PRELIMINARY HYDRAULIC ANALYSIS REPORT

December 2022
Revised: August 2024

WAUGAN ROAD OVER WILSON STREAM

FEDERAL PROJECT NUMBER
WIN 026234.00

Town of Monmouth
Kennebec County
Maine

PREPARED FOR
Maine Department of Transportation
16 State House Station
Augusta, ME 04333

PREPARED BY
HNTB Corporation
82 Running Hill Road
Suite 201
South Portland, ME 04106
Phone: (207) 774-5155

Contact: Steven C. Flormann, PE, CFM
Phone: (973) 434-3239

HNTB

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Appendices

1.0 Background Information

The following is a preliminary hydraulic analysis report for Bridge No. 0487, Waugan Road over Wilson Stream. The bridge is located in the Town of Monmouth, in Kennebec County, Maine, carries two-lanes of Waugon Road over Wilson Stream.

Bridge No. 0487, originally built in 1980, consists of a single span, steel girder superstructure with corrugated steel decking and an asphalt wearing surface. The bridge is approximately 39 feet long and is founded on stone abutments. At the crossing, the roadway carries a single travel lane of two-way traffic along Waugon Road. The bridge has an out-to-out width of 16 feet.

According to the 2024 inspection report, the superstructure is in poor condition. Recent site visits have noted that the bottom of the beams are approximately 1-foot above normal water surface elevations, with the bridge occasionally overtopping.

The proposed construction alternative is to replace the existing bridge with a single span superstructure. The proposed bridge will have a longer span than the existing bridge, with a proposed clear span of 61 feet. The existing stone abutments will be cut down beneath the streambed and the channel within the bridge will be regraded and lined with riprap. The proposed alternative will widen the bridge to allow for continuous two-way traffic. The proposed bridge has an out-to-out width of 32 feet. The proposed roadway profile will be raised to provide one foot of additional hydraulic clearance, compared to the existing condition.

1.1. Existing Data Review

- Site Photographs are provided in PDR Appendix B.
- There is no USGS stream gage located within the vicinity of the project site.
- FEMA data is not available for the bridge.
- Wilson Stream peak flows were calculated utilizing SIR 2015-4059 by MaineDOT. These values were used in the analysis and can be found in Table 1.

2.0 Hydrology

At Bridge No. 0487, Wilson Stream has a watershed area of 31.7 square miles, as calculated by the USGS StreamStats program. The watershed is bounded by a series of peaks and ridges within Kennebec County. Aerial photography of the watershed shows that it mostly consists of forests with some farmland. According to the USGS StreamStats website, the watershed contains approximately 16.3 percent storage area (combined waterbodies and wetland areas).

The Wilson Stream begins at the outlet of Wilson Pond in North Monmouth, Maine. The outletting flow is controlled by Wilson Pond Dam. From the dam, the stream flows approximately 3.1 miles southeast, at an average streambed slope of 22.3 feet per mile, before reaching the subject bridge. Between the Wilson Lake Dam and the subject bridge, the Wilson Stream passes underneath five rail/roadway crossings; Wilson Pond Road, New Street, Old Lewiston Road, Route 202 and CSX Railway.

After Wilson Stream passes through Bridge No. 0487, the stream continues to travel east, until discharging into Annabessacook Lake, approximately 0.3 miles downstream.

The FEMA FIS Report for Kennebec County provides water surface elevations of Annabessacook Lake for the 10-, 50-, 100-, and 500-year storm events. The report does not provide peak flow information on Wilson Stream. Bridge No. 0487 is located in a FEMA AE zone. The corresponding FEMA information can be found in Appendix B. Table 2 lists the water surface elevations provided in the FEMA FIS Report for Annabessacook Lake.

The recommended peak flows for the existing and proposed HEC-RAS analysis were provided by MaineDOT. These peak flows were developed using the USGS regression equations in the StreamStats Program. The regression analysis calculates peak flows for small ungaged streams and compares map-based to field-based variables (SIR 20154059 and SIR 20205092). The USGS regression equations use the watershed area and storage capacity as variables for calculating the peak flows. The MaineDOT hydrology calculations can be found in Appendix C. Table 1 lists the peak flows determined by MaineDOT.

Table 1: Peak Discharges at Bridge No. 0487 over Wilson Stream

Drainage Area	31.7 (sq. miles)
Storm Event (Years)	Peak Discharge (cfs)
1.1	375
10	1,255
25	1,560
50	1,810
100	2,050
200	2,305
500	2,660

Table 2: Annabessacook Lake Water Surface Elevations (ft, NAVD88)

Storm Event (Years)	Elevation
1.1	170.6 [1]
10	171.5
25	171.9 [2]
50	172.1
100	172.4
200	172.7 [2]
500	173.0

Note: 1. 1.1-Year elevation was extrapolated using the Log-Log Graph.

2. 25- and 200-Year elevations were interpolated using the Log-Log Graph.

3.0 Hydraulic Analysis

Hydraulic calculations for the project were performed using the U.S. Army Corps of Engineers HEC-RAS 5.0.7 computer program.

To develop a hydraulic model of Wilson Stream, a series of field cross-sections were taken between 990 feet upstream and 430 feet downstream of the existing bridge. Due to the bridge's proximity with Annabessacook Lake, Wilson Stream's floodplain width is controlled by the lake. The model's upstream extent matches the FEMA floodplain width, while the downstream extent was taken at the extents of available LIDAR data. Where available, project specific field survey information was used. Outside of surveyed limits, available LIDAR data from NOAA was used. All elevation data is in the NAVD 1988 vertical datum.

Within the extents of the hydraulic model, Wilson Stream is a meandering watercourse, with shallow pools and wide floodplains. A Manning's Roughness Coefficient of 0.040 was used to represent the channel. Outside of the main channel's banks, a Manning's Roughness Coefficient of 0.060 was used to represent the undeveloped, scattered brush floodplain, and 0.100 was used for undeveloped, wooded areas. Elsewhere, a Manning's Roughness Coefficient of 0.040 was used to represent adjacent, intersecting streams.

Values of 0.1 and 0.3 are used for contraction and expansion dynamic head losses, except at the bridge. At the bridge, where the flow area changes more suddenly, values of 0.3 and 0.5 are used.

All profiles were run utilizing a subcritical flow regime. The hydraulic model uses known water surface elevations, taken from Table 2, as the downstream boundary condition. The hydraulic analysis procedure used by the HEC-RAS program is based on the solution of the one-dimensional energy equation. The head loss in the energy equation is comprised of friction losses (utilizing Manning's equation) and contraction/expansion losses (coefficient multiplied by the change in velocity head).

3.1. Existing Conditions

An existing conditions model was developed for the existing one-span bridge. The existing bridge was modeled to match existing conditions, with a 39-foot clear span and a 16-foot out-to-out width. The bridge has a hydraulic opening of approximately 370 square feet.

HEC-RAS can compute multiple low flow energy equations (Momentum, Yarnell, and Energy) at the bridge and select the highest energy answer for the model's computations. Due to the bridge's proximity to Annabessacook Lake, the model is shown to begin inundating the bridge's low chord during the 1.1-year storm event. Each profile is run using pressure flow calculations. The bridge is shown to begin overtopping the roadway during the 100-year storm event. Therefore, the larger storm events (100-year to 500-year) are calculated using pressure/weir flow equations.

According to the MaineDOT Bridge Design Guide, minor riverine bridges are recommended to provide 2 feet of clearance between the bottom of the superstructure and the computed 50-year water surface elevation (WSEL). Minor riverine bridges should also be able to pass the 100-year event, ideally with one foot of clearance. Based on the Bridge Design Guide, the existing bridge does not provide the necessary clearance during the 50-year storm event, as it's shown to inundate the low chord.

The existing conditions' hydraulic parameter summary can be found in Table 3. Output for all studied storm events, including cross-sections, water surface profiles and profile output tables is located in Appendix D.

3.2. Calibration and Sensitivity

Between the origin point, Wilson Lake, to the project bridge, there are no active stream gages along Wilson Stream. Approximately 0.2 miles upstream, Mudd Mills Stream discharges into Wilson Stream. There is no stage-discharge data or any other relevant information available that could be used to calibrate the flows used for the model. As previously noted, the project peak flows were provided by MaineDOT, developed using the USGS regression equations in the StreamStats Program.

As for the downstream boundary condition, the model utilized computed water surface elevations of Annabessacook Lake listed in the FEMA FIS Report for Kennebec County. There isn't stream gage data located along the lake that could provide an updated downstream boundary condition. In addition, there is no stage-discharge data at the lake's outfall that can be used to calibrate the boundary condition.

Calibrating the model by correlating the top of bank of the waterway with the 1.1-year or 2-year events is not recommended due to the dominance of the downstream lake. As previously noted, the low chord of the existing bridge is approximately 1 foot above the normal water surface of the channel.

3.3. Proposed Conditions

The proposed conditions model replaces the existing bridge with a 61-foot clear span. The existing abutments will be cut down to beneath the streambed. Beneath the bridge, the channel will be regraded and lined with riprap. The proposed bridge activities also include removal of sediment and debris that have aggregated over time. The project will create a uniform channel section by regrading the channel, which will provide a larger bridge opening and uniform banks. Lining of the channel banks will provide a more stable condition and prevent potential degradation. Therefore, a revised manning's roughness coefficient is needed to reflect this change. To accommodate this change, the Manning's Roughness Coefficient was modified to 0.030 within the main channel. The proposed bridge will also widen the existing out-to-out width to 32 feet. Due to the widening, the upstream and downstream bridge face sections were shifted and relabeled to Sections 473 and 420, accordingly. The reach lengths were also adjusted, as necessary.

Compared to existing, the proposed bridge has a higher low chord, at elevation 171.47 feet, and a larger hydraulic opening, approximately 460 square feet. The proposed roadway profile is raised to accommodate the increased hydraulic clearance.

The proposed bridge will not meet the MaineDOT Bridge Design Guide's clearance guidelines. The proposed bridge allows the 10-year storm event to pass but inundates the low chord during the 50-year storm event. Unlike the existing model, the proposed bridge begins overtopping the roadway during the 200-year storm event.

To evaluate the proposed bridge's impact to the Wilson Stream's 100-year floodplain, the computed 100-year proposed WSELs were compared to existing. Upstream of the bridge, the proposed model is shown to reduce 100-year WSELs between 0.12 feet to 0.33 feet at every section. At the approach section, Section 505, the proposed elevation is 0.19 feet lower than existing. At the upstream bridge face section, Section 473, the proposed elevation is 0.33 feet lower than existing. At the downstream bridge face section, Section 420, the proposed model is within 0.04 feet of existing.

The proposed conditions' hydraulic parameters are summarized in Table 3. Output for all studied storm events, including cross-sections, water surface profiles and profile output tables are located in Appendix E.

Table 3: Hydraulic Analysis Summary

Summary of Hydraulic Data	Existing Conditions	Proposed Conditions
Low Chord Elevation (ft NAVD 88)	170.47	171.47
Clear Span (ft)	39	61
Bridge Opening Area (sq. ft)	372	456
Ordinary High-Water Elevation (Q1.1) at US Bridge Face (ft NAVD 88) [1]	170.61	170.59
Q10 Headwater Elevation (ft NAVD 88) [1]	171.64	171.44
Q50 Headwater Elevation (ft NAVD 88) [1]	172.43	172.03
Q100 Headwater Elevation (ft NAVD 88) [1]	172.85	172.52
Q200 Headwater Elevation (ft NAVD 88) [1]	173.17	172.90
Q500 Headwater Elevation (ft NAVD 88) [1]	173.41	173.12
Ordinary High-Water Velocity (Q1.1) at DS Bridge Face (ft/s) [2]	0.89	0.97
Q10 Discharge Velocity (fps) [2]	2.74	2.70
Q50 Discharge Velocity (fps) [2]	3.74	3.48
Q100 Discharge Velocity (fps) [2]	4.13	3.73
Q200 Discharge Velocity (fps) [2]	4.52	3.98
Q500 Discharge Velocity (fps) [2]	5.10	4.37
Q50 Clearance (ft) [3]	-1.96	-0.56
Q100 Clearance (ft) [3]	-2.38	-1.05

Note: 1. Headwater Elevation is taken at Section 460 (Existing Conditions) and Section 473 (Proposed Conditions).

2. Discharge Velocity is taken at Section 425 (Existing Conditions) and Section 420 (Proposed Conditions).

3. Negative Clearances indicate that the low chord of the bridge is submerged.

4.0 Scour Analysis

A scour analysis was performed based on equations from FHWA publication HEC-18 (Fifth Edition). The 100-year and 200-year events were analyzed for scour at the proposed bridge location. According to a 2019 underwater inspection report, the streambed at the bridge is described as a mixture of silt, sand and stones. Based on the report, the D50 of the streambed material was estimated to be approximately 0.063 mm.

In accordance with FHWA's HEC-18 and TechBrief HIF-19-007, abutment scour was calculated only using the NCHRP 24-20 method. The NCHRP method differs from the traditional method by computing total scour directly instead of requiring separate computations for contraction and local abutment scour. In accordance with Section 8 of the HEC-18 manual, the hydraulic parameters required by the NCHRP method were obtained from the project's HEC-RAS model.

The scour analysis was performed on the proposed conditions model. Scour depths for the proposed conditions model is summarized in Table 4. The scour calculations can be found in Appendix E.

Table 4: Scour Depths at Bridge No. 0487

Event	Location	Ground Elevation (ft NAVD88)	NCHRP Total Scour (ft)	Scour Bottom Elevation (ft NAVD88)
200-Year	Left Abutment	160.54	20.21	140.33
	Right Abutment	160.60	20.35	140.25
100-Year	Left Abutment	160.54	18.11	142.43
	Right Abutment	160.60	18.25	142.35

Notes:

1. Left = Northern, Right = Southern
2. The calculations do not account for any proposed scour protection such as riprap. See Section 5.0 Scour Countermeasure Analysis for additional discussion.

5.0 Scour Countermeasure Analysis

As part of the proposed alternative, the channel banks will be lined with riprap, through the bridge and extending through adjacent disturbed areas. The riprap sizing analysis will be performed based on equations from FHWA publication HEC-23 (Third Edition), Design Guideline 4 for Riprap Revetment. Design Guideline 14 for Rock Riprap at Bridge Abutments will be used to confirm riprap sizing. The 100- and 200- year storm events will be used for riprap sizing calculations. Based on the stream velocities in the proposed condition, it is anticipated that plain riprap will provide acceptable channel protection from scour and erosion.

6.0 Summary

The project proposes to replace the existing bridge that carries Waugan Road over Wilson Stream in the Town of Monmouth, Kennebec County with a single span structure. The proposed bridge will continue to be non-compliant with the MaineDOT Bridge Design Guide clearance requirements, as it does not provide the required clearance of 2 feet for the 50-year event. Although the proposed bridge will not have adequate clearance based on the guidelines, the bridge will reduce the risk of overtopping prior to the 200-year storm event Replacing the existing bridge will also reduce upstream water surface elevations for all studied storm events, without adversely impacting the floodplain or increasing flooding risks to adjacent properties. No overtopping was shown during any of the storm events.

APPENDIX A

Project Location Maps

Username: $user$ Date:$date$

Division: $wkgroup$

Filename: $file$

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

WIN

BRIDGE NO. 0487

SIGNATURE

P.E. NUMBER

DATE

PROJ. MANAGER $PROJMANAGER$	BY	DATE
DESIGN-DETAILED	NJP	11/22
CHECKED-REVIEWED	SCF	11/22
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

WAUGAN ROAD OVER
WILSON STREAM

TOWN OF MONMOUTH KENNEBEC COUNTY

LOCATION MAP

SHEET NUMBER

FIG -01

PROJECT LOCATION

2.000 0 2.000 4.000
Scale of Feet

HNTB

Apple Valley Lake
Wilson Pond
Ward Hill
North Monmouth
Lower Narrows Pond
Annabessacook Lake
Big Island
Wilson Stream
Mud Mills Stream
Tannery Brook
Gove
Grove Cem
Monmouth
Monmouth Center Cem
Monmouth Neck Cem
East Monmouth
East Monmouth Cem
Prescott Hill
Prescott Hill Cem
Lovers Island
Grape Island
South Bay
Undine Bay
Pine Island
Warrior Point

TAPPAN FARM RD
FIRE RD P-2
MOUNT PISGAH RD
SOPER RD
CROSS RD
DOVER DR
FR WP-6
PLOSSAY SHORES
OLD LEWISTON RD
N MAIN ST
NEW ST
BLAISDELL RD
ANNABESSACOOK RD
BACK ST
MAIN ST
ACADEMY ST
BLUE RD
NORRIS HILL RD
BERRY RD
FIRE RD N1
ROBINSON DR
WELCH AVE
MAPLE ST
ANNABESSACOOK RD
FIRE RD A-1
HENRY LN
HUBBARD LN
HOLMES RD
HOLMES BROOK LN
FIRE RD E-3C
LINDHOLM LN
RED TOP DR
WAUGAN RD
ALPAKALI DR
NEAL LN
LARRY DR
BLAKE RD
TILLSON RD
FROST DR
LAUNCH DR
CAMP CABOSSEE CIR
HOYT DR
LAKESIDE ESTATES DR
FIRE RD E79
HOWARD DR
CLEARVIEW DR
FIRE RD N

11 100
202
132
135

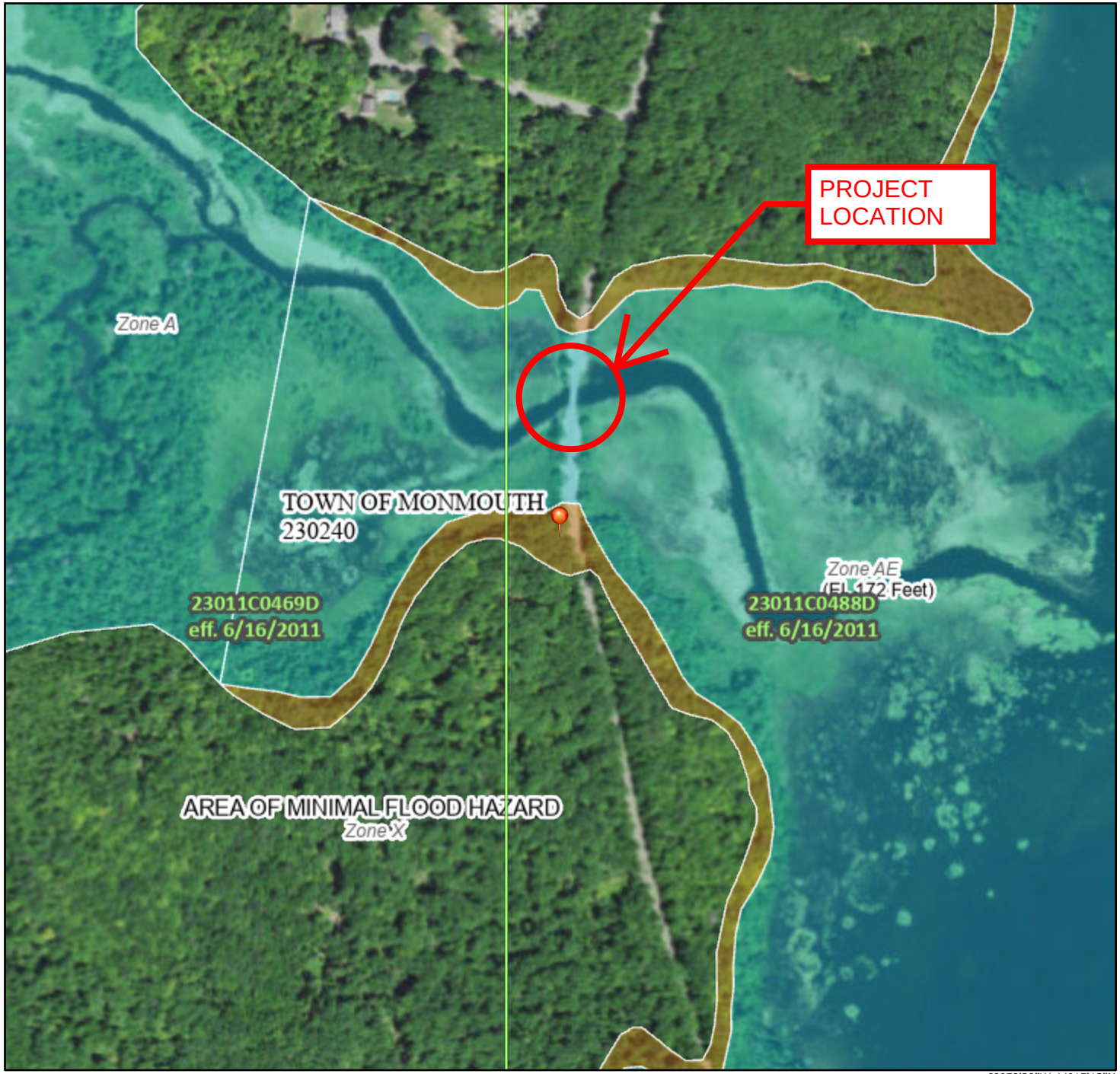
APPENDIX B

Corresponding FEMA Information

National Flood Hazard Layer FIRMette

FEMA

70°0'17"W 44°15'39"N



69°59'39"W 44°15'13"N

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

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 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- 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 11/22/2022 at 4:27 PM 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.

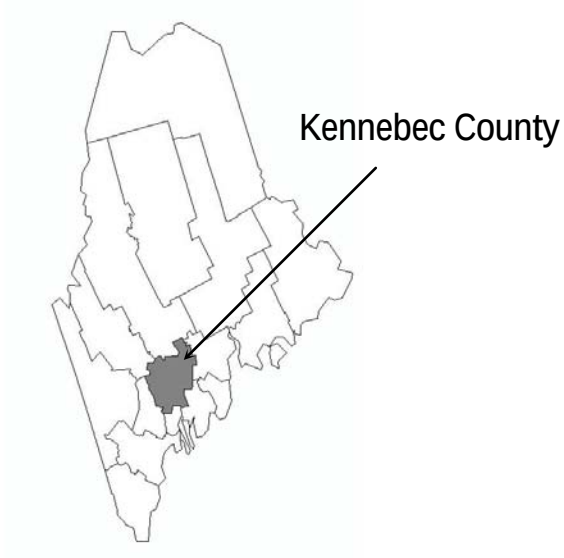
This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory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

FLOOD INSURANCE STUDY

KENNEBEC COUNTY, MAINE
(ALL JURISDICTIONS)

Volume 1 of 2

COMMUNITY NAME	COMMUNITY NUMBER
ALBION, TOWN OF	230231
AUGUSTA, CITY OF	230067
BELGRADE, TOWN OF	230232
BENTON, TOWN OF	230233
CHELSEA, TOWN OF	230234
CHINA, TOWN OF	230235
CLINTON, TOWN OF	230236
FARMINGDALE, TOWN OF	230164
FAYETTE, TOWN OF	230237
GARDINER, CITY OF	230068
HALLOWELL, CITY OF	230069
LITCHFIELD, TOWN OF	230238
MANCHESTER, TOWN OF	230239
MONMOUTH, TOWN OF	230240
MT VERNON, TOWN OF	230241
OAKLAND, TOWN OF	230242
PITTSTON, TOWN OF	230243
RANDOLPH, TOWN OF	230244
READFIELD, TOWN OF	230245
ROME, TOWN OF	230246
SIDNEY, TOWN OF	230247
UNITY, TOWNSHIP OF	230602
VASSALBORO, TOWN OF	230248
VIENNA, TOWN OF	230249
WATERVILLE, CITY OF	230070
WAYNE, TOWN OF	230188
WEST GARDINER, TOWN OF	230250
WINDSOR, TOWN OF	230251
WINSLOW, TOWN OF	230071
WINTHROP, TOWN OF	230072



Effective Date: June 16, 2011

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
23011CV001A

TABLE 6 – SUMMARY OF DISCHARGES (continued)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQUARE MILES)	PEAK DISCHARGES (CUBIC FEET PER SECOND) 10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
WEST BRANCH SHEEPSCOT RIVER - continued					
Approximately 1,490 Feet downstream of highway bridge in Village of Weeks Mills	18.6	*	*	1,650	*

*Data not computed

A summary of peak elevation-frequency relationships is shown in Table 7 “Summary of Stillwater Elevations”.

TABLE 7 – SUMMARY OF STILLWATER ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (FEET NAVD) 10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
ANDROSCOGGIN LAKE				
Entire shoreline within the Town of Wayne	*	*	285.8	*
ANNABESSACOOK LAKE				
Entire shoreline within the Town of Monmouth	171.5	172.1	172.4	173
Town of Winthrop	171.5	172.1	172.4	173
BELGRADE STREAM				
Above Wings Mills Dam in the Town of Mount Vernon	*	*	241.2	*
Below Wings Mills Dam in the Town of Mount Vernon	*	*	237.1	*

*Data not computed

APPENDIX C

MaineDOT Hydrology Report

WIN:	26234.00	**Project Name:**	
Town:	Monmouth	**Stream Name:**	Wilson Stream
Route No.	Waugan Rd	**Bridge Name:**	Waggon
Asset ID:	0487	**Analysis by:**	csh
Lat:	44.25800 **Long:** -69.99940	**Date:**	9/8/2022

Peak Flow Calculations by USGS Regression Equations (Lombard/Hodgkins, 2021; Hodgkins, 1999 & Lombard/Hodgkins, 2015)

Enter data in blue cells only!

ver. 2021 Jan 01

	km²	mi²	ac	*Enter data in [mi²]*
A	82.10	31.70	20288.0	Watershed Area *DRNAREA*
W	12.79	4.9	3160.9	Wetlands area (by NWI)

P_c	417984	4904185	watershed centroid (E, N; UTM 19N; meters)
County	Kennebec		*choose county from drop-down menu*

Worksheet prepared by:
Charles S. Hebson, PE
Environmental Office
Maine Dept. Transportation
Augusta, ME 04333-0016
207-557-1052
Charles.Hebson@maine.gov

Watershed Characteristics from StreamStats

STORAGE	16.33	
STORNWI	15.58	NWI Wetlands %
SANDGRAVF	0.026	sand & gravel aquifer as decimal fraction of watershed A
ELEV	340	mean basin elevation (ft)
BSLDEM10M	7.67	mean basin slope (%)
COASTDIST	66.00	distance from the coast (mi)
ELEVMAX	812	maximum basin elevation (ft)
LC06WATER	6.66	percent of drainage basin land cover as open water
PRECIP	44.3	mean annual precipitation
STATSGOA	2	mean basin percentage of hydrological soil group A

References:

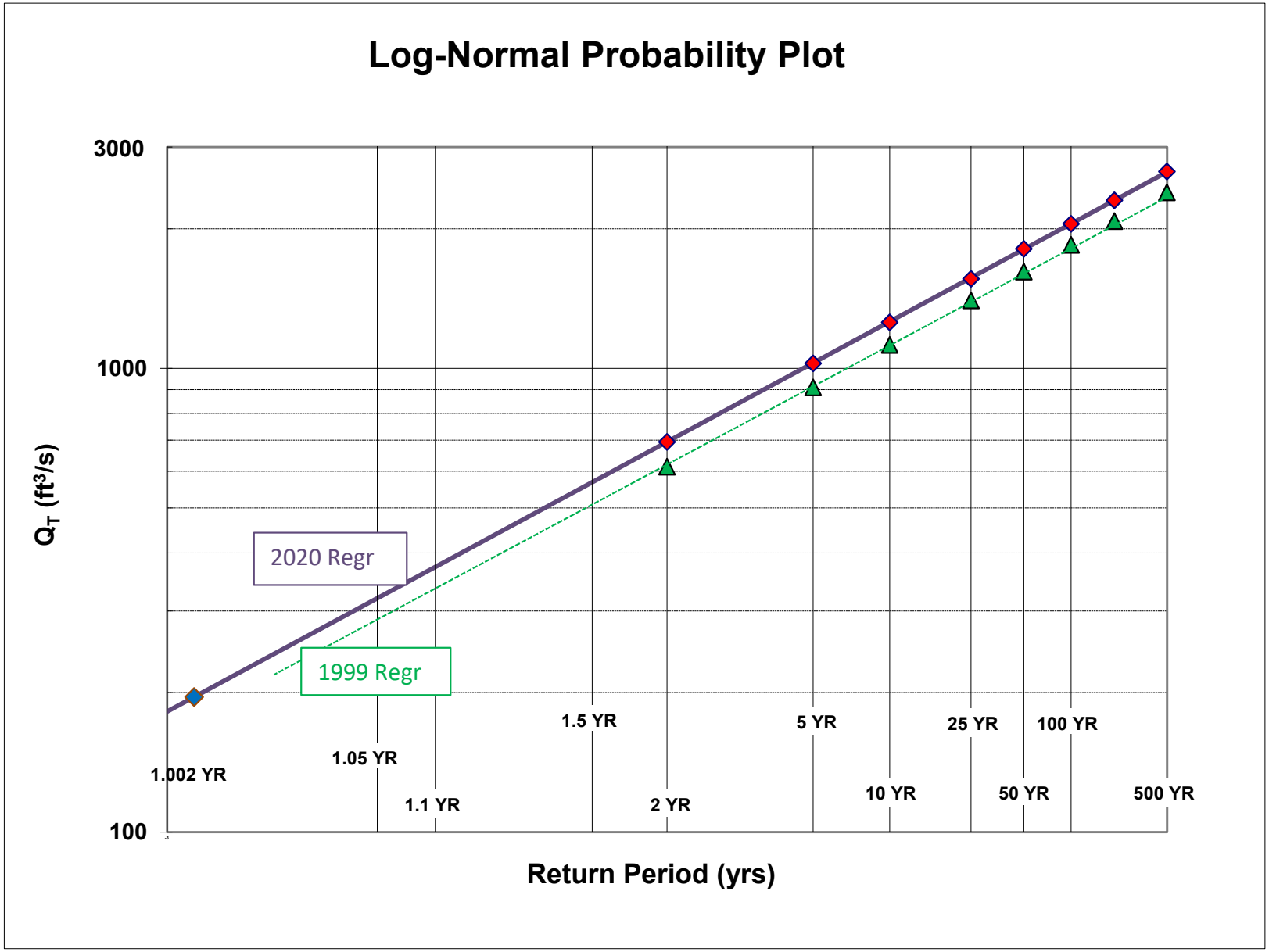
Hodgkins, G.A., 1999.
Estimating the magnitude of peak flows for streams in Maine for Selected Recurrence Intervals
WRIR 99-4008, USGS Augusta, ME

Lombard, P.J. & G.A. Hodgkins, 2015.
Peak flow regression equations for small, ungaged streams: in Maine: Comparing Map-Based to Field-Based Variables
SIR 2015-4059, USGS, Augusta, ME

Lombard, P.J. & G.A. Hodgkins, 2020.
Estimating Flood Magnitude and Frequency on Gaged and Ungaged Streams in Maine
SIR 2020-5092, USGS, Augusta, ME.

Ret Pd T (yr)	I24	Q_T (ft³/s) *1999 / 2015*	Q_T (ft³/s) *2020*	Q_T (ft³/s) *Design*
1.1			373	***375***
2	2.98	614	694	***695***
5	3.75	910	1024	***1025***
10	4.39	1123	1256	***1255***
25	5.27	1402	1560	***1560***
50	5.93	1616	1810	***1810***
100	6.63	1846	2050	***2050***
200	7.43	2077	2303	***2305***
500	8.68	2396	2658	***2660***

Instructions:
Enter values in blue cells only, watershed data from StreamStats
Copy I24 values from Stream Stats
Use results under "Design"
Check against gage data and FEMA studies if available
Questions? Check with ENV / Hydrology Section


Log-Normal Probability Plot
3000
1000
100
Q_T (ft^3/s)
2020 Regr
1999 Regr
1.002 YR
1.05 YR
1.1 YR
1.5 YR
2 YR
5 YR
10 YR
25 YR
50 YR
100 YR
500 YR
Return Period (yrs)

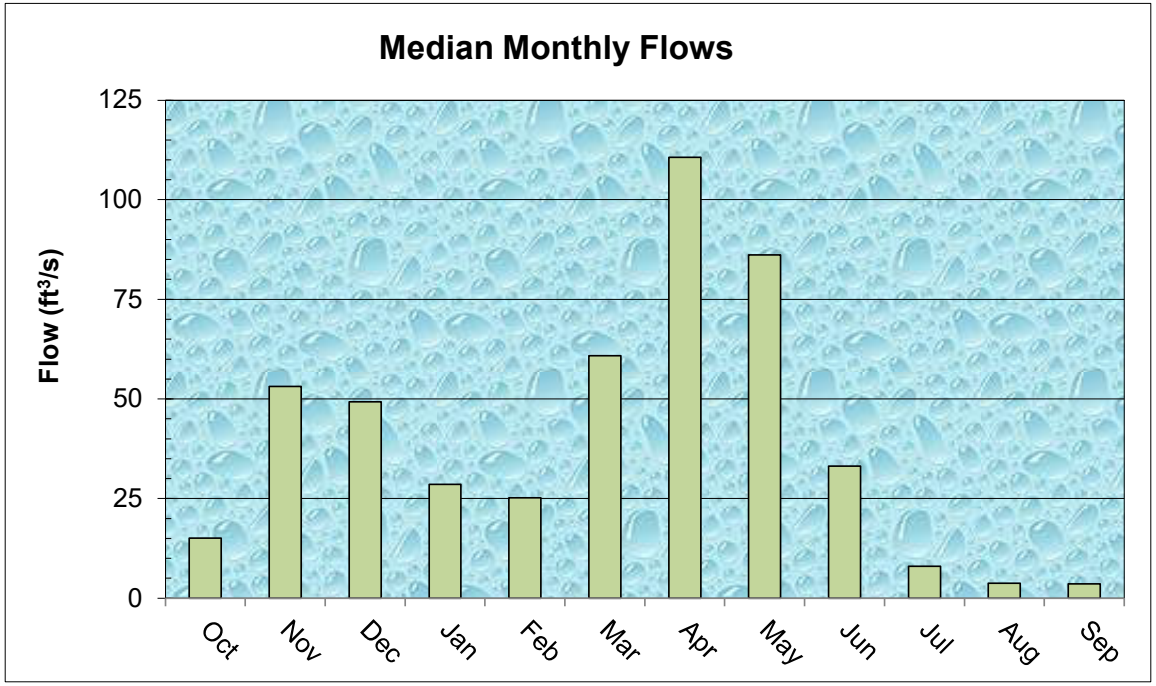
WIN:	26234.00	**Project Name:**	0
Town:	Monmouth	**Stream Name:**	Wilson Stream
Route No.	Waugan Rd	**Bridge Name:**	Waggon
Asset ID:	0487	**Analysis by:**	csh
Lat:	44.25800 **Long:** -69.99940	**Date:**	9/8/2022

DO NOT ENTER ANY DATA ON THIS PAGE; EVERYTHING IS CALCULATED

MAINE MONTHLY MEDIAN FLOWS and HYDRAULIC GEOMETRY BY USGS REGRESSION EQUATIONS (2004, 2013, 2015)

	Value	Variable	Explanation
	31.70	*A*	Area (mi^2)
417984	4904185	P_c	Watershed centroid (E,N; UTM; Zone 19; meters)
	65.22	*DIST*	Distance from Coastal reference line (mi)
	44.3	*pptA*	Mean Annual Precipitation (inches)
	0.00	*SG*	Sand & Gravel Aquifer (decimal fraction of watershed area)

Month	Q_{median} (ft3/s)	(m^3/s)
Jan	**28.56**	0.8093
Feb	**25.20**	0.7141
Mar	**60.85**	1.7245
Apr	**110.67**	3.1363
May	**86.13**	2.4409
Jun	**33.12**	0.9385
Jul	**8.01**	0.2269
Aug	**3.73**	0.1056
Sep	**3.57**	0.1013
Oct	**15.05**	0.4264
Nov	**53.14**	1.5059
Dec	**49.26**	1.3960



Q_{bf}	**195.6**	
ann avg	**64.9**	
ann med	**29.3**	
$Q_{1.002}$	**181.9**	
$Q_{1.01}$	**234.8**	
$Q_{1.05}$	**319.5**	
Q_{bf}	**359.9**	assume v = 4ft/s

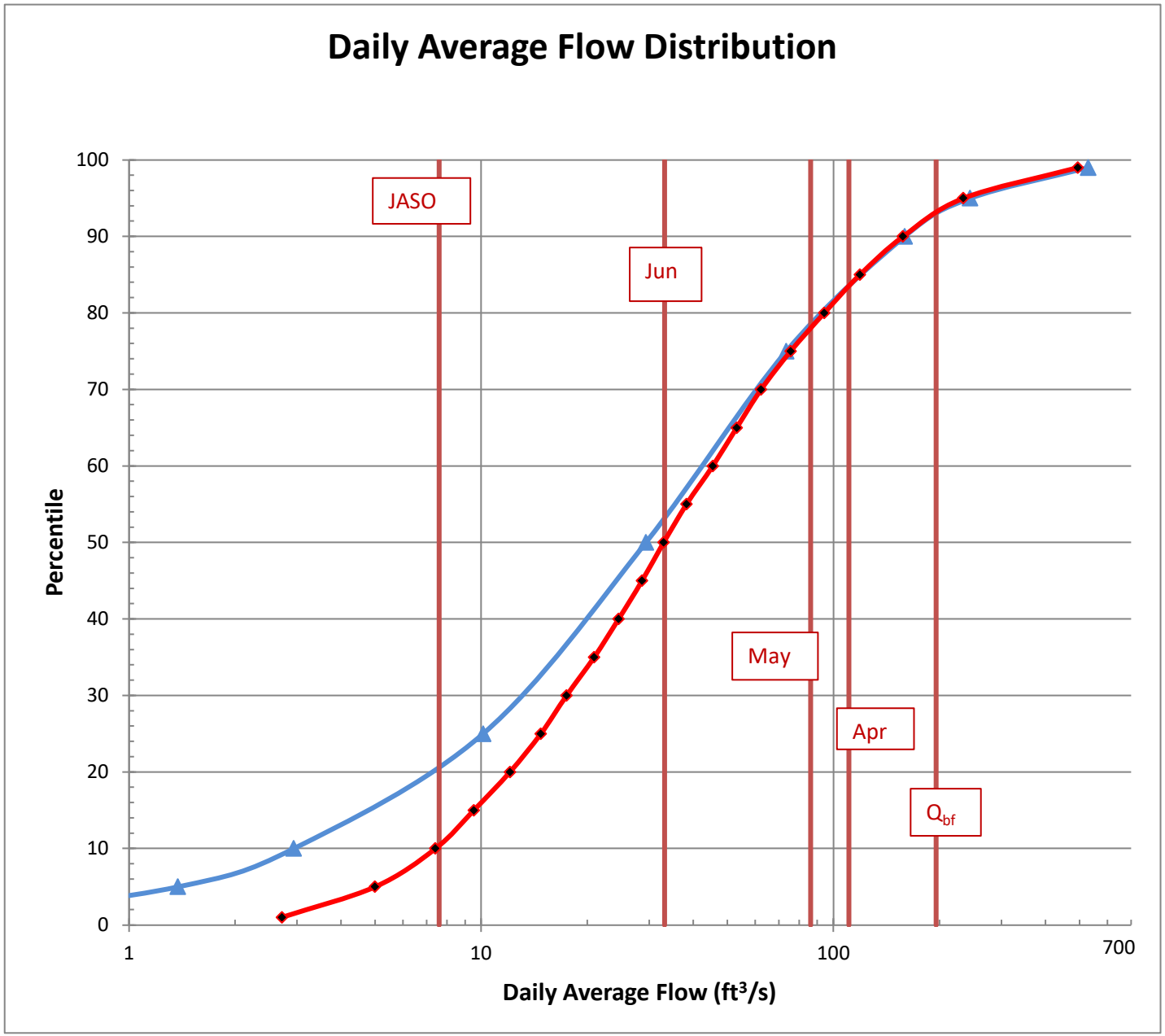
W_{bf}	**46.8**	estimated bankfull width (ft)
d_{bf}	**1.9**	estimated bankfull depth (ft)
A_{bf}	**88.9**	estimated bankfull flow area (ft^2)

References

Dudley, 2013. FY2013 Progress Report - Phase 1 …, USFWS QRP Project

Dudley, 2004. Estimating Monthly Streamflows … , SIR 2004-5026

Dudley, 2015. Regression Equations for Monthly & Annual Mean..., USGS SIR 2015-5151



	Daily Avg Flow Dist	
	A_{ws} = (mi^2)	31.7
	Q (ft^3/s)	
Pctl	**Median**	**84th pctl**
1.00E-06	0.00	0.00
1	2.72	4.81
5	4.99	8.03
10	7.41	11.14
15	9.53	13.92
20	12.06	16.88
25	14.76	19.78
30	17.47	22.53
35	20.92	25.75
40	24.54	29.61
45	28.60	33.48
50	32.93	39.53
55	38.24	46.01
60	45.41	54.00
65	53.13	62.92
70	62.32	73.40
75	75.55	88.27
80	94.22	105.39
85	118.88	135.06
90	157.48	181.36
95	233.72	282.02
99	494.23	650.67

Q_{bf}	195.6
$Q_{1.002}$	181.9
$Q_{1.1}$	373.0
Q_2	694.4

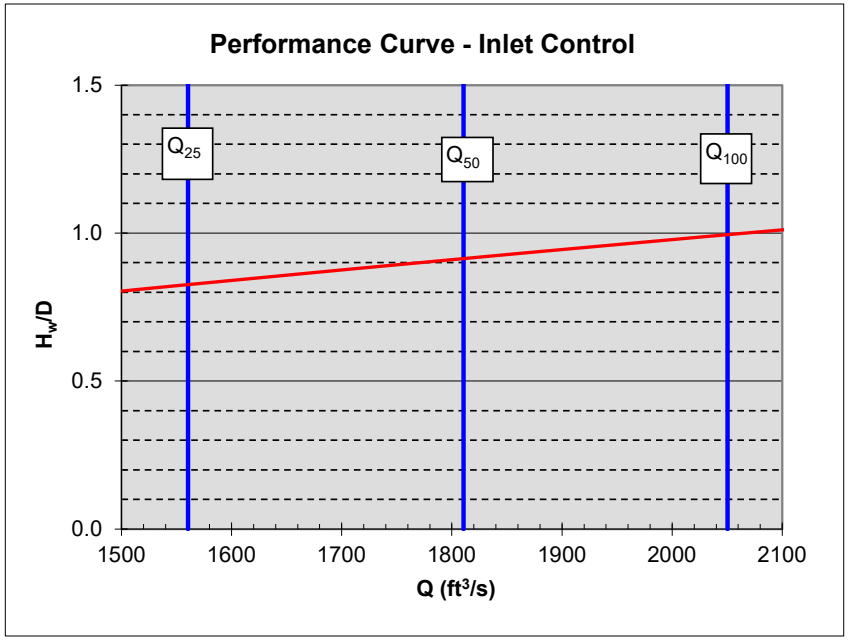
NOTE: ***This page is for preliminary sizing only.***
Final design should be done with HY8 or HDS-5

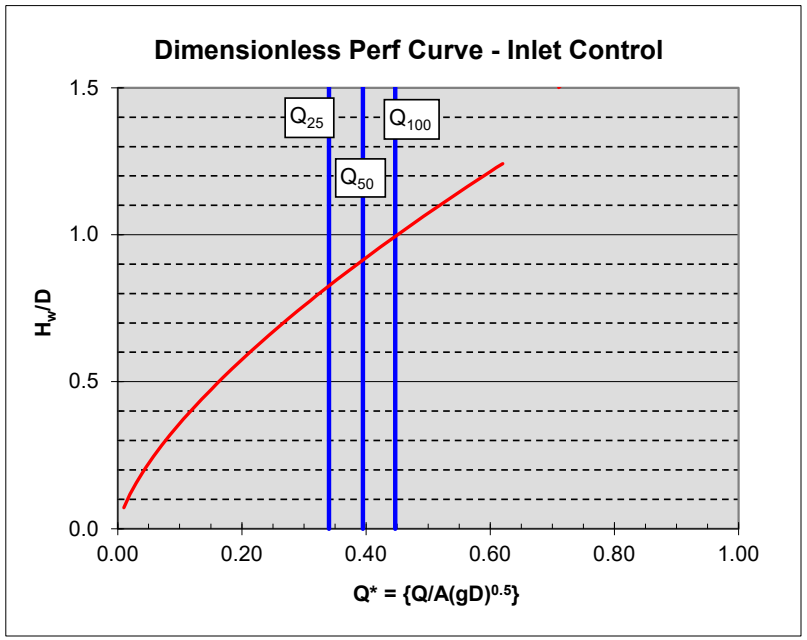
Note:
culvert dimensions are for open flow area; adjust for lost capacity due to embedding / backfilling (min {2' / 25% rise} embedment)
Finish analysis with HY-8

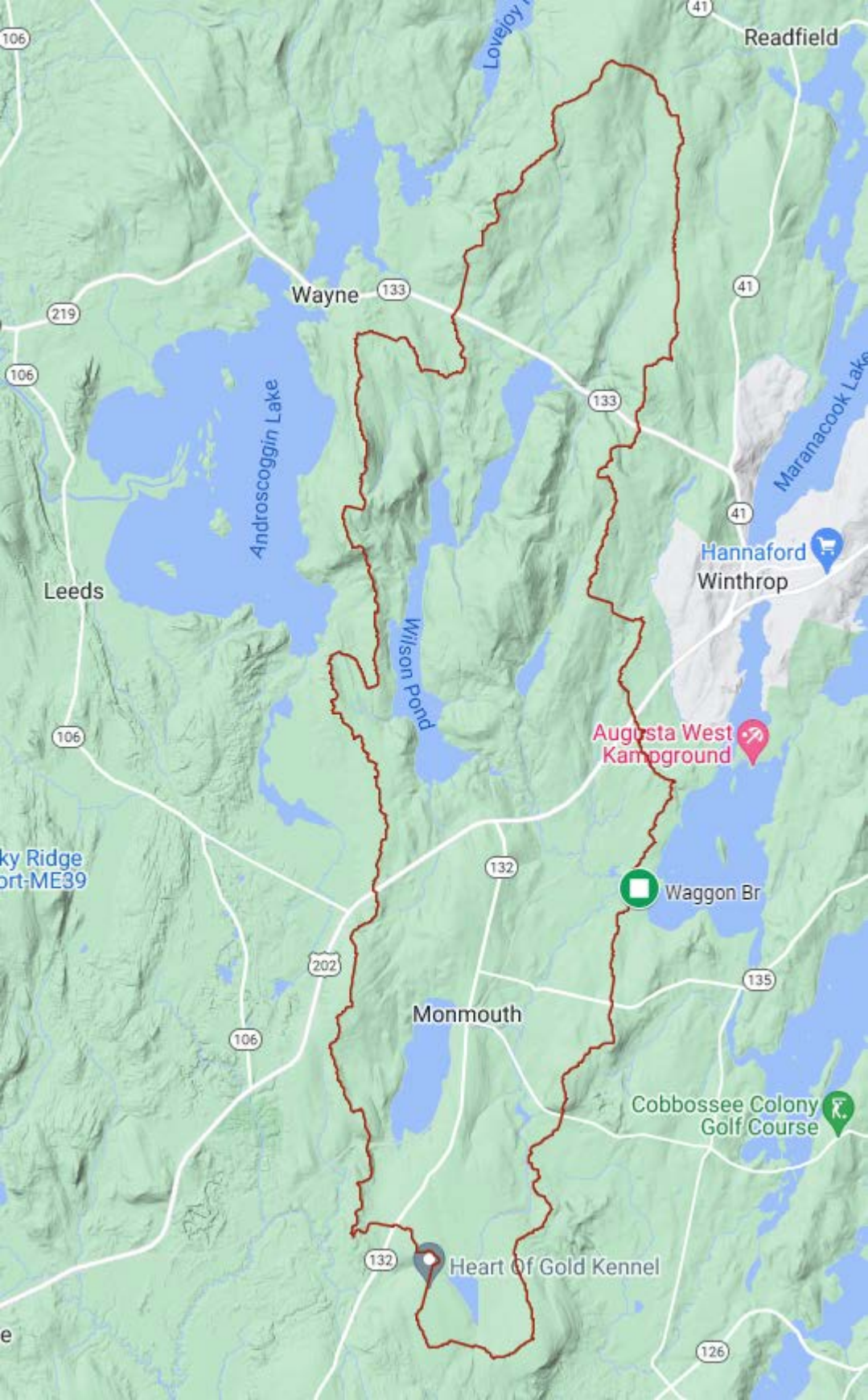
Preliminary Culvert Sizing - Round & Box Culverts

Choose shape and inlet type by pull-down menu in green cells

Shape:	Box					
Inlet Type:	Box 0 ww		Q_{25}	1560.2		
D or R (ft)	6	*diam / rise*	Q_{50}	1810.4	trial D / R =	16.6
w (ft)	*55*	*box span*	Q_{100}	2050.1	trial w: BFW =	46.8
Slope (ft/ft)	0.01					
A (ft^2)	330.00					
g (ft/s^2)	32.2					

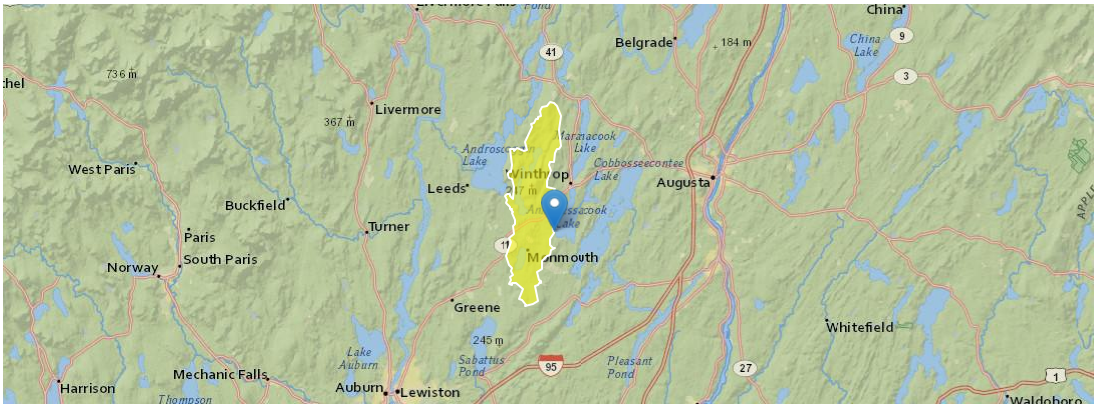





Readfield
Wayne
Androscoggin Lake
Leeds
Wilson Pond
Maranacook Lake
Hannaford
Winthrop
Augusta West
Kampground
Waggon Br
Monmouth
Cobbossee Colony
Golf Course
Heart Of Gold Kennel
106
219
133
41
132
202
135
126

StreamStats Report

Region ID: ME
Workspace ID: ME20240830174905380000
Clicked Point (Latitude, Longitude): 44.25802, -69.99935
Time: 2024-08-30 13:49:36 -0400



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
BSLDEM10M	Mean basin slope computed from 10 m DEM	7.67	percent
COASTDIST	Shortest distance from the coastline to the basin centroid	66.2	miles
ELEV	Mean Basin Elevation	339.7	feet
LC06WATER	Percent of open water, class 11, from NLCD 2006	6.66	percent
PRECIP	Mean Annual Precipitation	44.3	inches
SANDGRAVAP	Percentage of land surface underlain by sand and gravel aquifers	2.58	percent
STATSGOA	Percentage of area of Hydrologic Soil Type A from STATSGO	1.99	percent
STORAGE	Percentage of area of storage (lakes ponds reservoirs wetlands)	16.324	percent
STORNWI	Percentage of strorage (combined water bodies and wetlands) from the Nationa Wetlands Inventory	15.57	percent

Application Version: 4.23.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

APPENDIX D

Existing HEC-RAS Analysis

Username: $user$ Date:$date$

Division: $wkgroup$

Filename: $file$

WILSON STREAM

WILSON STREAM

1450
1300
1175
1025
675
750
885
605
555
505
460
225
105
0
425
375
330

300 0 300 600
Scale of Feet

HNTB

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

WIN

BRIDGE NO. 0487

PROJ. MANAGER #PROJMANAGER#	BY	DATE
DESIGN-DETAILED	NJP	11/22
CHECKED-REVIEWED	SCF	11/22
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

WAUGAN ROAD OVER
WILSON STREAM
TOWN OF MONMOUTH KENNEBEC COUNTY

EXISTING CROSS-SECTION MAP

SHEET NUMBER
FIG-02

HEC-RAS Plan: Existing River: Wilson Stream Reach: Waugan Rd

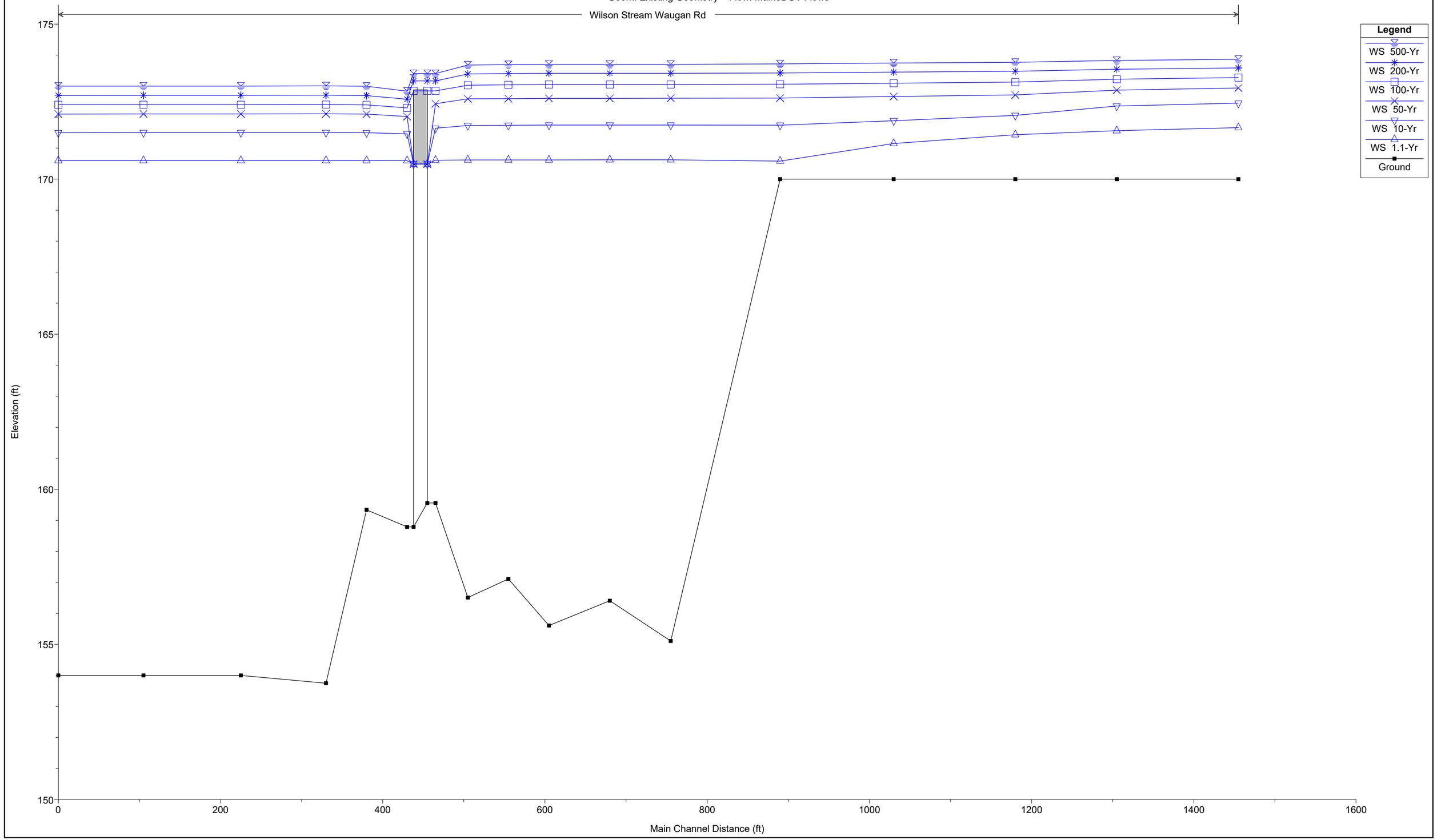
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Waugan Rd	1450	1.1-Yr	375.00	170.00	171.66		171.69	0.001146	1.49	331.19	806.15	0.23
Waugan Rd	1450	10-Yr	1255.00	170.00	172.45		172.52	0.001575	2.40	976.52	1029.85	0.29
Waugan Rd	1450	50-Yr	1810.00	170.00	172.94		173.00	0.001139	2.35	1485.96	1048.87	0.26
Waugan Rd	1450	100-Yr	2050.00	170.00	173.27		173.32	0.000819	2.16	1840.65	1086.07	0.22
Waugan Rd	1450	200-Yr	2305.00	170.00	173.59		173.63	0.000642	2.05	2189.07	1126.32	0.20
Waugan Rd	1450	500-Yr	2660.00	170.00	173.87		173.90	0.000586	2.07	2508.30	1161.98	0.20
Waugan Rd	1300	1.1-Yr	375.00	170.00	171.56		171.57	0.000509	0.94	746.51	1144.43	0.15
Waugan Rd	1300	10-Yr	1255.00	170.00	172.36		172.37	0.000517	1.33	1668.79	1174.85	0.17
Waugan Rd	1300	50-Yr	1810.00	170.00	172.87		172.88	0.000407	1.38	2273.39	1187.09	0.15
Waugan Rd	1300	100-Yr	2050.00	170.00	173.22		173.23	0.000306	1.30	2692.48	1195.52	0.14
Waugan Rd	1300	200-Yr	2305.00	170.00	173.55		173.56	0.000252	1.27	3082.38	1203.32	0.13
Waugan Rd	1300	500-Yr	2660.00	170.00	173.83		173.84	0.000240	1.31	3422.28	1210.08	0.12
Waugan Rd	1175	1.1-Yr	375.00	170.00	171.43		171.47	0.001579	1.59	238.41	963.94	0.27
Waugan Rd	1175	10-Yr	1255.00	170.00	172.06	171.35	172.23	0.003900	3.36	434.47	1092.88	0.45
Waugan Rd	1175	50-Yr	1810.00	170.00	172.72		172.80	0.001567	2.64	1162.01	1110.64	0.30
Waugan Rd	1175	100-Yr	2050.00	170.00	173.13		173.18	0.000884	2.20	1619.58	1121.88	0.23
Waugan Rd	1175	200-Yr	2305.00	170.00	173.48		173.52	0.000622	1.99	2012.84	1131.87	0.20
Waugan Rd	1175	500-Yr	2660.00	170.00	173.77		173.80	0.000542	1.97	2340.55	1140.12	0.19
Waugan Rd	1025	1.1-Yr	375.00	170.00	171.15	170.71	171.18	0.002518	1.51	346.72	1153.76	0.31
Waugan Rd	1025	10-Yr	1255.00	170.00	171.88		171.91	0.001149	1.62	1214.05	1205.88	0.24
Waugan Rd	1025	50-Yr	1810.00	170.00	172.67		172.68	0.000409	1.29	2171.64	1236.50	0.15
Waugan Rd	1025	100-Yr	2050.00	170.00	173.10		173.11	0.000264	1.16	2705.57	1250.72	0.13
Waugan Rd	1025	200-Yr	2305.00	170.00	173.45		173.46	0.000207	1.12	3153.94	1262.07	0.11
Waugan Rd	1025	500-Yr	2660.00	170.00	173.74		173.75	0.000195	1.15	3521.83	1271.30	0.11
Waugan Rd	885	1.1-Yr	375.00	170.00	170.58	170.36	170.64	0.006253	1.93	193.87	811.61	0.47
Waugan Rd	885	10-Yr	1255.00	170.00	171.74		171.77	0.000891	1.52	1109.85	1039.90	0.21
Waugan Rd	885	50-Yr	1810.00	170.00	172.61		172.63	0.000321	1.22	2036.81	1079.70	0.14
Waugan Rd	885	100-Yr	2050.00	170.00	173.06		173.07	0.000216	1.12	2523.07	1098.63	0.12
Waugan Rd	885	200-Yr	2305.00	170.00	173.42		173.44	0.000174	1.09	2924.37	1108.48	0.11
Waugan Rd	885	500-Yr	2660.00	170.00	173.72		173.73	0.000168	1.13	3248.48	1116.38	0.11
Waugan Rd	750	1.1-Yr	375.00	155.11	170.62		170.62	0.000002	0.31	1810.43	610.23	0.02
Waugan Rd	750	10-Yr	1255.00	155.11	171.75		171.76	0.000017	0.84	2600.32	740.54	0.04
Waugan Rd	750	50-Yr	1810.00	155.11	172.61		172.62	0.000023	1.03	3252.51	768.95	0.05
Waugan Rd	750	100-Yr	2050.00	155.11	173.05		173.07	0.000024	1.08	3596.90	781.48	0.05
Waugan Rd	750	200-Yr	2305.00	155.11	173.42		173.43	0.000026	1.13	3881.37	790.09	0.05
Waugan Rd	750	500-Yr	2660.00	155.11	173.70		173.72	0.000030	1.25	4110.66	796.97	0.06
Waugan Rd	675	1.1-Yr	375.00	156.41	170.62		170.62	0.000004	0.37	1829.86	516.18	0.02
Waugan Rd	675	10-Yr	1255.00	156.41	171.74		171.75	0.000026	0.99	2488.67	676.32	0.05
Waugan Rd	675	50-Yr	1810.00	156.41	172.61		172.62	0.000034	1.19	3107.94	734.45	0.06
Waugan Rd	675	100-Yr	2050.00	156.41	173.05		173.06	0.000035	1.23	3436.94	745.80	0.06
Waugan Rd	675	200-Yr	2305.00	156.41	173.41		173.43	0.000036	1.28	3708.70	755.10	0.06
Waugan Rd	675	500-Yr	2660.00	156.41	173.70		173.72	0.000042	1.40	3927.74	762.52	0.06
Waugan Rd	605	1.1-Yr	375.00	155.61	170.62		170.62	0.000006	0.41	1933.61	632.62	0.02
Waugan Rd	605	10-Yr	1255.00	155.61	171.74		171.75	0.000030	1.02	2696.19	747.73	0.05
Waugan Rd	605	50-Yr	1810.00	155.61	172.61		172.62	0.000037	1.18	3402.18	861.51	0.06
Waugan Rd	605	100-Yr	2050.00	155.61	173.05		173.06	0.000037	1.21	3793.84	898.86	0.06
Waugan Rd	605	200-Yr	2305.00	155.61	173.41		173.42	0.000038	1.25	4123.49	921.00	0.06
Waugan Rd	605	500-Yr	2660.00	155.61	173.70		173.71	0.000044	1.36	4391.97	938.64	0.06
Waugan Rd	555	1.1-Yr	375.00	157.11	170.62		170.62	0.000009	0.52	1487.10	624.55	0.03
Waugan Rd	555	10-Yr	1255.00	157.11	171.73		171.75	0.000047	1.26	2267.27	767.82	0.06
Waugan Rd	555	50-Yr	1810.00	157.11	172.60		172.61	0.000055	1.42	2973.04	867.19	0.07
Waugan Rd	555	100-Yr	2050.00	157.11	173.04		173.06	0.000053	1.43	3364.99	892.82	0.07
Waugan Rd	555	200-Yr	2305.00	157.11	173.41		173.42	0.000055	1.47	3692.52	914.26	0.07
Waugan Rd	555	500-Yr	2660.00	157.11	173.69		173.71	0.000062	1.59	3958.33	931.30	0.07
Waugan Rd	505	1.1-Yr	375.00	156.51	170.62		170.62	0.000011	0.54	1342.15	651.59	0.03
Waugan Rd	505	10-Yr	1255.00	156.51	171.73		171.75	0.000058	1.33	1958.28	788.29	0.07
Waugan Rd	505	50-Yr	1810.00	156.51	172.59		172.61	0.000071	1.55	2499.72	872.74	0.08
Waugan Rd	505	100-Yr	2050.00	156.51	173.03		173.05	0.000088	1.76	2829.27	900.33	0.08
Waugan Rd	505	200-Yr	2305.00	156.51	173.39		173.42	0.000087	1.78	3160.64	922.22	0.08

HEC-RAS Plan: Existing River: Wilson Stream Reach: Waugan Rd (Continued)

Reach	River Sta	Profile	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)	
Waugan Rd	505	500-Yr	2660.00	156.51	173.68		173.71	0.000096	1.90	3428.26	939.53	0.09
Waugan Rd	460	1.1-Yr	375.00	159.56	170.61	161.89	170.62	0.000029	0.85	491.10	659.02	0.05
Waugan Rd	460	10-Yr	1255.00	159.56	171.64	163.70	171.74	0.000223	2.50	569.61	777.24	0.14
Waugan Rd	460	50-Yr	1810.00	159.56	172.43	164.57	172.59	0.000353	3.30	629.67	852.02	0.17
Waugan Rd	460	100-Yr	2050.00	159.56	172.85	164.94	173.03	0.000395	3.57	661.17	891.66	0.18
Waugan Rd	460	200-Yr	2305.00	159.56	173.17	165.30	173.39	0.000462	3.93	781.06	918.99	0.20
Waugan Rd	460	500-Yr	2660.00	159.56	173.41	165.77	173.68	0.000552	4.35	880.91	937.46	0.22
Waugan Rd	440		Bridge									
Waugan Rd	425	1.1-Yr	375.00	158.79	170.60		170.61	0.000031	0.89	451.48	662.28	0.05
Waugan Rd	425	10-Yr	1255.00	158.79	171.46		171.57	0.000265	2.74	495.34	782.95	0.14
Waugan Rd	425	50-Yr	1810.00	158.79	172.02		172.23	0.000464	3.74	523.78	842.07	0.19
Waugan Rd	425	100-Yr	2050.00	158.79	172.30		172.55	0.000548	4.13	537.99	861.64	0.21
Waugan Rd	425	200-Yr	2305.00	158.79	172.58		172.88	0.000639	4.52	552.06	881.00	0.23
Waugan Rd	425	500-Yr	2660.00	158.79	172.84		173.22	0.000790	5.10	565.44	899.42	0.25
Waugan Rd	375	1.1-Yr	375.00	159.34	170.60		170.60	0.000011	0.52	1141.86	696.85	0.03
Waugan Rd	375	10-Yr	1255.00	159.34	171.50		171.52	0.000071	1.41	1522.32	924.42	0.08
Waugan Rd	375	50-Yr	1810.00	159.34	172.10		172.13	0.000105	1.78	1784.96	944.42	0.10
Waugan Rd	375	100-Yr	2050.00	159.34	172.40		172.43	0.000114	1.89	1917.59	952.84	0.10
Waugan Rd	375	200-Yr	2305.00	159.34	172.70		172.74	0.000123	2.00	2051.06	961.25	0.11
Waugan Rd	375	500-Yr	2660.00	159.34	172.99		173.04	0.000140	2.17	2185.26	969.65	0.11
Waugan Rd	330	1.1-Yr	375.00	153.75	170.60		170.60	0.000003	0.30	2394.91	712.39	0.02
Waugan Rd	330	10-Yr	1255.00	153.75	171.50		171.51	0.000021	0.82	3135.94	897.87	0.04
Waugan Rd	330	50-Yr	1810.00	153.75	172.11		172.12	0.000030	1.01	3682.28	916.16	0.05
Waugan Rd	330	100-Yr	2050.00	153.75	172.41		172.42	0.000032	1.06	3958.79	923.94	0.05
Waugan Rd	330	200-Yr	2305.00	153.75	172.71		172.72	0.000035	1.12	4237.61	931.72	0.06
Waugan Rd	330	500-Yr	2660.00	153.75	173.01		173.02	0.000039	1.21	4520.31	1060.02	0.06
Waugan Rd	225	1.1-Yr	375.00	154.00	170.60		170.60	0.000002	0.28	2354.88	672.19	0.01
Waugan Rd	225	10-Yr	1255.00	154.00	171.50		171.51	0.000016	0.80	3090.51	918.25	0.04
Waugan Rd	225	50-Yr	1810.00	154.00	172.10		172.11	0.000024	1.00	3648.05	984.87	0.05
Waugan Rd	225	100-Yr	2050.00	154.00	172.40		172.41	0.000026	1.07	3930.50	1025.02	0.05
Waugan Rd	225	200-Yr	2305.00	154.00	172.70		172.71	0.000028	1.13	4215.13	1065.16	0.05
Waugan Rd	225	500-Yr	2660.00	154.00	173.00		173.02	0.000033	1.22	4502.54	1155.89	0.06
Waugan Rd	105	1.1-Yr	375.00	154.00	170.60		170.60	0.000002	0.26	2676.37	844.86	0.01
Waugan Rd	105	10-Yr	1255.00	154.00	171.50		171.51	0.000013	0.73	3544.00	1031.50	0.04
Waugan Rd	105	50-Yr	1810.00	154.00	172.10		172.11	0.000020	0.91	4170.82	1143.89	0.04
Waugan Rd	105	100-Yr	2050.00	154.00	172.40		172.41	0.000021	0.96	4488.54	1178.97	0.05
Waugan Rd	105	200-Yr	2305.00	154.00	172.70		172.71	0.000023	1.02	4808.57	1214.05	0.05
Waugan Rd	105	500-Yr	2660.00	154.00	173.00		173.01	0.000027	1.10	5131.47	1288.48	0.05
Waugan Rd	0	1.1-Yr	375.00	154.00	170.60	156.66	170.60	0.000002	0.26	2719.63	1009.64	0.01
Waugan Rd	0	10-Yr	1255.00	154.00	171.50	158.55	171.51	0.000013	0.72	3694.38	1158.50	0.04
Waugan Rd	0	50-Yr	1810.00	154.00	172.10	159.34	172.11	0.000019	0.89	4410.97	1371.88	0.04
Waugan Rd	0	100-Yr	2050.00	154.00	172.40	159.64	172.41	0.000021	0.94	4779.29	1397.32	0.04
Waugan Rd	0	200-Yr	2305.00	154.00	172.70	159.96	172.71	0.000022	0.99	5150.66	1422.76	0.05
Waugan Rd	0	500-Yr	2660.00	154.00	173.00	160.39	173.01	0.000025	1.07	5525.05	1448.20	0.05

67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

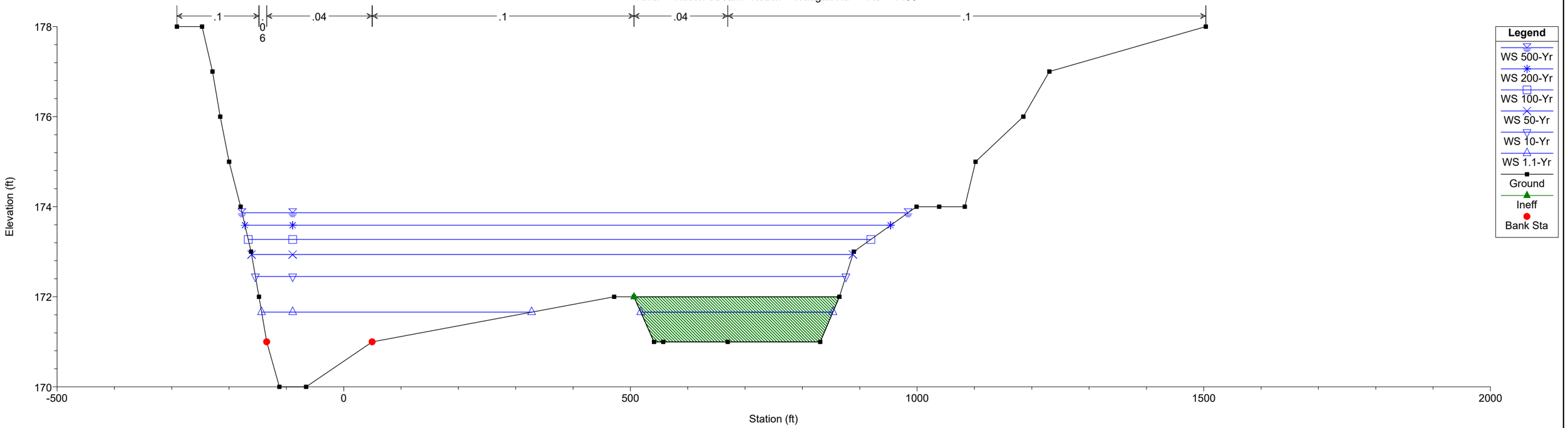
Geom: Existing Geometry Flow: MaineDOT Flows



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

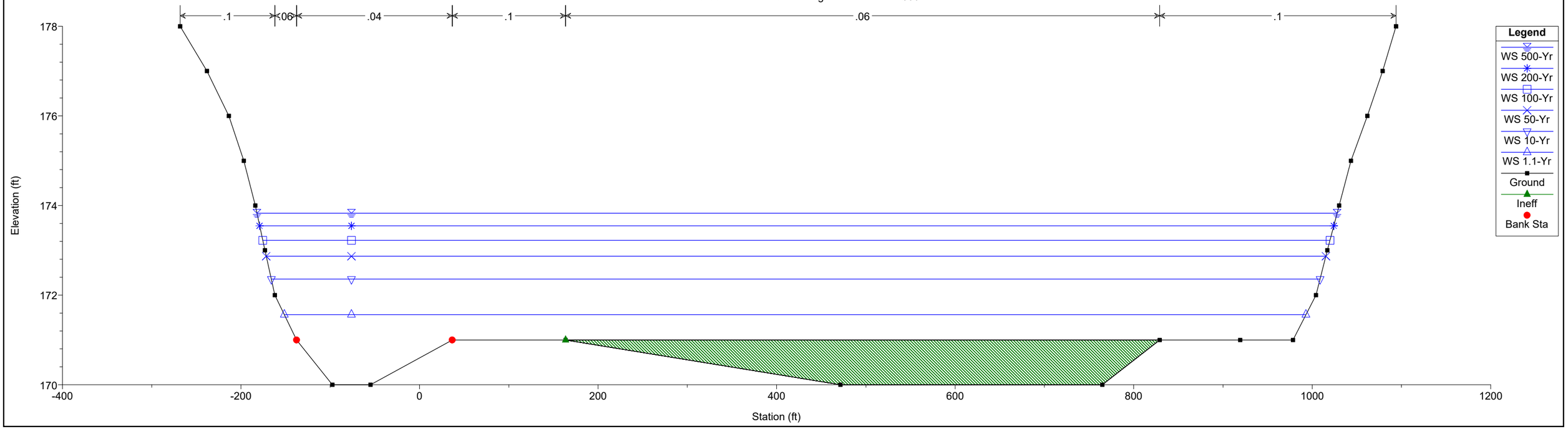
River = Wilson Stream Reach = Waugan Rd RS = 1450



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

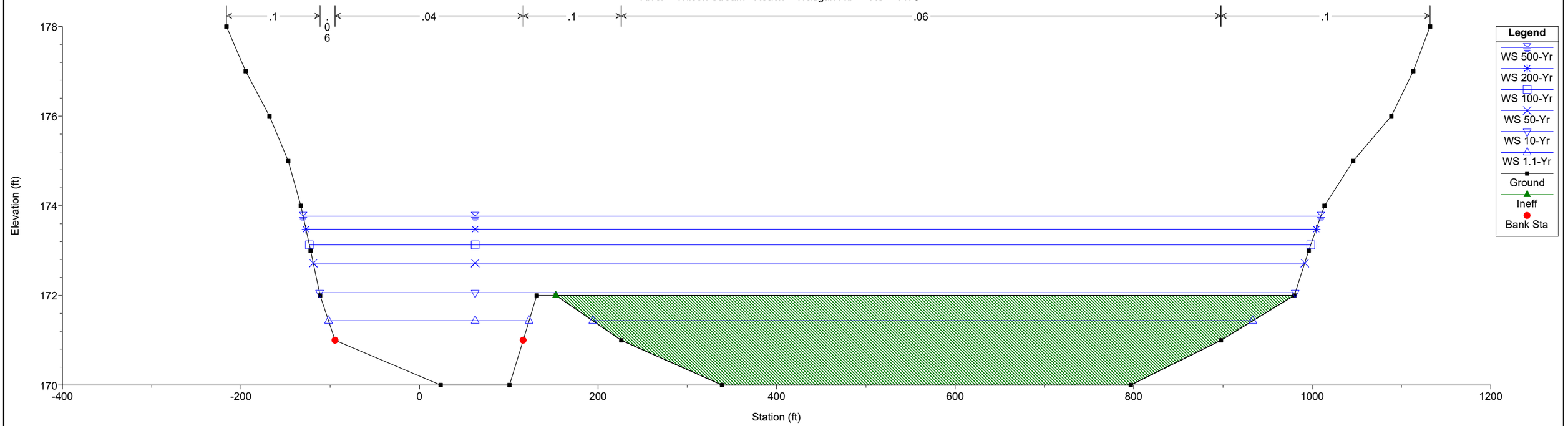
River = Wilson Stream Reach = Waugan Rd RS = 1300



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

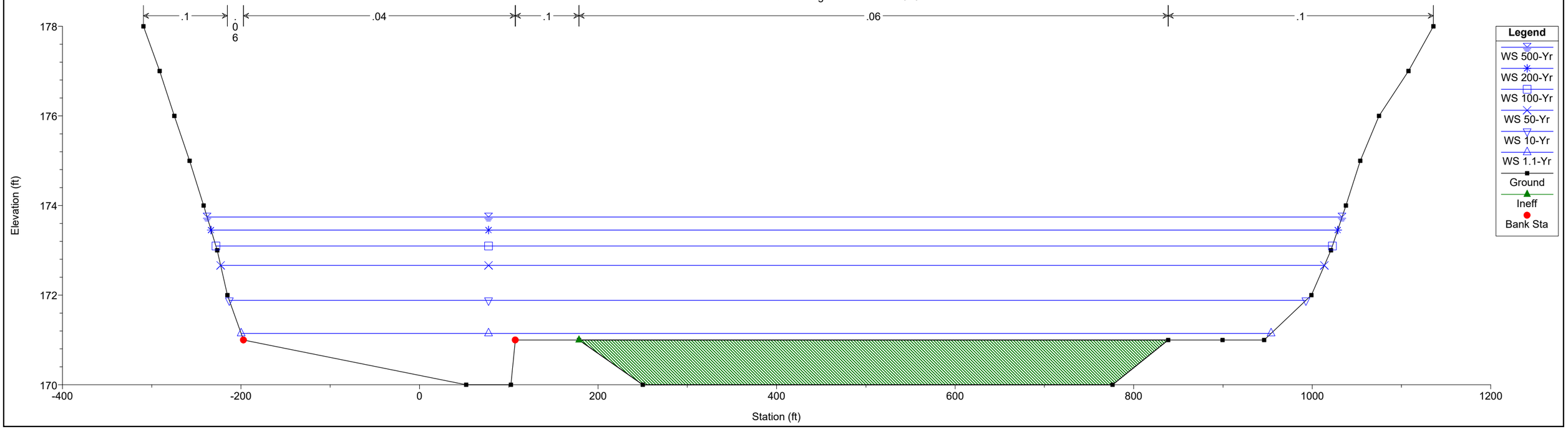
River = Wilson Stream Reach = Waugan Rd RS = 1175



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

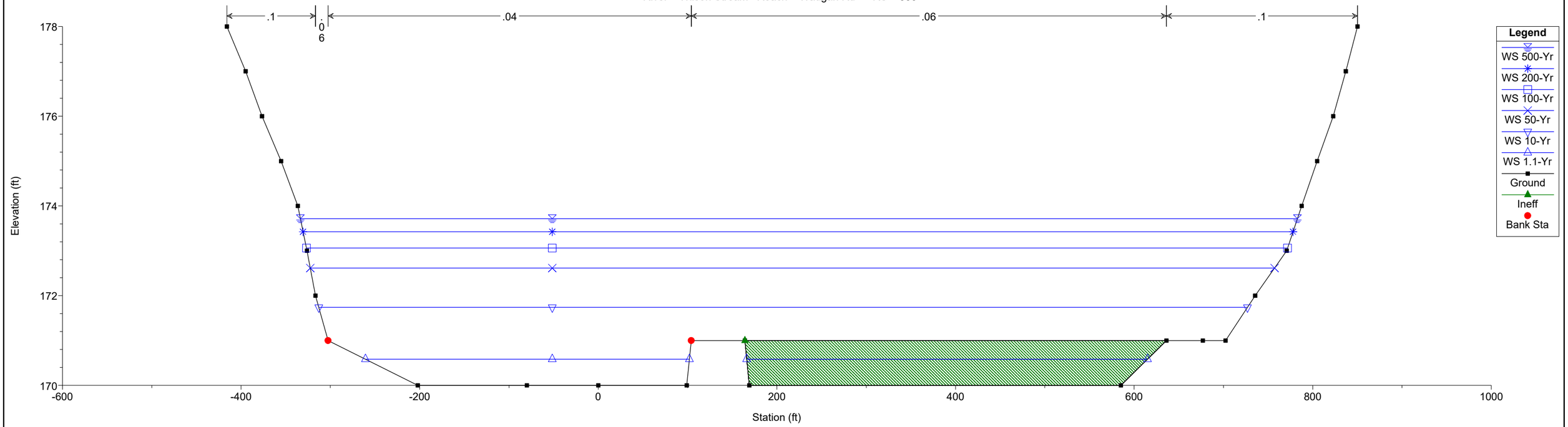
River = Wilson Stream Reach = Waugan Rd RS = 1025



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

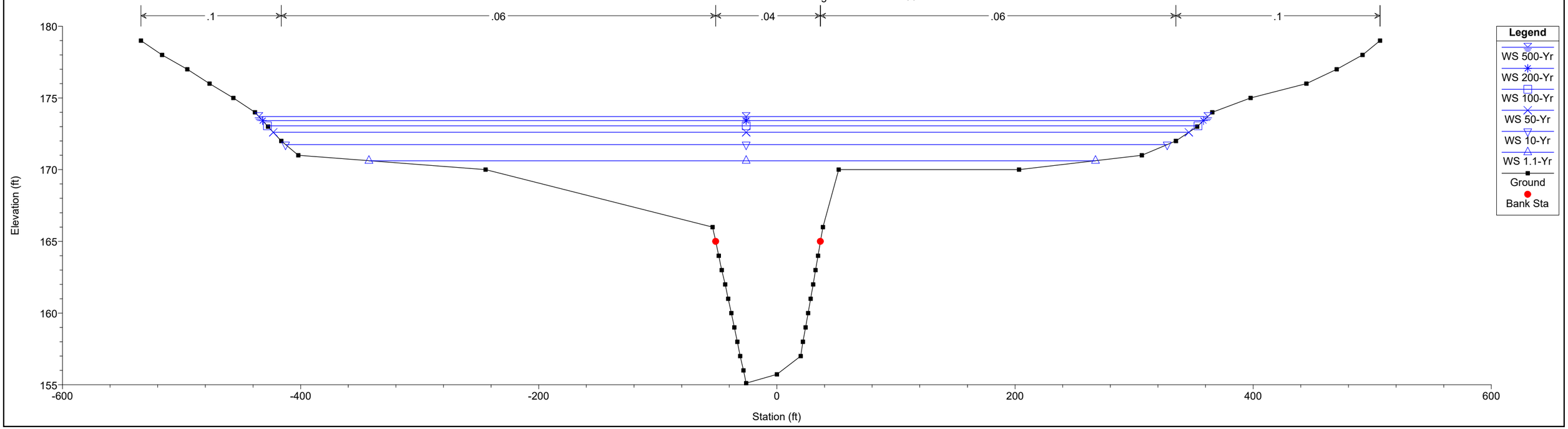
River = Wilson Stream Reach = Waugan Rd RS = 885



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

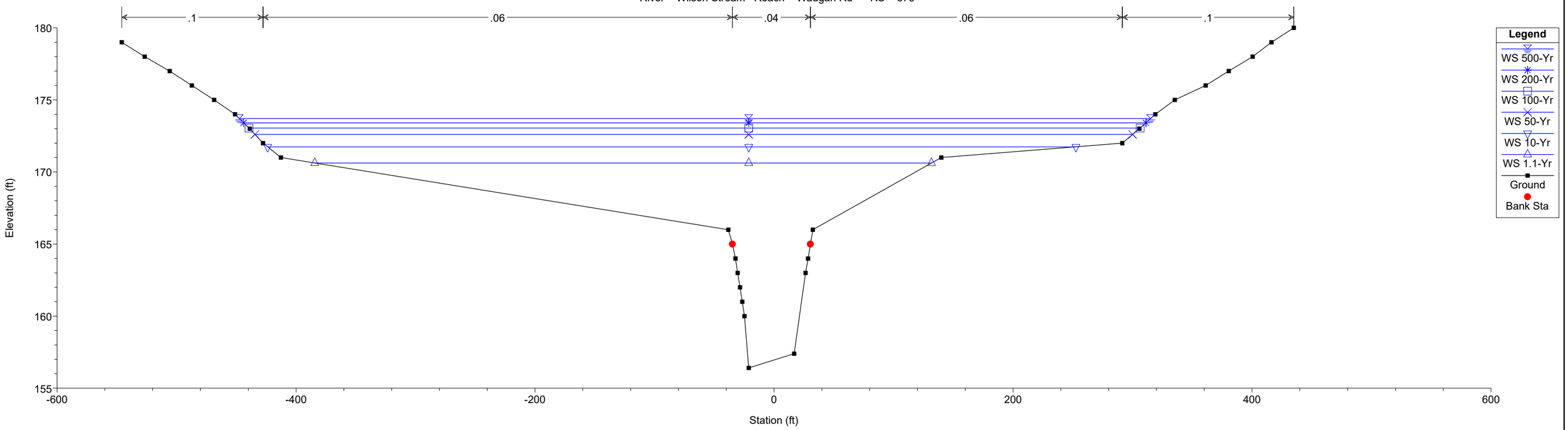
River = Wilson Stream Reach = Waugan Rd RS = 750



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

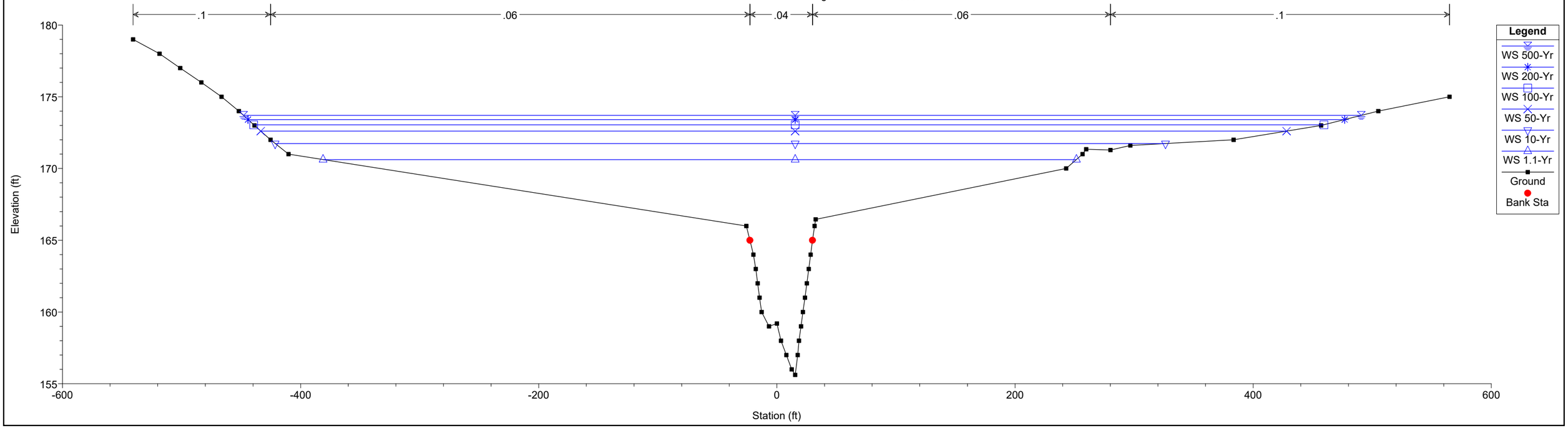
River = Wilson Stream Reach = Waugan Rd RS = 675



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

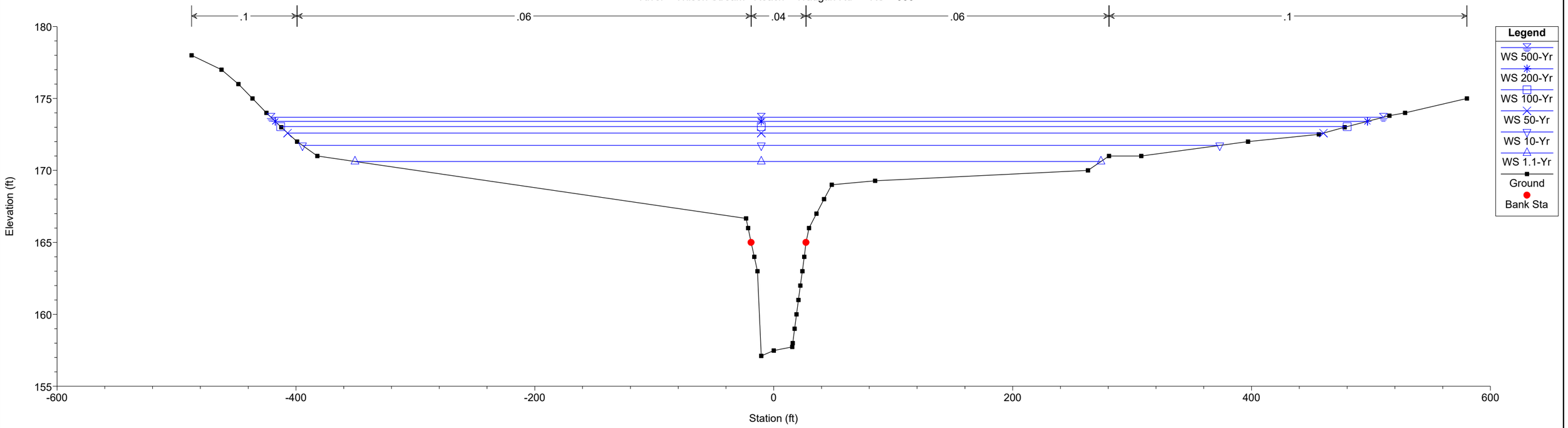
River = Wilson Stream Reach = Waugan Rd RS = 605



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

River = Wilson Stream Reach = Waugan Rd RS = 555



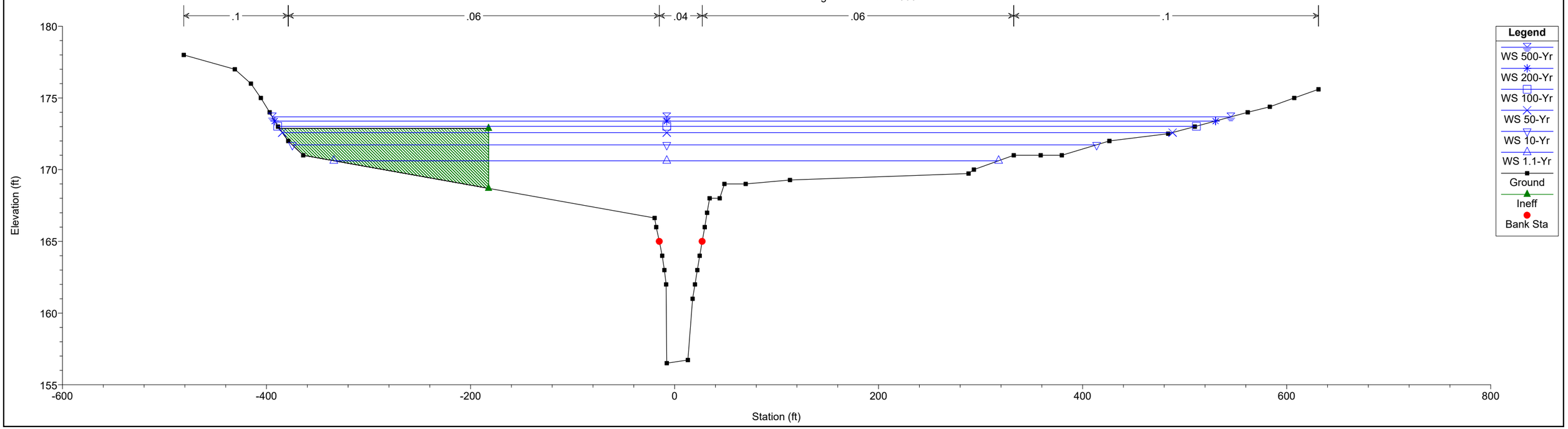
67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Station (ft)

67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

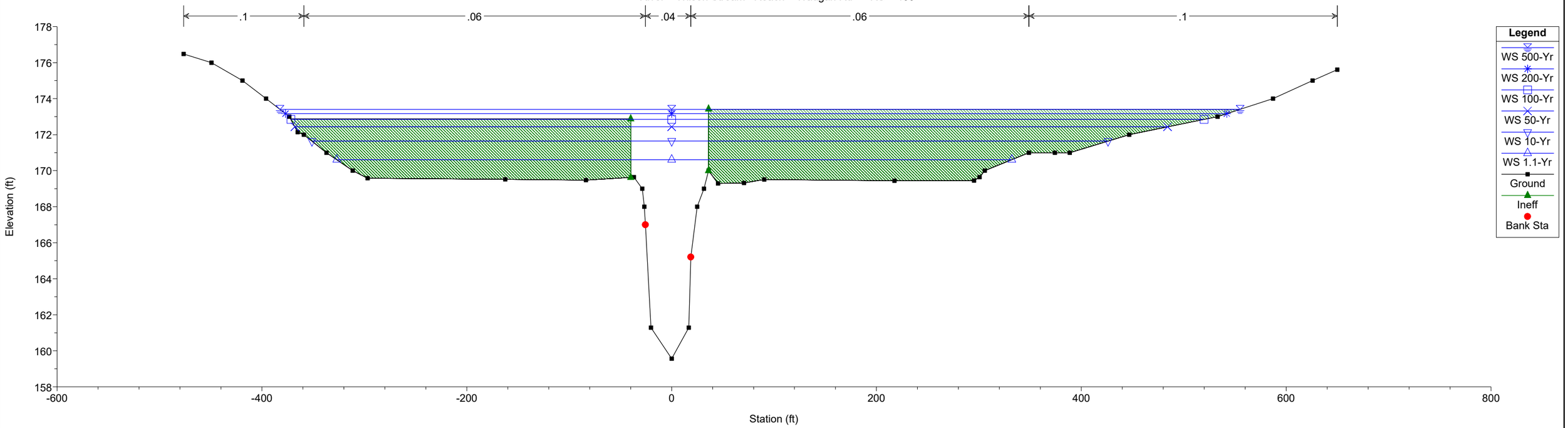
River = Wilson Stream Reach = Waugan Rd RS = 505



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

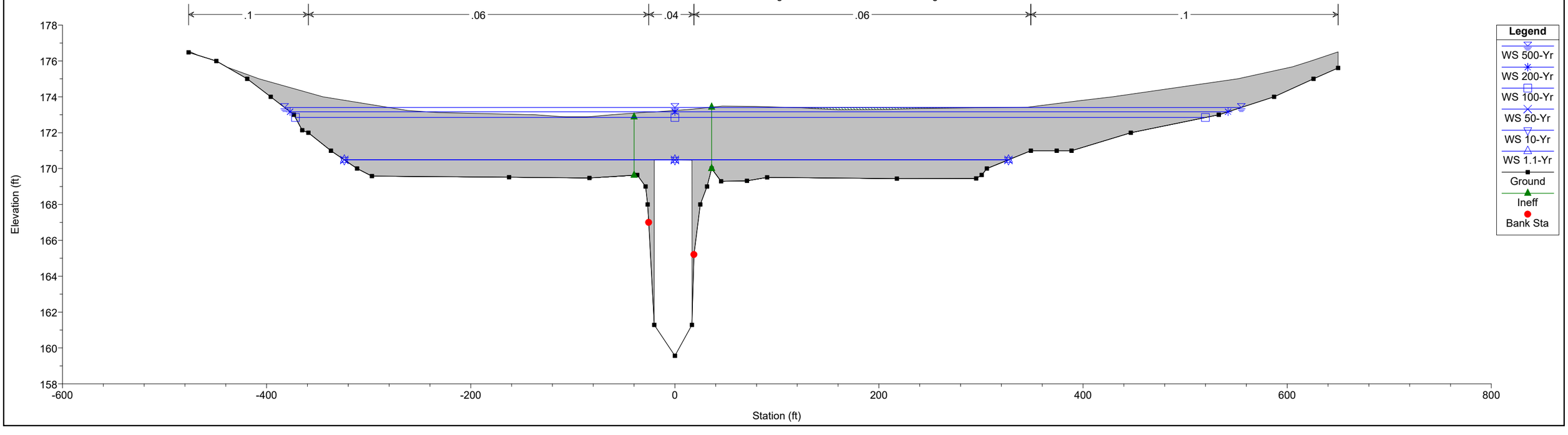
River = Wilson Stream Reach = Waugan Rd RS = 460



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

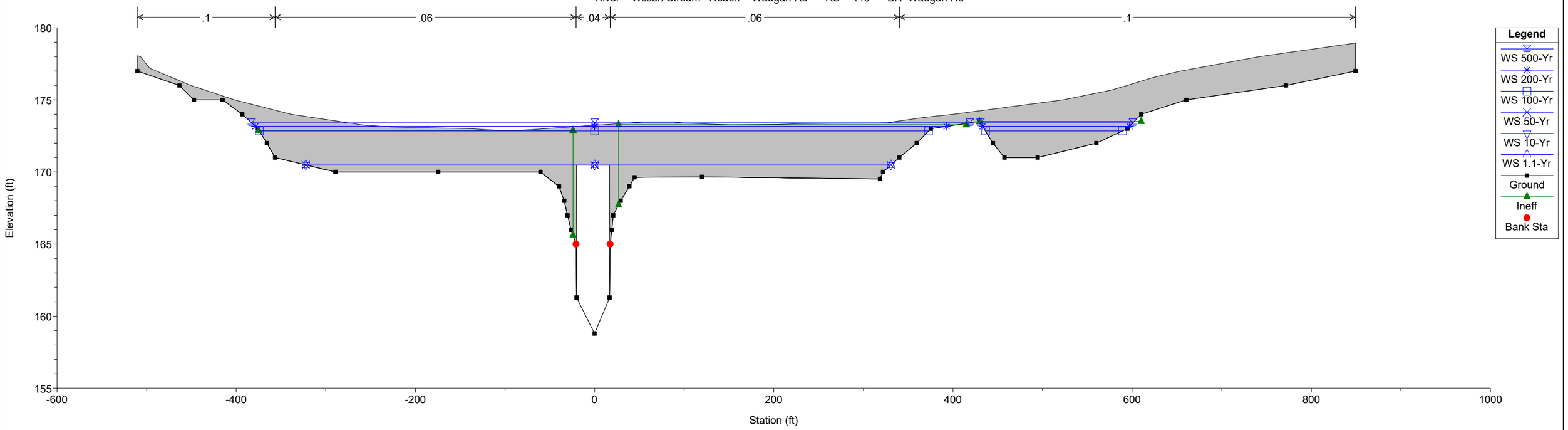
River = Wilson Stream Reach = Waugan Rd RS = 440 BR Waugan Rd



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

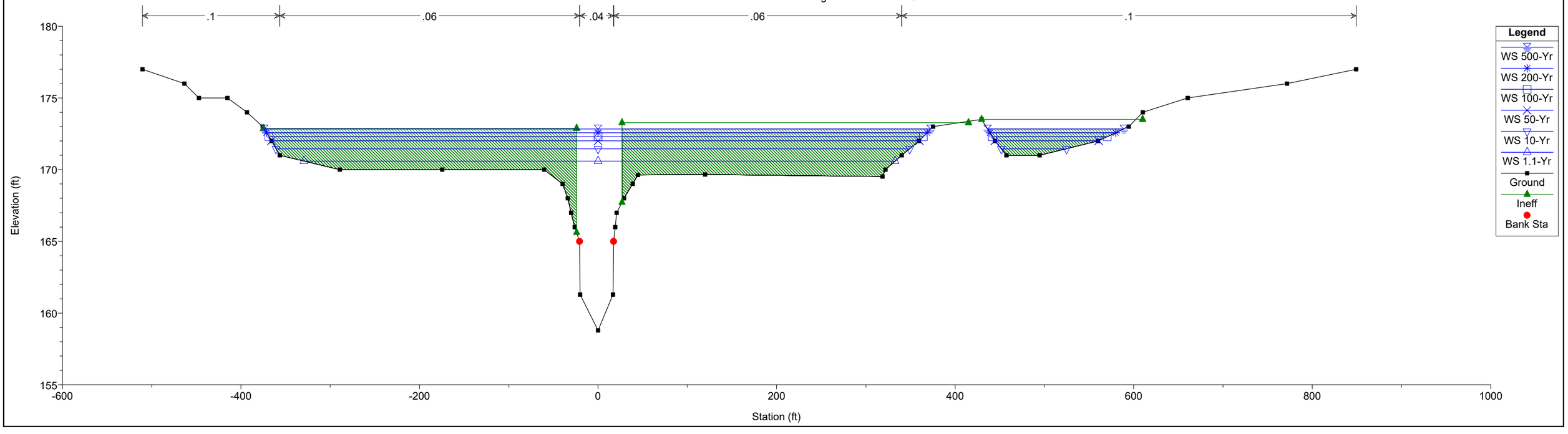
River = Wilson Stream Reach = Waugan Rd RS = 440 BR Waugan Rd



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

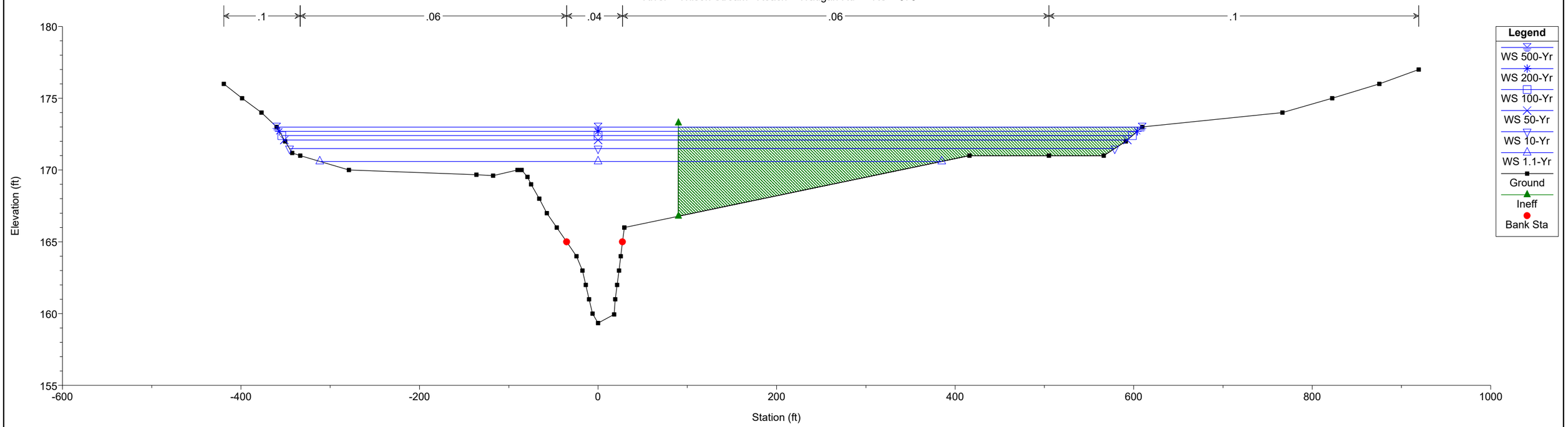
River = Wilson Stream Reach = Waugan Rd RS = 425



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

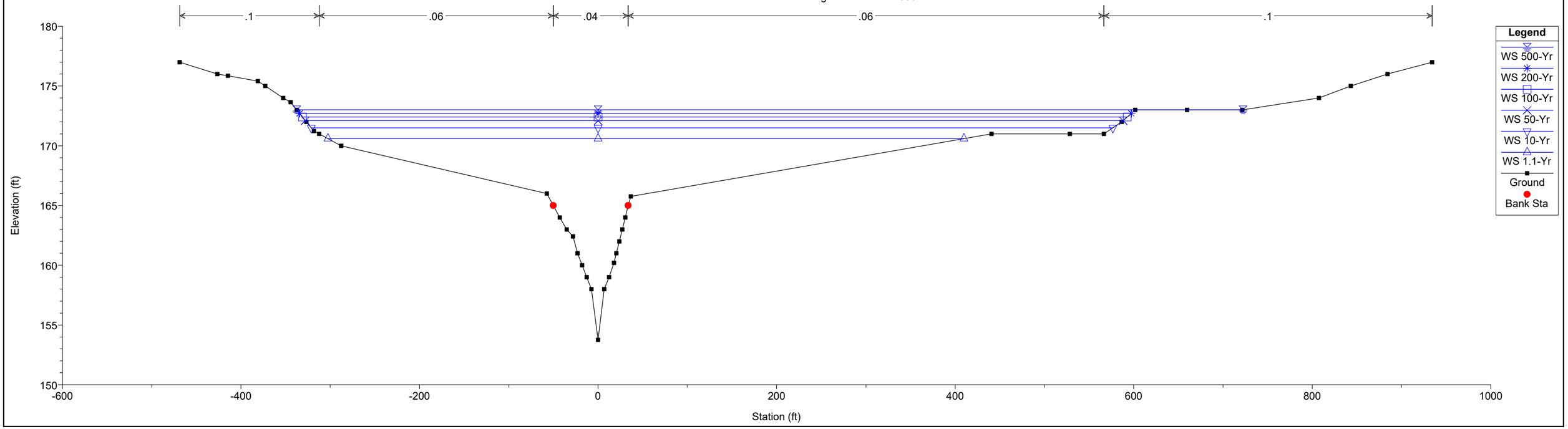
River = Wilson Stream Reach = Waugan Rd RS = 375



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

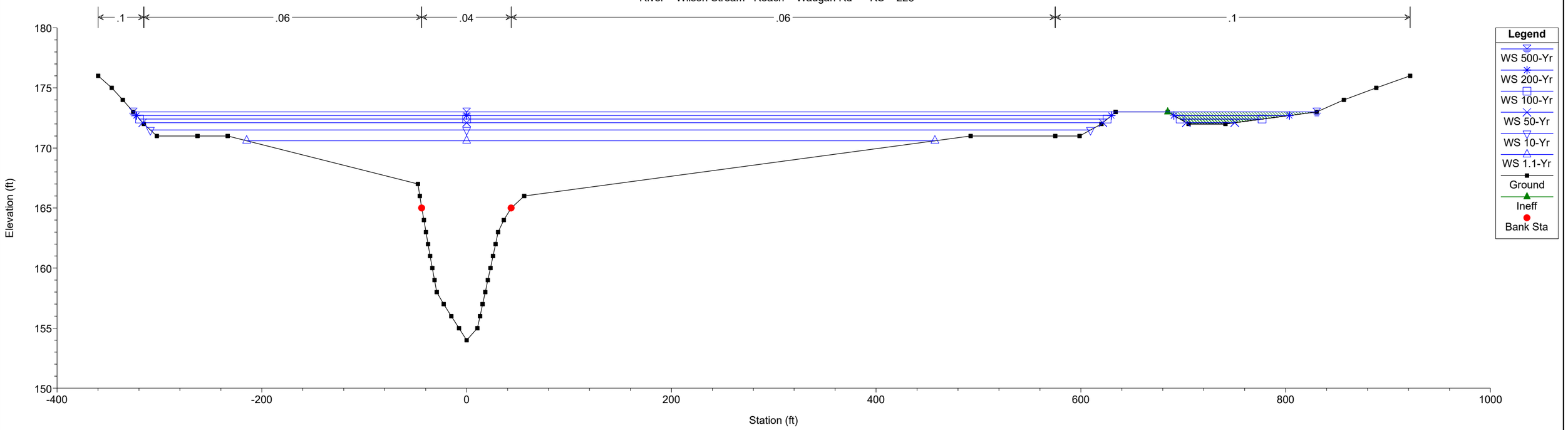
River = Wilson Stream Reach = Waugan Rd RS = 330



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

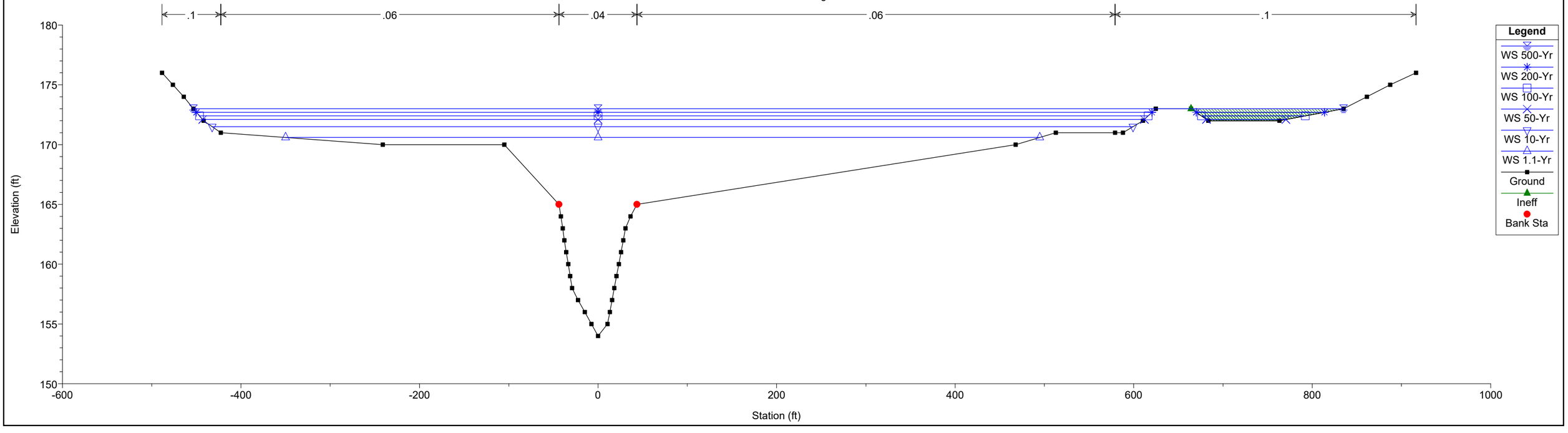
River = Wilson Stream Reach = Waugan Rd RS = 225



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

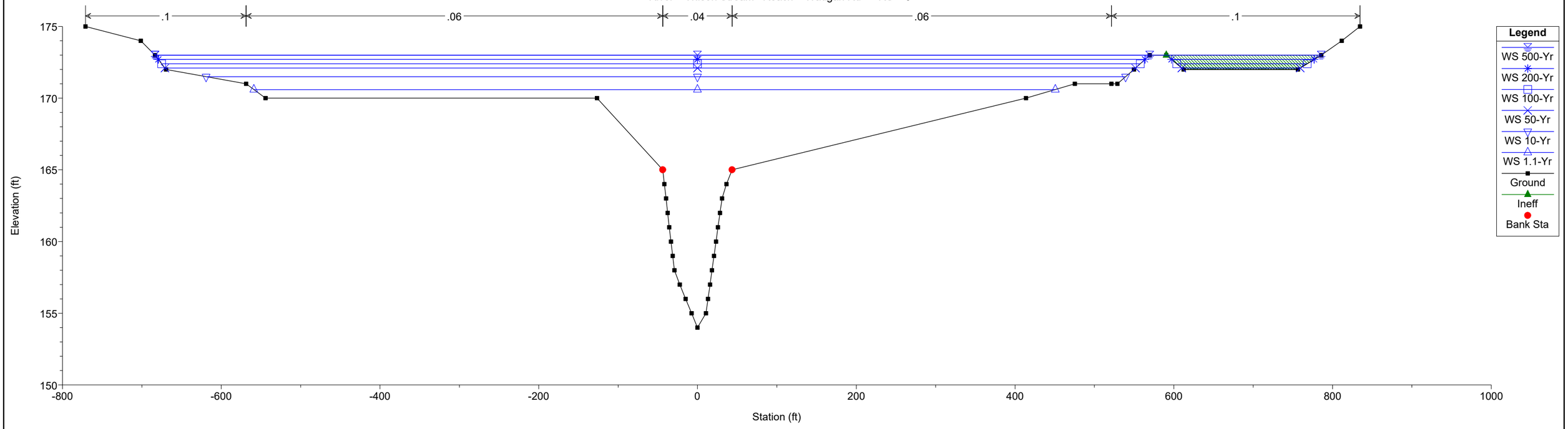
River = Wilson Stream Reach = Waugan Rd RS = 105



67328_MaineDOT Waugon Bridge Plan: Existing Plan 12/2/2022

Geom: Existing Geometry Flow: MaineDOT Flows

River = Wilson Stream Reach = Waugan Rd RS = 0



APPENDIX E

Proposed HEC-RAS Analysis

HNTB

HEC-RAS Plan: 0809 River: Wilson Stream Reach: Waugan Rd

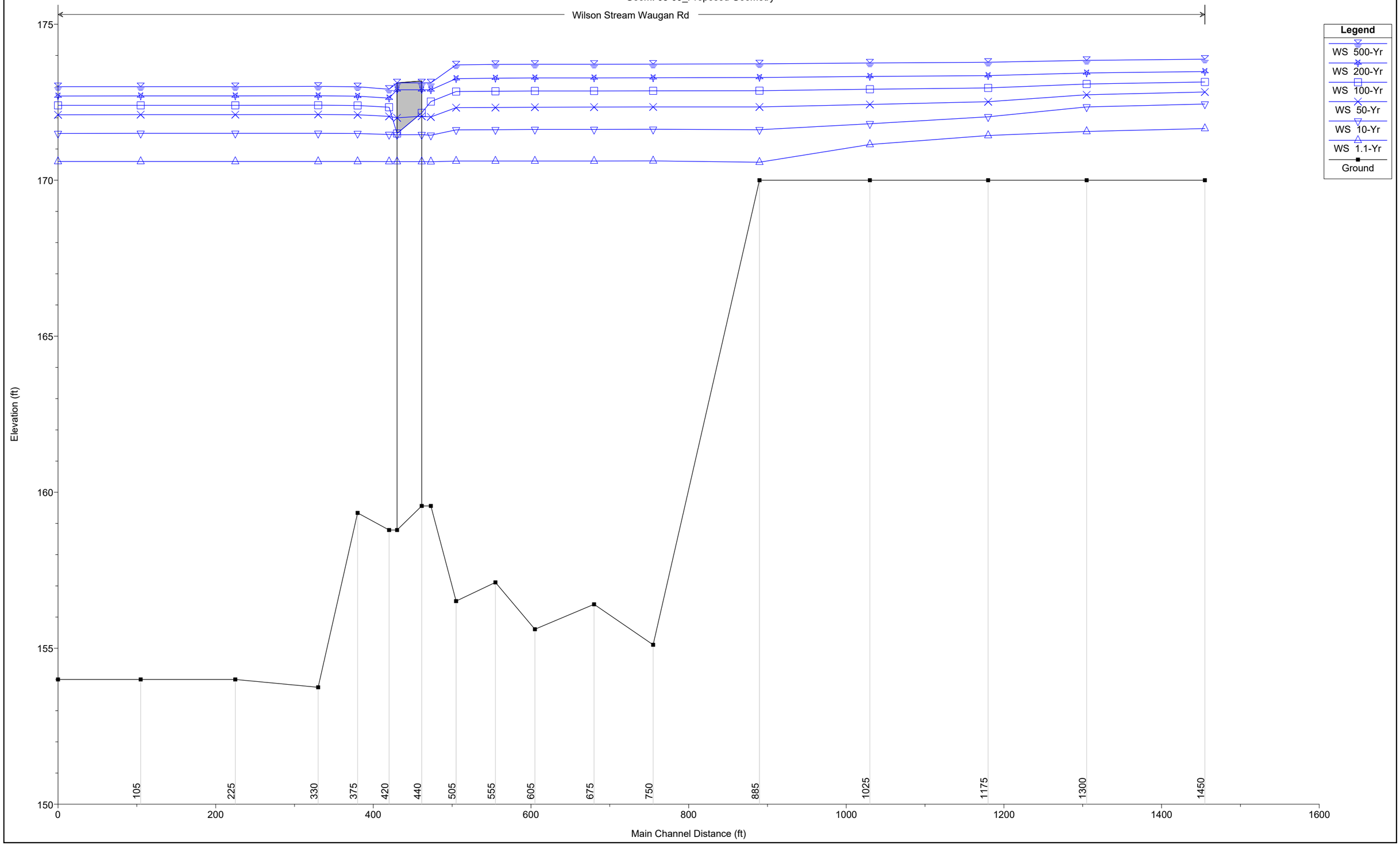
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Waugan Rd	1450	1.1-Yr	375.00	170.00	171.66		171.69	0.001147	1.49	331.18	806.14	0.23
Waugan Rd	1450	10-Yr	1255.00	170.00	172.44		172.51	0.001609	2.42	967.68	1029.52	0.30
Waugan Rd	1450	50-Yr	1810.00	170.00	172.83		172.90	0.001416	2.54	1369.21	1044.54	0.29
Waugan Rd	1450	100-Yr	2050.00	170.00	173.15		173.20	0.001008	2.33	1705.01	1069.99	0.25
Waugan Rd	1450	200-Yr	2305.00	170.00	173.49		173.53	0.000746	2.16	2074.10	1113.20	0.22
Waugan Rd	1450	500-Yr	2660.00	170.00	173.88		173.92	0.000576	2.06	2524.32	1163.74	0.19
Waugan Rd	1300	1.1-Yr	375.00	170.00	171.56		171.57	0.000510	0.94	746.46	1144.43	0.15
Waugan Rd	1300	10-Yr	1255.00	170.00	172.35		172.36	0.000529	1.34	1656.07	1174.60	0.17
Waugan Rd	1300	50-Yr	1810.00	170.00	172.74		172.76	0.000508	1.49	2119.86	1183.99	0.17
Waugan Rd	1300	100-Yr	2050.00	170.00	173.08		173.10	0.000373	1.39	2528.02	1192.21	0.15
Waugan Rd	1300	200-Yr	2305.00	170.00	173.44		173.45	0.000289	1.33	2951.20	1200.70	0.13
Waugan Rd	1300	500-Yr	2660.00	170.00	173.84		173.86	0.000236	1.31	3439.75	1210.43	0.12
Waugan Rd	1175	1.1-Yr	375.00	170.00	171.43		171.47	0.001580	1.59	238.39	963.93	0.27
Waugan Rd	1175	10-Yr	1255.00	170.00	172.03	171.35	172.21	0.004141	3.43	407.15	1092.20	0.46
Waugan Rd	1175	50-Yr	1810.00	170.00	172.52		172.64	0.002514	3.15	936.32	1105.16	0.37
Waugan Rd	1175	100-Yr	2050.00	170.00	172.96		173.03	0.001214	2.47	1431.52	1117.15	0.27
Waugan Rd	1175	200-Yr	2305.00	170.00	173.36		173.40	0.000756	2.14	1874.35	1128.36	0.22
Waugan Rd	1175	500-Yr	2660.00	170.00	173.78		173.82	0.000530	1.96	2358.41	1140.56	0.19
Waugan Rd	1025	1.1-Yr	375.00	170.00	171.14	170.71	171.18	0.002569	1.52	343.16	1153.54	0.31
Waugan Rd	1025	10-Yr	1255.00	170.00	171.81		171.84	0.001426	1.75	1127.97	1200.81	0.26
Waugan Rd	1025	50-Yr	1810.00	170.00	172.43		172.45	0.000637	1.49	1881.68	1228.62	0.19
Waugan Rd	1025	100-Yr	2050.00	170.00	172.92		172.93	0.000346	1.27	2482.34	1244.89	0.14
Waugan Rd	1025	200-Yr	2305.00	170.00	173.32		173.34	0.000244	1.18	2993.36	1258.02	0.12
Waugan Rd	1025	500-Yr	2660.00	170.00	173.76		173.77	0.000191	1.15	3542.32	1271.82	0.11
Waugan Rd	885	1.1-Yr	375.00	170.00	170.58	170.36	170.64	0.006491	1.96	191.58	810.59	0.47
Waugan Rd	885	10-Yr	1255.00	170.00	171.62		171.66	0.001227	1.70	986.56	1034.28	0.25
Waugan Rd	885	50-Yr	1810.00	170.00	172.35		172.37	0.000500	1.41	1753.28	1067.87	0.17
Waugan Rd	885	100-Yr	2050.00	170.00	172.87		172.89	0.000280	1.22	2315.98	1091.22	0.13
Waugan Rd	885	200-Yr	2305.00	170.00	173.29		173.31	0.000204	1.14	2778.06	1104.90	0.11
Waugan Rd	885	500-Yr	2660.00	170.00	173.73		173.75	0.000165	1.12	3267.00	1116.83	0.10
Waugan Rd	750	1.1-Yr	375.00	155.11	170.62		170.62	0.000002	0.31	1807.17	608.84	0.02
Waugan Rd	750	10-Yr	1255.00	155.11	171.63		171.64	0.000017	0.86	2515.94	735.63	0.04
Waugan Rd	750	50-Yr	1810.00	155.11	172.35		172.36	0.000026	1.08	3051.70	761.39	0.05
Waugan Rd	750	100-Yr	2050.00	155.11	172.86		172.88	0.000026	1.11	3449.70	776.30	0.05
Waugan Rd	750	200-Yr	2305.00	155.11	173.28		173.30	0.000027	1.16	3777.18	786.95	0.05
Waugan Rd	750	500-Yr	2660.00	155.11	173.72		173.74	0.000030	1.24	4123.89	797.36	0.06
Waugan Rd	675	1.1-Yr	375.00	156.41	170.62		170.62	0.000004	0.37	1827.11	515.66	0.02
Waugan Rd	675	10-Yr	1255.00	156.41	171.63		171.64	0.000027	1.02	2412.31	657.26	0.05
Waugan Rd	675	50-Yr	1810.00	156.41	172.34		172.36	0.000039	1.26	2915.46	727.74	0.06
Waugan Rd	675	100-Yr	2050.00	156.41	172.86		172.88	0.000038	1.28	3296.09	740.95	0.06
Waugan Rd	675	200-Yr	2305.00	156.41	173.28		173.30	0.000039	1.32	3608.91	751.70	0.06
Waugan Rd	675	500-Yr	2660.00	156.41	173.72		173.73	0.000042	1.39	3940.43	762.95	0.06
Waugan Rd	605	1.1-Yr	375.00	155.61	170.62		170.62	0.000006	0.41	1930.23	632.14	0.02
Waugan Rd	605	10-Yr	1255.00	155.61	171.63		171.64	0.000033	1.05	2611.96	720.46	0.05
Waugan Rd	605	50-Yr	1810.00	155.61	172.34		172.35	0.000044	1.26	3178.18	838.62	0.06
Waugan Rd	605	100-Yr	2050.00	155.61	172.86		172.87	0.000041	1.26	3624.79	883.68	0.06
Waugan Rd	605	200-Yr	2305.00	155.61	173.28		173.29	0.000041	1.29	4001.97	912.90	0.06
Waugan Rd	605	500-Yr	2660.00	155.61	173.72		173.73	0.000043	1.35	4407.60	939.66	0.06
Waugan Rd	555	1.1-Yr	375.00	157.11	170.61		170.62	0.000009	0.52	1483.76	624.01	0.03
Waugan Rd	555	10-Yr	1255.00	157.11	171.62		171.64	0.000051	1.30	2179.25	755.55	0.07
Waugan Rd	555	50-Yr	1810.00	157.11	172.33		172.35	0.000065	1.53	2746.01	839.06	0.07
Waugan Rd	555	100-Yr	2050.00	157.11	172.85		172.87	0.000060	1.50	3195.76	881.80	0.07
Waugan Rd	555	200-Yr	2305.00	157.11	173.27		173.29	0.000059	1.52	3571.21	906.38	0.07
Waugan Rd	555	500-Yr	2660.00	157.11	173.71		173.73	0.000061	1.58	3973.94	932.29	0.07
Waugan Rd	505	1.1-Yr	375.00	156.51	170.61		170.62	0.000011	0.54	1339.47	650.96	0.03
Waugan Rd	505	10-Yr	1255.00	156.51	171.61		171.63	0.000062	1.38	1889.59	781.21	0.07
Waugan Rd	505	50-Yr	1810.00	156.51	172.32		172.35	0.000083	1.65	2324.15	844.79	0.08
Waugan Rd	505	100-Yr	2050.00	156.51	172.84		172.87	0.000078	1.65	2671.49	888.76	0.08
Waugan Rd	505	200-Yr	2305.00	156.51	173.26		173.28	0.000095	1.85	3036.82	914.11	0.09
Waugan Rd	505	500-Yr	2660.00	156.51	173.70		173.72	0.000095	1.89	3444.18	940.55	0.09
Waugan Rd	473	1.1-Yr	375.00	159.56	170.59	163.99	170.61	0.000081	1.21	376.11	647.87	0.08
Waugan Rd	473	10-Yr	1255.00	159.56	171.44	166.39	171.61	0.000579	3.50	447.53	749.65	0.21

HEC-RAS Plan: 0809 River: Wilson Stream Reach: Waugan Rd (Continued)

Reach	River Sta	Profile	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)	
Waugan Rd	473	50-Yr	1810.00	159.56	172.03	167.36	172.31	0.000910	4.59	496.81	797.51	0.27
Waugan Rd	473	100-Yr	2050.00	159.56	172.52	167.68	172.83	0.000936	4.82	538.00	847.29	0.28
Waugan Rd	473	200-Yr	2305.00	159.56	172.90	168.03	173.25	0.001008	5.14	569.58	882.70	0.29
Waugan Rd	473	500-Yr	2660.00	159.56	173.12	168.57	173.64	0.001441	6.24	588.36	901.52	0.35
Waugan Rd	440		Bridge									
Waugan Rd	420	1.1-Yr	375.00	158.79	170.60		170.61	0.000040	0.97	556.40	652.17	0.06
Waugan Rd	420	10-Yr	1255.00	158.79	171.47		171.56	0.000272	2.70	706.74	771.92	0.15
Waugan Rd	420	50-Yr	1810.00	158.79	172.05		172.19	0.000419	3.48	806.55	831.18	0.19
Waugan Rd	420	100-Yr	2050.00	158.79	172.34		172.51	0.000465	3.73	856.93	851.31	0.20
Waugan Rd	420	200-Yr	2305.00	158.79	172.63		172.82	0.000511	3.98	907.24	871.41	0.21
Waugan Rd	420	500-Yr	2660.00	158.79	172.92		173.14	0.000595	4.37	956.57	891.13	0.23
Waugan Rd	375	1.1-Yr	375.00	159.34	170.60		170.60	0.000011	0.52	1141.86	696.85	0.03
Waugan Rd	375	10-Yr	1255.00	159.34	171.50		171.52	0.000071	1.41	1522.32	924.42	0.08
Waugan Rd	375	50-Yr	1810.00	159.34	172.10		172.13	0.000105	1.78	1784.96	944.42	0.10
Waugan Rd	375	100-Yr	2050.00	159.34	172.40		172.43	0.000114	1.89	1917.59	952.84	0.10
Waugan Rd	375	200-Yr	2305.00	159.34	172.70		172.74	0.000123	2.00	2051.06	961.25	0.11
Waugan Rd	375	500-Yr	2660.00	159.34	172.99		173.04	0.000140	2.17	2185.26	969.65	0.11
Waugan Rd	330	1.1-Yr	375.00	153.75	170.60		170.60	0.000003	0.30	2394.91	712.39	0.02
Waugan Rd	330	10-Yr	1255.00	153.75	171.50		171.51	0.000021	0.82	3135.94	897.87	0.04
Waugan Rd	330	50-Yr	1810.00	153.75	172.11		172.12	0.000030	1.01	3682.28	916.16	0.05
Waugan Rd	330	100-Yr	2050.00	153.75	172.41		172.42	0.000032	1.06	3958.79	923.94	0.05
Waugan Rd	330	200-Yr	2305.00	153.75	172.71		172.72	0.000035	1.12	4237.61	931.72	0.06
Waugan Rd	330	500-Yr	2660.00	153.75	173.01		173.02	0.000039	1.21	4520.31	1060.02	0.06
Waugan Rd	225	1.1-Yr	375.00	154.00	170.60		170.60	0.000002	0.28	2354.88	672.19	0.01
Waugan Rd	225	10-Yr	1255.00	154.00	171.50		171.51	0.000016	0.80	3090.51	918.25	0.04
Waugan Rd	225	50-Yr	1810.00	154.00	172.10		172.11	0.000024	1.00	3648.05	984.87	0.05
Waugan Rd	225	100-Yr	2050.00	154.00	172.40		172.41	0.000026	1.07	3930.50	1025.02	0.05
Waugan Rd	225	200-Yr	2305.00	154.00	172.70		172.71	0.000028	1.13	4215.13	1065.16	0.05
Waugan Rd	225	500-Yr	2660.00	154.00	173.00		173.02	0.000033	1.22	4502.54	1155.89	0.06
Waugan Rd	105	1.1-Yr	375.00	154.00	170.60		170.60	0.000002	0.26	2676.37	844.86	0.01
Waugan Rd	105	10-Yr	1255.00	154.00	171.50		171.51	0.000013	0.73	3544.00	1031.50	0.04
Waugan Rd	105	50-Yr	1810.00	154.00	172.10		172.11	0.000020	0.91	4170.82	1143.89	0.04
Waugan Rd	105	100-Yr	2050.00	154.00	172.40		172.41	0.000021	0.96	4488.54	1178.97	0.05
Waugan Rd	105	200-Yr	2305.00	154.00	172.70		172.71	0.000023	1.02	4808.57	1214.05	0.05
Waugan Rd	105	500-Yr	2660.00	154.00	173.00		173.01	0.000027	1.10	5131.47	1288.48	0.05
Waugan Rd	0	1.1-Yr	375.00	154.00	170.60	156.66	170.60	0.000002	0.26	2719.63	1009.64	0.01
Waugan Rd	0	10-Yr	1255.00	154.00	171.50	158.55	171.51	0.000013	0.72	3694.38	1158.50	0.04
Waugan Rd	0	50-Yr	1810.00	154.00	172.10	159.35	172.11	0.000019	0.89	4410.97	1371.88	0.04
Waugan Rd	0	100-Yr	2050.00	154.00	172.40	159.66	172.41	0.000021	0.94	4779.29	1397.32	0.04
Waugan Rd	0	200-Yr	2305.00	154.00	172.70	159.98	172.71	0.000022	0.99	5150.66	1422.76	0.05
Waugan Rd	0	500-Yr	2660.00	154.00	173.00	160.38	173.01	0.000025	1.07	5525.05	1448.20	0.05

0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

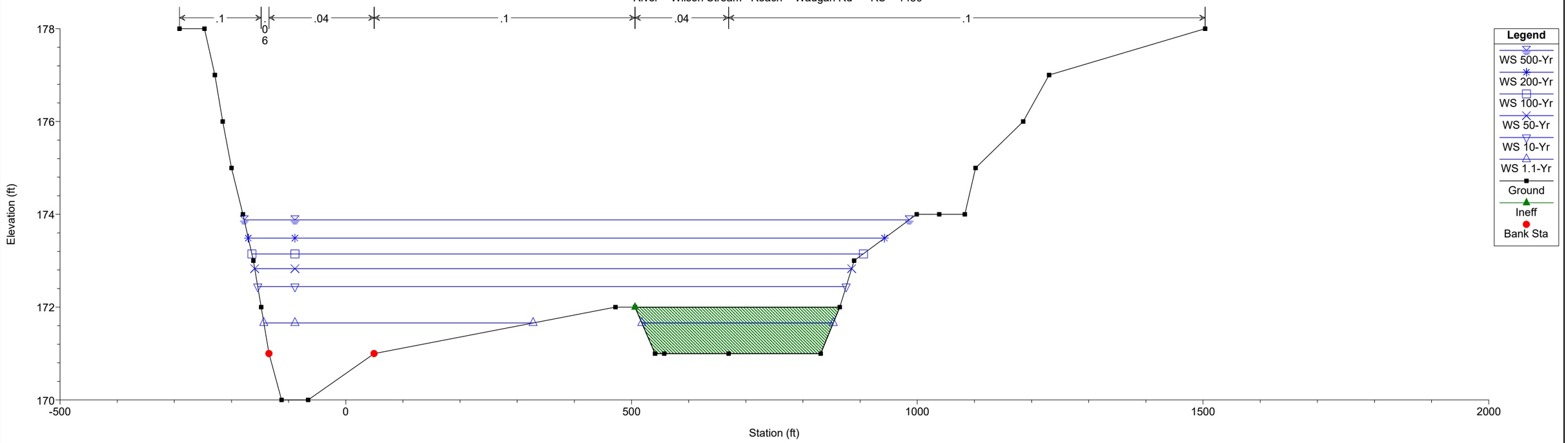
Geom: 08-09_Proposed Geometry



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

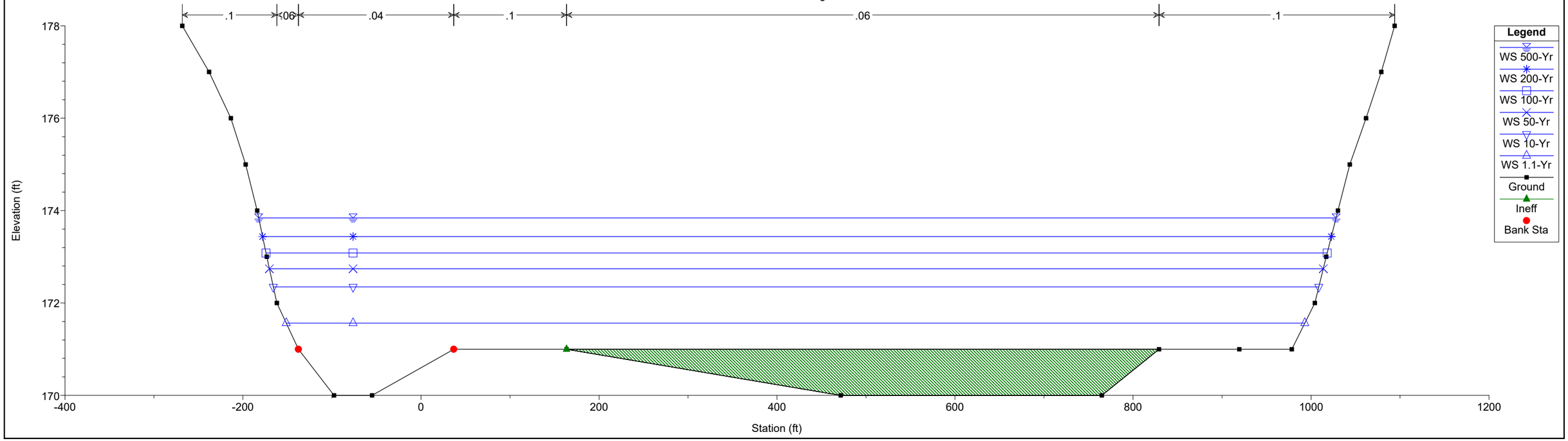
River = Wilson Stream Reach = Waugan Rd RS = 1450



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

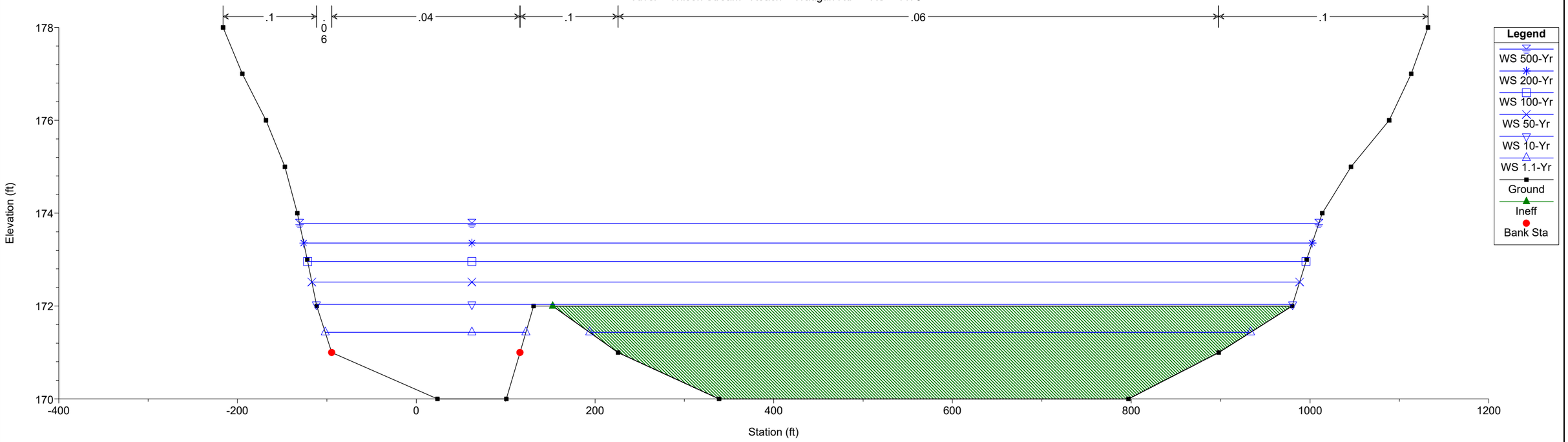
River = Wilson Stream Reach = Waugan Rd RS = 1300



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

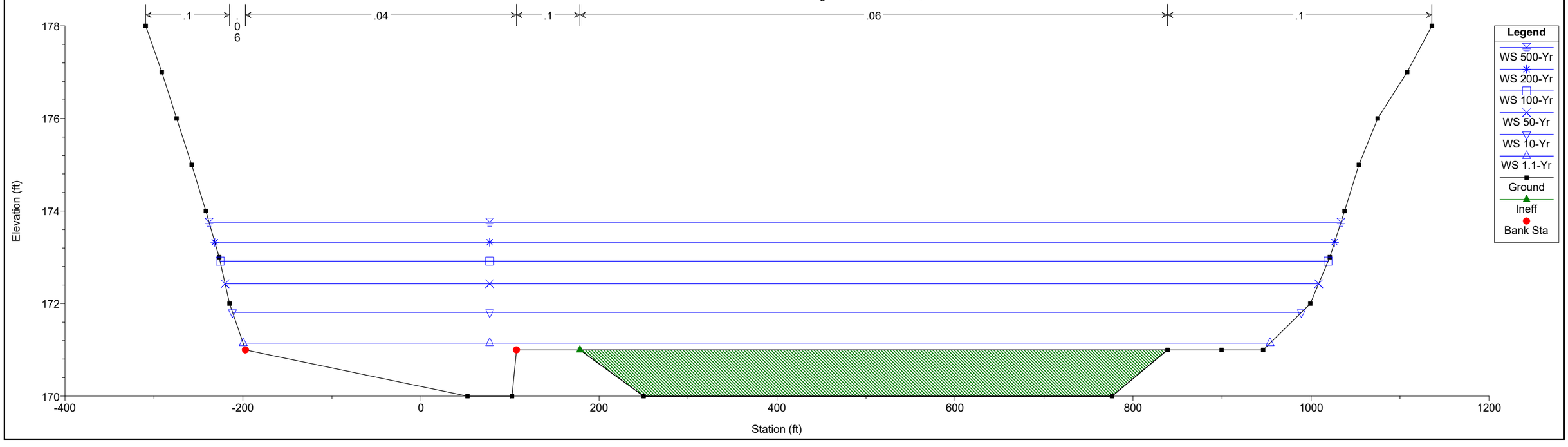
River = Wilson Stream Reach = Waugan Rd RS = 1175



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

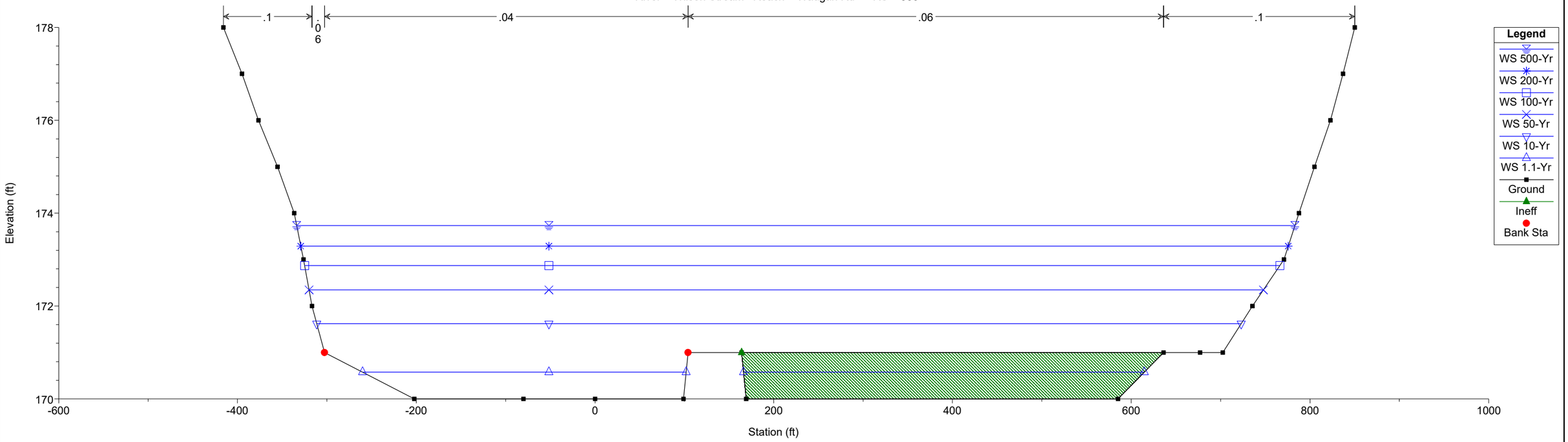
River = Wilson Stream Reach = Waugan Rd RS = 1025



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

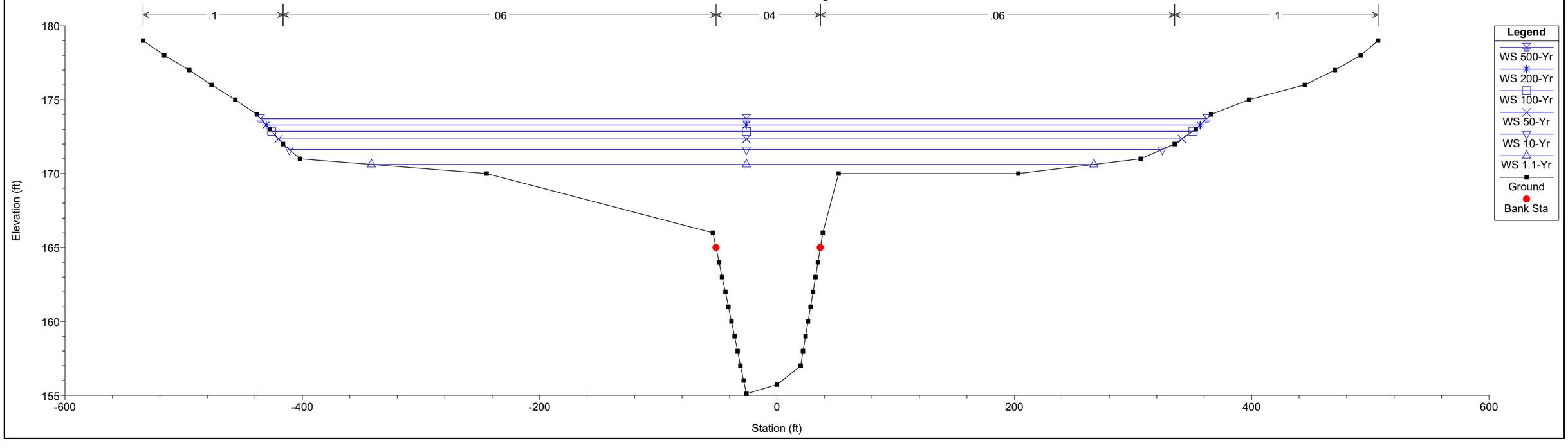
River = Wilson Stream Reach = Waugan Rd RS = 885



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

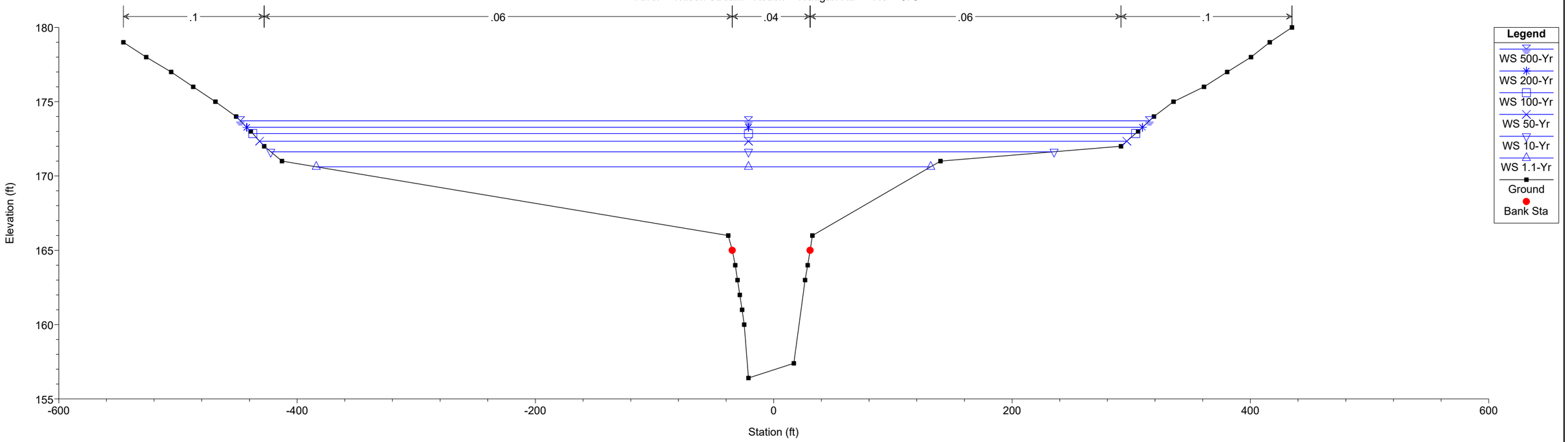
River = Wilson Stream Reach = Waugan Rd RS = 750



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

River = Wilson Stream Reach = Waugan Rd RS = 675



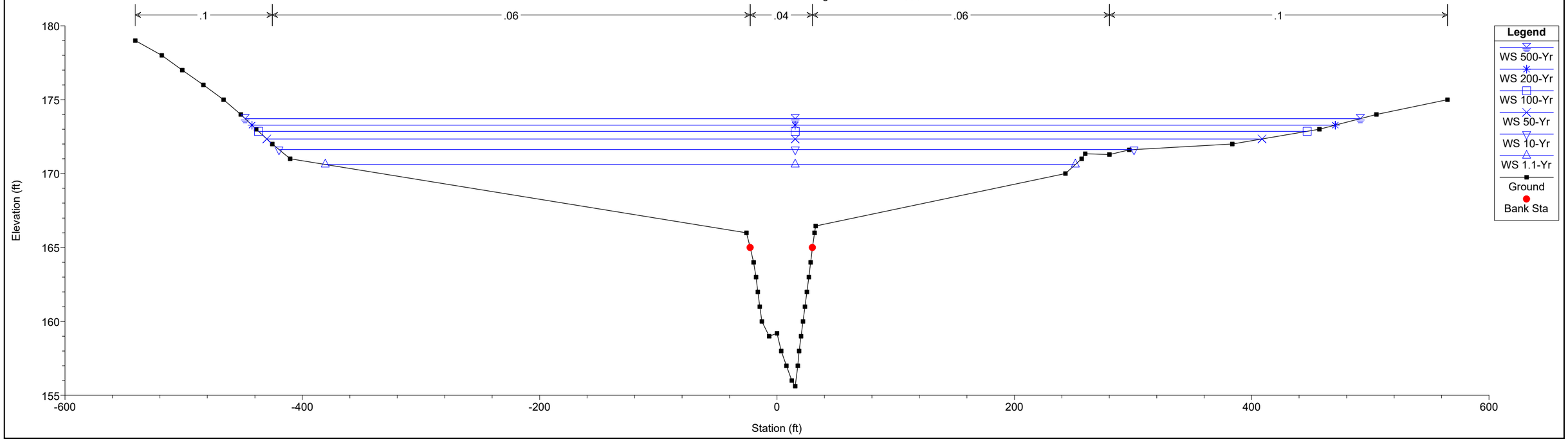
0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Station (ft)

0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

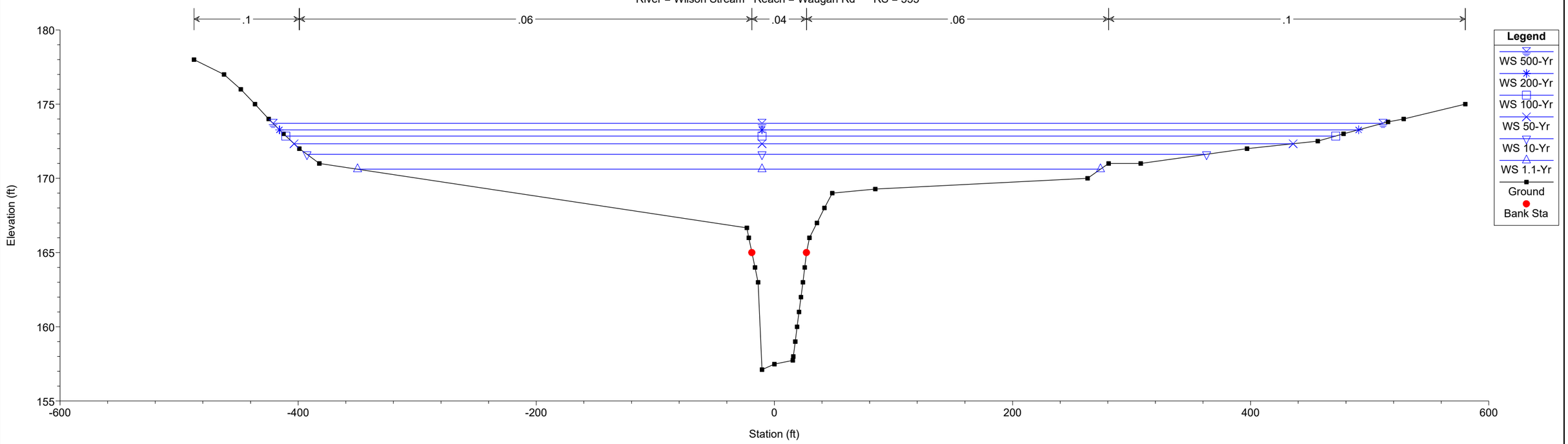
River = Wilson Stream Reach = Waugan Rd RS = 605



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

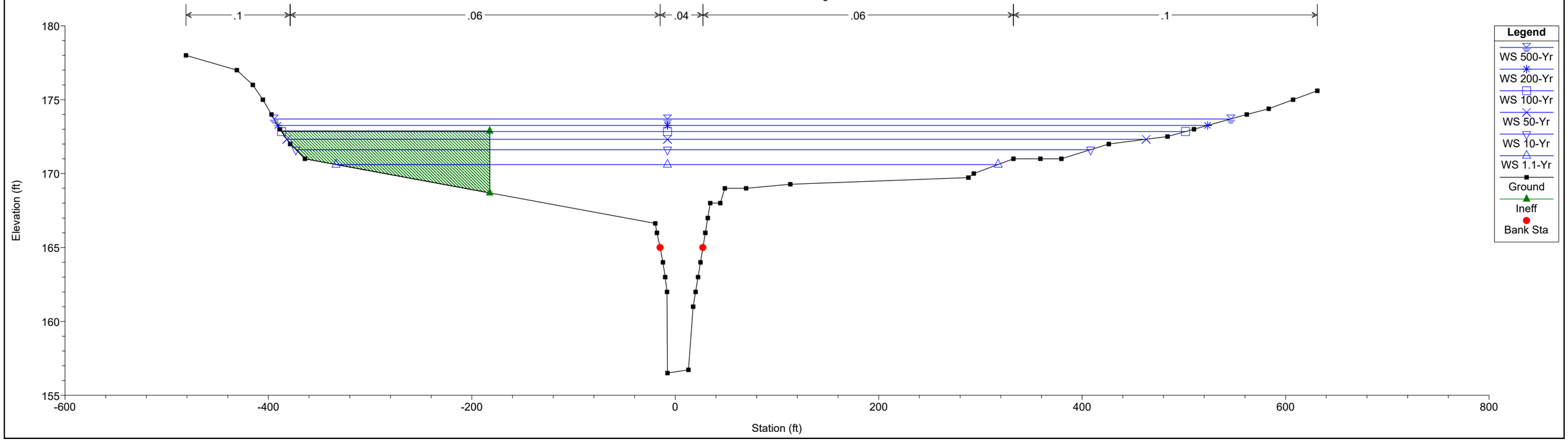
River = Wilson Stream Reach = Waugan Rd RS = 555



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

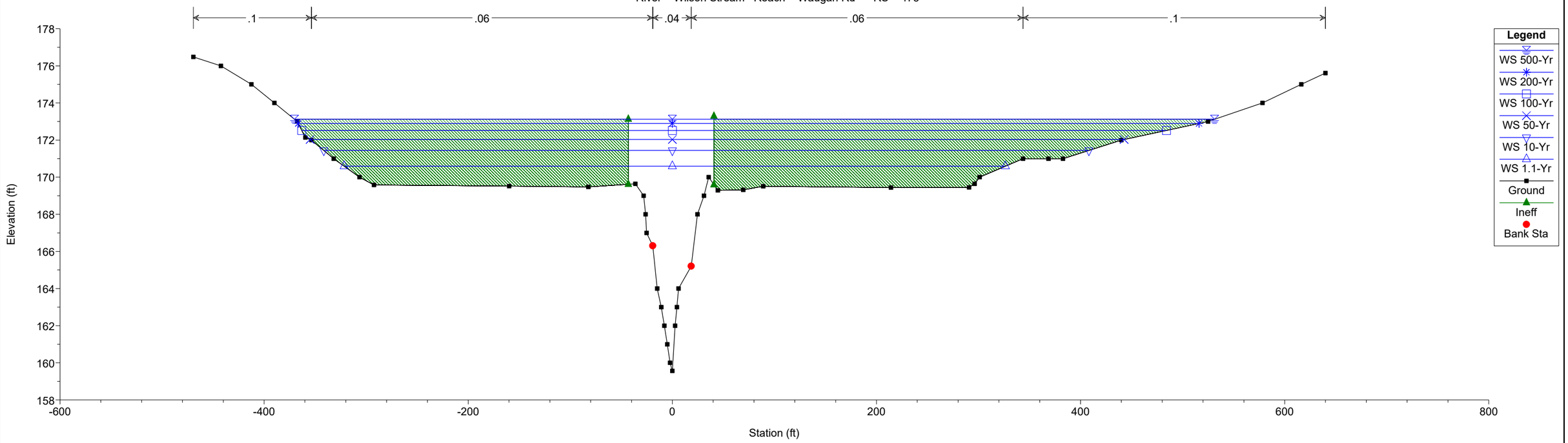
River = Wilson Stream Reach = Waugan Rd RS = 505



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

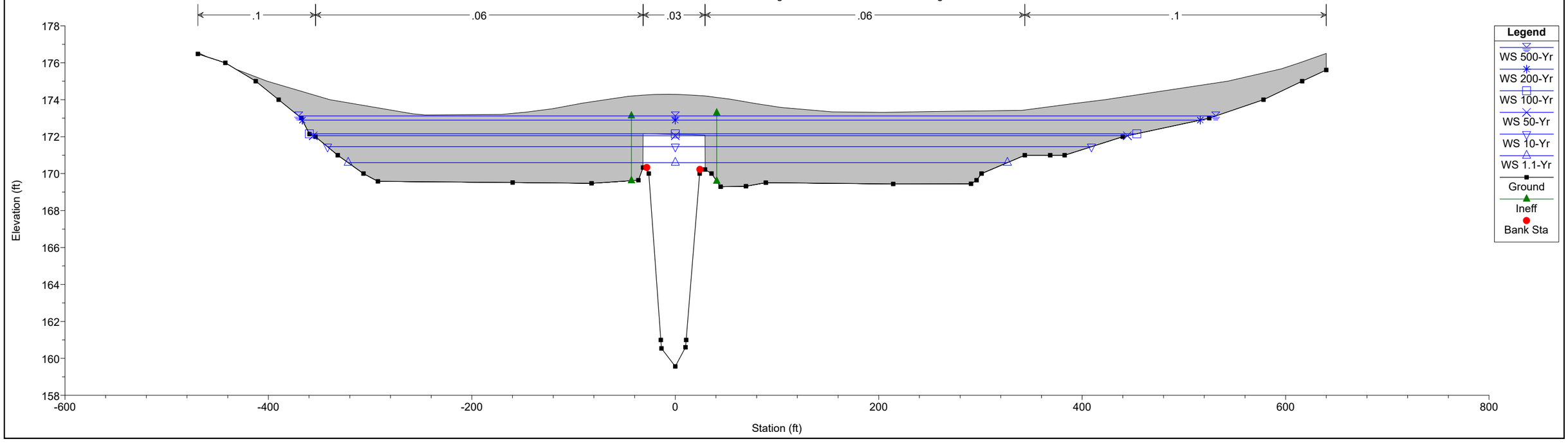
River = Wilson Stream Reach = Waugan Rd RS = 473



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

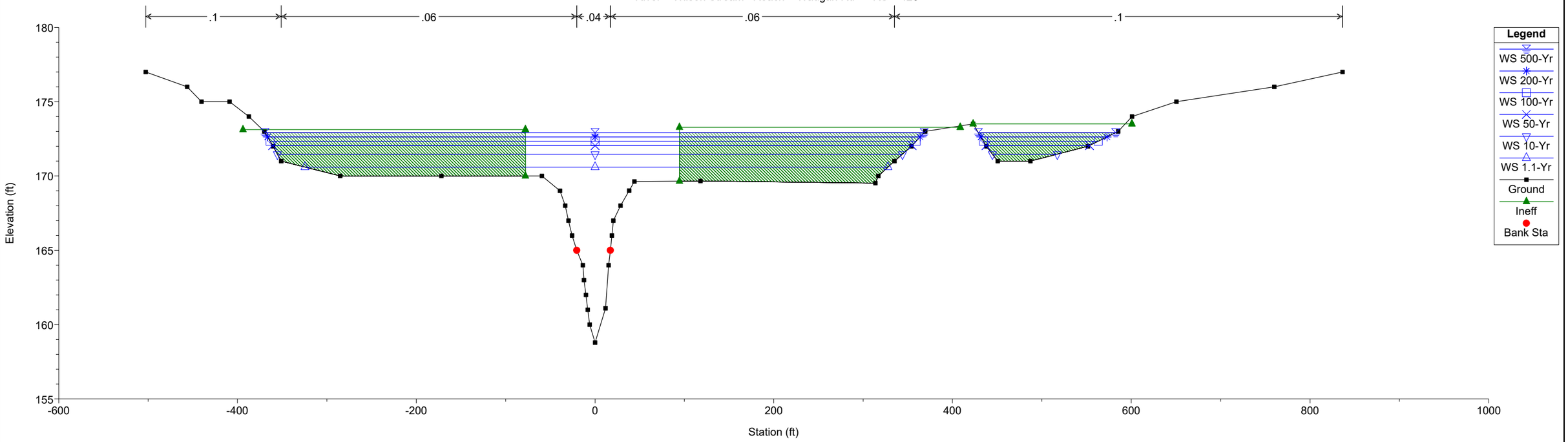
River = Wilson Stream Reach = Waugan Rd RS = 440 BR Waugan Rd



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

River = Wilson Stream Reach = Waugan Rd RS = 420



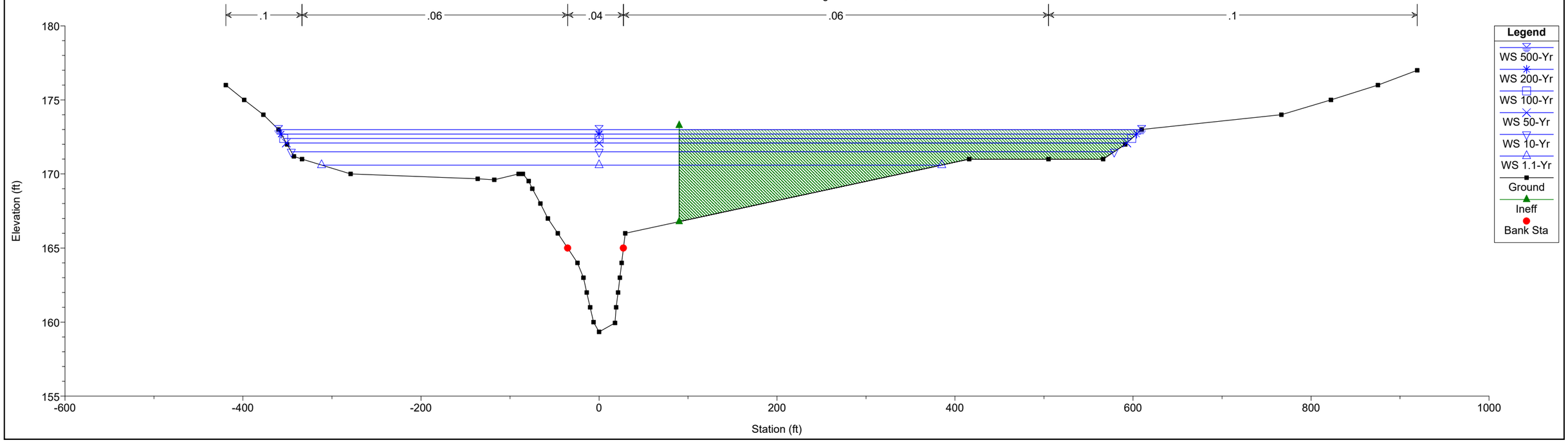
0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Station (ft)

0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

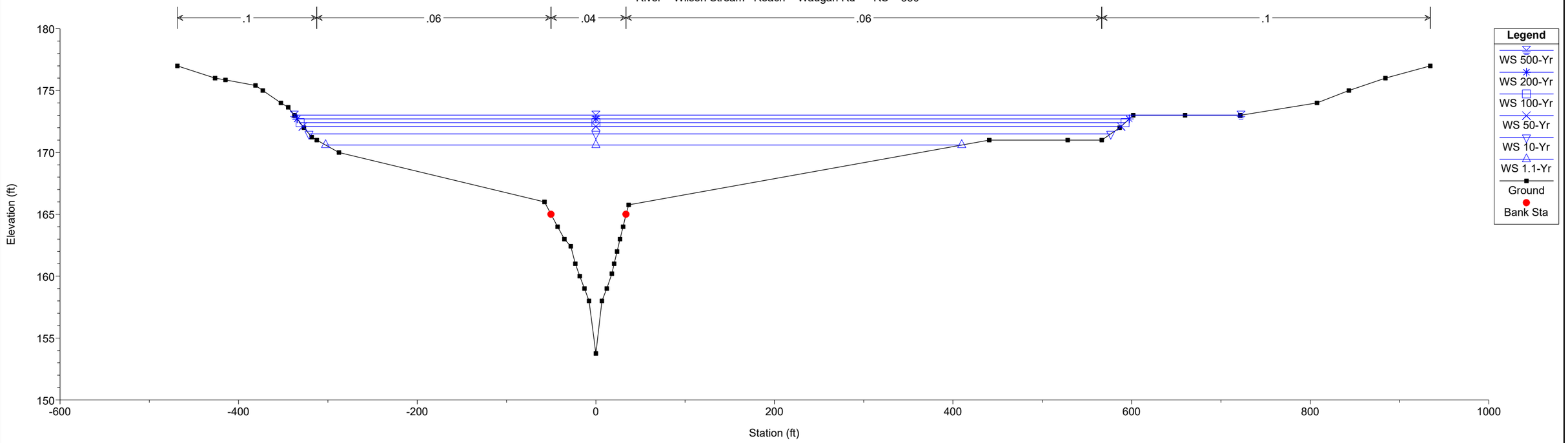
River = Wilson Stream Reach = Waugan Rd RS = 375



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

River = Wilson Stream Reach = Waugan Rd RS = 330



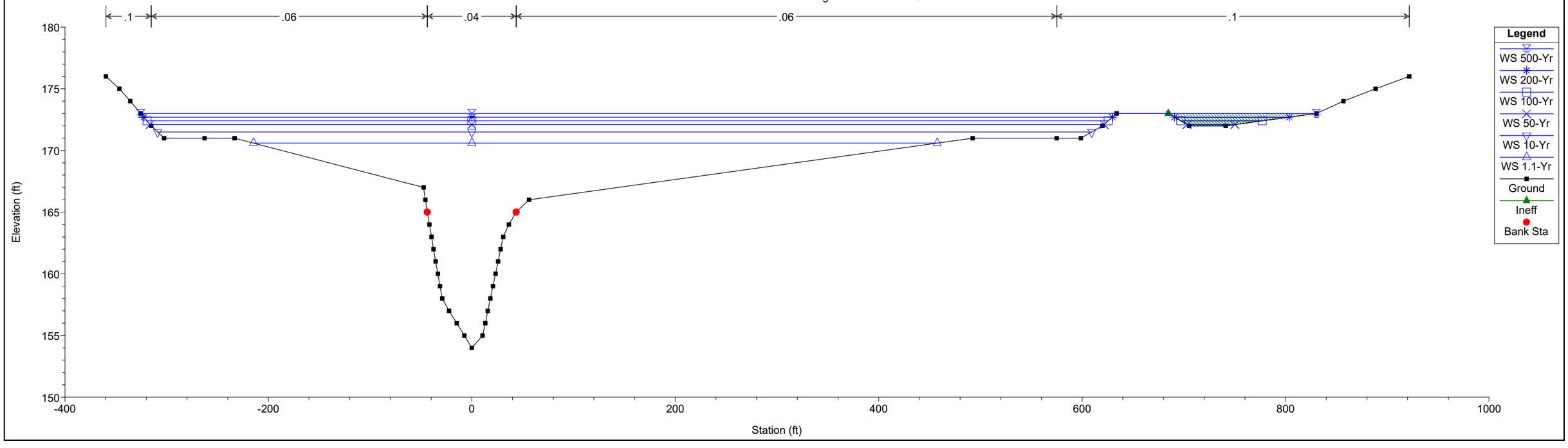
0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Station (ft)

0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

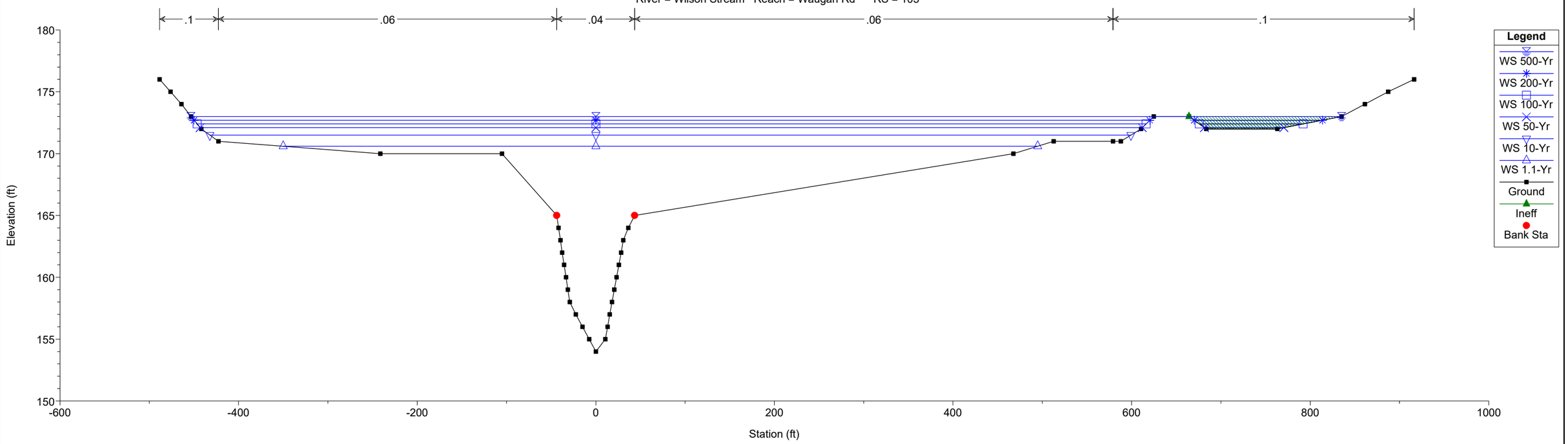
River = Wilson Stream Reach = Waugan Rd RS = 225



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

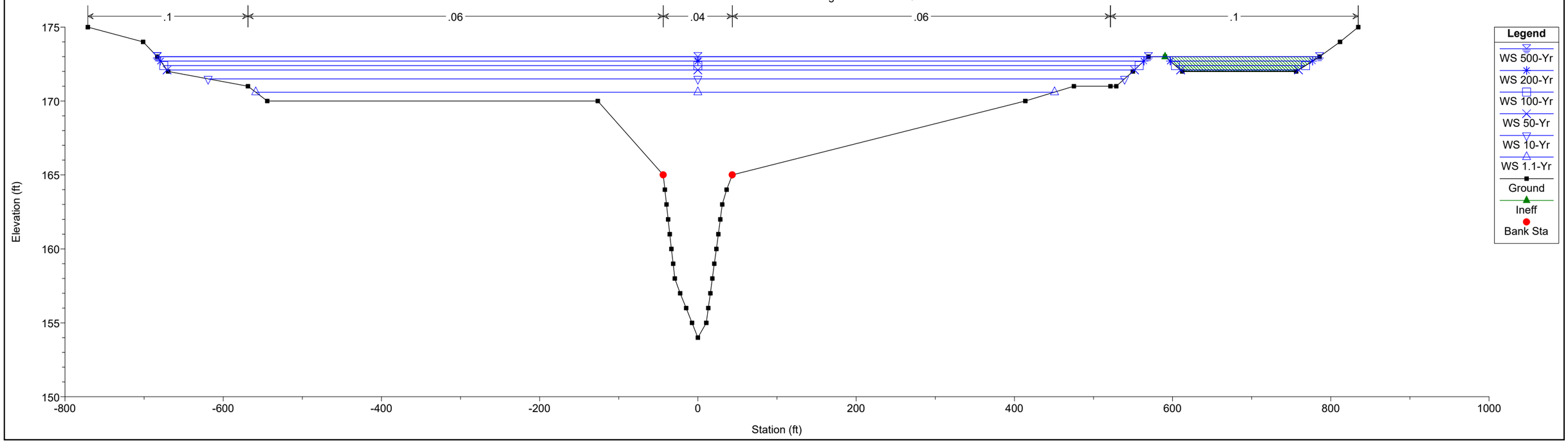
River = Wilson Stream Reach = Waugan Rd RS = 105



0809_67328_MaineDOT Waggon Bridge Plan: 08-09_Proposed Plan 8/30/2024

Geom: 08-09_Proposed Geometry

River = Wilson Stream Reach = Waugan Rd RS = 0



APPENDIX F

Scour Analysis

Summary of Scour Analysis Results

Abutment Scour			
Storm Event	**Streambed Material**	**Abutment Location**	**NCHRP Total Scour (ft)**
200-Year	D_{50} = 0.063 mm	Left	**20.21**
		Right	**20.35**
100-Year	D_{50} = 0.063 mm	Left	**18.11**
		Right	**18.25**

Notes:

1. Left = Northern, Right = Southern

National Cooperative Highway Research Program (NCHRP) 24-20 Abutment Scour Analysis

Check Event: 200-Year

Abutment Location	Floodplain Limit Station	Abutment Station	L (ft)	Channel Bank Station	B_f (ft)	L/B_f (%)	Contraction Scour Type	Set-Back Length (ft)	y_0 (ft)	Set-Back Ratio	Velocity Calculation Method
Left (North)	-366.57	-31.70	334.9	-27.97	338.60	98.9%	Live-Bed	3.73	11.62	0.32	Q/A of Bridge
Right (South)	516.12	29.30	486.8	24.23	491.89	99.0%	Live-Bed	5.07	11.48	0.44	Q/A of Bridge

Live-Bed Scour

Abutment Location	Q_{Bridge} (cfs)	A_{Bridge} (ft^2)	V_{Bridge} (ft/s)	$V_{Approach}$ (ft/s)	y_1 (ft)	q_1 (cfs/ft)	Bridge Opening Width (ft)	q_{2c} (cfs/ft)	q_{2c}/q_1	y_c (ft)	α_A	y_{max} (ft)
Left (North)	2,302	485.55	4.74	1.85	13.79	25.51	61.00	37.74	1.48	19.29	1.65	31.83
Right (South)	2,302	485.55	4.74	1.85	13.79	25.51	61.00	37.74	1.48	19.29	1.65	31.83

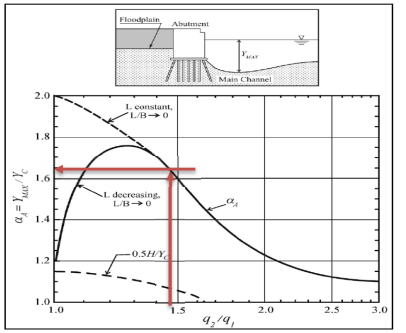


Figure 8.10. Scour amplification factor for wingwall abutments and live-bed conditions (NCHRP 2010b).

Clear-Water Scour

Abutment Location	WSEL at Bridge	Low Chord Elevation	Streambed Elevation at Abutment	Depth of Flow at Abutment (ft)	Q_{Bridge} (cfs)	A_{Bridge} (ft^2)	V_{Bridge} (ft/s)	q_{2f} (cfs/ft)	Upstream Floodplain Depth (ft)	q_f (cfs/ft)	q_{2f}/q_f	K_u	D_{50} (mm)	D_{50} (ft)	y_c (ft)	α_B	y_{max} (ft)
Left (North)	172.9	172.16	160.54	11.62	2,302	485.55	4.74	N/A	2.72	N/A	N/A	11.7	0.06	0.00	N/A		N/A
Right (South)	172.9	172.08	160.60	11.48	2,302	485.55	4.74	N/A	2.89	N/A	N/A	11.7	0.06	0.00	N/A		N/A

Total Scour

Abutment Location	y_{max} (ft)	WSEL at Bridge	Low Chord Elevation	Streambed Elevation at Abutment	y_0 (ft)	y_s (ft)
Left (North)	31.83	172.9	172.16	160.54	11.62	20.21
Right (South)	31.83	172.9	172.08	160.60	11.48	20.35

Equations:

$y_s = y_{max} - y_0$

Live-Bed

$y_{max} = \alpha_a\, y_c$

$y_c = y_1\,(q_{2c}/q_1)^{6/7}$

Clear-Water

$y_{max} = \alpha_b\, y_c$

$y_c = (q_{2f}/K_u D_{50}^{1/3})^{6/7}$

Legend

α_A	Amplification factor for live-bed conditions
α_B	Amplification factor for clear-water conditions
A_{Bridge}	Bridge Open Area, ft^2
B_f	Floodplain width, ft
D_{50}	Particle size with 50 percent finer, ft
K_u	11.17 English units
L	Embankment Length, ft
q_1	Upstream channel unit discharge, ft^2/s
q_{2c}	Unit discharge in the constricted opening accounting for non-uniform flow distribution, ft^2/s
q_{2f}	Unit discharge in the constricted opening accounting for non-uniform flow distribution, ft^2/s
Q_{Bridge}	Discharge though the bridge from HEC-RAS tables, cfs
q_f	Unit discharge in the floodplain upstream of the bridge, ft^2/s
y_0	Flow depth prior to scour, ft
y_1	Upstream channel flow depth, ft
y_c	Flow depth including live-bed or clear-water contraction scour, ft
y_{max}	Max. flow depth resulting from abutment scour, ft
y_s	Abutment scour depth, ft

National Cooperative Highway Research Program (NCHRP) 24-20 Abutment Scour Analysis

Design Event: 100-Year

Abutment Location	Floodplain Limit Station	Abutment Station	L (ft)	Channel Bank Station	B_f (ft)	L/B_f (%)	Contraction Scour Type	Set-Back Length (ft)	y_0 (ft)	Set-Back Ratio	Velocity Calculation Method
Left (North)	-359.74	-31.70	328	-27.97	331.77	98.9%	Live-Bed	3.73	11.62	0.32	Q/A of Bridge
Right (South)	453.59	29.30	424.3	24.23	429.36	98.8%	Live-Bed	5.07	11.48	0.44	Q/A of Bridge

Live-Bed Scour

Abutment Location	Q_{Bridge} (cfs)	A_{Bridge} (ft^2)	V_{Bridge} (ft/s)	$V_{Approach}$ (ft/s)	y_1 (ft)	q_1 (cfs/ft)	Bridge Opening Width (ft)	q_{2c} (cfs/ft)	q_{2c}/q_1	y_c (ft)	α_A	y_{max} (ft)
Left (North)	2,050	485.55	4.22	1.65	13.37	22.06	61.00	33.61	1.52	19.18	1.55	29.73
Right (South)	2,050	485.55	4.22	1.65	13.37	22.06	61.00	33.61	1.52	19.18	1.55	29.73

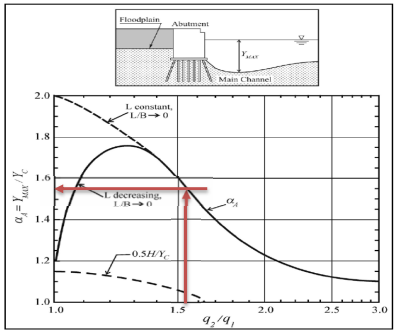


Figure 8.10. Scour amplification factor for wingwall abutments and live-bed conditions (NCHRP 2010b).

Clear-Water Scour

Abutment Location	WSEL at Bridge	Low Chord Elevation	Streambed Elevation at Abutment	Depth of Flow at Abutment (ft)	Q_{Bridge} (cfs)	A_{Bridge} (ft^2)	V_{Bridge} (ft/s)	q_{2f} (cfs/ft)	Upstream Floodplain Depth (ft)	q_f (cfs/ft)	q_{2f}/q_f	K_u	D_{50} (mm)	D_{50} (ft)	y_c (ft)	α_B	y_{max} (ft)
Left (North)	172.16	172.16	160.54	11.62	2,050	485.55	4.22	N/A	5.23	N/A	N/A	11.7	0.06	0.00	N/A	1.5	N/A
Right (South)	172.16	172.08	160.60	11.48	2,050	485.55	4.22	N/A	2.60	N/A	N/A	11.7	0.06	0.00	N/A	1.2	N/A

Total Scour

Abutment Location	y_{max} (ft)	WSEL at Bridge	Low Chord Elevation	Streambed Elevation at Abutment	y_0 (ft)	y_s (ft)
Left (North)	29.73	172.16	172.16	160.54	11.62	18.11
Right (South)	29.73	172.16	172.08	160.60	11.48	18.25

Equations:

$y_s = y_{max} - y_0$

Live-Bed

$y_{max} = \alpha_a\, y_c$

$y_c = y_1\,(q_{2c}/q_1)^{6/7}$

Clear-Water

$y_{max} = \alpha_b\, y_c$

$y_c = (q_{2f}/K_u D_{50}^{1/3})^{6/7}$

Legend

α_A	Amplification factor for live-bed conditions
α_B	Amplification factor for clear-water conditions
A_{Bridge}	Bridge Open Area, ft^2
B_f	Floodplain width, ft
D_{50}	Particle size with 50 percent finer, ft
K_u	11.17 English units
L	Embankment Length, ft
q_1	Upstream channel unit discharge, ft^2/s
q_{2c}	Unit discharge in the constricted opening accounting for non-uniform flow distribution, ft^2/s
q_{2f}	Unit discharge in the constricted opening accounting for non-uniform flow distribution, ft^2/s
Q_{Bridge}	Discharge though the bridge from HEC-RAS tables, cfs
q_f	Unit discharge in the floodplain upstream of the bridge, ft^2/s
y_0	Flow depth prior to scour, ft
y_1	Upstream channel flow depth, ft
y_c	Flow depth including live-bed or clear-water contraction scour, ft
y_{max}	Max. flow depth resulting from abutment scour, ft
y_s	Abutment scour depth, ft

Plan: Proposed Wilson Stream Waugan Rd RS: 505 Profile: 200-Yr

	E.G. Elev (ft)	173.25	Element	Left OB	Channel	Right OB	Approach
	Vel Head (ft)	0.35	Wt. n-Val.	0.06	0.04	0.063	
	W.S. Elev (ft)	172.9	Reach Len. (ft)	53	32	20	
	Crit W.S. (ft)	168.03	Flow Area (sq ft)	1024.07	579.01	1433.74	
S1 =	E.G. Slope (ft/ft)	0.001008	Area (sq ft)	1598.76	579.01	1433.74	
	Q Total (cfs)	2305	Flow (cfs)	490.41	1073.73	740.86	= Q1
	Top Width (ft)	882.7	Top Width (ft)	375.91	42	496.19	= W1
	Vel Total (ft/s)	4.05	Avg. Vel. (ft/s)	0.48	1.85	0.52	= V1
	Max Chl Dpth (ft)	13.34	Hydr. Depth (ft)	2.720	13.79	2.890	= Y1
	Conv. Total (cfs)	72589.1	Conv. (cfs)	50237.500	109992.60	75893.800	
	Length Wtd. (ft)	11.5	Wetted Per. (ft)	376.32	50.07	496.94	
	Min Ch El (ft)	159.56	Shear (lb/sq ft)	0.02	0.07	0.02	
	Alpha	1.37	Stream Power (lb/ft s)	0.01	0.13	0.01	
	Frctn Loss (ft)		Cum Volume (acre-ft)	13.23	11.45	17.14	
	C & E Loss (ft)		Cum SA (acres)	4.23	0.83	5.25	

Plan: Proposed Wilson Stream Waugan Rd RS: 473 Profile: 200-Yr

	E.G. Elev (ft)	173.25	Element	Left OB	Channel	Right OB	U/S Face
	Vel Head (ft)	0.35	Wt. n-Val.	0.06	0.04	0.06	
	W.S. Elev (ft)	172.9	Reach Len. (ft)	11.5	11.5	11.5	
	Crit W.S. (ft)	168.03	Flow Area (sq ft)	103.16	368.2	98.23	
	E.G. Slope (ft/ft)	0.001008	Area (sq ft)	1083.57	368.2	1284.87	
	Q Total (cfs)	2305	Flow (cfs)	210.27	1891.95	202.78	
	Top Width (ft)	882.7	Top Width (ft)	347.37	37.72	497.61	
	Vel Total (ft/s)	4.05	Avg. Vel. (ft/s)	2.04	5.14	2.06	
	Max Chl Dpth (ft)	13.34	Hydr. Depth (ft)	4.30	9.76	4.41	
	Conv. Total (cfs)	72589.1	Conv. (cfs)	6621.9	59581.3	6385.9	
	Length Wtd. (ft)	11.5	Wetted Per. (ft)	24.72	40.5	23.1	
	Min Ch El (ft)	159.56	Shear (lb/sq ft)	0.26	0.57	0.27	
	Alpha	1.37	Stream Power (lb/ft s)	0.54	2.94	0.55	
	Frctn Loss (ft)		Cum Volume (acre-ft)	11.6	11.1	16.52	
	C & E Loss (ft)		Cum SA (acres)	3.79	0.8	5.03	

Plan: Proposed Wilson Stream Waugan Rd RS: 440 BR U Profile: 200-Yr

	E.G. Elev (ft)	173.25	Element	Left OB	Channel	Right OB	
	Vel Head (ft)	0.36	Wt. n-Val.				
	W.S. Elev (ft)	172.9	Reach Len. (ft)	31.3	31.3	31.3	
	Crit W.S. (ft)	166.13	Flow Area (sq ft)	6.84	469.21	9.49	
	E.G. Slope (ft/ft)		Area (sq ft)	6.84	469.21	9.49	
	Q Total (cfs)	2305	Flow (cfs)	14.5	2273.52	16.69	$=Q_2$
	Top Width (ft)		Top Width (ft)				= W2
	Vel Total (ft/s)	4.75	Avg. Vel. (ft/s)	2.12	4.85	1.76	
	Max Chl Dpth (ft)	13.34	Hydr. Depth (ft)				$=Y_0$
	Conv. Total (cfs)		Conv. (cfs)				
	Length Wtd. (ft)	31.3	Wetted Per. (ft)	9.32	110.64	12.05	
	Min Ch El (ft)	159.56	Shear (lb/sq ft)				
	Alpha	1.03	Stream Power (lb/ft s)				
	Frctn Loss (ft)		Cum Volume (acre-ft)	11.45	10.99	16.35	
	C & E Loss (ft)		Cum SA (acres)	3.75	0.79	4.96	

Plan: Proposed Wilson Stream Waugan Rd RS: 440 Profile: 200-Yr

E.G. US. (ft)	173.25	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	172.9	E.G. Elev (ft)	173.25	173.24
Q Total (cfs)	2305	W.S. Elev (ft)	172.9	172.9
Q Bridge (cfs)	2302.1	Crit W.S. (ft)	166.13	165.86
Q Weir (cfs)	2.75	Max Chl Dpth (ft)	13.34	14.11
Weir Sta Lft (ft)	-253.54	Vel Total (ft/s)	4.75	5.06
Weir Sta Rgt (ft)	-190.47	Flow Area (sq ft)	485.55	455.68
Weir Submerg	0	Froude # Chl	0.23	0.24
Weir Max Depth (ft)	0.13	Specif Force (cu ft)	3171.3	3270.61
Min El Weir Flow (ft)	173.19	Hydr Depth (ft)		
Min El Prs (ft)	172.16	W.P. Total (ft)	132.01	130.89
Delta EG (ft)	0.43	Conv. Total (cfs)		
Delta WS (ft)	0.27	Top Width (ft)		
BR Open Area (sq ft)	455.68	Frctn Loss (ft)		
BR Open Vel (ft/s)	5.05	C & E Loss (ft)		
BR Sluice Coef		Shear Total (lb/sq ft)		
BR Sel Method	Press/Weir	Power Total (lb/ft s)		

Plan: Proposed Wilson Stream Waugan Rd RS: 505 Profile: 100-Yr — Approach

	E.G. Elev (ft)	172.87	Element	Left OB	Channel	Right OB	
	Vel Head (ft)	0.02	Wt. n-Val.	0.06	0.04	0.062	
	W.S. Elev (ft)	172.84	Reach Len. (ft)	53	32	20	
	Crit W.S. (ft)		Flow Area (sq ft)	876.74	561.65	1233.09	
S1 =	E.G. Slope (ft/ft)	0.000078	Area (sq ft)	1444.1	561.65	1233.09	
	Q Total (cfs)	2050	Flow (cfs)	578.43	924.98	546.59	= Q1
	Top Width (ft)	888.76	Top Width (ft)	372.23	42	474.53	= W1
	Vel Total (ft/s)	0.77	Avg. Vel. (ft/s)	0.66	1.65	0.44	= V1
	Max Chl Dpth (ft)	16.33	Hydr. Depth (ft)	5.230	13.37	2.600	= Y1
	Conv. Total (cfs)	231713.4	Conv. (cfs)	65380.900	104551.20	61781.300	
	Length Wtd. (ft)	33.76	Wetted Per. (ft)	167.79	50.07	475.28	
	Min Ch El (ft)	156.51	Shear (lb/sq ft)	0.03	0.05	0.01	
	Alpha	2.38	Stream Power (lb/ft s)	0.02	0.09	0.01	
	Frctn Loss (ft)	0.01	Cum Volume (acre-ft)	11.92	11.2	15.57	
	C & E Loss (ft)	0.03	Cum SA (acres)	4.19	0.83	5.07	

Plan: Proposed Wilson Stream Waugan Rd RS: 473 Profile: 100-Yr — U/S Face

E.G. Elev (ft)	172.83	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.31	Wt. n-Val.	0.06	0.04	0.06
W.S. Elev (ft)	172.52	Reach Len. (ft)	11.5	11.5	11.5
Crit W.S. (ft)	167.68	Flow Area (sq ft)	94.13	354.01	89.85
E.G. Slope (ft/ft)	0.000936	Area (sq ft)	953.62	354.01	1103.77
Q Total (cfs)	2050	Flow (cfs)	173.96	1707.62	168.42
Top Width (ft)	847.29	Top Width (ft)	343.88	37.72	465.69
Vel Total (ft/s)	3.81	Avg. Vel. (ft/s)	1.85	4.82	1.87
Max Chl Dpth (ft)	12.96	Hydr. Depth (ft)	3.92	9.39	4.03
Conv. Total (cfs)	66994.8	Conv. (cfs)	5685	55805.7	5504
Length Wtd. (ft)	11.5	Wetted Per. (ft)	24.72	40.5	23.1
Min Ch El (ft)	159.56	Shear (lb/sq ft)	0.22	0.51	0.23
Alpha	1.37	Stream Power (lb/ft s)	0.41	2.46	0.43
Frctn Loss (ft)		Cum Volume (acre-ft)	10.46	10.86	15.03
C & E Loss (ft)		Cum SA (acres)	3.76	0.8	4.86

Plan: Proposed Wilson Stream Waugan Rd RS: 440 BR U Profile: 100-Yr

E.G. Elev (ft)	172.83	Element	Left OB	Channel	Right OB	
Vel Head (ft)	0.29	Wt. n-Val.	0.03	0.03	0.03	
W.S. Elev (ft)	172.16	Reach Len. (ft)	31.3	31.3	31.3	
Crit W.S. (ft)	165.72	Flow Area (sq ft)	6.84	469.21	9.49	
E.G. Slope (ft/ft)	0.001105	Area (sq ft)	6.84	469.21	9.49	
Q Total (cfs)	2050	Flow (cfs)	10.58	2024.56	14.86	$=Q_2$
Top Width (ft)		Top Width (ft)				= W2
Vel Total (ft/s)	4.22	Avg. Vel. (ft/s)	1.55	4.31	1.57	
Max Chl Dpth (ft)	12.6	Hydr. Depth (ft)				$=Y_0$
Conv. Total (cfs)	61656.3	Conv. (cfs)	318.3	60891.00	447	
Length Wtd. (ft)	31.3	Wetted Per. (ft)	9.32	110.64	12.05	
Min Ch El (ft)	159.56	Shear (lb/sq ft)	0.05	0.29	0.05	
Alpha	1.03	Stream Power (lb/ft s)	0.08	1.26	0.09	
Frctn Loss (ft)		Cum Volume (acre-ft)	10.34	10.75	14.89	
C & E Loss (ft)		Cum SA (acres)	3.71	0.79	4.79	

Plan: Proposed Wilson Stream Waugan Rd RS: 440 Profile: 100-Yr

E.G. US. (ft)	172.83	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	172.52	E.G. Elev (ft)	172.83	172.51
Q Total (cfs)	2050	W.S. Elev (ft)	172.16	171.5
Q Bridge (cfs)	2050	Crit W.S. (ft)	165.72	165.45
Q Weir (cfs)		Max Chl Dpth (ft)	12.6	12.71
Weir Sta Lft (ft)		Vel Total (ft/s)	4.22	4.5
Weir Sta Rgt (ft)		Flow Area (sq ft)	485.55	455.68
Weir Submerg		Froude # Chl	0.21	0.23
Weir Max Depth (ft)		Specif Force (cu ft)	2741.58	2557.54
Min El Weir Flow (ft)	173.19	Hydr Depth (ft)		
Min El Prs (ft)	172.16	W.P. Total (ft)	132.01	130.89
Delta EG (ft)	0.33	Conv. Total (cfs)	61656.3	56059.4
Delta WS (ft)	0.18	Top Width (ft)		
BR Open Area (sq ft)	455.68	Frctn Loss (ft)		
BR Open Vel (ft/s)	4.5	C & E Loss (ft)		
BR Sluice Coef		Shear Total (lb/sq ft)	0.25	0.29
BR Sel Method	Press Only	Power Total (lb/ft s)	1.07	1.31

Plan: Proposed Wilson Stream Waugan Rd RS: 505 Profile: Q 200 Approach

	Pos	Left Sta (ft)	Right Sta	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)	Shear (lb/sq ft)	Power (lb/ft s)
1	LOB	-481	-381.47	0.13	4.73	9.4	0.01	0.51	0.03	0	0
2	LOB	-381.47	-281.93	3.12	256.86	99.59	0.14	2.58	0.01	0.02	0.00
3	LOB	-281.93	-182.40	3.15	391.20	99.54	0.14	3.93	0.01	0.02	0.00
4	LOB	-182.40	-98.65	202.89	426.55	83.76	8.80	5.09	0.48	0.03	0.01
5	LOB	-98.65	-14.90	281.12	519.42	84.03	12.20	6.20	0.54	0.04	0.02
6	Chan	-14.90	-6.50	107.65	91.09	13.98	4.67	10.84	1.18	0.04	0.05
7	Chan	-6.50	1.90	310.24	140.20	8.40	13.46	16.69	2.21	0.10	0.22
8	Chan	1.90	10.30	307.46	139.45	8.40	13.34	16.60	2.20	0.10	0.22
9	Chan	10.30	18.70	222.89	124.10	10.17	9.67	14.77	1.80	0.07	0.13
10	Chan	18.70	27.10	125.50	84.17	9.12	5.44	10.02	1.49	0.05	0.08
11	ROB	27.10	147.92	333.89	527.27	121.53	14.49	4.36	0.63	0.03	0.02
12	ROB	147.92	268.74	258.36	451.00	120.82	11.21	3.73	0.57	0.02	0.01
13	LOB	268.74	389.56	128.68	322.35	120.84	5.58	2.67	0.40	0.02	0.01
14	ROB	389.56	510.38	19.88	131.52	120.84	0.86	1.09	0.15	0.01	0.00
15	ROB	510.38	631.20	0.06	1.60	12.92	0.00	0.12	0.04	0.00	0.00

Plan: Proposed Wilson Stream Waugan Rd RS: 473 Profile: Q 200 U/S Face

	Pos	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)	Shear (lb/sq ft)	Power (lb/ft s)
1	LOB	-381.75	-294.24	0.00	121.78	67.82	0.00	1.80	0.00	0.11	0.00
2	LOB	-294.24	-206.72	0.00	283.39	85.22	0.00	3.33	0.00	0.21	0.00
3	LOB	-206.72	-119.21	0.00	287.33	85.21	0.00	3.37	0.00	0.21	0.00
4	LOB	-119.21	-31.7	0.00	287.92	85.21	0.00	3.38	0.00	0.21	0.00
5	LOB	-31.7	-19.2	210.27	103.16	24.72	9.12	4.30	2.04	0.26	0.54
6	Chan	-19.2	-11.66	289.29	63.44	8.22	12.55	8.41	4.56	0.49	2.22
7	Chan	-11.66	-4.12	456.80	82.36	7.95	19.82	10.92	5.55	0.65	3.62
8	Chan	-4.12	3.43	530.43	93.54	8.74	23.01	12.40	5.67	0.67	3.82
9	Chan	3.43	10.97	331.28	68.10	8.01	14.37	9.03	4.86	0.54	2.60
10	Chan	10.97	18.51	284.14	60.76	7.58	12.33	8.05	4.68	0.50	2.36
11	ROB	18.51	29.3	202.78	98.23	23.10	8.80	4.41	2.06	0.27	0.55
12	ROB	29.3	151.43	0.00	414.46	119.84	0.00	3.46	0.00	0.22	0.00
13	LOB	151.43	273.55	0.00	413.10	119.83	0.00	3.45	0.00	0.22	0.00
14	ROB	273.55	395.68	0.00	275.54	119.86	0.00	2.30	0.00	0.14	0.00
15	ROB	395.68	517.8	0.00	83.54	115.86	0.00	0.72	0.00	0.05	0.00

Plan: Proposed Wilson Stream Waugan Rd RS: 505 Profile: Q 100 Approach

	Pos	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)	Shear (lb/sq ft)	Power (lb/ft s)
1	LOB	-481.00	-381.47	0	1.59	5.69	0	0.28	0	0	0
2	LOB	-381.47	-281.93	0.00	215.72	99.59	0.00	2.17	0.00	0.01	0.00
3	LOB	-281.93	-182.40	0.00	350.06	99.54	0.00	3.52	0.00	0.02	0.00
4	LOB	-182.40	-98.65	238.80	391.94	83.76	11.65	4.68	0.61	0.02	0.01
5	LOB	-98.65	-14.90	339.63	484.80	84.03	16.57	5.79	0.70	0.03	0.02
6	Chan	-14.90	-6.50	91.24	87.62	13.98	4.45	10.43	1.04	0.03	0.03
7	Chan	-6.50	1.90	269.07	136.73	8.40	13.13	16.28	1.97	0.08	0.16
8	Chan	1.90	10.30	266.61	135.98	8.40	13.01	16.19	1.96	0.08	0.16
9	Chan	10.30	18.70	192.26	120.63	10.17	9.38	14.36	1.59	0.06	0.09
10	Chan	18.70	27.10	105.80	80.69	9.12	5.16	9.61	1.31	0.04	0.06
11	ROB	27.10	147.92	256.16	477.33	121.53	12.50	3.95	0.54	0.02	0.01
12	ROB	147.92	268.74	192.40	401.06	120.82	9.39	3.32	0.48	0.02	0.01
13	LOB	268.74	389.56	89.37	272.41	120.84	4.36	2.25	0.33	0.01	0.00
14	ROB	389.56	510.38	8.66	82.30	112.09	0.42	0.73	0.11	0.00	0.00
15	ROB	510.38	631.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

HNTB	Made by	NJP	Date	11/30/22	Job No.	67328
	Checked by	SCF	Date	12/01/22	Sheet No.	9 of 9
For Waugan Road Over Wilson Stream	Backchecked by	NJP	Date	08/23/24		

Plan: Proposed Wilson Stream Waugan Rd RS: 473 Profile: Q 100 U/S Face

	Pos	Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	Percent Conv	Hydr Depth(ft)	Velocity (ft/s)	Shear (lb/sq ft)	Power (lb/ft s)
1	LOB	-381.75	-294.24	0.00	96.96	64.31	0.00	1.51	0.00	0.09	0.00
2	LOB	-294.24	-206.72	0.00	251.35	85.22	0.00	2.95	0.00	0.17	0.00
3	LOB	-206.72	-119.21	0.00	255.29	85.21	0.00	3.00	0.00	0.18	0.00
4	LOB	-119.21	-31.70	0.00	255.88	85.21	0.00	3.00	0.00	0.18	0.00
5	LOB	-31.70	-19.20	173.96	94.13	24.72	8.49	3.92	1.85	0.22	0.41
6	Chan	-19.20	-11.66	258.06	60.60	8.22	12.59	8.03	4.26	0.43	1.84
7	Chan	-11.66	-4.12	414.80	79.52	7.95	20.23	10.54	5.22	0.58	3.05
8	Chan	-4.12	3.43	485.09	90.70	8.74	23.66	12.02	5.35	0.61	3.24
9	Chan	3.43	10.97	297.08	65.27	8.01	14.49	8.65	4.55	0.48	2.17
10	Chan	10.97	18.51	252.59	57.92	7.58	12.32	7.68	4.36	0.45	1.95
11	ROB	18.51	29.30	168.42	89.85	23.10	8.22	4.03	1.87	0.23	0.43
12	ROB	29.30	151.43	0.00	369.41	119.84	0.00	3.08	0.00	0.18	0.00
13	LOB	151.43	273.55	0.00	368.04	119.83	0.00	3.07	0.00	0.18	0.00
14	ROB	273.55	395.68	0.00	230.48	119.86	0.00	1.92	0.00	0.11	0.00
15	ROB	395.68	517.80	0.00	45.99	83.94	0.00	0.55	0.00	0.03	0.00