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Prepared for:
Naugatuck Valley Council of Governments

HYDRAULIC ANALYSIS REPORT
Pedestrian Footbridge over Branch Brook

BL Project No. 1800579

Naugatuck River Greenway Multi-Use Trail
Towns of Watertown and Thomaston, CT

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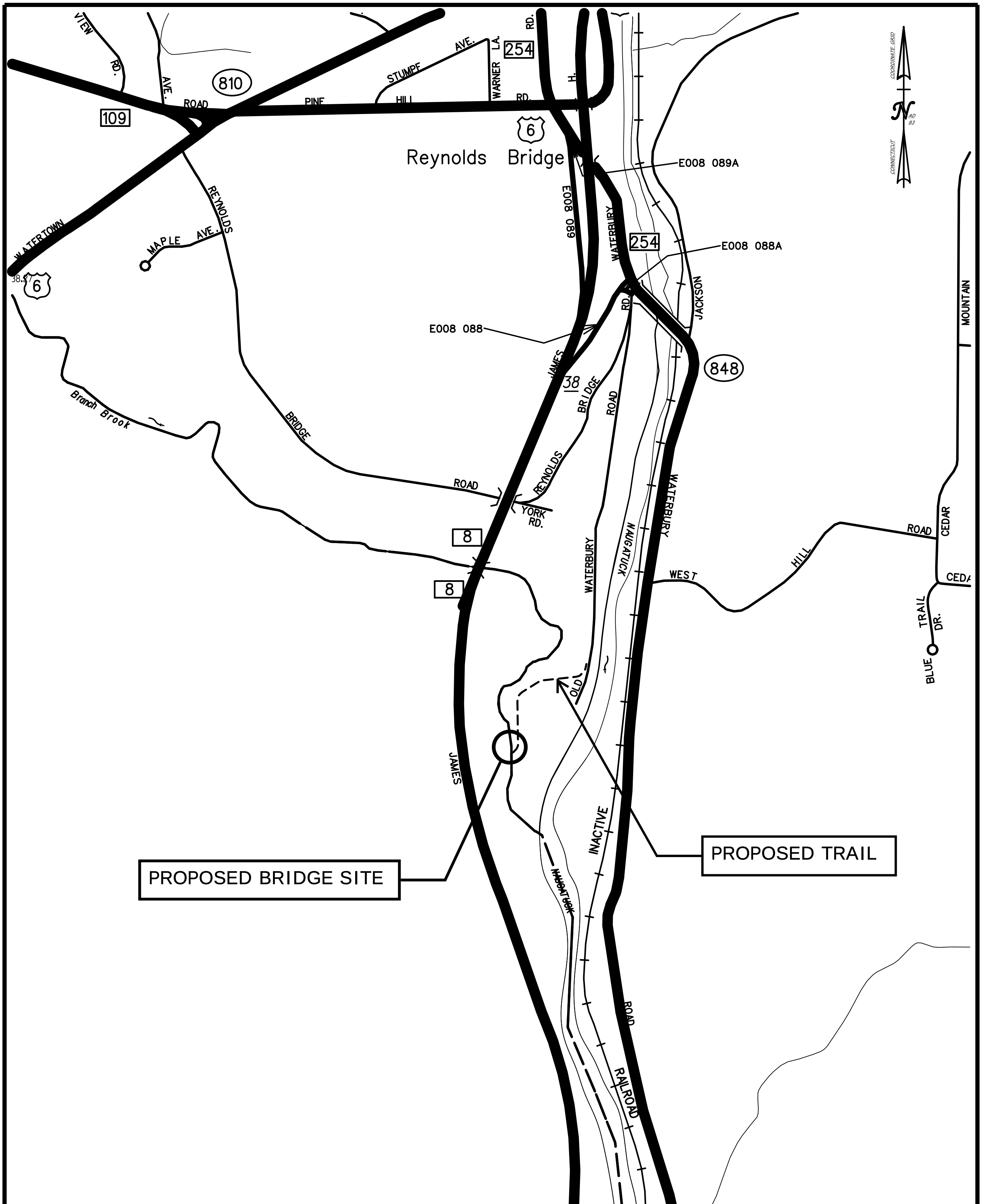


BL Companies	NAUGATUCK RIVER GREENWAY OVER BRANCH BROOK TOWNS OF WATERTOWN & THOMASTON, CONNECTICUT	LOCATION MAP	PROJ. NO.: 1800579 SCALE: 1" = 1,000'

II. INTRODUCTION

This project involves the construction of the Naugatuck River Greenway, a multi-use trail which includes a crossing over Branch Brook, a watercourse that forms the boundary between the towns of Watertown and Thomaston. The proposed trail is located east of Route 8 and west of the Naugatuck River. The trail crosses Branch Brook approximately 1,000 ft upstream of the brook's confluence with the Naugatuck River. Once the path crosses Branch Brook, it moves northeast just outside the ridgelines of the properties between the two watercourses (see Location Map), where it eventually connects to Old Waterbury Road.

At the site of the proposed bridge, the brook has a drainage area of approximately 22.6 square miles. The ConnDOT Drainage Manual designates the proposed bridge as a large structure due to the structure spanning a waterway with a drainage area between 10 mi^2 and 1,000 mi^2. Large structures require the 100-year storm to pass under the low chord with 2-ft of underclearance. Additionally, the 500-year storm is required to be checked. Table 1 below summarizes the flow discharges at the bridge location. The design flows were computed by the Flood Insurance Studies (FIS) for the Towns of Watertown and Thomaston, CT. For further information regarding the watershed characteristics and how the design flow was developed, refer to Appendix A.

TABLE 1: SUMMARY OF FLOWS (C.F.S.)

Pedestrian Bridge over Branch Brook	
Year	**Project Flows**
2	450
10	800
50	800
100	900
200	1,500
500	2,300

Branch Brook is a relatively sinuous, channelized watercourse, flowing from northwest to southeast through the project site. The normal stream channel is between approximately 35 to 40-ft wide through this section. Both banks are heavily vegetated with trees and light groundcover; flow impacts are accounted for through the Manning's n value.

The proposed bridge crossing site located approximately 0.5 miles downstream of Black Rock Dam; a large flood control structure built in 1971. The brook moves from the dam spillway under the Route 8 overpass located approximately 0.3 miles upstream of the proposed crossing. The confluence of Branch Brook and the Naugatuck River is approximately 1,000 downstream from the crossing site.

Within the vicinity of the project, the channel bottom is lined naturally with gravelly sand with smaller stones and cobbles. A dirt road bridge is located approximately 650 ft downstream of the subject bridge (approximately 265 ft upstream of the brook's confluence with Naugatuck

River). There is little evidence of erosion, drift, or degradation in the studied reach. The existing channel contains all the studied storm events including the design and check storm events, while the structures outside the project area are hydraulically adequate during storm events. There is currently no existing structure at the project site.

There are two proposed alternatives for the pedestrian crossing over Branch Brook, as described in the Structure Type Study (STS). Alternative 1 involves the installation of a prefabricated steel truss superstructure supported by precast concrete abutments and wingwalls. This structure is referred to as the preferred alternative in the STS. Alternative 2 consists of a timber glulam stringer superstructure founded on timber piles.

Alternative 1 spans 60-ft across Branch Brook and is founded on precast concrete abutments. The precast concrete abutments will be founded to a maximum depth of approximately 6-ft to 7-ft below existing grade and will not be adversely affected by scour. The analysis indicates the proposed alternative is hydraulically adequate for all studied storm events.

Alternative 2 provides a 60.4-ft clear span timber glulam stringer superstructure founded on timber piles and lagging. The hydraulic analysis indicates there is little difference in water surface elevations between the two alternatives during the 100-year design event. As with the preferred alternative, Alternative 2 is hydraulically adequate during all studied events and will not be adversely affected by scour.

While the initial construction cost of the preferred structure is higher, the life expectancy of Alternative 1 is approximately 25% greater than that of Alternative 2. The estimated construction duration for the preferred alternative is anticipated to be approximately 4 months.

III. HYDRAULIC DATA FORMS

- **Data Collection and Field Review (pages 4 to 14)**
- **Hydraulic Data (pages 15 to 18)**

A. DATA COLLECTION AND FIELD REVIEW

I. GENERAL PROJECT DATA

Bridge No.: **N/A**
Town: **Watertown & Thomaston** County: **Litchfield**
Feature carried: **Multipurpose Path** Feature crossed: **Branch Brook**
Quadrangle: **Thomaston** DEP watershed basin no.: **6910**

Functional class:
- ☐ urban principal arterial-interstate
- ☐ urban principal arterial-other expwy.
- ☐ urban principal arterial-other
- ☐ urban minor arterial
- ☐ urban collector
- ☐ urban local
- ☐ rural principal arterial-interstate
- ☐ rural principal arterial-other expwy.
- ☐ rural principal arterial-other
- ☐ rural minor arterial
- ☐ rural major collector
- ☐ rural minor collector
- ☒ Other

Year built: **New Construction** Year of reconstruction: ______
Overall NBIS structure rating: ______ NBIS Item 113: ______
USGS total scour index: ______ Sufficiency rating: ______

Plans available? ☐ yes ☒ no

II. SUPERSTRUCTURE INFORMATION

Bridge width: **N/A** ft Bridge length: **N/A** ft
Number of spans: **N/A** Bridge skew: **N/A**

Bearing connection type: ☒ Positive connection ☐ No positive connection

III. HYDROLOGIC AND HYDRAULIC INFORMATION

Watershed area: **22.6** sq. mi.

Is it tidally influenced? ☐ yes ☒ no

What information is available?
- ☐ hydraulic report
- ☐ scour report
- ☐ floodway analysis report
- ☐ SCEL analysis
- ☐ comparative report
- ☒ FEMA F.I.S.
- ☒ Other: **FEMA HEC-2 Backup Data**

	Source	2 Yr. Event	10 Yr. Event	50 Yr. Event	100 Yr. Event	500 Yr. Event
Flow rates (cfs)	**FEMA Flows**	**-**	**800**	**800**	**900**	**2,300**
	PeakFq for Gage No. 01208013	**560**	**770**	**940**	**1,010**	**1,180**
Precipitation (in)	**NOAA Atlas 14 24-hr**	**3.56**	**5.68**	**7.97**	**9.04**	**12.5**

Elevations (ft.)							
At Structure			Water Surface at Approach Cross-Section (200.65)				
Streambed	Low Chord	Roadway	2 Yr. Event	10 Yr. Event	50 Yr. Event	100 Yr. Event	500 Yr. Event
318.00	**NA**	**NA**	**-**	**324.31**	**324.31**	**324.63**	**327.90**

Pressure flow at design storm? ☐ yes ☐ underclearance ft.

Comments: **This is a new structure that does not currently exist. The streambed above is at Section 200.6, the location of the upstream face section of the proposed bridge. The WSELs listed above are from the Existing Conditions Model at Section 200.65, the approach section.**

IV. SITE DATA

A. Existing structure(s) – Provide sketch of culvert/structure with dimensions and brief description.

No Existing Structure **See Figures** **See Appendix A (Photographs)**

Comments: Include structure or culvert type and condition. Note particularly any scour adjacent to abutments or at culvert outlet and the presence of debris or sediment. Also note the location of any utilities in the area of the crossing.

B. High water marks – Describe the nature and location of any apparent high-water marks and relate to a date of occurrence, if possible.

N/A

C. Maximum allowable headwater – Describe the nature of the apparent controlling feature and note its location.

N/A

D. Fish passage requirements – Comment on the apparent need for fish passage or impediments to same; such as dams or restrictive crossings in the area.

The proposed bridge allows fish passage. Fish passage is blocked approximately 0.5 miles upstream of the subject location by the Black Rock Dam spillway.

V. PERIPHERAL SITE DATA

A. Hydraulic control – Note location and description.

The flood control structure upstream and known FEMA WSELs downstream of the project site at the mouth of Naugatuck River control.

B. Upstream and downstream structures – Provide sketches and brief descriptions of existing bridges/culverts. Include dimensions.

Upstream

- **Route 8 Overpass – twin span, 8-ft wide pier, 381.50 ft low chord, 85 ft span abutment to abutment.**

Downstream

- **Dirt road crossing – 330.00 ft low chord, 100 ft wide opening**

C. Watershed area – Check watershed boundaries for accuracy. Note current land uses within watershed.

See Appendix A

D. Flow control structures within watershed – Note the location and type of all significant flow control structures (dams, etc.) within the watershed. Provide sketches with dimensions as required.

Spillway 2,100-ft upstream.
See Appendix A.

E. Site photographs – Attach to report. Include an index and sketch of photograph locations. **No current photographs.**

VI. STREAM CHANNEL AND RELATED ASPECTS

A. Stream characterization

Twenty Groupings of Stream Characteristics (check box)

	Identifier	Drainage Area	Streambed Slope	Streambed Soils	Land Use
☐	A	Large	Low	SD	S/F
☐	B	Large	Low	SD	Urban
☒	C	Large	Moderate	SD	Forested
☐	D	Medium	Moderate	SD	Urban
☐	E	Medium	Moderate	SD	S/F
☐	F	Medium	Moderate	CLAY	S/F
☐	G	Medium	Moderate	TILL	S/F
☐	H	Medium	Moderate	SD	Forested
☐	I	Medium	Moderate	TILL	Forested
☐	J	Small	Low	SD	Urban
☐	K	Small	Moderate	TILL	Urban
☐	L	Small	Low	SD	S/F
☐	M	Small	Moderate	SD	S/F
☐	N	Small	Moderate	SD	Forested
☐	O	Small	Low	CLAY	S/F
☐	P	Small	Steep	TILL	S/F
☐	Q	Small	Moderate	TILL	S/F
☐	R	Small	Low	TILL	S/F
☐	S	Small	Moderate	TILL	Forested
☐	T	Small	Steep	TILL	Forested

Drainage area	Small	≤ 64.75km^2 (25 mi^2)
	Medium	> 64.75km^2 (25 mi^2) and ≤ 259 km^2 (100 mi^2)
	Large	> 259 km^2 (100 mi^2)
Streambed slope	Low	≤ 4.76 m/km (25 ft/mi)
	Moderate	> 4.76 m/km (25 ft/mi) and ≤ 19.05 m/km (100 ft. mi)
	Steep	> 19.05 m/km (100 ft. mi)
Streambed soils	SD = Stratified Drift	
Land Use	S/F = Suburban or Farming	

B. Channel stability

Previous NBIS Item 61 rating: **NA**

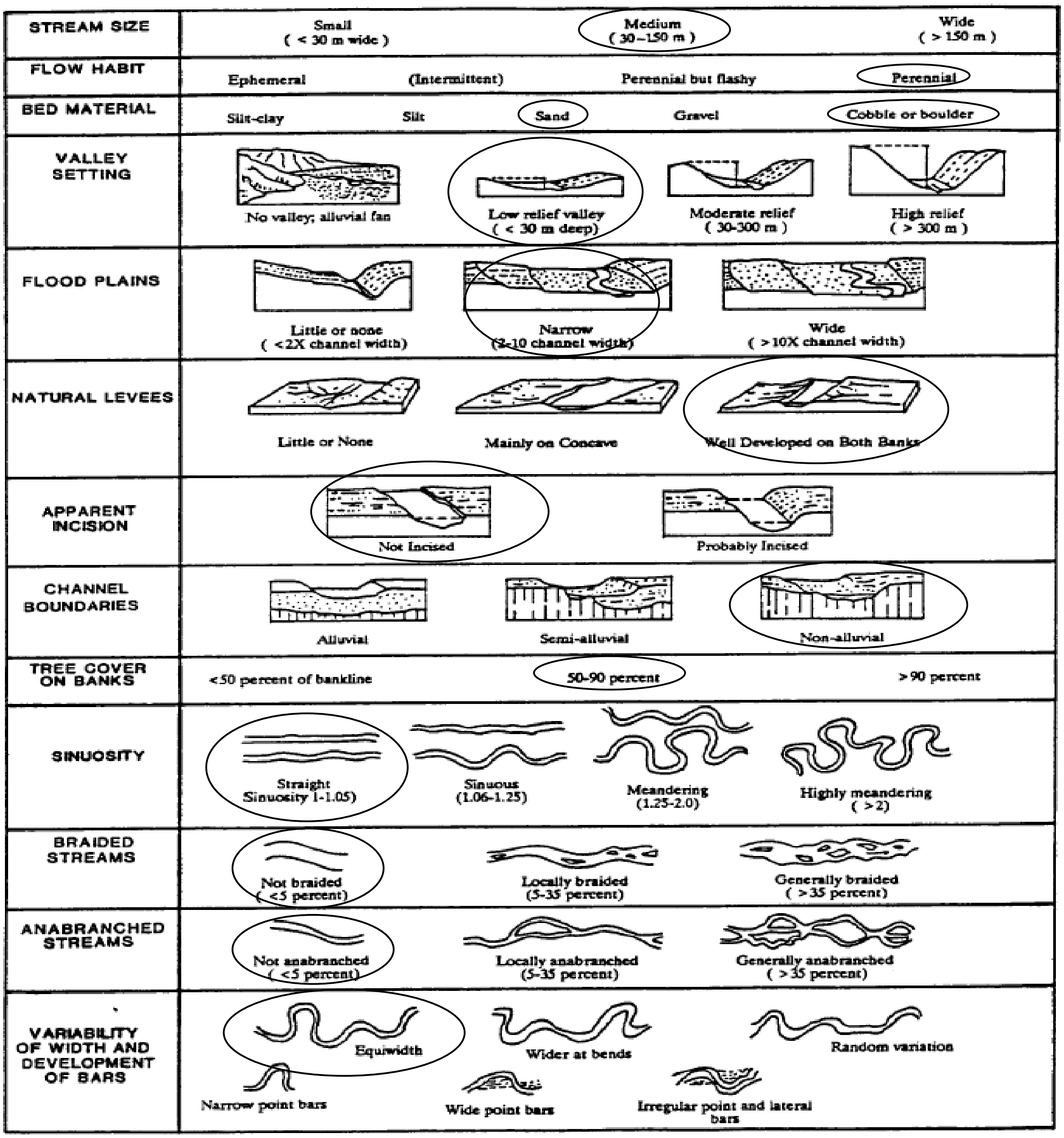
Lateral stability: ☒ stable ☐ unstable

Bank erosion:
☒ none ☐ light fluvial erosion ☐ heavy fluvial erosion ☐ mass wasting

Streambed: ☒ stable ☐ aggradating ☐ degrading

Armoring potential: ☐ none ☒ low ☐ moderate ☐ high

Geomorphic factors that affect stream stability (circle factors that apply)



Source: Adapted From Brice and Blodgett, 1978

(See also FHWA HEC-20, "Stream Stability at Highway Structures" for discussion of the above factors)

Secondary bed material: ☐ sand ☐ gravel ☐ boulders ☐ manmade
☐ silt/clay ☐ cobble ☐ bedrock

Bank protection

Type ☒ none ☐ modified ☐ intermediate ☐ standard
☐ concrete ☐ slope paving ☐ absent
☐ other

Condition ☒ n/a ☐ good ☐ weathered ☐ slumped
☐ poor ☐ missing ☐ fair

Comment on the need (if any) for training walls, cutoff walls or special slope or channel protection.

The side slopes of the brook in the vicinity of the bridge are generally stable. Backwater from the crossing downstream reduces velocities in project location.

C. Channel and overbank roughness coefficients

Basic channel description: ☐ channel in earth ☐ channel cut into rock
☐ channel fine gravel ☒ channel coarse gravel

Surface irregularity of channel:

☐ smooth – best obtainable section for materials involved
☒ minor – slightly eroded or scoured side slopes
☐ moderate – moderately sloughed or eroded side slopes
☐ severe – badly sloughed banks of natural channels or badly eroded sides of man-made channels – jagged and irregular sides or bottom sections of channels in rock

Variations in shape and size of cross sections

☐ changes in size or shape occurring gradually
☒ large and small sections alternating occasionally or shape changes causing occasional shifting of main flow from side to side
☐ moderate – moderately sloughed or eroded side slopes
☐ large and small sections alternating frequently or shape changes causing frequent shifting of main flow from side to side

Channel obstructions – (Judge the relative effect of obstructions – consider the degree to which the obstructions reduce the average cross sectional area, character of obstructions, and location and spacing of obstructions).

NOTE: Smooth or rounded objects create less turbulence than sharp, angular objects.

The effect of obstructions is:

☐ negligible
☒ minor
☐ appreciable
☐ severe

Degree of Vegetation (Note amount and character of foliage)

The effect of vegetative growth upon flow conditions is:

☐ LOW – Dense growths of flexible turf grasses where average depth of flow is 2 to 3 times the height of vegetation. Supple seedling tree switches where the average depth of flow is 3 to 4 times the height of the vegetation.

☐ MEDIUM – Turf grasses where the average depth of flow is 1 to 2 times the height of vegetation. Stemmy grasses, weeds or tree seedlings (moderate cover) where the average depth of flow is 2 to 3 times the height of vegetation. Bushy growths (moderately dense along channel side slopes with no significant vegetation along channel bottom).

☒ HIGH – Turf grasses where average height is about equal to the average depth of flow. Willow or cottonwood trees 8 to 10 years old with some weeds or brush. Bushy growths about 1 year old with some weeds. No significant vegetation along channel bottom.

☐ VERY HIGH – Turf grasses where the average depth of flow is less than ½ the height of vegetation. Bushy growths about 1-year old intergrown with weeds. Dense growth of cattails along channel bottom. Trees intergrown with weeds and brush (thick growth).

Additional Comments: **See Appendix A**

VII. HYDRAULIC VULNERABILITY

Previous Item 71 rating: **NA**

Is there confluence present? ☐ yes ☒ no

Angle of attack (flood flow): ☐ yes ☒ no

Bends in channel: ☒ upstream of bridge ☒ downstream of bridge ☐ straight channel reach ☐ at bridge

Velocity order of magnitude: **4.14 ft/s (approach section)**

Trapping potential: ☒ low ☐ medium ☐ high

Debris potential: ☒ low ☐ medium ☐ high

Overtopping relief: ☒ none ☐ left approach ☐ right approach ☐ on bridge ☐ relief bridge ☐ cannot be determined

Primary bed material: ☒ sand ☒ gravel ☐ boulders ☐ manmade ☐ silt/clay ☐ cobble ☐ bedrock

Comments: **The channel is comprised of gravelly sand, small cobbles and boulders.**

VIII. VISUAL SCOUR EVIDENCE

USGS observed scour index: **N/A**

History of scour problem: ☐ yes ☒ no

Comments: **There is no existing bridge at the crossing site.**

Note: Comment should address any evidence of scour at ALL substructure units.

CONTRACTION SCOUR SUSCEPTIBILITY

Channel width upstream: **40-ft**
Channel width under bridge: **N/A**
Channel width ratio (channel width upstream / channel width under the bridge: **N/A**

Overbank flow: ☒ yes ☐ no

Percent of flow in main channel of the approach section:
☐ >90% ☒ 75%-90% ☐ 50%-75% ☐ 25%-50% ☐ <25%

Average bed material size (D_{50}):
@ approach section **0.125 ft (field estimate)** ☐ sample taken from sieve analysis
@ bridge **0.125 ft (field estimate)** ☐ sample taken from sieve analysis

Contraction scour susceptibility rating: ☒ low ☐ medium ☐ high

Comments: **Scour with the proposed structure is unlikely due to the elevation of the substructure and velocities at the structure.**

ABUTMENT SUSCEPTIBILITY

Which abutment is worse? ☐ Left ☐ right

Observed scour depth: Remaining embedment in river bed:

Abutment shape: ☐ vertical ☐ vertical with wingwalls ☐ spillthrough

Abutment location: ☐ in channel ☐ at bank ☐ set back

Abutment foundation: ☐ unknown ☐ spread footing ☐ pile bent
☐ friction piles ☐ EB piles ☐ set in rock

Pile type: ☐ metal ☐ concrete ☐ metal ☐ stone

Pile length: ______ m (ft)

Abutment material; ☐ timber ☐ concrete ☐ metal ☐ stone

Angle of inclination: (degrees)

Primary bed material: ☐ sand ☐ gravel ☐ boulders ☐ manmade
☐ silt/clay ☐ cobble ☐ bedrock

Are borings available? ☐ yes ☐ no

Abutment protection

Type:	☐ modified	☐ intermediate	☐ standard	☐ slope
	☐ concrete	☐ other	☐ absent	☐ none
Permanent or Temporary:		☐ N/A	☐ permanent	☐ temporary
Condition:	☐ good	☐ weathered	☐ slumped	☐ missing
	☐ fair	☐ poor	☐ N/A	

Abutment exposure due to scour:

☐ none	☐ no exposure	☐ footing exposed	☐ piles exposed
☐ undermining	☐ settlement	☐ failed	

Abutment susceptibility rating: ☐ low ☐ medium ☐ high

Comments: **No existing abutments**

PIER SUSCEPTIBILITY

Worst pier number: **No Existing Piers**
Observed scour depth: Remaining embedment in river bed:

Angle of attack flood flow: (degrees)

Pier foundation: ☐ unknown ☐ spread footing ☐ pile bent
☐ EB piles ☐ set in rock ☐ friction piles ☐ N/A

Pile type: ☐ metal ☐ concrete ☐ timber ☐ N/A

Pile length: _____

Pier material: ☐ stone ☐ wood ☐ metal ☐ N/A

Pier shape: ☐ solid pier with square nose ☐ solid pier with round nose
☐ solid pier with sharp nose ☐ column with square nose ☐ column with round nose
☐ column with sharp nose ☐ cylinders/group of cylinders

Pier width: ____________ Pier dimensions: ____________

Cap/Footing dimensions: ____________

Pier exposure due to scour: ☐ none ☐ no exposure ☐ footing exposed
☐ piles exposed ☐ undermining ☐ settlement
☐ failed

Pier protection

Type:	☐ modified	☐ intermediate	☐ standard	☐ slope
	☐ concrete	☐ other	☐ absent	☐ none
Permanent or Temporary:		☐ N/A	☐ permanent	☐ temporary
Condition:	☐ good	☐ weathered	☐ slumped	☐ missing
	☐ fair	☐ poor	☐ N/A	

Primary bed material: ☐ sand ☐ gravel ☐ boulders ☐ manmade
☐ silt/clay ☐ cobble ☐ bedrock

Are borings available? ☐ yes ☐ no

Pier susceptibility rating: ☐ low ☐ medium ☐ high

Comments: ____________

B. HYDRAULIC DATA

1) Location

a) Town(s): **Thomaston & Watertown** State Project No.(s): ____

b) Highway: **N/A** Station(s): **N/A**

c) Location Relative to Highway Landmark: **Approximately 0.27 miles south of Route 8 crossing over Branch Brook.**

d) Stream: **Branch Brook**

e) Location Relative to Stream Landmark: **Approximately 1,000 ft upstream of the confluence with Naugatuck River.**

2) Design Flood

a) Hydrologic Procedure Used for Design: **FEMA Flood Insurance Study Flows**

b) Hydrologic Procedure Used by FEMA: **log-Pearson Type III**

c) Drainage Area: **22.6 square miles**

d) ConnDOT Drainage Manual Structure Classification: **Large**

e) Design Storm Frequency: **100-Year, Investigate 500-Year**

f) Required Underclearance at Design Discharge: **2 ft**

g) Design Discharge: **900 cfs**

i. D.O.T. Design: **N/A**

ii. FEMA: **900 cfs**

iii. SCEL: **N/A**

3) Hydraulic Analysis Procedure

a) Model Used and Version No.: **HEC-RAS Version 5.0.7**

b) Flow Regime: **Subcritical**

c) Boundary Conditions (starting water surface at the ends of the river system – i.e. known water surface, normal depth, critical depth, rating curve, etc.):

i. Downstream: **Known WSELs**

ii. Upstream: **N/A**

d) Other Method(s): **N/A**

4) Hydraulic Control (i.e.culvert/bridge, dam (weir), channel construction, tide, known water surface elevation, etc.)

a) Type of Control: **Dam**

b) Location Relative to Proposed Construction: **0.5 miles upstream**

5) Coefficients of Roughness

a) Downstream: Channel **0.035** Overbank **0.065-0.08**

b) At Crossing: Channel **0.035** Enclosed Conduit **N/A**

c) Upstream: Channel **0.035** Overbank **0.065-0.08**

6) Existing Structures

Upstream: **Route 8 bridge**

a) Type: **Two-span bridge on concrete abutments with wingwalls aligned with channel**

b) Gross Waterway Opening: **4,040 square feet (dimensions obtained from FEMA backup data)**

At Site: **None**

a) Type: **N/A**

b) Gross Waterway Opening: **N/A**

c) Effective Waterway Opening: **N/A**

d) Overall Width of Waterway Opening: **N/A**

e) Effective Depth of Waterway Opening: **N/A**

f) Minimum Low Chord Elevation: **N/A**

g) Minimum Roadway Elevation: **N/A**

h) Computed Water Surface Elevation at Approach Section Upstream of Structure at Design Discharge:
324.63-ft (Section 200.65)

i) Underclearance at Design Discharge: **N/A**

j) Mean Velocity of Channel: **4.14 ft/s (Approach Section)**

Downstream: **Dirt road crossing**

a) Type: **Clear-span bridge**

b) Gross Waterway Opening: **Approximately 1,120 square feet (dimensions from FEMA backup data)**

7) <u>Proposed Structures</u>

a) Type: **Prefabricated steel truss superstructure on precast concrete abutments**

b) Gross Waterway Opening: **590± sq ft**

c) Effective Waterway Opening: **208± sq ft**

d) Overall Width of Waterway Opening: **60 ft**

e) Effective Depth of Waterway Opening: **6.5 ft**

f) Minimum Low Chord Elevation: **331.25 ft**

g) Minimum Roadway Elevation: **332 ft (Proposed trail elevation)**

h) Computed Water Surface Elevation at Approach Section Upstream of Structure at Design Discharge:
324.63 ft at Section 200.65

i) Maximum Regulatory Elevation: **325.58 ft (natural conditions + 1-ft) calculated at Approach Section 200.65**

j) Other Controlling Water Surface Elevation (If Below Maximum Regulatory Elev.): **Known FEMA WSELs**

k) Difference in Water Surface Elevation (Approach Section) Proposed vs. Existing and Proposed vs. Regulatory @ Design Discharge: **At Section 200.65, the Proposed WSEL is 324.63-ft, equivalent to the Existing WSEL, and approximately 0.05-ft higher than the Natural Conditions (324.58 ft). The Proposed WSEL is 0.95-ft below the Regulatory Elevation (Natural plus 1 ft).**

l) Underclearance at Design Discharge with Respect to Structure Low Chord: **6.62-ft**

m) Mean Velocity Through Structure: **4.40 ft/s – Bridge Open Velocity**

8) Remarks

a) Navigational Requirements: **N/A**

b) Tidal Conditions: **N/A**

c) Record Floods: **August 1955, Over 500-year storm (FIS Report/CT Drainage Manual/NOAA Data)**

d) Average Daily Flow: **39.7 cfs**
(Q_{AD}(cfs) = [A (sm)]$^{0.98}$ * 1.87)

e) Average Spring Flow: **78.8 cfs**
(Q_{AS}(cfs) = [A (sm)]$^{0.988}$ * 3.62)

f) Flood Hazard Zone: **Zone A1**

g) Vertical Datum: **NAVD 1988 (FEMA data in NGVD 1929)**

IV. HYDRAULIC ANALYSIS METHODOLOGY

A hydraulic analysis at the project site was performed using the Hydrologic Engineering Center's River Analysis System (HEC-RAS version 5.0.7). A plan view showing the arrangement of cross-sections on Branch Brook and cross-sections with the existing and proposed 100-year WSELs are included in Appendix C (Cross-Section Locations and Cross-Sections). The proposed bridge classifies as a large structure since its drainage area is between 10 mi^2 and 1,000 mi^2.

FEMA studied Branch Brook in detail and published the findings in the latest Town of Watertown and Town of Thomaston Flood Insurance Studies (published May 1980). The Branch Brook portion of the report was last reviewed on December 19, 1978. (see Appendix B).

Existing hydraulic backup data was obtained from FEMA in HEC-2 format. This data was converted to RAS format to create the Duplicate Effective Model. Minor necessary input adjustments were made to run the model, which produced similar results to the original study. A Floodway Analysis was also performed and is submitted under a separate cover.

The design models utilize several FEMA cross-sections found in the backup data, notably as boundary conditions. The backup data was also the basis for the immediate structures located upstream and downstream of the proposed structure. The model was then supplemented by field survey cross-section data taken between the limits of the established FEMA sections.

A total of 18 cross-sections were used to build the model. This includes FEMA sections A-E in the FIS, as well as the additional modelled sections based from field survey data and LiDAR.

The Manning's Roughness Coefficients for the upstream and downstream channel in the existing and proposed models is 0.035. The river is clean, straight and stony. Generally, the "n" values used for the side slopes and overbank areas upstream and downstream of the bridge range from 0.055 to 0.08, depending on cover. This generalization is broken where a Manning's n value of 0.018 is chosen to represent flow over pavement, and residential areas having a value of 0.04.

Values of 0.1 and 0.3 are used for contraction and expansion dynamic head losses, except at bridge bounding sections. At the bounding sections, where the flow area typically changes abruptly, values of 0.3 and 0.5 are used. However, due to the elevation of the proposed bridge, bounding sections are not restrictive and match upstream and downstream conditions, therefore, further modification was not necessary.

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). The HEC-RAS bridge-modeling approach utilizes the energy equation for low flow.

The starting water surface elevation for the HEC-RAS analysis for all flows utilizes known WSELs at the furthest downstream section. All profiles utilized the subcritical flow regime. For information regarding the watershed characteristics and how the design flow was computed, please see Appendix A.

V. WATER SURFACE PROFILE ANALYSIS

See "Table 2: Summary of the 100-Year WSEL" for a numeric comparison of the calculated 100-year water surface elevations. See "Table 3: Summary of the 100-Year Velocity" for a comparison of the calculated 100-year velocities. These values will be utilized in discussions located further in this section.

Comparisons between the natural and existing/proposed condition profiles are noted in later sections. Comparison printouts of the HEC-RAS 100-year water surface profiles and a profile output tables for all storm events are included in Appendix D (Water Surface Profile Analysis).

A. NATURAL CONDITIONS

For all flood frequencies, a natural conditions model was developed by eliminating the existing Route 8 overpass and the dirt road crossing. The ineffective flow areas at the upstream and downstream sections were removed. The expansion and contraction ratios were set to 0.1 and 0.3.

The natural water surface elevation (WSEL) for the 100-year storm at the furthest upstream section (Section 203) is 330.43-ft and 320.94-ft at the furthest downstream section (Section 200). The WSEL change through the reach is due to the stream grade. The 100-year velocities for all sections range from 1.92 ft/s to 10.21 ft/s.

The 500-year existing WSELs for all sections range from 2.18-ft above to 3.58-ft above the 100-year natural WSELs. The 500-year existing velocities range from 0.02 ft/s above to 2.41 ft/s above the 100-year velocities.

B. EXISTING CONDITIONS

The existing 100-year WSELs at the proposed crossing bounding sections are 324.40-ft upstream and 324.42-ft downstream. At the structure location, the 100-year design flow is contained in the channel banks. The 500-year flow nearly overtops the left channel banks but is contained within an apparent natural channel levee.

The existing 100-year WSELs are generally higher than the natural condition. At Section 200.65, the approach section, the existing WSEL is 324.63 ft, 0.05-ft higher than the natural condition (324.58 ft). At the furthest upstream cross-section, the existing and natural WSELs match (330.43 ft). The furthest downstream sections also match with an elevation of 320.94 ft. Table 2 compares the 100-year WSEL at the end of this narrative.

Similar to the WSELs, the existing 100-year event velocities were compared with the natural velocities. As expected, the existing velocities are generally lower than the natural velocities. At Section 202.2, the natural and existing 100-year velocities are 4.98 and 4.85 ft/s, respectively. At the proposed upstream and downstream bridge face locations, the existing 100-year velocities are 4.80 and 4.01 ft/s, respectively. Table 3 reports comparison data at the end of this narrative.

The existing 500-year WSEL at the approach section is 327.90 ft, 3.27-ft higher than the existing 100-year WSEL. Through the studied reach, the 500-year WSEL ranges 2.18 ft to 3.58 ft above 100-year WSEL.

A comparison between the existing and proposed water surface elevations can be found in the section below.

C. PROPOSED CONDITIONS

Alternative 1 proposes building a prefabricated steel truss supported with reinforced concrete abutments and wingwalls. The new bridge will have a clear span of 60 ft and a low chord elevation of 331.25 ft. Within Sections 201 to 200.55, the 100-year WSELs for Alternative 1 range from 0.06 to 0.13-ft above existing conditions and match at the remaining sections.

During the 500-year storm event, the proposed WSELs demonstrate similar behavior as the proposed 100-year WSELs. Within Sections 201 to 200.55, the 500-year WSELs range from 0.13 and 0.23-ft above the 100-year WSELs. Beyond these limits, the proposed WSELs are shown to match the existing WSELs.

At the approach section, the proposed bridge provides 6.56-ft of clearance between the bridge low chord and the 100-year WSEL. This meets the required 1-ft of clearance during the design storm.

Scour is not expected to be an issue at the proposed abutments due to reduced velocities computed at the abutments, which are set back from, and elevated above the channel. The preliminary scour estimate for the 500-year storm event is 2.9-ft. Refer to the Scour Analysis Report, submitted under a separate cover, for detailed information.

The proposed 500-year WSEL at the approach section is 328.09 ft, 3.16-ft lower than the low chord of the bridge. During the 500-year storm, the bridge remains hydraulically adequate. Through the studied reach, the 500-year WSEL ranges 2.18-ft to 3.64-ft above 100-year WSELs.

The 500-year velocities range from 0.21 ft/s to 2.90 ft/s above the 100-year condition.

VI. TEMPORARY FACILITIES ANALYSIS

The estimated construction duration for the bridge is three months. In accordance with the ConnDOT Drainage Manual (Section 6.15.2), a temporary facilities analysis was performed to determine the percent design risk and associated design frequency (see Appendix E). The 2-year storm frequency (450 cfs) was determined and will be used for the temporary condition.

Construction will be completed by allowing work areas around the proposed abutments, creating a minimum waterway opening of 50 ft. Once the facilities are installed, the proposed abutments and truss will be placed.

A printout of the HEC-RAS 2-year water surface profile and 2-year profile output table are included in Appendix E (Temporary Facilities Analysis).

VII. FEMA ANALYSIS

The project is located in a FEMA detailed study area. The published FEMA regulatory flows were run in the HEC-RAS model with floodway encroachments applied to determine the regulatory flow WSEL. The results are presented under a separate cover.

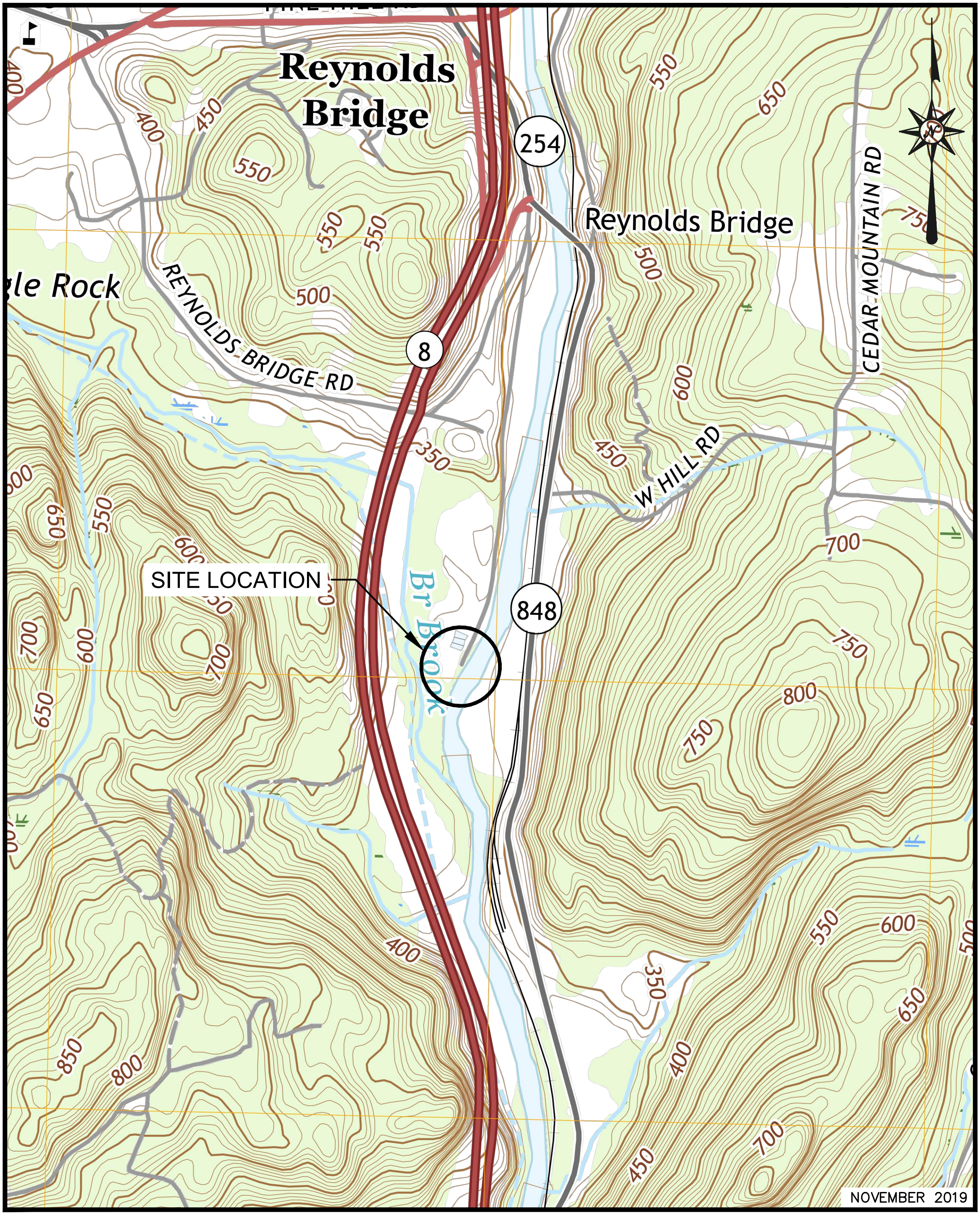
VIII. HYDRAULIC SUMMARY TABLES

TABLE 2: SUMMARY OF THE 100-YEAR WSEL

Water Surface Elevations (NAVD 88) 100-Year Flow – 900 cfs						
Section	Natural	Existing	Alternative 1	Existing vs. Natural	Alternative 1 vs. Natural	Alternative 1 vs. Existing
203	330.43	330.43	330.43	0.00	0.00	0.00
202.2	330.04	330.13	330.13	+0.09	+0.09	0.00
	Route 8 Bridge					
202.1	329.57	329.57	329.57	0.00	0.00	0.00
202	328.28	328.28	328.28	0.00	0.00	0.00
201	325.52	325.54	325.54	+0.02	+0.02	0.00
200.8	324.82	324.85	324.85	+0.03	+0.03	0.00
200.75	324.75	324.80	324.79	+0.05	+0.05	0.00
200.7	324.74	324.79	324.79	+0.05	+0.05	0.00
200.65	324.58	324.63	324.63	+0.05	+0.05	0.00
200.6	324.41	324.46	324.46	+0.05	+0.05	0.00
	Naugatuck River Greenway (Pedestrian Bridge)					
200.55	324.42	324.47	324.47	+0.05	+0.05	0.00
200.5	323.83	324.15	324.15	+0.32	+0.32	0.00
200.45	322.60	322.60	322.60	0.00	0.00	0.00
200.4	321.52	321.52	321.52	0.00	0.00	0.00
200.3	321.37	321.37	321.37	0.00	0.00	0.00
200.2	321.19	321.19	321.19	0.00	0.00	0.00
	Dirt Road Crossing					
200.1	321.16	321.16	321.16	0.00	0.00	0.00
200	320.94	320.94	320.94	0.00	0.00	0.00

TABLE 3: SUMMARY OF THE 100-YEAR VELOCITY

Velocity Comparison (ft/s) 100-Year Flow – 900 cfs						
Section	Natural	Existing	Alternative 1	Existing vs. Natural	Alternative 1 vs. Natural	Alternative 1 vs. Existing
203	8.83	8.83	8.83	0.00	0.00	0.00
202.2	4.98	4.85	4.85	-0.13	-0.13	0.00
	Route 8 Bridge					
202.1	5.70	5.70	5.70	0.00	0.00	0.00
202	8.93	8.93	8.93	0.00	0.00	0.00
201	1.92	1.90	1.90	-0.02	-0.02	0.00
200.8	4.31	4.28	4.28	-0.03	-0.03	0.00
200.75	4.02	3.98	3.98	-0.03	-0.03	0.00
200.7	3.10	3.07	3.07	-0.03	-0.03	0.00
200.65	4.18	4.14	4.14	-0.04	-0.04	0.00
200.6	4.80	4.74	4.74	-0.06	-0.06	0.00
	Naugatuck River Greenway (Pedestrian Bridge)					
200.55	4.01	3.97	3.97	-0.03	-0.03	0.00
200.5	6.99	5.31	5.31	-1.68	-1.68	0.00
200.45	10.21	10.21	10.21	0.00	0.00	0.00
200.4	6.74	6.74	6.74	0.00	0.00	0.00
200.3	2.24	2.24	2.24	0.00	0.00	0.00
200.2	3.68	3.68	3.68	0.00	0.00	0.00
	Dirt Road Crossing					
200.1	3.71	3.71	3.71	0.00	0.00	0.00
200	3.98	3.98	3.98	0.00	0.00	0.00



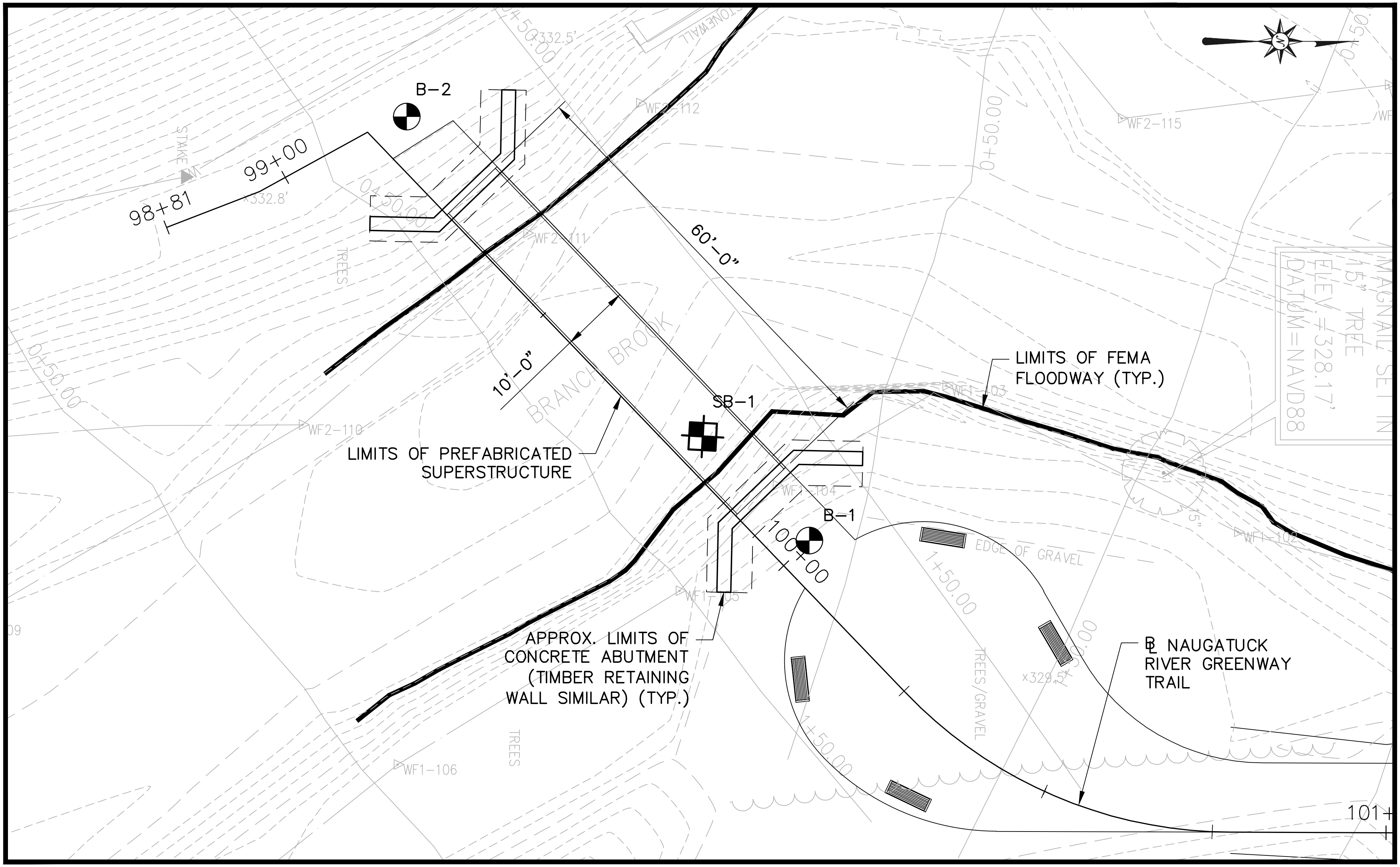
USGS LOCATION MAP
NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CT

SCALE: 1" = 1000'

FIGURE 1

BL Companies

CAD File: TLOC180057901.dwg



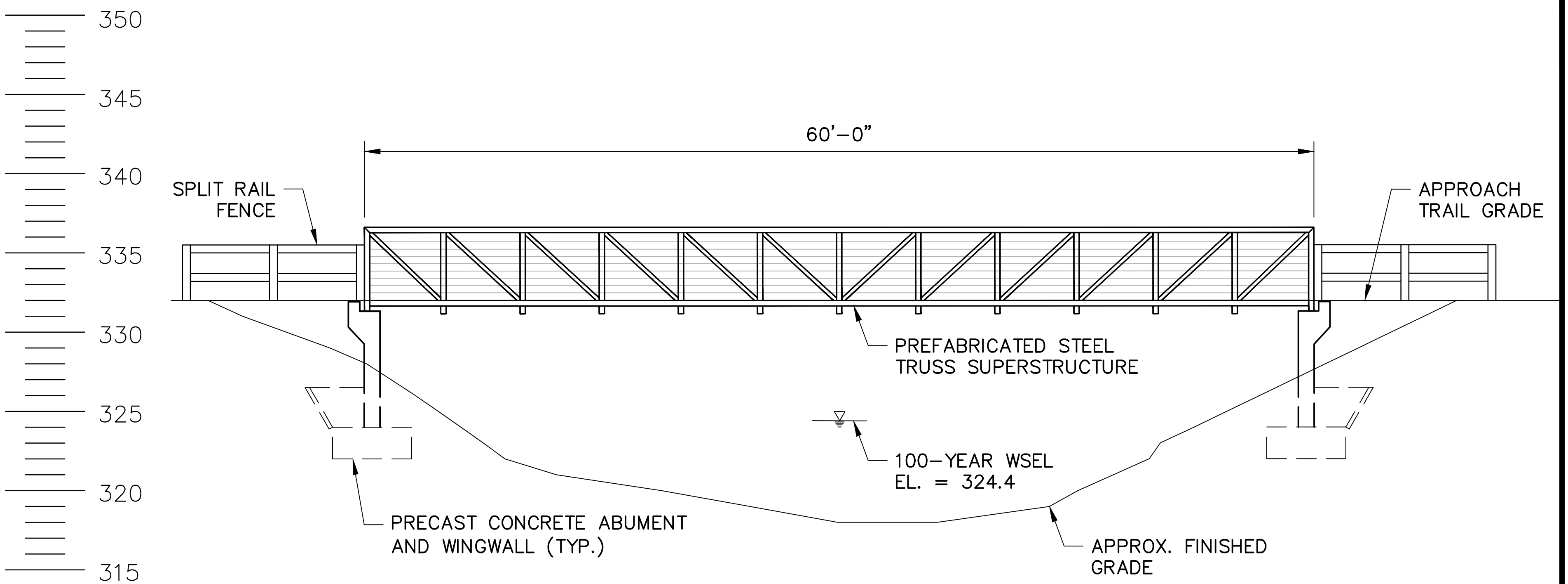
BL Companies

PROPOSED BRIDGE LOCATION

NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	1" = 20'-0"
Project No.	1800579
Date	11/2019
CAD File	Structure Type Study Figures

FIG. 2



NOTE: PRECAST CONCRETE WINGWALLS NOT SHOWN FOR CLARITY.

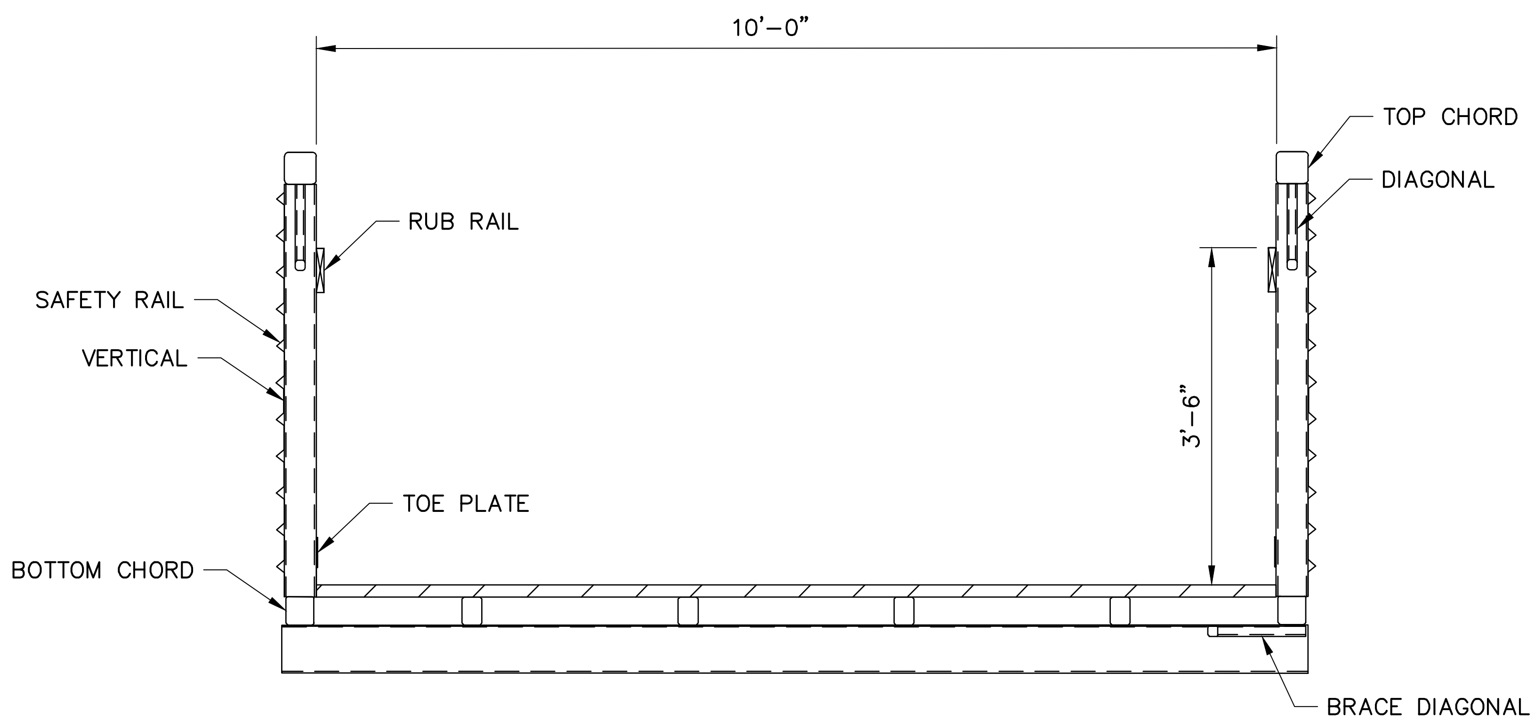
BL Companies

ALTERNATIVE 1 - DOWNSTREAM ELEVATION

NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	1" = 10'–0"
Project No.	1800579
Date	11/2019
CAD File	Structure Type Study Figures

FIG. 3



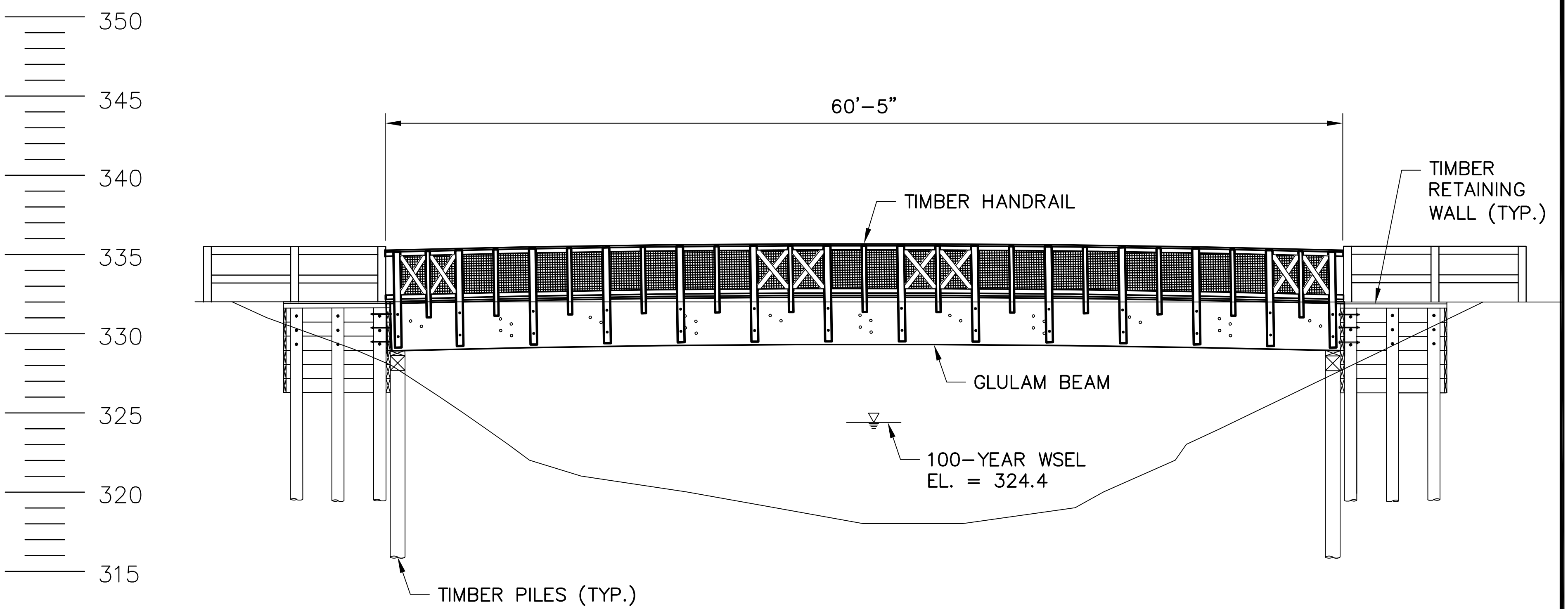
BL Companies

ALTERNATIVE 1 - TYPICAL SECTION

NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	1/2" = 1'–0"
Project No.	1800579
Date	11/2019
CAD File	Structure Type Study Figures

FIG. 4



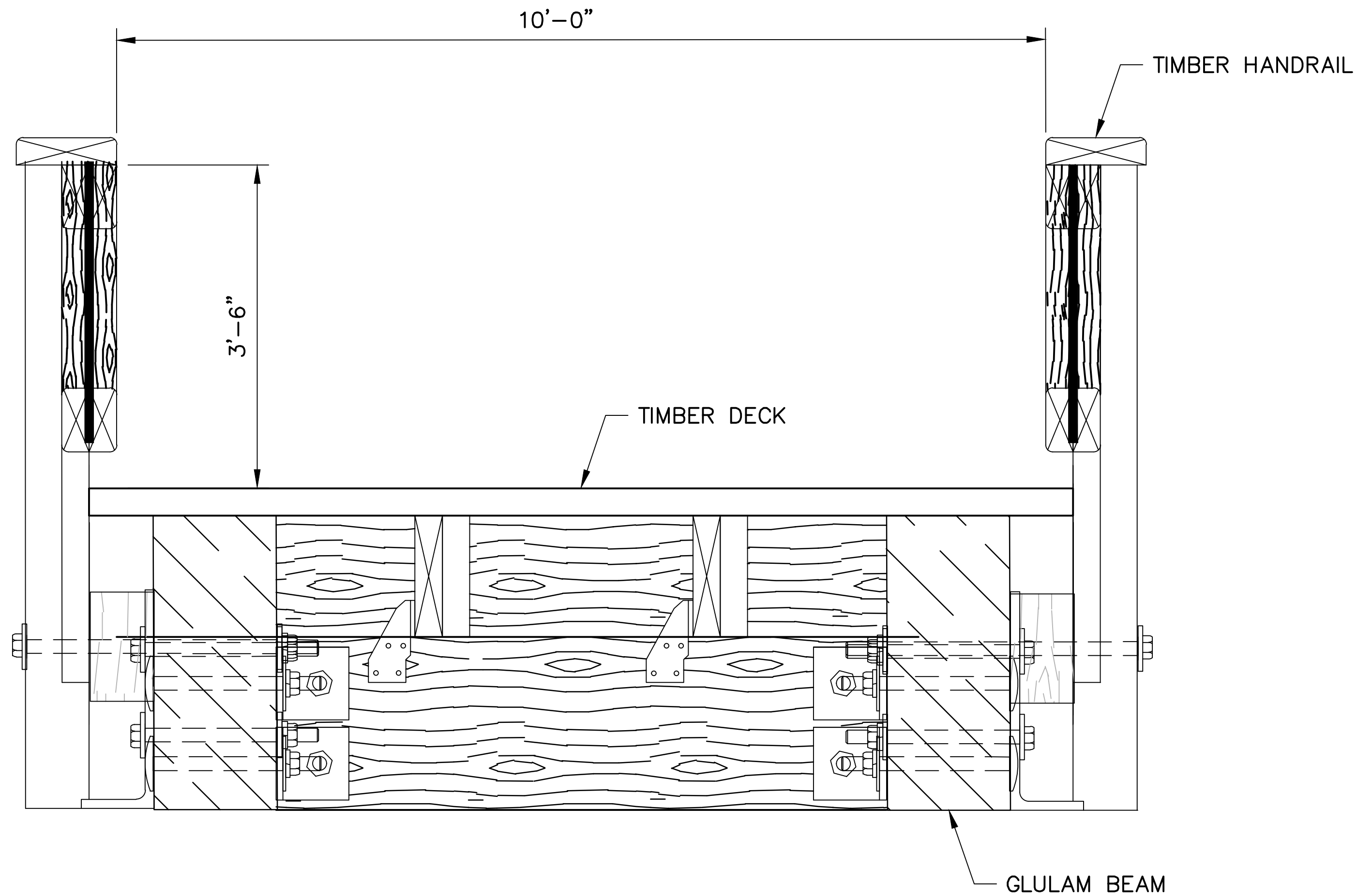
BL Companies

ALTERNATIVE 2 - DOWNSTREAM ELEVATION

NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	1" = 10'-0"
Project No.	1800579
Date	11/2019
CAD File	XBRG1800579_101

FIG. 5



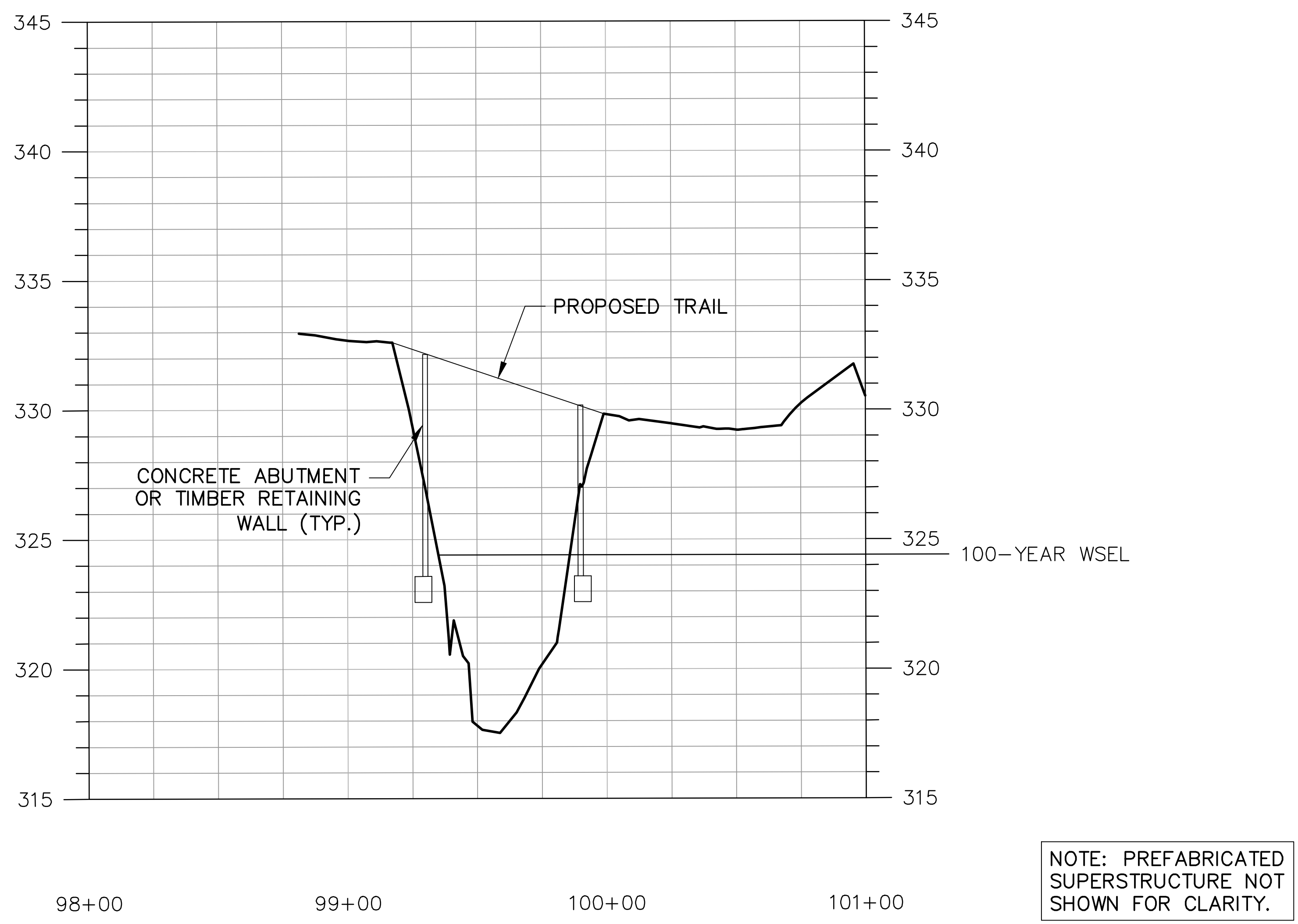
BL Companies

ALTERNATIVE 2 - TYPICAL SECTION

NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	1/2" = 1'–0"
Project No.	1800579
Date	11/2019
CAD File	Structure Type Study Figures

FIG. 6



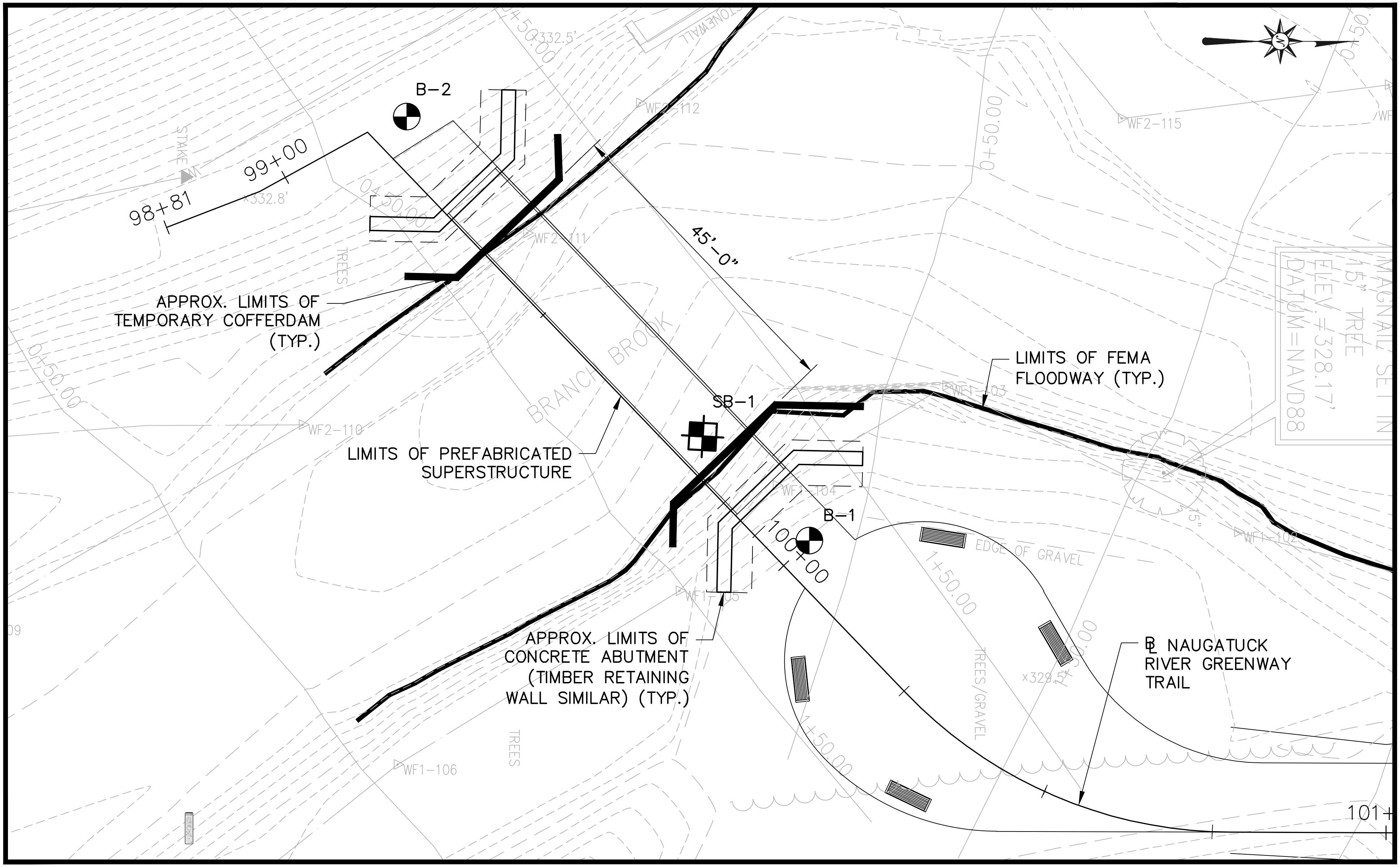
BL Companies

PROFILE

NAUGATUCK RIVER GREENWAY PEDESTRIAN BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	N.T.S.
Project No.	1800579
Date	10/2019
CAD File	Structure Type Study Figures

FIG. 7



PROPOSE BRIDGE LOCATION WITH TEMPORARY CONDITIONS

NAUGATUCK RIVER GREENWAY PEDESTRIAN
BRIDGE OVER BRANCH BROOK
THOMASTON, CONNECTICUT

Designed	M.W.
Drawn	T.B.
Checked	M.W.
Approved	C.P.
Scale	1" = 20'-0"
Project No.	1800579
Date	11/2019
CAD File	Structure Type Study Figures

FIG. 8

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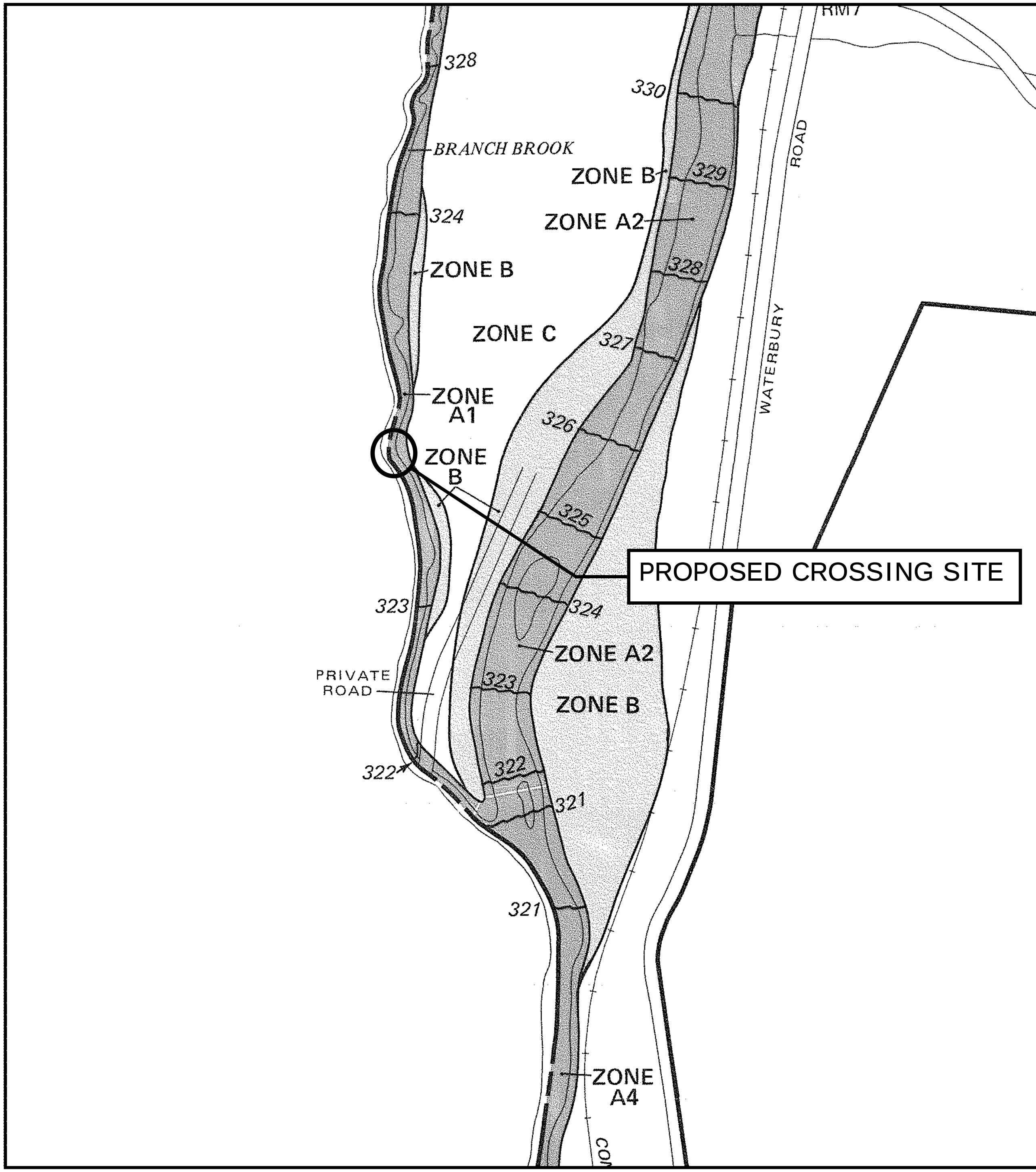

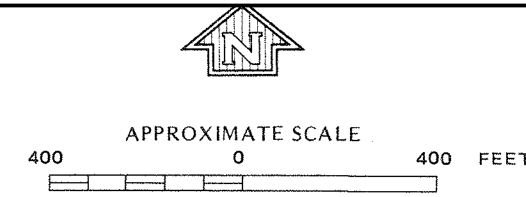

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

TOWN OF
THOMASTON,
CONNECTICUT
LITCHFIELD COUNTY

PANEL 5 OF 6
(SEE MAP INDEX FOR PANELS NOT PRINTED)

COMMUNITY-PANEL NUMBER
090055 0005 B

EFFECTIVE DATE:
JULY 5, 1982

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

APPENDIX A – HYDROLOGY

October 2019

ConnDOT Approved Hydraulic Engineer:

NVCOG

Prepared for:
Naugatuck Valley Council of Governments

HYDROLOGIC ANALYSIS REPORT
Pedestrian Footbridge over Branch Brook

BL Project No. 1800579

Naugatuck River Greenway Multi-Use Trail
Towns of Watertown and Thomaston, CT

Prepared By:____________________ Date: 10/14/2019
Brandon Rojas

Checked By:____________________ Date: 10/15/2019
David Cicia

PREPARED BY:
BL Companies
100 Constitution Plaza
10th Floor
Hartford, CT 06103

BL Companies

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TABLES AND FIGURES

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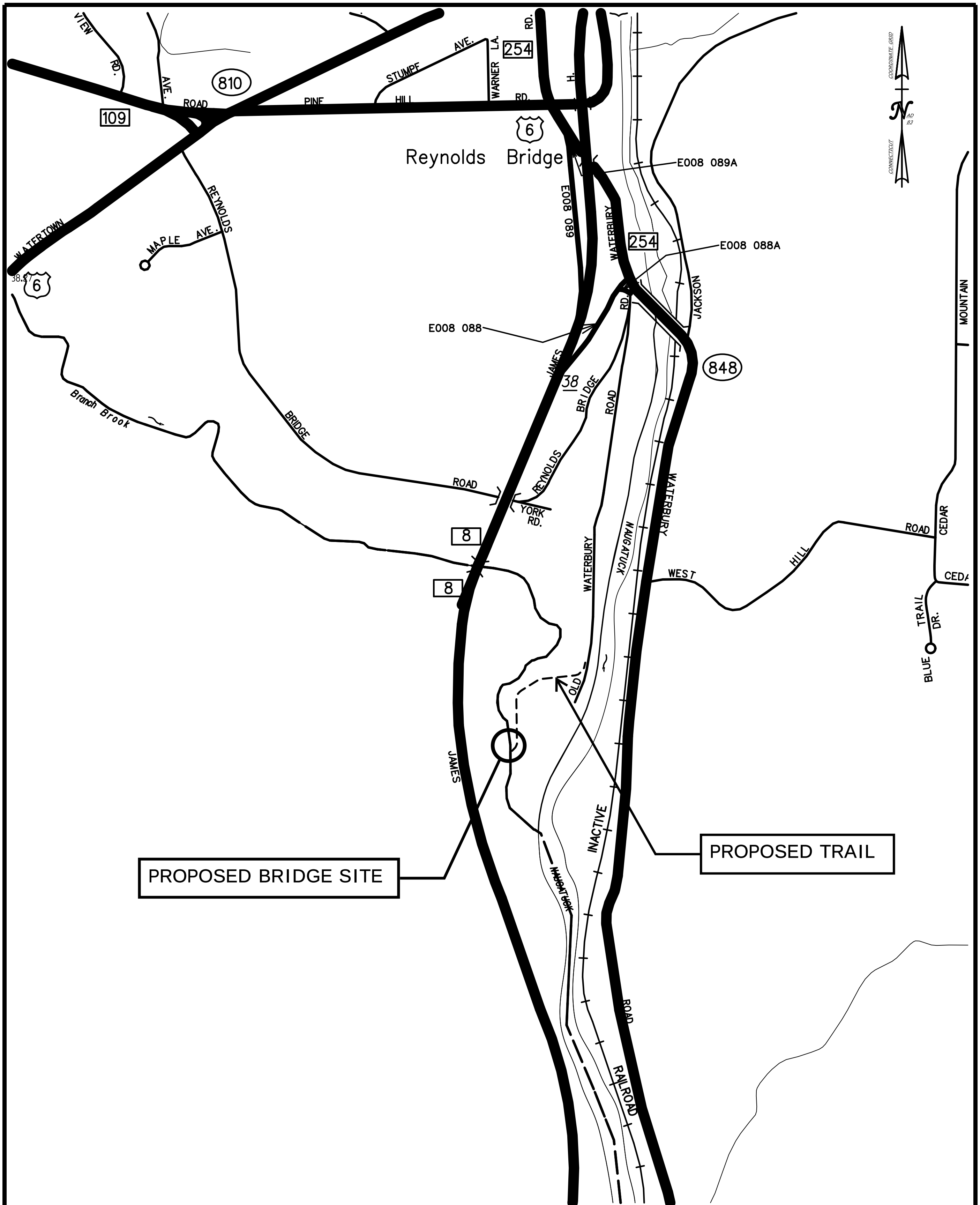


BL Companies	NAUGATUCK RIVER GREENWAY OVER BRANCH BROOK TOWNS OF WATERTOWN & THOMASTON, CONNECTICUT	LOCATION MAP	PROJ. NO.: 1800579 SCALE: 1" = 1,000'

II. WATERSHED CHARACTERISTICS

This project involves the construction of the Naugatuck River Greenway, a multi-use trail which includes a crossing over Branch Brook, which forms the boundary between the towns of Watertown and Thomaston. The proposed trail is located east of Route 8 and west of the Naugatuck River. The trail crosses Branch Brook approximately 1,000 ft upstream of the brook's confluence with the Naugatuck River. Once the path crosses Branch Brook, it moves northeast just outside the ridgelines of the properties between the two watercourses (see Location Map), where it eventually connects to Old Waterbury Road.

Branch Brook flows primarily southeast, beginning just downstream of the Wigwam Reservoir Dam, located approximately 3.0 miles upstream from the confluence of Branch Brook and Naugatuck River. Beyond this point (upstream direction), the main watercourse is segmented into a series of reservoirs and several dams, each with branching tributaries contributing to the watershed. As a result of the large water storage area, typical flow estimation methods involving StreamStats are not feasible and will not be used in this analysis. The largest watercourses within this area by extension (not including Branch Brook) are: Wigwam River, Moosehorn Brook, Slab Meadow Brook, East Morris Brook and Fenn Brook.

The river upstream of the bridge has an average streambed slope of 29.3 ft/mi. At the site of the proposed bridge, the brook has a drainage area of approximately 22.6 square miles. The watershed was generated by the USGS StreamStats 4.2 online application and revised for accuracy using USGS Quadrangle Maps from the National Map online viewer (see Figure 2). Utilizing the USGS StreamStats online utility, the watershed area exhibits that 9.69% of the land use is developed, 1.07% is wetlands and the remainder is forested or other pervious area. Delineation of surficial materials indicates that approximately 2.21% of the watershed area consists of coarse-grained stratified drift (see Figure 3) and the remainder is composed of various postglacial deposits and till.

The watershed extends northwest to a local high point located approximately 1.1 miles east of the intersection of Route 118 and Route 202. The eastern side of the watershed follows a ridgeline south, bordering the western limits of the larger Naugatuck River watershed. These extents of the watershed continue along a series of high points within the Towns of Litchfield, Thomaston and Watertown until it meets the location of the proposed pedestrian footbridge. The western extents of the watershed move from the northern portion of the watershed south along a series of high points until the southernmost limits, following the limits of the various watersheds surrounding the subject area. The southern extents of the watershed move along ridgelines until connecting with the eastern watershed limits at the bridge.

The upper third of the watershed is characterized by large amounts of rural pasture area unlike the other two thirds of the watershed which are mostly wooded and remote. The middle third consists of rural residential area as well as some open pasture. This area also includes large undeveloped wooded and water storage areas, including multiple large reservoirs such as Morris Reservoir and Pitch Reservoir. The lower third is similar in composition to the middle third of the watershed, characterized by large areas of water storage and forested area, although with substantially less open pasture-like area. This portion of the watershed contains the Branch

Brook watercourse, Black Rock Reservoir and the bridge itself. The ConnDOT Drainage Manual classifies the proposed bridge as a large structure (providing waterway for drainage areas of more than 10 square miles and less than 1,000 square miles) with a 100-year design storm event and a 500-year check storm event. The bridge is within Zone A1 on the FEMA Flood Insurance Rate Map (see Figure 4).

The FEMA Flood Insurance Study (*FIS*) denotes an area of 20.8 square miles, approximately 1.75 miles upstream of the bridge site at Black Rock Dam (effectively the beginning of the Branch Brook watercourse). The brook is listed in the Gazetteer of Drainage Areas of Connecticut. At the brook's mouth above Naugatuck River, the gazetteer lists Branch Brook with a drainage area of 22.646 sq. mi. The mouth is located approximately 1,100 feet downstream (south) of the subject bridge. There is also a USGS stream gage approximately 1.25 miles upstream from the proposed bridge.

III. HYDROLOGIC METHODOLOGY

The flows in this hydrologic study were prepared utilizing the methods described below:

1. **Method 1 – FEMA Flood Insurance Study (*FIS*):** This data was obtained from the *Flood Insurance Study (FIS), Prepared for the Town of Watertown, Connecticut, revised May 1980 by the Federal Emergency Management Agency* (FEMA). The *FIS* contains published flows along Branch Brook at three locations along the watercourse: at the mouth of the brook (the confluence with the Naugatuck River), at Black Rock Dam and at Wigwam Dam. At these locations, the drainage areas listed in the *FIS* are 22.8, 20.4, and 17.5 sq. miles, respectively. Black Rock Dam is the first structure upstream of the proposed bridge location. It is composed of a 933-ft long and 154-ft high earthen dam, a gated 4-ft by 5-ft concrete conduit in the right abutment of the dam, and a chute spillway with a 140-ft long crest adjacent to the right abutment. The structure has storage equivalent to 8 inches of runoff from the drainage area of 20.4 sq. miles. According to the *FIS,* the flows at Black Rock Dam are estimated based on hydrographs of major events routed through the reservoir. Refer to Appendix B of this report for additional *Flood Insurance Study* information. The *FIS* flows will be utilized for the hydraulic analysis.

2. **Method 2 – PeakFq Gage Analysis:** A gage analysis was performed on Gage No. 01208013 – Branch Brook near Thomaston, CT. The USGS program PeakFq, Version 7.2, computed estimates for the gages based on the Expected Moments Algorithm (EMA). Gage flow information was found in StreamStats, and is listed in the USGS publication, *Regression Equations for Estimating Flood Flows for the 2-, 10-, 25-, 50-, 100-, and 500-Year Recurrence Intervals in Connecticut, Report 2004-5126 (Ahearn, 2004)*. Refer to Appendix D for analysis of the stream gage in PeakFq. The flows computed by PeakFq and transferred to the site using the CTDOT Drainage Manual's flow transfer equation will not be utilized for the hydraulic analysis.

The flows calculated using the above methods are listed in "Table 1: Summary of Flows".

IV. HISTORICAL FLOODING

Numerous major floods have occurred within the Naugatuck River Basin, many of which caused severe damage to property and even loss of life. According to the FEMA *FIS*, the major floods of the century within the watershed occurred in August 1955 which saw the failure of multiple dams and bridges. This includes the downstream reaches of the Thomaston Dam where the Naugatuck River claimed an estimated 36 lives and caused damages estimated at $193,000,000. Stream flow records at the USGS gaging station along upstream of Black Rock Dam indicate that the August 1955 flood was greater than that of a 100-year event (*FIS*). Refer to Atlas 14 data (see Appendix E) to view relevant rainfall data.

V. STUDY RESULTS

The flows provided in the FEMA *Flood Insurance Study* at the mouth of Branch Brook will be utilized as the design flows for the hydraulic analysis. The FEMA and PeakFq rates are similar for all but the 500-year event. As noted in the *FIS*, the FEMA discharges for the 100-year and 500-year events "are estimated based on hydrographs of major events routed through the reservoir". The PeakFq flows are from a regression-based analysis and the 500-year flow appears too low for use. The flows within the *FIS* at the mouth of Branch Brook appear most accurate for the nature and use of the contributing watershed.

TABLE 1: SUMMARY OF FLOWS (C.F.S.)

Summary of Flows (cfs) vs. Design Frequency (years) Pedestrian Bridge over Branch Brook – Watertown/Thomaston, CT								
	Drainage Area (mi^2)	2-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
FEMA at Branch Brook mouth	22.8	-	800	-	800	900	-	2,300
FEMA at Black Rock Dam	20.4	-	800	-	800	900	-	2,300
PeakFq at Gage - No. 01208013	22.6	560	770	870	940	1,010	1,080	1,180

As previously mentioned, the proposed bridge is classified as a large structure. Large structures have a 100-year design storm event and a 500-year check storm event. At the location of the proposed bridge, the selected method has a 100-year flow of 900 cfs and a 500-year flow of 2,300 cfs. See Table 2 for the design flows recommended for this project.

TABLE 2: DESIGN FLOWS (C.F.S.)

Design Flows (cfs) vs. Design Frequency (years) Aircraft Road Bridge over Quinnipiac River – Southington, CT	
Year	**Flow**
Average Daily Flow	40
Average Spring Flow	80
2	450*
5	560*
10	800
25	800*
50	800
100 (Design Storm Event)	900
200	1,500*
500 (Check Storm Event)	2,300

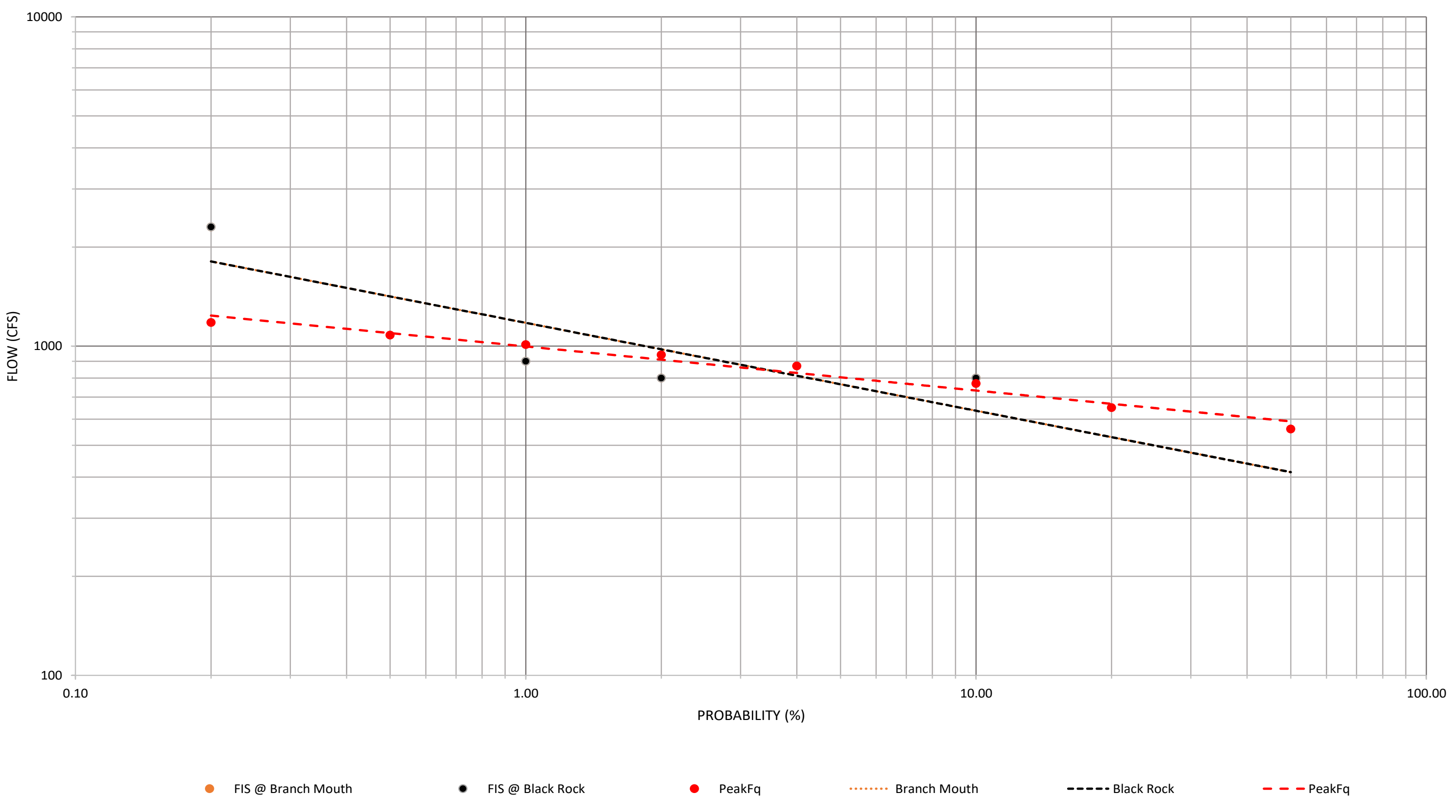
*These values were obtained based on a linear evaluation of the logarithmic chart.

To comply with the National Flood Insurance Program and the CT DEEP hydraulic guidelines for work within a regulated floodway, the FEMA FIS flows will also be used in the floodway analysis.

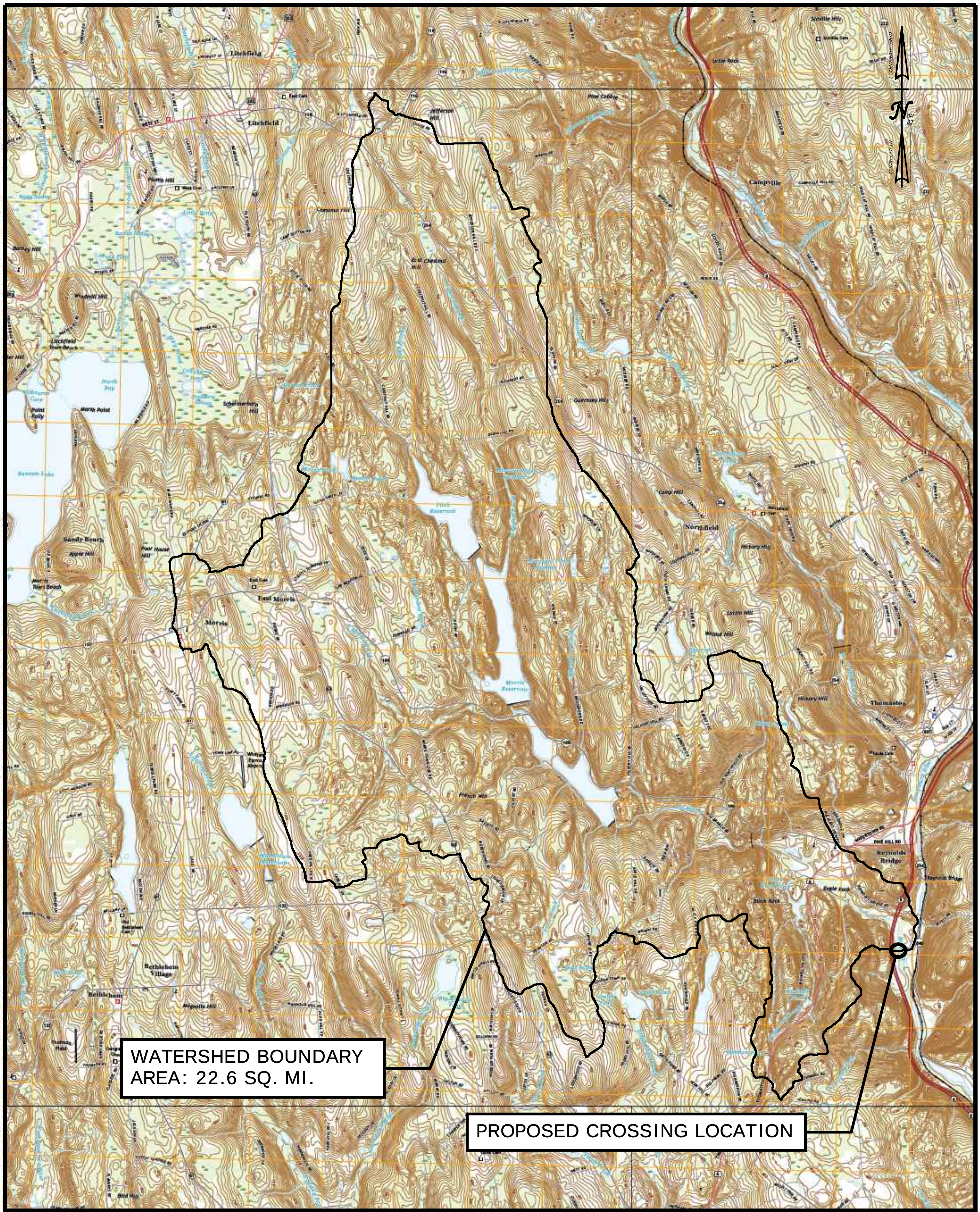
BL Companies
100 Constitution Plaza, 10th Floor
Hartford, Connecticut 06103

PROJECT: **Naugatuck River Greenway Multi-Use Trail**
Towns of Watertown & Thomaston, CT
PREPARED BY: Brandon Rojas
CHECKED BY: David Cicia

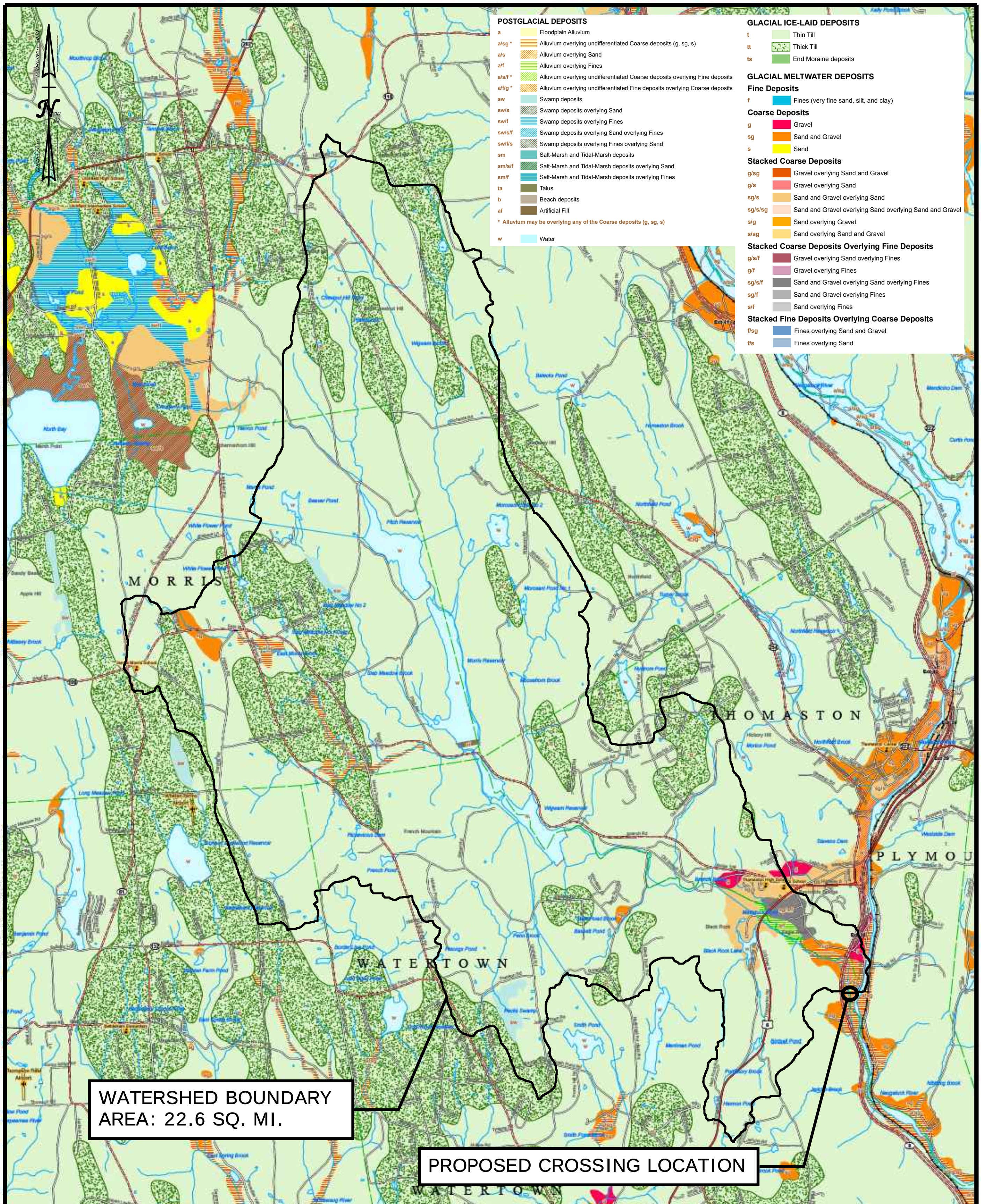
Year		PROBABILITY (%)	FEMA FIS at mouth of Branch Brook	FEMA FIS at Black Rock Dam	PeakFq at USGS Stream Gage No. 1208013
2	0.5	50			560
5	0.2	20			650
10	0.1	10	800	800	770
25	0.04	4			870
50	0.02	2	800	800	940
100	0.01	1	900	900	1,010
200	0.005	0.5			1,080
500	0.002	0.2	2,300	2,300	1,180



PROBABILITY CHART FOR ALL METHODS



BL Companies	NAUGATUCK RIVER GREENWAY OVER BRANCH BROOK TOWNS OF WATERTOWN & THOMASTON, CONNECTICUT	WATERSHED BOUNDARY MAP	BR. NO.:
			PROJ. NO.: 1800579
			SCALE: 1" = 6,000'



BL Companies

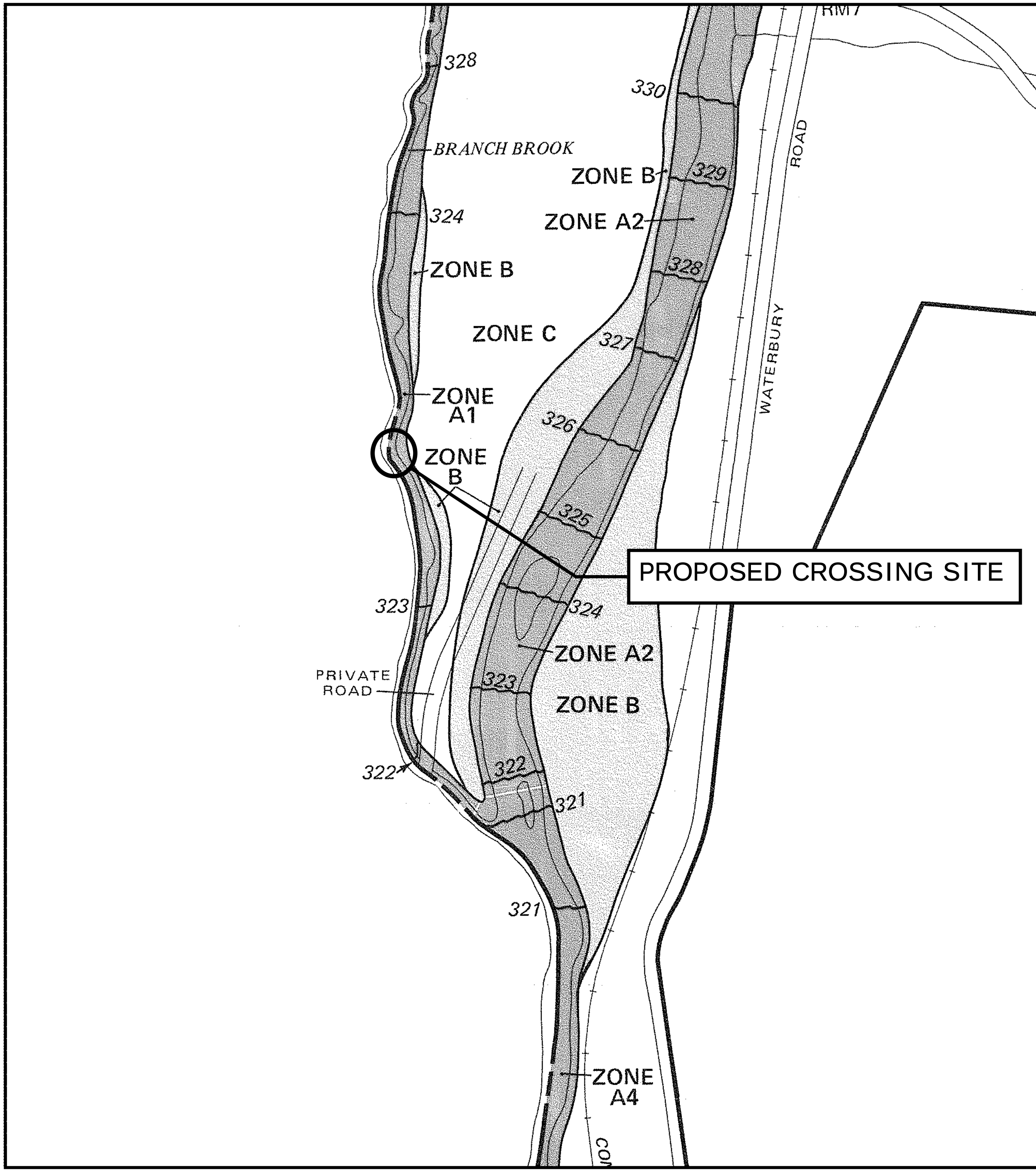
NAUGATUCK RIVER GREENWAY OVER BRANCH BROOK
TOWNS OF WATERTOWN & THOMASTON, CONNECTICUT

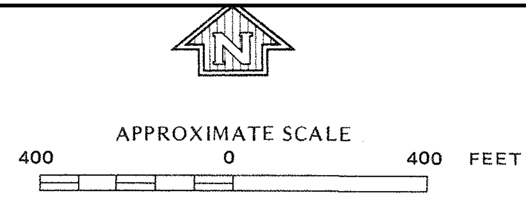
SURFICIAL MATERIALS MAP

BR. NO.:

PROJ. NO.: 1800579

SCALE: 1" = 6,000'





NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

TOWN OF
THOMASTON,
CONNECTICUT
LITCHFIELD COUNTY

PANEL 5 OF 6
(SEE MAP INDEX FOR PANELS NOT PRINTED)

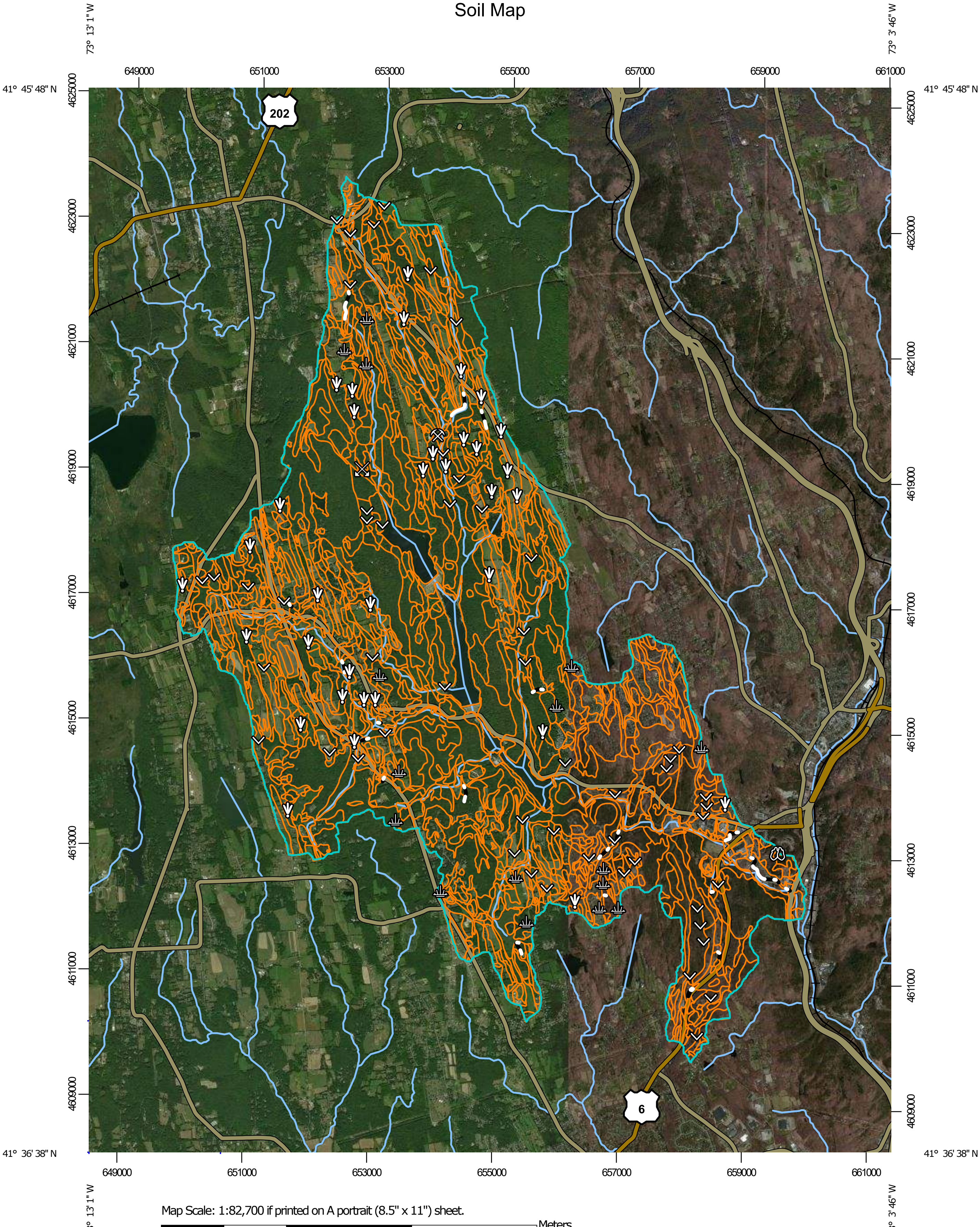
COMMUNITY-PANEL NUMBER
090055 0005 B

EFFECTIVE DATE:
JULY 5, 1982

Federal Emergency Management Agency

APPENDIX A: WEB SOIL SURVEY DATA

Custom Soil Resource Report
Soil Map



N

Map Scale: 1:82,700 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 1000, 2000, 4000, 6000

Feet: 0, 4000, 8000, 16000, 24000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: State of Connecticut
Survey Area Data: Version 19, Sep 13, 2019

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 28, 2011—Oct 5, 2016

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
2	Ridgebury fine sandy loam, 0 to 3 percent slopes	126.3	0.9%
3	Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony	727.8	5.0%
4	Leicester fine sandy loam	23.2	0.2%
12	Raypol silt loam	9.0	0.1%
13	Walpole sandy loam, 0 to 3 percent slopes	16.5	0.1%
15	Scarboro muck, 0 to 3 percent slopes	22.1	0.2%
16	Halsey silt loam	42.4	0.3%
17	Timakwa and Natchaug soils, 0 to 2 percent slopes	11.6	0.1%
18	Catden and Freetown soils, 0 to 2 percent slopes	160.1	1.1%
30B	Branford silt loam, 3 to 8 percent slopes	12.3	0.1%
34A	Merrimac fine sandy loam, 0 to 3 percent slopes	13.8	0.1%
34B	Merrimac fine sandy loam, 3 to 8 percent slopes	122.0	0.8%
34C	Merrimac fine sandy loam, 8 to 15 percent slopes	46.3	0.3%
38A	Hinckley loamy sand, 0 to 3 percent slopes	25.2	0.2%
38C	Hinckley loamy sand, 3 to 15 percent slopes	162.5	1.1%
38E	Hinckley loamy sand, 15 to 45 percent slopes	22.3	0.2%
45A	Woodbridge fine sandy loam, 0 to 3 percent slopes	44.8	0.3%
45B	Woodbridge fine sandy loam, 3 to 8 percent slopes	431.2	3.0%
45C	Woodbridge fine sandy loam, 8 to 15 percent slopes	55.2	0.4%
46B	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	87.5	0.6%
46C	Woodbridge fine sandy loam, 8 to 15 percent slopes, very stony	17.4	0.1%
47C	Woodbridge fine sandy loam, 3 to 15 percent slopes, extremely stony	549.8	3.8%

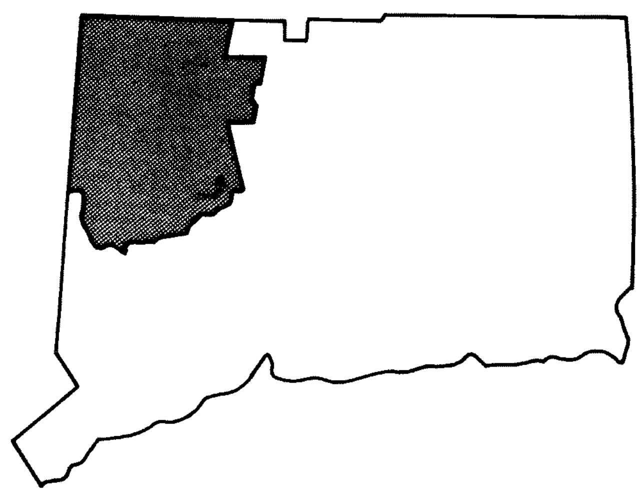
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
50A	Sutton fine sandy loam, 0 to 3 percent slopes	9.2	0.1%
50B	Sutton fine sandy loam, 3 to 8 percent slopes	29.8	0.2%
51B	Sutton fine sandy loam, 0 to 8 percent slopes, very stony	23.6	0.2%
52C	Sutton fine sandy loam, 2 to 15 percent slopes, extremely stony	77.7	0.5%
57C	Gloucester gravelly sandy loam, 8 to 15 percent slopes	0.2	0.0%
59C	Gloucester gravelly sandy loam, 3 to 15 percent slopes, extremely stony	29.1	0.2%
59D	Gloucester gravelly sandy loam, 15 to 35 percent slopes, extremely stony	17.2	0.1%
60B	Canton and Charlton fine sandy loams, 3 to 8 percent slopes	396.4	2.7%
60C	Canton and Charlton fine sandy loams, 8 to 15 percent slopes	193.8	1.3%
60D	Canton and Charlton soils, 15 to 25 percent slopes	49.9	0.3%
61B	Canton and Charlton fine sandy loams, 0 to 8 percent slopes, very stony	95.8	0.7%
61C	Canton and Charlton fine sandy loams, 8 to 15 percent slopes, very stony	70.0	0.5%
62C	Canton and Charlton fine sandy loams, 3 to 15 percent slopes, extremely stony	245.5	1.7%
62D	Canton and Charlton fine sandy loams, 15 to 35 percent slopes, extremely stony	168.1	1.2%
73C	Charlton-Chatfield complex, 0 to 15 percent slopes, very rocky	1,095.9	7.6%
73E	Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky	221.1	1.5%
75C	Hollis-Chatfield-Rock outcrop complex, 3 to 15 percent slopes	2,329.2	16.1%
75E	Hollis-Chatfield-Rock outcrop complex, 15 to 45 percent slopes	1,623.2	11.2%
76E	Rock outcrop-Hollis complex, 3 to 45 percent slopes	309.2	2.1%
76F	Rock outcrop-Hollis complex, 45 to 60 percent slopes	92.8	0.6%

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
84B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes	1,590.5	11.0%
84C	Paxton and Montauk fine sandy loams, 8 to 15 percent slopes	1,000.4	6.9%
84D	Paxton and Montauk fine sandy loams, 15 to 25 percent slopes	224.3	1.5%
85B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes, very stony	156.5	1.1%
85C	Paxton and Montauk fine sandy loams, 8 to 15 percent slopes, very stony	247.6	1.7%
86C	Paxton and Montauk fine sandy loams, 3 to 15 percent slopes, extremely stony	165.4	1.1%
86D	Paxton and Montauk fine sandy loams, 15 to 35 percent slopes, extremely stony	359.5	2.5%
100	Suncook loamy fine sand	2.9	0.0%
101	Occum fine sandy loam	66.1	0.5%
102	Pootatuck fine sandy loam	8.8	0.1%
107	Limerick and Lim soils	1.6	0.0%
108	Saco silt loam	16.1	0.1%
109	Fluvaquents-Udifluvents complex, frequently flooded	26.4	0.2%
301	Beaches-Udipsamments complex, coastal	1.1	0.0%
306	Udorthents-Urban land complex	107.7	0.7%
307	Urban land	14.7	0.1%
308	Udorthents, smoothed	112.5	0.8%
309	Udorthents, flood control	49.6	0.3%
702A	Tisbury silt loam, 0 to 3 percent slopes	12.1	0.1%
702B	Tisbury silt loam, 3 to 8 percent slopes	3.3	0.0%
703B	Haven silt loam, 3 to 8 percent slopes	10.2	0.1%
703C	Haven silt loam, 8 to 15 percent slopes	2.4	0.0%
W	Water	488.6	3.4%
Totals for Area of Interest		**14,475.5**	**100.0%**

APPENDIX B: FEMA FLOOD INSURANCE STUDY

FLOOD INSURANCE STUDY

TOWN OF WATERTOWN, CONNECTICUT
LITCHFIELD COUNTY



MAY 1980

federal emergency management agency
federal insurance administration

COMMUNITY NUMBER - 090058

The population of Watertown has increased steadily from 3,100 in 1900 to 18,610 in 1970. This population growth is a reflection of the change in Watertown from rural and agricultural in character to urban and suburban. Thirty percent of the town's land area, however, is still used for agricultural purposes. A modern superhighway system, which connects Watertown to the City of Waterbury, reducing commuting time, encourages suburban development.

Residential development in Watertown, as a whole, consists mainly of single- family detached houses. The most developed portion of the town's land area is arranged in a land use pattern consisting of an elongated urban core surrounded by suburban areas, that extend northwestward into rural countryside.

Watertown has only a small supply of easily developable land available. Much of the land presents problems for urban development because of uneven topography and less than ideal subsoil conditions.

The climate in Watertown is variable, with the average annual precipitation ranging between 44 and 52 inches. Temperatures in the area range from below 0 degrees Fahrenheit (°F) to greater than 100°F, with an annual average of approximately 50°F.

2.3 Principal Flood Problems

Numerous damaging floods have occurred in the Naugatuck River basin which have affected the Town of Watertown. Floods causing significant damage in this century occurred in 1927, 1936, 1938, 1948 and 1955.

The August, 1955 flood was the greatest flood ever recorded in the Naugatuck River basin with peak discharges three to four times the magnitude of any other flood. Between August 11-15, Hurricane Connie brought 4 to 8 inches of rainfall to the basin. Due to the unusually dry antecedent conditions, very little runoff resulted from this storm. However, when Hurricane Diane deposited 10 to 13 inches of rainfall in 24 hours, runoff of major proportions occurred due to the saturated condition of the soil. The failure of many dams and bridges contributed substantially to peak discharges. Downstream of the Thomaston Dam, the Naugatuck River claimed 36 lives and caused an estimated loss of nearly 193,000,000 dollars. Over 80 percent of this loss occurred in Waterbury, Watertown, Naugatuck and Ansonia.

High-water mark data were recorded at 332.5, 326.4, 314.9 and 309.9 feet, for the Naugatuck River at the mouth of Jericho Brook, at the mouth of Nibbling Brook, at Frost Bridge, and 0.1 mile below Frost Bridge, respectively.

Major floods occurred in the upper Naugatuck River basin in November 1927, March 1936, September 1938, December 1948, August 1955, and October 1955. With the exception of the August 1955 flood, the peak discharges of the other events generally ranged from 15,000 to 20,000 cubic feet per second (cfs) in the Naugatuck River at Waterbury, with estimated frequencies ranging from approximately 15 to 30 years. The August 1955 event was the greatest flood of record, by far, with a flow in the Naugatuck River at Waterbury of 90,000 cfs, with a corresponding frequency considered in excess of 100 years. The peak discharge on Branch Brook in 1955 was estimated at 10,300 cfs, approximately equal to the Leadmine Brook peak flow of 10,400 cfs.

In addition to the Naugatuck River, Steele Brook also has a history of damaging floods, the most serious of which occurred in August 1955. Areas close to the brook are susceptible to intense and sudden floods as a result of the steep sloping streets and terrain of the basin. The floodwaters converge from the fan-shaped drainage area and due to the limited natural storage in the upper basin, quickly exceed the channel capacity and overflow into the flood plain. Additionally, numerous restrictions such as low bridges, overhanging buildings, private dams and sharp bends in the channel all contribute to the flooding problems. In June 1973, and again in July 1975, Steele Brook overflowed its banks and resulted in extensive damage to commercial and manufacturing properties, homes and town installations.

Since 1955, the COE has constructed a system of reservoirs in the basin which will modify all future floods. In a repeat of historic flood events, the system would generally reduce flows on the Naugatuck River at Waterbury by 60 to 75 percent depending on storm orientation. Black Rock Reservoir on Branch Brook would generally maintain flows to safe channel capacity.

2.4 Flood Protection Measures

Following the devastating flood of 1955 along the Naugatuck River, the COE completed seven flood control dams and reservoirs in the Naugatuck River basin. Four of these, namely Thomaston, Hancock Brook, Black Rock and Northfield Brook, provided protection to the Town of Watertown.

was developed between the log of the 2-year flood and the drainage area and it was found that for New England, discharges vary in accordance with the drainage area raised to the exponent power of 0.70.

There are no discharge records for Branch Brook. In 1970, the COE completed Black Rock Dam, located on Branch Brook about two miles above the mouth. Discharges from the dam are controlled by gate operations. The anticipated releases for the 10- and 50-year events would probably not exceed the nondamaging downstream channel capacity and these releases would not be made until downstream flood conditions subsided. The 100- and 500-year discharges are estimated based on hydrographs of major events routed through the reservoir. On Branch Brook above Wigwam Reservoir, peak discharge frequencies were determined by using relationships based on records for the USGS gaging station on nearby Leadmine Brook and then relating it to the Branch Brook watershed based on a direct drainage area relationship. A regional study was not undertaken to determine the drainage area-discharge relationship for Leadmine and Branch Brooks. However, the runoff characteristics of Leadmine Brook are considered to be similar to those of Branch Brook.

A summary of drainage area-peak discharge relationships is shown in Table 1, "Summary of Discharges."

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
NAUGATUCK RIVER					
At downstream corporate limits	137	5,300	5,400	8,000	21,600
At upstream corporate limits	131	5,000	5,000	5,200	14,000
BRANCH BROOK					
At mouth	22.8	800	800	900	2,300
At Black Rock Dam	20.4	800	800	900	2,300
At Wigwam Dam	17.5	2,200	5,300	7,600	16,500
STEELE BROOK					
At downstream corporate limits	12.4	1,410	2,740	3,550	6,245
Above Wattles Brook	9.0	1,130	2,200	2,840	5,000
At Hemingway Pond	5.7	820	1,600	2,060	3,600
Below Smith Pond Brook confluence	4.0	640	1,250	1,600	2,800

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH[3] (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Naugatuck River (continued)								
T	20,440[1]	164	1,295	6.2	319.0	319.0	319.3	0.3
U	22,300[1]	118	884	5.7	320.5	320.5	320.6	0.1
Branch Brook								
A	100[2]	81	303	3.0	321.6	321.6	322.6	1.0
B	265[2]	88	469	1.9	322.0	322.0	322.8	0.8
C	1,700[2]	132	149	6.1	324.2	324.2	324.2	0.0
D	2,400[2]	46	146	6.2	330.0	330.0	330.0	0.0
E	2,600[2]	43	102	8.8	331.1	331.1	331.1	0.0
F	3,590[2]	68	186	4.8	338.1	338.1	338.1	0.0
G	5,410[2]	70	123	7.3	349.0	349.0	349.0	0.0
H	6,320[2]	72	218	4.1	353.6	353.6	353.7	0.1
I	7,130[2]	78	143	6.3	356.7	356.7	356.8	0.1
J	7,290[2]	54	119	7.6	357.5	357.5	357.5	0.0
K	8,400[2]	38	141	6.4	365.2	365.2	365.2	0.0
L	10,000[2]	31	92	9.8	381.9	381.9	381.9	0.0
M	20,500[2]	1,536	32,010	0.2	567.4	567.4	568.0	0.6
N	24,270[2]	370	4,953	1.5	567.4	567.4	568.0	0.6
O	24,670[2]	914	11,814	0.6	569.3	569.3	569.3	0.0

[1]Feet above corporate limits
[2]Feet above confluence with Naugatuck River
[3]This width extends beyond corporate limits

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWN OF WATERTOWN, CT
(LITCHFIELD CO.)

FLOODWAY DATA

NAUGATUCK RIVER AND BRANCH BROOK

TABLE 2

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND			FHF	ZONE	BASE FLOOD ELEVATION[3] (NGVD)
		10% (10 YR.)	2% (50 YR.)	0.2% (500 YR.)			
Naugatuck River							
Reach 1	03	-1.7	-1.6	+6.1	015	A3	Varies
Reach 2	02,03	-2.0	-1.9	+7.6	020	A4	Varies
Branch Brook							
Reach 1	01,02	-0.6	-0.3	+1.7	005	A1	Varies
Reach 2	04	-3.6	-1.7	+3.5	035	A7	Varies
Steele Brook							
Reach 1	06	-2.6	-0.8	+2.2	025	A5	Varies
Reach 2	06	-4.0	-1.4	+0.9	040	A8	Varies
Reach 3	06	-2.1	-0.5	+1.2	020	A4	Varies
Reach 4	06	-2.3	-0.7	+1.8	025	A5	Varies
Reach 5	06	-4.8	-1.5	+1.4	050	A10	Varies
Reach 6	06	-7.5	-4.1	+5.6	075	A15	Varies
Reach 7	05,06	-1.8	-0.6	+2.2	020	A4	Varies
Reach 8	05	-2.3	-0.8	+2.3	025	A5	Varies
Reach 9	05	-5.4	-1.9	+5.4	055	A11	Varies
Reach 10	05	-3.0	-1.2	+3.2	030	A6	Varies
Reach 11	05	-1.3	-0.3	+0.9	015	A3	Varies

[1]Flood Insurance Rate Map Panel
[2]Weighted average
[3]Rounded to the nearest foot - see map

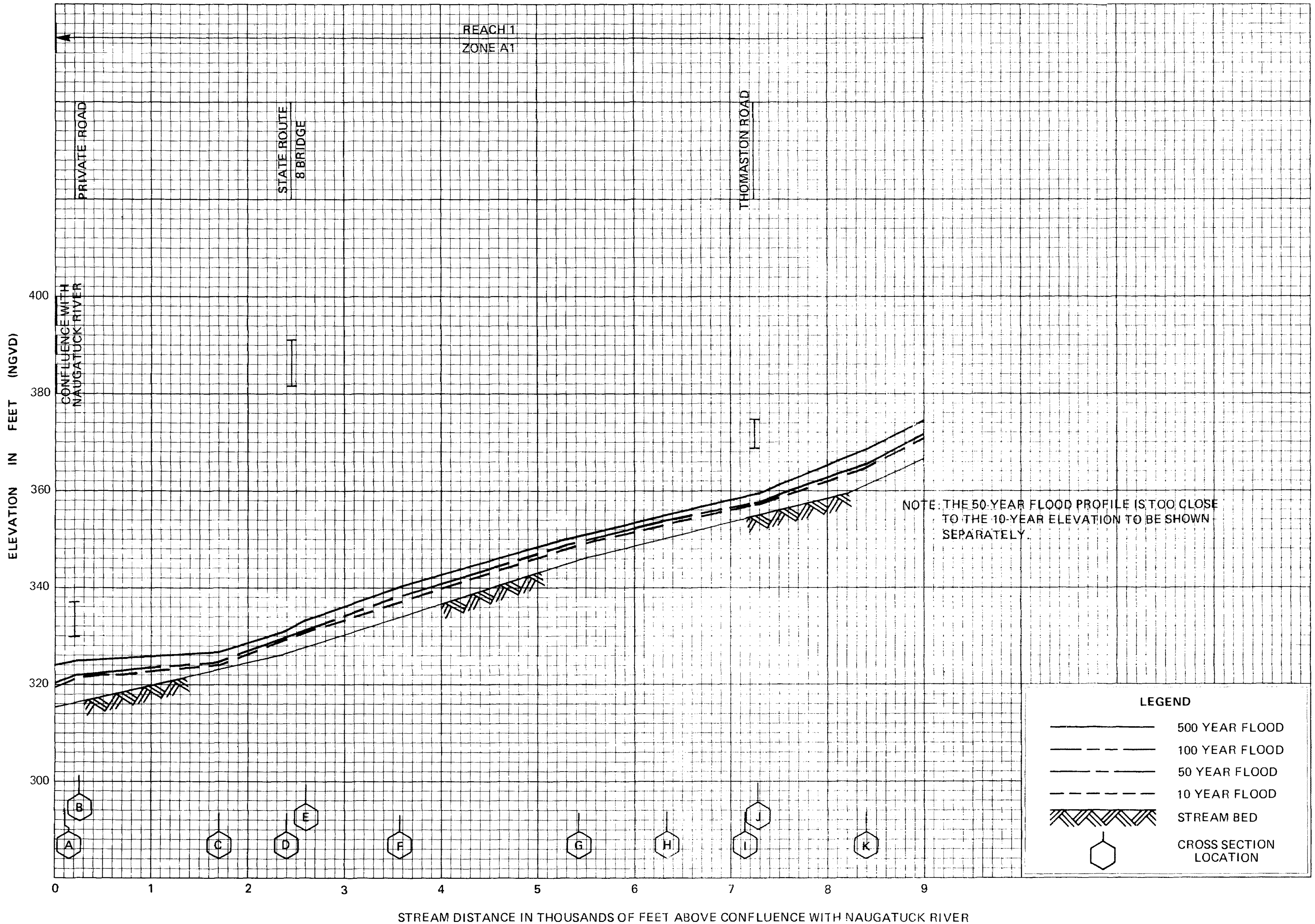
FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWN OF WATERTOWN, CT
(LITCHFIELD CO.)

FLOOD INSURANCE ZONE DATA

NAUGATUCK RIVER, BRANCH BROOK AND STEELE BROOK

TABLE 3



FLOOD PROFILES

BRANCH BROOK

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWN OF WATERTOWN, CT
(LITCHFIELD CO.)

APPENDIX C: USGS STREAM GAGE NO. 01208013 – BRANCH BROOK NEAR THOMASTON, CT

StreamStats Data-Collection Station Report

USGS Station Number	**01208013**
Station Name	**BRANCH BROOK NR THOMASTON,CT.**

Click here to link to available data on NWIS-Web for this site.

Descriptive Information

Station Type	Streamgage, continuous record
Location	
Gage	
Regulation and Diversions	
Regulated?	Unknown
Period of Record	1971-2001
Remarks	Peak flows affected by flood control.
Latitude (degrees NAD83)	41.65371
Longitude (degrees NAD83)	-73.09483
Hydrologic unit code	01100005
County	-
HCDN2009	No

Physical Characteristics

Characteristic Name	Value	Units	Citation Number
Descriptive Information			
Datum_of_Latitude_Longitude	NAD83	dimensionless	30
District_Code	09	dimensionless	30
Begin_date_of_record	10/1/1974	days	41
End_date_of_record	5/13/1993	days	41
Number_of_days_of_record	5549	days	41
Number_of_days_GT_0	5549	days	41
Basin Dimensional Characteristics			
Drainage_Area	20.8	square miles	30

Streamflow Statistics

Statistic Name	Value	Units	Citation Number	Preferred?	Years of Record	Standard Error, percent	Variance log-10	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Start Date	End Date	Remarks
Flow-Duration Statistics												
1_Percent_Duration	383.06	cubic feet per second	41	Y	15							
5_Percent_Duration	111	cubic feet per second	41	Y	15							
10_Percent_Duration	68	cubic feet per second	41	Y	15							
20_Percent_Duration	43	cubic feet per	41	Y	15							

		second			
25_Percent_Duration	37	cubic feet per second	41	Y	15
30_Percent_Duration	32	cubic feet per second	41	Y	15
40_Percent_Duration	23	cubic feet per second	41	Y	15
50_Percent_Duration	18	cubic feet per second	41	Y	15
60_Percent_Duration	13	cubic feet per second	41	Y	15
70_Percent_Duration	9.92	cubic feet per second	41	Y	15
75_Percent_Duration	8.3	cubic feet per second	41	Y	15
80_Percent_Duration	7.03	cubic feet per second	41	Y	15
90_Percent_Duration	3.6	cubic feet per second	41	Y	15
95_Percent_Duration	1.5	cubic feet per second	41	Y	15
99_Percent_Duration	0.41	cubic feet per second	41	Y	15
General Flow Statistics					
Minimum_daily_flow	0.18	cubic feet per second	41	Y	15
Maximum_daily_flow	713	cubic feet per second	41	Y	15
Std_Dev_of_daily_flows	63.769	cubic feet per second	41	Y	15
Average_daily_streamflow	34.999	cubic feet per second	41	Y	15
Base Flow Statistics					
Number_of_years_to_compute_BFI	15	years	42	Y	
Average_BFI_value	0.395	dimensionless	42	Y	
Std_dev_of_annual_BFI_values	0.112	dimensionless	42	Y	

Citations

Citation Number	*Citation Name and URL*
30	Imported from NWIS file
41	Wolock, D.M., 2003, Flow characteristics at U.S. Geological Survey streamgages in the conterminous United States: U.S. Geological Survey Open-File Report 03-146, digital data set
42	Wolock, D.M., 2003, Base-flow index grid for the conterminous United States: U.S. Geological Survey Open-File Report 03-263, digital data set

APPENDIX D: PEAKFQ FLOWS – BRANCH BROOK NEAR THOMASTON, CT

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY            Seq.002.000
  Version 7.2          Annual peak flow frequency analysis      Run Date / Time
  3/28/2018                                                      10/09/2019 11:00

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      Basin char output   = None
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  -
G:\JOBS18\04\1800579\ENG-TECH\TRANS\Hydra\Hydrology\PEAK_01208013_TEST.TXT

                         specifications -
G:\JOBS18\04\1800579\ENG-TECH\TRANS\Hydra\Hydrology\PKFQWPSF.TMP

                      Output file(s):
                         main -
G:\JOBS18\04\1800579\ENG-TECH\TRANS\Hydra\Hydrology\PEAK_01208013_TEST.PRT



  ***  User responsible for assessment and interpretation of the following analysis
 ***

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY            Seq.001.001
  Version 7.2          Annual peak flow frequency analysis      Run Date / Time
  3/28/2018                                                      10/09/2019 11:00

              Station - 01208013  BRANCH BROOK NEAR THOMASTON, CT


                     TABLE 1 - INPUT DATA SUMMARY

                Number of peaks in record            =       25
                Peaks not used in analysis           =        0
                Gaged peaks in analysis              =       25
                Historic peaks in analysis           =        0
                Beginning Year                       =     1971
                Ending Year                          =     1995
                Historical Period Length             =       25
                Skew option                          =   WEIGHTED
```

```
            Regional skew                         =    0.340
                 Standard error                   =    0.510
                 Mean Square error                =    0.260
            Gage base discharge                   =      0.0
            User supplied high outlier threshold =   --
            User supplied PILF (LO) criterion    =   --
            Plotting position parameter           =     0.00
            Type of analysis                                 EMA
            PILF (LO) Test Method                           MGBT
            Perceptible Ranges:
                Start Year  End Year  Lower Bound  Upper Bound
                      1971      1995          0.0          INF    DEFAULT

            Interval Data                     =   None Specified
```

TABLE 2 - DIAGNOSTIC MESSAGE AND PILF RESULTS

```
WCF002J-CALCS COMPLETED.  RETURN CODE =  2
EMA002W-CONFIDENCE INTERVALS ARE NOT EXACT IF HISTORIC PERIOD > 0
```

MULTIPLE GRUBBS-BECK TEST RESULTS

```
MULTIPLE GRUBBS-BECK PILF THRESHOLD   494.0
NUMBER OF PILFS IDENTIFIED                8
    CLASSIFICATION OF PILFS:
        NUMBER OF ZERO FLOWS              0
        NUMBER OF CENSORED FLOWS          0
        NUMBER OF GAGED PEAKS             8
            GAGED PEAKS AND CORRESPONDING P-VALUES
                   145.0    (0.1052)
                   145.0    (0.0011)
                   288.0    (0.2320)
                   288.0    (0.0440)
                   308.0    (0.0155)
                   332.0    (0.0057)
                   355.0    (0.0014)
                   390.0    (0.0007)
```

Kendall's Tau Parameters

```
                                    MEDIAN   No. of
                   TAU    P-VALUE    SLOPE   PEAKS
           ---------------------------------------
```

```
   GAGED PEAKS     -0.180      0.216     -9.982    25


1


  Program PeakFq          U. S. GEOLOGICAL SURVEY            Seq.001.002
  Version 7.2        Annual peak flow frequency analysis      Run Date / Time
  3/28/2018                                                    10/09/2019 11:00

            Station - 01208013  BRANCH BROOK NEAR THOMASTON, CT


     TABLE 3 - ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                                     LOGARITHMIC
                          -------------------------------
                                       STANDARD
                            MEAN     DEVIATION     SKEW
                          -------------------------------
 EMA WITHOUT REG SKEW      2.7402       0.1189     -0.423
 EMA WITH REG SKEW         2.7476       0.1062      0.134

 EMA ESTIMATE OF MSE OF SKEW WITHOUT REG SKEW              0.2364
 EMA ESTIMATE OF MSE OF SKEW W/GAGED PEAKS ONLY (AT-SITE)  0.2364



 TABLE 4 - ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE
PROBABILITIES

   ANNUAL   <- EMA ESTIMATE ->    <- FOR EMA ESTIMATE WITH REG SKEW ->
EXCEEDANCE    WITH     WITHOUT    LOG VARIANCE   <-CONFIDENCE LIMITS->
PROBABILITY REG SKEW  REG SKEW       OF EST.     5% LOWER    95% UPPER

   0.9950     307.2     243.7       0.0090         128.0        396.4
   0.9900     324.4     267.4       0.0071         149.3        405.1
   0.9500     377.6     339.9       0.0035         220.4        437.3
   0.9000     410.3     383.2       0.0023         265.1        460.9
   0.8000     454.6     439.9       0.0013         322.0        497.5
   0.6667     501.2     496.9       0.0008         372.6        543.0
   0.5000     556.3     560.5       0.0005         429.3        609.3
   0.4292     581.1     588.0       0.0005         492.1        643.8
   0.2000     685.9     695.0       0.0006         620.8        798.7
   0.1000     767.7     769.6       0.0009         684.7        941.4
   0.0400     867.7     851.5       0.0015         755.6       1160.0
   0.0200     940.4     905.3       0.0021         803.9       1349.0
   0.0100    1012.      954.0       0.0028         848.9       1559.0
   0.0050    1083.      998.7       0.0035         891.1       1791.0
   0.0020    1177.     1053.        0.0047         943.3       2136.0
```

*Note: If Station Skew option is selected then EMA ESTIMATE WITH REG SKEW will display values for and be equal to EMA ESTIMATE WITHOUT REG SKEW.

1

Station - 01208013 BRANCH BROOK NEAR THOMASTON, CT

TABLE 5 - INPUT DATA LISTING

WATER YEAR	PEAK VALUE	PEAKFQ CODES	FLOW INTERVALS (WHERE LOWER BOUND NOT = UPPER BOUND) LOWER BOUND	UPPER BOUND	REMARKS
1971	494.0	K			
1972	390.0	K			
1973	585.0	K			
1974	555.0	K			
1975	795.0	K			
1976	590.0	K			
1977	500.0	K			
1978	705.0	K			
1979	750.0	K			
1980	145.0	K			
1981	725.0	K			
1982	805.0	K			
1983	755.0	K			
1984	683.0	K			
1985	308.0	K			
1986	538.0	K			
1987	766.0	K			
1988	145.0	K			
1989	604.0	K			
1990	539.0	K			
1991	573.0	K			
1992	288.0	K			
1993	355.0	K			
1994	288.0	K			
1995	332.0	K			

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION

D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.004
Version 7.2 Annual peak flow frequency analysis Run Date / Time
3/28/2018 10/09/2019 11:00

Station - 01208013 BRANCH BROOK NEAR THOMASTON, CT

TABLE 6 - EMPIRICAL FREQUENCY CURVES -- HIRSCH-STEDINGER PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	EMA ESTIMATE	FLOW INTERVALS (WHERE LOWER BOUND NOT = UPPER BOUND) LOWER BOUND	UPPER BOUND
1982	805.0	0.0383		
1975	795.0	0.0768		
1987	766.0	0.1152		
1983	755.0	0.1537		
1979	750.0	0.1922		
1981	725.0	0.2307		
1978	705.0	0.2691		
1984	683.0	0.3076		
1989	604.0	0.3461		
1976	590.0	0.3846		
1973	585.0	0.4230		
1991	573.0	0.4615		
1974	555.0	0.5000		
1990	539.0	0.5385		
1986	538.0	0.5770		
1977	500.0	0.6154		
1971	494.0	0.6539		
* 1972	390.0	0.6924		
* 1993	355.0	0.7309		
* 1995	332.0	0.7693		
* 1985	308.0	0.8078		
* 1992	288.0	0.8848		

* 1994	288.0	0.8463
* 1980	145.0	0.9617
* 1988	145.0	0.9232

* DENOTES PILF (LO)

1

Station - 01208013 BRANCH BROOK NEAR THOMASTON, CT

TABLE 7 - EMA REPRESENTATION OF DATA

WATER	<----- OBSERVED	---->	<-------- EMA	------->	<---- USER-ENTERED PERCEPTIBLE RANGES	---->	<-------- FINAL PERCEPTIBLE RANGES	------->
YEAR	Q_LOWER	Q_UPPER	Q_LOWER	Q_UPPER	LOWER	UPPER	LOWER	UPPER
1971	494.0	494.0	494.0	494.0	0.0	INF	494.0	INF
1972	390.0	390.0	0.0	494.0	0.0	INF	494.0	INF
1973	585.0	585.0	585.0	585.0	0.0	INF	494.0	INF
1974	555.0	555.0	555.0	555.0	0.0	INF	494.0	INF
1975	795.0	795.0	795.0	795.0	0.0	INF	494.0	INF
1976	590.0	590.0	590.0	590.0	0.0	INF	494.0	INF
1977	500.0	500.0	500.0	500.0	0.0	INF	494.0	INF
1978	705.0	705.0	705.0	705.0	0.0	INF	494.0	INF
1979	750.0	750.0	750.0	750.0	0.0	INF	494.0	INF
1980	145.0	145.0	0.0	494.0	0.0	INF	494.0	INF
1981	725.0	725.0	725.0	725.0	0.0	INF	494.0	INF
1982	805.0	805.0	805.0	805.0	0.0	INF	494.0	INF
1983	755.0	755.0	755.0	755.0	0.0	INF	494.0	INF

```
   1984      683.0      683.0      683.0      683.0          0.0         INF
494.0        INF
   1985      308.0      308.0        0.0      494.0          0.0         INF
494.0        INF
   1986      538.0      538.0      538.0      538.0          0.0         INF
494.0        INF
   1987      766.0      766.0      766.0      766.0          0.0         INF
494.0        INF
   1988      145.0      145.0        0.0      494.0          0.0         INF
494.0        INF
   1989      604.0      604.0      604.0      604.0          0.0         INF
494.0        INF
   1990      539.0      539.0      539.0      539.0          0.0         INF
494.0        INF
   1991      573.0      573.0      573.0      573.0          0.0         INF
494.0        INF
   1992      288.0      288.0        0.0      494.0          0.0         INF
494.0        INF
   1993      355.0      355.0        0.0      494.0          0.0         INF
494.0        INF
   1994      288.0      288.0        0.0      494.0          0.0         INF
494.0        INF
   1995      332.0      332.0        0.0      494.0          0.0         INF
494.0        INF
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      25


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)

 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:  01208013       USGS BRANCH BROOK NEAR THOMASTON,


 For the station below, the following records were ignored:

 FINISHED PROCESSING STATION:
```

APPENDIX E: SUPPLEMENTARY REFERENCE DATA

- CTDOT Drainage Manual Transfer Calculations
- StreamStats Computation at Bridge Site
- NOAA Atlas 14 Data
- USGS Reference Publications

6.11 Transferring Gaged Data

6.11.1 Procedure

Gaged data can be transferred up or downstream on the gaged stream only. If the drainage area for the location of concern is ≥ 75% and ≤ 125% of the drainage area at the gage, then the gaged data can be transferred with equation 6.12.

6.11.2 Transfer Equation

The following equation shall be used to transfer gage data:

$$\frac{Q_1 / A_1}{Q_2 / A_2} = \frac{A_1^{[(0.894 / A_1^{0.048})-1]}}{A_2^{[(0.894 / A_2^{0.048})-1]}}$$ **(English only)**

(6.12)

Q_1 and A_1 represent the discharge rate and watershed area at one point in the watershed and Q_2 and A_2 represent the rate and area at the gage or known outlet which remain constant while Q_1 and A_1 are varied.

Q = discharge in cubic feet per second
A = drainage area in square miles

Source: Adopted from Mockus, V., SCS National Engineering Handbook, Section 4, Hydrology, 1972

Transfer Equation From DOT Drainage Manual

Prepared By: BGR Date: 10/9/2019
Checked By: DMC Date: 10/11/2019

A1 = 22.6 sq mi **Proposed Drain. Area**
A2 = 20.8 sq mi **Gage Drain. Area**

***PeakFQ trans. to Bridge**

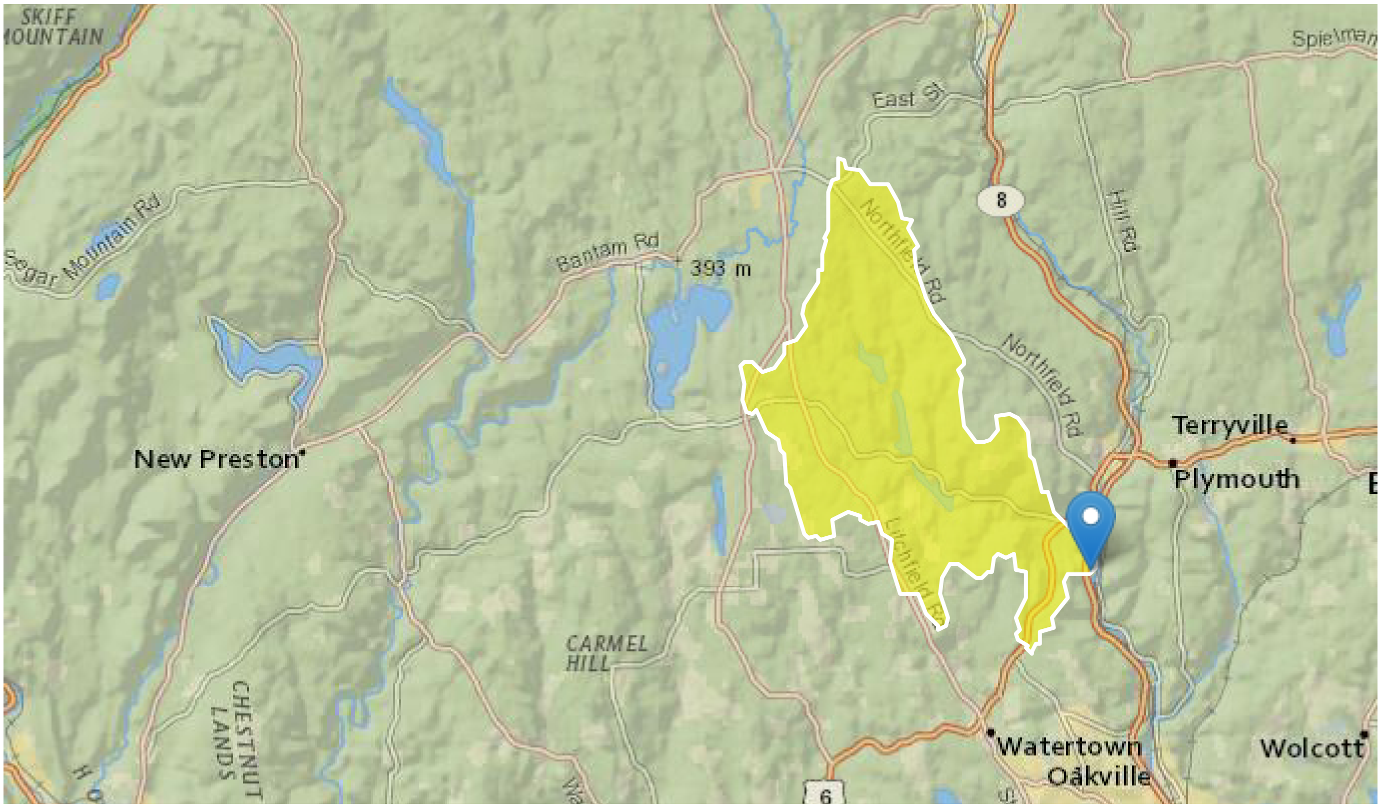
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
Q2 =	556.3	685.9	767.7	867.7	940.4	1012	1177

***Site Flows**

	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
Q1 =	587	724	811	916	993	1069	1243

StreamStats Report

Region ID: CT
Workspace ID: CT20191009150317053000
Clicked Point (Latitude, Longitude): 41.64395, -73.08096
Time: 2019-10-09 11:03:33 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	22.6	square miles
I24H2Y	Maximum 24-hour precipitation that occurs on average once in 2 years - Equivalent to precipitation intensity index	3.391	inches
ELEV	Mean Basin Elevation	859	feet
I24H10Y	Maximum 24-hour precipitation that occurs on average once in 10 years	4.807	inches
I24H25Y	Maximum 24-hour precipitation that occurs on average once in 25 years	5.867	inches

Parameter Code	Parameter Description	Value	Unit
I24H50Y	Maximum 24-hour precipitation that occurs on average once in 50 years	6.835	inches
I24H100Y	Maximum 24-hour precipitation that occurs on average once in 100 years	7.957	inches
CRSDFT	Percentage of area of coarse-grained stratified drift	2.21	percent
NOVAVPRE	Mean November Precipitation	4.5	inches
PRCWINTER	Mean annual precipitation for December through February	3.8	inches
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	9.69	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	1.59	percent
MAPM	Mean Annual Precip Basin Average	51.543	inches
SGSL	Total stream length intersecting sand and gravel deposits (in miles)	6.57	miles
SOILPERM	Average Soil Permeability	2.941	inches per hour
STRMTOT	total length of all mapped streams (1:24,000-scale) in the basin	68.4	miles
WETLAND	Percentage of Wetlands	1.07	percent

General Disclaimers

The delineation point is in an exclusion area. Warning! Peak flows affected by flood control structures. Peak-flow statistics represent near natural conditions or conditions prior to flood-control.

Peak-Flow Statistics Parameters[Statewide Multiparameter]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	22.6	square miles	1.69	715
I24H2Y	24 Hour 2 Year Precipitation	3.391	inches	2.95	3.82

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
ELEV	Mean Basin Elevation	859	feet	169	1310
I24H10Y	24 Hour 10 Year Precipitation	4.807	inches	4.15	5.53
I24H25Y	24 Hour 25 Year Precipitation	5.867	inches	4.93	7
I24H50Y	24 Hour 50 Year Precipitation	6.835	inches	5.62	8.36
I24H100Y	24 Hour 100 Year Precipitation	7.957	inches	6.41	9.99

Peak-Flow Statistics Flow Report[Statewide Multiparameter]

PIl: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SE	SEp	Equiv. Yrs.
2 Year Peak Flood	776	ft^3/s	31.8	31.8	3.5
10 Year Peak Flood	1640	ft^3/s	32.7	32.7	8.1
25 Year Peak Flood	2170	ft^3/s	34.4	34.4	10.9
50 Year Peak Flood	2630	ft^3/s	35.9	35.9	12.7
100 Year Peak Flood	3130	ft^3/s	37.6	37.6	14.3
500 Year Peak Flood	4980	ft^3/s	45	45	14.9

Peak-Flow Statistics Citations

Ahearn, E.A.,2004, Regression Equations for Estimating Flood Flows for the 2-, 10-, 25-, 50-, 100-, and 500-Year Recurrence Intervals in Connecticut: U.S. Geological Survey SRI 2004-5160, 62 p. (http://water.usgs.gov/pubs/sir/2004/5160/)

November Flow-Duration Statistics Parameters[Duration Flow 2010 5052]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	22.6	square miles	0.92	150
NOVAVPRE	Mean November Precipitation	4.5	inches	3.48	4.93
CRSDFT	Percent Coarse Stratified Drift	2.21	percent	0.1	55.1

November Flow-Duration Statistics Flow Report[Duration Flow 2010 5052]

Statistic	Value	Unit

Statistic	Value	Unit
November 25 Percent Duration	45.8	ft^3/s
November 50 Percent Duration	24.5	ft^3/s
November 75 Percent Duration	12.4	ft^3/s
November 90 Percent Duration	5.35	ft^3/s
November 99 Percent Duration	1.91	ft^3/s

November Flow-Duration Statistics Citations

Ahearn, E.A.,2010, Regional regression equations to estimate flow-duration statistics in Connecticut: U. S. Geological Survey Scientific Investigations Report 2010-5052, 45 p. (http://pubs.usgs.gov/sir/2010/5052/)

Seasonal Flow Statistics Parameters[Duration Flow 2010 5052]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	22.6	square miles	0.92	150
PRCWINTER	Mean Annual Winter Precipitation	3.8	inches	3.19	4.4
CRSDFT	Percent Coarse Stratified Drift	2.21	percent	0.1	55.1

Seasonal Flow Statistics Flow Report[Duration Flow 2010 5052]

Statistic	Value	Unit
25 Percent Duration December to February	57.1	ft^3/s
50 Percent Duration December to February	34.1	ft^3/s
75 Percent Duration December to February	20.6	ft^3/s
95 Percent Duration DEC FEB	9.31	ft^3/s
99 Percent Duration December to February	4.88	ft^3/s
25 Percent Duration March to April	96	ft^3/s
50 Percent Duration March to April	61.9	ft^3/s
75 Percent Duration March to April	38.5	ft^3/s
95 Percent Duration March to April	21.4	ft^3/s
99 Percent Duration March to April	14.9	ft^3/s

Statistic	Value	Unit
25 Percent Duration July to October	13.5	ft^3/s
50 Percent Duration July to October	5.53	ft^3/s
75 Percent Duration July to October	2.56	ft^3/s
80 Percent Duration July to October	2.16	ft^3/s
99 Percent Duration July to October	0.378	ft^3/s

Seasonal Flow Statistics Citations

Ahearn, E.A.,2010, Regional regression equations to estimate flow-duration statistics in Connecticut: U. S. Geological Survey Scientific Investigations Report 2010-5052, 45 p. (http://pubs.usgs.gov/sir/2010/5052/)

May Flow-Duration Statistics Parameters[Duration Flow 2010 5052]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	22.6	square miles	0.92	150
CRSDFT	Percent Coarse Stratified Drift	2.21	percent	0.1	55.1

May Flow-Duration Statistics Flow Report[Duration Flow 2010 5052]

Statistic	Value	Unit
May 25 Percent Duration	57.6	ft^3/s
May 50 Percent Duration	35.7	ft^3/s
May 75 Percent Duration	23.4	ft^3/s
May 95 Percent Duration	11.7	ft^3/s
May 99 Percent Duration	7.43	ft^3/s

May Flow-Duration Statistics Citations

Ahearn, E.A.,2010, Regional regression equations to estimate flow-duration statistics in Connecticut: U. S. Geological Survey Scientific Investigations Report 2010-5052, 45 p. (http://pubs.usgs.gov/sir/2010/5052/)

June Flow-Duration Statistics Parameters[Duration Flow 2010 5052]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	22.6	square miles	0.92	150
CRSDFT	Percent Coarse Stratified Drift	2.21	percent	0.1	55.1
WETLAND	Percent Wetlands	1.07	percent	0.3	18.1

June Flow-Duration Statistics Flow Report[Duration Flow 2010 5052]

Statistic	Value	Unit
June 25 Percent Duration	28	ft^3/s
June 50 Percent Duration	13.7	ft^3/s
June 75 Percent Duration	7.12	ft^3/s
June 90 Percent Duration	4.72	ft^3/s
June 99 Percent Duration	2.06	ft^3/s

June Flow-Duration Statistics Citations

Ahearn, E.A.,2010, Regional regression equations to estimate flow-duration statistics in Connecticut: U. S. Geological Survey Scientific Investigations Report 2010-5052, 45 p. (http://pubs.usgs.gov/sir/2010/5052/)

Flow-Duration Statistics Parameters[Duration Flow 2010 5052]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	22.6	square miles	0.92	150
ELEV	Mean Basin Elevation	859	feet	168	1287
CRSDFT	Percent Coarse Stratified Drift	2.21	percent	0.1	55.1

Flow-Duration Statistics Flow Report[Duration Flow 2010 5052]

Statistic	Value	Unit
25 Percent Duration	50.7	ft^3/s
99 Percent Duration	0.576	ft^3/s

Flow-Duration Statistics Citations

Ahearn, E.A.,2010, Regional regression equations to estimate flow-duration statistics in Connecticut: U. S. Geological Survey Scientific Investigations Report 2010-5052, 45 p. (http://pubs.usgs.gov/sir/2010/5052/)

Application Version: 4.3.8

NOAA Atlas 14, Volume 10, Version 3
Location name: Watertown, Connecticut, USA*
Latitude: 41.6436°, Longitude: -73.0809°
Elevation: 321.56 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.364 (0.277-0.478)	0.433 (0.329-0.569)	0.546 (0.413-0.720)	0.639 (0.481-0.847)	0.768 (0.562-1.06)	0.866 (0.622-1.22)	0.967 (0.675-1.40)	1.07 (0.719-1.60)	1.22 (0.790-1.88)	1.34 (0.846-2.10)
10-min	0.516 (0.392-0.677)	0.613 (0.466-0.807)	0.773 (0.585-1.02)	0.906 (0.682-1.20)	1.09 (0.796-1.50)	1.23 (0.881-1.73)	1.37 (0.956-1.99)	1.52 (1.02-2.27)	1.73 (1.12-2.67)	1.89 (1.20-2.98)
15-min	0.607 (0.461-0.797)	0.722 (0.548-0.949)	0.910 (0.689-1.20)	1.07 (0.803-1.41)	1.28 (0.936-1.77)	1.45 (1.04-2.03)	1.61 (1.13-2.34)	1.79 (1.20-2.67)	2.04 (1.32-3.14)	2.23 (1.41-3.50)
30-min	0.821 (0.624-1.08)	0.977 (0.742-1.29)	1.23 (0.932-1.63)	1.44 (1.09-1.91)	1.73 (1.27-2.39)	1.95 (1.40-2.75)	2.18 (1.52-3.16)	2.42 (1.62-3.61)	2.76 (1.78-4.25)	3.02 (1.91-4.74)
60-min	1.04 (0.787-1.36)	1.23 (0.935-1.62)	1.55 (1.18-2.05)	1.82 (1.37-2.41)	2.19 (1.60-3.01)	2.47 (1.77-3.46)	2.75 (1.92-3.99)	3.06 (2.04-4.55)	3.48 (2.25-5.36)	3.81 (2.41-5.98)
2-hr	1.36 (1.04-1.78)	1.61 (1.23-2.10)	2.00 (1.52-2.63)	2.33 (1.76-3.07)	2.78 (2.04-3.81)	3.13 (2.25-4.36)	3.48 (2.43-5.01)	3.85 (2.58-5.70)	4.34 (2.82-6.66)	4.73 (3.00-7.41)
3-hr	1.58 (1.21-2.06)	1.87 (1.43-2.43)	2.33 (1.77-3.04)	2.71 (2.05-3.56)	3.23 (2.38-4.42)	3.63 (2.62-5.06)	4.04 (2.84-5.81)	4.48 (3.01-6.62)	5.07 (3.30-7.76)	5.54 (3.52-8.64)
6-hr	2.00 (1.54-2.59)	2.38 (1.83-3.09)	3.01 (2.31-3.91)	3.53 (2.69-4.62)	4.25 (3.15-5.79)	4.79 (3.48-6.66)	5.35 (3.80-7.72)	5.99 (4.04-8.82)	6.89 (4.49-10.5)	7.64 (4.87-11.9)
12-hr	2.45 (1.89-3.15)	2.98 (2.31-3.84)	3.86 (2.97-4.99)	4.59 (3.52-5.96)	5.59 (4.17-7.62)	6.33 (4.65-8.83)	7.14 (5.13-10.4)	8.10 (5.48-11.9)	9.55 (6.24-14.5)	10.8 (6.91-16.7)
24-hr	2.85 (2.22-3.65)	3.56 (2.77-4.56)	4.72 (3.65-6.06)	5.68 (4.37-7.33)	7.00 (5.27-9.53)	7.97 (5.90-11.1)	9.04 (6.58-13.2)	10.4 (7.05-15.2)	12.5 (8.21-19.0)	14.4 (9.24-22.2)
2-day	3.21 (2.50-4.07)	4.07 (3.18-5.18)	5.48 (4.26-7.00)	6.66 (5.15-8.54)	8.27 (6.26-11.2)	9.44 (7.05-13.2)	10.8 (7.91-15.8)	12.5 (8.49-18.2)	15.3 (10.1-23.1)	17.8 (11.5-27.4)
3-day	3.48 (2.73-4.41)	4.43 (3.47-5.62)	5.99 (4.67-7.61)	7.28 (5.65-9.31)	9.05 (6.88-12.3)	10.3 (7.75-14.4)	11.8 (8.71-17.3)	13.7 (9.35-20.0)	16.9 (11.1-25.4)	19.7 (12.7-30.2)
4-day	3.73 (2.93-4.71)	4.75 (3.72-6.00)	6.40 (5.01-8.12)	7.78 (6.05-9.92)	9.67 (7.36-13.1)	11.0 (8.29-15.4)	12.6 (9.32-18.4)	14.6 (10.00-21.3)	18.0 (11.9-27.1)	21.1 (13.6-32.2)
7-day	4.44 (3.50-5.58)	5.58 (4.39-7.02)	7.44 (5.84-9.39)	8.98 (7.01-11.4)	11.1 (8.48-14.9)	12.7 (9.52-17.5)	14.4 (10.6-20.9)	16.6 (11.4-24.1)	20.3 (13.4-30.4)	23.6 (15.3-36.0)
10-day	5.16 (4.08-6.47)	6.36 (5.02-7.98)	8.32 (6.55-10.5)	9.95 (7.78-12.6)	12.2 (9.31-16.3)	13.8 (10.4-19.0)	15.6 (11.5-22.5)	18.0 (12.3-25.9)	21.7 (14.4-32.4)	25.0 (16.2-38.0)
20-day	7.43 (5.90-9.25)	8.68 (6.89-10.8)	10.7 (8.48-13.4)	12.4 (9.76-15.6)	14.7 (11.3-19.5)	16.5 (12.4-22.3)	18.3 (13.5-25.9)	20.6 (14.2-29.5)	24.1 (16.0-35.8)	27.1 (17.6-41.1)
30-day	9.32 (7.43-11.6)	10.6 (8.42-13.1)	12.6 (10.0-15.8)	14.4 (11.3-18.0)	16.7 (12.8-21.9)	18.5 (13.9-24.8)	20.3 (14.9-28.4)	22.5 (15.6-32.1)	25.7 (17.1-38.0)	28.3 (18.5-42.8)
45-day	11.6 (9.30-14.4)	12.9 (10.3-16.0)	15.0 (12.0-18.7)	16.8 (13.3-21.0)	19.2 (14.7-24.9)	21.0 (15.8-27.9)	22.9 (16.7-31.5)	24.9 (17.3-35.4)	27.7 (18.5-40.8)	29.8 (19.5-45.0)
60-day	13.5 (10.8-16.7)	14.9 (11.9-18.4)	17.1 (13.6-21.1)	18.9 (15.0-23.5)	21.4 (16.4-27.6)	23.3 (17.5-30.7)	25.2 (18.2-34.3)	27.0 (18.8-38.3)	29.4 (19.7-43.3)	31.2 (20.4-46.9)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.
Please refer to NOAA Atlas 14 document for more information.

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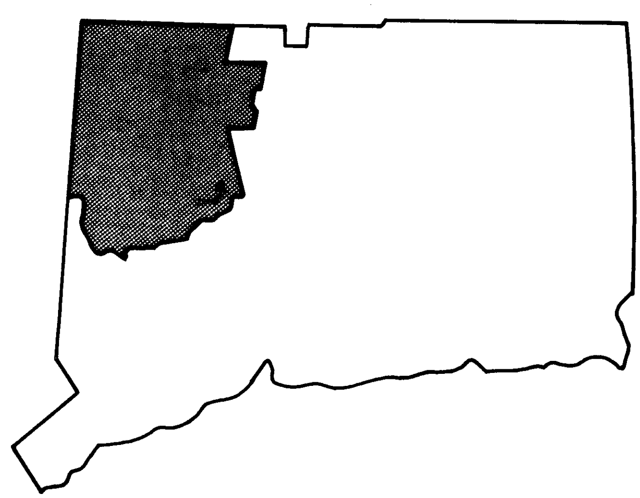
PF graphical

APPENDIX B – FEMA INFORMATION

FLOOD INSURANCE STUDY

TOWN OF WATERTOWN, CONNECTICUT
LITCHFIELD COUNTY



MAY 1980

federal emergency management agency
federal insurance administration

COMMUNITY NUMBER - 090058

was developed between the log of the 2-year flood and the drainage area and it was found that for New England, discharges vary in accordance with the drainage area raised to the exponent power of 0.70.

There are no discharge records for Branch Brook. In 1970, the COE completed Black Rock Dam, located on Branch Brook about two miles above the mouth. Discharges from the dam are controlled by gate operations. The anticipated releases for the 10- and 50-year events would probably not exceed the nondamaging downstream channel capacity and these releases would not be made until downstream flood conditions subsided. The 100- and 500-year discharges are estimated based on hydrographs of major events routed through the reservoir. On Branch Brook above Wigwam Reservoir, peak discharge frequencies were determined by using relationships based on records for the USGS gaging station on nearby Leadmine Brook and then relating it to the Branch Brook watershed based on a direct drainage area relationship. A regional study was not undertaken to determine the drainage area-discharge relationship for Leadmine and Branch Brooks. However, the runoff characteristics of Leadmine Brook are considered to be similar to those of Branch Brook.

A summary of drainage area-peak discharge relationships is shown in Table 1, "Summary of Discharges."

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
NAUGATUCK RIVER					
At downstream corporate limits	137	5,300	5,400	8,000	21,600
At upstream corporate limits	131	5,000	5,000	5,200	14,000
BRANCH BROOK					
At mouth	22.8	800	800	900	2,300
At Black Rock Dam	20.4	800	800	900	2,300
At Wigwam Dam	17.5	2,200	5,300	7,600	16,500
STEELE BROOK					
At downstream corporate limits	12.4	1,410	2,740	3,550	6,245
Above Wattles Brook	9.0	1,130	2,200	2,840	5,000
At Hemingway Pond	5.7	820	1,600	2,060	3,600
Below Smith Pond Brook confluence	4.0	640	1,250	1,600	2,800

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH[3] (FT.)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (F.P.S.)	REGULATORY (NGVD)	WITHOUT FLOODWAY (NGVD)	WITH FLOODWAY (NGVD)	INCREASE (FEET)
Naugatuck River (continued)								
T	20,440[1]	164	1,295	6.2	319.0	319.0	319.3	0.3
U	22,300[1]	118	884	5.7	320.5	320.5	320.6	0.1
Branch Brook								
A	100[2]	81	303	3.0	321.6	321.6	322.6	1.0
B	265[2]	88	469	1.9	322.0	322.0	322.8	0.8
C	1,700[2]	132	149	6.1	324.2	324.2	324.2	0.0
D	2,400[2]	46	146	6.2	330.0	330.0	330.0	0.0
E	2,600[2]	43	102	8.8	331.1	331.1	331.1	0.0
F	3,590[2]	68	186	4.8	338.1	338.1	338.1	0.0
G	5,410[2]	70	123	7.3	349.0	349.0	349.0	0.0
H	6,320[2]	72	218	4.1	353.6	353.6	353.7	0.1
I	7,130[2]	78	143	6.3	356.7	356.7	356.8	0.1
J	7,290[2]	54	119	7.6	357.5	357.5	357.5	0.0
K	8,400[2]	38	141	6.4	365.2	365.2	365.2	0.0
L	10,000[2]	31	92	9.8	381.9	381.9	381.9	0.0
M	20,500[2]	1,536	32,010	0.2	567.4	567.4	568.0	0.6
N	24,270[2]	370	4,953	1.5	567.4	567.4	568.0	0.6
O	24,670[2]	914	11,814	0.6	569.3	569.3	569.3	0.0

[1]Feet above corporate limits
[2]Feet above confluence with Naugatuck River
[3]This width extends beyond corporate limits

FEDERAL EMERGENCY MANAGEMENT AGENCY
Federal Insurance Administration

TOWN OF WATERTOWN, CT
(LITCHFIELD CO.)

FLOODWAY DATA

NAUGATUCK RIVER AND BRANCH BROOK

TABLE 2

APPENDIX C – CROSS-SECTION LOCATIONS & CROSS-SECTIONS

ARCHITECTURE
ENGINEERING
ENVIRONMENTAL
LAND SURVEYING

BL Companies

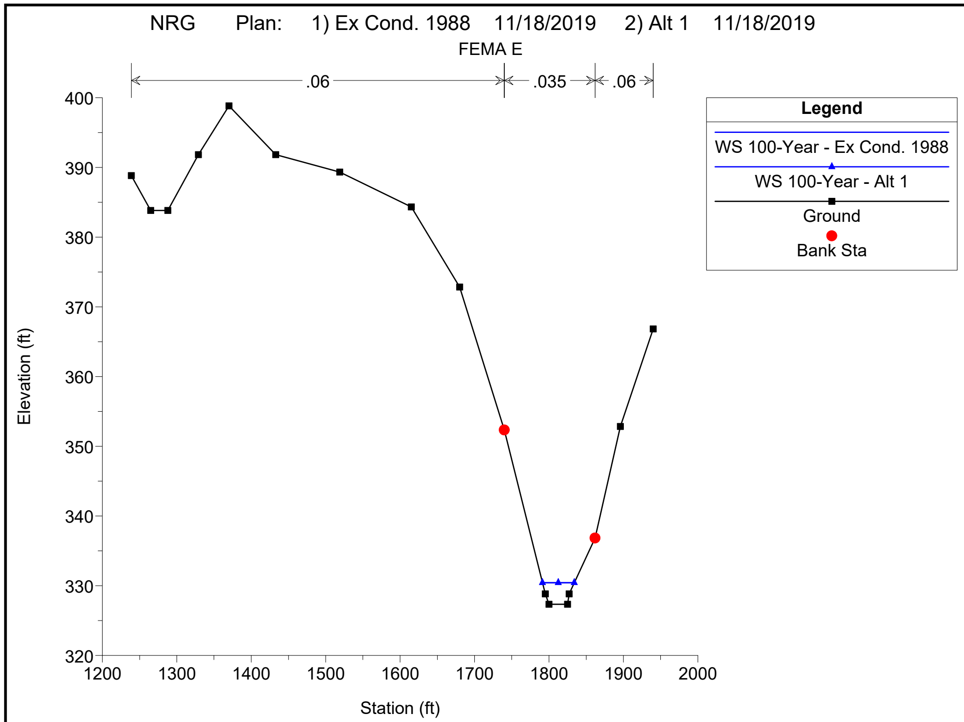
CROSS-SECTION LOCATION

NAUGATUCK RIVER GREENWAY
PEDESTRIAN BRIDGE OVER
BRANCH BROOK

Designed	B.G.R.
Drawn	B.G.R.
Reviewed	D.M.C.
Scale	1"= 400'
Project No.	1800579
Date	11/13/19
CAD File	CROSS_SECTIONS

LOC

Xref (s): ; 42224.00 Thomaston ; PR-422400 ; 8X11(port)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FEMA E
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.035
.06
Legend
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WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
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360
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1600
1700
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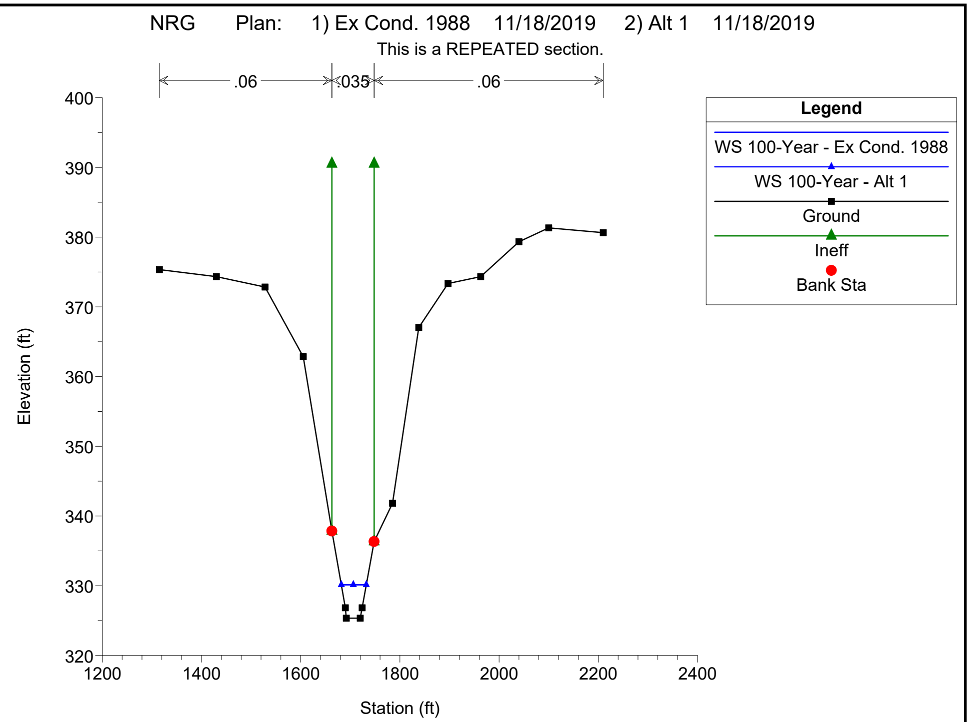
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WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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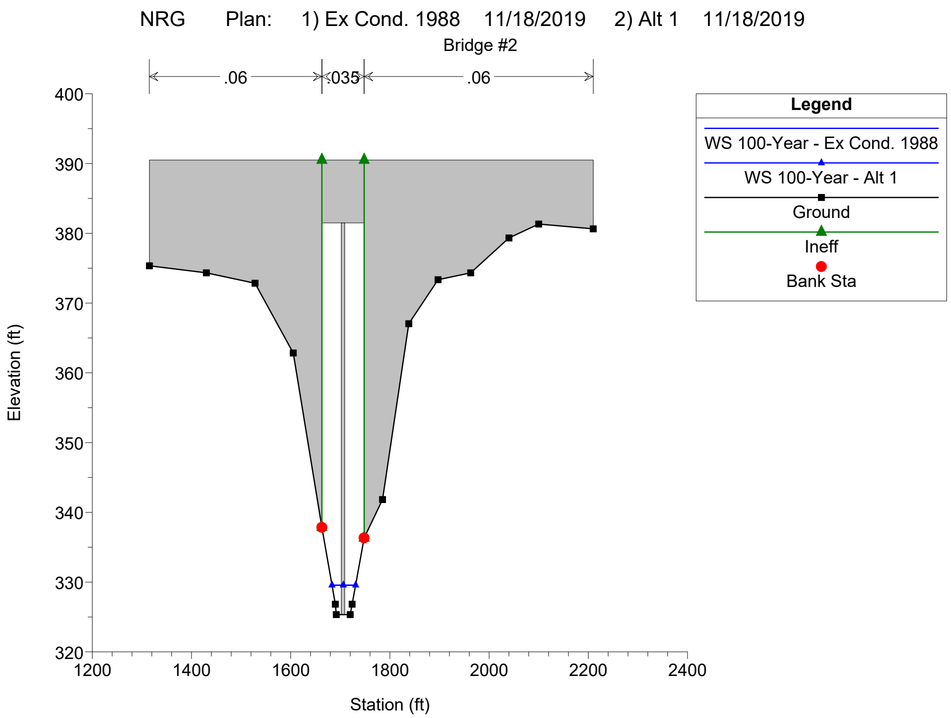
1600
1800
2000
2200
2400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WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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340
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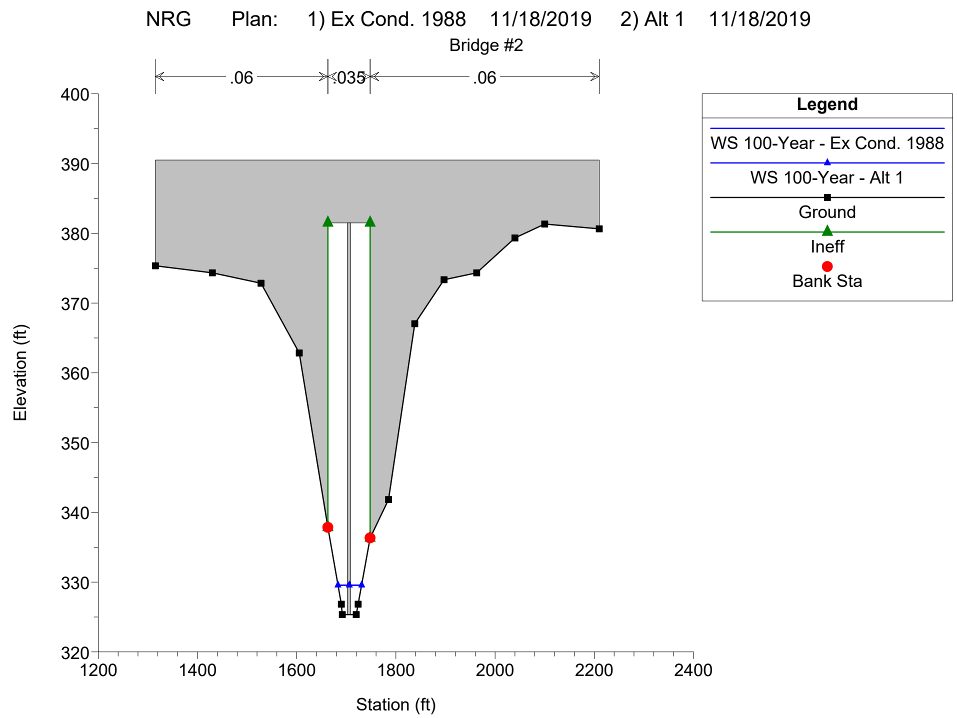
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WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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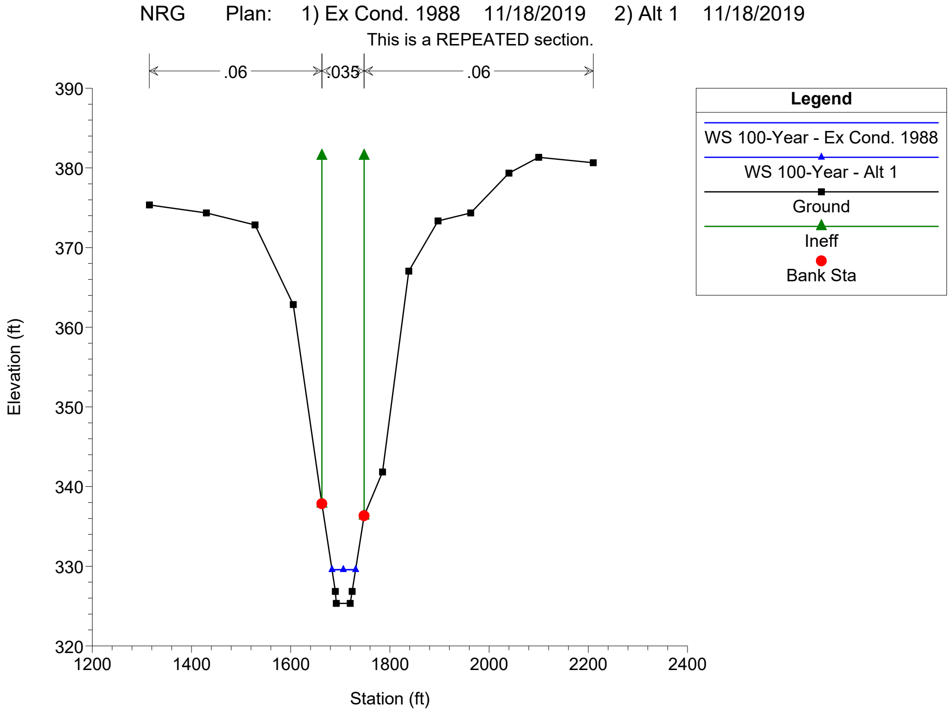
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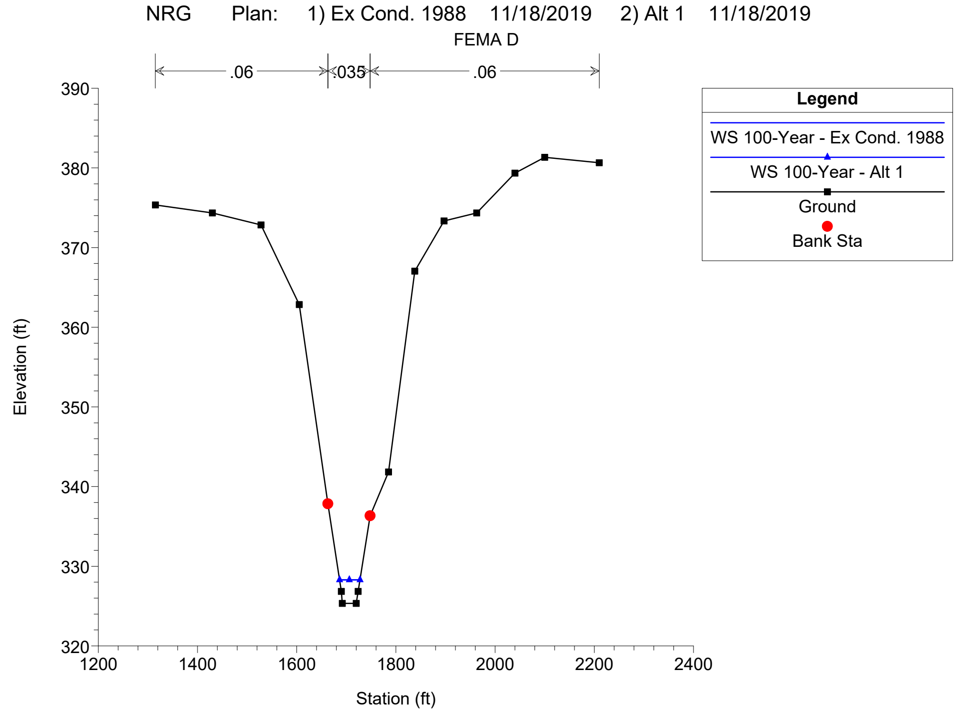
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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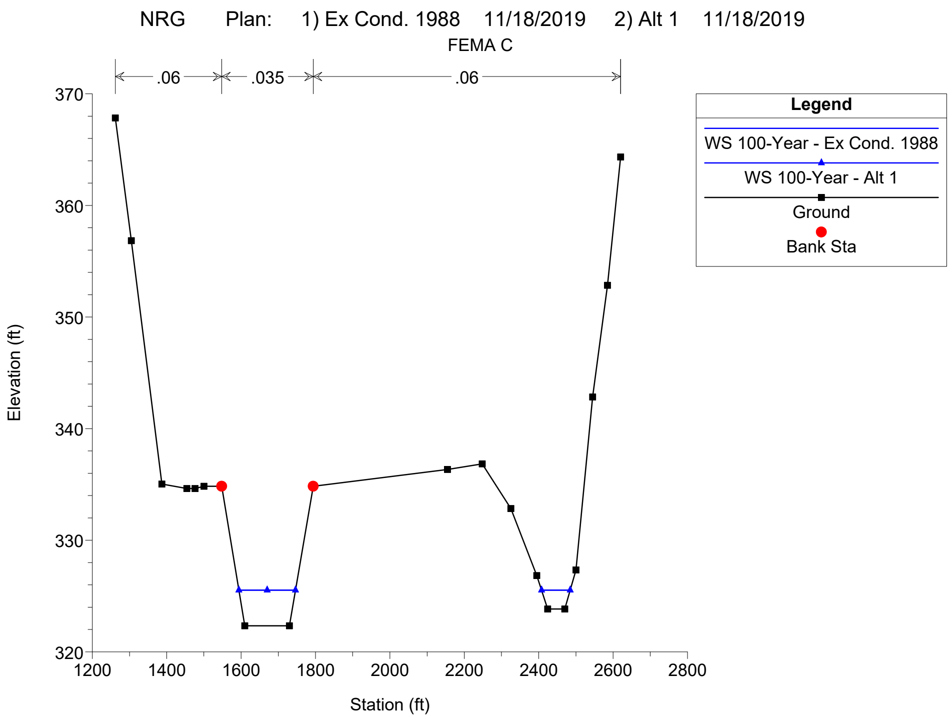
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)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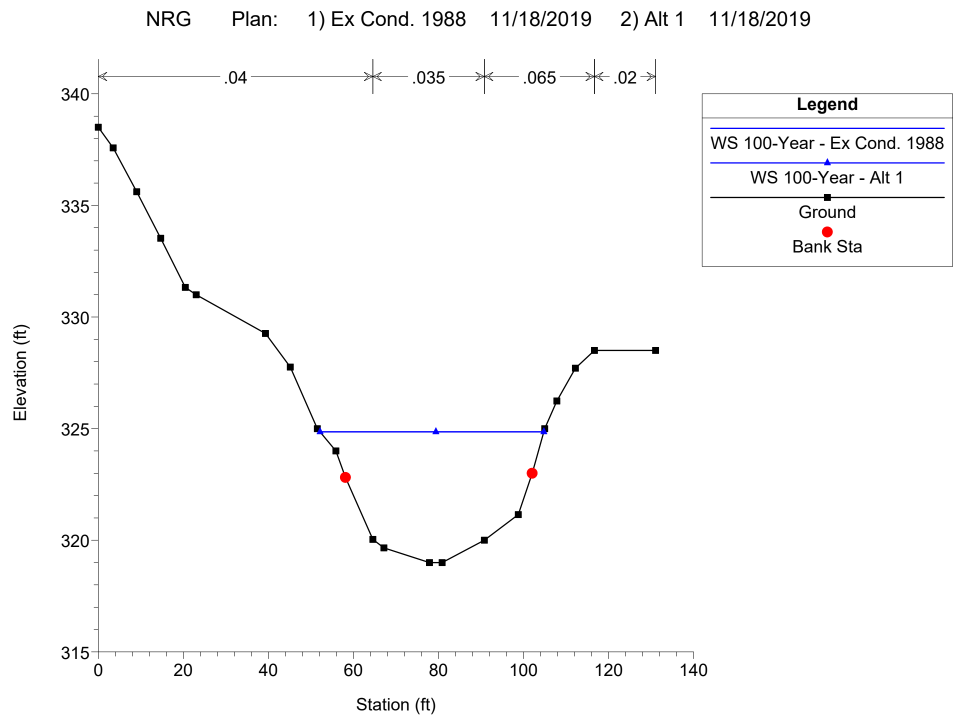
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)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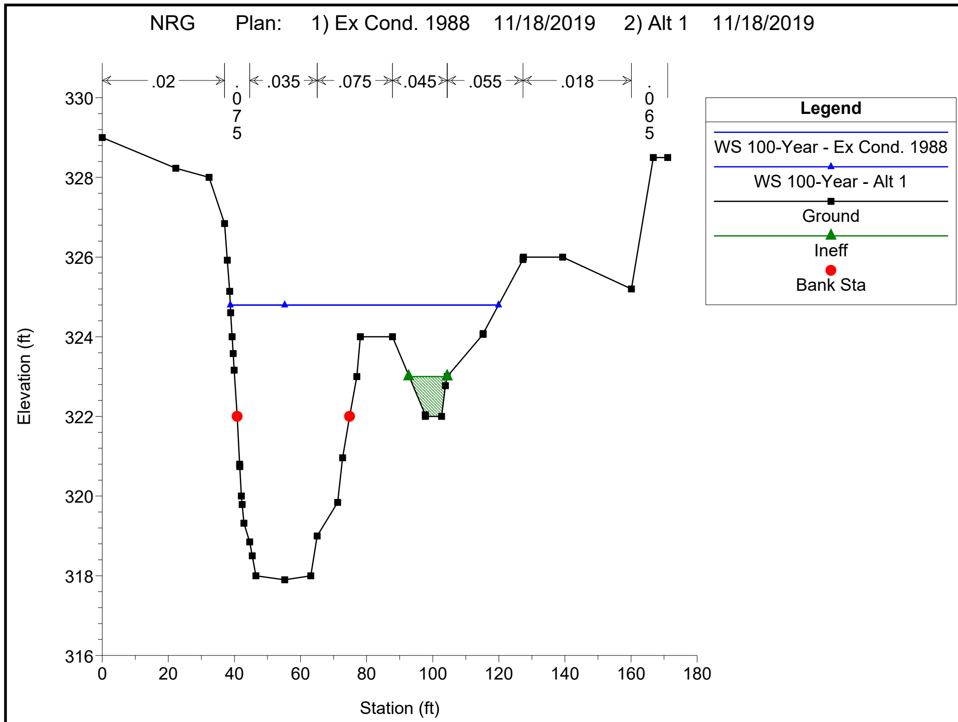
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)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WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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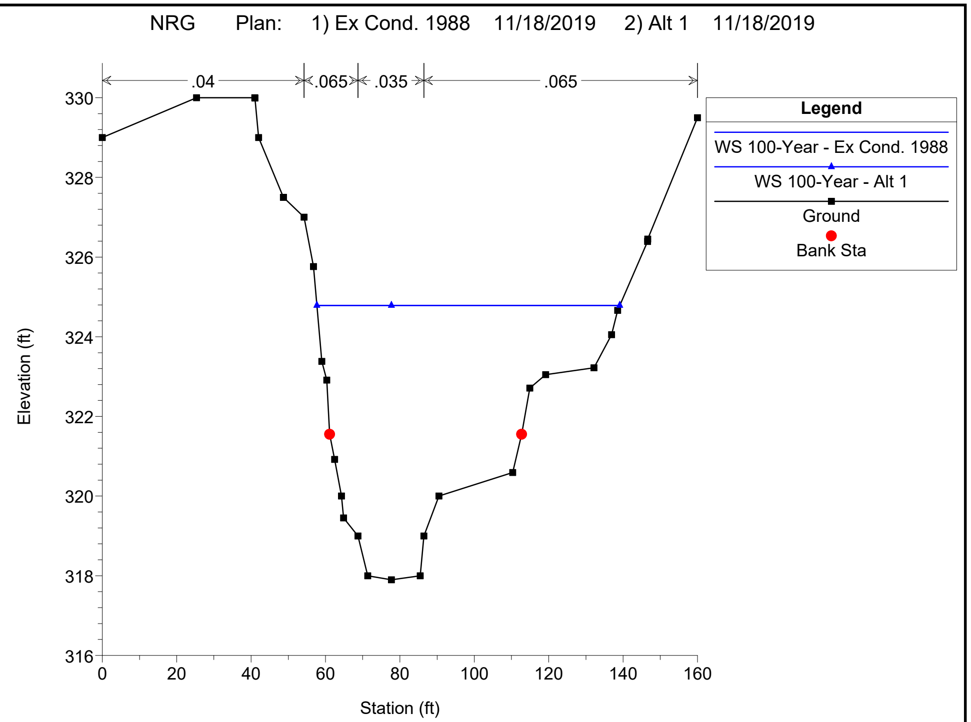
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WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
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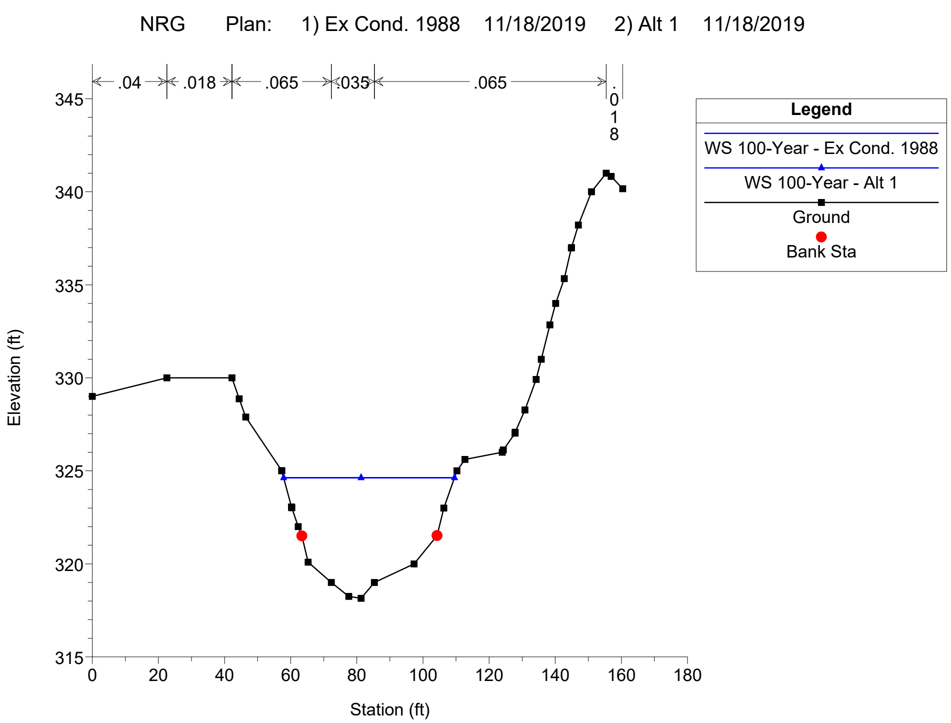
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Legend
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WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
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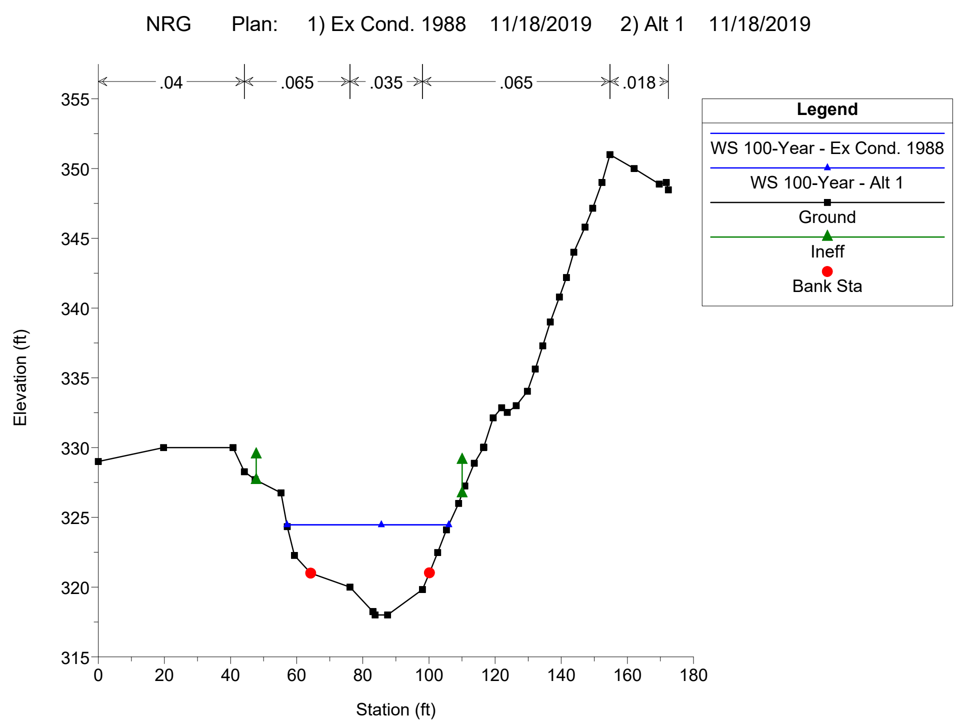
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Legend
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WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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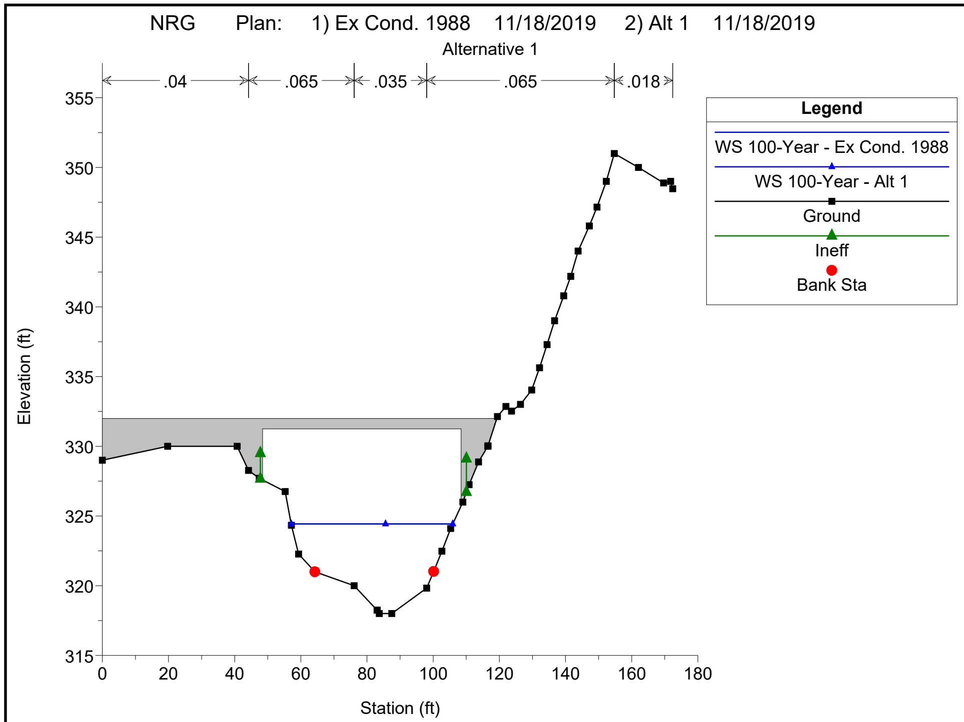
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Ground
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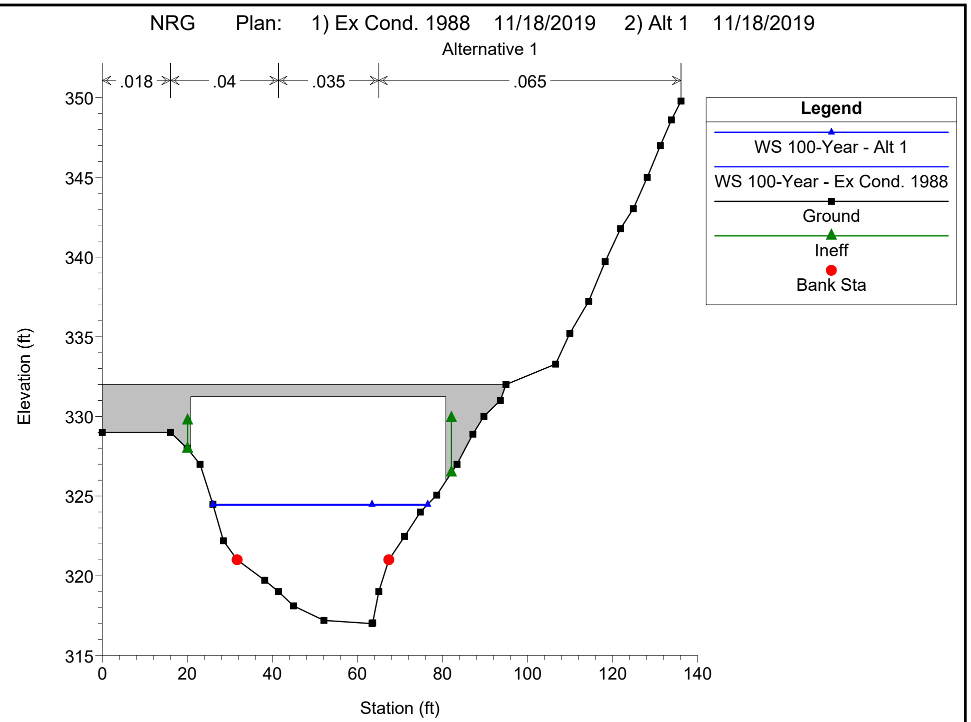
Bank Sta
Elevation (ft)
Station (ft)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Alternative 1
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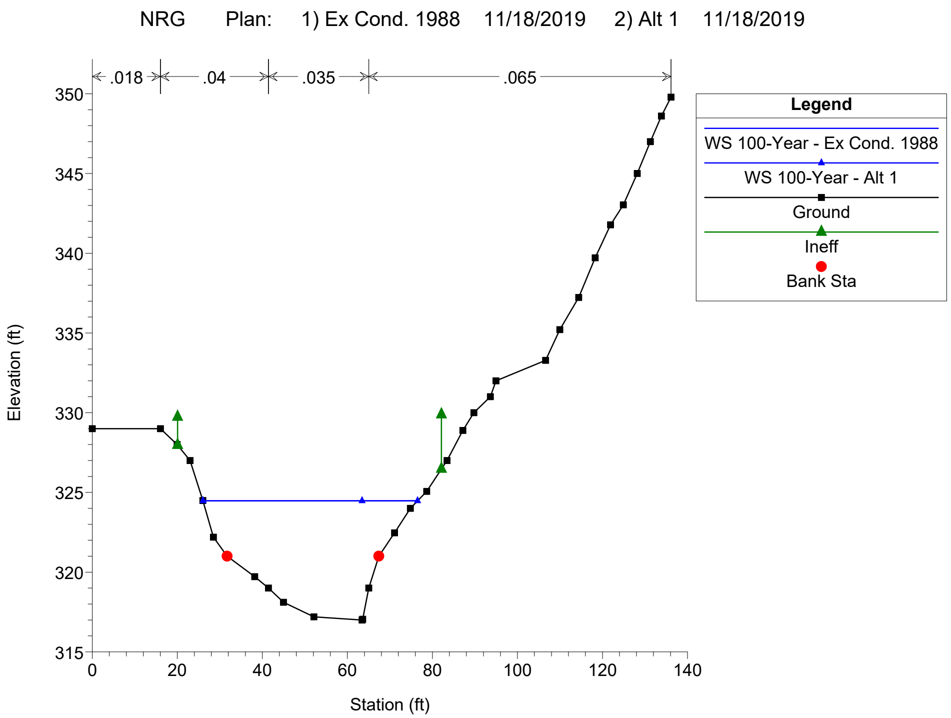
WS 100-Year - Ex Cond. 1988
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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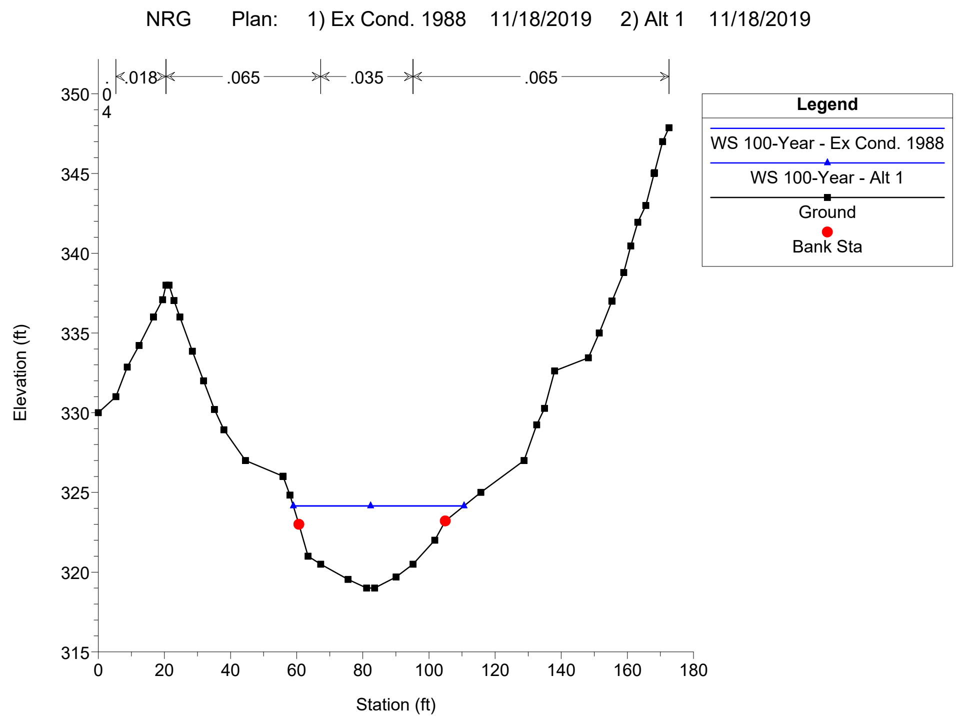
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)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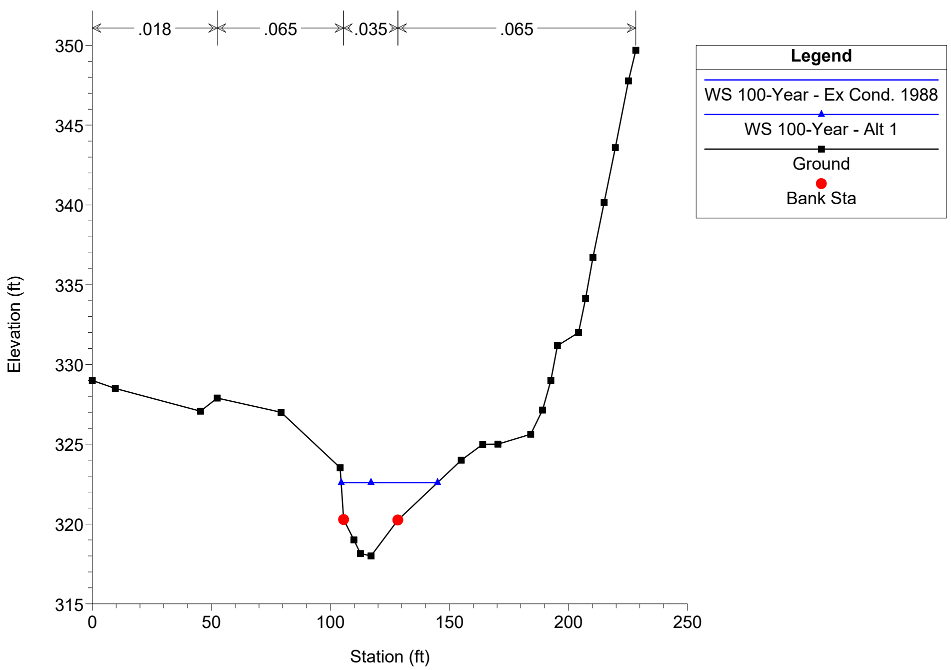
Ground
Bank Sta
Elevation (ft)
Station (ft)

NRG Plan: 1) Ex Cond. 1988 11/18/2019 2) Alt 1 11/18/2019



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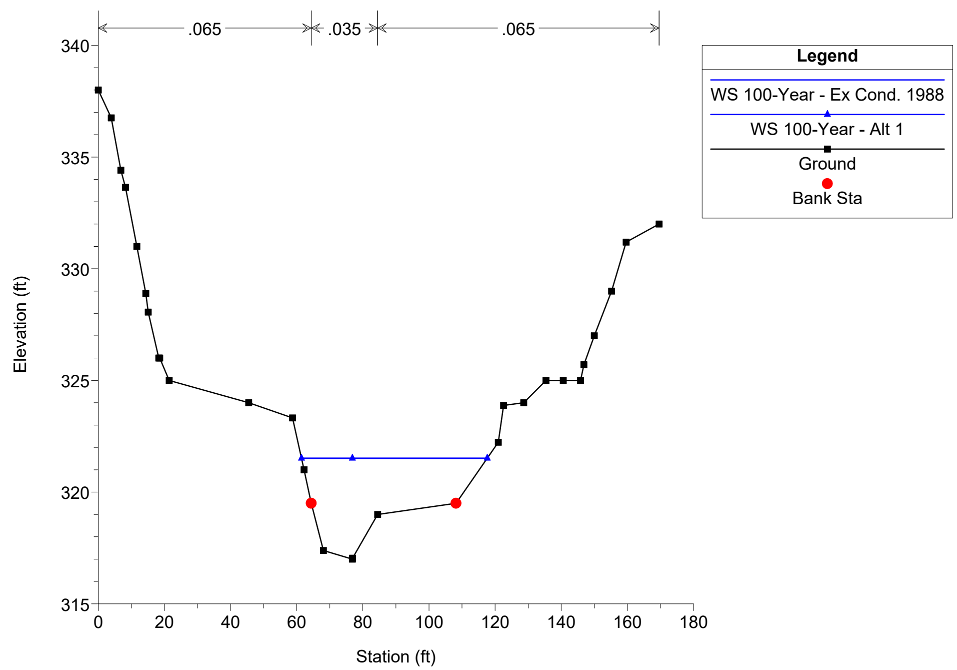

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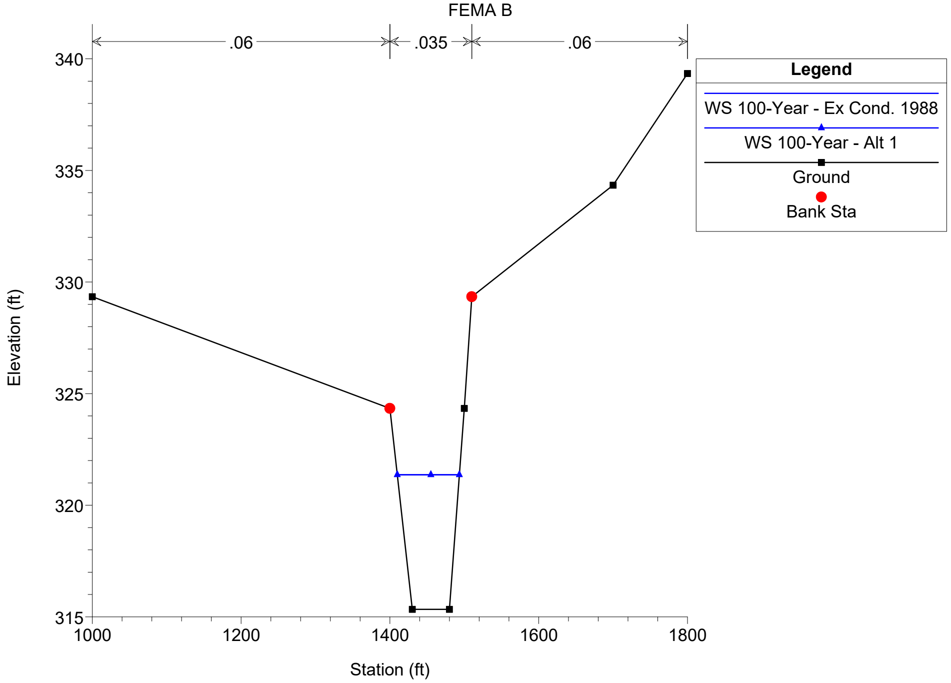
FEMA B



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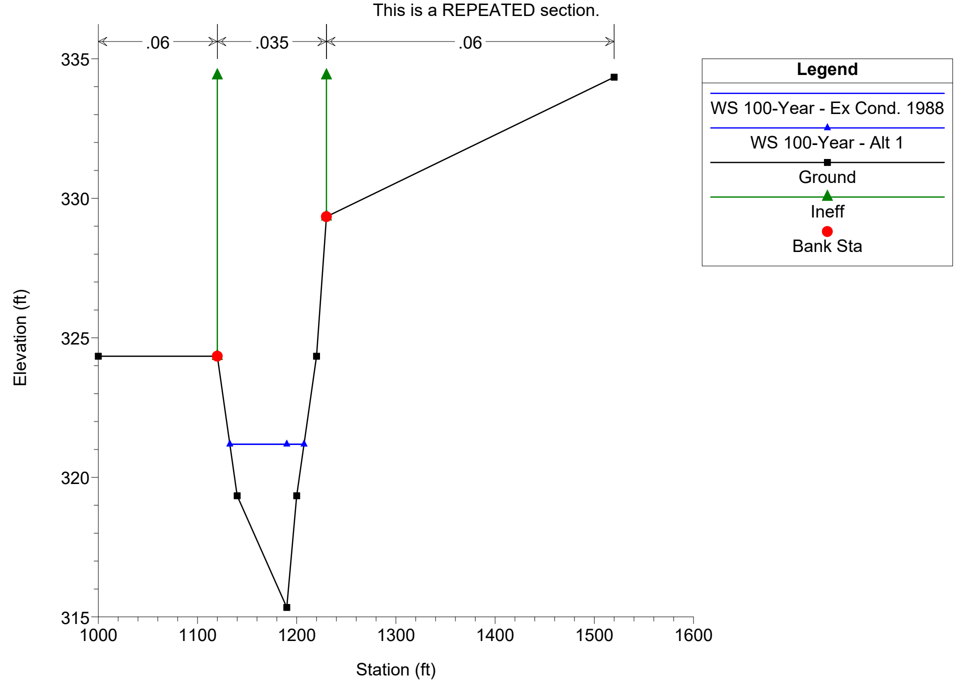

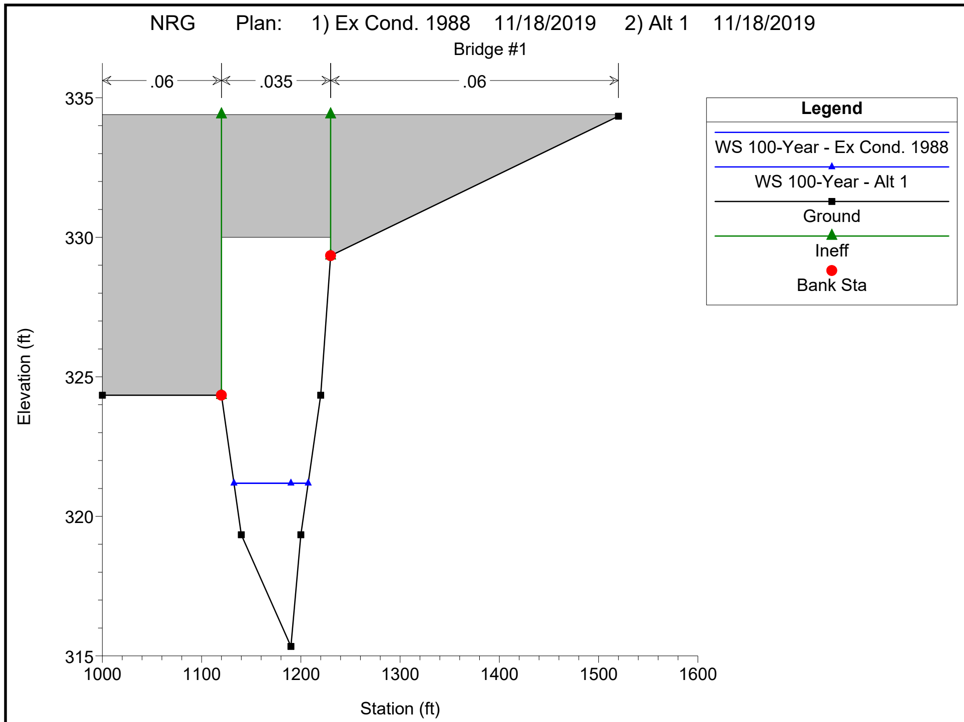
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WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
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1200
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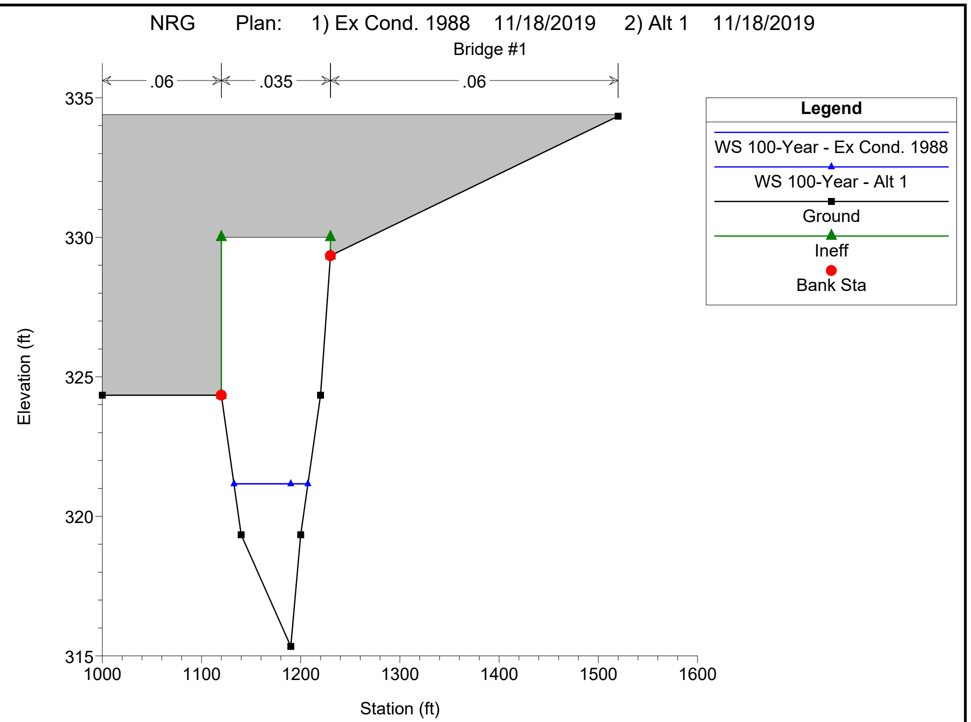
1400
1500
1600
Station (ft)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Ground
Ineff
Bank Sta
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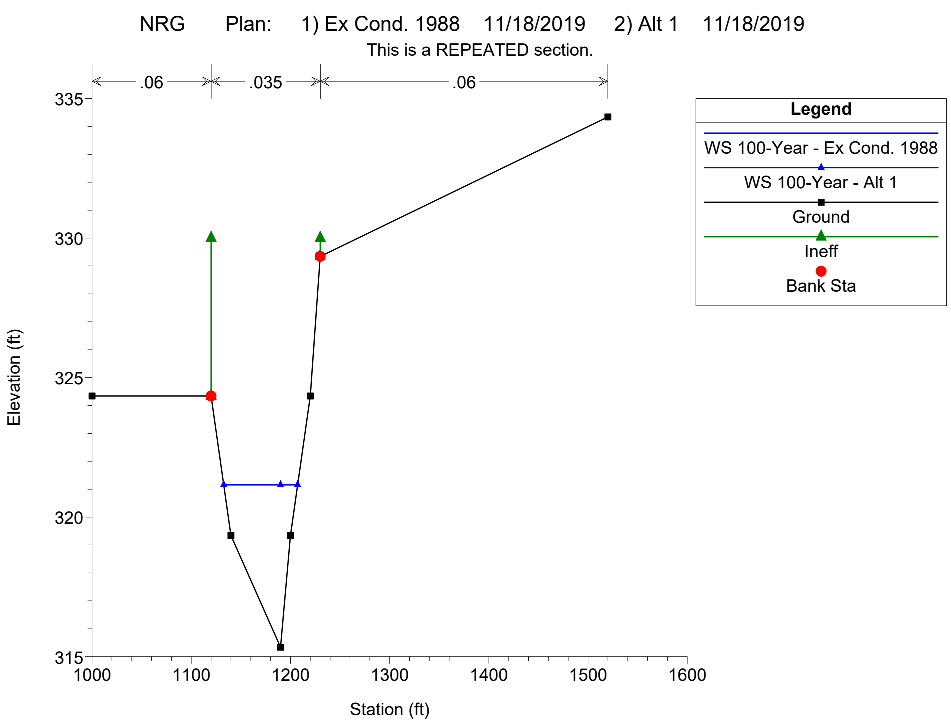
Station (ft)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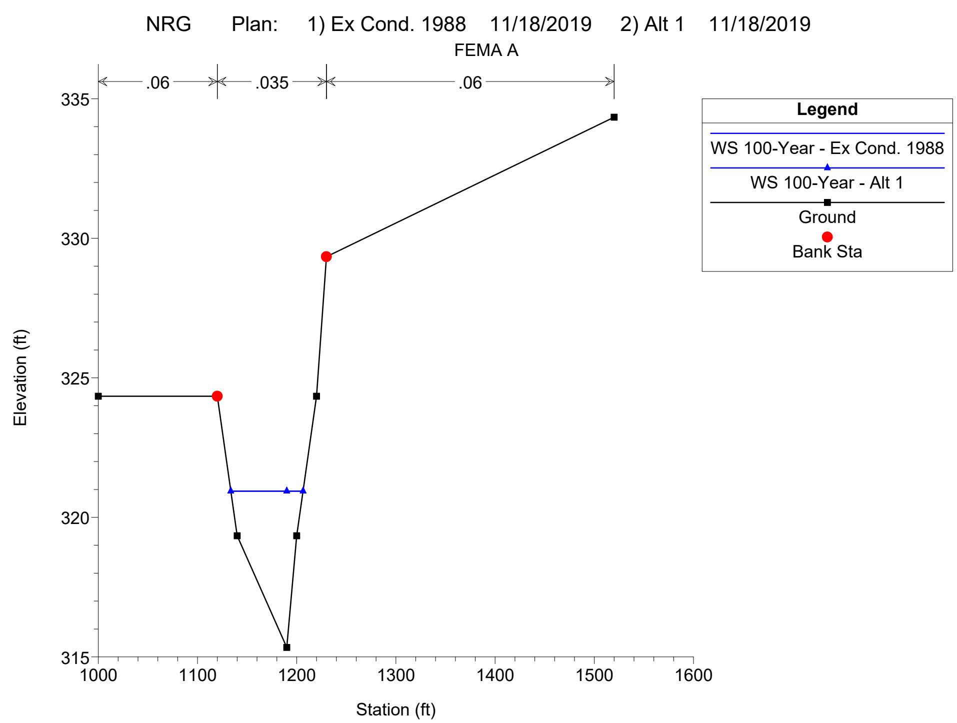
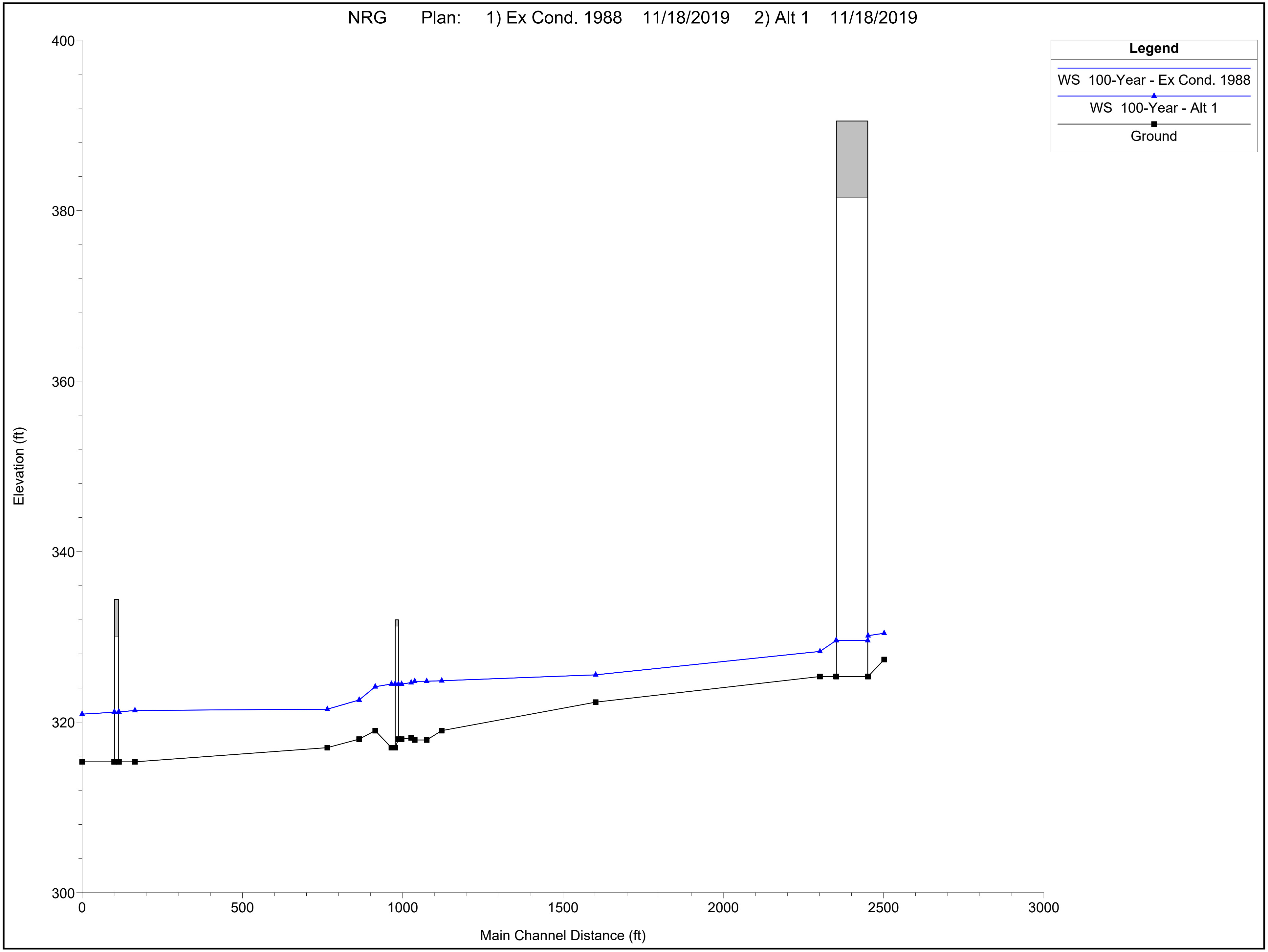
WS 100-Year - Alt 1
Ground
Ineff
Bank Sta
Elevation (ft)
335
330
325
320
315
1000
1100
1200
1300
1400
1500
1600
Station (ft)


NRG Plan: 1) Ex Cond. 1988 11/18/2019 2) Alt 1 11/18/2019
FEMA A
.06
.035
.06
Legend
WS 100-Year - Ex Cond. 1988
WS 100-Year - Alt 1
Ground
Bank Sta
Elevation (ft)
335
330
325
320
315
1000
1100
1200
1300
1400
1500
1600
Station (ft)

APPENDIX D – WATER SURFACE PROFILE ANALYSIS

- HEC-RAS 100-Year Water Surface Profile
- HEC-RAS Profile Output Table for All Storm Events


NRG Plan: 1) Ex Cond. 1988 11/18/2019 2) Alt 1 11/18/2019
Legend
WS 100-Year - Ex Cond. 1988
WS 100-Year - Alt 1
Ground
Elevation (ft)
400
380
360
340
320
300
0
500
1000
1500
2000
2500
3000
Main Channel Distance (ft)

HEC-RAS Plan: Alt 1 River: Branch Bk Reach: NRG

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)	
NRG	203	10-Year	800.00	327.34	330.22	330.22	331.36	0.014294	8.58	93.23	41.25	1.01
NRG	203	50-Year	800.00	327.34	330.22	330.22	331.36	0.014294	8.58	93.23	41.25	1.01
NRG	203	100-Year	900.00	327.34	330.43	330.43	331.64	0.014050	8.83	101.95	42.65	1.01
NRG	203	500-Year	2300.00	327.34	332.61	332.61	334.45	0.012129	10.91	210.90	57.29	1.00
NRG	202.2	10-Year	800.00	325.34	329.84	328.08	330.18	0.002417	4.68	170.89	48.94	0.44
NRG	202.2	50-Year	800.00	325.34	329.84	328.08	330.18	0.002417	4.68	170.89	48.94	0.44
NRG	202.2	100-Year	900.00	325.34	330.13	328.30	330.50	0.002422	4.85	185.55	50.41	0.45
NRG	202.2	500-Year	2300.00	325.34	333.17	330.49	333.80	0.002461	6.37	361.25	65.51	0.48
NRG	202.15		Bridge									
NRG	202.1	10-Year	800.00	325.34	329.31	328.08	329.78	0.003794	5.48	145.90	46.33	0.54
NRG	202.1	50-Year	800.00	325.34	329.31	328.08	329.78	0.003794	5.48	145.90	46.33	0.54
NRG	202.1	100-Year	900.00	325.34	329.57	328.30	330.07	0.003839	5.70	157.78	47.59	0.55
NRG	202.1	500-Year	2300.00	325.34	332.21	330.49	333.12	0.004081	7.64	300.90	60.75	0.61
NRG	202	10-Year	800.00	325.34	328.08	328.08	329.24	0.014263	8.66	92.41	40.17	1.01
NRG	202	50-Year	800.00	325.34	328.08	328.08	329.24	0.014263	8.66	92.41	40.17	1.01
NRG	202	100-Year	900.00	325.34	328.28	328.28	329.52	0.013992	8.93	100.80	41.19	1.01
NRG	202	500-Year	2300.00	325.34	330.49	330.49	332.47	0.012127	11.28	203.84	52.19	1.01
NRG	201	10-Year	800.00	322.34	325.23		325.29	0.000571	1.92	471.06	220.56	0.21
NRG	201	50-Year	800.00	322.34	325.23		325.29	0.000571	1.92	471.06	220.56	0.21
NRG	201	100-Year	900.00	322.34	325.54		325.59	0.000498	1.90	540.22	229.27	0.20
NRG	201	500-Year	2300.00	322.34	328.92		328.97	0.000212	1.90	1475.52	320.29	0.14
NRG	200.8	10-Year	800.00	319.00	324.53		324.79	0.002159	4.10	198.82	50.75	0.34
NRG	200.8	50-Year	800.00	319.00	324.53		324.79	0.002159	4.10	198.82	50.75	0.34
NRG	200.8	100-Year	900.00	319.00	324.85		325.14	0.002142	4.28	215.60	52.64	0.35
NRG	200.8	500-Year	2300.00	319.00	328.15		328.69	0.002131	6.07	416.23	71.09	0.38
NRG	200.75	10-Year	800.00	317.90	324.46		324.68	0.002154	3.86	236.29	78.78	0.29
NRG	200.75	50-Year	800.00	317.90	324.46		324.68	0.002154	3.86	236.29	78.78	0.29
NRG	200.75	100-Year	900.00	317.90	324.79		325.02	0.002118	3.98	263.13	81.16	0.29
NRG	200.75	500-Year	2300.00	317.90	328.32		328.52	0.001082	3.87	676.21	146.78	0.22
NRG	200.7	10-Year	800.00	317.90	324.45		324.58	0.001482	2.95	295.30	79.98	0.23
NRG	200.7	50-Year	800.00	317.90	324.45		324.58	0.001482	2.95	295.30	79.98	0.23
NRG	200.7	100-Year	900.00	317.90	324.79		324.93	0.001473	3.07	322.29	81.43	0.23
NRG	200.7	500-Year	2300.00	317.90	328.21		328.45	0.001453	4.24	641.39	108.82	0.25
NRG	200.65	10-Year	800.00	318.15	324.31		324.55	0.002813	3.94	211.78	50.57	0.32
NRG	200.65	50-Year	800.00	318.15	324.31		324.55	0.002813	3.94	211.78	50.57	0.32
NRG	200.65	100-Year	900.00	318.15	324.63		324.89	0.002853	4.14	228.07	51.69	0.32
NRG	200.65	500-Year	2300.00	318.15	327.90		328.40	0.003077	5.96	452.74	83.55	0.36
NRG	200.6	10-Year	800.00	318.00	324.15	321.97	324.46	0.002774	4.52	191.10	48.05	0.37
NRG	200.6	50-Year	800.00	318.00	324.15	321.97	324.46	0.002774	4.52	191.10	48.05	0.37
NRG	200.6	100-Year	900.00	318.00	324.46	322.19	324.80	0.002804	4.74	206.19	48.95	0.37
NRG	200.6	500-Year	2300.00	318.00	327.54	324.43	328.28	0.003401	7.19	370.79	62.55	0.45
NRG	200.58		Bridge									
NRG	200.55	10-Year	800.00	317.00	324.16	320.86	324.37	0.001013	3.74	229.00	49.00	0.27
NRG	200.55	50-Year	800.00	317.00	324.16	320.86	324.37	0.001013	3.74	229.00	49.00	0.27
NRG	200.55	100-Year	900.00	317.00	324.47	321.09	324.71	0.001065	3.97	244.51	50.47	0.28
NRG	200.55	500-Year	2300.00	317.00	327.57	323.49	328.14	0.001566	6.34	419.13	63.28	0.37
NRG	200.5	10-Year	800.00	319.00	323.84		324.25	0.005303	5.15	156.81	49.31	0.49
NRG	200.5	50-Year	800.00	319.00	323.84		324.25	0.005303	5.15	156.81	49.31	0.49
NRG	200.5	100-Year	900.00	319.00	324.15		324.59	0.005030	5.31	172.52	51.64	0.48
NRG	200.5	500-Year	2300.00	319.00	327.31		328.01	0.003856	6.95	382.54	85.81	0.46
NRG	200.45	10-Year	800.00	318.00	322.34	322.34	323.78	0.010938	9.86	93.61	38.54	0.94
NRG	200.45	50-Year	800.00	318.00	322.34	322.34	323.78	0.010938	9.86	93.61	38.54	0.94
NRG	200.45	100-Year	900.00	318.00	322.60	322.60	324.13	0.010618	10.21	103.83	40.50	0.94
NRG	200.45	500-Year	2300.00	318.00	325.86	325.86	327.67	0.006135	11.88	307.77	97.46	0.80
NRG	200.4	10-Year	800.00	317.00	321.26		321.93	0.008421	6.60	128.13	54.63	0.71
NRG	200.4	50-Year	800.00	317.00	321.26		321.93	0.008421	6.60	128.13	54.63	0.71

HEC-RAS Plan: Alt 1 River: Branch Bk Reach: NRG (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)	
NRG	200.4	100-Year	900.00	317.00	321.52		322.21	0.008058	6.74	142.32	56.21	0.69
NRG	200.4	500-Year	2300.00	317.00	324.29		325.31	0.006110	8.43	324.82	92.03	0.62
NRG	200.3	10-Year	800.00	315.34	321.14		321.21	0.000321	2.09	383.41	82.22	0.17
NRG	200.3	50-Year	800.00	315.34	321.14		321.21	0.000321	2.09	383.41	82.22	0.17
NRG	200.3	100-Year	900.00	315.34	321.37		321.45	0.000353	2.24	402.28	83.49	0.18
NRG	200.3	500-Year	2300.00	315.34	324.05		324.24	0.000597	3.56	645.85	98.37	0.25
NRG	200.2	10-Year	800.00	315.34	320.97	319.06	321.16	0.001517	3.50	228.78	73.08	0.35
NRG	200.2	50-Year	800.00	315.34	320.97	319.06	321.16	0.001517	3.50	228.79	73.08	0.35
NRG	200.2	100-Year	900.00	315.34	321.19	319.24	321.40	0.001586	3.68	244.61	74.79	0.36
NRG	200.2	500-Year	2300.00	315.34	323.80	320.98	324.18	0.001668	4.92	467.37	95.70	0.39
NRG	200.15		Bridge									
NRG	200.1	10-Year	800.00	315.34	320.95	319.05	321.14	0.001555	3.53	226.83	72.86	0.35
NRG	200.1	50-Year	800.00	315.34	320.95	319.05	321.14	0.001555	3.53	226.83	72.86	0.35
NRG	200.1	100-Year	900.00	315.34	321.16	319.24	321.37	0.001625	3.71	242.50	74.56	0.36
NRG	200.1	500-Year	2300.00	315.34	323.77	320.97	324.15	0.001697	4.95	464.46	95.45	0.40
NRG	200	10-Year	800.00	315.34	320.74	319.04	320.96	0.001893	3.78	211.84	71.20	0.39
NRG	200	50-Year	800.00	315.34	320.74	319.04	320.96	0.001893	3.78	211.84	71.20	0.39
NRG	200	100-Year	900.00	315.34	320.94	319.22	321.19	0.001983	3.98	226.24	72.80	0.40
NRG	200	500-Year	2300.00	315.34	323.54	320.98	323.96	0.001941	5.20	442.56	93.60	0.42

HEC-RAS Plan: Ex Cond. 1988 River: Branch Bk Reach: NRG

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)	
NRG	203	10-Year	800.00	327.34	330.22	330.22	331.36	0.014294	8.58	93.23	41.25	1.01
NRG	203	50-Year	800.00	327.34	330.22	330.22	331.36	0.014294	8.58	93.23	41.25	1.01
NRG	203	100-Year	900.00	327.34	330.43	330.43	331.64	0.014050	8.83	101.95	42.65	1.01
NRG	203	500-Year	2300.00	327.34	332.61	332.61	334.45	0.012129	10.91	210.90	57.29	1.00
NRG	202.2	10-Year	800.00	325.34	329.84	328.08	330.18	0.002417	4.68	170.89	48.94	0.44
NRG	202.2	50-Year	800.00	325.34	329.84	328.08	330.18	0.002417	4.68	170.89	48.94	0.44
NRG	202.2	100-Year	900.00	325.34	330.13	328.30	330.50	0.002422	4.85	185.55	50.41	0.45
NRG	202.2	500-Year	2300.00	325.34	333.17	330.49	333.80	0.002461	6.37	361.25	65.51	0.48
NRG	202.15		Bridge									
NRG	202.1	10-Year	800.00	325.34	329.31	328.08	329.78	0.003794	5.48	145.90	46.33	0.54
NRG	202.1	50-Year	800.00	325.34	329.31	328.08	329.78	0.003794	5.48	145.90	46.33	0.54
NRG	202.1	100-Year	900.00	325.34	329.57	328.30	330.07	0.003839	5.70	157.78	47.59	0.55
NRG	202.1	500-Year	2300.00	325.34	332.21	330.49	333.12	0.004081	7.64	300.90	60.75	0.61
NRG	202	10-Year	800.00	325.34	328.08	328.08	329.24	0.014263	8.66	92.41	40.17	1.01
NRG	202	50-Year	800.00	325.34	328.08	328.08	329.24	0.014263	8.66	92.41	40.17	1.01
NRG	202	100-Year	900.00	325.34	328.28	328.28	329.52	0.013992	8.93	100.80	41.19	1.01
NRG	202	500-Year	2300.00	325.34	330.49	330.49	332.47	0.012127	11.28	203.84	52.19	1.01
NRG	201	10-Year	800.00	322.34	325.23		325.29	0.000571	1.92	471.10	220.57	0.21
NRG	201	50-Year	800.00	322.34	325.23		325.29	0.000571	1.92	471.10	220.57	0.21
NRG	201	100-Year	900.00	322.34	325.54		325.59	0.000498	1.90	540.26	229.27	0.20
NRG	201	500-Year	2300.00	322.34	328.92		328.97	0.000212	1.90	1475.51	320.29	0.14
NRG	200.8	10-Year	800.00	319.00	324.53		324.79	0.002159	4.10	198.84	50.75	0.34
NRG	200.8	50-Year	800.00	319.00	324.53		324.79	0.002159	4.10	198.84	50.75	0.34
NRG	200.8	100-Year	900.00	319.00	324.85		325.14	0.002142	4.28	215.62	52.64	0.35
NRG	200.8	500-Year	2300.00	319.00	328.15		328.69	0.002132	6.07	416.22	71.09	0.38
NRG	200.75	10-Year	800.00	317.90	324.46		324.68	0.002153	3.86	236.32	78.78	0.29
NRG	200.75	50-Year	800.00	317.90	324.46		324.68	0.002153	3.86	236.32	78.78	0.29
NRG	200.75	100-Year	900.00	317.90	324.80		325.02	0.002118	3.98	263.16	81.16	0.29
NRG	200.75	500-Year	2300.00	317.90	328.32		328.52	0.001082	3.87	676.20	146.78	0.22
NRG	200.7	10-Year	800.00	317.90	324.45		324.58	0.001482	2.95	295.33	79.98	0.23
NRG	200.7	50-Year	800.00	317.90	324.45		324.58	0.001482	2.95	295.33	79.98	0.23
NRG	200.7	100-Year	900.00	317.90	324.79		324.93	0.001472	3.07	322.32	81.43	0.23
NRG	200.7	500-Year	2300.00	317.90	328.21		328.45	0.001453	4.25	641.38	108.82	0.25
NRG	200.65	10-Year	800.00	318.15	324.31		324.55	0.002812	3.94	211.80	50.57	0.32
NRG	200.65	50-Year	800.00	318.15	324.31		324.55	0.002812	3.94	211.80	50.57	0.32
NRG	200.65	100-Year	900.00	318.15	324.63		324.89	0.002853	4.14	228.09	51.69	0.32
NRG	200.65	500-Year	2300.00	318.15	327.90		328.40	0.003077	5.96	452.74	83.55	0.36
NRG	200.6	10-Year	800.00	318.00	324.15	321.97	324.46	0.002774	4.52	191.12	48.05	0.37
NRG	200.6	50-Year	800.00	318.00	324.15	321.97	324.46	0.002774	4.52	191.12	48.05	0.37
NRG	200.6	100-Year	900.00	318.00	324.46	322.19	324.80	0.002803	4.74	206.21	48.95	0.37
NRG	200.6	500-Year	2300.00	318.00	327.54	324.43	328.28	0.003401	7.19	370.78	62.55	0.45
NRG	200.58	10-Year	800.00	318.00	324.12		324.43	0.002842	4.55	189.55	47.96	0.37
NRG	200.58	50-Year	800.00	318.00	324.12		324.43	0.002842	4.55	189.55	47.96	0.37
NRG	200.58	100-Year	900.00	318.00	324.43		324.77	0.002870	4.78	204.58	48.86	0.38
NRG	200.58	500-Year	2300.00	318.00	327.48		328.24	0.003503	7.26	367.90	62.00	0.45
NRG	200.57	10-Year	800.00	317.00	324.17		324.38	0.001004	3.73	229.68	49.07	0.27
NRG	200.57	50-Year	800.00	317.00	324.17		324.38	0.001004	3.73	229.68	49.07	0.27
NRG	200.57	100-Year	900.00	317.00	324.49		324.72	0.001056	3.96	245.26	50.54	0.28
NRG	200.57	500-Year	2300.00	317.00	327.59		328.16	0.001564	6.34	421.68	63.37	0.37
NRG	200.55	10-Year	800.00	317.00	324.16	320.86	324.37	0.001013	3.74	229.00	49.00	0.27
NRG	200.55	50-Year	800.00	317.00	324.16	320.86	324.37	0.001013	3.74	229.00	49.00	0.27
NRG	200.55	100-Year	900.00	317.00	324.47	321.09	324.71	0.001065	3.97	244.51	50.47	0.28
NRG	200.55	500-Year	2300.00	317.00	327.57	323.49	328.14	0.001566	6.34	419.13	63.28	0.37
NRG	200.5	10-Year	800.00	319.00	323.84		324.25	0.005303	5.15	156.81	49.31	0.49
NRG	200.5	50-Year	800.00	319.00	323.84		324.25	0.005303	5.15	156.81	49.31	0.49
NRG	200.5	100-Year	900.00	319.00	324.15		324.59	0.005030	5.31	172.52	51.64	0.48
NRG	200.5	500-Year	2300.00	319.00	327.31		328.01	0.003856	6.95	382.54	85.81	0.46

HEC-RAS Plan: Ex Cond. 1988 River: Branch Bk Reach: NRG (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)	
NRG	200.45	10-Year	800.00	318.00	322.34	322.34	323.78	0.010938	9.86	93.61	38.54	0.94
NRG	200.45	50-Year	800.00	318.00	322.34	322.34	323.78	0.010938	9.86	93.61	38.54	0.94
NRG	200.45	100-Year	900.00	318.00	322.60	322.60	324.13	0.010618	10.21	103.83	40.50	0.94
NRG	200.45	500-Year	2300.00	318.00	325.86	325.86	327.67	0.006135	11.88	307.77	97.46	0.80
NRG	200.4	10-Year	800.00	317.00	321.26		321.93	0.008421	6.60	128.13	54.63	0.71
NRG	200.4	50-Year	800.00	317.00	321.26		321.93	0.008421	6.60	128.13	54.63	0.71
NRG	200.4	100-Year	900.00	317.00	321.52		322.21	0.008058	6.74	142.32	56.21	0.69
NRG	200.4	500-Year	2300.00	317.00	324.29		325.31	0.006110	8.43	324.82	92.03	0.62
NRG	200.3	10-Year	800.00	315.34	321.14		321.21	0.000321	2.09	383.41	82.22	0.17
NRG	200.3	50-Year	800.00	315.34	321.14		321.21	0.000321	2.09	383.41	82.22	0.17
NRG	200.3	100-Year	900.00	315.34	321.37		321.45	0.000353	2.24	402.28	83.49	0.18
NRG	200.3	500-Year	2300.00	315.34	324.05		324.24	0.000597	3.56	645.85	98.37	0.25
NRG	200.2	10-Year	800.00	315.34	320.97	319.06	321.16	0.001517	3.50	228.78	73.08	0.35
NRG	200.2	50-Year	800.00	315.34	320.97	319.06	321.16	0.001517	3.50	228.79	73.08	0.35
NRG	200.2	100-Year	900.00	315.34	321.19	319.24	321.40	0.001586	3.68	244.61	74.79	0.36
NRG	200.2	500-Year	2300.00	315.34	323.80	320.98	324.18	0.001668	4.92	467.37	95.70	0.39
NRG	200.15		Bridge									
NRG	200.1	10-Year	800.00	315.34	320.95	319.05	321.14	0.001555	3.53	226.83	72.86	0.35
NRG	200.1	50-Year	800.00	315.34	320.95	319.05	321.14	0.001555	3.53	226.83	72.86	0.35
NRG	200.1	100-Year	900.00	315.34	321.16	319.24	321.37	0.001625	3.71	242.50	74.56	0.36
NRG	200.1	500-Year	2300.00	315.34	323.77	320.97	324.15	0.001697	4.95	464.46	95.45	0.40
NRG	200	10-Year	800.00	315.34	320.74	319.04	320.96	0.001893	3.78	211.84	71.20	0.39
NRG	200	50-Year	800.00	315.34	320.74	319.04	320.96	0.001893	3.78	211.84	71.20	0.39
NRG	200	100-Year	900.00	315.34	320.94	319.22	321.19	0.001983	3.98	226.24	72.80	0.40
NRG	200	500-Year	2300.00	315.34	323.54	320.98	323.96	0.001941	5.20	442.56	93.60	0.42

APPENDIX E – TEMPORARY FACILITIES ANALYSIS

- Hydrology for Temporary Facilities
- HEC-RAS 2-Year Water Surface Profile
- HEC-RAS Profile Output Table for the 2-Year Event

Hydrology for Temporary Facilities

I. Determine Impact Ratings

The following selection factors are rated considering their severity as 1, 2, or 3 for low, medium or high conditions.

Potential Loss of Life: If inhabited structures, permanent or temporary, can be inundated or are in the path of a flood wave caused by an embankment failure, then this item will have a multiple of 15 applied. If no possibility of the above exists, then loss of life will be the same as the severity used for the A.D.T.

Property Damages: Private and public structures (houses, commercial, or manufacturing); appurtenances such as sewage treatment and water supply; utility structures either above or below ground, are to have a multiple of 10 applied. Active cropland, parking lots, recreational areas are to have a multiple of 5 applied. All other areas shall use the severity determined by site conditions.

Traffic Interruption: Includes consideration for emergency supplies and rescue; delays; alternate routes; busses; etc. Short duration flooding of a low volume roadway might be acceptable. If the duration of flooding is long (more than a day), and there is a nearby good quality alternate route, then the flooding of a higher volume highway might also be acceptable. The severity of this component is determined by the detour length multiplied by the average daily traffic projected for bi-directional travel.

Detour Length: The length in kilometers (miles) of an emergency detour by other roads should the temporary facility fail.

Height Above Streambed: The difference in elevation in meters (feet) between the traveled roadway and the bed of the waterway.

Drainage Area: The total area contributing runoff to the temporary facility, in hectares (acres).

Average Daily Traffic (ADT): The average amount of vehicles traveling bi-directional through the area in a 24-hour period.

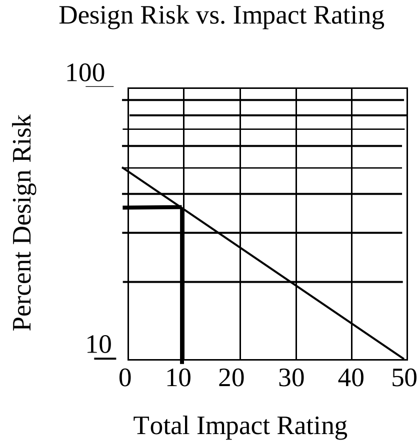
Rating Selection

Factor	Rating		
	1	2	3
Loss of Life	See Instructions		
Property Damage	See Instructions		
Traffic Interruption	< 2000	2000 – 4000	> 4000
Detour Length, km (mi)	< 8 (< 5)	8 – 16 (5 – 10)	> 16 (> 10)
Height Above Streambed, m (ft.)	< 3 (≤ 10)	3 – 6 (11 – 20)	> 6 (> 20)
Drainage Area, ha (sq. mi.)	< 260 (< 1)	260 – 2600 (1 – 10)	> 2600 (> 10)
Rural ADT	< 400	400 – 1500	> 1500
Suburban ADT	< 750	750 – 1500	> 1500
Urban ADT	< 1500	1500 – 300	> 3000

Impact Rating Table

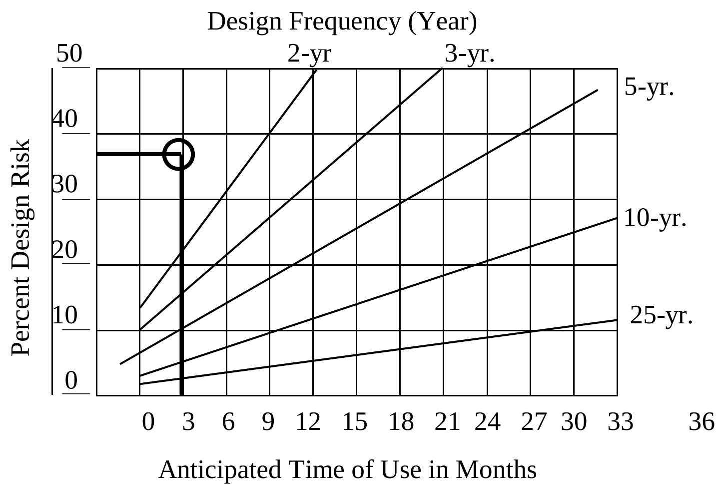
Loss of Life Rating X 15=	**1**
Property Damage Rating X 10 or X 5=	**1**
Traffic Interruption Rating =	**1**
Detour Length Rating =	**1**
Height Above Streambed Rating =	**2**
Drainage Area Rating =	**3**
Average Daily Traffic Rating =	**1**
Total Impact Rating = (sum of above)=	**10**

II. Determine Risk Percentage



Percent Design Risk = ___36___

III. Determine Temporary Design Frequency

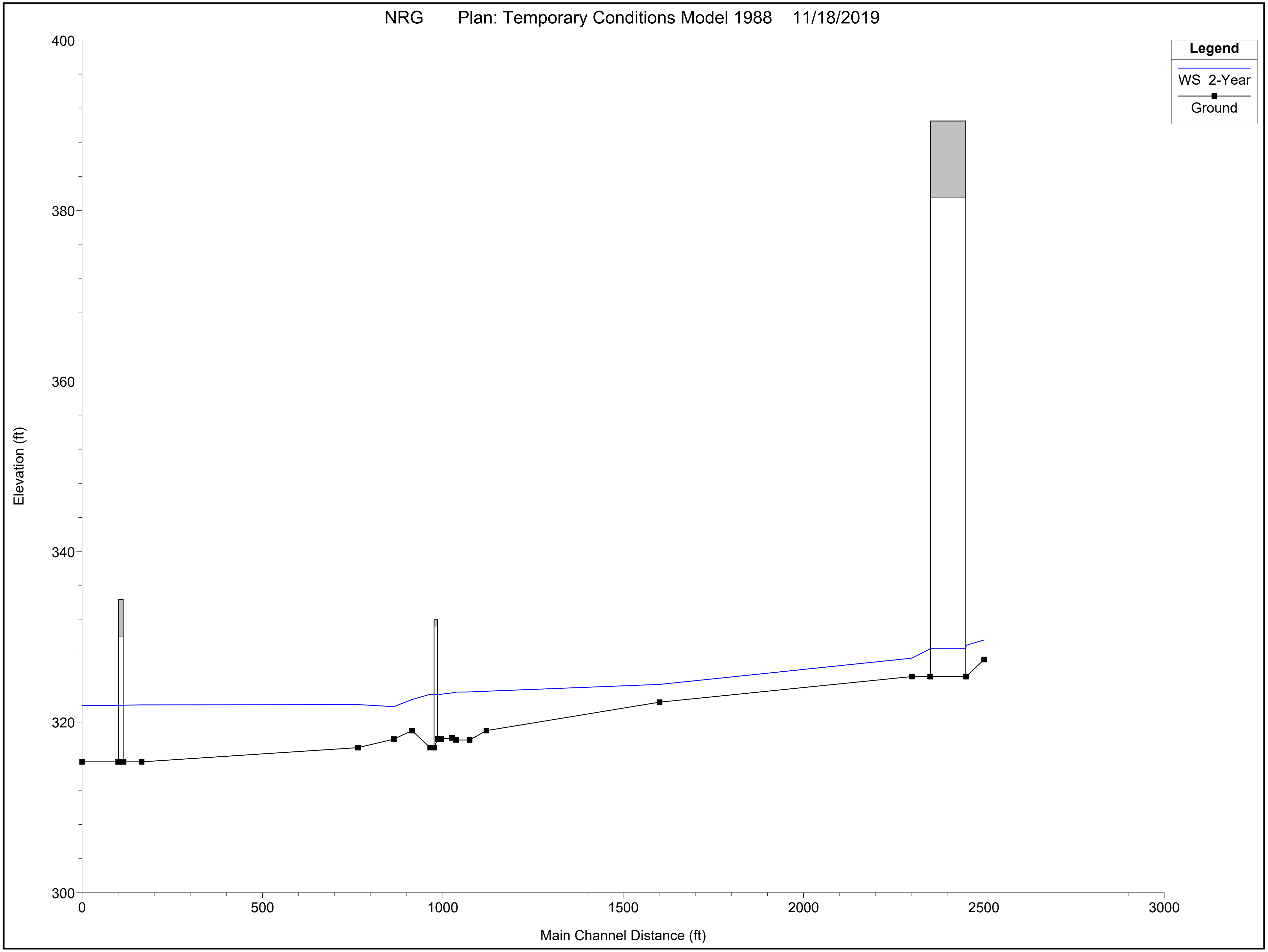


Design Frequency = __2__ years

IV. Determine Temporary Design Discharge

A. If sufficient discharges have been developed either by the designer or a Flood Insurance Study, then a frequency curve should be plotted to determine the Design Discharge instead of the final formula using the ratio.

Total Design Discharge = ___450___cfs


NRG Plan: Temporary Conditions Model 1988 11/18/2019
Legend
WS 2-Year
Ground
Elevation (ft)
400
380
360
340
320
300
0
500
1000
1500
2000
2500
3000
Main Channel Distance (ft)

HEC-RAS Plan: Temp. Cond. 88 River: Branch Bk Reach: NRG Profile: 2-Year

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)	
NRG	203	2-Year	450.00	327.34	329.36	329.36	330.23	0.015637	7.44	60.45	35.52	1.01
NRG	202.2	2-Year	450.00	325.34	328.62	327.26	328.86	0.002383	3.91	115.01	42.88	0.42
NRG	202.15		Bridge									
NRG	202.1	2-Year	450.00	325.34	328.27	327.26	328.59	0.003539	4.48	100.40	41.15	0.51
NRG	202	2-Year	450.00	325.34	327.25	327.25	328.10	0.015699	7.41	60.74	36.03	1.01
NRG	201	2-Year	450.00	322.34	324.08		324.14	0.001151	1.99	235.71	187.93	0.28
NRG	200.8	2-Year	450.00	319.00	323.21		323.38	0.002269	3.31	136.01	44.97	0.33
NRG	200.75	2-Year	450.00	317.90	323.13		323.27	0.001935	3.06	150.17	50.60	0.26
NRG	200.7	2-Year	450.00	317.90	323.10		323.19	0.001458	2.37	192.76	63.55	0.22
NRG	200.65	2-Year	450.00	318.15	323.02		323.16	0.002577	3.07	149.46	46.00	0.29
NRG	200.6	2-Year	450.00	318.00	322.89	321.16	323.08	0.002630	3.57	131.88	43.36	0.34
NRG	200.58		Bridge									
NRG	200.55	2-Year	450.00	317.00	322.88	319.84	322.99	0.000774	2.76	168.65	43.24	0.23
NRG	200.5	2-Year	450.00	319.00	322.33		322.80	0.004837	5.68	89.47	41.02	0.61
NRG	200.45	2-Year	450.00	318.00	321.88		322.52	0.005820	6.53	76.69	35.07	0.67
NRG	200.4	2-Year	450.00	317.00	322.01		322.14	0.001233	2.85	170.96	59.28	0.27
NRG	200.3	2-Year	450.00	315.34	321.99		322.01	0.000062	0.99	455.41	86.95	0.08
NRG	200.2	2-Year	450.00	315.34	321.97	318.29	322.00	0.000211	1.48	305.07	81.00	0.13
NRG	200.15		Bridge									
NRG	200.1	2-Year	450.00	315.34	321.96	318.29	322.00	0.000212	1.48	304.81	80.98	0.13
NRG	200	2-Year	450.00	315.34	321.94	318.29	321.97	0.000215	1.48	303.04	80.80	0.14