amec foster wheeler

Flood Study

Twin River – Tiverton Proposed Casino & Hotel
William S. Canning Blvd & Stafford Road
Tiverton, Rhode Island

Prepared for:

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March 2017

CONTENTS

1. INTRODUCTION

The proposed Twin River Casino project includes the construction of a casino building, a 3-story hotel, structured parking for 1,200± passenger vehicles, access drives, utilities, and stormwater management systems. To the greatest extent practicable, the state-regulated wetlands and wooded areas surrounding the casino and hotel will remain undisturbed. Preservation of existing natural resources are a critical component of the project design; therefore, a bridge and extensive retaining walls have been incorporated into the design, where necessary, to avoid disturbance of biological wetlands and to limit disturbance into the 50-foot perimeter wetlands and the 100-foot riverbank wetlands.

Base Flood Elevation (BFE) calculations were performed to determine the 100-year flood elevations associated with Sucker Brook and the RIDEM-designated ñIntermittent Streamò within the subject parcel. The Federal Emergency Management Agency (FEMA) defines the BFE as ñthe water surface elevation resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year, also known as the 100-year storm event.ò Figure 1 in Appendix A shows the project location and the watershed area.

The purpose of this analysis is to ensure that all proposed work is outside the boundaries of the 100-year flood plain and to safely convey runoff from the 100-year storm through the Site. Analysis for the Twin River ï Tiverton project was performed using the following:

- U.S. Army Corps of EngineersôRiver Analysis System (HEC-RAS) to model the 100-year flood elevations of the Sucker Brook and the intermittent steam onsite.
- RIGIS LIDAR 2-foot contours to develop cross-sections along the streams for the HEC-RAS model.
- HydroCAD Stormwater Modeling to estimate the 100-year stream flow of Sucker Brook and the intermittent stream onsite.

2. SUCKER BROOK ANALYSIS AND CONCLUSION

Based on documentation prepared by RIDEM, that portion of Sucker Brook that defines the western boundary of the Site has a watershed area of approximately 2.5 square miles. The watershed consists of 31% water/wetlands, 1% agriculture, 14% development, and 54% undeveloped wooded land (see Sucker Brook TMDL Summary in Appendix B). Based on the USGS soil survey, the watershed area consists of predominantly hydrologic group B, C, and D soils (see Appendix C). For purposes of this analysis, hydrologic group C soils have been assumed throughout the entire watershed for stream flow modeling.

2.1 Sucker Brook 100-Year Peak Stream Flow

Sucker Brook originates at Stafford Pond in Tiverton, RI and flows northerly into urban areas of Fall River, Massachusetts, ultimately discharging into South Watuppa Pond. Sucker Brook is controlled by a dam operated by the City of Fall River at the outlet of Stafford Pond. For the purposes of this analysis, Sucker Brook has been conservatively assumed as non-dam controlled for the 100-year storm event.

Based on HydroCAD modeling of the Sucker Brook watershed, the 100-year stream flow was determined to be 2,239 cfs (see Appendix D).

2.2 Sucker Brook 100-Year Peak Stream Flood Elevation

The HEC-RAS model developed for Sucker Brook consisted of 5 cross-sections spaced at roughly 500-foot intervals in the vicinity of the Site. The model determined 100-year flood elevations ranging from elevation 179.2 south of the Site to elevation 177.2 north of the Site (see Appendix E). These elevations were evaluated as lower than the verified edge of state-regulated wetland resources areas to the west of the proposed development (roughly at elevation 178.0±). No development is proposed within wetland resources; therefore, there is no anticipated flooding impact on proposed development areas resulting from Sucker Brook.

2.3 Sucker Brook Anticipated Impacts Resulting from Proposed Development

All proposed development was designed above elevation 178.0 and the predicted 100-year floodplain associated with Sucker Brook on site. Further, no work is proposed within biological wetland areas and post-development peak discharge rates will be at or below pre-development rates; therefore, proposed development activities result in no negative impact to the 100-year floodplain associated with Sucker Brook. See Appendix E for the HEC-RAS model and the Flood Analysis Figure 2 in Appendix A.

3. INTERMITTENT STREAM ANALYSIS AND CONCLUSION

Based on USGS mapping, the RIDEM-regulated ñIntermittent Streamò within the Site has a watershed area of approximately 40 acres (ac), as shown in the Existing Drainage Figure. (See Appendix A). Soils within the watersheds area consist of hydrologic soil group B, C, and D (See Appendix C).

3.1 Intermittent Stream 100-Year Peak Stream Flow

Based on HydroCAD modeling of the Intermittent Stream watershed, the 100-year stream flow was determined to be 85 cfs (see Appendix D). As a conservative measure for analysis, this peak flow was assumed to be consistent along the entire length of the Intermittent Stream. In actuality, streamflow is expected to be considerably less on the southern end of the stream (upstream) due to the smaller contributing watershed area associated with this portion of the stream.

3.2 Intermittent Stream 100-Year Peak Stream Flood Elevation

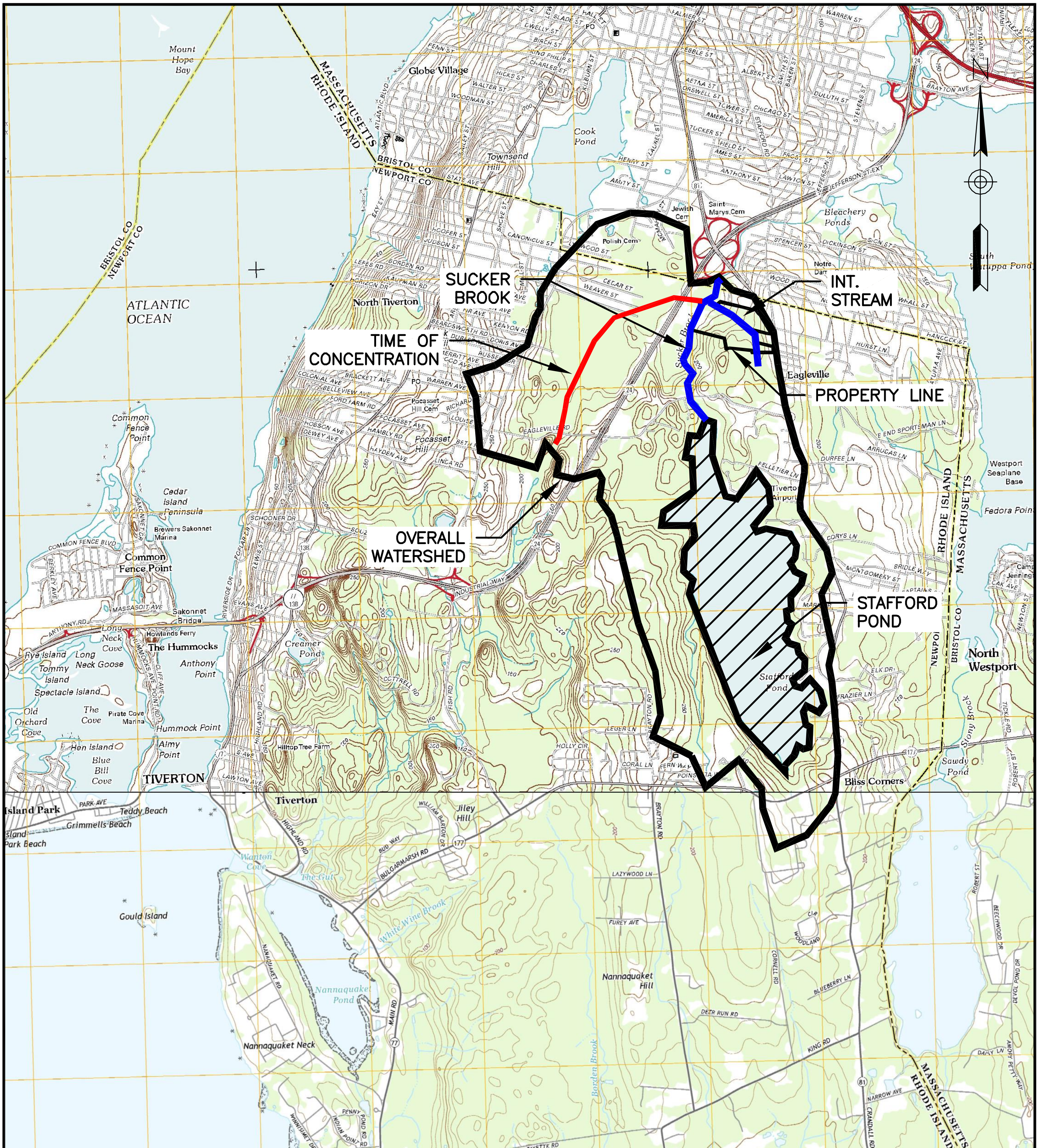
The HEC-RAS model developed for the Intermittent Steam consists of 10 cross-sections at roughly 250-foot intervals within the subject parcel. The model determined 100-year flood elevations ranging from 236.4 feet south of the Site to 182.4 feet north of the Site. At each of these cross-sections, the 100-year flood elevation is either contained entirely within or minimally extends beyond the state-regulated wetlands.

3.3 Intermittent Stream Anticipated Impacts Resulting from Proposed Development

All proposed development was designed above and outside the limits of the predicted 100-year floodplain associated with the Intermittent Stream on site. Further, no work is proposed within biological wetland areas and post-development peak discharge rates will be at or below pre-development rates; therefore, proposed development activities result in no negative impact to the 100-year floodplain associated with the Intermittent Stream. See Appendix E for the HEC-RAS model and the Flood Analysis Figure 2 in Appendix A.

APPENDIX A:

Figures



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CA JOB # 215010
JANUARY 4, 2017

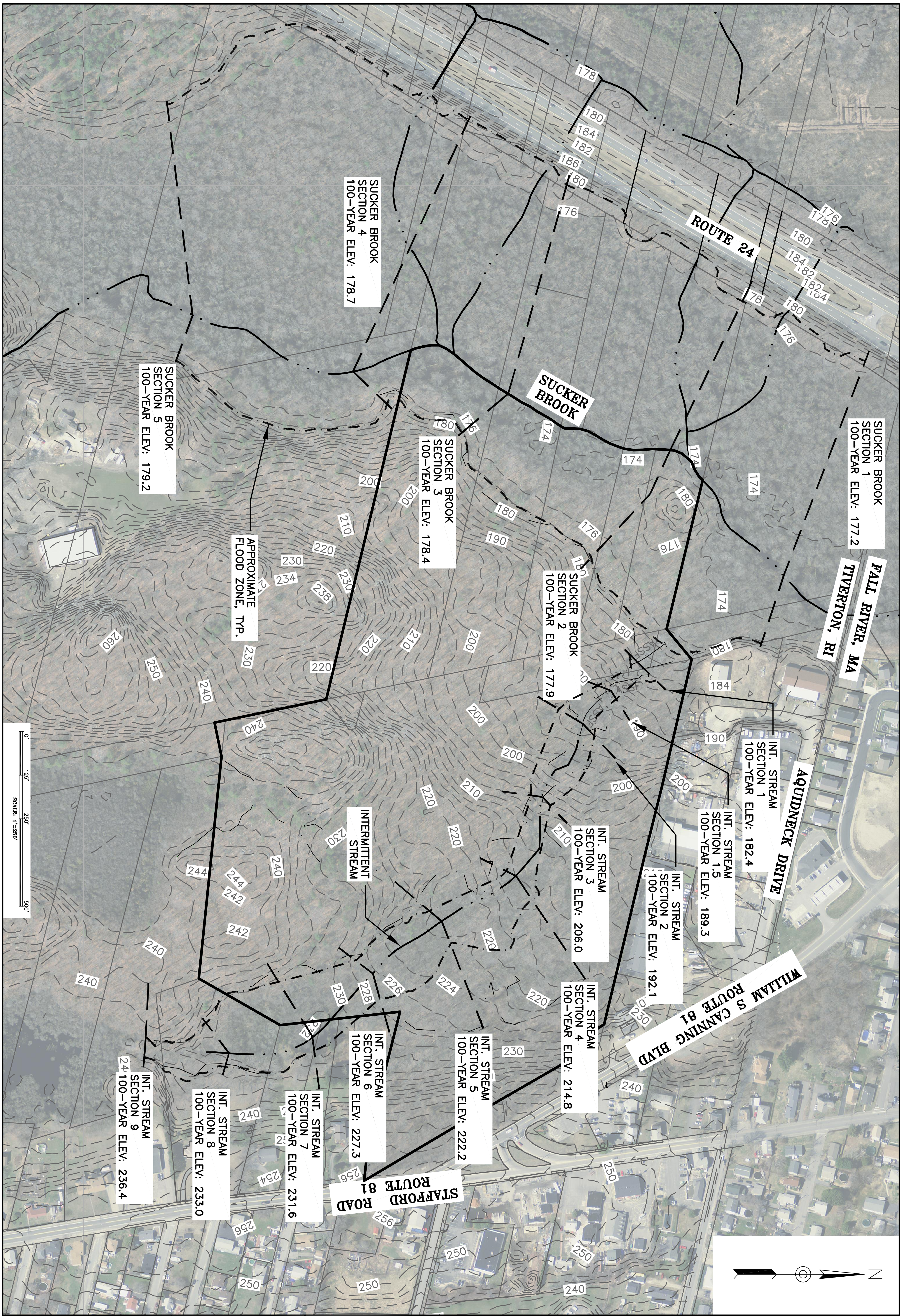
DRAWN BY:TMM/AKG
CHECK BY:CNB

TWIN RIVER – TIVERTON
PROPOSED CASINO & HOTEL
WILLIAM S. CANNING BLVD &
STAFFORD ROAD
TIVERTON, RHODE ISLAND

PREPARED FOR
FERRUCCI RUSSO PC

FLOOD ANALYSIS
FIGURE 1

0' 2,000 4,000 8,000
SCALE: 1"=4,000'



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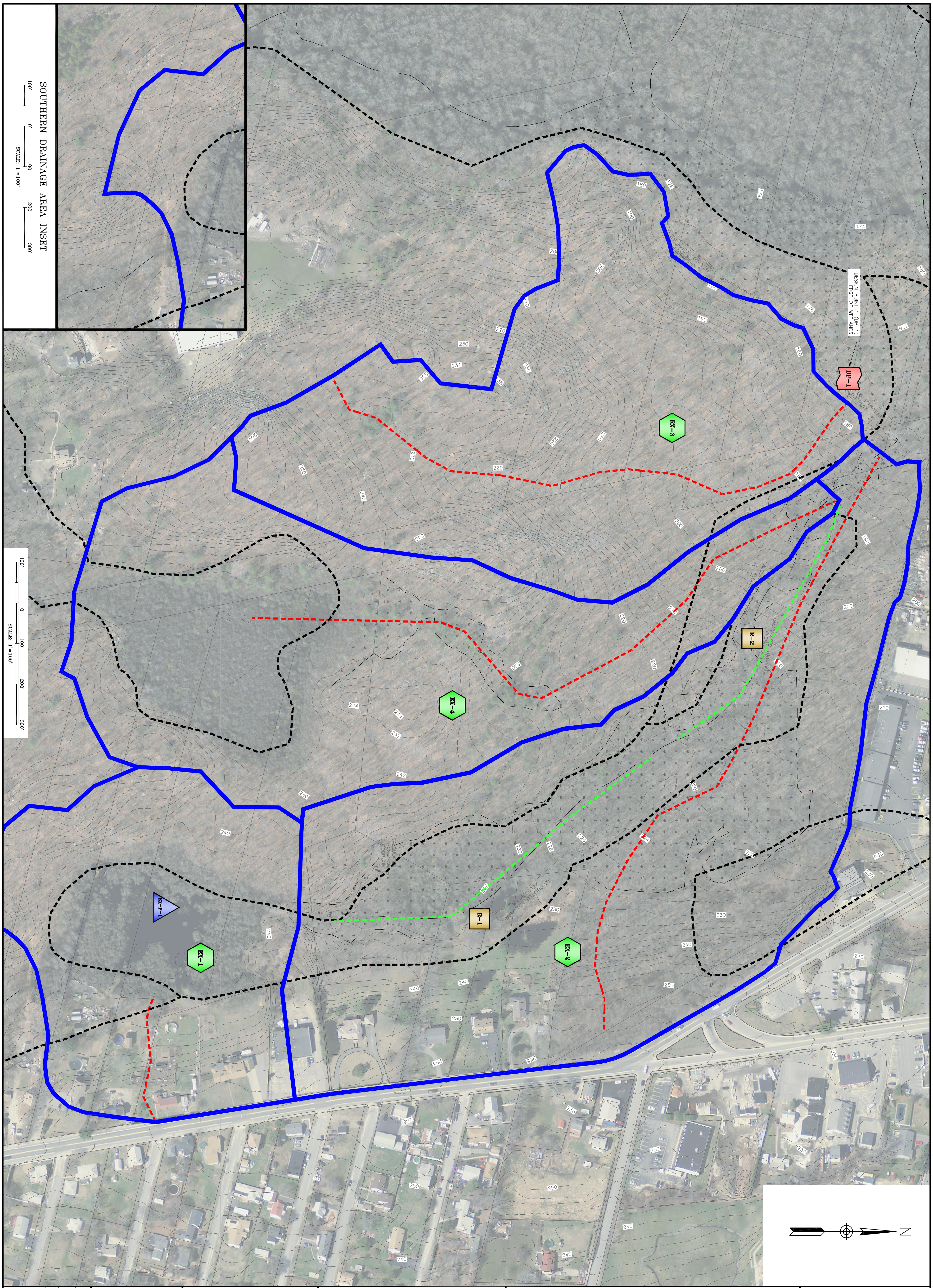
CLIENT:
TWIN RIVER
TIVERTON, LLC
C/O MARK RUSSO ESQ
55 PINE STREET
4TH FLOOR
PROVIDENCE, RI 02903

PROJECT:
TWIN RIVER - TIVERTON
PROPOSED LAND CLEARING & GRADING
PLAT 203 LOTS 107 & 111
PLAT 204 LOTS 101, 102, 103, 106 & 108
WILLIAM S. CANNING BLVD AND STAFFORD ROAD
TIVERTON, RHODE ISLAND

TITLE:
FLOOD ANALYSIS
FIGURE 2

DESIGNED BY: AKG/TMT
DRAWN BY: AKG/TMT
CHECKED BY: CNB
SCALE: 1" = 100'
PROJECT NUMBER:
DATE: 3/16/2017
DRAWING NUMBER: FIGURE 2
SHEET NUMBER: 1 OF 1



DESIGNED BY: AKG/TMT	DRAWN BY: AKG/TMT
CHECKED BY: CNB	SCALE: 1" = 80'
PROJECT NUMBER: 3653160007	DATE: 3/24/2017
DRAWING NUMBER:	
SHEET NUMBER: 1 OF 1	

CLIENT:

TWIN RIVER
TIVERTON, LLC
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PROVIDENCE, RI 02903

PROJECT:

TWIN RIVER - TIVERTON
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PLAT 203 LOTS 107 & 111
PLAT 204 LOTS 101, 102, 103, 106 & 108
WILLIAM S. CANNING BLVD AND STAFFORD ROAD
TIVERTON, RHODE ISLAND

TITLE:

EXISTING DRAINAGE FIGURE

LEGEND

- PROPOSED PROPERTY LINE
- DRAINAGE AREA DIVIDE
- HYDROLOGIC SOIL GROUP DIVIDE
- TIME OF CONCENTRATION
- REACH TRAVEL PATH
- EX-1 DRAINAGE AREA
- P-1 STORMWATER POND
- R-1 STORMWATER REACH
- DP DESIGN POINT

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APPENDIX B:

TMDL Summary

Sucker Brook

Watershed Description

This **TMDL** applies to the Sucker Brook assessment unit (RI0007037R-01), a 0.9-mile long stream located in Tiverton, RI (Figure 1). The Town of Tiverton is located in eastern Rhode Island and Sucker Brook is situated in the northeast corner of the town. The Sucker Brook watershed is presented in Figure 2 with land use types indicated.

Stafford Pond makes up the majority of the Sucker Brook watershed. Stafford Pond is a 487-acre reservoir that serves as a drinking water supply for Tiverton and Portsmouth, RI (RIDEM, 1998). Sucker Brook flows from Stafford Pond at the northern outlet in the Village of Eagleville, and flows north across Eagleville Road. The brook then flows parallel to Route 24 in a wooded area, flows into Massachusetts, and crosses Route 81 near the intersection with Route 24. In Massachusetts, the brook is surrounded by high-density development and transportation land uses. Sucker Brook empties into South Watuppa Pond near the South Watuppa Boat Ramp.

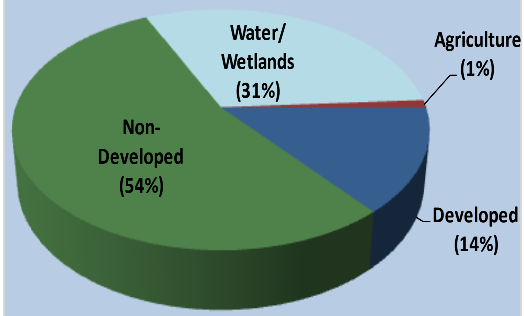
The Sucker Brook watershed covers 2.5 square miles and is mostly undeveloped (54%), as shown in Figures 2 and 3. Developed uses (including residential, commercial, and transportation land uses) occupy 14%. Most development is medium to high-density residential on the eastern bank of Stafford Pond, along Route 81. Agricultural uses occupy 1% of the total watershed. Surface waters and wetlands, including Stafford Pond, occupy 31% of the watershed.

Sucker Brook is controlled by a dam operated by the City of Fall River, MA. The city uses Sucker Brook as an emergency water supply (URI, 2006). State law prohibits swimming in Stafford Pond, however, boating is allowed and the pond is stocked with trout throughout the year by RIDEM. The pond is also used as a landing site for recreational seaplanes.

Assessment Unit Facts (RI0007037R-01)

- **Town:** Tiverton
- **Impaired Segment Length:** 0.9 miles
- **Classification:** Class A
- **Direct Watershed:** 2.5 mi^2 (1,621 acres)
- **Impervious Cover:** 7.8%
- **Watershed Planning Area:** Stafford Pond (#20)

Watershed Land Use



Watershed Land Uses

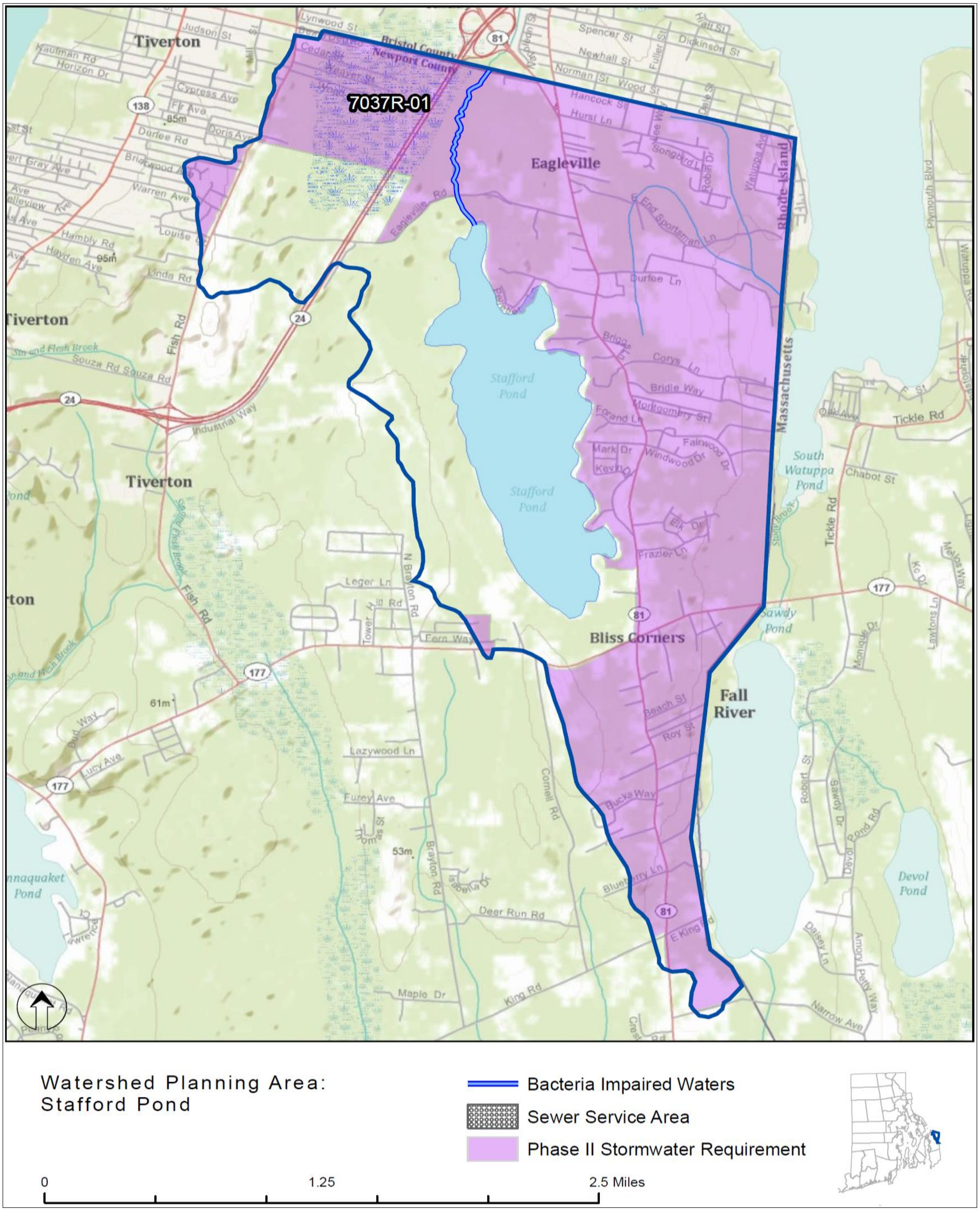


Figure 1: ***Map of Stafford Pond Watershed Planning Area with impaired segment addressed by the Statewide Bacteria TMDL, sewered areas, and stormwater regulated zone.***

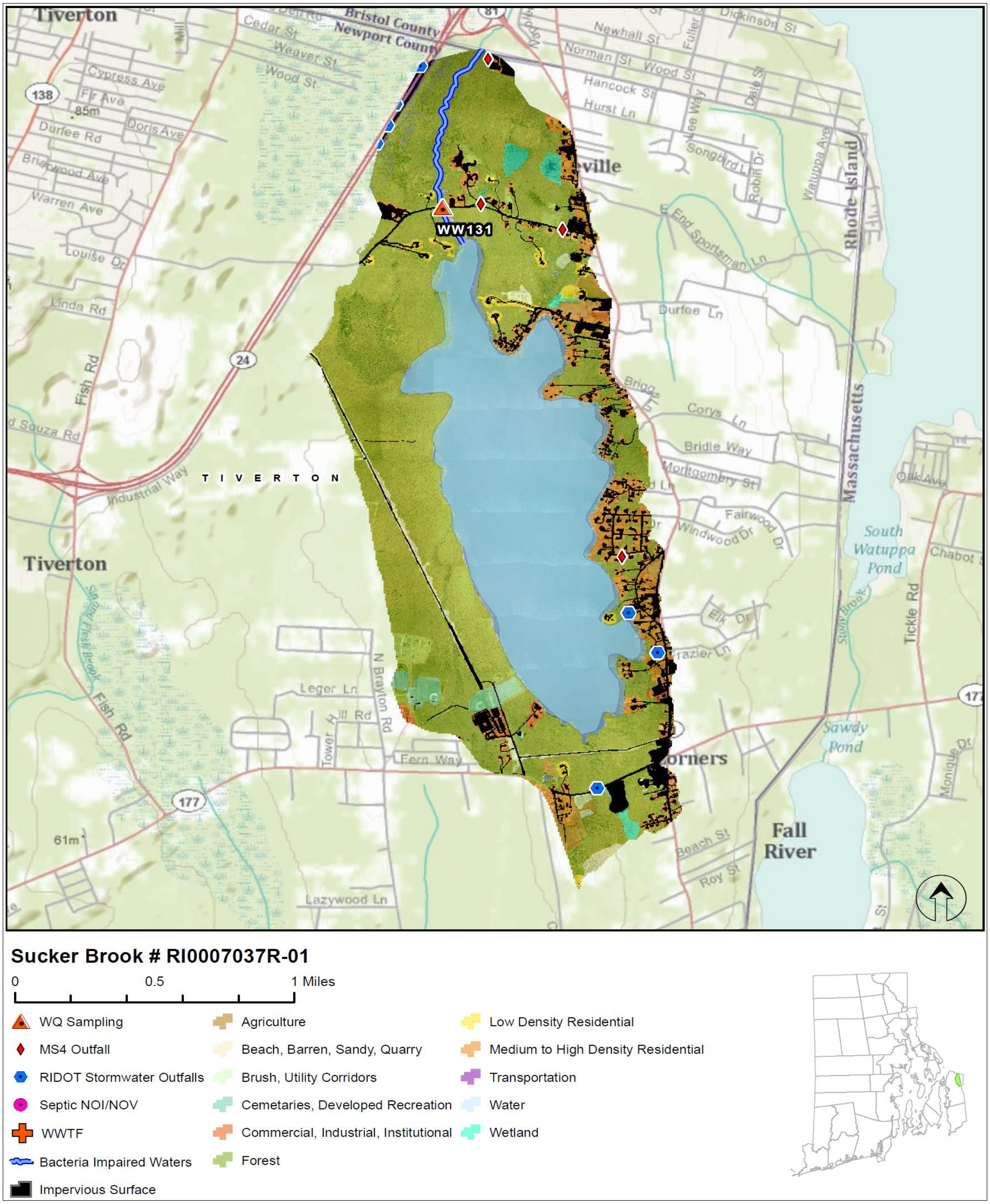


Figure 2: ***Map of Sucker Brook watershed with impaired segment, sampling location, and land cover indicated.***

Why is a TMDL Needed?

Sucker Brook is a Class A fresh water stream and its applicable designated uses are primary and secondary contact recreation and fish and wildlife habitat (RIDEM, 2009). From 2006-2008, water samples were collected from one sampling location (WW131) located near the outlet of Stafford Pond, and analyzed for the indicator bacteria, enterococci. The water quality criteria for enterococci, along with bacteria sampling results from 2006-2008 and associated statistics are presented in Table 1. The geometric mean was calculated for Station WW131 and exceeded the water quality criteria for enterococci.

Figure 3: ***Watershed aerial view of the Sucker Brook watershed (Source: Google Maps).***

To aid in identifying possible bacteria sources, the geometric mean was also calculated for wet and dry-weather sample days, where appropriate. The dry-weather geometric mean value exceeded the water quality criteria for enterococci. As only one sample was collected in wet-weather conditions, the geometric mean could not be calculated. However, this individual sample was extremely high (> 24,000 colonies/100mL).

Due to the elevated bacteria measurements presented in Table 1, the Sucker Brook assessment unit does not meet Rhode Island's water quality standards, was identified as impaired and was placed on the 303(d) list (RIDEM, 2008). The Clean Water Act requires that all 303(d) listed waters undergo a Total Maximum Daily Load (TMDL) assessment that describes the impairments and identifies the measures needed to res tore water quality. The goal is for all waterbodies to comply with state water quality standards.

Sucker Brook and Stafford Pond have previously been assessed by RIDEM as impaired for total phosphorus. A TMDL was developed in December 1998 for the Stafford Pond phosphorus impairment. No TMDL has been developed for the phosphorus impairment in Sucker Brook.

Potential Bacteria Sources

Previous investigations have concluded that there are several potential sources of bacteria in the Sucker Brook watershed including stormwater runoff from developed areas, failing onsite wastewater treatment systems, wildlife and domestic pet waste, and agricultural runoff. Each type of potential bacteria sources is described briefly below.

Agricultural Activities

Agricultural operations are an important economic activity and landscape feature in many areas of the state. Agricultural land use occupies only 1% of the watershed area in the Sucker Brook watershed. However, the primary agricultural operation in the watershed is a 55-acre dairy farm near the northeast corner of Stafford Pond. Agricultural runoff from this farm may contain multiple pollutants, including bacteria, and may be contributing to the high concentrations of bacteria in Sucker Brook. The farm has been identified in previous studies as a source of bacteria and nutrients to Stafford Pond (RIDEM, 1998).

Onsite Wastewater Treatment Systems

Residents in the Sucker Brook watershed rely entirely on onsite wastewater treatment systems (OWTS), such as septic systems and cesspools. There are an estimated 565 cesspool properties in the Town of Tiverton (URI, 2006). Failing OWTS can be significant sources of bacteria by allowing improperly treated waste to reach surface waters. Though no OWTS Notices of Violation/Notices of Intent to Violate have been issued by the RIDEM Office of Compliance and Inspection in the Sucker Brook watershed, soils in the area range from well-drained to poorly drained and some require special OWTS design and installation considerations (RIDEM, 1998). Failing or inadequate OWTS, including cesspools, are possibly contributing to ambient bacteria concentrations in Sucker Brook.

Wildlife and Domestic Animal Waste

Non-developed land accounts for 54% of the watershed area. Land uses directly adjacent to Sucker Brook are mostly forested and the western edge of Stafford Pond is entirely forested. Forests and open water areas are home to multiple species of wildlife and waterfowl. Continued development and encroachment into wildlife areas can cause animal densities to increase and animal waste to be more prevalent closer to the Brook. Wildlife, including waterfowl, may be a significant bacteria source to surface waters. With the construction of roads and drainage systems, these wastes may no longer be retained on the landscape, but instead may be conveyed via stormwater to the nearest surface water. As such these physical land alterations can exacerbate the impact of these natural sources on water quality.

Domestic animals are another potential source of bacteria to Sucker Brook. Medium to high density residential developments are found in the headwaters area of the watershed. If residents are not properly disposing of pet waste, the bacteria from that waste could enter and contaminate the brook either directly or through stormwater.

Developed Area Stormwater Runoff

The Sucker Brook watershed has an impervious cover of approximately 7.8%. Impervious cover is defined as land surface areas, such as roofs and roads that force water to run off land surfaces, rather than infiltrating into the soil. Impervious cover provides a useful metric for the potential for adverse stormwater impacts. While runoff from impervious areas in these portions of the watershed may be contributing bacteria to Sucker Brook, as discussed in Section 6.3 of the Core TMDL Document, as a general rule, impaired streams with watersheds having less than 10% impervious cover are assumed to be caused by sources other than urbanized stormwater runoff.

In accordance with Phase II requirements, Tiverton has identified and mapped all known outfalls to surface water bodies. The Rhode Island Department of Transportation (RIDOT) has also mapped stormwater outfalls within the Sucker Brook watershed, including those on Route 24. As shown in Figure 2, seven stormwater outfalls are located in the watershed, with four outfalls located near Sucker Brook.

Existing Local Management and Recommended Next Steps

Tiverton has developed and implemented programs to protect its surface waters from bacterial contamination. Future mitigative activities are necessary to ensure the long-term protection of Sucker Brook. Additional bacteria data collection would be beneficial to support identification of sources of potentially harmful bacteria in the Sucker Brook watershed. These activities could include sampling at several different locations and under different weather conditions (e.g., wet and dry). Field reconnaissance surveys focusing on stream buffers, stormwater runoff, and other source identification may also be beneficial.

Tiverton has a Comprehensive Plan that provides technical resources for protection of the Sucker Brook watershed. A brief description of existing local programs and recommended next steps from this plan, as well as Tiverton's Onsite Wastewater Management Plan, Phase II Stormwater Management Plan, Wastewater Facilities Plan, Source Water Assessment, as well as other sources are provided below. Stakeholders should review these documents directly for more detailed information.

Agricultural Activities

If not already in place, the U.S. Department of Agriculture Natural Resources Conservation Service and the RIDEM Division of Agriculture should to work with local agricultural operations, particularly the Joseph D. Arruda Dairy Farm near the northeastern shore of Stafford Pond, to develop conservation plans for farming activities within the watershed. NRCS and the RIDEM Division of Agriculture should ensure that all agricultural operations within the watershed have sufficient stream buffers, have fencing to restrict access of livestock and horses to streams and wetlands, and have animal waste handling, disposal, and other appropriate BMPs in place. A plan should be developed to evaluate the contributions of this farm and other sites to the bacterial contamination in Sucker Brook.

Onsite Wastewater Management

All residents in the Sucker Brook watershed rely on OWTS (Figure 1). It is expected that the Sucker Brook watershed will see a 50% increase in the number of OWTS in the next 30 years in response to increased development (RI HEALTH, 2003). Tiverton has an Onsite Wastewater Management Plan that provides a framework for managing the OWTS and has adopted a septic system ordinance requiring all OWTS to be inspected and pumped routinely. RIDEM recommends that all communities create an inventory of onsite systems through mandatory inspections. Inspections encourage proper maintenance and identify failed and sub-standard systems. Policies that govern the eventual replacement of sub-standard OWTS within a reasonable time frame should be adopted. The Rhode Island Wastewater Information System (RIWIS) can help develop an initial inventory of OWTS and can track voluntary inspection and pumping programs (RIDEM, 2010b).

The Town of Tiverton is eligible for Rhode Island's Community Septic System Loan Program (CSSLP) and has obtained $600,000 in CSSLP money since 2006. The CSSLP program provides low-interest loans to residents to help with maintenance and replacement of OWTS.

Wildlife and Domestic Animal Waste

Tiverton's education and outreach programs should highlight the importance of picking up after dogs and other pets and not feeding waterfowl. Animal wastes should be disposed of away from any waterway or stormwater system. Tiverton should work with volunteers to map locations where animal waste is a significant and chronic problem. This may include installing signage, providing pet waste receptacles or pet waste digester systems in high-use areas, enacting ordinances requiring clean-up of pet waste, and targeting educational and outreach programs in problem areas.

Towns and residents can take several measures to minimize waterfowl-related impacts. They can allow tall, coarse vegetation to grow in areas along the shores of Sucker Brook and Stafford Pond that are frequented by waterfowl. Waterfowl, especially grazers like geese, prefer easy access to the water. Maintaining an uncut vegetated buffer along the shore will make the habitat less desirable to geese and encourage migration. With few exceptions, Part XIV, Section 14.13, of Rhode Island's Hunting Regulations prohibits feeding wild waterfowl at any time in the state of Rhode Island. Educational programs should emphasize that feeding waterfowl, such as ducks, geese, and swans, may contribute to water quality impairments in Sucker Brook and can harm human health and the environment.

Stormwater Management

Tiverton (RIPDES permit RIR040039) and RIDOT (RIPDES permit RIR040036) are municipal separate storm sewer (MS4) operators in the Sucker Brook watershed and have prepared the required Phase II Stormwater Management Plans (SWMPP). The western portion of the watershed, including a small section of Sucker Brook and the western shore of Stafford Pond are outside of the regulate area. Route 24, located in the western portion of the watershed is regulated under the Phase II program because it is a divided highway.

Tiverton's SWMPP outlines goals for the reduction of stormwater runoff to Sucker Brook through the implementation of Best Management Practices (BMPs). Many of these BMPs are now in place, including mapping all stormwater outfalls, instituting annual inspections and cleaning of the town's catch basins, implementing an annual street sweeping program, adopting construction erosion and sediment control and post-construction stormwater ordinances, and conducting public education activities (RIDEM, 2010a).

The Town of Tiverton has adopted an IDDE ordinance (RIDEM, 2010). This type of ordinance prohibits illicit discharges to the MS4 and provides an enforcement mechanism. Stormwater outfalls discharging in the near vicinity of these sampling locations should be monitored to check for illicit discharges. Illicit discharges can be identified through dry weather outfall sampling and microbial source tracking.

RIDOT's SWMPP and its 2011 Compliance Update outline its goals for compliance with the General Permit. It should be noted that RIDOT has chosen to enact the General Permit statewide, beyond the General Permit's requirements regarding stormwater from urbanized and densely populated areas, as well as from divided highways outside of the urbanized and densely populated areas. RIDOT has finished mapping its outfalls throughout the state and is working to better document and expand its catch basin inspection and maintenance programs along with its BMP maintenance program. SWMPPs are being utilized for RIDOT construction projects. RIDOT also funds the University of Rhode Island Cooperative Extension's Stormwater Phase II Public Outreach and Education Project, which provides participating MS4s with education and outreach programs that can be used to address TMDL public education recommendations.

RIDOT and Tiverton will have no changes to their Phase II permit requirements and no TMDL Implementation Plan (TMDL IP) will be required at this time. As part of the larger Stafford Pond

Restoration Project, Tiverton has redesigned and upgraded stormwater outfalls to capture pollutants in the watershed. The town and RIDEM received a Successful Project Merit Award from the North American Lake Management Society (NALMS) in 2000 (RIDEM, 2000).

Land Use Protection

Woodland and wetland areas within the Sucker Brook watershed absorb and filter pollutants from stormwater runoff, and help protect both water quality in the stream and stream channel stability. As these areas currently represent approximately 54% of the land use in the Sucker Brook watershed, it is important to preserve these undeveloped areas. Much of the land area has soils that do not support development and controls on development in the Sucker Brook watershed should be instituted (RI HEALTH, 2003).

The steps outlined above will support the goal of mitigating bacteria sources and meeting water quality standards in Sucker Brook.

Table 1: Sucker Brook Bacteria Data

***Waterbody ID*:** RI0007037R-01

Watershed Planning Area: 20 – Stafford Pond

Characteristics: Freshwater, Class A, Primary and Secondary Contact Recreation, Fish and Wildlife Habitat

Impairment: Enterococci (colonies/100mL)

Water Quality Criteria for E. coli: Geometric Mean: 54 colonies/100 mL

***Percent Reduction to meet TMDL:* 70% (Includes 5% Margin of Safety)**

Data: 2006-2008 from RIDEM

Single Sample Enterococci (colonies/100 mL) Data for Sucker Brook (2006-2008) with Geometric Mean Statistic

Station Name	Station Location	Date	Result	Wet/Dry	Geometric Mean
WW131	Stafford Pond Inlet-Downstream/Sucker Brook	10/25/2008	36	Dry	**153 (70%)***
WW131	Stafford Pond Inlet-Downstream/Sucker Brook	9/20/2008	214	Dry	
WW131	Stafford Pond Inlet-Downstream/Sucker Brook	8/16/2008	20	Dry	
WW131	Stafford Pond Inlet-Downstream/Sucker Brook	6/7/2008	16	Dry	
WW131	Stafford Pond Inlet-Downstream/Sucker Brook	10/20/2007	24196	Wet	
WW131	Stafford Pond Inlet-Downstream/Sucker Brook	7/21/2007	613	Dry	
WW131	Stafford Pond Inlet-Downstream/Sucker Brook	5/12/2007	28	Dry	
WW131	Stafford Pond Inlet-Downstream/Sucker Brook	7/29/2006	1203	Dry	
WW131	Stafford Pond Inlet-Downstream/Sucker Brook	6/17/2006	36	Dry	

Shaded cells indicate an exceedance of water quality criteria
*Includes 5% Margin of Safety

Wet and Dry-Weather Geometric Mean Enterococci Values for Station WW131

Station Name	Station Location	Years Sampled	Number of Samples		Geometric Mean		
			Wet	Dry	All	Wet	Dry
WW131	Stafford Pond Inlet-Downstream/Sucker Brook	2006-2008	1	8	153	NA	81

Shaded cells indicate an exceedance of water quality criteria
Weather condition determined from rain gage at Newport County Airport in Middletown, RI

References

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Town of Tiverton (2006). The Comprehensive Community Plan, Tiverton, Rhode Island. Five Year Update. Prepared by the Tiverton Planning Board and the Tiverton Town Council. Updated November 2009.

URI (2006). Your Guide to Protecting Stafford Pond. University of Rhode Island Cooperative Extension. Developed for the Stafford Pond Education Committee.

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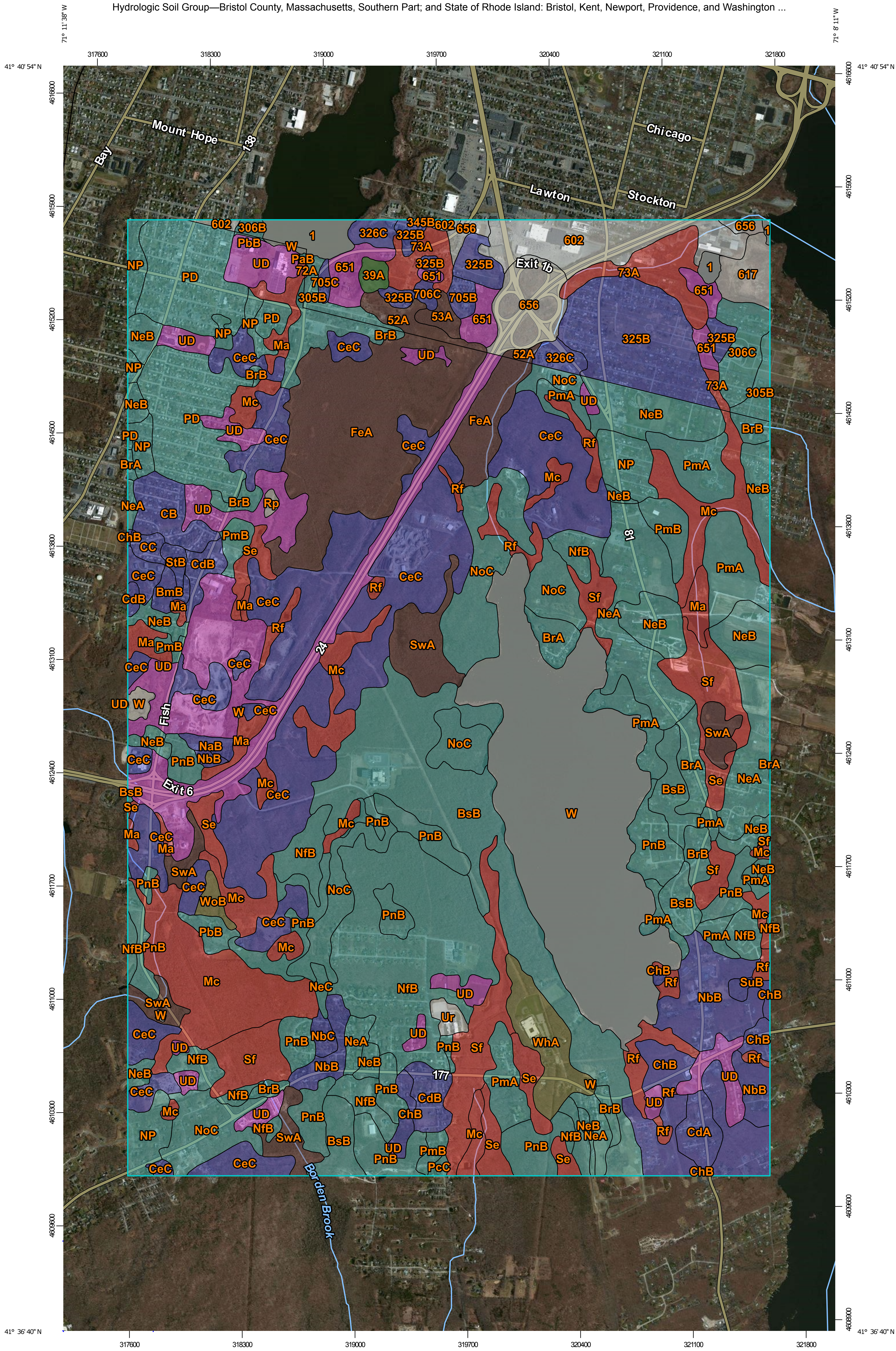
APPENDIX C:

NRCS Soils Maps

APPENDIX C.1:

Sucker Brook Soils Map



Map Scale: 1:21,900 if printed on B portrait (11" x 17") sheet.

N

Meters: 0, 300, 600, 1200, 1800

Feet: 0, 1000, 2000, 4000, 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

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 scales ranging from 1:12,000 to 1:20,000.

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: Bristol County, Massachusetts, Southern Part
Survey Area Data: Version 10, Sep 14, 2016

Soil Survey Area: State of Rhode Island: Bristol, Kent, Newport, Providence, and Washington Counties
Survey Area Data: Version 15, Sep 28, 2016

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: Apr 8, 2011—Apr 9, 2011

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.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Bristol County, Massachusetts, Southern Part (MA603)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
1	Water		31.8	0.5%
39A	Scarboro mucky fine sandy loam, 0 to 3 percent slopes	A/D	8.1	0.1%
52A	Freetown muck, 0 to 1 percent slopes	B/D	22.5	0.4%
53A	Freetown muck, ponded, 0 to 1 percent slopes	B/D	10.1	0.2%
72A	Whitman fine sandy loam, 0 to 3 percent slopes	D	0.3	0.0%
73A	Whitman fine sandy loam, 0 to 3 percent slopes, extremely stony	D	73.6	1.3%
305B	Paxton fine sandy loam, 3 to 8 percent slopes	C	28.6	0.5%
306B	Paxton fine sandy loam, 0 to 8 percent slopes, very stony	C	3.9	0.1%
306C	Paxton fine sandy loam, 8 to 15 percent slopes, very stony	C	35.7	0.6%
325B	Newport loam, 3 to 8 percent slopes	B	163.4	2.8%
326C	Newport loam, 3 to 15 percent slopes, very stony	B	22.9	0.4%
345B	Pittstown loam, 0 to 8 percent slopes	C	0.7	0.0%
602	Urban land		92.7	1.6%
617	Pits - Udorthents complex, gravelly		26.9	0.5%
651	Udorthents, smoothed	A	52.8	0.9%
656	Udorthents - Urban land complex		65.8	1.1%
705B	Charlton-Paxton fine sandy loams, 0 to 8 percent slopes, very rocky	B	8.8	0.2%
705C	Charlton-Paxton complex, 8 to 15 percent slopes, very rocky	B	4.0	0.1%

Hydrologic Soil Group— Summary by Map Unit — Bristol County, Massachusetts, Southern Part (MA603)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
706C	Charlton-Rock outcrop-Paxton complex, 3 to 15 percent slopes	B	4.6	0.1%
Subtotals for Soil Survey Area			**657.3**	**11.3%**
Totals for Area of Interest			**5,832.8**	**100.0%**

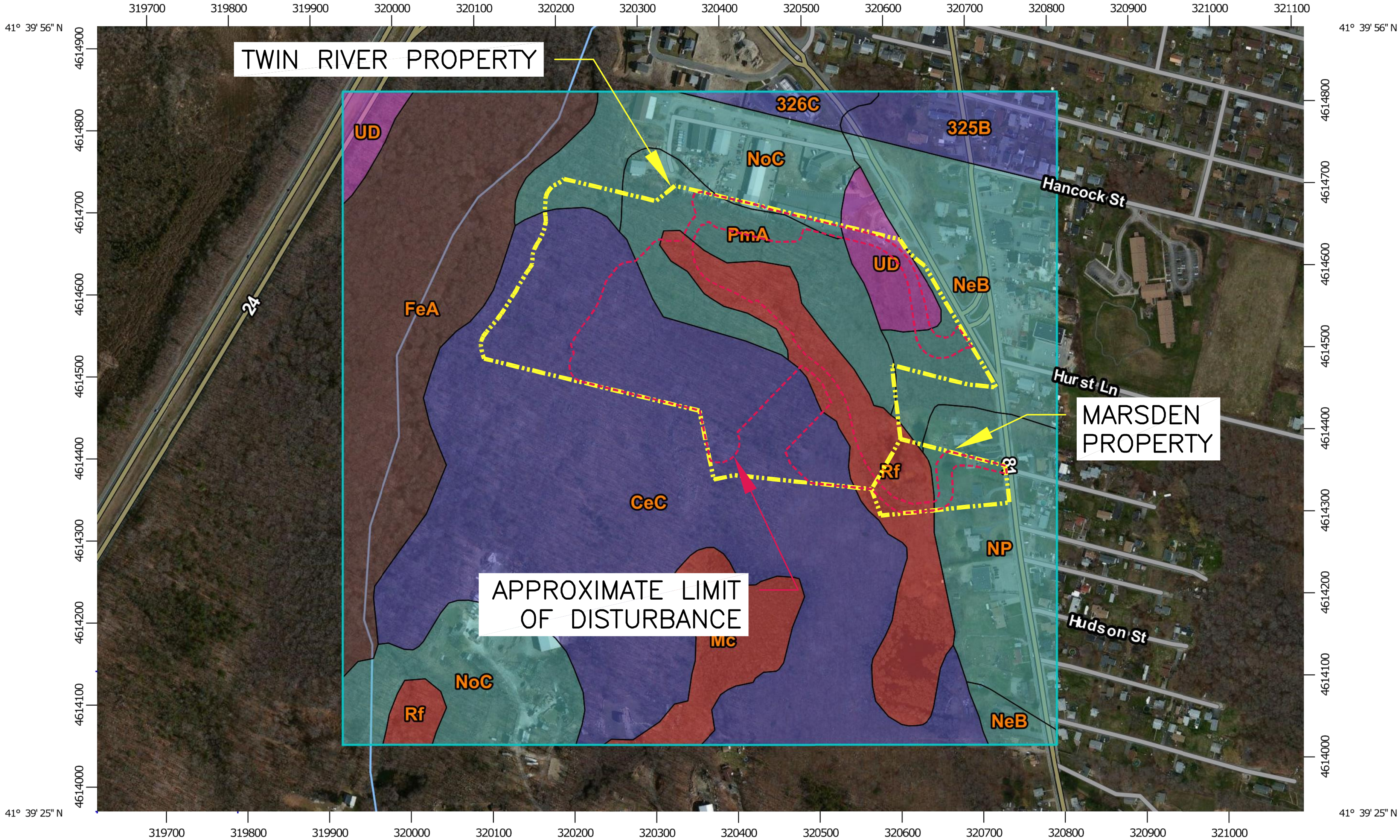
Hydrologic Soil Group— Summary by Map Unit — State of Rhode Island: Bristol, Kent, Newport, Providence, and Washington Counties (RI600)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
BmB	Bridgehampton silt loam, till substratum, 3 to 8 percent slopes	B	9.7	0.2%
BrA	Broadbrook silt loam, 0 to 3 percent slopes	C	40.0	0.7%
BrB	Broadbrook silt loam, 3 to 8 percent slopes	C	72.2	1.2%
BsB	Broadbrook very stony silt loam, 0 to 8 percent slopes	C	343.9	5.9%
CB	Canton-Urban land complex	B	36.2	0.6%
CC	Canton-Urban land complex, very rocky	B	8.1	0.1%
CdA	Canton and Charlton fine sandy loams, 0 to 3 percent slopes	B	23.1	0.4%
CdB	Canton and Charlton fine sandy loams, 3 to 8 percent slopes	B	40.6	0.7%
CeC	Canton and Charlton fine sandy loams, 3 to 15 percent slopes, very rocky	B	634.2	10.9%
ChB	Canton and Charlton fine sandy loams, 0 to 8 percent slopes, very stony	B	107.1	1.8%
FeA	Freetown muck, 0 to 1 percent slopes	B/D	287.2	4.9%
Ma	Mansfield mucky silt loam	D	60.3	1.0%
Mc	Mansfield very stony mucky silt loam	D	300.2	5.1%
NaB	Narragansett silt loam, 3 to 8 percent slopes	B	7.9	0.1%
NbB	Narragansett very stony silt loam, 0 to 8 percent slopes	B	112.1	1.9%

Hydrologic Soil Group— Summary by Map Unit — State of Rhode Island: Bristol, Kent, Newport, Providence, and Washington Counties (RI600)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
NbC	Narragansett very stony silt loam, 8 to 15 percent slopes	B	7.8	0.1%
NeA	Newport silt loam, 0 to 3 percent slopes	C	176.3	3.0%
NeB	Newport silt loam, 3 to 8 percent slopes	C	199.3	3.4%
NeC	Newport silt loam, 8 to 15 percent slopes	C	5.5	0.1%
NfB	Newport very stony silt loam, 3 to 8 percent slopes	C	331.1	5.7%
NoC	Newport extremely stony silt loam, 3 to 15 percent slopes	C	240.1	4.1%
NP	Newport-Urban land complex	C	93.2	1.6%
PaB	Paxton fine sandy loam, 3 to 8 percent slopes	C	0.6	0.0%
PbB	Paxton fine sandy loam, 0 to 8 percent slopes, very stony	C	12.3	0.2%
PcC	Paxton fine sandy loam, 3 to 15 percent slopes, extremely stony	C	2.9	0.0%
PD	Paxton-Urban land complex, 3 to 15 percent slopes	C	206.2	3.5%
PmA	Pittstown silt loam, 0 to 3 percent slopes	C	167.1	2.9%
PmB	Pittstown silt loam, 3 to 8 percent slopes	C	43.7	0.7%
PnB	Pittstown very stony silt loam, 0 to 8 percent slopes	C	242.4	4.2%
Rf	Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony	D	69.7	1.2%
Rp	Rock outcrop-Canton complex		2.8	0.0%
Se	Stissing silt loam	D	73.4	1.3%
Sf	Stissing very stony silt loam	D	178.0	3.1%
StB	Sutton fine sandy loam, 3 to 8 percent slopes	B	6.9	0.1%

Hydrologic Soil Group— Summary by Map Unit — State of Rhode Island: Bristol, Kent, Newport, Providence, and Washington Counties (RI600)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
SuB	Sutton very stony fine sandy loam, 0 to 8 percent slopes	B	7.2	0.1%
SwA	Swansea muck, 0 to 1 percent slopes	B/D	103.1	1.8%
UD	Udorthents-Urban land complex	A	360.7	6.2%
Ur	Urban land		9.0	0.2%
W	Water		488.8	8.4%
WhA	Woodbridge fine sandy loam, 0 to 3 percent slopes	C/D	55.6	1.0%
WoB	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	C/D	9.0	0.2%
Subtotals for Soil Survey Area			**5,175.5**	**88.7%**
Totals for Area of Interest			**5,832.8**	**100.0%**

APPENDIX C.2:

Site Soils Map



Map Scale: 1:6,750 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 100, 200, 400, 600

Feet: 0, 300, 600, 1200, 1800

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

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 scales ranging from 1:12,000 to 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
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: Bristol County, Massachusetts, Southern Part
Survey Area Data: Version 9, Sep 28, 2015

Soil Survey Area: State of Rhode Island: Bristol, Kent, Newport, Providence, and Washington Counties
Survey Area Data: Version 14, Sep 22, 2015

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Date(s) aerial images were photographed: Apr 8, 2011—Apr 9, 2011

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.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Bristol County, Massachusetts, Southern Part (MA603)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
325B	Newport loam, 3 to 8 percent slopes	B	5.1	3.0%
326C	Newport loam, 3 to 15 percent slopes, very stony	B	1.4	0.8%
Subtotals for Soil Survey Area			**6.5**	**3.8%**
Totals for Area of Interest			**172.6**	**100.0%**

Hydrologic Soil Group— Summary by Map Unit — State of Rhode Island: Bristol, Kent, Newport, Providence, and Washington Counties (RI600)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
CeC	Canton and Charlton fine sandy loams, very rocky, 3 to 15 percent slopes	B	62.7	36.3%
FeA	Freetown muck, 0 to 1 percent slopes	B/D	23.5	13.6%
Mc	Mansfield very stony mucky silt loam	D	5.6	3.3%
NeB	Newport silt loam, 3 to 8 percent slopes	C	16.2	9.4%
NoC	Newport extremely stony silt loam, 3 to 15 percent slopes	C	19.1	11.1%
NP	Newport-Urban land complex	C	12.3	7.1%
PmA	Pittstown silt loam, 0 to 3 percent slopes	C	9.8	5.7%
Rf	Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony	D	12.2	7.1%
UD	Udorthents-Urban land complex	A	4.6	2.7%
Subtotals for Soil Survey Area			**166.1**	**96.2%**
Totals for Area of Interest			**172.6**	**100.0%**

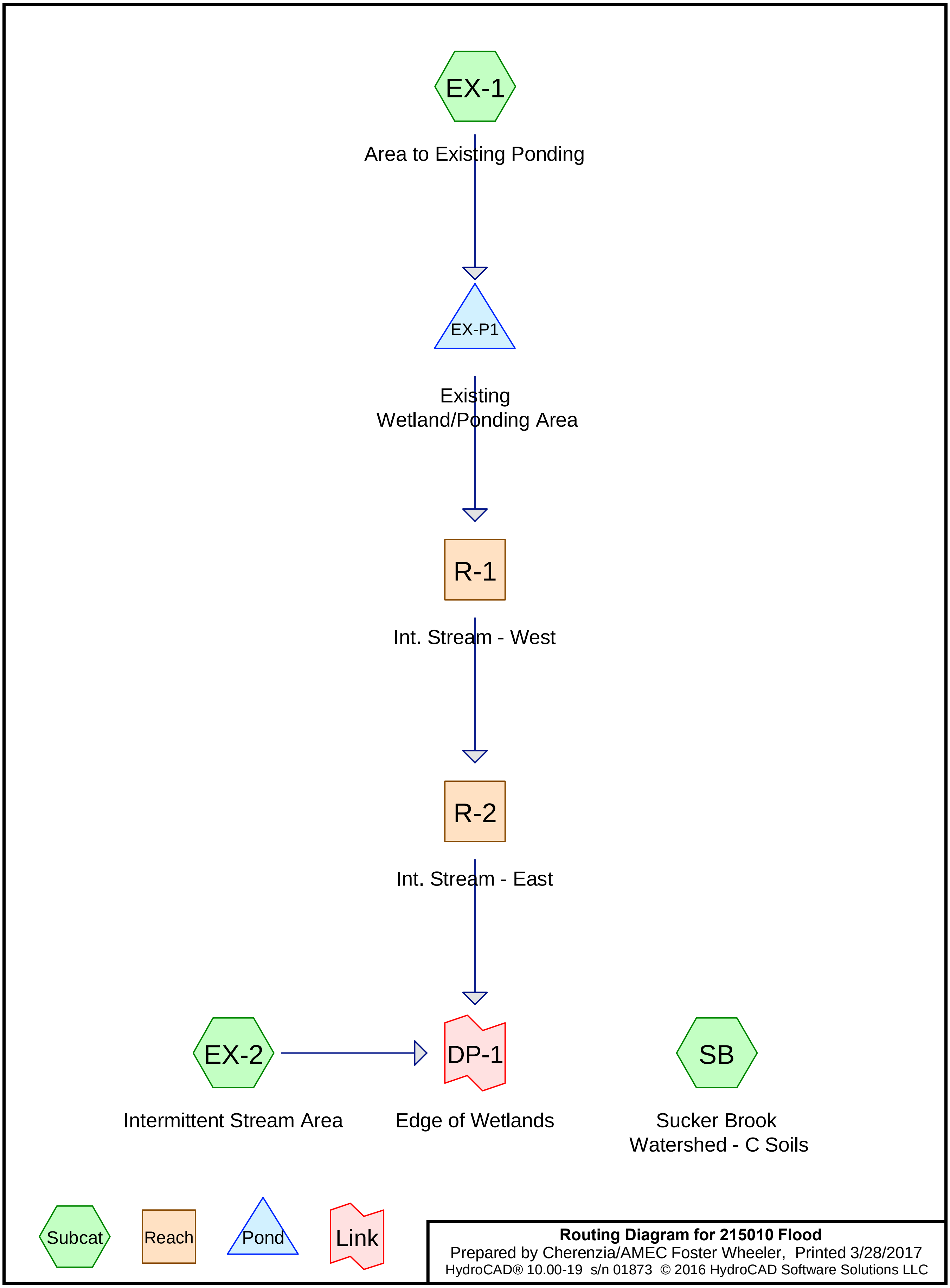
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

APPENDIX D:

HydroCAD Analysis



Routing Diagram for 215010 Flood
Prepared by Cherenzia/AMEC Foster Wheeler, Printed 3/28/2017

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment EX-1: Area to Existing Runoff Area=528,968 sf 6.38% Impervious Runoff Depth=4.74"
Flow Length=265' Tc=6.7 min CN=68 Runoff=65.94 cfs 4.801 af

Subcatchment EX-2: Intermittent Stream Runoff Area=1,211,380 sf 3.92% Impervious Runoff Depth=4.86"
Flow Length=1,634' Tc=44.0 min CN=69 Runoff=74.27 cfs 11.272 af

Subcatchment SB: Sucker Brook Runoff Area=1,621.000 ac 34.50% Impervious Runoff Depth=6.19"
Flow Length=6,990' Tc=176.8 min CN=80 Runoff=2,238.98 cfs 836.115 af

Reach R-1: Int. Stream - West Avg. Flow Depth=1.29' Max Vel=3.60 fps Inflow=22.28 cfs 1.737 af
n=0.040 L=995.0' S=0.0130 '/' Capacity=49.86 cfs Outflow=19.93 cfs 1.737 af

Reach R-2: Int. Stream - East Avg. Flow Depth=0.96' Max Vel=5.44 fps Inflow=19.93 cfs 1.737 af
n=0.040 L=715.0' S=0.0427 '/' Capacity=90.44 cfs Outflow=19.44 cfs 1.737 af

Pond EX-P1: Existing Wetland/Ponding Peak Elev=236.26' Storage=8,841 cf Inflow=65.94 cfs 4.801 af
Discarded=39.20 cfs 3.063 af Primary=22.28 cfs 1.737 af Outflow=61.48 cfs 4.801 af

Link DP-1: Edge of Wetlands Inflow=84.85 cfs 13.010 af
Primary=84.85 cfs 13.010 af

Total Runoff Area = 1,660.953 ac Runoff Volume = 852.188 af Average Runoff Depth = 6.16"
66.22% Pervious = 1,099.844 ac 33.78% Impervious = 561.109 ac

Summary for Subcatchment EX-1: Area to Existing Ponding

Runoff = 65.94 cfs @ 12.10 hrs, Volume= 4.801 af, Depth= 4.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr NEWP 100-YR Rainfall=8.60"

Area (sf)	CN	Description
218,538	55	Woods, Good, HSG B
141,671	77	Woods, Good, HSG D
18,095	68	1 acre lots, 20% imp, HSG B
150,664	79	1 acre lots, 20% imp, HSG C
528,968	68	Weighted Average
495,216		93.62% Pervious Area
33,752		6.38% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.2	50	0.0400	0.20		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.30"
0.7	91	0.1033	2.25		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.2	91	0.0330	1.27		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.6	33	0.0303	0.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
6.7	265	Total			

Summary for Subcatchment EX-2: Intermittent Stream Area

Runoff = 74.27 cfs @ 12.61 hrs, Volume= 11.272 af, Depth= 4.86"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr NEWP 100-YR Rainfall=8.60"

	Area (sf)	CN	Description
	82,157	30	Woods, Good, HSG A
	147,316	55	Woods, Good, HSG B
	418,623	70	Woods, Good, HSG C
	342,099	77	Woods, Good, HSG D
	205,945	79	1 acre lots, 20% imp, HSG C
	8,992	74	>75% Grass cover, Good, HSG C
*	6,248	98	Impervious surface
	1,211,380	69	Weighted Average
	1,163,943		96.08% Pervious Area
	47,437		3.92% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.1	50	0.0408	0.09		**Sheet Flow, TOC-1** Woods: Light underbrush n= 0.400 P2= 3.30"
8.1	50	0.0549	0.10		**Sheet Flow, TOC-2** Woods: Light underbrush n= 0.400 P2= 3.30"
1.2	126	0.1206	1.74		**Shallow Concentrated Flow, TOC-3** Woodland Kv= 5.0 fps
1.6	113	0.0531	1.15		**Shallow Concentrated Flow, TOC-4** Woodland Kv= 5.0 fps
15.6	733	0.0246	0.78		**Shallow Concentrated Flow, TOC-5** Woodland Kv= 5.0 fps
2.7	208	0.0673	1.30		**Shallow Concentrated Flow, TOC-6** Woodland Kv= 5.0 fps
3.6	203	0.0345	0.93		**Shallow Concentrated Flow, TOC-7** Woodland Kv= 5.0 fps
2.1	151	0.0583	1.21		**Shallow Concentrated Flow, TOC-8** Woodland Kv= 5.0 fps
44.0	1,634	Total			

Summary for Subcatchment SB: Sucker Brook Watershed - C Soils

Runoff = 2,238.98 cfs @ 14.34 hrs, Volume= 836.115 af, Depth= 6.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr NEWP 100-YR Rainfall=8.60"

Area (ac)	CN	Description
875.340	70	Woods, Good, HSG C
226.940	80	1/2 acre lots, 25% imp, HSG C
16.210	74	Pasture/grassland/range, Good, HSG C
502.510	98	Water Surface, HSG C
1,621.000	80	Weighted Average
1,061.755		65.50% Pervious Area
559.245		34.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.8	100	0.0092	0.06		**Sheet Flow, TOC 1** Woods: Light underbrush n= 0.400 P2= 3.30"
38.9	1,120	0.0092	0.48		**Shallow Concentrated Flow, TOC 2** Woodland Kv= 5.0 fps
109.1	5,770	0.0010	0.88	5.88	**Parabolic Channel, TOC 3** W=10.00' D=1.00' Area=6.7 sf Perim=10.3' n= 0.040 Winding stream, pools & shoals
176.8	6,990	Total			

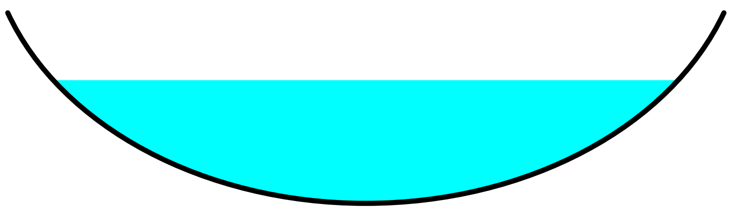
Summary for Reach R-1: Int. Stream - West

Inflow Area = 12.143 ac, 6.38% Impervious, Inflow Depth = 1.72" for NEWP 100-YR event
Inflow = 22.28 cfs @ 12.13 hrs, Volume= 1.737 af
Outflow = 19.93 cfs @ 12.26 hrs, Volume= 1.737 af, Atten= 11%, Lag= 7.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 3.60 fps, Min. Travel Time= 4.6 min
Avg. Velocity = 1.01 fps, Avg. Travel Time= 16.4 min

Peak Storage= 5,516 cf @ 12.18 hrs
Average Depth at Peak Storage= 1.29'
Bank-Full Depth= 2.00' Flow Area= 10.7 sf, Capacity= 49.86 cfs

8.00' x 2.00' deep Parabolic Channel, n= 0.040 Winding stream, pools & shoals
Length= 995.0' Slope= 0.0130 '/'
Inlet Invert= 232.90', Outlet Invert= 220.00'



Summary for Reach R-2: Int. Stream - East

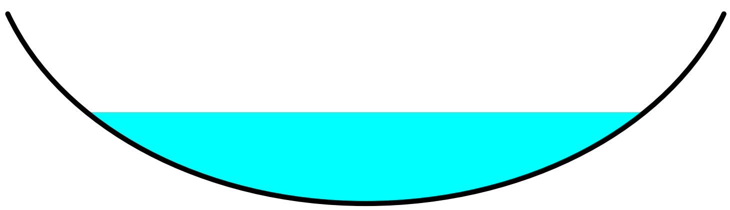
[61] Hint: Exceeded Reach R-1 outlet invert by 0.46' @ 12.29 hrs

Inflow Area = 12.143 ac, 6.38% Impervious, Inflow Depth = 1.72" for NEWP 100-YR event
Inflow = 19.93 cfs @ 12.26 hrs, Volume= 1.737 af
Outflow = 19.44 cfs @ 12.32 hrs, Volume= 1.737 af, Atten= 2%, Lag= 3.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Max. Velocity= 5.44 fps, Min. Travel Time= 2.2 min
Avg. Velocity = 1.56 fps, Avg. Travel Time= 7.6 min

Peak Storage= 2,554 cf @ 12.29 hrs
Average Depth at Peak Storage= 0.96'
Bank-Full Depth= 2.00' Flow Area= 10.7 sf, Capacity= 90.44 cfs

8.00' x 2.00' deep Parabolic Channel, n= 0.040 Mountain streams
Length= 715.0' Slope= 0.0427 '/'
Inlet Invert= 219.50', Outlet Invert= 189.00'



Summary for Pond EX-P1: Existing Wetland/Ponding Area

Inflow Area = 12.143 ac, 6.38% Impervious, Inflow Depth = 4.74" for NEWP 100-YR event
Inflow = 65.94 cfs @ 12.10 hrs, Volume= 4.801 af
Outflow = 61.48 cfs @ 12.13 hrs, Volume= 4.801 af, Atten= 7%, Lag= 2.0 min
Discarded = 39.20 cfs @ 12.13 hrs, Volume= 3.063 af
Primary = 22.28 cfs @ 12.13 hrs, Volume= 1.737 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 236.26' @ 12.13 hrs Surf.Area= 48,187 sf Storage= 8,841 cf

Plug-Flow detention time= 3.3 min calculated for 4.800 af (100% of inflow)
Center-of-Mass det. time= 3.3 min (829.7 - 826.4)

Volume	Invert	Avail.Storage	Storage Description
#1	236.00'	816,551 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
236.00	18,822	0	0
238.00	241,386	260,208	260,208
240.00	314,957	556,343	816,551

Device	Routing	Invert	Outlet Devices
#1	Primary	236.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 2.00 4.00 Width (feet) 47.00 105.00 248.00
#2	Discarded	236.00'	**Custom Weir/Orifice, Cv= 2.62 (C= 3.28)** Head (feet) 0.00 2.00 4.00 Width (feet) 83.00 179.00 270.00

Discarded OutFlow Max=39.08 cfs @ 12.13 hrs HW=236.26' (Free Discharge)
└─**2=Custom Weir/Orifice** (Weir Controls 39.08 cfs @ 1.66 fps)

Primary OutFlow Max=22.21 cfs @ 12.13 hrs HW=236.26' (Free Discharge)
└─**1=Custom Weir/Orifice** (Weir Controls 22.21 cfs @ 1.66 fps)

Summary for Link DP-1: Edge of Wetlands

Inflow Area = 39.953 ac, 4.67% Impervious, Inflow Depth = 3.91" for NEWP 100-YR event
Inflow = 84.85 cfs @ 12.56 hrs, Volume= 13.010 af
Primary = 84.85 cfs @ 12.56 hrs, Volume= 13.010 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

APPENDIX E:

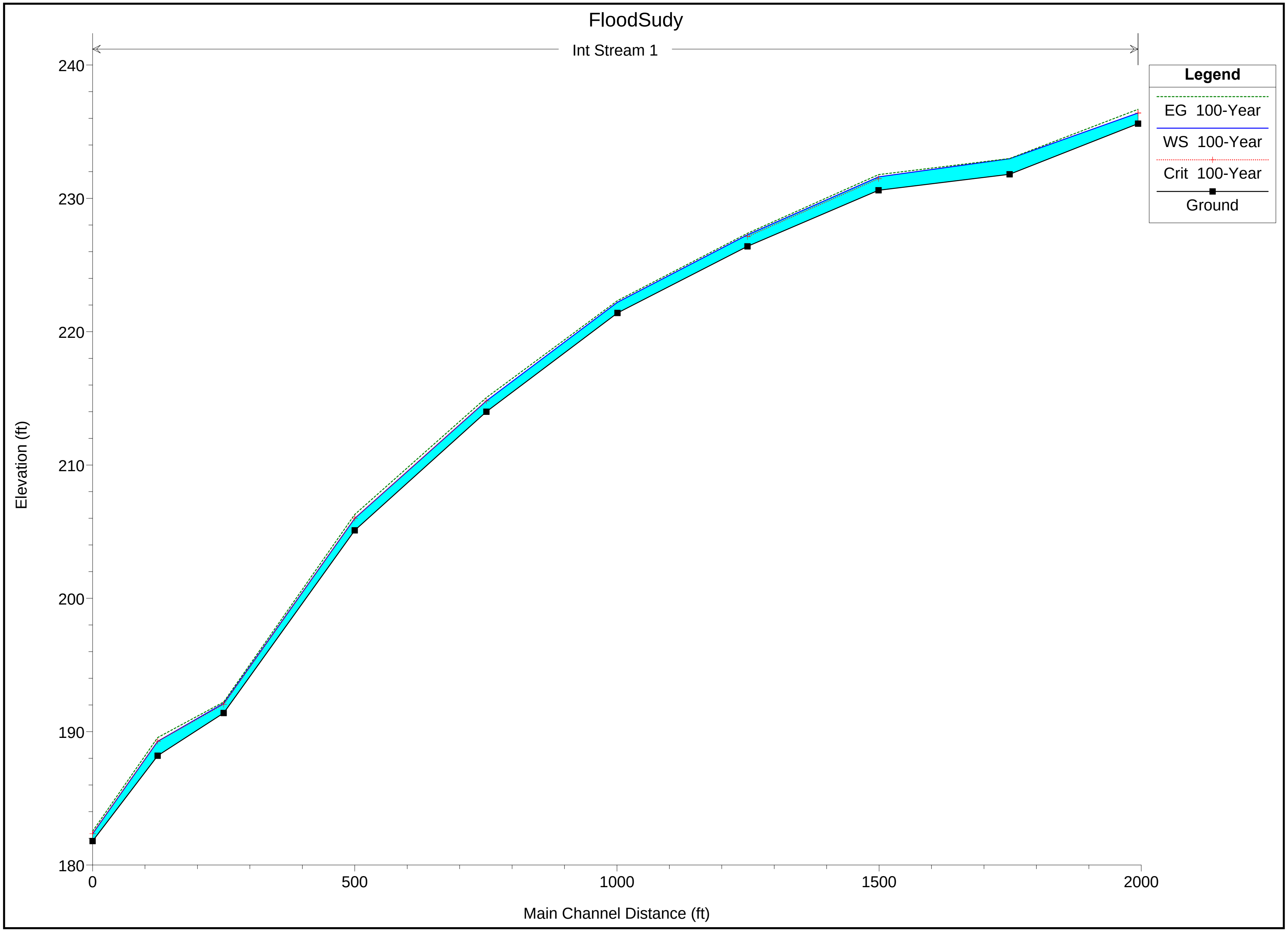
HEC-RAS Analysis

HEC-RAS Plan: 1 Profile: 100-Year

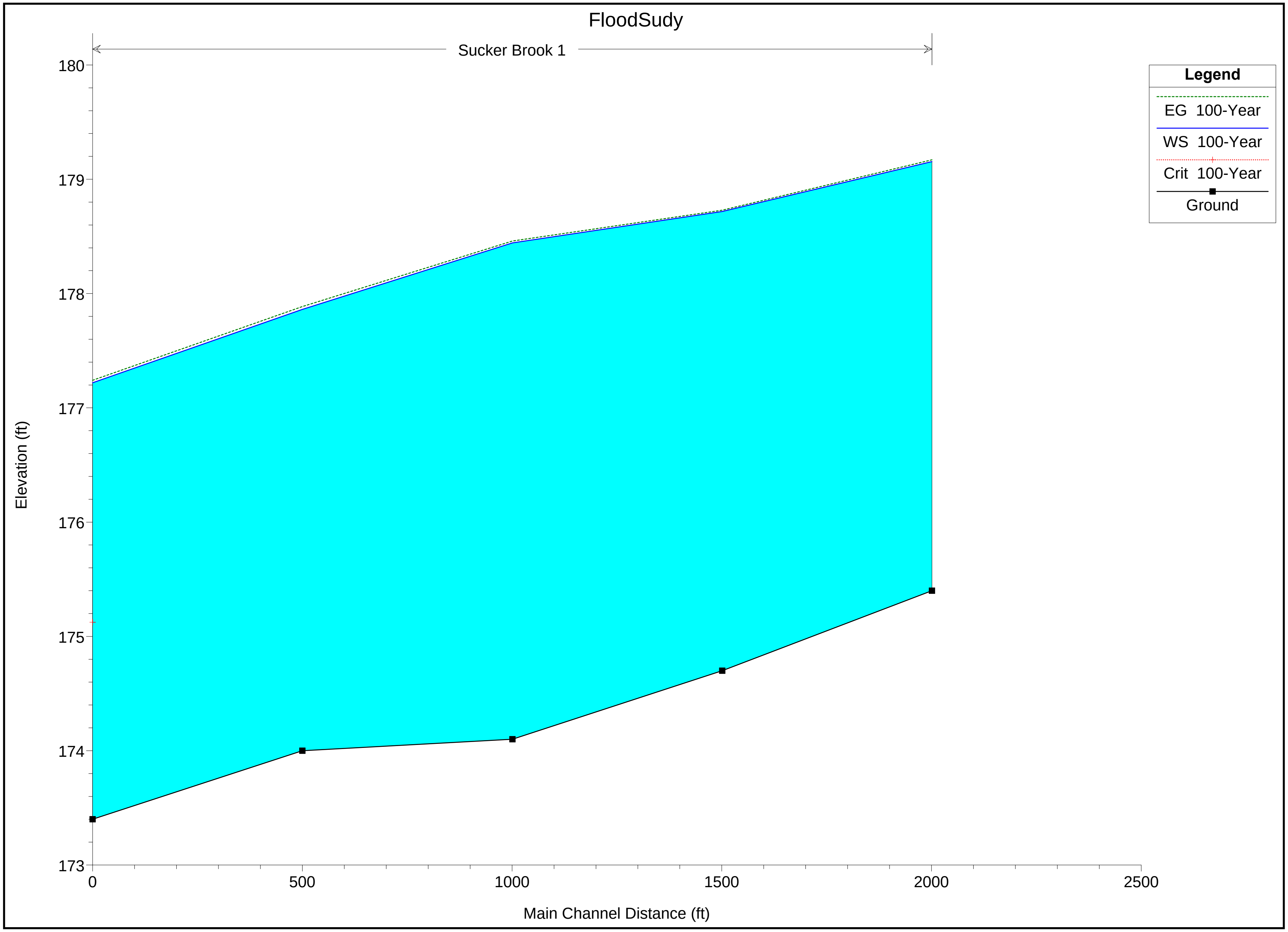
River	Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
				(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
Sucker Brook	1	5	100-Year	179.17	179.16	0.01	0.44	0.00	1792.30	81.89	364.81	744.79
Sucker Brook	1	4	100-Year	178.73	178.72	0.01	0.27	0.00	1912.18	82.95	243.87	957.66
Sucker Brook	1	3	100-Year	178.46	178.44	0.02	0.57	0.00	1696.26	107.21	435.54	765.18
Sucker Brook	1	2	100-Year	177.89	177.86	0.03	0.64	0.00	1470.99	122.95	645.05	856.83
Sucker Brook	1	1	100-Year	177.24	177.22	0.02			1478.76	111.12	649.13	859.23
Int Stream	1	9	100-Year	236.68	236.40	0.28	1.28	0.08	16.06	44.50	24.44	55.96
Int Stream	1	8	100-Year	232.98	232.97	0.02	1.18	0.02	53.43	19.84	11.73	136.37
Int Stream	1	7	100-Year	231.78	231.61	0.17	4.39	0.02	6.83	44.85	33.32	73.20
Int Stream	1	6	100-Year	227.38	227.26	0.12	5.06	0.00	19.64	34.84	30.52	111.60
Int Stream	1	5	100-Year	222.33	222.20	0.13	7.26	0.01	22.44	33.86	28.70	111.20
Int Stream	1	4	100-Year	215.05	214.81	0.24	8.44	0.01	15.09	43.18	26.73	78.36
Int Stream	1	3	100-Year	206.29	205.99	0.30	6.67	0.06	18.77	49.54	16.68	60.51
Int Stream	1	2	100-Year	192.23	192.13	0.10	2.65	0.02	36.46	28.80	19.74	129.61
Int Stream	1	1.5	100-Year	189.56	189.27	0.29	4.39	0.03	11.34	55.98	17.68	77.89
Int Stream	1	1	100-Year	182.54	182.35	0.19			23.12	29.39	32.50	96.18

HEC-RAS Plan: 1 Profile: 100-Year

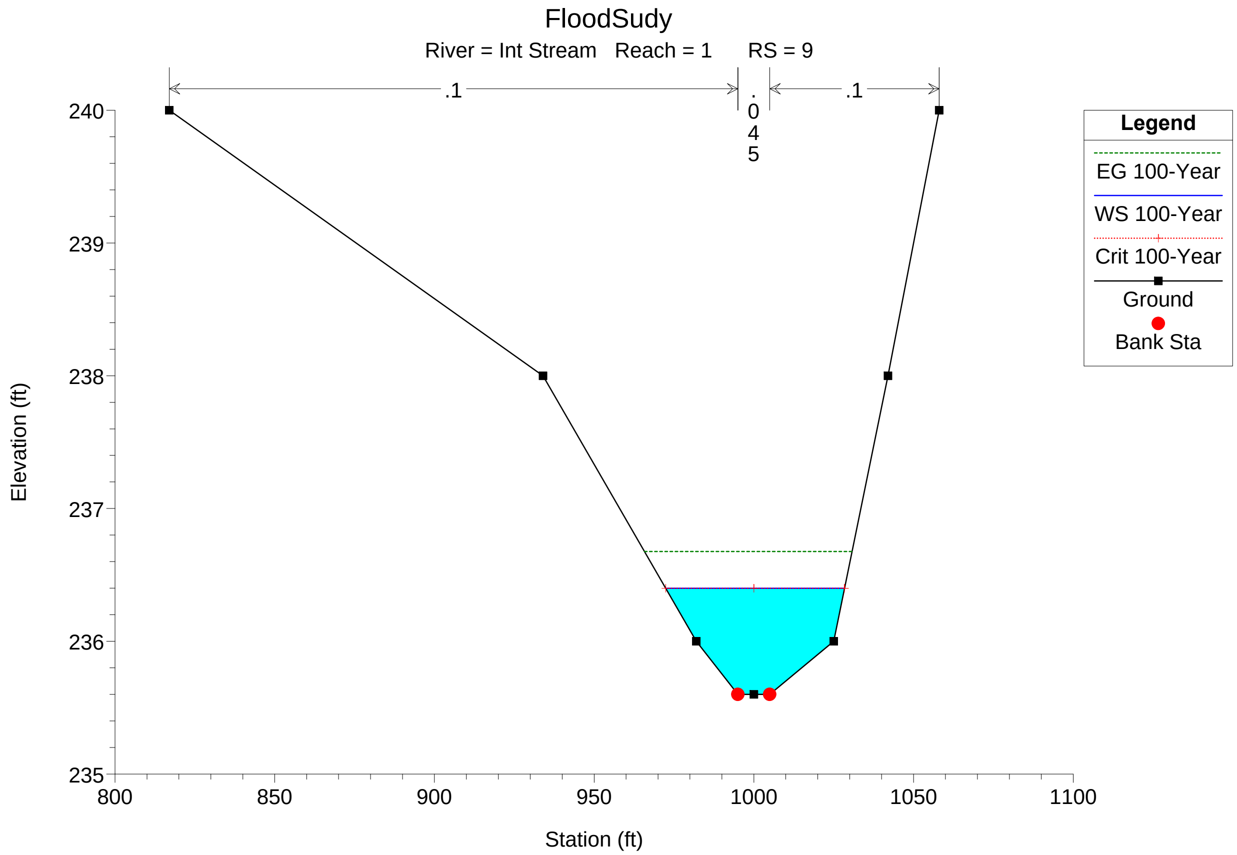
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Sucker Brook	1	5	100-Year	2239.00	175.40	179.16		179.17	0.000747	2.18	2444.98	744.79	0.20
Sucker Brook	1	4	100-Year	2239.00	174.70	178.72		178.73	0.000612	2.06	2864.75	957.66	0.18
Sucker Brook	1	3	100-Year	2239.00	174.10	178.44		178.46	0.000788	2.47	2421.32	765.18	0.21
Sucker Brook	1	2	100-Year	2239.00	174.00	177.86		177.89	0.001536	3.18	2046.26	856.83	0.29
Sucker Brook	1	1	100-Year	2239.00	173.40	177.22	175.12	177.24	0.001300	2.91	2173.91	859.23	0.26
Int Stream	1	9	100-Year	85.00	235.60	236.40	236.40	236.68	0.038431	5.57	30.33	55.96	1.10
Int Stream	1	8	100-Year	85.00	231.80	232.97		232.98	0.002147	1.70	117.29	136.37	0.28
Int Stream	1	7	100-Year	85.00	230.60	231.61	231.48	231.78	0.018111	4.46	41.83	73.20	0.78
Int Stream	1	6	100-Year	85.00	226.40	227.26	227.13	227.38	0.018391	4.05	52.30	111.60	0.77
Int Stream	1	5	100-Year	85.00	221.40	222.20		222.33	0.022129	4.23	49.72	111.20	0.83
Int Stream	1	4	100-Year	85.00	214.00	214.81	214.81	215.05	0.034659	5.34	35.74	78.36	1.05
Int Stream	1	3	100-Year	85.00	205.10	205.99	205.99	206.29	0.033021	5.56	31.43	60.51	1.04
Int Stream	1	2	100-Year	85.00	191.40	192.13	192.04	192.23	0.021853	3.95	54.69	129.61	0.82
Int Stream	1	1.5	100-Year	85.00	188.20	189.27	189.27	189.56	0.022678	5.21	35.42	77.89	0.89
Int Stream	1	1	100-Year	85.00	181.80	182.35	182.35	182.54	0.058096	5.34	36.26	96.18	1.27



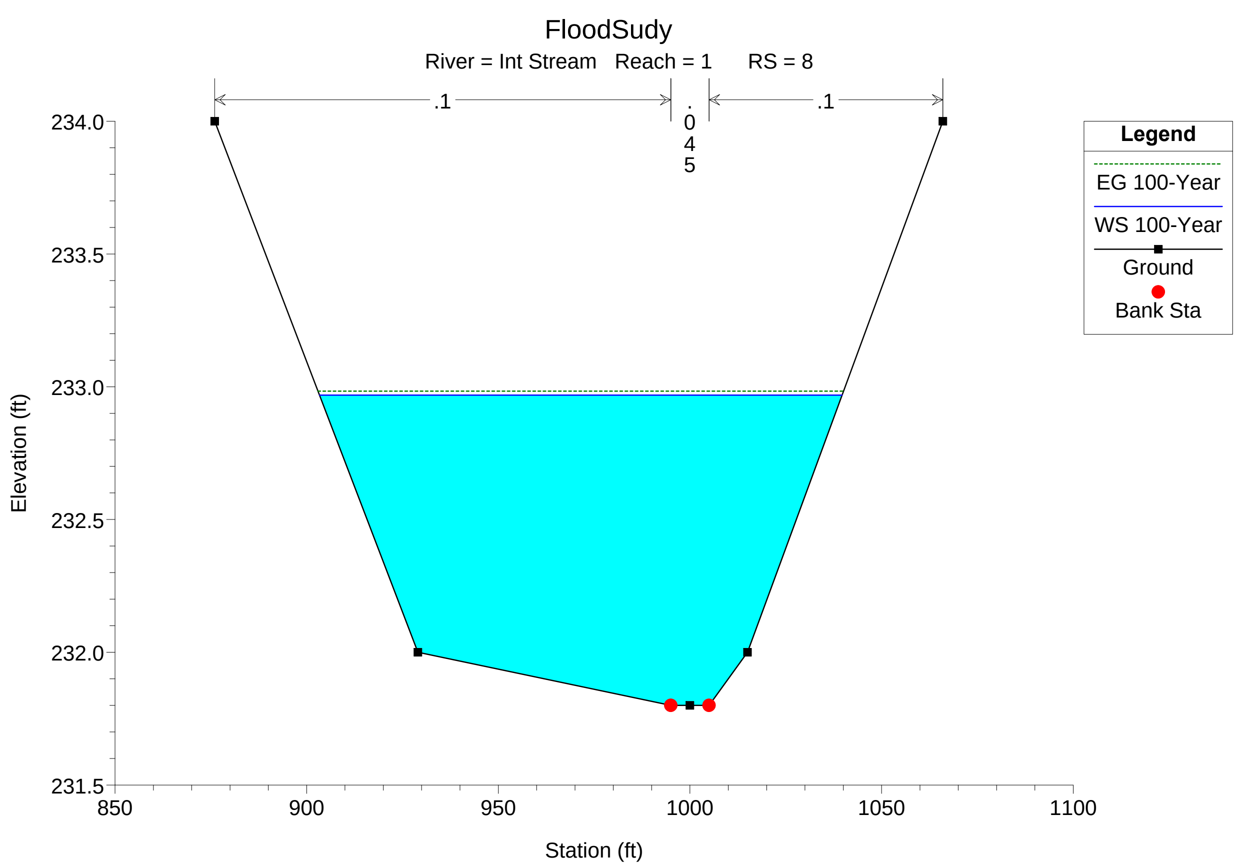
FloodSudy
Int Stream 1
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Elevation (ft)
Main Channel Distance (ft)
240
230
220
210
200
190
180
0
500
1000
1500
2000



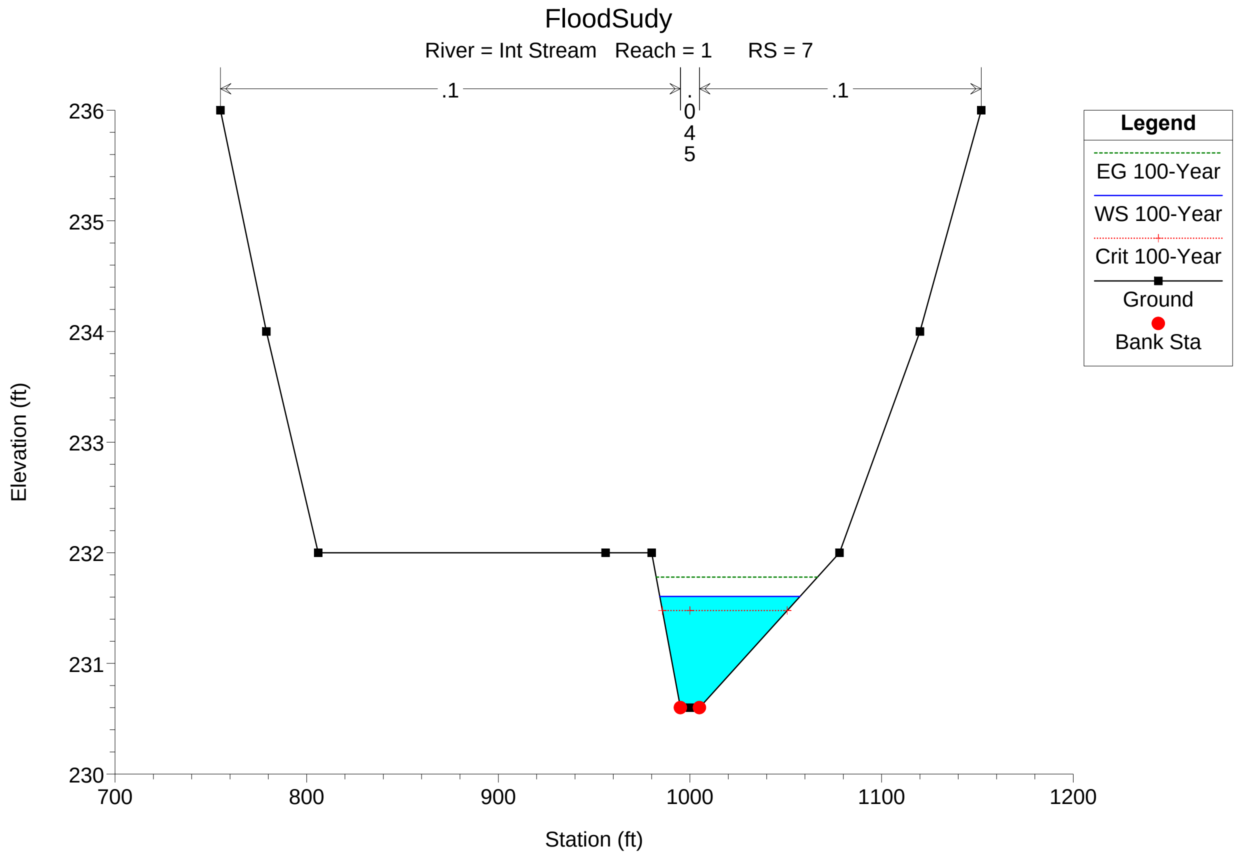
FloodSudy
Sucker Brook 1
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Elevation (ft)
180
179
178
177
176
175
174
173
0
500
1000
1500
2000
2500
Main Channel Distance (ft)

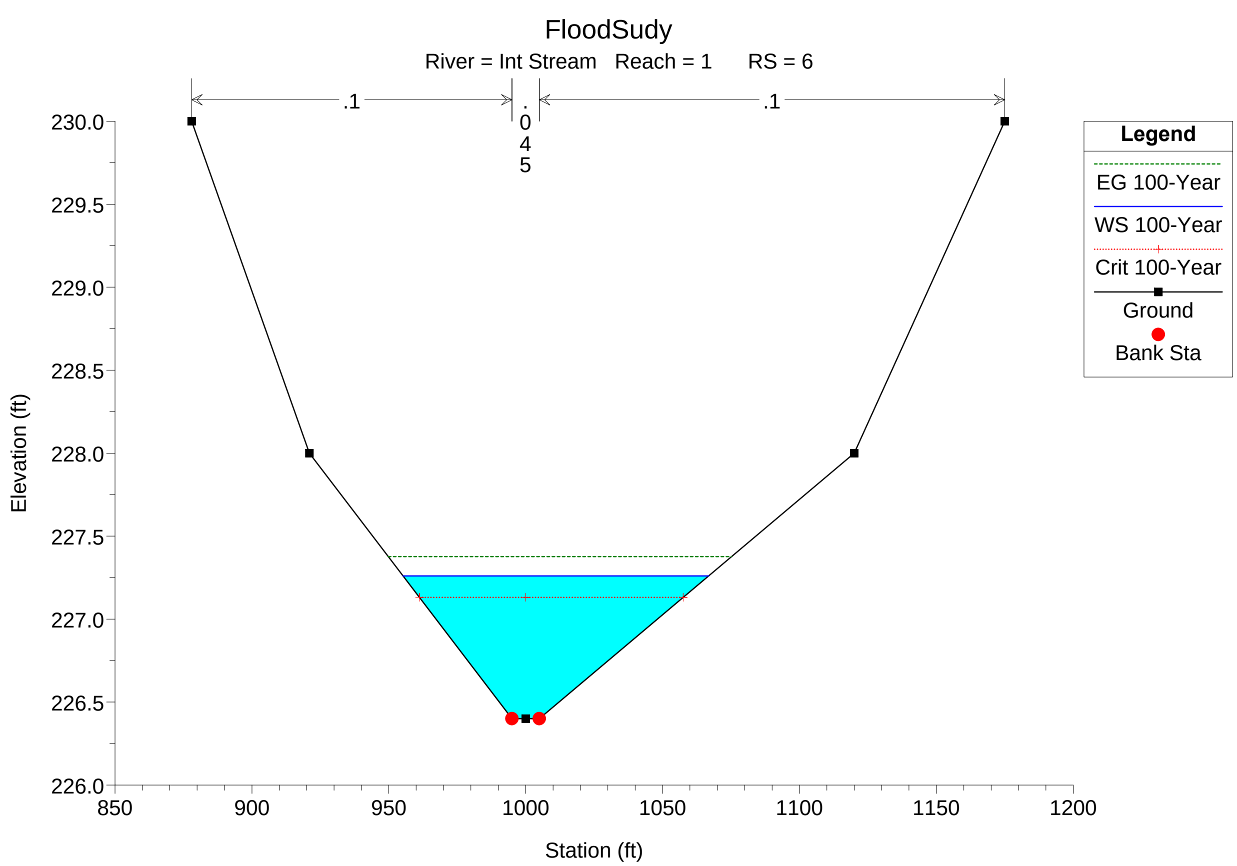


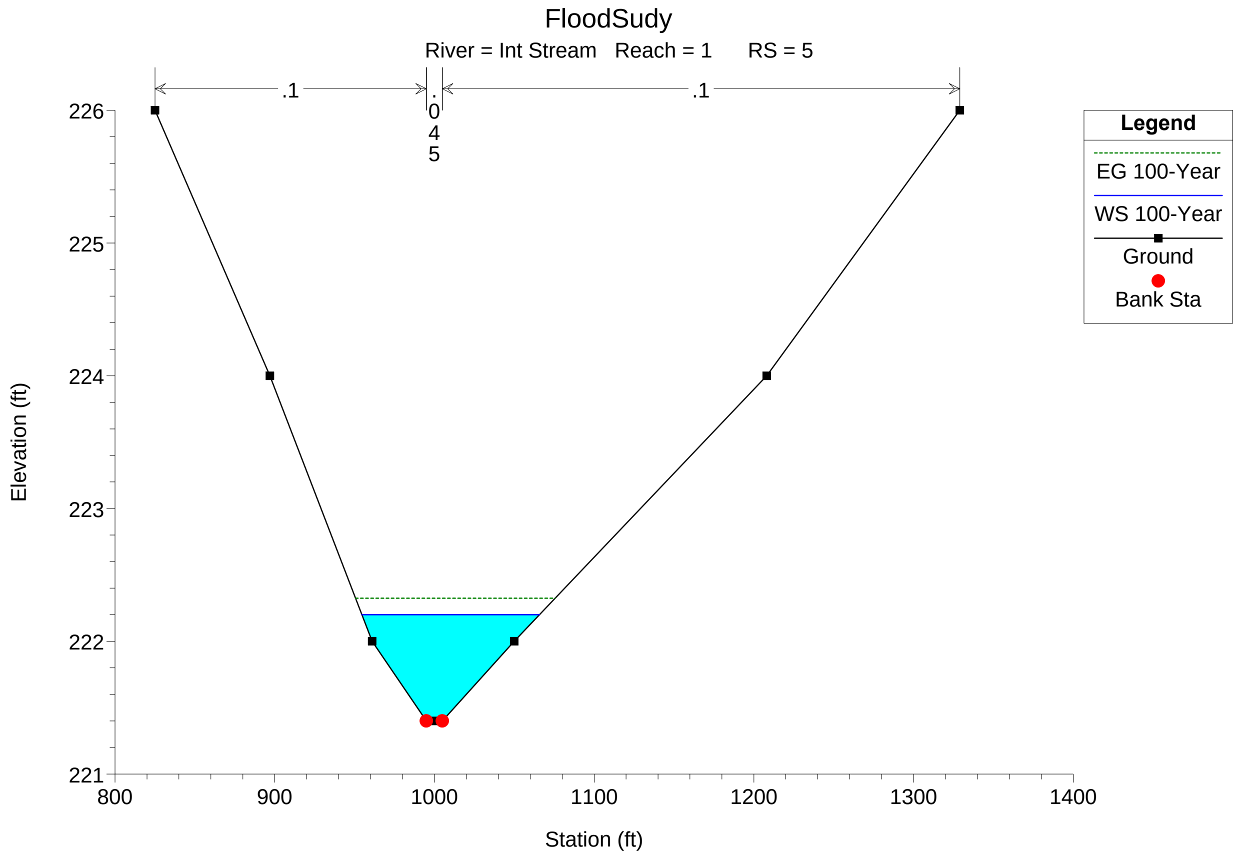
FloodSudy
River = Int Stream Reach = 1 RS = 9
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
240
239
238
237
236
235
800
850
900
950
1000
1050
1100
Station (ft)

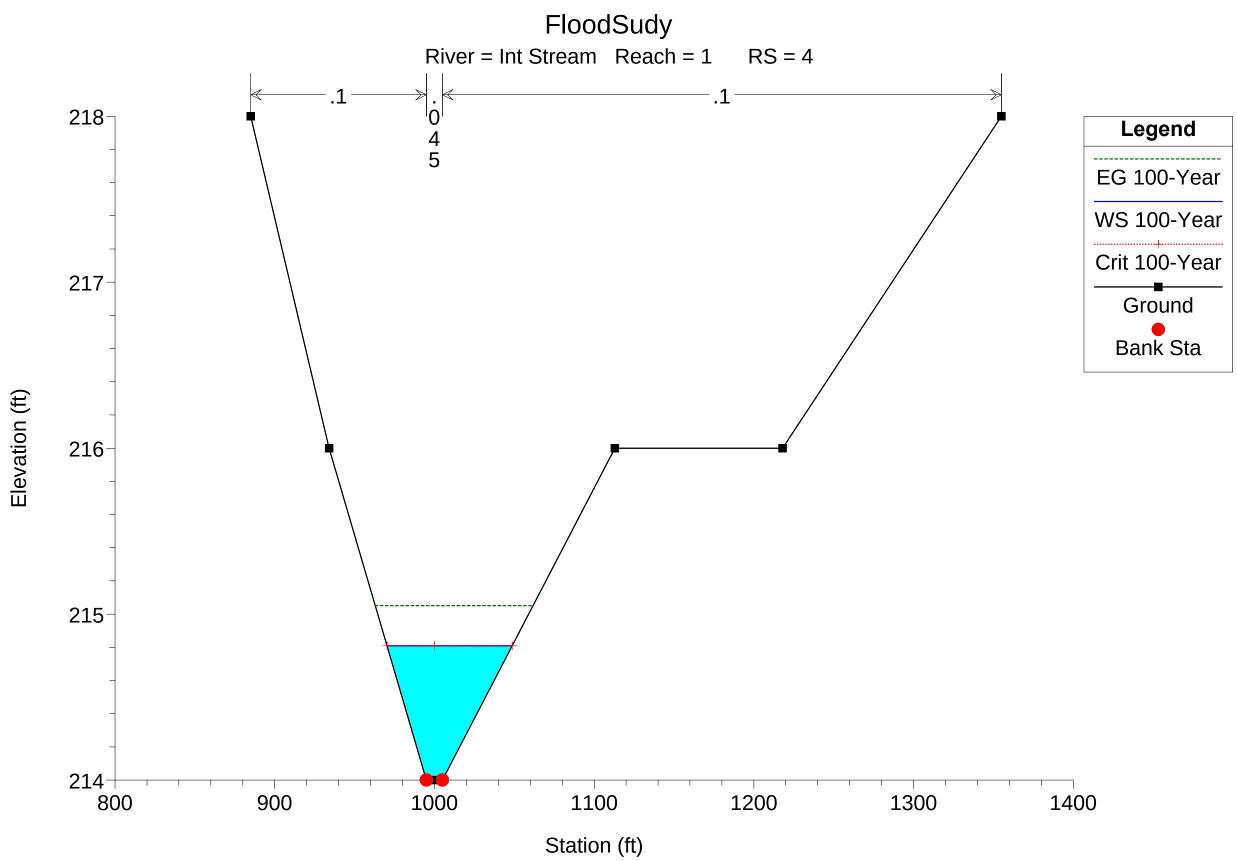


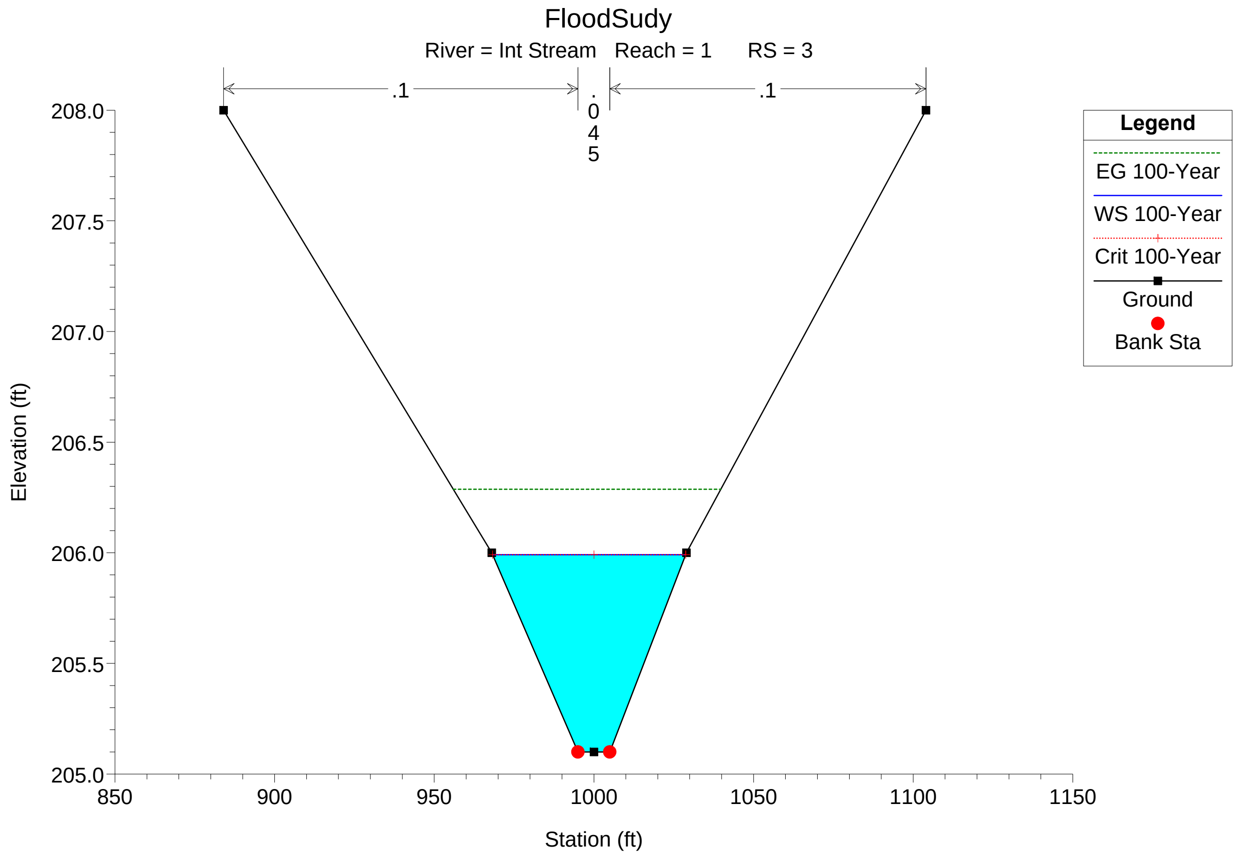
FloodSudy
River = Int Stream Reach = 1 RS = 8
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
234.0
233.5
233.0
232.5
232.0
231.5
850
900
950
1000
1050
1100
Station (ft)


FloodSudy
River = Int Stream Reach = 1 RS = 7
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
236
235
234
233
232
231
230
700
800
900
1000
1100
1200
Station (ft)

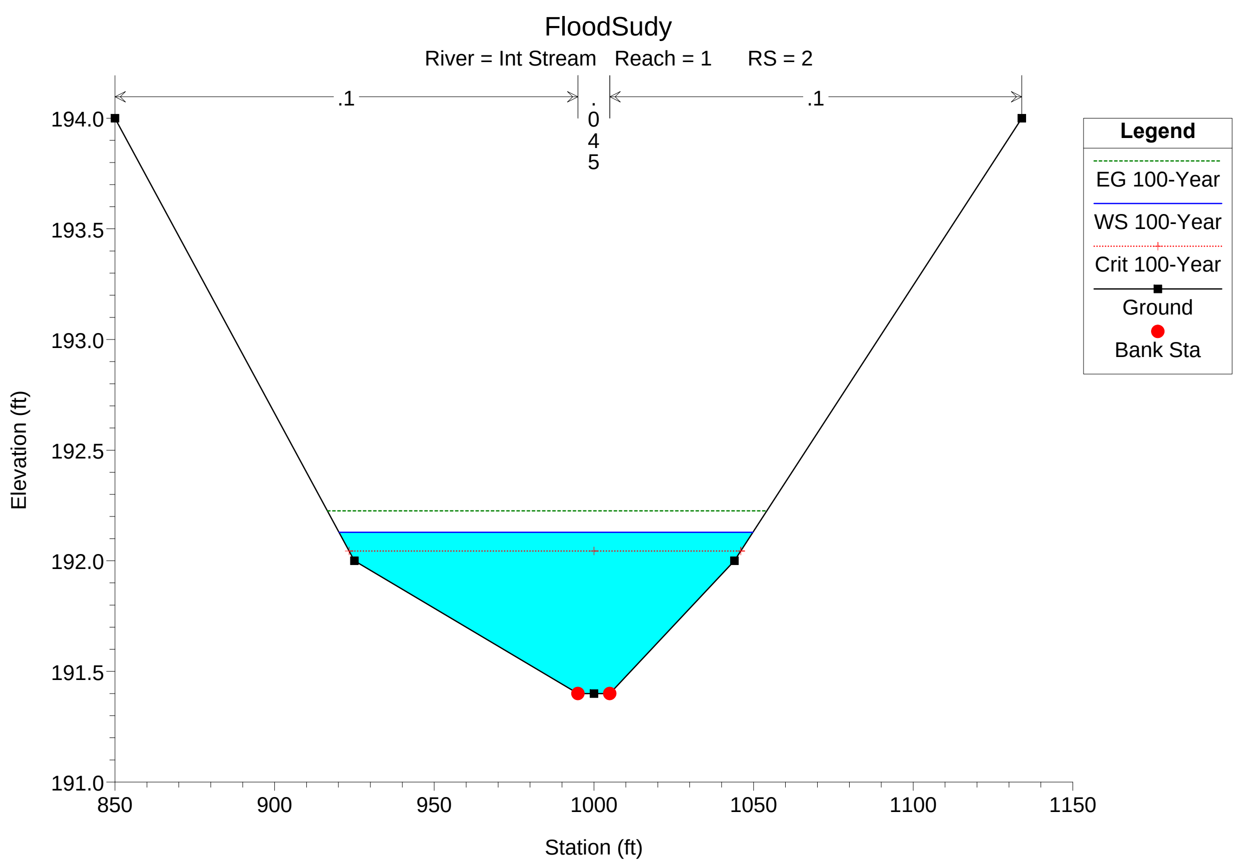

FloodSudy
River = Int Stream Reach = 1 RS = 6
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
230.0
229.5
229.0
228.5
228.0
227.5
227.0
226.5
226.0
850
900
950
1000
1050
1100
1150
1200
Station (ft)


FloodSudy
River = Int Stream Reach = 1 RS = 5
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
226
225
224
223
222
221
800
900
1000
1100
1200
1300
1400
Station (ft)

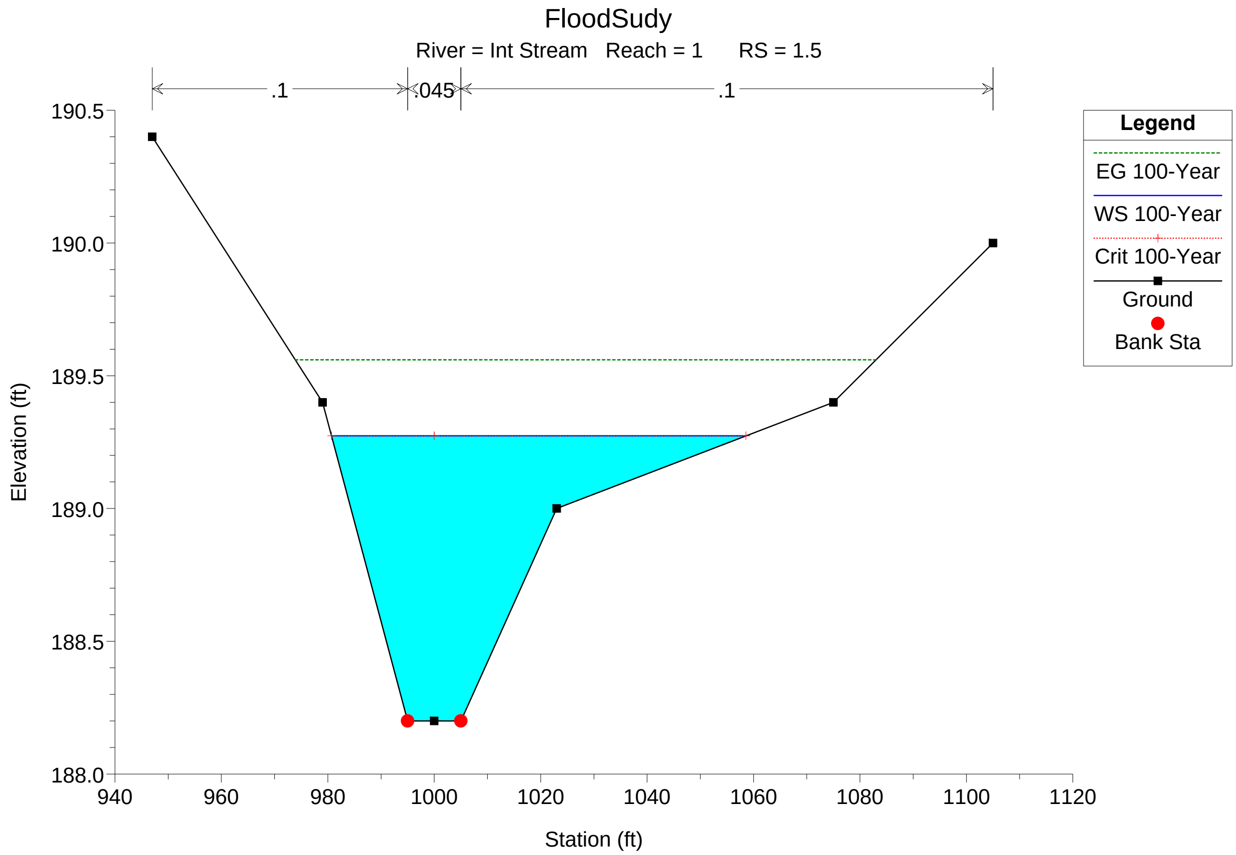

FloodSudy
River = Int Stream Reach = 1 RS = 4
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
218
217
216
215
214
800
900
1000
1100
1200
1300
1400
Station (ft)

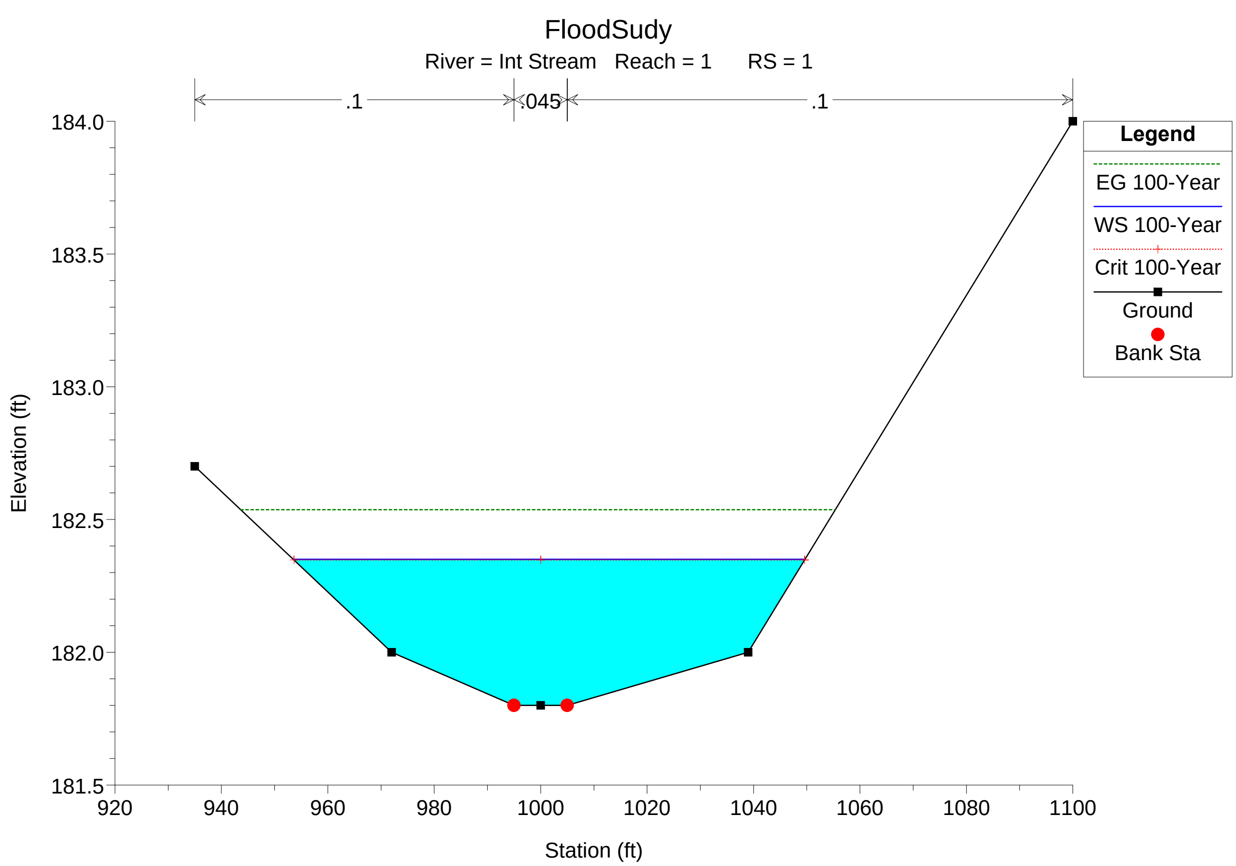


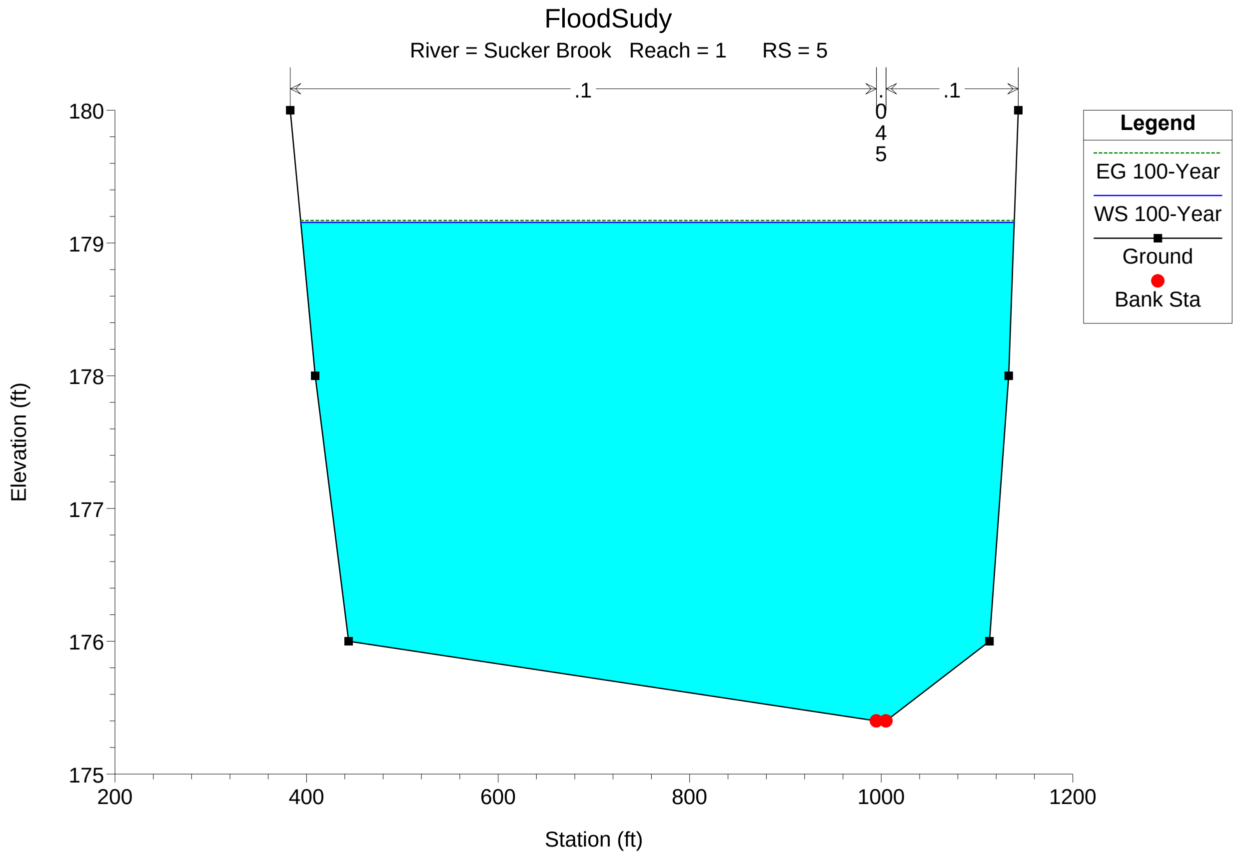
FloodSudy
River = Int Stream Reach = 1 RS = 3
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
208.0
207.5
207.0
206.5
206.0
205.5
205.0
850
900
950
1000
1050
1100
1150
Station (ft)

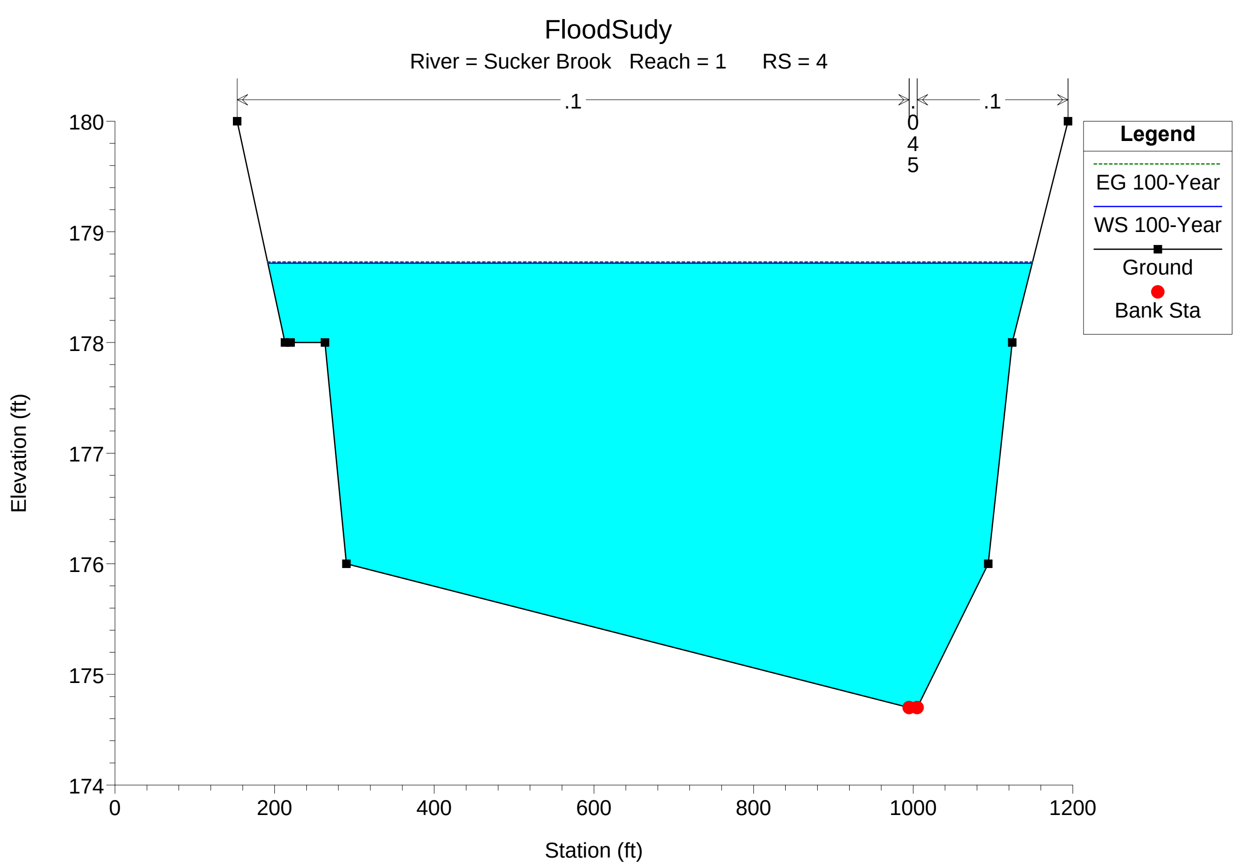


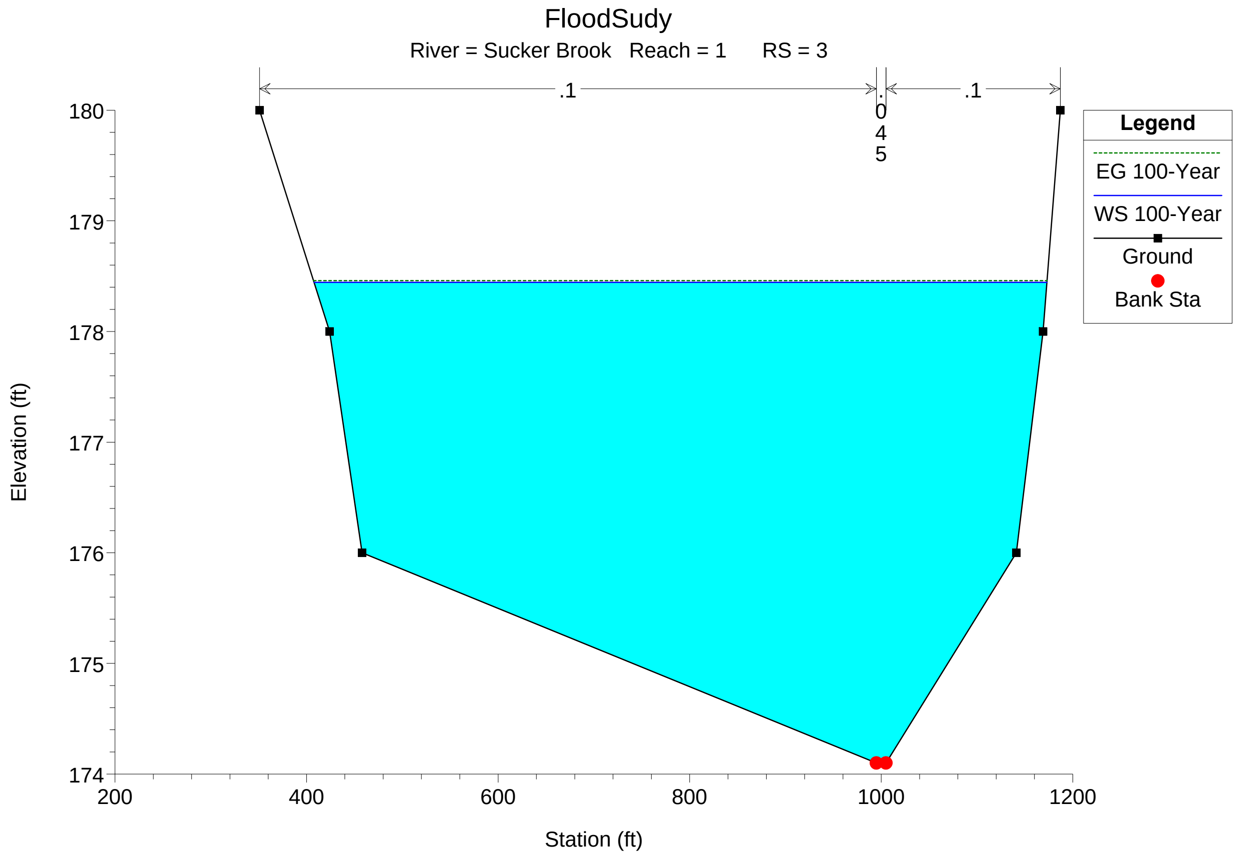
FloodSudy
River = Int Stream Reach = 1 RS = 2
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
194.0
193.5
193.0
192.5
192.0
191.5
191.0
850
900
950
1000
1050
1100
1150
Station (ft)

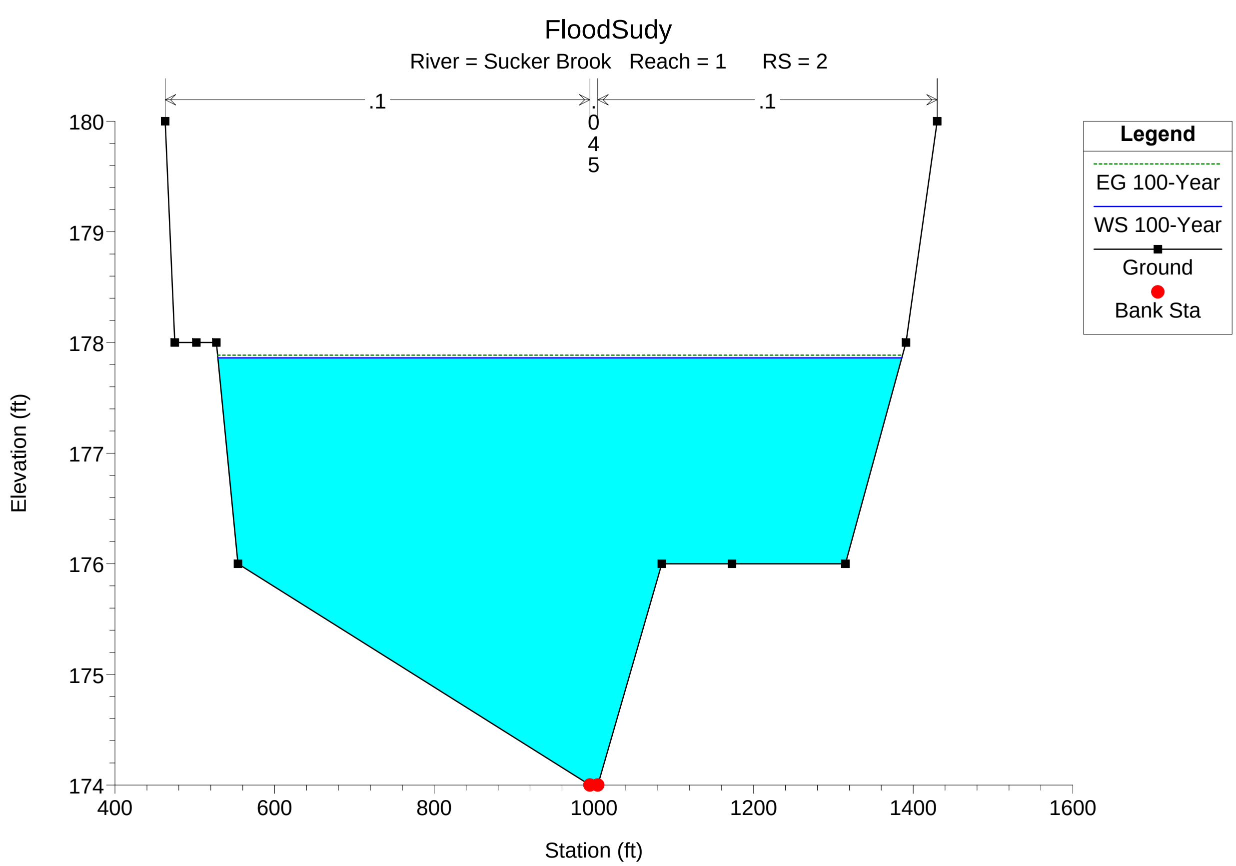

FloodSudy
River = Int Stream   Reach = 1   RS = 1.5
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
190.5
190.0
189.5
189.0
188.5
188.0
940
960
980
1000
1020
1040
1060
1080
1100
1120
Station (ft)

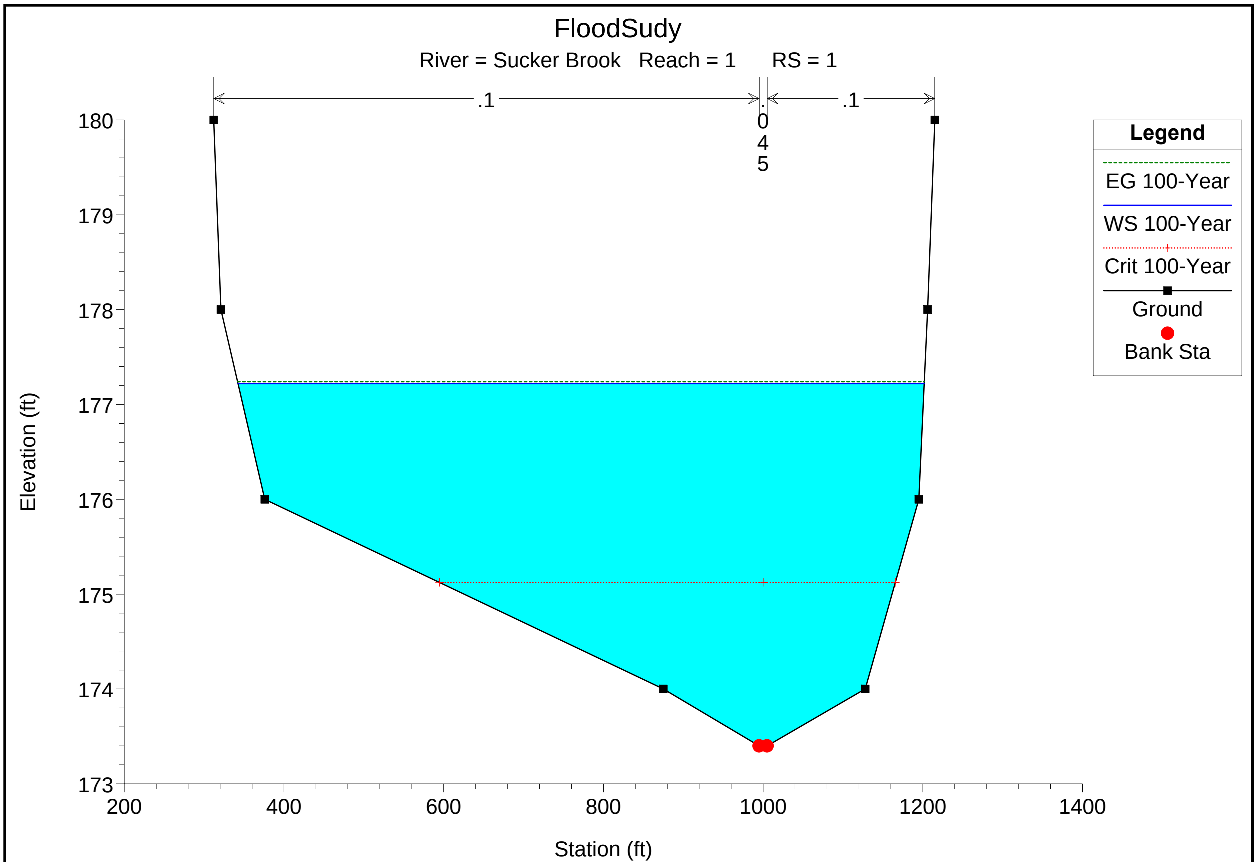

FloodSudy
River = Int Stream   Reach = 1   RS = 1
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
184.0
183.5
183.0
182.5
182.0
181.5
920
940
960
980
1000
1020
1040
1060
1080
1100
Station (ft)


FloodSudy
River = Sucker Brook Reach = 1 RS = 5
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
180
179
178
177
176
175
200
400
600
800
1000
1200
Station (ft)


FloodSudy
River = Sucker Brook Reach = 1 RS = 4
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
180
179
178
177
176
175
174
0
200
400
600
800
1000
1200
Station (ft)


FloodSudy
River = Sucker Brook Reach = 1 RS = 3
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
180
179
178
177
176
175
174
200
400
600
800
1000
1200
Station (ft)


FloodSudy
River = Sucker Brook Reach = 1 RS = 2
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Ground
Bank Sta
Elevation (ft)
180
179
178
177
176
175
174
400
600
800
1000
1200
1400
1600
Station (ft)


FloodSudy
River = Sucker Brook Reach = 1 RS = 1
.1
.045
.1
Legend
EG 100-Year
WS 100-Year
Crit 100-Year
Ground
Bank Sta
Elevation (ft)
180
179
178
177
176
175
174
173
200
400
600
800
1000
1200
1400
Station (ft)