacey's method
d_m	1.05	feet. Mean depth
d_s	**0.2625**	feet. Scour depth below streambed. $d_s = Z\ d_m$

Mainstem, HEC-RAS Section 922, 10-YR

GENERAL SCOUR

Zeller General Scour	Value	Description
Reference: Simons Li & Associates, 1985		
y_{max}	5.3	feet. Maximum depth of flow
V_m	5.27	ft/s. Average velocity of flow
Y_h	3.61	feet. Hydraulic or mean depth of flow
S_e	0.0042	Energy slope (or bed slope or uniform slope)
$y_{gs, calculated}$	-1.059302781	feet. $=y_{max}$ [(0.0685 $V_m^{0.8}$) / ($y_h^{0.4}$ $S_e^{0.3}$) -1]. Zeller equation general scour depth.
$y_{gs,}$ (minimum 0)	**0**	feet. Zeller General Scour (greater of 0 or Zeller equation).

Neill Incised	**Value**	**Description**
Reference: Neill, 1973		
y_i	1.52	feet. average depth at bankfull discharge in incised reach
q_f	18.76889255	(ft3/s/ft). Design flood discharge per unit width
$Q_{bankfull}$	387	cfs. Bankfull or channel forming discharge
$W_{bankfull}$	47.7	feet. Bankfull width.
q_i	8.113207547	(ft^3/s/ft). Bankfull discharge in incised reach per unit width
m	0.85	exponent varying from 0.67 for sand to 0.85 for coarse gravel
y_f	3.100649962	feet. Scoured depth (general scour) below design floodwater level
Z	0.5	Neill Incised Z
		$=Z * y_f$
y_s	**1.550324981**	Neill general scour below streambed.

Blench Zero Bed Factor	Value	Description
Reference: Pemberton & Lara, 1984		
q_f	18.76889255	cfs/ft. Design discharge per unit width.
D_{50}	60	mm.
F_{b0}	5.091639011	ft^2/s. Blench's "zero bed factor," (interpolated)
		feet. Water depth for zero bed sediment transport
y_{f0}	4.105252715	$= q_f^{2/3} / F_{b0}^{1/3}$
Degree of bend	straight	
Z	0.6	Blench Z
		feet. $=Z * y_{f0}$
y_s	**2.463151629**	Blench general scour below streambed.

Lacey	Value	Description
Reference: ASCE, Predicting Bed Scour, 2005		
Q	1366	design discharge, (ft^3/s)
d_m	60	mean grain size of bed material (mm)
f	13.63290138	Lacey's silt factor = 1.76 $(D_m)^{1/2}$
Use Laceys regime equation for mean depth?	no	
Mean depth using Lacey's regime eq.	2.182991242	feet.
Mean depth from inputs	3.61	feet.
y_m	3.61	feet. Mean water depth for Lacey scour equation.
Z	0.25	Lacey Z
y_s	**0.9025**	feet. $=Z * y_m$. Scour depth below streambed

Neill Competent Velocity	**Value**	Description
Reference: Pemberton & Lara, 1984		
D_{50}	60	mm
y_m	3.61	mean depth, (ft)
V_c	8.476584245	ft/sec. Competent mean velocity (interpolated)
V_m	5.27	mean velocity, (ft/s)
		$=y_m (V_m / V_c - 1)$
y_s	**-1.365617186**	scour depth below streambed, (ft)

USBR Envelope Curve	Value	Description
Reference: Pemberton & Lara, 1984		
q	18.76889255	Unit discharge, cfs per foot width
ds	**4.95212228**	Scour depth, feet below streambed, from curve.
Within valid slope range	TRUE	
Within valid D_{50} range	FALSE	

USBR Mean Velocity Method	Value	Description
Reference: Pemberton & Lara, 1984		
Z	0.25	Lacey Z from Lacey's method
d_m	3.61	feet. Mean depth
d_s	**0.9025**	feet. Scour depth below streambed. $d_s = Z\ d_m$

APPENDIX I
HYDROLOGIC AND HYDRAULIC REPORT

APPENDIX I.1

EXISTING CONDITIONS
HYDROLOGIC AND HYDRAULIC REPORT

APPENDIX I.1 – EXISTING CONDITIONS HYDROLOGIC AND HYDRAULICS REPORT

TO:	William Pines Maryland Transportation Authority 8019 Corporate Drive, Suite F White Marsh, MD 21236
FROM:	James Tomlinson, PE KCI Technologies, Inc. Water Resources Practice
DATE:	June 27, 2019
SUBJECT:	H&H Technical Memo Carsins Run Mitigation Project KCI Job Number: No. 22145228.47

INTRODUCTION

The Maryland Transportation Authority (MdTA or "The Authority") is currently developing plans for the extension of Express Toll Lanes (ETL) along Section 200 of Interstate 95 (I-95). KCI Technologies, Inc. (KCI) is providing services to provide field assessment, design services, and regulatory coordination to assist in the mitigation of impacts assocated with the project. For this project, KCI investigated a portion of Carsins Run near the I-95 culvert, and a tributary entering the channel just upstream from the culvert, from the right bank (facing downstream). The purpose of the investigation was to determine feasibility of restoration for the channels.

This memorandum documents the hydrologic modeling of the watershed and the hydraulic modeling of the stream, culvert crossing, and tributary.

HYDROLOGY

The hydrologic analysis was based on the Natural Resources Conservation Service (NRCS) methodology and computer program TR20 version 2.0 (NRCS 1992). The three primary hydrologic input parameters required to generate discharges were the drainage area (A), runoff curve number (RCN) and the time of concentration (Tc) computed by GIS Hydro 2000 (Moglen 2007).

APPENDIX I.1 – EXISTING CONDITIONS HYDROLOGIC AND HYDRAULICS REPORT

DRAINAGE AREA

The drainage area limits were determined for the main stem to the culvert under I-95 from GIS Hydro using 30 meter DEM by several subroutines developed by the Center for Research and Water Resources (CRWR) and the University of Maryland (UMD). This drainage area is inclusive of the tributary. The drainage area and patterns to the study point, delineated by GIS Hydro, were 3.88 square miles for both existing and ultimate conditions. The drainage area to the tributary was delineated manually, and calculated to be 11.60 acres.

A site visit was conducted in February 2018 to verify the drainage boundary to the study point. The drainage area derived from GIS Hydro was then modified digitally in GIS according to field reconnaissance notes in order to have a more accurate representation of the project drainage area. The revised drainage area was then imported back into GIS Hydro to compute the basin characteristics and peak discharges. The resultant field-verified drainage area was computed in GIS Hydro and determined to be 4.27 square miles.

RUNOFF CURVE NUMBER

The runoff curve number (RCN) reflects the runoff potential for a drainage area. Runoff potential is primarily dependent on soil type and land cover (i.e., land use) characteristics, and is computed for the drainage area using TR-55. Hydrologic soil groups (HSG) or runoff potential were determined from the United States Department of Agriculture (USDA) NRCS Web Soil Survey. Existing land use was determined from GIS Hydro 2000 embedded data derived from Maryland Department of Planning land use data for year 2010 and from zoning layers for the ultimate land use conditions. These conditions were field-verified. The RCN for the total drainage area to the outlet was estimated to be 75.7 for existing land use and 75.8 for ultimate zoning; therefore, the drainage area should be considered fully developed.

The runnoff curve number calculated for the tributary was 69.3 for existing land use conditions and 88.8 for ultimate zoning conditions.

TIME OF CONCENTRATION

The time of concentration (Tc) for both drainage areas were computed using the overland flow method as presented in TR-55. The Tc was determined by dividing the total flow path into segments (sheet, shallow concentrated, and channel flow) and computing the travel time through each segment. A maximum overland sheet flow length of 100 feet was used in this study. Shallow concentrated flow was assumed to extend to the point at which the flow path enters a closed storm drain system. Multiple channel segments, identified based on field inspection, provide the channel flow portion for the time of concentration. The total time of concentration for the watershed is 3.03 hours. The tributary time of concentration is 0.17 hours. Details of these computations are included in Appendix A of this report.

SUMMARY OF DISCHARGES

TR-20 uses the hydrologic characteristics to generate a hydrograph for defined rainfall depths and distributions that are based on NOAA Atlas 14.

The 4.27 square mile watershed is fully developed such that existing and ultimate RCN's are nearly equivalent and the times of concentration were considered to be identical. The TR-20 model was run for the 1-, 2-, 10-, and 100-year storm events.

The overall watershed analysis is inclusive of the tributary, so no subareas were defined. The analysis of the tributary is therefore independent of the overall watershed analysis.

The Tables 1 and 2 below provide a summary of the ultimate development discharges in the tributary and at the study point.

Table 1 : Summary of TR-55 Discharges to Tributary

Storm	Discharge (cfs) (12-hour for 1, 2 and 10-year and 24-hour for 100-yr)	
	Existing	Ultimate Land Use
1-year	6.42 cfs	24.85 cfs
2-year	10.92 cfs	32.66 cfs
10-year	27.99 cfs	57.83 cfs
100-year	73.21 cfs	111.47 cfs

Table 2 : Summary of TR-20 Discharges to Study Point

Storm	Discharge (cfs) (12-hour for 1, 2 and 10-year and 24-hour for 100-yr)	
	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

HYDRAULICS

EXISTING HEC-RAS CROSS SECTIONS

Cross sections were developed from the existing channel geometry, using field-run survey data. Sections were located at key points along the study reaches, typically at riffles. Cross section geometry data and elevations were generated from the field survey.

MANNING'S ROUGHNESS

The Manning's coefficient represents the roughness characteristics of a natural or artificial channel based on the type of material, sinuosity, changes in cross section geometry, and vegetation among other factors. It is intended to estimate the resistance to flow. The values for Manning's Roughness Coefficient was selected by field observation. For the existing conditions model, a value of 0.045 was used for the natural channel within the main stem. Values of 0.035, 0.015, and 0.050 were used for the section entering the concrete flume, the flume, and the riprap culvert outfall respectively. A value of 0.035 was used to represent the tributary channel. An overbank value of 0.100 was selected throughout the project area to represent the wooded areas with moderately dense vegetation for the overbanks. All the manning's n values for the stream channel and floodplain are using the Table 3-1 in the HECRAS Reference Manual as a reference.

Existing 2-yr and 10-yr shear stresses and velocities in the channel are presented in the tables below.

Table 3: Existing 2-yr Shear Stress and Velocity

River	Reach	River Station	Profile	Shear Channel (lb/sq ft)	Velocity Channel (ft/s)
Tributary	Main	867.2198	2-yr ex	0.88	4.40
Tributary	Main	718.7947	2-yr ex	0.77	4.18
Tributary	Main	602.422	2-yr ex	3.67	8.34
Tributary	Main	520.8726	2-yr ex	0.92	4.35
Tributary	Main	410.9627	2-yr ex	1.19	5.05
Tributary	Main	266.3346	2-yr ex	0.71	3.98
Tributary	Main	186.1341	2-yr ex	1.41	5.23
Tributary	Main	90.83922	2-yr ex	0.36	2.37
Carsins_Run	Main_Stem	1896	2-yr ex	1.08	4.97
Carsins_Run	Main_Stem	1598	2-yr ex	3.53	9.11
Carsins_Run	Main_Stem	1423	2-yr ex	3.49	8.66
Carsins_Run	Main_Stem	1233	2-yr ex	1.21	5.47
Carsins_Run	Main_Stem	1180	2-yr ex	1.94	6.78
Carsins_Run	Main_Stem	1134	2-yr ex	1.02	5.04
Carsins_Run	Main_Stem	1085	2-yr ex	1.30	5.43
Carsins_Run	Main_Stem	1049	2-yr ex	1.72	6.14

River	Reach	River Station	Profile	Shear Channel (lb/sq ft)	Velocity Channel (ft/s)
Carsins_Run	DS_Stem	922	2-yr ex	5.99	13.48
Carsins_Run	DS_Stem	868	2-yr ex	0.64	10.65
Carsins_Run	DS_Stem	721.4		Culvert	Culvert
Carsins_Run	DS_Stem	574	2-yr ex	3.82	8.26
Carsins_Run	DS_Stem	473	2-yr ex	2.1	6.80
Carsins_Run	DS_Stem	375	2-yr ex	1.11	4.80
Carsins_Run	DS_Stem	269	2-yr ex	1.05	4.52

Table 4: Existing 10-yr Shear Stress and Velocity

River	Reach	River Station	Profile	Shear Channel (lb/sq ft)	Velocity Channel (ft/s)
Tributary	Main	867.2198	10-yr ex	1.36	5.92
Tributary	Main	718.7947	10-yr ex	1.08	5.35
Tributary	Main	602.422	10-yr ex	5.64	11.19
Tributary	Main	520.8726	10-yr ex	1.58	6.14
Tributary	Main	410.9627	10-yr ex	1.58	6.23
Tributary	Main	266.3346	10-yr ex	0.99	5.17
Tributary	Main	186.1341	10-yr ex	2.83	7.94
Tributary	Main	90.83922	10-yr ex	0.52	3.17
Carsins_Run	Main_Stem	1896	10-yr ex	1.42	5.67
Carsins_Run	Main_Stem	1598	10-yr ex	1.58	6.20
Carsins_Run	Main_Stem	1423	10-yr ex	7.89	13.65
Carsins_Run	Main_Stem	1233	10-yr ex	1.92	7.34

APPENDIX I.1 – EXISTING CONDITIONS HYDROLOGIC AND HYDRAULICS REPORT

River	Reach	River Station	Profile	Shear Channel (lb/sq ft)	Velocity Channel (ft/s)
Carsins_Run	Main_Stem	1180	10-yr ex	3.59	9.71
Carsins_Run	Main_Stem	1134	10-yr ex	2.14	7.58
Carsins_Run	Main_Stem	1085	10-yr ex	2.17	7.49
Carsins_Run	Main_Stem	1049	10-yr ex	2.71	8.18
Carsins_Run	DS_Stem	922	10-yr ex	7.28	16.26
Carsins_Run	DS_Stem	868	10-yr ex	1.01	14.32
Carsins_Run	DS_Stem	721.4			Culvert
Carsins_Run	DS_Stem	574	10-yr ex	4.72	9.68
Carsins_Run	DS_Stem	473	10-yr ex	3.18	8.99
Carsins_Run	DS_Stem	375	10-yr ex	1.99	6.81
Carsins_Run	DS_Stem	269	10-yr ex	1.53	5.83

INEFFECTIVE FLOW AREAS

Ineffective flow areas were set upstream and downstream of the culvert to represent transition in flow from the broader floodplain to the culvert. A transition slope of 1:1 was set for the upstream approach, and 2:1 set for the downstream expansion. Inneffective areas were allowed to be active once the roadway elevation was met, and the road overtops (this does not occur for modeled profiles).

BOUNDARY CONDITIONS

Boundary conditions are necessary to establish the starting water surface at the limits of the modeled reach (upstream and downstream). The upstream and downstream boundary conditions for both the main stem and tributary were set to normal depth, with a channel slope based on surveyed data.

MODEL RESULTS

APPENDIX I.1 – EXISTING CONDITIONS HYDROLOGIC AND HYDRAULICS REPORT

The following discusses the existing conditions results of the model. The water surface elevations for the main stem 100-year ultimate conditions flows are contained within the stream valley for all reaches, all sections. The culvert passes all modeled storm events. The 100-year ultimate condition profile passes through the culvert with 10.88 feet of freeboard.

Shear stresses range in the main stem from 1.01 lb/sqft to 7.89 lb/sqft, for the 10-year existing conditions profile. The shear stresses at the dowstrean end of the upstream meandering channel and near the culvert are high. Downstream of the culvert, shear stresses remain moderately high for the first few cross sections.

Shear stresses in the tributary are relatively low.

References

Moglen, Glenn E (2007). *Introduction to GISHydro2000, GIS Based Hydrologic Analysis in Maryland.* College Park; University of Maryland.

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U.S. Army Corps of Engineers, Hydrologic Engineering Center, 2016. *HEC-RAS River Analysis System; Version 5.0.3.*

U.S. Army Corps of Engineers, Hydrologic Engineering Center, 2016. *HEC-RAS 5.0 Reference Manual.*

APPENDIX A

Existing Landuse

Basin Stats and Composition
TR-20
Small Tributary TR-55
Drainage Area Map

Ultimate Landuse

Basin Stats and Composition
TR-20
Small Tributary TR-55
Drainage Area Map

```
Watershed Statistics for:
GISHydro Release Version Date: January 8, 2011
Hydro Extension Version Date:  January 8, 2011
Analysis Date:                 November 26, 2018

Data Selected:
     Quadrangles Used: aberdeen, bel_air, conowingo_dam, delta
     DEM Coverage: NED DEMs
     Land Use Coverage: 2010 MOP Landuse
     Soil Coverage: SSURGO Soils
     Hydrologic Condition: (see Lookup Table)
     Impose NHD stream Locations: Yes
     Outlet Easting:        470532 m. (MD Stateplane, NAD 1983)
     Outlet Northing:       207356 m. (MD Stateplane, NAD 1983)

Findings:
     Outlet Location:       Piedmont
     Outlet State:          Maryland
     Drainage Area          4.3 square miles
       -Piedmont (100.0% of area)
     Channel Slope:         51.2 feet/mile
     Land Slope:            0.051 ft/ft
     Urban Area:            17.4%
     Impervious Area:       8.3%
 ******************************************************
     URBAN DEVELOPMENT IN WATERSHED EXCEEDS 15%.
     Calculated discharges from USGS Regression
     Equations may not be appropriate.
 ******************************************************
 ******************************************************
     Watershed is within 5km of physiographic
     province boundary.  You should consider
     sensitivity of discharges to region location.
 ******************************************************
     Time of Concentration: 3.7 hours  [W.O. Thomas, Jr. Equation]
     Time of Concentration: 3.5 hours  [From SCS Lag Equation * 1.67]
     Longest Flow Path:     4.80 miles
     Basin Relief:          354.0 feet
     Average CN:            76
     % Forest Cover:        44.4
     % Storage:             0.0
     % Limestone:           0.0
     Selected Soils Data Statistics:
        % A Soils:          0.6
        % B Soils:          26.7
        % C Soils:          46.6
        % D Soils:          26.2
     SSURGO Soils Data Statistics (used in Regression Equations):
```

% A Soils:	0.6
% B Soils:	26.7
% C Soils:	46.6
% D Soils:	26.2
2-Year,24-hour Prec.:	3.27 inches
Mean Annual Prec.:	46.23 inches

basincomposition.txt
GISHydro Release Version Date: January 8, 2011
Hydro Extension Version Date: January 8, 2011
Analysis Date: November 26, 2018

Landuse and Soil Distributions for:

Distribution of Landuse by Soil Group

	Acres on Indicated Soil Group			
Land Use	A-Soil	B-Soil	C-Soil	D-Soil
Low Density Residential	2.89	146.11	147.45	51.82
Medium Density Residential	1.33	60.05	20.68	3.56
High Density Residential	0	0	1.56	0.22
Commercial	0	15.57	23.35	2
Institutional	0	15.57	8.67	0.44
Open Urban Land	0	18.68	22.68	0.67
Cropland	3.11	188.59	304.46	103.19
Pasture	0	82.29	67.61	27.8
Deciduous Forest	0	112.53	531.74	444.79
Brush	7.34	0.44	0	0.22
Transportation	0	5.34	4.23	1.78
Large Lot Agricultural	1.33	39.81	94.74	36.47
Large Lot Forest	0	34.25	46.26	38.25
Agricultural Buildings	0	10.45	0.44	4.89
Total Area:	16.01	729.67	1273.87	716.11

Distribution of Land Use and Curve Numbers Used

Land Use	Acres	Percent	A	B	C	D
Low Density Residential	348.71	12.74	54	70	80	85
Medium Density Residential	85.62	3.13	61	75	83	87
High Density Residential	1.78	0.07	77	85	90	92
Commercial	40.92	1.5	89	92	94	95
Institutional	24.69	0.9	69	80	86	89
Open Urban Land	42.03	1.54	39	61	74	80
Cropland	599.35	21.9	67	78	85	89
Pasture	177.69	6.49	39	61	74	80
Deciduous Forest	1089.29	39.8	30	55	70	77
Brush	8.01	0.29	30	48	65	73
Transportation	11.34	0.41	83	89	92	94
Large Lot Agricultural	172.36	6.3	67	78	85	89
Large Lot Forest	118.98	4.35	30	55	70	77
Agricultural Buildings	15.79	0.58	59	74	82	86

```
 ****************80-80 LIST OF INPUT DATA FOR TR-20 HYDROLOGY*****************

 JOB TR-20                                                   NOPLOTS
 TITLE     Carsins Run
 TITLE     MD 2010 - SSURGO
  6 RUNOFF 1   3      1      4.2740     75.69       3.0363        1
  5 RAINFL 1             .1
  8          0.0000      0.0064      0.0129      0.0193      0.0257
  8          0.0321      0.0386      0.0450      0.0514      0.0578
  8          0.0643      0.0707      0.0771      0.0835      0.0900
  8          0.0964      0.1023      0.1082      0.1141      0.1200
  8          0.1260      0.1391      0.1522      0.1653      0.1784
  8          0.1915      0.2160      0.2404      0.2794      0.3412
  8          0.5000      0.6588      0.7206      0.7596      0.7840
  8          0.8085      0.8216      0.8347      0.8478      0.8609
  8          0.8740      0.8800      0.8859      0.8918      0.8977
  8          0.9036      0.9100      0.9165      0.9229      0.9293
  8          0.9357      0.9422      0.9486      0.9550      0.9614
  8          0.9679      0.9743      0.9807      0.9871      0.9936
  8          1.0000      1.0000      1.0000      1.0000      1.0000
  9 ENDTBL
  5 RAINFL 2             .1
  8          0.0000      0.0031      0.0062      0.0093      0.0124
  8          0.0155      0.0186      0.0216      0.0247      0.0278
  8          0.0309      0.0340      0.0371      0.0402      0.0433
  8          0.0464      0.0495      0.0526      0.0557      0.0588
  8          0.0619      0.0649      0.0680      0.0711      0.0742
  8          0.0773      0.0804      0.0835      0.0866      0.0897
  8          0.0928      0.0980      0.1032      0.1085      0.1137
  8          0.1189      0.1242      0.1294      0.1346      0.1399
  8          0.1451      0.1503      0.1556      0.1608      0.1660
  8          0.1713      0.1761      0.1809      0.1857      0.1905
  8          0.1954      0.2060      0.2167      0.2274      0.2381
  8          0.2488      0.2687      0.2885      0.3203      0.3706
  8          0.5000      0.6294      0.6797      0.7115      0.7313
  8          0.7512      0.7619      0.7726      0.7833      0.7940
  8          0.8046      0.8095      0.8143      0.8191      0.8239
  8          0.8287      0.8340      0.8392      0.8444      0.8497
  8          0.8549      0.8601      0.8654      0.8706      0.8758
  8          0.8811      0.8863      0.8915      0.8968      0.9020
  8          0.9072      0.9103      0.9134      0.9165      0.9196
  8          0.9227      0.9258      0.9289      0.9320      0.9351
  8          0.9381      0.9412      0.9443      0.9474      0.9505
  8          0.9536      0.9567      0.9598      0.9629      0.9660
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  8          0.9691      0.9722      0.9753      0.9784      0.9814
  8          0.9845      0.9876      0.9907      0.9938      0.9969
  8          1.0000      1.0000      1.0000      1.0000      1.0000
  9 ENDTBL
  5 RAINFL 3              .1
  8          0.0000      0.0011      0.0022      0.0033      0.0044
  8          0.0055      0.0066      0.0077      0.0088      0.0099
  8          0.0110      0.0121      0.0132      0.0143      0.0154
1
```

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 ********************80-80 LIST OF INPUT DATA (CONTINUED)*********************

  8          0.0165      0.0176      0.0187      0.0198      0.0209
  8          0.0220      0.0231      0.0242      0.0253      0.0264
  8          0.0275      0.0286      0.0297      0.0308      0.0319
  8          0.0330      0.0341      0.0352      0.0363      0.0374
  8          0.0385      0.0396      0.0407      0.0418      0.0429
  8          0.0440      0.0451      0.0462      0.0473      0.0484
  8          0.0495      0.0506      0.0518      0.0529      0.0540
  8          0.0551      0.0562      0.0573      0.0584      0.0595
  8          0.0606      0.0617      0.0628      0.0639      0.0650
  8          0.0661      0.0687      0.0714      0.0741      0.0768
  8          0.0795      0.0822      0.0849      0.0875      0.0902
  8          0.0929      0.0956      0.0983      0.1010      0.1036
  8          0.1063      0.1090      0.1117      0.1144      0.1171
  8          0.1197      0.1224      0.1251      0.1278      0.1305
  8          0.1332      0.1358      0.1385      0.1412      0.1439
  8          0.1466      0.1511      0.1557      0.1602      0.1647
  8          0.1693      0.1738      0.1784      0.1829      0.1875
  8          0.1920      0.1965      0.2011      0.2056      0.2102
  8          0.2147      0.2189      0.2231      0.2273      0.2314
  8          0.2356      0.2449      0.2542      0.2634      0.2727
  8          0.2820      0.2992      0.3165      0.3440      0.3877
  8          0.5000      0.6123      0.6560      0.6835      0.7008
  8          0.7180      0.7273      0.7366      0.7458      0.7551
  8          0.7644      0.7686      0.7727      0.7769      0.7811
  8          0.7853      0.7898      0.7944      0.7989      0.8035
  8          0.8080      0.8125      0.8171      0.8216      0.8262
  8          0.8307      0.8353      0.8398      0.8443      0.8489
  8          0.8534      0.8561      0.8588      0.8615      0.8642
  8          0.8668      0.8695      0.8722      0.8749      0.8776
  8          0.8803      0.8829      0.8856      0.8883      0.8910
  8          0.8937      0.8964      0.8990      0.9017      0.9044
  8          0.9071      0.9098      0.9125      0.9151      0.9178
  8          0.9205      0.9232      0.9259      0.9286      0.9313
  8          0.9339      0.9350      0.9361      0.9372      0.9383
```

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  8          0.9394      0.9405      0.9416      0.9427      0.9438
  8          0.9449      0.9460      0.9471      0.9482      0.9494
  8          0.9505      0.9516      0.9527      0.9538      0.9549
  8          0.9560      0.9571      0.9582      0.9593      0.9604
  8          0.9615      0.9626      0.9637      0.9648      0.9659
  8          0.9670      0.9681      0.9692      0.9703      0.9714
  8          0.9725      0.9736      0.9747      0.9758      0.9769
  8          0.9780      0.9791      0.9802      0.9813      0.9824
  8          0.9835      0.9846      0.9857      0.9868      0.9879
  8          0.9890      0.9901      0.9912      0.9923      0.9934
  8          0.9945      0.9956      0.9967      0.9978      0.9989
  8          1.0000      1.0000      1.0000      1.0000      1.0000
  9 ENDTBL
  5 RAINFL 4             .1
  8          0.0000      0.0063      0.0125      0.0188      0.0251
  8          0.0313      0.0376      0.0439      0.0501      0.0564
1


 ********************80-80 LIST OF INPUT DATA (CONTINUED)*********************

  8          0.0627      0.0689      0.0752      0.0815      0.0877
  8          0.0940      0.1001      0.1062      0.1122      0.1183
  8          0.1244      0.1374      0.1505      0.1635      0.1765
  8          0.1895      0.2147      0.2400      0.2799      0.3428
  8          0.5000      0.6572      0.7201      0.7600      0.7853
  8          0.8105      0.8235      0.8365      0.8495      0.8626
  8          0.8756      0.8817      0.8878      0.8938      0.8999
  8          0.9060      0.9123      0.9185      0.9248      0.9311
  8          0.9373      0.9436      0.9499      0.9561      0.9624
  8          0.9687      0.9749      0.9812      0.9875      0.9937
  8          1.0000      1.0000      1.0000      1.0000      1.0000
  9 ENDTBL
  5 RAINFL 5             .1
  8          0.0000      0.0031      0.0061      0.0092      0.0123
  8          0.0154      0.0184      0.0215      0.0246      0.0277
  8          0.0307      0.0338      0.0369      0.0400      0.0430
  8          0.0461      0.0492      0.0522      0.0553      0.0584
  8          0.0615      0.0645      0.0676      0.0707      0.0738
  8          0.0768      0.0799      0.0830      0.0861      0.0891
  8          0.0922      0.0973      0.1024      0.1075      0.1127
  8          0.1178      0.1229      0.1280      0.1331      0.1382
  8          0.1433      0.1484      0.1535      0.1587      0.1638
  8          0.1689      0.1738      0.1788      0.1838      0.1887
  8          0.1937      0.2043      0.2149      0.2255      0.2362
  8          0.2468      0.2673      0.2879      0.3205      0.3718
  8          0.5000      0.6282      0.6795      0.7121      0.7327
```

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  8          0.7532      0.7638      0.7745      0.7851      0.7957
  8          0.8063      0.8113      0.8162      0.8212      0.8262
  8          0.8311      0.8362      0.8413      0.8465      0.8516
  8          0.8567      0.8618      0.8669      0.8720      0.8771
  8          0.8822      0.8873      0.8925      0.8976      0.9027
  8          0.9078      0.9109      0.9139      0.9170      0.9201
  8          0.9232      0.9262      0.9293      0.9324      0.9355
  8          0.9385      0.9416      0.9447      0.9478      0.9508
  8          0.9539      0.9570      0.9600      0.9631      0.9662
  8          0.9693      0.9723      0.9754      0.9785      0.9816
  8          0.9846      0.9877      0.9908      0.9939      0.9969
  8          1.0000      1.0000      1.0000      1.0000      1.0000
  9 ENDTBL
  5 RAINFL 6             .1
  8          0.0000      0.0011      0.0022      0.0033      0.0044
  8          0.0055      0.0066      0.0077      0.0088      0.0099
  8          0.0109      0.0120      0.0131      0.0142      0.0153
  8          0.0164      0.0175      0.0186      0.0197      0.0208
  8          0.0219      0.0230      0.0241      0.0252      0.0263
  8          0.0274      0.0285      0.0296      0.0307      0.0317
  8          0.0328      0.0339      0.0350      0.0361      0.0372
  8          0.0383      0.0394      0.0405      0.0416      0.0427
  8          0.0438      0.0449      0.0460      0.0471      0.0482
  8          0.0493      0.0504      0.0515      0.0525      0.0536
1


 ********************80-80 LIST OF INPUT DATA (CONTINUED)*********************

  8          0.0547      0.0558      0.0569      0.0580      0.0591
  8          0.0602      0.0613      0.0624      0.0635      0.0646
  8          0.0657      0.0684      0.0710      0.0737      0.0764
  8          0.0790      0.0817      0.0844      0.0870      0.0897
  8          0.0924      0.0950      0.0977      0.1004      0.1031
  8          0.1057      0.1084      0.1111      0.1137      0.1164
  8          0.1191      0.1217      0.1244      0.1271      0.1298
  8          0.1324      0.1351      0.1378      0.1404      0.1431
  8          0.1458      0.1502      0.1547      0.1591      0.1635
  8          0.1680      0.1724      0.1769      0.1813      0.1857
  8          0.1902      0.1946      0.1991      0.2035      0.2079
  8          0.2124      0.2167      0.2210      0.2253      0.2296
  8          0.2339      0.2431      0.2524      0.2616      0.2708
  8          0.2800      0.2979      0.3158      0.3441      0.3886
  8          0.5000      0.6114      0.6559      0.6842      0.7021
  8          0.7200      0.7292      0.7384      0.7476      0.7569
  8          0.7661      0.7704      0.7747      0.7790      0.7833
  8          0.7876      0.7921      0.7965      0.8009      0.8054
```

```
  8           0.8098      0.8143      0.8187      0.8231      0.8276
  8           0.8320      0.8365      0.8409      0.8453      0.8498
  8           0.8542      0.8569      0.8596      0.8622      0.8649
  8           0.8676      0.8702      0.8729      0.8756      0.8783
  8           0.8809      0.8836      0.8863      0.8889      0.8916
  8           0.8943      0.8969      0.8996      0.9023      0.9050
  8           0.9076      0.9103      0.9130      0.9156      0.9183
  8           0.9210      0.9236      0.9263      0.9290      0.9316
  8           0.9343      0.9354      0.9365      0.9376      0.9387
  8           0.9398      0.9409      0.9420      0.9431      0.9442
  8           0.9453      0.9464      0.9475      0.9485      0.9496
  8           0.9507      0.9518      0.9529      0.9540      0.9551
  8           0.9562      0.9573      0.9584      0.9595      0.9606
  8           0.9617      0.9628      0.9639      0.9650      0.9661
  8           0.9672      0.9683      0.9693      0.9704      0.9715
  8           0.9726      0.9737      0.9748      0.9759      0.9770
  8           0.9781      0.9792      0.9803      0.9814      0.9825
  8           0.9836      0.9847      0.9858      0.9869      0.9880
  8           0.9891      0.9901      0.9912      0.9923      0.9934
  8           0.9945      0.9956      0.9967      0.9978      0.9989
  8           1.0000      1.0000      1.0000      1.0000      1.0000
  9 ENDTBL
  5 RAINFL 7             .1
  8           0.0000      0.0033      0.0066      0.0099      0.0132
  8           0.0165      0.0198      0.0232      0.0265      0.0298
  8           0.0331      0.0364      0.0397      0.0430      0.0463
  8           0.0496      0.0529      0.0562      0.0595      0.0629
  8           0.0662      0.0695      0.0728      0.0761      0.0794
  8           0.0827      0.0860      0.0893      0.0926      0.0959
  8           0.0992      0.1044      0.1095      0.1146      0.1197
  8           0.1249      0.1300      0.1351      0.1402      0.1454
  8           0.1505      0.1556      0.1607      0.1659      0.1710
1


 ********************80-80 LIST OF INPUT DATA (CONTINUED)*********************

  8           0.1761      0.1812      0.1863      0.1914      0.1966
  8           0.2017      0.2127      0.2238      0.2348      0.2459
  8           0.2570      0.2795      0.3021      0.3365      0.3874
  8           0.5000      0.6126      0.6635      0.6979      0.7205
  8           0.7430      0.7541      0.7652      0.7762      0.7873
  8           0.7983      0.8034      0.8086      0.8137      0.8188
  8           0.8239      0.8290      0.8341      0.8393      0.8444
  8           0.8495      0.8546      0.8598      0.8649      0.8700
  8           0.8751      0.8803      0.8854      0.8905      0.8956
  8           0.9008      0.9041      0.9074      0.9107      0.9140
```

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  8          0.9173     0.9206     0.9239     0.9272     0.9305
  8          0.9338     0.9371     0.9405     0.9438     0.9471
  8          0.9504     0.9537     0.9570     0.9603     0.9636
  8          0.9669     0.9702     0.9735     0.9768     0.9802
  8          0.9835     0.9868     0.9901     0.9934     0.9967
  8          1.0000     1.0000     1.0000     1.0000     1.0000
  9 ENDTBL
  5 RAINFL 8             .1
  8          0.0000     0.0012     0.0025     0.0037     0.0050
  8          0.0062     0.0075     0.0087     0.0100     0.0112
  8          0.0125     0.0137     0.0150     0.0162     0.0175
  8          0.0187     0.0200     0.0212     0.0225     0.0237
  8          0.0249     0.0262     0.0274     0.0287     0.0299
  8          0.0312     0.0324     0.0337     0.0349     0.0362
  8          0.0374     0.0387     0.0399     0.0412     0.0424
  8          0.0437     0.0449     0.0462     0.0474     0.0487
  8          0.0499     0.0511     0.0524     0.0536     0.0549
  8          0.0561     0.0574     0.0586     0.0599     0.0611
  8          0.0624     0.0636     0.0649     0.0661     0.0674
  8          0.0686     0.0699     0.0711     0.0724     0.0736
  8          0.0748     0.0777     0.0805     0.0833     0.0861
  8          0.0889     0.0917     0.0945     0.0974     0.1002
  8          0.1030     0.1058     0.1086     0.1114     0.1142
  8          0.1170     0.1199     0.1227     0.1255     0.1283
  8          0.1311     0.1339     0.1367     0.1395     0.1424
  8          0.1452     0.1480     0.1508     0.1536     0.1564
  8          0.1592     0.1636     0.1680     0.1723     0.1767
  8          0.1810     0.1854     0.1897     0.1941     0.1985
  8          0.2028     0.2072     0.2115     0.2159     0.2202
  8          0.2246     0.2289     0.2333     0.2376     0.2420
  8          0.2463     0.2557     0.2651     0.2745     0.2839
  8          0.2934     0.3125     0.3317     0.3610     0.4042
  8          0.5000     0.5958     0.6390     0.6683     0.6875
  8          0.7066     0.7161     0.7255     0.7349     0.7443
  8          0.7537     0.7580     0.7624     0.7667     0.7711
  8          0.7754     0.7798     0.7841     0.7885     0.7928
  8          0.7972     0.8015     0.8059     0.8103     0.8146
  8          0.8190     0.8233     0.8277     0.8320     0.8364
  8          0.8408     0.8436     0.8464     0.8492     0.8520
  8          0.8548     0.8576     0.8605     0.8633     0.8661
1


 ********************80-80 LIST OF INPUT DATA (CONTINUED)*********************

  8          0.8689     0.8717     0.8745     0.8773     0.8801
  8          0.8830     0.8858     0.8886     0.8914     0.8942
```

```
8           0.8970      0.8998      0.9026      0.9055      0.9083
8           0.9111      0.9139      0.9167      0.9195      0.9223
8           0.9252      0.9264      0.9276      0.9289      0.9301
8           0.9314      0.9326      0.9339      0.9351      0.9364
8           0.9376      0.9389      0.9401      0.9414      0.9426
8           0.9439      0.9451      0.9464      0.9476      0.9489
8           0.9501      0.9513      0.9526      0.9538      0.9551
8           0.9563      0.9576      0.9588      0.9601      0.9613
8           0.9626      0.9638      0.9651      0.9663      0.9676
8           0.9688      0.9701      0.9713      0.9726      0.9738
8           0.9751      0.9763      0.9775      0.9788      0.9800
8           0.9813      0.9825      0.9838      0.9850      0.9863
8           0.9875      0.9888      0.9900      0.9913      0.9925
8           0.9938      0.9950      0.9963      0.9975      0.9988
8           1.0000      1.0000      1.0000      1.0000      1.0000
9 ENDTBL
5 RAINFL 9               .1
8           0.0000      0.0015      0.0029      0.0044      0.0059
8           0.0073      0.0088      0.0103      0.0117      0.0132
8           0.0147      0.0161      0.0176      0.0191      0.0205
8           0.0220      0.0234      0.0249      0.0264      0.0278
8           0.0293      0.0308      0.0322      0.0337      0.0352
8           0.0366      0.0381      0.0396      0.0410      0.0425
8           0.0440      0.0454      0.0469      0.0484      0.0498
8           0.0513      0.0528      0.0542      0.0557      0.0572
8           0.0586      0.0601      0.0615      0.0630      0.0645
8           0.0659      0.0674      0.0689      0.0703      0.0718
8           0.0733      0.0747      0.0762      0.0777      0.0791
8           0.0806      0.0821      0.0835      0.0850      0.0865
8           0.0879      0.0912      0.0944      0.0976      0.1008
8           0.1041      0.1073      0.1105      0.1138      0.1170
8           0.1202      0.1234      0.1267      0.1299      0.1331
8           0.1364      0.1396      0.1428      0.1460      0.1493
8           0.1525      0.1557      0.1589      0.1622      0.1654
8           0.1686      0.1719      0.1751      0.1783      0.1815
8           0.1848      0.1895      0.1941      0.1988      0.2035
8           0.2082      0.2128      0.2175      0.2222      0.2269
8           0.2315      0.2362      0.2409      0.2456      0.2502
8           0.2549      0.2593      0.2637      0.2681      0.2725
8           0.2769      0.2867      0.2966      0.3064      0.3163
8           0.3261      0.3452      0.3642      0.3913      0.4279
8           0.5000      0.5721      0.6087      0.6358      0.6548
8           0.6739      0.6837      0.6936      0.7034      0.7133
8           0.7231      0.7275      0.7319      0.7363      0.7407
8           0.7451      0.7498      0.7544      0.7591      0.7638
8           0.7685      0.7731      0.7778      0.7825      0.7872
8           0.7918      0.7965      0.8012      0.8059      0.8105
8           0.8152      0.8185      0.8217      0.8249      0.8281
```

```
 ********************80-80 LIST OF INPUT DATA (CONTINUED)*********************

 8          0.8314      0.8346      0.8378      0.8411      0.8443
 8          0.8475      0.8507      0.8540      0.8572      0.8604
 8          0.8636      0.8669      0.8701      0.8733      0.8766
 8          0.8798      0.8830      0.8862      0.8895      0.8927
 8          0.8959      0.8992      0.9024      0.9056      0.9088
 8          0.9121      0.9135      0.9150      0.9165      0.9179
 8          0.9194      0.9209      0.9223      0.9238      0.9253
 8          0.9267      0.9282      0.9297      0.9311      0.9326
 8          0.9341      0.9355      0.9370      0.9385      0.9399
 8          0.9414      0.9428      0.9443      0.9458      0.9472
 8          0.9487      0.9502      0.9516      0.9531      0.9546
 8          0.9560      0.9575      0.9590      0.9604      0.9619
 8          0.9634      0.9648      0.9663      0.9678      0.9692
 8          0.9707      0.9722      0.9736      0.9751      0.9766
 8          0.9780      0.9795      0.9809      0.9824      0.9839
 8          0.9853      0.9868      0.9883      0.9897      0.9912
 8          0.9927      0.9941      0.9956      0.9971      0.9985
 8          1.0000      1.0000      1.0000      1.0000      1.0000
 9 ENDTBL
   ENDATA
 7 INCREM 6                      0.1
 7 COMPUT 7   3     3            0.0        1.91         1.01 2  1   1
   ENDCMP 1
 7 COMPUT 7   3     3            0.0        2.35         1.02 2  1   2
   ENDCMP 1
 7 COMPUT 7   3     3            0.0        2.70         1.03 2  1   3
   ENDCMP 1
 7 COMPUT 7   3     3            0.0        2.32         1.04 2  1   4
   ENDCMP 1
 7 COMPUT 7   3     3            0.0        2.84         1.05 2  1   5
   ENDCMP 1
 7 COMPUT 7   3     3            0.0        3.27         1.06 2  1   6
   ENDCMP 1
 7 COMPUT 7   3     3            0.0        4.28         1.07 2  1   7
   ENDCMP 1
 7 COMPUT 7   3     3            0.0        5.03         1.08 2  1   8
   ENDCMP 1
 7 COMPUT 7   3     3            0.0        8.67         1.09 2  1   9
   ENDCMP 1
   ENDJOB 2

 ******************************END OF 80-80 LIST******************************
```

```
1
 TR20 -------------------------------------------------------------------- SCS -
                                 Carsins Run                            VERSION
 11/28/**                      MD 2010 - SSURGO                        2.04TEST
 09:43:39                    PASS   1   JOB NO.   1                    PAGE   1



 EXECUTIVE CONTROL INCREM    MAIN TIME INCREMENT =   .100 HOURS


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
    STARTING TIME =   .00       RAIN DEPTH =  1.91       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 1            RAIN TABLE NO. = 1


 OPERATION RUNOFF   XSECTION   3

    PEAK TIME(HRS)            PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
        5.32                        282.3                        (RUNOFF)

    RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                    .36 WATERSHED INCHES;     989 CFS-HRS;      81.8 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   1


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
    STARTING TIME =   .00       RAIN DEPTH =  2.35       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 2            RAIN TABLE NO. = 2


 OPERATION RUNOFF   XSECTION   3

    PEAK TIME(HRS)            PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
        8.19                        386.7                        (RUNOFF)

    RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                    .59 WATERSHED INCHES;    1635 CFS-HRS;     135.1 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   2


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
```

```
   STARTING TIME =   .00       RAIN DEPTH =  2.70       RAIN DURATION =  1.00
   ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
   ALTERNATE NO. = 1           STORM NO. = 3            RAIN TABLE NO. = 3
1
 TR20 ------------------------------------------------------------------- SCS -
                             Carsins Run                                 VERSION
 11/28/**                  MD 2010 - SSURGO                            2.04TEST
 09:43:39               PASS   3   JOB NO.   1                         PAGE   2



 OPERATION RUNOFF   XSECTION   3

   PEAK TIME(HRS)             PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
     14.12                          474.6                         (RUNOFF)

   RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                   .80 WATERSHED INCHES;    2216 CFS-HRS;     183.1 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   3


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
   STARTING TIME =   .00       RAIN DEPTH =  2.32       RAIN DURATION =  1.00
   ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
   ALTERNATE NO. = 1           STORM NO. = 4            RAIN TABLE NO. = 4


 OPERATION RUNOFF   XSECTION   3

   PEAK TIME(HRS)             PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
      5.23                          468.4                         (RUNOFF)

   RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                   .58 WATERSHED INCHES;    1587 CFS-HRS;     131.2 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   4


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
   STARTING TIME =   .00       RAIN DEPTH =  2.84       RAIN DURATION =  1.00
   ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
   ALTERNATE NO. = 1           STORM NO. = 5            RAIN TABLE NO. = 5


 OPERATION RUNOFF   XSECTION   3
```

```
   PEAK TIME(HRS)             PEAK DISCHARGE(CFS)          PEAK ELEVATION(FEET)
       8.13                         611.7                        (RUNOFF)

   RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                   .89 WATERSHED INCHES;    2462 CFS-HRS;     203.5 ACRE-FEET.
1
 TR20 -------------------------------------------------------------------- SCS -
                              Carsins Run                               VERSION
 11/28/**                   MD 2010 - SSURGO                           2.04TEST
 09:43:39                PASS   6   JOB NO.   1                        PAGE   3



 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   5


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
    STARTING TIME =   .00       RAIN DEPTH =  3.27       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 6            RAIN TABLE NO. = 6


 OPERATION RUNOFF   XSECTION   3

    PEAK TIME(HRS)             PEAK DISCHARGE(CFS)          PEAK ELEVATION(FEET)
      14.07                         733.0                        (RUNOFF)

    RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                  1.18 WATERSHED INCHES;    3261 CFS-HRS;     269.5 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   6


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
    STARTING TIME =   .00       RAIN DEPTH =  4.28       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 7            RAIN TABLE NO. = 7


 OPERATION RUNOFF   XSECTION   3

    PEAK TIME(HRS)             PEAK DISCHARGE(CFS)          PEAK ELEVATION(FEET)
       8.06                        1365.8                        (RUNOFF)

    RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                  1.93 WATERSHED INCHES;    5328 CFS-HRS;     440.3 ACRE-FEET.
```

```
 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   7
1
 TR20 -------------------------------------------------------------------- SCS -
                                 Carsins Run                                VERSION
 11/28/**                      MD 2010 - SSURGO                            2.04TEST
 09:43:39                   PASS   8   JOB NO.   1                         PAGE   4



 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
    STARTING TIME =   .00       RAIN DEPTH =  5.03       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 8            RAIN TABLE NO. = 8


 OPERATION RUNOFF   XSECTION   3

    PEAK TIME(HRS)             PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
       14.00                        1578.6                          (RUNOFF)

    RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                  2.53 WATERSHED INCHES;    6988 CFS-HRS;     577.5 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   8


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
    STARTING TIME =   .00       RAIN DEPTH =  8.67       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 9            RAIN TABLE NO. = 9


 OPERATION RUNOFF   XSECTION   3

    PEAK TIME(HRS)             PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
       13.95                        3206.6                          (RUNOFF)

    RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                  5.73 WATERSHED INCHES;   15813 CFS-HRS;    1306.8 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   9
1
 TR20 -------------------------------------------------------------------- SCS -
                                 Carsins Run                                VERSION
```

SUMMARY TABLE 1

SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL IN ORDER PERFORMED.
A CHARACTER FOLLOWING THE PEAK DISCHARGE TIME AND RATE (CFS) INDICATES:
F-FLAT TOP HYDROGRAPH T-TRUNCATED HYDROGRAPH R-RISING TRUNCATED HYDROGRAPH

```
XSECTION/  STANDARD                                    PEAK DISCHARGE
STRUCTURE   CONTROL    DRAINAGE   RUNOFF   ------------------------------------
   ID      OPERATION     AREA     AMOUNT   ELEVATION   TIME      RATE    RATE
                        (SQ MI)    (IN)      (FT)      (HR)     (CFS)   (CSM)

RAINFALL OF   1.91 inches AND   6.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  1,    ARC 2
MAIN TIME INCREMENT   .100 HOURS

   ALTERNATE    1   STORM    1
   ---------------------------
XSECTION   3  RUNOFF     4.27      .36        ---      5.32      282     66.0

RAINFALL OF   2.35 inches AND  12.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  2,    ARC 2

   ALTERNATE    1   STORM    2
   ---------------------------
XSECTION   3  RUNOFF     4.27      .59        ---      8.19      387     90.6

RAINFALL OF   2.70 inches AND  24.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  3,    ARC 2

   ALTERNATE    1   STORM    3
   ---------------------------
XSECTION   3  RUNOFF     4.27      .80        ---     14.12      475    111.2

RAINFALL OF   2.32 inches AND   6.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  4,    ARC 2

   ALTERNATE    1   STORM    4
   ---------------------------
XSECTION   3  RUNOFF     4.27      .58        ---      5.23      468    109.6

RAINFALL OF   2.84 inches AND  12.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  5,    ARC 2

   ALTERNATE    1   STORM    5
```

```
   ---------------------------
XSECTION   3  RUNOFF     4.27      .89        ---      8.13      612    143.3
1
TR20 -------------------------------------------------------------------- SCS -
                              Carsins Run                              VERSION
11/28/**                    MD 2010 - SSURGO                         2.04TEST
09:43:39                  SUMMARY, JOB NO.   1                       PAGE   6


                          SUMMARY TABLE 1
                          ---------------
   SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL IN ORDER PERFORMED.
   A CHARACTER FOLLOWING THE PEAK DISCHARGE TIME AND RATE (CFS) INDICATES:
F-FLAT TOP HYDROGRAPH   T-TRUNCATED HYDROGRAPH   R-RISING TRUNCATED HYDROGRAPH

XSECTION/  STANDARD                                   PEAK DISCHARGE
STRUCTURE   CONTROL    DRAINAGE   RUNOFF   ------------------------------------
   ID      OPERATION     AREA     AMOUNT   ELEVATION   TIME      RATE    RATE
                       (SQ MI)    (IN)      (FT)      (HR)      (CFS)   (CSM)


RAINFALL OF   3.27 inches AND  24.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  6,    ARC 2

   ALTERNATE    1   STORM    6
   ---------------------------
XSECTION   3  RUNOFF     4.27     1.18        ---     14.07      733    171.7

RAINFALL OF   4.28 inches AND  12.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  7,    ARC 2

   ALTERNATE    1   STORM    7
   ---------------------------
XSECTION   3  RUNOFF     4.27     1.93        ---      8.06     1366    319.9

RAINFALL OF   5.03 inches AND  24.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  8,    ARC 2

   ALTERNATE    1   STORM    8
   ---------------------------
XSECTION   3  RUNOFF     4.27     2.53        ---     14.00     1579    369.8

RAINFALL OF   8.67 inches AND  24.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  9,    ARC 2

   ALTERNATE    1   STORM    9
   ---------------------------
XSECTION   3  RUNOFF     4.27     5.73        ---     13.95     3207    751.1
```

```
1
 TR20 -------------------------------------------------------------------- SCS -
                                 Carsins Run                             VERSION
 11/28/**                      MD 2010 - SSURGO                         2.04TEST
 09:43:39                    SUMMARY, JOB NO.   1                       PAGE   7


                            SUMMARY TABLE 3
                            ---------------
      STORM DISCHARGES (CFS) AT XSECTIONS AND STRUCTURES FOR ALL ALTERNATES
      QUESTION MARK (?) AFTER: OUTFLOW PEAK - RISING TRUNCATED HYDROGRAPH.

 XSECTION/          DRAINAGE
 STRUCTURE            AREA      STORM NUMBERS..........
   ID               (SQ MI)          1         2         3         4         5


 XSECTION    3         4.27
 ---------------------------
    ALTERNATE    1                  282       387       475       468       612

                            SUMMARY TABLE 3
                            ---------------
      STORM DISCHARGES (CFS) AT XSECTIONS AND STRUCTURES FOR ALL ALTERNATES
      QUESTION MARK (?) AFTER: OUTFLOW PEAK - RISING TRUNCATED HYDROGRAPH.

 XSECTION/          DRAINAGE
 STRUCTURE            AREA      STORM NUMBERS..........
   ID               (SQ MI)          6         7         8         9


 XSECTION    3         4.27
 ---------------------------
    ALTERNATE    1                  733      1366      1579      3207
1
 TR20 -------------------------------------------------------------------- SCS -
                                 Carsins Run                             VERSION
 11/28/**                      MD 2010 - SSURGO                         2.04TEST



 END OF  1 JOBS IN THIS RUN
```

```
                SCS  TR-20,  VERSION 2.04TEST
                                 FILES

 INPUT  = tr20in.dat                              , GIVEN DATA FILE
 OUTPUT = tr20in.OUT                              , DATED 11/28/**,09:43:39

          FILES GENERATED - DATED 11/28/**,09:43:39

                           NONE!


       TOTAL NUMBER OF WARNINGS =   0,  MESSAGES =   0

                 *** TR-20 RUN COMPLETED ***
```

KCI Technologies, Inc.

TR-55 DESIGN COMPUTATIONS

By:	KTC	Project Name:	I-95 Carsins Run
Date:	1/8/2019	County:	Harford County
		Drainage Area:	Small Tributary

Project Number: 22145228.36

Existing: ■
Proposed: ☐
Ultimate: ☐

WEIGHTED RUNOFF CURVE NUMBER

Soil Group	Land Use or Zoning No.	Description	% Imperv.	RCN Table 2-2	RCN Figure 2-3	RCN Figure 2-4	Area (Acre)	RCN x Area
B	65	Woods - (good)		55			0.632	34.74
C	65	Woods - (good)		70			4.698	328.89
D	65	Woods - (good)		77			0.143	11.01
B	3	Open Space (good) - grass >75%		61			2.758	168.23
C	3	Open Space (good) - grass >75%		74			2.881	213.19
B	4	Imperv. - paved parking lots,roofs,drives	100	98			0.077	7.51
C	4	Imperv. - paved parking lots,roofs,drives	100	98			0.413	40.45

Total Square Miles: 0.01813 Total Acres: 11.60 804.03

Weighted RCN: 69.30 Use: 69

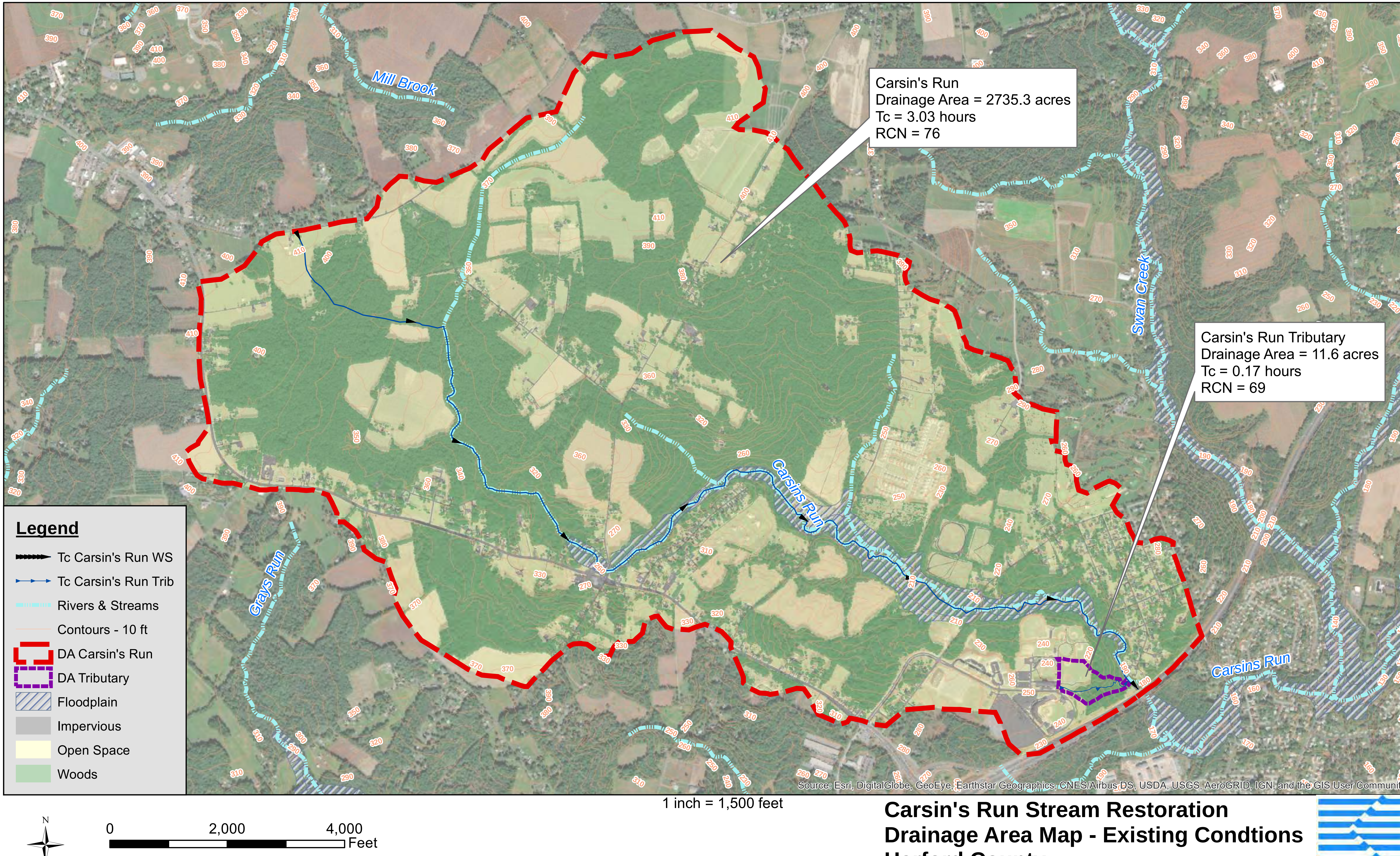
TIME OF CONCENTRATION

ID		Type of Flow		L(ft.)	n	A	WP	Slope (Percent)	Vel. (fps)	Time (Hours)
	Sheet Flow									
A-B	5	Grass - short		100	0.150			7.0		0.098
	Shallow Concentrated Flow									
B-C		paved x	unpaved	452.36				4.2	3.31	0.038
		paved	unpaved							
		paved	unpaved							
		paved	unpaved							
		paved	unpaved							
	Concentrated Flow*									
C-D	1	Channel Flow, d (ft) =	0.7	855.26	0.035	4.48	8.13	4.8	6.27	0.038
									Total	**0.174**

GRAPHICAL PEAK DISCHARGE METHOD

Initial Abstraction Ia = 0.899 in. (Table 5-1) Use Tc= 0.17 Tt=

Rainfall Freq. =	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Rainfall, P (in) =	2.7	3.2	4.2	5.0	6.2	7.3	8.5
Ia/P =	0.337	0.278	0.217	0.181	0.145	0.123	0.105
Peak csm/in. =	707	756	786	801	821	832	842
Runoff Q (in) =	0.50	0.80	1.37	1.93	2.87	3.75	4.79
Peak Dischg. (CFS)=	6.42	10.92	19.44	27.99	42.72	56.58	73.21



Carsin's Run Stream Restoration
Drainage Area Map - Existing Condtions
Harford County
KCI Job No. 22145228.47

KCI TECHNOLOGIES

```
Watershed Statistics for:
GISHydro Release Version Date: January 8, 2011
Hydro Extension Version Date:  January 8, 2011
Analysis Date:                 November 26, 2018

Data Selected:
     Quadrangles Used: aberdeen, bel_air
     DEM Coverage: NED DEMs
     Land Use Coverage: Ultimate Landuse
     Soil Coverage: SSURGO Soils
     Hydrologic Condition: (see Lookup Table)
     Impose NHD stream Locations: Yes
     Outlet Easting:        470531 m. (MD Stateplane, NAD 1983)
     Outlet Northing:       207357 m. (MD Stateplane, NAD 1983)

Findings:
     Outlet Location:       Piedmont
     Outlet State:          Maryland
     Drainage Area          4.3 square miles
       -Piedmont (100.0% of area)
     Channel Slope:         51.1 feet/mile
     Land Slope:            0.051 ft/ft
     Urban Area:            7.8%
     Impervious Area:       4.0%
 ******************************************************
     Watershed is within 5km of physiographic
     province boundary.  You should consider
     sensitivity of discharges to region location.
 ******************************************************
     Time of Concentration: 3.9 hours  [W.O. Thomas, Jr. Equation]
     Time of Concentration: 3.5 hours  [From SCS Lag Equation * 1.67]
     Longest Flow Path:     4.81 miles
     Basin Relief:          354.1 feet
     Average CN:            76
     % Forest Cover:        44.3
     % Storage:             0.0
     % Limestone:           0.0
     Selected Soils Data Statistics:
        % A Soils:          0.6
        % B Soils:          26.6
        % C Soils:          46.6
        % D Soils:          26.2
     SSURGO Soils Data Statistics (used in Regression Equations):
        % A Soils:          0.6
        % B Soils:          26.6
        % C Soils:          46.6
        % D Soils:          26.2
     2-Year,24-hour Prec.:  3.27 inches
```

Mean Annual Prec.:   46.24 inches

GISHydro Release Version Date: January 8, 2011
Hydro Extension Version Date: January 8, 2011
Analysis Date: November 26, 2018

Landuse and Soil Distributions for:

Distribution of Landuse by Soil Group

Land Use	Acres on Indicated Soil Group A-Soil	B-Soil	C-Soil	D-Soil
Low Density Residential	0.22	57.82	74.72	30.02
Medium Density Residential	3.56	16.23	3.78	2.67
Commercial	1.78	10.01	10.01	3.56
Open Urban Land	0	18.68	15.35	0.44
Cropland	4.23	339.6	471.7	138.11
Pasture	0	20.46	18.01	11.34
Orchards	0	0	0.89	0
Deciduous Forest	1.11	146.78	569.33	477.92
Brush	5.12	0.22	7.56	4.45
Res.: 2.00 ac <=x	0	108.31	101.19	44.92
Agricultural Buildings	0	10.9	1.33	3.11
Total Area:	16.01	729.01	1273.87	716.55

Distribution of Land Use and Curve Numbers Used

Land Use	Acres	Percent	A	B	C	D
Low Density Residential	162.79	5.95	54	70	80	85
Medium Density Residential	26.24	0.96	61	75	83	87
Commercial	25.58	0.93	89	92	94	95
Open Urban Land	34.47	1.26	39	61	74	80
Cropland	954.07	34.87	67	78	85	89
Pasture	49.82	1.82	39	61	74	80
Orchards	0.89	0.03	32	58	72	79
Deciduous Forest	1195.37	43.68	30	55	70	77
Brush	17.35	0.63	30	48	65	73
Res.: 2.00 ac <=x	254.42	9.3	46	65	77	82
Agricultural Buildings	15.35	0.56	59	74	82	86

```
 *****************80-80 LIST OF INPUT DATA FOR TR-20 HYDROLOGY******************

 JOB TR-20                                                  NOPLOTS
 TITLE     Carsins Run
 TITLE     Ultimate Land Use - SSURGO
  6 RUNOFF 1   3       1       4.2740      75.82        3.0363         1
  5 RAINFL 1             .1
  8          0.0000      0.0064      0.0129      0.0193      0.0257
  8          0.0321      0.0386      0.0450      0.0514      0.0578
  8          0.0643      0.0707      0.0771      0.0835      0.0900
  8          0.0964      0.1023      0.1082      0.1141      0.1200
  8          0.1260      0.1391      0.1522      0.1653      0.1784
  8          0.1915      0.2160      0.2404      0.2794      0.3412
  8          0.5000      0.6588      0.7206      0.7596      0.7840
  8          0.8085      0.8216      0.8347      0.8478      0.8609
  8          0.8740      0.8800      0.8859      0.8918      0.8977
  8          0.9036      0.9100      0.9165      0.9229      0.9293
  8          0.9357      0.9422      0.9486      0.9550      0.9614
  8          0.9679      0.9743      0.9807      0.9871      0.9936
  8          1.0000      1.0000      1.0000      1.0000      1.0000
  9 ENDTBL
  5 RAINFL 2             .1
  8          0.0000      0.0031      0.0062      0.0093      0.0124
  8          0.0155      0.0186      0.0216      0.0247      0.0278
  8          0.0309      0.0340      0.0371      0.0402      0.0433
  8          0.0464      0.0495      0.0526      0.0557      0.0588
  8          0.0619      0.0649      0.0680      0.0711      0.0742
  8          0.0773      0.0804      0.0835      0.0866      0.0897
  8          0.0928      0.0980      0.1032      0.1085      0.1137
  8          0.1189      0.1242      0.1294      0.1346      0.1399
  8          0.1451      0.1503      0.1556      0.1608      0.1660
  8          0.1713      0.1761      0.1809      0.1857      0.1905
  8          0.1954      0.2060      0.2167      0.2274      0.2381
  8          0.2488      0.2687      0.2885      0.3203      0.3706
  8          0.5000      0.6294      0.6797      0.7115      0.7313
  8          0.7512      0.7619      0.7726      0.7833      0.7940
  8          0.8046      0.8095      0.8143      0.8191      0.8239
  8          0.8287      0.8340      0.8392      0.8444      0.8497
  8          0.8549      0.8601      0.8654      0.8706      0.8758
  8          0.8811      0.8863      0.8915      0.8968      0.9020
  8          0.9072      0.9103      0.9134      0.9165      0.9196
  8          0.9227      0.9258      0.9289      0.9320      0.9351
  8          0.9381      0.9412      0.9443      0.9474      0.9505
  8          0.9536      0.9567      0.9598      0.9629      0.9660
```

```
  8          0.9691      0.9722      0.9753      0.9784      0.9814
  8          0.9845      0.9876      0.9907      0.9938      0.9969
  8          1.0000      1.0000      1.0000      1.0000      1.0000
  9 ENDTBL
  5 RAINFL 3              .1
  8          0.0000      0.0011      0.0022      0.0033      0.0044
  8          0.0055      0.0066      0.0077      0.0088      0.0099
  8          0.0110      0.0121      0.0132      0.0143      0.0154
1
```

********************80-80 LIST OF INPUT DATA (CONTINUED)*********************

```
  8          0.0165      0.0176      0.0187      0.0198      0.0209
  8          0.0220      0.0231      0.0242      0.0253      0.0264
  8          0.0275      0.0286      0.0297      0.0308      0.0319
  8          0.0330      0.0341      0.0352      0.0363      0.0374
  8          0.0385      0.0396      0.0407      0.0418      0.0429
  8          0.0440      0.0451      0.0462      0.0473      0.0484
  8          0.0495      0.0506      0.0518      0.0529      0.0540
  8          0.0551      0.0562      0.0573      0.0584      0.0595
  8          0.0606      0.0617      0.0628      0.0639      0.0650
  8          0.0661      0.0687      0.0714      0.0741      0.0768
  8          0.0795      0.0822      0.0849      0.0875      0.0902
  8          0.0929      0.0956      0.0983      0.1010      0.1036
  8          0.1063      0.1090      0.1117      0.1144      0.1171
  8          0.1197      0.1224      0.1251      0.1278      0.1305
  8          0.1332      0.1358      0.1385      0.1412      0.1439
  8          0.1466      0.1511      0.1557      0.1602      0.1647
  8          0.1693      0.1738      0.1784      0.1829      0.1875
  8          0.1920      0.1965      0.2011      0.2056      0.2102
  8          0.2147      0.2189      0.2231      0.2273      0.2314
  8          0.2356      0.2449      0.2542      0.2634      0.2727
  8          0.2820      0.2992      0.3165      0.3440      0.3877
  8          0.5000      0.6123      0.6560      0.6835      0.7008
  8          0.7180      0.7273      0.7366      0.7458      0.7551
  8          0.7644      0.7686      0.7727      0.7769      0.7811
  8          0.7853      0.7898      0.7944      0.7989      0.8035
  8          0.8080      0.8125      0.8171      0.8216      0.8262
  8          0.8307      0.8353      0.8398      0.8443      0.8489
  8          0.8534      0.8561      0.8588      0.8615      0.8642
  8          0.8668      0.8695      0.8722      0.8749      0.8776
  8          0.8803      0.8829      0.8856      0.8883      0.8910
  8          0.8937      0.8964      0.8990      0.9017      0.9044
  8          0.9071      0.9098      0.9125      0.9151      0.9178
  8          0.9205      0.9232      0.9259      0.9286      0.9313
  8          0.9339      0.9350      0.9361      0.9372      0.9383
```

```
  8          0.9394      0.9405      0.9416      0.9427      0.9438
  8          0.9449      0.9460      0.9471      0.9482      0.9494
  8          0.9505      0.9516      0.9527      0.9538      0.9549
  8          0.9560      0.9571      0.9582      0.9593      0.9604
  8          0.9615      0.9626      0.9637      0.9648      0.9659
  8          0.9670      0.9681      0.9692      0.9703      0.9714
  8          0.9725      0.9736      0.9747      0.9758      0.9769
  8          0.9780      0.9791      0.9802      0.9813      0.9824
  8          0.9835      0.9846      0.9857      0.9868      0.9879
  8          0.9890      0.9901      0.9912      0.9923      0.9934
  8          0.9945      0.9956      0.9967      0.9978      0.9989
  8          1.0000      1.0000      1.0000      1.0000      1.0000
  9 ENDTBL
  5 RAINFL 4            .1
  8          0.0000      0.0063      0.0125      0.0188      0.0251
  8          0.0313      0.0376      0.0439      0.0501      0.0564
1


 ********************80-80 LIST OF INPUT DATA (CONTINUED)*********************

  8          0.0627      0.0689      0.0752      0.0815      0.0877
  8          0.0940      0.1001      0.1062      0.1122      0.1183
  8          0.1244      0.1374      0.1505      0.1635      0.1765
  8          0.1895      0.2147      0.2400      0.2799      0.3428
  8          0.5000      0.6572      0.7201      0.7600      0.7853
  8          0.8105      0.8235      0.8365      0.8495      0.8626
  8          0.8756      0.8817      0.8878      0.8938      0.8999
  8          0.9060      0.9123      0.9185      0.9248      0.9311
  8          0.9373      0.9436      0.9499      0.9561      0.9624
  8          0.9687      0.9749      0.9812      0.9875      0.9937
  8          1.0000      1.0000      1.0000      1.0000      1.0000
  9 ENDTBL
  5 RAINFL 5            .1
  8          0.0000      0.0031      0.0061      0.0092      0.0123
  8          0.0154      0.0184      0.0215      0.0246      0.0277
  8          0.0307      0.0338      0.0369      0.0400      0.0430
  8          0.0461      0.0492      0.0522      0.0553      0.0584
  8          0.0615      0.0645      0.0676      0.0707      0.0738
  8          0.0768      0.0799      0.0830      0.0861      0.0891
  8          0.0922      0.0973      0.1024      0.1075      0.1127
  8          0.1178      0.1229      0.1280      0.1331      0.1382
  8          0.1433      0.1484      0.1535      0.1587      0.1638
  8          0.1689      0.1738      0.1788      0.1838      0.1887
  8          0.1937      0.2043      0.2149      0.2255      0.2362
  8          0.2468      0.2673      0.2879      0.3205      0.3718
  8          0.5000      0.6282      0.6795      0.7121      0.7327
```

```
  8          0.7532     0.7638     0.7745     0.7851     0.7957
  8          0.8063     0.8113     0.8162     0.8212     0.8262
  8          0.8311     0.8362     0.8413     0.8465     0.8516
  8          0.8567     0.8618     0.8669     0.8720     0.8771
  8          0.8822     0.8873     0.8925     0.8976     0.9027
  8          0.9078     0.9109     0.9139     0.9170     0.9201
  8          0.9232     0.9262     0.9293     0.9324     0.9355
  8          0.9385     0.9416     0.9447     0.9478     0.9508
  8          0.9539     0.9570     0.9600     0.9631     0.9662
  8          0.9693     0.9723     0.9754     0.9785     0.9816
  8          0.9846     0.9877     0.9908     0.9939     0.9969
  8          1.0000     1.0000     1.0000     1.0000     1.0000
  9 ENDTBL
  5 RAINFL 6           .1
  8          0.0000     0.0011     0.0022     0.0033     0.0044
  8          0.0055     0.0066     0.0077     0.0088     0.0099
  8          0.0109     0.0120     0.0131     0.0142     0.0153
  8          0.0164     0.0175     0.0186     0.0197     0.0208
  8          0.0219     0.0230     0.0241     0.0252     0.0263
  8          0.0274     0.0285     0.0296     0.0307     0.0317
  8          0.0328     0.0339     0.0350     0.0361     0.0372
  8          0.0383     0.0394     0.0405     0.0416     0.0427
  8          0.0438     0.0449     0.0460     0.0471     0.0482
  8          0.0493     0.0504     0.0515     0.0525     0.0536
1


 ********************80-80 LIST OF INPUT DATA (CONTINUED)*********************

  8          0.0547     0.0558     0.0569     0.0580     0.0591
  8          0.0602     0.0613     0.0624     0.0635     0.0646
  8          0.0657     0.0684     0.0710     0.0737     0.0764
  8          0.0790     0.0817     0.0844     0.0870     0.0897
  8          0.0924     0.0950     0.0977     0.1004     0.1031
  8          0.1057     0.1084     0.1111     0.1137     0.1164
  8          0.1191     0.1217     0.1244     0.1271     0.1298
  8          0.1324     0.1351     0.1378     0.1404     0.1431
  8          0.1458     0.1502     0.1547     0.1591     0.1635
  8          0.1680     0.1724     0.1769     0.1813     0.1857
  8          0.1902     0.1946     0.1991     0.2035     0.2079
  8          0.2124     0.2167     0.2210     0.2253     0.2296
  8          0.2339     0.2431     0.2524     0.2616     0.2708
  8          0.2800     0.2979     0.3158     0.3441     0.3886
  8          0.5000     0.6114     0.6559     0.6842     0.7021
  8          0.7200     0.7292     0.7384     0.7476     0.7569
  8          0.7661     0.7704     0.7747     0.7790     0.7833
  8          0.7876     0.7921     0.7965     0.8009     0.8054
```

```
  8          0.8098     0.8143     0.8187     0.8231     0.8276
  8          0.8320     0.8365     0.8409     0.8453     0.8498
  8          0.8542     0.8569     0.8596     0.8622     0.8649
  8          0.8676     0.8702     0.8729     0.8756     0.8783
  8          0.8809     0.8836     0.8863     0.8889     0.8916
  8          0.8943     0.8969     0.8996     0.9023     0.9050
  8          0.9076     0.9103     0.9130     0.9156     0.9183
  8          0.9210     0.9236     0.9263     0.9290     0.9316
  8          0.9343     0.9354     0.9365     0.9376     0.9387
  8          0.9398     0.9409     0.9420     0.9431     0.9442
  8          0.9453     0.9464     0.9475     0.9485     0.9496
  8          0.9507     0.9518     0.9529     0.9540     0.9551
  8          0.9562     0.9573     0.9584     0.9595     0.9606
  8          0.9617     0.9628     0.9639     0.9650     0.9661
  8          0.9672     0.9683     0.9693     0.9704     0.9715
  8          0.9726     0.9737     0.9748     0.9759     0.9770
  8          0.9781     0.9792     0.9803     0.9814     0.9825
  8          0.9836     0.9847     0.9858     0.9869     0.9880
  8          0.9891     0.9901     0.9912     0.9923     0.9934
  8          0.9945     0.9956     0.9967     0.9978     0.9989
  8          1.0000     1.0000     1.0000     1.0000     1.0000
  9 ENDTBL
  5 RAINFL 7             .1
  8          0.0000     0.0033     0.0066     0.0099     0.0132
  8          0.0165     0.0198     0.0232     0.0265     0.0298
  8          0.0331     0.0364     0.0397     0.0430     0.0463
  8          0.0496     0.0529     0.0562     0.0595     0.0629
  8          0.0662     0.0695     0.0728     0.0761     0.0794
  8          0.0827     0.0860     0.0893     0.0926     0.0959
  8          0.0992     0.1044     0.1095     0.1146     0.1197
  8          0.1249     0.1300     0.1351     0.1402     0.1454
  8          0.1505     0.1556     0.1607     0.1659     0.1710
1


 ********************80-80 LIST OF INPUT DATA (CONTINUED)*********************

  8          0.1761     0.1812     0.1863     0.1914     0.1966
  8          0.2017     0.2127     0.2238     0.2348     0.2459
  8          0.2570     0.2795     0.3021     0.3365     0.3874
  8          0.5000     0.6126     0.6635     0.6979     0.7205
  8          0.7430     0.7541     0.7652     0.7762     0.7873
  8          0.7983     0.8034     0.8086     0.8137     0.8188
  8          0.8239     0.8290     0.8341     0.8393     0.8444
  8          0.8495     0.8546     0.8598     0.8649     0.8700
  8          0.8751     0.8803     0.8854     0.8905     0.8956
  8          0.9008     0.9041     0.9074     0.9107     0.9140
```

```
  8          0.9173      0.9206      0.9239      0.9272      0.9305
  8          0.9338      0.9371      0.9405      0.9438      0.9471
  8          0.9504      0.9537      0.9570      0.9603      0.9636
  8          0.9669      0.9702      0.9735      0.9768      0.9802
  8          0.9835      0.9868      0.9901      0.9934      0.9967
  8          1.0000      1.0000      1.0000      1.0000      1.0000
  9 ENDTBL
  5 RAINFL 8             .1
  8          0.0000      0.0012      0.0025      0.0037      0.0050
  8          0.0062      0.0075      0.0087      0.0100      0.0112
  8          0.0125      0.0137      0.0150      0.0162      0.0175
  8          0.0187      0.0200      0.0212      0.0225      0.0237
  8          0.0249      0.0262      0.0274      0.0287      0.0299
  8          0.0312      0.0324      0.0337      0.0349      0.0362
  8          0.0374      0.0387      0.0399      0.0412      0.0424
  8          0.0437      0.0449      0.0462      0.0474      0.0487
  8          0.0499      0.0511      0.0524      0.0536      0.0549
  8          0.0561      0.0574      0.0586      0.0599      0.0611
  8          0.0624      0.0636      0.0649      0.0661      0.0674
  8          0.0686      0.0699      0.0711      0.0724      0.0736
  8          0.0748      0.0777      0.0805      0.0833      0.0861
  8          0.0889      0.0917      0.0945      0.0974      0.1002
  8          0.1030      0.1058      0.1086      0.1114      0.1142
  8          0.1170      0.1199      0.1227      0.1255      0.1283
  8          0.1311      0.1339      0.1367      0.1395      0.1424
  8          0.1452      0.1480      0.1508      0.1536      0.1564
  8          0.1592      0.1636      0.1680      0.1723      0.1767
  8          0.1810      0.1854      0.1897      0.1941      0.1985
  8          0.2028      0.2072      0.2115      0.2159      0.2202
  8          0.2246      0.2289      0.2333      0.2376      0.2420
  8          0.2463      0.2557      0.2651      0.2745      0.2839
  8          0.2934      0.3125      0.3317      0.3610      0.4042
  8          0.5000      0.5958      0.6390      0.6683      0.6875
  8          0.7066      0.7161      0.7255      0.7349      0.7443
  8          0.7537      0.7580      0.7624      0.7667      0.7711
  8          0.7754      0.7798      0.7841      0.7885      0.7928
  8          0.7972      0.8015      0.8059      0.8103      0.8146
  8          0.8190      0.8233      0.8277      0.8320      0.8364
  8          0.8408      0.8436      0.8464      0.8492      0.8520
  8          0.8548      0.8576      0.8605      0.8633      0.8661
1


 ********************80-80 LIST OF INPUT DATA (CONTINUED)*********************

  8          0.8689      0.8717      0.8745      0.8773      0.8801
  8          0.8830      0.8858      0.8886      0.8914      0.8942
```

```
8          0.8970     0.8998     0.9026     0.9055     0.9083
8          0.9111     0.9139     0.9167     0.9195     0.9223
8          0.9252     0.9264     0.9276     0.9289     0.9301
8          0.9314     0.9326     0.9339     0.9351     0.9364
8          0.9376     0.9389     0.9401     0.9414     0.9426
8          0.9439     0.9451     0.9464     0.9476     0.9489
8          0.9501     0.9513     0.9526     0.9538     0.9551
8          0.9563     0.9576     0.9588     0.9601     0.9613
8          0.9626     0.9638     0.9651     0.9663     0.9676
8          0.9688     0.9701     0.9713     0.9726     0.9738
8          0.9751     0.9763     0.9775     0.9788     0.9800
8          0.9813     0.9825     0.9838     0.9850     0.9863
8          0.9875     0.9888     0.9900     0.9913     0.9925
8          0.9938     0.9950     0.9963     0.9975     0.9988
8          1.0000     1.0000     1.0000     1.0000     1.0000
9 ENDTBL
5 RAINFL 9             .1
8          0.0000     0.0015     0.0029     0.0044     0.0059
8          0.0073     0.0088     0.0103     0.0117     0.0132
8          0.0147     0.0161     0.0176     0.0191     0.0205
8          0.0220     0.0234     0.0249     0.0264     0.0278
8          0.0293     0.0308     0.0322     0.0337     0.0352
8          0.0366     0.0381     0.0396     0.0410     0.0425
8          0.0440     0.0454     0.0469     0.0484     0.0498
8          0.0513     0.0528     0.0542     0.0557     0.0572
8          0.0586     0.0601     0.0615     0.0630     0.0645
8          0.0659     0.0674     0.0689     0.0703     0.0718
8          0.0733     0.0747     0.0762     0.0777     0.0791
8          0.0806     0.0821     0.0835     0.0850     0.0865
8          0.0879     0.0912     0.0944     0.0976     0.1008
8          0.1041     0.1073     0.1105     0.1138     0.1170
8          0.1202     0.1234     0.1267     0.1299     0.1331
8          0.1364     0.1396     0.1428     0.1460     0.1493
8          0.1525     0.1557     0.1589     0.1622     0.1654
8          0.1686     0.1719     0.1751     0.1783     0.1815
8          0.1848     0.1895     0.1941     0.1988     0.2035
8          0.2082     0.2128     0.2175     0.2222     0.2269
8          0.2315     0.2362     0.2409     0.2456     0.2502
8          0.2549     0.2593     0.2637     0.2681     0.2725
8          0.2769     0.2867     0.2966     0.3064     0.3163
8          0.3261     0.3452     0.3642     0.3913     0.4279
8          0.5000     0.5721     0.6087     0.6358     0.6548
8          0.6739     0.6837     0.6936     0.7034     0.7133
8          0.7231     0.7275     0.7319     0.7363     0.7407
8          0.7451     0.7498     0.7544     0.7591     0.7638
8          0.7685     0.7731     0.7778     0.7825     0.7872
8          0.7918     0.7965     0.8012     0.8059     0.8105
8          0.8152     0.8185     0.8217     0.8249     0.8281
```

```
 ********************80-80 LIST OF INPUT DATA (CONTINUED)*********************

 8          0.8314      0.8346      0.8378      0.8411      0.8443
 8          0.8475      0.8507      0.8540      0.8572      0.8604
 8          0.8636      0.8669      0.8701      0.8733      0.8766
 8          0.8798      0.8830      0.8862      0.8895      0.8927
 8          0.8959      0.8992      0.9024      0.9056      0.9088
 8          0.9121      0.9135      0.9150      0.9165      0.9179
 8          0.9194      0.9209      0.9223      0.9238      0.9253
 8          0.9267      0.9282      0.9297      0.9311      0.9326
 8          0.9341      0.9355      0.9370      0.9385      0.9399
 8          0.9414      0.9428      0.9443      0.9458      0.9472
 8          0.9487      0.9502      0.9516      0.9531      0.9546
 8          0.9560      0.9575      0.9590      0.9604      0.9619
 8          0.9634      0.9648      0.9663      0.9678      0.9692
 8          0.9707      0.9722      0.9736      0.9751      0.9766
 8          0.9780      0.9795      0.9809      0.9824      0.9839
 8          0.9853      0.9868      0.9883      0.9897      0.9912
 8          0.9927      0.9941      0.9956      0.9971      0.9985
 8          1.0000      1.0000      1.0000      1.0000      1.0000
 9 ENDTBL
   ENDATA
 7 INCREM 6                     0.1
 7 COMPUT 7   3     3           0.0        1.91         1.01 2  1   1
   ENDCMP 1
 7 COMPUT 7   3     3           0.0        2.35         1.02 2  1   2
   ENDCMP 1
 7 COMPUT 7   3     3           0.0        2.70         1.03 2  1   3
   ENDCMP 1
 7 COMPUT 7   3     3           0.0        2.32         1.04 2  1   4
   ENDCMP 1
 7 COMPUT 7   3     3           0.0        2.84         1.05 2  1   5
   ENDCMP 1
 7 COMPUT 7   3     3           0.0        3.27         1.06 2  1   6
   ENDCMP 1
 7 COMPUT 7   3     3           0.0        4.28         1.07 2  1   7
   ENDCMP 1
 7 COMPUT 7   3     3           0.0        5.03         1.08 2  1   8
   ENDCMP 1
 7 COMPUT 7   3     3           0.0        8.67         1.09 2  1   9
   ENDCMP 1
   ENDJOB 2

 *******************************END OF 80-80 LIST*******************************
```

```
1
 TR20 -------------------------------------------------------------------- SCS -
                                 Carsins Run                              VERSION
 11/28/**                   Ultimate Land Use - SSURGO                   2.04TEST
 09:45:54                     PASS   1   JOB NO.   1                     PAGE   1



 EXECUTIVE CONTROL INCREM    MAIN TIME INCREMENT =   .100 HOURS


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
    STARTING TIME =   .00       RAIN DEPTH =  1.91       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 1            RAIN TABLE NO. = 1


 OPERATION RUNOFF   XSECTION   3

    PEAK TIME(HRS)             PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
        5.31                         285.8                        (RUNOFF)

    RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                    .36 WATERSHED INCHES;    1000 CFS-HRS;      82.7 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   1


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
    STARTING TIME =   .00       RAIN DEPTH =  2.35       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 2            RAIN TABLE NO. = 2


 OPERATION RUNOFF   XSECTION   3

    PEAK TIME(HRS)             PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
        8.18                         390.9                        (RUNOFF)

    RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                    .60 WATERSHED INCHES;    1650 CFS-HRS;     136.3 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   2


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
```

```
   STARTING TIME =   .00       RAIN DEPTH =  2.70       RAIN DURATION =  1.00
   ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
   ALTERNATE NO. = 1           STORM NO. = 3            RAIN TABLE NO. = 3
1
 TR20 ------------------------------------------------------------------- SCS -
                                Carsins Run                              VERSION
 11/28/**                Ultimate Land Use - SSURGO                     2.04TEST
 09:45:54                  PASS   3   JOB NO.   1                       PAGE   2



 OPERATION RUNOFF   XSECTION   3

   PEAK TIME(HRS)            PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
      14.11                        479.2                          (RUNOFF)

   RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                   .81 WATERSHED INCHES;    2233 CFS-HRS;     184.6 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   3


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
   STARTING TIME =   .00       RAIN DEPTH =  2.32       RAIN DURATION =  1.00
   ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
   ALTERNATE NO. = 1           STORM NO. = 4            RAIN TABLE NO. = 4


 OPERATION RUNOFF   XSECTION   3

   PEAK TIME(HRS)            PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
       5.23                        473.1                          (RUNOFF)

   RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                   .58 WATERSHED INCHES;    1602 CFS-HRS;     132.4 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   4


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
   STARTING TIME =   .00       RAIN DEPTH =  2.84       RAIN DURATION =  1.00
   ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
   ALTERNATE NO. = 1           STORM NO. = 5            RAIN TABLE NO. = 5


 OPERATION RUNOFF   XSECTION   3
```

```
   PEAK TIME(HRS)             PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
       8.13                        617.1                       (RUNOFF)

   RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                   .90 WATERSHED INCHES;    2481 CFS-HRS;     205.0 ACRE-FEET.
1
 TR20 ------------------------------------------------------------------- SCS -
                                 Carsins Run                             VERSION
 11/28/**                 Ultimate Land Use - SSURGO                   2.04TEST
 09:45:54                   PASS   6   JOB NO.   1                     PAGE   3



 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   5


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
    STARTING TIME =   .00       RAIN DEPTH =  3.27       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 6            RAIN TABLE NO. = 6


 OPERATION RUNOFF   XSECTION   3

    PEAK TIME(HRS)             PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
      14.07                        738.8                       (RUNOFF)

    RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                  1.19 WATERSHED INCHES;    3283 CFS-HRS;     271.3 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   6


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
    STARTING TIME =   .00       RAIN DEPTH =  4.28       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 7            RAIN TABLE NO. = 7


 OPERATION RUNOFF   XSECTION   3

    PEAK TIME(HRS)             PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
       8.06                       1373.7                       (RUNOFF)

    RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                  1.94 WATERSHED INCHES;    5356 CFS-HRS;     442.6 ACRE-FEET.
```

```
 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   7
1
 TR20 -------------------------------------------------------------------- SCS -
                                 Carsins Run                               VERSION
 11/28/**                Ultimate Land Use - SSURGO                       2.04TEST
 09:45:54                  PASS   8   JOB NO.   1                         PAGE   4



 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
    STARTING TIME =   .00       RAIN DEPTH =  5.03       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 8            RAIN TABLE NO. = 8


 OPERATION RUNOFF   XSECTION   3

    PEAK TIME(HRS)             PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
       14.00                        1586.3                       (RUNOFF)

    RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                  2.54 WATERSHED INCHES;    7020 CFS-HRS;     580.1 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   8


 EXECUTIVE CONTROL COMPUT    FROM XSECTION   3  TO XSECTION   3
    STARTING TIME =   .00       RAIN DEPTH =  8.67       RAIN DURATION =  1.00
    ANT. RUNOFF COND. = 2       MAIN TIME INCREMENT =   .100 HOURS
    ALTERNATE NO. = 1           STORM NO. = 9            RAIN TABLE NO. = 9


 OPERATION RUNOFF   XSECTION   3

    PEAK TIME(HRS)             PEAK DISCHARGE(CFS)         PEAK ELEVATION(FEET)
       13.95                        3215.1                       (RUNOFF)

    RUNOFF ABOVE BASEFLOW  (BASEFLOW =    .00 CFS)
                  5.75 WATERSHED INCHES;   15857 CFS-HRS;    1310.4 ACRE-FEET.


 EXECUTIVE CONTROL ENDCMP    COMPUTATIONS COMPLETED FOR PASS   9
1
 TR20 -------------------------------------------------------------------- SCS -
                                 Carsins Run                               VERSION
```

SUMMARY TABLE 1

SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL IN ORDER PERFORMED.
A CHARACTER FOLLOWING THE PEAK DISCHARGE TIME AND RATE (CFS) INDICATES:
F-FLAT TOP HYDROGRAPH   T-TRUNCATED HYDROGRAPH   R-RISING TRUNCATED HYDROGRAPH

```
XSECTION/  STANDARD                                    PEAK DISCHARGE
STRUCTURE   CONTROL    DRAINAGE   RUNOFF   ------------------------------------
   ID      OPERATION     AREA     AMOUNT   ELEVATION   TIME      RATE    RATE
                        (SQ MI)    (IN)       (FT)      (HR)     (CFS)   (CSM)

RAINFALL OF   1.91 inches AND   6.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  1,    ARC 2
MAIN TIME INCREMENT   .100 HOURS

   ALTERNATE    1   STORM    1
   ---------------------------
XSECTION   3  RUNOFF     4.27      .36        ---      5.31      286     67.0

RAINFALL OF   2.35 inches AND  12.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  2,    ARC 2

   ALTERNATE    1   STORM    2
   ---------------------------
XSECTION   3  RUNOFF     4.27      .60        ---      8.18      391     91.6

RAINFALL OF   2.70 inches AND  24.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  3,    ARC 2

   ALTERNATE    1   STORM    3
   ---------------------------
XSECTION   3  RUNOFF     4.27      .81        ---     14.11      479    112.2

RAINFALL OF   2.32 inches AND   6.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  4,    ARC 2

   ALTERNATE    1   STORM    4
   ---------------------------
XSECTION   3  RUNOFF     4.27      .58        ---      5.23      473    110.8

RAINFALL OF   2.84 inches AND  12.00 hr DURATION, BEGINS AT    .0 hrs.
RAINTABLE NUMBER  5,    ARC 2

   ALTERNATE    1   STORM    5
```

```
    ---------------------------
 XSECTION   3  RUNOFF     4.27      .90        ---      8.13      617    144.5
1
 TR20 -------------------------------------------------------------------- SCS -
                                  Carsins Run                             VERSION
 11/28/**                  Ultimate Land Use - SSURGO                    2.04TEST
 09:45:54                     SUMMARY, JOB NO.   1                       PAGE   6


                               SUMMARY TABLE 1
                               ---------------
    SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL IN ORDER PERFORMED.
    A CHARACTER FOLLOWING THE PEAK DISCHARGE TIME AND RATE (CFS) INDICATES:
 F-FLAT TOP HYDROGRAPH   T-TRUNCATED HYDROGRAPH   R-RISING TRUNCATED HYDROGRAPH

 XSECTION/  STANDARD                                   PEAK DISCHARGE
 STRUCTURE   CONTROL    DRAINAGE   RUNOFF   ------------------------------------
    ID      OPERATION     AREA     AMOUNT   ELEVATION   TIME      RATE    RATE
                        (SQ MI)    (IN)      (FT)      (HR)      (CFS)   (CSM)


 RAINFALL OF   3.27 inches AND  24.00 hr DURATION, BEGINS AT    .0 hrs.
 RAINTABLE NUMBER  6,    ARC 2

    ALTERNATE    1   STORM    6
    ---------------------------
 XSECTION   3  RUNOFF     4.27     1.19        ---     14.07      739    173.1

 RAINFALL OF   4.28 inches AND  12.00 hr DURATION, BEGINS AT    .0 hrs.
 RAINTABLE NUMBER  7,    ARC 2

    ALTERNATE    1   STORM    7
    ---------------------------
 XSECTION   3  RUNOFF     4.27     1.94        ---      8.06     1374    321.8

 RAINFALL OF   5.03 inches AND  24.00 hr DURATION, BEGINS AT    .0 hrs.
 RAINTABLE NUMBER  8,    ARC 2

    ALTERNATE    1   STORM    8
    ---------------------------
 XSECTION   3  RUNOFF     4.27     2.54        ---     14.00     1586    371.4

 RAINFALL OF   8.67 inches AND  24.00 hr DURATION, BEGINS AT    .0 hrs.
 RAINTABLE NUMBER  9,    ARC 2

    ALTERNATE    1   STORM    9
    ---------------------------
 XSECTION   3  RUNOFF     4.27     5.75        ---     13.95     3215    752.9
```

```
1
 TR20 -------------------------------------------------------------------- SCS -
                              Carsins Run                                VERSION
 11/28/**                 Ultimate Land Use - SSURGO                    2.04TEST
 09:45:54                    SUMMARY, JOB NO.   1                       PAGE   7


                                SUMMARY TABLE 3
                                ---------------
      STORM DISCHARGES (CFS) AT XSECTIONS AND STRUCTURES FOR ALL ALTERNATES
      QUESTION MARK (?) AFTER: OUTFLOW PEAK - RISING TRUNCATED HYDROGRAPH.

 XSECTION/          DRAINAGE
 STRUCTURE            AREA      STORM NUMBERS..........
   ID               (SQ MI)         1         2         3         4         5


 XSECTION    3         4.27
 ---------------------------
    ALTERNATE    1                 286       391       479       473       617

                                SUMMARY TABLE 3
                                ---------------
      STORM DISCHARGES (CFS) AT XSECTIONS AND STRUCTURES FOR ALL ALTERNATES
      QUESTION MARK (?) AFTER: OUTFLOW PEAK - RISING TRUNCATED HYDROGRAPH.

 XSECTION/          DRAINAGE
 STRUCTURE            AREA      STORM NUMBERS..........
   ID               (SQ MI)         6         7         8         9


 XSECTION    3         4.27
 ---------------------------
    ALTERNATE    1                 739      1374      1586      3215
1
 TR20 -------------------------------------------------------------------- SCS -
                              Carsins Run                                VERSION
 11/28/**                 Ultimate Land Use - SSURGO                    2.04TEST



 END OF  1 JOBS IN THIS RUN
```

```
                SCS  TR-20,  VERSION 2.04TEST
                                 FILES

 INPUT  = tr20in.dat                              , GIVEN DATA FILE
 OUTPUT = tr20in.OUT                              , DATED 11/28/**,09:45:54

          FILES GENERATED - DATED 11/28/**,09:45:54

                           NONE!


      TOTAL NUMBER OF WARNINGS =   0,  MESSAGES =   0

                *** TR-20 RUN COMPLETED ***
```

KCI Technologies, Inc.

TR-55 DESIGN COMPUTATIONS

By:	KTC	Project Name:	I-95 Carsins Run	Project Number:	22145228.36
Date:	1/8/2019	County:	Harford County		
		Drainage Area:	Small Tributary	Proposed:	
				Proposed:	
				Ultimate:	

WEIGHTED RUNOFF CURVE NUMBER

Soil Group	Land Use or Zoning No.	Description	% Imperv.	RCN Table 2-2	RCN Figure 2-3	RCN Figure 2-4	Area (Acre)	RCN x Area
B	60	Woods/Grass combination - (poor)		73			0.576	42.06
B	11	Urban district - commercial/business	85	92			2.890	265.88
C	60	Woods/Grass combination - (poor)		82			3.405	279.20
C	11	Urban district - commercial/business	85	94			4.587	431.21
D	60	Woods/Grass combination - (poor)		86			0.143	12.30
		Total Square Miles:	0.01813		Total Acres:		11.60	1030.66
		Weighted RCN:	88.84		Use:		89	

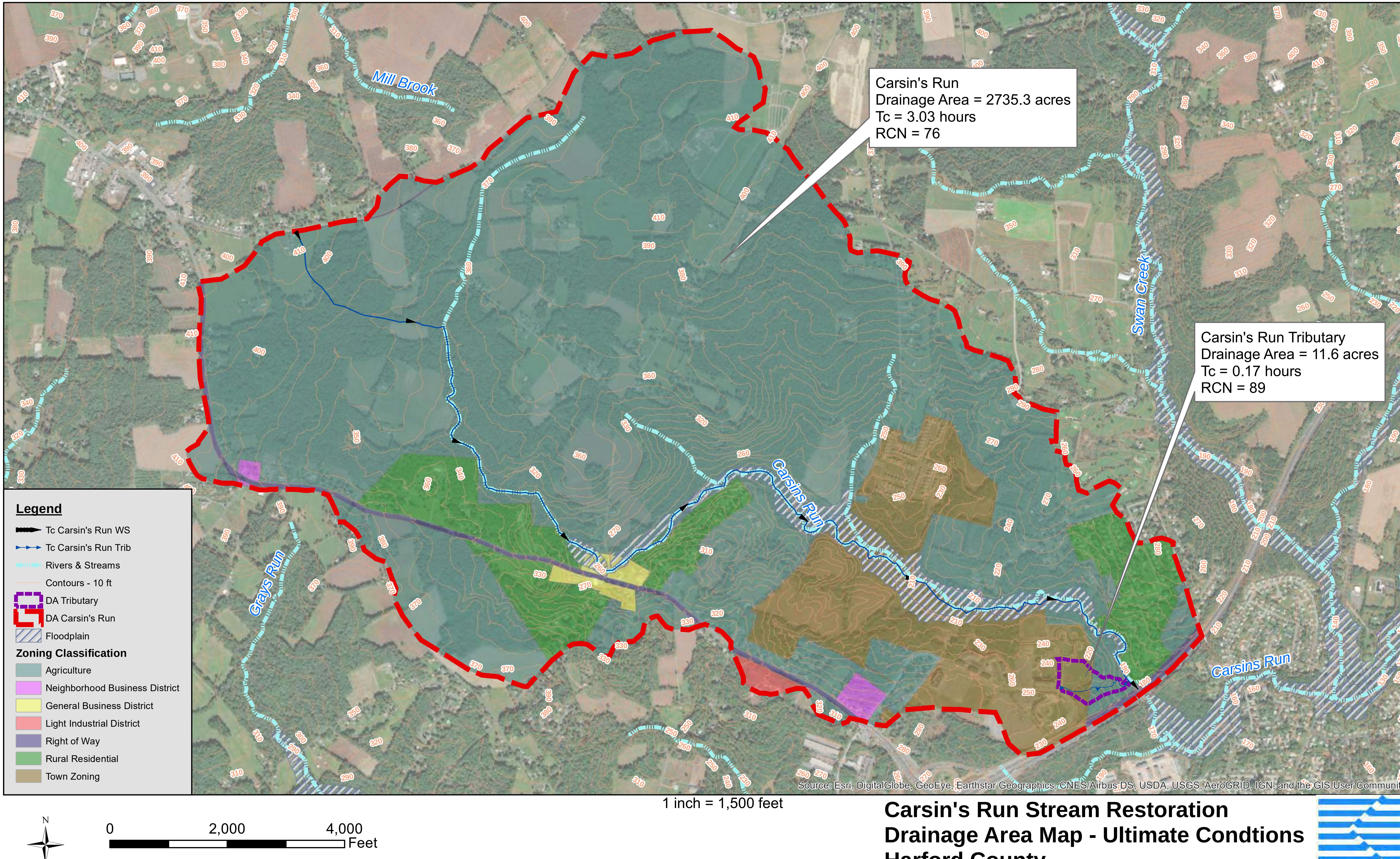
TIME OF CONCENTRATION

ID		Type of Flow			L(ft.)	n	A	WP	Slope (Percent)	Vel. (fps)	Time (Hours)
	Sheet Flow										
A-B	5	Grass - short			100	0.150			7.0		0.098
	Shallow Concentrated Flow										
B-C		paved	x	unpaved	452.36				4.2	3.31	0.038
		paved		unpaved							
		paved		unpaved							
		paved		unpaved							
		paved		unpaved							
	Concentrated Flow*										
C-D	1	Channel Flow, d (ft) =	1.0		855.26	0.035	7.00	9.47	4.8	7.62	0.031
										Total	**0.168**

GRAPHICAL PEAK DISCHARGE METHOD

Initial Abstraction Ia = 0.247 in. (Table 5-1) Use Tc= 0.17 Tt=

Rainfall Freq. =	1 Year	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Rainfall, P (in) =	2.7	3.2	4.2	5.0	6.2	7.3	8.5
Ia/P =	0.093	0.077	0.060	0.050	0.040	0.034	0.029
Peak csm/in. =	854	854	854	854	854	854	854
Runoff Q (in) =	1.60	2.11	2.96	3.73	4.93	5.99	7.20
Peak Dischg. (CFS)=	24.85	32.66	45.91	57.83	76.34	92.79	111.47



Carsin's Run Stream Restoration
Drainage Area Map - Ultimate Condtions
Harford County
KCI Job No. 22145228.47

KCI TECHNOLOGIES

APPENDIX B

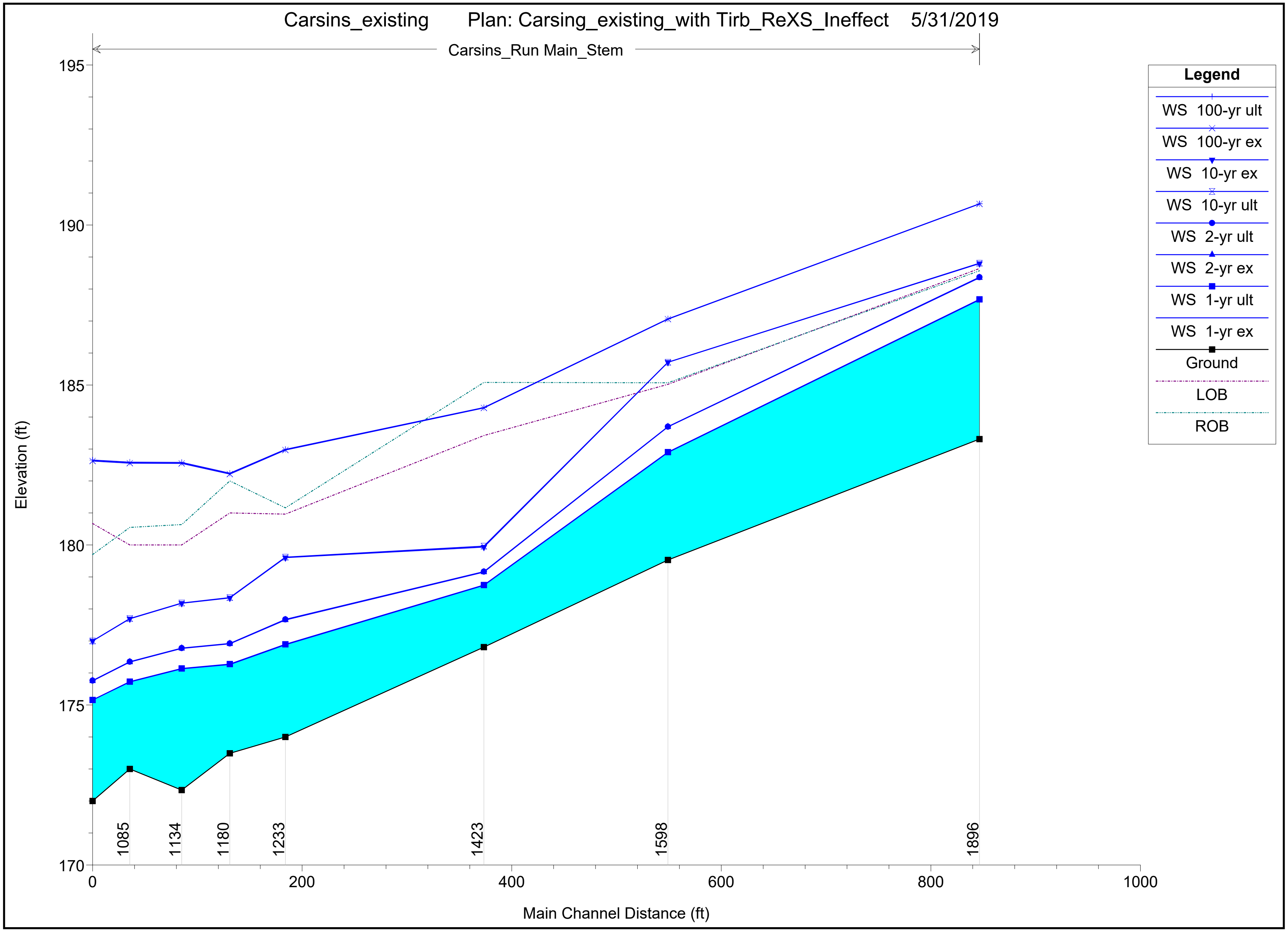
<u>Existing HEC-RAS Results</u>

Profiles

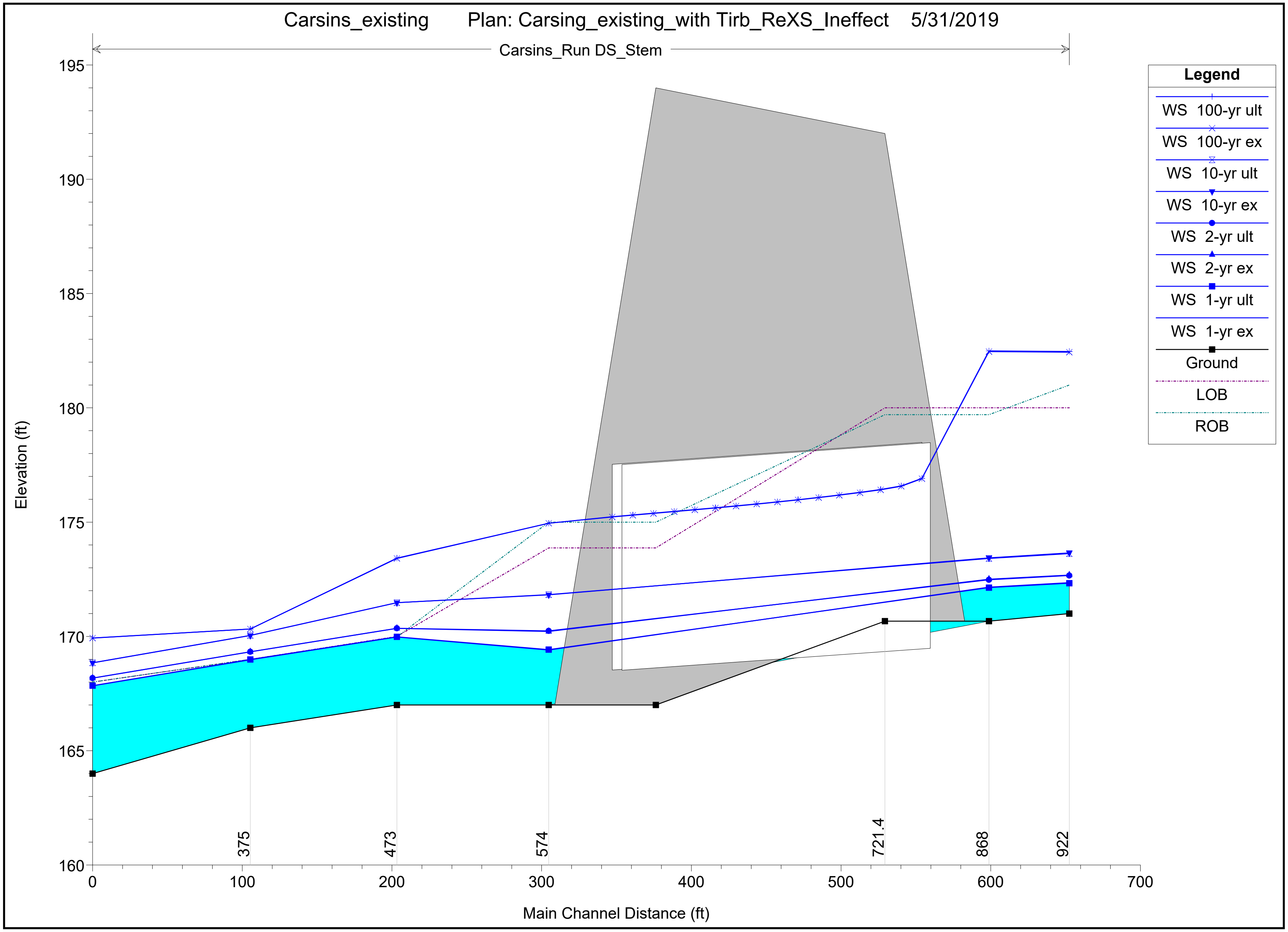
Summary Table

Cross Sections

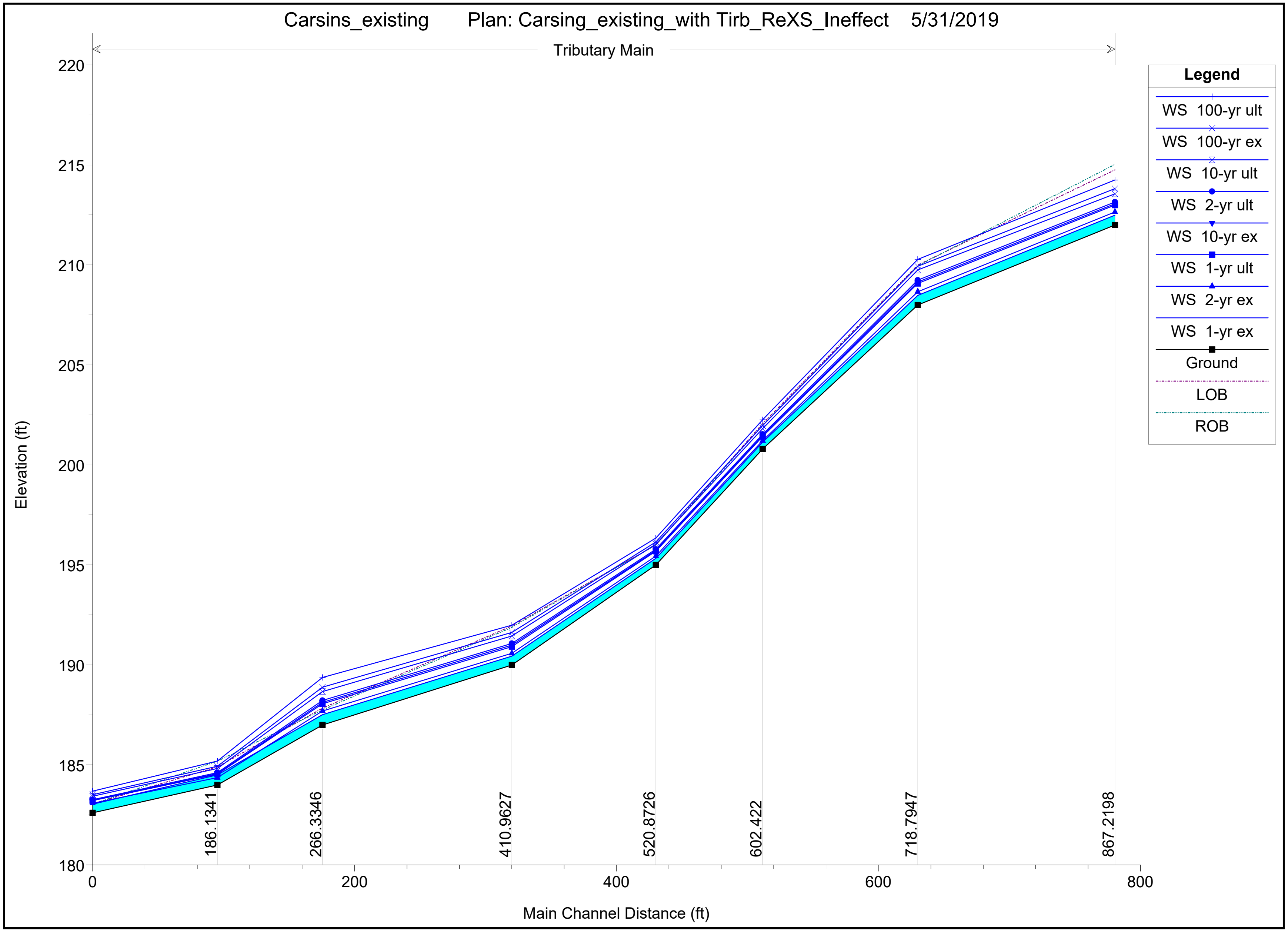
Cross Section Map



Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
Carsins_Run Main_Stem
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ex
WS 10-yr ult
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
LOB
ROB
Elevation (ft)
195
190
185
180
175
170
1085
1134
1180
1233
1423
1598
1896
0
200
400
600
800
1000
Main Channel Distance (ft)



Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
Carsins_Run DS_Stem
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
LOB
ROB
Elevation (ft)
195
190
185
180
175
170
165
160
375
473
574
721.4
868
922
0
100
200
300
400
500
600
700
Main Channel Distance (ft)



Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
Tributary Main
Elevation (ft)
Main Channel Distance (ft)
220
215
210
205
200
195
190
185
180
0
200
400
600
800
186.1341
266.3346
410.9627
520.8726
602.422
718.7947
867.2198
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
LOB
ROB

HEC-RAS Plan: Ex_RE

River	Reach	River Sta	Profile	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width	Shear LOB	Shear Chan	Shear ROB	Vel Left	Vel Chnl	Vel Right	Froude # Chl
				(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)	(ft/s)	
Tributary	Main	867.2198	1-yr ex	212.49	0.22	4.03	0.00		6.42		4.43		0.69			3.76		1.07
Tributary	Main	867.2198	2-yr ex	212.65	0.30	3.81	0.00		10.92		5.02		0.88			4.40		1.10
Tributary	Main	867.2198	10-yr ex	213.06	0.54	3.98	0.03		27.99		5.86		1.36			5.92		1.16
Tributary	Main	867.2198	100-yr ex	213.82	0.89	4.02	0.06		73.21		7.95		1.96			7.55		1.21
Tributary	Main	867.2198	1-yr ult	213.00	0.50	3.99	0.03		24.85		5.78		1.29			5.70		1.16
Tributary	Main	867.2198	2-yr ult	213.15	0.60	3.98	0.03		32.66		5.99		1.47			6.22		1.17
Tributary	Main	867.2198	10-yr ult	213.56	0.85	3.99	0.08		57.83		6.56		1.91			7.40		1.20
Tributary	Main	867.2198	100-yr ult	214.25	1.08	4.06	0.04		111.47		9.52		2.27			8.32		1.24
Tributary	Main	718.7947	1-yr ex	208.48	0.21	6.80	0.05		6.42		4.32		0.64			3.66		1.01
Tributary	Main	718.7947	2-yr ex	208.66	0.27	6.55	0.08		10.92		4.82		0.77			4.18		1.00
Tributary	Main	718.7947	10-yr ex	209.15	0.44	6.02	0.15		27.99		5.98		1.08			5.35		1.01
Tributary	Main	718.7947	100-yr ex	209.94	0.69	5.67	0.21		73.21		9.08		1.51			6.64		1.06
Tributary	Main	718.7947	1-yr ult	209.08	0.41	6.07	0.14		24.85		5.85		1.03			5.16		1.00
Tributary	Main	718.7947	2-yr ult	209.25	0.49	5.96	0.16		32.66		6.15		1.16			5.60		1.01
Tributary	Main	718.7947	10-yr ult	209.75	0.59	5.72	0.20		57.83		8.65		1.34			6.15		1.04
Tributary	Main	718.7947	100-yr ult	210.28	0.96	5.43	0.24	0.02	111.19	0.25	11.02	0.15	1.95	0.30	0.51	7.85	0.79	1.11
Tributary	Main	602.422	1-yr ex	201.14	0.69	6.16	0.15		6.42		4.26		2.55			6.67		2.47
Tributary	Main	602.422	2-yr ex	201.22	1.08	6.33	0.24		10.92		4.47		3.67			8.34		2.72
Tributary	Main	602.422	10-yr ex	201.47	1.95	6.69	0.41		27.99		5.15		5.64			11.19		2.83
Tributary	Main	602.422	100-yr ex	201.97	2.76	6.90	0.46		73.21		6.95		6.85			13.33		2.64
Tributary	Main	602.422	1-yr ult	201.43	1.85	6.65	0.39		24.85		5.02		5.46			10.90		2.85
Tributary	Main	602.422	2-yr ult	201.53	2.08	6.74	0.43		32.66		5.34		5.87			11.57		2.81
Tributary	Main	602.422	10-yr ult	201.82	2.60	6.89	0.48		57.83		6.25		6.66			12.93		2.70
Tributary	Main	602.422	100-yr ult	202.26	3.31	6.97	0.45	0.06	110.83	0.58	11.31	0.63	7.51	1.00	0.99	14.64	1.34	2.52
Tributary	Main	520.8726	1-yr ex	195.33	0.20	4.80	0.01		6.42		6.29		0.70			3.63		1.21
Tributary	Main	520.8726	2-yr ex	195.45	0.29	4.75	0.01		10.92		6.68		0.92			4.35		1.25
Tributary	Main	520.8726	10-yr ex	195.73	0.59	4.72	0.00		27.99		7.70		1.58			6.14		1.41
Tributary	Main	520.8726	100-yr ex	196.15	1.23	4.74	0.09	0.45	72.76	0.01	14.04	0.38	2.89	0.18	0.81	8.91	0.49	1.65
Tributary	Main	520.8726	1-yr ult	195.69	0.54	4.70	0.01		24.85		7.55		1.47			5.87		1.38
Tributary	Main	520.8726	2-yr ult	195.79	0.65	4.72	0.00		32.66		8.01		1.73			6.49		1.44
Tributary	Main	520.8726	10-yr ult	196.04	1.00	4.72	0.05	0.05	57.78	0.00	12.35	0.12	2.45		0.38	8.02	0.21	1.58
Tributary	Main	520.8726	100-yr ult	196.35	1.81	4.84	0.21	2.53	108.87	0.06	17.35	0.89	4.07	0.49	1.39	10.92	0.94	1.83
Tributary	Main	410.9627	1-yr ex	190.44	0.29	3.00	0.01		6.42		4.42		0.94			4.30		1.31
Tributary	Main	410.9627	2-yr ex	190.58	0.40	3.00	0.00		10.92		4.96		1.19			5.05		1.35
Tributary	Main	410.9627	10-yr ex	190.99	0.60	2.95	0.00		27.99		6.73		1.58			6.23		1.35
Tributary	Main	410.9627	100-yr ex	191.63	0.92	2.42	0.01		73.21		9.16		2.08			7.68		1.33
Tributary	Main	410.9627	1-yr ult	190.91	0.60	3.00	0.00		24.85		6.03		1.59			6.23		1.35
Tributary	Main	410.9627	2-yr ult	191.07	0.65	2.86	0.00		32.66		7.00		1.66			6.47		1.34
Tributary	Main	410.9627	10-yr ult	191.45	0.82	2.53	0.01		57.83		8.55		1.93			7.26		1.33
Tributary	Main	410.9627	100-yr ult	191.99	1.12	1.64	0.04	0.00	111.47	0.00	10.99		2.38	0.09	0.16	8.50	0.32	1.32
Tributary	Main	266.3346	1-yr ex	187.51	0.19	1.07	0.04		6.42		4.69		0.61			3.54		1.00
Tributary	Main	266.3346	2-yr ex	187.70	0.25	3.13	0.02		10.92		5.55		0.71			3.98		1.00
Tributary	Main	266.3346	10-yr ex	188.13	0.41	2.93	0.06	0.15	27.78	0.06	8.30	0.18	0.99	0.18	0.58	5.17	0.58	0.97
Tributary	Main	266.3346	100-yr ex	188.89	0.70	2.52	0.13	3.26	69.03	0.92	12.02	0.52	1.43	0.44	1.23	6.92	1.10	0.95
Tributary	Main	266.3346	1-yr ult	188.06	0.39	2.98	0.05	0.07	24.74	0.03	7.82	0.14	0.95	0.15	0.49	5.01	0.52	0.98
Tributary	Main	266.3346	2-yr ult	188.23	0.45	2.88	0.07	0.30	32.25	0.10	8.85	0.23	1.05	0.22	0.69	5.43	0.66	0.97
Tributary	Main	266.3346	10-yr ult	188.67	0.61	2.62	0.11	1.88	55.41	0.54	10.97	0.44	1.29	0.36	1.09	6.42	0.96	0.95
Tributary	Main	266.3346	100-yr ult	189.38	0.88	2.30	0.17	7.56	101.81	2.10	15.89	0.58	1.69	0.55	1.35	7.85	1.30	0.95
Tributary	Main	186.1341	1-yr ex	184.51	0.07	1.47	0.00		6.42		7.18		0.21			2.10		0.57
Tributary	Main	186.1341	2-yr ex	184.37	0.42	1.57	0.01		10.92		6.73		1.41			5.23		1.65
Tributary	Main	186.1341	10-yr ex	184.57	0.98	1.82	0.03		27.99		7.39		2.83			7.94		2.03
Tributary	Main	186.1341	100-yr ex	184.94	2.00	1.78	0.12	0.00	73.21		8.38		4.95		0.24	11.34		2.27
Tributary	Main	186.1341	1-yr ult	184.54	0.87	1.78	0.03		24.85		7.29		2.55			7.48		1.95
Tributary	Main	186.1341	2-yr ult	184.62	1.11	1.87	0.04		32.66		7.54		3.13			8.45		2.08
Tributary	Main	186.1341	10-yr ult	184.82	1.72	1.87	0.10		57.83		8.14		4.46			10.53		2.26
Tributary	Main	186.1341	100-yr ult	185.20	2.59	1.62	0.15	0.03	111.44		8.79	0.55	5.89		0.93	12.90		2.27

HEC-RAS Plan: Ex_RE (Continued)

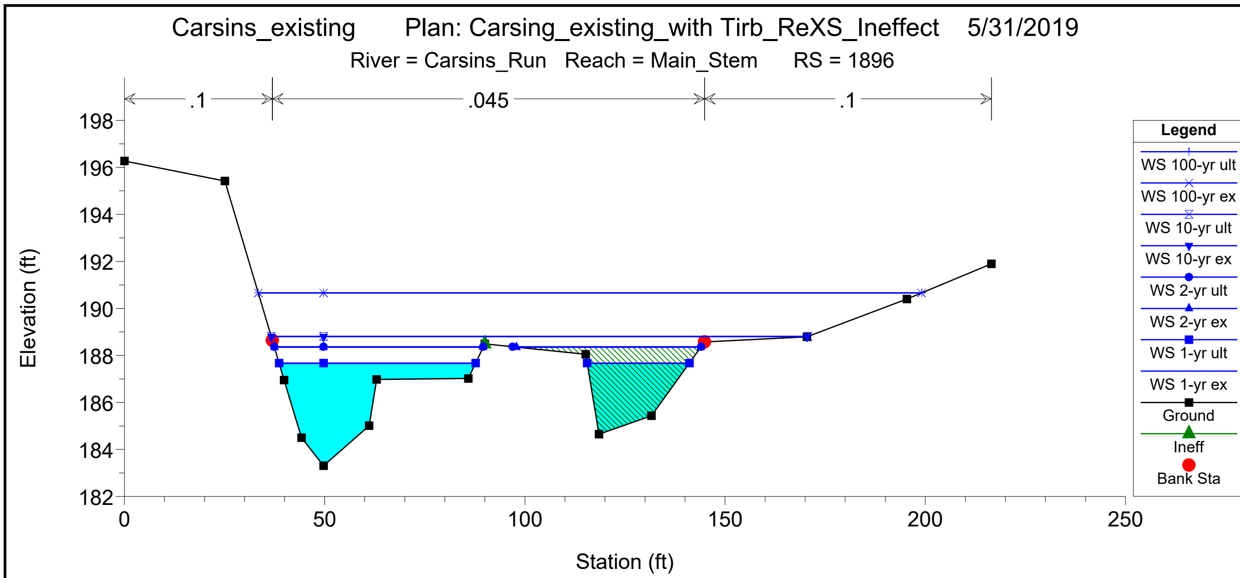
River	Reach	River Sta	Profile	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width	Shear LOB	Shear Chan	Shear ROB	Vel Left	Vel Chnl	Vel Right	Froude # Chl
				(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)	(ft/s)	
Tributary	Main	90.83922	1-yr ex	183.04	0.06	1.49	0.07		6.42		28.58		0.29			2.00		1.05
Tributary	Main	90.83922	2-yr ex	183.09	0.09	1.39	0.09	0.00	10.92	0.00	29.17		0.36		0.20	2.37	0.24	1.04
Tributary	Main	90.83922	10-yr ex	183.24	0.16	0.93	0.11	0.04	27.89	0.06	31.85	0.10	0.52	0.17	0.36	3.17	0.53	1.01
Tributary	Main	90.83922	100-yr ex	183.52	0.26	0.10	0.02	2.28	70.46	0.47	42.14	0.31	0.73	0.31	0.82	4.19	0.83	0.96
Tributary	Main	90.83922	1-yr ult	183.22	0.14	1.48	0.06	0.03	24.77	0.04	31.20	0.09	0.46	0.15	0.36	2.98	0.49	0.97
Tributary	Main	90.83922	2-yr ult	183.27	0.17	1.40	0.08	0.09	32.49	0.08	36.22	0.07	0.56	0.20	0.33	3.34	0.58	1.01
Tributary	Main	90.83922	10-yr ult	183.44	0.23	0.92	0.10	1.28	56.25	0.30	41.19	0.23	0.65	0.27	0.68	3.88	0.75	0.96
Tributary	Main	90.83922	100-yr ult	183.69	0.34	0.10	0.01	5.31	105.16	1.00	43.39	0.47	0.88	0.39	1.11	4.82	0.98	0.97
Carsins_Run	Main_Stem	1896	1-yr ex	187.66	0.30	3.98	0.07		387.00		74.46		0.92			4.39		0.58
Carsins_Run	Main_Stem	1896	2-yr ex	188.35	0.38	3.66	0.09		612.00		98.17		1.08			4.97		0.57
Carsins_Run	Main_Stem	1896	10-yr ex	188.79	0.50	2.98	0.01	0.01	1364.94	1.06	133.82	0.04	1.42	0.08	0.25	5.67	0.36	0.67
Carsins_Run	Main_Stem	1896	100-yr ex	190.66	0.73	2.85	0.07	4.11	3079.10	123.78	165.61	0.39	1.76	0.64	1.15	6.97	1.60	0.61
Carsins_Run	Main_Stem	1896	1-yr ult	187.68	0.30	3.97	0.07		391.00		74.61		0.92			4.39		0.58
Carsins_Run	Main_Stem	1896	2-yr ult	188.37	0.38	3.66	0.09		617.00		99.29		1.08			4.97		0.57
Carsins_Run	Main_Stem	1896	10-yr ult	188.81	0.50	2.99	0.01	0.01	1372.73	1.26	134.05	0.05	1.42	0.08	0.27	5.66	0.39	0.67
Carsins_Run	Main_Stem	1896	100-yr ult	190.66	0.73	2.85	0.07	4.14	3086.43	124.43	165.69	0.39	1.76	0.64	1.15	6.97	1.60	0.61
Carsins_Run	Main_Stem	1598	1-yr ex	182.89	1.02	4.35	0.08		387.00		41.22		2.99			8.11		0.99
Carsins_Run	Main_Stem	1598	2-yr ex	183.69	1.29	4.62	0.04		612.00		48.71		3.53			9.11		1.00
Carsins_Run	Main_Stem	1598	10-yr ex	185.71	0.60	3.25	0.23	2.18	1363.01	0.81	91.39	0.20	1.58	0.19	0.71	6.20	0.67	0.65
Carsins_Run	Main_Stem	1598	100-yr ex	187.06	1.41	2.21	0.05	49.34	3137.82	19.84	112.32	0.99	3.35	0.83	1.92	9.63	1.70	0.83
Carsins_Run	Main_Stem	1598	1-yr ult	182.90	1.03	4.35	0.08		391.00		41.32		3.02			8.15		0.99
Carsins_Run	Main_Stem	1598	2-yr ult	183.70	1.30	4.62	0.04		617.00		48.80		3.56			9.15		1.00
Carsins_Run	Main_Stem	1598	10-yr ult	185.71	0.60	3.26	0.23	2.19	1370.99	0.81	91.39	0.21	1.60	0.19	0.71	6.24	0.67	0.66
Carsins_Run	Main_Stem	1598	100-yr ult	187.07	1.41	2.20	0.05	49.89	3145.04	20.07	112.41	0.99	3.35	0.83	1.92	9.63	1.71	0.83
Carsins_Run	Main_Stem	1423	1-yr ex	178.74	0.75	2.15	0.13		387.00		35.71		2.41			6.95		0.98
Carsins_Run	Main_Stem	1423	2-yr ex	179.15	1.16	2.06	0.13		612.00		36.64		3.49			8.66		1.10
Carsins_Run	Main_Stem	1423	10-yr ex	179.94	2.90	1.91	0.13		1366.00		38.40		7.89			13.65		1.49
Carsins_Run	Main_Stem	1423	100-yr ex	184.28	1.93	1.66	0.15	0.69	3206.31		49.21	0.29	4.02		0.86	11.14		0.80
Carsins_Run	Main_Stem	1423	1-yr ult	178.75	0.75	2.15	0.13		391.00		35.74		2.41			6.96		0.98
Carsins_Run	Main_Stem	1423	2-yr ult	179.17	1.17	2.06	0.13		617.00		36.67		3.49			8.66		1.10
Carsins_Run	Main_Stem	1423	10-yr ult	179.96	2.87	1.91	0.13		1374.00		38.46		7.80			13.59		1.48
Carsins_Run	Main_Stem	1423	100-yr ult	184.30	1.93	1.65	0.15	0.72	3214.28		49.25	0.29	4.02		0.87	11.14		0.80
Carsins_Run	Main_Stem	1233	1-yr ex	176.88	0.33	0.44	0.02		387.00		34.73		0.92			4.59		0.52
Carsins_Run	Main_Stem	1233	2-yr ex	177.66	0.47	0.47	0.02		612.00		36.28		1.21			5.47		0.55
Carsins_Run	Main_Stem	1233	10-yr ex	179.60	0.84	0.57	0.06		1366.00		40.05		1.92			7.34		0.60
Carsins_Run	Main_Stem	1233	100-yr ex	182.97	1.44	0.43	0.03	15.07	3184.97	6.96	59.85	0.52	2.83	0.35	1.40	9.64	1.07	0.62
Carsins_Run	Main_Stem	1233	1-yr ult	176.90	0.33	0.44	0.02		391.00		34.76		0.92			4.61		0.52
Carsins_Run	Main_Stem	1233	2-yr ult	177.67	0.47	0.47	0.03		617.00		36.30		1.21			5.49		0.55
Carsins_Run	Main_Stem	1233	10-yr ult	179.62	0.84	0.57	0.06		1374.00		40.08		1.92			7.36		0.60
Carsins_Run	Main_Stem	1233	100-yr ult	182.99	1.44	0.42	0.03	15.35	3192.50	7.15	59.99	0.52	2.83	0.35	1.41	9.64	1.07	0.62
Carsins_Run	Main_Stem	1180	1-yr ex	176.27	0.49	0.30	0.07		387.00		32.29		1.42			5.60		0.67
Carsins_Run	Main_Stem	1180	2-yr ex	176.91	0.71	0.37	0.10		612.00		33.10		1.94			6.78		0.72
Carsins_Run	Main_Stem	1180	10-yr ex	178.35	1.47	0.57	0.17		1366.00		37.44		3.59			9.71		0.88
Carsins_Run	Main_Stem	1180	100-yr ex	182.22	1.73	0.28	0.26	2.63	3204.25	0.12	56.41	0.24	3.54	0.07	0.80	10.56	0.33	0.72
Carsins_Run	Main_Stem	1180	1-yr ult	176.28	0.49	0.31	0.07		391.00		32.31		1.43			5.62		0.68
Carsins_Run	Main_Stem	1180	2-yr ult	176.92	0.72	0.37	0.10		617.00		33.14		1.95			6.80		0.73
Carsins_Run	Main_Stem	1180	10-yr ult	178.36	1.48	0.57	0.17		1374.00		37.46		3.61			9.74		0.89
Carsins_Run	Main_Stem	1180	100-yr ult	182.24	1.73	0.27	0.26	2.89	3211.95	0.17	56.95	0.26	3.53	0.07	0.83	10.55	0.35	0.72
Carsins_Run	Main_Stem	1134	1-yr ex	176.13	0.25	0.31	0.01		387.00		36.87		0.67			3.98		0.43
Carsins_Run	Main_Stem	1134	2-yr ex	176.77	0.40	0.36	0.01		612.00		38.87		1.02			5.04		0.50
Carsins_Run	Main_Stem	1134	10-yr ex	178.18	0.89	0.50	0.01		1366.00		45.12		2.14			7.58		0.67
Carsins_Run	Main_Stem	1134	100-yr ex	182.55	0.86	0.17	0.07	25.28	3160.90	20.82	88.71	0.40	1.71	0.28	1.29	7.49	1.01	0.49
Carsins_Run	Main_Stem	1134	1-yr ult	176.14	0.25	0.31	0.01		391.00		36.91		0.68			4.00		0.43
Carsins_Run	Main_Stem	1134	2-yr ult	176.78	0.40	0.36	0.01		617.00		38.90		1.03			5.07		0.50
Carsins_Run	Main_Stem	1134	10-yr ult	178.19	0.90	0.50	0.01		1374.00		45.16		2.15			7.60		0.67
Carsins_Run	Main_Stem	1134	100-yr ult	182.58	0.86	0.17	0.07	25.77	3167.72	21.52	88.89	0.40	1.70	0.28	1.29	7.48	1.02	0.49

HEC-RAS Plan: Ex_RE (Continued)

River	Reach	River Sta	Profile	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width	Shear LOB	Shear Chan	Shear ROB	Vel Left	Vel Chnl	Vel Right	Froude # Chl
				(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)	(ft/s)	
Carsins_Run	Main_Stem	1085	1-yr ex	175.72	0.34	0.53	0.04		387.00		45.93		1.04			4.69		0.62
Carsins_Run	Main_Stem	1085	2-yr ex	176.34	0.46	0.52	0.04		612.00		49.95		1.30			5.43		0.64
Carsins_Run	Main_Stem	1085	10-yr ex	177.69	0.87	0.53	0.05		1366.00		53.70		2.17			7.49		0.72
Carsins_Run	Main_Stem	1085	100-yr ex	182.56	0.61	0.08	0.06	14.26	3127.71	65.03	107.67	0.26	1.21	0.31	1.04	6.35	1.15	0.41
Carsins_Run	Main_Stem	1085	1-yr ult	175.73	0.34	0.53	0.04		391.00		46.01		1.05			4.71		0.62
Carsins_Run	Main_Stem	1085	2-yr ult	176.35	0.46	0.52	0.04		617.00		49.98		1.30			5.44		0.64
Carsins_Run	Main_Stem	1085	10-yr ult	177.70	0.88	0.53	0.05		1374.00		53.72		2.19			7.52		0.72
Carsins_Run	Main_Stem	1085	100-yr ult	182.59	0.61	0.08	0.06	14.53	3134.15	66.31	107.83	0.26	1.20	0.31	1.04	6.33	1.16	0.41
Carsins_Run	Main_Stem	1049	1-yr ex	175.16	0.44	8.38	0.21		387.00		42.38		1.38			5.33		0.72
Carsins_Run	Main_Stem	1049	2-yr ex	175.75	0.59	7.40	0.27		612.00		48.21		1.72			6.14		0.75
Carsins_Run	Main_Stem	1049	10-yr ex	177.00	1.04	5.23	0.40		1366.00		59.51		2.71			8.18		0.84
Carsins_Run	Main_Stem	1049	100-yr ex	182.63	0.40			3.44	3164.03	39.53	118.28	0.12	0.79	0.19	0.65	5.09	0.89	0.34
Carsins_Run	Main_Stem	1049	1-yr ult	175.16	0.45	8.47	0.22		391.00		42.39		1.41			5.39		0.73
Carsins_Run	Main_Stem	1049	2-yr ult	175.76	0.59	7.51	0.28		617.00		48.30		1.73			6.17		0.76
Carsins_Run	Main_Stem	1049	10-yr ult	177.00	1.05	5.34	0.41		1374.00		59.50		2.75			8.23		0.85
Carsins_Run	Main_Stem	1049	100-yr ult	182.65	0.40			3.54	3171.03	40.44	118.39	0.12	0.78	0.19	0.65	5.09	0.89	0.33
Carsins_Run	DS_Stem	922	1-yr ex	172.35	2.17	0.88	0.29		387.00		37.38		5.06			11.81		2.22
Carsins_Run	DS_Stem	922	2-yr ex	172.69	2.83	0.91	0.32		612.00		38.48		5.99			13.48		2.19
Carsins_Run	DS_Stem	922	10-yr ex	173.66	4.11	0.87	0.28		1366.00		40.77		7.28			16.26		2.00
Carsins_Run	DS_Stem	922	100-yr ex	182.43	0.41	0.02	0.02	14.66	3185.87	6.46	138.99	0.08	0.48	0.03	0.55	5.18	0.30	0.32
Carsins_Run	DS_Stem	922	1-yr ult	172.33	2.34	0.95	0.32		391.00		37.30		5.51			12.27		2.34
Carsins_Run	DS_Stem	922	2-yr ult	172.66	2.99	0.98	0.34		617.00		38.41		6.37			13.87		2.27
Carsins_Run	DS_Stem	922	10-yr ult	173.63	4.29	0.91	0.30		1374.00		40.71		7.62			16.61		2.05
Carsins_Run	DS_Stem	922	100-yr ult	182.46	0.41	0.02	0.02	15.15	3192.82	7.04	139.40	0.08	0.47	0.03	0.56	5.17	0.31	0.32
Carsins_Run	DS_Stem	868	1-yr ex	172.15	1.20				387.00		37.50		0.47			8.79		1.43
Carsins_Run	DS_Stem	868	2-yr ex	172.51	1.76				612.00		38.90		0.64			10.65		1.55
Carsins_Run	DS_Stem	868	10-yr ex	173.44	3.18				1366.00		42.40		1.01			14.32		1.68
Carsins_Run	DS_Stem	868	100-yr ex	182.46	0.35			7.79	3189.06	10.15	182.70	0.01	0.07	0.01	0.19	4.77	0.16	0.28
Carsins_Run	DS_Stem	868	1-yr ult	172.14	1.26				391.00		37.43		0.50			9.02		1.48
Carsins_Run	DS_Stem	868	2-yr ult	172.48	1.86				617.00		38.79		0.68			10.94		1.60
Carsins_Run	DS_Stem	868	10-yr ult	173.41	3.29				1374.00		42.33		1.04			14.55		1.72
Carsins_Run	DS_Stem	868	100-yr ult	182.49	0.35			8.04	3196.33	10.63	183.52	0.01	0.07	0.01	0.19	4.76	0.16	0.28
Carsins_Run	DS_Stem	721.4		Culvert														
Carsins_Run	DS_Stem	574	1-yr ex	169.40	0.93				387.00		26.99		3.50			7.73		1.00
Carsins_Run	DS_Stem	574	2-yr ex	170.22	1.06				612.00		35.04		3.82			8.26		1.00
Carsins_Run	DS_Stem	574	10-yr ex	171.82	1.46				1366.00		48.30		4.72			9.68		1.00
Carsins_Run	DS_Stem	574	100-yr ex	174.95	1.49	1.48	0.01	7.54	3199.47		124.53	1.02	4.18		1.91	9.80		0.81
Carsins_Run	DS_Stem	574	1-yr ult	169.42	0.93				391.00		27.05		3.50			7.74		1.00
Carsins_Run	DS_Stem	574	2-yr ult	170.24	1.05				617.00		35.25		3.78			8.23		0.99
Carsins_Run	DS_Stem	574	10-yr ult	171.83	1.46				1374.00		48.40		4.73			9.70		1.00
Carsins_Run	DS_Stem	574	100-yr ult	174.95	1.50	1.48	0.00	7.53	3207.47		124.50	1.03	4.21		1.92	9.83		0.82
Carsins_Run	DS_Stem	473	1-yr ex	169.97	0.44	1.13	0.06		387.00		43.40		1.38			5.33		0.73
Carsins_Run	DS_Stem	473	2-yr ex	170.35	0.71	1.29	0.11	1.65	604.41	5.95	75.47	0.23	2.10	0.33	0.70	6.80	0.89	0.84
Carsins_Run	DS_Stem	473	10-yr ex	171.48	1.14	1.45	0.16	48.11	1239.00	78.89	107.33	0.90	3.18	1.20	1.74	8.99	2.11	0.89
Carsins_Run	DS_Stem	473	100-yr ex	173.41	1.55	2.23	0.08	340.16	2491.70	375.15	165.74	1.64	4.22	1.89	2.69	11.22	2.96	0.87
Carsins_Run	DS_Stem	473	1-yr ult	169.99	0.45	1.13	0.06		391.00		43.45		1.39			5.35		0.73
Carsins_Run	DS_Stem	473	2-yr ult	170.36	0.71	1.29	0.11	1.72	609.10	6.17	75.75	0.23	2.12	0.34	0.71	6.83	0.91	0.84
Carsins_Run	DS_Stem	473	10-yr ult	171.48	1.15	1.45	0.16	48.57	1245.88	79.55	107.41	0.91	3.20	1.21	1.75	9.03	2.12	0.89
Carsins_Run	DS_Stem	473	100-yr ult	173.43	1.54	2.22	0.08	342.59	2494.98	377.43	165.93	1.64	4.21	1.89	2.69	11.20	2.96	0.87
Carsins_Run	DS_Stem	375	1-yr ex	168.98	0.25	1.14	0.00		387.00		107.73		0.84			4.04		0.60
Carsins_Run	DS_Stem	375	2-yr ex	169.32	0.34	1.18	0.01	4.99	574.30	32.71	177.00	0.18	1.11	0.30	0.63	4.80	0.91	0.64
Carsins_Run	DS_Stem	375	10-yr ex	170.04	0.61	1.33	0.06	42.55	1149.29	174.17	246.06	0.44	1.99	0.85	1.12	6.81	1.73	0.77
Carsins_Run	DS_Stem	375	100-yr ex	170.33	2.33	1.45	0.12	157.50	2561.16	488.34	252.78	2.19	7.61	3.72	2.66	13.58	3.79	1.45
Carsins_Run	DS_Stem	375	1-yr ult	168.99	0.25	1.14	0.00		391.00		108.83		0.84			4.05		0.60
Carsins_Run	DS_Stem	375	2-yr ult	169.33	0.34	1.18	0.01	5.17	578.39	33.44	177.41	0.18	1.12	0.31	0.64	4.82	0.91	0.64
Carsins_Run	DS_Stem	375	10-yr ult	170.04	0.61	1.33	0.06	43.33	1154.68	175.99	246.19	0.45	1.99	0.85	1.13	6.82	1.74	0.77

HEC-RAS Plan: Ex_RE (Continued)

River	Reach	River Sta	Profile	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width	Shear LOB	Shear Chan	Shear ROB	Vel Left	Vel Chnl	Vel Right	Froude # Chl
				(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)	(ft/s)	(ft/s)	(ft/s)	
Carsins_Run	DS_Stem	375	100-yr ult	170.33	2.34	1.45	0.12	157.96	2567.40	489.64	252.79	2.20	7.64	3.74	2.67	13.61	3.80	1.45
Carsins_Run	DS_Stem	269	1-yr ex	167.84	0.25				387.00		118.86		0.87			4.00		0.64
Carsins_Run	DS_Stem	269	2-yr ex	168.17	0.29			34.19	566.65	11.16	277.59	0.28	1.05	0.17	0.85	4.52	0.60	0.66
Carsins_Run	DS_Stem	269	10-yr ex	168.84	0.42			182.22	1070.16	113.62	309.97	0.68	1.53	0.63	1.53	5.83	1.46	0.71
Carsins_Run	DS_Stem	269	100-yr ex	169.93	0.64			623.26	2138.84	444.90	377.49	1.14	2.32	1.37	2.15	7.69	2.43	0.76
Carsins_Run	DS_Stem	269	1-yr ult	167.84	0.25				391.00	0.00	121.25		0.87			4.01	0.03	0.64
Carsins_Run	DS_Stem	269	2-yr ult	168.18	0.30			35.00	570.37	11.63	277.87	0.29	1.05	0.17	0.86	4.53	0.61	0.66
Carsins_Run	DS_Stem	269	10-yr ult	168.85	0.42			183.98	1075.14	114.89	310.26	0.68	1.54	0.64	1.53	5.84	1.46	0.71
Carsins_Run	DS_Stem	269	100-yr ult	169.93	0.64			625.35	2143.23	446.42	377.79	1.14	2.32	1.37	2.15	7.69	2.44	0.76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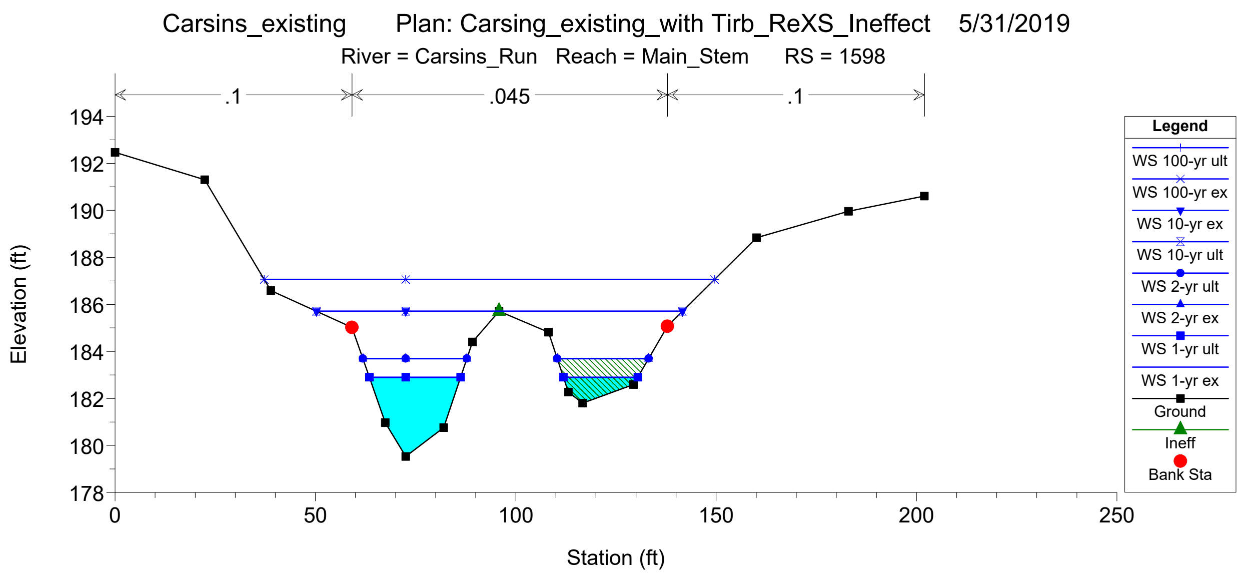
River = Carsins_Run Reach = Main_Stem RS = 1896
.1
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Ineff
Bank Sta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River = Carsins_Run Reach = Main_Stem RS = 1598
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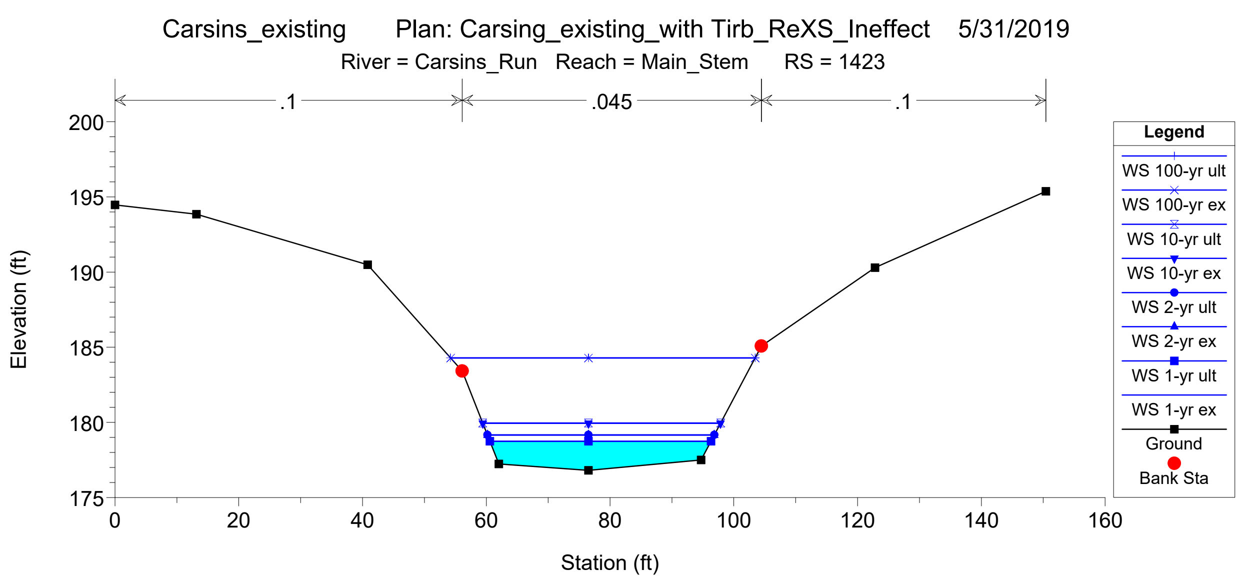
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ex
WS 10-yr ult
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Ineff
Bank Sta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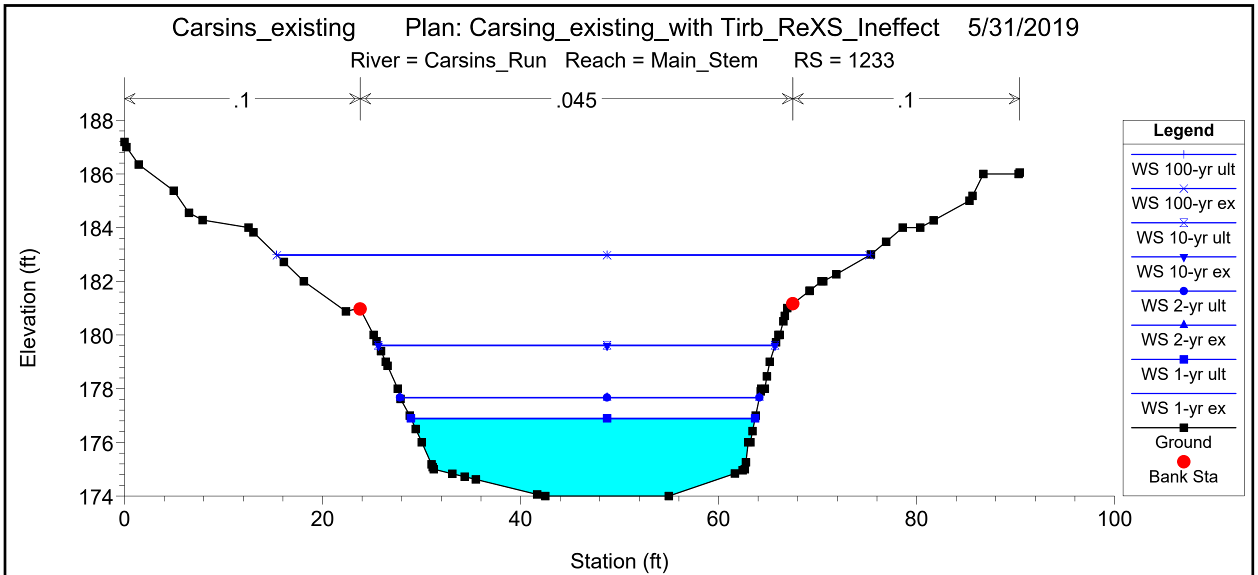
River = Carsins_Run Reach = Main_Stem RS = 1423
.1
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Bank Sta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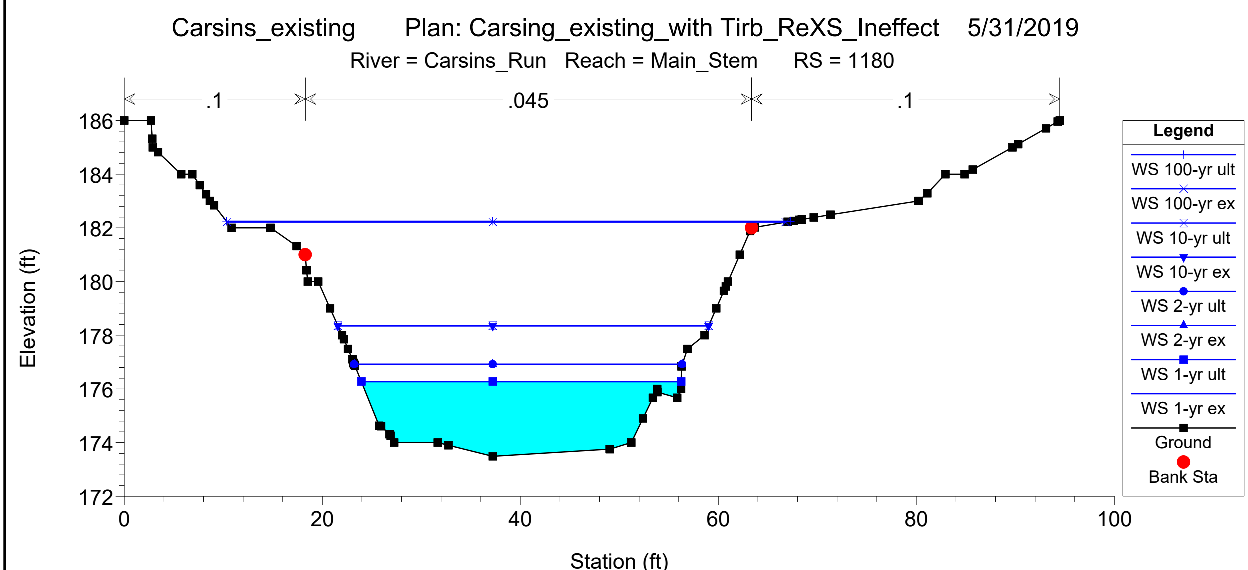
River = Carsins_Run Reach = Main_Stem RS = 1233
.1
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Bank Sta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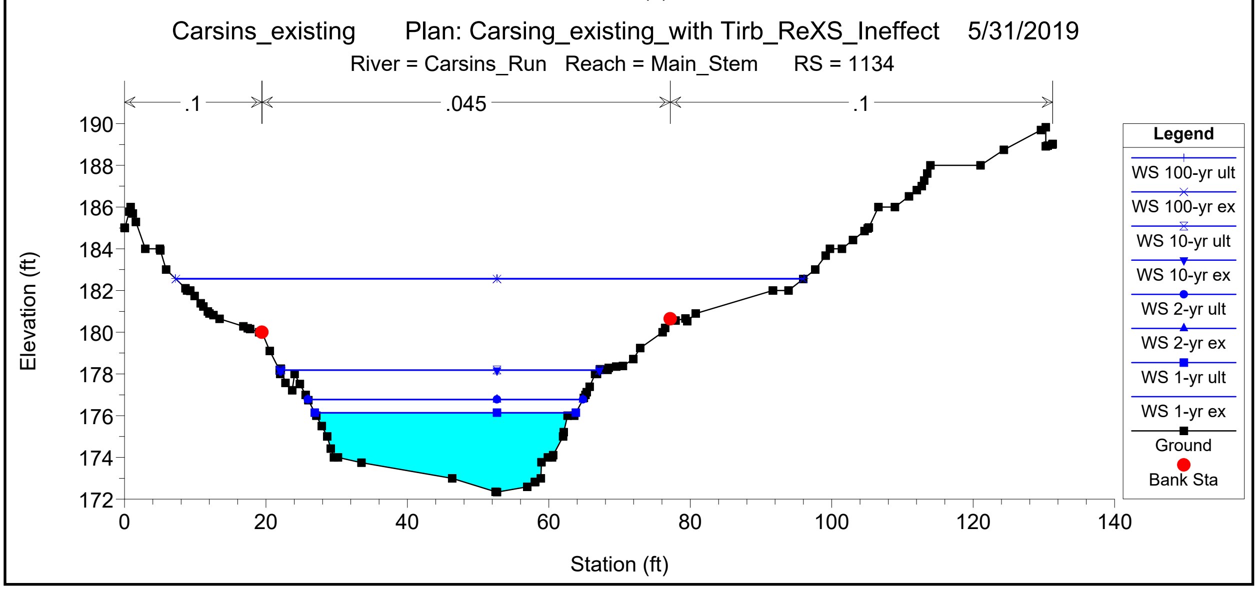
River = Carsins_Run Reach = Main_Stem RS = 1180
.1
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Bank Sta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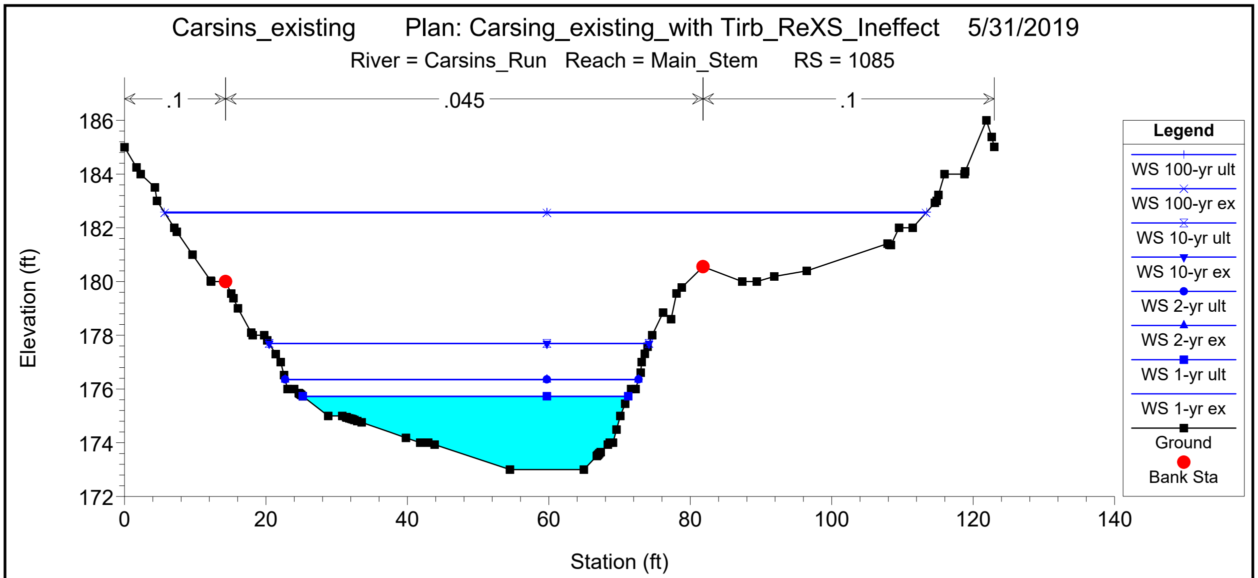
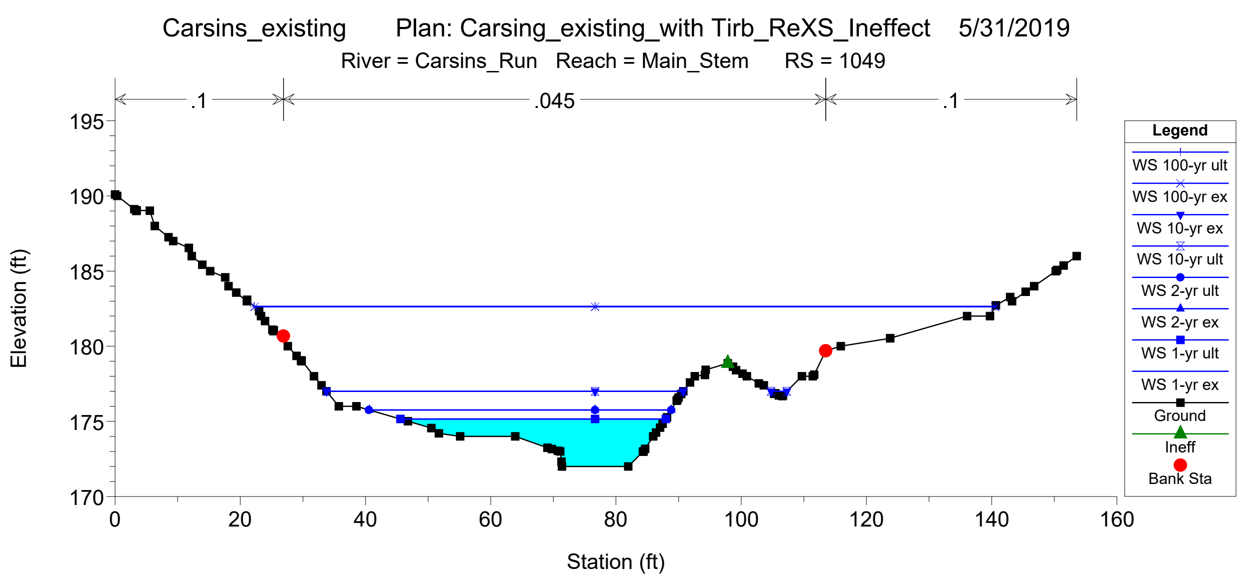
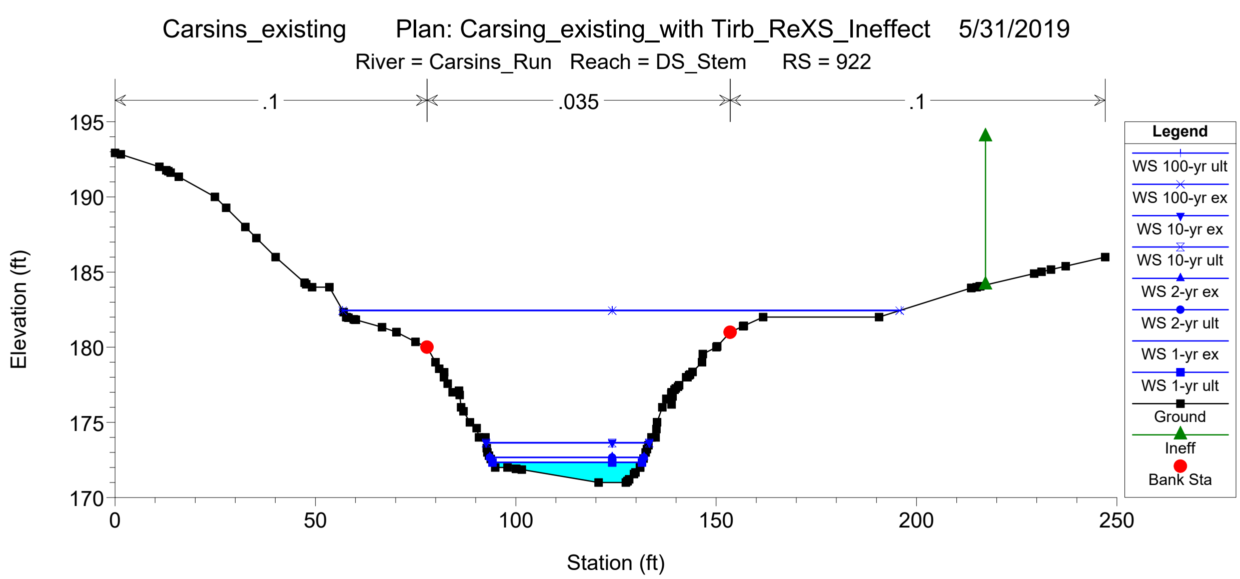
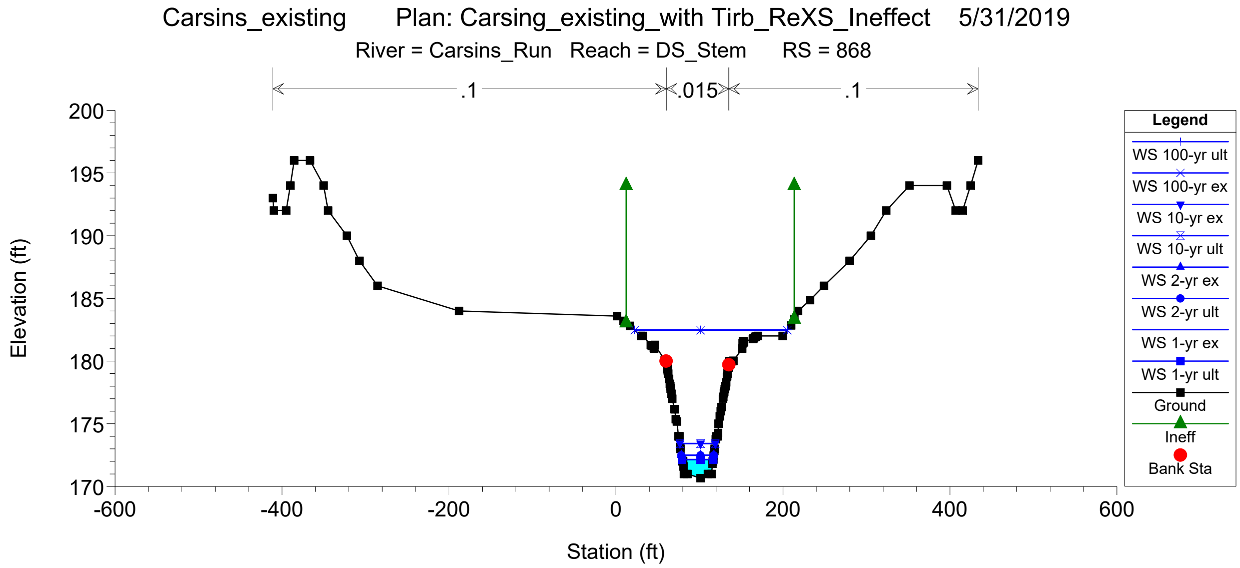
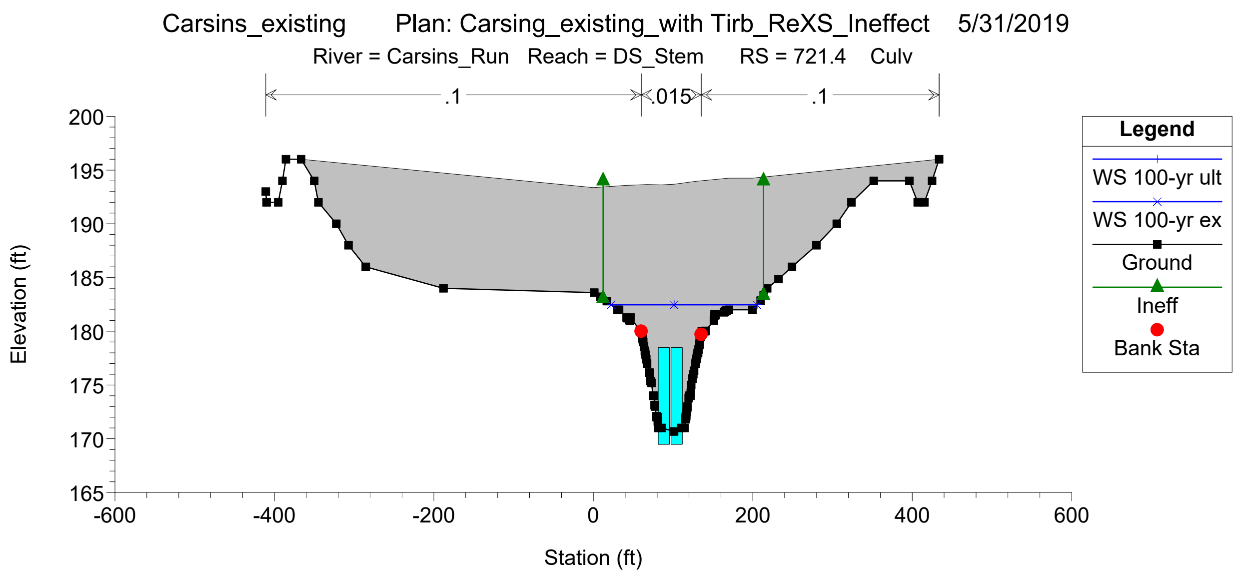
River = Carsins_Run Reach = Main_Stem RS = 1134
.1
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Bank Sta


Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Carsins_Run Reach = Main_Stem RS = 1085
.1
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Bank Sta


Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Carsins_Run Reach = Main_Stem RS = 1049
.1
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ex
WS 10-yr ult
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Ineff
Bank Sta


Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Carsins_Run Reach = DS_Stem RS = 922
.1
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ex
WS 10-yr ult
WS 2-yr ex
WS 2-yr ult
WS 1-yr ex
WS 1-yr ult
Ground
Ineff
Bank Sta


Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Carsins_Run Reach = DS_Stem RS = 868
.1
.015
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ex
WS 10-yr ult
WS 2-yr ex
WS 2-yr ult
WS 1-yr ex
WS 1-yr ult
Ground
Ineff
Bank Sta


Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Carsins_Run Reach = DS_Stem RS = 721.4 Culv
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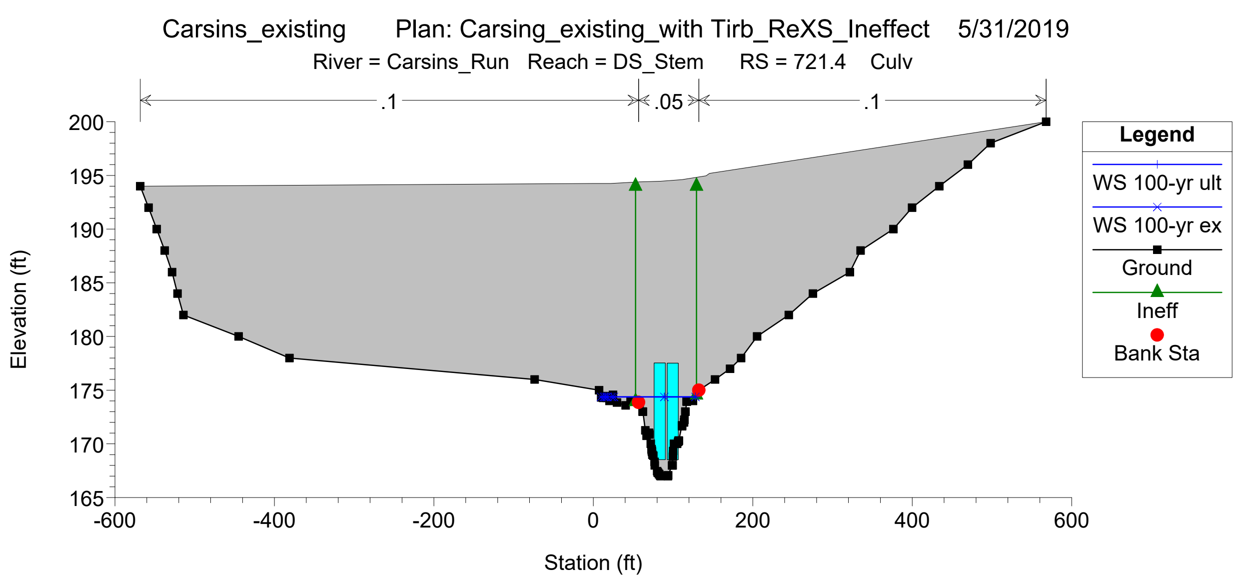
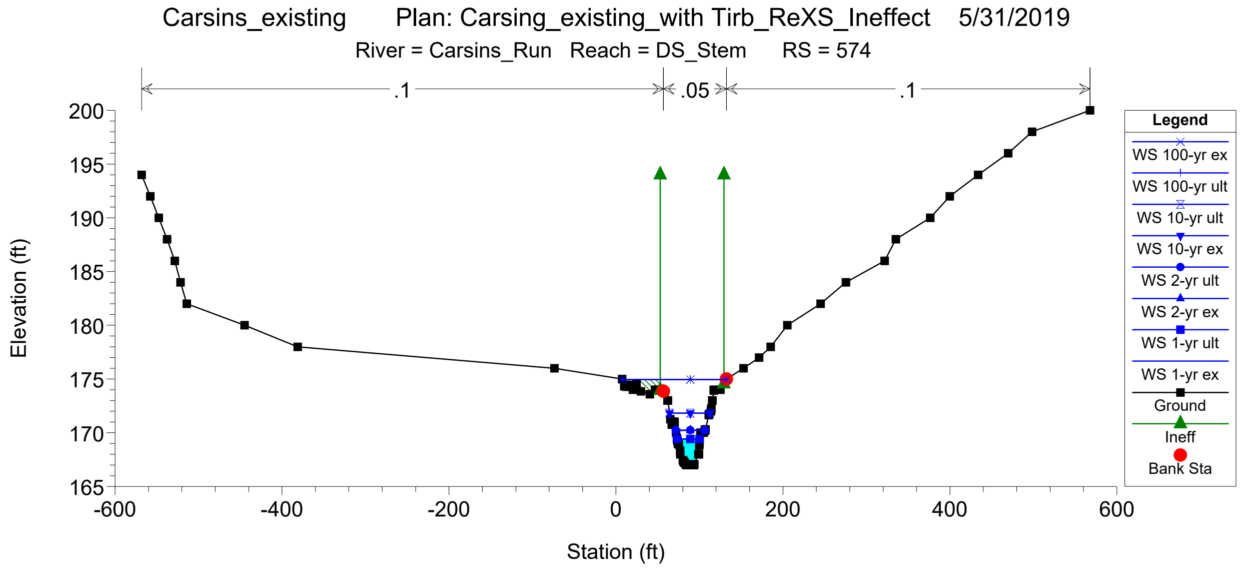
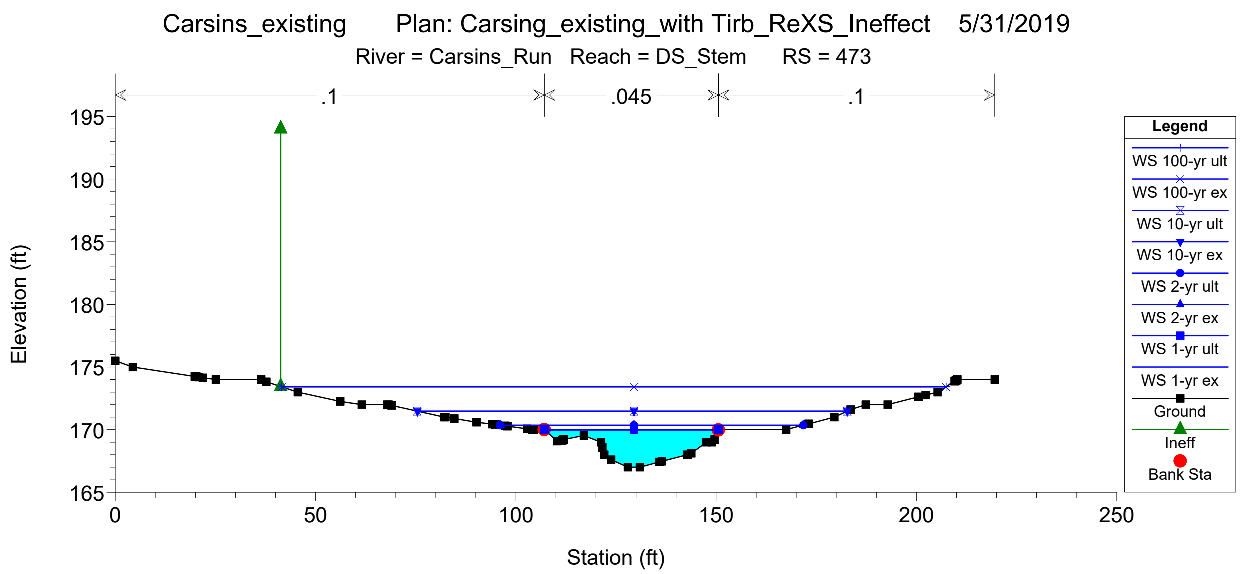
.015
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
Ground
Ineff
Bank Sta

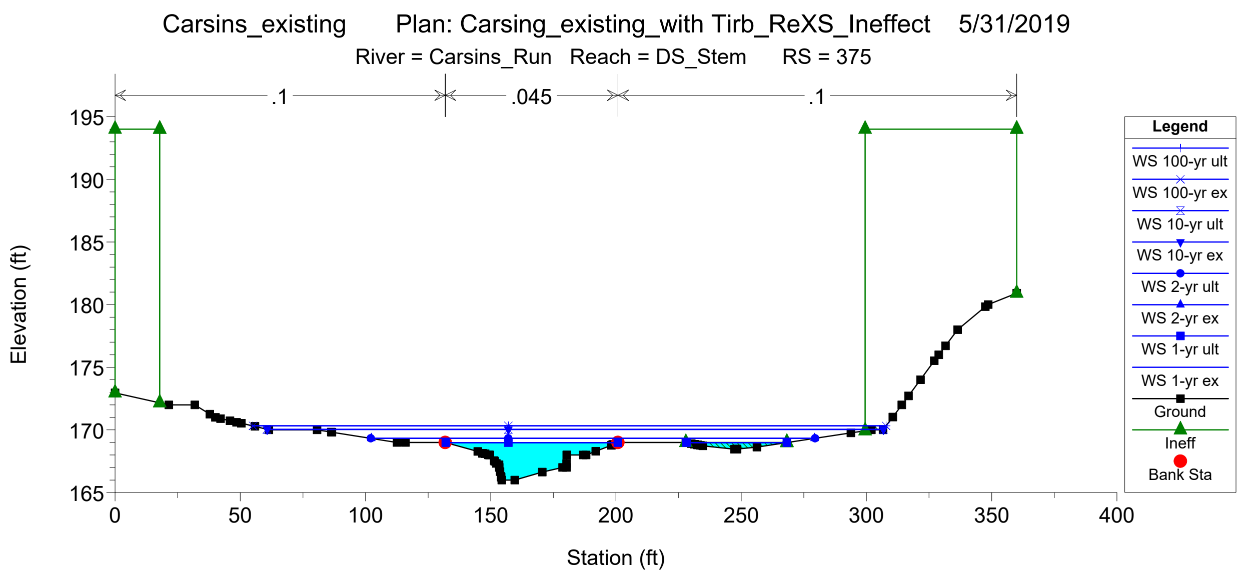

Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Carsins_Run Reach = DS_Stem RS = 721.4 Culv
.1
.05
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
Ground
Ineff
Bank Sta



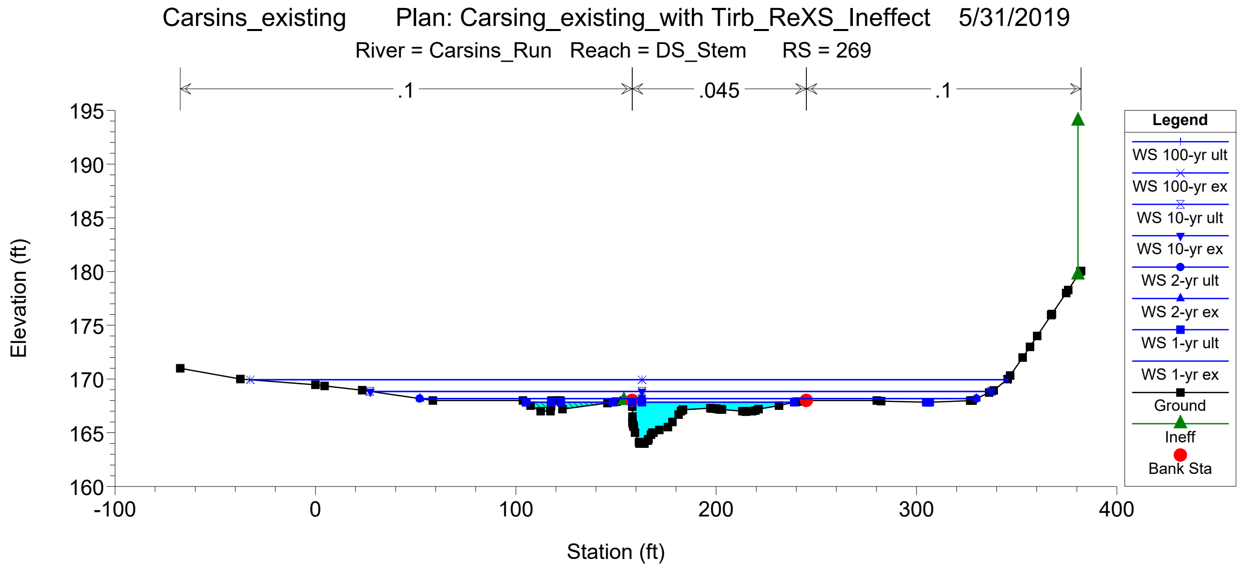
Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Carsins_Run Reach = DS_Stem RS = 574
.1
.05
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ex
WS 100-yr ult
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Ineff
Bank Sta



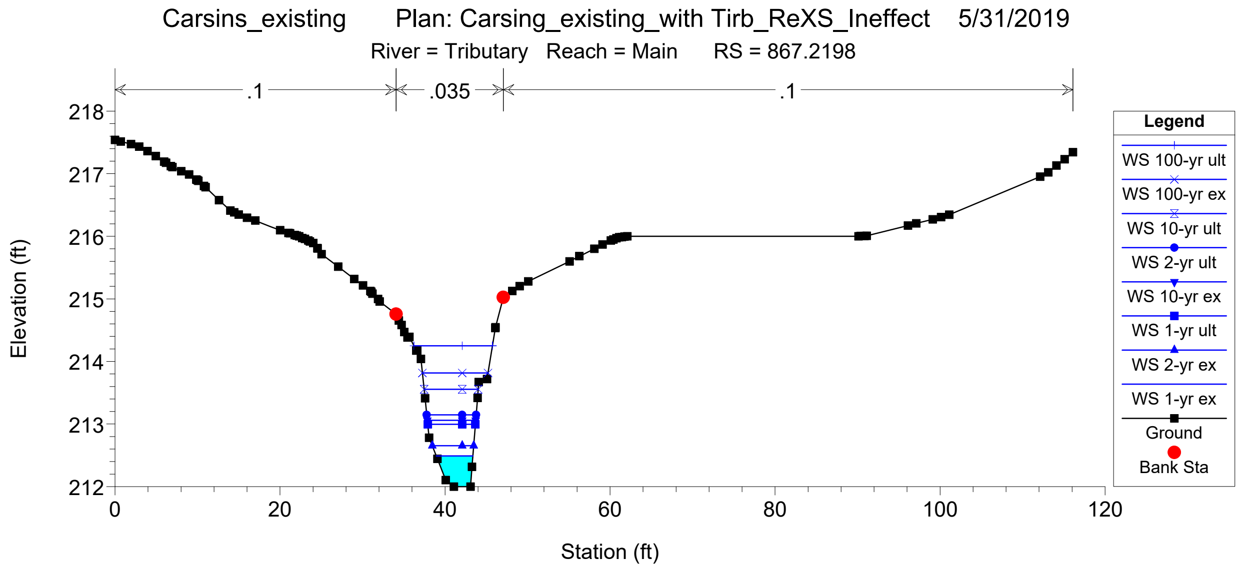
Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Carsins_Run Reach = DS_Stem RS = 473
.1
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Ineff
Bank Sta



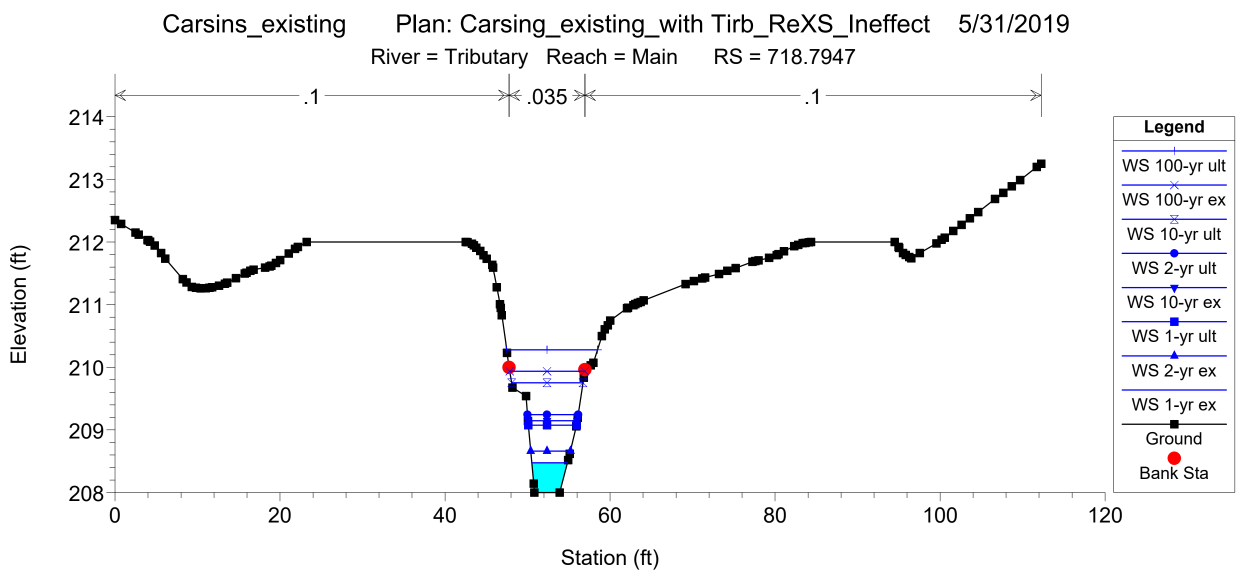
Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Carsins_Run Reach = DS_Stem RS = 375
.1
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Ineff
Bank Sta



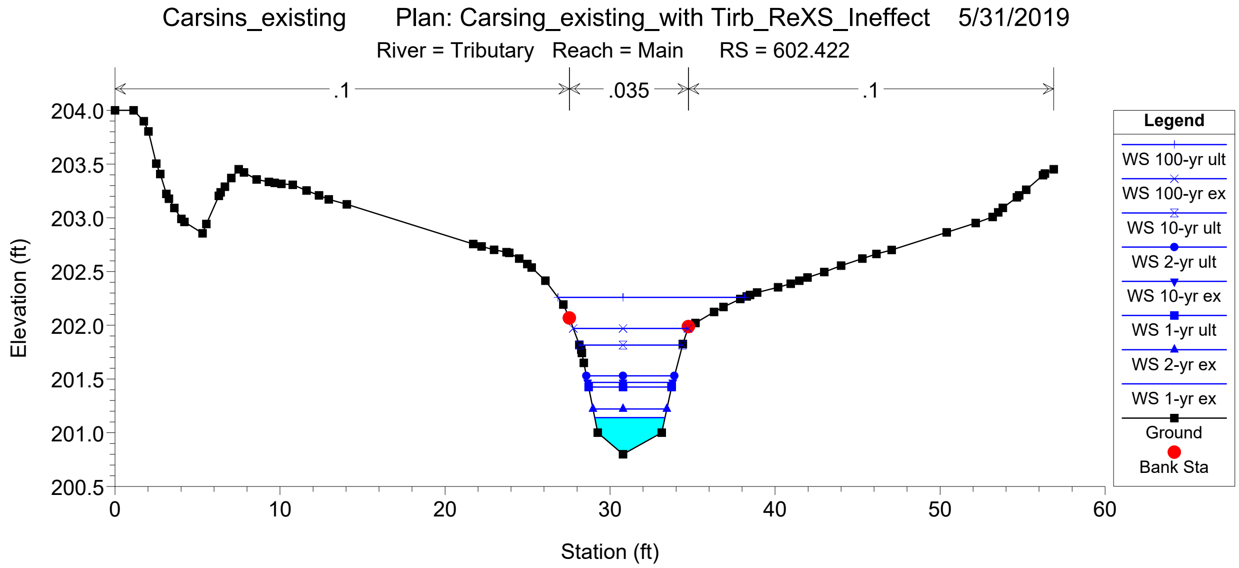
Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Carsins_Run Reach = DS_Stem RS = 269
.1
.045
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Ineff
Bank Sta

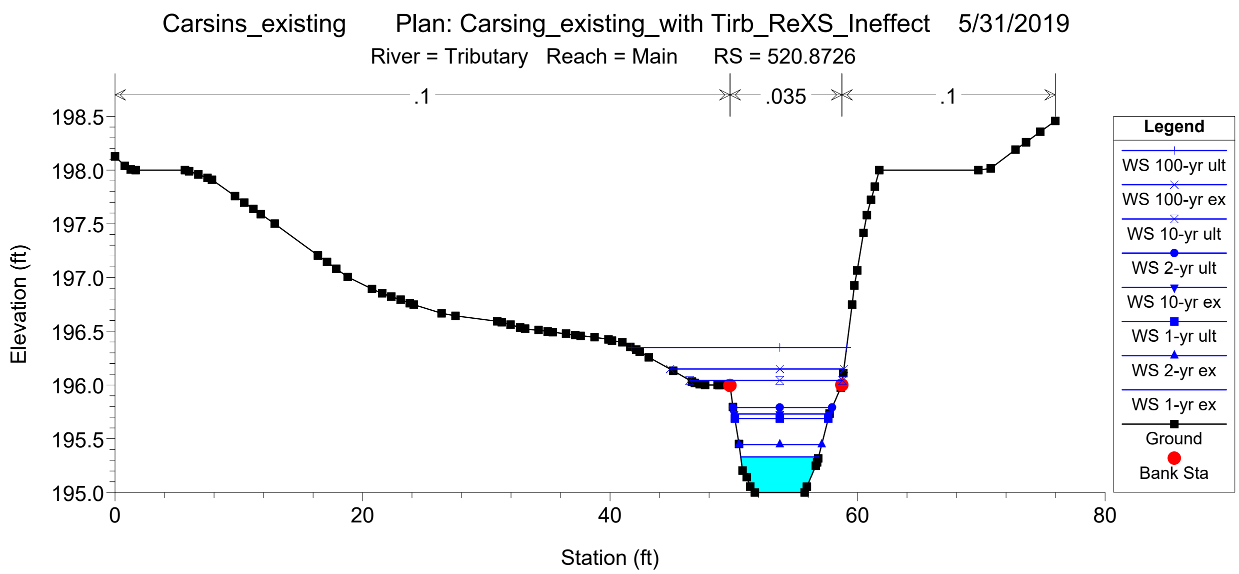


Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Tributary Reach = Main RS = 867.2198
.1
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Bank Sta



Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Tributary Reach = Main RS = 718.7947
.1
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Bank Sta


Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Tributary Reach = Main RS = 602.422
.1
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Bank Sta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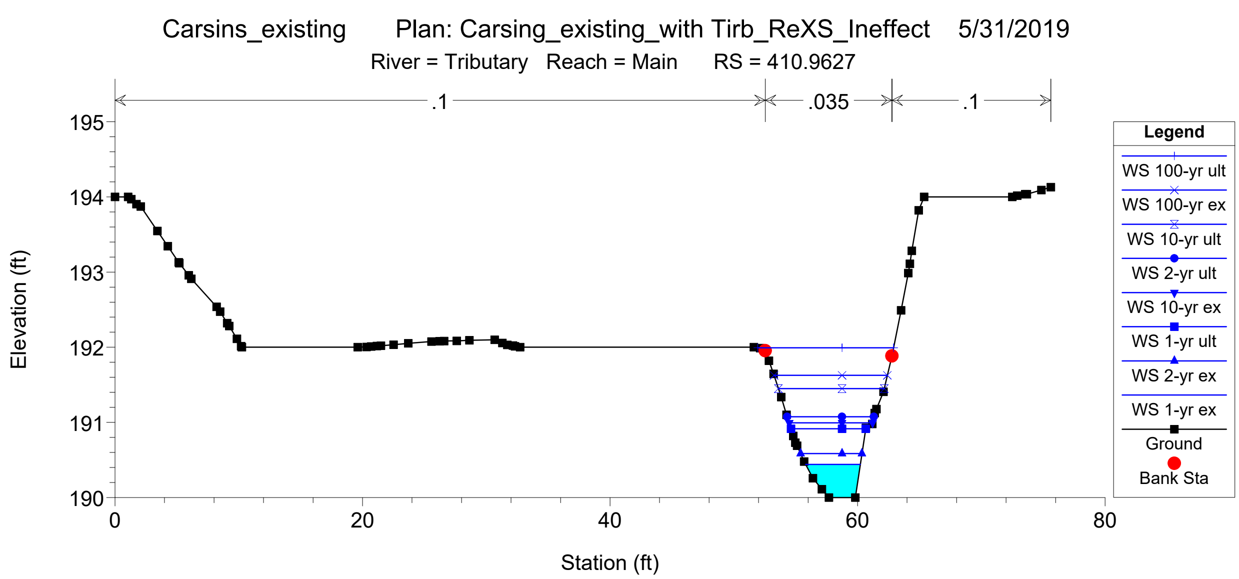
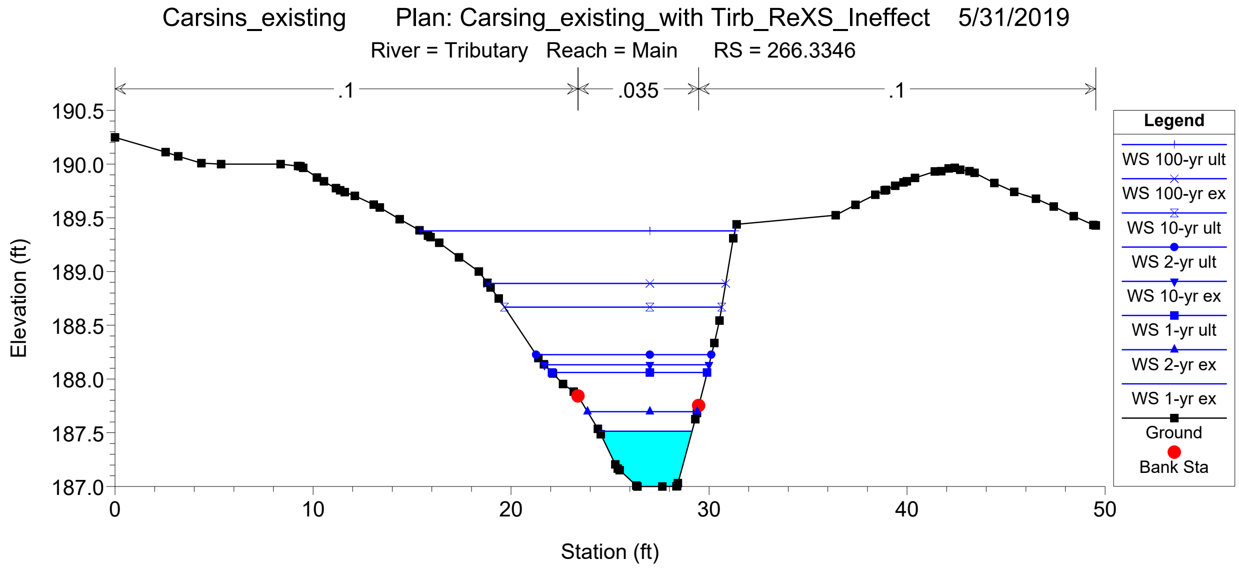
River = Tributary Reach = Main RS = 520.8726
.1
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Bank Sta


Carsins_existing Plan: Carsing_existing_with Tirb_ReXS_Ineffect 5/31/2019
River = Tributary Reach = Main RS = 410.9627
.1
.035
.1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Bank Sta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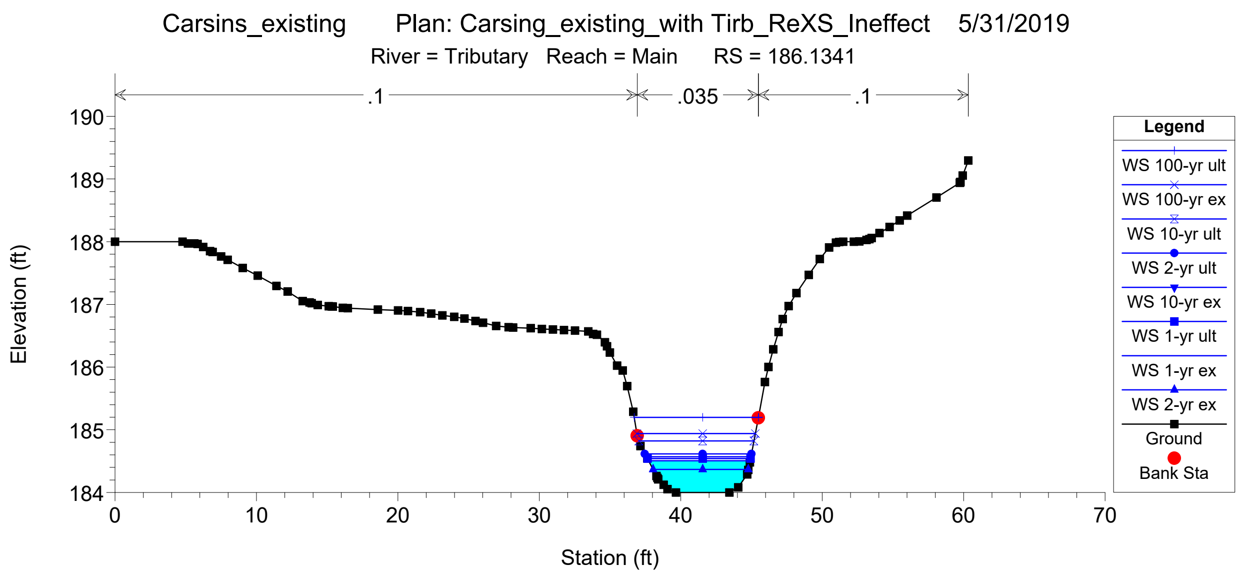
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WS 2-yr ex
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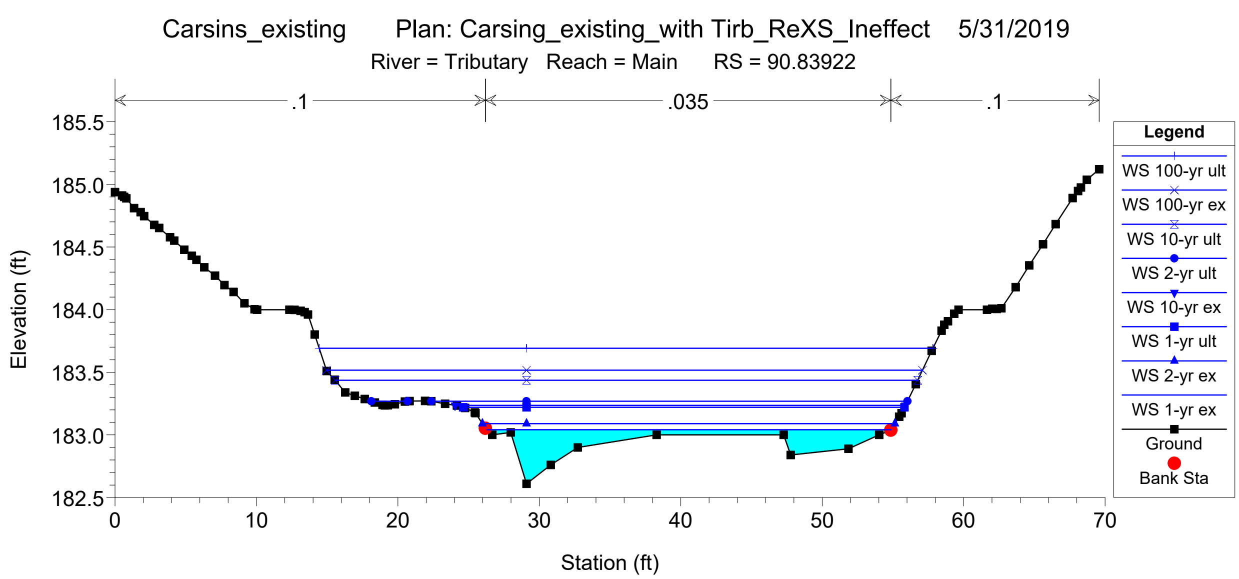
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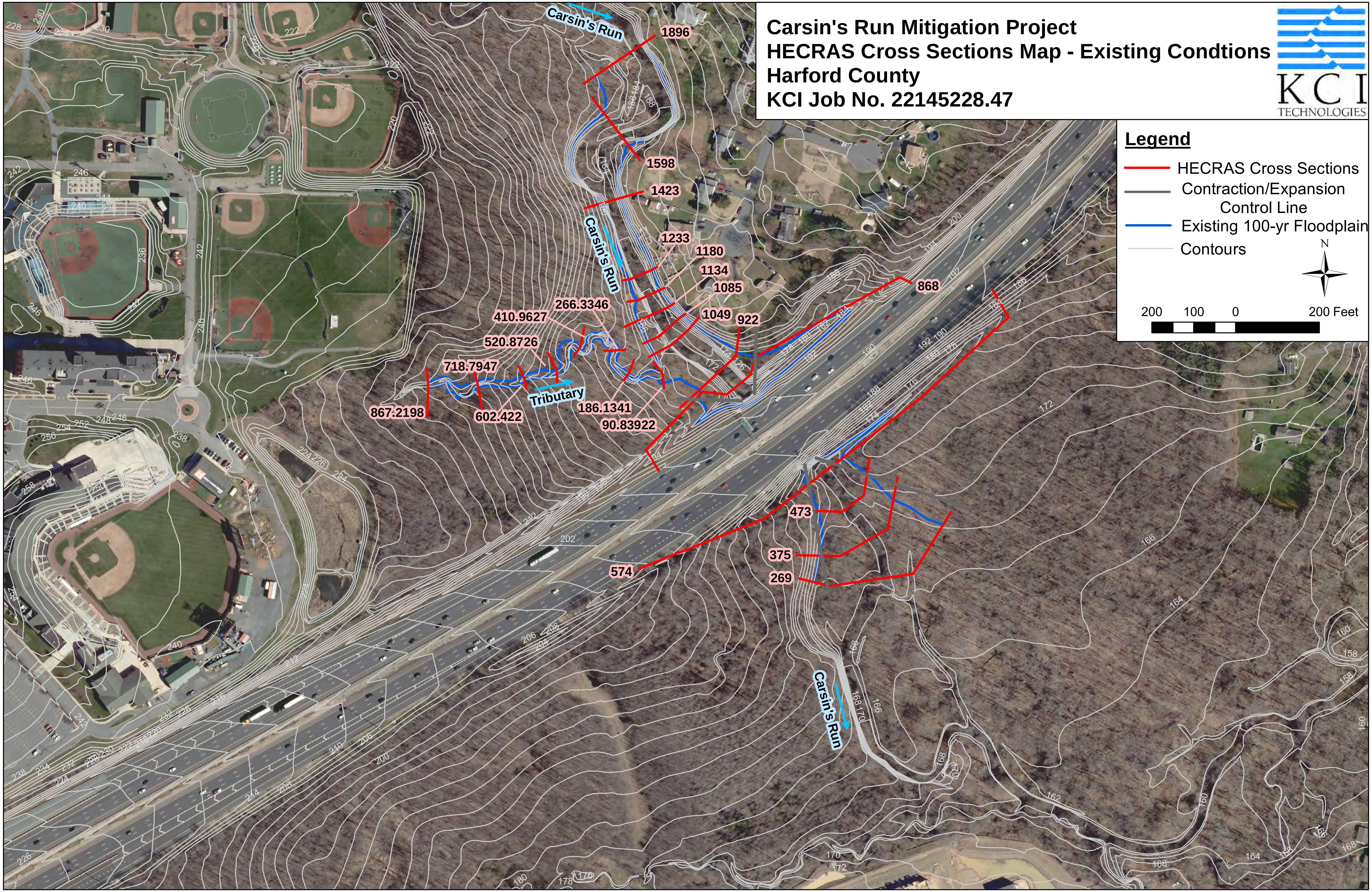
WS 2-yr ex
WS 1-yr ex
Ground
Bank Sta


Carsin's Run Mitigation Project
HECRAS Cross Sections Map - Existing Condtions
Harford County
KCI Job No. 22145228.47
KCI TECHNOLOGIES
Legend
HECRAS Cross Sections
Contraction/Expansion Control Line
Existing 100-yr Floodplain
Contours
N
200 100 0 200 Feet
Carsin's Run
Tributary
1896
1598
1423
1233
1180
1134
1085
1049
922
868
266.3346
410.9627
520.8726
718.7947
867.2198
602.422
186.1341
90.83922
473
375
269
574

APPENDIX I.2

PROPOSED CONDITIONS
HYDRAULIC REPORT

HYDRAULICS

PROPOSED CONDITIONS

The Carsins Run Mainstem and Tributary will be improved to provide long term stability and enhanced habitat conditions. Improvements to the Carsins Run Mainstem include removal of the current failing concrete channel section; installation of two riffle grade controls; and installation of one W-Weir at the entrance to the existing I-95 box culvert. Improvements to the Tributary include Re-alignment of portions of the channel and installation of rock step pools and riffle pools to protect the channel bed and banks from erosion. The existing conditions HEC-RAS model serves as the base; updated to include the proposed improvements. This effort included adding new cross sections to the main stem model and re-defining Manning's 'n' values along the tributary reach to simulate losses within the step pools.

PROPOSED HEC-RAS CROSS SECTIONS

The existing conditions cross section locations have been utilized, where possible, in the proposed HEC-RAS geometry model to serve as a point of comparison (water surface elevation and shear stress) between the two development conditions. The existing cross section geometry has been revised to incorporate the proposed grading. Additional cross sections have been provided within the study reaches to define key points such as changes in profile grade, changes in channel geometry or locations of grade control structures. Regarding the tributary channel improvements, cross sections were placed at the end of step pools or other critical areas to analyze the maximum velocities and shear stresses within the system.

MANNING'S ROUGHNESS

The values for Manning's 'n' coefficient have been selected to simulate the roughness characteristics of the channel bed, banks and floodplain based on the proposed improvements. All values utilized are within the acceptable ranges based on Chow's *Open Channel Hydraulics, 1959*. The 'n' value of 0.045 assigned to the main stem natural channel in the existing conditions model remains unchanged in the proposed condition model, except the portion of the reach containing the proposed 'W' weir. For the 'W' weir cross section, a value of 0.6 has been assigned to simulate the effect of the energy losses imposed by this structure within the contraction zone of the I-95 box culvert. Regarding the tributary reaches 1 & 3, a Manning's 'n' value of 0.04 is used where rock is introduced by the riffles. In reaches 2 & 4, an 'n' value of 0.1 is defined for the proposed step pools. The overbank 'n' value for all reaches remains at 0.1 (the same as the existing conditions model) to represent the wooded nature of the landscape.

MODELING APPROACH AND SUMMARY TABLES

As previously referenced within the report, the ultimate buildout scenario within the watershed is unlikely; therefore, the existing condition hydrology has been utilized within the steady flow data for the two (2) and ten (10) year storm recurrence intervals to evaluate and validate the stream restoration design. A comparison summary of results for the existing vs. proposed conditions modeling (shear stress and channel velocity) is provided in Tables 1 through 4. The complete HEC-RAS results are provided in Appendix I.2.1. See report Section 4.1.4 and Appendix G. for a discussion concerning the channel bed stone sizing and material design methodology.

Table 1. Existing and Proposed 2-yr Shear Stress – Existing Hydrology

River	Reach	Existing River Station	Existing Shear Channel (lb/sq ft)**	Proposed River Station	Proposed Shear Channel (lb/sq ft) ***	% Change
Carsins_Run	Main_Stem	1896	1.08	1896	1.08	0%
Carsins_Run	Main_Stem	1598	3.53	1598	3.53	0%
Carsins_Run	Main_Stem	1423	3.49	1423	2.43	-30%
Carsins_Run	Main_Stem	1233	1.21	1233	1.41	17%
Carsins_Run	Main_Stem	1180	1.94	1180	1.59	-18%
Carsins_Run	Main_Stem	1134	1.02	1134	1.03	1%
Carsins_Run	Main_Stem	1085	1.30	1085	1.33	2%
Carsins_Run	Main_Stem	1049	1.72	1049	1.50	-13%
Carsins_Run	Main_Stem	922	5.99	922	4.58	-24%
Carsins_Run	DS_Stem	868	0.64	868	5.11	698%
Carsins_Run	DS_Stem	574	3.82	574	3.82	0%
Carsins_Run	DS_Stem	473	2.10	473	2.10	0%
Carsins_Run	DS_Stem	375	1.11	375	1.11	0%
Carsins_Run	DS_Stem	269	1.05	269	1.05	0%
Tributary	Reach 1	867.2198	0.88	854.56	0.9	2%
Tributary	Reach 2A	718.7947	0.77	713.14	2.25	192%
Tributary	Reach 2B	602.422	3.67	597.94	2.92	-20%
Tributary	Reach 2B	520.8726	0.92	518.16	1.10	20%
Tributary	Reach 3	410.9627	1.19	420.35	0.9	-24%

**Results from Existing HEC-RAS model – See Appendix I.1.1

***Results from Proposed HEC-RAS model – See Appendix I.2.1

Table 2. Existing and Proposed 10-yr Shear Stress – Existing Hydrology

River	Reach	Existing River Station	Existing Shear Channel (lb/sq ft)	Proposed River Station	Proposed Shear Channel (lb/sq ft)	% Change
Carsins_Run	Main_Stem	1896	1.42	1896	1.42	0%
Carsins_Run	Main_Stem	1598	1.58	1598	1.58	0%
Carsins_Run	Main_Stem	1423	7.89	1423	7.88	0%
Carsins_Run	Main_Stem	1233	1.92	1233	2.24	17%
Carsins_Run	Main_Stem	1180	3.59	1180	3.11	-13%
Carsins_Run	Main_Stem	1134	2.14	1134	2.18	2%
Carsins_Run	Main_Stem	1085	2.17	1085	2.30	6%
Carsins_Run	Main_Stem	1049	2.71	1049	2.74	1%
Carsins_Run	Main_Stem	922	7.28	922	1.01	-86%

River	Reach	Existing River Station	Existing Shear Channel (lb/sq ft)	Proposed River Station	Proposed Shear Channel (lb/sq ft)	% Change
Carsins_Run	DS_Stem	868	1.01	868	3.65	261%
Carsins_Run	DS_Stem	574	4.72	574	1.92	-59%
Carsins_Run	DS_Stem	473	3.18	473	3.18	0%
Carsins_Run	DS_Stem	375	1.99	375	1.99	0%
Carsins_Run	DS_Stem	269	1.53	269	1.53	0%
Tributary	Reach 1	867.2198	1.36	854.56	0.88	-35%
Tributary	Reach 2A	718.7947	1.08	713.14	3.81	253%
Tributary	Reach 2B	602.422	5.64	597.94	4.35	-23%
Tributary	Reach 2B	520.8726	1.58	518.16	2.11	34%
Tributary	Reach 3	410.9627	1.58	420.35	1.27	-20%

Table 3. Existing and Proposed 2-yr Channel Velocity – Existing Hydrology

River	Reach	Existing River Station	Existing Channel Velocity (ft/s)	Proposed River Station	Proposed Channel Velocity (ft/s)	% Change
Carsins_Run	Main_Stem	1896	4.97	1896	4.97	0%
Carsins_Run	Main_Stem	1598	9.11	1598	9.11	0%
Carsins_Run	Main_Stem	1423	8.66	1423	7.38	-15%
Carsins_Run	Main_Stem	1233	5.47	1233	5.87	7%
Carsins_Run	Main_Stem	1180	6.78	1180	6.22	-8%
Carsins_Run	Main_Stem	1134	5.04	1134	5.06	0%
Carsins_Run	Main_Stem	1085	5.43	1085	5.49	1%
Carsins_Run	Main_Stem	1049	6.14	1049	5.77	-6%
Carsins_Run	Main_Stem	922	13.48	922	9.37	-30%
Carsins_Run	DS_Stem	868	10.65	868	7.85	-26%
Carsins_Run	DS_Stem	574	8.26	574	8.26	0%
Carsins_Run	DS_Stem	473	6.8	473	6.80	0%
Carsins_Run	DS_Stem	375	4.8	375	4.81	0%
Carsins_Run	DS_Stem	269	4.52	269	4.52	0%
Tributary	Reach 1	867.2198	4.40	854.56	3.89	-12%
Tributary	Reach 2A	718.7947	4.18	713.14	2.63	-37%
Tributary	Reach 2B	602.422	8.34	597.94	2.95	-65%
Tributary	Reach 2B	520.8726	4.35	518.16	4.25	-2%
Tributary	Reach 3	410.9627	5.05	420.35	3.89	-23%

Table 4. Existing and Proposed 10-yr Channel Velocity – Existing Hydrology

River	Reach	Existing River Station	Existing Channel Velocity (ft/s)	Proposed River Station	Proposed Channel Velocity (ft/s)	% Change
Carsins_Run	Main_Stem	1896	5.67	1896	5.67	0%
Carsins_Run	Main_Stem	1598	6.20	1598	6.20	0%
Carsins_Run	Main_Stem	1423	13.65	1423	13.65	0%
Carsins_Run	Main_Stem	1233	7.34	1233	7.87	7%
Carsins_Run	Main_Stem	1180	9.71	1180	9.12	-6%
Carsins_Run	Main_Stem	1134	7.58	1134	7.64	1%
Carsins_Run	Main_Stem	1085	7.49	1085	7.70	3%
Carsins_Run	Main_Stem	1049	8.18	1049	8.21	0%
Carsins_Run	Main_Stem	922	16.26	922	5.27	-68%
Carsins_Run	DS_Stem	868	14.32	868	7.34	-49%
Carsins_Run	DS_Stem	574	9.68	574	6.46	-33%
Carsins_Run	DS_Stem	473	8.99	473	8.99	0%
Carsins_Run	DS_Stem	375	6.81	375	6.82	0%
Carsins_Run	DS_Stem	269	5.83	269	5.83	0%
Tributary	Reach 1	867.2198	5.92	854.56	4.27	-28%
Tributary	Reach 2A	718.7947	5.35	713.14	3.69	-31%
Tributary	Reach 2B	602.422	11.19	597.94	3.82	-66%
Tributary	Reach 2B	520.8726	6.14	518.16	6.29	2%
Tributary	Reach 3	410.9627	6.23	420.35	5.04	-19%

In order to evaluate the possible changes in the 100-yr floodplain due to the restoration improvements, the ultimate hydrology has been incorporated into the proposed condition steady flow data. (provided in Table 5 below). A comparison summary of the water surface elevation results for the existing vs. proposed conditions modeling is provided in Table 5. The complete HEC-RAS results are provided in Appendix I.2.1.

Table 5. Existing and Proposed 100 yr Water Surface Elevation-Ultimate Hydrology

River	Reach	Existing River Station	Existing W.S Elev (ft)*	Proposed River Station	Proposed W.S Elev (ft)**	Change (ft)
Carsins_Run	Main_Stem	1896	191.38	1896	190.67	-0.71
Carsins_Run	Main_Stem	1598	188.47	1598	187.06	-1.41
Carsins_Run	Main_Stem	1423	186.21	1423	184.31	-1.90
Carsins_Run	Main_Stem	1233	184.41	1233	183.05	-1.36
Carsins_Run	Main_Stem	1180	183.95	1180	182.46	-1.49
Carsins_Run	Main_Stem	1134	183.41	1134	182.73	-0.68
Carsins_Run	Main_Stem	1085	183.17	1085	182.74	-0.43
Carsins_Run	Main_Stem	1049	183.02	1049	182.78	-0.24
Carsins_Run	Main_Stem	922	182.43	922	182.63	+0.20
Carsins_Run	DS_Stem	868	182.46	868	182.52	+0.06

Carsins_Run	DS_Stem	574	174.95	574	174.95	+0.0
Carsins_Run	DS_Stem	473	173.42	473	173.43	+0.01
Carsins_Run	DS_Stem	375	170.32	375	170.33	+0.01
Carsins_Run	DS_Stem	269	169.93	269	169.93	+0.0
Tributary	Reach 1	867.2198	214.70	854.56	216.43	+1.73
Tributary	Reach 2A	718.7947	210.62	713.14	210.22	-0.40
Tributary	Reach 2B	602.422	204.73	597.94	202.79	-1.94
Tributary	Reach 2B	520.8726	197.38	518.16	196.37	-1.01
Tributary	Reach 3	410.9627	192.54	420.35	193.39	+0.85

*Results from Existing HEC-RAS model using existing hydrology
**Results from Proposed HEC-RAS model using ultimate hydrology

Table 6 identifies the location of each river reach with respect to the baseline of construction.

Table 6. Reach Summary

Reach Name	River	Upstream Beginning Construction Baseline Station	Ending Construction Baseline Station	Upstream Beginning Reach Station	Ending Reach Station
DS_Stem	Carsins Run DS of I-95 culvert	NA	NA	NA	NA
Main_Stem	Carsins Run US of I-95 culvert	10+00	14+34	92.07	0
Reach 1	Tributary	20+00	21+95	946.36	751.37
Reach 2a	Tributary	21+95	22+27	751.37	718.61
Reach 2b	Tributary	23+23	24+28	718.61	518.16
Reach 3	Tributary	24+28	27+37	518.16	209.36
Reach 4	Tributary	27+37	29+37	209.36	0.0

ADDITIONAL MODELING EVALUATION

Two HEC-RAS models were developed for the proposed condition in order to identify the relationship between maximum channel flows vs. maximum shear stress within the tributary channel. Our reasoning for the two models is based on the assumption that the Tributary will convey the peak discharge well ahead of the Carsins Run Mainstem; therefore, no back flooding of the Tributary will occur. The evaluation was conducted to confirm the controlling flood event for evaluation of the maximum shear stress. The two scenarios posited were: 1. The peak discharge occurs within the tributary channel before the Carsins Run main stem floods; thereby creating maximum velocities and shear stresses in the lower downstream portion of the channel; and 2. Flooding from Carsins Run will drown out the lower section of the tributary, thus creating an ineffective flow pool. In the first case, only the tributary channel was considered in the analysis, ignoring any flow or flooding effects from the main stem. The second scenario considered the combined impact while both river systems were operating. Based on the results, the two models did not differ significantly; therefore, we have only provided the results of the combined HEC-RAS model.

LEVEE COMMAND

The levee command was utilized in the main stem analysis to prevent program interpretation of the tributary channel as divided flow. It is assumed that during high flow events in the main channel, the tributary channel will be back flooded, and thus not acting as a flow channel. As discussed in the Additional Modeling Evaluation section above, the peak flow within the tributary channel will occur prior to the main stem flood event.

INEFFECTIVE FLOW AREAS

The ineffective flow area inputs at the approach and exit to the I-95 culvert remain unchanged from existing conditions.

BOUNDARY CONDITIONS

In the proposed condition, the upstream and downstream boundary conditions for both the main stem and tributary channel were assumed to be normal depth of flow.

CONTRACTION AND EXPANSION COEFFICIENTS

In the proposed condition, a 'W' weir will be installed within the contraction zone of the box culvert carrying Carsins Run under I-95. In order to simulate the losses imposed by this structure, the contraction and expansion coefficients have been adjusted to 0.3 and 0.5; respectively. The contraction and expansion coefficients for all other cross sections were set to 0.1 and 0.3, respectively.

MODEL RESULTS

The results show that for the 10-year proposed conditions model, main stem shear stress and velocities range from 1.01 lb/sq-ft to 7.88 lb/sq-ft and from 5.27 ft/s to 7.93 ft/s; respectively. Notable shear stress increases occur at cross section Stations 868 and 1233. As a point of discussion, cross-section 868 is located immediately upstream of the I-95 culvert within the new 'W' weir installation section of the channel. It is also located near the junction of the tributary channel which most likely is a contributing factor to the shear stress increase. Cross-section 1233 is located immediately upstream of a pre-formed scour hole (designed to dissipate energy at the storm drain culvert outfall). The shear stress increase at this location is local and associated with the channel improvement.

Ten year (10-yr) proposed shear stresses and velocities in the tributary stem vary from 0.88 lb/sq-ft to 4.35 lb/sq-ft and from 3.69 ft/s to 6.29 ft/s. It should be noted that shear stress changes in the tributary stem occur at cross-sections 518 and 713; whereby increases of more than 10% are computed. Rock step pools and riffle pools with proper stone sizes have been proposed to protect the channel bed and banks from erosion. A summary of proposed stone sizing is provided in the section 4.1.4 of the main report. Equations, distribution calculations, and stone size computations can be found in Appendix G.

The proposed water surface elevation for the main stem during the 100-year ultimate condition flow event shows an increase at four river stations (375, 473, 868 and 922). The water surface will remain unchanged or be lowered at all other main stem river station locations. The installation of the 'W' weir upstream of the I-95 culvert resulted in minor ultimate 100-yr water surface elevation increases in the 100 linear foot reach upstream of I-95; at Station 868 (0.06' increase) and 922 (0.20' increase). It should be noted that on the north side of the channel in this reach where there are private properties, the 100-year floodplain is completely within the existing drainage easement and there is about 9.3 ft of freeboard during 100-year flows. Therefore; no impacts to the adjacent private properties are anticipated for the ultimate 100-yr flow event.

Regarding the tributary channel, the 100 yr water surface, based on ultimate conditions, increases slightly within Reach 1 due to the horizontal and vertical re-alignment improvements. By design, the new channel will be significantly raised to provide flood relief during higher flow events. It should be noted that the tributary water surface increases occur on public State land and there is no infrastructure in the vicinity of the channel that would be impacted by the improvements.

References

Moglen, Glenn E (2007). *Introduction to GISHydro2000, GIS Based Hydrologic Analysis in Maryland.* College Park; University of Maryland.

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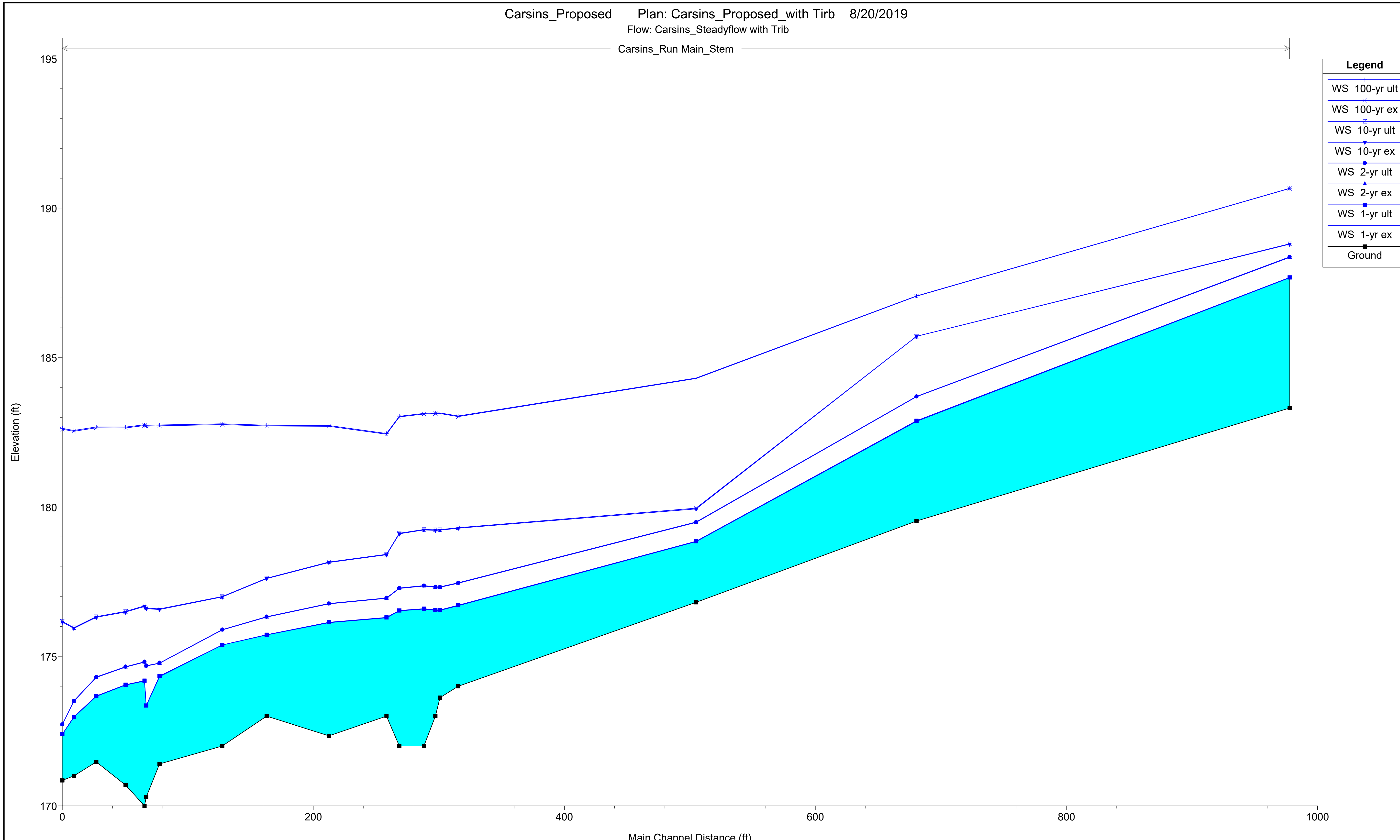
U.S. Army Corps of Engineers, Hydrologic Engineering Center, 2016. *HEC-RAS River Analysis System; Version 5.0.3.*

U.S. Army Corps of Engineers, Hydrologic Engineering Center, 2016. *HEC-RAS 5.0 Reference Manual.*

APPENDIX I.2.1

PROPOSED HEC-RAS RESULTS



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Flow: Carsins_Steadyflow with Trib
Carsins_Run Main_Stem
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Elevation (ft)
Main Channel Distance (ft)
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190
185
180
175
170
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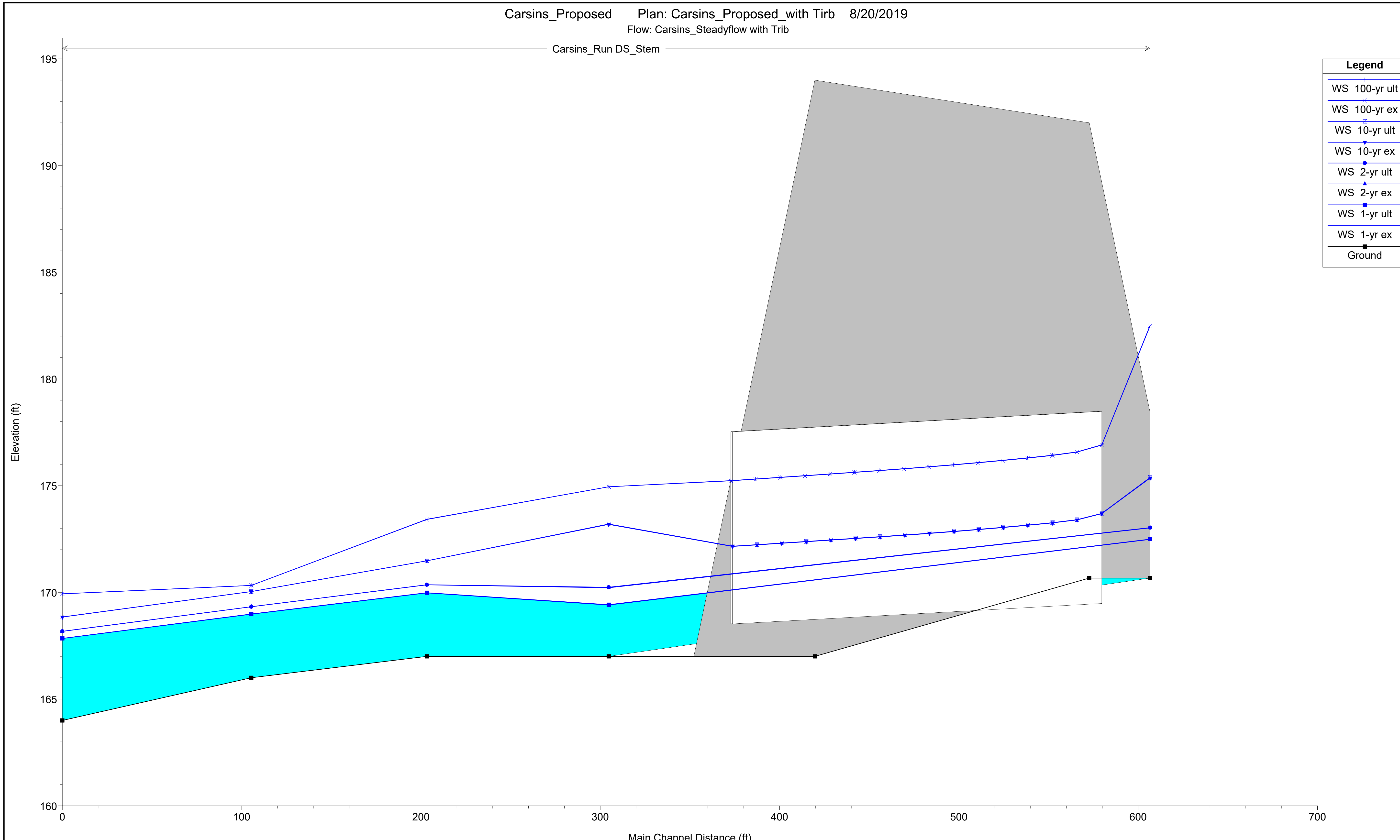
200
400
600
800
1000



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Flow: Carsins_Steadyflow with Trib
Carsins_Run DS_Stem
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Elevation (ft)
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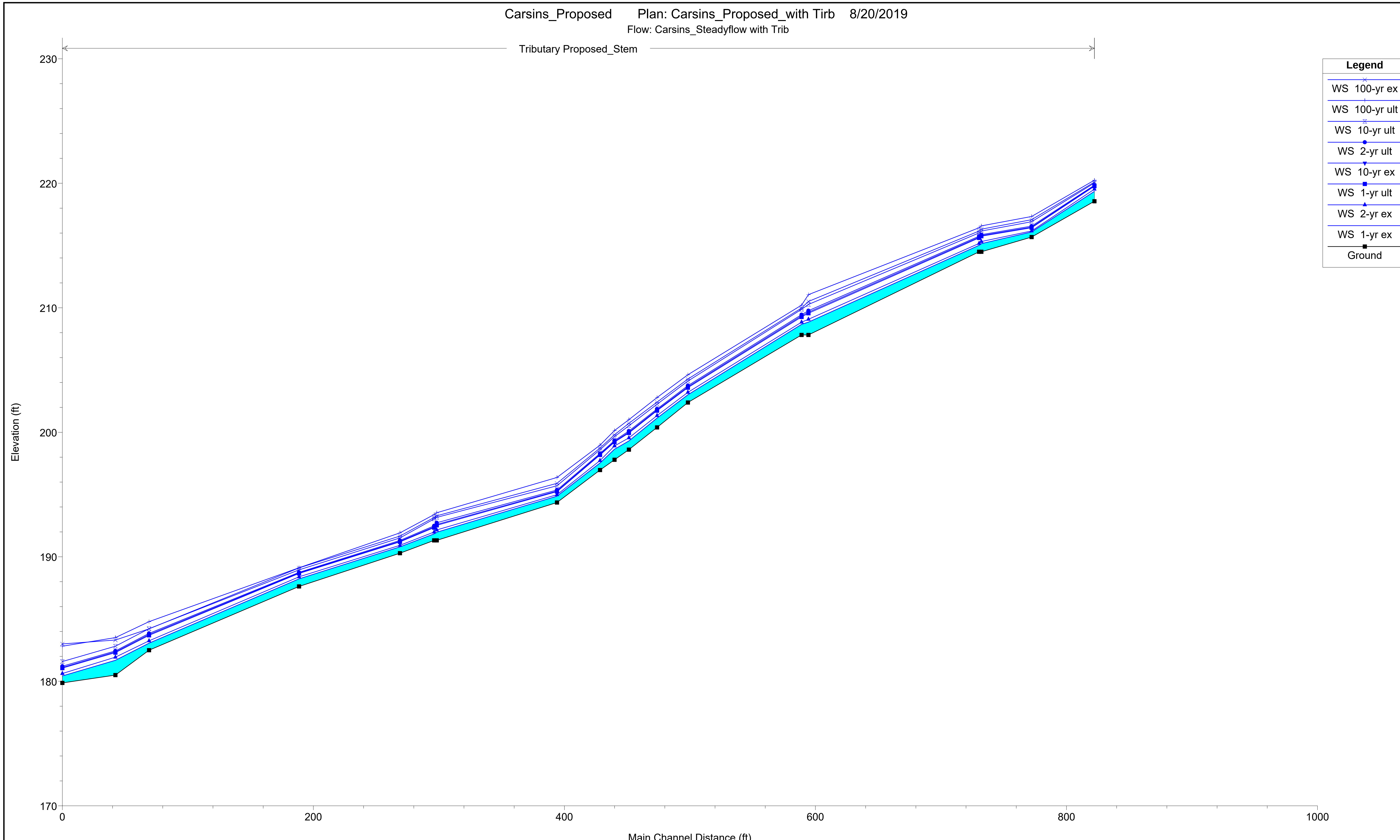
190
185
180
175
170
165
160
0
100
200
300
400
500
600
700
Main Channel Distance (ft)



Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
Tributary Proposed_Stem
Legend
WS 100-yr ex
WS 100-yr ult
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Elevation (ft)
Main Channel Distance (ft)
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180
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400
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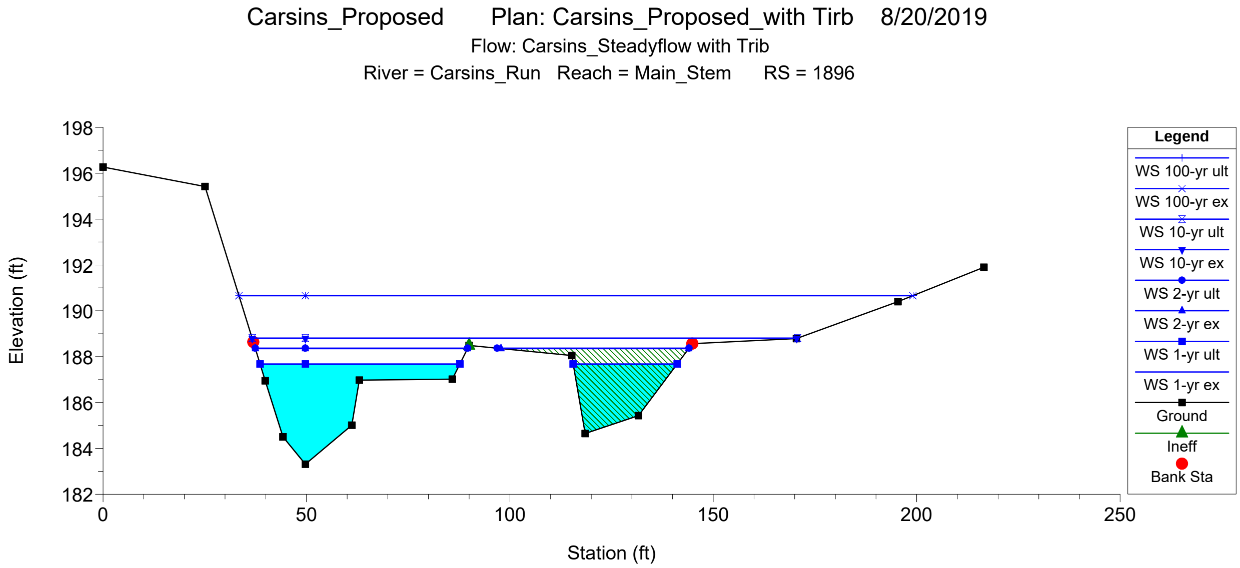
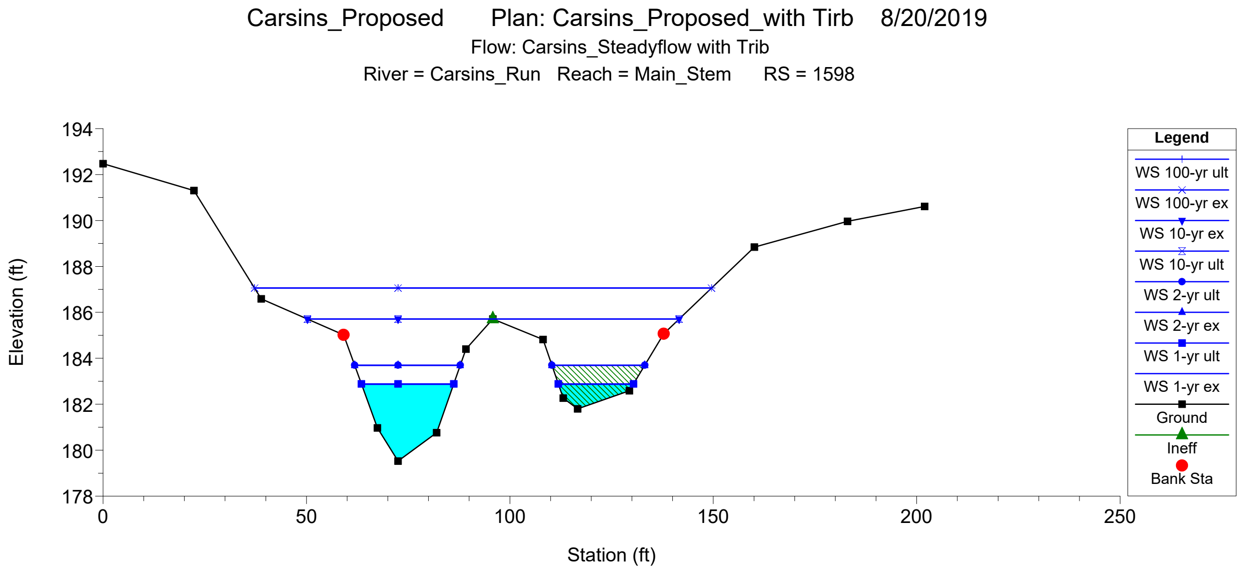
800
1000



Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 1896
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Ineff
Bank Sta



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Elevation (ft)
Station (ft)
Legend
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WS 2-yr ex
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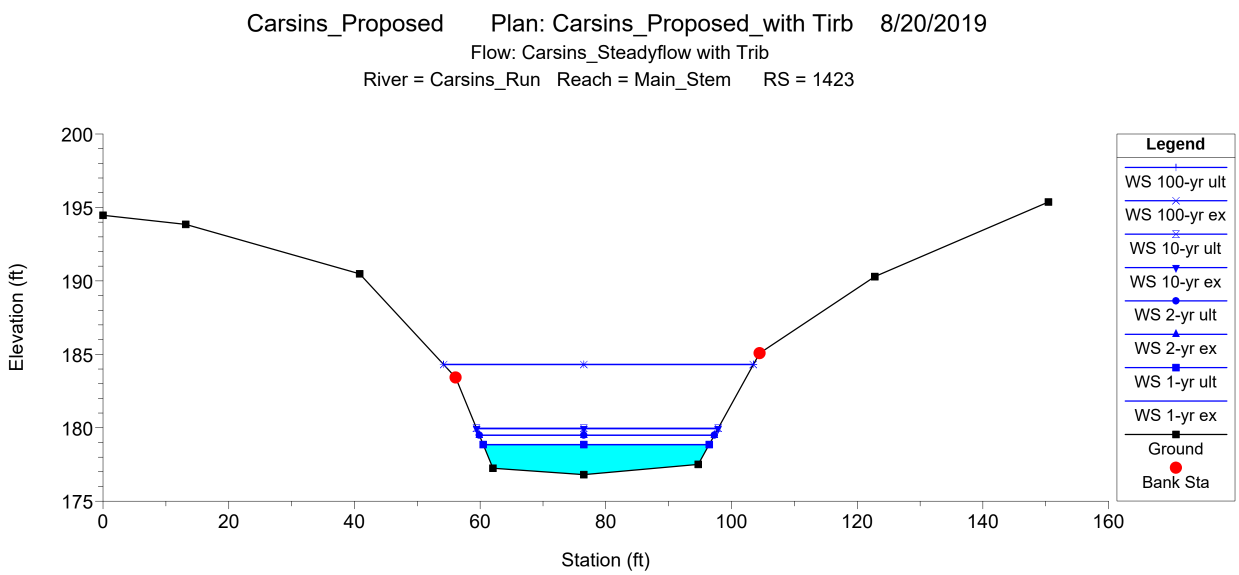
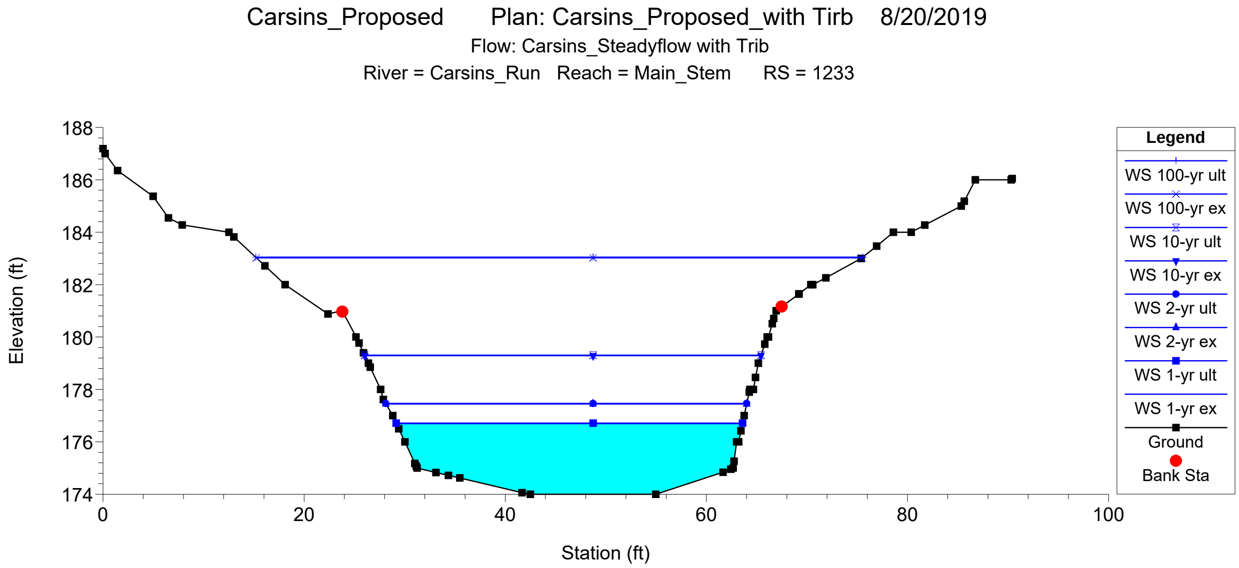
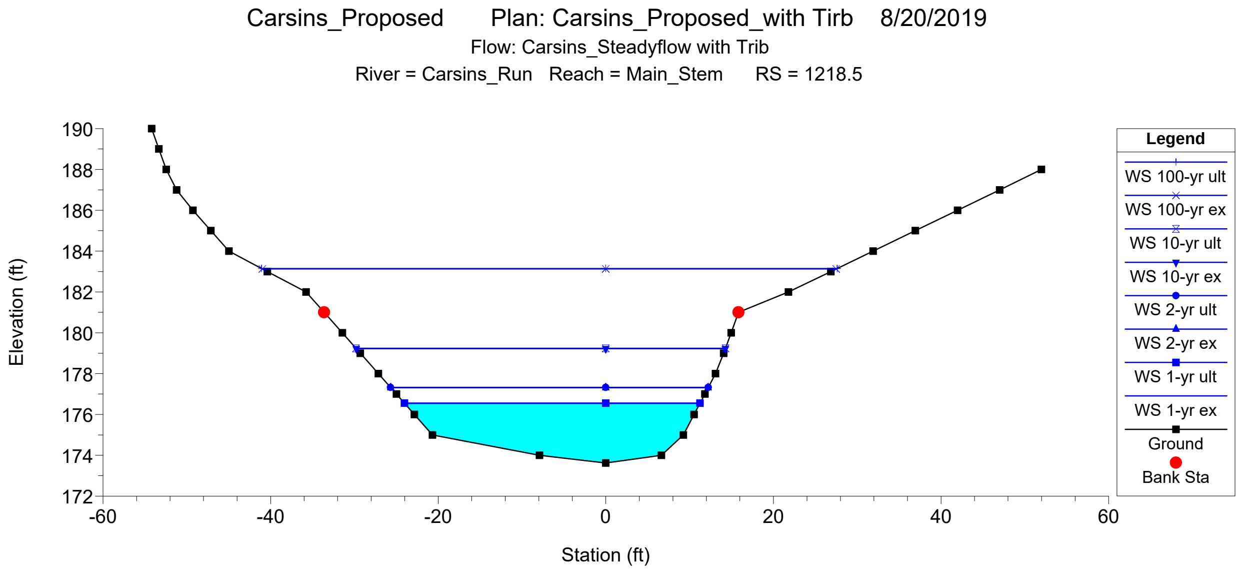
WS 1-yr ex
Ground
Ineff
Bank Sta



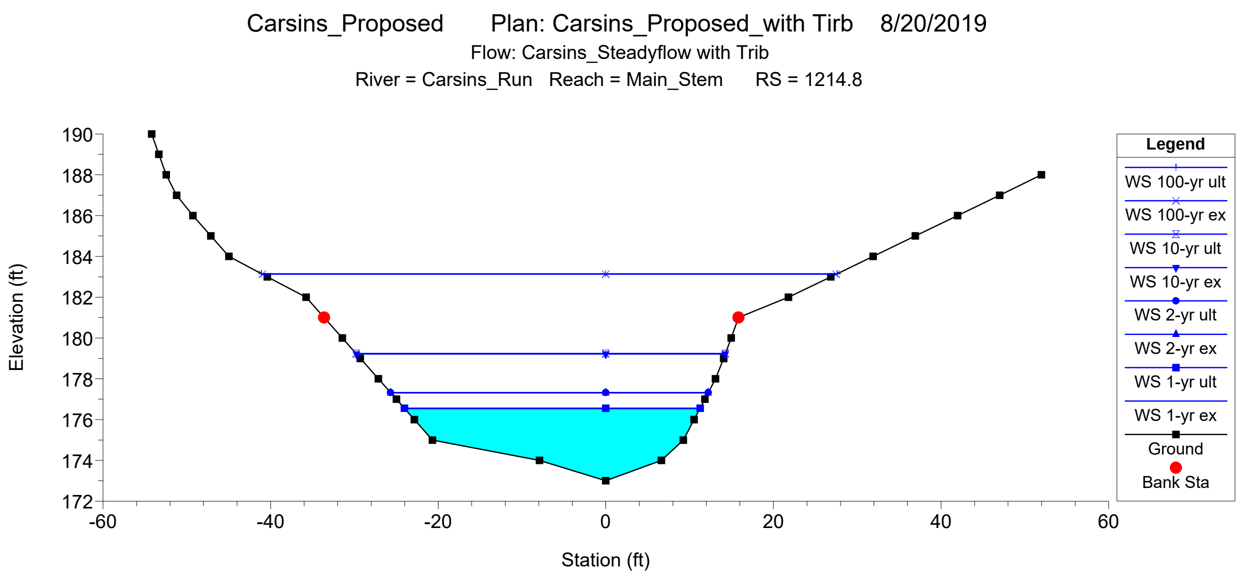
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 1423
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Bank Sta



Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 1233
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Bank Sta

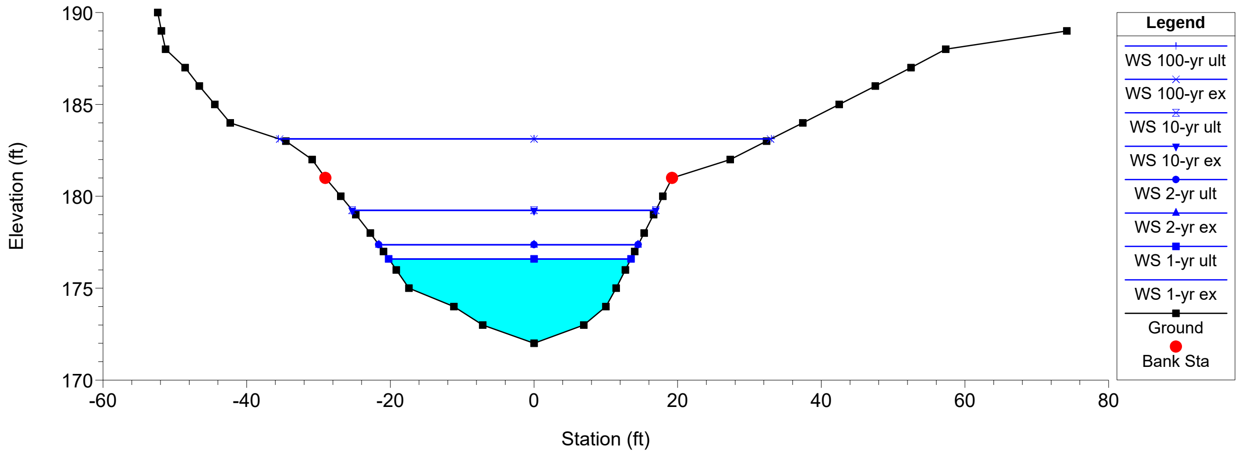


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 1218.5
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Bank Sta

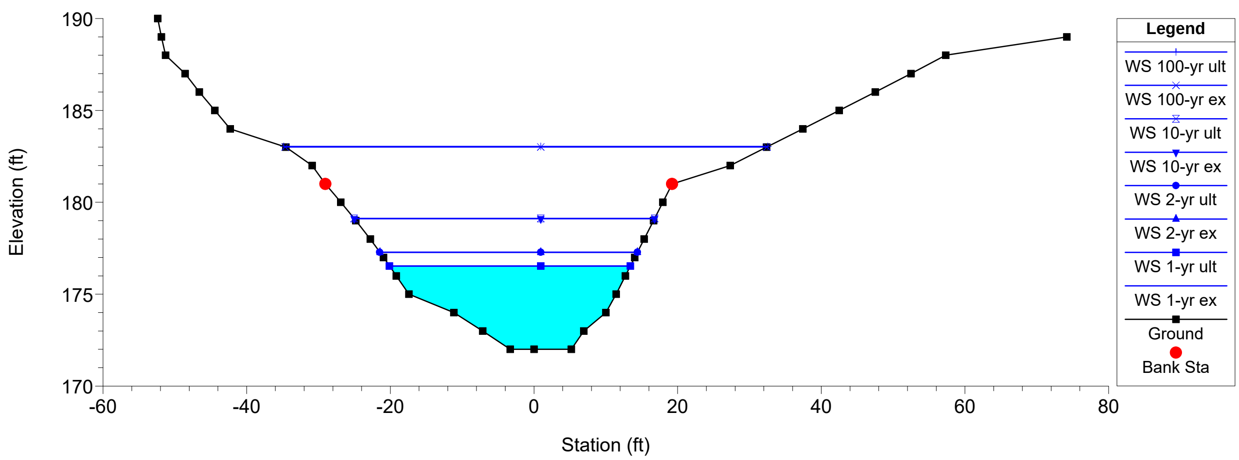


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 1214.8
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Bank Sta

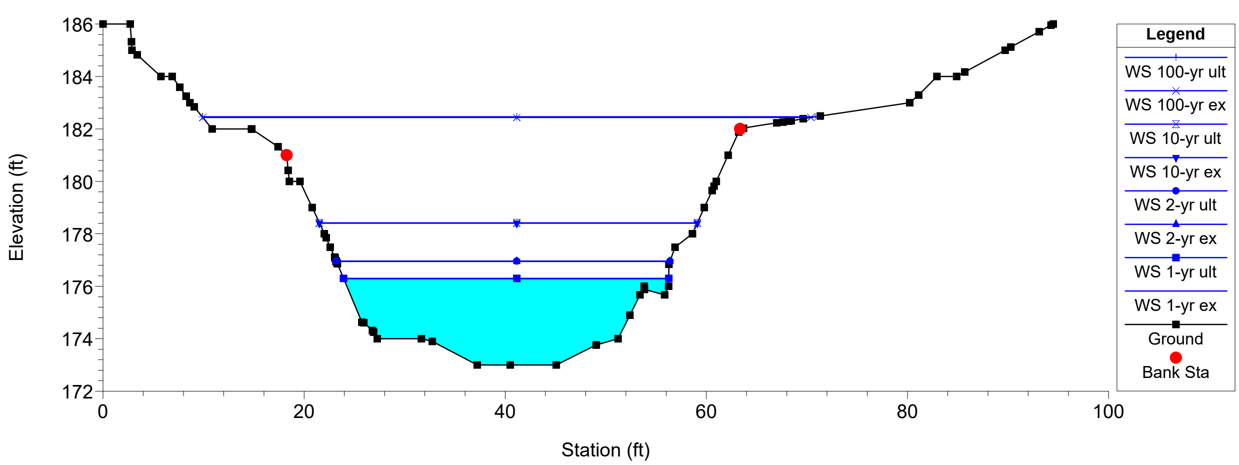
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 1205.67

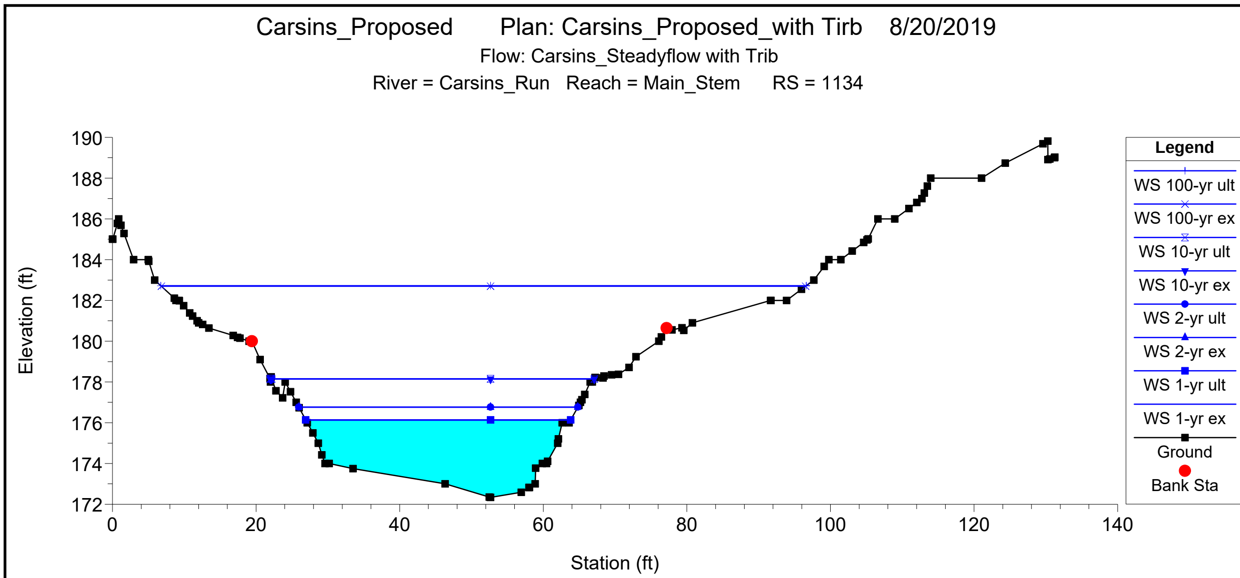


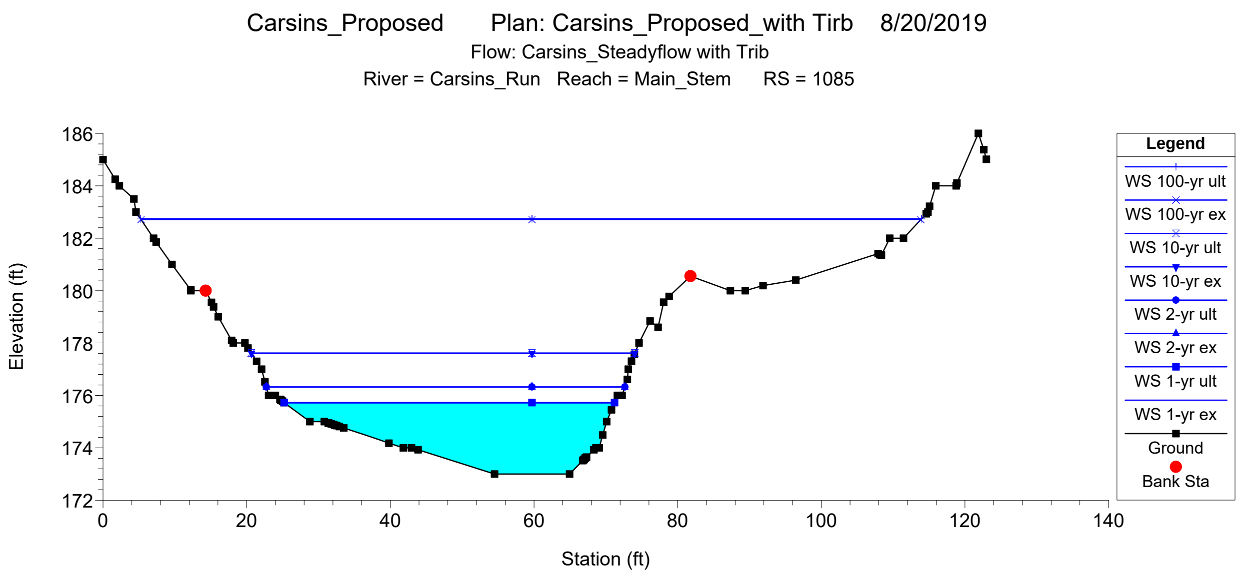
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 1186.07

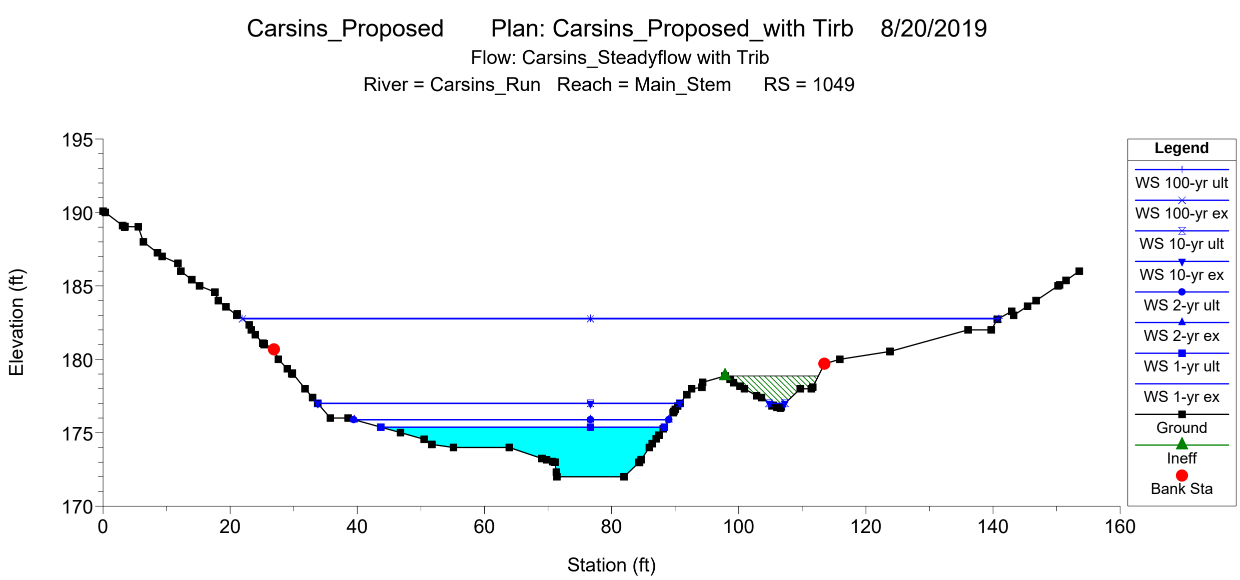


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 1180

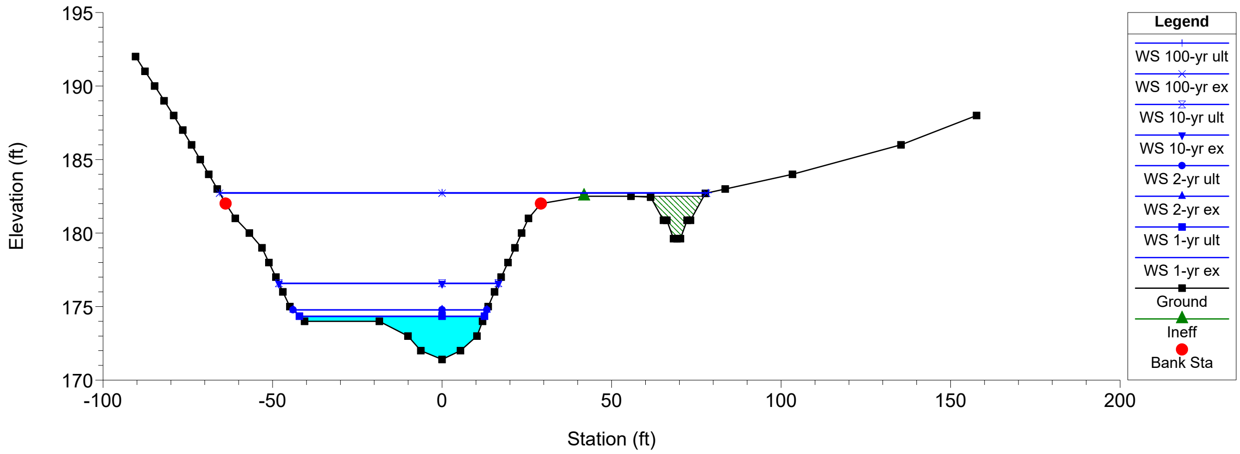



Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 1134
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Bank Sta

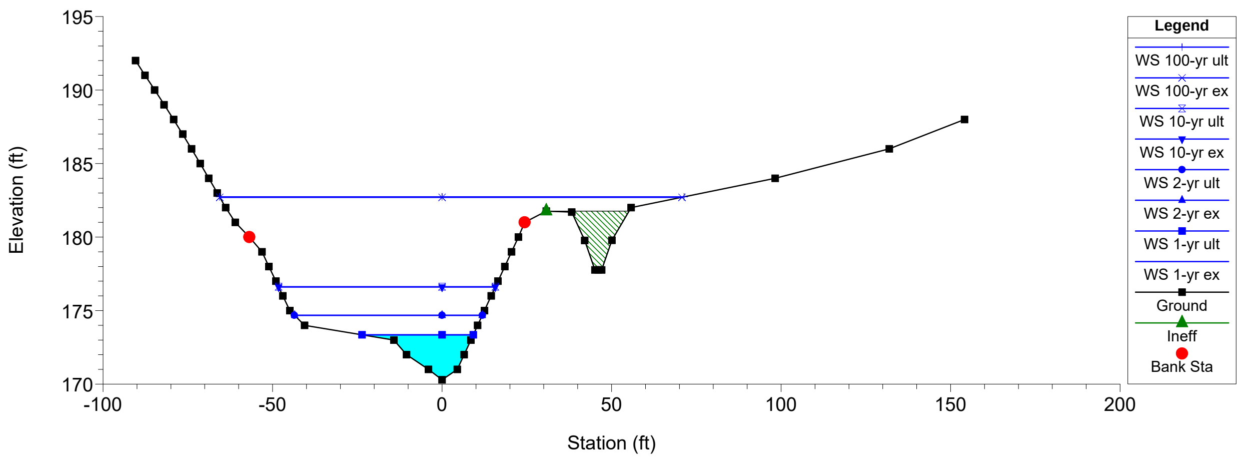

Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 1085
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Bank Sta


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 1049
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Ineff
Bank Sta

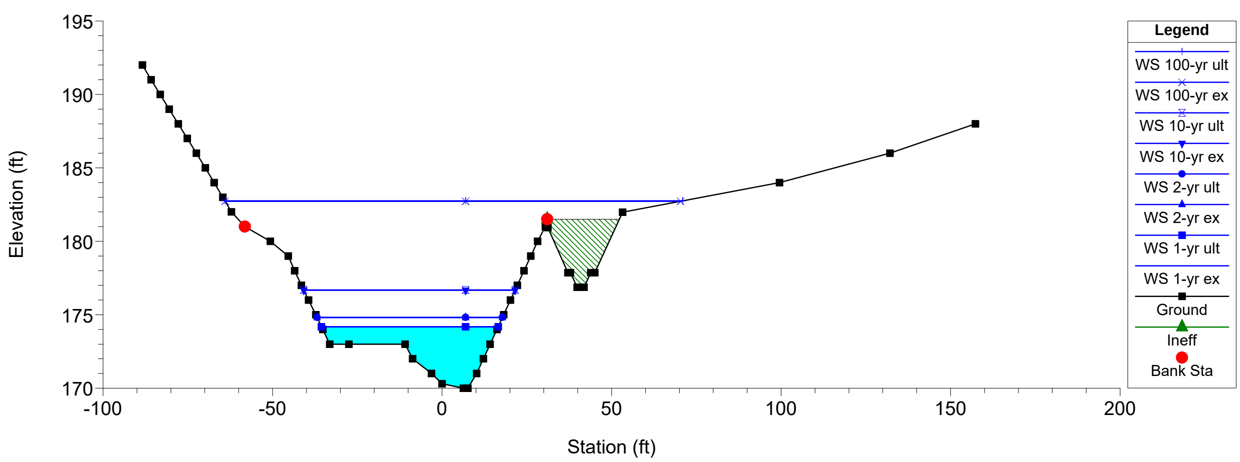
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 996.9



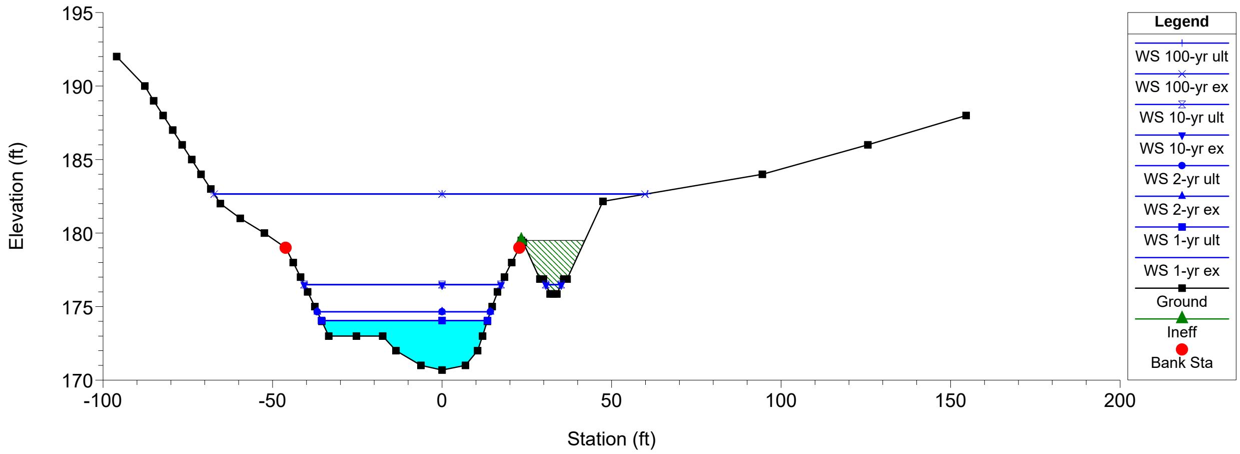
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 985.43



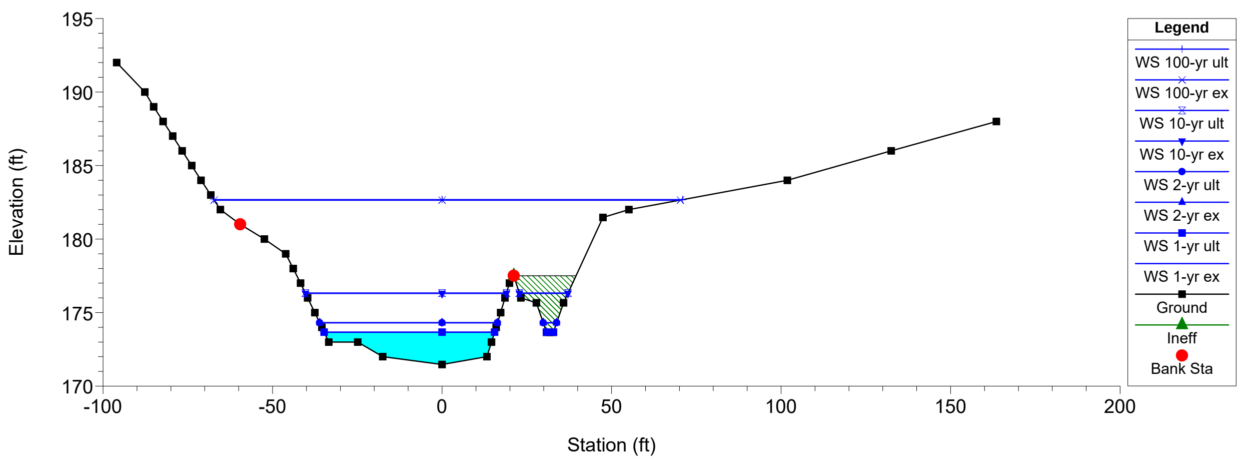
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 973



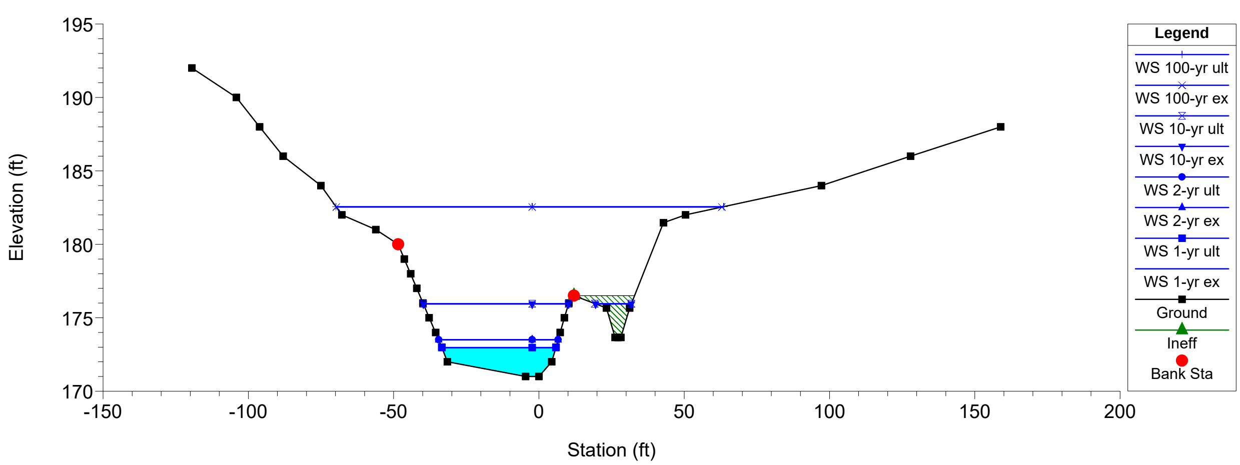
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 950.49



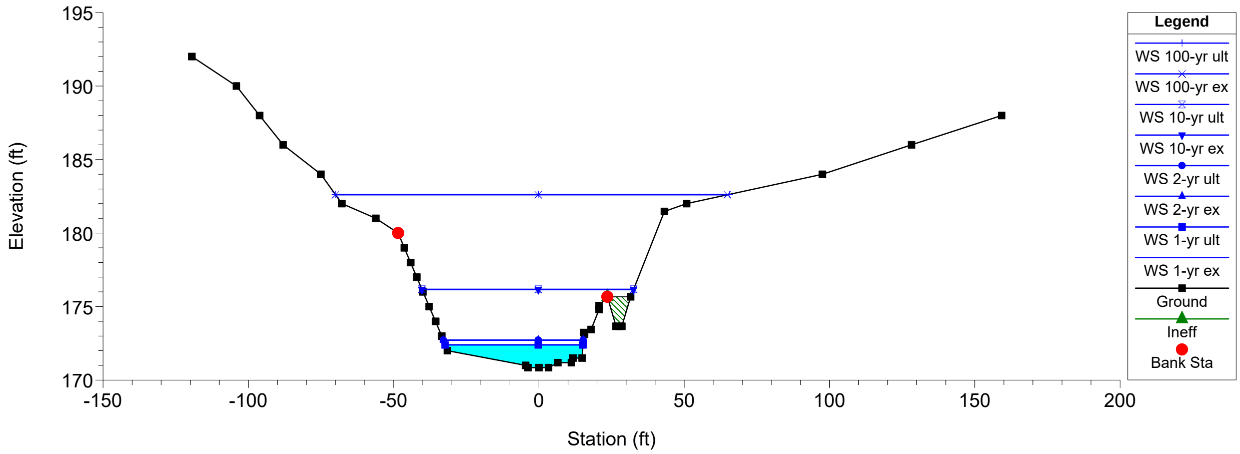
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 926.8



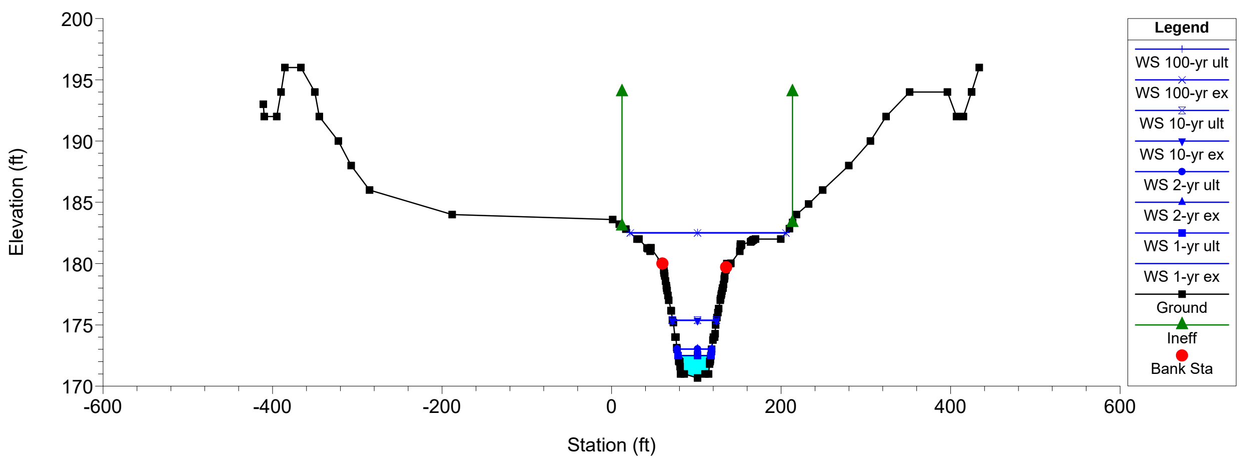
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 926



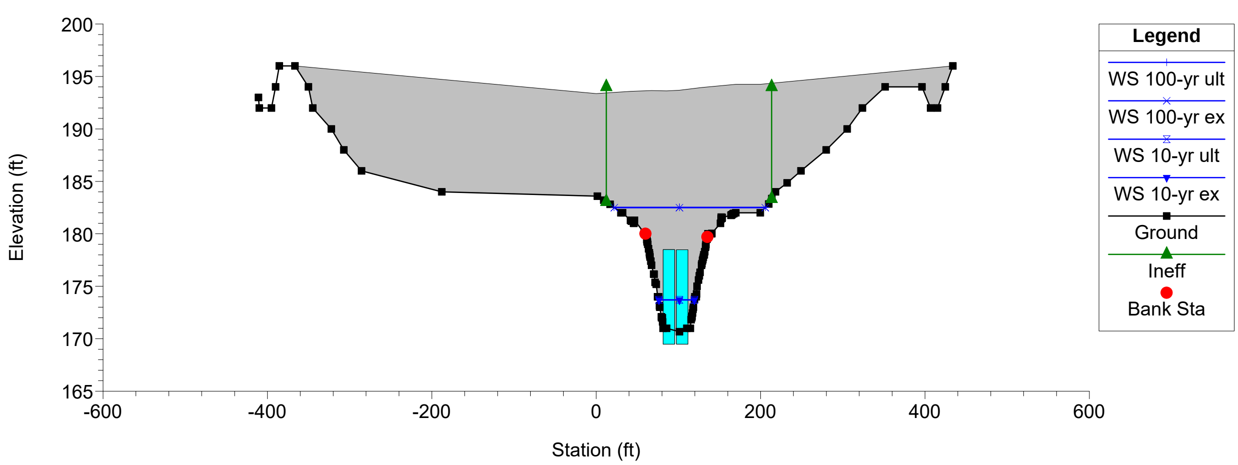
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = Main_Stem RS = 922



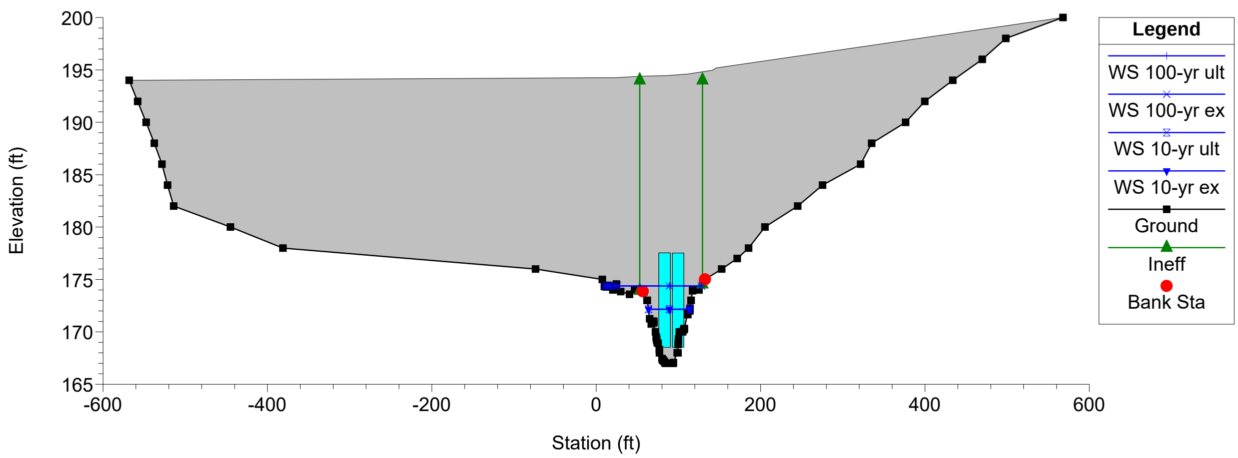
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = DS_Stem RS = 868



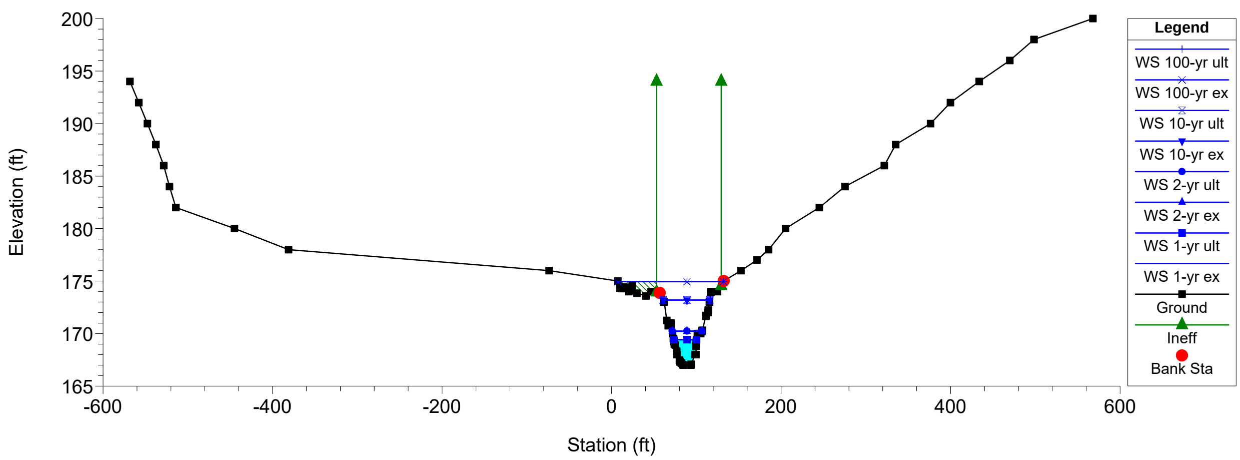
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = DS_Stem RS = 721.4 Culv



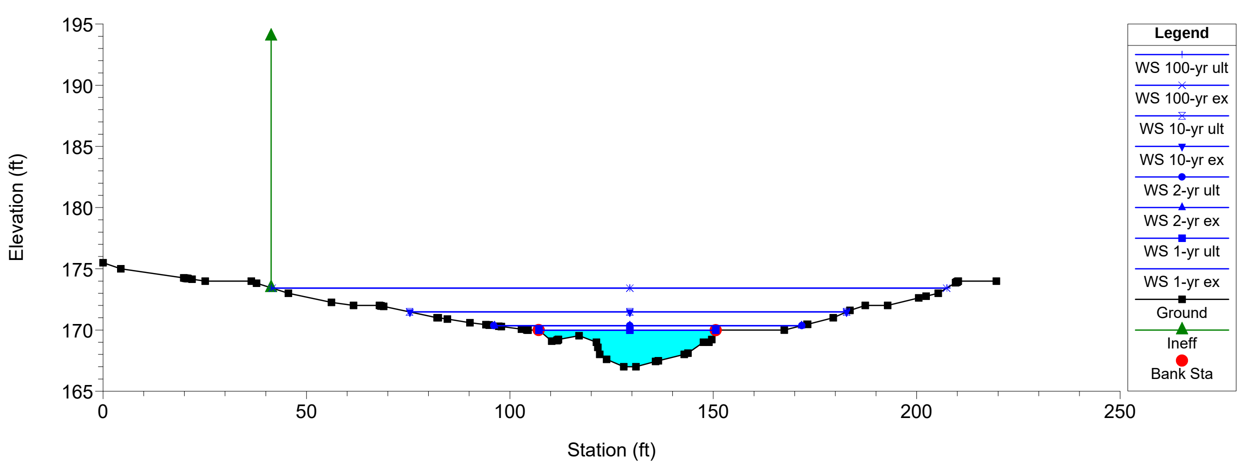
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = DS_Stem RS = 721.4 Culv

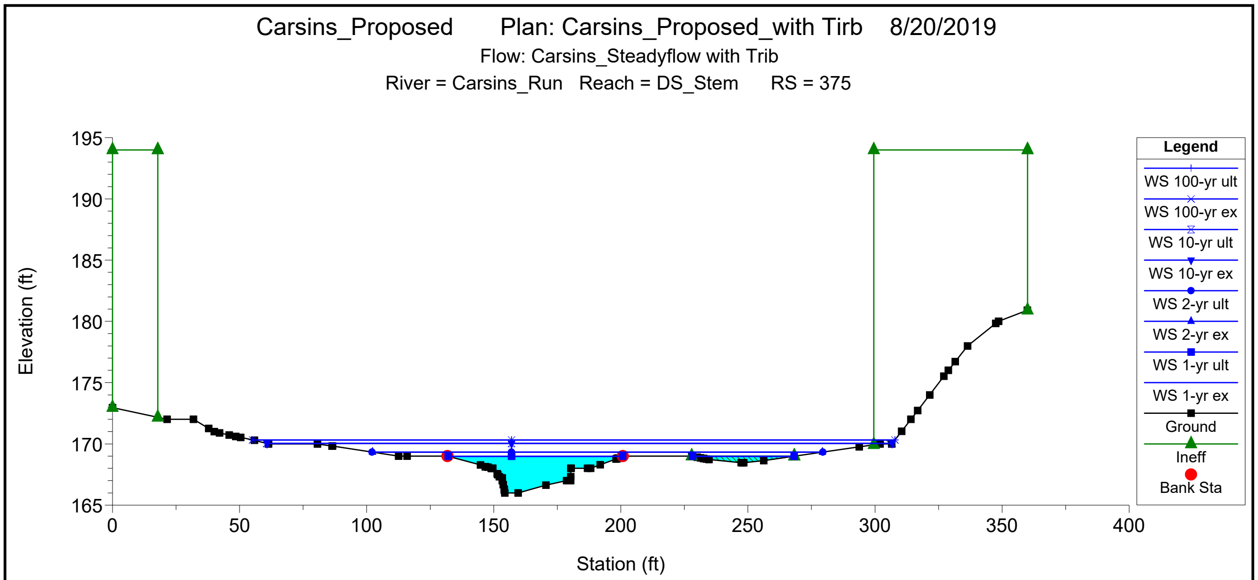


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = DS_Stem RS = 574

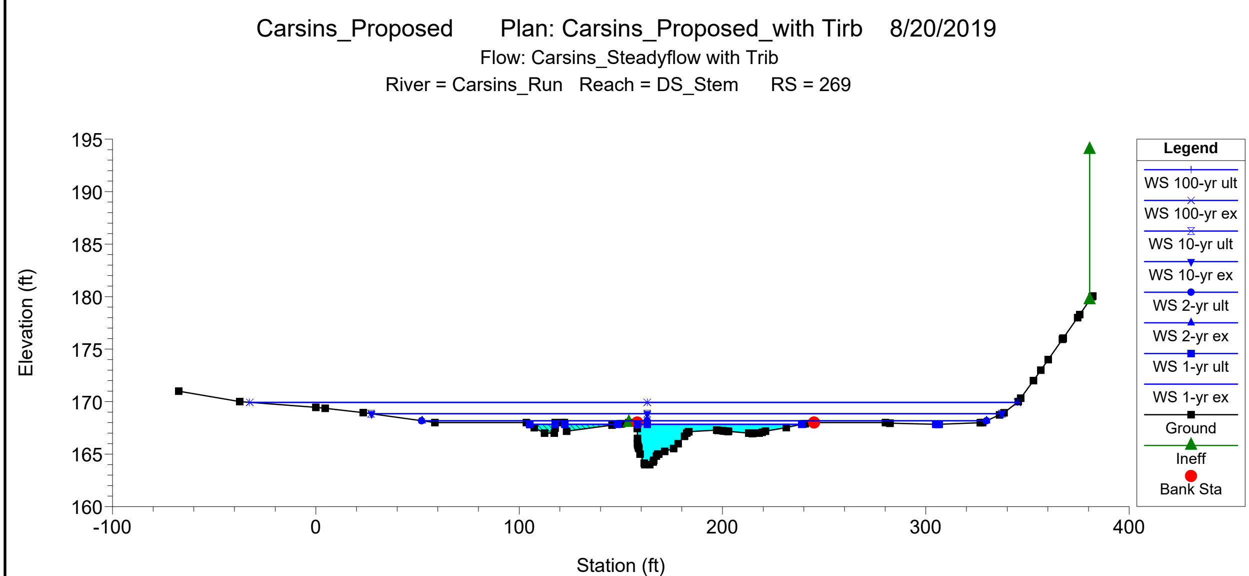


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = DS_Stem RS = 473

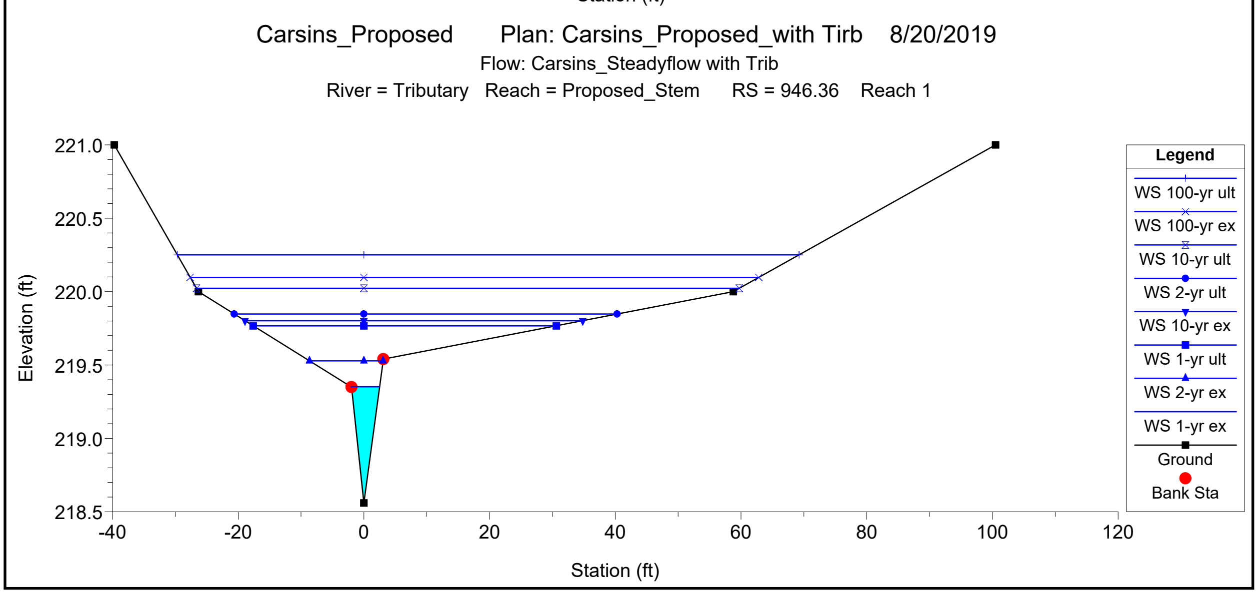




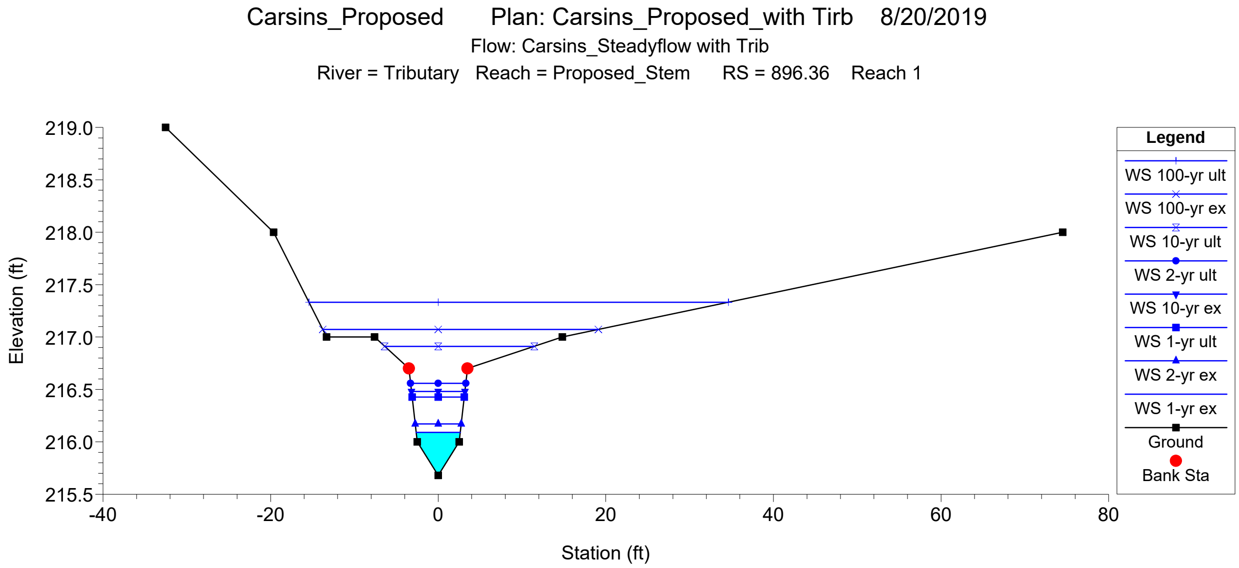
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = DS_Stem RS = 375
Elevation (ft)
195
190
185
180
175
170
165
0
50
100
150
200
250
300
350
400
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Ineff
Bank Sta

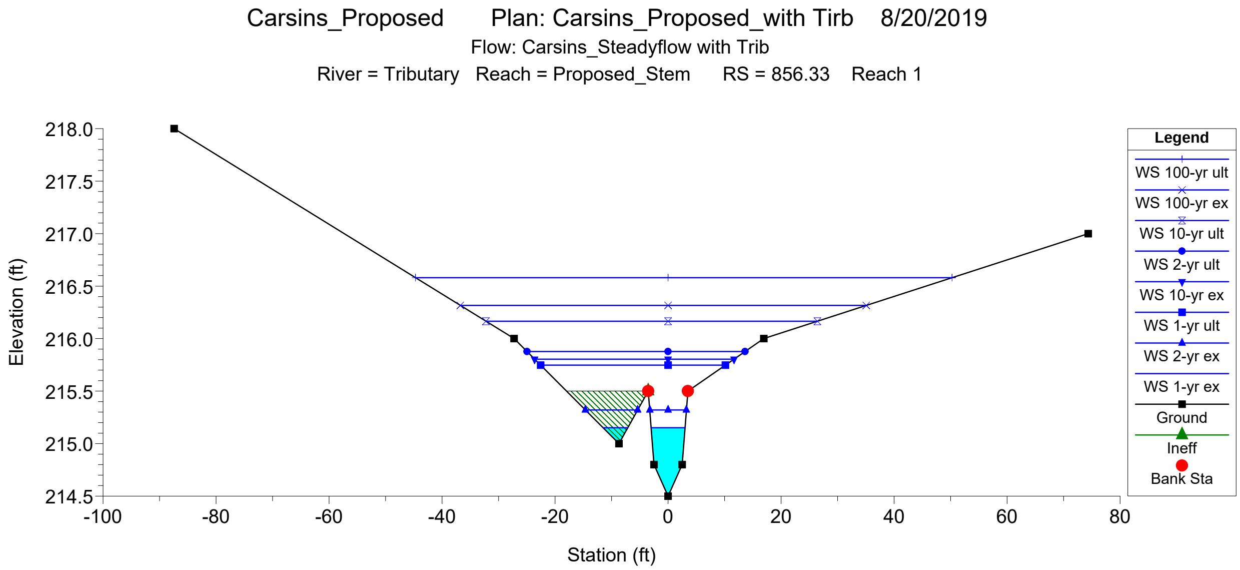


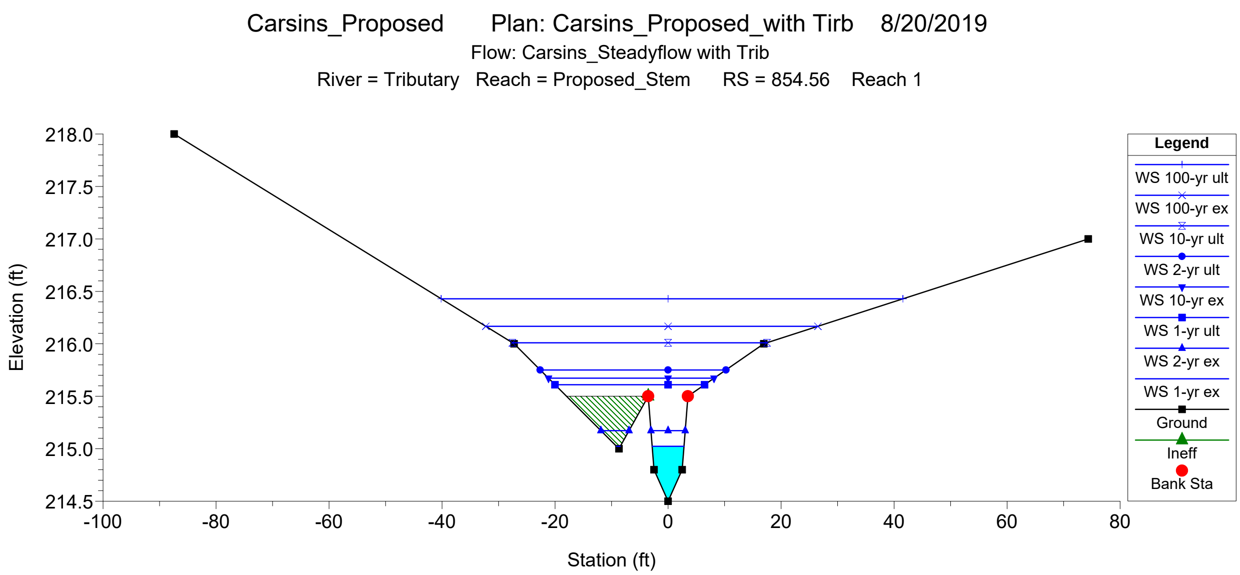
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Carsins_Run Reach = DS_Stem RS = 269
Elevation (ft)
195
190
185
180
175
170
165
160
-100
0
100
200
300
400
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 10-yr ex
WS 2-yr ult
WS 2-yr ex
WS 1-yr ult
WS 1-yr ex
Ground
Ineff
Bank Sta



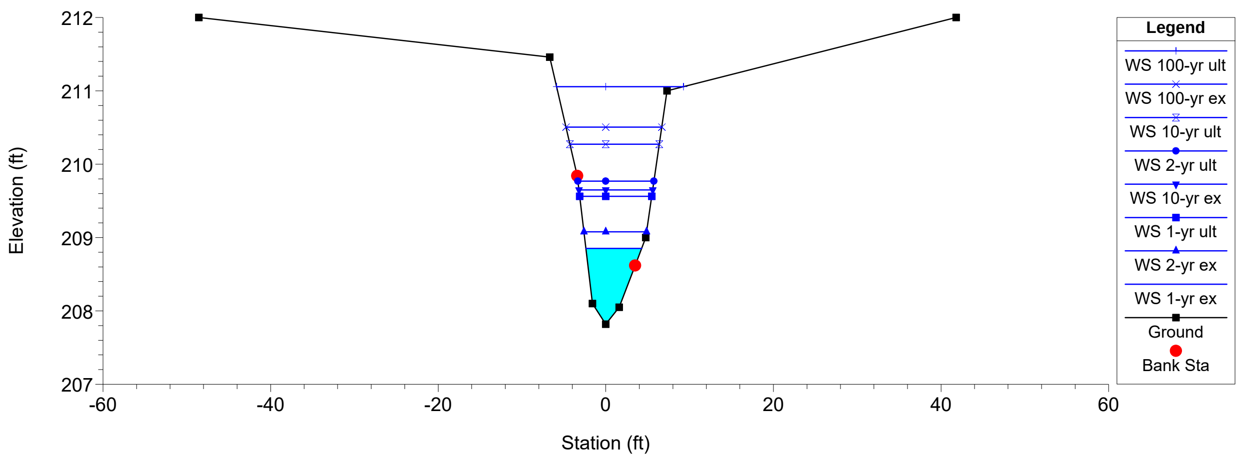
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 946.36 Reach 1
Elevation (ft)
221.0
220.5
220.0
219.5
219.0
218.5
-40
-20
0
20
40
60
80
100
120
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Bank Sta


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 896.36 Reach 1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Bank Sta

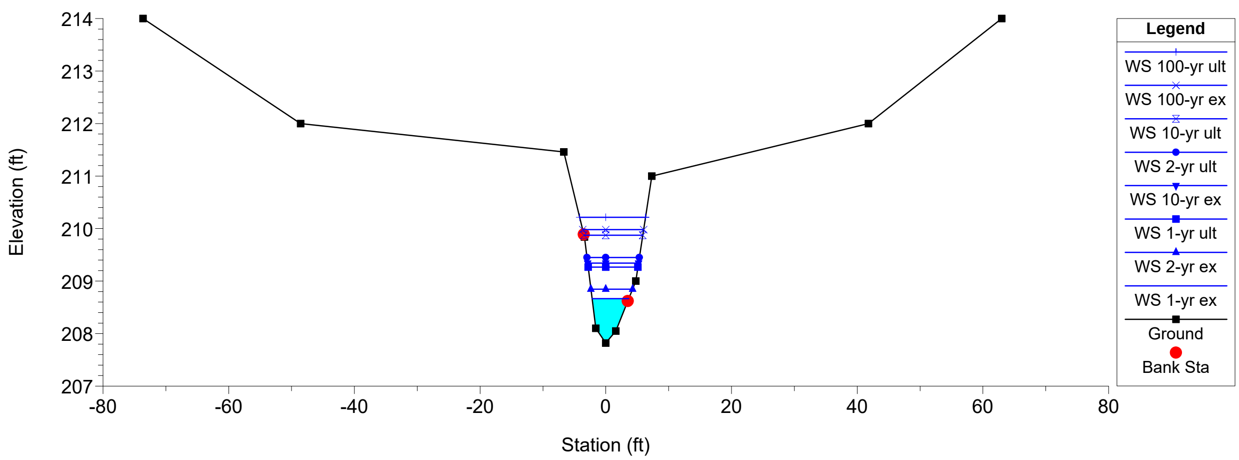

Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 856.33 Reach 1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Ineff
Bank Sta


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 854.56 Reach 1
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Ineff
Bank Sta

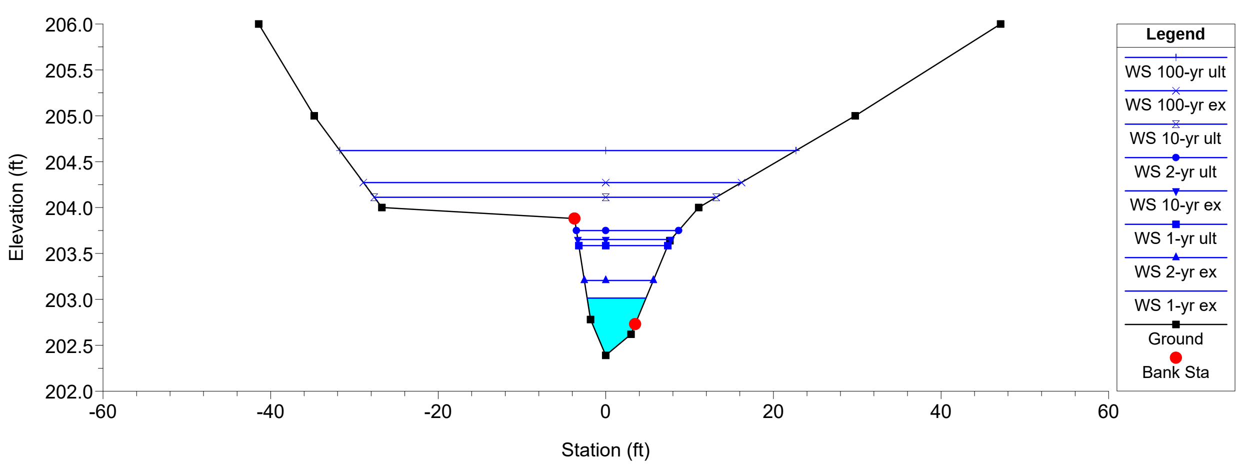
Carsins_Proposed   Plan: Carsins_Proposed_with Tirb   8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary   Reach = Proposed_Stem   RS = 719.16   Reach 2



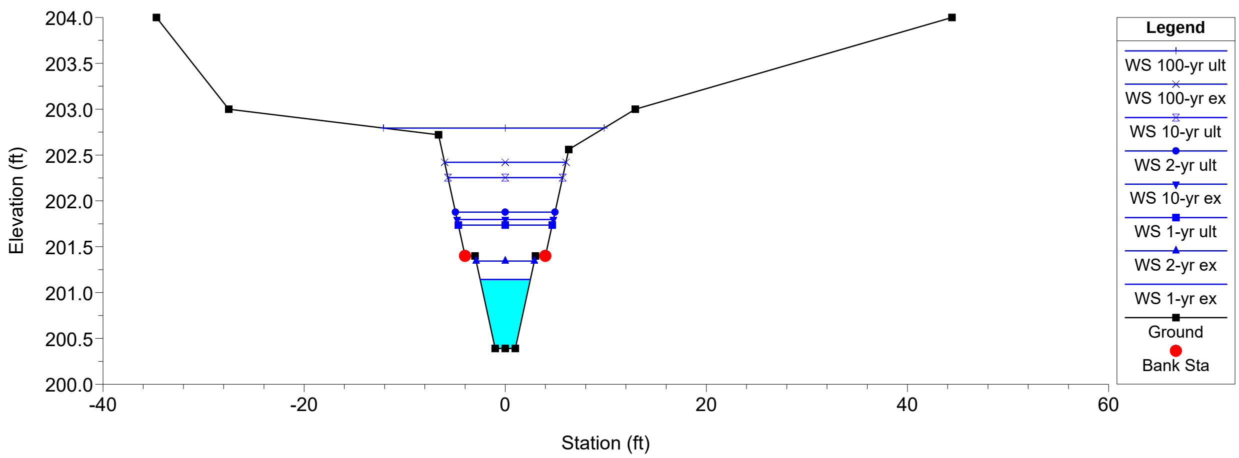
Carsins_Proposed   Plan: Carsins_Proposed_with Tirb   8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary   Reach = Proposed_Stem   RS = 713.14   Reach 2



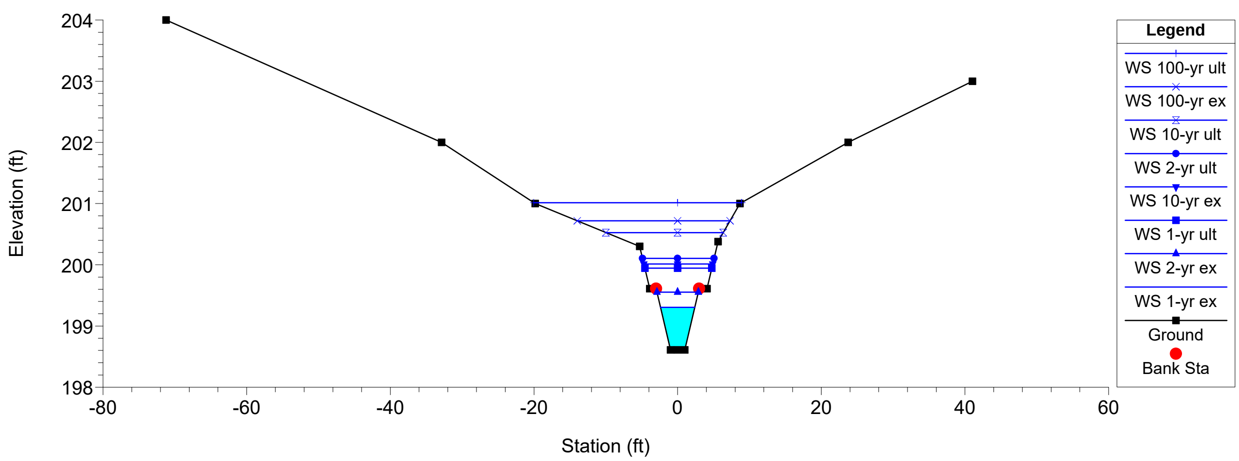
Carsins_Proposed   Plan: Carsins_Proposed_with Tirb   8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary   Reach = Proposed_Stem   RS = 622.5   Reach 2



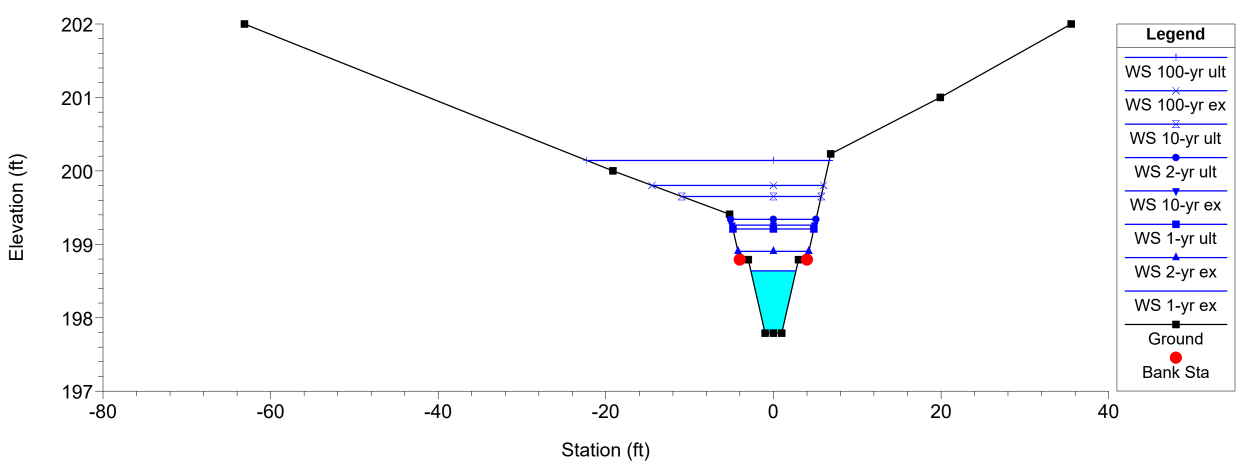
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 597.94 Reach 2



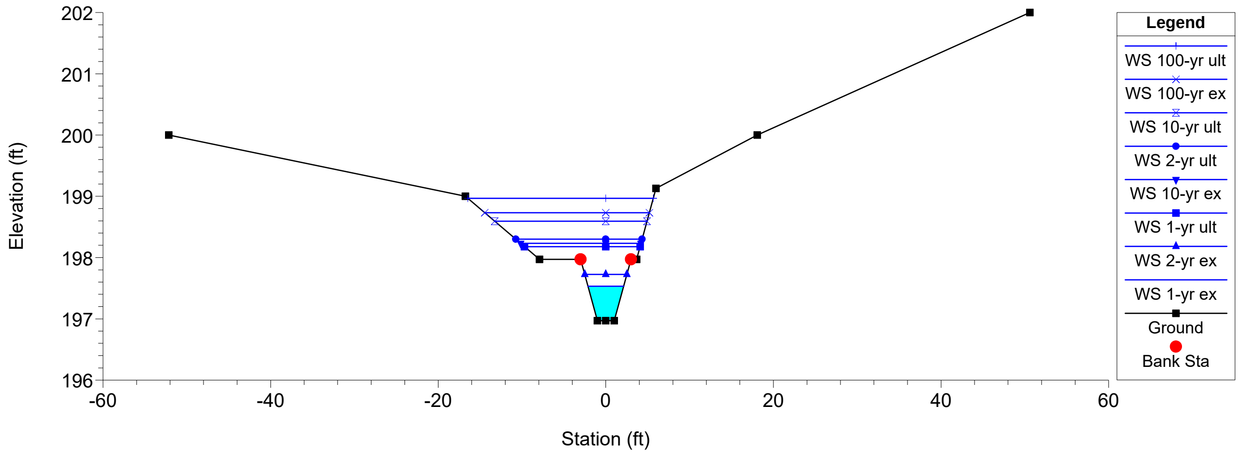
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 575.51 Reach 2



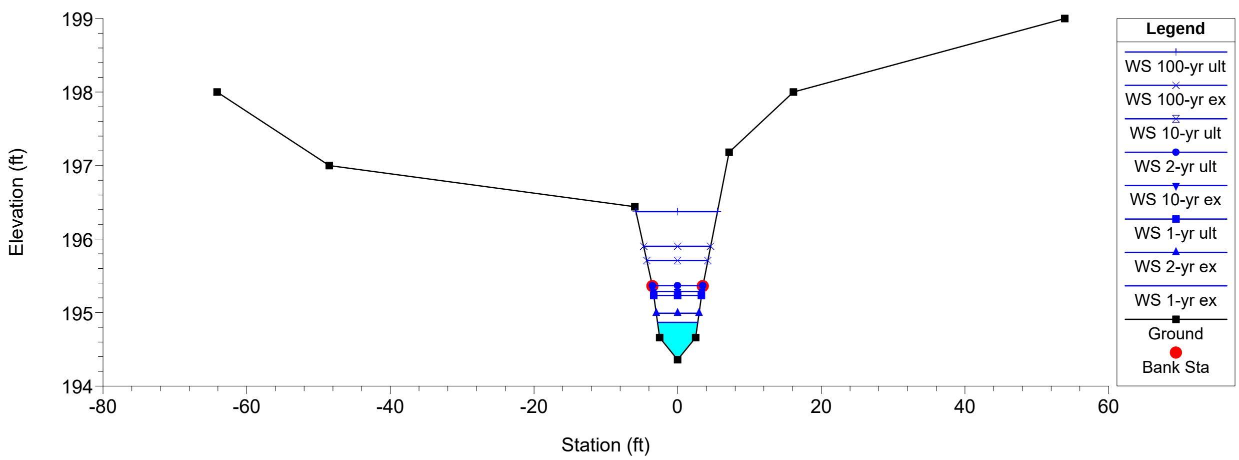
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 564.00 Reach 2



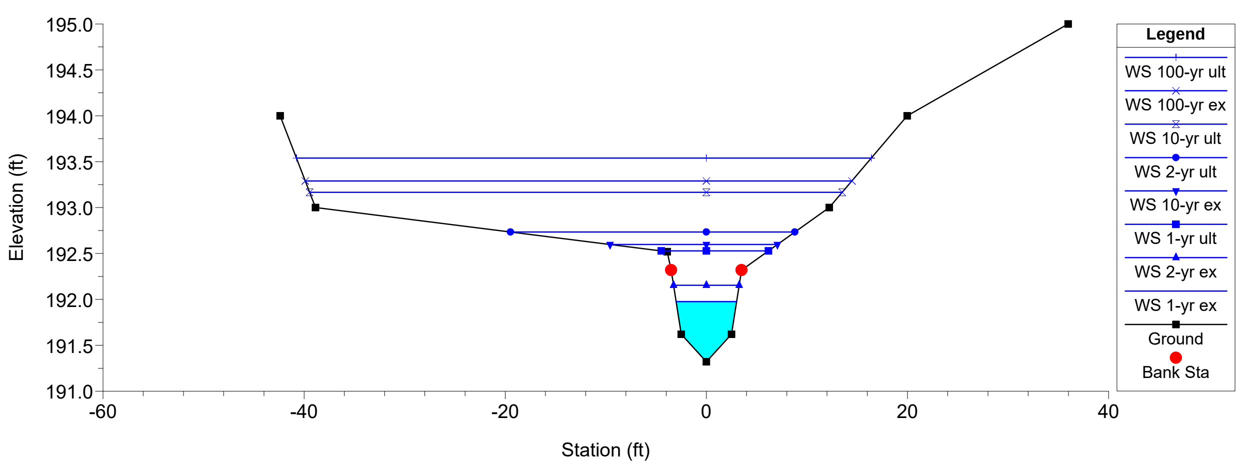
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 552.49 Reach 2

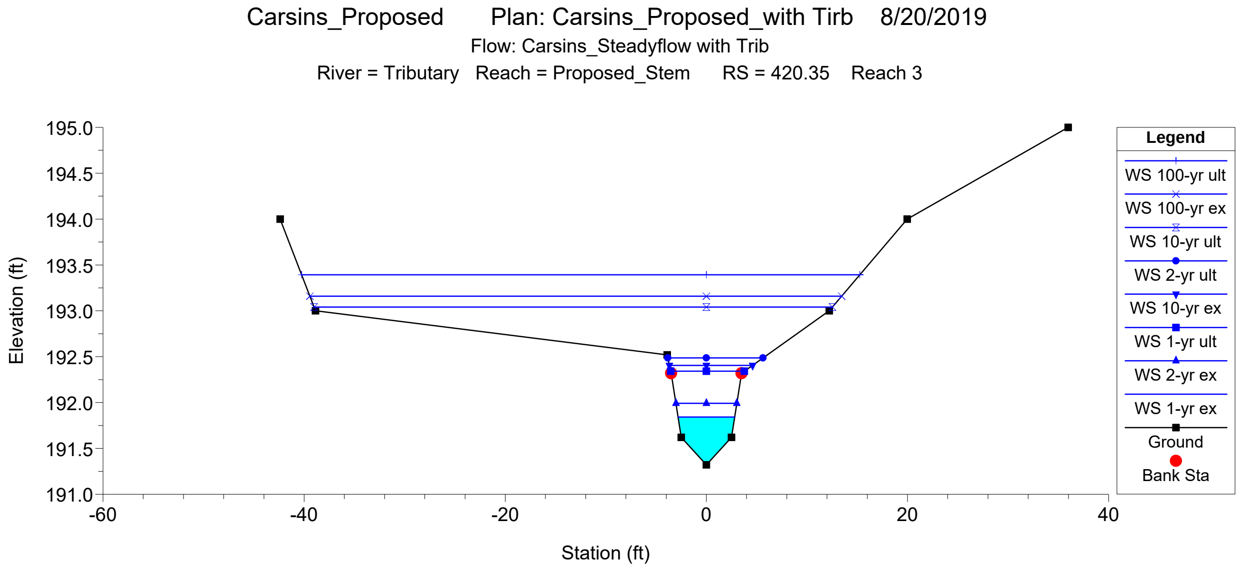


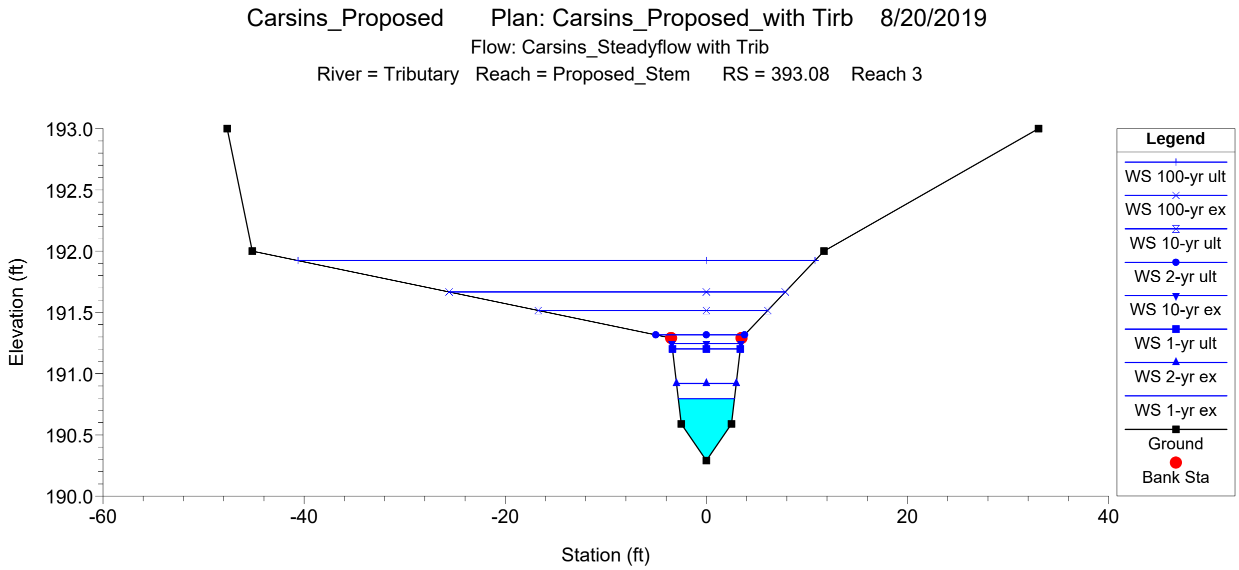
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 518.16 Reach 2

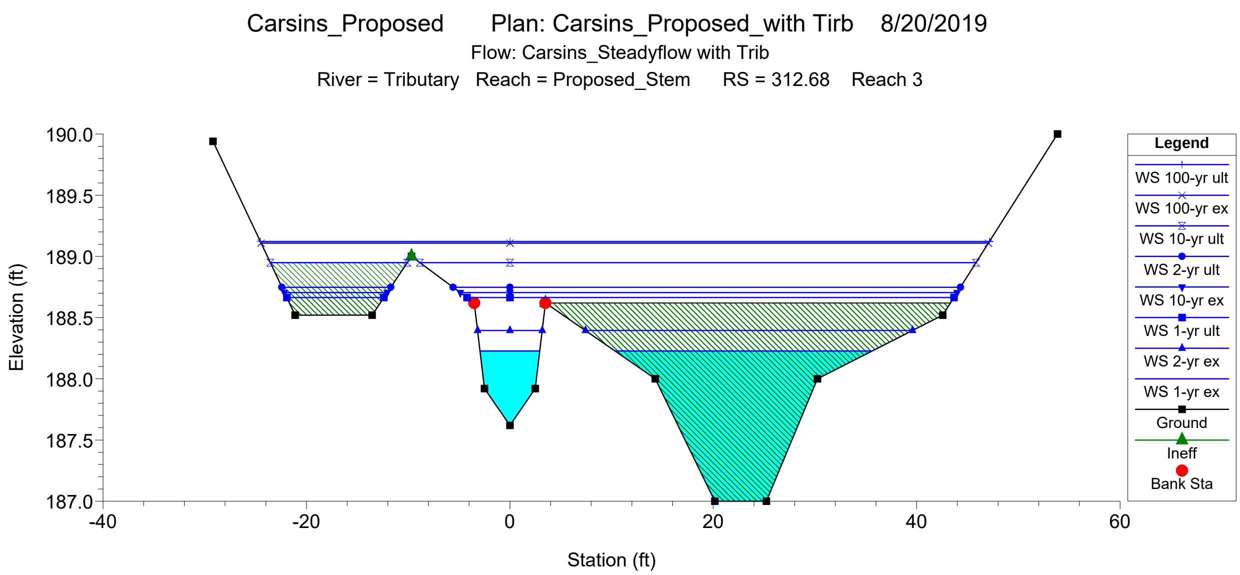


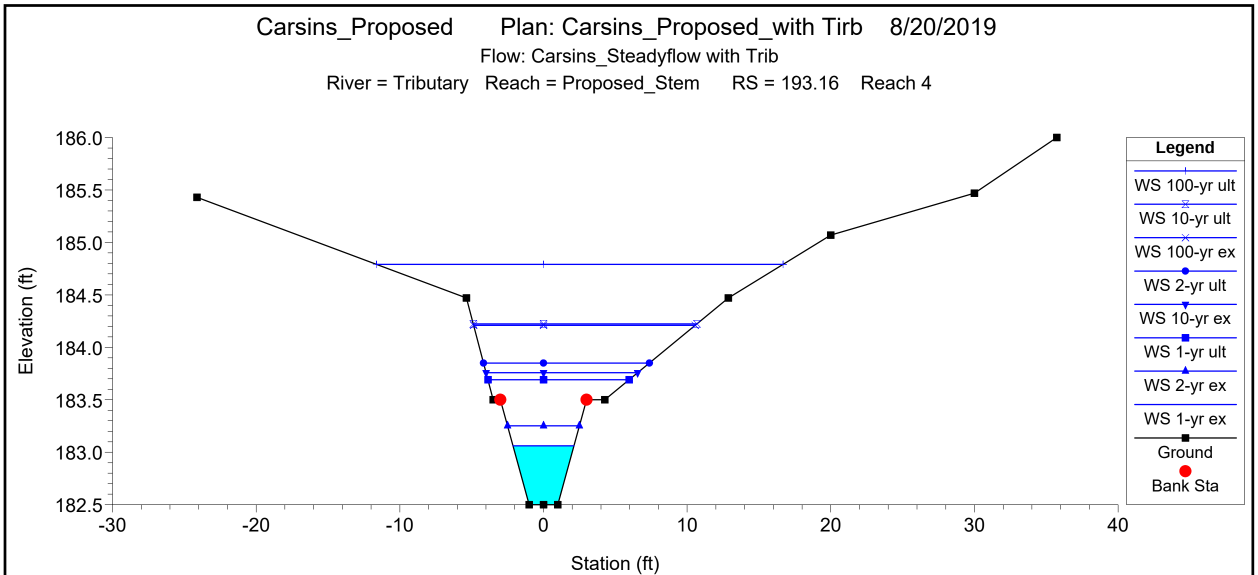
Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 422.37 Reach 3

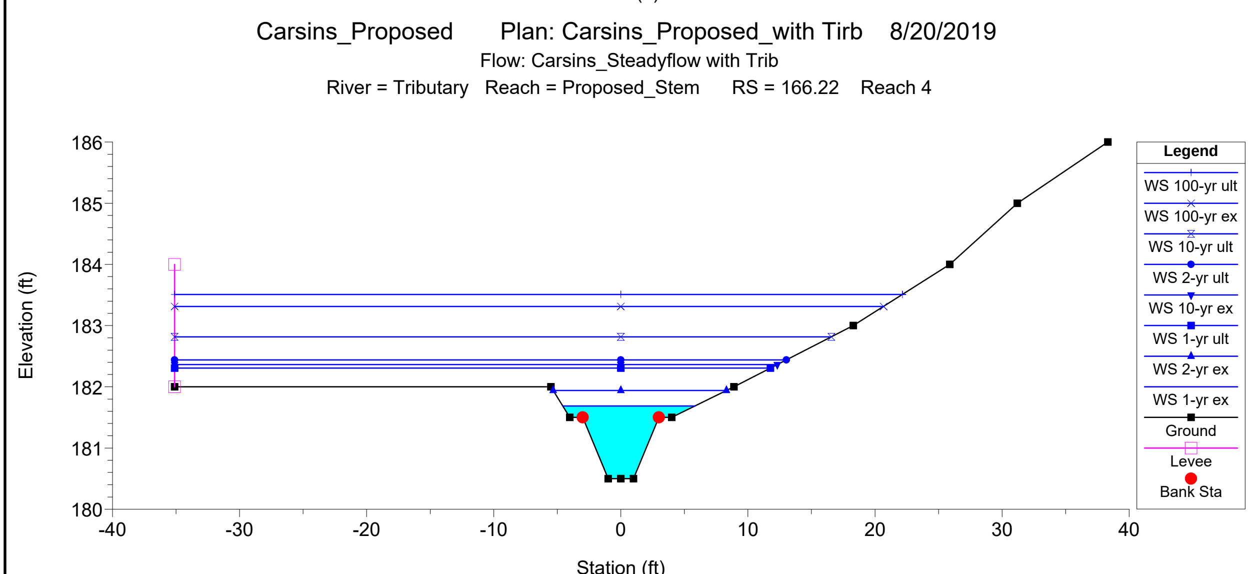


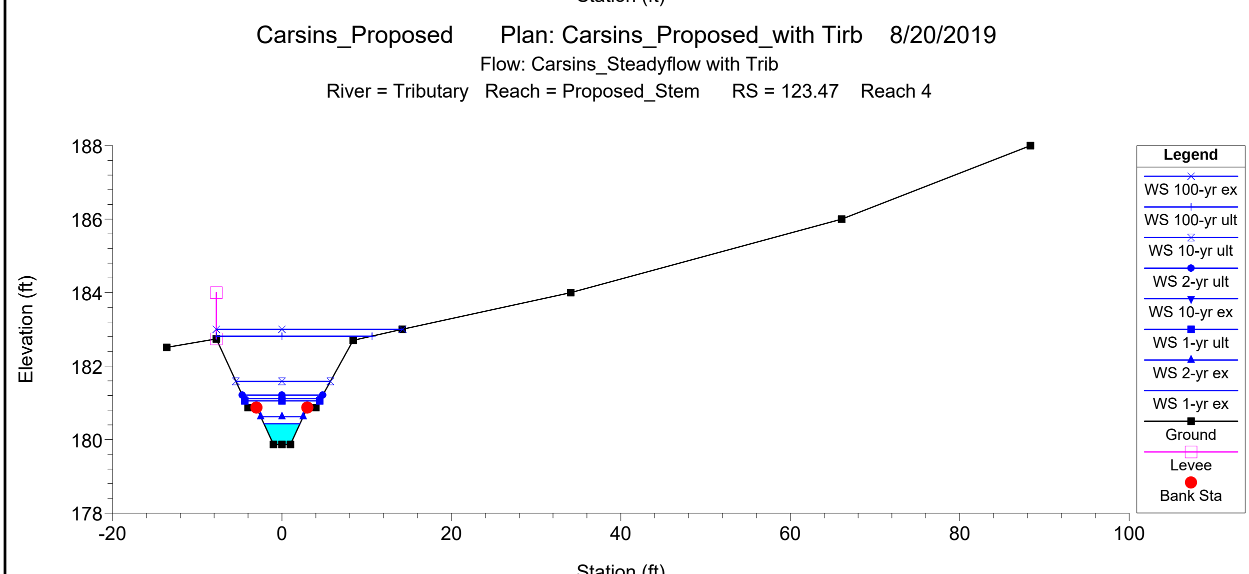

Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 420.35 Reach 3
Elevation (ft)
195.0
194.5
194.0
193.5
193.0
192.5
192.0
191.5
191.0
-60
-40
-20
0
20
40
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Bank Sta


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 393.08 Reach 3
Elevation (ft)
193.0
192.5
192.0
191.5
191.0
190.5
190.0
-60
-40
-20
0
20
40
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Bank Sta


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 312.68 Reach 3
Elevation (ft)
190.0
189.5
189.0
188.5
188.0
187.5
187.0
-40
-20
0
20
40
60
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Ineff
Bank Sta


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 193.16 Reach 4
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 10-yr ult
WS 100-yr ex
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Bank Sta


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 166.22 Reach 4
Elevation (ft)
Station (ft)
Legend
WS 100-yr ult
WS 100-yr ex
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Levee
Bank Sta


Carsins_Proposed Plan: Carsins_Proposed_with Tirb 8/20/2019
Flow: Carsins_Steadyflow with Trib
River = Tributary Reach = Proposed_Stem RS = 123.47 Reach 4
Elevation (ft)
Station (ft)
Legend
WS 100-yr ex
WS 100-yr ult
WS 10-yr ult
WS 2-yr ult
WS 10-yr ex
WS 1-yr ult
WS 2-yr ex
WS 1-yr ex
Ground
Levee
Bank Sta

HEC-RAS Plan: Carsing_Prop1

River	Reach	River Sta	Profile	W.S. Elev	Q Left	Q Channel	Q Right	Top Width	Vel Left	Vel Head	Vel Right	Shear LOB	Shear Chan	Shear ROB	Froude # XS	Hydr Depth L	Hydr Depth C	Hydr Depth R
				(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft/s)	(ft)	(ft/s)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)		(ft)	(ft)	(ft)
Tributary	Proposed_Stem	946.36	1-yr ex	219.35		6.42		4.53		0.20			0.83		1.02		0.40	
Tributary	Proposed_Stem	946.36	2-yr ex	219.53	0.31	10.61		11.72	0.52	0.25		0.17	0.95		1.35	0.09	0.52	
Tributary	Proposed_Stem	946.36	10-yr ex	219.80	3.72	21.46	2.81	53.73	0.97	0.35	0.68	0.44	1.44	0.25	1.76	0.23	0.79	0.13
Tributary	Proposed_Stem	946.36	100-yr ex	220.10	14.78	36.43	21.99	90.47	1.43	0.35	1.19	0.78	1.98	0.60	1.37	0.40	1.08	0.31
Tributary	Proposed_Stem	946.36	1-yr ult	219.77	3.01	19.92	1.92	48.24	0.92	0.34	0.61	0.40	1.38	0.22	1.80	0.21	0.75	0.11
Tributary	Proposed_Stem	946.36	2-yr ult	219.85	4.80	23.56	4.30	60.92	1.04	0.35	0.75	0.48	1.53	0.30	1.72	0.25	0.83	0.15
Tributary	Proposed_Stem	946.36	10-yr ult	220.02	10.88	32.37	14.58	86.37	1.28	0.36	1.04	0.67	1.84	0.48	1.49	0.34	1.01	0.25
Tributary	Proposed_Stem	946.36	100-yr ult	220.25	24.49	45.46	41.52	98.93	1.70	0.36	1.48	1.01	2.26	0.82	1.20	0.52	1.24	0.42
Tributary	Proposed_Stem	896.36	1-yr ex	216.09		6.42		5.26		0.40			1.89		1.82		0.24	
Tributary	Proposed_Stem	896.36	2-yr ex	216.17		10.92		5.49		0.64			2.79		2.04		0.31	
Tributary	Proposed_Stem	896.36	10-yr ex	216.48		27.99		6.37		0.98			3.52		1.88		0.55	
Tributary	Proposed_Stem	896.36	100-yr ex	217.07	1.23	69.03	2.95	32.90	0.92	1.21	1.11	0.47	3.71	0.62	2.62	0.13	1.09	0.17
Tributary	Proposed_Stem	896.36	1-yr ult	216.43		24.85		6.22		0.94			3.47		1.91		0.51	
Tributary	Proposed_Stem	896.36	2-yr ult	216.56		32.66		6.59		1.02			3.56		1.83		0.61	
Tributary	Proposed_Stem	896.36	10-yr ult	216.91	0.26	56.84	0.73	17.86	0.86	1.18	0.86	0.44	3.65	0.45	2.35	0.11	0.93	0.11
Tributary	Proposed_Stem	896.36	100-yr ult	217.33	7.06	91.87	12.54	50.07	1.67	1.22	1.43	1.12	3.98	0.89	2.34	0.35	1.35	0.28
Tributary	Proposed_Stem	856.33	1-yr ex	215.15		6.42		10.38		0.09			0.34		0.63		0.45	
Tributary	Proposed_Stem	856.33	2-yr ex	215.32		10.92		15.76		0.13			0.47		0.68		0.58	
Tributary	Proposed_Stem	856.33	10-yr ex	215.80	3.08	24.41	0.51	35.30	0.58	0.16	0.41	0.15	0.55	0.09	0.92	0.26	1.01	0.15
Tributary	Proposed_Stem	856.33	100-yr ex	216.32	17.92	48.14	7.15	71.83	0.97	0.21	0.68	0.32	0.82	0.19	0.88	0.56	1.52	0.33
Tributary	Proposed_Stem	856.33	1-yr ult	215.75	2.16	22.40	0.29	32.69	0.52	0.16	0.36	0.13	0.53	0.07	0.94	0.22	0.95	0.12
Tributary	Proposed_Stem	856.33	2-yr ult	215.88	4.47	27.30	0.89	38.59	0.66	0.17	0.47	0.18	0.58	0.11	0.90	0.32	1.08	0.19
Tributary	Proposed_Stem	856.33	10-yr ult	216.17	12.48	41.40	3.95	58.66	0.90	0.21	0.62	0.29	0.77	0.17	0.91	0.48	1.37	0.28
Tributary	Proposed_Stem	856.33	100-yr ult	216.58	31.49	62.71	17.27	94.96	1.11	0.23	0.83	0.39	0.96	0.25	0.84	0.69	1.79	0.45
Tributary	Proposed_Stem	854.56	1-yr ex	215.02		6.42		6.30		0.17			0.72		1.00		0.34	
Tributary	Proposed_Stem	854.56	2-yr ex	215.17		10.92		11.05		0.23			0.90		1.01		0.46	
Tributary	Proposed_Stem	854.56	10-yr ex	215.67	1.56	26.28	0.15	29.29	0.56	0.27	0.38	0.17	0.88	0.09	1.29	0.16	0.88	0.09
Tributary	Proposed_Stem	854.56	100-yr ex	216.17	15.82	52.38	5.02	58.79	1.13	0.33	0.78	0.46	1.23	0.27	1.15	0.48	1.37	0.28
Tributary	Proposed_Stem	854.56	1-yr ult	215.61	0.76	24.05	0.05	26.49	0.44	0.27	0.29	0.12	0.87	0.06	1.36	0.10	0.82	0.06
Tributary	Proposed_Stem	854.56	2-yr ult	215.75	2.90	29.36	0.40	32.88	0.69	0.27	0.47	0.22	0.90	0.13	1.22	0.22	0.96	0.13
Tributary	Proposed_Stem	854.56	10-yr ult	216.01	10.36	44.80	2.67	45.06	1.06	0.34	0.76	0.43	1.20	0.26	1.18	0.41	1.22	0.25
Tributary	Proposed_Stem	854.56	100-yr ult	216.43	29.30	68.59	13.58	81.73	1.30	0.35	0.94	0.56	1.41	0.35	1.09	0.61	1.64	0.38
Tributary	Proposed_Stem	719.16	1-yr ex	208.85		6.38	0.04	6.66		0.04	0.47		0.76	0.13	0.34		0.71	0.12
Tributary	Proposed_Stem	719.16	2-yr ex	209.08		10.63	0.29	7.48		0.06	0.83		1.11	0.32	0.38		0.90	0.25
Tributary	Proposed_Stem	719.16	10-yr ex	209.65		25.77	2.22	8.80		0.12	1.66		2.08	0.95	0.44		1.37	0.64
Tributary	Proposed_Stem	719.16	100-yr ex	210.51	0.54	63.29	9.38	11.44	1.20	0.25	2.61	0.61	3.98	1.95	0.55	0.33	2.19	1.13
Tributary	Proposed_Stem	719.16	1-yr ult	209.56		23.06	1.79	8.60		0.11	1.55		1.92	0.85	0.43		1.30	0.58
Tributary	Proposed_Stem	719.16	2-yr ult	209.77		29.78	2.88	9.07		0.13	1.81		2.29	1.09	0.45		1.46	0.71
Tributary	Proposed_Stem	719.16	10-yr ult	210.27	0.17	50.89	6.77	10.66	0.87	0.21	2.35	0.37	3.36	1.64	0.51	0.22	1.95	1.00
Tributary	Proposed_Stem	719.16	100-yr ult	211.06	2.78	94.72	13.98	15.13	1.85	0.35	2.50	1.18	5.29	1.86	0.63	0.61	2.74	0.97
Tributary	Proposed_Stem	713.14	1-yr ex	208.67		6.42	0.00	5.84		0.07	0.26		1.52		0.50		0.54	0.02
Tributary	Proposed_Stem	713.14	2-yr ex	208.84		10.85	0.07	6.62		0.11	0.79		2.25	0.37	0.58		0.70	0.11
Tributary	Proposed_Stem	713.14	10-yr ex	209.34		26.50	1.49	8.09		0.20	1.97		3.81	1.49	0.64		1.13	0.44
Tributary	Proposed_Stem	713.14	100-yr ex	209.98	0.00	65.71	7.49	9.69	0.52	0.48	3.58	0.23	8.21	4.04	0.83	0.04	1.64	0.83
Tributary	Proposed_Stem	713.14	1-yr ult	209.27		23.72	1.13	7.91		0.19	1.82		3.60	1.32	0.64		1.06	0.39
Tributary	Proposed_Stem	713.14	2-yr ult	209.45		30.61	2.05	8.34		0.23	2.17		4.15	1.73	0.65		1.21	0.51
Tributary	Proposed_Stem	713.14	10-yr ult	209.87		52.28	5.55	9.34		0.35	3.03		6.07	2.96	0.72		1.54	0.77
Tributary	Proposed_Stem	713.14	100-yr ult	210.22	0.16	98.50	12.81	10.48	1.48	0.81	4.70	1.18	13.44	6.65	1.03	0.16	1.87	0.97
Tributary	Proposed_Stem	622.5	1-yr ex	203.01		6.21	0.21	7.02		0.09	1.15		2.27	0.73	0.69		0.44	0.14
Tributary	Proposed_Stem	622.5	2-yr ex	203.21		10.15	0.77	8.23		0.11	1.50		2.60	1.03	0.67		0.60	0.24
Tributary	Proposed_Stem	622.5	10-yr ex	203.65		23.66	4.33	11.10		0.18	2.24		3.82	1.85	0.69		0.96	0.45
Tributary	Proposed_Stem	622.5	100-yr ex	204.27	12.21	46.38	14.62	45.13	1.53	0.20	2.16	0.97	4.46	1.63	0.83	0.32	1.52	0.53
Tributary	Proposed_Stem	622.5	1-yr ult	203.59		21.26	3.59	10.63		0.17	2.14		3.62	1.74	0.69		0.91	0.43
Tributary	Proposed_Stem	622.5	2-yr ult	203.75		27.25	5.41	12.21		0.20	2.25		4.05	1.87	0.71		1.03	0.46
Tributary	Proposed_Stem	622.5	10-yr ult	204.11	4.39	42.04	11.40	40.81	1.10	0.22	2.29	0.62	4.76	1.87	0.99	0.17	1.36	0.51
Tributary	Proposed_Stem	622.5	100-yr ult	204.62	33.51	53.38	24.58	54.42	1.95	0.15	2.00	1.26	3.65	1.31	0.61	0.61	1.87	0.64
Tributary	Proposed_Stem	597.94	1-yr ex	201.14		6.42		4.98		0.09			2.14		0.59		0.53	
Tributary	Proposed_Stem	597.94	2-yr ex	201.34		10.92		5.78		0.13			2.92		0.65		0.64	
Tributary	Proposed_Stem	597.94	10-yr ex	201.80	0.21	27.57	0.21	9.58	1.34	0.22	1.34	0.91	4.35	0.91	0.75	0.20	0.90	0.20
Tributary	Proposed_Stem	597.94	100-yr ex	202.42	2.68	67.84	2.69	12.07	2.58	0.45	2.59	2.45	7.74	2.46	0.87	0.51	1.53	0.51
Tributary	Proposed_Stem	597.94	1-yr ult	201.74	0.14	24.58	0.14	9.34	1.20	0.21	1.20	0.77	4.08	0.77	0.74	0.17	0.84	0.17
Tributary	Proposed_Stem	597.94	2-yr ult	201.88	0.35	31.97	0.35	9.90	1.53	0.25	1.53	1.11	4.80	1.11	0.78	0.24	0.98	0.24
Tributary	Proposed_Stem	597.94	10-yr ult	202.25	1.62	54.57	1.63	11.41	2.24	0.37	2.24	1.95	6.56	1.96	0.83	0.43	1.36	0.43
Tributary	Proposed_Stem	597.94	100-yr ult	202.79	3.89	102.13	5.46	21.93	1.82	0.65	2.38	1.49	10.53	2.21	1.21	0.26	1.90	0.39
Tributary	Proposed_Stem	575.51	1-yr ex	199.30		6.42		4.78		0.12			2.72		0.69		0.49	
Tributary	Proposed_Stem	575.51	2-yr ex	199.55		10.92		5.77		0.14			2.99		0.66		0.63	
Tributary	Proposed_Stem	575.51	10-yr ex	200.01	0.93	25.97	1.09	9.59	1.79	0.24	1.83	1.36	4.65	1.41	0.78	0.31	1.07	0.32
Tributary	Proposed_Stem	575.51	100-yr ex	200.72	7.53	58.60	7.08	21.26	1.95	0.39	2.73	1.53	7.26	2.54	0.99	0.35	1.77	0.60
Tributary	Proposed_Stem	575.51	1-yr ult	199.94	0.67	23.40	0.79	9.31	1.62	0.22	1.66	1.18	4.40	1.23	0.78	0.26	1.00	0.27
Tributary	Proposed_Stem	575.51	2-yr ult	200.11	1.37	29.70	1.59	9.96	1.99	0.26	2.04	1.59	5.00	1.66	0.79	0.36	1.16	0.38
Tributary	Proposed_Stem	575.51	10-yr ult	200.53	3.84	49.13	4.86	16.34	1.79	0.37	2.61	1.36	6.66	2.38	0.94	0.31	1.58	0.56
Tributary	Proposed_Stem	575.51	100-yr ult	201.01	19.86	78.85	12.76	28.93	2.47	0.48	3.13	2.23	9.16	3.17	1.06	0.47	2.07	0.69
Tributary	Proposed_Stem	564.00	1-yr ex	198.64		6.42		5.39		0.07			1.46		0.47		0.58	
Tributary	Proposed_Stem	564.00	2-yr ex	198.90	0.01	10.91	0.01	8.45	0.44	0.08	0.44	0.15	1.67	0.15	0.51	0.06	0.61	0.06
Tributary	Proposed_Stem	564.00	10-yr ex	199.26	0.30	27.40	0.29	9.88	1.32	0.19	1.32	0.83	3.61	0.83	0.67	0.24	0.97	0.24
Tributary	Proposed_Stem	564.00	100-yr ex	199.80	4.62	66.03	2.56	20.49	1.72	0.42	2.53	1.32	7.48	2.36	1.05	0.26	1.51	0.51
Tributary	Proposed_Stem	564.00	1-yr ult	199.21	0.21	24.43	0.21	9.66	1.20	0.17	1.19	0.71	3.28	0.71	0.65	0.21	0.92	0.21
Tributary	Proposed_Stem	564.00	2-yr ult	199.34	0.45	31.76	0.44	10.19	1.49	0.22	1.49	1.01	4.05	1.00	0.70	0.28	1.05	0.28
Tributary	Proposed_Stem	564.00	10-yr ult	199.65	1.94	54.26	1.63	16.65	1.41	0.36	2.23	0.97	6.45	1.93	0.97	0.20	1.36	0.43
Tributary	Proposed_Stem	564.00	100-yr ult	200.14	17.38	88.78	5.31	28.96	2.28	0.46	2.95	1.98	8.42	2.90	1.05	0.42	1.85	0.68
Tributary	Proposed_Stem	552.49	1-yr ex	197.53		6.42		4.24		0.21			5.20		1.01		0.41	
Tributary	Proposed_Stem	552.49	2-yr ex	197.73		10.92		5.02		0.26			6.07		1.00		0.53	
Tributary	Proposed_Stem	552.49	10-yr ex	198.23	2.84	24.75	0.40	14.36	1.79	0.28	1.65	1.50	5.85	1.32	1.03	0.22	0.93	0.20
Tributary	Proposed_Stem	552.49	100-yr ex	198.73	20.05	50.02	3.14	19.64	3.22	0.41	2.88	3.59	8.77	3.04	1.01	0.54	1.43	0.50
Tributary	Proposed_Stem	552.49	1-yr ult	198.18	1.92	22.66	0.27	13.79	1.58	0.27	1.47	1.25	5.64	1.12	1.05	0.18	0.88	0.17
Tributary	Proposed_Stem	552.49	2-yr ult	198.30	4.25	27.79	0.61	15.07	2.04	0.30	1.86	1.83	6.28	1.59	1.03	0.27	1.00	0.25
Tributary	Proposed_Stem	552.49	10-yr ult	198.59	13.60	42.15	2.08	18.17	2.88	0.37	2.58	3.03	7.90	2.58	1.01	0.46	1.29	0.42
Tributary	Proposed_Stem	552.49	100-yr ult	198.97	36.58	68.95	5.94	22.14	3.99	0.55	3.57	5.13	11.67	4.34	1.08	0.68	1.66	0.62
Tributary	Proposed_Stem	518.16	1-yr ex	194.87		6.42		5.59		0.19			0.80		1.07		0.33	
Tributary	Proposed_Stem	518.16	2-yr ex	194.99		10.92		5.95		0.28			1.10		1.14		0.43	
Tributary	Proposed_Stem	518.16	10-yr ex	195.29		27.99		6.79		0.62			2.11		1.37		0.65	
Tributary	Proposed_Stem	518.16	100-yr ex	195.90	0.39	72.47	0.34	9.32	1.18	1.06	1.16	0.63	2.95	0.61	1.45	0.27	1.25	0.27
Tributary	Proposed_Stem	518.16	1-yr ult	195.23		24.85		6.64		0.57			2.00		1.37		0.62	
Tributary	Proposed_Stem	518.16	2-yr ult	195.37		32.66		7.02		0.67			2.22		1.37		0.71	
Tributary	Proposed_Stem	518.16	10-yr ult	195.71	0.13	57.59	0.11	8.49	0.92	0.94	0.91	0.45	2.76	0.44	1.45	0.17	1.05	0.17
Tributary	Proposed_Stem	518.16	100-yr ult	196.37	1.82	108.06	1.59	11.34	1.56	1.21	1.54	0.89	3.11	0.88	1.39	0.51	1.72	0.51
Tributary	Proposed_Stem	422.37	1-yr ex	191.98		6.42		6.02		0.09			0.34		0.62		0.45	
Tributary	Proposed_Stem	422.37	2-yr ex	192.15		10.92		6.53		0.13			0.45		0.66		0.59	
Tributary	Proposed_Stem	422.37	10-yr ex	192.60	0.07	27.70	0.23	16.65	0.22	0.25	0.45	0.04	0.75	0.11	1.04	0.05	0.99	0.14
Tributary	Proposed_Stem	422.37	100-yr ex	193.29	16.21	52.00	5.00	54.37	0.85	0.22	0.86	0.25	0.76	0.26	0.81	0.52	1.68	0.53
Tributary	Proposed_Stem	422.37	1-yr ult	192.53	0.01	24.74	0.10	10.65	0.21	0.23	0.38	0.04	0.71	0.09	0.85	0.05	0.92	0.10
Tributary	Proposed_Stem	422.37	2-yr ult	192.73	0.64	31.42	0.59	28.28	0.36	0.24	0.54	0.08	0.71	0.14	1.12	0.11	1.12	0.21
Tributary	Proposed_Stem	422.37	10-yr ult	193.17	10.10	44.35	3.37	52.96	0.69	0.20	0.75	0.18	0.66	0.21	0.84	0.40	1.55	0.45
Tributary	Proposed_Stem	422.37	100-yr ult	193.54	32.55	69.47	9.45	57.18	1.15	0.26	1.07	0.41	0.99	0.37	0.77	0.76	1.93	0.68
Tributary	Proposed_Stem	420.35	1-yr ex	191.84		6.42		5.63		0.17			0.73		1.01		0.34	
Tributary	Proposed_Stem	420.35	2-yr ex	191.99		10.92		6.06		0.24			0.90		1.01		0.46	
Tributary	Proposed_Stem	420.35	10-yr ex	192.41	0.00	27.97	0.01	8.26	0.28	0.39	0.30	0.07	1.27	0.07	1.08	0.04	0.79	0.04
Tributary	Proposed_Stem	420.35	100-yr ex	193.16	12.61	56.37	4.23	52.89	0.88	0.33	0.95	0.30	1.08	0.33	1.08	0.40	1.55	0.45
Tributary	Proposed_Stem	420.35	1-yr ult	192.34	0.00	24.85	0.00	7.31	0.11	0.37	0.12		1.22		1.03	0.01	0.73	0.01
Tributary	Proposed_Stem	420.35	2-yr ult	192.49	0.01	32.57	0.08	9.46	0.43	0.44	0.46	0.12	1.37	0.14	1.15	0.08	0.87	0.08
Tributary	Proposed_Stem	420.35	10-yr ult	193.04	6.91	48.21	2.71	51.55	0.69	0.30	0.81	0.20	0.95	0.26	1.15	0.28	1.43	0.37
Tributary	Proposed_Stem	420.35	100-yr ult	193.39	28.25	74.81	8.41	55.51	1.24	0.38	1.20	0.51	1.38	0.49	1.00	0.62	1.78	0.59
Tributary	Proposed_Stem	393.08	1-yr ex	190.80		6.42		5.59		0.19			0.81		1.07		0.33	
Tributary	Proposed_Stem	393.08	2-yr ex	190.92		10.92		5.94		0.28			1.11		1.15		0.43	
Tributary	Proposed_Stem	393.08	10-yr ex	191.25		27.99		6.87		0.56			1.91		1.29		0.68	
Tributary	Proposed_Stem	393.08	100-yr ex	191.67	4.81	67.45	0.94	33.44	1.16	1.13	1.15	0.66	3.56	0.66	2.46	0.19	1.08	0.19

HEC-RAS Plan: Carsing_Prop1 (Continued)

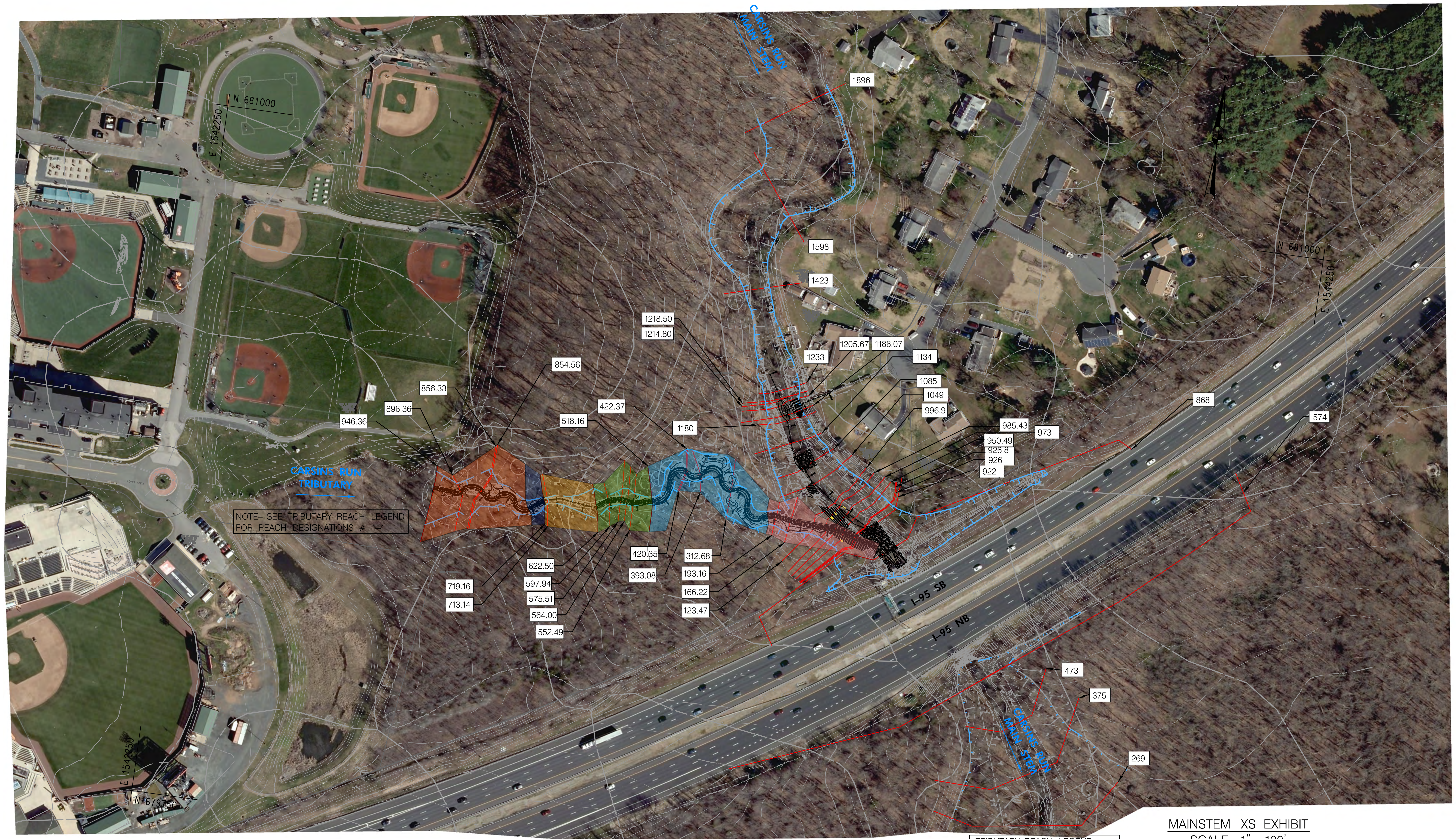
River	Reach	River Sta	Profile	W.S. Elev	Q Left	Q Channel	Q Right	Top Width	Vel Left	Vel Head	Vel Right	Shear LOB	Shear Chan	Shear ROB	Froude # XS	Hydr Depth L	Hydr Depth C	Hydr Depth R
				(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft/s)	(ft)	(ft/s)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)		(ft)	(ft)	(ft)
Tributary	Proposed_Stem	393.08	1-yr ult	191.20		24.85		6.75		0.51			1.75		1.26		0.64	
Tributary	Proposed_Stem	393.08	2-yr ult	191.32	0.00	32.66	0.00	8.82	0.18	0.63	0.18	0.04	2.08		1.47	0.01	0.73	0.01
Tributary	Proposed_Stem	393.08	10-yr ult	191.52	1.31	56.26	0.26	22.83	0.88	1.12	0.88	0.45	3.52	0.45	2.48	0.11	0.93	0.11
Tributary	Proposed_Stem	393.08	100-yr ult	191.92	17.97	89.97	3.53	51.41	1.53	1.16	1.53	0.97	3.86	0.97	2.26	0.32	1.34	0.32
Tributary	Proposed_Stem	312.68	1-yr ex	188.23		6.42		31.18		0.11			0.43		0.73		0.41	
Tributary	Proposed_Stem	312.68	2-yr ex	188.39		10.92		38.52		0.16			0.57		0.76		0.54	
Tributary	Proposed_Stem	312.68	10-yr ex	188.70	0.02	26.47	1.50	58.95	0.28	0.34	0.44	0.06	1.14	0.13	1.91	0.04	0.79	0.08
Tributary	Proposed_Stem	312.68	100-yr ex	189.11	8.81	41.78	22.61	71.51	1.02	0.23	1.11	0.40	1.09	0.45	0.94	0.41	1.20	0.47
Tributary	Proposed_Stem	312.68	1-yr ult	188.66	0.00	24.35	0.50	57.41	0.18	0.33	0.29	0.03	1.09	0.07	2.11	0.02	0.75	0.04
Tributary	Proposed_Stem	312.68	2-yr ult	188.75	0.05	29.54	3.07	60.58	0.38	0.36	0.60	0.10	1.25	0.20	1.80	0.06	0.83	0.13
Tributary	Proposed_Stem	312.68	10-yr ult	188.95	0.63	42.23	14.97	68.17	0.71	0.39	1.11	0.26	1.55	0.51	1.40	0.16	1.04	0.32
Tributary	Proposed_Stem	312.68	100-yr ult	189.12	13.71	62.80	34.97	71.70	1.54	0.50	1.67	0.89	2.39	1.01	1.37	0.42	1.21	0.48
Tributary	Proposed_Stem	193.16	1-yr ex	183.06		6.42		4.24		0.21			5.22		1.01		0.41	
Tributary	Proposed_Stem	193.16	2-yr ex	183.25		10.92		5.01		0.27			6.16		1.01		0.53	
Tributary	Proposed_Stem	193.16	10-yr ex	183.76	0.33	26.63	1.03	10.55	1.71	0.34	1.66	1.46	6.86	1.39	1.07	0.19	0.92	0.17
Tributary	Proposed_Stem	193.16	100-yr ex	184.21	2.85	59.68	10.68	15.43	3.40	0.69	3.40	4.39	13.60	4.40	1.32	0.45	1.38	0.41
Tributary	Proposed_Stem	193.16	1-yr ult	183.69	0.19	24.08	0.58	9.82	1.49	0.33	1.44	1.20	6.69	1.14	1.07	0.15	0.86	0.14
Tributary	Proposed_Stem	193.16	2-yr ult	183.85	0.57	30.21	1.88	11.54	1.95	0.36	1.90	1.75	7.07	1.69	1.06	0.25	1.02	0.23
Tributary	Proposed_Stem	193.16	10-yr ult	184.22	2.30	46.91	8.62	15.57	2.66	0.42	2.66	2.67	8.22	2.67	1.02	0.46	1.39	0.42
Tributary	Proposed_Stem	193.16	100-yr ult	184.79	6.75	74.73	29.99	28.30	2.14	0.47	3.27	1.84	9.39	3.45	1.05	0.36	1.96	0.67
Tributary	Proposed_Stem	166.22	1-yr ex	181.69	0.10	6.19	0.13	10.41	0.40	0.02	0.36	0.09	0.45	0.07	0.28	0.15	0.85	0.13
Tributary	Proposed_Stem	166.22	2-yr ex	181.94	0.48	9.64	0.81	13.62	0.65	0.03	0.58	0.18	0.59	0.15	0.30	0.32	1.11	0.26
Tributary	Proposed_Stem	166.22	10-yr ex	182.36	8.86	15.46	3.67	47.43	0.71	0.03	0.82	0.19	0.71	0.24	0.32	0.39	1.53	0.48
Tributary	Proposed_Stem	166.22	100-yr ex	183.31	39.59	20.16	13.46	55.79	0.92	0.02	0.77	0.22	0.39	0.17	0.16	1.34	2.48	0.99
Tributary	Proposed_Stem	166.22	1-yr ult	182.31	6.92	14.76	3.16	46.89	0.65	0.03	0.80	0.17	0.71	0.23	0.34	0.33	1.47	0.45
Tributary	Proposed_Stem	166.22	2-yr ult	182.44	11.73	16.50	4.43	48.15	0.78	0.03	0.85	0.22	0.73	0.25	0.30	0.47	1.61	0.52
Tributary	Proposed_Stem	166.22	10-yr ult	182.82	27.86	20.95	9.02	51.69	1.03	0.03	0.93	0.32	0.72	0.28	0.24	0.84	1.98	0.71
Tributary	Proposed_Stem	166.22	100-yr ult	183.51	61.43	28.40	21.64	57.28	1.24	0.03	1.03	0.39	0.65	0.29	0.20	1.54	2.68	1.10
Tributary	Proposed_Stem	123.47	1-yr ex	180.43		6.42		4.25		0.21			5.19		1.00		0.41	
Tributary	Proposed_Stem	123.47	2-yr ex	180.62		10.92		5.02		0.27			6.11		1.00		0.53	
Tributary	Proposed_Stem	123.47	10-yr ex	181.12	0.57	26.83	0.59	9.09	1.86	0.36	1.84	1.68	7.15	1.65	1.03	0.21	0.91	0.20
Tributary	Proposed_Stem	123.47	100-yr ex	183.00	12.00	50.49	10.71	22.01	1.81	0.11	1.28	0.87	1.86	0.52	0.39	1.39	2.80	0.74
Tributary	Proposed_Stem	123.47	1-yr ult	181.06	0.35	24.14	0.36	8.82	1.60	0.34	1.58	1.34	6.80	1.32	1.03	0.16	0.85	0.16
Tributary	Proposed_Stem	123.47	2-yr ult	181.21	0.99	30.64	1.03	9.51	2.16	0.38	2.13	2.06	7.42	2.02	1.01	0.27	1.01	0.26
Tributary	Proposed_Stem	123.47	10-yr ult	181.59	3.81	49.94	4.08	11.16	3.09	0.51	3.06	3.48	9.44	3.42	1.02	0.50	1.38	0.49
Tributary	Proposed_Stem	123.47	100-yr ult	182.82	16.85	78.47	16.15	18.39	2.94	0.31	2.44	2.37	5.28	1.80	0.64	1.21	2.61	0.87
Carsins_Run	Main_Stem	1896	1-yr ex	187.67		387.00		74.56		0.30			0.91		0.57		1.81	
Carsins_Run	Main_Stem	1896	2-yr ex	188.35		612.00		98.27		0.38			1.08		0.57		2.36	
Carsins_Run	Main_Stem	1896	10-yr ex	188.79	0.01	1364.94	1.06	133.82	0.25	0.50	0.36	0.04	1.42	0.08	0.74	0.08	2.23	0.11
Carsins_Run	Main_Stem	1896	100-yr ex	190.66	4.12	3078.97	123.91	165.64	1.15	0.72	1.60	0.39	1.76	0.64	0.68	1.01	4.10	1.43
Carsins_Run	Main_Stem	1896	1-yr ult	187.68		391.00		74.68		0.30			0.91		0.57		1.82	
Carsins_Run	Main_Stem	1896	2-yr ult	188.37		617.00		99.38		0.38			1.08		0.57		2.38	
Carsins_Run	Main_Stem	1896	10-yr ult	188.81	0.01	1372.73	1.26	134.05	0.27	0.50	0.39	0.05	1.42	0.08	0.74	0.08	2.25	0.13
Carsins_Run	Main_Stem	1896	100-yr ult	190.67	4.15	3086.28	124.57	165.72	1.15	0.73	1.60	0.39	1.76	0.64	0.68	1.01	4.10	1.44
Carsins_Run	Main_Stem	1598	1-yr ex	182.87		387.00		40.99		1.05			3.07		1.00		2.09	
Carsins_Run	Main_Stem	1598	2-yr ex	183.69		612.00		48.71		1.29			3.53		1.00		2.59	
Carsins_Run	Main_Stem	1598	10-yr ex	185.71	2.18	1363.01	0.81	91.39	0.71	0.60	0.67	0.20	1.58	0.19	0.70	0.35	2.79	0.32
Carsins_Run	Main_Stem	1598	100-yr ex	187.05	49.16	3138.07	19.77	112.28	1.92	1.41	1.70	0.99	3.36	0.83	0.94	1.17	4.14	0.99
Carsins_Run	Main_Stem	1598	1-yr ult	182.89		391.00		41.17		1.05			3.07		1.00		2.10	
Carsins_Run	Main_Stem	1598	2-yr ult	183.70		617.00		48.80		1.30			3.56		1.00		2.60	
Carsins_Run	Main_Stem	1598	10-yr ult	185.71	2.19	1370.99	0.81	91.39	0.71	0.60	0.67	0.21	1.60	0.19	0.70	0.35	2.79	0.32
Carsins_Run	Main_Stem	1598	100-yr ult	187.06	49.69	3145.32	19.99	112.37	1.92	1.41	1.71	0.99	3.36	0.83	0.93	1.18	4.14	1.00
Carsins_Run	Main_Stem	1423	1-yr ex	178.84		387.00		35.94		0.66			2.08		0.89		1.65	
Carsins_Run	Main_Stem	1423	2-yr ex	179.48		612.00		37.38		0.85			2.43		0.87		2.22	
Carsins_Run	Main_Stem	1423	10-yr ex	179.94		1366.00		38.40		2.90			7.88		1.49		2.61	
Carsins_Run	Main_Stem	1423	100-yr ex	184.30	0.73	3206.27		49.27	0.87	1.92		0.29	4.00		0.81	0.44	6.09	
Carsins_Run	Main_Stem	1423	1-yr ult	178.85		391.00		35.96		0.66			2.09		0.89		1.66	
Carsins_Run	Main_Stem	1423	2-yr ult	179.50		617.00		37.41		0.85			2.43		0.87		2.23	
Carsins_Run	Main_Stem	1423	10-yr ult	179.96		1374.00		38.46		2.87			7.80		1.48		2.63	
Carsins_Run	Main_Stem	1423	100-yr ult	184.31	0.76	3214.24		49.32	0.88	1.92		0.29	4.00		0.81	0.45	6.11	
Carsins_Run	Main_Stem	1233	1-yr ex	176.70		387.00		34.41		0.38			1.09		0.58		2.26	
Carsins_Run	Main_Stem	1233	2-yr ex	177.45		612.00		35.87		0.54			1.41		0.61		2.91	
Carsins_Run	Main_Stem	1233	10-yr ex	179.29		1366.00		39.39		0.96			2.24		0.66		4.41	
Carsins_Run	Main_Stem	1233	100-yr ex	183.02	15.77	3183.74	7.50	60.22	1.41	1.41	1.08	0.52	2.78	0.35	0.70	1.31	7.61	0.87
Carsins_Run	Main_Stem	1233	1-yr ult	176.71		391.00		34.44		0.39			1.10		0.58		2.28	
Carsins_Run	Main_Stem	1233	2-yr ult	177.46		617.00		35.90		0.54			1.42		0.61		2.92	
Carsins_Run	Main_Stem	1233	10-yr ult	179.31		1374.00		39.43		0.97			2.25		0.66		4.42	
Carsins_Run	Main_Stem	1233	100-yr ult	183.05	16.08	3191.18	7.74	60.35	1.41	1.41	1.09	0.52	2.77	0.35	0.70	1.32	7.63	0.88
Carsins_Run	Main_Stem	1218.5	1-yr ex	176.54		387.00		35.23		0.41			1.19		0.62		2.13	
Carsins_Run	Main_Stem	1218.5	2-yr ex	177.31		612.00		37.88		0.54			1.45		0.63		2.73	
Carsins_Run	Main_Stem	1218.5	10-yr ex	179.22		1366.00		44.04		0.88			2.06		0.65		4.13	
Carsins_Run	Main_Stem	1218.5	100-yr ex	183.13	6.11	3186.31	14.58	68.47	0.95	1.15	1.13	0.27	2.23	0.35	0.63	0.88	7.48	1.11
Carsins_Run	Main_Stem	1218.5	1-yr ult	176.55		391.00		35.28		0.41			1.20		0.62		2.15	
Carsins_Run	Main_Stem	1218.5	2-yr ult	177.33		617.00		37.93		0.55			1.46		0.63		2.74	
Carsins_Run	Main_Stem	1218.5	10-yr ult	179.24		1374.00		44.09		0.88			2.06		0.65		4.14	
Carsins_Run	Main_Stem	1218.5	100-yr ult	183.15	6.29	3193.78	14.93	68.68	0.95	1.14	1.13	0.27	2.22	0.35	0.63	0.89	7.51	1.12
Carsins_Run	Main_Stem	1214.8	1-yr ex	176.54		387.00		35.23		0.37			1.04		0.57		2.26	
Carsins_Run	Main_Stem	1214.8	2-yr ex	177.31		612.00		37.88		0.50			1.32		0.59		2.85	
Carsins_Run	Main_Stem	1214.8	10-yr ex	179.22		1366.00		44.02		0.84			1.95		0.63		4.23	
Carsins_Run	Main_Stem	1214.8	100-yr ex	183.13	6.00	3186.69	14.31	68.47	0.93	1.12	1.11	0.26	2.17	0.34	0.62	0.88	7.58	1.11
Carsins_Run	Main_Stem	1214.8	1-yr ult	176.56		391.00		35.28		0.37			1.05		0.57		2.27	
Carsins_Run	Main_Stem	1214.8	2-yr ult	177.33		617.00		37.93		0.50			1.32		0.59		2.86	
Carsins_Run	Main_Stem	1214.8	10-yr ult	179.24		1374.00		44.08		0.84			1.95		0.63		4.24	
Carsins_Run	Main_Stem	1214.8	100-yr ult	183.15	6.18	3194.17	14.66	68.68	0.93	1.12	1.11	0.26	2.16	0.34	0.62	0.89	7.60	1.12
Carsins_Run	Main_Stem	1205.67	1-yr ex	176.58		387.00		33.70		0.24			0.62		0.40		2.94	
Carsins_Run	Main_Stem	1205.67	2-yr ex	177.35		612.00		36.09		0.37			0.91		0.46		3.49	
Carsins_Run	Main_Stem	1205.67	10-yr ex	179.23		1366.00		42.23		0.73			1.64		0.56		4.72	
Carsins_Run	Main_Stem	1205.67	100-yr ex	183.11	4.47	3184.62	17.91	68.34	0.85	1.08	1.11	0.22	2.06	0.33	0.60	0.83	7.90	1.18
Carsins_Run	Main_Stem	1205.67	1-yr ult	176.60		391.00		33.74		0.24			0.63		0.40		2.95	
Carsins_Run	Main_Stem	1205.67	2-yr ult	177.37		617.00		36.13		0.37			0.91		0.46		3.50	
Carsins_Run	Main_Stem	1205.67	10-yr ult	179.25		1374.00		42.29		0.73			1.65		0.56		4.73	
Carsins_Run	Main_Stem	1205.67	100-yr ult	183.13	4.59	3192.09	18.32	68.62	0.85	1.08	1.12	0.22	2.06	0.33	0.60	0.83	7.92	1.19
Carsins_Run	Main_Stem	1186.07	1-yr ex	176.52		387.00		33.51		0.23			0.59		0.39		3.02	
Carsins_Run	Main_Stem	1186.07	2-yr ex	177.27		612.00		35.84		0.36			0.89		0.45		3.55	
Carsins_Run	Main_Stem	1186.07	10-yr ex	179.10		1366.00		41.79		0.74			1.66		0.56		4.74	
Carsins_Run	Main_Stem	1186.07	100-yr ex	183.01	4.00	3186.97	16.03	67.09	0.85	1.08	1.08	0.22	2.08	0.32	0.60	0.83	7.89	1.12
Carsins_Run	Main_Stem	1186.07	1-yr ult	176.54		391.00		33.56		0.23			0.59		0.39		3.04	
Carsins_Run	Main_Stem	1186.07	2-yr ult	177.29		617.00		35.88		0.36			0.89		0.45		3.56	
Carsins_Run	Main_Stem	1186.07	10-yr ult	179.12		1374.00		41.85		0.74			1.67		0.56		4.76	
Carsins_Run	Main_Stem	1186.07	100-yr ult	183.04	4.10	3194.48	16.43	67.37	0.85	1.08	1.09	0.22	2.07	0.32	0.60	0.83	7.91	1.14
Carsins_Run	Main_Stem	1180	1-yr ex	176.29		387.00		32.32		0.39			1.11		0.57		2.38	
Carsins_Run	Main_Stem	1180	2-yr ex	176.94		612.00		33.19		0.60			1.59		0.64		2.96	
Carsins_Run	Main_Stem	1180	10-yr ex	178.40		1366.00		37.58		1.29			3.11		0.81		3.98	
Carsins_Run	Main_Stem	1180	100-yr ex	182.43	4.73	3201.54	0.73	60.46	0.94	1.55	0.48	0.30	3.12	0.11	0.76	0.60	7.10	0.22
Carsins_Run	Main_Stem	1180	1-yr ult	176.30		391.00		32.34		0.40			1.12		0.58		2.39	
Carsins_Run	Main_Stem	1180	2-yr ult	176.96		617.00		33.21		0.61			1.60		0.64		2.97	
Carsins_Run	Main_Stem	1180	10-yr ult	178.42		1374.00		37.61		1.30			3.12		0.81		4.00	
Carsins_Run	Main_Stem	1180	100-yr ult	182.46	5.03	3209.13	0.85	60.95	0.96	1.55	0.50	0.30	3.11	0.11	0.76	0.63	7.12	0.23
Carsins_Run	Main_Stem	1134	1-yr ex	176.13		387.00		36.87		0.25			0.67		0.43		2.64	
Carsins_Run	Main_Stem	1134	2-yr ex	176.76		612.00		38.84		0.40			1.03		0.51		3.11	
Carsins_Run	Main_Stem	1134	10-yr ex	178.14		1366.00		44.98		0.91			2.18		0.68		3.97	
Carsins_Run	Main_Stem	1134	100-yr ex	182.70	27.62	3154.98	24.40	89.72	1.29	0.82	1.04	0.40	1.63	0.29	0.56	1.70	7.46	1.21
Carsins_Run	Main_Stem	1134	1-yr ult	176.14		391.00		36.91		0.25			0.68		0.43		2.65	
Carsins_Run	Main_Stem	1134	2-yr ult	176.77		617.00		38.87		0.40			1.04		0.51		3.12	
Carsins_Run	Main_Stem	1134	10-yr ult	178.16		1374.00		45.04		0.91			2.19		0.68		3.98	
Carsins_Run	Main_Stem	1134	100-yr ult	182.73	28.11	3161.78	25.11	89.90	1.29	0.82	1.05	0.40	1.62	0.29	0.55	1.72	7.48	1.23

HEC-RAS Plan: Carsing_Prop1 (Continued)

River	Reach	River Sta	Profile	W.S. Elev	Q Left	Q Channel	Q Right	Top Width	Vel Left	Vel Head	Vel Right	Shear LOB	Shear Chan	Shear ROB	Froude # XS	Hydr Depth L	Hydr Depth C	Hydr Depth R
				(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft/s)	(ft)	(ft/s)	(lb/sq ft)	(lb/sq ft)	(lb/sq ft)		(ft)	(ft)	(ft)
Carsins_Run	Main_Stem	1085	1-yr ex	175.72		387.00		45.93		0.34			1.04		0.62		1.80	
Carsins_Run	Main_Stem	1085	2-yr ex	176.32		612.00		49.90		0.47			1.33		0.65		2.23	
Carsins_Run	Main_Stem	1085	10-yr ex	177.60		1366.00		53.35		0.92			2.30		0.74		3.33	
Carsins_Run	Main_Stem	1085	100-yr ex	182.71	15.60	3120.27	71.13	108.56	1.03	0.58	1.16	0.26	1.15	0.31	0.47	1.68	7.45	1.91
Carsins_Run	Main_Stem	1085	1-yr ult	175.73		391.00		45.99		0.35			1.05		0.62		1.80	
Carsins_Run	Main_Stem	1085	2-yr ult	176.33		617.00		49.92		0.47			1.34		0.65		2.24	
Carsins_Run	Main_Stem	1085	10-yr ult	177.62		1374.00		53.40		0.92			2.31		0.74		3.34	
Carsins_Run	Main_Stem	1085	100-yr ult	182.74	15.88	3126.72	72.40	108.72	1.03	0.58	1.16	0.26	1.14	0.31	0.47	1.69	7.48	1.93
Carsins_Run	Main_Stem	1049	1-yr ex	175.38		387.00		44.60		0.34			1.04		0.61		1.85	
Carsins_Run	Main_Stem	1049	2-yr ex	175.88		612.00		49.49		0.52			1.50		0.70		2.14	
Carsins_Run	Main_Stem	1049	10-yr ex	176.99		1366.00		59.39		1.05			2.74		0.85		2.92	
Carsins_Run	Main_Stem	1049	100-yr ex	182.76	4.03	3157.77	45.21	118.89	0.68	0.40	0.94	0.13	0.80	0.21	0.38	1.19	7.11	1.76
Carsins_Run	Main_Stem	1049	1-yr ult	175.38		391.00		44.62		0.35			1.06		0.61		1.85	
Carsins_Run	Main_Stem	1049	2-yr ult	175.89		617.00		49.58		0.52			1.51		0.70		2.15	
Carsins_Run	Main_Stem	1049	10-yr ult	177.00		1374.00		59.53		1.05			2.74		0.85		2.93	
Carsins_Run	Main_Stem	1049	100-yr ult	182.78	4.13	3164.81	46.07	119.08	0.68	0.40	0.94	0.13	0.80	0.21	0.38	1.20	7.13	1.78
Carsins_Run	Main_Stem	996.9	1-yr ex	174.32		387.00		54.42		0.60			2.13		1.03		1.14	
Carsins_Run	Main_Stem	996.9	2-yr ex	174.77		612.00		57.12		0.77			2.47		1.00		1.53	
Carsins_Run	Main_Stem	996.9	10-yr ex	176.57		1366.00		64.73		0.75			1.91		0.70		3.05	
Carsins_Run	Main_Stem	996.9	100-yr ex	182.72	0.18	3203.59	3.23	143.62	0.28	0.34	0.24	0.03	0.66	0.03	0.37	0.36	7.35	0.28
Carsins_Run	Main_Stem	996.9	1-yr ult	174.34		391.00		54.55		0.59			2.09		1.01		1.16	
Carsins_Run	Main_Stem	996.9	2-yr ult	174.78		617.00		57.17		0.77			2.48		1.00		1.53	
Carsins_Run	Main_Stem	996.9	10-yr ult	176.59		1374.00		64.81		0.74			1.91		0.70		3.06	
Carsins_Run	Main_Stem	996.9	100-yr ult	182.74	0.20	3211.05	3.75	144.23	0.28	0.34	0.25	0.03	0.65	0.03	0.37	0.37	7.38	0.30
Carsins_Run	Main_Stem	985.43	1-yr ex	173.34		387.00		32.46		1.15			3.82		1.29		1.39	
Carsins_Run	Main_Stem	985.43	2-yr ex	174.68		612.00		55.35		0.50			1.47		0.71		1.96	
Carsins_Run	Main_Stem	985.43	10-yr ex	176.60		1366.00		63.88		0.58			1.42		0.58		3.50	
Carsins_Run	Main_Stem	985.43	100-yr ex	182.71	8.82	3182.02	16.16	136.37	0.67	0.33	0.44	0.11	0.62	0.06	0.35	1.51	8.42	0.80
Carsins_Run	Main_Stem	985.43	1-yr ult	173.36		391.00		32.81		1.15			3.84		1.29		1.39	
Carsins_Run	Main_Stem	985.43	2-yr ult	174.69		617.00		55.44		0.50			1.47		0.71		1.97	
Carsins_Run	Main_Stem	985.43	10-yr ult	176.62		1374.00		63.96		0.58			1.42		0.57		3.52	
Carsins_Run	Main_Stem	985.43	100-yr ult	182.73	9.02	3189.06	16.92	137.03	0.67	0.33	0.44	0.11	0.62	0.06	0.35	1.53	8.45	0.82
Carsins_Run	Main_Stem	973	1-yr ex	174.18		387.00		52.08		0.20			0.59		0.44		2.06	
Carsins_Run	Main_Stem	973	2-yr ex	174.81		612.00		54.65		0.29			0.79		0.48		2.58	
Carsins_Run	Main_Stem	973	10-yr ex	176.67		1366.00		62.31		0.46			1.09		0.48		4.02	
Carsins_Run	Main_Stem	973	100-yr ex	182.73	2.65	3189.58	14.77	134.31	0.48	0.30	0.44	0.07	0.57	0.06	0.33	0.95	8.06	0.85
Carsins_Run	Main_Stem	973	1-yr ult	174.19		391.00		52.13		0.20			0.59		0.44		2.07	
Carsins_Run	Main_Stem	973	2-yr ult	174.82		617.00		54.70		0.29			0.80		0.48		2.60	
Carsins_Run	Main_Stem	973	10-yr ult	176.69		1374.00		62.39		0.46			1.09		0.48		4.03	
Carsins_Run	Main_Stem	973	100-yr ult	182.75	2.75	3196.87	15.38	135.02	0.49	0.30	0.45	0.07	0.57	0.06	0.33	0.97	8.09	0.86
Carsins_Run	Main_Stem	950.49	1-yr ex	174.04		387.00		48.95		0.25			0.74		0.50		1.97	
Carsins_Run	Main_Stem	950.49	2-yr ex	174.64		612.00		51.03		0.36			1.00		0.54		2.48	
Carsins_Run	Main_Stem	950.49	10-yr ex	176.48		1366.00		62.48		0.56			1.34		0.54		3.91	
Carsins_Run	Main_Stem	950.49	100-yr ex	182.65	34.38	3115.13	57.49	127.08	0.81	0.36	0.78	0.15	0.66	0.14	0.35	2.01	9.25	1.99
Carsins_Run	Main_Stem	950.49	1-yr ult	174.05		391.00		48.99		0.25			0.74		0.50		1.98	
Carsins_Run	Main_Stem	950.49	2-yr ult	174.65		617.00		51.08		0.37			1.00		0.54		2.49	
Carsins_Run	Main_Stem	950.49	10-yr ult	176.50		1374.00		62.65		0.56			1.34		0.54		3.92	
Carsins_Run	Main_Stem	950.49	100-yr ult	182.67	34.99	3122.01	58.00	127.87	0.82	0.36	0.78	0.15	0.66	0.14	0.35	2.03	9.28	1.98
Carsins_Run	Main_Stem	926.8	1-yr ex	173.66		387.00		52.27		0.40			1.31		0.73		1.51	
Carsins_Run	Main_Stem	926.8	2-yr ex	174.30		612.00		56.32		0.50			1.44		0.69		2.07	
Carsins_Run	Main_Stem	926.8	10-yr ex	176.31		1366.00		73.60		0.60			1.43		0.57		3.72	
Carsins_Run	Main_Stem	926.8	100-yr ex	182.65	3.58	3078.19	125.23	137.54	0.49	0.31	0.95	0.07	0.60	0.19	0.33	0.95	8.34	2.68
Carsins_Run	Main_Stem	926.8	1-yr ult	173.68		391.00		52.35		0.41			1.31		0.73		1.52	
Carsins_Run	Main_Stem	926.8	2-yr ult	174.31		617.00		56.40		0.50			1.45		0.69		2.08	
Carsins_Run	Main_Stem	926.8	10-yr ult	176.33		1374.00		73.75		0.60			1.43		0.56		3.74	
Carsins_Run	Main_Stem	926.8	100-yr ult	182.68	3.72	3085.31	125.96	138.27	0.49	0.31	0.95	0.07	0.60	0.19	0.33	0.97	8.37	2.67
Carsins_Run	Main_Stem	926	1-yr ex	172.97		387.00		39.19		0.73			2.39		1.01		1.44	
Carsins_Run	Main_Stem	926	2-yr ex	173.50		612.00		41.09		0.96			2.87		1.00		1.90	
Carsins_Run	Main_Stem	926	10-yr ex	175.94		1366.00		62.23		0.81			1.95		0.66		3.78	
Carsins_Run	Main_Stem	926	100-yr ex	182.53	18.56	2986.69	201.76	132.68	0.66	0.40	1.18	0.11	0.76	0.27	0.37	1.33	9.42	3.35
Carsins_Run	Main_Stem	926	1-yr ult	172.98		391.00		39.23		0.73			2.40		1.01		1.45	
Carsins_Run	Main_Stem	926	2-yr ult	173.51		617.00		41.13		0.96			2.88		1.00		1.91	
Carsins_Run	Main_Stem	926	10-yr ult	175.96		1374.00		62.66		0.81			1.95		0.65		3.80	
Carsins_Run	Main_Stem	926	100-yr ult	182.56	19.11	2993.49	202.40	133.44	0.66	0.40	1.18	0.11	0.76	0.27	0.37	1.35	9.45	3.33
Carsins_Run	Main_Stem	922	1-yr ex	172.39		387.00		47.40		0.94			3.42		1.34		1.05	
Carsins_Run	Main_Stem	922	2-yr ex	172.72		612.00		48.14		1.36			4.58		1.42		1.36	
Carsins_Run	Main_Stem	922	10-yr ex	176.15		1363.81	2.19	72.78		0.43	0.53		1.01	0.11	0.49		4.06	0.46
Carsins_Run	Main_Stem	922	100-yr ex	182.60	16.26	3096.04	94.71	134.85	0.55	0.29	0.84	0.08	0.52	0.14	0.30	1.38	9.83	2.74
Carsins_Run	Main_Stem	922	1-yr ult	172.40		391.00		47.41		0.95			3.45		1.34		1.06	
Carsins_Run	Main_Stem	922	2-yr ult	172.72		617.00		48.15		1.37			4.60		1.42		1.36	
Carsins_Run	Main_Stem	922	10-yr ult	176.17		1371.64	2.36	72.88		0.43	0.54		1.01	0.11	0.49		4.08	0.48
Carsins_Run	Main_Stem	922	100-yr ult	182.63	16.72	3103.13	95.16	135.60	0.55	0.29	0.83	0.08	0.52	0.14	0.30	1.40	9.85	2.73
Carsins_Run	DS_Stem	868	1-yr ex	172.48		387.00		38.81		0.73			4.24		1.00		1.46	
Carsins_Run	DS_Stem	868	2-yr ex	173.02		612.00		40.97		0.96			5.11		1.00		1.90	
Carsins_Run	DS_Stem	868	10-yr ex	175.36		1366.00		51.91		0.84			3.65		0.68		3.58	
Carsins_Run	DS_Stem	868	100-yr ex	182.49	31.55	3133.72	41.73	183.54	0.73	0.33	0.64	0.15	1.09	0.12	0.40	1.13	8.91	0.93
Carsins_Run	DS_Stem	868	1-yr ult	172.50		391.00		38.86		0.73			4.24		1.00		1.47	
Carsins_Run	DS_Stem	868	2-yr ult	173.03		617.00		41.03		0.96			5.11		1.00		1.91	
Carsins_Run	DS_Stem	868	10-yr ult	175.39		1374.00		52.12		0.83			3.62		0.68		3.60	
Carsins_Run	DS_Stem	868	100-yr ult	182.52	32.54	3138.80	43.66	184.37	0.74	0.33	0.65	0.15	1.09	0.12	0.39	1.15	8.94	0.95
Carsins_Run	DS_Stem	721.4		Culvert														
Carsins_Run	DS_Stem	574	1-yr ex	169.40		387.00		26.99		0.93			3.50		1.00		1.85	
Carsins_Run	DS_Stem	574	2-yr ex	170.22		612.00		35.04		1.06			3.82		1.00		2.11	
Carsins_Run	DS_Stem	574	10-yr ex	173.19		1366.00		54.98		0.65			1.92		0.58		3.85	
Carsins_Run	DS_Stem	574	100-yr ex	174.95	7.51	3199.49		124.50	1.91	1.49		1.02	4.19		0.83	1.04	4.50	
Carsins_Run	DS_Stem	574	1-yr ult	169.42		391.00		27.05		0.93			3.50		1.00		1.87	
Carsins_Run	DS_Stem	574	2-yr ult	170.24		617.00		35.25		1.05			3.78		0.99		2.13	
Carsins_Run	DS_Stem	574	10-yr ult	173.20		1374.00		55.08		0.65			1.92		0.58		3.86	
Carsins_Run	DS_Stem	574	100-yr ult	174.95	7.53	3207.47		124.50	1.92	1.50		1.03	4.21		0.83	1.04	4.50	
Carsins_Run	DS_Stem	473	1-yr ex	169.97		387.00		43.40		0.44			1.38		0.73		1.67	
Carsins_Run	DS_Stem	473	2-yr ex	170.35	1.65	604.40	5.95	75.48	0.70	0.71	0.89	0.23	2.10	0.33	1.05	0.22	2.04	0.32
Carsins_Run	DS_Stem	473	10-yr ex	171.48	48.11	1239.00	78.89	107.33	1.74	1.14	2.11	0.90	3.18	1.20	1.10	0.87	3.17	1.16
Carsins_Run	DS_Stem	473	100-yr ex	173.42	340.58	2490.92	375.50	165.79	2.68	1.54	2.95	1.64	4.21	1.89	1.04	1.94	5.11	2.24
Carsins_Run	DS_Stem	473	1-yr ult	169.99		391.00		43.45		0.44			1.39		0.73		1.68	
Carsins_Run	DS_Stem	473	2-yr ult	170.36	1.72	609.10	6.17	75.75	0.71	0.71	0.91	0.23	2.12	0.34	1.05	0.22	2.05	0.32
Carsins_Run	DS_Stem	473	10-yr ult	171.48	48.57	1245.88	79.55	107.41	1.75	1.15	2.12	0.91	3.20	1.21	1.10	0.87	3.17	1.17
Carsins_Run	DS_Stem	473	100-yr ult	173.43	342.59	2494.98	377.43	165.93	2.69	1.54	2.96	1.64	4.21	1.89	1.03	1.94	5.12	2.25
Carsins_Run	DS_Stem	375	1-yr ex	168.98		387.00		107.72		0.25			0.84		0.60		1.40	
Carsins_Run	DS_Stem	375	2-yr ex	169.32	4.99	574.31	32.70	176.99	0.63	0.34	0.91	0.18	1.11	0.30	0.85	0.27	1.73	0.46
Carsins_Run	DS_Stem	375	10-yr ex	170.04	42.40	1149.66	173.94	246.02	1.12	0.61	1.73	0.44	1.99	0.85	0.98	0.53	2.45	1.02
Carsins_Run	DS_Stem	375	100-yr ex	170.32	157.29	2561.65	488.06	252.75	2.67	2.33	3.79	2.19	7.62	3.72	1.74	0.77	2.73	1.30
Carsins_Run	DS_Stem	375	1-yr ult	168.99		391.00		108.61		0.26			0.85		0.60		1.40	
Carsins_Run	DS_Stem	375	2-yr ult	169.33	5.17	578.39	33.43	177.41	0.64	0.34	0.91	0.18	1.12	0.31	0.86	0.27	1.74	0.46
Carsins_Run	DS_Stem	375	10-yr ult	170.04	43.04	1155.41	175.55	246.12	1.13	0.62	1.74	0.45	2.00	0.85	0.98	0.53	2.45	1.02
Carsins_Run	DS_Stem	375	100-yr ult	170.33	157.96	2567.40	489.64	252.79	2.67	2.34	3.80	2.20	7.64	3.74	1.74	0.77	2.74	1.31
Carsins_Run	DS_Stem	269	1-yr ex	167.84		387.00		118.86		0.25			0.87		0.64		1.20	
Carsins_Run	DS_Stem	269	2-yr ex	168.17	34.19	566.65	11.16	277.59	0.85	0.29	0.60	0.28	1.05	0.17	0.94	0.38	1.44	0.22
Carsins_Run	DS_Stem	269	10-yr ex	168.84	182.22	1070.16	113.62	309.97	1.53	0.42	1.46	0.68	1.53	0.63	0.83	0.91	2.11	0.85
Carsins_Run	DS_Stem	269	100-yr ex	169.93	623.26	2138.84	444.90	377.49	2.15	0.64	2.43	1.14	2.32	1.37	0.80	1.52	3.20	1.83
Carsins_Run	DS_Stem	269	1-yr ult	167.84		391.00	0.00	121.25		0.25	0.03		0.87		0.65		1.21	0.00
Carsins_Run	DS_Stem	269	2-yr ult	168.18	35.00	570.37	11.63	277.87	0.86	0.30	0.61	0.29	1.05	0.17	0.94	0.39	1.45	0.23
Carsins_Run	DS_Stem	269	10-yr ult	168.85	183.98	1075.13	114.89	310.26	1.53	0.42	1.46	0.68	1.54	0.64	0.83	0.92	2.12	0.85
Carsins_Run	DS_Stem	269	100-yr ult	169.93	625.35	2143.23	446.42	377.79	2.15	0.64	2.44	1.14	2.32	1.37	0.80	1.53	3.20	1.83

APPENDIX I.2.2

PROPOSED CROSS SECTION MAP



MAINSTEM XS EXHIBIT

SCALE- 1" =100'

TRIBUTARY REACH LEGEND:
REACH 1
REACH 2A
STABLE (N/A)
REACH 2B
REACH 3
REACH 4

LEGEND:

- HEC-RAS PROPOSED CONDITION CROSS SECTIONS
- EXISING CONTOURS
- PROPOSED CONTOURS
- EXISTING 100 YR FLOODPAIN
- PROPOSED 100 YR FLOODPAIN

100' 0 100' 200'

SCALE: 1" =100'

HORIZONTAL DATUM NAD 83/91

VERTICAL DATUM NAVD 88

CONSTELLATION DESIGN GROUP, INC.
CONSULTING ENGINEERS
57 W. TIMONIUM ROAD
SUITE 200
TIMONIUM, MD 21093
410-252-1884

P.E. STAMP HERE

Maryland Transportation Authority
Engineering Division

ADDENDUMS & REVISIONS			
NO.	DESCRIPTION	BY	DATE

JOHN F. KENNEDY MEMORIAL HIGHWAY
I-95 EXPRESS TOLL LANES NORTHBOUND EXTENSION
CARSINS RUN STREAM MITIGATION MAP

HEC-RAS CROSS SECTION MAP-
PROPOSED CONDITIONS

DESIGNED BY FNA | DRAWN BY JCT | CHECKED BY FNA

CONST. REVIEW BY | DATE MARCH 2019 | SCALE AS SHOWN

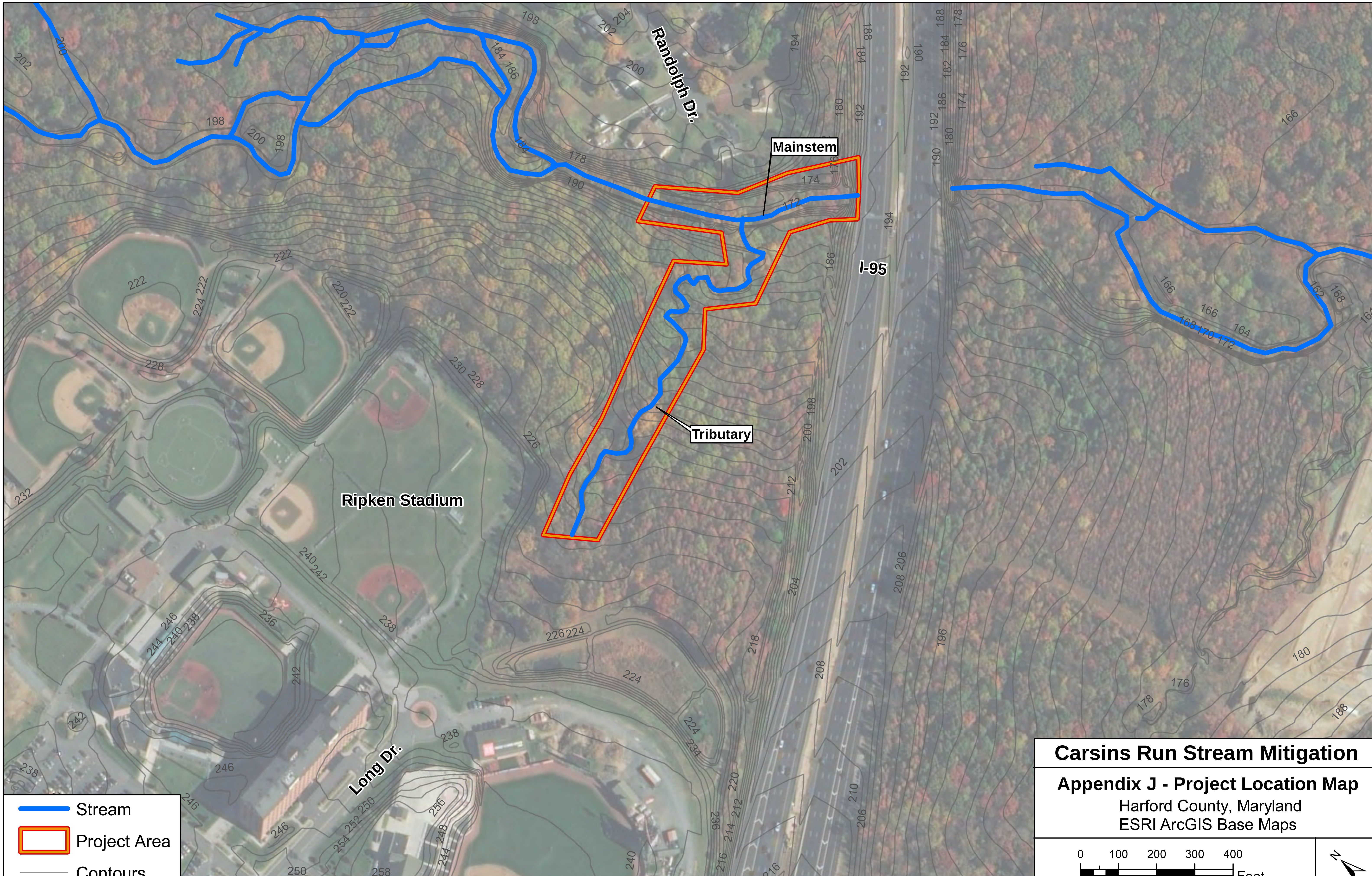
CONTRACT NO. TBD

DRAWING NO. XS-P-1

SHEET NO. OF 74

FILE: pw:\\MDTAPWAPP1:MDTA_PW_OEC\Documents\20 - OEC Design Projects\KH (Kennedy Highway)\ETL NB Extension\4. 2019 - Carsins Run Stream Mitigation\07 Design Computations\06 Hydraulics & Hydrology\Revised Proposed HEC-RAS\Revised XS Trib\pXS-P001_CarsinsRun_prop

APPENDIX J
PROJECT LOCATION MAP



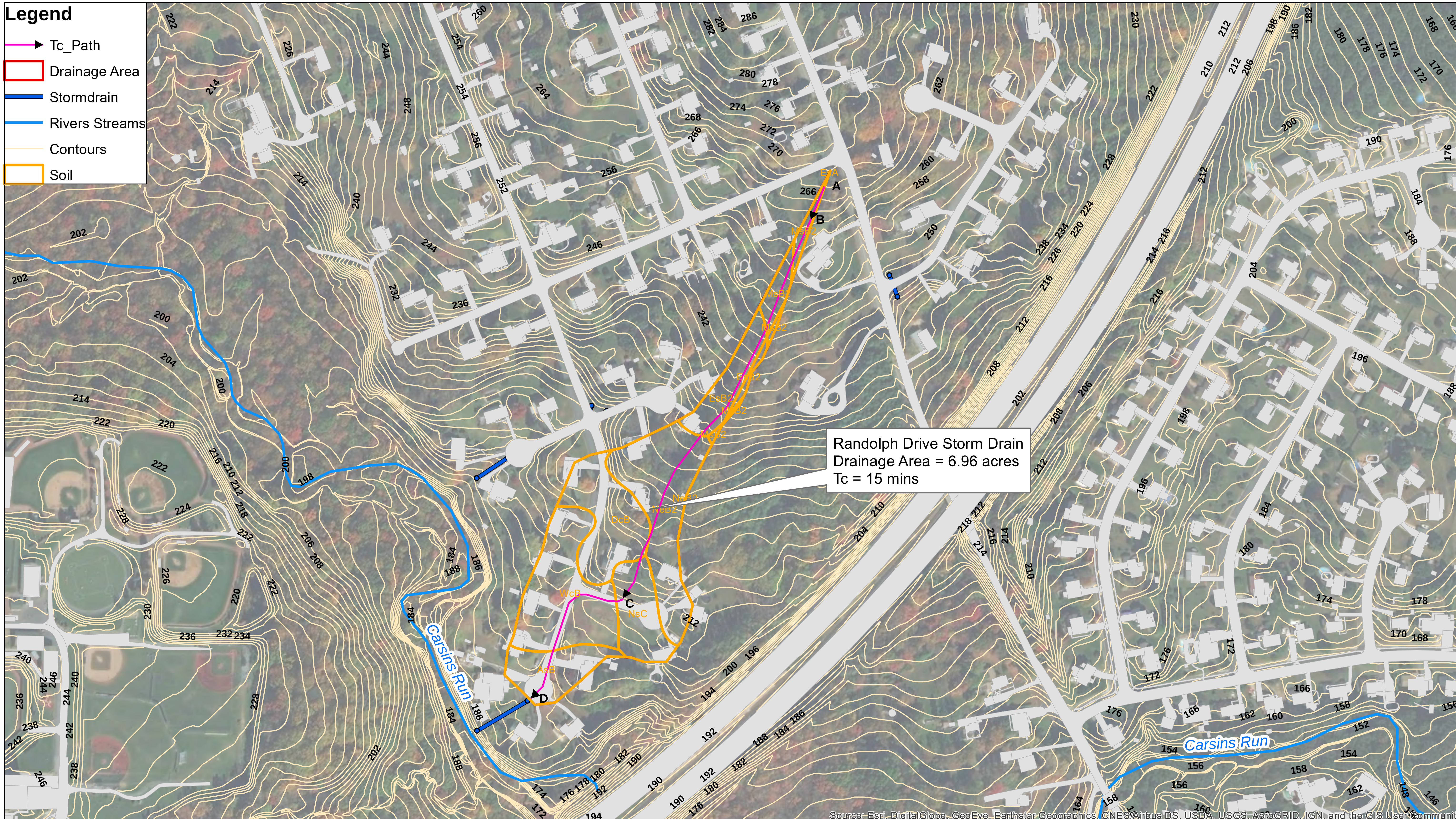
Carsins Run Stream Mitigation

Appendix J - Project Location Map

Harford County, Maryland

ESRI ArcGIS Base Maps

APPENDIX K
STORM DRAIN COMPUTATIONS



1 inch = 250 feet

0 170 340 680 1,020 1,360 Feet

Carsins Run Stream Restoration
Randolph Drive SD Drainage Area Map
Harford County
KCI Job No.22145228.47

KCI TECHNOLOGIES

"C" FACTOR COMPUTATIONS

JOB NAME: Carsins Run   DPZ NO.: ______   DATE: 5/9/2019
QC DATE: ______

Structure ID: EX-Inlet   Total Area 303,308 s.f.

				< 25 Year Storm		25+ Year Storm	
Land Use	Soil Type	Slope (%)	Area (s.f.)	"C" Factor	Partical "C"	"C" Factor	Partical "C"
Impervious	B	6.3	15,115	0.87	0.04	0.97	0.05
Open Space	B	6.3	85,813	0.21	0.06	0.26	0.07
Impervious	C	6.3	36,721	0.87	0.11	0.97	0.12
Open Space	C	6.3	93,828	0.24	0.07	0.32	0.10
Impervious	D	6.3	23,261	0.87	0.07	0.97	0.07
Open Space	D	6.3	48,569	0.28	0.04	0.37	0.06
				Composite "C" =	**0.39**		**0.47**

KCI Technologies, Inc.

936 Ridgebrook Road, Sparks MD. 21152

TIME OF CONCENTRATION COMPUTATIONS

By:	YH	Project Name:	Carsins Run Stream Restoration Ramdolph Dr SD	Project Number:	22145228.47
Date:	5/9/2019	County:	Harford	Existing:	
Check:				Ultimate:	
Date:				Proposed:	

I-A10

ID	Type of Flow				L(ft.)	n	A	WP	Slope (Percent)	Vel. (fps)	Time (Hours)
	Sheet Flow										
A-B	5	Grass - short			96	0.150			4.2		0.118
	Shallow Conc. Flow										
B-C		paved	X	unpaved	1166				4.7	3.50	0.092
C-D	X	paved		unpaved	446				2.5	3.19	0.039
										Total (Hours)	0.25
										Total (Min.)	15

MARYLAND STATE HIGHWAY ADMINISTRATION
STORM DRAIN DESIGN - 10-YEAR PIPE CAPACITY

DESIGNED BY: YH
CHECKED BY: JT

CONTRACT: KH3028
TITLE: Carsins Run Stream Restoration Randolph Dr. SD

RAINFALL FACTOR: 0.998
RET. PERIOD: 10

Structure		Contributing Area			10 Year Runoff					Pipe									Remarks
From	To	C Area (#)	A Area ac.	Δ CA	Σ A	ΣCA	tc Time Conc. Min	iif Rainfall Intens. in./hr.	Q cfs	Size (in)	Type	n Mann-ing's Coef.	So Slope %	Vo Vel. fps	L Leng. Ft.	tt Travel Time Min	Capac. Full cfs	
EX-Inlet	DS-1	0.39	6.96	2.71	6.96	2.71	15.00	5.04	13.68	21	RCP	0.013	6.10%	14.8	156	0.18	39.2	
DS-1	EW-1	--	--	--	6.96	2.71	15.18	5.04	13.68	24	RCP	0.013	0.50%	5.7	24	0.07	16.0	

STATE HIGHWAY ADMINISTRATION

STORM DRAIN DESIGN - 10 YEAR

DESIGNED BY: YH — CONTRACT: KH3028 — RAINFALL FACTOR: 0.998 — RET. PERIOD: 10 YEAR

CHECKED BY: JT — TITLE: Carsins Run Stream Restoration Randolph Dr. SD — Harford County, Maryland

Structure		Contributing Area				10 YEAR Runoff				Pipe								Hydraulic Gradient								
From	To	C Area (#)	A Area ac.	Δ CA	Σ A	ΣCA	tc Time Conc. Min	i_r Rainfall Intens. in./hr.	Q cfs	Size (in)	Type	n Mann-ing's Coef.	S_o Slope %	S_f Slope %	V_f Vel. fps	L Leng. Ft.	d_n Normal Depth ft	Angle (0)	Kb	Hb (ft)	Hf (ft)	INV IN	INV OUT	Elev. Out	Elev High	Top Elev
EX-Inlet	DS-1	0.39	6.96	2.714	6.96	2.71	15.00	5.04	13.68	21	RCP	0.013	6.10%	0.74	5.7	156	0.71	180	1.00	0.50	1.16	193.38	183.86	194.09	194.60	196.90
DS-1	EW-1	--	--	--	6.96	2.71	15.18	5.04	13.68	24	RCP	0.013	0.50%	0.36	4.4	24	1.42	180	1.50	0.44	0.09	174.12	174.00	175.54	175.98	186.50

STATE HIGHWAY ADMINISTRATION
STORM DRAIN DESIGN - 25 YEAR

DESIGNED BY: YH CONTRACT: KH3028 RAINFALL FACTOR: 0.998 RET. PERIOD: 25 YEAR

CHECKED BY: JT TITLE: Carsins Run Stream Restoration Randolph Dr. SD Harford County, Maryland

KCI TECHNOLOGIES

Structure		Contributing Area				25 YEAR Runoff				Pipe								Hydraulic Gradient								
From	To	C Area (#)	A Area ac.	Δ CA	Σ A	ΣCA	tc Time Conc. Min	ii Rainfall Intens. in./hr.	Q cfs	Size (in)	Type	n Mann-ing's Coef.	S_o Slope %	S_f Slope %	V_f Vel. fps	L Leng. Ft.	d_n Normal Depth ft	Angle (0)	Kb	Hb (ft)	Hf (ft)	INV IN	INV OUT	Elev. Out	Elev High	Top Elev
EX-Inlet	DS-1	0.47	6.96	3.271	6.96	3.27	15.00	5.04	16.49	21	RCP	0.013	6.10%	1.08	6.9	156	0.79	90	1.50	1.09	1.68	193.38	183.86	194.17	195.27	196.90
DS-1	EW-1	--	--	--	6.96	3.27	15.18	5.04	16.49	24	RCP	0.013	0.50%	0.53	5.2	24	2.00	90	1.50	0.64	0.13	174.12	174.00	176.12	176.76	186.50

Hydraulic Analysis Report

Project Data

Project Title: Carsins Run Stream Restoration Randolph SD Outfall

Designer: YH

Project Date: Friday, May 10, 2019

Project Units: U.S. Customary Units

Notes: The side slopes and channel longitudinal slope are using the steepest section of the outfall channel to be conservative.

Channel Analysis: Channel Analysis

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.5500 ft/ft

Side Slope 2 (Z2): 2.5500 ft/ft

Channel Width: 8.0000 ft

Longitudinal Slope: 0.2530 ft/ft

Manning's n: 0.0137

Lining Type: Rock Riprap

Flow: 13.6500 cfs (Q10 from Drainage Design)

Result Parameters

Depth: 0.1247 ft

Area of Flow: 1.0375 ft^2

Wetted Perimeter: 8.6833 ft

Hydraulic Radius: 0.1195 ft

Average Velocity: 13.1563 ft/s

Top Width: 8.6361 ft

Froude Number: 6.6891

Critical Depth: 0.4281 ft

Critical Velocity: 3.5066 ft/s

Critical Slope: 0.0039 ft/ft

Critical Top Width: 10.18 ft

Calculated Max Shear Stress: 1.9692 lb/ft^2

Calculated Avg Shear Stress: 1.8863 lb/ft^2

Channel Lining Analysis: Channel Lining Design Analysis

Notes:

Lining Input Parameters

Channel Lining Type: Riprap, Cobble, or Gravel

D50: 0.79 ft

Riprap Specific Weight: 165 lb/ft^3

Water Specific Weight: 62.4 lb/ft^3

Riprap Shape is Angular

Safety Factor: 1.5

Calculated Safety Factor: 1.09857

Lining Results

Angle of Repose: 41.7 degrees

Relative Flow Depth: 0.180307 ft

Manning's n method: Bathurst

Manning's n: 0.0137334

Channel Bottom Shear Results

V*: 1.10136

Reynold's Number: 71493.5

Shield's Parameter: 0.0672739

shear stress on channel bottom: 2.35065 lb/ft^2

Permissible shear stress for channel bottom: 4.21326 lb/ft^2

channel bottom is stable

Stable D50: 0.661133 ft

Channel Side Shear Results

K1: 0.8383

K2: 1

Kb: 0

shear stress on side of channel: 2.35065 lb/ft^2

Permissible shear stress for side of channel: 4.21326 lb/ft^2

Stable Side D50: 0.554227 lb/ft^2

side of channel is stable

Channel Lining Stability Results

the channel is stable

Channel Summary

Name of Selected Channel: Channel Analysis

APPENDIX L
U.S. ARMY CORP OF ENGINEERS
PERMIT

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, U.S. ARMY CORPS OF ENGINEERS
2 HOPKINS PLAZA
BALTIMORE, MD 21201

DEPARTMENT OF THE ARMY PERMIT

Application Name and Permit Number: **CENAB-OPR-MN (MDTA//I-95 - Stage I/ETL NORTHBOUND EXTENTION) 2018-60368-M12**

Issuing Office: U.S. Army Engineer District, Baltimore
Corps of Engineers
2 Hopkins Plaza
Baltimore, MD 21201

NOTE: The term "you" and its derivatives, as used in this permit, means the Permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the Corps of Engineers having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer.

You are authorized to perform work in accordance with the terms and conditions specified below.

Project Description: To impact waters of the United States, including jurisdictional wetlands, associated with proposed Stage I improvements to I-95 from New Forge Road in Baltimore County to MD 24 in Harford County, Maryland. The implementation of the improvements, as currently proposed, would result in permanent impacts to 26,807 square feet/0.62 acres of non-tidal wetlands and 8,246 linear feet/60,161 square feet of streams. The construction would also result in temporary impacts to 33,464 square feet/0.77 acres of non-tidal wetlands and 446 linear feet/ 12,555 square feet of streams. Proposed improvements to I-95 would include the addition of a two-lane express toll lane (ETL) that would be added to I-95 northbound (NB) from MD 43 to MD 152. A slip ramp would also be added to I-95 NB to the north of MD 43 that would allow ETL users to merge onto general purpose lanes. The addition of an auxiliary lane along I-95 NB from MD 152 to MD 24. The replacement of Bradshaw Road, Raphel Road, and Old Joppa Road overpasses. The reconstruction and widening of the bridges over the Big Gunpowder River, Little Gunpowder River and Winters Run. A new intelligent transportation system (ITS) communication system for improved operations and incident management to be added along the I-95 southbound (SB) shoulder. Two noise walls would be added along I-95 NB and SB. Existing utilities would be relocated where necessary.

Project Location: I-95 from New Forge Road in Baltimore County to MD 24 in Harford County, Maryland.

Permit Conditions:

General Conditions

1. The time limit for completing the work authorized ends on December 31, 2023. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least six (6) months before the above date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and state coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit, you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions.

6. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

Special Conditions:

1. The MDTA must comply with all conditions of the Section 401 Water Quality Certification from the Maryland Department of the Environment. The terms and conditions of the Water Quality Certification are conditions of this permit.

2. Final construction plans for impacts to waters of the U.S., including jurisdictional wetlands for the project must be reviewed and approved by the Corps prior to construction.

3. The MDTA must provide further avoidance and minimization of impacts to waters of the U.S., including jurisdictional nontidal wetlands, throughout the construction process.

4. No in-stream work will be conducted within Gunpowder Falls associated with the project from March 1 through June 15, inclusive, of any year.

5. No in-stream work will be conducted within Little Gunpowder Falls associated with the project from October 1 through June 15, inclusive, of any year.

6. All excavated materials must be removed, dewatered, and deposited in upland areas. Any disposal of said materials into streams and/or wetlands outside the limits of this authorization is not permitted.

7. Construction equipment must not encroach into wetlands or waterways beyond the limits of disturbance as depicted on the project plans.

8. Concrete mixer trucks must not be washed out in a manner that would allow the cement-laden wash water to enter any stream or wetland.

9. No stockpiling or storage equipment or materials, staging areas, or erection of ancillary facilities, such as concrete or asphalt plants, or construction trailer(s), are permitted within waters of the United States, including jurisdictional wetlands.

10. Any debris entering any wetlands or waterways must be promptly removed.

11. Permanent and/or temporary erosion & sediment controls and, stormwater management facilities must not be placed in wetlands or waterways without prior approval from this office.

12. All temporarily disturbed wetlands and waterways must be restored to preconstruction conditions. This includes the removal of any construction material (e.g., silt fencing, etc.) and the restoration of vegetation (wetlands are to be restored with original native vegetation species with the exception of invasive species), contours, elevations, and hydrology. At the conclusion of construction and after one full growing season for restored vegetation, this office will assess the viability of the restored wetlands, and any remnant wetlands. Should it be determined that any of the wetlands are no longer jurisdictional due to changed vegetation or hydrology, mitigation will be assessed for the additional impact(s).

Compensatory Mitigation Special Conditions

13. MDTA must provide all compensatory mitigation that is required by the Corps for permanent impacts to waters of the United States, including jurisdictional wetlands must be provided at the locations depicted on the enclosed map entitled 'Figure 3: Proposed Mitigation Sites' dated September 2018 and in accordance with Compensatory Mitigation Plans dated September 2018.

14. MDTA must submit a draft declaration of restrictive covenants (DRC) for each mitigation site to Mr. Steve Elinsky of this office within 90 days prior to the start of construction for the respective mitigation site.

15. MDTA must submit a completed fully executed DRC for each site to Mr. Steve Elinsky of this office prior to the start of construction.

16. The construction of the compensatory mitigation required at MD7 in Charlestown must be completed no later than February 1, 2021. All other required mitigation must be completed prior to the expiration of this authorization.

17. No in-stream work will be conducted within Carsins Run or its tributaries associated with the project from March 1 through June 15, inclusive, of any year.

18. No in-stream work will be conducted within an unnamed tributary to the Northeast River or its tributaries associated with the project from March 1 through June 15, inclusive, of any year.

19. The mitigation construction and plantings must be completed by the end of construction of the highway improvements. The mitigation sites must be monitored for a period of 10 years. Monitoring must commence during the first spring season following completion of construction and planting of the wetland mitigation sites.

20. Reporting and Performance Standards: All required documentation, including monitoring reports and as-built surveys shall be submitted electronically to the Corps (steve.elinsky@usace.army.mil). Monitoring reports must be submitted by December 31 of the year following completion of the mitigation site 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:

    - Wetland Area(s):

        - **Wetland Vegetation Dominance:** Wetland vegetation dominance, defined as a vegetation community where more than 50% of all dominant plant species across all strata are rated obligate ("OBL"), facultative wet ("FACW"), or facultative ("FAC"), using the vegetation sampling procedures as described in the appropriate regional supplement to the Corps of Engineers Wetland Delineation Manual, must be achieved; and

- **Aerial Cover Vegetative Standards:**
    - By the end of monitoring year one, a minimum of 50% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native (FAC or wetter) species.
    - By the end of monitoring year two, a minimum of 60% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native (FAC or wetter) species.
    - By the end of monitoring year three, a minimum of 70% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native (FAC or wetter) species.
    - By the end of monitoring year five and each monitoring year thereafter, a minimum of 85% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native (FAC or wetter) species.
    - Volunteer species should support functions consistent with the project design goals.

- **Invasive Species:** The goal of any mitigation site is to have no invasive species. However, if invasive species are present, no more than 10% of relative plant cover[1] over the entire site shall be made up by non-native or invasive species, with no individual colony greater than or equal to 5% of relative plant cover. No more than 5% of relative plant cover over the entire site shall be made up of *Phragmites australis*[2], *Persicaria perfoliata*, or *Lythrum salicaria*. Native status will be based on the Natural Resources Conservation Service Plants Database. Invasive species are identified on the 2010 National Park Service/U.S. Fish and Wildlife Service document Plant Invaders of Mid-Atlantic Natural Areas (http://www.nps.gov/plants/alien/pubs/midatlantic/) and the Maryland Invasive Species Council Invasive Species of Concern in Maryland (http://www.mdinvasivesp.org/invasive_species_md.html).

[1] "Relative plant cover" is defined as the cover of a particular species as a percentage of total plant cover. Thus, relative cover will always total 100%, even when total absolute cover is quite low.

[2] American Common Reed, *Phragmites australis* subsp. *americanus*, is not considered to be an invasive plant.

Phalaris arundinacea and *Typha* spp. may also be considered as invasive species; and

- **Wetland Species Richness:**
    - For scrub/shrub wetlands, establish a minimum of three species of native wetland shrubs (FAC or wetter) with each wetland shrub species having an aerial cover of at least 15%. No more than 50% shall be FAC.
    - For forested wetlands, establish a minimum of three species of native wetland trees and two species of native wetland shrubs (FAC or wetter) with each wetland tree and shrub species having an aerial cover of at least 15%. No more than 50% shall be FAC; and

- **Wetland Vegetation Density for Scrub-Shrub and Forested Wetlands:** For scrub-shrub or forested wetlands, native wetland (FAC or wetter) plant density of at least 435 living trees/shrubs per acre with a minimum height of 10 inches shall be achieved by the end of the first growing season following planting and maintained each monitoring year thereafter through the end of the monitoring period; and

- **Wetland Vegetation Cover for Forested Wetlands:** For forested wetlands, average tree height of tallest five native wetland trees within each sample plots shall be at least three feet in height at year three and at least five feet in height at year five and each monitoring year thereafter. Canopy cover[3] of native wetland trees and shrubs must be at least 30% by year ten; and

- **Wetland Hydrology:** Wetland hydrology, defined as 14 consecutive days of flooding or ponding, or a water table 12 inches (30 cm) or less below the soil surface, during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability). For the purpose of this determination, the growing season is based on two indicators of biological activity that are readily observable in the field: (1) above-ground growth and development of vascular plants and (2) soil temperature as an indicator of soil microbial activity. These indicators of biological activity shall be used for determinations of growing season and are more fully described in the appropriate regional supplement

[3] "Canopy cover" is defined as the percentage of ground covered by tree and shrub leaves, when the edges of the leaves are mentally projected down to the ground surface.

to the Corps of Engineers Wetland Delineation Manual.

- **Wetland Soils:** The entire wetland restoration or creation area must meet the Hydric Soil Technical Standard (Technical Note 11) developed by the National Technical Committee for Hydric Soils for saturated conditions and aerobic conditions:
  - Free water must exist within 10 inches (25 cm) of the ground surface for at least 14 consecutive days; and
  - Anaerobic conditions must exist within 10 inches (25 cm) of the ground surface for at least 14 consecutive days. Anaerobic conditions may be determined by one of the following methods, as detailed in the Hydric Soil Technical Standard:
    a. Positive reaction to alpha-alpha dipyridyl, determined as least weekly.
    b. Reduction of iron determined with IRIS tubes installed for 30 days.
    c. Measurement of redox potential (Eh) using platinum electrodes, determined at least weekly.

- Buffer Area(s):

  - **Aerial Cover Vegetative Standards:**
    - By the end of monitoring year one, a minimum of 50% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native species.
    - By the end of monitoring year two, a minimum of 60% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native species.
    - By the end of monitoring year three, a minimum of 70% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native species.
    - By the end of monitoring year five and each monitoring year thereafter, a minimum of 85% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native species.
    - Volunteer species should support functions consistent with the project design goals.

  - **Invasive Species:** The goal of any site is to have no invasive species. However, if invasive species are present, no more than 10% of relative plant cover[1] over the entire site shall be made up by non-native or invasive species, with no individual colony greater than or equal to 5% of relative plant cover. No more than 5% of relative plant cover over the entire site shall be made up of *Phragmites australis*[2], *Persicaria perfoliata*, or *Pueraria montana*. Native status will be based on the Natural Resources Conservation Service Plants Database. Invasive species are identified on the National Park Service/U.S. Fish and Wildlife Service document *Plant Invaders of Mid-Atlantic Natural Areas* (http://www.nps.gov/plants/alien/pubs/midatlantic/) and the Maryland Invasive Species Council *Invasive Species of Concern in Maryland* (http://www.mdinvasivesp.org/invasive_species_md.html); and

- **Buffer Species Richness:** For forested buffers, establish a minimum of three species of native trees and two species of native shrubs with each tree and shrub species having an aerial cover of at least 15%; and

- **Vegetation Density for Forested Buffers:** For forested buffers, native plant density of at least 435 living trees/shrubs per acre with a minimum height of 10 inches shall be achieved by the end of the first growing season following planting and maintained each monitoring year thereafter through the end of the monitoring period; and

- **Vegetation Cover for Forested Buffers:** For forested buffers, average tree height of tallest five native trees within each sample plots shall be at least three feet in height at year three and at least five feet in height at year five and each monitoring year thereafter. Canopy cover[2] of native trees and shrubs must be at least 30% by year ten;

- Stream Relocations:

  i. The permittee must monitor the stream relocation 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.

     At a minimum, the monitoring reports must:

     - Classify stream flow before and after construction for each stream (perennial, intermittent, and ephemeral).

- Evaluate channel stability by documenting changes in cross-sections across three riffles. The representative riffle cross-section must be monumented and shown in a graphical display which overlays previous cross-sections in annual reports.

- Evaluate vertical stability by performing a longitudinal profile survey to document thalweg and water surfaces elevations. Longitudinal profiles must be shown in a graphical display which overlays previous profiles in annual reports.

- Report vegetation species richness and cover.

- Evaluate stream habitat quality using an assessment method such as EPA's Rapid Bioassessment Protocol (RBP) high gradient stream habitat form. Results of the stream habitat assessment must be shown for all monitoring years assessed at the time the report is submitted, including preconstruction in each monitoring report.

- Photograph site conditions annually along the entire stream relocated project area. Photos of each grade control structure and riffle crest are required.

- Identify any necessary corrective measures.

- 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. Success Criteria for Stream Relocation

Level and Category	Parameter	Measurement	Success Criteria	Monitoring Year
1-Hydrology	Flow	Visual Characterization (Perennial, intermittent, or ephemeral)	Meets or exceeds baseline	PC, 3, 5
2-Hydraulics	Floodplain Connectivity	Bank height Ratio	<1.2	AB, 5
	Floodplain Connectivity	Documented or modeled at	Demonstrate substantial increase in floodplain	By Year 3

		discretion of consultant	connection following construction	
3-Geomorphology	Vertical Stability	Longpro/riffle crest and vertical control elevations	<0.5 ft thalweg degradation from as-built	AB, 3, 5
	Lateral Stability	BEHI	Moderate or better after construction	PC, 3, 5
	Habitat Assessment	RBP-High gradient (or alternative metric)*	Exceeds Baseline	PC, 3, 5
	Vegetative Cover	% cover	>80% cover in LOD	5
4-Water Quality	Summary	Descriptive	Summarize improvements to water quality as a result of project. May use peer reviewed literature to supplement measurements.	N/A
5-Biology	Richness and abundance of fishes	Richness and abundance of fishes	Reported	N/A
	Richness and abundance of amphibians	Richness and abundance of amphibians/Physical or audio sampling	Reported	N/A
	Vegetative Cover in LOD	% cover	>80% cover in LOD	5
	Invasive Plant Reduction	% cover invasive species in LOD	Less than Baseline	PC, 3, 5

Table 1 showing performance standards for stream restoration. AB=As-built, PC=Pre-construction, 1-5 corresponds to the monitoring year following construction, NA = Not applicable. Any alternative metric assessing stream habitat must be approved by Corps project manager.

21. The permittee must prepare an invasive species eradication and maintenance plan to remove non-native invasive plant species within the project site if site visits document their presence. The plan must be submitted to the Corps for review and approval along with the first monitoring report.

22. The permittee must maintain the as-built integrity of the authorized stream relocation and must ensure that the relocation is stable and self-sustaining. The permittee must notify and provide to the Corps, a detailed description and construction plans for any necessary correctives measures, including maintenance and repair, or alteration in any way, of the permitted stream relocation no later than 15 days prior to performance of such corrective measures for Corps review and approval.

23. The permittee must assume all liability for accomplishing the corrective work should the Corps determine the project has not been fully satisfactory. If the Corps does not find the project satisfactory, the permittee will be required to develop a remediation plan and an extension of monitoring time may be required to cover any necessary remedial work.

24. Best management practices must be employed to minimize impacts to wetlands and waterways. Temporary disturbance to wetlands and waterways must be restored to preconstruction conditions or better.

25. All temporary wetland impacts must be replanted and must be delineated under the 1987 Corps Wetland Delineation Manual and Regional Supplement. All timber mats must be removed after construction and the disturbed wetland areas must be planted with FAC or wetter tree species and groundcover. If the temporary wetland disturbance area does not delineate as wetland by year 5, the Corps must be notified in the year 5 monitoring report, corrective actions must be initiated and monitoring may be extended.

26. Please consider seeding all or portions of the site with a pollinator seed mix which includes milkweed (genus Asclepias) to support declining monarch butterfly populations. The Corps can provide example seed mix lists upon request for guidance on the planting plan.

27. MDTA 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. The as-built plans shall be accompanied by a narrative describing the site and any deviations from the original plans.

    Note: Your responsibility to complete the required compensatory mitigation as set forth in the Special Conditions will not be considered fulfilled until you have demonstrated compensatory mitigation project success and have received written verification of that success from the U.S. Army Corps of Engineers, Baltimore District.

    As stated above, MDTA must ensure that the mitigation area will result in 85% hydrophytic vegetation (facultative or wetter) by the end of the 10-year establishment period and the site must meet the regulatory definition of a wetland, per the Regional Supplement to Corps of Engineers Wetland Delineation Manual, Atlantic and Gulf Coastal Plain Region (Version 2). If the required compensatory mitigation is not successful, the reasons for the failure must be determined and remedial measures proposed and advanced to this office. Remedial measures taken must include, but are not limited to; regarding, replanting, excavation, the removal of sediment, the placement of fill or substrate amendments, the alteration of hydrology, and the removal of exotic or invasive plant species such as Purple Loosestrife *Lythrum salicaria*, Reed Canary Grass *Phalaris arundinacea*, and/or Common Reed *Phragmites australis*. The mitigation area must have less than 10 percent cover of invasive species. Extensive open water and submerged vegetation areas having no emergent and/or floating vegetation shall not exceed 20 percent of the mitigation area. Extensive areas (areas greater than 0.01-acre in size) of bare soil shall not exceed 5 percent of the wetland mitigation area. If the remedial action is not feasible, practicable, or fails within the designated timeframe, as determined by the Corps, then the permittee must meet the compensatory mitigation requirements at another location approved by the Corps.

Further Information:

1. Congressional Authorities: You have been authorized to undertake the activity described above pursuant to:

( ) Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403).
(X) Section 404 of the Clean Water Act (33 U.S.C. 1344).
( ) Section 103 of the Marine Protection, Research and Sanctuaries Act of U.S.C. 1413).

2. Limits of this authorization.

a. This permit does not obviate the need to obtain other Federal, State, or local authorizations required by law or to comply with the appropriate local critical area regulations.

b. This permit does not grant any property rights or exclusive privileges.

c. This permit does not authorize any injury to the property or rights of others.

d. This permit does not authorize interference with any existing or proposed federal projects.

3. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

a. Damages to the permitted project or uses thereof as a result of other permitted or unpermitted activities or from natural causes.

b. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

c. Damages to persons, property, or to other permitted or unpermitted active structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data. The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (see 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General Condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

Your signature below, as Permittee, indicates that you accept and agree to comply with the terms and conditions of this permit.

1/7/2019

(PERMITTEE) (DATE)

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

<u>Issued for and in behalf of:</u>

John T. Litz, PMP
Colonel, U.S. Army
Commander and District Engineer

Joseph P. DaVia (DATE)
Chief, Maryland Section Northern

When the structures or work authorized by this permit are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

(TRANSFEREE) (DATE)

KCI