Lubber Run
Pedestrian Bridge Replacement
Over Lubber Run

HYDROLOGY & HYDRAULICS ANALYSIS

Prepared for:

Arlington County Department of Parks & Recreation

July 2022

Prepared by

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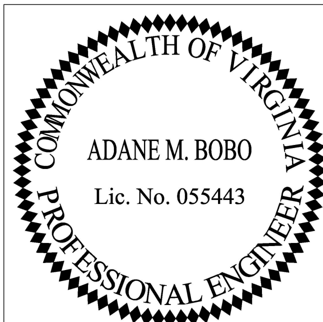


Volkert, Inc.
Springfield, Virginia
Hydraulic Engineer

Contents

1.0 INTRODUCTION

1.1 Project Description

The Pedestrian bridge over Lubber Run is located within the Lubber Run Park close to the intersection of 1st Road North and North Columbus Street, Arlington, Virginia (see Figure 1). The bridge provides connectivity between various trails within the Park. This bridge is one of a few bridges washed out during massive flash flooding in July 2019.

The proposed bridge will replace the existing bridge with similar or better hydraulics opening and structural performance than the existing one. The proposed abutments will be placed approximately the same location as the existing abutments with minor modification. The proposed super-and sub-structure design will have a minimum impact on existing stream channel.

The proposed improvement is located within the FEMA delineated flood Zone AE without regulatory floodway (Map Number 51013C0076C (See Appendix A)). According to Arlington County Code Chapter 48 (Floodplain Management), any proposed improvement located within Zone AE should conduct the Hydrology & Hydraulics Analysis (H&H) and determine if there is any impact of the proposed improvements on existing flood base elevation.

Volkert had a similar project with the County approximately 1800' upstream of the current pedestrian bridge (called Lubber Run 1 now on). The bridge design and hydraulics analysis for Lubber Run 1 has been completed almost two years ago and approved by the County. The construction has been completed and the bridge is opened for service. During the hydraulics analysis of Lubber Run 1 project, as a data gathering process, Volkert contacted Arlington County, FEMA through Arlington County and United State Army Corps of Engineers (USCAE) Baltimore office to request available effective model hydrology and hydraulics data for the project site. The County and FEMA informed us the effective hydraulics model was not available for the Lubber Run. The USACE couldn't find the model in their database which was originally developed in 1971. However, the County provided us the LOMR Hydraulics model with the case number 98-03-175P for part of Lubber Run between Carlin Springs Road & Wilson Blvd. The Model used HEC2 hydraulics modeling software to conduct the hydraulics analysis. The downstream limit of the LOMR study was at immediate upstream of the Lubber Run 1 pedestrian Bridge located close to the intersection of 3rd Street Lane and North Columbus Street. The downstream limit of this LOMR study is about 1700 feet upstream of Lubber Run 1 bridge. The flow used in the LOMR study was approved by the county and FEMA, those flows were used for Lubber Run 1 project after the flows were evaluated in the hydrology analysis. These flows will be revaluated in this study before being used in the hydraulics model.

1.2 Purpose

The main purpose of this report is to discuss the method, criteria and results of the H&H analysis of the proposed pedestrian bridge improvement over Lubber Run. This analysis is conducted based on the Arlington County Floodplain Management Ordinance (Chapter 48).

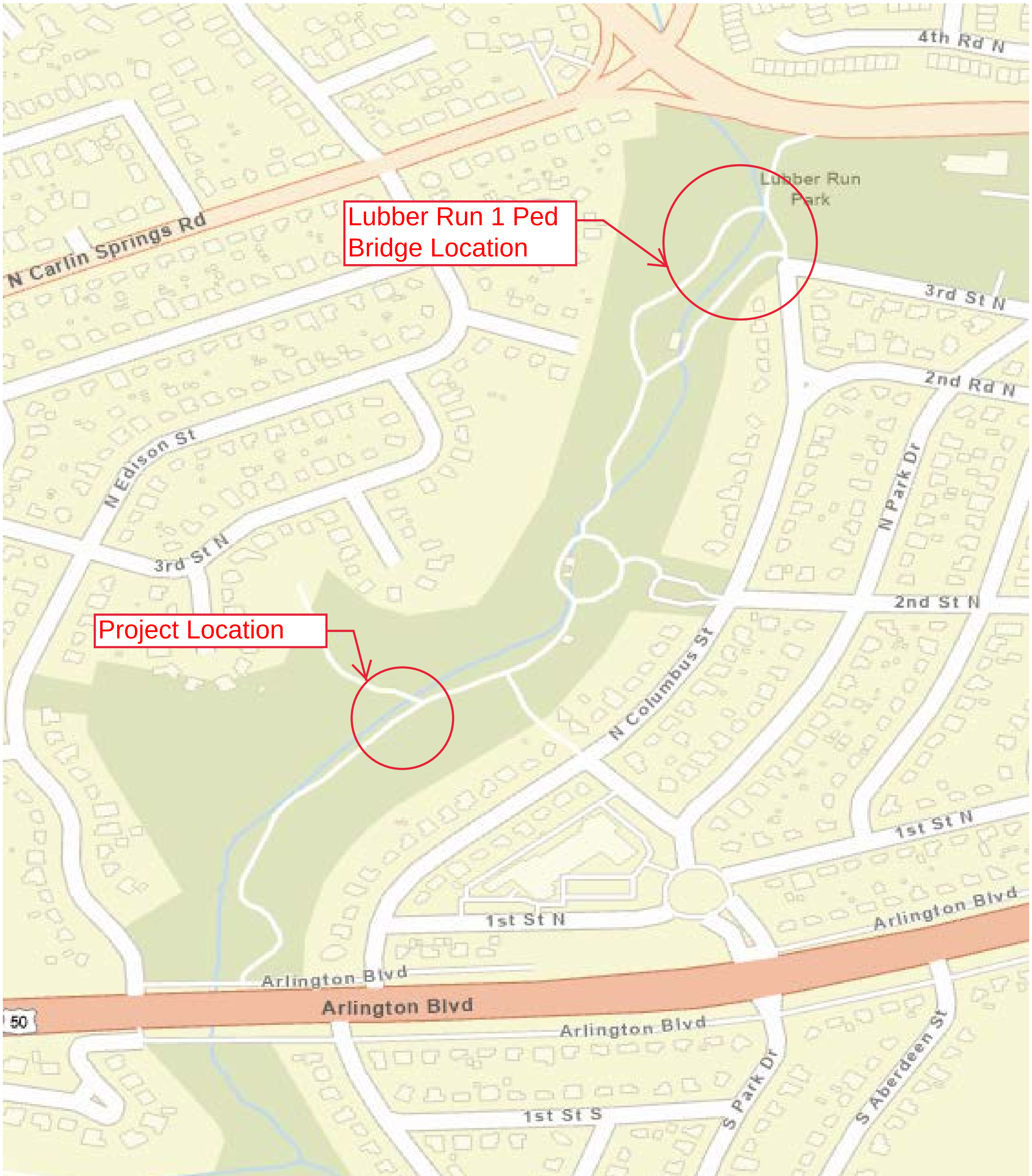


Figure 1: Project Location Map

2.0 HYDROLOGY

The project is located in Potomac River-Fourmile Run watershed (PL25) Lubber Run sub-basin with 8-digit Hydrologic Units Code (HUC) of 02070010. Lubber Run sub-basin starts immediate upstream of Route 29 (Lee Hwy) and ends immediate downstream of Route 50 (Arlington Blvd) and merges with the Four Mile Run. The Four Mile Run ultimately flows to Potomac River. The Lubber Run total drainage area is approximately 1.6 square miles, and about 50 percent of the drainage area is impervious. The proposed improvement is located approximately 1700' upstream of the junction of Lubber Run and Four Mile Run.

2.1 HYDROLOGIC METHODOLOGY

According to FEMA General Hydrologic Consideration Guidance Document 71, the effective flow should be compared with the newly calculated flows and need to be checked if the newly calculated flow is significantly different from the effective flow. As it was mentioned above the County gave us the LOMR model (case number 98-03-175P) that was developed for the improvements close to the Lubber Run 1 project. The hydrologic analysis was conducted for Lubber Run 1 project and it was determined that the LOMR flows are higher than newly calculated flows for all storm events except 500- year storms. Similarly, because of the proximity of the Lubber Run 1 project and the current project, the LOMR flows were compared with the Streamstats flows calculated at various locations within the project limit. The first point of interest is at the current project location right at the pedestrian bridge (Appendix B). The second point of interest is at the downstream end of the project close to Lubber Run crossing at Route 50 (Arlington Blvd). The comparisons were made between the Streamstats and LOMR flows for all storm events as shown on Table 1 below. The drainage areas and newly calculated flows from Streamstats are attached in Appendix B.

Table 1: Calculated and LOMR flows

	Drainage Area	Flows (CFS)						Sources
		2-year	10-year	25-year	50-year	100-year	500-year	
POI#1	1.46	642	1230	1550	1920	2600	4930	Streamstat*
POI#2	1.52	645	1240	1570	1950	2630	5020	Streamstat*
LOMR		1089	1728	2024	2303	2914	3403	The County

*: The Flows are from StreamStats Urban Peak using 2011 land cover

LOMR flows are greater than the newly calculated flows on both areas for all storm events except the 500-year storm events. Therefore, for the hydraulics analysis the LOMR flows were used except for 50-year storm event. For 500-year storm event, the flow calculated at POI#1 is used.

Volkert used the flows used in LOMR model for the following two reasons: 1) The flows used in the LOMR model is higher than the newly calculated flows all storm events except 500-year storm and 2) LOMR flows were already approved by the County and FEMA.

3.0 HYDRAULICS

3.1 METHODS

The hydraulic analysis for the pedestrian bridge over Lubber Run was conducted using GeoHECRAS from CivilGEO. GeoHECRAS is a Microstation and ESRI ArcGIS compatible interactive 2D/3D graphical user interface data wrapper to the Hydrologic Engineering Center-River Analysis System (HECRAS) hydraulics software. To determine the study limit on the upstream side of the project, the impact of the previous study (Lubber Run 1) on the current project was analyzed. The most downstream cross-section of the Lubber Run 1 study is located less than 1000' upstream of the current bridge under study. In addition, Lubber Run 1 hydraulics model has been approved by the County and the bridge has been constructed. Therefore, the upstream limit of Lubber Run 1 is used as starting cross-section of the current hydraulics model. At the downstream end, Route 50 (Arlington Blvd) crossing is approximately a 1000' and the junction of the Lubber Run and Four Mile Run is approximately 1600' downstream of the pedestrian bridge. To include the impact of a Four Mile Run as a back water effect and a culvert crossing at the Arlington Blvd on the hydraulics analysis, the downstream limit the analysis was considered at the junction point of the Lubber Run and Four Mile Run.

Existing and proposed model plans were prepared using GeoHECRAS and HECRAS version 5.0.7 to compare the proposed water surface elevation with the existing one. Based on the County Floodplain ordinance for delineated floodplains (Zone AE), it is not allowed to increase the level of the 1% (100-year) water surface elevation more than one foot due to the proposed improvements. Therefore, the analysis was conducted to limit the rise in 100-year proposed water surface elevation to the maximum of 1.0'.

Horizontal datum for the project control is based upon NAD 83 Virginia North Zone while the vertical datum for the project control is based upon NAVD 88.

Existing Condition Model:

The cross-sections data for the hydraulics model were developed based on the previous cross-sections developed for the Lubber Run 1 project, field survey data around the project limit and the contour data generated from VA LiDAR (Appendix C).

The cross-section and all parameters used in Lubber Run 1 proposed model are used as a part of the existing condition model of this study because the hydraulics analysis for the Lubber Run 1 was approved and the construction of the bridge has been completed (Appendix C). Field estimated Manning's "n" values of 0.08/0.1, 0.05 and 0.06/0.1 were used for left overbank, channel and right overbank, respectively. Those values correspond to trees, bushes and grass combination on left and right overbanks and rough and rocky irregular channel (see pictures in Appendix D for the study limit). Known water surface elevation was used as a downstream boundary condition for 10, 25, 50, 100 & 500-year storm events based on the Preliminary Flood Insurance Study report developed for the Four Mile Run at the junction point of the Lubber Run and the Four Mile Run (FEMA web site). The 2-year WSE was not found in the report; therefore, normal depth was used as a boundary condition. Contraction and expansion coefficients of 0.1 and 0.3 were used at all cross-sections except the cross-section immediately upstream and downstream of a bridge and culverts where the coefficients were changed to 0.3 and 0.5.

All existing culverts and bridges which were part of the original proposed Lubber Run 1 study are included in this existing condition model. In addition, a 12' standard Arch culvert at the Route 50 crossing was added in the model as well. This structure and the Arlington Blvd roadway profile were not a part of the field survey. The roadway profile was extracted from the Lidar data and the culvert data was extracted from another project (Appendix E).

The geometry of the existing pedestrian bridge is not available because the bridge was washed out during July 2019 storm events and not in place during field survey. Therefore, few assumptions have been made to create an existing bridge geometry in the hydraulics model. Both left and right abutments are still in place and they were used as reference point to create the existing bridge geometry. To create the existing deck elevation, the elevations at the top of the left and right bank stations were used from the existing surface data. Based on this assumption, the existing bridge had 6' wide deck and approximately 46' wide span.

This model was used as a basis to evaluate the impact of the proposed improvement on existing water surface elevation and surrounding structures.

Proposed Condition Model:

This model was prepared to simulate the proposed condition of the pedestrian bridge replacement project. This model used the same cross-sections data, Manning's n values, expansion and contraction coefficients and flows as the Existing Condition Model. The proposed bridge will be a single span, prefabricated bridge with 6' wide by 48'-8" long and 43.85' span. Abutment B of the proposed bridge is located at the same location as the existing abutment while the Abutment A is shifted approximately 10' north east of the existing abutment. Proposed bridge plans are attached in Appendix F for reference.

Slope protection riprap has been proposed around the abutments and left and right overbank area close to the bridge. All proposed improvement were included in the proposed condition model.

3.2 RESULTS

The summary of the results from the hydraulics model for 100-year storm event is presented in Table 2 (detailed results are presented in Appendix G). Based on the H&H analysis, the following results are observed:

- Water surface elevation generated from all storm events are overtopped the pedestrian bridge both in existing and proposed conditions (Appendix G). Even for the 2-year storm events, the water surface overtopped the bridge at abutment A side of the bridge (lowest side of the bridge).
- There is no rise in 100-Year WSE comparing proposed and existing condition for all cross-sections within the study limit (Table 2).
- The proposed improvement has no impact on WSE or on floodplain boundary both upstream and downstream of the proposed improvement (Appendix G).

Table 2: 100-year Water Surface Elevation for Existing and Proposed Conditions for Selected Cross-sections

Reach	River Sta	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	-485	EX_	2914	198.76	206.54	205.95	208.35	0.014067	10.98	303.89	82.94	0.79
Reach_1	-485	Prop	2914	198.76	206.54	205.95	208.35	0.014067	10.98	303.89	82.94	0.79
Reach_1	-809	EX_	2914	196.08	205.1		205.68	0.004332	7.46	690.99	143.64	0.46
Reach_1	-809	Prop	2914	196.08	205.1		205.68	0.004335	7.46	690.84	143.64	0.46
Reach_1	-1050	EX_	2914	190	204.18		204.83	0.002863	7.04	617.73	112.83	0.37
Reach_1	-1050	Prop	2914	190	204.18		204.83	0.002865	7.04	617.54	112.82	0.37
Reach_1	-1312	EX_	2914	183.7	204.49		204.56	0.000142	2.24	1652.81	144.9	0.09
Reach_1	-1312	Prop	2914	183.7	204.49		204.56	0.000142	2.24	1652.6	144.9	0.09
Reach_1	-1534	EX_	2914	179.9	204.51	186.41	204.53	0.000037	1.38	3719.77	256.69	0.05
Reach_1	-1534	Prop	2914	179.9	204.51	186.41	204.53	0.000037	1.38	3719.4	256.68	0.05

Reach_1	-1561		Lubber Run Ped Bridge									
Reach_1	-1578	EX_	2914	178	204.51	186.7	204.52	0.000042	1.54	4329.23	310.55	0.05
Reach_1	-1578	Prop	2914	178	204.51	186.7	204.52	0.000042	1.54	4329.23	310.55	0.05
Reach_1	-1897	EX_	2914	174.1	204.5		204.51	0.000017	1.1	5405.6	275.42	0.04
Reach_1	-1897	Prop	2914	174.1	204.5		204.51	0.000017	1.1	5405.6	275.42	0.04
Reach_1	-2195	EX_	2914	170.3	204.5		204.5	0.000009	0.91	6299.16	278.26	0.03
Reach_1	-2195	Prop	2914	170.3	204.5		204.5	0.000009	0.91	6299.16	278.26	0.03
Reach_1	-2441	EX_	2914	167	204.47	174.51	204.5	0.000023	1.46	3012.76	217.69	0.04
Reach_1	-2441	Prop	2914	167	204.47	174.51	204.5	0.000023	1.46	3012.76	217.69	0.04

4.0 SCOUR ANALYSIS

Abutment scour was witnessed during field visit (dated August, 2021) on both sides of the existing Bridge abutments. To determine the potential scour depth and to proposed possible counter measures, scour analysis was conducted for the bridge abutments. The scour analysis was conducted based on the guidelines outlined in HEC-18, HEC-23 and VDOT Drainage Manual. NCHRP 24-20 method was used to conduct the abutment scour analysis for the proposed pedestrian bridge. This analysis was conducted using the HEC-RAS results for 100-year and 500-year storm events and a D50 particle size from Geotechnical Report. The summary of the scour analysis results was presented in Table 3 below and detail scour calculations are presented in Appendix H.

Table 3: Summary of Scour Depth for the bridge abutments

Storm Event	Abutment Scour Depth	Remarks
100-year	3.37	
500-year	4.48	The proposed footing elevation will be at or close to the bedrock elevation.

To protect the proposed abutments from scour, the footing elevation was set to be at or close to the bedrock elevation. However, for slope protection Riprap Class II was recommended for slope stabilization underneath the bridge & around the abutments (Appendix F).

5.0 CONCLUSION

The H&H analysis was conducted for the proposed Pedestrian Bridge Replacement over Lubber Run based on Federal, State and the County standards and regulations. As the proposed improvement is located within the designated flood zone AE and Resource Protected Area (RPA), Volkert hydraulics and structure design teams worked together from the very beginning to minimize the impact of the proposed improvements on the floodplain or on the park. Therefore, the structural design was performed so that it will not have an impact on channel geometry and water surface elevation. The proposed bridge detail has been provided with the construction plan set. Based on this design, the H&H analysis clearly show that the proposed improvement has no impact on 100-year water surface elevation or floodplain boundary.

Scour analysis was also conducted for the proposed bridge based on the HEC-RAS results and field data and counter measures was proposed to protect future potential scour around the bridge abutments.

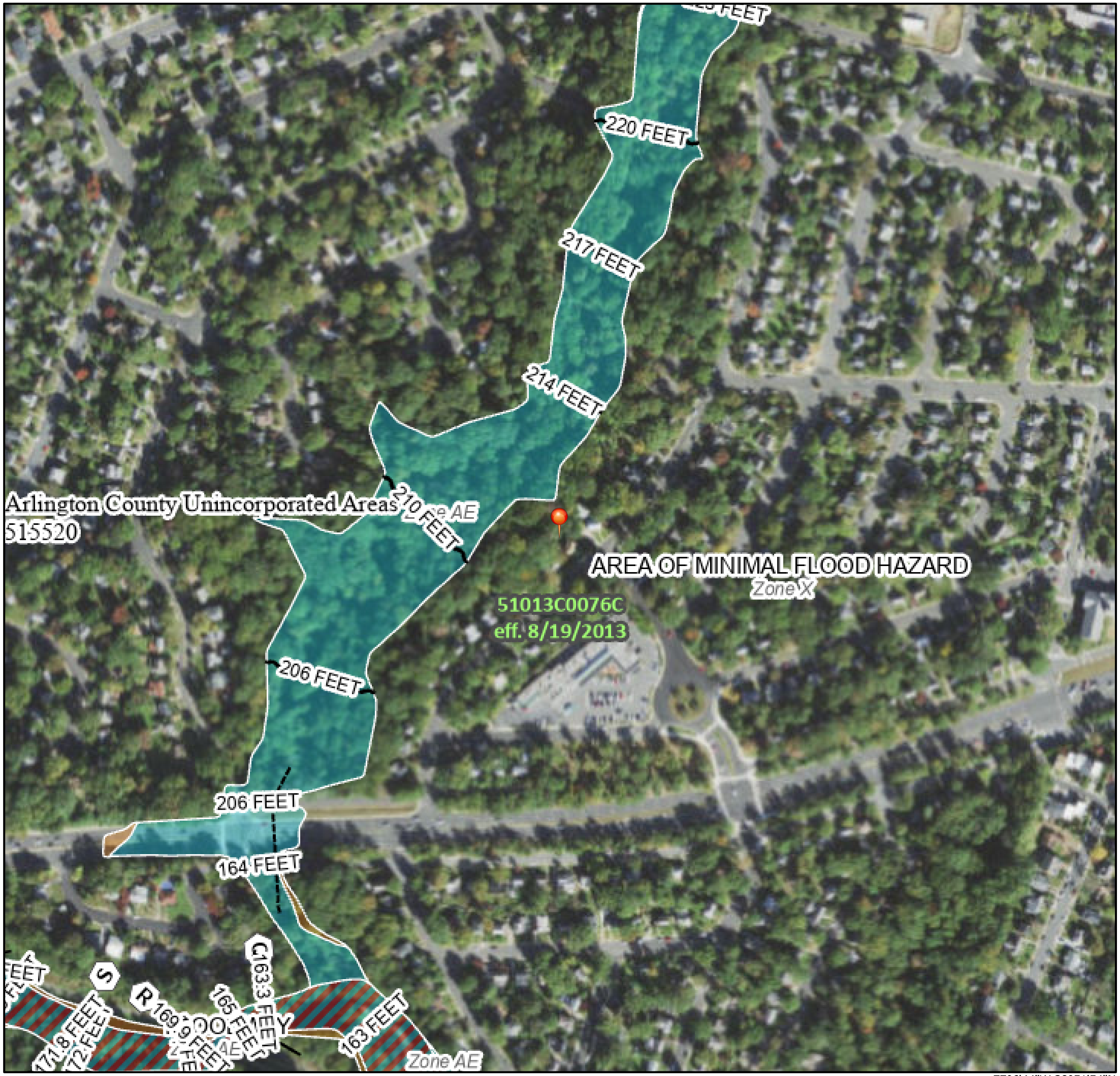
It is our understanding that this H&H analysis follows all the standards & regulations mentioned in the County Floodplain Ordinance and meets all the requirements and the analysis results show that the proposed improvements have no impact on the stream flow volume, velocity or flood elevation of the surrounding area.

APPENDIX A: FLOOD INSURANCE RATE MAP (FIRM)

National Flood Hazard Layer FIRMette

FEMA

77°7'21"W 38°52'22"N



77°6'44"W 38°51'54"N

Feet 0 250 500 1,000 1,500 2,000

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 5/15/2022 at 10:01 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

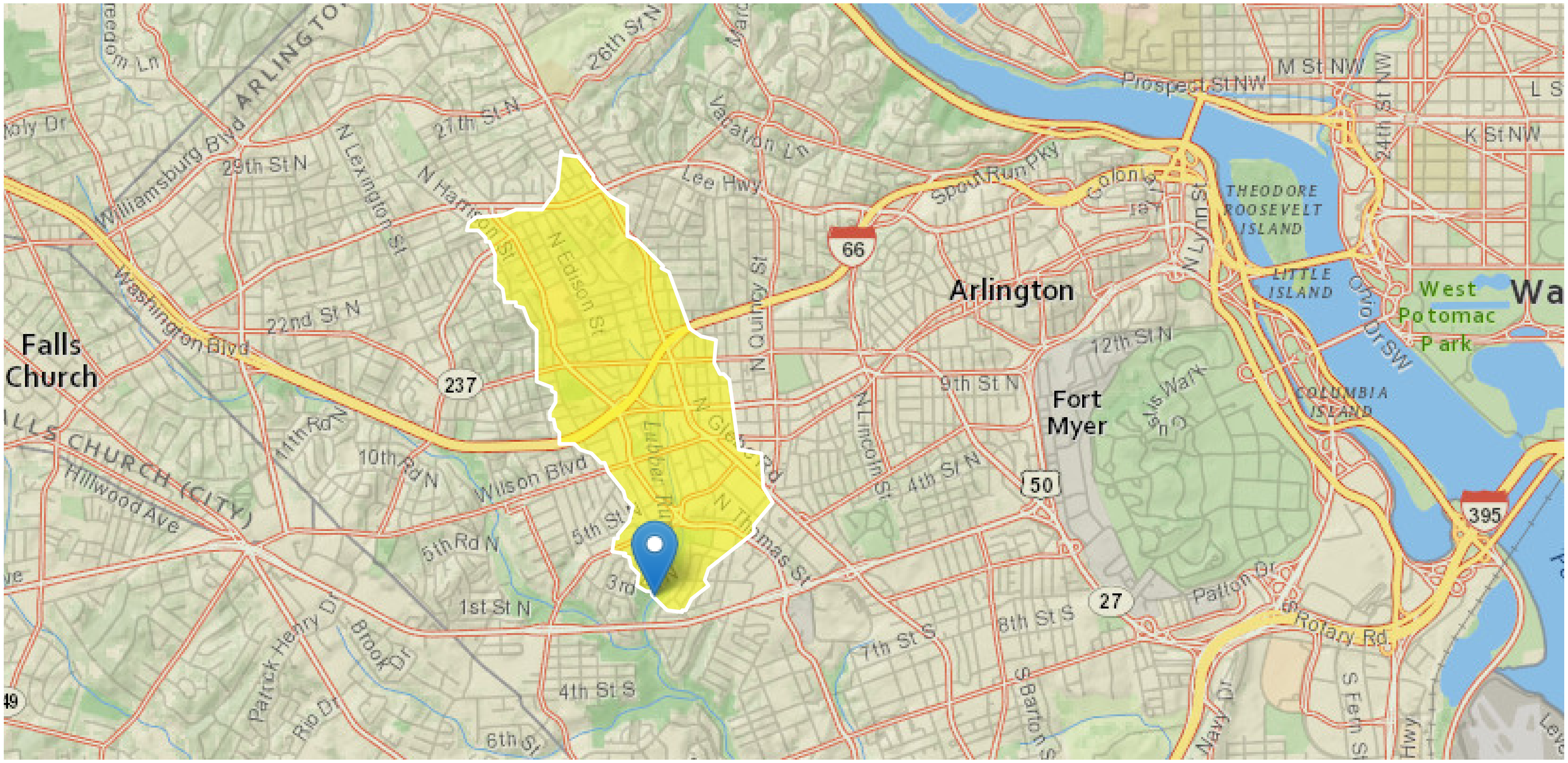
This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

APPENDIX B: USGS STREAMSTATS FLOW CALCULATIONS

APPENDIX B1: POINT OF INTEREST #1 (AT THE PEDESTRIAN BRIDGE LOCATION)

StreamStats Report

Region ID: VA
Workspace ID: VA20220717154229466000
Clicked Point (Latitude, Longitude): 38.86880, -77.11877
Time: 2022-07-17 11:42:51 -0400



⊞ Collapse All

› Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	1.46	square miles
LC01DEV	Percentage of land-use from NLCD 2001 classes 21-24	94.26	percent
LC06DEV	Percentage of land-use from NLCD 2006 classes 21-24	94.23	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	94.3	percent

Urban Peak-Flow Statistics

Urban Peak-Flow Statistics Parameters [Peak Urban01 2014 5090]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.46	square miles	0.07	2404
LC01DEV	Percent_Developed_from_NLCD2001	94.26	percent	10	96

Urban Peak-Flow Statistics Parameters [Peak Urban06 2014 5090]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.46	square miles	0.07	2404
LC06DEV	Percent Developed from NLCD2006	94.23	percent	10	96

Urban Peak-Flow Statistics Parameters [Peak Urban11 2014 5090]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.46	square miles	0.07	2404
LC11DEV	Percent Developed from NLCD2011	94.3	percent	10	96

Urban Peak-Flow Statistics Flow Report [Peak Urban01 2014 5090]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	ASEp
Urban 99.5-percent AEP flood	323	ft^3/s	70.4
Urban 99-percent AEP flood	335	ft^3/s	67.8
Urban 95-percent AEP flood	345	ft^3/s	60.5
Urban 90-percent AEP flood	383	ft^3/s	59.3
Urban 80-percent AEP flood	435	ft^3/s	57.5
Urban 66.7-percent AEP flood	556	ft^3/s	57.3
Urban 50-percent AEP flood	642	ft^3/s	57.3
Urban 42.9-percent AEP flood	695	ft^3/s	57.1
Urban 20-Percent AEP flood	959	ft^3/s	60.6
Urban 10-percent AEP flood	1230	ft^3/s	64.1
Urban 4-percent AEP flood	1550	ft^3/s	74.4
Urban 2-percent AEP flood	1920	ft^3/s	84.8
Urban 1-percent AEP flood	2600	ft^3/s	97.9
Urban 0.5-percent AEP flood	3320	ft^3/s	102
Urban 0.2-percent AEP flood	4930	ft^3/s	134

Urban Peak-Flow Statistics Flow Report [Peak Urban06 2014 5090]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	ASEp
Urban 99.5-percent AEP flood	323	ft^3/s	70.4

Statistic	Value	Unit	ASEp
Urban 99-percent AEP flood	335	ft^3/s	67.8
Urban 95-percent AEP flood	345	ft^3/s	60.5
Urban 90-percent AEP flood	383	ft^3/s	59.3
Urban 80-percent AEP flood	435	ft^3/s	57.5
Urban 66.7-percent AEP flood	556	ft^3/s	57.3
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Urban 2-percent AEP flood	1920	ft^3/s	84.8
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Urban 0.5-percent AEP flood	3320	ft^3/s	102
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Urban Peak-Flow Statistics Flow Report [Peak Urban11 2014 5090]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	ASEp
Urban 99.5-percent AEP flood	324	ft^3/s	70.4
Urban 99-percent AEP flood	335	ft^3/s	67.8
Urban 95-percent AEP flood	346	ft^3/s	60.5
Urban 90-percent AEP flood	384	ft^3/s	59.3

Statistic	Value	Unit	ASEp
Urban 80-percent AEP flood	436	ft^3/s	57.5
Urban 66.7-percent AEP flood	557	ft^3/s	57.3
Urban 50-percent AEP flood	642	ft^3/s	57.3
Urban 42.9-percent AEP flood	695	ft^3/s	57.1
Urban 20-Percent AEP flood	960	ft^3/s	60.6
Urban 10-percent AEP flood	1230	ft^3/s	64.1
Urban 4-percent AEP flood	1550	ft^3/s	74.4
Urban 2-percent AEP flood	1920	ft^3/s	84.8
Urban 1-percent AEP flood	2600	ft^3/s	97.9
Urban 0.5-percent AEP flood	3320	ft^3/s	102
Urban 0.2-percent AEP flood	4930	ft^3/s	134

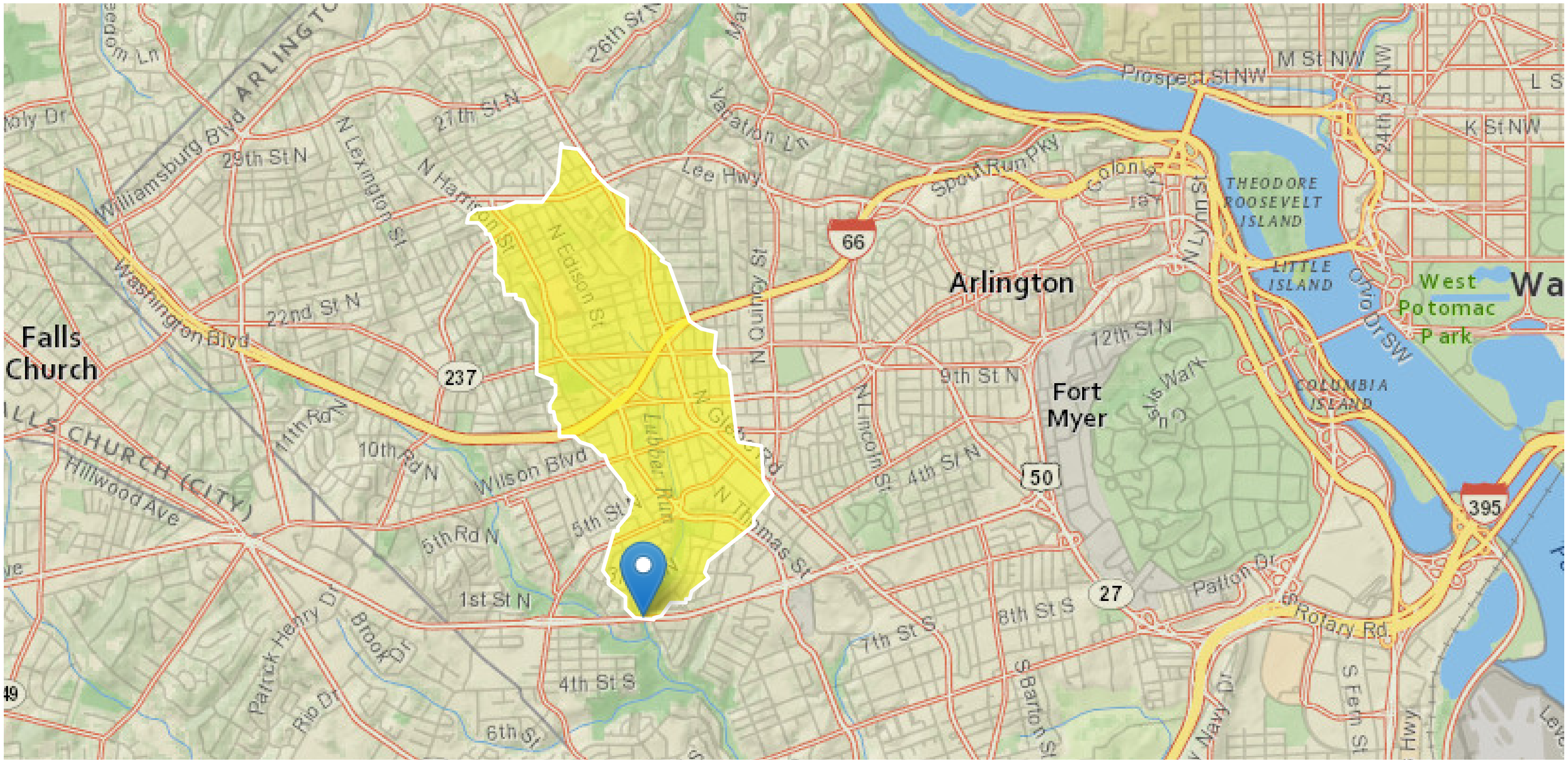
Urban Peak-Flow Statistics Citations

Austin, S.H.,2014, Methods and equations for estimating peak streamflow per square mile in Virginia’s urban basins: U.S. Geological Survey Scientific Investigations Report 2014–5090, 25 p. (http://pubs.usgs.gov/sir/2014/5090)

APPENDIX B2: POINT OF INTEREST #2 (AT THE ROUTE 50 CROSSING)

StreamStats Report

Region ID: VA
Workspace ID: VA20220717152727781000
Clicked Point (Latitude, Longitude): 38.86673, -77.11993
Time: 2022-07-17 11:27:50 -0400



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	1.52	square miles
LC01DEV	Percentage of land-use from NLCD 2001 classes 21-24	93.64	percent
LC06DEV	Percentage of land-use from NLCD 2006 classes 21-24	93.64	percent
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	93.7	percent

Urban Peak-Flow Statistics

Urban Peak-Flow Statistics Parameters [Peak Urban01 2014 5090]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.52	square miles	0.07	2404
LC01DEV	Percent_Developed_from_NLCD2001	93.64	percent	10	96

Urban Peak-Flow Statistics Parameters [Peak Urban06 2014 5090]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
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LC06DEV	Percent Developed from NLCD2006	93.64	percent	10	96

Urban Peak-Flow Statistics Parameters [Peak Urban11 2014 5090]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	1.52	square miles	0.07	2404
LC11DEV	Percent Developed from NLCD2011	93.7	percent	10	96

Urban Peak-Flow Statistics Flow Report [Peak Urban01 2014 5090]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	ASEp
Urban 99.5-percent AEP flood	320	ft^3/s	70.4
Urban 99-percent AEP flood	332	ft^3/s	67.8
Urban 95-percent AEP flood	344	ft^3/s	60.5
Urban 90-percent AEP flood	383	ft^3/s	59.3
Urban 80-percent AEP flood	436	ft^3/s	57.5
Urban 66.7-percent AEP flood	556	ft^3/s	57.3
Urban 50-percent AEP flood	644	ft^3/s	57.3
Urban 42.9-percent AEP flood	698	ft^3/s	57.1
Urban 20-Percent AEP flood	966	ft^3/s	60.6
Urban 10-percent AEP flood	1240	ft^3/s	64.1
Urban 4-percent AEP flood	1570	ft^3/s	74.4
Urban 2-percent AEP flood	1950	ft^3/s	84.8
Urban 1-percent AEP flood	2630	ft^3/s	97.9
Urban 0.5-percent AEP flood	3360	ft^3/s	102
Urban 0.2-percent AEP flood	5010	ft^3/s	134

Urban Peak-Flow Statistics Flow Report [Peak Urban06 2014 5090]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	ASEp
Urban 99.5-percent AEP flood	320	ft^3/s	70.4

Statistic	Value	Unit	ASEp
Urban 99-percent AEP flood	332	ft^3/s	67.8
Urban 95-percent AEP flood	344	ft^3/s	60.5
Urban 90-percent AEP flood	383	ft^3/s	59.3
Urban 80-percent AEP flood	436	ft^3/s	57.5
Urban 66.7-percent AEP flood	556	ft^3/s	57.3
Urban 50-percent AEP flood	644	ft^3/s	57.3
Urban 42.9-percent AEP flood	698	ft^3/s	57.1
Urban 20-Percent AEP flood	966	ft^3/s	60.6
Urban 10-percent AEP flood	1240	ft^3/s	64.1
Urban 4-percent AEP flood	1570	ft^3/s	74.4
Urban 2-percent AEP flood	1950	ft^3/s	84.8
Urban 1-percent AEP flood	2630	ft^3/s	97.9
Urban 0.5-percent AEP flood	3360	ft^3/s	102
Urban 0.2-percent AEP flood	5010	ft^3/s	134

Urban Peak-Flow Statistics Flow Report [Peak Urban11 2014 5090]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

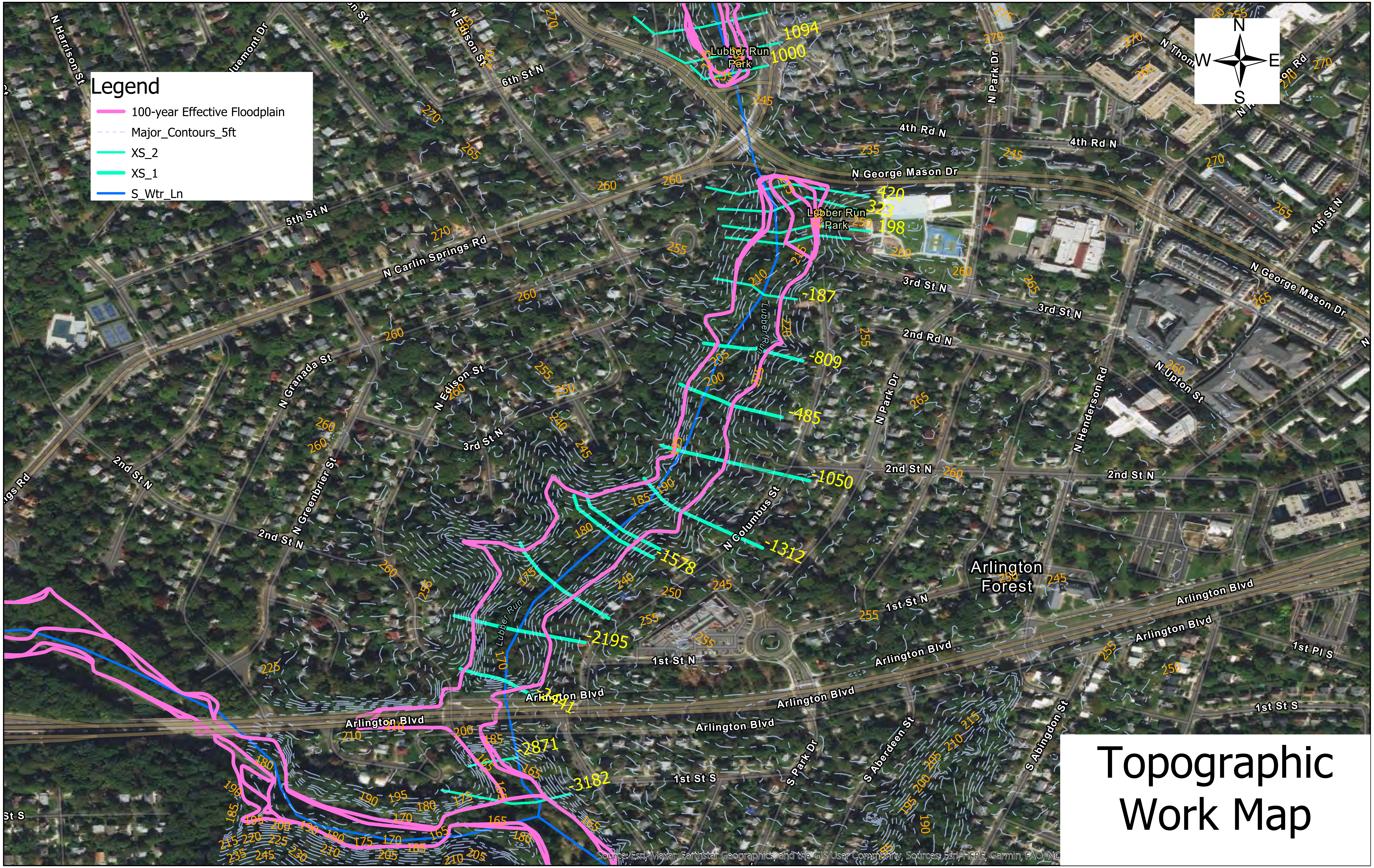
Statistic	Value	Unit	ASEp
Urban 99.5-percent AEP flood	321	ft^3/s	70.4
Urban 99-percent AEP flood	333	ft^3/s	67.8
Urban 95-percent AEP flood	345	ft^3/s	60.5
Urban 90-percent AEP flood	383	ft^3/s	59.3

Statistic	Value	Unit	ASEp
Urban 80-percent AEP flood	436	ft^3/s	57.5
Urban 66.7-percent AEP flood	557	ft^3/s	57.3
Urban 50-percent AEP flood	645	ft^3/s	57.3
Urban 42.9-percent AEP flood	699	ft^3/s	57.1
Urban 20-Percent AEP flood	967	ft^3/s	60.6
Urban 10-percent AEP flood	1240	ft^3/s	64.1
Urban 4-percent AEP flood	1570	ft^3/s	74.4
Urban 2-percent AEP flood	1950	ft^3/s	84.8
Urban 1-percent AEP flood	2630	ft^3/s	97.9
Urban 0.5-percent AEP flood	3370	ft^3/s	102
Urban 0.2-percent AEP flood	5020	ft^3/s	134

Urban Peak-Flow Statistics Citations

Austin, S.H.,2014, Methods and equations for estimating peak streamflow per square mile in Virginia’s urban basins: U.S. Geological Survey Scientific Investigations Report 2014–5090, 25 p. (http://pubs.usgs.gov/sir/2014/5090)

APPENDIX C: TOPOGRAPHIC WORK MAP


Topographic Work Map
Legend
100-year Effective Floodplain
Major_Contours_5ft
XS_2
XS_1
S_Wtr_Ln
N
S
E
W
Lubber Run Park
Lubber Run Park
Lubber Run
Arlington Forest
N George Mason Dr
N Carlin Springs Rd
Arlington Blvd
N Edison St
N Granada St
N Greenbrier St
N Columbus St
N Park Dr
N Henderson Rd
N Upton St
4th Rd N
3rd St N
2nd Rd N
2nd St N
1st St N
1st St S
5th St N
6th St N
1st Pl S
S Park Dr
S Aberdeen St
S Abingdon St
N Harrison St
1094
1000
420
323
198
-187
-809
-485
-1050
-1312
-1578
-2195
-2441
-2871
-3182
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community, Sources: Esri, HERE, Garmin, FAO, NO

APPENDIX D: PROJECT SITE PICTURES

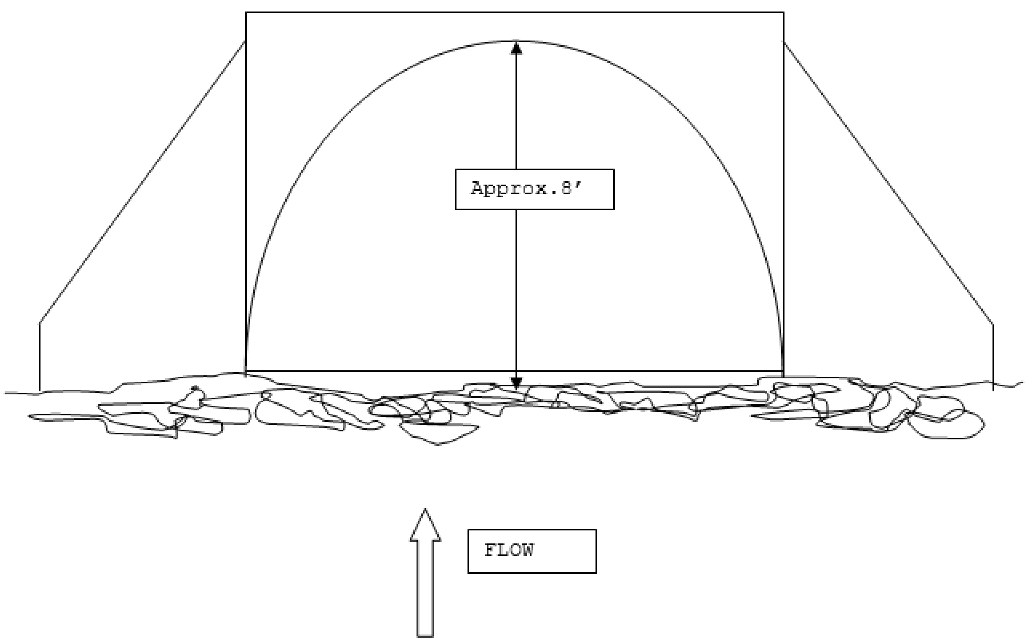
Picture 1: Stream Channel upstream of the Pedestrian Bridge (Picture taken 08-03-2021 & 02-11-2021)

Picture 2: Right and Left Abutment remains after the existing bridge has been washed out. (Picture taken 10-22-2020)

Picture 3: Vegetation Cover on Right and Left Overbank. (Picture taken 10-22-2020)

APPENDIX E: STANDARD 12'X8' ARCH CULVERT AT THE ROUTE 50 CROSSING


09/22/2020


Approx.8'
FLOW


09/22/2020

APPENDIX F: PROPOSED BRIDGE LAYOUT

REVISED ON 1/24/2022

GENERAL NOTES

1) UTILITY LOCATIONS SHOWN HEREON ARE PER A FIELD SURVEY PERFORMED BY UPI ON 08/25/21.
2) PRIVATE LIGHT FEED GOES ABOVE GROUND AT NOTED LOCATION.
3) WATER LINES WERE OBSERVED TO BE PLASTIC AT NOTED LOCATION AND NOT TRACEABLE BY UPI USING GEOPHYSICAL METHODS AT THE TIME OF THE INVESTIGATION, UPI RECOMMENDS PRIOR TO CONSTRUCTION, TEST PITS ARE PERFORMED IN THE VICINITY OF THE CONSTRUCTION ON THESE LINES.

MISS UTILITY OF DELMARVA
CALL BEFORE YOU DIG

UTILITY MARKING NOTES:

1) THE LOCATION OF UTILITIES LISTED IN THE TABLE BELOW AND SHOWN ON THIS PLAT ARE FROM OBSERVED EVIDENCE OF ABOVE GROUND APPURTENANCES, SURFACE GROUND MARKINGS, AND EXISTING PLANS AND MAPS.
2) BEFORE DIGGING IN THIS AREA, CALL "MISS UTILITY" 1-800-552-7001 FOR FIELD LOCATIONS (REQUEST FOR GROUND MARKINGS) OF UNDERGROUND UTILITY LINES.
3) THIS INVESTIGATION DOES NOT INCLUDE THE USE OF GROUND PENETRATING RADAR OR INTRUSIVE METHODS OF INVESTIGATION SUCH AS TEST PITS OR BORINGS.
4) THIS INVESTIGATION DOES NOT INCLUDE DESIGNATING SPRINKLER OR IRRIGATION SYSTEMS, BURIED TANKS, SEWER SYSTEMS, NON-CONDUCTIVE UTILITIES, OR WELLS.
5) DETECTING AND DESIGNATING UTILITIES THAT ARE BURIED DIRECTLY BELOW OTHER UTILITIES ARE NOT PROVIDED.

UTILITY DESCRIPTION	PLANS	MARKED	LOCATED	NOTES
ELECTRIC				
PRIVATE ELECTRIC	NO PLANS RECEIVED AT THIS TIME	X	X	MARKED AND LOCATED.
WATER				
PRIVATE WATER	NO PLANS RECEIVED AT THIS TIME	X	X	MARKED AND LOCATED.

LEGEND

Utilities - Electric
EX LIGHT POLE

Utilities - Water
EX WATER FOUNTAIN
EX WATER MANHOLE

Utilities - Miscellaneous
END OF INFORMATION - EOI

Linetypes
LIMITS OF UPI UTILITY SURVEY

SUE Level B - Field Located (Underground)
UGE — ELECTRIC (UNDERGROUND)
W — PRIVATE WATER MARKING

TREE LEGEND

DECIDUOUS TREE
CONIFEROUS TREE
BUSH
#1234 ALUMINUM TREE TAG NUMBER
DT DECIDUOUS TREE
CT CONIFEROUS TREE
CT SZ 15/7 — TRUNK SIZE (DIAMETER IN INCHES); TREE COVER (RADIUS IN FEET); TREE TYPE

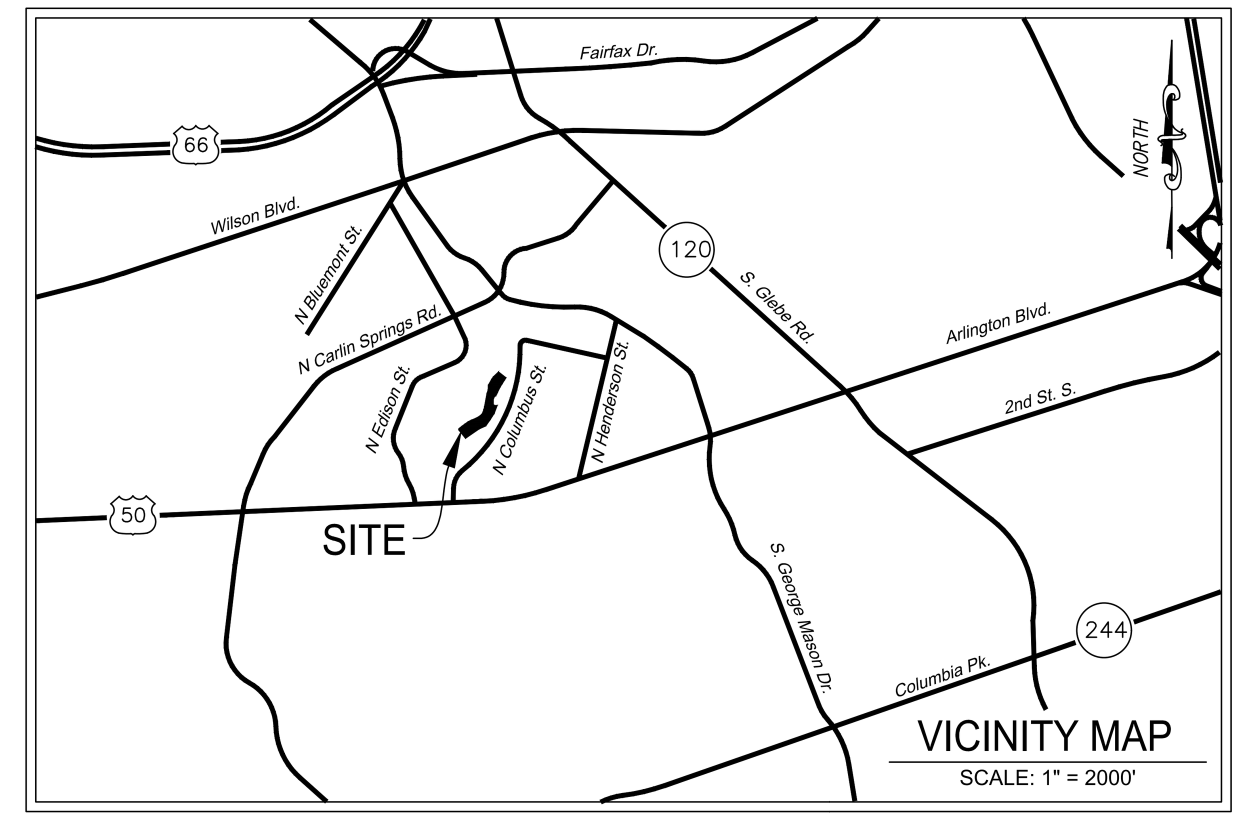
LEGEND

Utilities - Storm
STORM MANHOLE
STORM CULVERT
Utilities - Sanitary
SANITARY MANHOLE
Utilities - Water
WATER METER
WATER MANHOLE
Utilities - Electric
UTILITY POLE
Surfaces
ASPHALT AREA
CONCRETE AREA
BRICK AREA
GRAVEL AREA

Misc. Structures
150.0 SPOT ELEVATION
SIGN
HANDICAP PARKING
FLOW DIRECTION

Abbreviations
EX. — EXISTING
CONC. — CONCRETE
EP — EDGE OF PAVEMENT
RCP — REINFORCED CONCRETE PIPE
DIP — DUCTILE IRON PIPE
PVC — POLYVINYL CHLORIDE PIPE
CPP — CORRUGATED PLASTIC PIPE

Linetypes
INDEX CONTOUR (10')
INT. CONTOUR (2')
OHU — OVERHEAD UTILITY WIRE
SANITARY PIPE
STORM PIPE
EDGE OF WATER



VICINITY MAP
SCALE: 1" = 2000'

SANITARY STRUCTURE DATA

EX. S 1491
RIM EL. = 205.83
INV IN (24" DIP FROM NORTHEAST) = 196.43
INV IN (8" DIP FROM NORTH) = 197.53
INV IN (10" DIP FROM EAST) = 197.03
INV OUT (24" DIP TO 302) = 196.33

EX. S 302
RIM EL. = 199.85
INV IN (24" DIP FROM 1491) = 193.35
INV OUT (24" DIP TO 351) = 193.25

EX. S 351
RIM EL. = 198.59
INV IN (24" DIP FROM 302) = 189.39
INV OUT (24" DIP TO 1481) = 189.29

EX. S 960
RIM EL. = 206.33
INV IN (8" DIP FROM EAST) = 198.13
INV OUT (8" DIP TO 807) = 197.73

EX. S 807
RIM EL. = 199.49
INV IN (8" DIP FROM 960) = 190.59
INV OUT (12" DIP TO 1481) = 189.49

EX. S 1481
RIM EL. = 195.05
INV IN (12" DIP FROM 807) = 187.65
INV IN (24" DIP FROM 351) = 187.35
INV OUT (24" DIP TO 966) = 187.25

EX. S 966
RIM EL. = 194.63
INV IN (24" DIP FROM 1481) = 184.53
INV OUT (24" DIP TO 1456) = 184.43

EX. S 1456
RIM EL. = 197.28
INV IN (24" DIP FROM 966) = 180.68
INV OUT (24" DIP TO 1178) = 180.58

EX. S 1178
RIM EL. = 190.78
INV IN (24" DIP FROM 1456) = 175.98
INV OUT (24" DIP TO 1455) = 175.88

EX. S 1455
RIM EL. = 180.26
INV IN (24" DIP FROM 1178) = 170.16
INV OUT (24" DIP TO SOUTHWEST) = 170.06

EX. S 1471
RIM EL. = 204.00
INV IN (8" DIP FROM SOUTHEAST) = 194.40
INV OUT (8" DIP TO 990) = 194.20

EX. S 990
RIM EL. = 191.60
INV IN (8" DIP FROM 1471) = 185.30
INV OUT (20" DIP TO 1273) = 183.80

EX. S 1273
RIM EL. = 187.97
INV IN (20" DIP FROM 990) = 180.97
INV OUT (20" DIP TO 1454) = 180.87

EX. S 1454
RIM EL. = 182.80
INV IN (20" DIP FROM 1273) = 175.00
INV OUT (20" DIP TO SOUTHWEST) = 174.90

STORM STRUCTURE DATA

EX. 941
RIM EL. = 204.97
INV IN (18" CPP FROM EAST) = 201.27
INV OUT (18" CPP TO 961) = 197.27

EX. 961 EX. 962
RIM EL. = 194.00
INV (18" CPP FROM 941) = 191.60

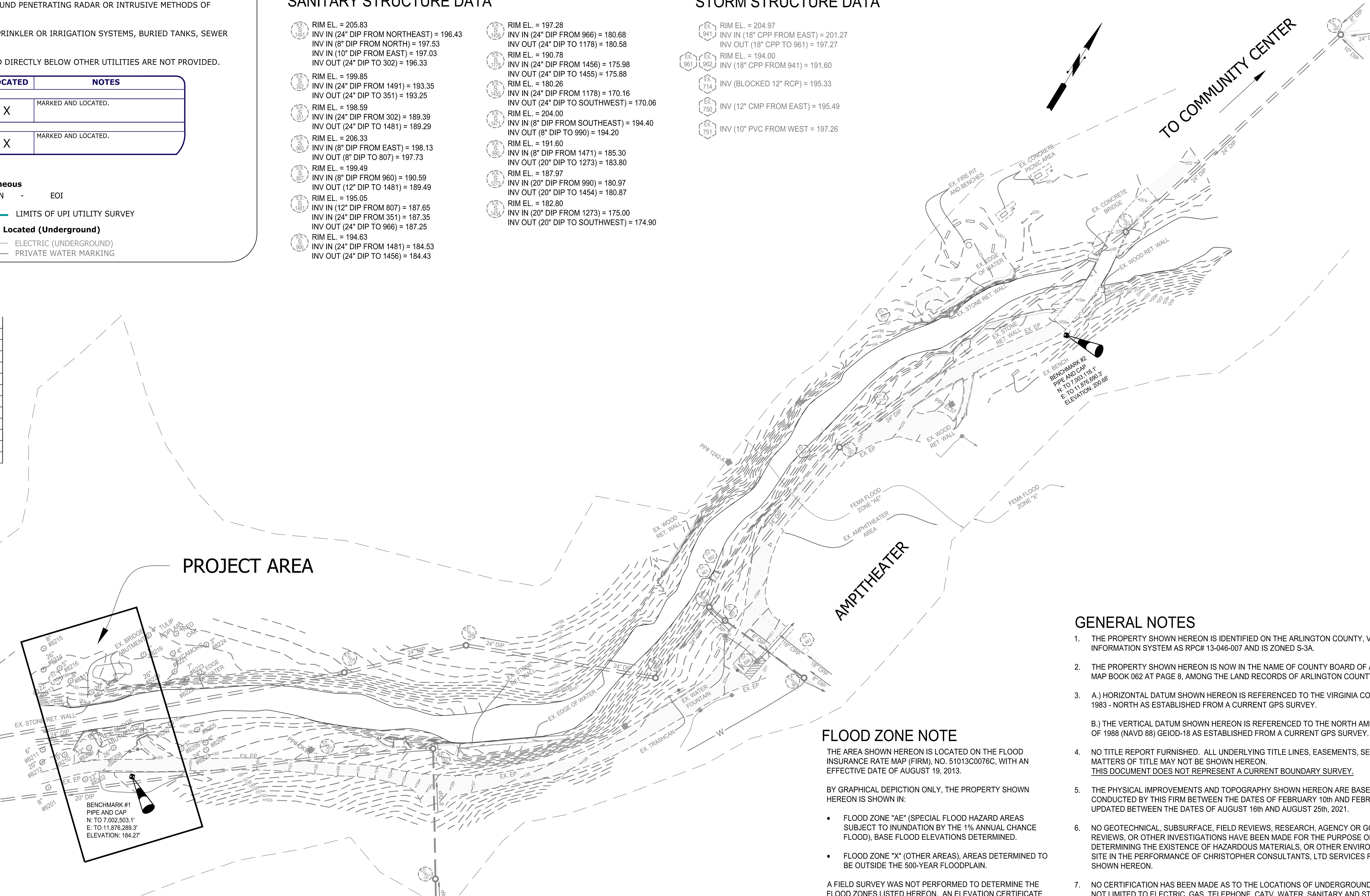
EX. 714
INV (BLOCKED 12" RCP) = 195.33

EX. 750
INV (12" CMP FROM EAST) = 195.49

EX. 751
INV (10" PVC FROM WEST = 197.26

SCHEDULE OF TREES

Tree Tag #	Tree Description	Tree Tag #	Tree Description
8201	DT SZ8/8 LOCUST	8213	DT SZ20/22 POPLAR
8202	DT SZ22/22 W.OAK	8214	DT/26" DEAD TREE
8203	DT SZ24/24 OAK	8215	DT SZ8/8 OAK
8204	DT SZ6/4	8216	DT SZ8/5
8205	DT SZ10/4X2	8217	DT SZ12/8
8206	DT SZ10/5	8218	DT SZ24/26 POPLAR
8207	DT SZ6/3.5	8219	DT SZ6/4
8208	DT SZ24/26 W.OAK	8220	DT SZ24/26 OAK
8209	DT SZ32/32 OAK	8221	DT SZ6/4
8210	DT SZ14/10	8222	DT SZ10/7 POPLAR
8211	DT SZ7/6	8223	DT SZ10/7 POPLAR
8212	DT SZ20/20 POPLAR	8224	DT SZ6/3 POPLAR



Survey Prepared By
christopher consultants

FLOOD ZONE NOTE

THE AREA SHOWN HEREON IS LOCATED ON THE FLOOD INSURANCE RATE MAP (FIRM), NO. 51013C0076C, WITH AN EFFECTIVE DATE OF AUGUST 19, 2013.

BY GRAPHICAL DEPICTION ONLY, THE PROPERTY SHOWN HEREON IS SHOWN IN:

- FLOOD ZONE "AE" (SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD), BASE FLOOD ELEVATIONS DETERMINED.
- FLOOD ZONE "X" (OTHER AREAS), AREAS DETERMINED TO BE OUTSIDE THE 500-YEAR FLOODPLAIN.

A FIELD SURVEY WAS NOT PERFORMED TO DETERMINE THE FLOOD ZONES LISTED HEREON. AN ELEVATION CERTIFICATE MAY BE NEEDED TO VERIFY THIS DETERMINATION OR APPLY FOR A VARIANCE FROM THE FEDERAL EMERGENCY MANAGEMENT AGENCY.

GENERAL NOTES

1. THE PROPERTY SHOWN HEREON IS IDENTIFIED ON THE ARLINGTON COUNTY, VIRGINIA GEOGRAPHIC INFORMATION SYSTEM AS RPC# 13-046-007 AND IS ZONED S-3A.
2. THE PROPERTY SHOWN HEREON IS NOW IN THE NAME OF COUNTY BOARD OF ARLINGTON, RECORDED IN MAP BOOK 062 AT PAGE 8, AMONG THE LAND RECORDS OF ARLINGTON COUNTY, VIRGINIA.
3. A.) HORIZONTAL DATUM SHOWN HEREON IS REFERENCED TO THE VIRGINIA COORDINATE SYSTEM (VCS) 1983 - NORTH AS ESTABLISHED FROM A CURRENT GPS SURVEY.

   B.) THE VERTICAL DATUM SHOWN HEREON IS REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) GEOID-18 AS ESTABLISHED FROM A CURRENT GPS SURVEY.
4. NO TITLE REPORT FURNISHED. ALL UNDERLYING TITLE LINES, EASEMENTS, SERVITUDES AND OTHER MATTERS OF TITLE MAY NOT BE SHOWN HEREON. THIS DOCUMENT DOES NOT REPRESENT A CURRENT BOUNDARY SURVEY.
5. THE PHYSICAL IMPROVEMENTS AND TOPOGRAPHY SHOWN HEREON ARE BASED UPON A FIELD SURVEY CONDUCTED BY THIS FIRM BETWEEN THE DATES OF FEBRUARY 10th AND FEBRUARY 26th, 2021, AND UPDATED BETWEEN THE DATES OF AUGUST 16th AND AUGUST 25th, 2021.
6. NO GEOTECHNICAL, SUBSURFACE, FIELD REVIEWS, RESEARCH, AGENCY OR GOVERNMENTAL RECORD REVIEWS, OR OTHER INVESTIGATIONS HAVE BEEN MADE FOR THE PURPOSE OF LOCATING, OR DETERMINING THE EXISTENCE OF HAZARDOUS MATERIALS, OR OTHER ENVIRONMENTAL CONCERNS ON SITE IN THE PERFORMANCE OF CHRISTOPHER CONSULTANTS, LTD SERVICES FOR THE PROJECT AS SHOWN HEREON.
7. NO CERTIFICATION HAS BEEN MADE AS TO THE LOCATIONS OF UNDERGROUND UTILITIES SUCH AS, BUT NOT LIMITED TO ELECTRIC, GAS, TELEPHONE, CATV, WATER, SANITARY AND STORM SEWERS.
8. DURING THE PROCESS OF OUR PHYSICAL SURVEY NO INDICATIONS OF A CEMETERY WERE FOUND. NO FURTHER INSPECTION OF THIS PROPERTY HAS BEEN MADE FOR POSSIBLE CEMETERIES.

ARLINGTON VIRGINIA
DEPARTMENT OF ENVIRONMENTAL SERVICES
FACILITIES & ENGINEERING DIVISION
ENGINEERING BUREAU
2100 CLARENDON BOULEVARD, SUITE 813
ARLINGTON, VA 22201
PHONE: 703.228.3629
FAX: 703.228.3606

SEAL

APPROVALS	DATE
DESIGN TEAM ENGINEER SUPERVISOR	
CONSTRUCTION MANAGEMENT SUPERVISOR	
WATER, SEWER, STREETS BUREAU CHIEF	
TRANSPORTATION DIRECTOR	
PROJECT MANAGER	

REVISIONS	DATE

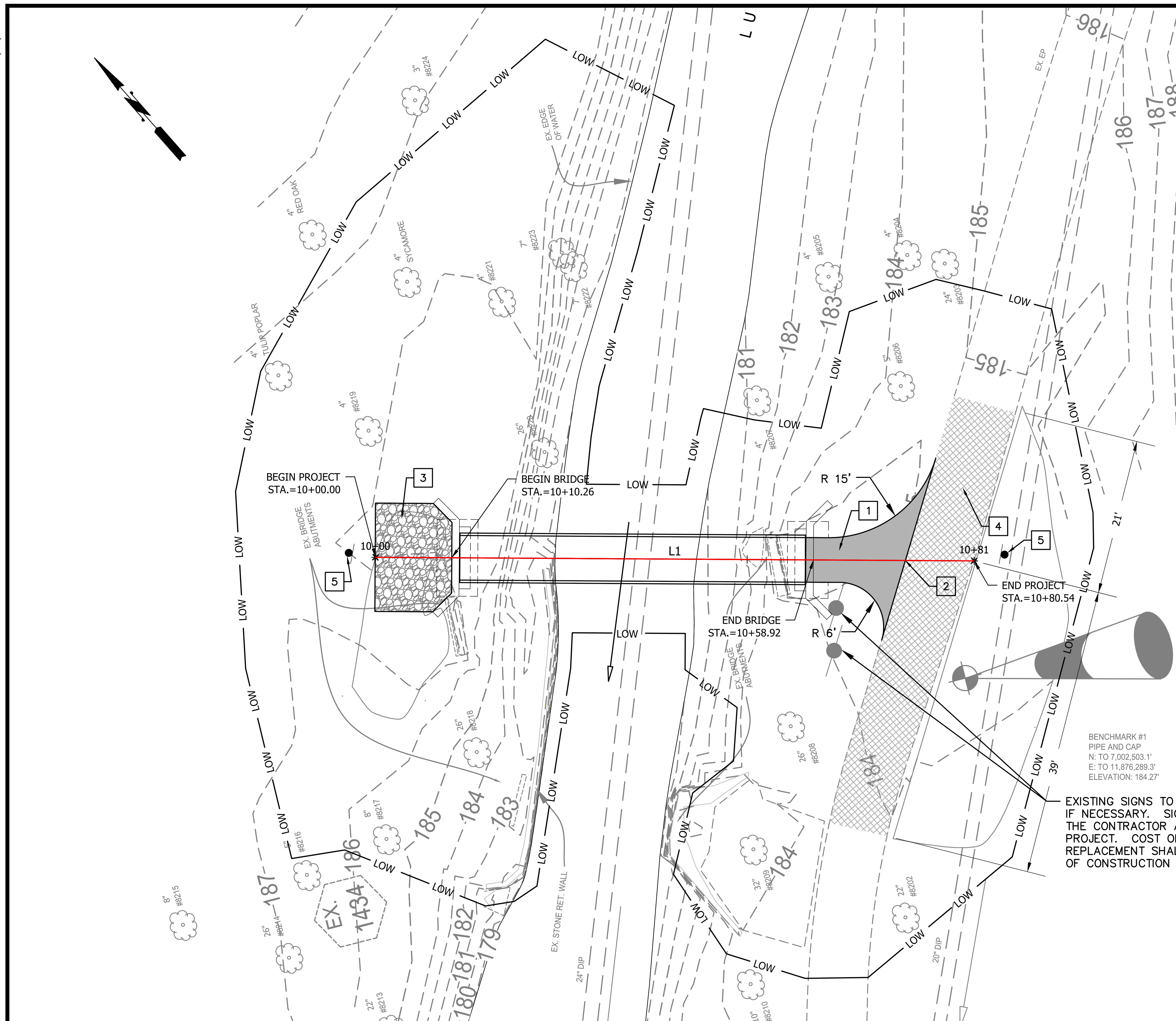
LUBBER RUN PEDESTRIAN BRIDGE
LUBBER RUN PARK
PEDESTRIAN BRIDGE OVER LUBBER RUN
EXISTING CONDITIONS

DESIGNED: BD
DRAWN: BD
CHECKED: BCG
PLOTTED: JULY 15 2022

SCALE:
0 40 80
GRAPHIC SCALE

C011.1

FILENAME: XXXX-214-EXISTING_CONDITIONS.DWG PATH: T:\1009400 - MASTER-ARLINGTON COUNTY ON-CALL\1009467 - LUBBER RUN PEDESTRIAN BRIDGE 2\07 DESIGN\DWG PLOTTED BY: BRENDA.DUONG

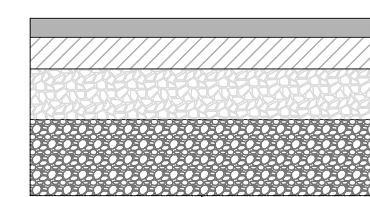


CONSTRUCTION NOTES

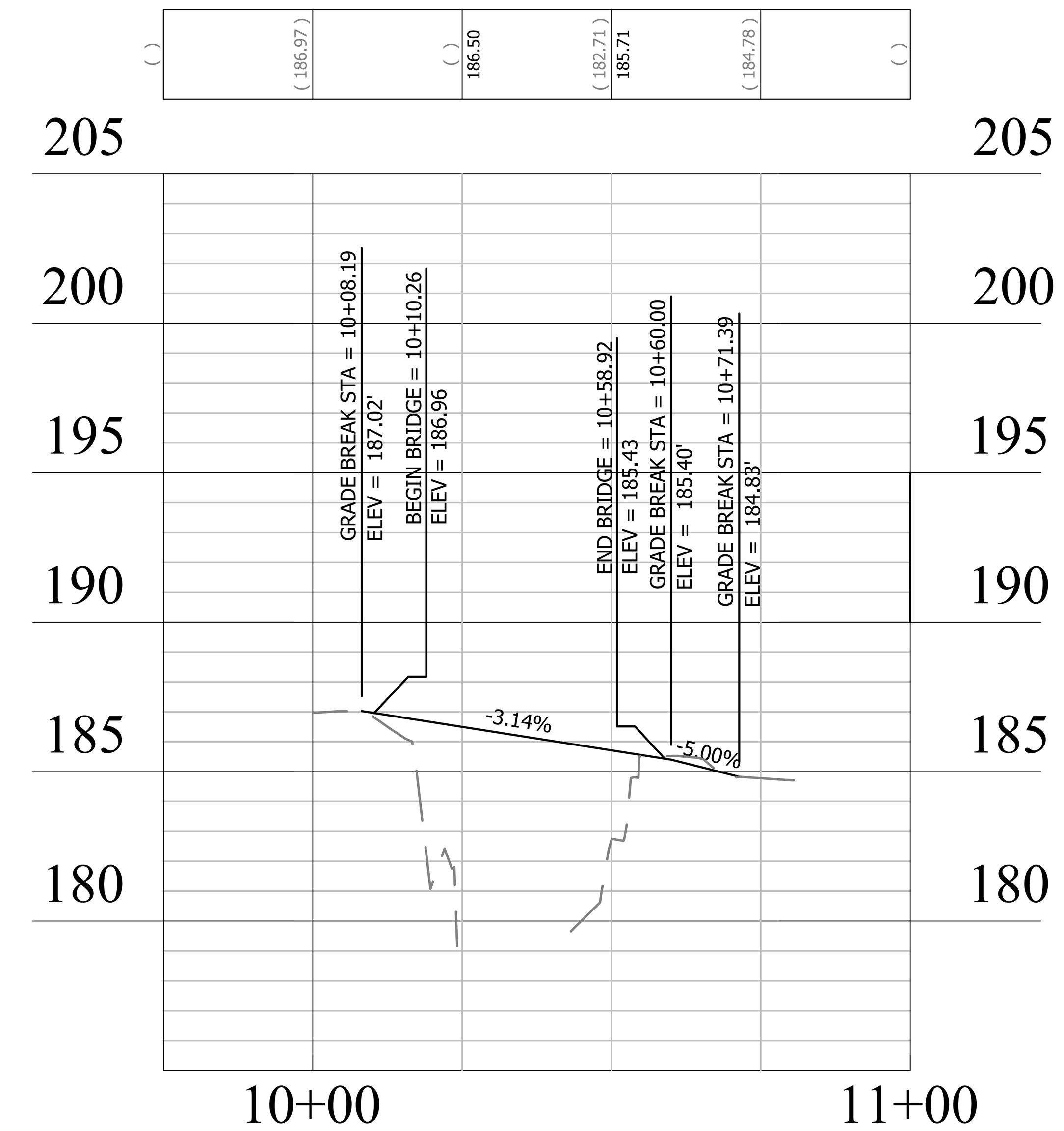
1. ASPHALT CONCRETE TRAIL. SEE DETAIL A
2. SAWCUT EXISTING PAVEMENT
3. 6" CRUSHER RUN AGGREGATE NO. 25 OR 26
4. 1.5" MILL AND OVERLAY
5. APPROXIMATE LOCATION OF WAYFINDING SIGN. SEE DETAILS BELOW.

RIPRAP NOT SHOWN FOR CLARITY. FOR RIPRAP LOCATION AND DETAILS SEE SHEET B001.1 AND B001.3.

DETAIL A
NTS

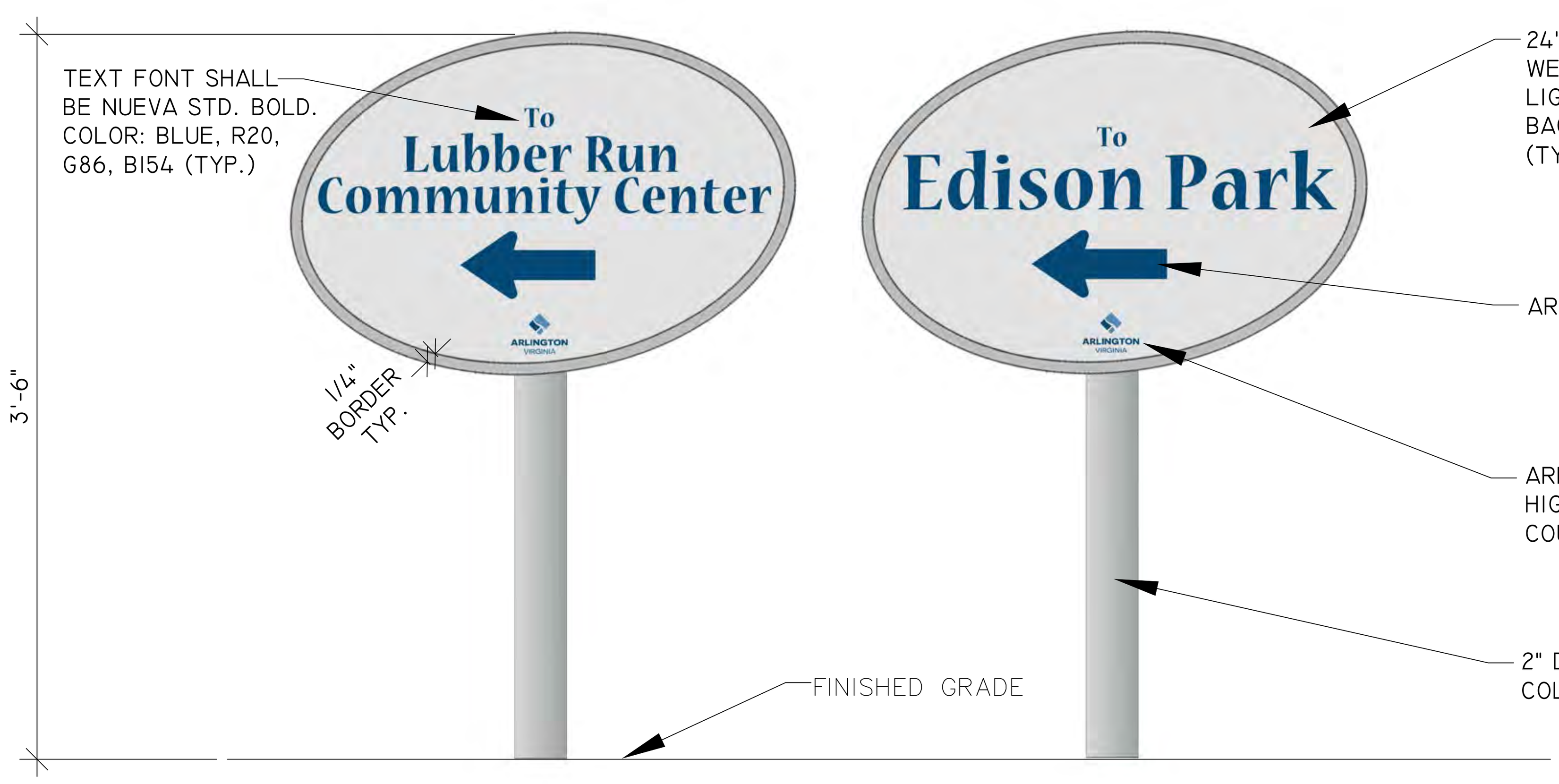


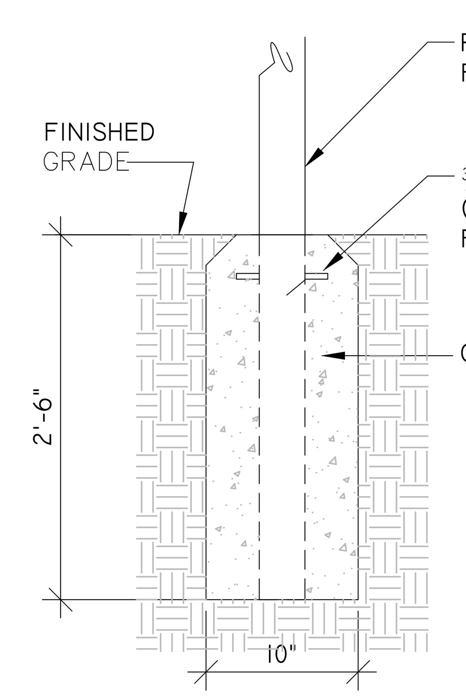
LUBBER RUN PED BRIDGE CONSTR. BASE LINE PROFILE



Lubber Run Ped Bridge										
Number	Length	Radius	Line/Chord Direction	Chord Length	Delta (Δ)	Tangent	STA (Start)	STA (End)	Northing, Easting (Start)	Northing, Easting (End)
L1	80.54'		S48° 13' 20.46"E				10+00.00	10+80.54	7002567.7388, 11876240.5669	7002514.0788, 11876300.6295

0 25 50
HORIZ. SCALE
0 5 10
VERT. SCALE





FOOTING DETAIL

NOTES:
1. PROVIDE SHOP DRAWINGS PRIOR TO ANY FABRICATION.
2. FINAL COLORS SHALL BE APPROVED BY LANDSCAPE ARCHITECT PRIOR TO ANY FABRICATION.
3. LOCATIONS SHALL BE FIELD LOCATED BY LANDSCAPE ARCHITECT.
4. SIGNS SHALL BE FABRICATED BY ENGRAPHIX ARCHITECTURAL SIGNAGE OR APPROVED EQUAL. SEE SPECIFICATIONS.
5. HIGH RESOLUTION IMAGES TO BE PROVIDED BY THE COUNTY.

WAYFINDING SIGN DETAILS
NTS

ARLINGTON
VIRGINIA
DEPARTMENT OF ENVIRONMENTAL SERVICES
FACILITIES & ENGINEERING DIVISION
ENGINEERING BUREAU
2100 CLARENDON BOULEVARD, SUITE 813
ARLINGTON, VA 22201
PHONE: 703.228.3629
FAX: 703.228.3606

SEAL

COMMONWEALTH OF VIRGINIA
BRENDA DUONG
Lic. No. 052964
07-15-2022
PROFESSIONAL ENGINEER

APPROVALS	DATE
DESIGN TEAM ENGINEER SUPERVISOR	
CONSTRUCTION MANAGEMENT SUPERVISOR	
WATER, SEWER, STREETS BUREAU CHIEF	
TRANSPORTATION DIRECTOR	
PROJECT MANAGER	

REVISIONS	DATE

LUBBER RUN PEDESTRIAN BRIDGE
LUBBER RUN PARK
PEDESTRIAN BRIDGE OVER LUBBER RUN
PLAN & PROFILE

DESIGNED: BD
DRAWN: BD
CHECKED: BCG
PLOTTED: JULY 15 2022

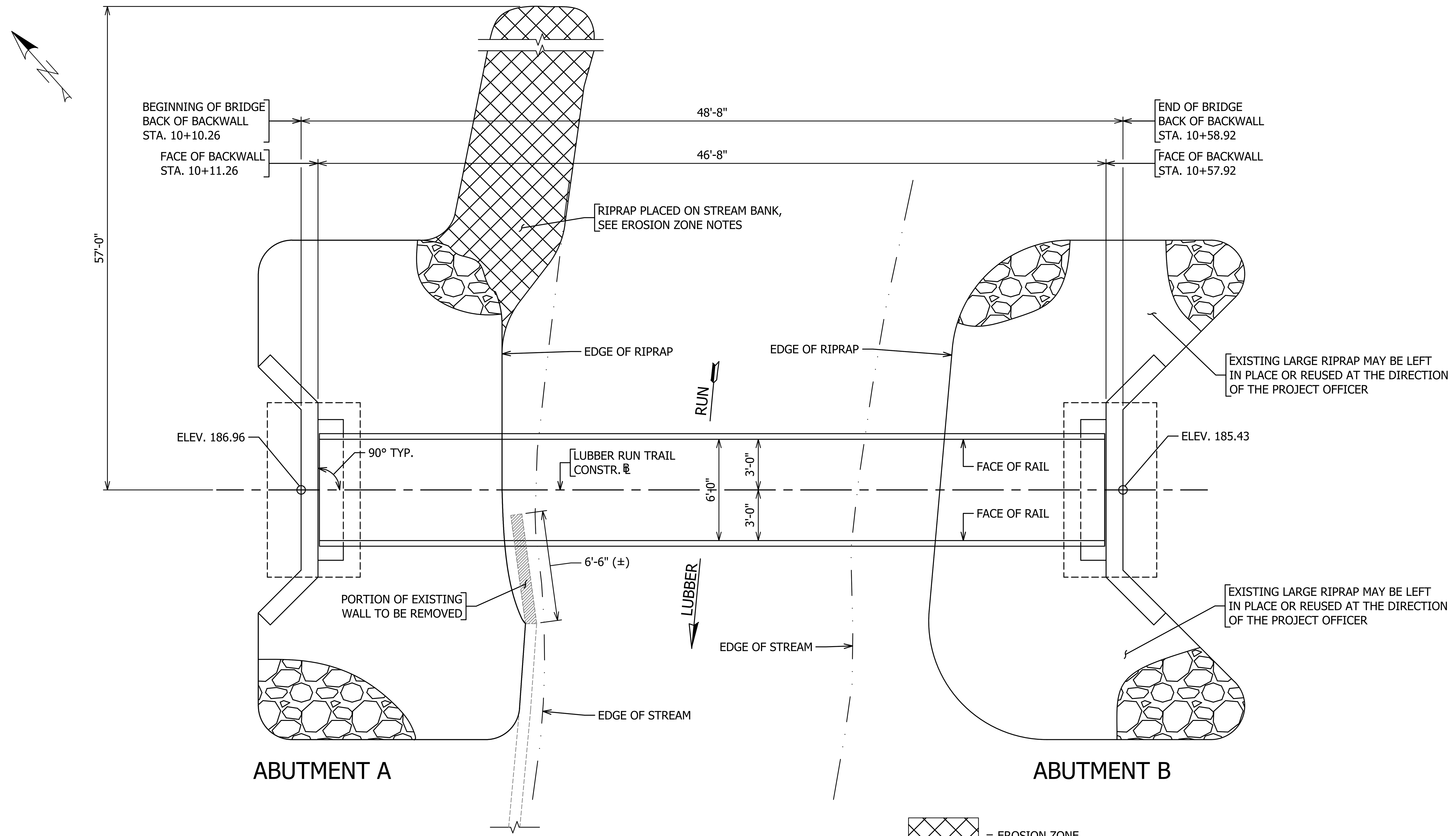
SCALE:
AS SHOWN

C041.1

FILENAME: XXXX-230-PLAN_PROFILE.DWG PATH: T:\1009400 - MASTER-ARLINGTON COUNTY ON-CALL\1009467 - LUBBER RUN PEDESTRIAN BRIDGE 2\07 DESIGN\DWG PLOTTED BY: BRENDA.DUONG

REVISED ON 1/24/2022

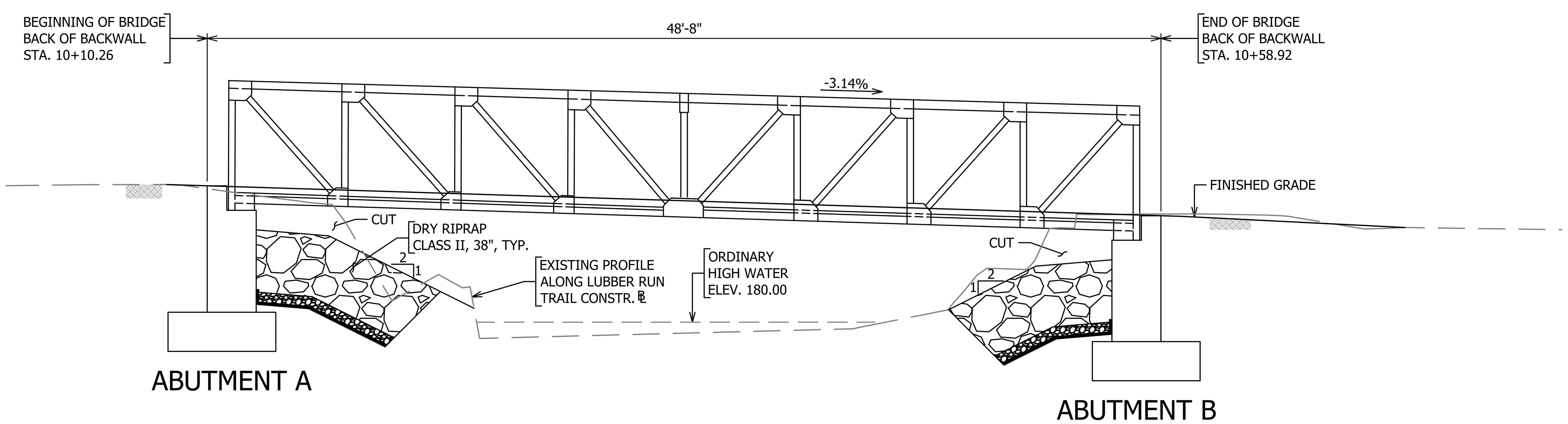
FILENAME: XXXX-BRIDGE.DWG PATH: T:\1009400 - MASTER-ARLINGTON COUNTY ON-CALL\1009467 - LUBBER RUN PEDESTRIAN BRIDGE 2\07 DESIGN\DWG PLOTTED BY: BRENDA.DUONG



PLAN

= EROSION ZONE

RIPRAP IN THE "EROSION ZONE" SHALL BE DRY RIPRAP CLASS I, 26" AND PLACED IN A MANNER THAT WILL CAUSE MINIMUM DISTURBANCE TO THE STREAM AND VEGETATION. NO EXCAVATION OR TREE ROOT REMOVAL WILL BE PERMITTED WITHIN THE LIMITS OF THE "EROSION ZONE". RIPRAP IN THE "EROSION ZONE" SHALL BE PLACED TO CREATE A SMOOTH TRANSITION TO THE EXISTING BANKS AT THE DIRECTION OF THE COUNTY PROJECT OFFICER.



ELEVATION

GENERAL NOTES

WIDTH: 6'-0" FACE-TO-FACE OF RAILS.

SPAN LAYOUT: 46'-8" STEEL TRUSS SPAN.

CAPACITY: 90 PSF PEDESTRIAN LIVE LOAD AND 4,000 LBS VEHICULAR LIVE LOAD

DRAINAGE AREA: 1.46 SQ. MI.

SPECIFICATIONS:

CONSTRUCTION: VIRGINIA DEPARTMENT OF TRANSPORTATION ROAD AND BRIDGE SPECIFICATIONS, 2020.

DESIGN: AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS, 8TH EDITION, 2017.

LRFD GUIDE SPECIFICATIONS FOR THE DESIGN OF PEDESTRIAN BRIDGES, 2ND EDITION, 2009.

STANDARDS: VIRGINIA DEPARTMENT OF TRANSPORTATION ROAD AND BRIDGE STANDARDS, 2016; INCLUDING ALL CURRENT REVISIONS.

THESE PLANS ARE INCOMPLETE UNLESS ACCOMPANIED BY THE SUPPLEMENTAL SPECIFICATIONS AND SPECIAL PROVISIONS INCLUDED IN THE CONTRACT DOCUMENTS.

SUPERSTRUCTURE FOR PEDESTRIAN BRIDGE SHALL BE DESIGNED, FABRICATED AND SUPPLIED BY THE TRUSS MANUFACTURER. SHOP DRAWINGS SHALL BE SUBMITTED TO THE ENGINEER FOR REVIEW AND APPROVAL. FOR ADDTIONAL NOTES, SEE SHEET B001.2.

CONCRETE IN SUBSTRUCTURE SHALL BE CLASS A3 IN ACCORDANCE WITH SECTION 217 OF THE VDOT ROAD AND BRIDGE SPECIFICATIONS.

PERMEABILITY TESTING DOES NOT APPLY TO THIS PROJECT.

FOOTINGS SHALL BEAR ON FIRM MATERIAL WITH A MINIMUM NOMINAL BEARING RESISTANCE OF 6.8 KSF.

IF GEOTECHNICAL ENGINEER DETERMINES THAT UNDERCUT EXCAVATION IS REQUIRED TO ACHIEVE THE REQUIRED BEARING CAPACITY, THE COST OF UNDERCUT EXCAVATION SHALL BE MEASURED IN CY AND PAID FOR AT THE UNIT COST FOR STRUCTURAL EARTHWORK. THE COST OF FILLING COMPACTED VDOT 21A SHALL BE CONSIDERED INCIDENTAL AND WILL NOT BE MEASURED FOR PAYMENT.

DEFORMED REINFORCING BARS SHALL CONFORM TO ASTM A615, GRADE 60. ALL REINFORCING BAR DIMENSIONS ON THE DETAILED DRAWINGS ARE TO CENTERS OF BARS EXCEPT WHERE OTHERWISE NOTED AND ARE SUBJECT TO FABRICATION AND CONSTRUCTION TOLERANCES.

THE CONTRACTOR SHALL BACKFILL AREAS WITH APPROVED MATERIALS PER THE REQUIREMENTS OF THE VIRGINIA DEPARTMENT OF TRANSPORTATION. THE COST OF BACKFILL IS INCLUDED IN THE COST OF STRUCTURAL EXCAVATION.

PREFABRICATED STEEL TRUSS SHALL BE PAID ON A LUMP SUM BASIS, THE PRICE SHALL INCLUDE DESIGN, FABRICATION, DELIVERY, ERECTION, RUB RAILS, SAFETY RAILS, TOE PLATES, BEARING ASSEMBLIES, AND ANY ASSOCIATED FALSE WORK OR TEMPORARY SUPPORTS.

ALL COST ASSOCIATED WITH SITE ACCESS AND STAGING SHALL BE INCLUDED IN THE LUMP SUM BID PRICE FOR CONSTRUCTION ACCESS AND RESTORATION. THE LUMP SUM PRICE SHALL INCLUDE ALL COSTS FOR STORING EQUIPMENT AND MATERIALS, TEMPORARY GRADING, TEMPORARY WORK BRIDGE, AND RESTORING THE AREA TO ITS ORIGINAL CONDITION AFTER CONSTRUCTION IS COMPLETE.

REMOVE EXISTING ABUTMENTS AND PORTION OF EXISTING WALL AS SHOWN. THIS COST SHALL BE INCLUDED IN THE PRICE BID FOR REMOVE EXISTING STRUCTURES.

TEMPORARY WORK BRIDGE:

THE CONTRACTOR MAY CONSTRUCT A TEMPORARY WORK BRIDGE TO ACCESS EACH SIDE OF STREAM. THE TEMPORARY WORK BRIDGE SHALL BE DESIGNED BY A REGISTERED PROFESSIONAL ENGINEER HOLDING A VALID LICENSE TO PRACTICE ENGINEERING IN THE COMMONWEALTH OF VIRGINIA. WORKING DRAWINGS OF THE WORK BRIDGE SHALL BE SUBMITTED TO THE ENGINEER FOR REVIEW 14 DAYS PRIOR TO INSTALLATION OF THE WORK BRIDGE. THE DRAWINGS SHALL INCLUDE PLAN AND PROFILE VIEW, AND DETAILS OF ALL STRUCTURAL MEMBERS AS DETERMINED BY THE CONTRACTOR AND HIS ENGINEER. THE CONTRACTOR SHALL DETERMINE THE METHODS AND MEANS OF SUPPORT REQUIRED FOR THE LOADS IMPOSED BY CONSTRUCTION EQUIPMENT DURING THE CONSTRUCTION OF THE PROJECT.

THE LOCATION OF THE TEMPORARY WORK BRIDGE SHALL BE WITHIN THE LIMITS OF WORK SHOWN ON THE PLANS. THE CONTRACTOR SHALL USE A MATERIAL AND DESIGN FOR THE TEMPORARY WORK BRIDGE THAT DOES NOT IMPACT THE STREAM. ALL SUPPORTS SHALL BE OUTSIDE OF ORDINARY HIGH WATER. WORK BRIDGE MATERIALS AND SUPPORT STRUCTURES SHALL BE NON-ERODIBLE MATERIAL. EQUIPMENT SHALL NOT BE ALLOWED TO ENTER THE WATER TO CONSTRUCT THE WORK BRIDGE.

THE COST OF THE DESIGN, INSTALLATION, AND REMOVAL OF THE TEMPORARY WORK BRIDGE, WHEN NO LONGER REQUIRED, SHALL BE INCLUDED IN PRICE BID FOR CONSTRUCTION ACCESS AND RESTORATION. THIS PRICE SHALL BE FULL COMPENSATION FOR ALL LABOR, TOOLS, MATERIALS, EQUIPMENT, AND INCIDENTALS REQUIRED FOR THE SATISFACTORY COMPLETION OF THE WORK.

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DEPARTMENT OF ENVIRONMENTAL SERVICES
FACILITIES & ENGINEERING DIVISION
ENGINEERING BUREAU
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SEAL

COMMONWEALTH OF VIRGINIA
BRIAN C. GRAHAM
Lic. No. 053140
07-15-2022
PROFESSIONAL ENGINEER

APPROVALS	DATE
DESIGN TEAM ENGINEER SUPERVISOR	
CONSTRUCTION MANAGEMENT SUPERVISOR	
WATER, SEWER, STREETS BUREAU CHIEF	
TRANSPORTATION DIRECTOR	
PROJECT MANAGER	

REVISIONS	DATE

LUBBER RUN PEDESTRIAN BRIDGE
LUBBER RUN PARK
PEDESTRIAN BRIDGE OVER LUBBER RUN

GENERAL PLAN AND ELEVATION

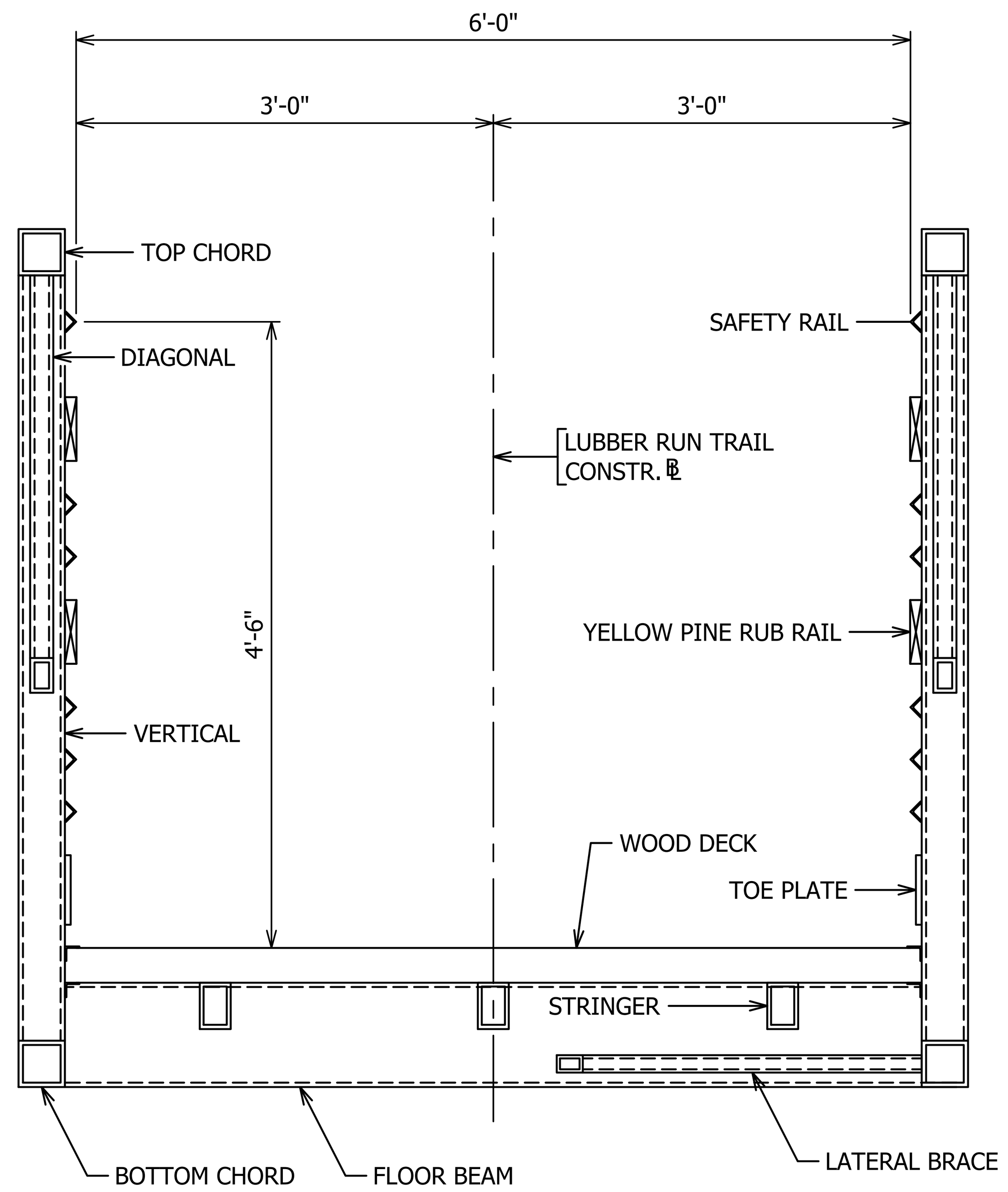
DESIGNED: DJ
DRAWN: DJ
CHECKED: BCG

PLOTTED: JULY 15 2022

SCALE:

$\frac{1}{4}$" = 1'-0"

B001.1



TRANSVERSE SECTION

SCALE: 1" = 1'-0"

NOTES:

THE SUPERSTRUCTURE SHALL BE A STEEL TRUSS BRIDGE AND SHALL BE DESIGNED AND MANUFACTURED BY CONTECH ENGINEERED SOLUTIONS AT WWW.CONTECHES.COM OR EQUIVALENT AS APPROVED BY THE PROJECT OFFICER.

THE TRUSS STRUCTURE SHALL BE A TRUSS (SIMILAR TO THE CONTECH CONNECTOR TRUSS) AND INCLUDE A WOOD DECK CONSISTING OF SOUTHERN YELLOW PINE.

THE TRUSS FABRICATOR SHALL PROVIDE A PLATE ON THE BRIDGE WITH LOAD CAPACITY AND DATE OF MANUFACTURE.

THE CONTRACTOR SHALL COORDINATE WITH THE TRUSS MANUFACTURER FOR BEARING DETAILS AND SHALL PROVIDE BEARING AND ANCHOR BOLT DESIGN FOR THE ENGINEER'S REVIEW AND APPROVAL. ANCHOR BOLTS SHALL BE LOCATED A MINIMUM OF 6" FROM THE EDGE OF THE ABUTMENT SEAT AND HAVE A MINIMUM EMBEDMENT LENGTH OF 2'-0".

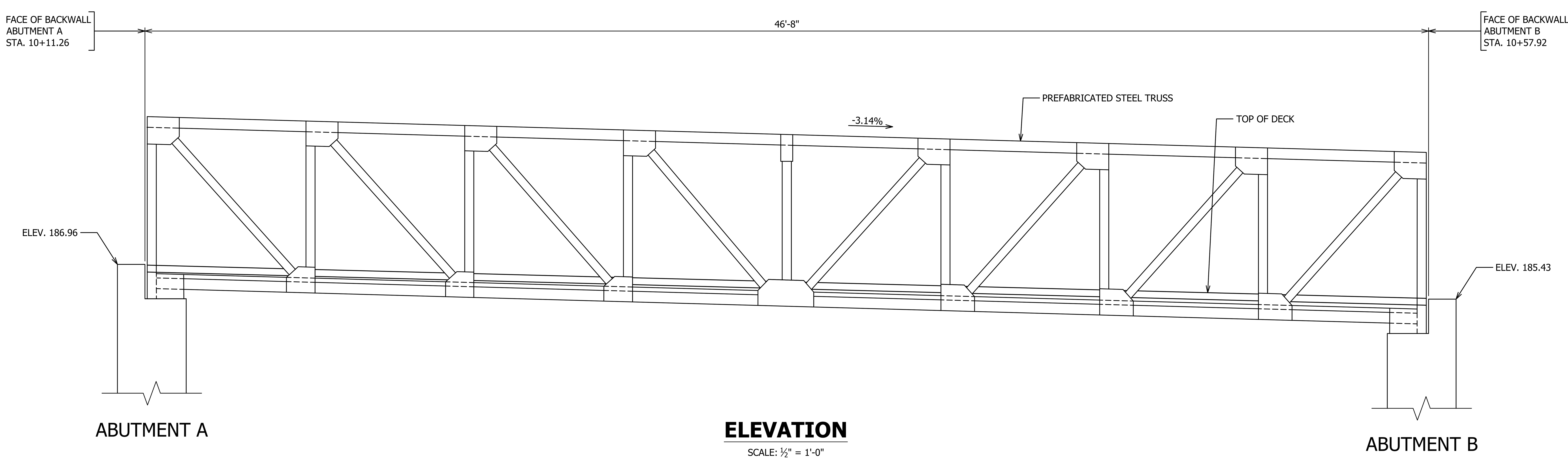
THE STRUCTURE DEPTH, MEASURED FROM TOP OF DECK TO THE LOWEST POINT ON THE STRUCTURE, SHALL BE A MAXIMUM OF 1'-3".

LOWER CHORD MEMBERS SHALL ALLOW FOR FREE DRAINAGE AND BE CONFIGURED AS TO NOT CAPTURE DEBRIS.

THE SUBSTRUCTURE IS DESIGNED AND SIZED FOR A TOTAL SUPERSTRUCTURE WEIGHT OF 13,000 LBS. SHOULD THE WEIGHT BE GREATER THAN THIS VALUE, THE TRUSS MANUFACTURER SHALL BRING IT TO THE ATTENTION OF THE ENGINEER TO RE-EVALUATE THE DESIGN OF THE SUBSTRUCTURE.

ALL PREFABRICATED TRUSS COMPONENTS SHALL BE UNPAINTED WEATHERING STEEL UNLESS NOTED OTHERWISE.

THE STEEL TRUSS AND BEARING ANCHORAGE SHALL BE DESIGNED TO RESIST A STREAM VELOCITY OF 10.7 FT/SEC, ASSUMING THE TRUSS IS OVERTOPPED DURING THE DESIGN STORM EVENT.



ELEVATION

SCALE: ½" = 1'-0"

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SEAL

COMMONWEALTH OF VIRGINIA
BRIAN C. GRAHAM
Lic. No. 037140
07-15-2022
PROFESSIONAL ENGINEER

APPROVALS	DATE
DESIGN TEAM ENGINEER SUPERVISOR	
CONSTRUCTION MANAGEMENT SUPERVISOR	
WATER, SEWER, STREETS BUREAU CHIEF	
TRANSPORTATION DIRECTOR	
PROJECT MANAGER	

REVISIONS	DATE

LUBBER RUN PEDESTRIAN BRIDGE
LUBBER RUN PARK
PEDESTRIAN BRIDGE OVER LUBBER RUN

BRIDGE ELEVATION AND TYPICAL SECTION

DESIGNED: DJ
DRAWN: DJ
CHECKED: BCG

PLOTTED: JULY 15 2022

SCALE:

AS SHOWN

B001.2

APPENDIX G: HECRAS SUMMARY RESULTS

HEC-RAS Summary Results for Existing and Proposed Condition Model

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	1244	2 year	EX_	936	224.00	229.18		229.76	0.01	6.10	153.32	40.62	0.55
Reach_1	1244	2 year	Prop	936	224.00	229.18		229.76	0.01	6.10	153.32	40.62	0.55
Reach_1	1244	10 Year	EX_	1440	224.00	230.39		231.15	0.01	6.99	208.31	57.21	0.58
Reach_1	1244	10 Year	Prop	1440	224.00	230.39		231.15	0.01	6.99	208.31	57.21	0.58
Reach_1	1244	25 Year	EX_	1668	224.00	230.84		231.67	0.01	7.34	237.55	73.60	0.58
Reach_1	1244	25 Year	Prop	1668	224.00	230.84		231.67	0.01	7.34	237.55	73.60	0.58
Reach_1	1244	50 Year	EX_	1880	224.00	231.63		232.36	0.01	6.96	308.50	104.99	0.51
Reach_1	1244	50 Year	Prop	1880	224.00	231.63		232.36	0.01	6.96	308.50	104.99	0.51
Reach_1	1244	100 Year	EX_	2376	224.00	233.22		233.76	0.00	6.26	503.99	133.59	0.41
Reach_1	1244	100 Year	Prop	2376	224.00	233.22		233.76	0.00	6.26	503.99	133.59	0.41
Reach_1	1244	500 Year	EX_	2697	224.00	238.82		238.91	0.00	2.96	1440.57	199.88	0.14
Reach_1	1244	500 Year	Prop	2697	224.00	238.82		238.91	0.00	2.96	1440.57	199.88	0.14
Reach_1	1094	2 year	EX_	936	223.13	227.78	226.52	228.46	0.01	6.61	141.67	38.44	0.61
Reach_1	1094	2 year	Prop	936	223.13	227.78	226.52	228.46	0.01	6.61	141.67	38.44	0.61
Reach_1	1094	10 Year	EX_	1440	223.13	228.89		229.81	0.01	7.69	193.99	59.34	0.64
Reach_1	1094	10 Year	Prop	1440	223.13	228.89		229.81	0.01	7.69	193.99	59.34	0.64
Reach_1	1094	25 Year	EX_	1668	223.13	229.71		230.53	0.01	7.39	250.12	78.51	0.57
Reach_1	1094	25 Year	Prop	1668	223.13	229.71		230.53	0.01	7.39	250.12	78.51	0.57
Reach_1	1094	50 Year	EX_	1880	223.13	231.05		231.61	0.00	6.25	371.50	100.04	0.43
Reach_1	1094	50 Year	Prop	1880	223.13	231.05		231.61	0.00	6.25	371.50	100.04	0.43
Reach_1	1094	100 Year	EX_	2376	223.13	232.89		233.31	0.00	5.63	580.18	128.90	0.34
Reach_1	1094	100 Year	Prop	2376	223.13	232.89		233.31	0.00	5.63	580.18	128.90	0.34
Reach_1	1094	500 Year	EX_	2697	223.13	238.78		238.86	0.00	2.78	1509.46	173.61	0.13
Reach_1	1094	500 Year	Prop	2697	223.13	238.78		238.86	0.00	2.78	1509.46	173.61	0.13
Reach_1	1000	2 year	EX_	933	222.00	225.56	225.56	226.96	0.03	9.50	98.19	34.92	1.00
Reach_1	1000	2 year	Prop	933	222.00	225.56	225.56	226.96	0.03	9.50	98.19	34.92	1.00
Reach_1	1000	10 Year	EX_	1437	222.00	228.08	226.56	228.91	0.01	7.30	197.31	44.87	0.60
Reach_1	1000	10 Year	Prop	1437	222.00	228.08	226.56	228.91	0.01	7.30	197.31	44.87	0.60

HEC-RAS Summary Results for Existing and Proposed Condition Model

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	1000	25 Year	EX_	1664	222.00	229.17	226.95	229.89	0.01	6.78	250.68	53.13	0.51
Reach_1	1000	25 Year	Prop	1664	222.00	229.17	226.95	229.89	0.01	6.78	250.68	53.13	0.51
Reach_1	1000	50 Year	EX_	1876	222.00	230.75	227.32	231.27	0.00	5.84	348.01	71.94	0.38
Reach_1	1000	50 Year	Prop	1876	222.00	230.75	227.32	231.27	0.00	5.84	348.01	71.94	0.38
Reach_1	1000	100 Year	EX_	2369	222.00	232.65	228.06	233.10	0.00	5.57	480.62	100.58	0.33
Reach_1	1000	100 Year	Prop	2369	222.00	232.65	228.06	233.10	0.00	5.57	480.62	100.58	0.33
Reach_1	1000	500 Year	EX_	2691	222.00	238.66	228.51	238.82	0.00	3.46	901.50	183.53	0.16
Reach_1	1000	500 Year	Prop	2691	222.00	238.66	228.51	238.82	0.00	3.46	901.50	183.53	0.16
Reach_1	706			Culvert									
Reach_1	420	2 year	EX_	1089	214.00	218.12	217.23	218.80	0.01	6.60	168.67	56.08	0.63
Reach_1	420	2 year	Prop	1089	214.00	218.12	217.23	218.80	0.01	6.60	168.67	56.08	0.63
Reach_1	420	10 Year	EX_	1728	214.00	219.55	218.15	220.36	0.01	7.27	253.95	70.68	0.58
Reach_1	420	10 Year	Prop	1728	214.00	219.55	218.15	220.36	0.01	7.27	253.95	70.68	0.58
Reach_1	420	25 Year	EX_	2024	214.00	220.31	218.55	221.11	0.01	7.29	304.93	80.81	0.54
Reach_1	420	25 Year	Prop	2024	214.00	220.31	218.55	221.11	0.01	7.29	304.93	80.81	0.54
Reach_1	420	50 Year	EX_	2303	214.00	220.71	218.91	221.59	0.01	7.68	333.21	89.30	0.55
Reach_1	420	50 Year	Prop	2303	214.00	220.71	218.91	221.59	0.01	7.68	333.21	89.30	0.55
Reach_1	420	100 Year	EX_	2914	214.00	224.26	219.61	224.74	0.00	5.80	581.61	216.18	0.33
Reach_1	420	100 Year	Prop	2914	214.00	224.26	219.61	224.74	0.00	5.80	581.61	216.18	0.33
Reach_1	420	500 Year	EX_	4930	214.00	227.42	221.58	228.14	0.00	7.19	802.62	277.07	0.36
Reach_1	420	500 Year	Prop	4930	214.00	227.42	221.58	228.14	0.00	7.19	802.62	277.07	0.36
Reach_1	323	2 year	EX_	1089	212.00	217.32		217.96	0.01	6.45	177.84	56.33	0.55
Reach_1	323	2 year	Prop	1089	212.00	217.32		217.96	0.01	6.45	177.84	56.33	0.55
Reach_1	323	10 Year	EX_	1728	212.00	218.94		219.69	0.01	7.10	287.78	79.65	0.52
Reach_1	323	10 Year	Prop	1728	212.00	218.94		219.69	0.01	7.10	287.78	79.65	0.52
Reach_1	323	25 Year	EX_	2024	212.00	219.83		220.54	0.00	7.02	364.88	94.99	0.48
Reach_1	323	25 Year	Prop	2024	212.00	219.83		220.54	0.00	7.02	364.88	94.99	0.48

HEC-RAS Summary Results for Existing and Proposed Condition Model

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	323	50 Year	EX_	2303	212.00	220.22		221.01	0.00	7.45	403.51	102.88	0.49
Reach_1	323	50 Year	Prop	2303	212.00	220.22		221.01	0.00	7.45	403.51	102.88	0.49
Reach_1	323	100 Year	EX_	2914	212.00	224.20		224.50	0.00	5.03	1032.56	213.97	0.27
Reach_1	323	100 Year	Prop	2914	212.00	224.20		224.50	0.00	5.03	1032.56	213.97	0.27
Reach_1	323	500 Year	EX_	4930	212.00	227.50		227.79	0.00	5.37	1814.71	257.26	0.25
Reach_1	323	500 Year	Prop	4930	212.00	227.50		227.79	0.00	5.37	1814.71	257.26	0.25
Reach_1	198	2 year	EX_	1089	209.18	216.49	214.43	217.10	0.01	6.30	174.13	59.62	0.51
Reach_1	198	2 year	Prop	1089	209.18	216.49	214.43	217.10	0.01	6.30	174.13	59.62	0.51
Reach_1	198	10 Year	EX_	1728	209.18	218.44	215.80	219.01	0.00	6.36	385.73	129.13	0.43
Reach_1	198	10 Year	Prop	1728	209.18	218.44	215.80	219.01	0.00	6.36	385.73	129.13	0.43
Reach_1	198	25 Year	EX_	2024	209.18	219.51	216.31	219.96	0.00	5.94	534.33	147.79	0.37
Reach_1	198	25 Year	Prop	2024	209.18	219.51	216.31	219.96	0.00	5.94	534.33	147.79	0.37
Reach_1	198	50 Year	EX_	2303	209.18	219.90	217.27	220.39	0.00	6.25	593.89	154.32	0.38
Reach_1	198	50 Year	Prop	2303	209.18	219.90	217.27	220.39	0.00	6.25	593.89	154.32	0.38
Reach_1	198	100 Year	EX_	2914	209.18	219.87	218.12	220.67	0.00	7.95	590.02	153.90	0.49
Reach_1	198	100 Year	Prop	2914	209.18	219.87	218.12	220.67	0.00	7.95	590.02	153.90	0.49
Reach_1	198	500 Year	EX_	4930	209.18	221.21	219.00	222.50	0.01	10.53	808.56	172.85	0.60
Reach_1	198	500 Year	Prop	4930	209.18	221.21	219.00	222.50	0.01	10.53	808.56	172.85	0.60
Reach_1	169	Bridge (Lubber Run 1 Pedestrian Bridge)											
Reach_1	147	2 year	EX_	1089	210.35	215.46	214.58	216.31	0.01	7.43	147.48	99.99	0.71
Reach_1	147	2 year	Prop	1089	210.35	215.46	214.58	216.31	0.01	7.43	147.48	99.99	0.71
Reach_1	147	10 Year	EX_	1728	210.35	216.44	216.02	217.50	0.01	8.54	258.87	116.50	0.72
Reach_1	147	10 Year	Prop	1728	210.35	216.44	216.02	217.50	0.01	8.54	258.87	116.50	0.72
Reach_1	147	25 Year	EX_	2024	210.35	216.68	216.41	217.92	0.01	9.30	287.90	123.03	0.77
Reach_1	147	25 Year	Prop	2024	210.35	216.68	216.41	217.92	0.01	9.30	287.90	123.03	0.77
Reach_1	147	50 Year	EX_	2303	210.35	216.97	216.73	218.30	0.01	9.74	324.93	131.94	0.78
Reach_1	147	50 Year	Prop	2303	210.35	216.97	216.73	218.30	0.01	9.74	324.93	131.94	0.78

HEC-RAS Summary Results for Existing and Proposed Condition Model

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	147	100 Year	EX_	2914	210.35	217.54	217.36	219.04	0.01	10.56	405.05	149.50	0.80
Reach_1	147	100 Year	Prop	2914	210.35	217.54	217.36	219.04	0.01	10.56	405.05	149.50	0.80
Reach_1	147	500 Year	EX_	4930	210.35	219.00	219.00	220.91	0.02	12.55	657.19	196.46	0.84
Reach_1	147	500 Year	Prop	4930	210.35	219.00	219.00	220.91	0.02	12.55	657.19	196.46	0.84
Reach_1	-187	2 year	EX_	1089	204.40	208.43	208.43	209.96	0.03	9.91	109.86	36.28	1.00
Reach_1	-187	2 year	Prop	1089	204.40	208.43	208.43	209.96	0.03	9.91	109.86	36.28	1.00
Reach_1	-187	10 Year	EX_	1728	204.40	209.64	209.64	211.53	0.02	11.05	159.55	51.27	0.98
Reach_1	-187	10 Year	Prop	1728	204.40	209.64	209.64	211.53	0.02	11.05	159.55	51.27	0.98
Reach_1	-187	25 Year	EX_	2024	204.40	210.26	210.26	212.12	0.02	11.02	201.24	70.38	0.92
Reach_1	-187	25 Year	Prop	2024	204.40	210.26	210.26	212.12	0.02	11.02	201.24	70.38	0.92
Reach_1	-187	50 Year	EX_	2303	204.40	210.66	210.66	212.60	0.02	11.36	230.53	77.02	0.91
Reach_1	-187	50 Year	Prop	2303	204.40	210.66	210.66	212.60	0.02	11.36	230.53	77.02	0.91
Reach_1	-187	100 Year	EX_	2914	204.40	211.46	211.46	213.55	0.02	11.96	298.34	92.89	0.88
Reach_1	-187	100 Year	Prop	2914	204.40	211.46	211.46	213.55	0.02	11.96	298.34	92.89	0.88
Reach_1	-187	500 Year	EX_	4930	204.40	213.53	213.53	215.88	0.01	13.31	555.13	145.70	0.84
Reach_1	-187	500 Year	Prop	4930	204.40	213.53	213.53	215.88	0.01	13.31	555.13	145.70	0.84
Reach_1	-485	2 year	EX_	1089	198.76	204.49		205.10	0.01	6.28	173.52	40.48	0.53
Reach_1	-485	2 year	Prop	1089	198.76	204.49		205.10	0.01	6.28	173.52	40.48	0.53
Reach_1	-485	10 Year	EX_	1728	198.76	205.38		206.42	0.01	8.23	218.39	60.97	0.64
Reach_1	-485	10 Year	Prop	1728	198.76	205.38		206.42	0.01	8.23	218.39	60.97	0.64
Reach_1	-485	25 Year	EX_	2024	198.76	205.81		207.00	0.01	8.82	247.14	72.04	0.66
Reach_1	-485	25 Year	Prop	2024	198.76	205.81		207.00	0.01	8.82	247.12	72.03	0.66
Reach_1	-485	50 Year	EX_	2303	198.76	205.94	204.89	207.40	0.01	9.78	256.50	74.78	0.73
Reach_1	-485	50 Year	Prop	2303	198.76	205.94	204.89	207.40	0.01	9.78	256.51	74.79	0.73
Reach_1	-485	100 Year	EX_	2914	198.76	206.54	205.95	208.35	0.01	10.98	303.89	82.94	0.79
Reach_1	-485	100 Year	Prop	2914	198.76	206.54	205.95	208.35	0.01	10.98	303.89	82.94	0.79
Reach_1	-485	500 Year	EX_	4930	198.76	208.44	208.22	210.90	0.01	13.16	488.84	111.04	0.83
Reach_1	-485	500 Year	Prop	4930	198.76	208.44	208.22	210.90	0.01	13.16	488.77	111.04	0.83

HEC-RAS Summary Results for Existing and Proposed Condition Model

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	-809	2 year	EX_	1089	196.08	201.19	200.78	202.14	0.01	8.07	179.92	108.03	0.70
Reach_1	-809	2 year	Prop	1089	196.08	201.19	200.78	202.14	0.01	8.07	179.92	108.03	0.70
Reach_1	-809	10 Year	EX_	1728	196.08	202.50		203.36	0.01	8.26	337.30	126.86	0.62
Reach_1	-809	10 Year	Prop	1728	196.08	202.50		203.36	0.01	8.26	337.30	126.86	0.62
Reach_1	-809	25 Year	EX_	2024	196.08	202.84		203.77	0.01	8.76	380.72	129.30	0.64
Reach_1	-809	25 Year	Prop	2024	196.08	202.84		203.77	0.01	8.76	380.82	129.31	0.64
Reach_1	-809	50 Year	EX_	2303	196.08	203.78		204.47	0.01	7.82	505.54	136.08	0.53
Reach_1	-809	50 Year	Prop	2303	196.08	203.78		204.47	0.01	7.83	505.44	136.08	0.53
Reach_1	-809	100 Year	EX_	2914	196.08	205.10		205.68	0.00	7.46	690.99	143.64	0.46
Reach_1	-809	100 Year	Prop	2914	196.08	205.10		205.68	0.00	7.46	690.84	143.64	0.46
Reach_1	-809	500 Year	EX_	4930	196.08	207.43		208.14	0.00	8.63	1040.82	156.99	0.47
Reach_1	-809	500 Year	Prop	4930	196.08	207.43		208.14	0.00	8.63	1040.52	156.98	0.47
Reach_1	-1050	2 year	EX_	1089	190.00	195.79	195.79	197.69	0.03	11.05	98.57	26.00	1.00
Reach_1	-1050	2 year	Prop	1089	190.00	195.79	195.79	197.69	0.03	11.05	98.57	26.00	1.00
Reach_1	-1050	10 Year	EX_	1728	190.00	197.24	197.24	199.68	0.03	12.54	137.83	28.27	1.00
Reach_1	-1050	10 Year	Prop	1728	190.00	197.24	197.24	199.68	0.03	12.54	137.83	28.27	1.00
Reach_1	-1050	25 Year	EX_	2024	190.00	198.54	197.84	200.59	0.02	11.49	179.11	39.00	0.84
Reach_1	-1050	25 Year	Prop	2024	190.00	198.54	197.84	200.59	0.02	11.49	178.99	38.93	0.84
Reach_1	-1050	50 Year	EX_	2303	190.00	202.74		203.41	0.00	6.88	460.58	106.13	0.38
Reach_1	-1050	50 Year	Prop	2303	190.00	202.74		203.41	0.00	6.89	460.43	106.13	0.38
Reach_1	-1050	100 Year	EX_	2914	190.00	204.18		204.83	0.00	7.04	617.73	112.83	0.37
Reach_1	-1050	100 Year	Prop	2914	190.00	204.18		204.83	0.00	7.04	617.54	112.82	0.37
Reach_1	-1050	500 Year	EX_	4930	190.00	205.99		207.09	0.00	9.46	834.51	126.44	0.46
Reach_1	-1050	500 Year	Prop	4930	190.00	205.99		207.09	0.00	9.46	834.01	126.42	0.46
Reach_1	-1312	2 year	EX_	1089	183.70	187.55	187.55	188.84	0.03	9.12	119.39	47.07	1.01
Reach_1	-1312	2 year	Prop	1089	183.70	187.55	187.55	188.84	0.03	9.12	119.39	47.07	1.01
Reach_1	-1312	10 Year	EX_	1728	183.70	192.35		192.68	0.00	4.59	376.19	61.27	0.33

HEC-RAS Summary Results for Existing and Proposed Condition Model

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	-1312	10 Year	Prop	1728	183.70	192.35		192.68	0.00	4.60	375.82	61.25	0.33
Reach_1	-1312	25 Year	EX_	2024	183.70	199.73		199.81	0.00	2.26	1028.03	118.77	0.11
Reach_1	-1312	25 Year	Prop	2024	183.70	199.73		199.81	0.00	2.26	1027.84	118.76	0.11
Reach_1	-1312	50 Year	EX_	2303	183.70	203.08		203.14	0.00	1.96	1454.60	137.01	0.09
Reach_1	-1312	50 Year	Prop	2303	183.70	203.08		203.14	0.00	1.96	1454.44	137.00	0.09
Reach_1	-1312	100 Year	EX_	2914	183.70	204.49		204.56	0.00	2.24	1652.81	144.90	0.09
Reach_1	-1312	100 Year	Prop	2914	183.70	204.49		204.56	0.00	2.24	1652.60	144.90	0.09
Reach_1	-1312	500 Year	EX_	4930	183.70	206.47		206.62	0.00	3.32	1951.87	156.34	0.13
Reach_1	-1312	500 Year	Prop	4930	183.70	206.47		206.62	0.00	3.33	1951.36	156.32	0.13
Reach_1	-1534	2 year	EX_	1089	179.90	186.24	183.92	186.54	0.00	4.39	272.16	82.30	0.37
Reach_1	-1534	2 year	Prop	1089	179.90	186.39	183.92	186.66	0.00	4.23	284.28	82.85	0.35
Reach_1	-1534	10 Year	EX_	1728	179.90	192.39	185.07	192.46	0.00	2.31	1117.57	173.08	0.13
Reach_1	-1534	10 Year	Prop	1728	179.90	192.39	185.07	192.45	0.00	2.31	1116.52	173.03	0.13
Reach_1	-1534	25 Year	EX_	2024	179.90	199.75	185.48	199.77	0.00	1.31	2580.63	222.90	0.05
Reach_1	-1534	25 Year	Prop	2024	179.90	199.75	185.48	199.77	0.00	1.31	2580.28	222.90	0.05
Reach_1	-1534	50 Year	EX_	2303	179.90	203.10	185.79	203.11	0.00	1.19	3364.53	246.67	0.05
Reach_1	-1534	50 Year	Prop	2303	179.90	203.10	185.79	203.11	0.00	1.19	3364.24	246.66	0.05
Reach_1	-1534	100 Year	EX_	2914	179.90	204.51	186.41	204.53	0.00	1.38	3719.77	256.69	0.05
Reach_1	-1534	100 Year	Prop	2914	179.90	204.51	186.41	204.53	0.00	1.38	3719.40	256.68	0.05
Reach_1	-1534	500 Year	EX_	4930	179.90	206.52	188.22	206.56	0.00	2.08	4249.34	270.59	0.07
Reach_1	-1534	500 Year	Prop	4930	179.90	206.52	188.22	206.56	0.00	2.08	4248.46	270.57	0.07
Reach_1	-1561	Lubber Run Pedestrian Bridge											
Reach_1	-1578	2 year	EX_	1089	178.00	183.90	183.90	185.65	0.02	10.67	111.93	56.34	0.94
Reach_1	-1578	2 year	Prop	1089	178.00	183.90	183.90	185.65	0.02	10.67	111.93	56.34	0.94
Reach_1	-1578	10 Year	EX_	1728	178.00	192.35	185.43	192.42	0.00	2.75	1297.14	195.92	0.14
Reach_1	-1578	10 Year	Prop	1728	178.00	192.35	185.43	192.42	0.00	2.75	1297.14	195.92	0.14
Reach_1	-1578	25 Year	EX_	2024	178.00	199.75	185.82	199.76	0.00	1.50	2965.82	260.98	0.06

HEC-RAS Summary Results for Existing and Proposed Condition Model

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	-1578	25 Year	Prop	2024	178.00	199.75	185.82	199.76	0.00	1.50	2965.82	260.98	0.06
Reach_1	-1578	50 Year	EX_	2303	178.00	203.10	186.14	203.11	0.00	1.33	3901.08	296.65	0.05
Reach_1	-1578	50 Year	Prop	2303	178.00	203.10	186.14	203.11	0.00	1.33	3901.08	296.65	0.05
Reach_1	-1578	100 Year	EX_	2914	178.00	204.51	186.70	204.52	0.00	1.54	4329.23	310.55	0.05
Reach_1	-1578	100 Year	Prop	2914	178.00	204.51	186.70	204.52	0.00	1.54	4329.23	310.55	0.05
Reach_1	-1578	500 Year	EX_	4930	178.00	206.51	188.84	206.54	0.00	2.29	4971.38	329.91	0.08
Reach_1	-1578	500 Year	Prop	4930	178.00	206.51	188.84	206.54	0.00	2.29	4971.38	329.91	0.08
Reach_1	-1897	2 year	EX_	1089	174.10	180.22		180.71	0.01	5.98	256.88	105.55	0.48
Reach_1	-1897	2 year	Prop	1089	174.10	180.22		180.71	0.01	5.98	256.88	105.55	0.48
Reach_1	-1897	10 Year	EX_	1728	174.10	192.34		192.36	0.00	1.37	2448.98	212.46	0.06
Reach_1	-1897	10 Year	Prop	1728	174.10	192.34		192.36	0.00	1.37	2448.98	212.46	0.06
Reach_1	-1897	25 Year	EX_	2024	174.10	199.74		199.75	0.00	0.98	4160.37	250.42	0.03
Reach_1	-1897	25 Year	Prop	2024	174.10	199.74		199.75	0.00	0.98	4160.37	250.42	0.03
Reach_1	-1897	50 Year	EX_	2303	174.10	203.09		203.10	0.00	0.93	5024.36	266.21	0.03
Reach_1	-1897	50 Year	Prop	2303	174.10	203.09		203.10	0.00	0.93	5024.36	266.21	0.03
Reach_1	-1897	100 Year	EX_	2914	174.10	204.50		204.51	0.00	1.10	5405.60	275.42	0.04
Reach_1	-1897	100 Year	Prop	2914	174.10	204.50		204.51	0.00	1.10	5405.60	275.42	0.04
Reach_1	-1897	500 Year	EX_	4930	174.10	206.50		206.52	0.00	1.71	5968.29	287.96	0.05
Reach_1	-1897	500 Year	Prop	4930	174.10	206.50		206.52	0.00	1.71	5968.29	287.96	0.05
Reach_1	-2195	2 year	EX_	1089	170.30	180.36		180.40	0.00	1.77	1019.76	165.77	0.11
Reach_1	-2195	2 year	Prop	1089	170.30	180.36		180.40	0.00	1.77	1019.76	165.77	0.11
Reach_1	-2195	10 Year	EX_	1728	170.30	192.34		192.35	0.00	0.94	3328.62	218.05	0.04
Reach_1	-2195	10 Year	Prop	1728	170.30	192.34		192.35	0.00	0.94	3328.62	218.05	0.04
Reach_1	-2195	25 Year	EX_	2024	170.30	199.74		199.75	0.00	0.76	5052.55	248.77	0.03
Reach_1	-2195	25 Year	Prop	2024	170.30	199.74		199.75	0.00	0.76	5052.55	248.77	0.03
Reach_1	-2195	50 Year	EX_	2303	170.30	203.09		203.09	0.00	0.75	5915.37	267.34	0.02
Reach_1	-2195	50 Year	Prop	2303	170.30	203.09		203.09	0.00	0.75	5915.37	267.34	0.02
Reach_1	-2195	100 Year	EX_	2914	170.30	204.50		204.50	0.00	0.91	6299.16	278.26	0.03

HEC-RAS Summary Results for Existing and Proposed Condition Model

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	-2195	100 Year	Prop	2914	170.30	204.50		204.50	0.00	0.91	6299.16	278.26	0.03
Reach_1	-2195	500 Year	EX_	4930	170.30	206.49		206.51	0.00	1.43	6867.92	291.78	0.04
Reach_1	-2195	500 Year	Prop	4930	170.30	206.49		206.51	0.00	1.43	6867.92	291.78	0.04
Reach_1	-2441	2 year	EX_	1089	167.00	180.27	171.52	180.34	0.00	2.17	582.85	81.31	0.12
Reach_1	-2441	2 year	Prop	1089	167.00	180.27	171.52	180.34	0.00	2.17	582.85	81.31	0.12
Reach_1	-2441	10 Year	EX_	1728	167.00	192.31	172.76	192.34	0.00	1.52	1377.38	145.42	0.06
Reach_1	-2441	10 Year	Prop	1728	167.00	192.31	172.76	192.34	0.00	1.52	1377.38	145.42	0.06
Reach_1	-2441	25 Year	EX_	2024	167.00	199.72	173.27	199.74	0.00	1.32	1866.59	187.93	0.04
Reach_1	-2441	25 Year	Prop	2024	167.00	199.72	173.27	199.74	0.00	1.32	1866.59	187.93	0.04
Reach_1	-2441	50 Year	EX_	2303	167.00	203.07	173.70	203.09	0.00	1.21	2832.50	206.72	0.04
Reach_1	-2441	50 Year	Prop	2303	167.00	203.07	173.70	203.09	0.00	1.21	2832.50	206.72	0.04
Reach_1	-2441	100 Year	EX_	2914	167.00	204.47	174.51	204.50	0.00	1.46	3012.76	217.69	0.04
Reach_1	-2441	100 Year	Prop	2914	167.00	204.47	174.51	204.50	0.00	1.46	3012.76	217.69	0.04
Reach_1	-2441	500 Year	EX_	4930	167.00	206.46	176.90	206.50	0.00	2.02	4596.31	230.03	0.06
Reach_1	-2441	500 Year	Prop	4930	167.00	206.46	176.90	206.50	0.00	2.02	4596.31	230.03	0.06
Reach_1	-2645			Culvert									
Reach_1	-2871	2 year	EX_	1089	158.69	161.93	160.96	162.40	0.01	5.48	198.93	68.10	0.56
Reach_1	-2871	2 year	Prop	1089	158.69	161.93	160.96	162.40	0.01	5.48	198.93	68.10	0.56
Reach_1	-2871	10 Year	EX_	1728	158.69	162.22	161.72	163.19	0.02	7.93	218.29	68.92	0.78
Reach_1	-2871	10 Year	Prop	1728	158.69	162.22	161.72	163.19	0.02	7.93	218.29	68.92	0.78
Reach_1	-2871	25 Year	EX_	2024	158.69	162.94	162.03	163.83	0.01	7.58	269.06	71.33	0.67
Reach_1	-2871	25 Year	Prop	2024	158.69	162.94	162.03	163.83	0.01	7.58	269.06	71.33	0.67
Reach_1	-2871	50 Year	EX_	2303	158.69	163.54	162.30	164.41	0.01	7.48	312.39	73.18	0.62
Reach_1	-2871	50 Year	Prop	2303	158.69	163.54	162.30	164.41	0.01	7.48	312.39	73.18	0.62
Reach_1	-2871	100 Year	EX_	2914	158.69	164.65	162.87	165.54	0.01	7.58	395.15	83.76	0.56
Reach_1	-2871	100 Year	Prop	2914	158.69	164.65	162.87	165.54	0.01	7.58	395.15	83.76	0.56
Reach_1	-2871	500 Year	EX_	4930	158.69	171.19	164.51	171.71	0.00	5.84	887.18	140.99	0.29

HEC-RAS Summary Results for Existing and Proposed Condition Model

Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach_1	-2871	500 Year	Prop	4930	158.69	171.19	164.51	171.71	0.00	5.84	887.18	140.99	0.29
Reach_1	-3182	2 year	EX_	1089	152.78	157.56	156.80	157.90	0.03	4.67	233.17	119.35	0.59
Reach_1	-3182	2 year	Prop	1089	152.78	157.56	156.80	157.90	0.03	4.67	233.17	119.35	0.59
Reach_1	-3182	10 Year	EX_	1728	152.78	160.80	157.45	160.90	0.00	2.57	672.88	146.31	0.21
Reach_1	-3182	10 Year	Prop	1728	152.78	160.80	157.45	160.90	0.00	2.57	672.88	146.31	0.21
Reach_1	-3182	25 Year	EX_	2024	152.78	162.00	157.69	162.09	0.00	2.36	858.64	164.79	0.18
Reach_1	-3182	25 Year	Prop	2024	152.78	162.00	157.69	162.09	0.00	2.36	858.64	164.79	0.18
Reach_1	-3182	50 Year	EX_	2303	152.78	162.80	157.91	162.88	0.00	2.32	994.08	173.30	0.17
Reach_1	-3182	50 Year	Prop	2303	152.78	162.80	157.91	162.88	0.00	2.32	994.08	173.30	0.17
Reach_1	-3182	100 Year	EX_	2914	152.78	164.10	158.28	164.19	0.00	2.38	1226.70	185.19	0.16
Reach_1	-3182	100 Year	Prop	2914	152.78	164.10	158.28	164.19	0.00	2.38	1226.70	185.19	0.16
Reach_1	-3182	500 Year	EX_	4930	152.78	171.20	159.34	171.25	0.00	1.88	2709.59	227.35	0.09
Reach_1	-3182	500 Year	Prop	4930	152.78	171.20	159.34	171.25	0.00	1.88	2709.59	227.35	0.09

APPENDIX H: SCOUR ANALYSIS

SOIL LABORATORY TEST RESULTS

Selected soil samples obtained from the field investigation were tested for grain size distribution, Atterberg limits, and natural moisture contents. A summary of soil laboratory test results is presented below in the table, and the results of natural moisture content tests are presented on the test boring logs at the end of this report.

Test Boring/ Test Pit No.	Depth (ft)	Sample Type	Stratum	Description of Soil Specimen	Sieve Results		Atterberg Limits			Natural Moisture Content (%)
					Percent Retained #4 Sieve	Percent Passing #200 Sieve	LL	PL	PI	
20BH001	4-6	Split-Spoon	Alluvium	SILTY SAND (SM)	0	21.9	NP	NP	NP	4.2
20BH001	6-8	Split-Spoon	Residual	SILTY SAND (SM)	14.2	25.7	NP	NP	NP	7.8
20BH002	5-10	Bulk	Residual	POORLY GRADED SAND WITH SILT (SP-SM)	0.9	6.8	NP	NP	NP	11.0

Notes:

1. Soil tests are in accordance with applicable ASTM standards
2. Soil classification symbols are in accordance with Unified Soil Classification System
3. Visual identification of samples is in accordance with ASTM D2488
4. Key to abbreviations: LL = liquid limit; PL = plastic limit; PI = plasticity index ; NP= Non-Plastic

Grain Size (D_{50} and D_{90}) Test Results

Selected soil samples obtained from the field investigation were tested for grain size distribution. The interpretation of D_{50} and D_{90} was performed by us and summary of the results are presented in the table below. Scour analysis is to be completed by client. Scour depths are not provided to at the time of writing this report.

Test Boring/Test Pit No.	Approximate Depth (feet)	Approximate Elevation (feet)	D50 (mm)	D90 (mm)	USCS Group Name
22BH001	4-6	181	0.18	0.69	SILTY SAND (SM)
22BH001	6-8	179	0.20	1.2	SILTY SAND (SM)

Test Boring/Test Pit No.	Approximate Depth (feet)	Approximate Elevation (feet)	D50 (mm)	D90 (mm)	USCS Group Name
21BH002	5-10	182	0.41	9.5	POORLY GRADED SAND WITH SILT (SP-SM)

EARTHWORK

Earthwork is anticipated to include excavations and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavement.

Site Preparation

Unsuitable existing fill, soft or loose natural soils, organic material, and rubble should be stripped to approved subgrades as determined by the geotechnical engineer. Topsoil was not encountered in the soil test borings drilled at the site. However, topsoil may be encountered in the location off the existing trail, topsoil depths may vary widely across the site, particularly in previously cultivated areas. Stripping depths will probably extend to greater depths than the topsoil depths indicated herein due to the presence of minor amounts of organics, roots, and other surficial materials that will require removal as a part of the stripping operations.

The final subgrade should be observed by Geotechnical Engineer or by his or her representative to confirm that the subgrade appears to be stable. Since a proofroll cannot be performed, we recommend that a dynamic cone penetrometer (DCP) or geoprobe should be used to evaluate the subgrade. If unsuitable or soft soils are encountered at the proposed subgrade level, we recommend that the subgrade be undercut to a depth of 2 feet and the resulting excavation be filled with compacted VDOT 21A.

Existing Fill

As noted in **Geotechnical Characterization**, boring 22BH001 and sample location 22BH002 encountered existing fill to depths of about two to four feet. The fill appears to have been placed in a controlled manner, but we have no records to indicate the degree of control. Support of footings, floor slabs, and pavements, on or above existing fill soils, is discussed in this report. However, even with the recommended construction procedures, there is inherent risk for the owner that compressible fill or unsuitable material, within or buried by the fill will, not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing

Determination of Scour Type

HEC-RAS Output- Proposed Bridge Condition									
River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Hydr Depth C	Vel Chnl	Flow Area	Top Width	Froude # Chl
		(cfs)	(ft)	(ft)	(ft)	(ft/s)	(sq ft)	(ft)	
Section Upstream									
-1050	100-Yr	2914	190	204.18	11.42	7.04	347.27	30.41	0.37
-1050	500-Yr	4930	190	205.99	13.23	9.46	402.25	30.41	0.52
Section at Bridge Opening									
-1558 BR U	100-Yr	2914	179.9	204.51	22.49	1.22	810.97	36.06	0.03
-1558 BR U	500-Yr	4930	179.9	206.52	24.50	1.81	883.46	36.06	0.04

Abutment Scour Condition Check - NCHRP 24-20							
Storm Event	K_u	Depth y	Particle Size D	Critical Velocity (Vc)	Channel Velocity (V)	Scour Condition Check	
	(constant)	(ft)	(ft)	(ft/s)	(ft/s)		
100-yr	11.17	11.42	0.000623	1.43	7.04	Vc < V	Live Bed
500-yr	11.17	13.23	0.000623	1.47	9.46	Vc < V	Live Bed
D50 of Material = 0.26 mm				If Vc > V, clear water contraction scour condition			
D50 of Material = 0.000853 ft				If Vc < V, live bed contraction scour condition			

Equation 6.1

$$Vc = K_u Y^{1/6} D^{1/3}$$

V_c = Critical velocity aove which bed material of size D and smaller will be transported, ft/s

y = Average depth of flow upstream of the bridge, ft

D = Particle Size for Vc, ft

D50 = Particle size in a mixture of which 50 percent are smaller, ft

K_u = 6.19 Si units

K_u = 11.17 english unit

Abutment Scour Analysis Based on NCHRP 24-20 from Hydraulic Engineering Circular No. 18, Evaluating Scour at Bridges Fifth Edition.

8.6.3 NCHRP 24-20 Abutment Scour Approach

NCHRP (2010b) developed abutment scour equations considering a range of abutment types, abutment locations, flow conditions, and sediment transport conditions. These equations use contraction scour as the starting calculation for abutment scour and apply a factor to account for large-scale turbulence that develops in the vicinity of the abutment. One important distinction regarding the contraction scour calculation is that the abutment creates a non-uniform flow distribution in the contracted section. The flow is more concentrated in the vicinity of the abutment and the contraction scour component is greater than for average conditions in the constricted opening. The three scour conditions illustrated in Figure 8.7 are (a) scour occurring when the abutment is in or close to the main channel, (b) scour occurring when the abutment is set back from the main channel, and (c) scour occurring when the embankment breaches and the abutment foundation acts as a pier. As illustrated in Figure 8.8, the NCHRP study also concluded that there is a limiting depth of abutment scour when the geotechnical stability of the embankment or channel bank is reached. The abutment scour computed from the NCHRP approach is total scour at the abutment; it is not added to contraction scour because it already includes contraction scour. The advantages of using the NCHRP abutment scour equations include (1) not using the effective embankment length, L', which is difficult to determine in many situations, (2) the equations are more physically representative of the abutment scour process, and (3) the equations predict total scour at the abutment rather than the abutment scour component that is then added to contraction scour. The scour equations for conditions (a) and (b) are:

$$y_{max} = \alpha_A\, y_c \quad \text{or} \quad y_{max} = \alpha_B\, y_c \tag{8.3}$$

$$y_s = y_{max} - y_0 \tag{8.4}$$

where:

y_{max}	=	Maximum flow depth resulting from abutment scour, ft (m)
y_c	=	Flow depth including live-bed or clear-water contraction scour, ft (m)
α_A	=	Amplification factor for live-bed conditions
α_B	=	Amplification factor for clear-water conditions
y_s	=	Abutment scour depth, ft (m)
y_0	=	Flow depth prior to scour, ft (m)

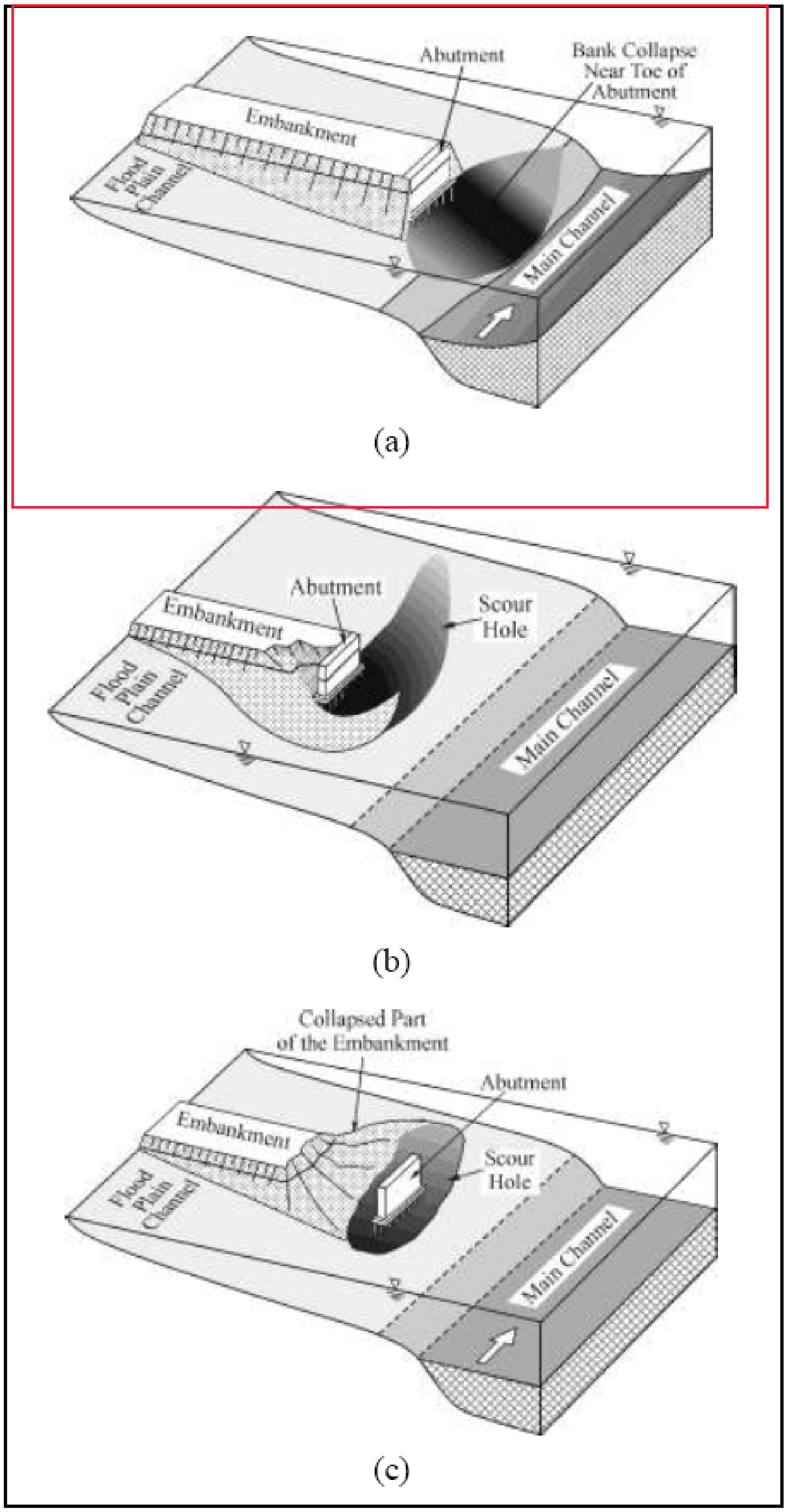

Figure 8.7. Abutment scour conditions (NCHRP 2010b).

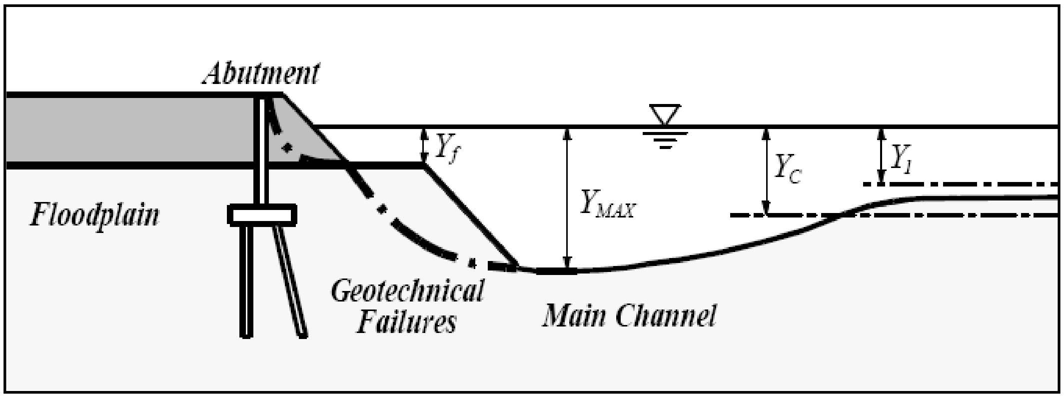

Figure 8.8. Conceptual geotechnical failures resulting from abutment scour (NCHRP 2010b).

Based on the NCHRP (2010b) study, if the projected length of the embankment, L, is 75 percent or greater than the width of the floodplain (B_f), scour condition (a) in Figure 8.7 occurs and the contraction scour calculation is performed using a live-bed scour calculation. The contraction scour equation is a simplified version of the live-bed contraction scour equation (see Chapter 6). The equation combines the discharge and width ratios due to the similarity of the exponents because other uncertainties are more significant. By combining the discharge and width, the live-bed contraction scour equation simplifies to the ratio of two unit discharges. Unit discharge (q) can be estimated either by discharge divided by width or by the product of velocity and depth. The contraction scour equation is:

$$y_c = y_1\left(\frac{q_{2c}}{q_1}\right)^{6/7} \tag{8.5}$$

where:

y_c	=	Flow depth including live-bed contraction scour, ft (m)
y_1	=	Upstream flow depth, ft (m)
q_1	=	Upstream unit discharge, ft^2/s (m^2/s)
q_{2c}	=	Unit discharge in the constricted opening accounting for non-uniform flow distribution, ft^2/s (m^2/s)

The value of q_{2c} can be estimated as the total discharge in the bridge opening divided by the width of the bridge opening. The value of y_c is then used in Equation 8.3 to compute the total flow depth at the abutment. The value of α_A is selected from Figure 8.9 for spill through abutments and Figure 8.10 for wingwall abutments. The solid curves should be used for design. The dashed curves represent theoretical conditions that have yet to be proven experimentally. For low values of q_2/q_1, contraction scour is small, but the amplification factor is large because flow separation and turbulence dominate the abutment scour process. For large values of q_2/q_1, contraction scour dominates the abutment scour process and the amplification factor is small.

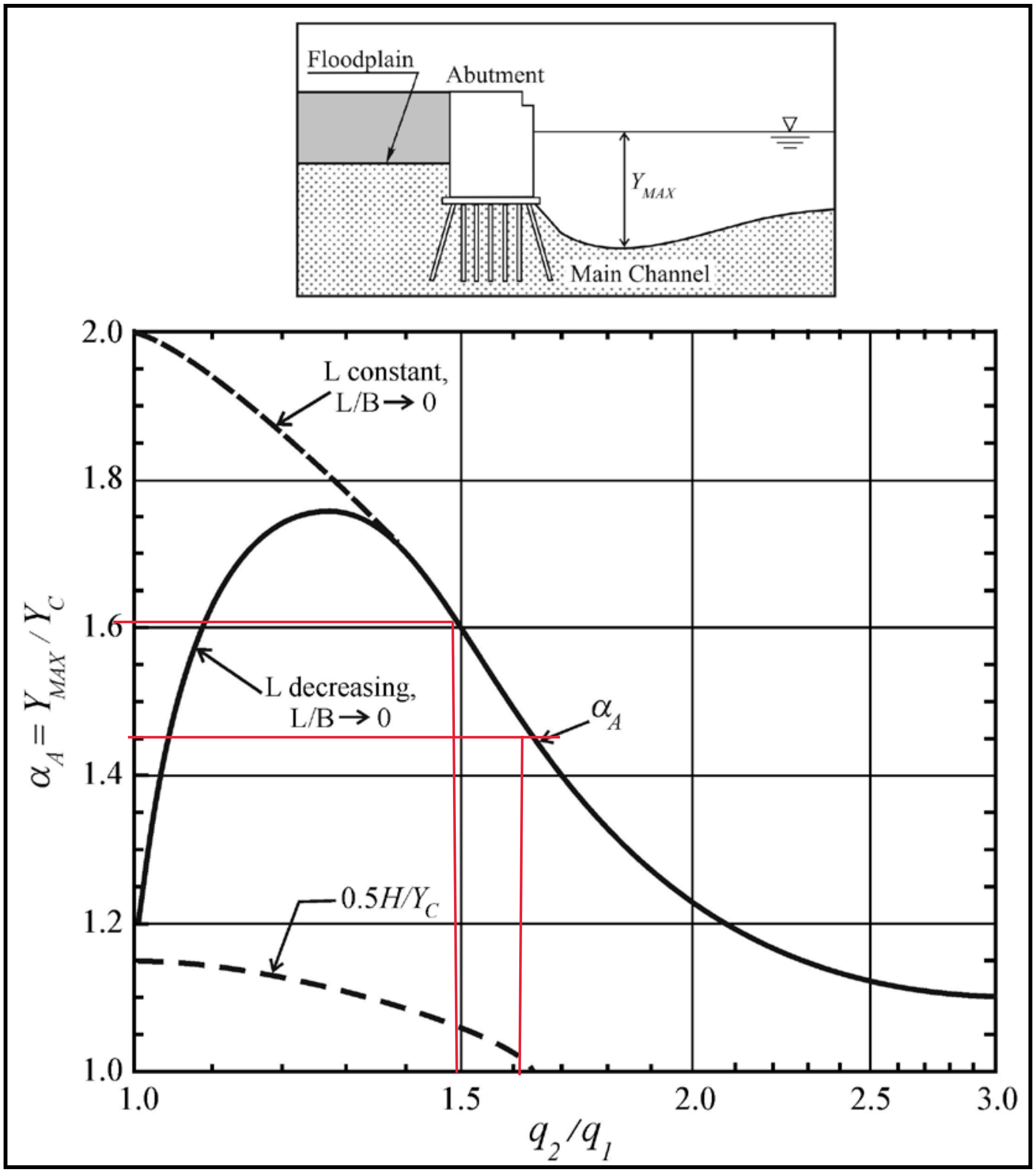

Figure 8.10. Scour amplification factor for wingwall abutments and live-bed conditions (NCHRP 2010b).

If the projected length of the embankment, L, is less than 75 percent of the width of the floodplain (B_f), scour condition (b) in Figure 8.7 occurs and the contraction scour calculation is performed using a clear-water scour calculation (see Chapter 6). The clear-water contraction scour equation also uses unit discharge (q), which can be estimated either by discharge divided by width or by the product of velocity and depth. Two clear-water contraction scour equations may be applied. The first equation is the standard equation based on grain size:

$$y_c = \left(\frac{q_{2f}}{K_u D_{50}^{1/3}} \right)^{6/7} \tag{8.6}$$

Abutment Scour - NCHRP 24-20													
Rainfall Event	UpStream (XS - 1050)				At Bridge Opening (XS- 1558 BR U)								
	Channel Velocity, V1	Y_1 Depth	W1	q_1 =Y1V1	Q Total (cfs)	BR opening width (ft)	q_{2c}	q_{2c}/q_1	y_c	α_A	y_{max}	y_0	y_s
100-yr	7.04	11.42	30.41	80.40	2914	24.34	119.72	1.49	16.06	1.61	25.86	22.49	3.37
500-yr	9.46	13.23	30.41	125.16	4930	24.34	202.55	1.62	19.99	1.45	28.98	24.50	4.48

Equation 8.5	Yc = Flow depth including live-bed contraction scour, ft
$Y_c = Y_1 (q_{2C}/q_1)^{6/7}$	Y1 = Upstream flow depth, ft q1 = upstream unit discharge, ft2/s q2c = Unit discharge in the constricted opening accounting for non-uniform flow distribution, ft2/s
Equation 8.3	Ymax = maximum flow depth resulting from abutment scour, ft
$Y_{max} = \alpha_A Y_c$	Yc = Flow depth including live-bed or clear-water contraction scour, ft αA = Amplification facto for live-bed conditions
Equation 8.4	Ys = Abutment scour depth, ft
$Y_s = Y_{max} - Y_0$	Y0 = Flow depth prior to scour, ft

W = Bottom/top width of the channel

Rainfall Event	Water Surface Elevation	Scour Hole Elevation		Bed Rock Elevation	Countermeasure proposed
100-yr	204.51	178.65		N/A	The proposed footing Elevation will be at or close to the bedrock elevation
500-yr	206.52	177.54		N/A	